Dredged Material Evaluation Framework

Lower Columbia River Management Area
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US Army Corps of Engineers®
Northwestern Division
Portland District
Seattle District

EPA
Region 10

WASHINGTON STATE DEPARTMENT OF ECOLOGY

deq
Oregon Department of Environmental Quality

WASHINGTON STATE DEPARTMENT OF
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LOWER COLUMBIA RIVER MANAGEMENT AREA

The program established by this document becomes effective upon signature by the agency heads listed below. Each agency will carry out its roles and responsibilities for program implementation under existing authorities. Programmatic changes will be made in conjunction with an annual review process, and any major plan changes will be subject to the approval of the agencies.

Division Commander
U.S. Army Corps of Engineers, Northwestern Division

District Engineer
U.S. Army Corps of Engineers, Portland District

District Engineer
U.S. Army Corps of Engineers, Seattle District

Regional Administrator
U.S. Environmental Protection Agency, Region 10

Director
Oregon Department of Environmental Quality

Director
Washington Department of Ecology

Commissioner of Public Lands
Washington Department of Natural Resources

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Lower Columbia River Management Area

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PREFACE

The U.S. Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) share the responsibility of regulating dredged material management activities under the Marine Protection, Research, and Sanctuaries Act (MPRSA), and the Federal Water Pollution Control Act Amendments of 1972, also called the Clean Water Act (CWA). Such management activities must also comply with the applicable requirements of the National Environmental Policy Act (NEPA). Several state agencies in Oregon and Washington have responsibility for assuring that dredging and disposal activities which take place in state waters comply with applicable state regulations. This framework provides a consistent set of procedures for determining sediment quality for these activities.

The area covered by this document is called the Lower Columbia River Management Area (LCRMA). The LCRMA includes the following water bodies: (1) the Lower Columbia River from its mouth near Ilwaco, Washington to Bonneville Dam at river mile (CRM) 148; (2) the segment of the mid-Columbia River extending from Bonneville Dam upstream to McNary Dam; (3) the Willamette River from its confluence with the Lower Columbia River upstream to its headwaters, and (4) all side channel and tributaries branching from the lower and mid-Columbia River and Willamette River.

This document provides a consistent technical framework to follow in identifying environmentally acceptable alternatives for the management of dredged material. The framework is consistent with and meets the substantive and procedural requirements of NEPA, CWA, and MPRSA and is applicable to dredged material management alternatives. Application of this framework will enhance consistency and coordination in Corps/EPA and state agency decision-making in accordance with Federal and State environmental statutes regulating dredged material management.

This document represents the best available knowledge regarding dredged material assessment at the time of preparation. This is a living document and will be updated as new information and new technologies become available. Recipients of the final document will receive notice of any updates.

This manual was prepared by a joint Federal/State work group consisting of the following members: Rick Vining, Washington Department of Ecology, Ted Benson, Washington Department of Natural Resources, Gene Foster and Tom Rosetta, Oregon Department of Environmental Quality; Jim Reese, U.S. Army Engineer Division, Northwestern; Mark Siipola, Eric Braun and Sheryl Carrubba, U.S. Army Engineer District, Portland; Stephanie Stirling, U.S. Army Engineer District, Seattle; and John Malek, EPA, Region 10.

DEFINITIONS

Acid volatile sulfide: (AVS): The sulfides removed from sediment by cold acid extraction, consisting mainly of H, S and FeS. AVS is a possible predictive tool for divalent metal sediment toxicity.

Acute toxicity: Short-term toxicity to organism(s) that have been affected by the properties of a substance, such as contaminated sediment. The acute toxicity of a sediment is generally determined by quantifying the mortality of appropriately sensitive organisms that are exposed to the sediment, under either field or laboratory conditions, for a specified period. .

Adjacent: Bordering, contiguous or neighboring. Wetlands separated from other waters of the United States by man-made dikes or barriers, natural river berms, beach dunes and the like are adjacent wetlands.

Aquatic disposal: Placement of dredged material in rivers, lakes, estuaries, or oceans via pipeline or surface release from hopper dredges or barges.

Aquatic environment: The geochemical environment in which dredged material is submerged under water and remains water saturated after disposal is completed.

Aquatic ecosystem: Bodies of water, including wetlands, that serve as the habitat for interrelated and interacting communities and populations of plants and animals.

Atterberg limits: Consistency limits, including the liquid limit, the plastic limit, and the shrinkage limit, which define the three stages of fine-grained material.

Bathymetry: Physical configuration of the sea bed; the measurement of depths of water in oceans, seas, and lakes; also information derived from such measurements.

Benchmark organism: Test organism designated by Corps and EPA as appropriately sensitive and useful for determining biological data applicable to the real world. Test protocols with such organisms are published, reproducible and standardized.

Beneficial use: Placement or use of dredged material for some productive use.

Beneficial uses: Placement or use of dredged material for some productive purpose. Beneficial uses may involve either the dredged material or the placement site as the integral component of the beneficial use.

Berm: Narrow shelf of ground left undisturbed; usually at the base of a levee.

Bioaccumulation: The accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, or dredged material.

Bioaccumulation factor: The degree to which an organism accumulates a chemical compared to the source. It is a dimensionless number or factor derived by dividing the concentration in the organism by that in the source.

Bioassay: A bioassay is a test using a biological system. It involves exposing an organism to a test material and determining a response. There are two major types of bioassays differentiated by response: toxicity tests which measure an effect (e.g., acute toxicity, sublethal/chronic toxicity) and bioaccumulation tests which measure a phenomenon (e.g., the uptake of contaminants into tissues).

Biomagnification: Bioaccumulation up the food chain, e.g., the route of accumulation is solely through food. Organisms at higher trophic levels will have higher body burdens than those at lower trophic levels.

Biota sediment accumulation factor (BSAF): Relative concentration of a substance in the tissues of an organism compared to the concentration of the same substance in the sediment.

Bulk sediment chemistry: Results of chemical analyses of whole sediments (in terms of wet or dry weight), without normalization (e.g., to organic carbon, grain-size, acid volatile sulfide).

Capping: The controlled, accurate placement of contaminated material at an open-water site, followed by a covering or cap of clean isolating material.

Chemical of concern: A chemical present in a given sediment thought to have the potential for unacceptable adverse environmental impact due to a proposed discharge.

Chronic: Involving a stimulus that is lingering or which continues for a long time.

Clay: Soil particle having a grain size of less than 2 micrometers.

Coastal zone: Includes coastal waters and the adjacent shorelands designated by a State as being included within its approved coastal zone management program. The coastal zone may include open waters, estuaries, bays, inlets, lagoons, marshes, swamps, mangroves, beaches, dunes, bluffs, and coastal uplands. Coastal-zone uses can include housing, recreation, wildlife habitat, resource extraction, fishing, aquaculture, transportation, energy generation, commercial development, and waste disposal.

Comparability: The confidence with which one data set can be compared to others and the expression of results consistent with other organizations reporting similar data. Comparability of procedures also implies using methodologies that produce results comparable in terms of precision and bias.

Confined disposal: A disposal method that isolates the dredged material from the environment.

Confined disposal facility (CDF): An engineered structure for containment of dredged material consisting of dikes or other structures that enclose a disposal area above any adjacent water surface, isolating the dredged material from adjacent waters during placement. Other terms used for CDFs that appear in the literature include confined disposal area, confined disposal site, and dredged material containment area.

Constituents: Chemical substances, solids, liquids, organic matter, and organisms associated with or contained in or on dredged material.

Contained aquatic disposal: Form of capping which includes the added provision of some form of lateral containment (for example, placement of the contaminated and capping materials in bottom depressions or behind subaqueous berms) to minimize spread of the materials on the bottom.

Contaminant: Chemical or biological substance in a form that can be incorporated into, onto, or be ingested by and is harmful to aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment.

Contaminated sediment: Sediment that has been demonstrated to cause an unacceptable adverse effect on human health or the environment.

Control sediment: A sediment essentially free of contaminants and which is used routinely to assess the acceptability of a test. Control sediment may be the sediment from which the test organisms are collected or a laboratory sediment, provided the organisms meet control standards. The grain-size of the control sediment should be similar to that of the dredged material. Test procedures are conducted with the control sediment in the same way as the reference sediment and dredged material. The purpose of the control sediment is to confirm the biological acceptability of the test conditions and to help verify the health of the organisms during the test. Excessive mortality in the control sediment indicates a problem with the test conditions or organisms, and can invalidate the results of the corresponding dredged material test.

Data quality indicators: Quantitative statistics and qualitative descriptors which are used to interpret the degree of acceptability or utility of data to the user; include bias (systematic error), precision, accuracy, comparability, completeness, representativeness and statistical confidence.

Disposal site: That portion of the waters of the United States where specific disposal- activities are permitted and consist of a bottom surface area and any overlying volume of water. In the case of wetlands on which surface water is not present, the disposal site consists of the wetland surface area

Dredged material: Material excavated from inland or ocean waters.

EC50: The median effective concentration. The concentration of a substance that causes a specified effect (generally sublethal rather than acutely lethal) in 50% of the organisms tested in a laboratory toxicity test of specified duration.

Ecosystem: A system made up of a community of animals, plants, and bacteria and its interrelated physical and chemical environment.

Effluent: Water that is discharged from a confined disposal facility during and as a result of the filling or placement of dredged material.

Elutriate: Material prepared from the sediment dilution water and used for chemical analyses and toxicity testing. Different types of elutriates are prepared for two different procedures as noted in this manual.

Emergency: In the context of dredging operations, emergency is defined in 33 CFR Part 335.7 as a >situation which would result in an unacceptable hazard to life or navigation, a significant loss of property, or an immediate and unforeseen significant economic hardship if corrective action Is not taken within a time period of less than the normal time needed under standard procedures.

Evaluation: The process of judging data in order to reach a decision.

Factual determination: A determination in writing of the potential short-term or long-term effects of a proposed discharge of dredged or fill material on the physical, chemical and biological components of the aquatic environment.

Grain-size effects: Mortality or other effects in laboratory toxicity tests due to sediment granulometry, not chemical toxicity.

Gravel: A loose mixture of pebbles and rock fragments coarser than sand, often mixed with clay, etc.

Habitat: The specific area or environment in which a particular type of plant or animal lives. An organism's habitat provides all of the basic requirements for the maintenance of life. Typical coastal habitats include beaches, marshes, rocky shores, bottom sediments, mudflats, and the water itself.

LC50: The median lethal concentration. The concentration of a substance that kills 50% of the organisms tested in a laboratory toxicity test of specified duration.

Leachate: Water or any other liquid that may contain dissolved (leached) soluble materials, such as organic salts and mineral salts, derived from a solid material. For example, rainwater that percolates through a confined disposal facility and picks up dissolved contaminants is considered leachate.

Leaching: a process which causes a liquid to filter down through another material.

Level bottom capping: A form of capping in which the contaminated material is placed on the bottom in a mounded configuration.

Loading density: The ratio of organism biomass or numbers to the volume of test solution in an exposure chamber.

Management actions: Those actions considered necessary to rapidly render harmless the material proposed for discharge (e.g., non-toxic, non-bioaccumulative) and which may include containment in or out of the waters of the US (see 40 CFR Subpart H). Management actions are employed to reduce adverse impacts of proposed discharges of dredged material.

Management unit: A manageable, dredgeable unit of sediment which can be differentiated by sampling and which can be separately dredged and disposed within a larger dredging area. Management units are not differentiated solely on physical or other measures or tests but are also based on site and project-specific considerations.

Method detection limit (MDL): The minimum concentration of a substance which can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

Pathway: In the case of bioavailable contaminants, the route of exposure (e.g., water, food).

Practicable: Available and capable of being done after taking into consideration cost, existing-technology, and logistics in light of overall project purposes.

QA: Quality assurance, the total integrated program for assuring the reliability of data. A system for integrating the quality planning, quality control, quality assessment, and quality improvement efforts to meet user requirements and defined standards of quality with a stated level of confidence.

QC: Quality control, the overall system of technical activities for obtaining prescribed standards of performance in the monitoring and measurement process to meet user requirements.

Reason to believe: Subpart G of the CWA 404(b) (1) guidelines requires the use of available information to make a preliminary determination concerning the need for testing of the material proposed for dredging. This principle is commonly known as "reason to believe" and is used in Tier I evaluations to determine acceptability of the material for discharge without testing. The decision to not perform additional testing based on prior information must be documented, in order to provide a reasonable assurance that the proposed discharge material is not a carrier of contaminants.

Reference sediment: A whole sediment used to assess sediment conditions exclusive of the material(s) of interest, that is as similar as practicable to the grain size and total organic carbon (TOC) of the dredged material and the sediment at the disposal site, and that reflects the conditions that would exist in the vicinity of the disposal site had no dredged-material disposal ever taken place, but had all other influences on sediment condition taken place. The reference sediment serves as a point of comparison to identify potential effects of contaminants in the dredged material.

Reference site: The location from which reference sediment is obtained.

Representativeness: The degree to which sample data depict an existing environmental condition; a measure of the total variability associated with sampling and measuring that includes the two major error components: systematic error (bias) and random error. Sampling representativeness is accomplished through proper selection of sampling locations and sampling techniques, collection of sufficient number of samples, and use of appropriate subsampling and handling techniques.

Salinity: Salt content, usually expressed in grams of salt per kilogram of water.

Sand: Soil particles having a grain size ranging between about 63 micrometers and 2,000 micrometers.

Sediment: Material, such as sand, silt, or clay, suspended in or settled on the bottom of a water body. Sediment input to a body of water comes from natural sources, such as erosion of soils and weathering of rock, or as the result of anthropogenic activities such as forest or agricultural practices, or construction activities. The term dredged material refers to material which has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

Silt: soil having a grain size ranging between about 2 micrometers and 63 micrometers.

Sublethal (chronic) toxicity: Biological tests which use such factors as abnormal development, growth and reproduction, rather than solely lethality, as end-points. These tests involve all or at least an important, sensitive portion of an organism's life-history. A sublethal endpoint may result either from short-term or long-term (chronic) exposures.

Suspended solids: Organic or inorganic particles that are suspended in water. The term includes sand, silt, and clay particles as well as other solids, such as biological material, suspended in the water column.

Tiered approach: A structured, hierarchical procedure for determining data needs relative to decision-making, which involves a series of tiers or levels of intensity of investigation. Typically, tiered testing involves decreased uncertainty and increased available information with increasing tiers. This approach is intended to ensure the maintenance and protection of environmental quality, as well as the optimal use of resources. Specifically, least effort is required in situations where clear determinations can be made of whether (or not) unacceptable adverse impacts are likely to occur based on available information. Most effort is required where clear determinations cannot be made with available information.

Toxicity: Level of mortality or other end point demonstrated by a group of organisms that have been affected by the properties of a substance, such as contaminated water, sediment, or dredged material.

Toxicity test: A bioassay which measures an effect (e.g., acute toxicity, sublethal/chronic toxicity). Not a bioaccumulation test (see definition of bioassay).

Turbidity: An optical measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. Very high levels of turbidity can be harmful to aquatic life.

Upland environment: The geochemical environment in which dredged material may become unsaturated, dried out, and oxidized.

Water quality certification: A state certification, pursuant to Section 401 of the Clean Water Act, that the proposed discharge of dredged material will comply with the applicable provisions of Sections 301, 303, 306 and 307 of the Clean Water Act and relevant State laws. Typically this certification is provided by the affected State. In instances where the State lacks jurisdiction (e.g., Tribal Lands), such certification is provided by EPA or the Tribe (with an approved certification program).

Waters of the US: In general, all waters landward of the baseline of the territorial sea and the territorial sea. Specifically, all waters defined in the CWA 404(b)(1) guidelines.

Whole sediment: The sediment and interstitial waters of the proposed dredged material or reference sediment that have had minimal manipulation. For purposes of this manual, press-sieving to remove organisms from test sediments, homogenization of test sediments, compositing of sediment samples, and additions of small amounts of water to facilitate homogenizing or compositing sediments may be necessary to conducting bioassay tests. These procedures are considered unlikely to substantially alter chemical or toxicological properties of the respective whole sediments except in the case of AVS (acid volatile sulfide) measurements (EPA, 1991a) which are not presently required. Alternatively, wet sieving, elutriation, or freezing and thawing of sediments may alter chemical and/or toxicological properties, and sediment so processed should not be considered as whole sediment for bioassay purposes.

ACRONYMS

AMD	Advance Maintenance Dredging
BT	Bioaccumulation Trigger
CoC	Chemical of Concern
CRM	Columbia River Mile
CWA	Clean Water Act
CY	Cubic Yard
CZM	Coastal Zone Management
DAIS	Dredged Analysis Information System
DEQ	Oregon Department of Environmental Quality
DLCD	Oregon Dept. of Land Conservation and Development
DMMO	Dredged Material Management Office
DMMT	Dredged Material Management Team
DNR	Washington Department of Natural Resources
DSL	Oregon Division of State Lands
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
ITM	Inland Testing Manual
LCR	Lower Columbia River
ML	Maximum Level
MPRSA	Marine Protection Research and Sanctuaries Act
NEPA	National Environmental Policy Act
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PSDDA	Puget Sound Dredged Disposal Analysis
QA/QC	Quality Assurance/Quality Control
RM	River Mile
RMT	Regional Management Team
SAP	Sampling and Analysis Plan
SL	Screening Level
SMS	Washington Sediment Management Standards
TBT	Tributyltin
TOC	Total Organic Carbon
TVS	Total Volatile Solids

CHAPTER 1

GOALS, DESCRIPTION, AND ORGANIZATION

1.1 INTRODUCTION

Dredging is necessary to maintain waterways and harbors used for waterborne commerce and water-related industry shipping, and for new port and marina construction in the Pacific Northwest. In addition to federal navigation project-related dredging (which is performed by the Corps of Engineers), a number of ports, maritime industries, and private interests perform dredging and dredged material disposal. Commercial navigation and recreational boating are important factors to the economic well-being of the Pacific Northwest. Consequently, dredging in the region has been a commonplace activity historically and will be an ongoing necessity for the foreseeable future.

Five basic dredged material disposal options are possible. These include: unconfined aquatic (including nearshore); unconfined upland; confined aquatic; confined nearshore; and confined upland. Of these options, this manual study focused primarily on unconfined aquatic disposal of materials dredged from Federal and non-Federal navigation projects. Unconfined aquatic disposal occurs when material is allowed to free fall from barges or hoppers to the bottom, or is placed via pipeline discharge. Aquatic disposal sites are located in areas which minimize conflicts with other aquatic land uses.

Cost-effective disposal of dredged material is essential to the economy of the region. Periodic dredging, including maintenance dredging of Federal navigation channels, is necessary to maintain the navigability of our waterways. For relatively clean dredged material, without significant levels of chemicals of concern, disposal at unconfined aquatic sites is often the least costly and most convenient alternative. Beneficial uses of the material, including erosion control and use as fill material, are an attractive, if somewhat more expensive, option for disposal. This dredged material evaluation framework will be the basis for determining what materials will continue to be acceptable for unconfined aquatic disposal.

This document addresses the development of a comprehensive evaluation framework governing sampling, sediment testing, and test interpretation (disposal guidelines) for determining the suitability of dredged material. This framework will ensure adequate regulatory controls and public accountability for disposal of sediment placed at dredged material disposal sites. It has been developed pursuant to the Clean Water Act of 1977 (Public Law 92-500), as amended, to the

Marine Protection, Research, and Sanctuaries Act of 1972 (Public Law 92-532), as amended, and to the national level dredging and disposal guidance developed subsequent to the passage of these laws (40 CFR 230-233; 40 CFR 220-229). Applicable national guidance documents include the jointly prepared Environmental Protection Agency/Corps of Engineers national ocean disposal testing manual, entitled *Evaluation of Dredged Material Proposed for Ocean Disposal - Testing Manual*, dated February 1991 (referred to as the Ocean Testing Manual and also known as the "Green Book"), and the jointly prepared EPA/Corps inland testing manual, entitled *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual*, dated February 1998 (referred to as the "Inland Testing Manual").

The framework planning group attempted to identify the most reliable, recognized and cost effective sampling and analysis procedures for appropriately characterizing dredged material, and to incorporate these procedures into this document for application to the region. Chemical and biological tests and interpretation guidelines were developed for assessing the acceptability of dredged material for unconfined aquatic disposal. Application of these tests and guidelines will also provide preliminary information on the need for other disposal or management options, such as confined aquatic, nearshore, or upland disposal.

This framework document distills the accumulated knowledge and experience with dredged material management in the Pacific Northwest over the last 25 years. It describes stepwise procedures for dredged material assessment and is intended for use by the regulatory community in the Lower Columbia River Management Area (LCRMA). Documents containing justification for the guidelines and procedures in this framework are contained in the reference section. Full consideration was made of all pertinent State and Federal laws, regulations, and guidance, including other regional dredged material management programs. The framework is consistent with the guidelines of the two national-level manuals.

1.2 DREDGED MATERIAL EVALUATION FRAMEWORK - LOWER COLUMBIA RIVER

The dredged material evaluation framework for the Lower Columbia River is the result of a cooperative interagency/intergovernmental program established by the U.S. Army Corps of Engineers (Corps); Region 10, U.S. Environmental Protection Agency (EPA); Washington Department of Ecology (Ecology); Washington Department of Natural Resources (DNR); and Oregon Department of Environmental Quality (DEQ) as principal agencies. These five agencies have regulatory and proprietary responsibilities for dredged material evaluation and disposal in the region, and constitute the Regional Management Team (RMT). The Lower Columbia River Dredged Material Evaluation Framework represents an expansion toward a broader dredged material management program throughout the region. The procedures used in development of the manual were derived from, and inspired by, similar regional programs, including the successful Puget Sound Dredged Disposal Analysis (PSDDA) program for the Puget Sound region of the state of Washington, the Grays Harbor/Willapa Bay Dredged Material Evaluation Procedures Manual, and Portland District Corps of Engineers dredged material tiered testing procedures.

The goal of the manual is to provide the basis for publicly acceptable guidelines governing environmentally safe unconfined aquatic disposal of dredged material, thereby improving consistency and predictability in dredged material management. The establishment of evaluation procedures is necessary to ensure continued operation and maintenance of navigation facilities in the region, to minimize delays in scheduled maintenance dredging, and to reduce uncertainties in regulatory activities. The framework guidelines ensure consistency in evaluation between Corps and non-Corps dredging projects.

1.3 FRAMEWORK OBJECTIVES

This manual satisfies several objectives.

(1) It establishes a uniform framework for evaluating sediment quality for unconfined aquatic disposal in the Lower Columbia River.

> The Lower Columbia River (LCR) is a contiguous bi-state coastal water body lying within Oregon and Washington. Dredging and aquatic dredged material disposal occur on both the Oregon and Washington sides of the river. Projects may involve dredging in one state with disposal in the other state. Potential problems associated with disposal of dredged material can affect both states equally. Because dredging, disposal, and associated impacts affect both states, regulation of these activities must be consistent between Oregon and Washington.
>
> States have statutory control over water quality impacts resulting from a neighboring state. Section 401 (a)(2) of the Clean Water Act requires that a neighboring state be notified of actions that may affect its water quality. In order to work efficiently under this regulation, water quality requirements in a bi-state waterway must be uniform. Without uniform requirements, the implementation of water quality programs in shared water bodies may not be consistent or predictable. Section 103 of the Clean Water Act encourages states to develop uniform laws for the prevention, reduction and elimination of pollution

and to negotiate and enter into agreements or compacts not contrary to any laws or treaties of the United States.

(2) It establishes a uniform framework under which the Corps of Engineers will carry out federal requirements in conducting the dredging and disposal program for the LCR.

This document is the result of a cooperative effort involving Washington Department of Ecology, Washington Department of Natural Resources, Oregon Department of Environmental Quality, U.S. Environmental Protection Agency, Corps of Engineers, and other interested parties. A cooperative effort was necessary to ensure that each agency's mandates and regulations were incorporated into a single manual to the extent possible. The laws and regulations under which the Corps operates require the Corps, to the maximum extent practicable, to predict dredged material types, contaminant levels, and biological effects, both in water and sediments, before dredging and disposal actions can be considered environmentally acceptable. This document provides the regulatory framework that will facilitate a consistent application of regional criteria and guidelines.

(3) It establishes an appropriate sediment characterization framework agreeable to the public, stakeholders and resource agencies.

This regional manual establishes a sediment sampling and testing framework acceptable to stakeholders, such as ports and private industries that maintain navigation access in the study area, and to resource agencies having an interest in, concern for, or some form of permit authority in the LCR area. These are resource agencies that did not participate in the development of the manual but have expertise related to the natural resource values of the river. Such a framework will provide clarity, maximize consistency and, allow informed discussions to take place on the need for and extent of sediment characterization for dredging projects.

(4) It establishes appropriate databases to track the long-term trends in sediment quality of specific dredging projects/locations and the river in general.

Management of dredging and disposal program requires the collection and maintenance of data about projects and their characteristics. This objective includes the establishment of appropriate databases which will track sediment quality trends over time at specific locations and for the river in general. Systematic database development will provide useful input into larger planning efforts, such as the Dredged Material Management Plan (DMMP) for disposal of sediment dredged in the estuary. The DMMP includes plans and alternatives developed to address the future needs and availability of disposal sites in the estuary. Implementation of the framework will generate regular reporting on sediment quality in the study area and thus raise the information level available to the Corps and resource agencies when making decisions on dredging and disposal.

1.4 EVALUATION PROCEDURES PHILOSOPHY

Evaluation procedures consist of the sampling requirements, tests, and guidelines for test interpretation (i.e., disposal guidelines) that are to be used in assessing the quality of dredged material and its acceptability for disposal. Evaluation procedures identify whether unacceptable adverse effects on biological resources or human health might result from dredged material disposal. A regulatory decision on acceptability of material for disposal is determined from the test results. This manual defines the minimum requirements for evaluation of dredged material for regulatory decision-making under CWA and MPRSA. For example, the maximum volumes of dredged material that can be represented by a single sample or by a single analysis is defined for different categories of material. Application of this requirement to a proposed volume of sediment means that a minimum number of samples or analyses must be conducted and fewer than that number are insufficient for agency decision-making. Similarly, these requirements are considered "minimum" in that the dredging proponent may opt, or regulatory agencies may impose additional samples or analyses if warranted.

As previously noted, this document primarily addresses aquatic disposal issues. However, the broad concept of evaluation goes beyond open-water disposal to include such alternatives as upland, nearshore, and confined aquatic disposal. Depending on the specific circumstances, these disposal options may be characterized as beneficial uses of dredged material as well. From a regional perspective, we have relied upon open-water disposal to a considerable extent, particularly in recent years. This is due, in part, to a collective desire to avoid or minimize wetland filling. With few exceptions, sediments in the region have been deemed suitable for unconfined aquatic disposal. It is recognized that evaluation procedures applicable to upland, nearshore, and confined disposal, particularly as related to contaminated sediments, also need to be established. The necessity for doing so is recognized and efforts are underway to set these procedures in place.

Dredged material containing high chemical concentrations that may result in unacceptable adverse effects must be placed in a confined disposal site (aquatic, upland, or nearshore). Likely effects are determined by conducting chemical and biological tests on the sediment prior to dredging. Material that is found to be unacceptable for unconfined aquatic disposal may or may not be acceptable for conventional upland/nearshore disposal, because of differing behavior of chemicals in upland and nearshore disposal environments. As a result, testing for disposal at upland and nearshore sites could differ from that for disposal in water, and test results for one environment are not directly transferable to the other.

There is no single best option when confined disposal is required. Although all options may be feasible, not all confined disposal options may be available to every dredging project. Additionally, confined disposal decisions will often revolve around the advantages and disadvantages of specific sites (e.g., proximity to resources). Besides availability and siting, the issues of cost and the necessary degree of chemical isolation must be considered. The joint EPA/Corps manual *Technical Framework for Dredged Material Management* (USACE/EPA 1992) provides a framework for the full continuum of management alternatives, and will be consulted for options whenever material is found unsuitable by this manual for unconfined aquatic disposal.

1.5 CHARACTERISTICS OF THE EVALUATION FRAMEWORK

Evaluation procedures comprise the complete process of dredged material assessment and incorporate a range of scientific and administrative factors. Beyond the decision to base dredged material evaluation on avoiding unacceptable adverse biological effects, effective evaluation procedures should also have certain characteristics. The following nine characteristics are inherent in the evaluation process:

- **Consistent** - Evaluation procedures must be applicable on a uniform basis regardless of project or site variability.
- **Flexible** - Evaluation procedures must be flexible enough to allow for exceptions due to project and site-specific concerns and be adaptable to projects of any size.
- **Accountable** - The need for, and cost implications of, evaluation procedures must be justifiable to the individual permittee and to the public.
- **Cost Effective** - Evaluation procedures must be timely and cost effective.

- **Objective** - Evaluation procedures are clearly stated and logical, and must be applicable in an objective manner.

- **Revisable** - Evaluation procedures are based upon best available technical and policy information and will be revised periodically to incorporate new information and management decisions.

- **Understandable** - Evaluation procedures must be clear and concise.

- **Technically Sound** - Evaluation procedures must be reproducible, have adequate quality assurance and quality control guidelines and generally have standardized protocols.

- **Verifiable** - The implementation of the evaluation procedures must be verifiable. One means of judging effectiveness is monitoring at a disposal site.

1.5.1 The Need for Consistency in Dredged Material Evaluation

Regulatory consistency is important to the regulated community, demanded by local government agencies, and needed to obtain public acceptance. Though consistent and "objective" evaluation procedures may somewhat reduce flexibility and reliance on best professional judgement, they achieve agreement among the various regulatory agencies and allow the transfer of knowledge as staffs change. The approach used was to compile the consensus "best judgement" of professionals currently involved in dredged material management in the region and nationally and build this judgement into the procedures and guidelines presented in this manual.

1.5.2 The Need for Flexibility in Application of Evaluation Procedures

Although consistency is an important objective, it is recognized that flexibility must be maintained in the way the evaluation procedures and disposal guidelines are applied. When project-specific technical indications warrant, suitability evaluations or determinations which deviate from those indicated by the guidelines presented in this manual may be made. Consequently, professional judgement is essential in reaching project-specific decisions. The evaluation procedures (including the disposal guidelines) require full consideration of all pertinent project factors. Flexibility will be provided "by exception." The guidelines are expected to apply in the majority of cases. Rather than integrating flexibility into the guideline statements (by showing ranges of values, or by using terms such as "may do"), exceptions to the guidelines are allowed with appropriate technical rationale and documentation, when such rationale warrants a different conclusion. A consensus between the Corps, EPA, and the affected state(s) will be required for use of this management by exception approach. Further, this exception approach will only be used where applicable federal and/or state law does not otherwise preclude its application.

A good example of how flexibility enters into the decision making process using evaluation procedures is the use of statistics and professional judgement in data interpretation. Statistics are primarily applied in the initial data analysis stage of the disposal guidelines. Statistical significance is used to determine if observed differences are "potentially real" when natural variability of the parameters being measured is considered. Ultimate data interpretation requires judgement on the part of a professional who is intimately familiar with the testing procedures, the project specifics, and the initial data analysis conclusions.

Analysis of data consists of a comparison to guideline values that are developed using statistical significance as a clear indicator of toxicity. However, ecological significance cannot be determined by this process. Determination of ecological significance requires both an understanding of the data and evaluation procedures, and evaluation of those test results based on best professional judgment. In addition to data analysis and interpretation, decisions on the acceptability of material for unconfined aquatic disposal may be further influenced by administrative considerations of factors such as magnitude of the proposed discharge, the degree of environmental risk that the discharge may present, and other project-specific features.

1.6 FUTURE REGIONAL FRAMEWORKS

EPA Region 10 and Northwestern Division, Corps of Engineers, will use the experience gained by the development and implementation of this framework to develop a Northwest regional framework. The RMT will work closely with other regional dredging teams to assure that the framework will reflect consistency and advances in testing and evaluation in the Northwest. This future framework is intended for use within the boundaries of Region 10, which includes three of Northwestern Division's Districts, and the states of Washington, Oregon and Idaho. EPA also intends to develop a framework to evaluate dredging projects in Alaska. Details of that process will be developed jointly with Alaska District, Corps of Engineers, and the state of Alaska.

1.7 STUDY PARTICIPANTS AND PUBLIC INVOLVEMENT

As noted above in Section 1.1, a variety of interests participated in the preparation of the LCRMA dredged material evaluation framework. Representatives of the Corps' Seattle District, Portland District, Northwestern Division Corps, EPA Region 10, Washington Department of Ecology, Washington Department of Natural Resources, and Oregon Department of Environmental

Quality met as necessary to coordinate the work group activities, and to draft the framework. Participation by affected users was sought via review of this document by representatives of the ports, maritime industries, and other navigation project users. In addition, federal, state and local agencies, Indian tribes, and special interest groups participated in the review of the draft framework. This participation ensured that the framework reflects a balance of all appropriate views. A full public interest review was completed, including a public notice, and all comments received from the public were carefully considered during preparation of the final document and prior to agency acceptance.

CHAPTER 2

DREDGED MATERIAL MANAGEMENT REGULATION

2.1 OVERVIEW

Several state and federal entities have regulatory or proprietary authority governing dredged material management. On the federal level, the U.S. Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) share the responsibility for regulating the discharge of dredged material. In Washington state, regulation is shared by the Departments of Ecology, Natural Resources, and Fish and Wildlife. In Oregon, this regulation is carried out by the Department of Environmental Quality, Division of State Lands, and Department of Land Conservation and Development. This chapter gives a brief overview of agency laws, regulations and authorities as they relate to the dredging and disposal of sediments.

2.2 FEDERAL REGULATIONS OVERVIEW

The Clean Water Act (CWA) governs discharges of dredged material into "waters of the United States," defined as all waters landward of the baseline of the territorial sea. The Marine Protection, Research, and Sanctuaries Act (MPRSA) governs the transportation of dredged material seaward of the baseline (in ocean waters) for the purpose of disposal.

The geographical jurisdictions of the MPRSA and CWA are indicated in Figure 2-1. As shown in Figure 2-1, an overlap of jurisdiction exists within the territorial sea. The precedence of MPRSA or CWA in the area of the territorial sea is defined in 40 CFR 230.2 (b) and 33 CFR 336.0 (b). Material dredged from waters of the United States and disposed in the territorial sea is evaluated under MPRSA. In general, dredged material discharged as fill (e.g., beach nourishment, island creation, or underwater berms) and placed within the territorial sea is evaluated under the CWA. In addition, all activities regulated by these statutes must comply with the applicable requirements of the National Environmental Policy Act (NEPA), as well as other federal laws, regulations and Executive Orders which apply to activities involving the discharge of dredged material. NEPA usually acts as an umbrella authority which assures all applicable environmental requirements are complied with for federal dredging projects. An overview of MPRSA, CWA, and other federal laws is given in the following paragraphs.

2.2.1 Rivers and Harbors Act Section 10/Clean Water Act Section 404. The Corps administers a regulatory program under Section 10 of the Rivers and Harbors Act of 1899 which requires approval by the Secretary of the Army of any work in navigable waters.

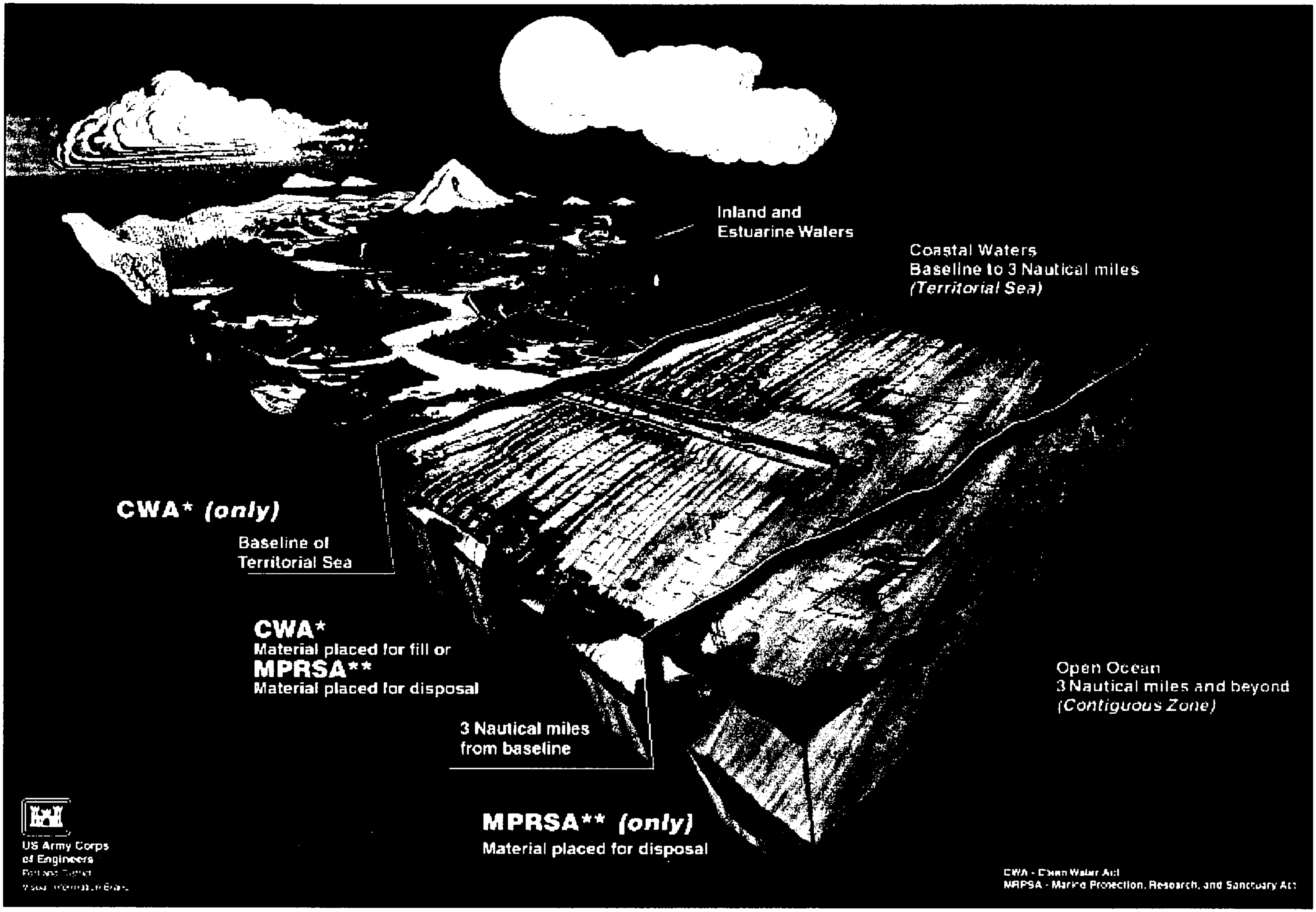

Figure 2.1: Geographic Jurisdiction of the Marine Protection, Research and Sanctuaries Act and the Clean Water Act

The Corps also has the primary responsibility for the CWA Section 404 regulatory permit program. Section 404 of the Clean Water Act requires a permit for the discharge of dredged or fill material into the waters of the United States. These permits, known as Section 10/404, may be processed concurrently when both dredging and disposal/filling are necessary, as is often the case with in-water or nearshore disposal.

The Clean Water Act applies to "waters of the United States." The Corps' administrative definition of "waters of the United States" extends to all waters, including lakes, streams, mudflats, wetlands and sloughs, "the use, degradation or destruction of which" could affect interstate or foreign commerce. This definition includes wetlands adjacent to these waters. Section 404, therefore, covers more than Section 10. (CWA Section 502(7), and Section 230.3 of the Guidelines).

All parties, including federal agencies, are subject to regulation under Section 10 and Section 404. Though the Corps does not issue itself a permit, these same regulations govern the Corps' own dredging and disposal activities.

Section 10. A Section 10 permit is required for any dredging activity in navigable waters, regardless of the location of the disposal site. For purposes of Section 10, navigable waters generally are those U.S. waters below the mean high water mark, and those used or usable for interstate or foreign commerce. A dredging project with no return flow to the waters of the U.S. would require only a Section 10 permit.

Section 404. A Section 404 permit is required only for discharges of dredged or fill material into waters of the United States. A Section 404 permit is required when dredged material is disposed in either an aquatic or nearshore environment. It is also required when dredged material will be hydraulically placed in an upland environment and effluent from the disposal will be returned to waters of the U.S. This can occur where dredged material that is not de-watered is placed in nearshore or upland disposal sites.

Under Section 404(b)(1), the Administrator of the Environmental Protection Agency (EPA) has developed, in conjunction with the Secretary of the Army, Guidelines for evaluating specific proposed aquatic or nearshore disposal sites.

The Guidelines evaluate potential disposal sites based on potential impacts on the physical, chemical, and biological characteristics of the aquatic environment. The Guidelines specify four conditions for the selection of any aquatic site for the disposal of dredged or fill material (Section 404 (b)(1) Final Rule 40 CFR 230). They are:

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

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

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

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

While considering the Guidelines, the Corps conducts a public interest review and considers comments from agencies and the public. The final permit decision is based on whether the activity is in compliance with the Guidelines (including sediment quality) and a determination that the proposed activity is not contrary to the public interest. The public interest review includes a broad range of factors, from environmental concerns to public health issues to property ownership as well as compliance with other federal laws. The Corps has substantial authority to require mitigation to avoid, minimize, rectify, reduce, or compensate for resource losses. In cases where no aquatic site is proposed for disposal, the Corps' decision to issue a permit is based solely on the public interest review and not the Guidelines.

EPA retains oversight authority regarding the Corps' decision to issue a permit and may veto permit approval if it concludes that the discharge of dredged or fill materials would have an "unacceptable adverse effect" on municipal water supplies, shellfish beds and fisheries, wildlife, or recreational areas.

2.2.2 Marine Protection, Research, and Sanctuaries Act of 1972. The Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972, as amended (Public Law 92-532), specifies that all proposed operations involving the transportation and dumping of dredged material into the ocean have to be evaluated to determine the potential environmental impact of such activities. Section 103 of the MPRSA appoints the Corps the permitting agency, subject to EPA review. Regulations are at 40 CFR 220-228. An Ocean Testing Manual has been jointly issued by EPA and the Corps (EPA/USACE 1991)in which a "tiered" testing approach is employed. Section 102 of the MPRSA requires EPA, in consultation with the Corps, to develop environmental Criteria that must be complied with before any proposed ocean-disposal activity is allowed to proceed. The Criteria call for no unacceptable adverse effects. Section 103 of the MPRSA assigns to the Corps the specific responsibility for authorizing the transport of dredged material for ocean disposal at designated sites.

In evaluating proposed ocean-disposal activities, the Corps is required to apply the Criteria developed by EPA relating to the effects of the proposed disposal activity. In addition, in reviewing permit applications, the Corps is also required to consider navigation, economic, and industrial development, and foreign and domestic commerce, as well as the availability of alternatives to ocean disposal. EPA has a major environmental oversight role in reviewing the Corps' determination of compliance with the ocean-disposal Criteria relating to the effects of the proposed disposal. If EPA determines the Criteria are not met, disposal may not occur without a waiver of the Criteria by EPA (40 CFR 225.2 (e)). In addition, EPA has authority under Section 102 to designate ocean-disposal sites. The Corps is required to use such sites for ocean disposal to the extent feasible. Section 103 authorizes the Corps, where use of an EPA-designated site is not feasible or a site has not been designated, to select ocean-disposal sites. In exercising this authority, the Corps utilizes the EPA site-selection Criteria (40 CFR 228), and the site selection is subject to EPA concurrence.

2.2.3 Coastal Zone Management Act of 1972. The Coastal Zone Management Act (CZMA) of 1972, as amended (Public Law 92-583), declared a national interest in the effective management, beneficial use, protection and development of the coastal zone. The law grants to state and local governments the primary responsibility for planning and regulation of land and water uses in the coastal zone. States are charged with developing and administering land and water use management programs for the coastal zone. Federal projects within the coastal zone, including dredging and disposal projects, must be consistent, to the maximum extent practicable, with the approved state programs. For non-federal projects, a required Corps permit cannot be issued until the State of Washington (Ecology) and/or Oregon (DLCD) has concurred that the project is in compliance with the approved coastal zone management plan. Concurrence with CZMA is considered waived after a six-month period has elapsed since the Corps public notice.

2.2.4 Endangered Species Act of 1973. Section 7 of the Endangered Species Act of 1973, as amended, requires Federal agencies to ensure their actions do not jeopardize endangered or threatened species or their critical habitats. If a project could affect an endangered species, coordination with the U.S. Fish and Wildlife Service or National Marine Fisheries Service is required.

2.2.5 National Environmental Policy Act (NEPA). These dredging programs are operated in accordance with NEPA, which requires documentation of potential primary and secondary impacts, including those associated with dredging and disposal.

2.3 WASHINGTON STATE REGULATIONS

2.3.1 Section 401 Certification Program. Section 401 of the Clean Water Act requires state certification that any federally-permitted project discharging into U.S. waters will not violate state water quality standards which are based on federal water quality criteria. For non-federal dredging, Section 401 certification is a precondition to compliance with Section 404 guidelines and is required before receiving a Section 404 permit for disposal of dredged or fill material. The Section 401 certification is required when dredged material is to be placed in an aquatic or nearshore environment, or when dredged material is hydraulically placed in an upland environment where return flows may affect waters of the U.S.

The Washington State Department of Ecology is the agency for certifying under Section 401 that a proposed discharge will comply with state water quality standards. As a condition of certification, Ecology may apply any requirement or policy of state law that protects aquatic habitat. In situations where the state has no jurisdiction (for example, tribal lands and military installations), EPA provides Section 401 certification. EPA may also comment on compliance with state and federal water quality under Section 401. These conditions may be accepted by the Corps and used as conditions in the Section 404 permit.

2.3.2 Hydraulic Project Approval. A State Hydraulic Project Approval permit is required for actions affecting the natural flow of waters. This generally means any action in saltwater or a stream below the ordinary high water mark. The permit application must be acted upon by the Washington Department of Fish and Wildlife (WDFW) within 30 days after receipt of the full permit application, including determination of compliance under the State Environmental Policy Act.

2.3.3 Aquatic Lands Act. The Aquatic Lands Act, Revised Code of Washington, Chapter 79.90, gives the Department of Natural Resources (DNR) proprietary authority to manage state-owned aquatic lands in trust for the public. In accordance with the Act, and implementing regulations cited as Chapter 332-30 of the Washington Administrative Code (WAC), DNR has the power to lease state-owned aquatic lands for development and charge a fee for the discharge or use of dredged material. Aquatic or nearshore disposal sites can be subject to DNR's management. However, DNR does not directly control upland disposal of dredged material except on DNR-managed lands.

2.3.4 Sediment Management Standards. The State of Washington has adopted Sediment Management Standards (SMS) as Chapter 173-204 WAC. The SMS were promulgated for the purpose of reducing and ultimately eliminating adverse effects on biological resources and significant health threats to humans from surface sediment contamination. They apply to marine, low salinity, and freshwater surface sediments within the state of Washington. Numerical criteria exist for marine waters only.

The SMS provide two levels of effects specific to the contamination of marine sediments: a "No Adverse Effects" criteria (defined as the Sediment Quality Standard, or SQS) and a "Minor Adverse Effects" criteria (defined as the Cleanup Screening Level, or CSL). These criteria guide decisions pertaining to sediment cleanup and source control actions.

The SQS represents the goal to be attained for all sediments. However, it is recognized that this goal (No Adverse Effects) may be impractical in some cases. The CSL represents an acceptable upper limit (Minor Adverse Effects level) of chemical contamination.

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

Local Shoreline Master Programs have been adopted as state regulations under the Administrative Procedures Act. These state regulations, as well as others affecting the quality of the shoreline environment, were approved by the Secretary of Commerce as the state's Coastal Zone Management Program. Thus, in Washington, a local Shoreline Permit which has been issued and survived appeals is the mechanism for determining compliance with Federal Coastal Zone Management Act.

Preferential uses for shorelines are (in their order of preference):

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

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

2.4 OREGON STATE REGULATIONS

2.4.1 Coastal Program Approval. Federal projects and those projects receiving a federal permit are reviewed by the Department of Land Conservation and Development for consistency with enforceable state and local policies of the Oregon coastal management program. Projects complying with this program are issued a coastal program approval.

2.4.2 Section 401 Certification Program. Section 401 of the Clean Water Act requires state certification that any federally-permitted project discharging into U.S. waters will not violate state water quality standards which are based on federal water quality criteria. For non-federal dredging, Section 401 certification is a precondition to compliance with Section 404 guidelines and is required before receiving a Section 404 permit for disposal of dredged or fill material. The Section 401 certification is required when dredged material is to be placed in an aquatic or nearshore environment, or when dredged material is to be hydraulically placed in an upland environment where return flows may affect waters of the United States.

The Oregon Department of Environmental Quality (DEQ) is the agency for certifying under Section 401 that a proposed discharge will comply with state water quality standards. Under the Section 401 certification program, DEQ certifies and may use any requirement or policy of state law that protects aquatic habitat to condition the Section 401 certification. In situations where the state has no jurisdiction (for example, tribal lands and military installations), EPA provides Section 401 certification.

2.4.3 Removal/Fill Permit. The Oregon Division of State Lands issues a permit for any activity that proposes removal, fill or alterations equal to or exceeding 50 cubic yards of material within the beds or banks of the waters of the state of Oregon. In addition, any amount of removal, filling or alteration in State Scenic Waterways and essential Indigenous Salmonid streams requires approval from the Division. Typical examples of projects requiring a permit include gravel mining, dredging, gold mining, placement of riprap, bulkheads, land reclamation, channel alteration or relocation and stream crossings.

2.4.4 State Beaches. Oregon State Parks issues permits for any activity, including placement of dredged material, on state beaches.

CHAPTER 3

LOWER COLUMBIA RIVER MANAGEMENT AREA

3.1 OVERVIEW

The area covered by this manual is called the Lower Columbia River Management Area (LCRMA). The LCRMA includes the following water bodies: (1) the Lower Columbia River from its mouth near Ilwaco, Washington to Bonneville Dam at river mile (CRM) 148; (2) the segment of the mid-Columbia River extending from Bonneville Dam upstream to McNary Dam; (3) the Willamette River from its confluence with the Lower Columbia River upstream to its headwaters, and (4) all side channel and tributaries branching from the lower and mid-Columbia River and Willamette River. The LCRMA is shown in Figure 3-1.

The scope of the LCRMA was chosen because all of the water bodies are connected in a common watershed and they fall under a common regulatory jurisdiction, the USACE, Portland District. A minor exception to this regulatory scheme is a small number of non-port (private) dredging projects on the Washington side of the river which fall under the USACE, Seattle District. Within this broad reach, the mainstem navigation channel runs the full length of the river varying in depths of 55 feet at the entrance, 40 feet to Portland/Vancouver, 32 feet to Bonneville Dam and 15 feet to McNary Dam. The navigation channel in the Lower Willamette River is maintained at a depth of 40 feet.

The following sections provide a general description of the LCRMA and a summary of hydrodynamic characteristics that have, or may have, a relationship to dredging and disposal. Much of the focus is on the Lower Columbia River segment of the LCRMA since that is where the majority of dredging and disposal takes place.

3.2 GENERAL DESCRIPTION OF THE LCR

The Lower Columbia River (LCR) forms the border between Washington and Oregon and supports the most concentrated population and industrial base along the U.S. portion of the river. The utility of the LCR as a major shipping channel has encouraged the development of major port facilities and heavy industrial activity in the population centers. Major population centers include Astoria, Rainier, Portland, St. Helens and Troutdale in Oregon and Longview-Kelso, Kalama, Vancouver, and Camas-Washougal in Washington. Land use adjacent to the river is devoted mainly to forestry and, to a lesser extent, agriculture, urban and suburban development, and residential use.

Lower Columbia River Management Area
Lower Columbia River Basin

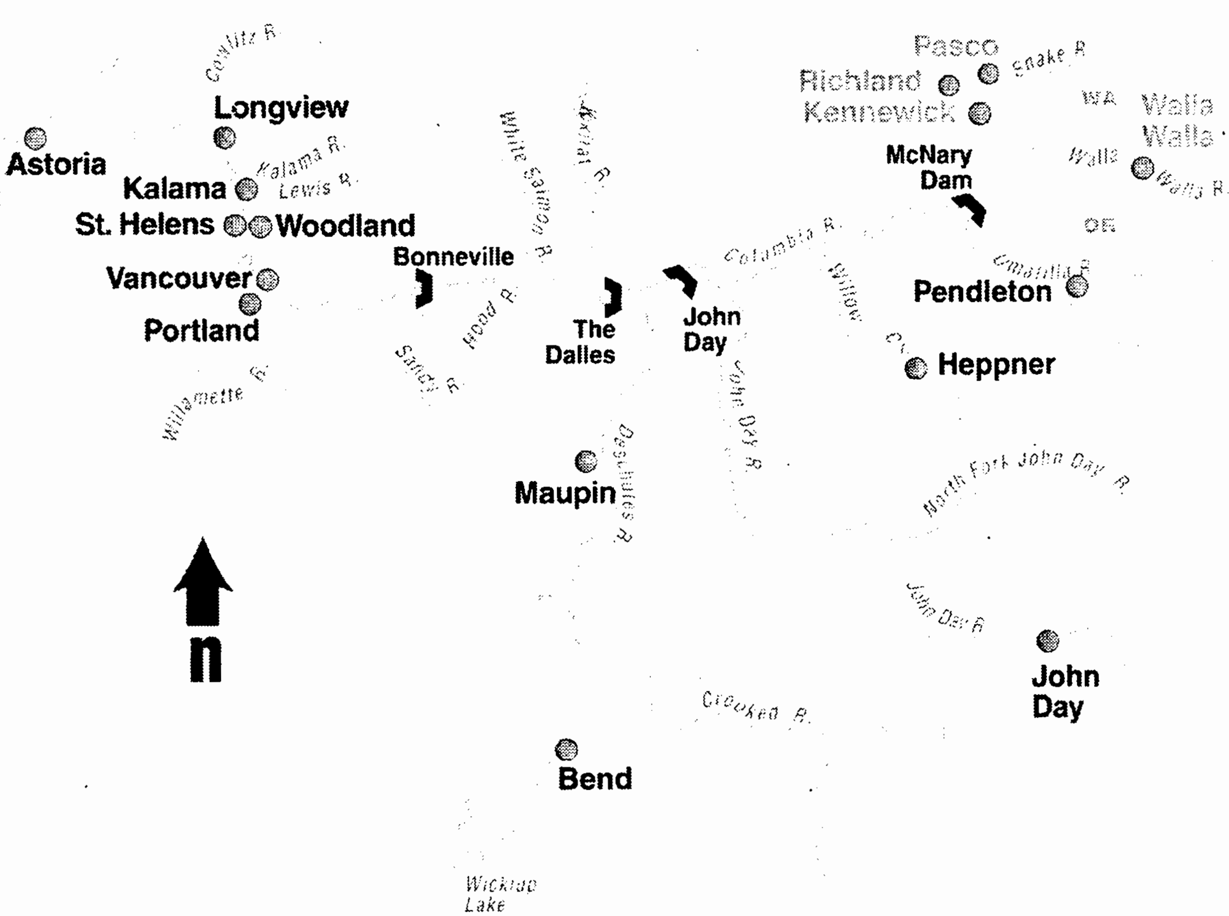

Figure 3-1a Lower Columbia River Management Area, Lower Columbia River Basin

Lower Columbia River Management Area
Willamette River Basin

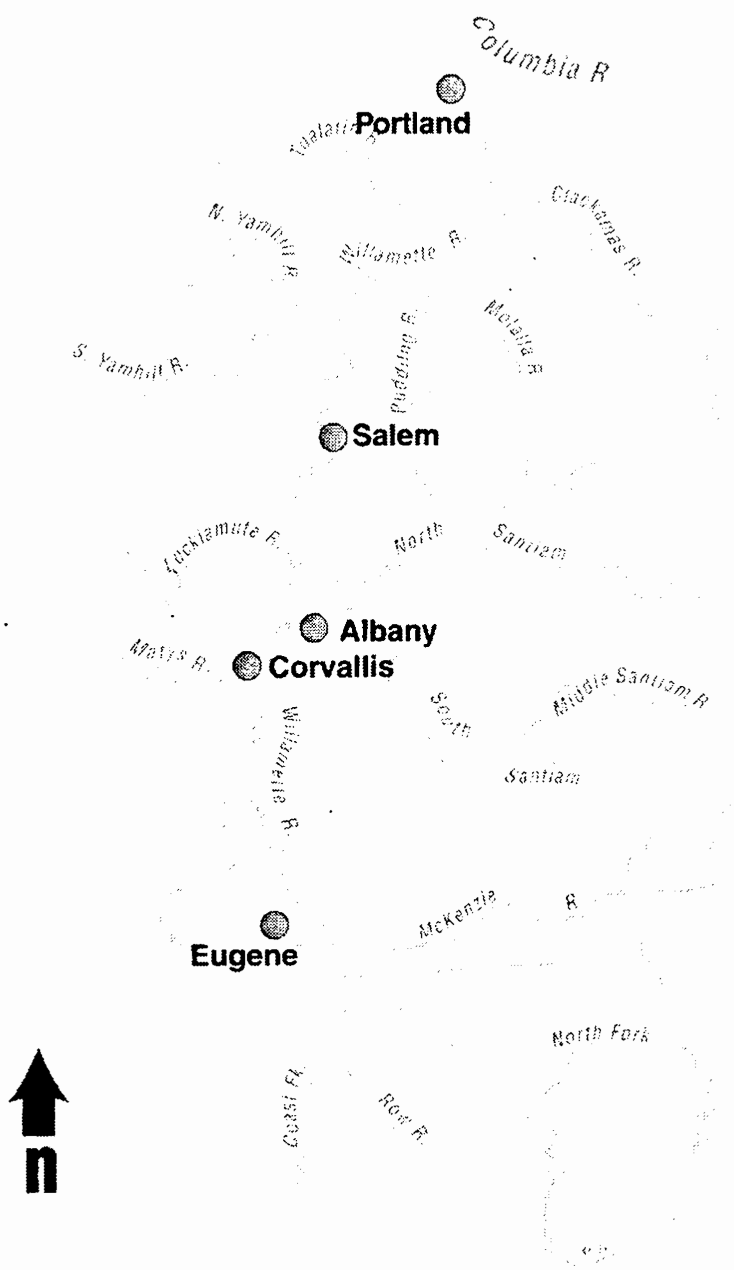

Figure 3-1b Lower Columbia River Management Area, Willamette River Basin

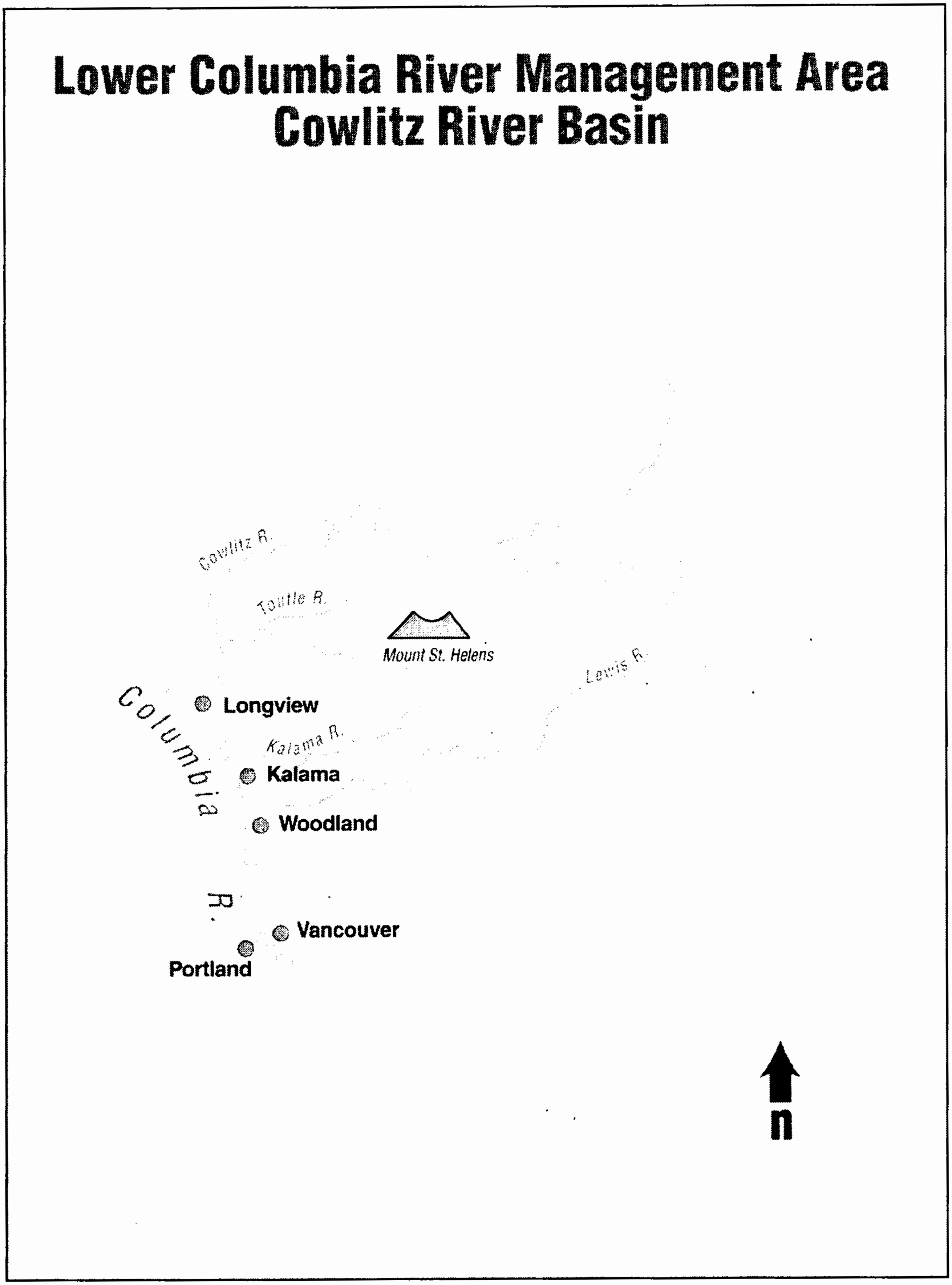

Figure 3-1c Lower Columbia River Management Area, Cowlitz River Basin

The LCR is augmented by several major tributaries, including the Grays, Cowlitz, Kalama, Lewis, and Washougal Rivers in Washington and the Youngs, Clatskanie, Willamette, and Sandy Rivers in Oregon. The LCR supports major salmon and sturgeon fisheries and provides habitat in the form of three national wildlife refuges (Lewis and Clark, Julia Butler Hansen, and the Ridgefield National Wildlife Refuges) and a wildlife management area (Sauvie Island Wildlife Management Area). The estuarine portion of the LCR provides critical nursery and feeding habitat for many important fish and invertebrate species.

The LCR is differentiated into an estuarine reach downstream of CRM 25 and a free-flowing riverine reach upstream to Bonneville Dam.

3.2.1 Estuarine Reach. The LCR River estuary averages 4-5 miles wide and extends upstream to about CRM 25. The estuary is divided into two primary paths of current flow, a north and a south channel. The south channel is an extension of the main river channel upstream of the estuary and carries most of the river discharge. The navigation channel follows the south channel through the estuary. The south channel is heavily ebb dominant, giving the estuary a net clockwise circulation pattern. The north channel extends upstream to about CRM 20 and is connected to the main river channel by shallow cross channels and tidal flats.

Tides at the entrance of the estuary are diurnal, the mixed type characteristic of the Pacific Coast. The influence of the tides on the Columbia River and its estuary is manifested in three primary ways: (1) intrusion of saline, ocean water, (2) periodic river flow reversal, and (3) water-level fluctuations.

Intruding ocean water tends to move upstream like a wedge under the less dense river water and may extend as far as CRM 20, near Harrington Point. The extent of intrusion varies with the tidal stage and the river flow, with maximum intrusion occurring during the highest high tide when river flow is at its lowest. Turbulence causes the intruding ocean water to mix slowly upward with the river water so that the water near the bed has a net movement upstream, whereas less saline surface water has a net movement downstream.

As the tide advances upriver, it causes a river flow reversal, surface and bottom, that has been observed as far upstream as Prescott at CRM 72. A third effect of the tides is that of fluctuations in water level which decrease with increased distance from the mouth. The tidal effect during low river flow varies from 7 to 8 feet at Astoria, Oregon to 1 to 2 feet at Bonneville Dam.

Between CRM 20 and 30, the main channel shifts to the north side while numerous shallow channels flow through Cathlamet Bay to the south. Upstream of CRM 30, the river has a single main channel, with occasional side channels around islands. In the main channel, typical peak ebb velocities are in the 3 feet per second (fps) range, with freshet velocities over 6 fps.

3.2.2 Free-flowing Riverine Reach. Upstream of CRM 25, to the confluence with the Willamette River, the main channel of the LCR generally varies from 1700 ft to 3000 ft wide, with minor bifurcations. Select river reaches have been constricted by pile dikes and sand fills in efforts to decrease shoaling in the mainstem navigation channel. The amount of constriction varies from a few hundred feet to several thousand feet. Bends within the river tend to have very long radii, typically over 15,000 feet. Sharper bends only occur where basalt cliffs control the river's alignment.

The bed of the main channel is composed of deep deposits of mostly fine and medium sand. Silt and clay make up less than 1 percent of the main channel bed material. Natural riverbanks consist of basalt or erosion resistant silt and clay deposits. These riverbank deposits range from 20 ft to 150 ft thick and overlay much deeper sand deposits. Sandy beaches occur only where dredged material has been placed along the shore. There has been little change in the river's location in the last 6,000 years.

The upper reach of the LCR extends immediately upstream of the Willamette River to Bonneville Dam. Major tributaries in this segment include the Washougal River in Washington and the Sandy River in Oregon. Flow is regulated and moderated by upstream dams.

River stage elevation may vary as much as 7 feet in a day near Bonneville Dam due to power peaking requirements. Because of the limited drainage area of the tributaries, the tributary inflow in this reach contributes minimally to winter flooding, and is not a factor during spring flooding.

The main channel of the Columbia River in this reach is slightly meandering and contains several bifurcations caused by mid-channel islands such as Government and Reed Islands. The flood plain is generally narrow (less than one mile wide) through the Columbia River Gorge which starts at the Sandy River. The flood plain is several miles wide near the downstream end of the reach, but flood flow is restricted by levees that extend downstream on both sides of the river to Vancouver and Portland. Channel hydraulics in the upper reach is complex because of the presence of mid-channel islands and rapidly varying discharges from Bonneville Dam.

Bedload sediments in the upper reach are quite diverse. Downstream of the Sandy River (CRM 121), bed sediments in the navigation channel and secondary channels are composed predominantly of fine to coarse sand, 0.250 millimeter (mm) to 1.0 mm in size. From the Sandy River upstream to Bonneville Dam, bed sediments range from fine sand to cobble size (0.250 mm to 256 mm). The navigation channel in the upper reach is at lesser dimensions than downstream reaches, 27 feet deep by 300 feet wide. As a result, dredging requirements are much less than any other segment. The primary purpose for dredging in this reach of the LCR is for structural fill or for making concrete.

3.3 SHOAL PROCESSES IN THE LCR

Shoal dynamics in the LCR is of particular interest because of its effect on the origin and movement of a large volume of sediment. Currently an average annual volume of 5 to 7 million cubic yards (mcy) of sediment is dredged from the LCR. A sediment budget for the LCR has been developed by the Portland Corps District to identify the historic source of shoal material in the mainstem navigation channel. Suspended and bedload transport have been analyzed, as well as pre- and post-regulation sediment transport.

3.3.1 Suspended Load. The LCR experiences a low volume of suspended load (i.e., sediment transported in the water column), much of which is carried out to sea. What remains tends to be deposited in the estuary's bays and shallow backwaters and sloughs. Only a small percentage of suspended sediment contributes to the shoaling problems that occur annually in the mainstem navigation channel. Generally 80-90 percent of the suspended sediment is silt or clay size which is not found in significant quantities in the bed of the navigation channel. Sand, which makes up about 99 percent of the bed material, is generally less than 15 percent of the suspended load, and increases to over 30 percent only when the discharge exceeds 400,000 cubic feet per second (cfs).

3.3.2 Bedload. As one method to determine pre- and post-dam conditions, bedload in the LCR has been estimated by the U.S. Geological Survey by relating unmeasured load to river discharge. This method resulted in estimates of 1.5 mcy/yr (before dams) and 0.2 mcy/yr (after dams). A second estimate was made by equating bedload transport to the movement of the sand waves present on the bottom of the river. Sequential surveys were made of two sets of sand waves, one during high flow conditions and the second during average discharge conditions. The analyses of those surveys and flow conditions resulted in bedload estimates ranging from 0.1 mcy/yr to 0.4 mcy/yr. The analysis also found that large sand waves only moved several hundred feet a year.

3.3.3 Shoal Material. Comparing the average maintenance dredging volume of 6.5 mcy/yr to an average total bed material transport rate of 1.0 mcy/yr indicates less material is being transported into the LCR than is dredged from the navigation channel. Therefore, the main source of shoal material must be within the LCR itself. Bathymetric surveys indicate that there has been significant bed degradation in areas adjacent to the most commonly dredged reaches. Significant beach erosion also occurs at many of the shoreline and/or beach nourishment disposal sites. These sandy shorelines are much more easily eroded than the natural silt/clay banks.

Given the small amount of bed material inflow and the stability of the natural banks, the most likely sources of shoal material are riverbed degradation outside of the navigation channel and erosion from beach nourishment and shoreline disposal sites. Where dredged material has been removed from the active sediment transport system, there has been a gradual lowering of riverbed elevations and a corresponding reduction in shoaling.

3.3.4 Shoaling Processes. The vast majority of shoaling in the navigation channel is the direct result of bedload transport. The two dominant shoal forms are large sand waves and cutline shoals. Sand waves are present throughout the river channel and cause shoals across the channel where wave crests rise above the channel design depth of -40 ft Columbia River Datum (CRD). Cutline shoals are much larger and run parallel to the channel. Cutline shoals develop at the same locations year after year.

Sand waves of 8 to 10 ft in height can form ridges across the navigation channel. The volume of an individual sand wave shoal is small, generally less than 30,000 cy, but they are numerous enough to represent a significant amount of the annual maintenance dredging. Sand wave shoals do not appear at the same location each year because of the time required for the waves to form and grow. The main source of material for sand waves is the bed of the navigation channel. Sand wave shoals are unlikely to occur where the channel bottom is deeper then 45 feet CRD.

Cutline shoals form along the navigation channel dredging cutline, parallel to flow, and can extend several thousand feet along the channel. The primary cause of cutline shoals is gravity pulling bedload down the side-slopes and into the main navigation channel. Cutline shoals begin forming at the edge of the dredged cut and grow out toward the center of the navigation channel. In the LCR, these shoals occur on the inside of long bends and on straight river reaches. They are especially severe in areas of the river that were less than 40-ft deep prior to construction of the existing channel. Cutline shoals are much larger than sand wave shoals and the 12 largest cutline shoals account for nearly half the volume of material dredged annually.

3.4 MAINSTEM NAVIGATION CHANNEL OF THE LCR

Dredging has been required to construct and maintain each stage of the mainstem navigation channel of the Lower Columbia River since 1906. Each stage of development has had an impact on channel depths as well on widths. At present, thalweg depths are generally near 50 ft throughout most of the LCR. This is only slightly deeper than prior to channel development when much of the main river channel had natural thalweg depths in the 35-ft to 45-ft range. However, the controlling depth or the minimum depth available anywhere along the navigation channel, has increased from about 12 ft prior to development, to 40 ft for the present channel. Typically, depths across the entire channel have also increased in reaches with large hydraulic control structures or high dredging rates. Channel areas with depths of over 50 ft occur mainly on the outside of bends and around rock outcroppings.

A period of riverbed adjustment has followed each development stage of the mainstem navigation channel. The amount of dredging required to maintain the channel during these adjustment periods has depended on the magnitude of the disturbance to the preexisting riverbed. Development actions have included channel deepening, constrictions (pile dikes), realignments, and fills. Deepening of the channel may be viewed as low intensity disturbances that impact large areas and significantly increase maintenance dredging. Many of the other developments (constrictions, realignments and fills) have also caused high intensity, local area disturbances that resulted in significant increases in maintenance dredging. Because of the frequency and variation of channel development activities, there is no simple correlation between channel depth and dredging requirements. Future maintenance dredging will depend on the magnitude of the overall disturbance to the riverbed and management of the river's peak flows.

3.5 MAINTENANCE DREDGING AND DISPOSAL IN THE LCR

The Portland District primarily with hopper and pipeline dredges does the majority of the dredging in the LCR. A few select shoaling locations are dredged by clamshell and a few by the "Sandwick", a propwash dredge. The type of dredge used on a shoal depends on several factors, including dredge availability, size and location of the shoal, and disposal options available. Currently, most placement is done at unconfined aquatic sites (called flowlane disposal) with the remainder (1 to 2 mcy/yr) placed on upland sites or at beach nourishment sites.

3.5.1 Hopper Dredging. Hopper dredges currently do about 3 mcy/yr of dredging in the LCR and 3-5 mcy/yr at the mouth. Most of this dredging is done by the Corps' hopper dredge, the "Essayons." Hopper dredges provide flexibility for dredging operations because they can operate anywhere on the river and can be rapidly deployed to problem shoals. Hopper dredges are most often used upriver on small volume shoals, such as sand wave areas, and on larger shoals in the estuary. The "Essayons" may spend several weeks in the early spring and in the fall dredging small shoals in the river upstream of CRM 25.

During the summer, dredging in the estuary work is done as backup work for the dredging at the mouth of the river. When the entrance becomes too rough or foggy for hopper dredges to work, they move to one of the estuary bars to dredge. The main restriction on the use of hopper dredges is the limited availability of in-water disposal sites with enough deep water to allow disposal without creating a new shoal. Flowlane disposal, in which material is deposited in deep-water areas adjacent to the navigation channel, is used for hopper operations upstream of CRM 25. In the estuary, hopper disposal is done at a large disposal site (called Area D) located away from the navigation channel near CRM 6 and at Harrington Sump, an in-water rehandling site located near CRM 21.

3.5.2 Pipeline Dredging. Pipeline dredges are used for large cutline shoals and areas with multiple sand wave shoals. About 3.5 mcy/yr are dredged by the pipeline dredge owned by the Port of Portland, the "Oregon". Pipeline dredging is done mostly during the summer. Typically, the "Oregon" is scheduled to start at one end of the navigation channel and work its way to the other end. This minimizes the amount of time spent moving the dredge and related equipment.

The most frequent pipeline disposal practice is to place the dredged material slurry along the shoreline near the dredging site. These shoreline or beach nourishment sites occupy about half of the total shoreline upstream of the estuary. Many of the beach nourishment sites are actively eroding and need a resupply of sand every 2-3 years. Upland disposal is an efficient disposal method but there are only a limited number of sites available. About half of the pipeline disposal is done at upland sites. In a few cases, pipeline disposal is done at flowlane sites with the use of a downspout that discharges dredged material at least 20 feet below the surface.

3.5.3 Advance Maintenance Dredging. Advance maintenance dredging (AMD) is the removal of sediment beyond the prescribed channel dimensions for the purpose of reducing costs by decreasing the frequency of dredging. AMD of up to 5 ft in depth is authorized for the mainstem channel. Five feet has been found to be sufficient to minimize sand wave shoaling problems, but is not well suited for cutline shoals. For the past 25 years, AMD has been done outside the channel boundaries to intercept material moving toward the large cutline shoals. Advanced maintenance dredging is also done for some side-channel projects which experience rapid shoaling, such as the Baker Bay/Chinook Marina channel. This channel is dredged to a dimension that is 5 feet deeper and 150 feet wider than the authorized channel dimensions.

3.6 RIVER CONTROL STRUCTURES IN THE LCR

Pile dikes are a common hydraulic control measure used in the river to improve channel alignment for navigation, reduce cross-sectional area, restrict flow in back channels, and provide bank protection. The Corps initiated pile dike construction in 1885, but the bulk of the pile dike system was built between 1917 and 1939. The last significant additions to the pile dikes system were built during construction of the 40 ft channel in the 1960s to further constrict flow and reduce erosion at dredged material disposal sites. The Corps currently maintains a total of 236 pile dikes within the LCR.

Sand fills, constructed with dredged material, have also been used extensively to reduce channel cross-section and control channel alignment. Most fill material has been placed along the shoreline to constrict flow. Upstream of CRM 20, nearly half the shoreline along the main channel is composed of dredged material fill. Dredged material has also been used to create several islands to control channel alignment, such as Coffeepot, Lord, Sandy, Goat, and Sand Islands. Pile dike fields protect most of these dredged material fill sites from erosion.

River control structures aid channel maintenance by controlling flow alignment, reducing erosion, and providing areas for disposal. The current network of control structures provides a smooth channel alignment that reduces erosion and aids navigation. The pile dike fields protect many millions of cubic yards of disposal material from erosion. However, the system has reached, and often exceeded, its limits for disposal site protection. Many shoreline sites have been filled beyond the limits of erosion protection provided by the dike fields and are actively eroding. Recent investigations by the Corps have recommended construction of additional pile dikes to protect disposal sites at Miller Sands, Pillar Rock, Puget Island, and Westport bars.

3.7 SEDIMENT QUALITY CHARACTERISTICS OF THE LCR

The following discussion of sediment quality characteristics is focused primarily on the reaches and/or locations where maintenance dredging is a common requirement. Some sediment characterization, such as was done for the Bi-state Study, includes a fairly broad survey of the entire Lower Columbia River. The information presently available to characterize the quality of sediments in the LCR includes: (1) published and unpublished surveys done by the Portland District Corps of Engineers; (2) the Bi-state Study[1]; (3) proposed projects such as port development, water-dependent industries, and marinas; (4) approvals/permits for point source discharges, such as industry and sewage outfalls; and (5) studies done by the U.S. Geological Survey and others to evaluate specific contaminants and/or reaches of the Lower Columbia and/or Willamette Rivers.

No single source of sediment information can be relied upon to portray the status of sediment quality because each source presents only a brief snapshot of the conditions encountered at a specific point on the river at a specific time of the year. For example, the Lower Columbia River is such a dynamic system that what was found before the flood events of 1996/97 may not be so today. The sediment survey done for the Bi-state Study is probably the most comprehensive survey done to date; however, it too presents limitations in that it was a one-time sample of the river (circa 1993) and it only sampled the top 2 centimeters of sediment.

3.7.1 Grain Size. Grain size is a commonly measured sediment parameter because it involves a relatively inexpensive test and the results are applicable to dredged material management decisions. Sediment in the LCR ranges from gravel-sized material to very fine clay.

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[1] The Bi-state Study undertook a systematic assessment of sediment quality of the lower Columbia River from the mouth to Bonneville Dam. The survey results are contained in *Task 6: Reconnaissance Report* dated May 17, 1993 and *Task 7: Conclusions and Recommendations* dated May 25, 1993. The survey obtained sediment samples from 54 locations, 40 of which were intentionally positioned to collect fine-grained sediment. The investigators targeted those locations because of the general finding that finer-grained sediment is more likely to contain contaminants. Sediment samples were collected in a range of water depths but the majority (40) were from depths of 5 to 20 feet; 7 from depths of 20-30 feet and 6 from depths over 30 feet. As a general guideline, resource agencies consider water depths of less than 20 feet to be the most biologically productive zone of the river and of special importance as the shallow water corridor used by out-migrating juvenile salmon.

Based upon historical survey data collected by the USACE, Portland District, sediment from the main navigation channel of the LCR has been found to be predominantly fine to medium-sized sand with less than 1.0 percent silt, clay and finer material. The most recent survey of channel sediment was done in 1997 in connection with the proposal to deepen the navigation channel. Out of a total of 89 samples, only six had a fines content greater than 5 percent. Of these six samples, four had a fines content greater than 20 percent. All but one of these samples was collected outside of the areas dredged to maintain the channel. This one exception is associated with the Morgan Bar disposal area that receives fine-grained material from the Willamette River.

Sediments sampled in the side channel projects by the Corps have been found to vary considerably more in grain size composition, particularly as channels near their destination, such as at a marina. Areas of finer-grained sediment accumulation are generally believed to be areas where sediment contaminants are more likely to be found. This is because many chemical compounds have electrochemical properties that cause an affinity for finer-grained sediment. However, sediments with greater than 20 percent fines have been subjected to additional chemical testing and, in the majority of cases, found to not exceed screening value guidelines in existence at the time of sampling. Only 2 samples were collected from the navigation channel.

Higher levels of contamination in fine-grained sediments were also not found in the surveys done for the Bi-state Study. As summarized in the *Integrated Technical Report* dated May 20, 1996, page 35: *Only trace metal concentrations were higher in the finer-grained backwater sediments (1993 survey) compared to the more open-water sediment stations sampled in 1991. These higher metals concentrations were generally due to the natural association of metals with finer-grained sediment, although some locations did appear to have elevated concentrations potentially related to human inputs . The expected higher concentrations of organic pollutants in backwater sediments were not observed in the 1993 survey.*

3.7.2 Metals. All of the metals noted below are natural components of soils and sediments of the Lower Columbia River drainage basin. The concentration of individual metals may vary depending upon additional inputs from human activity or sources.

Bi-state Study. The Bi-state Study reconnaissance survey provides a fairly comprehensive snapshot of the chemical composition of Lower Columbia River sediments. Many of the metals listed in Table 8-1 were found in the finer-grained sediment samples but none at levels that exceed the screening level guidelines (SL) adopted in this manual. Likewise, none of the coarser-grained samples had any metal exceedances above SL

The relatively low level of metals in Lower Columbia River sediments is summarized in the Reconnaissance Report, page 3-81: *Metals were the most frequently detected substances in sediment samples from the study area. The high detection frequency, which occurs at* *concentrations above the detection limits of conventional laboratory techniques, is due to the natural occurrence of many of these metals in Columbia River sediments. In most locations, the degree to which the metals exceeded the predicted distribution of average concentrations was not great, indicating limited alteration of the sediment quality by anthropogenic influences in the areas sampled.*

Portland Corps' 1997 Survey. The 1997 sediment survey reaffirmed the results of the Bi-state Study in that main channel sediments contain very low levels of metal. Only about one third of the samples had any metal detects, and of those, none exceeded the screening levels shown on Table 8-1. The results of the survey are summarized as follows:

Arsenic: 66 non-detects, range of detects = 1.0-3.0 ppm, screening level = 57.0 ppm.
Cadmium: all non-detects
Copper: 66 non-detects, range of detects = 4.0 – 33.0 ppm, screening level = 390 ppm.
Lead: 66 non-detects, range of detects = 1.0-10.0 ppm, screening level = 450 ppm.
Mercury: 88 non-detects, one detect = .07 ppm, screening level = 0.41 ppm.
Nickel: 66 non-detects, range of detects = 5.0-22.0 ppm, screening level = 140 ppm.
Silver: 88 non-detects, one detect = 1.0 ppm, screening level = 6.1 ppm.
Zinc: 66 non-detects, range of detects = 28.0-85.0 ppm, screening level = 410 ppm.

3.7.3 Polycyclic Aromatic Hydrocarbons (PAHs). PAHs are a broad range of contaminants associated with forest fires, combustion of fossil fuels, petroleum spills, wood treatment facilities that use creosote, and urban stormwater discharges. PAHs are typically concentrated with finer-grained sediment downstream of urban areas.

Bi-state Study. This study detected relatively few instances of significant PAH contamination in Lower Columbia River sediment. The few samples where PAHs were detected are located downstream of larger urban areas and may be associated with stormwater runoff.

Portland Corps' 1997 Survey. A similar trend of low levels of PAH contamination was determined during this sediment characterization survey. Of the 22 samples analyzed, 18 had detectable quantities of low molecular weight PAHs (LPAH) ranging from 1 to 112 parts per billion (ppb). The screening level for LPAH is 5,200 ppb. Similarly, 15 samples had detectable levels of high molecular weight PAHs (HPAH) with a range of 1 to 407 ppb; the screening level for HPAH is 12,000 ppb.

Ecology. Sediments from Columbia River port locations at Kalama, Longview, and Ilwaco were examined during a screening survey conducted by the Department of Ecology, Survey Report 26-00-01, Dec 1988. PAHs were the major concern among the contaminants analyzed. PAH concentrations were elevated in sediments below Reynolds Aluminum in Longview (950 mg PAH/kg organic carbon). Contaminants at all other sites were found at relatively low concentrations or were undetectable. Bioassays performed on two species did not show any significant mortality. Further sampling in the vicinity of the Reynolds site was recommended to determine the extent of PAH contamination.

3.7.4 Pesticides and Polychlorinated Biphenyls (PCBs). The use of herbicides and insecticides (pesticides) has been and continues to be a common practice in the Columbia River drainage basin. Historic pesticide residues, such as DDT, continue to be detected in Lower Columbia River sediments, albeit low levels, even though some have been out of production for years. This situation reflects the persistent nature of these types of chemicals. The continued occurrence of pesticides is linked to widespread agricultural land uses in the drainage basin and the effects of ever-increasing urbanization adjacent to the river. PCBs are industrial chemicals used as cooling fluids and lubricants in transformers, capacitors, and other electrical equipment. Although also banned from production for some time, transformers manufactured or imported prior to the ban are still in use and continue to be potential sources of PCBs, particularly at sites where discarded transformers are stored or recycled.

Bi-state Study. When adjusted for non-detects, only 3.0 percent of the sampling stations yielded detectable levels of pesticides. While admittedly still persistent in the Lower Columbia River, the report considered pesticides in sediments to be a minor problem. Similarly, PCBs were detected very rarely in the sediment and were determined to not be a problem.

Portland Corps 1997 Survey. The Corps' survey reflects the findings of the Bi-state Study; only a few stations revealed any pesticides or PCBs and of those that did, the levels of detection were well below levels of concern.

3.7.5 Dioxin/Furans. At present there are no effects-based reference values for these compounds. The presence of these compounds in the environment is associated with chlorophenol production, wood-treating facilities, the aerial application of phenoxy herbicides (2,4-D and 2,4,5-T), effluent discharges from kraft pulp mills and chlorinated municipal treatment plants, and from combustion events.

Most of the research with regard to dioxins/furans has concentrated on the "bad actor" or 2,3,7,8-TCDD and little or no information exists on the other congeners. It is generally accepted that the higher weighted dioxins/furans are not as readily taken up or bioaccumulated by organisms and are less toxic. These higher weighted dioxins/furans occur naturally as combustion byproducts from such things as forest fires and wood stoves.

The Columbia River has recently been identified by EPA as "water quality limited" due to the prediction that dioxin (2,3,7,8-TCDD) concentrations in the water exceed the water column criteria for consumption of contaminated fish and water and the finding that tissue levels in Columbia River fish exceed the human cancer risk factor. EPA has developed a total maximum daily load (TMDL) allowance to better regulate the discharge of dioxin from U.S. pulp and paper mills located in the river basin, with the goal of reducing levels to below the water quality standard. Further investigations are being conducted to provide additional information to refine the TMDL and monitor the effect of regulatory actions.

Bi-state Study. Dioxins and furans were analyzed in 20 of the survey sampling stations and detected at each one. However, this could be expected since a very low detection limit was achieved for the reconnaissance survey, less than one part per trillion, and these compounds are known to be have a very widespread distribution in the Lower Columbia River watershed. Levels of 2,3,7,8-TCDD ranged from undetects to a high of 12.0 part per trillion (pptr). Levels of 2,3,7,8-TCDF were higher with a range of 6.0 to 123.0 ppt. The highest concentrations of these compounds occurred downstream of the Multnomah Channel and the cities of St. Helens, OR and Longview, WA. Each of these locations is affected by an active or historical discharge from a bleach kraft pulp mill.

1990 Portland Corps' Survey. Sediment samples specifically targeted for the determination of potential dioxin/furan contamination were collected within the navigation channel alignment at various locations along the Lower Willamette River (LWR) and Lower Columbia River (LCR) in May of 1990. Samples from the LWR were taken in the Portland Harbor reach (WRM 4 to 11). Samples from the LCR were taken at Camas (CRM 118), St. Helens (CRM 85), Longview (CRM 63 to 65) and Wauna (CRM 38 to 43). Most sample locations were chosen from within the normal dredging boundaries, including the channel and sideslopes, where dioxins/furans were most expected to be found.

In the LCR, samples were taken near or downstream of discharges from pulp and paper mills. Sample locations were chosen from shoals or where previous sampling had indicated the presence of similar hydrophobic organic compounds (i.e. PCBs, PAHs, pesticides) and where previous analyses by the Oregon Department of Environmental Quality indicated that dioxins/furans were present.

A total of nineteen samples or composites were obtained from the channel areas of the two rivers and analyzed for dioxins/furans. The isomer 2,3,7,8-TCDD was confirmed in only two of the nineteen analyses, both from the Lower Willamette River, at 0.63 part per trillion (pptr) and 0.62 pptr. The associated furan isomer (2,3,7,8-TCDF) was detected at concentrations ranging from a low of 0.73 pptr to a high of 110.0 pptr, also in the LWR samples. One sample was collected from the Doan Lake area where contamination of DDD, DDT and PAHs have been noted in the past. Though 2,3,7,8-TCDD and the lower-weighted dioxins were found only at low levels, the higher-weighted less toxic dioxins and the furans are significantly elevated above background. Further testing and evaluation was recommended in this area.

Though various isomers of dioxin/furan were detected in all of the samples tested, many of the individual isomer concentrations found in the LCR samples were attributed to background levels in the analytical system. In addition, concentrations found in samples from the LCR were orders of magnitude below those found in the Lower Willamette River samples. No significant dioxin/furan contamination was found in the sediments of the LCR.

3.8 MID-COLUMBIA RIVER (BONNEVILLE DAM TO McNARY DAM)

The 146 miles of mid-Columbia River in the reach between Bonneville Dam and McNary Dam also forms the boundary between Washington and Oregon. This reach of the river has mile after mile of open country, with widely spaced, small population centers. The only major city within this reach (over 10,000 population) is The Dalles, Oregon. The major tributaries to the mid-Columbia River between McNary and Bonneville Dams include the Umatilla, John Day, Deschutes, Klickitat, and White Salmon Rivers.

This reach of the Columbia River is almost totally regulated by four dams (McNary, John Day, The Dalles and Bonneville). The John Day Dam is the only dam in this reach that provides flood control in addition to providing a slack water reservoir. When high runoff is forecast, the pool is lowered to provide space for control of about 500,000 acre-feet of floodwaters. The other three dams are known as run-of-river dams and have no flood storage capacity.

3.8.1 Hydrodynamics. The volume of sediments transported by the Columbia River and its major tributaries is small compared to other major rivers in the United States. Sedimentation in the middle Columbia River reservoirs is a minor problem except at isolated areas, such as where local sediment bearing tributaries enter the reservoirs. As the dams do not have large storage capacities, river flows are strong and resident time for the water is short. Because of these flow regimes, fine-grained material is held in suspension and transported through and out of the system.

The slack water pools provide sufficient depth for navigation without the need for dredging of the federal channel. The federal channel is authorized to 15 feet. Recent dredging of the federal projects has been limited to the upstream end of the new navigation-lock at Bonneville, the forebay of the second Bonneville powerhouse, and at river mile 214 in Lake Celilo.

3.8.2 Sediment Quality Characteristics. Sediments in the mid-Columbia reach, that are dredged, are primarily fine to medium sands and gravels with very low organic content. Most of the dredged sediments have qualified for unconfined aquatic disposal back into the river although several projects have utilized the clean dredged material for beneficial upland purposes.

3.9 LOWER WILLAMETTE RIVER

The Willamette River basin lies entirely within the State of Oregon occupying a total area of about 12,000 square miles. The Willamette Valley forms a north-south trough through the northwestern portion of the state, with a width of about 75 miles from the crest of the Coast Range on the west to the crest of the Cascade Range on the east and has a length of 150 miles.

The Willamette River has a total length of approximately 187 miles, flowing principally northward through the central part of the Willamette Valley to its confluence with the Lower Columbia River at CRM 101. Its upper 133 miles flows northward in a braided, meandering channel. Through most of the remaining 54 miles, it flows between higher and more defined banks unhindered by falls or rapids, except for the basaltic intrusion which blocks the valley at Oregon City and creates Willamette Falls. The stretch below the falls is subject to ocean tidal effects which are transmitted through the Columbia River. Portland Harbor is located in the Lower Willamette River from its mouth upstream to approximately WRM 14.

3.9.1 Hydrodynamics. The Willamette River contributes a mean annual discharge of about 38,490 cfs to the Lower Columbia River. Peak flows, with a range of 20,800 to 130,000 cfs, occur in the high rainfall months of November through January; low flows, with a range of 5,000 to 7,100 cfs, occur in the lesser rainfall months of July through September. Flooding in the Lower Willamette Basin occurs frequently with an average of one or two floods in the winter season and with severe floods occurring about every ten years. Flows in the Willamette River are significantly regulated by reservoirs and hydroelectric dams located on the tributaries.

The Lower Willamette River is considered to be that portion of the river in close proximity to metropolitan Portland. In general, this area is bounded on the south at river mile (WRM) 25 on the Willamette River below Willamette Falls at Oregon City. Because of the Lower Willamette River's low elevation and proximity to the coast, tidal effects on river stage can be significant. River stage is also influenced by the regulation of upstream water storage projects as well as natural stream-flows on both the Columbia and Willamette Rivers.

The Willamette River's average annual suspended sediment load is estimated to be 1.7 mcy/yr. Less than 20 percent, or about 0.3 mcy/yr, of that material is sand, the rest is silt or clay. The Lower Willamette River's transport capacity is very low and fine sediments are deposited within the Portland Harbor reach. The bed material in the lower reach varies from fine sand and medium sand at the mouth, to over 80 percent silt and clay in the upstream part of the navigation channel. Given the channel dimensions and the type of bed material, bedload transport in the Willamette River is estimated to be insignificant.

3.9.2 Sediment Quality Characteristics. Sediments dredged from the Lower Willamette River range from clean sand to clayey, sandy silt high in organic content. A cutline shoal develops between RM 8.0 and 10.1 along the west side of the channel. This is the primary location requiring maintenance dredging every 2 to 5 years. Other areas are not dredged or dredged infrequently. Willamette River sediments have been subjected to chemical characterization because of the physical characteristics of the material dredged and close proximity of numerous known sources of contamination. The bulk of the material evaluated from the present 40-foot channel has repeatedly been found to be suitable for unconfined aquatic disposal, but some material has been found to contain chemicals-of-concern above established concern levels. Sediments from outside of the main channel tend to be finer and more likely to be contaminated. Information on sediment quality is included in the previous discussion on dioxin/furans sampling in the Lower Columbia and Willamette Rivers (Section 3.7.5).

3.10 SIDE CHANNEL PROJECTS

The Portland District maintains several navigation projects or channels that branch from the mainstem Lower Columbia River to select points in Washington and Oregon. Many of these channels provide access that benefits commercial enterprises, such as access to moorage facilities for commercial fishing fleets and forest product or other water-dependent companies. The Baker Bay/Ilwaco Marina navigation channel provides access to a federal facility, a Coast Guard station, while another provides the access route for a Washington State ferry. In some cases, access to moorage facilities also benefits recreational boaters. In a less typical case, the dredging of the Cowlitz River navigation channel serves as a means to reduce flooding in the upper watershed. Severe flooding could have resulted from the blockage of the channel by material swept into the river by the eruption of Mt. St. Helens.

3.10.1 Baker Bay West Channel, WA (CRM 2.5). The side channel known as the Baker Bay West Channel branches off from the entrance channel and provides access to the Baker Bay Coast Guard Station and the large marina at Ilwaco, WA. Between 1984 -1990, an average of 111,000 cys of fine to silty sand was dredged annually from about three major shoals in the channel. The dredged material has been disposed of at the unconfined aquatic (estuarine) site designated as Area "D" (hopper and clamshell) or on adjacent sand islands (pipeline).

3.10.2 Baker Bay/Chinook Channel, WA (CRM 5.0). The Chinook Channel provides access to the large marina at Chinook, WA by means of a long narrow channel that cuts through a reach of extreme shoaling. Because of extreme shoaling conditions, advanced maintenance dredging is done in certain sections of the channel. From 1986 to 1990 clamshell dredges have removed an average of 177,000 cys of fine to silty sand sediments with disposal at Area "D".

3.10.3 Hammond Boat Basin, OR (CRM 7.0). The Hammond project consists of an access channel through breakwaters to a mooring basin used primarily by small boats. The channel was last dredged by pipeline in 1990 when 15,300 cys of fine to silty sand was disposed of on an adjacent upland site.

3.10.4 Skipanon River, OR (CRM 11.0). The authorized project for the Skipanon Channel provides for an entrance channel from the Columbia River to the boat basin. Shoaling occurs at the entrance due to the deposition of sand across the mouth of the Skipanon River. Deposition also occurs in the inner reaches of the channel near the boat basin. The sandy dredged material has been found suitable for unconfined aquatic disposal at Area "D". The finer silty sediments from the inner reaches have been tested at regular intervals and disposed at upland confined sites. The outer channel requires dredging about every third year by hopper whereas the inner reach is dredged about once every five years.

3.10.5 Tongue Point/Cathlamet Bay (CRM 18.5). The authorized project includes an access channel from the Columbia River to commercial moorages and a turning basin inside Cathlamet Bay. The project was last dredged in 1989 and has not required any maintenance dredging since then.

3.10.6 Skamokawa Creek (CRM 33.6). The authorized project provides for an access channel from the Columbia River through the mouth of Skamokawa Creek to Brooks Slough. The channel provides navigation access to a boat launch facility and to upriver private and commercial vessel moorages. The channel is maintained every 3 to 5 years with either a pipeline or the agitation dredge. Use of the pipeline allows beneficial placement of the dredged material on the beach nourishment site at the nearby county park.

3.10.7 Elochoman Slough (CRM 39). The authorized project is an access channel from the Columbia River 1.5 miles up the Elochoman Slough to the mouth of the Elochoman River. The channel provides access to a marina and to a water-dependent forest products company. The channel is maintained every 3 to 5 years by use of the agitation dredge.

3.10.8 Wahkiakum Ferry, WA/Westport Slough, OR (CRM 43.2). The authorized project is a navigation channel extending from the ferry landing on Puget Island, WA to the mouth of Westport Slough on the Oregon side of the river. The channel provides access for the small ferry that traverses the river at this location. The channel tends to shoal fairly rapidly at the reaches closest to the shorelines on each side. Maintenance of the channel is done by clamshell or agitation dredge every 2 to 3 years.

3.10.9 Cowlitz/Old Mouth Cowlitz River (CRM 67.7). One of the authorized projects is an access channel from the Columbia River 3,800 feet up the Old Mouth Cowlitz River. The channel provides access for the transportation of log rafts to commercial facilities at Longview, WA. This channel is maintained annually by agitation dredging. Another authorized project provides for an access channel up the Cowlitz River to Ostrander, WA. Significant volumes of sediment were removed from this reach following the eruption of Mt. St. Helens, but has since stabilized to the point that maintenance dredging is very infrequent.

CHAPTER 4

OVERVIEW OF REGULATORY PROCESSES

4.1 OVERVIEW

This chapter summarizes the state and federal regulatory processes for obtaining approval of dredging projects undertaken in the Lower Columbia River Management Area (LCRMA). Distinctions are made among three processes: a) the overall permit process for new dredging projects (Section 4.3 and Figure 4.1); b) the verification or renewal of approval for on-going maintenance dredging work (Section 4.4 and 4.5 and Figure 4.2); and c) the dredged material evaluation process that is integrated into the other two processes (Section 4.6 and Figure 4.3). The submittal of a Dredging Quality Control Plan constitutes the last step before starting dredging (Section 4.7)

Included in Section 4.8 of this chapter is a description of the role of the Portland District Corps of Engineers in carrying out congressionally authorized dredging projects in the LCRMA. Below is a description of the role of the two district offices, Seattle and Portland, who share the workload for issuing permits for dredging projects in the LCRMA.

4.2 THE ROLE OF THE CORPS DISTRICT OFFICES

The Seattle and Portland Districts share the workload for permits issued in the Lower Columbia River. The Portland District handles permits for Corps or congressionally authorized dredging; all permits originating from the Oregon side of the river; and all permits for Ports located on the Washington side of the river. The Seattle District handles all other private applicant permit applications originating from the Washington side of the river.

4.2.1 Seattle District. The Seattle District's Dredged Material Management Office (DMMO) provides a common point for dredged material evaluations. The staff is available to answer questions related to dredged material evaluations, assist in the development of sampling and analysis plans (SAP), and help troubleshoot during sediment sampling and testing (see DMMO on Figures 4-1, 4-2, and 4-3). The DMMO coordinates SAP and data reviews with the other regulatory agencies which jointly administer the Lower Columbia River Dredged Material Evaluation Framework, prepares the SAP approval letters, and prepares the draft and final suitability determinations. The DMMO interfaces with the Regulatory Branch and provides consultation services on dredged material management issues. Any questions, problems or issues related to dredged material management should be directed to the DMMO, via phone, fax, or mail at:

Department of Army, Corps of Engineers
Seattle District, CENWS-OD-TS-DMMO
P.O. Box 3755
Seattle, WA 98124-2255
Telephone: (206) 764-6945, 764-6550, or 764-3768
Fax: 206-764-6602

4.2.2 Portland District. The Dredged Material Management Team (DMMT) in Portland District is comprised of personnel from the Portland District's Regulatory Branch, Navigation Section, and Hydraulics and Hydrology Branch. The DMMT provides a unified process for the evaluation of sediment quality for both Corps and non-Corps dredging projects. The Regulatory Branch and Navigation Section coordinate permits and dredging projects in their functional areas. The Dredged Material Quality Manager interfaces with the Corps Regulatory Branch and Navigation Section and provides consulting services on dredged material quality issues.

The DMMT coordinates SAPs and data review with the other regulatory agencies which jointly administer the Lower Columbia River Dredged Material Evaluation Framework. Staff is available to answer questions related to dredged material evaluations, assist in the development of (SAPs), and help troubleshoot during sediment sampling and testing (see DMMT on Figures 4.1, 4.2, and 4.3). Issues related to Columbia River dredged material evaluation may be directed to the DMMT, via phone, fax, or mail at:

Dredged Material Quality Manager
Department of Army, Corps of Engineers
Portland District, CENWP-EC-HR
P.O. Box 2946
Portland, OR 97208-2946
Telephone: (503) 808-4885
Fax: (503) 808-4875

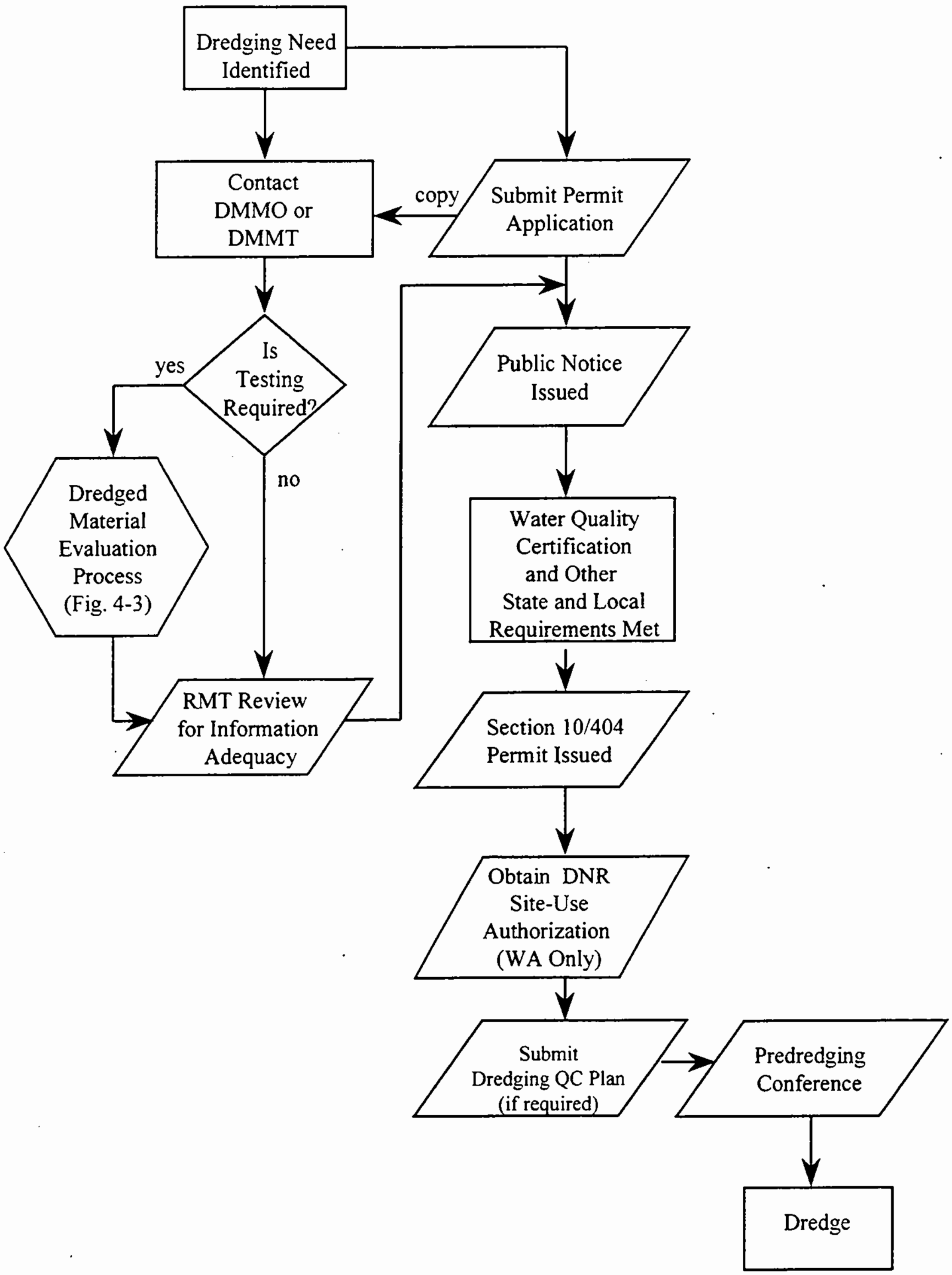

FIGURE 4-1
SECTION 10/404 REGULATORY PROCESS
(NEW PERMIT REQUIRED)

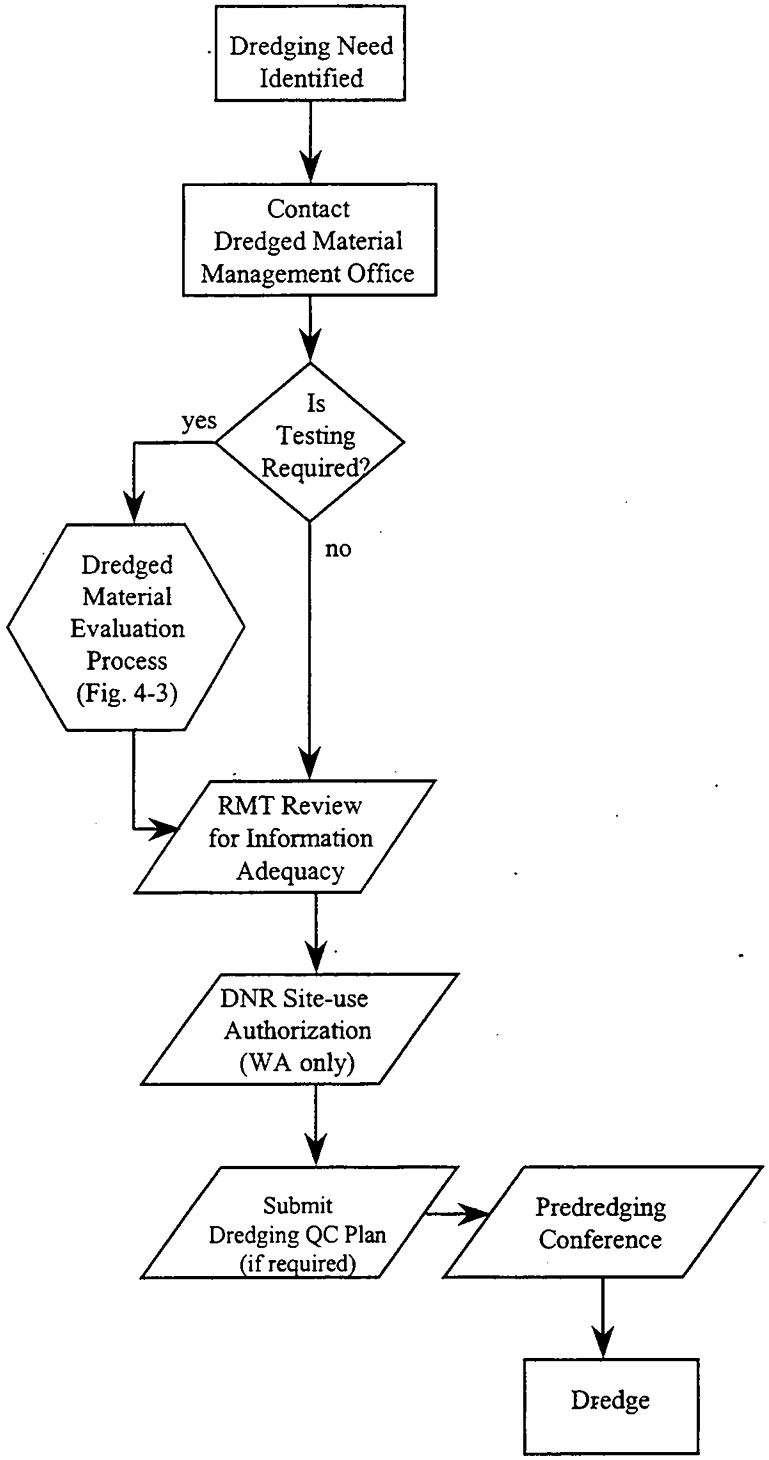

FIGURE 4-2
SECTION 10/404 REGULATORY PROCESS
(NEW PERMIT NOT REQUIRED)

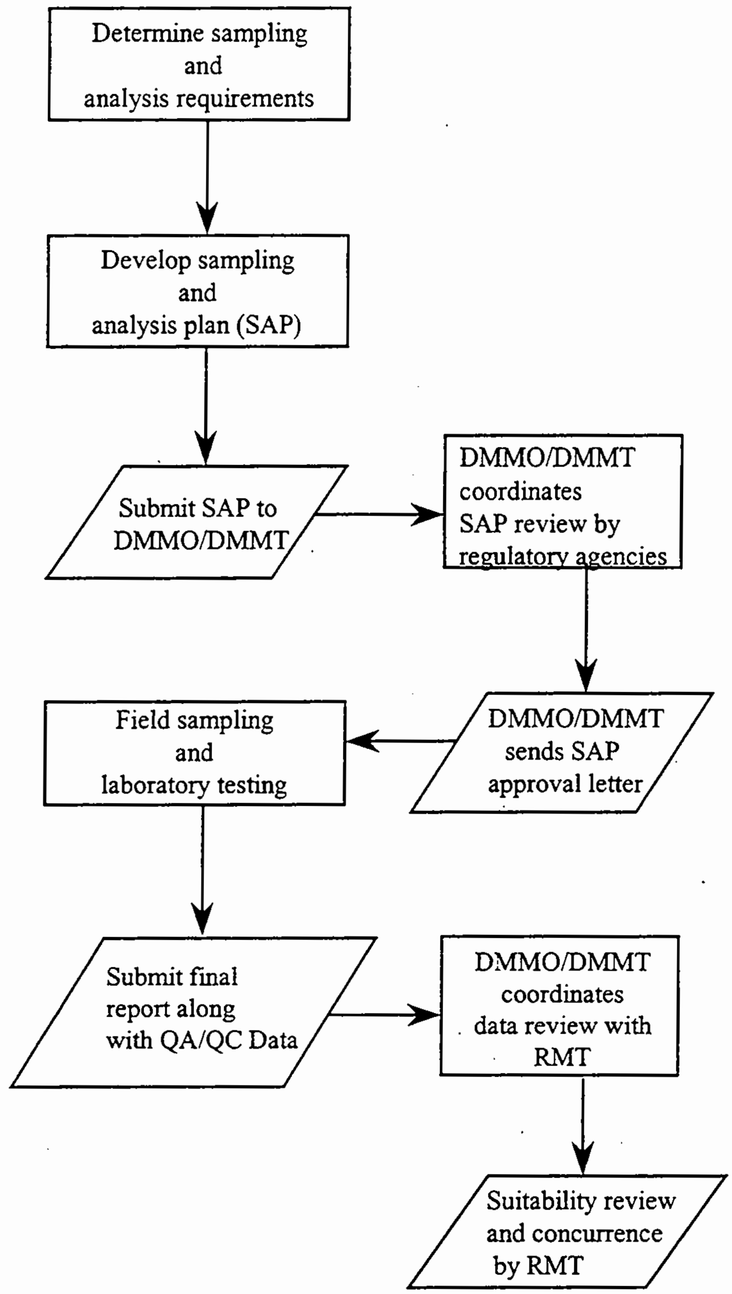

FIGURE 4-3
DREDGED MATERIAL EVALUATION PROCESS

4.3 STANDARD REGULATORY PROCESS FOR NEW DREDGING

Figure 4-1 illustrates the standard regulatory process for acquiring the major permits required for a new dredging proposal. This process involves a second integrated process, the dredged material evaluation process, described in Section 4.6. The standard process consists of a series of progressive steps applicable to most dredging projects, as summarized below:

- A Section 10/404/103 permit application is submitted to the Regulatory Branch of either the Portland or Seattle District Corps of Engineers.

- The permit application is forwarded to the Dredged Material Management Office (DMMO) of the Seattle District or Dredged Material Management Team (DMMT) of the Portland District which initiates the dredged material evaluation process. Note: Applicants (dredging proponents) are strongly encouraged to begin this evaluation process prior to submitting a formal application.

- The dredged material evaluation process is carried out by the applicant with guidance from DMMO/DMMT. The adequacy of the resulting information is verified by the DMMO/DMMT. If the information is determined to be adequate, the permit application is considered complete from the perspective of the sediment evaluation process. The project is then returned to the Regulatory Branch to begin or continue the standard Public Notice process.

- During the Public Notice process, the Regulatory Branch may receive comments from the general public and state and federal agencies. Comments that bring up potential issues of concern may be passed on to the dredging proponent for response.

- Prior to or concurrent with the Corps permit process, dredging proponents will be required to obtain permits/approvals from local jurisdictions and/or state agencies.

  Likely permits/approvals required in the State of Washington include:

  (a) Shoreline Permits
  (b) Hydraulic Project Approval Permit
  (c) Section 401 Water Quality Certification

  Likely permits/approvals required in the State of Oregon include:

(a) Removal/Fill Permit
(b) Section 401 Water Quality Certification
(c) Coastal Program Approval
(d) State Beaches

- The Regulatory Branch issues a Section 10/404/103 permit that incorporates the provisions of state 401 certification and other appropriate conditions that result as a response to comments or as revisions to the project.

- The dredging proponent must prepare and submit a Dredging Quality Control Plan to the Regulatory Branch of the respective Corps offices for approval prior to the start of the dredging operation.

- In Washington, the dredging proponent must get a disposal site use authorization from the Department of Natural Resources.

4.4 RENEWAL OF CORPS PERMITS FOR MAINTENANCE DREDGING

Corps permits must be renewed on a periodic basis (as specified in the permit). This requires completion of a new public interest review process. The permit renewal follows a process similar to the process described in Section 4.3, but some state and local permits may not need to be renewed. Sediment testing information will be reviewed, and existing information may be adequate for permit renewal without additional testing.

4.5 VERIFICATION OF MULTI-YEAR MAINTENANCE DREDGING PERMITS

Corps permits for maintenance dredging may be issued for a period of up to 10 years. During this time no additional Corps permitting activity may be required. The dredged material evaluation process has a different set of approval requirements and timelines that focus on a year-to-year evaluation of maintenance dredging projects to assure that the material is still suitable for unconfined aquatic disposal. These requirements are covered under the concepts of Recency and Frequency described in Chapter 5. Holders of permits for maintenance dredging will have to continue to coordinate with DMMO/DMMT to determine if additional sampling and analysis is necessary before dredging is begun anew in any given year. Figure 4.2 summarizes the steps involved in obtaining approval for the continuation of maintenance dredging for a particular project.

4.6 DREDGED MATERIAL EVALUATION PROCESS

The dredged material evaluation process is integrated into both the overall permit process (Section 4.3) and the verification of existing permits (Section 4.5) as explained above. The dredged material evaluation process for the LCRMA is undertaken as a "Tiered Evaluation Process" as described in Chapter 5 and is summarized below.

- Applicant contacts either the DMMO (Seattle) or DMMT (Portland) to initiate the dredged material evaluation process (Section 4.2).

- Applicant submits project description and historical information as required in the Tier I evaluation (Chapter 5).

- If DMMO/DMMT can make a favorable suitability determination based upon the existing Tier I information, the determination is distributed for review and concurrence by the LCRMA Regional Management Team (RMT). No further sediment evaluation will be required.

- If DMMO/DMMT finds that Tier I information is not adequate to make a favorable suitability determination, the Applicant will be advised to prepare and submit a proposed sampling and analysis plan (SAP) to acquire additional information. The SAP must be approved by DMMO/DMMT with concurrence from the RMT (Chapter 6)..

- Applicant conducts sampling and analysis of proposed dredged material as directed by the SAP in order to furnish the information required in one of the subsequent tiers: Tiers IIA, IIB, III, or IV (Chapters 7, 8, 9 and 10).

- Applicant prepares and submits report of results of sampling and analysis effort to the DMMO/DMMT (Chapters 6 and 11).

- The DMMO/DMMT reviews the adequacy of the information and prepares a suitability determination and distributes for review and concurrence by RMT.

4.7 DREDGING QUALITY CONTROL PLAN

The final step before beginning a dredging project is the preparation and submittal of a dredging quality control plan, noted in Figures 4.1 and 4.2. The purpose of the plan is to ensure that the applicant and/or dredging contractor are aware of and understand all the conditions placed on the dredging operation and the disposal of the dredged material. When required, the plan must be submitted to the respective Corps Regulatory Branch, who will then coordinate review of the plan with other appropriate agencies. The timing of submittal is shown on Figures 4.1 and 4.2. The dredging quality control plan provides the following types of information:

- Description of the final project.
- Schedule for dredging and disposal.
- Description of dredging methods and controls, including procedures to remove debris; measures to control or minimize potential water quality impacts; and, if applicable, measures to dredge and dispose contaminated sediments separate from clean sediments and subsequent verification of such work.
- Disposal method, site coordinates, positioning procedures, and data recording and reporting.
- List of regulatory personnel to be contacted prior to the start of work.
- Tug operator's name and telephone number.
- Environmental emergency procedures, such as spill containment measures.

4.8 THE PROCESS FOR CORPS CIVIL WORKS DREDGING

The majority of current Corps civil works dredging involves the maintenance of existing channels and harbor ways. The coordination of maintenance dredging in Federally authorized channels is governed by the process described in 33 CFR 335-338 (Discharge of Dredged Material Into Waters of the U.S. or Ocean Waters; Operations and Maintenance). Generally, the coordination process for civil works dredging projects mirrors the regulatory program, with a few procedural exceptions. Corps dredging is subject to requirements under the following acts: National Environmental Policy Act, Clean Water Act and amendments, Marine Protection and Research, and Sanctuaries Act, and the Endangered Species Act.

The general steps in coordinating Corps civil works dredging include:

1) A public notice is issued describing the proposed work. If a new sediment characterization is necessary, data are collected and analyzed prior to the issuance of the public notice.

2) An environmental impact statement (EIS) or environmental assessment (EA) is prepared for the project. Typically, for maintenance dredging, a "Finding of No Significant Impact" or

FONSI is prepared in conjunction with the completion of a CWA Section 404 (b)(1) evaluation. If an EIS is prepared for new dredging work, Corps authorization to proceed is documented in a Record of Decision document. For work found to have "no significant impact", a document called a Statement of Findings (SOF) is completed at the end of the public coordination period.

3) For projects in the coastal zone, a determination of consistency with the enforceable provisions of the state coastal zone program is prepared and submitted to the appropriate state agency along with the public notice. Federal CZM consistency concurrence will be requested from the state.

4) If endangered species are known or suspected in the project area, the Biological Opinion will be checked to assure that the activity is covered. National Marine Fisheries Service will be notified that the activity is included in the biological opinion. If the activity is not included as part of the existing biological opinion, a biological assessment for the project will be prepared.

5) Any substantive comments received as a result of the public notice will be addressed to the greatest extent practicable. Maintenance dredging is not initiated until all necessary environmental coordination is completed, including the receipt of a water quality certification from the applicable state. For ocean disposal, a letter of concurrence for the activity is required from the regional EPA.

CHAPTER 5

TIERED EVALUATION PROCESS AND TIER I

5.1 OVERVIEW

Over 99 percent of the volume of sediment dredged annually in the Lower Columbia River Management Area (LCRMA) and adjacent channel reaches has been found to be suitable for placement at ocean and flow-lane disposal sites or used for beach nourishment. However, the potential exists for various degrees of sediment contamination at some dredging sites, particularly those located near urban and industrial areas. Projects in such locations may have to undergo a more extensive sediment evaluation. Such an evaluation, as called for in this manual, is essential so that dredged material will be disposed of in a manner that is consistent with environmental and regulatory mandates.

The chemical and biological testing required under this guidance manual can be expensive. One of the objectives of the manual is to develop and refine procedures that reduce the cost of dredged material testing while providing an appropriate evaluation of the potential environmental impact of dredged material disposal. The basic framework for evaluating dredging and disposal proposals consists of a tiered evaluation process.

5.2 TIERED EVALUATION PROCESS

The tiers or categories of information/data needs described below are used in a sequential manner for evaluating the suitability of dredged material for unconfined aquatic disposal. This sequential approach is called a tiered evaluation process. At each tier a decision is made regarding the adequacy of the existing data to make a suitability determination. If the existing data are adequate for decision purposes, then there is no need to proceed to the next tier. If not, data at the next tier are required before dredged material may be approved for unconfined aquatic disposal. The tiered arrangement is summarized in Table 5-1 and illustrated in Figure 5-1.

TABLE 5-1
Summary of Tiered Evaluation Approach for Aquatic Disposal

Tier I	Applicant and agencies compile and evaluate existing information on specific dredging site; determine if exclusion-from-testing or recency/frequency guidelines apply; and determine if there exists a reason-to-believe that significant contamination is present. Agencies prepare a suitability determination if sufficient information is available to approve unconfined aquatic disposal. (Chapter 5) If sediment information is not adequate, applicant must prepare and submit a sampling and analysis plan or SAP. (Chapter 6 and 7)
Tier IIA	Sediments are sampled and analyzed for grain size and total volatile solids (TVS), and any other conventional chemical parameter determined applicable to the proposed dredging location (Chapter 8). If the results of grain size analysis are at least 80% sand and TVS is less than 5.0%, the proposed dredged material qualifies for unconfined aquatic disposal based on exclusionary status.
Tier IIB	If the sediment fails either the grain size or TVS test, **or if active sources of contamination are determined to be present,** the sediment must be tested for chemicals-of-concern (Chapter 8). If the results of sediment testing do not exceed screening level guidelines, the proposed dredged material qualifies for unconfined aquatic disposal.
Tier III	If the results of the chemistry test exceed screening guidelines, the sediment must undergo appropriate biological tests (Chapter 9). If the sediment passes the biological testing guidelines, the proposed dredged material qualifies for unconfined aquatic disposal. Sediment that fails the biological tests of Tier III is determined to be unsuitable for unconfined aquatic disposal.
Tier IV	Two circumstances can trigger Tier IV evaluation (Chapter 10): a) the results of Tier III bioaccumulation tests are indeterminate, or b) the sediments contain chemicals which do not have threshold sediment quality values or for which the routine biological tests are inappropriate. If Tier IV testing is considered necessary by the RMT, then specific tests or evaluations and interpretive criteria will be designed by the RMT in coordination with the project proponent.

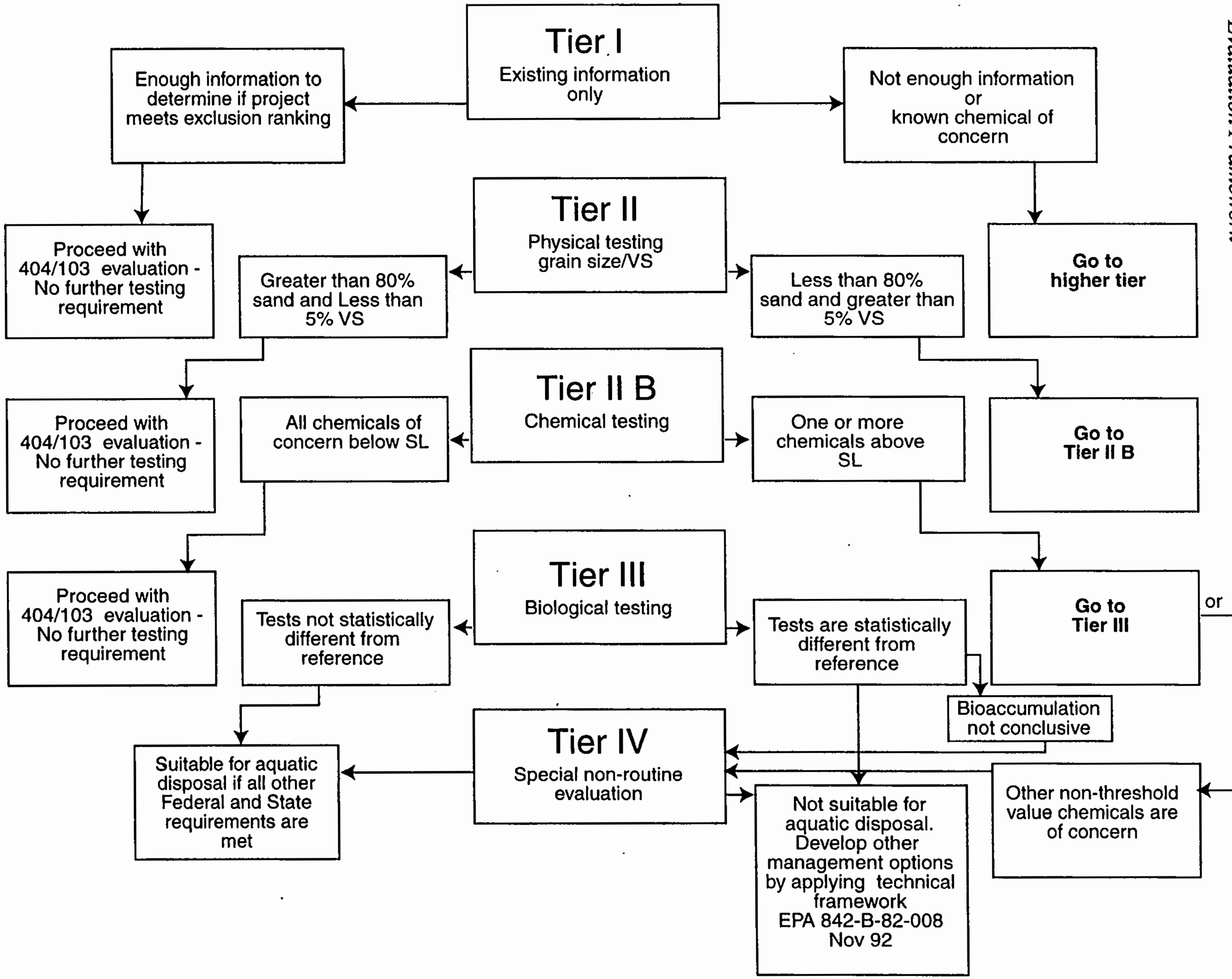

Figure 5-1 Regional tiered testing (aquatic)

5.3 TIER I

This section contains both an ***initial management area ranking*** (Section 5.3.1) and an ***individual project evaluation*** (Section 5.3.2). The management area ranking refers to the initial rankings assigned to specific sites or reaches of the Lower Columbia River where dredging is occurring or has occurred historically. These initial rankings serve as one of the project variables factored into the development of sediment sampling and analysis plans.

The individual project component refers to the Tier I evaluation process for a specific dredging proposal. Included in the Tier I evaluation for specific dredging proposals are guidelines pertaining to:

Exclusion from further testing based upon grain size and TVS (Section 5.3.3)

Proximity to known sources of contamination

Frequency of dredging (Section 5.3.4), and

Recency of data (Section 5.3.5).

5.3.1 Initial Management Area Rankings. In order to assign initial rankings in the LCRMA, the Regional Management Team (RMT) evaluated all known and available sediment quality data of the LCRMA and adjacent side channels. Reaches or sites where dredging may be expected or has occurred in the past were assigned one of five possible ranks: **exclusionary, low, low-moderate, moderate** or **high**. In that order, these ranks represent a scale of increasing potential for concentrations of chemicals-of-concern and/or adverse biological effects. Table 5-2 identifies the parameters that better define these rankings. The ranking system is based on two major factors:

- ✦ The availability of historic information on the physical, chemical, and/or biological-response characteristics of the sediments from a reach or site
- ✦ The number, kinds, and proximity of chemical sources (existing and historical) known to occur in or near a particular reach or site

The initial management area rankings are contained in Table 5-3. These rankings represent existing information at the time of initial ranking. Revisions to the rankings can and will occur as the result of additional information brought to the attention of the RMT. In addition, a specific project site or reach can be re-ranked based upon the results of new sediment testing or by means of a partial characterization. (see Section 6.7)

TABLE 5-2
MANAGEMENT AREA RANKING DEFINITIONS

RANKING	PARAMETERS
Exclusionary	Available data indicate coarse-grained sediment with at least 80% sand retained in a No. 230 sieve and a Total Volatile Solids content of less than 5.0%. Locations sufficiently removed from potential sources of sediment contamination based on historical information and/or best professional judgement. Typical locations include the mouth and mainstem channel of the Lower Columbia River.
Low	Available data indicate low concentrations of chemicals-of-concern (CoCs) and/or no significant response in biological tests. Locations with higher percentage of finer-grained sediments and organic material but few sources of potential contamination. Typical locations include adjacent entrance channels, rural marinas, navigable side sloughs, and small community berthing facilities.
Low-Moderate	Available data indicate a "low" rank may be warranted but data are not sufficient to validate the ranking.
Moderate	Available data indicate moderate concentrations of CoCs in sediments in a range known to cause adverse response in biological tests. Locations where sediments are subject to several sources of contamination, or where existing or historical use of the site has the potential to cause sediment contamination. Typical locations include urban marinas, fueling and ship berthing facilities; areas downstream of major sewer or stormwater outfalls; and medium-sized urban areas with limited shoreline industrial development.
High	Available data indicates high concentrations of CoCs in sediments and/or significant adverse responses in at least one of the last two cycles of biological tests. Locations where sediments are subject to numerous sources of sediment contamination, including industrial runoff and outfalls, or where existing or historical use of the site has the potential to cause sediment contamination. Typical locations include large urban areas and shoreline areas with major industrial development.

5.3.2 Project Specific Evaluations. Tier I involves the review of all available historical information to determine if there is a reason-to-believe that significant contamination may be present at a site proposed to be dredged. Included in the Tier I evaluation is the determination of whether the sediments to be dredged fall under an "exclusionary" category (Section 5.3.3). Projects requiring frequent dredging may also be excluded from further testing following two rounds of successive evaluation (Section 5.3.4). For projects with newly obtained sediment characterization data, Recency Guidelines have a bearing on the longevity of the information for decision purposes (Section 5.3.5).

a) Review of Historical Information. The agencies involved in the review and approval of dredging projects in the LCRMA can and do serve as a significant source of historical information about sediments and proposed dredging locations. The agencies share a common responsibility to make available any and all such information. However, the compilation of all available historical information about sediment quality or potential sources of contamination for a specific dredging project is the responsibility of the project proponent. An accurate compilation of historical data can result in substantial cost savings. For example, qualified data may eliminate or reduce the need for testing; may help limit the number of contaminants tested for; and may reduce the amount of dredged material needed to be tested.

b) Quality Assurance of Existing Data. The value of historical data is controlled by its reliability, which in turn depends upon the quality, timeliness, and completeness of the data. For example, twenty year old data may provide valuable input on a historical contaminant source which no longer exists, even though it can not be used for determinations of suitability. In contrast, recent data from a well designed sampling effort may be sufficient to make a final suitability determination on a project or to substantially reduce additional testing requirements. The following types of information are required in order to use existing data for suitability determinations:

- Sampling and analytical methods for both chemistry and biological tests
- Chemical detection limits
- Biological test control sediment
- Quality control measures for both chemistry and biological tests

TABLE 5-3. COLUMBIA RIVER FEDERAL PROJECT RANKING

PROJECT AREA	PROJECT	EXCLUSIONARY	LOW	LOW - MODERATE	MODERATE	HIGH
Mouth of the Columbia	RM -2 to 5	X				
Main Stem Columbia	RM 5 to 20	X				
	RM 20 to 29	X				
	RM 29 to 47	X				
	RM 47 to74	X				
	RM 74 to 88	X				
	RM 88 to 99	X				
	RM 99 to 106	X				
Columbia Side Channels						
	Hammond Boat Basin		X			
	Skipanon Channel			X		
	Baker Bay West Channel to mi.1+30	X				
	Baker Bay West Channel mi.1+30 to end		X			
	Illwaco Boat Basin		X			
	Chinook Channel	X				
	Chinook Marina		X			
	Toungue Point Access Ch & Turning Basin		X			
	Toungue Point Finger Piers				X	
	Skamokawa Creek		X			
	Elochoman Slough				X	
	Wahkiakum Ferry	X				
	Westport Slough		X			
	Old Mouth of the Cowlitz	X	X			
	St. Helens X-Over Ch.		X			
	Oregon Slough		X			
Willamette River						
	Main Federal Channel		X	X	X	
	US Moorings					X

5.3.3 Exclusion from Further Testing. The determination of a possible exclusionary status for a particular dredging project is done during Tier I or at Tier IIA. Exclusions from testing for coarse-grained dredged material is provided for in national guidelines (40 CFR 230.6(a) and 40 CFR 227.13(b)). In those guidelines, dredged material which meets the criteria set forth in the following three paragraphs is considered environmentally acceptable for unconfined aquatic disposal without further testing:

> (1) Dredged material that is composed predominantly of sand, gravel, rock, or any other naturally occurring bottom material with particle sizes larger than silt, and the material is found in areas of high current or wave energy such as streams with large bed loads or coastal areas with shifting bars and channels; or
>
> (2) Dredged material that is identified for beach nourishment or restoration and is composed predominantly of sand, gravel or shell with particle sizes compatible with material on the receiving beaches; or
>
> (3) When: (a) the dredged material proposed for disposal is substantially the same as the substrate at the proposed disposal site; and (b) the site from which the material proposed for disposal is to be taken is far removed from known existing and historical sources of pollution so as to provide reasonable assurance that such material has not been contaminated by such pollution.

This regional manual endorses the concepts embodied in categories (1) and (2) above by adopting the following exclusionary language:

*Sediments which meet the criteria set forth in the following two paragraphs are considered environmentally acceptable for unconfined aquatic disposal in the Lower Columbia River Management Area without further testing; **provided however, the sediments are not located within the likely impact zone of an active and significant contaminant source:***

(1) Sediments that are composed of greater than 80% sand, gravel or other naturally occurring bottom material (retained on a 230 sieve) and that have a total volatile solids content of less than 5.0 %.

(2) Sediments targeted for beach nourishment or restoration that are composed of greater than 80% sand, gravel or shell (retained on 230 sieve), that have a total volatile solids content of less than 5.0 %, and that are compatible with material on the receiving beaches.

The adoption of exclusion category is based upon numerous studies and sampling efforts done on the Lower Columbia River verifying that coarser-grained sediments are characterized by very low to negligible levels of chemical contamination. This exclusion category was used as one of the guidelines in determining the initial rankings in the LCRMA.

5.3.4 "Frequency of Dredging" Guideline. The frequency of dredging guideline provides a second method by which dredged material may be excluded from further testing for specific periods of time. The frequency guideline pertains to dredging projects that occur on a frequent basis, such as every year or, at most, every two or three years. Such dredging commonly reflects a situation of routine and rapid buildup of shoals with relatively homogeneous sediments. The quality of the sediment at the dredging site tends to stay the same for successive years, barring any significant changed condition at or upstream of the site.

To qualify for consideration under the frequency guideline, a project requires full characterization of sediments for two successive dredging events. Provided the sediments are found suitable for unconfined aquatic disposal for each dredging event, the "frequency" of additional characterization after that will depend upon the rank of the project site determined by the results of the first two rounds of testing.

In effect, the frequency guideline specifies a period of time in which a qualified dredging project is "excluded" from having to do any further testing. The time durations provided for by the frequency guidelines are the same as for the "recency of data" guidelines described below: that is, two years for high-ranked areas; and 5, 6, and 7 years for moderate, low-moderate, and low-ranked areas, respectively. Areas or projects ranked Exclusionary under Section 5.3.3 do not need to be considered under the frequency guideline since they have already qualified for exclusion from further testing on the basis of grain size and total volatile solids.

5.3.5 "Recency of Data" Guideline. The recency of data guideline refers to the duration of time for which newly obtained and qualified physical, chemical or biological information is considered adequate for decision making without further testing. Recency guidelines are based on the area or project site rankings which, in turn, reflect a consideration of the presence and operating status of contaminant sources located at or near the area to be dredged. The recency guideline for exclusionary, low, low-moderate, and moderate ranked areas is 10, 7, 6, and 5 years, respectively. In high-ranked areas, the recency guidelines allow characterization data to be valid for a period of 2 years.

The recency guidelines do not apply when a known "changed" condition has occurred since the most recent sampling effort, such as an accidental spill or the siting of a new discharge outfall. For subsurface sediments, the potential for contamination from groundwater sources must also be considered.

5.4 TRANSITION TO SUBSEQUENT TIER(S)

The compilation and review of existing information and other locational factors comprise the first tier of the tiered approach to sediment evaluation. If existing information adequately support a decision for unconfined aquatic disposal, no additional data are needed. If existing information does not exist or is not adequate for purposes of the initial site/sediment characterization, the project proponent will be required to prepare and submit a sampling and analysis plan (SAP). Chapter 6 describes the details of a sampling plan applicable to the complexities of a dredging project and the guidelines for preparing and submitting the plan. Chapter 7 provides further details on the proper implementation of sediment sampling and laboratory analyses.

CHAPTER 6

SAMPLING AND ANALYSIS PLAN

6.1 OVERVIEW

The development of a sampling and analysis plan by the dredging proponent is the next step in the tiered evaluation process for those projects found to require additional information following review under Tier I. The basic sampling and analysis structure that follows is patterned after those developed for Puget Sound and Grays Harbor. This manual includes guidelines that take into account the fact that the Lower Columbia River Management Area (LCRMA) is a very large and dynamic river/estuarine system.

6.2 INFORMATION IN A DRAFT SAMPLING AND ANALYSIS PLAN

A sampling plan serves as the main source of information about a proposed dredging project and the project site. A sampling and analysis plan (SAP) should contain the following general categories of information in as much detail as possible. Some of these categories of information are further described in subsequent sections of this chapter. Examples of SAPs are presented in Appendices 6-A and 6-B.

- **Tier I Information:** site history, current site use, identification of potential sources of contamination, past permitting and present rank. Rank affects the number of sediment samples and analyses required of the project. More than one rank could be assigned to a single project depending upon the size of the proposed dredging area and the distribution of potential contaminant sources.

- **Project Description:** a plan view of the site, one or more cross-sections of the dredging prism, and the type and volume of sediment to be dredged. Dredged material volume is another factor that affects the number of sediment samples and analyses required of a dredging project. This proposed dredging plan should contain such information as the depth and physical nature of the sediments; side slope and overdepth dredging; practicable widths and depths of dredging; and available dredging methods and equipment.

- **Computation of Sampling and Analysis Requirements**: project rank and volume of dredged material, development of a proposed dredging plan; identification of dredged material management units; allocation of field samples and development of a compositing plan.

- **Sampling Procedures:** 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.

- **Physical and Chemical Testing:** grain-size analysis, sediment conventionals, chemicals-of-concern, extraction/digestion methods, analysis methods, holding time requirements and quality assurance requirements.

- **Biological Testing:** holding time requirements, proposed testing sequence, bioassay protocols and quality assurance requirements.

- **Personnel Responsibilities:** individual roles and responsibilities, project planning and coordination, field sampling, chemical and biological testing, QA/QC management, and final report preparation.

- **Reports:** draft SAP submitted to DMMO/DMMT, comments or concerns by agencies addressed in final SAP, results of sampling and analyses written up in standard format and submitted to DMMO/DMMT for review and concurrence of the RMT.

6.3 DETERMINATION OF DREDGED MATERIAL VOLUMES

The volume of dredged material determines, in part, the minimum number of sediment samples and analyses required for full characterization of a dredging project. The potential volume of sediment is usually determined from a pre-sampling bathymetric survey. The calculation of dredged material volume must include:

- sediments anticipated to slough from the side slopes and from under piers and wharves during dredging,

- "overdepth dredging" - a term used to account for the limitation of dredges to achieve a precise depth of cut. Overdepth dredging refers to the removal of sediment one to two feet deeper than the planned depth of dredging, and

- "advanced maintenance dredging" - a term used to described additional dredging cut or width in locations known to shoal very rapidly. Advance maintenance refers to the removal of a sufficient volume of sediment to ensure a reasonable length of time before having to dredge again.

The calculation and/or differentiation of dredged volume may be affected by one of the following variables:

a) Heterogeneous Sediments. Heterogeneous sediments are those in which the physical characteristics are dissimilar within the sampling depth. Characteristics of such sediments include obvious layering of sediments, lenses of dissimilar material (either in grain size or color), or obvious gradation of sediment size. Sediments that are deposited over a long period of time may be heterogeneous in nature.

In heterogeneous sediments, the volume of dredged material may be differentiated either by discreet sediment lenses or by depth. If a discreet lens is present in the sediment profile, then volumes may be calculated on the basis of that lens. However, to qualify for a separate characterization, the volume of the discreet lens must be amenable to being dredged separately from other sediment occurring in the dredging prism.

Lacking discreet lenses, projects with heterogeneous sediment greater than four feet deep must divide the volumes between a "surface layer" (generally the top four feet) and a "subsurface layer" (the next 4-foot layer) down to the bottom of the planned dredge cut. The volumes comprising each of the 4-foot layers must be calculated separately. A four-foot cut is considered a manageable unit of dredged material as it represents the typical depth achieved by one drop of the bucket of a moderately-sized clamshell dredge in unconsolidated sediments.

b) Homogeneous Sediment. The majority of sediments dredged in the LCRMA are homogeneous. The sediments appear the same in physical characteristics throughout the sampling depth and lack obvious color striations, layering, or sorting of grain size. For shoals which are dredged frequently or new projects which involve the dredging of native material, the entire dredging prism may be considered homogeneous and the volume need not distinguish between surface and subsurface layers.

6.4 DETERMINATION OF SAMPLING AND ANALYSIS REQUIREMENTS

The following guidelines specify the maximum volume of dredged material that can be represented by a single analysis. The guidelines are considered "the minimum requirements" in that the dredging proponent may opt, or regulatory agencies may require, additional analyses for volumes less than the maximum.

a) Dredged Material Management Units. In determining the number of samples and analyses required to fully characterize project sediments, the concept of a "dredged material management unit" (DMMU) is used. A DMMU can represent the total volume of sediment to be dredged for a small project or can be a sub-unit of the total volume of a larger project. Typically, a DMMU represents a unit of sediments similar in nature that can be characterized by a single sediment analysis. Thus, a separate decision can be made for a management unit that can be characterized and dredged separately from other sediment in the project. The acceptability of dredged material for unconfined aquatic disposal is determined for individual DMMUs independently of other management units within the project, and is based on the results of the analysis representing that DMMU.

Table 6-1 presents the maximum volume of sediment in a DMMU that can be characterized by a single analysis based on area ranking. The presence of heterogeneous or discreet layers in the dredge cut may warrant further sub-sampling or assignment of a smaller DMMU. Dredging proponents have the option to propose smaller DMMUs. For example, if 25% of the sample volume is visually different from the rest of the sediment profile, and can be sampled and dredged separately, then an additional DMMU may be warranted.

b) Sampling Intensity Within a DMMU. The number of samples required of a proposed project, or that can be composited or combined for a single analysis, will be determined on a case-by-case basis using best professional judgment. The number of samples and the compositing scheme will vary depending upon such factors as (1) a reason to believe that contamination may exist at the surface or in subsurface sediments, (2) the heterogeneity of the sediments, (3) the project rank, (4) the aerial extent of a DMMU, and (4) the proposed depth of dredging. In general, sampling intensity will increase with suspected contamination, higher project ranking, greater aerial extent, increasing depth, or the occurrence of stratification. In heterogeneous sediments, a minimum of three samples composited for one analysis will be required to characterize a single DMMU.

6.5 PREPARATION AND SUBMITTAL OF A DRAFT SAMPLING AND ANALYSIS PLAN

A draft sampling and analysis plan is prepared once the number of samples and analyses have been calculated in conjunction with the dredging plan. The draft plan identifies specific sampling locations for the dredged material management units (DMMUs) and, if applicable, specifies the compositing of samples for individual analyses.

In applying the above concepts to a workable draft sampling plan, it is not necessary or always desirable to restrict the volumes characterized by each individual sample or DMMU in the field to the minimums specified in Table 6-1. Additional sampling and/or analyses beyond the minimum number may be required to achieve an appropriate dredging plan. Sample stations may be added and/or moved to select different, equally representative spots to insure uniformity of acceptability throughout the project. Stations may be moved or added in response to information on point sources, spills, or new chemicals of concern, or to acquire data that helps draw boundaries between clean and contaminated sediments.

TABLE 6-1. DREDGED MATERIAL MANAGEMENT UNITS

Ranking	**Heterogeneous**	**Homogeneous**
(Volumes in cubic yards)		
Exclusionary	NA	NA
Low	50,000	100,000
Low-Moderate	35,000	70,000
Moderate	20,000	40,000
High	5,000	10,000

The draft sampling and analysis plan must be submitted to the DMMO/DMMT for review by the agencies comprising the RMT. The DMMO/DMMT will then prepare a letter of approval to proceed with the sampling effort with recommended corrections or changes to the draft SAP. Such corrections and changes must be reflected in the final SAP that is submitted to the DMMO/DMMT with the report containing the results of the sampling and analysis effort.

6.6 SAMPLING AND ANALYSIS CONSIDERATIONS FOR SPECIAL CASES

The following sections discuss special types of sediment evaluation for the Lower Columbia River Management Area. These special cases will be evaluated by the RMT on a case-by-case basis. These include the requirements for establishing exclusionary status, methods for evaluating sediment in areas of rapid shoaling, methods for confirming project ranking, exceptions for small projects and evaluation of sediment exposed by dredging.

6.6.1 Establishment of Exclusionary Status

This section provides a process to establish an exclusionary status for projects or project locations that would likely qualify as exclusionary but which are lacking data to validate such a determination. Typically such areas or projects would already be ranked low or low-moderate and exist in a high current location. Three factors have to be considered in order to establish an exclusionary status: (1) the potential influence of active point sources of contamination on the sediments to be dredged, (2) the grain size of the sediments, and (3) the total volatile solids contents in the sediments.

The latter two criteria trigger the need to do sediment sampling if sufficient data are not available. The intensity of sampling and analysis to establish an exclusionary ranking will be based upon the existing rank of the project or project location and the volume of sediment to be dredged. For projects below 300,000 cubic yards, testing is conducted at the same intensity as a low-ranked homogeneous project. For projects between 300,000 and one million cubic yards, four samples are required. Above one million cubic yards, five samples are required.

Sediment samples obtained for the initial determination of an exclusionary status should be taken to the full depth of the proposed dredge cut by a core sampling device. Core sampling indicates the grain size distribution of the sediments for the entire depth of the dredge cut. However, core sampling is not always possible in the Lower Columbia River. Some reaches of the river can not be sampled by coring devices because of the inability to position a research vessel in high currents or to drive a coring device into very compact, coarse sandy sediment. In such cases, the inability to use a coring device will have to be documented in the final sampling report. Sediment samples obtained to "confirm" an existing exclusionary status (see Section 6.6.2) may be taken with a suitable grab sampler.

6.6.2 Confirmation of Project Ranking

Confirmatory sampling and analysis is primarily intended for application to frequently dredged projects ranked low or exclusionary. It should be done at least as often as called for under the frequency guidelines. The main purpose of confirmatory sampling is to reaffirm the historical record and to show that no significant environmentally unacceptable changes have occurred to the project sediments. It is also intended to be accomplished at lesser cost but with an acceptable level of confidence in support of an existing project ranking or suitability determination. Confirmatory sampling shall duplicate earlier sediment testing as much as possible and thereby provide spatial and analytical consistency between testing periods.

If the results of confirmatory sampling and analysis indicate that the project or shoal sediments have changed significantly to the worse, project reranking to a higher level and further sampling may be necessary.

6.6.3 Rapid Shoaling Events

Many reaches of the Lower Columbia River and some tributaries are affected by a rapid build up of shoals that pose serious risk to the navigation of commercial vessels. Shoaling typically occurs following major storm events in December through February, but may occur at any time as a result of bedload redistribution. In general, the largest number of recurring shoals are dredged by the Corps of Engineers from the mainstem navigation channel. However, some shoal locations involve non-Corps dredging.

Because of rapid shoaling events, a port or other water dependent enterprise may be faced with a situation where a particular shoal must be dredged as soon as possible. The situation may be complicated by the fact that some dredging is restricted to an operating period of only four months, that being from November 1 to February 28 of any year due to endangered species concerns. In that time frame, the size of a potential problem shoal can increase substantially from what was there during a prior sampling effort to characterize the sediment already in the shoal. The following guidelines address the rapid buildup of new shoal material in locations where sediment characterization has been done and is still valid under Recency Guidelines. These guidelines do not apply to shoal locations ranked Exclusionary.

a) **No additional testing required.** For projects or shoal locations where historical information documents the occurrence of sediments suitable for unconfined aquatic disposal for two dredging cycles, no additional testing will be required regardless of the depth of the new shoal material.

b) **Lack of sufficient historical record and in a location ranked low or low-moderate.** No additional testing will be required if the newly deposited shoal material averages less than two feet in depth. If greater than two feet in depth, the dredging proponent will be required to obtain grab samples to characterize the new shoal sediments. The number of grab samples/analyses required will be determined by the ranking of the location and the estimated volume of new material.

c) **Lack of sufficient historical record and in a location ranked moderate or high.** The dredging proponent will be required to obtain grab samples to characterize newly deposited sediments/shoal material if the material averages more than one foot in depth

The number of grab samples/analyses required will be determined by the ranking of the location and the estimated volume of new material.

6.6.4 Exceptions for Small Projects

For small projects (as defined in Table 6-2), the cost of testing must be balanced against the environmental risks posed by a very small volume of dredged material. Small volumes generally represent low potential risk that unacceptable adverse effects will result at the disposal site from the specific and/or cumulative discharges. As a result, a small volume of sediment to be removed at a dredging site can obviate the need for 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 a multiple-project dredging contract 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..

For small projects in low, low-moderate, or moderately ranked areas, volumes for which no testing need be conducted are shown in Table 6-2. There is no "no test" volume for high-ranked areas. In the absence of conclusive evidence of unsuitable sediments, projects with these or lesser volumes will be considered suitable for unconfined aquatic disposal.

TABLE 6-2
"NO TEST" VOLUMES FOR SMALL PROJECTS

Ranking	**"No-Test" Volume**
Low	Less than 10,000 cy
Low-Moderate	Less than 1000 cy
Moderate	Less than 1000 cy
High	Not Applicable

6.6.5 New Sediment Surface Exposed by Dredging

Dredging operations can alter the condition of a project site by exposing a new surface layer of bottom material to direct contact with biota and the water column. This aspect of dredging must be considered during preparation of the SAP because, for some projects, the newly exposed surface could have greater concentrations of chemicals-of-concern (CoCs) than existed before dredging.

Where there exists a reason-to-believe the new surface material (NSM) could be contaminated, the material will be included in the sampling effort by obtaining a core sample to a depth of at least one foot below the planned depth of dredging. The NSM from each sampling location will be archived for possible future analyses. Chemical analysis of the NSM will be required only if the sediment immediately above the NSM has concentrations of chemicals-of-concern exceeding screening levels and fails the applicable biological tests (see Section 7.6). Chemical analysis of the exposed surface will not be required if the overlying sediments pass the biological tests.

Several options were considered for inclusion as decision guidelines pertaining to the issue of newly exposed surface material. One of the following courses of action may be triggered to address the disposition of, and responsibility for NSM that might be left following a dredging operation:

- If dredging results in the exposure of NSM having higher chemical concentrations than the sediment that was dredged, the dredging proponent may be required to over-dredge the site or cap the newly exposed bottom material. Final decisions pertaining to the need to over-dredge or to cap will be based upon the results of appropriate biological tests.

- If dredging results in the exposure of NSM as clean as, or cleaner than, the overlying sediments, no additional requirements are triggered under this manual.

- If surface sediments with elevated concentrations of CoCs are present adjacent to the dredging site, but not in the site proposed to be dredged, nothing in this guidance manual requires a dredging proponent to address the fate of the sediment in the adjacent area. The issue to be considered, however, is the potential impact of the adjacent contaminated sediments on the cleaner sediments in the area to be dredged.

6.7 SAMPLING AND ANALYSIS FOR SITE-SPECIFIC DOWNRANKING

Areas or reaches of the Lower Columbia River where dredging has occurred or is expected to occur were ranked by the RMT (see Table 5-3). These rankings reflect the most current condition of sediment quality at a particular dredging site at the time this manual was developed. Two downranking options are provided in this manual to allow dredging proponents the opportunity to provide new information to rerank a specific site lower than the initial ranking.

A project site can be ranked lower either on a temporary or a permanent basis. Two rounds of full sediment characterization are required to downrank a dredging location or project site on a permanent basis.

Temporary downranking can be achieved by a process called "partial characterization" or PC. A partial characterization is intended to be a relatively low cost method of providing a reasonable level of data in support of a reranking decision by the RMT. In practice, partial characterization has been used in connection with relatively large dredging projects where significant cost savings have been gained because of reduced testing and analysis requirements. However, the potential cost savings have to be weighed against the added cost of potentially undertaking two separate sediment sampling efforts.

a) Sampling and Analysis Plan for Partial Characterization (PC). An approved sampling and analysis plan (SAP) is required for a partial characterization. The SAP must be prepared in coordination with, and submitted to the DMMO/DMMT. The purpose of the PC effort must be clearly stated in the SAP, such as to partially characterize an entire dredging site or only a subunit or subunits of the total site.

The focus of a typical PC is to obtain the chemical analysis of a limited number of surface samples, surface meaning the top four feet of sediment. In some cases, the sampling stations will be located to help determine "worst-case" sediment quality relative to known point sources of contamination. In addition, a dredging proponent may opt or may be required to perform subsurface sampling and analysis for a PC if there is reason to believe that subsurface sediments are also contaminated.

The number of samples and analyses required for a temporary downranking is based on a percentage of the number of samples and analyses that would be required for a full characterization (FC) under the current ranking. To lower a site by one rank, ten percent of the FC minimum analysis requirements must be obtained for the PC. To lower a ranking two levels, 20 percent of the FC minimum requirement must be obtained. For either option, a minimum of three samples must be analyzed. For the PC of a subunit of a larger site, a minimum of two samples must be analyzed. No compositing is allowed for partial characterization; each sediment sample requires a separate analysis. PC samples must be analyzed for the full list of chemicals-of-concern (see Table 8-1) including sediment conventionals and any relevant "chemicals-of-concern for limited areas."

b) Decision Guidelines for Downranking. The decision to downrank a site or subunit within a site will be based on the results of the sediment sample having the highest level of chemicals-of-concern. Ranking guidelines based on partial characterization data are shown in Table 6-3.

TABLE 6-3
RANKING GUIDELINES BASED ON PC DATA

Ranking	**PC Guideline**
Low	All chemicals ≤SL
Low-Moderate	At least one chemical > SL and ≤ (SL + ML)/2
Moderate	At least one chemical > (SL +ML)/2 and ≤ML
High	At least one chemical > ML

The results of a PC can be used to downrank a project on a one-time basis only. Two cycles of full characterization (FC) are necessary for a permanent downranking (see Chapter 5). Data from the PC may also be used as a basis to screen out certain chemicals-of-concern, or groups of chemicals (such as PCBs). If a chemical is not found in the PC and is not available from nearby sources, the chemical may be deleted from the requirements of the subsequent full characterization. In addition, the data from a PC may be used in partial fulfillment of full characterization requirements.

If the PC data indicate a higher rank is warranted at a particular unit, subunit or sampling station, then that area will be ranked higher and the FC will be conducted in that area on the basis of the higher rank.

CHAPTER 7

SAMPLING PROTOCOLS

7.1 OVERVIEW

When required, sampling and testing must be coordinated far enough in advance of dredging to allow time for chemical testing, possible biological testing, and data review. An accurate assessment of the physical, chemical and biological characteristics of proposed dredged sediment is dependent upon the collection of representative samples. Steps must be taken during the sampling process to ensure that samples accurately represent the area to be dredged. This chapter discusses the recommended procedures for sample acquisition and handling. This is the first step in the quality assurance, quality control process that is needed to guarantee reliable data for dredged material evaluation. A number of regional programs have developed standard sampling protocols. This chapter and the associated appendices provide an overview of these widely accepted practices.

Pre-sampling bathymetric surveys should be conducted to provide information on current shoaling patterns and volumes of sediment present at the time of sampling. **The timing of sampling should be coordinated with the DMMO/DMMT.**

7.2 SAMPLING APPROACH

If sampling and analysis are required for a project, the applicant will be required to sample the sediment for chemical, and if necessary, biological analyses. The recommended volume needed for each type of analysis is listed in Table 7-1. There are four sampling approaches which the dredging proponent may take:

Alternative #1: Collect enough sediment for physical characterization only.

Alternative #2: Collect only enough sediment to conduct the physical and chemical analyses. If biological testing is necessary, resampling will be required.

Alternative #3. Collect sufficient sediment for all physical, chemical and biological tests. Archive adequate sediment for biological testing pending the results of the chemical analysis.

Alternative #4: Collect sufficient sediment for all chemical and biological tests. Run these tests concurrently.

The sampling approach should be clearly documented in the sampling and analysis plan. The selection of either alternative #3 or #4 is encouraged if chemical analysis is anticipated, 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 #4 is the least time consuming, and is likely the most economical when the need for biological testing is expected (Note the sediment holding times in Table 7-1). For alternative #2, biological analysis can proceed without re-analysis of sediment chemistry. Biological samples must be taken from the same stations as the sediment chemistry samples.

7.3 POSITIONING METHODS

Accurate positioning of sampling stations is essential in investigations of sediment characteristics. All samples should be obtained as close as possible to the target locations provided in the project sampling plan. All sediment sampling locations should be recorded to a horizontal accuracy of ± 2 meters (or as approved in the sampling and analysis plan). Such accuracy can be obtained by survey landmarks and a variety of positional hardware. If sampling locations are referenced to a local coordinate grid, the local grid should be tied to the North American Datum (NAD 1983) to allow conversion to latitudes and longitudes. The use of a standard horizontal datum will allow dredging data to be accurately mapped, including display and analysis using geographic information system (GIS) software.

7.4 SAMPLING METHODS

The goal of sediment sampling for characterization of each individual dredged material management unit (DMMU) is to collect a sample (or a number of composited samples) which will be representative of the DMMU. The agencies have established minimum sampling requirements 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.

a. Core Sampling. For projects in heterogeneous areas and for most new-work dredging, the proponent will be required to take core samples from the sediment/water interface down to the maximum depth of dredging. 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.

b. Grab Sampling. It is anticipated that sediments in frequently dredged areas or in areas of high energy will be relatively homogeneous. In these locations, grab samples will be considered adequate to represent the dredged material, even if shoaling results in sediment accumulation greater than four feet. A number of factors need to be considered in the selection of a grab sampler, including type of sediment, volume needed and ease of deployment.

7.5 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. Guidance can be found in the *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound* (PSEP 1996) which contains detailed information on sample handling procedures. Project proponents are urged to contact the DMMO/DMMT for the latest protocols. General guidance can be found in Appendix 7-A and is summarized below.

a. Decontamination Procedures. Sampling containers should be decontaminated by the laboratory or manufacturer 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 aquatic disposal, being found unacceptable.

b. 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. 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.

c. 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 for each DMMU should be selected for the volatiles and sulfides sampling.

d. Sampling Logs. As samples are collected, and after the volatiles and sulfides sub-samples have been taken, logs and field notes of all samples should be taken and correlated to the sampling location map.

e. Extrusion, Compositing and Sub-sampling. Depending on the sampling methodology and procedure proposed, sample extrusion, compositing and subsampling may take place at different times and locations.

f. Sample Transport and Chain-of-Custody Procedures. Sample transport and chain of custody procedures are listed in Appendix 7-A.

g. Sample Storage and Holding Times. Proper sample storage is critical to accurate assessment of sediment toxicity. Table 7-1 outlines the storage and holding time requirements for each type of analysis.

TABLE 7-1
SAMPLE STORAGE CRITERIA

SAMPLE TYPE	HOLDING TIME	SAMPLE SIZE[1]	TEMPERATURE[2]	CONTAINER	ARCHIVE[3]
Particle Size	6 Months	100-200 g (150 ml)	4°C	1-liter Glass (combined)	X
Total Solids	14 Days	125 g (100 ml)	4°C		
Total Volatile Solids	14 Days	125 g (100 ml)	4°C		
Total Organic Carbon	14 Days	125 g (100 ml)	4°C		
Ammonia	7 Days	25 g (20 ml)	4°C		
Metals (except Mercury)	6 Months	50 g (40 ml)	4°C		
Semi-volatiles, Pesticides and PCBs	14 Days until extraction 1 Year until extraction 40 Days after extraction	150 g (120 ml)	4°C -18°C		
Total Sulfides	7 Days	50 g (40 ml)	4°C[4]	125 ml Plastic	
Mercury	28 Days	5 g (4 ml)	-18°C	125 ml Glass	
Volatile Organics	14 Days	100 g (2-40 ml jars)	4°C	2-40 ml Glass	
Bioassay	8 Weeks	4 liters	4°C[5]	5-1 liter Glass	
Bioaccumulation	8 Weeks	16 liters	4°C[5]	16-1 liter Glass	

[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.

7.6 ARCHIVING ADDITIONAL SEDIMENT

In areas where the exposed sediment is anticipated to be contaminated above the *in situ* sediment, a sample from the first foot below the dredging overdepth will be collected and archived. This will allow possible future analysis to evaluate chemical concentrations in the newly exposed sediment if this is deemed necessary by the Regional Management Team.

The archived sediment must be frozen. Because the holding time for mercury will likely be exceeded, and sediments for volatiles analysis can not be frozen, mercury and any volatile chemicals-of-concern will not need to be analyzed for the archived sediments unless these chemicals are anticipated to be a problem in the newly-exposed sediments. In this case, analysis will need to occur immediately.

7.7 DATA SUBMITTAL

A key component of the sampling effort is the completeness of the data package submitted for regulatory review. Chapter 11 contains detailed information regarding data submittal requirements.

CHAPTER 8

TIER II: PHYSICAL AND CHEMICAL TESTING

8.1 OVERVIEW

Consistent with the tiered testing approach, and following an assessment of existing information in Tier I, physical and/or chemical characterization of the dredged material will be required. Tier II is designed to provide a reliable screen to predict potential contaminant effects from discharge of that material. The pathways of concern for potential effects are through the bulk sediment itself and/or through the water column. The collective experience in this region, as well as nationally, has shown that significant releases of chemicals of concern do not occur in the water column during dredging and disposal. Accordingly, this manual focuses on requirements and procedures for testing bulk sediments. When judged necessary by the Regional Management Team (RMT), water column testing will be required as outlined in this manual.

For this manual, Tiers IIA and IIB are subtiers which may be pursued individually. Tier IIA involves two conventional tests: grain size and total volatile solids. The term conventionals refers to a group of physical and chemical parameters often measured to aid in the interpretation of chemical and biological test results. Tier IIB involves a more complex combination of physical and chemical tests which measure concentrations of individual or groups of chemicals specified for the project or project area. Following testing, the results of the analysis for each dredged material management unit is compared to the appropriate decision guidelines. Determinations are then made concerning whether the sediment is suitable for unconfined aquatic disposal or whether further testing is required (Tier III or Tier IV).

There are three categories of "chemicals of concern" that will be considered in developing specific testing requirements for dredging projects: a standard list of chemicals of concern (CoC), a list for limited areas, and CoCs with bioaccumulation potential, which is typically a subset of the two lists. Although performed as part of Tier III, the determination whether bioaccumulation testing should be conducted is made in Tier II and depends upon the concentration of the chemical present in the sediment. The model to make this determination for ocean disposal (Theoretical Bioaccumulation Potential) requires sediment chemistry data.

8.2 PROTOCOLS

Sediment testing protocols to be used in Tiers IIA and IIB are generally those summarized in the latest version of the *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound* (PSEP 1996) for marine sediments. Freshwater sediment protocols will follow Appendix F: Methods for Chemical and Physical Analysis, from the *Great Lakes Dredged Material Testing and Evaluation Manual* (EPA/USACE 1994). The Regional Management Team must approve any modifications of these protocols. This should occur during the preparation and finalization of the project sampling and analysis plan (see Chapter 6).

Standard protocols should be followed in assessing conventional parameters, with the following specifications:

Grain size: Measurement of grain size will be determined following the measurement techniques specified in ASTM D 422 (modified). Measurement requires use of a sedimentation sieve series consisting of the following sieve sizes: 5 inch, 2.5 inch, 1.25 inch, 5/8 inch, 5/16 inch, No. 5, No. 10, No. 18, No. 35, No. 60, No. 120, and No. 230. Material passing the 230 sieve determines the percent fines. Reporting shall include both the percent of sediment retained in each sieve as well as the percent passing. Hydrogen peroxide will not be used in preparations for grain-size analysis. (Hydrogen peroxide breaks down organic aggregates and its use may provide an overestimation of the percent fines found in undisturbed sediment. Incorrect grain size matches could result when reference sediments are collected.) Hydrometer analysis should be used for particle sizes finer than the 230 mesh. Water content will be determined using ASTM D 2216. Sediment classification designation will be made in accordance with U.S. Soil Classification System, ASTM D 2487 using the above sieves as an approximation.

Total Volatile Solids (TVS): Standard Method 2540 E, contained in the 19th Edition of Standard Methods of the Examination of Water and Wastewater (Franson 1995), is the required method for TVS analysis. Data must be presented as percent total volatile solids in the sample.

Total Organic Carbon (TOC): Detailed methods for analyzing TOC samples may be found in the 18th Edition of Standard Methods for Examination of Water and Wastewater (Franson, 1992). Method 5310B is recommended, slightly modified for sediment samples. A description of the modified TOC method is provided as a clarification in the proceedings from the PSDDA Fifth Annual Review Meeting (Bragdon-Cook, 1993).

Ammonia: Analyses should be conducted according to standard EPA/Corps procedures (Plumb, 1981). Reports detailing conventional tests should report detection limits and also report QA/QC.

Water quality tests: Program experience has shown that in most cases the existing data are sufficient to make water column determinations. However, Tier I evaluation may show that existing information is insufficient to make a determination. If a determination cannot be made in Tier I, Tier II evaluation is necessary. There are two approaches for the Tier II water column evaluation. One approach is to use the numerical models provided in the Inland Testing Manual (Appendix C) as a screen, assuming that all of the contaminants in the dredged material are released into the water column during the disposal process. The other approach applies the same model with results from chemical analysis of the elutriate test (DiGiano 1995, Ludwig 1988).

8.3 TIER IIA TESTING

Tier IIA is designed to characterize sediments likely to have minimal amounts of fine-grained material and therefore lower potential for concentrations of chemicals of concern. Sediments are sampled and analyzed for grain size and total volatile solids (TVS), the latter to assess the organic content of the sediment. However, other conventional parameters (such as TOC, total solids, and ammonia) may be required as determined applicable to the proposed dredging location. If the results of the grain size analysis are greater than 20 percent fines and TVS is less than 5 percent, then the dredged material may qualify for unconfined aquatic disposal based on exclusionary status (see Table 5-1). If the results fail either guideline then the sediment must undergo bulk sediment analysis to test for chemicals of concern.

8.4 TIER IIB TESTING

Due to the relationship between CoCs and biological effects, chemical testing for these substances can be used to relate the potential for adverse biological effects in the environment to specific contaminants. Chemical data by themselves are useful surrogates for potential biological effects. Knowledge of the specific types of chemicals is also important to the management of dredged material, because different chemicals may require different controls.

Chemicals of concern are differentiated into three categories in this manual; a standard list, a list of chemicals that occur in limited areas, and chemicals which may bioaccumulate. In general, it is preferable to have a relatively limited list of chemicals of concern for routine testing, and to add chemicals to this list on a project-specific basis. However, few chemicals can be tied to a specific geographic area, because they are widespread and have multiple sources. For those chemicals which can be linked to specific sources or activities, testing will be required only when those activities have been present in the vicinity.

Tier IIB testing is designed to assess the presence of the conventionals and chemicals of concern listed in Table 8-1. Chemicals of concern generally have the following characteristics:

- A demonstrated or suspected adverse biological or human health effect.
- A relatively widespread distribution and high concentration when compared to natural or background conditions.
- A potential for remaining in a toxic form for long periods in the environment (persistent).
- A potential for entering the food web (bioavailable).

8.4.1 Standard List of Chemicals of Concern. The chemicals of concern on the standard list have been shown to be present in developed areas in the Pacific Northwest. The CoCs listed on Table 8-1 and 8-2 are considered to be applicable to the LCRMA. If data collected in accordance with the guidelines in Chapters 6 and 7 shows that certain CoCs are not present in the project vicinity, these chemicals need not be included in any further testing.

Table 8-1 presents the dry weight interpretive guideline values for each chemical, including a bioaccumulation trigger. Table 8-2 presents preparation methods, analytical methods, and method detection limits. These are recommended methods, and ones that have been able to achieve the analyte-specific detection limits on past projects. Other methods may be proposed and will be considered during the sampling and analysis plan review. Exceedance of the bioaacumulation trigger indicates that the chemical may accumulate at levels that pose a risk to aquatic biota and/or human health. Use of the guideline values is discussed in Section 8.5.

Table 8-1
Screening Levels (SL), Bioaccumulation Triggers (BT) and Maximum Levels (ML)

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	7440-43-9	5.1	---	14
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
Silver	7440-22-4	6.1	6.1	8.4
Zinc	7440-66-6	410	---	3,800
ORGANOMETALLIC COMPOUNDS (ug/L)				
Tributyltin (2) (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	91-57-6	670	---	1,900

TABLE 8-1 (CONTINUED)

CHEMICAL	CAS (1) NUMBER	SCREENING LEVEL	BIOACCUM TRIGGER	MAXIMUM LEVEL
Total HPAH	---	12,000	---	69,000
Fluoranthene	206-44-0	1,700	4,600	30,000
Pyrene	129-00-0	2,600	---	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	3,600	3,600
Indeno(1,2,3-c,d)pyrene	193-39-5	600	---	16,000
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	1,241	---
1,4-Dichlorobenzene	106-46-7	110	120	120
1,2-Dichlorobenzene	95-50-1	35	37	110
1,2,4-Trichlorobenzene	120-82-1	31	---	64
Hexachlorobenzene (HCB)	118-74-1	22	168	230
PHTHALATES				
Dimethyl phthalate	131-11-3	1,400	1,400	---
Diethyl phthalate	84-66-2	1,200	---	---
Di-n-butyl phthalate	84-74-2	5,100	10,220	---
Butyl benzyl phthalate	85-68-7	970	---	---
Bis(2-ethylhexyl) phthalate	117-81-7	8,300	13,870	---
Di-n-octyl phthalate	117-84-0	6,200	---	---

TABLE 8-1 (CONTINUED)

CHEMICAL	CAS (1) NUMBER	SCREENING LEVEL	BIOACCUM TRIGGER	MAXIMUM LEVEL
PHENOLS				
Phenol	108-95-2	420	876	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	10,220	14,000
Hexachlorobutadiene	87-68-3	29	212	270
N-Nitrosodiphenylamine	86-30-6	28	130	130
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	37	---
alpha-Chlordane	12789-03-6	10	37	---
Dieldrin	60-57-1	10	37	---
Heptachlor	76-44-8	10	37	---
gamma-BHC (Lindane)	58-89-9	10	---	---
Total PCBs	---	130	38 (3)	3,100

(1) Chemical Abstract Service Registry Number.
(2) See *Testing, Reporting, and Evaluation of Tributyltin Data in PSDDA and SMS Programs* at URL *http://www.nws.usace.army.mil/dmmo/8th_arm/tbt_96.htm*
(3) This value is normalized to total organic carbon, and is expressed in mg/kg (TOC normalized).

8.4.2 Chemicals of Special Occurrence. The following chemicals are known to be associated with specific activities or industries. They are not believed to be widespread in the Lower Columbia River. Testing for these chemicals or other chemicals will be required when there is a reason-to-believe that they might be present.

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

Resin Acids. May include abietic acid, dehydroabietic acid, dichlorodehydroabietic acid, isopimaric acid, and sandaracopimaric acid.

Chromium. Chromium appears to derive largely from the natural erosions of crustal rocks, but localized sources of chromium also exist in industrial locations where plating took place or in the vicinity of chemical manufacturers. Testing will be required when sources are present.

Butyltins. Butyltin testing is indicated in various areas, such as those near boat and vessel maintenance and construction. Pore water analysis is recommended over bulk sediment analysis. Details concerning TBT analysis are contained in Appendix 8-A.

Dioxin/furans. Testing will generally be required when projects are in areas potentially impacted by known sources of dioxin/furan or in areas where the presence of dioxin/furan compounds has been demonstrated in past testing. It is anticipated that those projects indicating previously low levels of concern for dioxin/furan compounds will not need to provide dioxin/furan data on a routine basis in the future unless there is a reason-to-believe that existing conditions have changed. A P450 biomarker test may be utilized in screening for the presence of dioxin/furan.

8.5 INTERPRETIVE GUIDELINES

The purpose of evaluating dredged material is to anticipate (and manage) the potential biological effects, rather than merely the chemical presence, of the possible CoCs. Biological tests serve to integrate chemical and biological interactions of contaminants present in a sediment sample, including the availability for biological uptake, by measuring the effects on test organisms through bioassays and bioaccumulation. Such testing, however, is expensive.

Within the Pacific Northwest, scientists and regulatory personnel have developed sediment quality values to predict potential adverse biological effects based on demonstrated toxicity in bioassay tests (not bioaccumulation) involving appropriately sensitive benthic organisms and a decision model for their use. The use of sediment quality values as regulatory screens has proven to be environmentally protective as well as economically efficient. Both Washington and Oregon have used the approach as the basis for developing water quality standards for sediments. EPA Region 10 has used the approach and specific values for sediment management decisions throughout the Pacific Northwest, including the lower Columbia and Willamette Rivers for the past several years.

These screening values were developed for the marine environment. Freshwater values are under development. In the interim, the marine/estuarine values are useful as indicators of the need for effects-based testing. A comparison with the draft Washington Department of Ecology freshwater AETs show the screening levels contained in Table 8-1 to be conservative for a freshwater environment.

A screening level (SL) value for each chemical identifies chemical concentrations at or below which there is no reason-to-believe that dredged material disposal would result in unacceptable adverse effects due to toxicity measured by sediment bioassays. Sediments containing chemical concentrations at or below all SL values are judged to be suitable for aquatic disposal without the need for biological testing.

A second, higher maximum level (ML) is identified for each chemical above which there is reason-to-believe that the material would likely fail the standard suite of biological tests and thus be unacceptable for unconfined aquatic disposal. Recent biological testing at one location in Puget Sound indicated "suitable" responses in the standard bioassay tests although the chemical data measured several compounds well above the ML. These data suggest that the ML is not a de facto "failure" criterion and should not be assumed to be such. However, regional experience still indicates that there is a significantly greater likelihood of failing the bioassay tests when chemical levels in dredged material exceed the ML.

A third chemical screen, the bioaccumulation trigger (BT) has been determined for some chemicals of concern. This may be an important factor in determining sediment suitability for sediments at or above the ML.

8.5.1 Interpretive Guidelines for Bioassay Testing. Results of chemical testing will be compared to chemical guideline values presented in Table 8-1 (dry weight normalized).

For each dredged material management unit, the SL guideline values will be used to determine if biological testing is required. The following two situations are possible: 1) all chemicals are at or below the SL guideline; no biological testing is required and the management unit is considered suitable for unconfined, aquatic disposal, or 2) one or more chemicals are present at levels above the SL guideline; standard biological testing (including bioaccumulation if triggered) is required (see Chapter 9).

When chemicals of concern exceed the ML values, the dredging proponent will have two options regarding the evaluation of the dredged material. First, the proponent may elect to accept the indication of the ML and conclude that the material is unsuitable for unconfined, aquatic 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 ML. For this option, the proponent would conduct the standard suite of bioassays, bioaccumulation (if a bioaccumulation trigger is exceeded), and other additional tests required by the RMT in order to determine final biological suitability of the material for unconfined, aquatic disposal. The RMT will make its decision as to whether specific, effect-based tests beyond the standard suite should be required based on the type and number of chemicals and best available scientific knowledge. Such non-standard testing may involve Tier IV (see Chapter 10).

8.5.2 Interpretive Guidelines for Bioaccumulation Testing. In addition to comparisons to SL and ML and subsequent determinations outlined above, chemical concentrations are used as triggers for determining when bioaccumulation testing is required. These values are found in Tables 8-1. If any listed chemical of concern exceeds the BT value, bioaccumulation testing will be required in order to determine whether dredged material is suitable for unconfined, aquatic disposal. When dioxins/furans and/or butyltins are the only CoCs that are detected above SL values, bioaccumulation testing may be triggered rather than toxicity tests. Specific discussion on conducting bioaccumulation tests is presented in Chapter 9.

8.5.3 The Role of Detection Limits in Interpretation. Where detection limits are above SL, sample-specific detection limits will be used to determine biological testing requirements. The guidelines for detected chemicals of concern apply equally to detection limits. The (sub)contractor performing the chemical testing should strive to achieve limits of detection below the screening levels, including additional cleanup steps, re-extraction, etc. This is the only way to preclude the biological testing requirement. If problems or questions arise, the dredger or chemical testing (sub)contractor should contact the RMT through the appropriate DMMO/DMMT. The following scenarios are possible and need to be understood and handled appropriately:

One or more CoCs have limits of detection exceeding screening levels while all other CoCs are quantitated or have limits of detection at or below the SL. The requirement to conduct biological testing will be triggered solely by limits of detection.

One or more CoCs have limits of detection exceeding screening levels for a lab sample, but below respective BTs and MLs, and other CoCs have quantitated concentrations above screening levels. The need to conduct bioassays is based on the detected exceedances of SLs and the limits of detection above SL become irrelevant. No further action is necessary.

One or more CoCs have limits of detection exceeding SL and exceeding BT or ML, and other CoCs have quantitated concentrations above screening levels. The need to conduct bioassays is based on the detected exceedances of SLs. All other limits of detection must be brought below BTs and MLs to avoid bioaccumulation testing or Tier IV testing.

In all cases, sediments or extracts should be kept under proper storage conditions until the chemistry data are deemed acceptable by the regulatory agencies (see Table 7-1). This retains the option for retesting or higher level quantitation. Quality assurance and quality control are an important element of chemical testing. Chemistry QA requirements are listed in Chapter 11.

TABLE 8-2

TESTING METHODS
(Testing Parameter, Preparation Method, Analytical Method, Sediment Method Detection Limit (MDL)

PARAMETER	PREP METHOD (recommended)	ANALYSIS METHOD (recommended)	SEDIMENT MDL (1)
CONVENTIONALS:			
Total Solids (%)	---	Pg.17 (2)	0.1
Total Volatile Solids(%)	---	Pg.20 (2)	0.1
Total Organic Carbon (%)	---	Pg.23 (2, 3)	0.1
Total Sulfides (mg/kg)	---	Pg.32 (2)	1
Ammonia (mg/kg)	---	Plumb 1981 (4)	1
Grain Size	---	Modified ASTM with Hydrometer	---
METALS (ppm):			
Antimony	APNDX D (5)	GFAA (6)	2.5
Arsenic	APNDX D (5)	GFAA (6)	2.5
Cadmium	APNDX D (5)	GFAA (6)	0.3
Chromium	APNDX D (5)	GFAA (6)	0.3
Copper	APNDX D (5)	ICP (7)	15.0
Lead	APNDX D (5)	ICP (7)	0.5
Mercury	MER (8)	7471 (8)	0.02
Nickel	APNDX D (5)	ICP (7)	2.5
Silver	APNDX D (5)	GFAA (6)	0.2
Zinc	APNDX D (5)	ICP (7)	15.0
ORGANOMETALLIC COMPOUNDS (ug/L):			
Tributyltin (interstitial water)	NMFS	Krone	0.01

TABLE 8-2 (CONTINUED)

ORGANICS (ppb):			
LPAH			
Naphthalene	3550 (9)	8270 (10)	20
Acenaphthylene	3550 (9)	8270 (10)	20
Acenaphthene	3550 (9)	8270 (10)	20
Fluorene	3550 (9)	8270 (10)	20
Phenanthrene	3550 (9)	8270 (10)	20
Anthracene	3550 (9)	8270 (10)	20
2-Methylnaphthalene	3550 (9)	8270 (10)	20
Total LPAH			
HPAH			
Fluoranthene	3550 (9)	8270 (10)	20
Pyrene	3550 (9)	8270 (10)	20
Benzo(a)anthracene	3550 (9)	8270 (10)	20
Chrysene	3550 (9)	8270 (10)	20
Benzofluoranthenes	3550 (9)	8270 (10)	20
Benzo(a)pyrene	3550 (9)	8270 (10)	20
Indeno(1,2,3-c,d)pyrene	3550 (9)	8270 (10)	20
Dibenzo(a,h)anthracene	3550 (9)	8270 (10)	20
Benzo(g,h,i)perylene	3550 (9)	8270 (10)	20
Total HPAH			
CHLORINATED HYDROCARBONS			
1,3-Dichlorobenzene	P&T (12)	8260 (11)	3.2
1,4-Dichlorobenzene	P&T (12)	8260 (11)	3.2
1,2-Dichlorobenzene	P&T (12)	8260 (11)	3.2
1,2,4-Trichlorobenzene	3550 (9)	8270 (10)	6
Hexachlorobenzene (HCB)	3550 (9)	8270 (10)	12

TABLE 8-2 (CONTINUED)

PHTHALATES			
Dimethyl phthalate	3550 (9)	8270 (10)	20
Diethyl phthalate	3550 (9)	8270 (10)	20
Di-n-butyl phthalate	3550 (9)	8270 (10)	20
Butyl benzyl phthalate	3550 (9)	8270 (10)	20
Bis(2-ethylhexyl)phthalate	3550 (9)	8270 (10)	20
Di-n-octyl phthalate	3550 (9)	8270 (10)	20
PHENOLS			
Phenol	3550 (9)	8270 (10)	20
2 Methylphenol	3550 (9)	8270 (10)	6
4 Methylphenol	3550 (9)	8270 (10)	20
2,4-Dimethylphenol	3550 (9)	8270 (10)	6
Pentachlorophenol	3550 (9)	8270 (10)	61
MISCELLANEOUS EXTRACTABLES			
Benzyl alcohol	3550 (9)	8270 (10)	6
Benzoic acid	3550 (9)	8270 (10)	100
Dibenzofuran	3550 (9)	8270 (10)	20
Hexachloroethane	3550 (9)	8270 (10)	20
Hexachlorobutadiene	3550 (9)	8270 (10)	20
N-Nitrosodiphenylamine	3550 (9)	8270 (10)	12
PESTICIDES			
Total DDT	---	---	---
p,p'-DDE	3540 (13)	8081 (13)	2.3
p,p'-DDD	3540 (13)	8081 (13)	3.3
p,p'-DDT	3540 (13)	8081 (13)	6.7
Aldrin	3540 (13)	8081 (13)	1.7
Chlordane	3540 (13)	8081 (13)	1.7
Dieldrin	3540 (13)	8081 (13)	2.3
Heptachlor	3540 (13)	8081 (13)	1.7
Lindane	3540 (13)	8081 (13)	1.7
Total PCBs	3540 (13)	8081 (13)	67

* Total PCBs BT value in ppm carbon-normalized.

1. Dry Weight Basis.
2. Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound, Puget Sound Estuary Program, 1997.
3. Recommended Methods for Measuring TOC in Sediments, Kathryn Bragdon-Cook, Clarification Paper, Puget Sound Dredged Disposal Analysis Annual Review, May, 1993.
4. Procedures For Handling and Chemical Analysis of Sediment and Water Samples, Russell H. Plumb, Jr., EPA/Corps of Engineers, May, 1981.
5. Recommended Protocols for Measuring Metals in Puget Sound Water, Sediment and Tissue Samples, Puget Sound Estuary Program, 1997.
6. Graphite Furnace Atomic Absorption (GFAA) Spectrometry - SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
7. Inductively Coupled Plasma (ICP) Emission Spectrometry - SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
8. Mercury Digestion and Cold Vapor Atomic Absorption (CVAA) Spectrometry - Method 7471, SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
9. Sonication Extraction of Sample Solids - Method 3550 (Modified), SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986. Method is modified to add matrix spikes before the dehydration step rather than after the dehydration step.
10. GCMS Capillary Column - Method 8270, SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
11. GCMS Analysis - Method 8260, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
12. Purge and Trap Extraction and GCMS Analysis - Method 8260, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.
13. Soxhlet Extraction and Method 8080, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1997.

CHAPTER 9

TIER III: BIOLOGICAL TESTING

9.1 OVERVIEW

Biological effects tests may be necessary if Tier I or Tier II evaluations indicate that the dredged material contains contaminant concentrations which may be harmful to aquatic organisms. Tier III biological testing of dredged material will be required when chemical testing results exceed guideline values. A standard suite of bioassays is used to make a determination regarding the suitability of the dredged material for aquatic disposal. Tests involving whole sediment determine the potential effects for bottom-dwelling organisms. Tests using suspension/elutriates of dredged material are used to assess the potential effects on water column organisms. A bioaccumulation test is required when certain chemicals of concern are detected at concentrations which may pose a potential risk to human health or ecological health in the aquatic environment (Chapter 8).

Prior to the 1980s, the assessment of water and sediment quality was often limited to physical and chemical characterizations. However, quantifying chemical concentrations alone is not always adequate to assess potential adverse environmental effects, interactions among chemicals, or bioavailability of chemicals to aquatic organisms. Because the relationship between total chemical concentrations and biological availability is poorly understood, when regulatory limits are exceeded, controlled laboratory bioassay and bioaccumulation tests are performed to assess environmental effects.

The approach most often adopted is to expose representative aquatic species for relatively short periods of time: up to 10 days for acute toxicity, up to 20 days to assess potential chronic/sublethal effects, and 28 days to assess bioaccumulation potential. These tests provide information about different possible biological effects. In addition, testing multiple species reduces uncertainty about the results and limits errors in interpretation.

This chapter includes information on which biological test species should be used, on the quality control requirements for each test, and on the interpretive criteria used for decision-making. References are provided for more detailed information on test protocols and test interpretation.

9.2 SEDIMENT SOLID PHASE BIOLOGICAL TESTS

Biological testing can be conducted to measure effects on organisms exposed to the water column or to whole sediment. The biological testing suite discussed in this section addresses solid phase toxicity testing using whole sediment. Both marine and freshwater species are specified. Several biological tests are under development/review, and may be added in the future. Biological test species are selected based on the salinity conditions at the disposal site for the dredged material. For projects in the Lower Columbia River Management Area, the use of the Ocean Disposal sites will require marine bioassays (if bioassay testing is required).

9.2.1 Marine Bioassays

<u>10-day amphipod acute mortality test</u>
Rhepoxynius abronius
Ampelisca abdita[1]
Eohaustorius estuarius[2]

<u>Chronic Tests</u>
Neanthes arenaceodentata (Los Angeles karyotype) 20-day growth test

<u>Sediment larval test</u>
Echinoderm
-*Dendraster excentricus*[3]
-*Strongylocentrotus purpuratus*
-*Strongylocentrotus droebachiensis*
Bivalve
-*Crassostrea gigas*
-*Mytilus provincialis*

The protocols to be used to run the recommended marine bioassays are described by the Puget Sound Estuary Program (PSEP), and can be found in *Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments* (PSEP,

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

[2]may be considered for substitution if test sediment is greater than 60% fines and salinity is less than 25 ppt.

[3]recommended species.

1995). Project applicants should contact the DMMO/DMMT or the Puget Sound Water Quality Action Team for recent protocol updates. The PSEP protocols are consistent with national guidance on bioassay testing.

Amphipod Species Substitution. *Rhepoxynius abronius* has been shown to be responsive to high percent fines in sediments, particularly high clay content sediments, and has been shown to exhibit mortalities greater than 20 percent in clean, reference area sediments with this grain-size(DeWitt et al, 1988; Fox, 1993). Applicants may wish to consider substituting *Ampelisca abdita* for *Rhepoxynius abronius* when fines exceed 60 percent. *Ampelisca* is relatively grain-size-insensitive to concentrations of fines greater than 60 percent. Any proposed species substitutions must be submitted to the DMMO/DMMT for approval by the RMT prior to use, and the substitutions must be documented in the sampling and analysis plan for the proposed dredging project.

9.2.2 Freshwater Bioassays. The following freshwater bioassays will be required when the proposed disposal location for dredged material is in a low salinity (generally 5 parts per thousand or below) environment.

Amphipod - *Hyalella azteca* 10 day Survival Test

Midge - *Chironomus tentans* 10 day Survival and Growth Test

Standard protocols exist for each of these tests, established both by ASTM and EPA (ASTM 1995, EPA 1994). Either protocol may be used for the freshwater bioassays. The protocols specify negative control, positive control, and test performance criteria. Adherence to these performance standards aids in interpreting bioassay responses by limiting effects from factors other than sediment toxicity. Other biological tests to measure chronic effects in freshwater are still under development. One may be added to this test suite in the future.

9.2.3 Bioassay Testing Performance Standards. This section contains the specific quality assurance/quality control requirements for solid phase biological testing. The parameters covered include:

- Negative Control and Reference Samples
- Quality Control Limits for the Negative Control Treatment
- Quality Control Limits for the Reference Treatment
- Reference Toxicant
- Water Quality Monitoring

General procedures are given first, followed by specific performance standards for each bioassay. These standards aid in interpreting the bioassay responses, since they control for environmental effects which may produce effects not associated with toxicity.

Negative Controls. Negative control sediments are used in bioassays to check laboratory performance. Negative control sediments are clean sediments in which the test organism normally lives and which are expected to produce low mortality. Control reliability must be demonstrated.

The sediment larval test utilizes a negative seawater control rather than a control sediment. The seawater control will be collected from a location approved by the DMMO/DMMT.

Reference Sediment. Agency regulations prescribe the use of bioassay reference sediments for test comparison and interpretations which closely match the grain size characteristics of the dredged materials test sediments. The reference sediment provides a point of comparison for evaluating the potential effects of the dredged material. If chemical concentrations in the reference area are not well-documented, a complete characterization may be required.

All bioassays have performance standards for reference sediments. Failure to meet these standards may result in the requirement to retest.

All reference sediments will be analyzed for total solids, total volatile solids, total organic carbon, ammonia, sulfides and grain-size.

Replication. Five laboratory replicates of test sediments, reference sediments and negative controls will be run for each bioassay.

Positive Controls. A positive control will be run for each bioassay. Positive controls are chemicals known to be toxic to the test organism and which provide an indication of the sensitivity of the particular organisms used in a bioassay.

Water Quality Monitoring. Water quality monitoring of the overlying water will be conducted for the bioassays. This consists of daily measurements of salinity, temperature, pH and dissolved oxygen for the amphipod and sediment larval tests. These measurements will be made every three days for the *Neanthes* bioassay. Ammonia and sulfides will be determined at test initiation and termination for all tests. Monitoring will be conducted for all test and reference sediments and negative controls (including seawater controls). Parameter measurements must be within the limits specified for each bioassay. Measurements for each treatment will be made on a separate chemistry beaker set up to be identical to the other replicates within the treatment group, including the addition of test organisms.

Bioassay-specific Procedures - Marine

Amphipod Bioassay. This test involves exposing amphipods to test sediment for ten (10) days and counting the surviving animals at the end of the exposure period. Daily emergence data and the number of amphipods failing to rebury at the end of the test will be recorded as well. The control sediment has a performance standard of 10 percent mortality. The reference sediment has a performance standard of 20 percent mortality greater than control. Test species selection is discussed in Section 9.2.1

Sediment Larval Bioassay. This test monitors larval development of a suitable echinoderm species in the presence of test sediment. The test is run until the appropriate stage of development is achieved in a sacrificial seawater control. At the end of the test, larvae from each test sediment exposure are examined to quantify abnormality and mortality.

The seawater control has a performance standard of 30 percent combined mortality and abnormality. The reference sediment has a performance standard of 35 percent combined mortality and abnormality greater than the seawater control performance.

Initial counts will be made for a minimum of five 10-ml aliquots. Final counts for seawater control, reference sediment and test sediment will be made on 10-ml aliquots.

The sediment larval bioassay has a variable duration (not necessarily 48 hours) which is determined by the developmental stage of organisms in a sacrificial seawater control.

Ammonia and sulfides toxicity may interfere with test results for this bioassay. Aeration will be conducted throughout the test to minimize these effects if required.

***Neanthes* Growth Test.** This test utilizes the polychaete *Neanthes arenaceodentata*, in a 20-day growth test. The growth rate of organisms exposed to test sediments is compared to the average individual growth rate of organisms exposed to a reference sediment. The control sediment has a performance standard of 10 percent mortality. The reference sediment has a performance standard of 80 percent of the control average individual growth rate and 20 percent mortality.

Bioassay-specific Procedures - Freshwater

Amphipod Bioassay. This bioassay measures the survival of amphipods after a 10-day exposure to the test sediment. The control has a performance standard of 20 percent absolute mean mortality. The reference sediment performance standard is 30 percent absolute mean mortality.

Midge Bioassay. This test measures the survival and growth of the midge *Chironomus tentans* after a 10-day exposure to the test sediment. The control has a performance standard of 30 percent absolute mean mortality and a growth performance standard of 0.6 mg minimum mean weight per organism (per ASTM). The reference performance standard is 35 percent absolute mean mortality.

9.2.4 Bioassay Interpretive Criteria. The response of bioassay organisms exposed to the tested dredged material representing each management unit will be compared to the response of these organisms in both control and reference treatments. This will determine whether the material is suitable for unconfined aquatic disposal.

Biological test interpretation relies on two levels of observed response in the test organisms. These are known as one-hit or two-hit failures. The bioassay-specific guidelines for each of these response categories is listed below. In general, a one-hit failure is a marked response in any one biological test. A two-hit failure is a lower intensity of response. It must be found in two or more biological tests in order for the sediment to be found unsuitable for aquatic disposal.

(1) One-Hit Failure. When **any one** biological test shows a test sediment response relative to the negative control and reference sediment which exceeds the bioassay-specific response guidelines, and which is "statistically different" from the reference, the dredged material management unit is judged to be unsuitable for aquatic disposal. The acceptable methods for determining statistical significance are in Appendix 9-A.

(2) Two-Hit Failure. When **any two** biological tests show test sediment responses, which are less than the bioassay specific guidelines noted above for a single-hit failure, but show a lower level effect and are significantly different statistically from the reference sediment, the dredged material management unit is judged to be unsuitable for aquatic disposal.

This interpretation of solid phase biological test results will be used for both the CWA Section 404(b)(1) evaluation/Section 401 water quality certification process, and for the MPRSA Section 103 evaluation process. The application of these interpretive guidelines to a set of sample test results is described in Appendix 9-B.

The determination of a "statistically different " response involves two conditions: first, the response in the tested dredged material management unit 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. The appropriate method for making the latter determination is discussed in Appendix 9-A. This appendix also contains a description of the Biostat bioassay software developed by the Corps of Engineers. This software contains the appropriate statistical tests to determine sediment suitability.

Marine Bioassays

Amphipod Bioassay. For the amphipod bioassay, mean test mortality greater than 20 percent absolute over the mean negative control response, and greater than 30 percent absolute over the mean reference sediment response, and statistically different from the reference (alpha = 0.05), is considered a "one-hit".

Juvenile Infaunal Growth Test. Juvenile *Neanthes* growth test results that show a mean test individual growth rate less than 80 percent of the mean negative control growth rate, and less than 50 percent (relative) of the mean reference sediment growth rate, and statistically different from the reference (alpha = 0.05), is considered a "one-hit".

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 30 percent absolute over the mean reference sediment NCMA, and statistically different from the reference (alpha = 0.10), it is considered a "hit".

Freshwater Bioassays

Amphipod Bioassay. For the amphipod bioassay, mean test mortality greater than 15 percent over the mean reference response, and statistically different from the reference (alpha = 0.05), is considered a "hit".

Midge Bioassay. For the midge mortality test, a mean mortality in the test sediment of 20 percent over reference and statistically different from reference (alpha = 0.05) is a hit. For the growth test, a mean reduction in biomass greater than 40% and statistical significance is considered a "hit". If either or both endpoints fail the guideline, the test is considered a "hit".

9.3 WATER COLUMN BIOASSAY TESTING

The Tier III evaluation of dredged material will include an evaluation of potential water column effects when warranted. Water column testing for biological effects is not routinely required for regulated or federal dredging projects evaluated under CWA Section 404. The test is required under MPRSA Section 103 for ocean disposal when biological testing is required. This test will need to be conducted only when the water quality certification agency (Washington Department of Ecology or Oregon Department of Environmental Quality for Section 404/401 permits or the Environmental Protection Agency for Section 103 ocean disposal permits) requires an assessment of potential water column toxicity effects relative to a particular chemical of concern.

In the event that water column testing is required, one of the following tests will be conducted. The appropriate assessment is described in the Ocean Testing Manual (EPA/USACE 1991) and the Inland Testing Manual (USACE/EPA 1998). The interpretation guidelines specified in either manual will be used, depending on whether the ultimate disposal environment proposed is in the Section 103 (ocean) or in 404 (fresh water, estuarine, or near coastal) waters. Protocols for the water column test should follow the test specification requirements described in the Inland Testing Manual (Appendix E). The following species may be used for the water column bioassay test:

Marine

- ✳ Echinoderm
  - *Dendraster excentricus*
  - *Strongylocentrotus purpuratus*
  - *Strongylocentrotus droebachiensis*
- ✳ Bivalve

- *Crassostrea gigas*
- *Mytilus provincialis*

Freshwater

✳Crustaceans

Daphnia magna
Ceriodaphnia dubia

✳Fish

Pimephales promelas

9.4 BIOACCUMULATION TESTING

The Ocean Testing Manual and Inland Testing Manual provide information necessary to estimate the potential for bioaccumulation to occur. Plausible exposure scenarios, using the theoretical bioaccumulation potential (TBP) approach, were developed. The outcome of these assessments were the bioaccumulation triggers of chemicals likely to be assimilated in aquatic tissue. These reason-to-believe triggers serve as a surrogate for the TBP approach outlined in the OTM and ITM. When non-polar organic compounds (other than those on our existing list of chemicals of concern) are identified for individual projects, the TBP model will be run for those compounds.

Body burdens of chemicals are of concern for both ecological and human health reasons. A bioaccumulation test in Tier III will normally only be conducted on those dredged materials in which a reason-to-believe has been established that specific chemicals of concern may be accumulated in the tissues of target organisms. Bioaccumulation testing evaluating exposures to two species will be required when any given sediment chemical level exceeds any bioaccumulation trigger value. These values establish the reason-to-believe levels for chemicals likely to bioaccumulate. Bioaccumulation of compounds listed in Appendix 9-C should be detectable, following a 28-day exposure period, even though steady state may not have been reached. The purpose of a Tier III bioaccumulation test is not to determine steady state bioaccumulation rate (this is accomplished in Tier IV), but to assess the potential for bioaccumulation.

Following a comparison of residue levels in dredged material exposed organisms to FDA action levels, a statistical comparison is made between organisms exposed to dredged material and organisms exposed to a suitable reference material. No adverse effects are likely if the concentration in the dredged material exposed tissue is less than that in the reference exposed tissue. A higher concentration, however, does not necessarily mean adverse effects. Additional contaminant-specific information is required to determine if adverse effects are likely.

To assist in making determinations about the likelihood for effects, USACE Waterways Experiment Station, and EPA have developed the Environmental Residue-Effects Database (ERED). The database contains over 2000 records including information on more than 200 contaminants and 100 aquatic species. ERED can be accessed at http://www.wes.army.mil/el/ered. For those compounds at statistically elevated concentrations in dredged material-exposed organisms, making determinations about the likelihood for adverse effects should be based on measurable effects listed in the ERED. Not all effects are created equal. Data in ERED may reflect a particular tissue residue, and may be species specific. Cellular/subcellular responses are an indication of organism stress, but the causal relationship between these effects and higher order effects is unknown in most cases.

The Inland Testing Manual requires two bioaccumulation tests utilizing species from two different trophic niches representing a suspension-feeding/filter-feeding and a burrowing deposit-feeding organism. A Tier III 28-day bioaccumulation test will conduct an evaluation with both an adult bivalve (*Macoma nasuta*) and an adult polychaete (*Nereis virens, Nepthys,* or *Arenicola marina*) for marine sediments. For freshwater sediments, the test will be conducted with the oligochaete *Lumbriculus variegatus* and another species to be determined at the time of testing. The test exposure duration will be 28 days utilizing the EPA protocol (Lee *et al* 1989), after which a chemical analysis will be conducted of the tissue residue to determine the concentration of selected chemicals of human health concern, and to assess ecological effects through a statistical comparison with a suitable reference area sediment. Protocols for tissue digestion and chemical analysis will follow the PSEP recommended procedures for metals and organic chemicals.

Human Health. The bioaccumulation test results are compared to guideline values to determine exceedance of allowable tissue residue concentrations. If the 28-day bioaccumulation test results in tissue levels greater than the FDA action levels, (see Table 3, Appendix 9-B) or agency guidelines in effect at the time, the sediment will be considered unsuitable for aquatic disposal. Chemicals of concern without or below FDA action levels will be evaluated by the RMT using best professional judgment and risk assessment approaches.

Ecological Effects. The results of a Tier III 28-day bioaccumulation test will be compared directly with reference results for statistical significance. 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 generally be considered unsuitable for unconfined aquatic disposal.

If results of the bioaccumulation test in Tier III are found to be equivocal, 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.

Bioaccumulation testing for the assessment of dredged material is currently under Corps/EPA review. Additional guidance will be added to this manual as it becomes available.

9.5 REFERENCE SEDIMENT COLLECTION SITES

Bioassays must be run with a reference sediment which is well-matched to the test sediments for grain-size, and for other sediment conventionals such as total organic carbon and must match the disposal environment. 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 protocols
- Sample from biologically active zone
- Avoid anoxic sediment below the Redox Potential Discontinuity (RPD) horizon
- Use wet-sieving method

The wet-sieving protocol is used in the location of an appropriate reference station. 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. Wet-sieving results will not perfectly match the dry-weight-normalized grain size results from the laboratory analysis, but should be relatively close.

The Corps of Engineers and EPA have identified locations suitable as reference stations. Reference site selection will be made on a case-by-case basis with information and guidance provided by the Corps and EPA. Reference site grain-size should match, as closely as possible, that of the test sediment and the disposal environment. In the absence of a match, the agencies will select a coarser grained sediment for use. This is likely to yield better test performance, and to be environmentally conservative. Reference site selection and reference sample collection must be coordinated with the DMMO/DMMT.

CHAPTER 10

TIER IV EVALUATIONS

10.1 OVERVIEW

A Tier IV evaluation is a special, non-routine evaluation that requires coordination between the RMT and the dredging proponent to determine the specific testing required. As part of this on-going process, the RMT will continually review new tests and evaluation procedures that have been peer reviewed and are deemed ready for use in the regulatory evaluation of dredged material. The RMT will subsequently make recommendations about their potential implementation and use. Tier II and III evaluations of dredged material may result in a requirement to conduct Tier IV evaluations.

Three circumstances are expected to trigger Tier IV evaluations: (1) the results of Tier III bioaccumulation tests (tissue analysis) are indeterminate, (2) the sediments/tissues contain chemicals for which threshold values have not been established or (3) for which the routine Tier III biological tests are inappropriate. If Tier IV testing or evaluations are determined necessary by the RMT, specific tests or evaluations and interpretive criteria will be specified by the RMT in coordination with the applicant. Alternative analyses which may be conducted in this tier may include any or all of the following.

10.2 STEADY STATE BIOACCUMULATION TEST

In a Tier IV evaluation, bioaccumulation testing may be necessary to determine the steady state concentrations of contaminants in organisms exposed to the dredged material when compared with organisms exposed to the reference material. Testing may be done in the lab, or in rare cases, in the field. Testing options may also include time-sequenced laboratory exposures in excess of the standard 28 days in order to reach a steady state concentration. Tier IV evaluations of data collected will follow the interpretation guidance specified in Section 9-4 (also see Appendix D of the Inland Testing Manual).

10.2.1 <u>Time-Sequenced Laboratory Testing</u>. 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 (depuration) 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.

10.2.2 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, to the above referenced database. This may be difficult to accomplish, because the same species in similar size ranges must be available for collection from both the dredging site and a suitable reference area to enable a statistical comparison of the tissue levels between the two areas.

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 on 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.

A field assessment should only be allowed where the quality of the sediment to be dredged can be shown not to have degraded or become more contaminated since the last dredging and disposal operation.

10.3 HUMAN HEALTH/ECOLOGICAL RISK ASSESSMENT

When deemed appropriate by the RMT, a human health and/or ecological risk assessment may be required to evaluate a particular chemical of concern, such as dioxin, mercury, PCBs, etc. National guidance on chemicals such as dioxin is subject to rapid changes as new information becomes available. Project specific risks to human health or ecological health should be evaluated using the best available current technical information and risk assessment models. A risk assessment must be developed on a case specific basis and be formulated with all interested parties participating. If a risk assessment is the method of choice for a Tier IV evaluation, either as a stand alone or in concert with tissue analysis, it must be accomplished with the RMT and all parties actively participating.

CHAPTER 11

SUBMITTAL OF SAMPLING AND TESTING DATA

11.1 OVERVIEW

Data obtained from a qualified sampling and testing effort will be submitted to the DMMO/DMMT covering the following categories of information:

- A sediment characterization report, which includes the items described below.

- Biological and chemical data in the format required for inclusion in the Dredged Analysis Information System.

  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.

- Sampling and testing costs. This information is optional, but it allows the agencies to track program costs and assess the economic impacts of the program. This data is vital in tracking trends in costs and will provide dredging proponents with information useful in planning future dredging. The Corps will include cost information in reports summarizing the annual dredging done in the LCR study area.

11.2 SEDIMENT CHARACTERIZATION REPORT

The sediment characterization report should include the following items:

- Quality assurance report documenting deviations from the sampling and analysis plan and the effects of quality assurance deviations on the testing results.

- A plan view showing the actual sampling locations.

- The sampling coordinates in latitude and longitude.

- Methods used to locate the sampling positions within an accuracy of ± 2m.

- The compositing scheme.

- The type of sampling equipment used, the protocols used during sampling and compositing

- The type of sampling equipment used, the protocols used during sampling and compositing and an explanation of any deviations from the sampling plan.

- Sampling logs with sediment descriptions.

- Chain-of-custody procedures used, and explanation of any deviations from the sampling plan.

- Chemical and biological testing results, including quality assurance data Chemical testing results shall be presented in the same order as the list of chemicals of concern presented in Table 8-1.

- Explanation of any deviations from the analysis plan.

11.3 QUALITY ASSURANCE/QUALITY CONTROL DATA

In order to facilitate timely decision-making, the QA1 data must be submitted with the sediment evaluation report. The QA2 data may be submitted later, and should be sent directly to the Washington Department of Ecology. Data entered into DAIS will be converted to SEDQUAL format and provided to Ecology for direct import into SEDQUAL. Additional quality assurance data is needed to fully validate the chemical and biological testing data. This includes information such as chromatograms, calibration curves, etc., and is referred to as QA2. 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.

11.4 QA1 Data Checklist

The following checklist can be used to ensure that the data to be submitted is complete.

DATA CHECKLIST

Sample Locations and Compositing				
	Test Sediment	Reference Sediment	Control Sediment	Seawater Control
Latitude and Longitude (to nearest 0.1 second)				
NAD 1927 or 1983				
Station name (e.g. Carr Inlet)				
Water depth (corrected to MLLW)				
Drawing showing sampling locations and ID numbers				
Compositing scheme (sampling locations/depths for composites)				
Sampling method				
Sampling dates				
Estimated volume of dredged material represented by each DMMU				
Positioning method				
Sediment Conventionals				
Preparation and analysis methods				
Sediment conventional data and QA/QC qualifiers				
QA qualifier code definitions				
Triplicate data for each sediment conventional for each batch				
Units (dry weight except total solids)				
Method blank data (sulfides, ammonia, TOC)				
Method blank units (dry weight)				
Analysis dates (sediment conventionals, blanks, TOC CRM)				
TOC CRM ID				
TOC CRM analysis data				
TOC CRM target values				
Grain Size Analysis				
Fine grain analysis method				
Analysis dates				
Triplicate for each batch				
Grain size data (complete sieve and phi size distribution)				

Chemicals of Concern Analysis Data				
	Metals	Semivol.	Pest./PCBs	Volatiles
Extraction/digestion method				
Extraction/digestion dates (test sediment, blanks, matrix spike, reference material)				
Analysis method				
data and QA qualifier included for:				
test sediments				
reference materials including 95% confidence interval (each batch)				
method blanks (each batch)				
matrix spikes (each batch)				
matrix spike added (dry weight basis)				
replicates (each batch)				
Units (dry weight)				
Method blank units (dry weight)				
QA/QC qualifier definitions				
Surrogate recovery for test sediment, blank, matrix spike, ref. material				
Analysis dates (test sediment, blanks, matrix spike, reference material)				

Shaded areas indicate required data

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APPENDIX 6-A

SMALL PROJECT SAMPLING AND ANALYSIS PLAN

This is an example of a sampling and analysis plan (SAP) for a small PSDDA project. It was adapted from an actual SAP for the Port Townsend Marina. Some of the information regarding this project has been altered to provide examples of scenarios that dredging applicants might encounter for a small dredging project. Where this liberty was taken a note was included with the form: [NOTE:]. Additional notes of the same form were included where guidance regarding other possible scenarios was needed. These notes should be deleted if this example SAP is used as a template for SAP development for your project.

SAMPLING & ANALYSIS PLAN

PORT TOWNSEND MARINA
ENTRANCE CHANNEL

U.S. ARMY CORPS OF ENGINEERS
SEATTLE, WASHINGTON

May 23, 1997

Prepared by:

Therese Littleton
David Fox

Seattle District
Corps of Engineers

1.0 PROJECT TEAM AND RESPONSIBILITIES

Table 1. Project Team and Responsibilities

Task/Responsibility	Therese Littleton	David Fox	Mary Smith	Mike Jones	Bob White
Overall project management	✓				
Sampling plan development	✓	✓			
Agency coordination		✓			
Positioning			✓		
Sediment sampling			✓		
Compositing/subsampling			✓		
Chemical analysis & QA				✓	
Biological analysis & QA					✓
Final Report			✓		

Therese Littleton, Corps of Engineers, Seattle District, Environmental Resources Section
David Fox, Corps of Engineers, Seattle District, Dredged Material Management Office
Mary Smith, Marine Technologies, Tacoma
Mike Jones, Environmental Testing Service, Seattle
Bob White, Biological Testing Laboratories, Seattle

[NOTE: Contractors and Labs are fictitious; you won't find them in the yellow pages!)

2.0 PROJECT DESCRIPTION AND SITE HISTORY

2.1 Project Description. The Corps of Engineers proposes to perform maintenance dredging of the Port Townsend Marina entrance channel in December 1997. This project consists of clamshell dredging of approximately 6,200 cubic yards (cy) of sand and silt, including side-slopes and overdepth, from a shoal area near the U.S. Coast Guard boat basin. Dredged materials that pass PSDDA chemical and biological guidelines will be disposed of at the Port Townsend open-water disposal site. Materials which do not pass PSDDA guidelines will be disposed of at a Port of Port Townsend furnished upland disposal site. Figures 1 through 3 show the project location, dredging area and potential upland disposal sites respectively. [NOTE: the actual volume for this project was 1,000 cy.]

2.2 Site History. The existing entrance channel was authorized in 1958 at a depth of 14 to 16 feet and a width of 40 to 60 feet. Maintenance dredging was last conducted in 1973 when 3,300 cy of material was removed from the channel. Sediment testing was not conducted at that time. [NOTE: the actual authorized depth is 10 to 12 feet.] In July 1989,

sediment information for the Port Townsend Marina was included in the Puget Sound Estuary Program report *Contaminant Loading to Puget Sound from Two Marinas* (EPA 910/9-89-014). Sediment chemistry data from twenty van Veen grab samples (top 2.0 cm) collected both inside and outside the marina were included in the report. One sampling station (Station 10) was located within the proposed dredging area. At this station, LPAH and HPAH exceeded PSDDA screening levels with concentrations of 3,900 and 32,000 ug/kg respectively. Several individual PAHs also exceeded their screening levels. In addition, 23 ug/kg of TBT (as TBT) were found at this station. Appendix A includes excerpts from the PSEP report. [NOTE: The actual LPAH and HPAH concentrations were 870 and 3,800 ug/kg respectively.]

Potential sources of contaminants existing in the marina and entrance channel include a stormwater outfall in the Coast Guard boat basin and a fueling dock near the boat ramp. A past source was a boat repair facility that existed within the marina prior to 1982. Sandblasting and painting services were provided by the facility. The land was undeveloped prior to construction of the marina. There are no other major industrial or wastewater outfalls within a mile of the marina. [NOTE: The source information provided here is fictitious.]

CORPS OF ENGINEERS

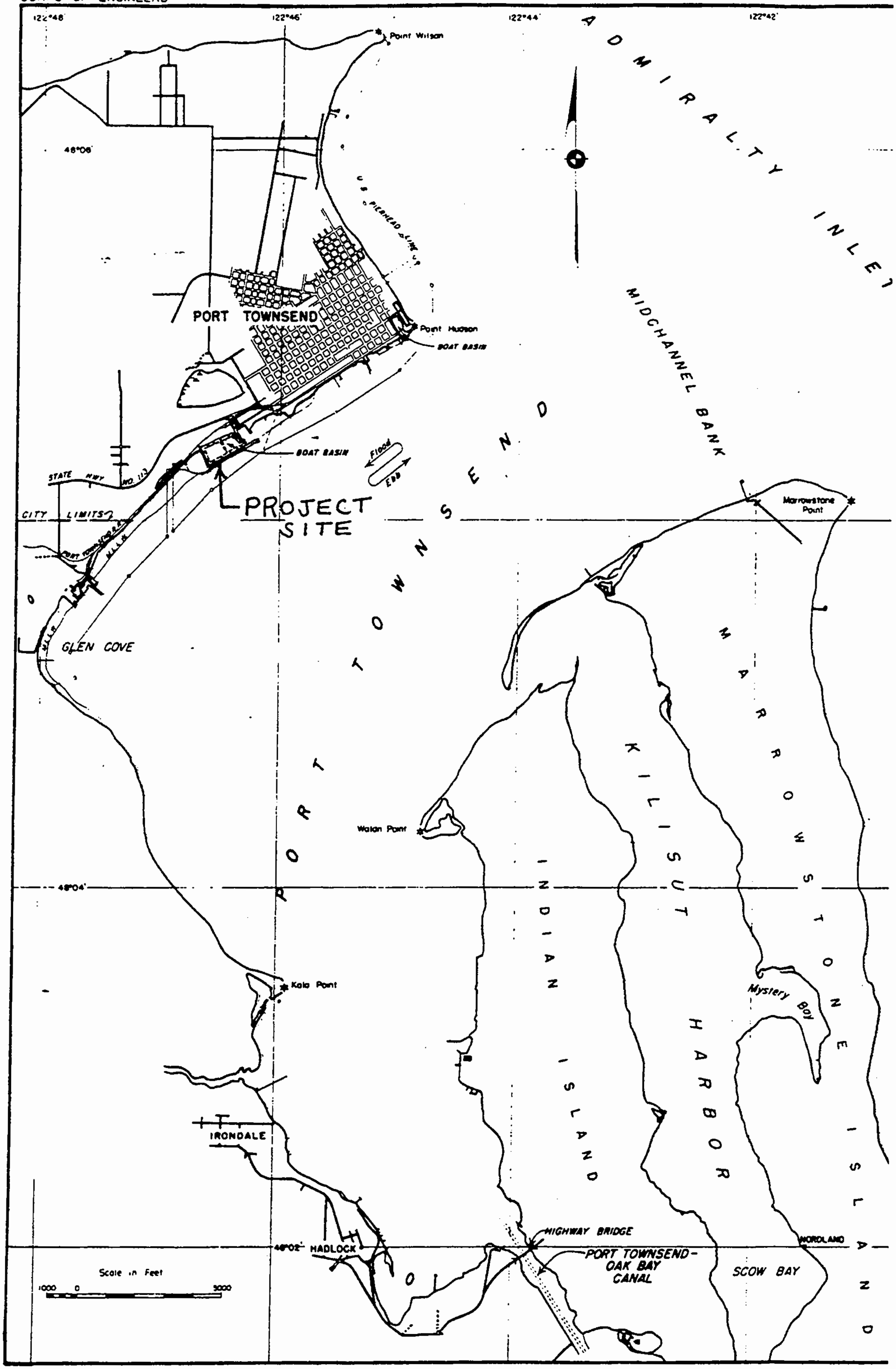
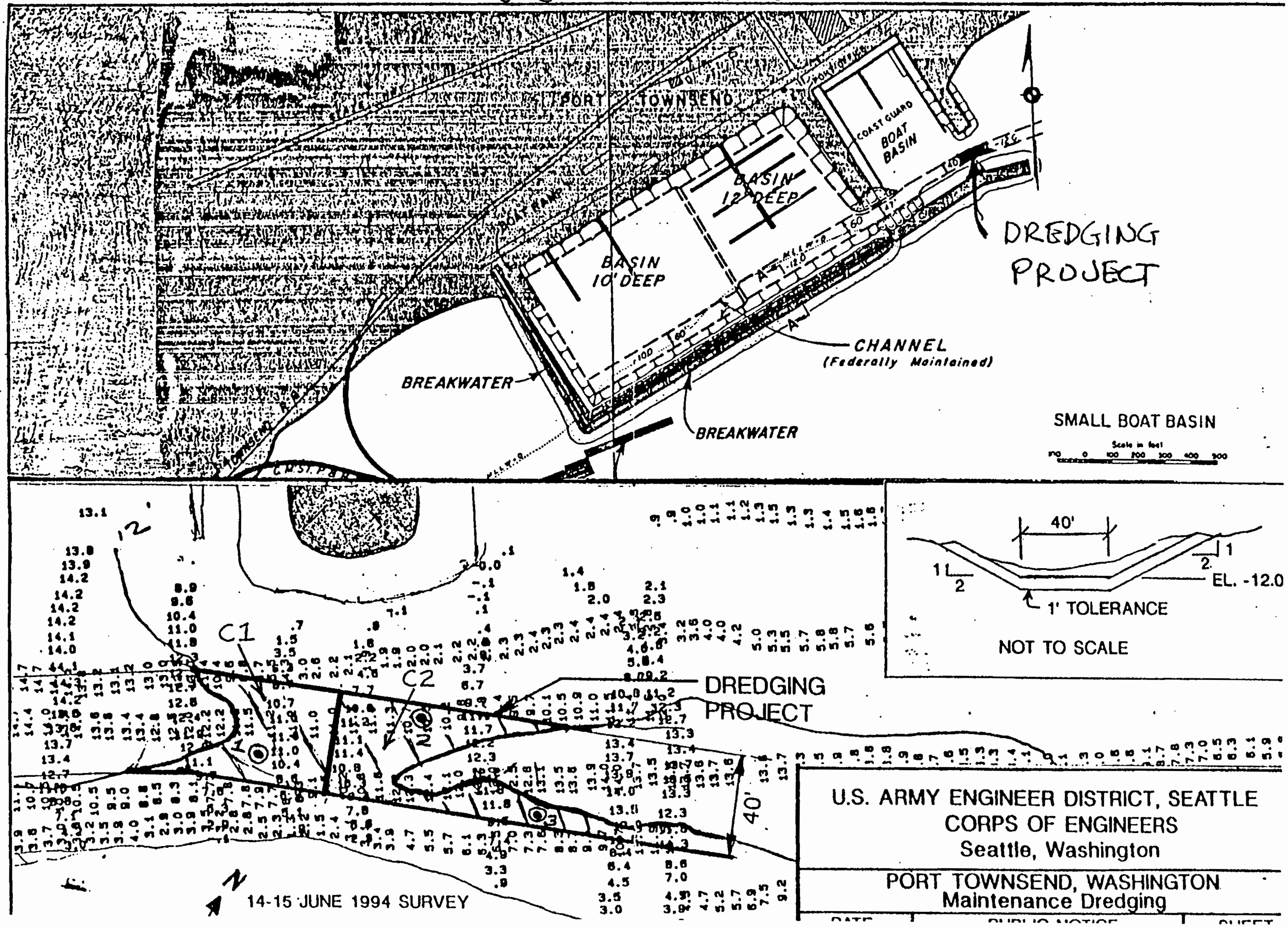
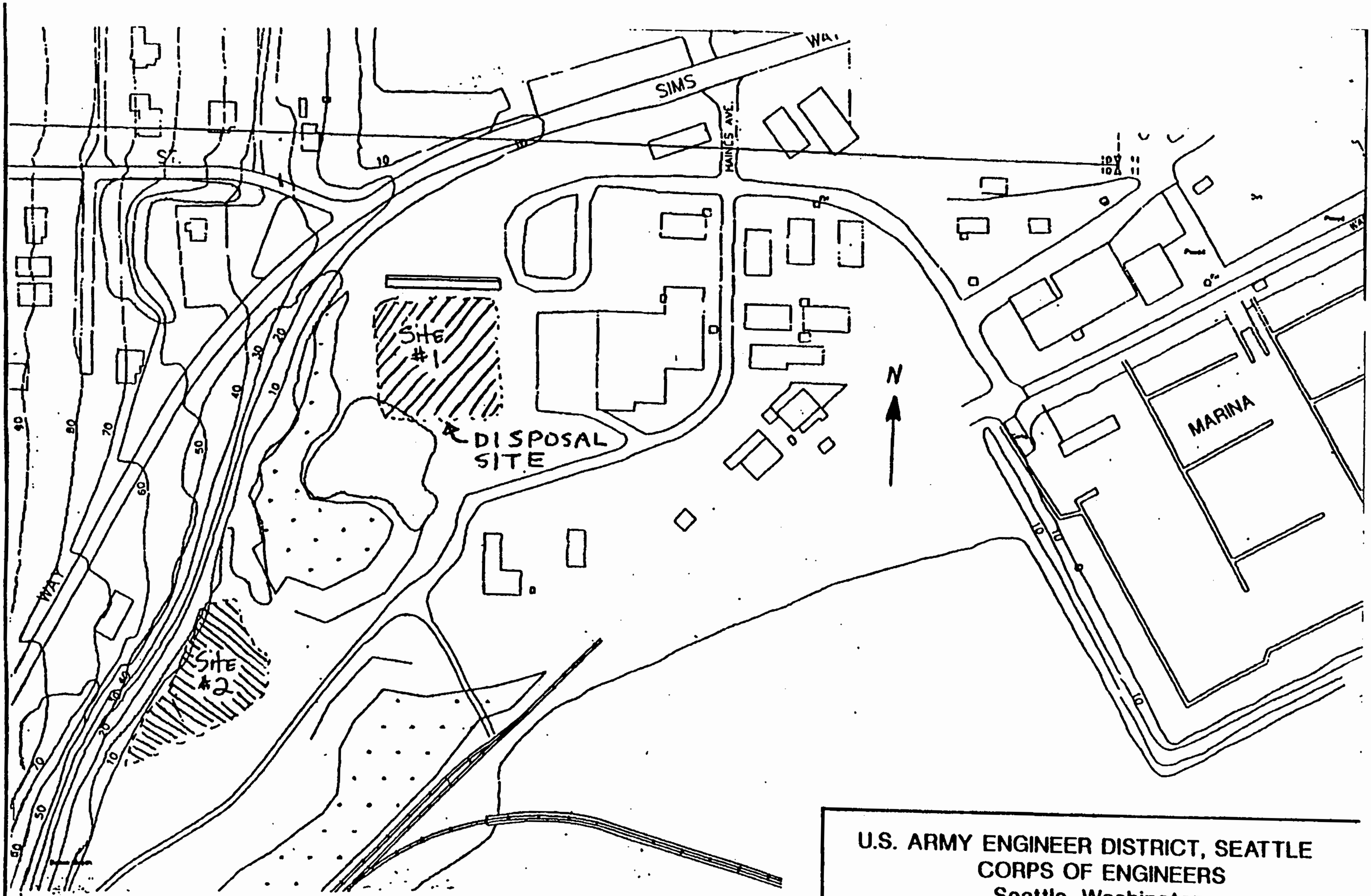


FIGURE 1 - PROJECT LOCATION

FIGURE 2 - Dredging Area, Sampling Stations & Compositing





U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
Seattle, Washington

PORT TOWNSEND, WASHINGTON
Maintenance Dredging

DATE	PUBLIC NOTICE	SHEET

3.0 PSDDA SAMPLING AND ANALYSIS REQUIREMENTS

3.1 PSDDA Ranking.

The Port Townsend Marina was assigned a rank of "high" in the PSDDA Management Plan Report - Phase II (page A-11). The data presented in *Contaminant Loading to Puget Sound from Two Marinas* supports this rank. While none of the chemicals-of-concern at Station 10 exceeded the PSDDA maximum level (ML), other stations from the marina did have chemical concentrations exceeding the ML. Therefore, a "high" rank was applied in this case. [NOTE: The actual rank in MPR-II is "moderate"; the PSEP report supports a rank of "moderate"].

3.2 Sampling and Analysis Requirements.

Based on a high rank, full characterization requirements for this project are as follows:

Surface Sediments: (0 to 4 ft.)	One core section for every 4,000 cubic yards and one laboratory analysis for each 4,000 cubic yards.
Subsurface Sediments: (> 4 ft.)	One core section for every 4,000 cubic yards and one laboratory analysis for each 12,000 cubic yards.

The estimated total volume of material to be characterized for PSDDA disposal is 6,200 cubic yards. The dredged material volume and related sampling requirements are distributed as follows:

Table 2. PSDDA sampling and testing requirements

Depth Interval	Volume (cy)	Minimum Number of Core Sections	Minimum Number of Analyses
0-4 ft.	3,500	.875	.875
>4 ft.	2,700	.675	.225
Total	6,200	1.55 (round up to 2)	1.1 (round up to 2)

The dredging depth ranges from 0-9 feet over the project area. Given the shoaling pattern, it is not practical to separate surface from subsurface material and the entire shoal will be dredged by clamshell to the design depth in one pass. Therefore, the dredging footprint will be divided spatially into the two required DMMUs. In order to represent sediment in DMMU C2, samples will be taken from two locations and composited. See Figure 2 for proposed DMMUs and sampling locations. [NOTE: actual dredging depth was 0-4 feet.]

4.0 SAMPLE COLLECTION AND HANDLING PROCEDURES

4.1 Sampling and Compositing Scheme.

Table 3 includes the existing elevation, design elevation (including overdepth), the total length of each sediment bore and the core section designations at each sampling location. Table 4 shows the compositing plan. The "Z" samples will be taken from the first foot beyond the overdepth at each station and archived for potential future analysis. [NOTE: "Z" samples must be taken for high-ranked projects only.]

Table 3. Sampling station elevations, boring depths and core sections

Sampling Station Number	Existing Elevation (MLLW)	Design + Overdepth Elevation (MLLW)	Length of Sediment Bore	Core Section Designations and Depths
1	-11	-17	6	A -11 to -15 B -15 to -17 Z -17 to -18
2	-10.5	-17	6.5	A -10.5 to -14.5 B -14.5 to -17.0 Z -17 to -18
3	-9	-17	8	A -9 to -13 B -13 to -17 Z -17 to -18

Table 4. Sample Compositing Plan

DMMU	Core Sections	Volume (CY)
C1	1AB	3,000
C2	2AB/3AB	3,200

4.2 Field Sampling Schedule. Sampling is planned for August 1997. All sampling will be completed in a single day using a vibracore deployed from the Corps of Engineers vessel "Puget". Compositing will occur in the field and laboratory samples will be delivered the same day to Environmental Testing Service.

4.3 Field Notes. Field notes will be maintained during sampling and compositing operations. Included in the field notes will be the following:

- Names of the vibracore operator, vessel captain and person(s) collecting and logging in the samples.
- Weather conditions.
- Mudline elevation of each sampling station as measured from mean lower low water (NAD83).
- Date and time of collection of each vibracore sample.
- The sample station number as derived from Figure 2 and Table 3.
- Descriptions of cores.
- Any deviation from the approved sampling plan.

4.4 Decontamination. The stainless steel compositing pans and sampling utensils will be thoroughly cleaned prior to use according to the following procedure:

- Wash with brush and Alconox soap
- Tap Water Rinse
- Rinse with distilled water
- Rinse with 10% nitric acid solution
- Rinse with methanol
- Rinse with distilled water

Volatiles sampling utensils will not receive the nitric acid or methanol rinse. All hand work will be conducted with disposable latex gloves which will be rinsed with distilled water before and after handling each individual sample, as appropriate, to prevent sample contamination. Gloves will be disposed of between composites to prevent cross contamination between the DMMUs.

4.5 Positioning. A differential global positioning system (DGPS) will be used aboard the "Puget" for station positioning. The Coast Guard's differential correction signal will be utilized to obtain an accuracy of $\pm$ 3 meters. The DGPS receiver will be placed above the block on the vibracore deployment boom to accurately record the position of the vibracore. Coordinates of the proposed sampling locations will be calculated in advance and programmed into the Puget's navigation system. Once the vibracore has been deployed, the actual position will be recorded when the vibracore quadrupod is on the channel bottom and the deployment cable is in a vertical position. Horizontal coordinates will be referenced to the Washington Coordinate System North Zone (NAD 83) and converted to latitude and longitude to the nearest 0.1 second.

Water depths will be measured directly by lead-line and converted to mudline elevations using the CURRENTMASTER tide program. The lead-line measurements also serve as a check on station positioning as the actual water depth at the station coordinates should match the predicted depth at those stations.

4.6 Sample Collection Method. Lexan tubes (4-inch diameter) are manually inserted into the vibracore, the vibracore quadrupod is mechanically lowered into position on the channel bottom, activated and allowed to penetrate to the proper sampling depth. Painted markers, spaced one foot apart along the deployment cable, are used to measure penetration depth. When sampling is completed, the vibracore quadrupod is retrieved and the lexan tube is removed and placed in a yoke for processing.

A tape measure is used to determine the length of the recovered sediment core in the transparent lexan tube. This core length is divided by the depth of penetration to calculate the decimal percent recovery. There is no way of determining the actual recovery on a foot-by-foot basis so a uniform recovery factor will be applied to the entire core. Using this recovery factor, the lexan tube will be marked to show the lower extent of the dredging prism (including overdepth) and the "Z" samples. Marks will be made around the entire circumference of the tube. The tube will then be scored lengthwise on opposite sides of the tube using a circular saw set to a depth 1/32-inch less than the thickness of the tube wall. Once scored, a decontaminated carpet knife will be used to complete both cuts so that the top of the tube may be removed. Past analyses of lexan shavings have not resulted in detection of any PSDDA chemicals of concern, but every attempt will be made to prevent shavings from contacting the sediment samples inside the tube.

4.7 Volatiles Subsampling. From one core section for each composite, samples will be removed for volatile organics testing immediately upon removing the side of the tube. The samples will be taken from along the entire length of the core section representing the dredging depth.

Two separate 4-ounce containers will be completely filled with sample sediment for volatiles, with no headspace allowed. Two samples are collected to ensure that an acceptable sample with no headspace is submitted to the laboratory for analysis. Prior to sampling, the containers, screw caps, and cap septa (silicone vapor barriers) will have been washed with detergent, rinsed once with tap water, rinsed at least twice with distilled water, and dried at >105 C. A solvent rinse will 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 will be filled to overflowing so that a convex meniscus forms at the top. Once sealed, the bottle will be inverted to verify the seal by demonstrating the absence of air bubbles. If there is little or no water in the sediment, jars will be filled as tightly as possible, eliminating obvious air pockets. With the cap liner's PTFE side down, the cap will be carefully placed on the opening of the vial, displacing any excess material.

The volatiles sampling jars will 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

4.8 Core Logging. After the volatiles sample has been taken, each core section will then be inspected and described. For each vibracore sample, the following data will be recorded on the core log:

- Depth interval of each core section as measured from MLLW.
- Sample recovery
- Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, color)
- Odor (e.g., hydrogen sulfide, petroleum products)
- Visual stratifications and lenses
- Vegetation
- Debris
- Biological Activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
- Presence of oil sheen
- Any other distinguishing characteristics or features

4.9 Compositing. After the core section has been logged, the remaining contents of the vibracore tube from above the dredging design depth (including overdepth) will be placed in a stainless-steel pan and the pan covered with foil. Separate pans will be kept for the individual "Z" samples. Once all core sections for a composite have been collected and placed into the same stainless steel pan, the sample will be stirred and homogenized until a consistent color and texture is achieved.

At least 7 liters of homogenized sample will be prepared to provide adequate volume for laboratory analyses. Physical, chemical and bioassay samples will be taken from the same homogenate. Portions of each composite sample will be placed in appropriate containers obtained from the chemical and biological laboratories ("Z" samples will be archived for physical and chemical testing only). Each sample container will 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. See Table 5 for sample volume and storage information.

Approximately 15-20 additional liters of sediment would be required for bioaccumulation testing. This additional volume will not be collected at this time. If a bioaccumulation trigger is exceeded, a decision will be made at that time whether or not to conduct bioaccumulation testing. A decision to conduct bioaccumulation testing will require a second field mobilization to retrieve additional sediment for testing.

4.10 Sample Transport and Chain-of-Custody Procedures. After sample containers have been filled they will be packed on blue ice in coolers. The coolers will be transferred to Environmental Testing Service at the end of the day. Chain-of-custody procedures will commence in the field and will track delivery of the samples to Environmental Testing Service. Specific procedures are as follows:

- Samples will 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.
- Individual sample containers will be packed to prevent breakage.
- The coolers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the cooler and Marine Technologies' office name and address) to enable positive identification.
- A sealed envelope containing chain-of-custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
- Signed and dated chain-of-custody seals will be placed on all coolers prior to shipping.

Upon transfer of sample possession to the testing laboratory, the chain-of-custody form will be signed by the persons transferring custody of the coolers. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the condition of the samples will be recorded by the receiver.

Table 5. Sample volume and storage

Sample Type	Holding Time	Sample Size[a]	Temperature[b]	Container	Archive[c]
Particle Size	6 Months	200g	4°C	1-liter Glass (combined)	X
Total Solids	14 Days	125g	4°C		
Total Volatile Solids	14 Days	125 g	4°C		
Total Organic Carbon	14 Days	125 g	4°C		
Metals (except Mercury)	6 Months	50 g	4°C		
Semivolatiles, Pesticides and PCBs	14 Days until extraction 1 Year until extraction 40 Days after extraction	150 g	4°C -18°C 4°C		
Mercury	28 Days	5 g	-18°C	125 ml Glass	
Volatile Organics	14 Days	100 g	4°C	2-40 ml Glass	
Bioassay	8 Weeks	4 L	4°C	6-1 liter Glass[d]	

a. Required sample sizes for one laboratory analysis. Actual volumes to be collected have been increased to provide a margin of error and allow for retests.
b. During transport to the lab, samples will be stored on blue ice.
c. For every DMMU, a 250 ml container is filled and frozen to run any or all of the analyses indicated.
d. Containers will be completely filled with no headspace allowed.

5.0 LABORATORY PHYSICAL AND CHEMICAL SEDIMENT ANALYSIS

The composited samples will be analyzed for all the parameters listed in Appendix B and will be compared to PSDDA guidelines for open-water disposal, as well as the SMS sediment quality standards (SQS) to determine the potential for beneficial use [NOTE: sediment from a high-ranked project would not normally be evaluated for beneficial use. This evaluation is included here to address those cases in which beneficial use is a real alternative.]

5.1 Laboratory Analyses Protocols. Laboratory testing procedures will be conducted in accordance with the PSDDA Evaluation Procedures Technical Appendix, June 1988; the PSDDA Phase II Management Plan Report, September 1989; and with the PSEP Recommended Protocols. Several details of these procedures are discussed below.

5.1.1 Chain-of-custody. A chain-of-custody record for each set of samples will be maintained throughout all sampling activities and will accompany samples and shipment to the laboratory. Information tracked by the chain-of-custody records in the laboratory include sample identification number, date and time of sample receipt, analytical parameters required, location and conditions of storage, date and time of removal from and return to storage, signature of person removing and returning the sample, reason for removing from storage, and final disposition of the sample.

5.1.2 PSDDA Limits of Detection. For purposes of PSDDA testing, detection limits of all chemicals of concern must be below PSDDA screening levels. Failure to achieve this may result in a requirement to reanalyze or perform bioassays. The testing laboratory will be specifically cautioned by Marine Technologies to make certain that it complies with the PSDDA detection limit requirements. All reasonable means, including additional cleanup steps and method modifications, will be used to bring all limits-of-detection below PSDDA SLs. In addition, an aliquot (250 ml) of each sediment sample for analysis will be archived and preserved at -18 C for additional analysis if necessary.

The following scenarios are possible and will be handled appropriately:

1. One or more chemicals-of-concern (COC) have limits of detection exceeding screening levels while all other COCs are quantitated or have limits of detection at or below the screening levels: the requirement to conduct biological testing would be triggered solely by limits of detection. In this case the chemical testing subcontractor will do everything possible to bring limits of detection 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 will be directed to contact the Dredged Material Management Office.

2. One or more COCs have limits of detection 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 limits of detection above SL become irrelevant. No further action is necessary.

3. One or more COCs have limits of detection 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 limits of detection must be brought below BTs and MLs to avoid the requirement to do bioaccumulation testing or special biological testing. As in case i) everything possible will be done to lower the limits of detection.

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 chronic sublethal testing data. In the absence of chronic sublethal data, problems with limits of detection 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 will be kept under proper storage conditions until the chemistry data is deemed acceptable by the PSDDA agencies.

5.1.3 SMS Limits of Detection. For purposes of comparison to SQS, a tiered approach will be used to evaluate detection limits [NOTE: this evaluation is only necessary for beneficial use projects and the analysis of "Z" samples]:

- Detection limits will be compared to the July 1996 draft SMS detection limits. While the laboratory will be instructed to attempt to meet these recommended detection limits, it should be noted that some of these are very low (e.g. Aroclors) and may be unobtainable.
- If the recommended SMS detection limits cannot be met, a secondary comparison will be made directly to SQS, carbon-normalizing where appropriate.
- In addition, the 1988 dry-weight LAETs may be used if necessary to evaluate detection limits.

See Appendix B for a complete listing of these guidelines.

5.1.4 Sediment Conventionals. Analysis of total solids and total volatile solids will follow the *Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound* (PSEP, 1986). Appendix D of *Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples* (PSEP, 1996) will be followed for analysis of total organic carbon.

Particle size will be determined by ASTM Method D-422, using the following sieve numbers: 4, 10, 20, 40, 60, 140, 230. The fine-grained fraction will be classified by phi size (+5, +6, +7, +8, >8) using hydrometer analysis. Hydrogen peroxide will not be used in preparations for grain-size analysis. Water content will be determined using ASTM D 2216. Sediment classification designation will be made in accordance with U.S. Soil Classification System, ASTM D 2487.

5.1.5 Holding Times. All samples for physical and chemical analysis will be maintained at the testing laboratory at the temperatures specified in Table 5 and analyzed within the holding times shown in the table. Sediment samples reserved for potential bioassays will be stored under chain-of-custody by Marine Technologies.

5.1.6 Quality Assurance/Quality Control. The chemistry QA/QC procedures found in Table 6 will be followed.

5.2 Laboratory Written Report. A written report will be prepared by the analytical laboratory documenting all the activities associated with sample analyses. As a minimum, the following will be included in the report:

- Results of the laboratory analyses and QA/QC results.
- All protocols used during analyses.
- Chain of custody procedures, including explanation of any deviation from those identified herein.
- Any protocol deviations from the approved sampling plan.
- Location and availability of the data.

As appropriate, this sampling plan may be referenced in describing protocols.

In addition, QA2 data required by Ecology for the SEDQUAL database will be submitted to the DMMO along with the report (see Appendix C for QA2 requirements).

Table 6. Minimum Laboratory QA/QC

Analysis Type	Method Blank[2]	Duplicate[2]	RM[2,4]	Matrix Spikes[2]	Surrogates[7]
Volatile Organics[1]	X	X[3]		X	X
Semivolatiles[1]	X	X[3]	X[5]	X	X
Pesticides/PCBs[1]	X	X[3]	X[5]	X	X
Metals	X	X	X[6]	X	
Total Organic Carbon	X	X	X[6]		
Total Solids		X			
Total Volatile Solids		X			
Particle Size		X			

1. Initial calibration required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet criteria. Ongoing calibration required at the beginning of each work shift, every 10-12 samples or every 12 hours (whichever is more frequent), and at the end of each shift.

2. Frequency of Analysis = one per batch

3. Matrix spike duplicate will be run

4. Reference Material

5. Canadian standard SRM-1

6. NIST certified reference material 2704

7. Surrogate spikes will be included with every sample, including matrix-spiked samples, blanks and reference materials

6.0 BIOLOGICAL TESTING

6.1 Bioassay Laboratory Protocols. The tiered testing approach will be used. Biological testing will be undertaken on any composite sample which has one or more chemicals of concern above the PSDDA screening level (SL). If more than one COC exceeds the PSDDA maximum level (ML) or if a single COC is greater than two times its ML, then biological testing will not be conducted. If any COC exceeds a bioaccumulation trigger (BT), a decision will be made as to whether or not to pursue biological testing. To the maximum extent practicable, chemical results will be provided for bioassay decisions within 28 days of first sample collection. The remaining four-week period will allow time for bioassay preparation as well as time for retests if necessary.

Marine Technologies will coordinate with DMMO in selection of an appropriate PSDDA-approved reference sediment. Wet-sieving in the field, using a 63-micron sieve, will be utilized in identifying a suitable reference station.

The 10-day amphipod mortality, sediment larval combined mortality and abnormality, and *Neanthes* growth bioassays will be conducted on each sample identified for biological testing. All biological testing will be in strict compliance with *Recommended Protocols for Conducting Laboratory Bioassays on Puget Sound sediments* (1995), with appropriate modifications as specified by PSDDA in the MPR-Phase II, public workshops and the annual review process. General biological testing procedures and specific procedures for each sediment bioassay are summarized below:

6.2 General Biological Testing Procedures.

- All reference sediments will be analyzed for total solids, total volatile solids, total organic carbon and grain-size.

- Five laboratory replicates of test sediments, reference sediments and negative controls will be run for each bioassay.

- Cadmium chloride will be used as a reference toxicant for all three bioassays, using standardized concentrations specified by PSDDA.

- For the *Neanthes* and amphipod bioassays, sacrificial beakers will be used to determine interstitial salinity, ammonia and sulfides for all test and reference sediments at the beginning and end of the test period. Overlying ammonia and sulfides will be determined at test initiation and termination for the larval test.

- Water quality monitoring will be conducted, consisting of daily measurements of salinity, temperature, pH and dissolved oxygen for the amphipod and sediment larval bioassays and measurements every three days for the *Neanthes* test. Monitoring will be conducted for all test and reference sediments and negative controls (including seawater controls). Parameter measurements must be within the limits specified for each bioassay. Measurements for each treatment will be made on a separate chemistry beaker set up to be identical to the other replicates within the treatment group, including the addition of test organisms.

6.3 Bioassay-specific Procedures.

6.3.1 Amphipod Bioassay. The test organism once the results of the particle size analysis are known. Data to be reported for this bioassay include survival, daily emergence and the number of amphipods failing to rebury at the end of the test. The control sediment has a performance standard of 10 percent mortality. The reference sediment has a performance standard of 20 percent mortality greater than control.

6.3.2 Sediment Larval Bioassay. The test organism will be selected in consultation with the testing lab and DMMO. Initial counts will be made for a minimum of five 10-ml aliquots. The test will be run until the appropriate stage of development is achieved in a sacrificial seawater control (PSDDA MPR-Phase II, pp. 5-20). Aeration will be conducted throughout the test to minimize effects from hydrogen sulfide. At the end of the test, larvae from each test sediment exposure will be examined to quantify abnormality and mortality. Final counts for seawater control, reference sediment and test sediment will be made on 10-ml aliquots.

The seawater control has a performance standard of 30 percent combined mortality and abnormality. The reference sediment has a performance standard of 35 percent combined mortality and abnormality normalized to seawater control.

6.3.4 *Neanthes* Growth Test. *Neanthes arenaceodentata* will be obtained from Dr. Don Reish in Long Beach, California. Because *Neanthes* take 2 or 3 weeks to culture and deliver, test organisms will be ordered early enough to begin testing four weeks after the sediment sampling date.

The control sediment has a performance standard of 10 percent mortality. The reference sediment has performance standards of 20 percent mortality and 80 percent of the control growth rate.

6.4 Interpretation. Test interpretations consist of endpoint comparisons to control and reference on an absolute percentage basis as well as statistical comparison to reference. Test interpretation will follow the guidelines established in the PSDDA Management Plan Report-Phase II (page 5-17) for the amphipod and sediment larval bioassays, and the minutes of the dredging year 1991 annual review meeting for the *Neanthes* bioassay, as modified by subsequent annual review proceedings and workshops.

6.5 Bioassay Retest. Any bioassay retests must be fully coordinated with, and approved by, the PSDDA agencies. The DMMO will be contacted to handle this coordination.

6.6 Laboratory Written Report. A written report will be prepared by the biological laboratory documenting all the activities associated with sample analyses. As a minimum, the following will be included in the report:

- Results of the laboratory bioassay analyses and QA/QC results, including all DAIS data found in Appendix D.
- All protocols used during analyses, including explanation of any deviation from PSEP and the approved sampling plan.
- Chain of custody procedures, including explanation of any deviation from the identified protocols.
- Location and availability of data, laboratory notebooks and chain-of-custody forms.

As appropriate, this sampling plan may be referenced in describing protocols.

7.0 REPORTING

7.1 QA Report. The project quality assurance representative will prepare a quality assurance report based upon activities involved with the field sampling and review of the laboratory analytical data. The laboratory QA/QC reports will be incorporated by reference. This report will identify any field and laboratory activities that deviated from the approved sampling plan and the referenced protocols and will make a statement regarding the overall validity of the data collected. The QA/QC report will be incorporated into the Final Report.

7.2 Final Report. A written report shall be prepared by Marine Technologies documenting all activities associated with collection, compositing, transportation of samples, and chemical and biological analysis of samples. The chemical and biological reports will be included as appendices. As a minimum, the following will be included in the Final Report:

- Type of sampling equipment used.
- Protocols used during sampling and testing and an explanation of any deviations from the sampling plan protocols.
- Descriptions of each sample.
- Locations where the sediment samples were collected. Locations will be reported in latitude and longitude to the nearest tenth of a second.
- A plan view of the project showing the actual sampling location.
- Chain of-custody procedures used, and explanation of any deviations from the sampling plan procedures.
- Description of sampling and compositing procedures.
- Final QA report for Section 7.1 above.

- **Chemical and biological testing data, with comparisons to PSDDA and SMS guidelines.**
- **QA2 data required by the Department of Ecology for data validation prior to entering data in their Sediment Quality database. These data are listed in Appendix C.**
- **Sampling and analysis cost data will be submitted upon project completion on forms provided by the Dredged Material Management Office.**

8.0 REFERENCES

PSEP, *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound*, 1986-1996, Puget Sound Estuary Program.

PSDDA, 1988. *Evaluation Procedures Technical Appendix - Phase I*, prepared by the PSDDA agencies.

PSDDA, 1989. *Management Plan Report - Phase II*, prepared by the PSDDA agencies.

Puget Sound Estuary Program, 1989, *Contaminant Loading to Puget Sound from Two Marinas* (EPA 910/9-89-014).

APPENDIX A

Excerpts from
Contaminant Loading to Puget Sound from Two Marinas

Puget Sound Estuary Program
1989

(EPA 910/9-89-014)

APPENDIX B

PSDDA PARAMETERS AND METHODS

Parameter	Prep Method	Analysis Method	PSDDA SL	PSDDA BT	PSDDA ML	SMS SQS	July 96 draft SMS detection limits (1)	1988 LAET
CONVENTIONALS:								
Total Solids (%)	---	Pg.17 (2)	---	---	---	---	---	---
Total Volatile Solids(%)	---	Pg.20 (2)	---	---	---	---	---	---
Total Organic Carbon (%)	---	DOE (3)	---	---	---	---	---	---
Grain Size	---	Modified ASTM with Hydrometer	---	---	---	---	---	---
METALS			units: mg/kg dw (4)			units: mg/kg dw	units: mg/kg dw	
Antimony	3050 (5)	GFAA (6)	150	150	200	---	---	150
Arsenic	3050	GFAA	57	507.1	700	57	19	57
Cadmium	3050	GFAA	5.1	---	14	5.1	1.7	5.1
Chromium	3050	GFAA	---	---	---	260	87	260
Copper	3050	ICP (7)	390	---	1,300	390	130	390
Lead	3050	ICP	450	---	1,200	450	150	450
Mercury	7471 (8)	7471	0.41	1.5	2.3	0.41	0.14	0.59
Nickel	3050	ICP	140	370	370	---	---	>140
Silver	3050	GFAA	6.1	6.1	8.4	6.1	2.0	>0.56
Zinc	3050	ICP	410	---	3,800	410	137	410
ORGANICS								
LPAH			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Naphthalene	3540 (9)	8270 (10)	2,100	---	2,400	99	700	2100
Acenaphthylene	3540	8270	560	---	1,300	66	433	>560
Acenaphthene	3540	8270	500	---	2,000	16	167	500
Fluorene	3540	8270	540	---	3,600	23	180	540
Phenanthrene	3540	8270	1,500	---	21,000	100	500	1500
Anthracene	3540	8270	960	---	13,000	220	320	960
2-Methylnaphthalene	3540	8270	670	---	1,900	38	223	670
Total LPAH			5,200	---	29,000	370	---	5200
HPAH			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Fluoranthene	3540	8270	1,700	4600	30,000	160	567	1700
Pyrene	3540	8270	2,600	---	16,000	1000	867	2600
Benzo(a)anthracene	3540	8270	1,300	---	5,100	110	433	1300
Chrysene	3540	8270	1,400	---	21,000	110	467	1400
Benzofluoranthenes	3540	8270	3,200	---	9,900	230	1067	3200
Benzo(a)pyrene	3540	8270	1,600	3,600	3,600	99	533	1600
Indeno(1,2,3-c,d)pyrene	3540	8270	600	---	4,400	34	200	600
Dibenzo(a,h)anthracene	3540	8270	230	---	1,900	12	77	230
Benzo(g,h,i)perylene	3540	8270	670	---	3,200	31	223	670
Total HPAH			12,000	---	69,000	960		12000
CHLORINATED HYDROCARBONS			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
1,3-Dichlorobenzene	P&T (11)	8260 (11)	170	1,241	---	---	---	>170

Parameter	Prep Method	Analysis Method	PSDDA SL	PSDDA BT	PSDDA ML	SMS SQS	July 96 draft SMS detection limits (1)	1988 LAET
1,4-Dichlorobenzene	P&T	8260	110	120	120	3.1	37	110
1,2-Dichlorobenzene	P&T	8260	35	37	110	2.3	35	35
1,2,4-Trichlorobenzene	3540	8270	31	---	64	0.81	31	31
Hexachlorobenzene (HCB)	3540	8270	22	168	230	0.38	22	22
PHTHALATES				units: ug/kg dw		units: mg/kg oc	units: ug/kg dw	
Dimethyl phthalate	3540	8270	1,400	1,400	---	53	24	71
Diethyl phthalate	3540	8270	1,200	---	---	61	67	>48
Di-n-butyl phthalate	3540	8270	5,100	10,220	---	220	467	1400
Butyl benzyl phthalate	3540	8270	970	---	---	4.9	21	63
Bis(2-ethylhexyl)phthalate	3540	8270	8,300	13,870	---	47	433	1300
Di-n-octyl phthalate	3540	8270	6,200	---	---	58	2067	>420
PHENOLS				units: ug/kg dw		units: ug/kg dw	units: ug/kg dw	
Phenol	3540	8270	420	876	1,200	420	140	420
2 Methylphenol	3540	8270	63	---	77	63	63	63
4 Methylphenol	3540	8270	670	---	3,600	670	223	670
2,4-Dimethylphenol	3540	8270	29	---	210	29	29	29
Pentachlorophenol	3540	8270	400	504	690	360	120	>140
MISCELLANEOUS EXTRACTABLES				units: ug/kg dw		units: ug/kg dw	units: ug/kg dw	
Benzyl alcohol	3540	8270	57	---	870	57	57	57
Benzoic acid	3540	8270	650	---	760	650	217	650
				units: ug/kg dw		units: mg/kg oc	units: ug/kg dw	
Dibenzofuran	3540	8270	540	---	1,700	15	180	540
Hexachloroethane	3540	8270	1,400	10,220	14,000	---	---	---
Hexachlorobutadiene	3540	8270	29	212	270	3.9	11	11
N-Nitrosodiphenylamine	3540	8270	28	130	130	11	28	28
VOLATILE ORGANICS				units: ug/kg dw			units: ug/kg dw	
Trichloroethene	P&T	P&T	160	1,168	1,600	---	---	---
Tetrachloroethene	P&T	P&T	57	102	210	---	---	57
Ethylbenzene	P&T	P&T	10	27	50	---	---	10
Total Xylene	P&T	P&T	40	---	160	---	---	40
PESTICIDES & PCBs				units: ug/kg dw		units: mg/kg oc	units: ug/kg dw	
Total DDT	---	---	6.9	50	69	---	---	---
p,p'-DDE	3540	8081 (12)	---	---	---	---	---	9
p,p'-DDD	3540	8081	---	---	---	---	---	16
p,p'-DDT	3540	8081	---	---	---	---	---	>6
Aldrin	3540	8081	10	37	---	---	---	---
Chlordane	3540	8081	10	37	---	---	---	---
Dieldrin	3540	8081	10	37	---	---	---	---
Heptachlor	3540	8081	10	37	---	---	---	---
Lindane	3540	8081	10	---	---	---	---	---
Total PCBs	3540	8081	130	38 (13)	3,100	12	6	130

1. *Recommended* Sample Preparation Methods, Cleanup Methods, Analytical Methods and Detection Limits for Sediment Management Standards, Chapter 173-204 WAC, Draft - July 1996.

2. *Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound*, Puget Sound Estuary Program, March, 1986.

3. *Recommended Methods for Measuring TOC in Sediments*, Kathryn Bragdon-Cook, Clarification Paper, Puget Sound Dredged Disposal Analysis Annual Review, May, 1993.

4. units: ug = microgram, mg = milligram, kg = kilogram, dw = dry weight, oc = organic carbon.

5. *Test Methods for Evaluating Solid Waste. Laboratory manual physical/chemical methods*. Method 3050, SW-846, 3rd ed., Vol 1A, Chapter 3, Sec 3.2, Rev 1. Office of Solid Waste and Emergency Response, Washington, DC.

6. Graphite Furnace Atomic Absorption (GFAA) Spectrometry - SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

7. Inductively Coupled Plasma (ICP) Emission Spectrometry - SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

8. *Test Methods for Evaluating Solid Waste. Laboratory manual physical/chemical methods*. Method 7471, SW-846, 3rd ed., Vol 1A, Chapter 3, Sec 3.3. Office of Solid Waste and Emergency Response, Washington, DC.

9. Soxhlet Extraction - Method 3540, SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

10. GCMS Capillary Column - Method 8270, SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

11. Purge and Trap Extraction and GCMS Analysis - Method 8260, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

12. GCMS Capillary Column - Method 8081, SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

13. Total PCBs BT value in mg/kg oc.

APPENDIX C

QA2 DATA REQUIREMENTS

CHEMICAL VARIABLES

ORGANIC COMPOUNDS

The following documentation is needed for organic compounds:

- A cover letter referencing or describing the procedure used and discussing any analytical problems
- Reconstructed ion chromatograms for GC/MS analyses for each sample
- Mass spectra of detected target compounds (GC/MS) for each sample and associated library spectra
- GC/ECD and/or GC/flame ionization detection chromatograms for each sample
- Raw data quantification reports for each sample
- A calibration data summary reporting calibration range used [and decafluorotriphenylphosphine (DFTPP) and bromofluorobenzene (BFB) spectra and quantification report for GC/MS analyses]
- Final dilution volumes, sample size, wet-to-dry ratios, and instrument detection limit
- Analyte concentrations with reporting units identified (to two significant figures unless otherwise justified)
- Quantification of all analytes in method blanks (ng/sample)
- Method blanks associated with each sample
- Recovery assessments and a replicate sample summary (laboratories should report all surrogate spike recovery data for each sample; a statement of the range of recoveries should be included in reports using these data)
- Data qualification codes and their definitions.

METALS

For metals, the data report package for analyses of each sample should include the following:

- Tabulated results in units as specified for each matrix in the analytical protocols, validated and signed in original by the laboratory manager
- Any data qualifications and explanation for any variance from the analytical protocols
- Results for all of the QA/QC checks initiated by the laboratory
- Tabulation of instrument and method detection limits.

All contract laboratories are required to submit metals results that are supported by sufficient backup data and quality assurance results to enable independent QA reviewers to conclusively determine the quality of the data. The laboratories should be able to supply legible photocopies of original data sheets with sufficient information to unequivocally identify:

- Calibration results
- Calibration and preparation blanks
- Samples and dilutions
- Duplicates and spikes

- **Any anomalies in instrument performance or unusual instrumental adjustments.**

BIOASSAYS

Amphipod Mortality Test

The following data should be reported by all laboratories performing this bioassay:

- **Daily water quality measurements during testing (e.g., dissolved oxygen, temperature, salinity, pH) (plus ammonia & sulfides at test initiation and termination)**
- **Daily emergence for each beaker and the 10-day mean and standard deviation for each treatment**
- **10-day survival in each beaker and the mean and standard deviation for each treatment**
- **Interstitial salinity values of test sediments**
- **96-hour LC_{50} values with reference toxicants.**
- **Any problems that may have influenced data quality.**

***Neanthes* Growth Test**

The following data should be reported by all laboratories performing this bioassay:

- **Water quality measurements at test initiation and termination and every three days during testing (e.g., dissolved oxygen, temperature, salinity, pH) (plus ammonia & sulfides at test initiation and termination)**
- **20-day survival in each beaker and the mean and standard deviation for each treatment.**
- **Initial biomass**
- **Final biomass (20-day) for test, reference and control treatments.**
- **96-hour LC_{50} values with reference toxicants.**
- **Any problems that may have influenced data quality.**

Sediment Larval Test

The following data should be reported by all laboratories performing this bioassay:

- **Daily water quality measurements (e.g., dissolved oxygen, temperature, salinity, pH) (plus ammonia + sulfides at test initiation & termination)**
- **Individual replicate and mean and standard deviation data for larval survival at test termination.**
- **Individual replicate and mean and standard deviation data for larval abnormalities at test termination**
- **48-hour LC_{50} and EC_{50} values with reference toxicants.**
- **Any problems that may have influenced data quality.**

APPENDIX D - DAIS DATA REQUIREMENTS

Sample Locations and Compositing				
	Test Sediment	Reference Sediment	Control Sediment	Seawater Control
Latitude and Longitude (to nearest 0.1 second)				
NAD 1927 or 1983				
USGS Benchmark ID				
Station name (e.g. Carr Inlet)				
Water depth (corrected to MLLW)				
Drawing showing sampling locations and ID numbers				
Compositing scheme (sampling locations/depths for composites)				
Sampling method				
Sampling dates				
Estimated volume of dredged material represented by each DMMU				
Positioning method				
Sediment Conventionals				
Preparation and analysis methods				
Sediment conventional data and QA/QC qualifiers				
QA qualifier code definitions				
Triplicate data for each sediment conventional for each batch				
Units (dry weight except total solids)				
Method blank data (sulfides, ammonia, TOC)				
Method blank units (dry weight)				
Analysis dates (sediment conventionals, blanks, TOC CRM)				
TOC CRM ID				
TOC CRM analysis data				
TOC CRM target values				
Grain Size Analysis				
Fine grain analysis method				
Analysis dates				
Triplicate for each batch				
Grain size data (complete sieve and phi size distribution)				

Chemicals of Concern Analysis Data				
	Metals	Semivol.	Pest./ PCBs	Volatiles
Extraction/digestion method				
Extraction/digestion dates (test sediment, blanks, matrix spike, reference material)				
Analysis method				
data and QA qualifier included for:				
test sediments				
reference materials including 95% confidence interval (each batch)				
method blanks (each batch)				
matrix spikes (each batch)				
matrix spike added (dry weight basis)				
replicates (each batch)				
Units (dry weight)				
Method blank units (dry weight)				
QA/QC qualifier definitions				
Surrogate recovery for test sediment, blank, matrix spike, ref. material				
Analysis dates (test sediment, blanks, matrix spike, reference material)				

Shaded areas indicate required data

BIOASSAYS

Amphipod Mortality and Emergence				
	Each Batch	Test Sediment	Reference Sediment	Control Sediment
Species Name				
Mortality and Emergence:				
Start date				
Daily emergence (for 10 days)				
Survival at end of test				
Number failing to rebury at end of test				
Positive Control:				
Toxicant used				
Toxicant concentrations				
Exposure time				
LC50				
LC50 method of calculation				
Start date				
Survival data				
Water Quality Measurement Methods:				
Dissolved oxygen				
Ammonia				
Interstitial salinity				
Sulfide				
Water salinity				
Water Quality:				
Temperature (day 0 through day 10)				
pH (day 0 through day 10)				
Dissolved oxygen (day 0 through day 10)				
Water salinity (day 0 through day 10)				
Sulfide (day 0, day 10)				
Ammonia (day 0, day 10)				
Interstitial water salinity (day 0)				

Neanthes 20-day Growth Test				
	Each Batch	Test Sediment	Reference Sediment	Control Sediment
Starting age (in days post-emergence)				
Food type				
Quantity (mg/beaker/interval)				
Feeding interval (hours)				
Biomass and Mortality:				
Start date				
Initial counts and weights (mg dry weight)				
Number of survivors and final weights (mg dry weight)				
Positive Control:				
Toxicant used				
Toxicant concentration				
Exposure time				
LC50				
LC50 method of calculation				
Start date				
Survival data				
Water Quality Measurement Methods				
Dissolved oxygen				
Ammonia				
Interstitial salinity				
Sulfide				
Water salinity				
Water Quality:				
Temperature (days 0, 3, 6, 9, 12, 15, 18, 20)				
pH (days 0, 3, 6, 9, 12, 15, 18, 20)				
Dissolved oxygen (days 0, 3, 6, 9, 12, 15, 18, 20)				
Water salinity (days 0, 3, 6, 9, 12, 15, 18, 20)				
Interstitial salinity (day 0)				
Sulfide (initial and final)				
Ammonia (initial and final)				

Sediment Larval Mortality and Abnormality				
	Each Batch	Test Sediment	Reference Sediment	Seawater Control
Species Name				
Bioassay Parameters				
Inoculation time (hours)				
Exposure time (hours)				
Stocking beaker density (#/ml)				
Stocking aliquot size (ml)				
Aeration (yes/no)				
Mortality and Abnormality:				
Start date				
Initial count (minimum of five 10-ml aliquots)				
Final Count:				
Aliquot size (ml)				
Number normal per aliquot				
Number abnormal per aliquot				
Water Quality Measurement Methods:				
Dissolved oxygen				
Ammonia				
Sulfide				
Water salinity				
Water Quality:				
Temperature (daily)				
pH (daily)				
Dissolved oxygen (daily)				
Water salinity (daily)				
Sulfide (initial and final)				
Ammonia (initial and final)				
Positive Control:				
Toxicant used				
Toxicant concentrations				
Exposure time				
EC50				
EC50 method of calculation				
Start date				
Normal/abnormal counts				

APPENDIX 6-B

LARGE PROJECT SAMPLING
AND
ANALYSIS PLAN

Revised 4/18/97

SAMPLING & ANALYSIS PLAN FOR SEDIMENT CHARACTERIZATION AT PIER D

U.S. NAVY PUGET SOUND SHIPYARD BREMERTON, WASHINGTON

September 20, 1994

Prepared by:

ProTech Consulting, Inc.
2525 N. Main Street, Suite 430
Seattle, Washington 98204

In Association With:

GeoMetrics, Inc.

SAMPLING & ANALYSIS PLAN
FOR
SEDIMENT CHARACTERIZATION AT PIER D

U.S. NAVY PUGET SOUND SHIPYARD
BREMERTON, WASHINGTON

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LIST OF FIGURES AND TABLES:

1.0 INTRODUCTION

1.1 Project Description. The U.S. Navy Puget Sound Naval Shipyard, Bremerton, WA, proposes to upgrade Pier D in Sinclair Inlet (see vicinity and location maps, Figures 1 and 2) to provide flexibility to homeport the following vessel mooring combinations: two AOE Class vessels; one CVN-68 (NIMITZ-size carrier) and one AOE; one CVN-68 and two smaller class (DDG or FFG) ships; or two CVN-68's. This project includes dredging two mooring basins: one along each side of Pier D. Each mooring basin will be 158-ft. wide by 1050 ft. along the pier and dredged to a design depth of -49.4 ft., MLLW (45 ft. navigation depth at Extreme Low Water, ELW = -4.4 ft., MLLW) (see Figures 4 and 5). Existing bottom depths are on the order of -40 ft. Estimated total dredging quantity for both basins is approximately 170,400 cyds, including side slopes and one-foot overdepth.

Dredging will be by clamshell and barge. Depending on the results of PSDDA sediment characterization proposed in this sampling plan, disposal will be either inwater to the PSDDA Elliott Bay site by bottom dump barge, or upland to the Kitsap County landfill (Olympic View Landfill) by offloading and truck haul. It is possible that each site may receive some of the dredged materials.

1.2 Sediment Description. PSDDA guidance identifies Sinclair Inlet as an area of high concern for sediment contamination. Limited available data show that sediments to be dredged at Pier D consist of a 2 to 4 ft. surface layer of black, soft silts and fine sands (mud) overlying a more dense, gray silty fine-to-medium sand. A pilot sediment characterization study at Pier D was conducted for the Navy in 1989 (see APPENDIX A). Results indicated that PSDDA screening levels (SL's) were marginally exceeded for some parameters in each of four representative surface layer composite samples, and that maximum levels (ML's) were exceeded at one station for DDT and for silver. Based on these limited results, the Navy proposes to conduct a comprehensive sediment characterization program by collecting and analyzing representative core samples in accordance with PSDDA requirements for each of the two mooring basins to be dredged. The tiered chemistry/biological testing approach will be used. These results will be provided to the PSDDA agencies as the basis to identify the acceptable disposal option(s).

The Pier D area was last dredged in the mid-1940's to a design depth of -40 ft., MLLW, as part of an area-wide dredging project for the Navy shipyard. The most recent hydrographic survey (GeoMetrics-November 1990) shows that less than four feet of infill has since occurred.

1.3 Site History. The upland area directly north of Pier D was purchased by the Navy in 1891 as part of the original purchase for the Shipyard, however the original development of the industrial area of the Shipyard began about a mile east of this site.

Between 1910-1923 fill extended the natural shoreline to the currently existing quay wall at the head of Pier D. The area was beginning to be developed by this time, with a coaling pier in use about 200 ft. east of Pier D and commercial oil tank farms in use on property northwest of the

Shipyard about 1000 ft. This property was later purchased by the Shipyard in 1942 and used for barracks, steel storage and parking.

The fill area directly north of Pier D became heavily used for storage/support functions by the 1930's and these uses continue to this day but are not major sources of contamination. The major industrial activity of the Shipyard is still located from 1500 ft. to over a mile from Pier D.

In 1946, an area along the entire west shoreline of the Shipyard was dredged to -40 ft., MLLW, to allow use of this area as inactive ship storage. Pier D, along with Pier B and Moorings A, E ,F and G, were constructed in 1947 for this purpose.

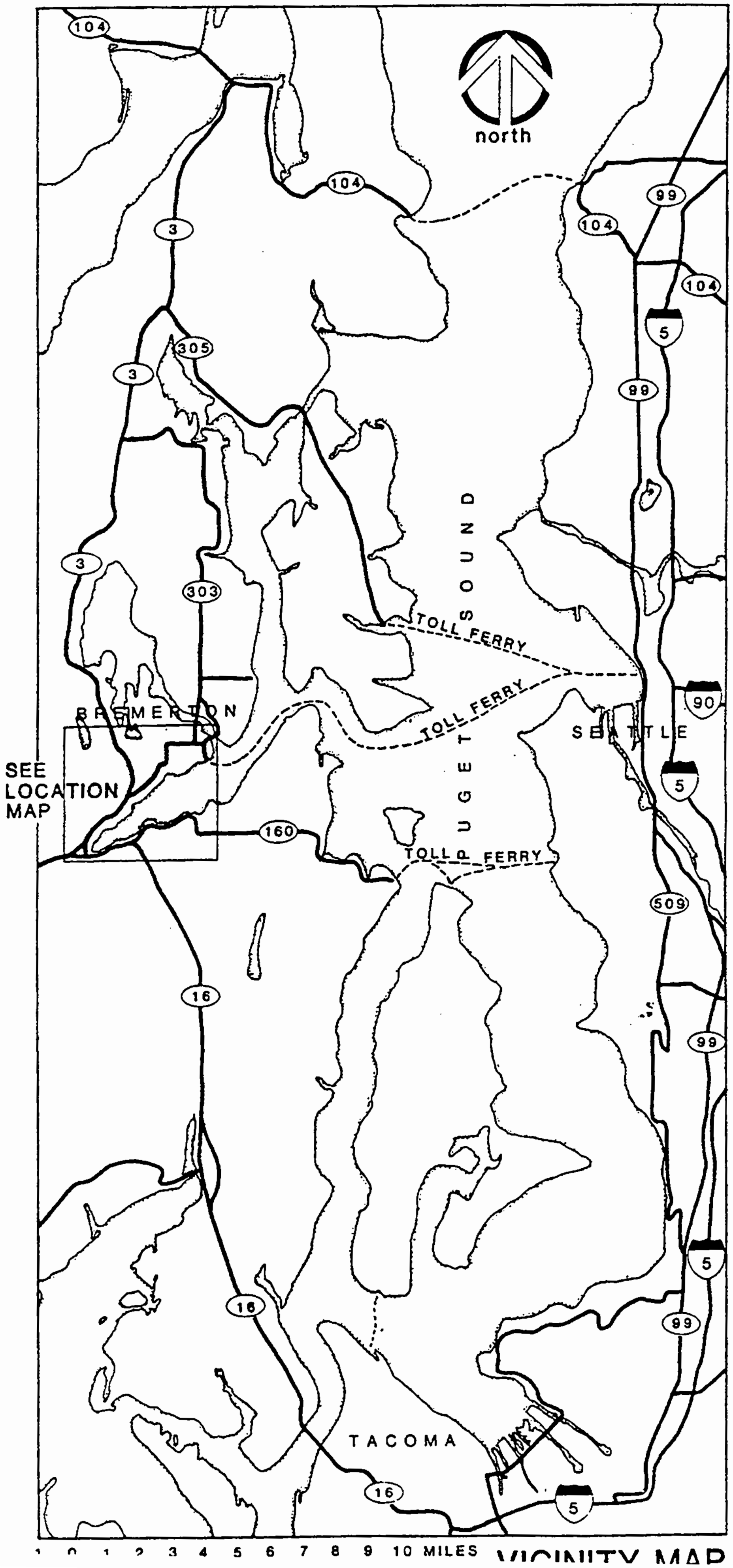
This area continues to be used for the storage of inactive ships with associated minor maintenance and painting activities. The Navy has, however, never used tributyltin as an antifouling agent during any of its painting activities at the Bremerton shipyard. Analysis for tributyltin therefore should not be necessary.

Historical site uses and possible sources of past contamination are shown in Figure 3. There are no active sources, such as stormwater outfalls, in the immediate vicinity of Pier D.

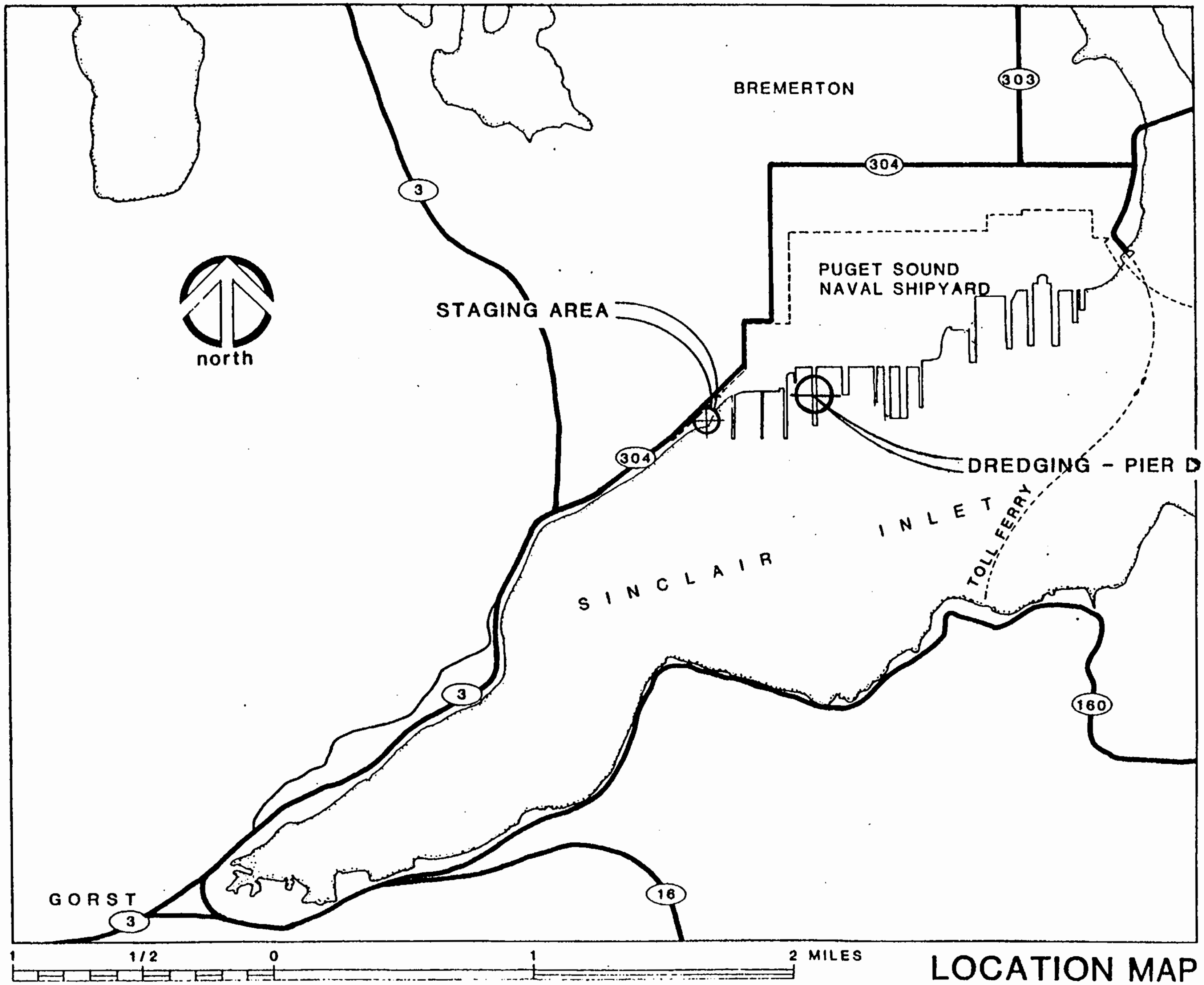
1.4 Permitting. A permit application for Pier D dredging and disposal was submitted by the Navy to US Army Corps of Engineers, Seattle District, in April 1989 (Application No. OYB-1-012791, see APPENDIX A). Permitting actions required include a Corps of Engineers Section 10/404, State of Washington Hydraulic Project Approval and Section 401 Water Quality Certification, City of Bremerton Shorelines Development permit and a DNR Open-water Disposal Site Use permit. Designation of acceptable disposal site(s) based on results of sediment characterization proposed herein is a critical remaining element prior to final project design and permit applications.

An EIS for the proposed Pier D upgrade project, including dredging and disposal, is being prepared by the Navy (AOE Homeporting EIS).

FIGURE 1

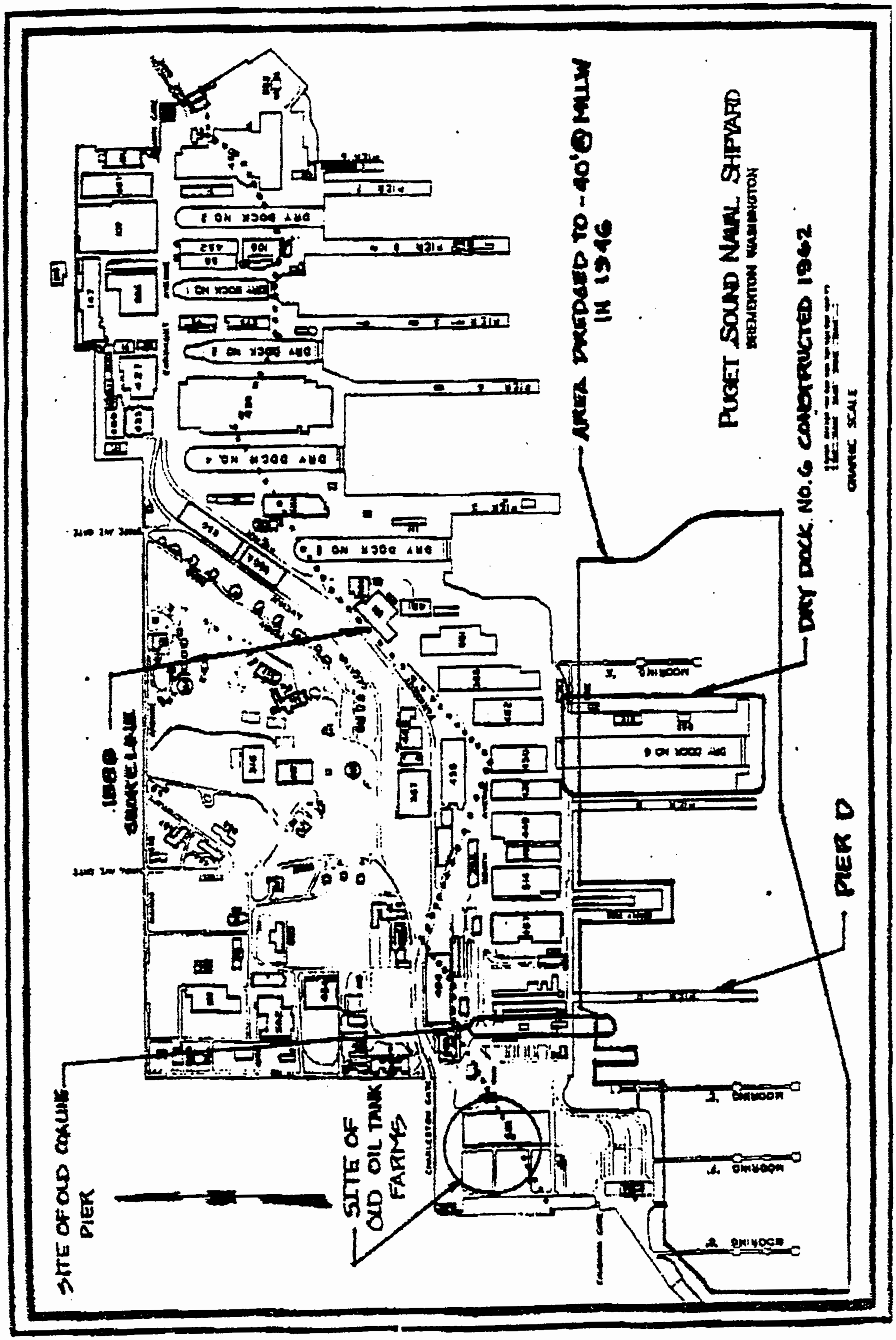


VICINITY MAP



LOCATION MAP

FIGURE 3



PUGET SOUND NAVAL SHIPYARD
BREMERTON WASHINGTON
AREA DREDGED TO -40' @ MLLW IN 1946
DRY DOCK NO. 6 CONSTRUCTED 1962
PIER D
1889 SHORELINE
SITE OF OLD COALING PIER
SITE OF OLD OIL TANK FARMS
GRAPHIC SCALE
DRY DOCK NO 1
DRY DOCK NO 2
DRY DOCK NO 3
DRY DOCK NO 4
DRY DOCK NO 5
DRY DOCK NO 6

2.0 PROGRAM OBJECTIVES AND CONSTRAINTS

The sediment characterization program objectives and constraints are summarized below:

- To characterize sediments to be dredged in conformance with PSDDA requirements to enable the PSDDA agencies to designate approved disposal option(s);

- To optimize the prospect of identifying all Dredged Material Management Units acceptable for disposal at the Elliott Bay PSDDA disposal site while assuring that unacceptable sediments are disposed of at an approved upland site.

- To collect, handle and analyze representative sediment core samples characterizing the full dredging prism in accordance with protocols, timing, and QA/QC requirements outlined in the PSDDA Evaluation Procedures Technical Appendix (June 1988), the updated procedures documented in Chapter 5 and Appendix A of the PSDDA Phase II Management Plan Report (September, 1989), modifications made through the PSDDA and Sediment Management Annual Review Process and procedures presented in PSEP Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound.

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3.0 PROJECT TEAM AND RESPONSIBILITIES

The sediment characterization program will include 1) project planning and agency coordination, 2) field sample collection, 3) laboratory preparation and analysis, 4) QA/QC management and 5) final data report. Staffing and responsibilities are outlined below:

3.1 Project Planning and Coordination. Mr. Peter Ramsey, US Navy Field Engineering Station, Silverdale, WA, will be the overall project manager responsible for developing and completing the sampling program. As the applicant's principal representative he will also provide the primary contact for PSDDA agencies. John Torres, ProTech Consulting, Seattle, WA will assist Mr. Ramsey in technical matters pertaining to the sediment characterization plan and program and its relation to dredging and disposal methods. Following plan approval by the PSDDA agencies, Mr. Torres will be responsible for monitoring and administrative coordination to assure timely and successful completion of the project. Mr. Torres will provide a copy of the approved sampling plan along with the PSDDA-agency approval letter to all sampling and testing subcontractors. Any significant deviation from the approved sampling plan will be coordinated with the Dredged Material Management Office.

3.2 Field Sample Collection. Mr. Jim Bailey, GeoMetrics, Tacoma, WA, will provide overall direction to the field sampling and laboratory analysis programs in terms of logistics, personnel assignments, field operations and analytical laboratory selection. Mr. Brad Smaller, GeoMetrics, will supervise field collection of the sediment core samples. Mr. Smaller will also be responsible for assuring accurate sample positioning; recording sample locations, depths and identification; assuring conformance to sampling and handling requirements including field decontamination procedures; photographing, physical evaluation and logging the samples; and for chain-of-custody of the sample cores until they are delivered to GeoMetrics's sample preparation laboratory.

3.3 Laboratory Preparation and Analyses. The delivered core samples will be physically evaluated, composited and placed in appropriate sample containers by Mr. Jim Bailey or Mr. Brad Smaller and assistants at the GeoMetrics sample preparation laboratory. Appropriate protocols for decontamination, sample preservation and holding times will be observed. Mr. Bailey will be responsible for documenting sample preparation, observations and chain-of-custody up until the time he delivers the samples for analyses to ChemTest, Inc., analytical laboratory in Bothell, WA. He will also instruct the analytical laboratory on the need to maintain required handling and analytic protocols including meeting PSDDA minimum detection limits. Mr. Bailey will ensure that bioassay and archived sediments are stored under proper conditions.

Mr. Mark Havey, Technical Director, at ChemTest will be responsible for physical and chemical analysis. ChemTest will handle and analyze the submitted samples in accordance with PSDDA analytical testing protocols and QA/QC requirements. A written report of analytical results and QA/QC procedures will be prepared by ChemTest and included as an appendix in the final report.

Mr. Timothy Michaels, BioScience, Inc., Edmonds, WA, will be responsible for the sediment bioassay analyses and reporting. BioScience will analyze the submitted samples in accordance with PSDDA biological testing and QA/QC requirements. A written report of analytical results and QA/QC procedures will be prepared by BioScience and included as an appendix in the final report.

3.4 QA/QC Management. Ms. Julia Farr, GeoMetrics, will serve as Quality Assurance Representative for the sediment characterization project. She will perform assurance oversight for both the field sampling and laboratory programs. She will keep fully informed of field program procedures and progress during sample collection and laboratory activities during sample preparation. She will record and correct any activities which vary from the written sampling and analysis plans. She will also review the laboratory analytical and QA/QC data to assure that data is valid and procedures meet the required analytical quality control limits. Upon completion of the sampling and analytical program she will incorporate findings into a QA/QC report.

3.5 Final Data Report. Mr. Jim Bailey, GeoMetrics, will be responsible for preparation of the final sediment characterization report describing sample locations and depths; sampling, handling and analytical methods; QA/QC; and data results.

4.0 SAMPLE COLLECTION AND HANDLING PROCEDURES

4.1 Definitions. The following definitions apply to this sampling program:

- Dredging Prism: the entire volume of sediments to be dredged, including both (east and west) mooring basins, related side-slopes and one-foot overdepth (to -50.4 ft., MLLW).

- Sediment Bore: the entire cumulative length of sediment core extracted by the coring device. This extends from the sediment/water interface down to the total sampling depth of the hole. Each sediment bore is a sampling location identified by number on the sampling plan.

- Core Section: each core section is 4 feet long, except where the total sediment bore (length) leaves a core section less than 4 feet at the bottom of the dredging prism. Core sections for each sediment bore are designated alphabetically, beginning with "A" for the 4-foot surface layer and proceeding downward from the top in 4-foot increments...A, B, C, etc., to the bottom core section. Core sections are composited within Dredge Material Management Units for laboratory analyses.

- Dredged Material Management Unit (DMMU): the volume of dredged material for which a separate decision on suitability for unconfined open-water disposal can be made. DMMUs are typically represented by chemical and biological testing of a single sample, composited from one or more core sections within the DMMU.

- Surface Sediments: sediments located within a 4-foot thick surface layer. Surface sediment samples are represented by core sections designated by the capital letter "A".

- Subsurface Sediments: sediments located beneath the 4-foot layer of surface sediments. Subsurface sediment samples are represented by core sections designated by the capital letters "B", "C", etc.

- "Z" samples: sediments below the dredge prism which will be exposed by dredging and represent the surface that will remain when dredging is completed.

4.2 Number of Samples and Analyses Required. PSDDA ranks all of Sinclair Inlet, including the Pier D dredging area, as an area of high concern for sediment contamination. In accordance with PSDDA requirements, full sediment characterization requirements for a dredging area ranked high concern are outlined below:

Surface Sediments: (0 to 4 ft.)	One core section and one laboratory analysis for each 4000 cubic yards.
Subsurface Sediments: (> 4 ft.)	One core section for each 4000 cyds, and one laboratory analysis for each 12,000 cyds

The estimated total volume of materials to be dredged from both basins is 170,400 cyds, including one-foot overdepth. The quantity and related sampling requirements are distributed as follows:

Depth Interval	Volume (cu.yds.)	Minimum No. of Core Sections	Minimum No. of Analyses
0-4 ft.	77,600	20	20
>4 ft.	92,800	24	8 (composites)
	170,400 (Total)		

<u>4.3 Conceptual Dredging Plan, Sampling and Compositing Scheme.</u> The sampling and analysis program is developed with consideration of site-specific project and environmental factors. A key requirement is assuring that if an individual DMMU (represented by one or more core sections) is found unsuitable for unconfined open water disposal, then that unit can be feasibly dredged independently from surrounding clean sediments so that the contaminated material can be disposed of at an alternate approved upland site. The sampling program for the Pier D dredging project was developed as follows:

- Prepare Conceptual Dredging Plan. Criteria for a dredging plan were established for this site based on the depth and physical characteristics of the sediments, the dredge layout plan including side slopes, appropriate dredging methods and equipment, and conventional construction practices at similar dredging projects in Puget Sound.

- Prepare Sampling Scheme. Basic criteria for selecting sampling locations and compositing for analysis are contained in PSDDA guidance documents relative to sediment volumes to be characterized. The approach is to delineate sediment sampling grid units as basic building blocks for identifying DMMUs capable of being dredged independently.

- Integrate the dredging plan with the sampling and compositing scheme. This step consisted of using judgement to relate the operational aspects of dredging to the compositing scheme to ensure that specific sediment volumes represented by sampling and analytical results can be feasibly dredged independently from adjacent volumes. A primary consideration was to provide common lateral boundaries between the surface DMMUs and the underlying subsurface DMMUs as much as practicable to enable full depth dredging with each dredge setup where sampling results allow use of the same disposal site.

4.3.1 Conceptual Dredging Plan. Criteria for dredging are:

- Dredge by clamshell and bottom-dump barge
- Most practicable dredge cut widths are in the range of 50-90 ft.
- Full box-cutting of dredge slopes will not be allowed along the pier in order to protect the piling from potential slope failure due to overcutting, i.e., the pierside slope will be excavated as close to the 1V-on-4H design slope as practicable.
- Dredged removal of the pierside slope will be conducted by advancing the dredge cut longitudinally along the pier length. This will take advantage of increased bucket control by side swing (compared to more difficult control by raising and lowering the boom as would be required by advancing into the side slope perpendicular to the pier). Advancing parallel to the pier will also enhance operator control by creating a pattern of repetitive excavation along the slope cut in reference to the pier face.
- Remaining dredge cuts will also be oriented longitudinally along the pier, i.e., parallel to the pier face and the pierside slope cut. However, if USN ship movement and/or interim berthing requirements become controlling factors during dredging it is also practicable to orient selected dredge cuts perpendicular to the pier; however, this would require more dredge positioning to initiate the additional cuts and alignments.
- Except for the pierside slope cut (which may require successive passes), the full allowable depth of removal, based on testing results, will be accomplished as the dredge advances into the cut.

4.3.2 Sampling and Compositing Scheme. The basic approach for establishing the sampling array and compositing scheme included the following criteria:

- Array sediment grid units in rows parallel to the dock consistent with the dredging plan.
- Arrange sediment grid units in two rows along each side of the pier to provide testing of at least surface sediments both near and away from the dock.
- Maintain common lateral boundaries between surface and subsurface sediment units as much as practicable to enable full depth dredging where allowed by testing results.
- Where possible utilize the same sediment bore location for characterizing both surface and subsurface sediments.

An additional factor is that ships and barges are moored at Pier D within the area to be sampled. Several can be moved or do not interfere with sampling access. However, movement of two existing mooring combinations would present considerable difficulty and expense:

1. The three-barge installation for personnel berthing located at the southeast corner of Pier D. These barges house approximately 500 Navy personnel and are connected to shoreside utilities (water, electricity, sewage and communications), which would be displaced or disrupted by temporary relocation for sampling access. One of the two outer barges can be drifted shoreward to enable limited sampling access between the barges.

2. The 800+ ft. carrier BON HOMME RICHARD located along the outer west side of Pier D. The procedure for moving the carrier is complex, requiring 3-4 major tugs at an estimated cost of $60-70,000, and is contingent upon locating alternate moorage space that can be temporarily vacated elsewhere on the base.

Because of the considerable difficulty and expense in moving either the two main berthing barges or the carrier, the following sampling and compositing scheme is proposed to provide representative sampling without removing these vessels for sampling access.

<u>Surface Sampling Locations and DMMUs.</u> The first step in defining the sampling grid was to estimate the relative volume distribution for dredging the similar sized basins on each side of Pier D. This analysis showed that surface and subsurface volumes are distributed roughly equally on each side of the pier. Therefore, a minimum of ten core samples and ten DMMUs would need to be located on each side of the pier to satisfy the requirement for a total of 20 surface sediment samples and DMMUs. This allocation is the basis for development of the sampling and compositing scheme for both surface and subsurface sediments as outlined below.

Ten approximately equal-volume rectangular DMMUs were laid out in two rows along each side of the pier to best reflect the dredging approach. Each surface unit is sized to meet the PSDDA requirement of 4000 cu.yds. or less (4 ft. depth of surface layer times average surface area, including side slopes). Each surface DMMU is identified either with an "S", which designates is as a single-station uncomposited DMMU (see Figure 4), or with a "C", which designates it as a composite of samples from two sampling locations.

The sediment core sampling locations are numbered sequentially in Figure 5 and Table I. The sampling location for each surface DMMU was established near the center of the unit except for those units occupied by the berthing barge and outboard of the carrier. Sample No. 10 at the berthing barges is located near the quarter point along the mid-line of the grid area (see Figure 5), and as close to the barge as possible. Note that sampling of surface sediments at location Nos. 13, 14 and 15 occupied by the carrier BON HOMME RICHARD will be collected by diver-operated shallow coring device. Each surface DMMU outboard of the carrier is represented by two core samples (corresponding to subsurface sampling locations, see below).

Estimated sediment volumes represented by each surface DMMU is shown in Table IIA. Surface DMMU estimated volumes range from 3500 cyds to 4000 cyds, and average about 3900 cyds.

Subsurface Sampling Units. The above pattern of surface grid units is also used as the basis for the subsurface sampling, except where floating access by the coring barge is precluded by the carrier BON HOMME RICHARD (diver-sampled surface core locations 13, 14 and 15). For this latter area, rectangular subsurface units are laid out perpendicular to the dock with core sampling locations situated outboard of the carrier hull. The resulting subsurface sampling grid units with corresponding location numbering are shown on Figure 6. Size (surface area) of the perpendicular subsurface units is comparable to that of units not affected by the carrier.

Surface core sections will be collected coincidentally with subsurface coring outboard of the carrier at each of the perpendicular subsurface units sample locations, i.e. at Nos. 18, 19, 20, 21, 22, and 23. Two of these surface core sections will be composited for analysis to represent the related outboard surface DMMU grid units (e.g., surface core sections from bore locations 18 and 19 will be composited for analysis representing surface unit C1; see Figure 4). This will ensure a good spatial representation for these DMMUs.

Subsurface DMMUs. Subsurface DMMUs were designated by aggregating adjacent subsurface sampling units (Figure 6) into eight composites for subsurface analyses. The resulting eight subsurface DMMUs are shown in Figure 7. This subsurface compositing scheme was developed in consideration of the dredging plan and the above sampling and compositing criteria and limitations.

The subsurface DMMU compositing scheme and related estimated sediment volumes are shown in Table IIB. Estimated sediment volumes for subsurface DMMUs range from 9300 cyds to 13,000 cyds, and average about 11,600 cyds.

It is noted that four composite samples (C5, C6, C7 and C8) slightly exceed the 12,000 cyd general compositing criteria for dredging areas designated high concern by PSDDA, although the PSDDA basic criteria is satisfied by the number of composites (8) and the average volume represented by DMMUs (11,700 cyds). In addition, such exceedance appears justified based on the following:

- The required eight DMMU composites are laid out to support the most practicable dredging plan by observing cuts parallel to the pier and maximizing common lateral boundaries between surface and subsurface DMMUs, except where subsurface units accommodate the BON HOMME RICHARD.

- Essentially all of the subsurface sediment lies below the previously dredged depth of -40 ft., MLLW. Since none of the sediment volume in these subsurface DMMUs has been dredged previously, the subsurface sediments are judged native materials.

- The amount of exceedance for any composite is minor, less than 10 percent.

Core Sampling Characteristics. Consistent with PSDDA guidance, sediment bores at each common surface/subsurface sampling location will be taken from the sediment-water interface down to a depth of -50.4 ft., MLLW, i.e., to the full design depth of -49.4 ft. plus one foot overdepth. Surface core sections at location Nos. 13, 14 and 15 will be taken by diver-operated core sampling to a depth of 4-feet. Sediment bore characteristics and core section designations are summarized in Table I.

In addition, PSDDA recommends that in high-ranked areas, where the potential exists for leaving subsurface sediments exposed which are more contaminated than the present surface sediments, one-foot cores beyond overdepth will be collected from and archived at each subsurface boring location. For this project, the archived depth would be from -50.4 ft. to -51.4 ft. Each archived sample will be placed in its own jar and stored at -20^{o}C for up to six months after sample collection. These samples will be available for future reference should it become necessary to characterize sediments to be exposed after dredging. Archived samples will be labelled "Z" followed by the boring number.

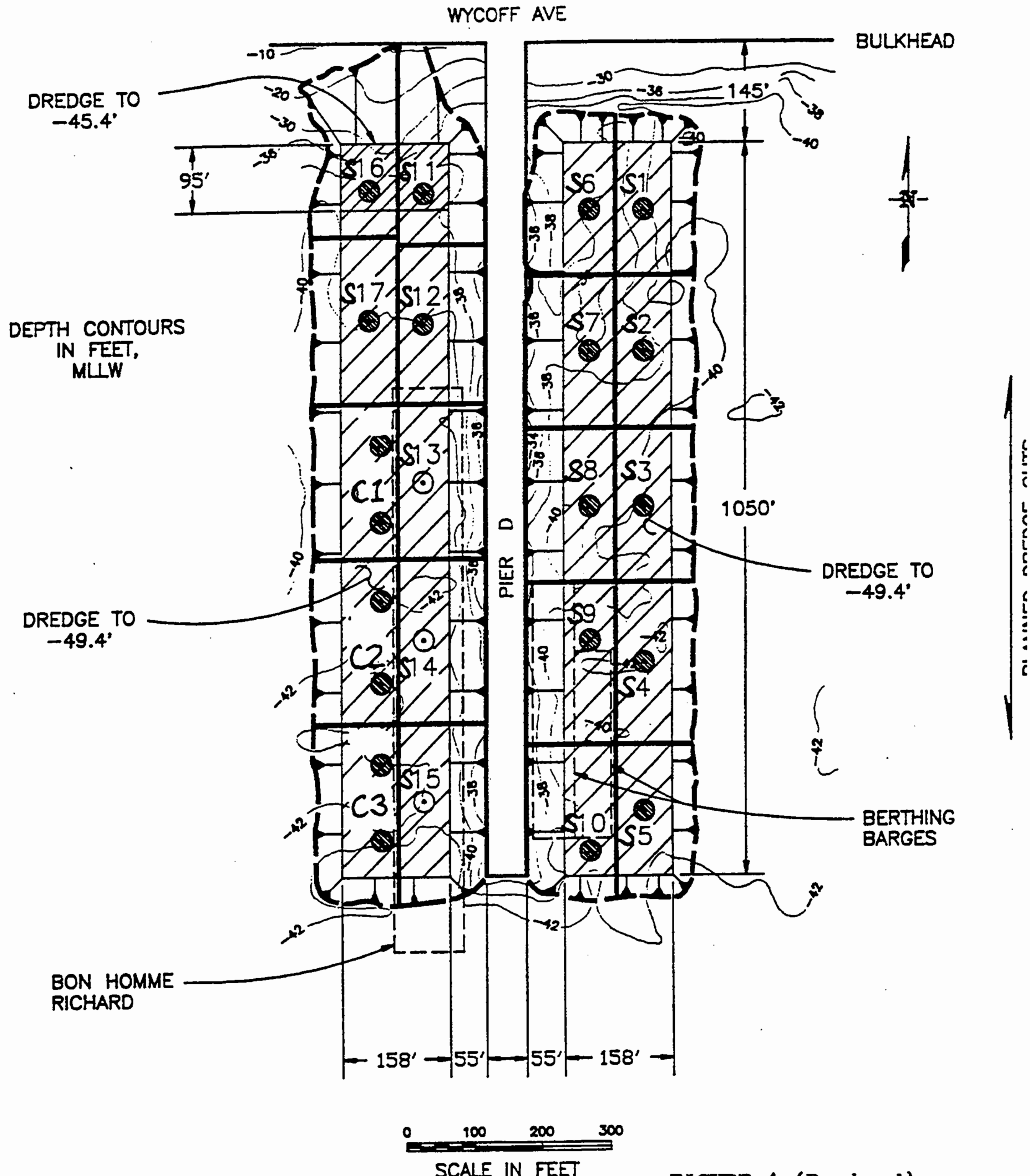


FIGURE 4 (Revised)

SURFACE

⊙ SURFACE CORE (TOP 4')

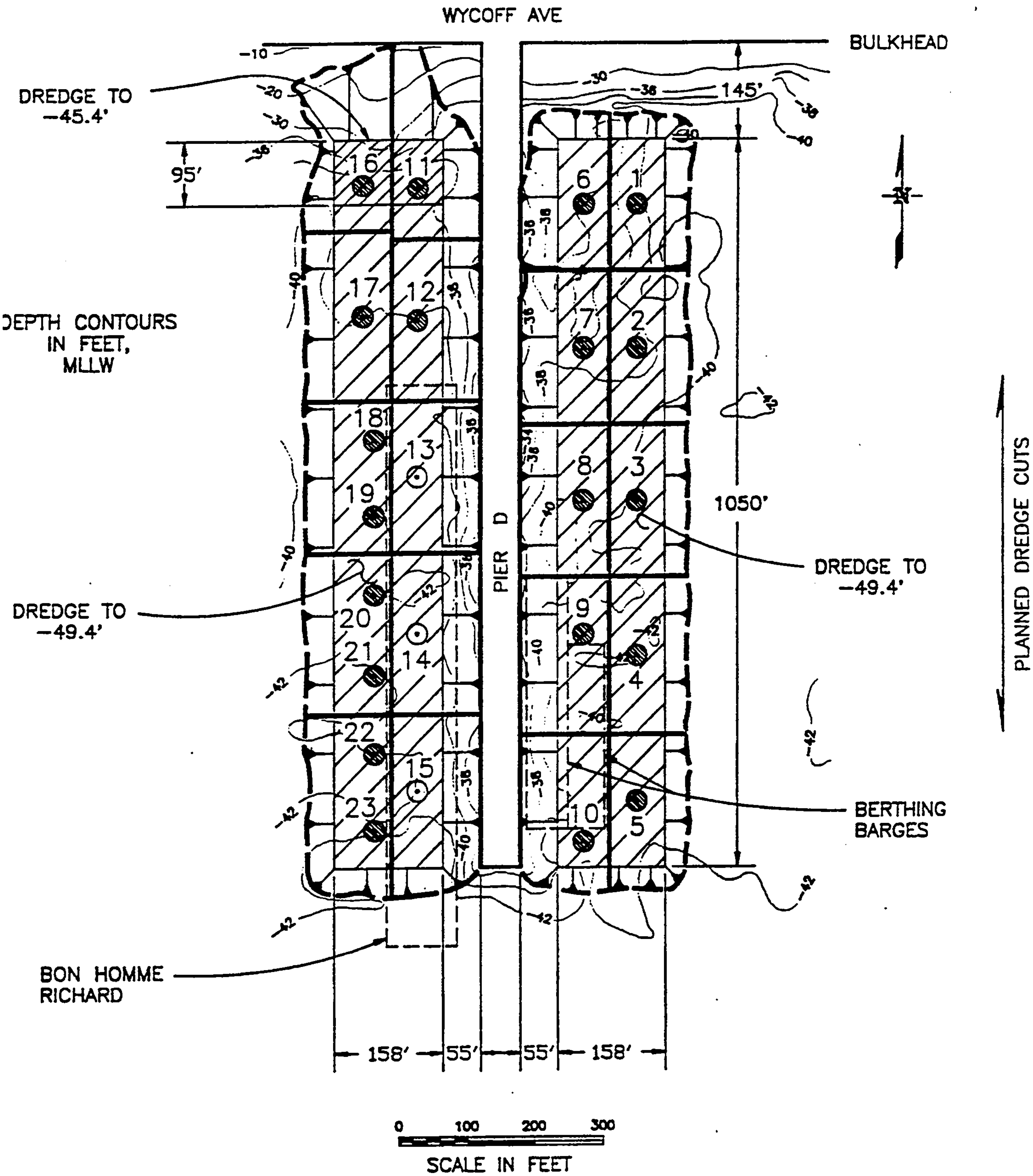
● FULL DEPTH CORE (SURFACE & SUBSURFACE)

USN PUGET SOUND NAVAL SHIPYARD
BREMERTON, WA

PIER D DREDGING
SEDIMENT UNITS & SAMPLING LOCATIONS

FIGURE 4

(REVISED 3/18/9



SURFACE

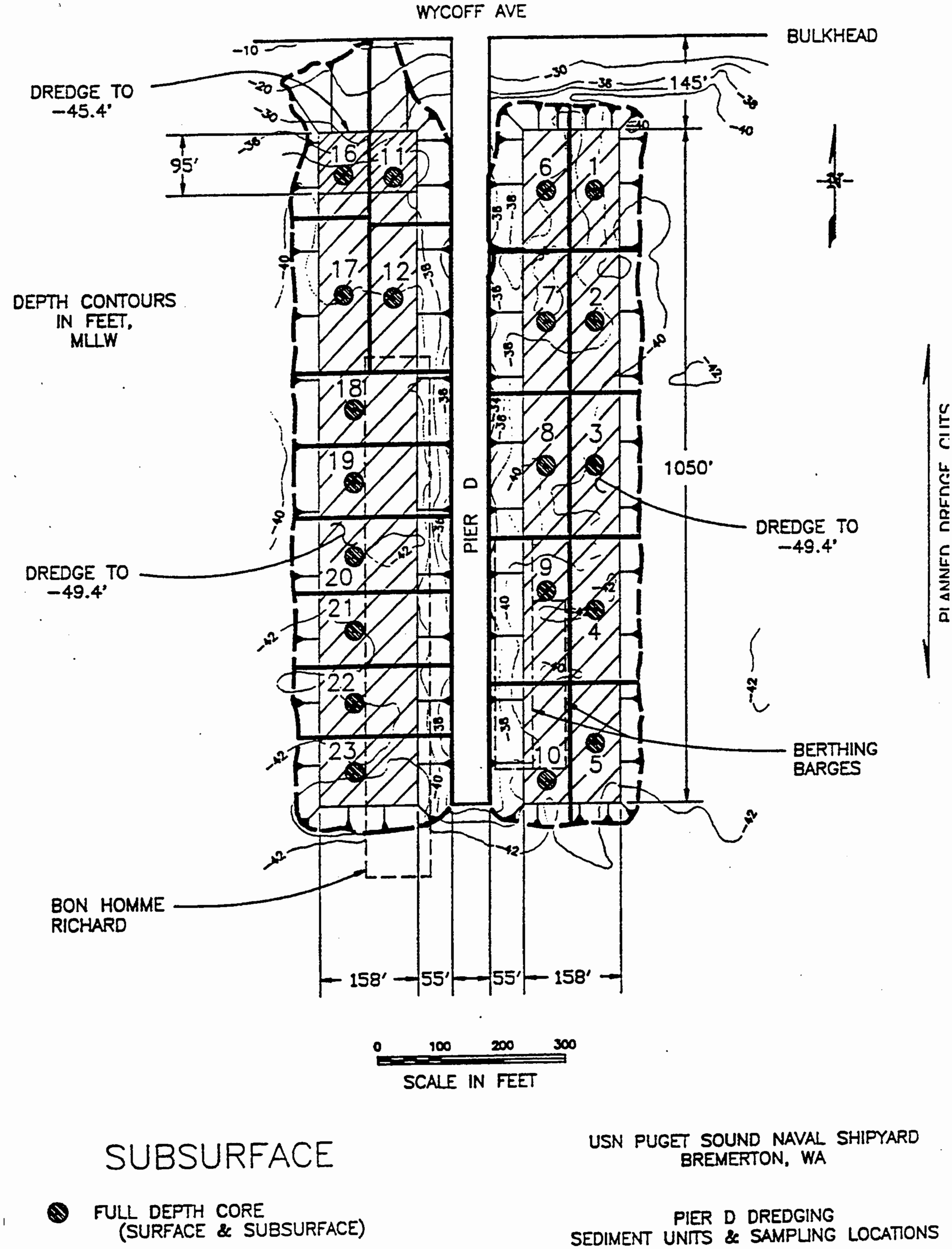
USN PUGET SOUND NAVAL SHIPYARD
BREMERTON, WA

PIER D DREDGING
SEDIMENT UNITS & SAMPLING LOCATIONS

FIGURE 5

SURFACE CORE (TOP 4')

FULL DEPTH CORE
(SURFACE & SUBSURFACE)

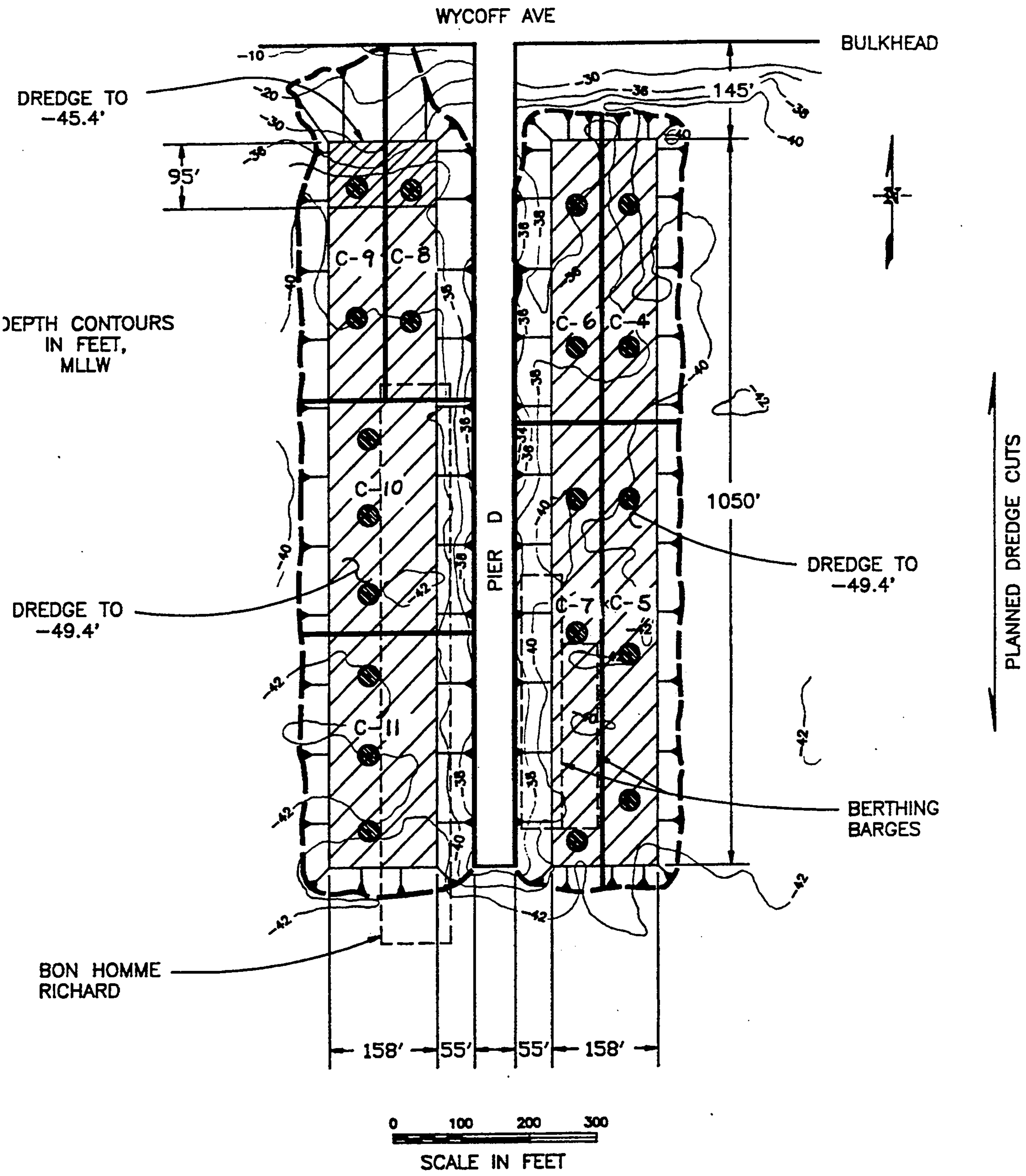


SUBSURFACE

USN PUGET SOUND NAVAL SHIPYARD
BREMERTON, WA

PIER D DREDGING
SEDIMENT UNITS & SAMPLING LOCATIONS

FIGURE 6



SUBSURFACE COMPOSITES

CORE SAMPLE LOCATION

USN PUGET SOUND NAVAL SHIPYARD
BREMERTON, WA

PIER D DREDGING
SEDIMENT UNITS & SAMPLING LOCATIONS

FIGURE 7

TABLE I:

USN PSNS PIER D DREDGING
SEDIMENT BORE CHARACTERISTICS AND CORE SECTIONS
(depths in feet referenced to MLLW)

Sediment Bore Number	Existing Bottom Depth	Length of Sediment Bores (to nearest ft., dredge to -50.4')	Core Section Designations and Depths
1	-39.5	11	A -39.5 to -43.5 B -43.5 to -47.5 C -47.5 to -50.4
2	-37.6	13	A -37.6 to -41.6 B -41.6 to -45.6 C -45.6 to -49.6 D -49.6 to -50.4
3	-40.1	10	A -40.1 to -44.1 B -44.1 to -48.1 C -48.1 to -50.4
4	-42.0	8	A -42.0 to -46.0 B -46.0 to -50.0 C -50.0 to -50.4
5	-40.8	10	A -40.8 to -44.8 B -44.8 to -48.8 C -48.8 to -50.4
6	-38.0	12	A -38.0 to -42.0 B -42.0 to -46.0 C -46.0 to -50.0 D -50.0 to -50.4
7	-37.0	13	A -37.0 to -41.0 B -41.0 to -45.0 C -45.0 to -49.0 D -49.0 to -50.4
8	-40.0	10	A -40.0 to -44.0 B -44.0 to -48.0 C -48.0 to -50.4
9	-41.5	9	A -41.5 to -45.5 B -45.5 to -49.5 C -49.5 to -50.4
10	-41.4	9	A -41.4 to -45.4 B -45.4 to -49.4 C -49.4 to -50.4
11	-38.8	12	A -38.8 to -42.8 B -42.8 to -46.8 C -46.8 to -50.4
12	-40-1	10	A -40.1 to -44.1 B -44.1 to -48.1 C -48.1 to -50.4
13	-41.0	4	A -41.0 to -45.0
14	-41.1	4	A -41.1 to -45.1

15	-41.8	4	A -41.8 to -45.8

16	-39.8	11	A -39.8 to -43.8 B -43.8 to -47.8 C -47.8 to -50.4
17	-40.0	10	A -40.0 to -44.0 B -44.0 to -48.0 C -48.0 to -50.4
18	-41.1	9	A -41.1 to -45.1 B -45.1 to -49.1 C -49.1 to -50.4
19	-40.8	10	A -40.8 to -44.8 B -44.8 to -48.8 C -48.8 to -50.4
20	-41.7	9	A -41.7 to -45.7 B -45.7 to -49.7 C -49.7 to -50.4
21	-42.0	8	A -42.0 to -46.0 B -46.0 to -50.0 C -50.0 to -50.4
22	-42.0	8	A -42.0 to -46.0 B -46.0 to -50.0 C -50.0 to -50.4
23	-42.0	8	A -42.0 to -46.0 B -46.0 to -50.0 C -50.0 to -50.4

TABLE II:

PIER D SAMPLE COMPOSITING SCHEME

A. SURFACE SEDIMENTS (top 4 ft. of dredge prism)

DMMU AND SAMPLE IDENTIFICATION		DMMU Volume Represented (cubic yards)
DMMU (Grid Unit No.)	SAMPLE (Core Section)	
S1	1A	3900
S2	2A	3900
S3	3A	3700
S4	4A	3900
S5	5A	3500
S6	6A	4000
S7	7A	4000
S8	8A	3900
S9	9A	3900
S10	10A	3800
S11	11A	3500
S12	12A	4000
S13	13A	4000
S14	14A	4000
S15	15A	4000
S16	16A	4000
S17	17A	4000
C1	18A & 19A	3800
C2	20A & 21A	3900
C3	22A & 23A	3900

B. SUBSURFACE SEDIMENTS (remainder of dredge prism)

Composite Sample I.D. No.	Samples Composited (by Core section)	DMMU Volume Represented (approx. Cy)
C4	1B, 1C, 2B, 2C, 2D	11,600
C5	3B, 3C, 4B, 4C, 5B, 5C	13,000
C6	6B, 6C, 6D, 7B, 7C, 7D	12,300
C7	8B, 8C, 9B, 9C, 10B, 10C	12,800
C8	11B, 11C, 12B, 12C	9,300
C9	16B, 16C, 17B, 17C	11,100
C10	18B, 18C, 19B, 19C, 20B, 20C	12,400
C11	21B, 21C, 22B, 22C, 23B, 23C	11,300

4.4 Field Sampling Schedule. The field sampling schedule is constrained by the shortest sample holding time (seven days). To safely meet the holding times for composited samples, the field samples will be composited and delivered for laboratory testing within three days of sampling the first core section within each composite. Sampling will generally proceed by completing all coring within a given subsurface composite (up to three sampling locations) before proceeding to bore locations for the next composite. Based on a review of the limited available sediment data and expected logistic considerations, it is projected that up to three full depth sediment bores can be completed per sampling day. The entire core-sampling program is expected to be completed within 10 working days.

Initiation of core sampling will be preceded by cleanup and other preparation of sample coring and handling equipment in the GeoMetrics laboratory, acquisition of appropriate EPA-approved decontaminated sample containers from the analytic laboratories, on-site establishment of positioning references and tide gage by the surveyor, and mobilization of the drill barge to the site.

4.5 Field Operations and Equipment. The field crew and equipment will be mobilized from GeoMetrics's Tacoma Office.

The field crew will make sure all equipment is in good working order prior to collection of cores. Program plans will be developed and final arrangements made for logistics and field operations. The drill barge will mobilize from Bainbridge Island to Bremerton.

4.5.1 Drill Barge. The drill barge to be employed for the coring program will be provided by GeoTechnica, Inc., of Des Moines, Washington. The barge is a 70.9 foot by 24.4 foot self-contained coring and sampling vessel with a moon-pool opening for drill deployment and a four-point anchor winch system. The vessel has about 1500 square feet of working deck space and adequate power and electronics to work self-contained. A tender tug and a power skiff will also be available full time to provide logistical and anchoring support.

4.5.2 Navigation and Positioning. The station location will be referenced to the drill casing during sampling, and will be accomplished by the range-azimuth method. Distances will be measured from known references using an EDM (electronic distance measurement), and horizontal angles from established points and baseline(s) will be measured using a surveying theodolite. Elevations will be referenced to local MLLW (NOAA) and corrected using the tide gage. Horizontal coordinates will be referenced to Washington Coordinate System for proper North or South Zones NAD 83 (North American Datum 1983). Horizontal coordinates will be converted and identified as latitude and longitude (NAD 83) to the nearest 0.1 second.

Diver collected core sample locations will be determined underwater using taped distance from the sampling point to at least two fixed (known) reference points.

These systems are expected to document sampling locations to +/- 3 meters accuracy to allow the dredge to discretely remove different DMMUs (Phase I EPTA, Sect. 4.4.1, 1988).

4.5.3 Sample Collection Techniques. Samples will be collected using a barge-mounted, hollow-stem auger drilling rig equipped with a Gregory sampler. The hydraulically operated barge coring system acquires marine sediment cores up to two feet long in shallow water. The Gregory sampler uses compressed nitrogen to push the sampling tube into the sediments. Shelby tubes will be used for sampling and will be made of stainless steel. Tubes are 2.0 ft. long with 3-inch-outside diameters and were selected based on the type of sediments expected at the project site. The thin wall of the Shelby tube is suited for soft silts and sands, since they can be pushed or driven into the material with limited disturbance. Thicker-walled samplers used in denser soils increase the lateral displacement of the material in the sampling area; sample recovery may be reduced and inflow of the material into the casing (heaving) may be increased. Heaving will be controlled by maintaining positive pressure in the drill head.

Casing will be installed from the deck surface to the mud line. The first sample will be collected from zero to two feet of depth. The casing will then be advanced to the bottom of the sample depth and the next two-foot sample will be taken. These two subsamples will be labelled "A1" and "A2" on the boring logs. The subsamples will be composited in the GeoMetrics lab and labeled "S" (for single-station, single-stratum), as stated previously for surface samples.

This method of sampling, retrieval and casing advancement at two foot intervals will be utilized until the total sample depth (-51.4 feet) is reached. The recovered subsurface core-segments will be labeled in alphabetical order starting with "B". There will be two cores for each letter, except in those cases where the deepest core is two feet long or less. Laboratory compositing will follow the scheme presented in Table II. Compositing will be performed in GeoMetrics' Tacoma facility.

For the three diver-collected surface cores beneath the carrier Bon Homme Richard, (Nos. 13, 14 and 15), a four foot long sediment sampling tube assembly will be hand-inserted by the divers.

4.6 Sample Collection and Handling Procedures. All sampling tubes and cutter heads will be thoroughly cleaned prior to use according to the following procedure:

- Hot Water Rinse
- Wash with brush and Alconox soap
- Double Rinse with distilled water
- Rinse with nitric acid
- Rinse with deionized water
- Rinse with methanol

After cleaning, all core tubes will be foil wrapped and capped to limit the risk of contamination. Caps will only be removed as the tubes are loaded onto the sampling device. Once the cap has been removed, a final wash as defined above will be performed at the cutter head just prior to deployment. For the diver-collected surface cores, the protective cutter head cap and wrapper will be removed underwater upon inserting the core tube. Sufficient extra sampling tubes will be available on-site to allow for uninterrupted operations should a sampling tube become contaminated. The rule of "potential for contaminants" will be used such that any sampling tube suspected of contamination will be rejected and recycled on shore for use later in the program.

As samples are taken, logs and field notes of all core samples will be maintained and correlated to the sampling location map. Included in this log will be the following:

- Elevation of each boring station sampled as measured from mean lower low water (MLLW NAD83). This will be accomplished using a lead line to determine depth at the sampling location referenced to an on-site tide gage set to MLLW.
- Date and time of collection of each sediment bore sample.
- Names of field supervisor and person(s) collecting and logging in the sample.
- Weather conditions.
- The sample station number as derived from Table I and Figures 4 and 5, and individual designation numbers assigned for each individual core section.
- Length and depth intervals of each core section and recovery for each sediment sample as measured from MLLW.
- Qualitative notation of apparent resistance of sediment column to coring.
- Any deviation from the approved sampling plan.

During deployment and retrieval of the coring device, care will be taken to ensure that the cutter head or end of the core tube does not come into contact with the vessel. Once on deck, the cutter head will be inspected and a physical description of the material at the mouth of the core will be entered into the core log. The cutter head will be removed and a cap will be placed over the end of the tube and secured firmly in place with duct tape. The core will then be removed from the sampler and the other end of the core will be capped and taped. A label identifying the core will be securely attached to the outside of the core and wrapped with transparent tape to prevent loss or damage of the label. The core sections will be stored on their sides on Blue Ice in coolers. Three 12-cubic-foot coolers will be on board, with enough capacity to handle 40 2-foot core sections. The cores will be sealed tightly enough to prevent leakage.

4.7 Sample Transport and Chain-of-Custody Procedures. At the end of each day the cores will be transferred to GeoMetrics compositing facility. Chain-of-custody procedures will commence onboard the sampling barge and will track delivery of each of the cores to the GeoMetrics laboratory. Specific procedures are as follows:

- Samples will 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.

- The coolers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the cooler and GeoMetrics' office name and address) to enable positive identification.

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

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

Upon transfer of sample possession to the compositing laboratory, the chain-of-custody form will be signed by the persons transferring custody of the coolers. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the condition of the samples will be recorded by the receiver. Chain-of-custody forms will be used to track the compositing of individual core samples.

4.8 Sample Compositing and Subsampling.

4.8.1 Decontamination. Prior to each day's use, sediment compositing equipment in the soils laboratory (including stainless steel mixing bowls, extrusion tray, sampling spoons and core splitter) will be scrubbed with sponges and/or nylon scrubbers in a solution of laboratory grade non-phosphate based soap and potable water. Following initial scrubbing, all soap and dirt will be removed by successive rinses of distilled water, rinsed with nitric acid, deionized water and methanol. Volatiles sampling utensils will not receive the nitric acid or methanol rinse.

All hand work (using the core extrusion dowel and core splitter, and stainless steel spoons for extracting the sample from the split cores, mixing the samples and filling sample containers) will be conducted with disposable latex gloves which will be rinsed with distilled water before and after handling each individual sample, as appropriate, to prevent sample contamination. Gloves will be disposed of between composites to prevent cross contamination between the DMMUs.

4.8.2 Extrusion. For each individual laboratory sample, the core sections comprising that sample will have their sealed caps removed one-by-one for extrusion. The sediment from each sample tube will be extruded onto a stainless steel tray using a foil-covered wooden dowel. The sample will be disturbed as little as possible when extruding. The foil covering on the dowel will be replaced between composites. Upon extrusion, the core will be split with a decontaminated stainless steel wire core splitter.

4.8.3 Volatiles and Sulfides Subsampling. Volatile and sulfides subsamples will be removed immediately upon extrusion and splitting, and prior to compositing (volatiles and sulfides could be lost while compositing), from one randomly chosen core representing each composite. For example, for a composite consisting of 6 core samples, one of the 6 would be chosen (using a random numbers table) for volatiles and sulfides subsampling prior to any other processing. Volatiles and sulfides subsamples will be taken simultaneously from the representative sampling core section by two laboratory staff members. Subsamples will be taken along the entire length of the representative core section, from sediment which has not had contact with the core lining.

(Samples will not be taken from "Z" cores as these are to be archived for possible analysis at some later time, at which time volatiles and sulfides would not be required to be analyzed.)

Two separate 4-ounce containers will be completely filled with sample sediment for volatiles. No headspace will 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) will be washed with detergent, rinsed once with tap water, rinsed at least twice with distilled water, and dried at >105 C. A solvent rinse will 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 will be filled to overflowing so that a convex meniscus forms at the top. Once sealed, the bottle will be inverted to verify the seal by demonstrating the absence of air bubbles. If there is little or no water in the sediment, jars will be filled as tightly as possible, eliminating obvious air pockets. With the cap liner's PTFE side down, the cap will be carefully placed on the opening of the vial, displacing any excess material.

For sulfides sampling, 8 mls of 2N zinc acetate will be placed in a 4-ounce sampling jar. The sulfides sample (approximately 50 g) will be placed in the jar, covered, and shaken vigorously to completely expose the sediment to the zinc acetate.

The volatiles and sulfides sampling jars will 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 will indicate that zinc acetate has been added as a preservative.

Table III contains those cores, randomly selected, which will be used to collect representative sediment for volatiles and sulfides sampling.

TABLE III:

RANDOM CORES FOR VOLATILES AND SULFIDES SUBSAMPLING

DMMU AND RANDOM CORE IDENTIFICATION	
DMMU	**RANDOM CORE SECTION**
S1	1A1
S2	2A1
S3	3A2
S4	4A1
S5	5A2
S6	6A2
S7	7A1
S8	8A2
S9	9A2
S10	10A2
S11	11A1
S12	12A2
S13	13A1
S14	14A1
S15	15A2
S16	16A1
S17	17A1
C1	19A1
C2	20A1
C3	23A1
C4	2C1
C5	3B2
C6	7D1
C7	9B1
C8	12C1
C9	16B2
C10	20B2
C11	23B1

4.8.4 Core Logging. After volatiles and sulfides subsampling, each discrete core section will then be color photographed. A sediment description of each core sample will be recorded on the core log for the following parameters as appropriate and present:

- Sample recovery
- Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, color)
- Odor (e.g., hydrogen sulfide, petroleum)
- Visual stratifications and lenses
- Vegetation
- Debris
- Biological Activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
- Presence of oil sheen
- Any other distinguishing characteristics or features

4.8.5 Compositing and Other Subsampling. Samples will then be composited by GeoMetrics in accordance with the compositing plan shown in Table II and PSDDA protocols. For subsurface composite samples, equal volumes of sediment will be removed from each core section comprising a composite. Sediments representing each composite sample will be placed in a stainless steel bowl and mixed using stainless steel mixing spoons. The composited sediment in the stainless steel bowl will be mixed until homogenous and will continue to 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 six liters of homogenized sample will 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. Both chemistry and bioassay samples will be taken from the same homogenate. Portions of each composite sample will be placed in appropriate containers obtained from the chemical and biological laboratories. See Table IV for container and sample size information. For "Z" cores, a 250 ml glass jar will be filled and frozen for possible future analysis.

Approximately 19 additional liters of sediment would be required for bioaccumulation testing. This additional volume will not be collected at this time. If a BT is exceeded, and the Navy decides to pursue biological testing, additional sediment will be collected prior to bioaccumulation testing. The Navy balanced the costs involved with collecting large volumes of additional sediments for each DMMU immediately, versus the costs of a resampling effort, and decided on the latter strategy.

TABLE IV:

SAMPLE STORAGE CRITERIA

Sample Type	Holding Time	Sample Size[a]	Temperature[c]	Container	Archive[b]
Particle Size	6 Months	100-200g (150 ml)	4°C	1-liter Glass (combined)	
Total Solids	14 Days	125g (100 ml)	4°C		X
Total Volatile Solids	14 Days	125 g (100 ml)	4°C		
Total Organic Carbon	14 Days	125 g (100 ml)	4°C		
Ammonia	7 Days	25 g (20 ml)	4°C		
Metals (except Mercury)	6 Months	50 g (40 ml)	4°C		
Semivolatiles, Pesticides and PCBs	14 Days until extraction 1 Year until extraction 40 Days after extraction	150 g (120 ml)	4°C -18°C 4°C		
Total Sulfides	7 Days	50 g (40 ml)	4°C[d]	125 ml Plastic	
Mercury	28 Days	5 g (4 ml)	-18°C	125 ml Glass	
Volatile Organics	14 Days	100 g (2-40 ml jars)	4°C	2-40 ml Glass	
Bioassay	8 Weeks	4 L	4°C	6-1 liter Glass	
Bioaccumulation	8 Weeks	19[e]	4°C	8-1 liter Glass	

a. 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.

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

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

d. The sulfides sample will be preserved with 5 ml of 2 Normal zinc acetate per 30 g of sediment.

e. Depends on which two species are used. *Macoma* test requires about 8 L/treatment, *Nereis* test requires about 10 L/treatment, and *Arenicola* test requires about 1 L/treatment.

After placement, each sample will have chain-of-custody labels attached and will be stored at approximately 4°C until withdrawn for analysis. Each sample reserved for bioassays will be stored at 4°C in a nitrogen atmosphere, i.e., nitrogen gas in the container headspace, for up to 56 days pending initiation of any required biological testing. Each sample container will 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.

4.9 Sample Transport and Chain-of-Custody Procedures. All containerized sediment samples will be transported to the analytical laboratory after compositing is completed. Specific sample shipping procedures will be as follows:

- Each cooler or container containing the sediment samples for analysis will be delivered to the laboratory within 24 hours of being sealed.
- Samples will 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.
- Individual sample containers will be packed to prevent breakage and transported in a sealed ice chest or other suitable container.
- The shipping containers will 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.
- Glass jars will be separated in the shipping container by shock absorbent material (e.g., bubble wrap) to prevent breakage.
- Ice will be placed in separate plastic bags and sealed.
- A sealed envelope containing chain-of-custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
- Signed and dated chain-of-custody seals will be placed on all coolers prior to shipping.

Upon transfer of sample possession to the analytical laboratory, the chain-of-custody form will be signed by the persons transferring custody of the sample container. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the condition of the samples will be recorded by the receiver. Chain-of-custody forms will be used internally in the lab to track sample handling and final disposition.

5.0 LABORATORY PHYSICAL AND CHEMICAL SEDIMENT ANALYSIS

5.1 Laboratory Analyses Protocols. Laboratory testing procedures will be conducted in accordance with the PSDDA Evaluation Procedures Technical Appendix, June 1988; the PSDDA Phase II Management Plan Report, September 1989; and with the PSEP Recommended Protocols. Several details of these procedures are discussed below.

5.1.1 Chain-of-custody. A chain-of-custody record for each set of samples will be maintained throughout all sampling activities and will accompany samples and shipment to the laboratory. Detailed information on chain-of-custody is in Section 4.9.

5.1.2 Limits of Detection. The surface and subsurface composite samples identified in Section 4.2 and Tables IIA and IIB will be analyzed for all the parameters listed in Appendix D and for grain size distribution. The preparation procedures, test methods, method detection limits to be achieved by the analytical laboratory, and PSDDA screening levels are also identified in Appendix D. Detection limits of all chemicals of concern must be below PSDDA screening levels. Failure to achieve this may result in a requirement to reanalyze or perform bioassays. The testing laboratory will be specifically cautioned by the GeoMetrics sampling and analysis director to make certain that it complies with the PSDDA detection limit requirements. All reasonable means, including additional cleanup steps and method modifications, will be used to bring all limits-of-detection below PSDDA SLs. In addition, an aliquot (8 oz) of each sediment sample for analysis will be archived and preserved at -18 C for additional analysis if necessary.

The following scenarios are possible and will be handled appropriately:

1. One or more chemicals-of-concern (COC) have limits of detection exceeding screening levels while all other COCs are quantitated or have limits of detection at or below the screening levels: the requirement to conduct biological testing would be triggered solely by limits of detection. In this case the chemical testing subcontractor will do everything possible to bring limits of detection 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 will be directed to contact the Dredged Material Management Office.

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

3. One or more COCs have limits of detection exceeding SL <u>and</u> exceeding BT or ML, <u>and</u> other COCs have <u>quantitated</u> concentrations above screening levels: the need to do bioassays is based on the detected exceedances of SLs but all other limits of detection must be brought below BTs and MLs to avoid the requirement to do bioaccumulation testing or special

biological testing. As in case i) everything possible will be done to lower the limits of detection.

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 chronic sublethal testing data. In the absence of chronic sublethal data, problems with limits of detection 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 will be kept under proper storage conditions until the chemistry data is deemed acceptable by the PSDDA agencies.

5.1.3 Sediment Conventionals. All conventional parameters will be analyzed. Particle grain size distribution for each composite sample will be determined in accordance with ASTM D 422 (modified). Wet sieve analysis will be used for the sieve sizes U.S. No. 4, 10, 20, 40, 60, 140, 200 and 230. Hydrogen peroxide will not be used in preparations for grain-size analysis. (Hydrogen peroxide breaks down organic aggregates and its use may provide an overestimation of the percent fines found in undisturbed sediment. Incorrect grain size matches could result when reference sediments are collected.) Hydrometer analysis will used for particle sizes finer than the 230 mesh. Water content will be determined using ASTM D 2216. Sediment classification designation will be made in accordance with U.S. Soil Classification System, ASTM D 2487.

5.1.4 Holding Times. The tiered testing option will be implemented for biological testing (see Section 6, Biological Testing). To the maximum extent practicable all chemical results will be provided within 28 days of sampling to allow a timely decision for tiered biological testing. Sediment samples reserved for potential bioassays will be stored under chain-of-custody at GeoMetrics's laboratory.

All samples for physical, chemical and biological testing will be maintained at the testing laboratory at the following temperatures and analyzed prior to the expiration times specified in Table IV.

5.1.5 Quality Assurance/Quality Control. The chemistry QA/QC procedures found in Table V will be followed.

5.2 Laboratory Written Report. A written report will be prepared by the analytical laboratory documenting all the activities associated with sample analyses. As a minimum, the following will be included in the report:

- Results of the laboratory analyses and QA/QC results.

- All protocols used during analyses.

- Chain of custody procedures, including explanation of any deviation from those identified herein.

- Any protocol deviations from the approved sampling plan.

- Location and availability of data.

- QA2 data required by Ecology for the SEDQUAL database.

As appropriate, this sampling plan may be referenced in describing protocols.

TABLE V:

MINIMUM LABORATORY QA/QC

ANALYSIS TYPE	METHOD BLANKS[4]	DUPLI-CATES[4]	CRM[5]	MATRIX SPIKE[4]	SURRO-GATES[1]
Volatile Organics[2,3]	X	X[7]		X	X
Semivolatiles[2,3]	X	X[7]	X[6]	X	X
Pesticides/PCBs[2,3]	X	X[7]	X[6]	X	X
Metals	X	X	X	X	
Ammonia	X	X			
Total Sulfides	X	X			
Total Organic Carbon	X	X	X[7]		
Total Solids		X			
Total Volatile Solids		X			
Particle Size		X			

1. Surrogate spikes required for every sample, including matrix spiked samples, blanks and reference materials

2. Initial calibration required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet criteria.

3. Ongoing calibration required at the beginning of each work shift, every 10-12 samples or every 12 hours (whichever is more frequent), and at the end of each shift

4. Frequency of Analysis (FOA) = one per extraction batch; batches limited to 20 samples

5. Certified Reference Material

6. Sequim Bay Reference (one replicate)

7. Matrix spike duplicate will be run

6.0 BIOLOGICAL TESTING

6.1 Bioassay Laboratory Protocols. The tiered testing approach will be used. Biological testing will be undertaken on any composite sample which has one or more chemicals of concern above the PSDDA screening level (SL) but below the PSDDA maximum level (ML), although a sample with a single ML exceedance which is less than or equal to two times the ML still qualifies for biological testing. If any COC exceeds a bioaccumulation trigger (BT), a decision will be made as to whether or not to pursue biological testing, which would include the standard suite of PSDDA bioassays plus bioaccumulation testing with Macoma. To the maximum extent practicable, chemical results will be provided for bioassay decisions within 28 days of first sample collection. The remaining four week (28 day) period will allow time for bioassay preparation as well as time for retests if necessary.

The DMMO project manager will be kept informed of analytical progress to support bioassay decisions. His active participation and judgement are considered vital to final decisions. Bioassay testing requires that test sediments be matched and run with an appropriate PSDDA-approved reference sediment to factor out sediment grain-size effects on bioassay organisms. The approach to selecting reference sediment samples is outlined below:

- Highest priority by ChemTest will be the sieve analysis portion of grain size determination to identify the proportions of fines (hydrometer analysis for clay size distribution will be conducted later). These early results are expected to support selection of the reference sediment(s).

- Ammonia and sulfides analysis will also be expedited to provide a basis to evaluate the need for aeration in the sediment larval test.

- Sample collection is scheduled to be completed within about 10 days. Regardless, on or before about day 15 all available grain size information will be collated and reviewed by GeoMetrics and BioTesting. Based on this analysis a recommendation on appropriate reference sediment will be made to the DMMO project manager. The DMMO will coordinate the reference sediment selection with the other PSDDA agencies.

- BioTesting will collect the identified reference sediments as soon as possible. The guidance received by DMMO will assist BioTesting in locating a suitably matched reference sediment. Wet-sieving in the field, however, is essential in finding an adequate match. The location of the reference sediment sampling location will be recorded to the nearest 0.1 second.

All sediment samples for potential bioassays will be stored at 4°C, pending completion of chemical analyses and initiation of any required biological testing. All bioassay analyses, including retests, will commence within 56 days after collection of the first core section in the sediment composite to be analyzed. Chain-of-custody procedures will be maintained by the laboratory throughout biological testing.

Bioassay testing will be pre-planned to initiate appropriate testing as soon as possible after the first chemical results become available and the decision is made to conduct bioassays. This includes obtaining test organisms and control and reference sediments in a timely manner. This approach will support the opportunity for any second-round (additional) biological testing within the allowable 56-day holding period if such need arises. As initial chemistry data becomes available, the US Navy project manager and the bioassay laboratory representative will maintain close coordination with the Corps of Engineers DMMO to expedite biological testing decisions.

The acute toxicity and chronic sublethal bioassays prescribed by PSDDA (amphipod, sediment larval, *Neanthes* growth) will be conducted on each sample identified for biological testing. All biological testing will be in strict compliance with <u>Recommended Protocols for Conducting Laboratory Bioassays on Puget Sound Sediments (for USEPA Region 10)</u>, 1995, with appropriate modifications as specified by PSDDA in the MPR-Phase II, public workshops and the sediment management annual review process. General biological testing procedures and specific procedures for each sediment bioassay are summarized below:

6.2 General Biological Testing Procedures.

6.2.1 Negative Controls. Negative control sediments are used in the amphipod and *Neanthes* bioassays to check laboratory performance. Negative control sediments are clean sediments in which the test organism normally lives and which are expected to produce low mortality. Control sediments will be collected from West Beach of Whidbey Island for both the amphipod and *Neanthes* bioassays.

The sediment larval test utilizes a negative seawater control rather than a control sediment. The seawater control will be collected from approximately 20 meters of water off West Beach.

The amphipod, sediment larval and *Neanthes* tests all have performance standards for negative controls, which are identified in Section 6.3.

6.2.2 Reference Sediment. PSDDA prescribes the use of bioassay reference sediments for test comparison and interpretations which closely match the grain size characteristics of the dredged materials test sediments. The reference sediment is used to block for physical effects of the test sediment.

All bioassays have performance standards for reference sediments (see Section 6.3). Failure to meet these standards may result in the requirement to retest.

All reference sediments will be analyzed for total solids, total volatile solids, total organic carbon, bulk ammonia, bulk sulfides and grain-size.

6.2.3 Replication. Five laboratory replicates of test sediments, reference sediments and negative controls will be run for each bioassay.

6.2.4 Positive Controls. A positive control will be run for each bioassay. Positive controls are chemicals known to be toxic to the test organism and which provide an indication of the sensitivity of the particular organisms used in a bioassay. Cadmium chloride will be used for the amphipod, sediment larval and *Neanthes* bioassays.

6.2.5 Water Quality Monitoring. Water quality monitoring will be conducted for the amphipod, sediment larval and *Neanthes* bioassays. This consists of daily measurements of salinity, temperature, pH and dissolved oxygen for the amphipod and sediment larval tests. These measurements will be made every three days for the *Neanthes* bioassay. Ammonia and sulfides will be determined at test initiation and termination for all three tests. Monitoring will be conducted for all test and reference sediments and negative controls (including seawater controls). Parameter measurements must be within the limits specified for each bioassay. Measurements for each treatment will be made on a separate chemistry beaker set up to be identical to the other replicates within the treatment group, including the addition of test organisms.

6.3 Bioassay-specific Procedures.

6.3.1 Amphipod Bioassay. This test involves exposing the amphipod *Rhepoxynius abronius* to test sediment for ten (10) days and counting the surviving animals at the end of the exposure period. Daily emergence data and the number of amphipods failing to rebury at the end of the test will be recorded as well. The control sediment has a performance standard of 10 percent mortality. The reference sediment has a performance standard of 20 percent mortality greater than control.

6.3.2 Sediment Larval Bioassay. This test monitors larval development of a suitable echinoderm species (either *Stronglyocentrotus purpuratus* or *Dendraster excentricus*) in the presence of test sediment. The test is run until the appropriate stage of development is achieved in a sacrificial seawater control (PSDDA MPR-Phase II, pp. 5-20). At the end of the test, larvae from each test sediment exposure are examined to quantify abnormality and mortality.

The seawater control has a performance standard of 30 percent combined mortality and abnormality. The reference sediment has a performance standard of 35 percent combined mortality and abnormality normalized to seawater control.

Initial counts will be made for a minimum of five 10-ml aliquots. Final counts for seawater control, reference sediment and test sediment will be made on 10-ml aliquots.

The sediment larval bioassay has a variable endpoint (not necessarily 48 hours) which is determined by the developmental stage of organisms in a sacrificial seawater control (PSDDA MPR Phase II, page 5-20).

Ammonia and sulfides toxicity may interfere with test results for this bioassay. Aeration will be conducted throughout the test to minimize these effects.

6.3.3 *Neanthes* Growth Test. This test utilizes the polychaete *Neanthes arenaceodentata*, in a 20-day growth test. The growth rate of organisms exposed to test sediments is compared to the growth rate of organisms exposed to a reference sediment. *Neanthes* will be obtained from Dr. Don Reish in Long Beach, California. Neanthes worms from Don Reish's lab may take 2 or 3 weeks to culture and deliver and will be ordered regardless of the outcome of the chemical characterization.

The control sediment has a performance standard of 10 percent mortality. The reference sediment has a performance standard of 80 percent of the control growth rate. The control growth guideline is 0.72 mg/ind/day.

6.4 Interpretation. Test interpretations consist of endpoint comparisons to controls and reference on an absolute percentage basis as well as statistical comparison to reference. Test interpretation will follow the guidelines established in the PSDDA Management Plan Report-Phase II (page 5-17) for the amphipod, and sediment larval bioassays, and the minutes of the dredging year 1991 annual review meeting for the *Neanthes* bioassay, as modified by subsequent annual review proceedings and workshops.

6.5 Bioassay Retest. Any bioassay retests must be fully coordinated with, and approved by, the PSDDA agencies. The DMMO should be contacted to handle this coordination.

6.6 Laboratory Written Report. A written report will be prepared by the biological laboratory documenting all the activities associated with sample analyses. As a minimum, the following will be included in the report:

- Results of the laboratory bioassay analyses and QA/QC results, reported both in hard copy and in the Corps' DAIS data format. Raw data will be legible or typed. Illegible data may result in the need for a retest if the PSDDA agencies cannot interpret the data as a result. See Appendix E for the complete set of submittals.

- All protocols used during analyses, including explanation of any deviation from the Recommended Protocols and the approved sampling plan.

- Chain of custody procedures, including explanation of any deviation from the identified protocols.

- Location and availability of data, laboratory notebooks and chain-of-custody forms.

As appropriate, this sampling plan may be referenced in describing protocols.

7.0 REPORTING

7.1 QA Report. The project quality assurance representative will prepare a quality assurance report based upon activities involved with the field sampling and review of the laboratory analytical data. The laboratory QA/QC reports will be incorporated by reference. This report will identify any field and laboratory activities that deviated from the approved sampling plan and the referenced protocols and will make a statement regarding the overall validity of the data collected. The QA/QC report will be incorporated into the Final Report.

7.2 Final Report. A written report shall be prepared by GeoMetrics documenting all activities associated with collection, compositing, transportation of samples, and chemical and biological analysis of samples. The chemical and biological reports will be included as appendices. As a minimum, the following will be included in the Final Report:

- Type of sampling equipment used.
- Protocols used during sampling and testing and an explanation of any deviations from the sampling plan protocols.
- Descriptions of each sample accompanied by photographs adequate to provide a visual representation of the sediments.
- Methods used to locate the sampling positions within an accuracy of ± 2m.
- Locations where the sediment samples were collected. Locations will be reported in latitude and longitude to the nearest tenth of a second.
- A plan view of the project showing the actual sampling location.
- Chain-of-custody procedures used, and explanation of any deviations from the sampling plan procedures.
- Description of sampling and compositing procedures.
- Final QA report for Section 7.1 above.
- Data results. In addition, all field and laboratory analyses results and associated QA data will be submitted on floppy diskettes using the Corps of Engineers' Dredged Analysis Information System format.
- QA2 data required by the Department of Ecology for data validation prior to entering data in their Sediment Quality database. These data are listed in Appendix D.

- Sampling and analysis cost data will be submitted upon project completion on forms provided by the Dredged Material Management Office.

APPENDIX A

Data Summary

PILOT SEDIMENT CHARACTERIZATION RESULTS

PIER D, AUGUST, 1989

(From GeoMetrics, Inc. Report, 9/26/89)

APPENDIX B

SECTION 10/404 DRAFT PERMIT APPLICATION

PIER D

PLACE DEPT. OF ARMY LETTER HERE
PLACE PUGET SOUND NAVAL SHIPYARD LETTER HERE
PLACE APPLICATION FOR DEPT OF ARMY PERMIT HERE
PLACE APPLICATION FOR DEPT OF ARMY PERMIT - Page 2 HERE
PLACE VICINITY MAP HERE
PLACE SECTION A-A HERE
PLACE SECTION B-B HERE
PLACE SECTION C-C HERE

APPENDIX C

PSDDA PARAMETERS AND METHODS

APPENDIX C

PSDDA PARAMETERS

(Testing Parameter, Preparation Method, Analytical Method, Sediment Method Detection Limit (MDL), PSDDA Screening Levels (SL), Maximum Levels (ML) and Bioaccumulation Levels (BT))

PARAMETER	PREP METHOD (recommended)	ANALYSIS METHOD (recommended)	SEDIMENT MDL (1)	PSDDA(1) SL	PSDDA(1) BT	PSDDA(1) ML
CONVENTIONALS:						
Total Solids (%)	---	Pg.17 (2)	0.1	---	---	---
Total Volatile Solids(%)	---	Pg.20 (2)	0.1	---	---	---
Total Organic Carbon (%)	---	Pg.23 (2, 3)	0.1	---	---	---
Total Sulfides (mg/kg)	---	Pg.32 (2)	1	---	---	---
Ammonia (mg/kg)	---	Plumb 1981 (4)	1	---	---	---
Grain Size	---	Modified ASTM with Hydrometer	---	---	---	---
METALS (ppm):						
Antimony	APNDX D (5)	GFAA (6)	2.5	150	150	200
Arsenic	APNDX D (5)	GFAA (6)	2.5	57	507.1	700
Cadmium	APNDX D (5)	GFAA (6)	0.3	5.1	---	14
Chromium	APNDX D (5)	GFAA (6)	0.3	---	---	---
Copper	APNDX D (5)	ICP (7)	15.0	390	---	1,300
Lead	APNDX D (5)	ICP (7)	0.5	450	---	1,200
Mercury	MER (8)	7471 (8)	0.02	0.41	1.5	2.3
Nickel	APNDX D (5)	ICP (7)	2.5	140	370	370
Silver	APNDX D (5)	GFAA (6)	0.2	6.1	6.1	8.4
Zinc	APNDX D (5)	ICP (7)	15.0	410	---	3,800
ORGANOMETALLIC COMPOUNDS (ug/L):						
Tributyltin (interstitial water)	NMFS	Krone	0.01	---	0.15	---
ORGANICS (ppb):						
LPAH						
Naphthalene	3550 (9)	8270 (10)	20	2,100	---	2,400
Acenaphthylene	3550 (9)	8270 (10)	20	560	---	1,300
Acenaphthene	3550 (9)	8270 (10)	20	500	---	2,000
Fluorene	3550 (9)	8270 (10)	20	540	---	3,600
Phenanthrene	3550 (9)	8270 (10)	20	1,500	---	21,000

Anthracene	3550 (9)	8270 (10)	20	960	---	13,000
2-Methylnaphthalene	3550 (9)	8270 (10)	20	670	---	1,900
Total LPAH				5,200	---	29,000
HPAH						
Fluoranthene	3550 (9)	8270 (10)	20	1,700	4,600	30,000
Pyrene	3550 (9)	8270 (10)	20	2,600	---	16,000
Benzo(a)anthracene	3550 (9)	8270 (10)	20	1,300	---	5,100
Chrysene	3550 (9)	8270 (10)	20	1,400	---	21,000
Benzofluoranthenes	3550 (9)	8270 (10)	20	3,200	---	9,900
Benzo(a)pyrene	3550 (9)	8270 (10)	20	1,600	3,600	3,600
Indeno(1,2,3-c,d)pyrene	3550 (9)	8270 (10)	20	600	---	4,400
Dibenzo(a,h)anthracene	3550 (9)	8270 (10)	20	230	---	1,900
Benzo(g,h,i)perylene	3550 (9)	8270 (10)	20	670	---	3,200
Total HPAH				12,000	---	69,000
CHLORINATED HYDROCARBONS						
1,3-Dichlorobenzene	P&T (12)	8240 (11)	3.2	170	1,241	---
1,4-Dichlorobenzene	P&T (12)	8240 (11)	3.2	110	120	120
1,2-Dichlorobenzene	P&T (12)	8240 (11)	3.2	35	37	110
1,2,4-Trichlorobenzene	3550 (9)	8270 (10)	6	31	---	64
Hexachlorobenzene (HCB)	3550 (9)	8270 (10)	12	22	168	230
PHTHALATES						
Dimethyl phthalate	3550 (9)	8270 (10)	20	1,400	1,400	---
Diethyl phthalate	3550 (9)	8270 (10)	20	1,200	---	---
Di-n-butyl phthalate	3550 (9)	8270 (10)	20	5,100	10,220	---
Butyl benzyl phthalate	3550 (9)	8270 (10)	20	970	---	---
Bis(2-ethylhexyl)phthalate	3550 (9)	8270 (10)	20	8,300	13,870	---
Di-n-octyl phthalate	3550 (9)	8270 (10)	20	6,200	---	---
PHENOLS						
Phenol	3550 (9)	8270 (10)	20	420	876	1,200
2 Methylphenol	3550 (9)	8270 (10)	6	63	---	77
4 Methylphenol	3550 (9)	8270 (10)	20	670	---	3,600
2,4-Dimethylphenol	3550 (9)	8270 (10)	6	29	---	210
Pentachlorophenol	3550 (9)	8270 (10)	61	400	504	690
MISCELLANEOUS EXTRACTABLES						
Benzyl alcohol	3550 (9)	8270 (10)	6	57	---	870
Benzoic acid	3550 (9)	8270 (10)	100	650	---	760
Dibenzofuran	3550 (9)	8270 (10)	20	540	---	1,700
Hexachloroethane	3550 (9)	8270 (10)	20	1,400	10,220	14,000
Hexachlorobutadiene	3550 (9)	8270 (10)	20	29	212	270

N-Nitrosodiphenylamine	3550 (9)	8270 (10)	12	28	130	130
VOLATILE ORGANICS						
Trichloroethene	P&T (12)	8240 (11)	3.2	160	1,168	1,600
Tetrachloroethene	P&T (12)	8240 (11)	3.2	57	102	210
Ethylbenzene	P&T (12)	8240 (11)	3.2	10	27	50
Total Xylene	P&T (12)	8240 (11)	3.2	40	---	160
PESTICIDES						
Total DDT	---	---	---	6.9	50	69
p,p'-DDE	3540 (13)	8080 (13)	2.3	---	---	---
p,p'-DDD	3540 (13)	8080 (13)	3.3	---	---	---
p,p'-DDT	3540 (13)	8080 (13)	6.7	---	---	---
Aldrin	3540 (13)	8080 (13)	1.7	10	37	---
Chlordane	3540 (13)	8080 (13)	1.7	10	37	---
Dieldrin	3540 (13)	8080 (13)	2.3	10	37	---
Heptachlor	3540 (13)	8080 (13)	1.7	10	37	---
Lindane	3540 (13)	8080 (13)	1.7	10	---	---
Total PCBs	3540 (13)	8080 (13)	67	130	38*	3,100

* Total PCBs BT value in ppm carbon-normalized.

1. Dry Weight Basis.

2. Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound, Puget Sound Estuary Program, 1997.

3. Recommended Methods for Measuring TOC in Sediments, Kathryn Bragdon-Cook, Clarification Paper, Puget Sound Dredged Disposal Analysis Annual Review, May, 1993.

4. Procedures For Handling and Chemical Analysis of Sediment and Water Samples, Russell H. Plumb, Jr., EPA/Corps of Engineers, May, 1981.

5. Recommended Protocols for Measuring Metals in Puget Sound Water, Sediment and Tissue Samples, Puget Sound Estuary Program, 1997.

6. Graphite Furnace Atomic Absorption (GFAA) Spectrometry - SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

7. Inductively Coupled Plasma (ICP) Emission Spectrometry - SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

8. Mercury Digestion and Cold Vapor Atomic Absorption (CVAA) Spectrometry - Method 7471, SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

9. Sonication Extraction of Sample Solids - Method 3550 (Modified), SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986. Method is modified to add matrix spikes before the dehydration step rather than after the dehydration step.

10. GCMS Capillary Column - Method 8270, SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

11. GCMS Analysis - Method 8240, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

12. Purge and Trap Extraction and GCMS Analysis - Method 8240, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

13. Soxhlet Extraction and Method 8080, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

APPENDIX D

QA2 DATA REQUIREMENTS

CHEMICAL VARIABLES

ORGANIC COMPOUNDS

The following documentation is needed for organic compounds:

- A cover letter referencing or describing the procedure used and discussing any analytical problems
- Reconstructed ion chromatograms for GC/MS analyses for each sample
- Mass spectra of detected target compounds (GC/MS) for each sample and associated library spectra
- GC/ECD and/or GC/flame ionization detection chromatograms for each sample
- Raw data quantification reports for each sample
- A calibration data summary reporting calibration range used [and decafluorotriphenylphosphine (DFTPP) and bromofluorobenzene (BFB) spectra and quantification report for GC/MS analyses]
- Final dilution volumes, sample size, wet-to-dry ratios, and instrument detection limit
- Analyte concentrations with reporting units identified (to two significant figures unless otherwise justified)
- Quantification of all analytes in method blanks (ng/sample)
- Method blanks associated with each sample
- Recovery assessments and a replicate sample summary (laboratories should report all surrogate spike recovery data for each sample; a statement of the range of recoveries should be included in reports using these data)
- Data qualification codes and their definitions.

METALS

For metals, the data report package for analyses of each sample should include the following:

- Tabulated results in units as specified for each matrix in the analytical protocols, validated and signed in original by the laboratory manager
- Any data qualifications and explanation for any variance from the analytical protocols
- Results for all of the QA/QC checks initiated by the laboratory
- Tabulation of instrument and method detection limits.

All contract laboratories are required to submit metals results that are supported by sufficient backup data and quality assurance results to enable independent QA reviewers to conclusively determine the quality of the data. The laboratories should be able to supply legible photocopies of original data sheets with sufficient information to unequivocally identify:

- Calibration results
- Calibration and preparation blanks
- Samples and dilutions
- Duplicates and spikes
- Any anomalies in instrument performance or unusual instrumental adjustments.

BIOASSAYS

Amphipod Mortality Test

The following data should be reported by all laboratories performing this bioassay:

- Daily water quality measurements during testing (e.g., dissolved oxygen, temperature, salinity, pH) (plus ammonia & sulfides at test initiation and termination)
- Daily emergence for each beaker and the 10-day mean and standard deviation for each treatment
- 10-day survival in each beaker and the mean and standard deviation for each treatment

- Interstitial salinity values of test sediments
- 96-hour LC_{50} values with reference toxicants.
- Any problems that may have influenced data quality.

Neanthes Growth Test

The following data should be reported by all laboratories performing this bioassay:

- Water quality measurements at test initiation and termination and every three days during testing (e.g., dissolved oxygen, temperature, salinity, pH) (plus ammonia & sulfides at test initiation and termination)
- 20-day survival in each beaker and the mean and standard deviation for each treatment.
- Initial biomass
- Final biomass (20-day) for test, reference and control treatments.
- 96-hour LC_{50} values with reference toxicants.

Any problems that may have influenced data quality.

Echinoderm Larval Test (Solid Phase)

The following data should be reported by all laboratories performing this bioassay:

- Daily water quality measurements (e.g., dissolved oxygen, temperature, salinity, pH) (plus ammonia + sulfides at test initiation & termination)

- Individual replicate and mean and standard deviation data for larval survival at test termination.

- Individual replicate and mean and standard deviation data for larval abnormalities at test termination

- 48-hour LC_{50} and EC_{50} values with reference toxicants.

- Any problems that may have influenced data quality.

APPENDIX E

PROJECT COST DATA SHEET

PROJECT SAMPLING AND TESTING COST SUMMARY (Required fields shaded)		
Project Name:		
Total Project Volume Tested (cubic yards)		
SAMPLING COSTS: (includes: bathymetric survey, SAP development, sample positioning, project sediment sampling costs, reference/control sediment sampling costs)		$
CHEMICAL TESTING COSTS: (PSDDA or Grays Harbor-Willapa Bay DMMP chemicals of concern)		
Number of DMMU analyzed		
Conventionals (unit cost)		$
Metals (unit cost)		$
Organics (unit cost)		$
Special Chemicals (if any, specify which chemicals, e.g., TBT, Dioxin)		$
Total Chemical Testing Costs (includes cumulative chemical testing costs, chemistry report, QA/QC report including QA2 data)		$
BIOLOGICAL TESTING COSTS:		
Number of DMMU analyzed		
Amphipod (specify species and unit cost)		$
Sediment Larval (specify species and unit cost)		$
Neanthes Growth (unit cost)		$
Microtox (unit cost)		$
Bioaccumulation test (2 species) (specify species, unit cost)		$
		$
Total Biological Testing Costs (includes total bioassay testing cost, QA/QC costs, bioaccumulation costs if any)		$
MISCELLANEOUS COSTS: (includes any costs not covered such as administrative overhead, final report Cost)		**$**
GRAND TOTAL COSTS: (summary of sampling + testing costs + miscellaneous costs)		$

APPENDIX F

DATA REQUIREMENTS FOR DAIS

DAIS DATA CHECKLIST

Sample Locations and Compositing	Test Sediment	Reference Sediment	Control Sediment	Seawater Control
Latitude and Longitude (to nearest 0.1 second)				
NAD 1927 or 1983				
USGS Benchmark ID				
Station name (e.g. Carr Inlet)				
Water depth (corrected to MLLW)				
Drawing showing sampling locations and ID numbers				
Compositing scheme (sampling locations/depths for composites)				
Sampling method				
Sampling dates				
Estimated volume of dredged material represented by each DMMU				
Positioning method				
Sediment Conventionals				
Preparation and analysis methods				
Sediment conventional data and QA/QC qualifiers				
QA qualifier code definitions				
Triplicate data for each sediment conventional for each batch				
Units (dry weight except total solids)				
Method blank data (sulfides, ammonia, TOC)				
Method blank units (dry weight)				
Analysis dates (sediment conventionals, blanks, TOC CRM)				
TOC CRM ID				
TOC CRM analysis data				
TOC CRM target values				
Grain Size Analysis				
Fine grain analysis method				
Analysis dates				
Triplicate for each batch				
Grain size data (complete sieve and phi size distribution)				

Chemicals of Concern Analysis Data				
	Metals	Semivol.	Pest./ PCBs	Volatiles
Extraction/digestion method				
Extraction/digestion dates (test sediment, blanks, matrix spike, reference material)				
Analysis method				
data and QA qualifier included for:				
test sediments				
reference materials including 95% confidence interval (each batch)				
method blanks (each batch)				
matrix spikes (each batch)				
matrix spike added (dry weight basis)				
replicates (each batch)				
Units (dry weight)				
Method blank units (dry weight)				
QA/QC qualifier definitions				
Surrogate recovery for test sediment, blank, matrix spike, ref. material				
Analysis dates (test sediment, blanks, matrix spike, reference material)				

Shaded areas indicate required data

BIOASSAYS

Amphipod Mortality and Emergence				
	Each Batch	Test Sediment	Reference Sediment	Control Sediment
Species Name				
Mortality and Emergence:				
Start date				
Daily emergence (for 10 days)				
Survival at end of test				
Number failing to rebury at end of test				
Positive Control:				
Toxicant used				
Toxicant concentrations				
Exposure time				
LC50				
LC50 method of calculation				
Start date				
Survival data				
Water Quality Measurement Methods:				
Dissolved oxygen				
Ammonia				
Interstitial salinity				
Sulfide				
Water salinity				
Water Quality:				
Temperature (day 0 through day 10)				
pH (day 0 through day 10)				
Dissolved oxygen (day 0 through day 10)				
Water salinity (day 0 through day 10)				
Sulfide (day 0, day 10)				
Ammonia (day 0, day 10)				
Interstitial water salinity (day 0)				

Juvenile Infaunal Mortality				
	Each Batch	Test Sediment	Reference Sediment	Control Sediment
Species Name				
Mortality:				
Start date				
Survival at end of test				
Positive Control:				
Toxicant used				
Toxicant concentrations				
Exposure time				
LC50				
LC50 method of calculation				
Start date				
Survival data				
Water Quality Measurement Methods:				
Dissolved oxygen				
Ammonia				
Interstitial salinity				
Sulfide				
Water salinity				
Water Quality:				
Temperature (day 0 through day 10)				
pH (day 0 through day 10)				
Dissolved oxygen (day 0 through day 10)				
Water salinity (day 0 through day 10)				
Sulfide (day 0, day 10)				
Ammonia (day 0, day 10)				
Interstitial water salinity (day 0)				

Neanthes 20-day Growth Test				
	Each Batch	Test Sediment	Reference Sediment	Control Sediment
Starting age (in days post-emergence)				
Food type				
Quantity (mg/beaker/interval)				
Feeding interval (hours)				
Biomass and Mortality:				
Start date				
Initial counts and weights (mg dry weight)				
Number of survivors and final weights (mg dry weight)				
Positive Control:				
Toxicant used				
Toxicant concentration				
Exposure time				
LC50				
LC50 method of calculation				
Start date				
Survival data				
Water Quality Measurement Methods				
Dissolved oxygen				
Ammonia				
Interstitial salinity				
Sulfide				
Water salinity				
Water Quality:				
Temperature (days 0, 3, 6, 9, 12, 15, 18, 20)				
pH (days 0, 3, 6, 9, 12, 15, 18, 20)				
Dissolved oxygen (days 0, 3, 6, 9, 12, 15, 18, 20)				
Water salinity (days 0, 3, 6, 9, 12, 15, 18, 20)				
Interstitial salinity (day 0)				
Sulfide (initial and final)				
Ammonia (initial and final)				

Sediment Larval Mortality and Abnormality				
	Each Batch	Test Sediment	Reference Sediment	Seawater Control
Species Name				
Bioassay Parameters				
Inoculation time (hours)				
Exposure time (hours)				
Stocking beaker density (#/ml)				
Stocking aliquot size (ml)				
Aeration (yes/no)				
Mortality and Abnormality:				
Start date				
Initial count (minimum of five 10-ml aliquots)				
Final Count:				
Aliquot size (ml)				
Number normal per aliquot				
Number abnormal per aliquot				
Water Quality Measurement Methods:				
Dissolved oxygen				
Ammonia				
Sulfide				
Water salinity				
Water Quality:				
Temperature (daily)				
pH (daily)				
Dissolved oxygen (daily)				
Water salinity (daily)				
Sulfide (initial and final)				
Ammonia (initial and final)				
Positive Control:				
Toxicant used				
Toxicant concentrations				
Exposure time				
EC50				
EC50 method of calculation				
Start date				
Normal/abnormal counts				

APPENDIX 7-A

SAMPLE HANDLING PROCEDURES

SAMPLE HANDLING PROCEDURES

Listed below are details concerning the sample handling procedures outlined in Chapter 7. Al l sample handling procedures should be specified in the sampling and analysis plan.

Decontamination Procedures

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:

- √ Wash with brush and Alconox soap.
- √ Double rinse with distilled water.
- √ Rinse with nitric acid.
- √ Rinse with metal-free water.
- √ Rinse with methanol.

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

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.

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 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. 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/ 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.

Sampling Logs
As samples are collected, and after the volatiles and sulfides sub-samples 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:

Date and time of collection of each sediment sample.

Names of field supervisors and person(s) collecting and logging in the sample.

The sample station number and individual designation numbers assigned for individual core sections.

Quantitative notation of apparent resistance of sediment column to coring.

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.

Length, depth interval (referenced to the sediment/water interface) and percent recovery of core sections.

Weather conditions

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.

Any deviation from the approved sampling plan.

Extrusion, Compositing and Sub-sampling

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 4/C 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 continue to 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. Both 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 chemical and biological laboratories. See Table 7-1 for container and sample size information. In high-ranked areas, the sample taken from the foot beyond the dredging overdepth should be placed in a 250 ml glass jar and frozen for possible future analysis.

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/C in a nitrogen atmosphere, i.e., nitrogen gas in the container headspace, 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..

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

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.

√ 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.

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

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

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

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

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

√ 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.

√ 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.

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

Appendix 8A

TESTING, REPORTING, AND EVALUATION OF TRIBUTYLTIN DATA

TESTING, REPORTING, AND EVALUATION OF TRIBUTYLTIN DATA IN PSDDA AND SMS PROGRAMS

Dr. Teresa Michelsen, Travis C. Shaw, and Stephanie Stirling

INTRODUCTION

Tributyltin (TBT) is a special chemical of concern under the PSDDA program and is classified as a deleterious substance under the SMS rule. Testing for this chemical in areas where it is likely to be found (e.g., marinas, ship repair facilities, shipping lanes) may be required under both programs. In 1988, the PSDDA agencies conducted a study on the presence of TBT in marinas in Puget Sound, and funded a risk assessment of TBT (Cardwell, 1989). In 1988, the PSDDA agencies developed a screening level (SL) and bioaccumulation trigger (BT) for use in the PSDDA program, based on the best available knowledge of this chemical and its properties. In the past year, additional information has come to light on TBT, its distribution in Puget Sound, and its effects on the environment that support a change in the way the agencies approach evaluation of TBT in sediments. Most recently, an interagency work group was convened by EPA to develop a site-specific screening value for the Commencement Bay Nearshore/Tideflats and Harbor Island Superfund sites (see EPA, 1996). This paper discusses some of the issues raised by this new information and modifications to the PSDDA and SMS programs to address these issues.

Authority to develop testing programs, interpretation guidelines, and regulatory levels for deleterious substances (substances that currently do not have standards) under SMS is provided by WAC 173- 204-110(6) and WAC 173-204-310(3). This technical memorandum was circulated for public review and comment in conjunction with the 1996 Sediment Management Annual Review Meeting. Many comments were received and a substantial number of revisions and additions to this memorandum have been made.

PROBLEM IDENTIFICATION

Worldwide information documenting TBT's adverse impact on the aquatic environment is extensive. In addition to direct mortality, adverse impacts on a wide variety of aquatic organisms include reduced larval growth, sexual abnormalities, reproductive failure, gross morphological abnormalities, immune system dysfunction, nervous system disorders, and skin and eye disorders. TBT has a strong inhibitory effect on the cytochrome P450 system, reducing the ability of the organism to metabolize and detoxify environmental pollutants, and on ATP synthesis, reducing the ability of the organism to produce energy. These effects are generalized enough to occur in many organisms (including invertebrates, fish, and mammals). Available evidence indicates that serious chronic effects resulting in population declines occur at water concentrations in the parts per trillion (ng/L) to parts per billion (μg/L) range, depending on the species (Fent, 1996; EPA, 1991).

The available literature indicates that the toxicity and bioaccumulation of TBT are affected by a variety of factors, including organic carbon in sediment and water, pH, salinity, clay fraction, and the presence of inorganic constituents such as iron oxides. TBT partitioning is further complicated by the fact that it occurs in several forms, including TBT^{+}, TBTCl, and TBTOH, and may interconvert among these forms with fluctuations in salinity and pH (Fent, 1996; EPA, 1991). Finally, TBT has been released into the environment in a variety of forms, including leaching directly from vessel hull paints (the most toxic and bioavailable form) and in the form of paint wastes from sandblasting (which may be less bioavailable but may represent a long-term source of the contaminant).

Sediment sampling in Puget Sound and elsewhere indicates that sediments in areas with vessel activity (e.g., marinas, harbors, boatyards, shipyards) are a significant reservoir of TBT (Parametrix, 1995). Worldwide, TBT-contaminated sediments adversely impact benthic organisms and contribute to water column concentrations that continue to be toxic to aquatic life (Fent, 1996). Very high, widespread TBT sediment concentrations have been found in the waterways of Commencement Bay, Elliott Bay (Harbor Island), and the Salmon Bay/Ship Canal area. Additional ongoing sources include domestic vessels that are still allowed to use TBT paints and shipping traffic from countries without TBT regulations.

Efforts to interpret environmental data in Puget Sound have been frustrated by the complexity of TBT partitioning in the environment and uncertainty over appropriate effects levels, testing strategies, and interpretive criteria. Recent data provided by NOAA suggest that the bioassay tests routinely used in the PSDDA and SMS program may not be of long enough duration to accurately reflect *in situ* effects due to TBT, and that other approaches may be more appropriate to the types of toxicity exhibited by this chemical (Meador *et al.*, 1996 in press).

TECHNICAL BACKGROUND AND DISCUSSION

Analytical Methods

Analytical methods and detection limits for TBT are provided in the 1996 PSEP Organics Protocol, Appendix A (PSWQA, 1996). The recommended method involves reaction with sodium borohydride, methylene chloride extraction and analysis by GC/MS (Matthias *et al.*, 1986). However, this method is somewhat experimental and is not available at most commercial laboratories. Alternative methods involve methylene chloride extraction, followed by Grignard derivatization and analyzed by GC/MS (Krone et al., 1989) or GC/FPD (Unger et al., 1986).

Reporting Conventions

TBT data have historically been reported in a number of different ways. For example, in the literature TBT may be reported as Sn, TBT, TBTCl, or TBTO. For the same environmental concentration, these reporting conventions result in different numerical values because each of these forms has a different molecular weight. This has resulted in some confusion interpreting the data and in setting standards. It is important that all data be reported in comparable units, and that any standards or guidance levels also be in those same units. The PSDDA program has used Sn in the past and the existing SL and BT are based in units of Sn. However, much of the analytical and research community recommends reporting TBT as the TBT ion (TBT^{+}).

A simple conversion based on the ratio of molecular weights can be used to convert older data into these units for comparison with newer data:

To convert TBT reported as:	To:	Multiply By
mg Sn/kg	mg TBT/kg	2.44
mg TBTCl/kg	mg TBT/kg	0.89
mg TBTO/kg	mg TBT/kg	0.95

The existing PSDDA SL for sediments (30 μg Sn/kg) corresponds to 73 μg TBT/kg

TBT and Apparent Effects Threshold Values

The interagency work group followed the traditional approach in establishing regulatory thresholds for Puget Sound sediments by attempting to establish apparent effects threshold (AET) values for TBT. This effort was unsuccessful because of the widely varying responses in the bioassay and benthic data reviewed over a wide range of TBT concentrations (EPA, 1996). In some cases, despite extremely high TBT concentrations in sediments, no acute toxicity was exhibited by the standard suite of bioassay organisms. Current research shows that TBT partitioning is highly complex, and the relationship between concentrations and observed effects data is much stronger for interstitial water and tissue concentrations. Therefore, the work group discontinued efforts to develop AET values and instead focused its attention on using effects data associated with interstitial water and tissue concentrations as regulatory endpoints. However, Ecology will evaluate any additional synoptic data that are collected to further explore whether a reliable AET value can be calculated.

Interstitial Water Concentrations

As part of the TBT work group's efforts, an extensive literature review and compilation of effects levels in marine waters was developed for use in setting a site-specific screening value for the Commencement Bay Nearshore/Tideflats Superfund site (EPA, 1996). The reader is referred to this report, which received substantial public and technical review, for a detailed presentation of effects levels in water. TBT water concentrations that result in acute and chronic adverse effects to a wide range of marine species have been reported in the literature (Fent, 1996; EPA, 1991; EPA, 1996). Chronic effects to aquatic organisms have been reported at concentrations ranging from 0.002 - 74 μgTBT/L, with the majority of species responding below 0.5 μg TBT/L. Acute effects have been reported at concentrations ranging from 0.3 - 200 μg TBT/L.

The consensus of the TBT work group was that an interstitial water concentration of 0.05 μg TBT/L corresponds to a no adverse effects level that would protect most (approximately 95%) of the Puget Sound species that have been tested. This level is conceptually equivalent to the SQS under the Sediment Management Standards, and is consistent with the EPA approach to developing water quality and sediment criteria. For comparison, the EPA proposed draft marine chronic water quality criterion has been set at 0.01 μg TBT/L (EPA, 1991). A higher adverse effects level was also evaluated by the TBT work group; however, less consensus was achieved on an upper or maximum allowable regulatory level. As one possibility, the work group discussed a value of 0.7 μg TBT/L. This concentration is lower than most of the acute effects levels reported in the literature. However, significant chronic effects are likely at this concentration, particularly to bivalve species present in Puget Sound. On the basis of the work group discussion and an associated report (EPA, 1996), an interstitial water concentration of 0.7 μg TBT/L was selected by EPA as the basis for a site-specific sediment trigger level for cleanup in the Hylebos Waterway (Commencement Bay Nearshore/Tideflats Superfund site). ***This value is not currently proposed as an upper regulatory level for either the PSDDA or SMS programs.*** For comparison, the EPA proposed draft marine acute water quality criterion has been set at 0.36 μg TBT/L (EPA, 1991).

Tissue Concentrations

In contrast to toxicity levels based on TBT water concentrations, which range over several orders of magnitude for various species, recent studies on tissue concentrations in Puget Sound organisms indicate that a much narrower range of tissue concentrations is associated with adverse effects to these organisms (see citations below). Different species have widely varying uptake, metabolic, and elimination rates for TBT, in part explaining the widely varying sediment and water concentrations that yield similar tissue concentrations and associated effects.

This finding provides an opportunity to develop tissue TBT concentrations that are directly correlated with observed effects in a wide range of ecologically relevant species. Meador *et al.* (1993; 1996 in press) have reported acute toxicity (LD_{50}s) for *Rhepoxynius abronius*, *Eohaustorius washingtonianus* and *Armandia brevis* at concentrations ranging from 34 - 89 mg TBT/kg body weight (dry weight). Tissue concentrations within or above this range would represent a severe adverse effect and sediments associated with these levels would exceed the level at which cleanup would be required, and would also be inappropriate for open-water disposal.

However, PSDDA and SMS require consideration of both acute and chronic effects. Chronic effects levels for species of concern in Puget Sound can be found in the literature (Salazar and Salazar, 1992, 1995; Moore et al, 1991; Davies et al., 1987, 1988; Page and Widdows, 1991; Widdows and Page, 1993; Thain et al., 1987; Waldock et al., 1992; Waldock and Thain, 1983; Meador *et al.*, in press; Minchin et al., 1987; Alzieu and Heral; these values typically fall within a range of 2-12 mg TBT/kg body weight (dry weight), with a median value of about 4.

Direct measurements of TBT in tissues of biota collected from the site and *in situ* bioaccumulation studies are considered promising methods for assessing TBT toxicity, and may be recommended by the agencies to support sediment management decisions. The ranges discussed above provide a starting point for interpretation of bioaccumulation data from dredging projects or cleanup sites.

PSDDA Screening Level for TBT

A review of the existing SL was conducted to evaluate its relationship to known effects levels in water. Butyltins were added to the list of chemicals-of-concern for limited areas in the PSDDA Management Plan Report - Phase II (PSDDA, 1989). At the time of the listing, an interim SL for TBT was established at 30 μg/kg (as Sn). This SL was established using the available information on TBT contamination in Puget Sound and an equilibrium partitioning model that estimated interstitial water concentrations of TBT based on TBT sediment concentrations. In addition, the professional judgment of dredged material decision-makers in other regions of the country was sought in selecting the interim SL.

The interstitial water TBT concentration corresponding to the SL can be calculated using an equilibrium partitioning approach and a representative partitioning coefficient of 25,000 (σ = 5,500) derived from Meador *et al.* (1996 in press). Assuming a sediment organic carbon content of 2%, the SL of 30 µg/kg TBT (as Sn) corresponds to an interstitial water concentration of 0.06 µg/L TBT (as Sn) or 0.15 µg/L TBT (as TBT). Because there are many uncertainties associated with the original PSDDA SL and with the partitioning approach described above, this proposed interstitial water level was further evaluated based on a comparison to acute and chronic adverse effects levels compiled by EPA (1996).

This concentration is below approximately 2/3 of the chronic effects levels reported in the literature, and is below the entire range of acute effects levels reported in the literature. PSDDA disposal sites have been carefully sited to avoid sensitive habitat areas (such as shellfish growing areas) and most are sited in deep water. For these reasons, many of the chronic impacts to bivalves and other species that would be predicted at lower concentrations are not expected to occur at the disposal sites. This interstitial water level is therefore expected to be protective of acute and most chronic effects, without being over conservative. Thus, an interstitial water concentration of 0.15 µg/L TBT is appropriate for use as an SL for the PSDDA open-water disposal sites.

Bioassay Testing

Exceedances of the SL for TBT currently trigger the requirement to conduct bioassay testing. The PSDDA bioassays include a 10-day amphipod mortality test, a sediment larval bioassay and the 20-day *Neanthes* biomass test. Bioassay testing under SMS includes these same bioassays, although Microtox or benthic infaunal analysis can be substituted for the biomass test. However, recent project data and evidence from the scientific literature indicate that most or all of the bioassay tests typically used under SMS and PSDDA may not be appropriate for evaluation of TBT toxicity, particularly with the short testing durations routinely used (Meador *et al.*, in press; Moore et al., 1991; Langston and Burt, 1991; Fent, 1996). Most of the bioassay organisms currently used have been demonstrated to show serious acute and chronic toxicity associated with TBT in sediments, but at much longer exposure periods than employed in the standard PSEP bioassay protocols (EPA, 1996; Salazar and Salazar, 1991, 1996).

Results from recent projects (e.g., Puget Sound Naval Shipyard, Commencement Bay, Coos Bay, Harbor Island) would seem to bear out this prediction. Several sites have shown adverse benthic effects in areas with high TBT sediment concentrations, even when acute and/or chronic bioassays did not show adverse effects. In addition, bioaccumulation of TBT and associated adverse effects has been demonstrated at a number of these sites when short-term laboratory bioassays did not show a response. This may be because the longer-term bioaccumulation studies and *in situ* benthic assemblages better reflect the chronic endpoints with which TBT is associated and include long enough exposure durations for TBT in sediments and water to come into equilibrium with the organisms.

PSDDA Bioaccumulation Testing for TBT

The TBT bioaccumulation trigger was established at 219 µg/kg (as Sn), based on a multiple of the SL (PSDDA, 1989). Bioaccumulation testing is required when this threshold is exceeded. However, using the method described above for the SL, the existing BT corresponds to an interstitial water concentration of 1.07 µg/L (as TBT). This concentration is well above a level considered protective by the PSDDA agencies and the EPA Superfund work group. Based on the evidence provided above, significant bioaccumulation and adverse effects may occur at much lower concentrations. The interstitial water SL (0.15 µg/L TBT) corresponds to a level above which adverse reproductive and population-level effects due to bioaccumulation of TBT have been observed, and will also be used as the BT.

PROPOSED ACTIONS/MODIFICATIONS

Testing Locations

The SMS program and PSDDA agencies have required testing for TBT in marinas, boat maintenance areas, and other locations where TBT is likely to be present. Sediment testing in Commencement Bay (Thea Foss and Hylebos Waterways), in the Duwamish River, and in Salmon Bay and Lake Union Ship Canal have shown TBT to be present throughout the waterways and at levels substantially above the existing sediment SL. These studies show that TBT is more widely distributed, and at higher levels, than previously thought. For this reason, the SMS and PSDDA agencies will require testing for TBT in areas where past data have demonstrated its presence (particularly urban bays), and at other appropriate project locations where it would be likely to be present, such as marinas, shipyards, boatyards, and in the vicinity of large CSOs or treatment plant outfalls. Persons who have evidence that TBT is not present at their project location can ask to have this requirement waived.

TBT Testing Strategy for PSDDA Projects

The available evidence indicates that neither sediment chemistry screening levels nor the existing PSEP bioassay protocols may be as useful in predicting actual environmental effects as measurement of TBT concentrations in interstitial water and tissues. Therefore, the current tiered testing protocol utilizing bulk sediment chemistry and short-term bioassays is not considered appropriate for evaluating the potential adverse effects of TBT. Because of the complexity of TBT speciation in the aquatic environment (including ionic forms) and because other factors may strongly affect its bioavailability, an alternative testing strategy is proposed.

Measurement of TBT in interstitial water provides a more direct measure of potential bioavailability, and hence toxicity, than bulk sediment concentrations. This approach also avoids the difficulties inherent in extrapolating to a sediment cleanup level, particularly where paint wastes or other less bioavailable forms may be present. Therefore, ***the agencies propose that interstitial water analysis replace bulk sediment analysis*** as the initial step in a tiered assessment of TBT toxicity for PSDDA projects.

TBT should be analyzed using approved methods as described above, and reported as TBT. A standard method for collection of interstitial water has not yet been determined, though several techniques are available. Recommendations for a standardized method will be developed over the next year and discussed at the 1997 SMARM.

If the TBT concentration in the interstitial water is above 0.15 µg 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. If unacceptable tissue concentrations are measured at the end of the bioaccumulation test, the sediment will be found unsuitable for open-water disposal.

TBT Testing for SMS Cleanup Sites

Although specific regulatory levels corresponding to the SQS and CSL have not yet been promulgated, a similar conceptual approach will be used for evaluation of TBT toxicity at SMS sites. As is typical of cleanup sites, a preponderance of evidence approach may be used rather than a strict tiered testing approach. However, interstitial water data and bioaccumulation (tissue) data will be given more weight in evaluating potential ecological effects than sediment concentrations or short-term bioassay results. Either laboratory or *in situ* bioaccumulation tests may be employed.

At many sites, bioassay testing will be conducted to evaluate the ecological effects of other chemicals in sediments. To evaluate ecological effects of TBT at these sites, longer-term bioassay/ bioaccumulation studies could be considered as alternative chronic tests to those listed in SMS. Such alternative testing approaches may be particularly appropriate when other chemicals are also present that are slow to reach equilibrium in the laboratory, such as dioxins/furans and pesticides. Biological tests that measure both bioaccumulation and associated effects endpoints are recommended to assess the significance of measured tissue concentrations.

At sites where these alternative approaches are used to assess the effects of TBT, site-specific cleanup standards will need to be set based on the interstitial water and tissue effects ranges described in this paper. Consistent with the narrative standards set forth in WAC 173-204-100(3) and (7), site-specific cleanup standards shall include consideration of acute and chronic effects to aquatic organisms and human health, and shall range between no adverse effects and minor adverse effects levels. With respect to TBT, the presence of natural or cultured bivalve growing or collection areas shall be given special consideration in setting protective cleanup standards, since Other chemicals of concern may trigger acute toxicity testing. Very low levels of TBT in water and sediments are known to adversely affect reproduction and growth of these culturally and economically important resources.

Further Development of Bioassay/Bioaccumulation Tests

Public comments recommended a wide variety of possible bioassay and bioaccumulation test strategies. Recommendations included side-by-side testing of amphipod species to determine relative sensitivity to TBT; use of a 60-day *Neanthes* bioassay with growth and reproduction endpoints; use of a 20-day *Macoma nasuta* test with bioaccumulation, tissue growth, and shell growth as endpoints; field-validation of laboratory bioaccumulation tests; use of longer-term larval tests with sensitive organisms such as oysters, mysids, and the copepod *Acartia tonsa*; and interstitial water bioassays. Although it is not currently within the PSDDA budget to conduct such studies, it may be possible to conduct some studies as part of large cleanup projects or through academic or agency research projects. The PSDDA agencies welcome and will carefully consider any information that is useful in better defining appropriate chronic tests for assessment of TBT and other compounds for which existing short-term bioassays may be inadequate to predict chronic effects.

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Appendix 9A

BIOASTAT SOFTWARE

DMMP CLARIFICATION PAPER
SMS TECHNICAL INFORMATION MEMORANDUM

BIOSTAT SOFTWARE FOR THE ANALYSIS OF DMMP/SMS BIOASSAY DATA

Prepared by David F. Fox (U.S. Army Corps of Engineers), David A. Gustafson (U.S. Army Corps of Engineers) and Travis C. Shaw (U.S. Army Corps of Engineers) for the DMMP/SMS agencies.

INTRODUCTION

Biological testing can be used to determine both the toxicity of sediments to a suite of organisms and the bioavailability of chemicals for uptake and storage. In both cases, the experimental results are statistically analyzed to determine whether there is a significant difference between test and reference samples. Thus, statistical analysis plays a critical role in the interpretation of bioassay results and in regulatory determinations made with regard to the sediment. It is important that the statistical procedures used be technically sound, consistently applied and provide reproducible results by regulators, bioassay practitioners and consultants alike.

PROBLEM IDENTIFICATION

Statistical procedures for the DMMP were first established in the PSDDA Management Plan Report Phase II (PSDDA 1989, page 5-25). Modifications of these procedures have been made twice by the regulatory agencies via the annual review process. In 1994, the experimental significance level for the larval test was increased to 0.10 and the use of power analysis was established for that bioassay (Fox & Littleton, 1994). In 1996, use of the Shapiro-Wilk test for normality was incorporated into the statistical procedures (Michelsen & Shaw, 1996). An additional modification, replacement of Cochran's test with Levene's test for equality of variances, was proposed but not formally adopted during the 1997 annual review process (Shaw & Fox, 1997).

The modifications, adopted and proposed, provide a statistically more rigorous treatment of bioassay data but also increase the complexity of the analysis. When Levene's test was proposed for adoption as the standard test for equality of variances, concern was expressed that the statistics were becoming more complicated than agency staff and most consultants could readily handle. It was therefore proposed (Shaw & Fox, 1997) that statistical software be developed to facilitate bioassay data analysis. This software would incorporate Levene's test, as well as the other modifications made earlier.

The primary purpose of this paper is to introduce the software that was promised in 1997 and to describe the statistical procedures used by the program. Secondarily, where modifications have been made to statistical procedures currently used in the DMMP and SMS programs, technical justification is provided.

TECHNICAL DISCUSSION

Student's t-test and underlying assumptions. Interpretation of DMMP and SMS bioassays includes a statistical comparison between test and reference sediment data. The basic statistic used in this analysis is the student's t-test. However, use of the t-test is based on the assumption that test and reference samples have been taken from a normally distributed population and have equal variances. The consequences of violating these assumptions include loss of confidence in the type I error rate and a decrease in statistical power. Violations of the assumptions can be addressed through the use of data transformation or the application of alternate statistical procedures.

Development of the BioStat Software. Seattle District developed BioStat to automate the testing of statistical assumptions and to perform the comparison test between experimental treatments that best matches the outcome of the assumptions tests. BioStat also provides the ability to do data transformations prior to the statistical analysis. Figure 1 is a flow diagram which depicts the basic statistical logic and procedures incorporated into the software. Details are provided in the BioStat Users Guide (Fox *et al.*, 1998) and the following sections of this paper.

Test for Normality. The test and reference data must be evaluated to determine whether or not they have been taken from a normally distributed population. As indicated in Michelsen and Shaw (1996) and EPA/USACE (1994), the recommended test for normality is the Shapiro-Wilk W-statistic (Shapiro and Wilk, 1965).

Test for Equality of Variance. The statistical clarification paper presented at the 1996 Sediment Management Annual Review Meeting recommended the use of Cochran's test to evaluate equality of variance (Michelsen and Shaw, 1996). Subsequent to presentation of that paper, simulations conducted at the Corps of Engineers Waterways Experiment Station (WES) revealed that Cochran's test may have very high Type I error rates when the data set has an asymmetric non-normal distribution (Clarke and Brandon, 1995).

In its work, WES determined that Levene's test outperforms all the commonly used tests for equality of variance. Levene's test is performed by conducting an analysis of variance on the absolute deviations of treatment observations from the treatment means (Levene, 1960). The analysis of variance simplifies to a t-test when a single test treatment is being compared to a single reference treatment, which is the case in the interpretation of DMMP and SMS bioassays.

The first step in conducting Levene's test is to transform the data set into absolute deviations from the mean in each of the two treatment groups. The transformed scores are then tested using a two-tailed t-test. If the results are significant, then the conclusion is that heterogeneity of variances exists and a key assumption of the Student's t-test (for the comparison of the bioassay endpoint data) is violated by the data set. The data set must then be transformed (e.g. arcsine-square root) or the approximate t-test used.

User-selected Data Transformations. In cases where at least one of the distribution assumptions is violated, a simple transformation may allow both assumptions to be met and the t-test employed. BioStat includes three common data transformations that are user-selectable:

1) arcsine square root = $\sin^{-1}\sqrt{x}$
2) square root = $\sqrt{x+.375}$
3) log = $\log_{10}(x+1)$

The arcsine square root transformation is used with percentage data and is the most commonly used transformation for DMMP and SMS bioassays. The square root transformation is used when the variances are proportional to the means (Zar 1984, p. 241). The logarithmic transformation is sometimes useful in the analysis of growth data (Sokal and Rohlf, 1969).

Rank Transformation. In the event that none of these transformations can establish normality or homoscedasticity, BioStat automatically transforms the data to rankits (Sokal and Rohlf, 1969). Rank transformation normalizes the distribution, permitting the transformed data to be evaluated using a t-test (Conover and Iman, 1981).

Statistical Comparison of Treatment Means. Depending on the outcome of the tests for normality and equality of variance, BioStat uses the following statistical tests to compare treatment means:

Outcome of W-test	Outcome of Levene's test	Statistic used to compare treatment means	References
normal distribution	equal variances	student's t-test	Sokal & Rohlf 1969, p. 220
normal distribution	unequal variances	approximate t-test	Zar 1984, p.131
non-normal distribution	equal variances	Mann-Whitney	Sokal & Rohlf 1969, p. 393 Zar 1984, p. 139 Potvin & Roff, 1993
non-normal distribution	unequal variances	t-test on rankits	Sokal & Rohlf 1969, p. 121 Conover & Iman, 1981

One-sample t-test. There are two cases where a one-sample t-test would be used. The evaluation of bioaccumulation data sometimes includes a statistical comparison of replicate test data to a numerical standard, such as a Food and Drug Administration Action Level. The standard is not an experimental treatment and does not have replicate data, therefore a one-sample t-test must be run (EPA/USACE, 1994, page D-43 and Zar, 1984, page 102).

A second case in which BioStat uses the one-sample t-test is one in which there is no variance in the reference treatment replicates. This is an uncommon occurrence but is possible if, for example, the amphipod test is run and there is zero mortality in all of the reference treatment replicates. In this case, BioStat automatically applies the one-sample t-test.

Power Analysis. Power analysis procedures have been incorporated into BioStat for all three forms of the t-test. Technical guidance for this portion of the software came from Dixon and Massey (1957, Chapter 14), supplemented by Cohen (1988, Chapter 12) and is fully documented in the BioStat Users Guide (Fox *et al.*, 1998).

PROPOSED MODIFICATION.

The BioStat software provides for a statistically rigorous treatment of bioassay data and will be used in the future by the DMMP and SMS agencies to compare test and reference treatment data. Concomitment to the implementation of BioStat, the agencies officially adopt Levene's test to assess equality of variance rather than Cochran's test.

BioStat can be downloaded from Seattle District's FTP (file transfer protocol) server. For instructions, contact David Fox at *david.f.fox@usace.army.mil*.

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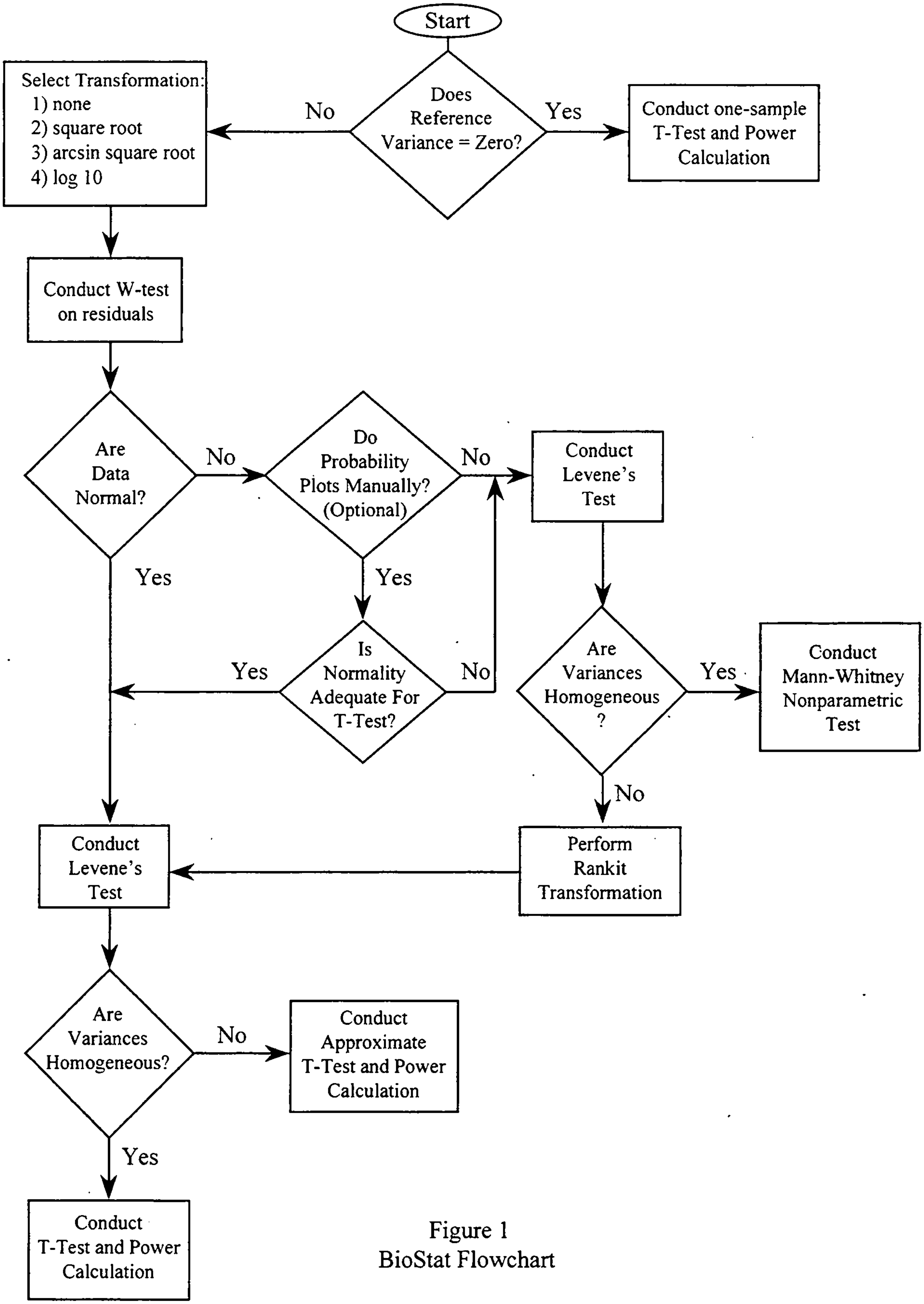

Figure 1
BioStat Flowchart

Appendix 9-B

ILLUSTRATION OF BIOASSAY INTERPRETATION GUIDELINES

Illustration of Solid Phase Interpretation Guidelines

Following is an example of the application of the solid phase interpretation guidelines to three DMMUs. Results for the negative control and the reference sediment are included for comparison to test sediment treatments and to illustrate the application of performance standards. Results have been expressed as means plus or minus the standard deviation.

Table 9A-1 illustrates that the performance standards for the negative control and reference sediment were met for all three bioassays, and that the results were acceptable for decision making.

Test DMMU-1 shows that all three biological responses were within the guidelines for suitable material. The amphipod test mortality was less than 30 percent over reference; sediment larval normalized combined mortality and abnormality was less than 30 percent over reference; and *Neanthes* growth rate was greater than 50 percent of reference. None of these were significantly different from reference. This DMMU would be suitable for aquatic disposal.

Test DMMU-2 illustrates an example of a two-hit bioassay failure. Both the amphipod and sediment larval responses are less than the single-hit response guideline, but are significantly different than reference responses, and therefore considered hits under two-hit guidelines. The *Neanthes* growth rate response is greater than 50 percent of reference and is not significantly different than reference. This DMMU would be judged to be unsuitable for aquatic disposal based on the significance of the amphipod and sediment larval responses relative to reference sediments.

Test DMMU-3 illustrates an example of a single two-hit response with no corroborating hits from the other two bioassays. It shows an amphipod response less than 20 percent over the control response, less than 10 percent over reference and not statistically different from reference. The sediment larval response is greater than 20 percent over control but is less than 15 percent over reference and not statistically different from reference. In the *Neanthes* test, the growth rate response is greater than 50 percent of the reference, but is statistically different from reference (two-hit response, requiring another bioassay hit for DMMU failure). This DMMU would be judged suitable for aquatic disposal because there are no corroborating hits from the other two bioassays.

DMMU-4 exhibits "single hits" for all three bioassays, each exceeding the numerical comparison guidelines for the negative control and reference and are statistically different from reference sediments. The individual results for each of these bioassays fails disposal guidelines for aquatic disposal for the "single-hit" response, and this DMMU is unsuitable for aquatic disposal.

Table 9A-1
HYPOTHETICAL PROJECT INTERPRETATION EXAMPLE

TREATMENT	AMPHIPOD TEST (% mortality)	SEDIMENT LARVAL TEST (% NCMA)	NEANTHES GROWTH TEST (mg/individual-day) (% of reference)	DMMU SUITABILITY
Negative control	4 ± 1	0[1]	0.7 ± 0.06 3 ± 1 % mortality [2]	
Reference sediment	16 ± 4	7 ± 3	0.66 ± 0.07	
DMMU-1	17 ± 5 [ns]	10 ± 4 [ns]	0.62 ± 0.06 [ns] (93.9%)	Suitable
DMMU-2	**25 ± 2***	21 ± 3	0.59 ± 0.05 [ns] (89.4%)	Unsuitable
DMMU-3	19 ± 3 [ns]	21 ± 6 [ns]	**0.55 ± 0.1 (75.8%)**	Suitable
DMMU-4	**33 ± 4**	**36 ± 4**	**0.41 ± 0.08 (62.1%)**	Unsuitable

1 For clarity the negative seawater control has been normalized (i.e., set to zero). The actual combined mortality and abnormality for the seawater control was 23%. Therefore, the seawater control met its performance standard of ≤ 30% combined mortality and abnormality.

2 The test met the performance standard of ≤ 10% mortality.

ns - not statistically significant.

* - statistically significant response relative to the reference sediment. Shaded portions of the table highlight test results which indicate that the DMMU is considered a hit under either the single-hit or two-hit guidelines for unconfined open-water disposal.

Appendix 9-C

BIOACCUMULATION CONCENTRATIONS AND STEADY STATE LEVELS

Bioaccumulation Concentrations and Steady State Levels

The following tables contain information concerning bioaccumulation testing. The first contains the sediment chemistry trigger values. The second concerns the steady state tissue residue levels. These levels have been compiled from the relevant literature, and will updated as new information becomes available.

SEDIMENT CHEMISTRY TRIGGER VALUES FOR BIOACCUMULATION TESTING

CHEMICAL	LOG KOW [1]	CONCENTRATION [2]
METALS (ppm dry weight basis)		
Arsenic	N/A	507.1
Mercury	N/A	1.5
Silver	N/A	4.6
ORGANIC COMPOUNDS (ppb dry)		
Fluoranthene	5.5	4,600
Benzo(a)pyrene	6.0	4,964
1,2-Dichlorobenzene	3.4	37
1,4-Dichlorobenzene	3.5	190
Dimethyl phthalate	1.6	1,168 [3]
Di-n-butyl phthalate	5.1	10,220 [3]
Bis(2-ethylhexyl) phthalate	4.2	13,870 [3]
Hexachlorobutadiene	4.3	212
Phenol	1.5	876
Pentachloropenol	5.0	504
N-Nitrosodiphenylamine	3.1	161
Tributyltin		219
Total DDT	(5.7 - 6.0) [5]	50
Aldrin	3.0	37 [3]37
Chlordane	6.0	37 [3]
Dieldrin	5.5	37 [3]
Heptachlor	5.4	37 [3]
Total PCBs	(4.0 - 6.9) [5]	338 [4]

[1] Octanol/Water Partitioning Coefficients (log KOW) for organic chemicals of concern.
[2] Concentration = 0.7 X (ML-SL) + SL. When the concentration of any chemical is above this value, bioaccumulation testing is required.
[3] These chemicals do not have an ML value. Therefore, the concentration = ((10SL-SL) X 0.7) + SL = 7.3 X SL.
[4] This value is normalized to Total Organic Carbon and is expressed in ppm (TOC normalized).
[5] 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 judgment after reviewing the Tier II data.

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
	10-DAY	28-DAY		
METALS				
Copper	75	100	Macoma nasuta	G[3]
Lead	81	100	Macoma nasuta	G
Cadmium	17	50	Callianassa australiensis	G
Mercury	ND[4]	ND[4]	Neanthes succinea	G
ORGANICS				
PCBs				
Aroclor 1242	18	87	Nereis virens	G
Aroclor 1254	12	82	Macoma balthica	G
Aroclor 1254	25	56	Nereis virens	K[6]
Aroclor 1260	53	100	Macoma balthica	G
Total PCBs	21	54	Nereis virens	G
Total PCBs	48	80	Macoma nasuta	G
Total PCBs	23	71	Macoma nasuta	G
PAHs				
Benzo(a)pyrene	43	75	Macoma inquinata	G
Benzo(bk)fluoranthene	71	100	Macoma nasuta	G
Chrysene	43	87	Macoma inquinata	G
Fluoranthene	100	100	Macoma nasuta	G
Phenanthrene	100	100	Macoma inquinata	G
Phenanthrene	100	100	Macoma nasuta	G
Pyrene	84	97	Macoma nasuta	G

Note: See footnotes at end of table.

COMPOUND	% OF STEADY STATE[2] TISSUE RESIDUE		SPECIES	ESTIMATED BY
	10-DAY	28-DAY		
TCDD/TCDF				
2,3,7,8-TCDD	6	22	Nereis virens	G
2,3,7,8-TCDD	63	100	Macoma nasuta	G
2,3,7,8-TCDF	43	62	Nereis virens	G
2,3,7,8-TCDF	92	100	Macoma nasuta	G
MISCELLANEOUS				
4,4-DDE	20	50	Macoma nasuta	G
2,4-DDD	31	56	Macoma nasuta	G
4,4-DDD	32	60	Macoma nasuta	G
4,4-DDT	17	10	Macoma nasuta	G

[1] Modified from draft 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 factor) 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.

A problem with tissue chemistry data, which must be addressed prior to statistical analysis, is tissue concentrations which are quantitated below the detection limit. Such non-numeric data cannot be statistically analyzed unless numeric values are substituted for the less-than detection limit observations. For this evaluation, substituting one-half the detection limit for each less-than observation should be utilized. (Clarke 1996)

Test interpretation guidelines for both human health and ecological effects assessments are discussed below:

♦ Human Health. The bioaccumulation test results are compared to guideline values to determine exceedance of allowable tissue residue concentrations. If the 28-day bioaccumulation test results in tissue levels greater than the FDA action levels, (see Table 3), the sediment will be considered unsuitable for aquatic disposal. Chemicals of concern without or below FDA action levels will be evaluated by the RMT using best professional judgment and risk assessment approaches. Interpretation of test results requires an evaluation of the statistical significance of the mean bioaccumulation of contaminants in animals exposed to dredged material compared to a specified action level or standard. 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 depicted below is appropriate to allow independent decisions to be made on each dredged material management unit tested:

$$t = \frac{\bar{x} - \text{action level}}{\sqrt{\frac{s^2}{n}}}$$

where "x", "s^2", and "n" refer to the mean, variance, and number of replicates for contaminant bioaccumulation from the proposed dredged material.

♦ Ecological Effects. The results of a Tier III 28-day bioaccumulation test will be compared directly with reference results for statistical significance. 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 generally be considered unsuitable for unconfined aquatic disposal.

The five factors summarized below will be reviewed as part of the regulatory assessment process when statistical significance is shown. In reviewing these factors, the best regional guidance will be consulted 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.

(4) What is the potential for the identified contaminates to biomagnify within aquatic food webs?

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

FOOD AND DRUG ADMINISTRATION (FDA) ACTION LEVELS FOR POISONOUS AND DELETERIOUS SUBSTANCES IN FISH AND SHELLFISH FOR HUMAN FOOD

CHEMICAL	TISSUE GUIDELINES (ppm wet weight)
METALS	
Arsenic	TBD[1]
Mercury (Methyl Mercury)	1.0
Silver	TBD
ORGANIC COMPOUNDS	
Fluoranthene	TBD
Benzo(a)pyrene	TBD
1,2-Dichlorobenzene	TBD
1,4-Dichlorobenzene	TBD
Dimethyl phthalate	TBD
Di-n-butyl phthalate	TBD
Bis(2-ethylhexyl) phthalate	TBD
Hexachlorobutadiene	TBD
Phenol	TBD
Pentachloropenol	TBD
Ethylbenzene	TBD
N-Nitrosodiphenylamine	TBD
Total DDT + DDE	5.0
Aldrin	0.3
Chlordane	0.3
Dieldrin + Aldrin	0.3
Heptachlor + Heptachlor Epoxide	0.3
Total PCBs	2.0

"TBD" = To Be Determined, using best professional judgement and best available guidance.