SEDIMENT MANAGEMENT PROGRAM BIENNIAL REPORT

Dredging Years 1994/1995

Puget Sound Dredged Disposal Analysis Program

Sediment Management Program

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PREPARED BY THE PSDDA AGENCIES

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Biennial Report

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LIST OF ACRONYMS

AET	Apparent Effects Threshold
ARM	Annual Review Meeting
BT	Bioaccumulation Trigger
COC	Chemical of Concern
CWA	Clean Water Act
CY	Cubic Yard
DAIS	Dredged Analysis Information System
DFW	Department of Fisheries and Wildlife
DMEAR	Dredged Material Evaluation Application Report
DMMO	Dredged Material Management Office
DMMU	Dredged Material Management Unit
DNR	Department of Natural Resources
DY	Dredging Year
EPA	Environmental Protection Agency
EPTA	Evaluation Procedures Technical Appendix
FC	Full Characterization
GIS	Geographic Information System
HPA	Hydraulic Project Approval
HPAH	High-molecular-weight PAH
LPAH	Low-molecular-weight PAH
ML	Maximum Level
MPAR	Management Plan Assessment Report
MPR	Management Plan Report
NOAA	National Oceanic and Atmospheric Administration
NRDA	Natural Resource Damage Assessment
O&M	Operations and Maintenance
PAH	Polynuclear Aromatic Hydrocarbon
PC	Partial Characterization
PCBs	Polychlorinated Biphenyls
PPB	Parts Per Billion
PPM	Parts Per Million
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
PSVTS	Puget Sound Vessel Traffic Service
QA/QC	Quality Assurance/Quality Control
SAP	Sampling and Analysis Plan
SMS	Sediment Management Standards
SL	Screening Level
TOC	Total Organic Carbon
USACE	US Army Corps of Engineers
UCOWD	Unconfined Open Water Disposal

EXECUTIVE SUMMARY

This Sediment Management Program Biennial Report reviews the application of PSDDA sediment evaluation procedures in dredging years 1994 and 1995, summarizes disposal activities at the eight open-water sites in Puget Sound, and discusses monitoring efforts at the sites. This report also includes proposed modifications in the PSDDA and Washington State Sediment Management Standards programs and status reports on important initiatives. This year marks the eighth annual review of the PSDDA program and the second joint annual review of PSDDA and the state sediment program.

In dredging years 1994 and 1995, nineteen projects completed the PSDDA evaluation process, representing more than 1.5 million cubic yards of dredged material. These projects included maintenance dredging of the Squalicum Waterway in Bellingham and the Swinomish Channel by the Corps of Engineers; at Pier D in Bremerton and Norton Terminal in Everett by the US Navy; and dredging associated with development projects by the Ports of Everett, Seattle and Tacoma. Approximately ninety-three percent of the dredged material was found to be suitable for open-water disposal under the PSDDA guidelines. The average time required for a PSDDA evaluation was 189 days. This includes review of the sediment characterization plan, field sampling, sediment testing, data compilation, report-writing and the suitability review. The average sampling and testing costs were ninety-three cents per cubic yard.

Five of the eight PSDDA open-water sites were utilized in dredging years 1994 and 1995, with disposal of nearly one million cubic yards of dredged material. All disposal events were monitored by the Coast Guard or an on-board silent inspector. More than ninety-nine percent of the dredged material was dumped on-site, within the disposal zone. The majority of the material was disposed at Port Gardner and Commencement Bay, triggering physical and environmental monitoring at these sites. In addition, cumulative disposal volumes since 1991 triggered physical monitoring at the Rosario Strait site. Monitoring results indicated that the PSDDA site management objectives were met. The dredged material placed at the nondispersive sites remained on site and did not produce greater than minor adverse effects at the sites. At the Rosario Strait dispersive site, no accumulation of dredged material occurred.

Adjustments to site monitoring requirements are proposed in this report in the form of a PSDDA issue paper. PSDDA clarification papers include refinements in the dredged material volume estimation process; the need for some small projects at outfalls to be ranked of high concern; species substitution and co-testing of species in bioaccumulation evaluations; and implementation of differential global positioning as the navigational standard for site monitoring. Joint PSDDA/SMS clarification papers address standards and protocols for the *Neanthes* bioassay; and statistical evaluation of bioassay results.

Status reports are presented on beneficial uses of dredged material; the Puget Sound multi-user disposal site study; an interagency sediment cleanup strategy; human health-based sediment criteria for Puget Sound; the re-evaluation of the Puget Sound apparent effects thresholds; and the Sediment Management Standards triennial review.

SEDIMENT MANAGEMENT PROGRAM BIENNIAL REPORT
DREDGING YEARS 1994/1995

This report summarizes the application of the PSDDA sediment evaluation guidelines to dredging projects during Dredging Years (DY) 1994 and 1995. It also describes the disposal of tested material at the eight PSDDA open-water disposal sites in Puget Sound during that period. For the second year, the PSDDA agencies have combined their annual review process with that of the Washington State Sediment Management Standards (Chapter 173-204, WAC) (SMS). Minor clarifications of the evaluation procedures, status reports on work undertaken by the agencies, and papers discussing major issues are also presented in preparation for the eighth annual review meeting (SMARM). Papers address PSDDA program issues, joint PSDDA/SMS issues, or SMS issues alone. The format of this report continues the consolidation under one cover, of the reporting requirements of the Corps, DNR and Ecology pursuant to the PSDDA Phase I and II Management Plan Reports (MPR). This report includes information previously reported in the Dredged Material Evaluation Application Report (DMEAR) and in the Management Plan Assessment Report (MPAR). The intention is to streamline the reporting process and provide readers with all important information in one report.

This report is divided into three chapters. Chapter 1 reviews PSDDA project evaluation activities for DY 94/95 (June 16, 1993 to June 15, 1995). Chapter 2 describes PSDDA disposal operations and the associated disposal site monitoring activities that occurred in DY 94/95. Chapter 3 presents both programs' issue papers, clarifications and status reports of on-going activities.

CHAPTER 1

PSDDA EVALUATION ACTIVITIES

A. INTRODUCTION

This chapter summarizes the application of PSDDA evaluation guidelines for Dredging Years 1994 and 1995. Tables related to project-specific ranking, sampling, testing, suitability determinations and costs are presented in the first part of the chapter. The second half of the chapter presents an overall assessment of these activities and data. Where projects involved unusual circumstances or the application of best professional judgment by the agencies, more detailed descriptions are provided in Appendix A.

During DY94/95 there were nineteen projects at some stage of the PSDDA process. Table 1-1 provides a complete summary of these activities. Activities which occurred in other dredging years are indicated by parentheses.

Of the projects listed in Table 1-1, ten had final suitability determinations made, or applications withdrawn, by June 15, 1994 and are considered DY94 projects for the purpose of this chapter. Nine projects had suitability determinations by June 15, 1995. These are considered DY95 projects. DY94 and DY95 project locations can be seen in Figures 1-1a and 1-1b respectively.

TABLE 1-1. DY94/95 PSDDA EVALUATION ACTIVITIES

PROJECT	Project Volume (cy)	Ranking Determination	Sampling Plan Approval	Suitability Determination
Dredging Year 1994				
Port of Brownsville Marina	10,000	(90)[1]	(93)	94
City of Des Moines Marina	5,200	(93)	94	94
Indian Cove	9,600	(92)	(93)	94
Lone Star Northwest - Hylebos	7,000	94	94	94
Konoike-Pacific	10,500	(93)	(93)	AW
Port of Seattle - Terminal 30	32,150	(93)	(93)	94
Sinclair Inlet Marina	1,900	(92)	94	94
US Navy Bremerton - Pier D (Round 2)	105,100	(91)	94	94
US Navy Everett - Norton Terminal	82,000	(93)	(93)	94
City of Bremerton - Warren Avenue CSO	4,000	94	NS	94
Dredging Year 1995				
USACE Swinomish	144,000	(93)	94	95
USACE Bellingham	258,000	95	95	95
Port of Tacoma - Blair Bridge	47,000	94	95	95
POT - West Blair Terminal Development	525,000	94	94	95
Port of Seattle - T5 Pier Extension	34,000	(93)	94	95
Holnam Cement	18,200	(93)	95	95
Port of Everett - South Terminal	183,000	(93)	94	95
Port of Everett - Piers 1 and 3	51,000	94	94	95
Lake Forest Park Civic Club	480	94	N/A	95

[1]Activities noted in parentheses occurred outside DY94/95.
AW = Application for open-water disposal withdrawn
NS = Not submitted for PSDDA agency approval prior to sampling
N/A = Not applicable

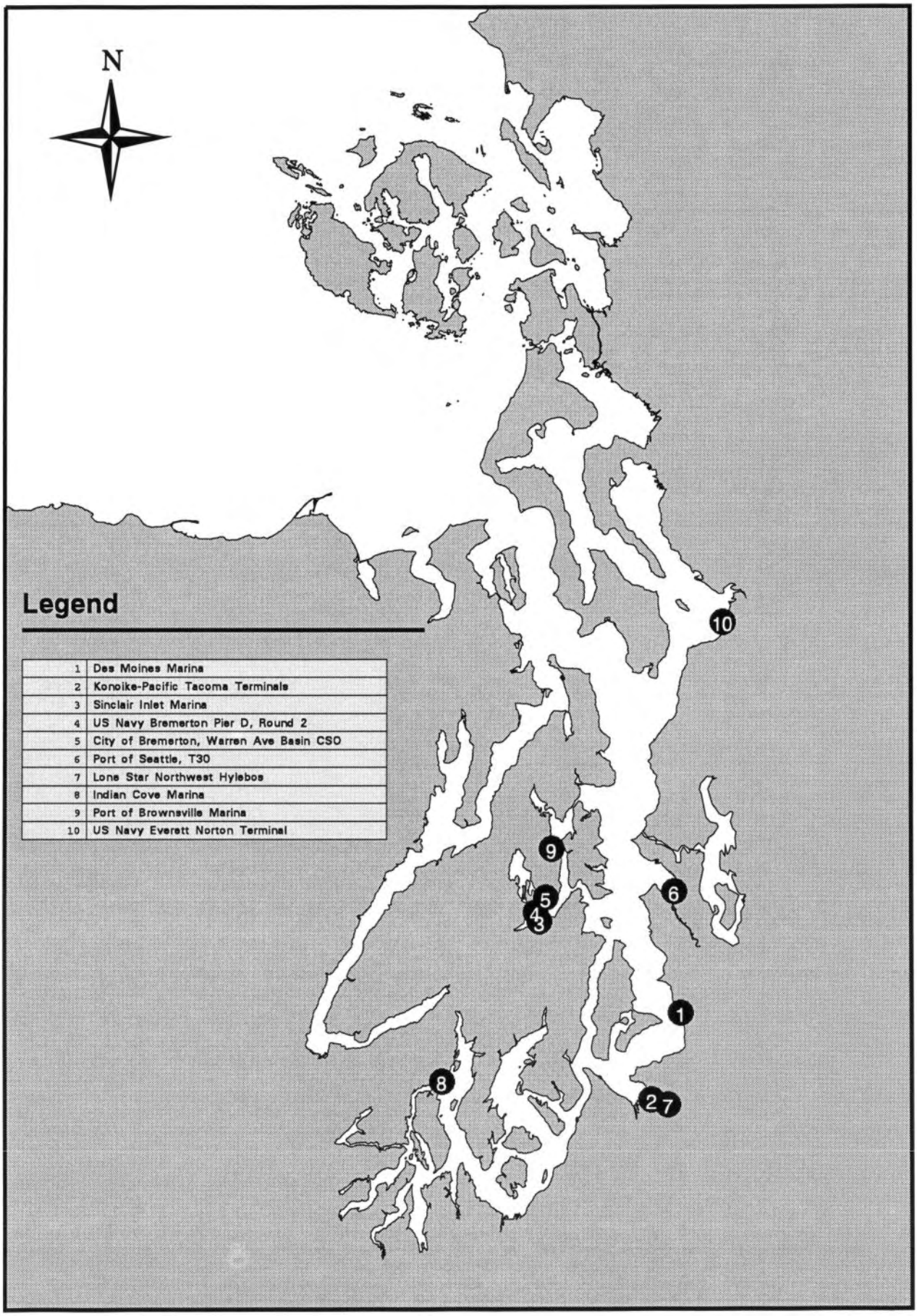


Figure 1-1a Dredging Year 1994 Project Locations

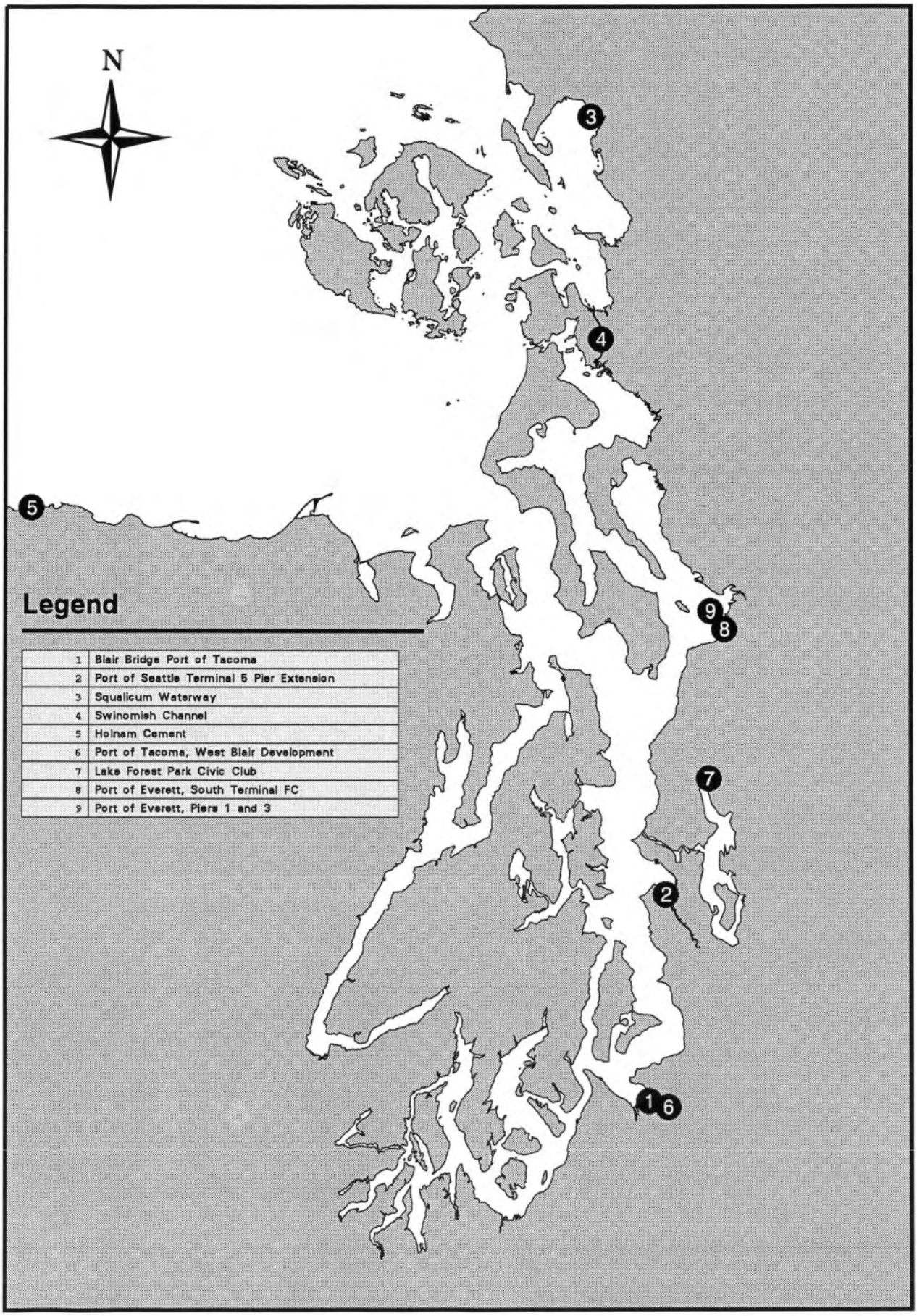


Figure 1-1b Dredging Year 1995 Project Locations

B. DY94/95 PROJECTS

Ranking

Sampling and analysis requirements under the PSDDA program are fully explained in the 1988 Phase I Evaluation Procedures Technical Appendix (EPTA) and the 1989 Phase II MPR. Under these guidelines, the initial appraisal of a proposed dredging project requires a careful examination of all existing sediment quality data within the dredging area. An initial area ranking is based on a "reason to believe" that chemicals of concern may or may not be present in the project area. The PSDDA agencies have established ranks for general areas (e.g. Elliott Bay) and activities (e.g. marinas) based on historical data or awareness of active sources of contamination. In the absence of project-specific data, representatives of the Corps of Engineers, Washington State Departments of Ecology and Natural Resources, and the Environmental Protection Agency apply an initial ranking based on guidance contained in the Phase I and Phase II documents (EPTA: page II-40; Phase II MPR: page A-10).

PSDDA guidelines allow for a reconsideration of the initial ranking if historical data at the site are adequate or the applicant conducts a partial characterization (PC) as described in EPTA (pages II-63 to II-65) to survey sediments in the project area for the PSDDA chemicals of concern (COCs). The initial rank may also be reviewed if there are indications/activities that may warrant a higher rank. If the PC chemistry data support a lower ranking (using criteria stipulated in EPTA: pages II-63 to II-65), sampling and analysis requirements for surface and subsurface sediments may be reduced during the full characterization (FC), commensurate with the revised ranking requirements. Chemicals of concern may also be eliminated for analysis during the FC, based on the PC data. Table 1-2 contains the initial and full characterization rankings of all DY94/95 projects. The "initial rank" was taken from the PSDDA Phase II MPR, pages A-10 and A-11. The "full characterization" rank was the rank actually used in the full characterization of project sediments. Of ten DY94 projects, two had ranking adjustments made (one higher and one lower) based on historical data. Of nine DY95 projects, two projects had lower rankings based on partial characterization data, and two were reranked upon review of historical data (one higher and one lower ranked).

Sampling and Analysis Plans

Approved sampling and analysis plans are required before applicants collect representative sediment samples for either a PC or FC. The applicant or dredging consultant receives guidance in sampling plan development based on the ranking which has been assigned to the proposed project. A conceptual dredging plan and representative sampling plan are established in close coordination with the Corps of Engineers' Dredged Material Management Office (DMMO), Protocols for station positioning, decontamination, field sampling, compositing, chemical analysis, biological testing, QA/QC and data submittal are all included in the sampling and analysis plan. Once completed, DMMO coordinates review and approval of the plan with representatives of the PSDDA agencies.

Table 1-3 contains data related to sampling plans approved for DY94/95 projects. Application of PSDDA sampling and analysis requirements resulted in the number of field samples and dredged material management units (DMMUs) formulated for each of the projects. Descriptions of those projects for which no testing was required, or for which best professional judgment was applied, are discussed in the project descriptions in Appendix A.

Sampling

Table 1-4 contains data related to sampling efforts during DY94/95. Two general requirements for PSDDA sampling are to sample to the depth of dredging (including overdepth), and to provide positioning data to a minimum precision of one-tenth of a second ("2 meters), latitude and longitude. For the majority of the projects listed in the table, the maximum sediment depths correspond to both the actual length of the deepest boring as well as to the maximum depth of the dredging prism including overdepth. In high-ranked areas there is an additional requirement to provide an archived sample from the one foot of sediment beyond the dredging prism. This additional depth is not reflected in the table. A variety of positioning techniques were used to provide the required precision. Great emphasis is placed on positioning in order to provide high-quality data. Precise positioning is important to provide repeatability in sampling and to provide data which can be utilized in a geographic information system (GIS).

Chemical Testing

Chemical testing was conducted for ten projects in DY94 and seven projects in DY95. During DY95, one project, Lake Forest Park Civic Club, did not require chemical testing based on PSDDA no-test guidelines. The Port of Tacoma's West Blair Terminal Development project underwent reduced chemical testing due to the large volume of native material. In general, the QA/QC for projects undergoing testing was excellent, and acceptable by the PSDDA agencies for regulatory decision-making. A complete listing of PSDDA sediment guideline value exceedances for DY94/95 projects is included in Appendix C.

Biological Testing

Biological testing data can be found in Table 1-5. For those projects undergoing tiered testing, only those DMMUs which had exceedances of SLs were subject to biological testing. Based on a reason-to-believe that at least one COC would exceed SL, and to save time in the testing process, several project proponents opted for concurrent biological testing. Regulatory use of the saline extract Microtox® test was suspended for DY94 and DY95. The effectiveness of this bioassay for assessment of dredged material suitability is currently under review by the PSDDA agencies.

Bioaccumulation testing on a PSDDA project was performed for the first time in DY94. Sediment from one surface DMMU on the US Navy Pier D project exceeded the bioaccumulation trigger for PCBs. Results of this testing are discussed in Appendix A.

Suitability Determinations

A suitability determination outlines the evaluation procedures used in the characterization of project sediments, summarizes chemical and biological testing data and associated QA/QC issues, and documents the interpretation of testing results. The suitability determination is a technical memorandum, drafted by the Corps' DMMO, and signed by PSDDA representatives from the Corps of Engineers, Environmental Protection Agency, Department of Ecology and Department of Natural Resources. The suitability determination documents the suitability of proposed dredged sediments for open-water disposal at one of the eight PSDDA sites. It does not, however, constitute final project approval by the agencies. Comprehensive agency comments on the overall project are provided through the regulatory public notice and review process.

Table 1-6 contains information taken from the suitability determinations for each of the projects which completed their PSDDA review during DY94/95. For the ten projects receiving suitability determinations in DY94, three had at least one DMMU that was found unsuitable for open-water disposal under PSDDA evaluation guidelines. In DY95, of nine projects receiving suitability determinations, only one had at least one DMMU that was found unsuitable for open-water disposal.

Cost Data

Figure 1-2 shows the total costs for DY94/95 projects submitting cost data to the Dredged Material Management Office (DMMO). Cost data were submitted for sixteen projects. Cost data were not submitted for one DY94 project (US Navy, Everett, Norton Terminal) and one DY95 project (Port of Seattle/Terminal 5). Cost data depicted for the Corps of Engineers-Bellingham Harbor Project and maintenance dredging from the Port of Bellingham's berthing areas in Bellingham Harbor were summarized jointly for this report. One project qualified for no testing under PSDDA small project no-test guidelines (Lake Forest Park Civic Club).

Total project costs were divided by the total number of DMMUs for each project and are shown in Figure 1-3. The average DMMU sampling, chemical analysis, biological analysis and miscellaneous costs are depicted for comparison among projects.

Figures 1-4a, 1-4b and 1-4c depict project costs on a per-cubic yard basis compared with project specific testing volumes. The projects are grouped within each assigned area ranking. Two projects had multiple ranking, and the estimated costs within each rank were distributed among ranking subareas on a cost-per-DMMU basis for comparison. For the Port of Tacoma West Blair Terminal Development dredging project, the PSDDA agencies assigned a high rank for the near surface tidal marsh fill material (5-14 feet MLLW) and a low rank for the subsurface native soil layer (below 1-5 feet MLLW). The Corps-Bellingham Harbor maintenance dredging project included moderate and high ranked material. The project specific data illustrate how the size of the project (volume) influenced the testing cost per cubic yard.

TABLE 1-2a. DY94 PROJECT RANKING

PROJECT	LOCATION	WATERBODY	INITIAL RANK	FULL CHARACTERIZATION RANK
Port of Brownsville Marina	Brownsville	Port Orchard	M	M
City of Des Moines Marina	Des Moines	Puget Sound	M	H
Indian Cove	Hartstene Isl.	Pickering Passage	M	M
Lone Star/Hylebos	Tacoma	Hylebos Waterway	H	H
Konoike-Pacific	Tacoma	Blair Waterway	H	H
POS - Terminal 30	Seattle	Elliott Bay	H	H
Sinclair Inlet Marina	Port Orchard	Sinclair Inlet	H	H
US Navy Pier D	Bremerton	Sinclair Inlet	H	H
US Navy Norton Terminal	Everett	Port Gardner	M	LM
City of Bremerton Warren Avenue CSO	Bremerton	Sinclair Inlet	M	M

TABLE 1-2b. DY95 PROJECT RANKING

PROJECT	LOCATION	WATERBODY	INITIAL RANK	FULL CHARACTERIZATION RANK
USACE Swinomish	LaConner	Swinomish Channel	L	L
USACE Bellingham	Bellingham	Squalicum Waterway	M	H/M
POT - Blair Bridge	Tacoma	Blair Waterway	H	M
POS T5 Pier Extension	Seattle	Elliott Bay	H	LM
Holnam Cement	Port Angeles	Strait of Juan de Fuca	M	M
POE - South Terminal	Everett	Port Gardner	H	M/LM
POE - Piers 1 and 3	Everett	Port Gardner	H	H
Lake Forest Park Civic Club	Lake Forest	Lake Washington	M	M
Tacoma - West Blair Terminal Development	Tacoma	Blair Waterway	H	H

Abbreviations:

L = Low M = Moderate

LM = Low-Moderate H = High

TABLE 1-3a. DY94 PROJECTS - APPROVED SAMPLING PLANS

PROJECT	Rank	Total Volume (cy)	Surface Volume (cy)	Number of Surface Samples	Number of Surface DMMUs	Subsurface Volume (cy)	Number of Subsurface Samples	Number of Subsurface DMMUs
Port of Brownsville	M	10,000	10,000	5	1	0	0	0
Des Moines Marina	M	5,200	5,200	3	2	0	0	0
Indian Cove	M	8,000	8,000	4	1	0	0	0
Lone Star/Hylebos	H	8,000	4,000	2	2	4,000	2	1
Konoike-Pacific	H	10,500	10,500	3	3	0	0	0
POS - Terminal 30	H	33,400	9,000	5	3	24,400	21	3
Sinclair Inlet Marina	H	1,900	1,900	2	1	0	0	0
US Navy Pier D	H	105,100	63,100	17	17	42,000	27	5
US Navy Norton Terminal	LM	115,000	60,000	8	2	55,000	7	2
City of Bremerton Warren Avenue CSO	M	4,000	2,000	2	1	2,000	2	1
Total:		301,100	173,700	51	33	127,400	59	12

TABLE 1-3b. DY95 PROJECTS - APPROVED SAMPLING PLANS

PROJECT	Rank	Total Volume (cy)	Surface Volume (cy)	Number of Surface Samples	Number of Surface DMMUs	Subsurface Volume (cy)	Number of Subsurface Samples	Number of Subsurface DMMUs
USACE Swinomish	L	144,000	144,000	20	3	0	0	0
USACE Bellingham	H/M	258,000	210,000	16	4	48,000	4	2
POT - Blair Bridge	M	47,000	12,100	5	2	34,900[1]	0	0
POS - T5 Pier Extension	LM	34,000	12,000	3	1	22,000[2]	3	1
Holnam Cement	M	18,200	18,200	5	1	0	0	0
POE - South Terminal	M/LM	183,000	94,300	17	8	88,700	0	0
POE - Piers 1 and 3	H	51,000	34,000	9	9	17,000	5	2
Lake Forest Park Civic Club	M	480[3]	480	-	-	-	-	-
POT - West Blair Terminal Development	H/L	525,000	26,000[4]	7	7	499,000[5]	14	2
Total:		1,260,680	551,080	83	35	709,600	26	7

[1]no testing of native sediments required

[2]included 12,500 cubic yards of native sediment for which no testing was required

[3]less than no-test volume of 500 cubic yards for a moderate-ranked project

[4]the "surface material", ranked "high", represented the first five feet of material underlying the soil to be cleaned up under MTCA (see Appendix A)

[5]of this subsurface volume, the upper 26,000 cubic yards were ranked "low" and tested; the remaining 473,000 cubic yards consisted of native soils and were not tested

TABLE 1-4a. DY94 PROJECT SAMPLING

PROJECT	GRAIN SIZE (PERCENTAGES)				SAMPLING EQUIPMENT	MAXIMUM SEDIMENT DEPTH (FT)	MEAN SEDIMENT DEPTH (FT)
	GRAVEL > 2mm	SAND .063 - 2mm	SILT .004 - .063mm	CLAY < .004mm			
Port of Brownsville	6	79	12	3	impact corer	6.0	4.6
Des Moines Marina	18-30	49-77	1-14	1-7	hand corer	2.3	1.8
Indian Cove	42	52	4	2	diver corer	3.7	2.9
Lone Star/Hylebos	11-37	49-52	10-28	2-13	auger/split-spoon	9.0	9.0
Konoike-Pacific	0-3	10-76	17-66	6-24	impact corer	11.0	11.0
POS - Terminal 30	1-48	28-64	1-52	1-8	diver corer auger/Shelby auger/spoon	22.0	19.3
Sinclair Inlet Marina	3	87	7	3	weighted impact corer	4.0	4.0
US Navy Pier D	0-65	8-68	14-60	7-38	Dames & Moore/split-spoon	10.0	7.6
US Navy Norton Terminal	0-1	27-41	46-54	9-17	impact corer	7.5	5.4
City of Bremerton Warren Avenue CSO	25-31	48-71	3-18	0-5	Dames & Moore/split-spoon	8.0	8.0

TABLE 1-4b. DY95 PROJECT SAMPLING

PROJECT	GRAIN SIZE (PERCENTAGES)				SAMPLING EQUIPMENT	MAXIMUM SEDIMENT DEPTH (FT)	MEAN SEDIMENT DEPTH (FT)
	GRAVEL > 2mm	SAND .063 - 2mm	SILT .004 - .063mm	CLAY < .004mm			
USACE Swinomish	1-8	92-97	2.6	0	van Veen grab	N/A	N/A
USACE Bellingham	0-53	1-62	1-75	1-53	vibracore	14.5	6.9
POT - Blair Bridge	1-7	53-81	12-30	5-12	impact corer	4.0	4.0
POS - T5 Pier Extension	0-1	50-89	6-38	2-11	vibracore	8.0	7.8
Holnam Cement	0	47	48	5	van Veen grab	N/A	N/A
POE - South Terminal	3-22	40-88	5-34	3-14	impact corer	12.0	6.2
POE - Piers 1 and 3	1-21	31-95	1-40	1-16	impact corer	12.0	6.7
Lake Forest Park Civic Club	-	-	-	-	-	-	-
POT - West Blair Terminal Development	0-1	13-96	3-62	1-25	auger/split-spoon	12.0	7.8

TABLE 1-5a. DY94 BIOLOGICAL TESTING DATA

PROJECT	Number of Biological Analyses	Number of Analyses Failing Bioassays	Number Undergoing Concurrent Testing	Number Undergoing Tiered Testing	Bioassays Conducted (✓= yes)				Control Sediment Location	Reference Sediment Location
					Amphipod	Sediment Larval	Microtox (*Va*)	20-day Biomass (*Na*)		
Port of Brownsville	0	-	-	-	-	-	-	-	-	-
Des Moines Marina	0	-	-	-	-	-	-	-	-	-
Indian Cove	1	0	0	1	*Ra*	*De*	✓	✓	West Beach	West Beach
Lone Star/Hylebos	0	-	-	-	-	-	-	-	-	-
Konoike-Pacific	1	QA	0	1	*Aa*	*Sp*	✓	✓	West Beach	Carr Inlet
POS - Terminal 30	1	0	0	1	*Ra*	*De*	✓	✓	West Beach	Carr Inlet
Sinclair Inlet Marina	0	-	-	-	-	-	-	-	-	-
US Navy Pier D	22	11	22	0	*Ra, Aa*	*De*	✓	✓	West Beach	Carr Inlet
Norton Terminal	1	0	0	1	*Ra*	*Sp*	✓	✓	West Beach	Holmes Harbor
Warren Avenue CSO	2	0	0	2	*Ra*	*De*	✓	✓	West Beach	West Beach

QA = uninterpretable results due to QA/QC problems

Aa = *Ampelisca abdita*

De = *Dendraster excentricus*

Na = *Neanthes arenaceodentata*

Ra = *Rhepoxynius abronius*

Sp = *Stronglyocentrotus purpuratus*

Va = *Vibrio fischeri*

TABLE 1-5b. DY95 BIOLOGICAL TESTING DATA

PROJECT	Number of Biological Analyses	Number of Analyses Failing Bioassays	Number Undergoing Concurrent Testing	Number Undergoing Tiered Testing	Bioassays Conducted (✓ = yes)				Control Sediment Location	Reference Sediment Location
					Amphipod	Sediment Larval	Microtox (*Va*)	20-day Biomass (*Na*)		
USACE Swinomish	0	-	-	-	-	-	-	-	-	-
USACE Bellingham	8	0	0	8	*Ra, Aa*	*Sp*	✓	✓	West Beach	Carr Inlet
POT Blair Bridge	0	-	-	-	-	-	-	-	-	-
POS T5 Pier Extension	1	0	0	1	*Ra*	*De*	✓	✓	West Beach	Carr Inlet
Holnam Cement	0	-	-	-	-	-	-	-	-	-
POE South Terminal	8	0	8	0	*Ra, Aa*	*Sp*	✓	✓	West Beach Narragansett Bay	Carr Inlet West Beach
POE Piers 1 & 3	9	8	0	9	*Ra, Aa*	*De, Sp*	✓	✓	West Beach Narragansett Bay	Carr Inlet West Beach
LFP Civic Club	-	-	-	-	-	-	-	-	-	-
POT West Blair	0	-	-	-	-	-	-	-	-	-

Aa = Ampelisca abdita
De = Dendraster excentricus
Na = Neanthes arenaceodentata
Ra = Rhepoxynius abronius
Sp = Stronglyocentrotus purpuratus
Va = Vibrio fischeri

TABLE 1-6a. DY94 SUITABILITY DETERMINATIONS

PROJECT	Rank	Total Volume	Number of Chemical Analyses	Number of Biological Analyses	DMMUs Failing	Volume Failing	DMMUs Passing	Volume Passing	Proposed PSDDA Disposal Site
Port of Brownsville	M	10,000	1	0	0	0	1	10,000	Elliott Bay
Des Moines Marina	M	5,200	1	0	0	0	1	5,200	Commencement Bay
Indian Cove	M	9,600	1	1	0	0	1	9,600	Anderson-Ketron
Lone Star/Hylebos	H	8,000	2	0	0	0	2	8,000	Commencement Bay
Konoike-Pacific[1]	H	10,500	3	2	3	10,500	0	0	Commencement Bay
POS - Terminal 30	H	33,400	6	1	2	5,376	4	28,024	Elliott Bay
Sinclair Inlet Marina	H	2,200	1	0	0	0	1	2,200	Elliott Bay/Port Townsend
US Navy Pier D	H	105,100	22	22	12	53,400	10	51,700	Elliott Bay
US Navy Norton Terminal	LM	82,000	4	1	0	0	4	82,000	Port Gardner
Warren Avenue CSO	M	4,000	2	2	0	0	2	4,000	Elliott Bay

[1]Application for open-water disposal withdrawn; no suitability determination made; material is assumed unsuitable for open-water disposal in the absence of additional biological testing data

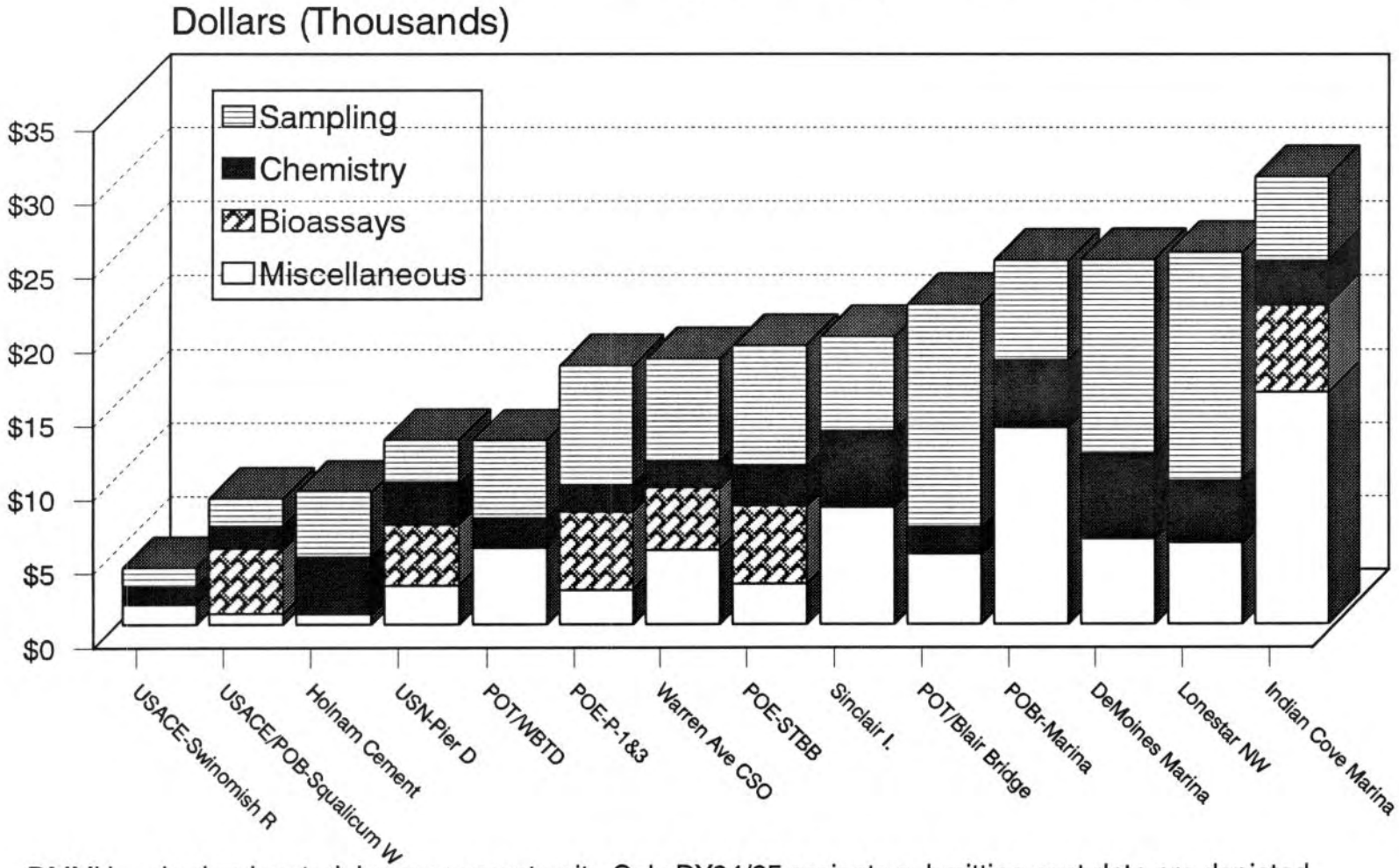
TABLE 1-6b. DY95 SUITABILITY DETERMINATIONS

PROJECT	Rank	Total Volume	Number of Chemical Analyses	Number of Biological Analyses	DMMUs Failing	Volume Failing	DMMUs Passing	Volume Passing	Proposed PSDDA Disposal Site
USACE Swinomish	L	144,000	3	0	0	0	3	144,000	Rosario Strait
USACE Bellingham	M/H	258,000	20	8	0	0	6	258,000	Bellingham Bay (44,000 cy) Rosario Strait (214,000 cy)
Blair Bridge[1]	M	47,000	2	0	0	0	2	47,000	Commencement Bay
POS - T5 Pier Extension	LM	34,000	2	1	0	0	2	34,000[2]	Elliott Bay
Holnam Cement	M	18,200	1	0	0	0	1	18,200	Port Angeles
POE - South Terminal	M/LM	183,000	8	8	0	0	8	183,000	Port Gardner
POE - Piers 1 and 3	H	51,000	11	9	9	41,000	2	10,000	Port Gardner
POT - West Blair Terminal Develop.[1]	H	525,000	7	0	0	0	7	525,000	Commencement Bay
Lake Forest Park Civic Club	M	480	0	0	0	0	1	480	Elliott Bay

[1] Underlying native sediment not tested based on surface results.

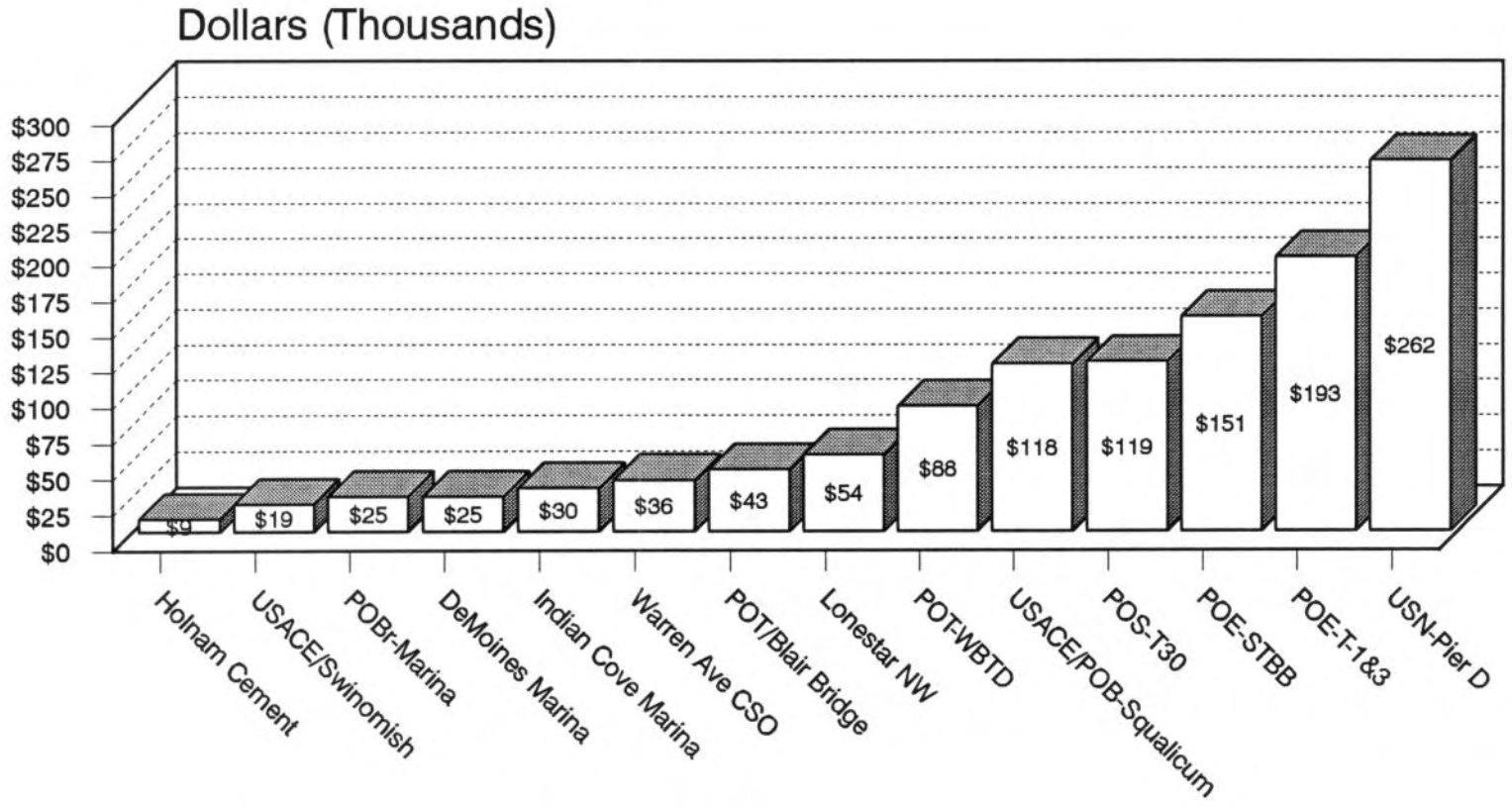
[2] Included 12,500 cubic yards of native sediment for which testing was not required.

Figure 1-2. Average Cost per DMMU



DMMU = dredged material management unit; Only DY94/95 projects submitting cost data are depicted.
Miscellaneous = SAP & report preparation, administrative overhead, etc.

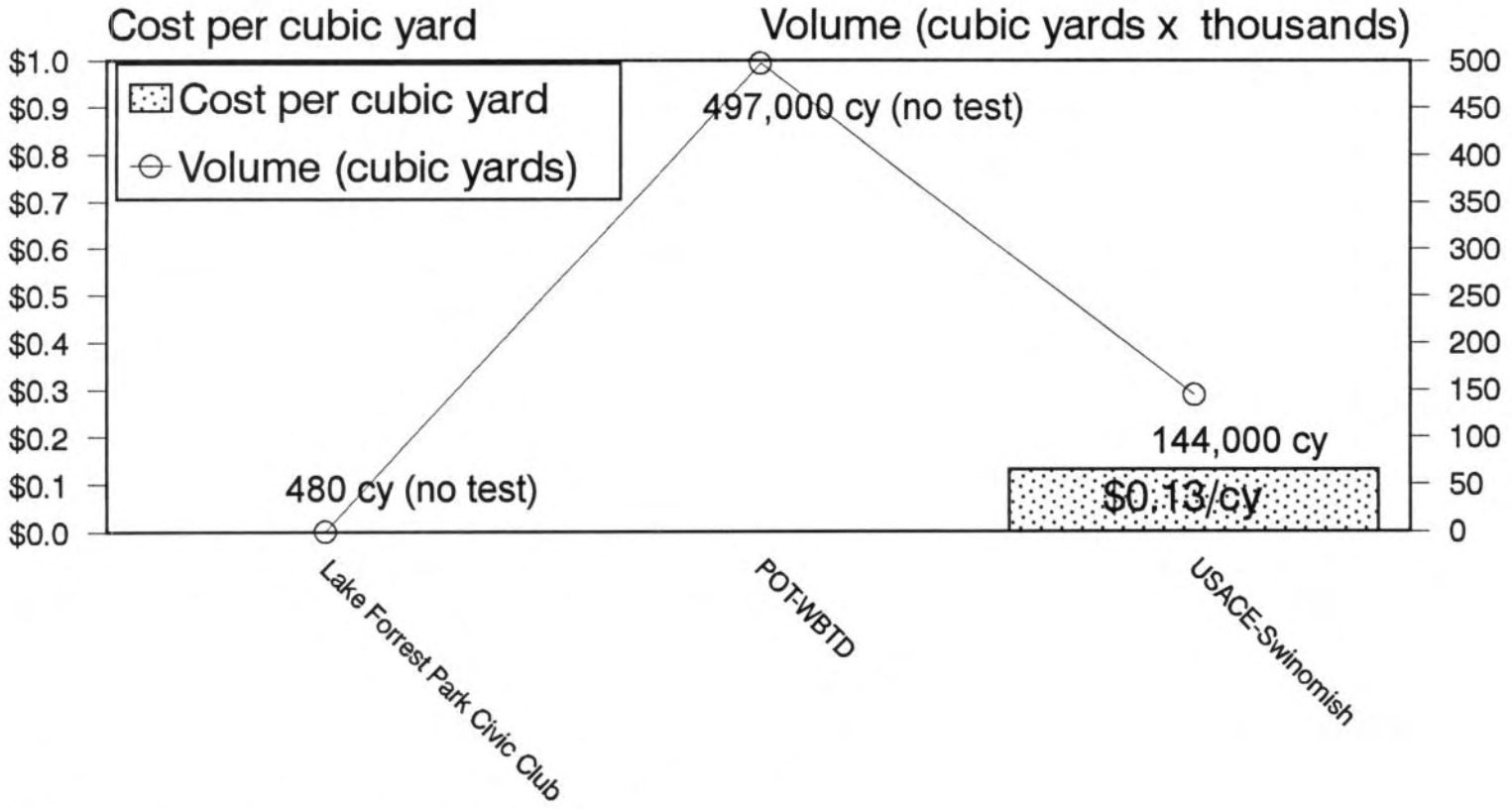
Figure 1-3. Total Project Sampling/Testing Costs*



* only depicts projects submitting data, where testing was required.

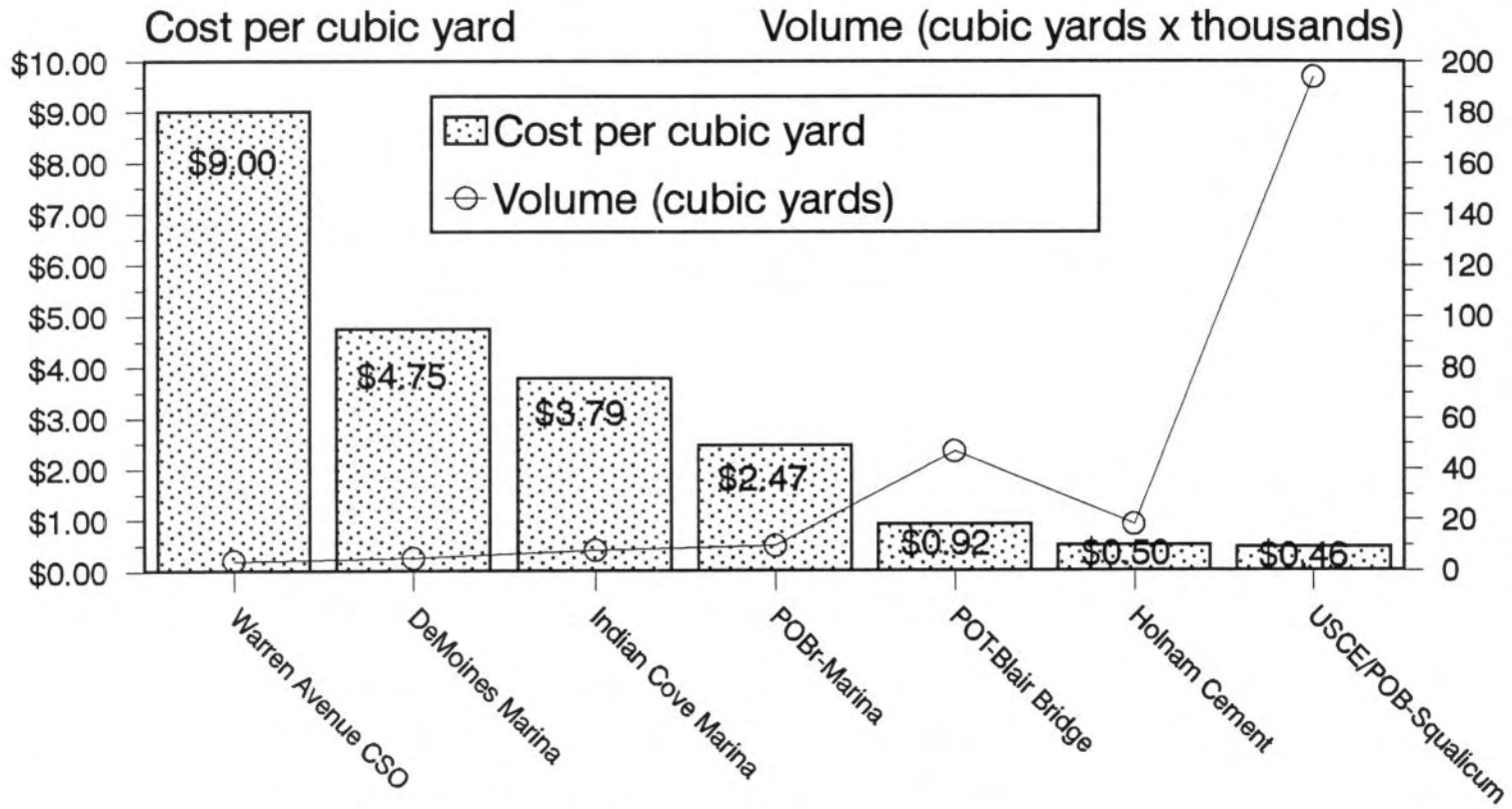
Figure 1-4a. Average Project Sampling/Testing Costs

Low Ranked Projects



weighted average = $0.03/cy for DY94/95

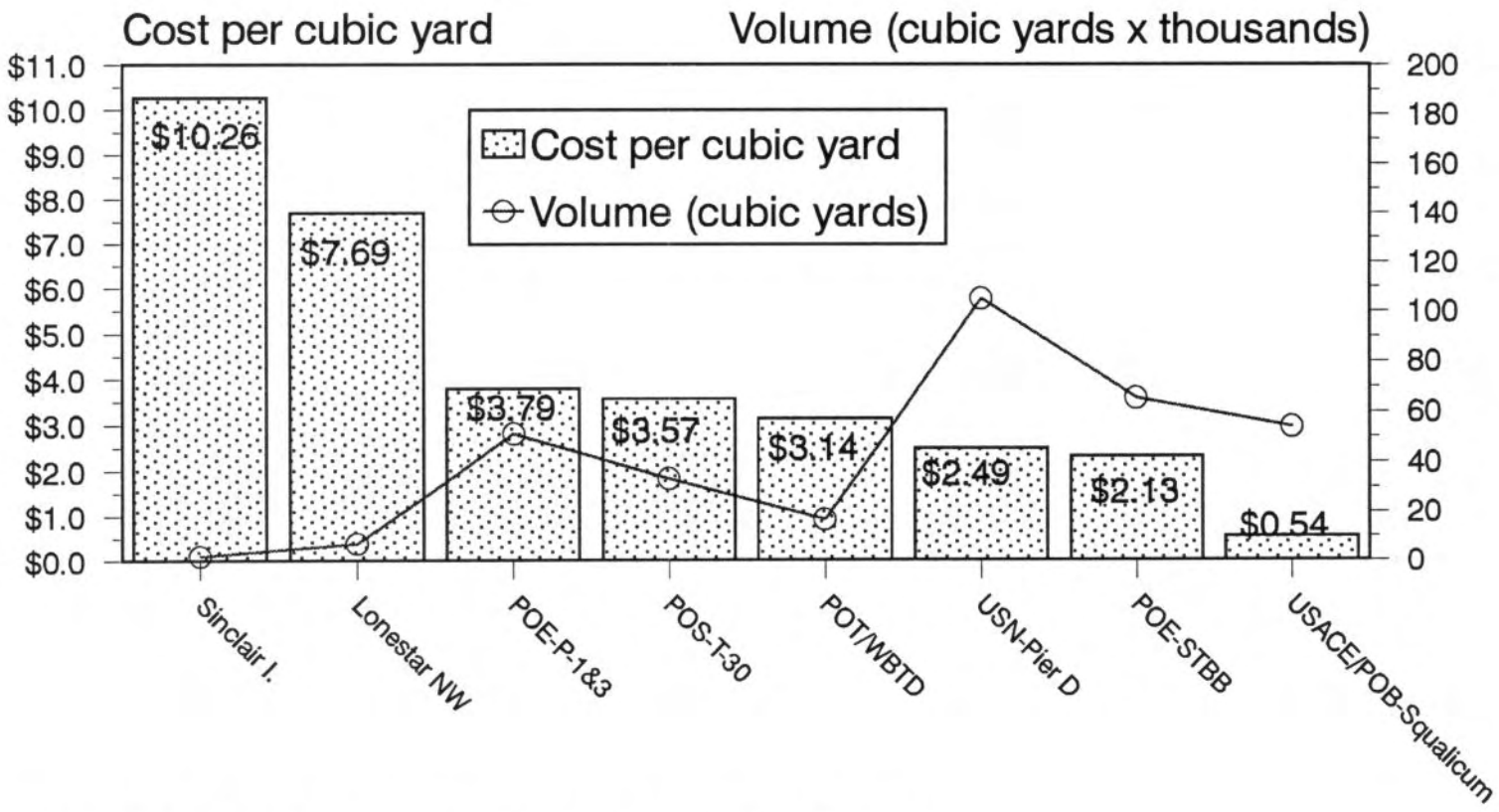
Figure 1-4b. Average Project Sampling/Testing Costs Moderate Ranked Projects



weighted average = $0.90/cy for DY94/95 Projects

Figure 1-4c. Average Project Sampling/Testing Costs

High Ranked Projects



weighted average = $2.57/cy for DY94/95 Projects

C. SUMMARY AND ASSESSMENT OF DY94/95 DATA

Summary of Testing Results

Chemical Testing. Table 1-7 summarizes the chemical testing results from DY94 and DY95. A total of 44 of the 58 PSDDA COCs had their screening levels exceeded for at least one project. These included both detected exceedances (34 COCs) and detection limit exceedances (21 COCs). Five COCs had detected concentrations above the BT, while 8 COCs were detected above the ML. Table 1-8 highlights those chemicals which had detected concentrations exceeding SL, BT and ML most often. Also included are those chemicals for which the detection limit exceeded SL the most often.

From Table 1-8 it can be seen that the chemicals most often detected above SL, BT and ML included four metals, three individual PAHs, total HPAH and total PCBs. The chemicals for which detection limits most often exceeded SL included hexachlorobenzene, hexachlorobutadiene and DDT. Detection limit exceedances were generally inconsequential. Only two of them (South Terminal and Norton Terminal) would have triggered, on their own, the need to conduct biological testing. Concurrent biological testing was conducted for all South Terminal DMMUs, and biological testing was required for Norton Terminal DMMU C4 due to detected exceedances of the SL. Therefore, detection limit exceedances did not result in any additional biological testing during DY94/95.

TABLE 1-7. DY94/95 CHEMICAL TESTING SUMMARY

CHEMICAL OF CONCERN	# of DMMU D>SL	# of Projects D>SL	# of DMMU D>BT	# of Projects D>BT	# of DMMU D>ML	# of Projects D>ML	# of DMMU U>SL	# of Projects U>SL	# of DMMU U>BT	# of Projects U>BT	# of DMMU U>ML	# of Projects U>ML
METALS												
Antimony	4	2	2	2	1	1						
Arsenic	1	1										
Cadmium (1)	28	4										
Copper (1)	20	6			1	1						
Lead (1)	16	6										
Mercury	22	5	1	1								
Nickel	3	1										
Silver	2	2										
Zinc (1)	16	6										
LPAH												
2-Methylnaphthalene (1)	9	4					3	2				
Acenaphthene (1)	13	4			2	2	2	2				
Acenaphthylene (1)	3	2					6	2				
Anthracene (1)	16	6			1	1						
Fluorene (1)	14	4			3	2	2	2				
Naphthalene (1)	10	3										
Phenanthrene (1)	14	4										
Total LPAH (1)	15	4			1	1						
HPAH												
Benzo(a)anthracene (1)	7	3										
Benzo(a)pyrene	3	3										
Benzofluoranthenes (1)	6	4										
Chrysene (1)	5	3										
Dibenzo(a,h)anthracene (1)	2	2					1	1				
Fluoranthene	15	5	1	1								
Indeno(1,2,3-c,d)pyrene (1)	26	7										
Pyrene (1)	21	6										
Total HPAH (1)	25	6										

total projects = 18, total DMMUs = 89

D=Detected U=Undetected SL=Screening Level BT=Bioaccumulation Trigger ML=Maximum Level
(1)=No BT exists (2)=No ML exists (3)=No BT or ML exists

TABLE 1.7 (CONTINUED) - DY94/95 CHEMICAL TESTING SUMMARY

CHEMICAL OF CONCERN	# of DMMU D>SL	# of Projects D>SL	# of DMMU D>BT	# of Projects D>BT	# of DMMU D>ML	# of Projects D>ML	# of DMMU U>SL	# of Projects U>SL	# of DMMU U>BT	# of Projects U>BT	# of DMMU U>ML	# of Projects U>ML
CHLORINATED HYDROCARBONS												
1,2,4-Trichlorobenzene (1)							2	1				
Hexachlorobenzene							13	3				
PHTHALATES												
Bis(2-ethylhexyl) Phthalate (2)	2	2										
Diethyl Phthalate (3)							2	1				
PHENOLS												
2 Methylphenol (1)							11	2				
2,4-Dimethyl phenol (1)							9	2			1	1
4 Methylphenol (1)	7	3					1	1				
Pentachlorophenol							11	2				
Phenol	2	2					1	1				
MISCELLANEOUS EXTRACTABLES												
Benzoic Acid (1)							8	2			1	1
Benzyl Alcohol (1)	1	1					15	2				
Dibenzofuran (1)	12	3			2	2	2	2				
Hexachlorobutadiene							16	4				
N-Nitrosodiphenylamine							11	2				
PESTICIDES AND PCBs												
Aldrin (2)	2	1										
Dieldrin (2)	2	1	1	1								
Heptachlor (2)	1	1										
Lindane (2)							1	1				
Total DDT	5	4					3	3				
Total PCBs	12	4	4	3	2	2	3	2	2	1		

total projects = 18, total DMMUs = 89

D=Detected U=Undetected SL=Screening Level BT=Bioaccumulation Trigger ML=Maximum Level
(1)=No BT exists (2)=No ML exists (3)=No BT or ML exists

TABLE 1-8. MULTIPLE EXCEEDANCES OF PSDDA GUIDELINE VALUES

CHEMICAL	CHEMICALS EXCEEDING SL IN AT LEAST ONE-THIRD OF THE PROJECTS	CHEMICALS EXCEEDING BT IN AT LEAST TWO PROJECTS	CHEMICALS EXCEEDING ML IN AT LEAST THREE PROJECTS	CHEMICALS WITH DETECTION LIMITS EXCEEDING SL IN AT LEAST THREE PROJECTS
Antimony		X		
Copper	X			
Lead	X			
Zinc	X			
Anthracene	X			
Indeno(1,2,3-c,d)pyrene	X			
Pyrene	X			
Total HPAH	X			
Hexachlorobenzene				X
Hexachlorobutadiene				X
Total DDT				X
Total PCBs		X		

Biological Testing. Biological testing was conducted for ten of the nineteen projects which underwent chemical testing during DY94/95. Table 1-9 shows the number of times each of the four bioassays was conducted and the number of hits for each. Use of the saline Microtox bioassay was suspended at the 1994 ARM. Only three of the DY94/95 projects had sampling plans approved subsequent to that time. Of these three, only one required biological testing, USACE Bellingham. The Corps of Engineers elected to run the Microtox test on Squalicum Waterway sediments to acquire additional data on the test. Therefore, all DY94/95 projects requiring biological testing included Microtox in the suite of bioassays.

TABLE 1-9 - DY94/95 BIOASSAY "HITS"[1]

BIOASSAY	Number of DMMUs Tested	Number of Hits Under the "Two-Hit Rule"	Number of Hits Under the "Single-Hit Rule"
Amphipod	50	5	3
Sediment Larval	50	7	10
Neanthes Biomass	50	6	4
Microtox	50	4	---

[1]Nondispersive interpretation

As can be seen from this tabulation, there were hits reported for each of the bioassays. The sediment larval test exhibited the most hits, with 17 hits out of 50 bioassays. However, fourteen of these hits occurred for a single project, US Navy Pier D. The *Neanthes* biomass test resulted in 10 hits, with eight of these occurring for Port of Everett Piers 1 & 3. The amphipod bioassay resulted in eight hits in three projects, while the Microtox test exhibited four hits, all occurring for the Port of Everett's South Terminal and Piers 1 & 3 projects. The four Microtox hits in DY95 represented the highest number of hits for this test since DY90.

Regulatory Processing

PSDDA sampling and testing is undertaken as one of the requirements for receiving a permit under Section 404 of the Clean Water Act. There is a sequence of steps in the regulatory process which dredging proponents must take before obtaining these permits. These are as follows:

(1) Submit application for permit.

(2) Prepare sampling and analysis plan (SAP) for characterization of proposed dredged material.

(3) Receive approval of sampling and analysis plan from PSDDA agencies.

(4) Perform sampling and chemical/biological analysis.

(5) Submit testing results.

(6) Receive suitability determination for open-water disposal from PSDDA agencies.

(7) Complete application details required to issue public notice.

(8) Issue public notice, undergo 30-day public comment period.

(9) Public interest review and permit decision.

The average time requirements for these steps are included in Figures 1-5a and 1-5b, which were constructed using data from DY94/95 dredging projects.

Permit Application. An application for a Corps of Engineers' Section 10/404 permit for dredging and dredged material disposal must be submitted before any PSDDA processing may take place. An application number and Regulatory Branch Project Manager are assigned at this time and the Dredged Material Management Office begins review of information relevant to the proposed dredging.

Sampling and Analysis Plan Development. In Figures 1-5a and 1-5b, 200 days was the average time required for SAP development. This number includes the entire time from submittal of the permit application to submittal of the final SAP. In some cases (four cases in DY 94/95), a preliminary SAP is submitted for review by the PSDDA agencies and a revised SAP is requested of the applicant. This time has been included in the "Sampling and Analysis Plan Development" phase of the process. The mean time for preliminary SAP review for these four projects was 24 days, with an average of 51 days required for SAP revision by the applicant. Because a revised sampling plan is only required when the preliminary SAP has

major flaws, and because the time taken by the applicant to revise the SAP is highly variable (16-110 days), this time was not included in the "PSDDA Process" time on Figure 1-5b.

During DY91, through an iterative process involving several projects, dredging consultants and the PSDDA agencies, a prototype sampling and analysis plan was developed. This prototype is available from the DMMO in both hard copy and electronic format. The availability of this prototype has reduced the amount of time required for sampling plan development and reduced the number of times sampling plans have been returned for revision.

Sampling Plan Approval. Once a complete sampling plan has been submitted, the DMMO coordinates review of the SAP with the other PSDDA agencies: the Environmental Protection Agency and the Departments of Natural Resources and Ecology. An approval letter is sent which includes PSDDA agency comments and recommended modifications of the SAP. Once these comments and modifications have been acknowledged by the applicant, via telephone or letter, sampling and analysis may proceed. It is the goal of the Dredged Material Management Office to complete the review of SAPs within three weeks. During DY 94/95 the average time from the submittal of the final SAP for a project to SAP approval was 16 days. When the preliminary SAPs are included, the average time for review of a SAP was 18 days.

Sampling and Analysis. During this phase, field sampling and chemical/biological analysis are completed following the protocols established in the approved SAP. Data are compiled and submitted in a hard copy report. These data are entered into the Dredged Analysis Information System by the DMMO. Sampling and characterization consume a substantial portion of the PSDDA Process time budget, averaging 154 days during DY94/95. There was a high degree of variability in this phase, with projects ranging from 48 to 294 days. Factors influencing the time required for this phase include weather, laboratory capacity and turn-around, QA problems arising during chemical and biological testing, and report compilation time.

Data Review. Once a full set of chemical/biological testing data is submitted along with the sampling report, the DMMO conducts a data review with the other PSDDA agencies. The result of this review is the signing, by PSDDA agency representatives, of a Memorandum for Record documenting the determination reached on the suitability/ unsuitability of each of the dredged material management units defined in the approved SAP. The goal of the DMMO is to complete this review within three weeks of data submittal. In DY94/95, the average time required was 17 days.

Completed Permit Application, Public Notice, and Permit Decision. When the suitability determination has been made, the DMMO informs the Regulatory Branch project manager and preparations are made to issue a public notice. At the time of the original application, construction details may not have been known for the project. Alternatively, construction plans may be altered due to the suitability determination. In these cases, new drawings may be required of the applicant along with other information pertinent to the preparation of the Public Notice on a project.

Often the local shorelines process runs concurrently with PSDDA testing. The decision may be made to wait to go out to public notice until the local shoreline jurisdiction has issued a permit. In this case there may be a time lapse between the suitability determination and the public notice. Controversial projects are usually processed concurrently. During DY94/DY95 the average time between completion of the suitability determination and the issuance of the public notice was 106 days. One project, Sinclair Inlet Marina, had 255 days between the suitability determination and the public notice due to the resolution of complex fisheries issues. When this project is excluded from the average, the result is an average time of 78 days between suitability determination and public notice. This is a reduction of 41 days from the average time of 119 days in DY92/93.

By regulation, the Regulatory Branch must issue a public notice within fifteen days of the completion of the permit application. A PSDDA project typically undergoes a 30-day public comment period. Comments received during this period are considered during a public interest review.

A Section 404(b)(1) evaluation is performed after the 30-day comment period closure. The Corps Project Manager prepares a permit decision upon completion of the public interest review. This stage of the process may be very time consuming. Dredging and PSDDA processing are often only part of complex projects. Other elements may be involved, such as wetland fills or eelgrass bed impacts. Resolution of controversial issues such as these may consume additional time after a suitability determination has been made. To improve regulatory response time, the Department of Ecology recommends that applicants seek a hydraulic project approval (HPA) from the Department of Fisheries and Wildlife, and resolve other problems earlier in the permit process. Pre-application meetings could serve to improve turn-around times and could be held earlier in the process. This stage, from the date of the public notice, took an average of 125 days per project, ranging from 57 to 293 days. Four projects from these dredging years have yet to receive their permits, and are not included in this average.

PSDDA Processing Time. PSDDA processing time, as depicted in Figure 1-5b, includes final sampling and analysis plan review and approval, field sampling and analysis, data review and suitability determination. This took an average of 187 days in DY94/95, with the majority of that time taken up by sampling, testing, and data report preparation. Sampling and analysis plan preparation, although a part of the PSDDA process, was not included because of the variability in time which can elapse between permit application and sampling and analysis plan submittal. This is largely outside the control of the PSDDA agencies.

Time Elapsing for Each Regulatory Stage:

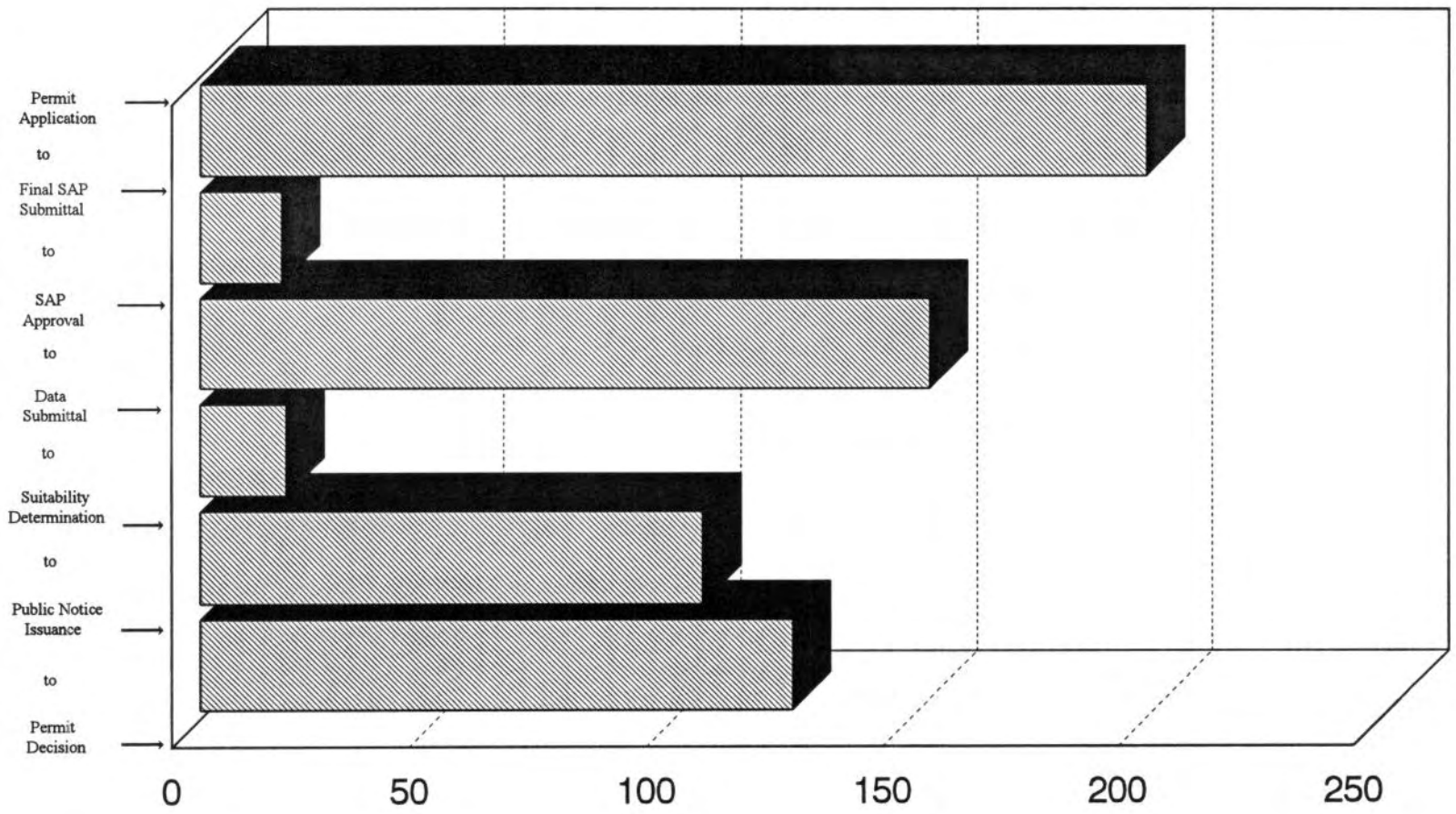
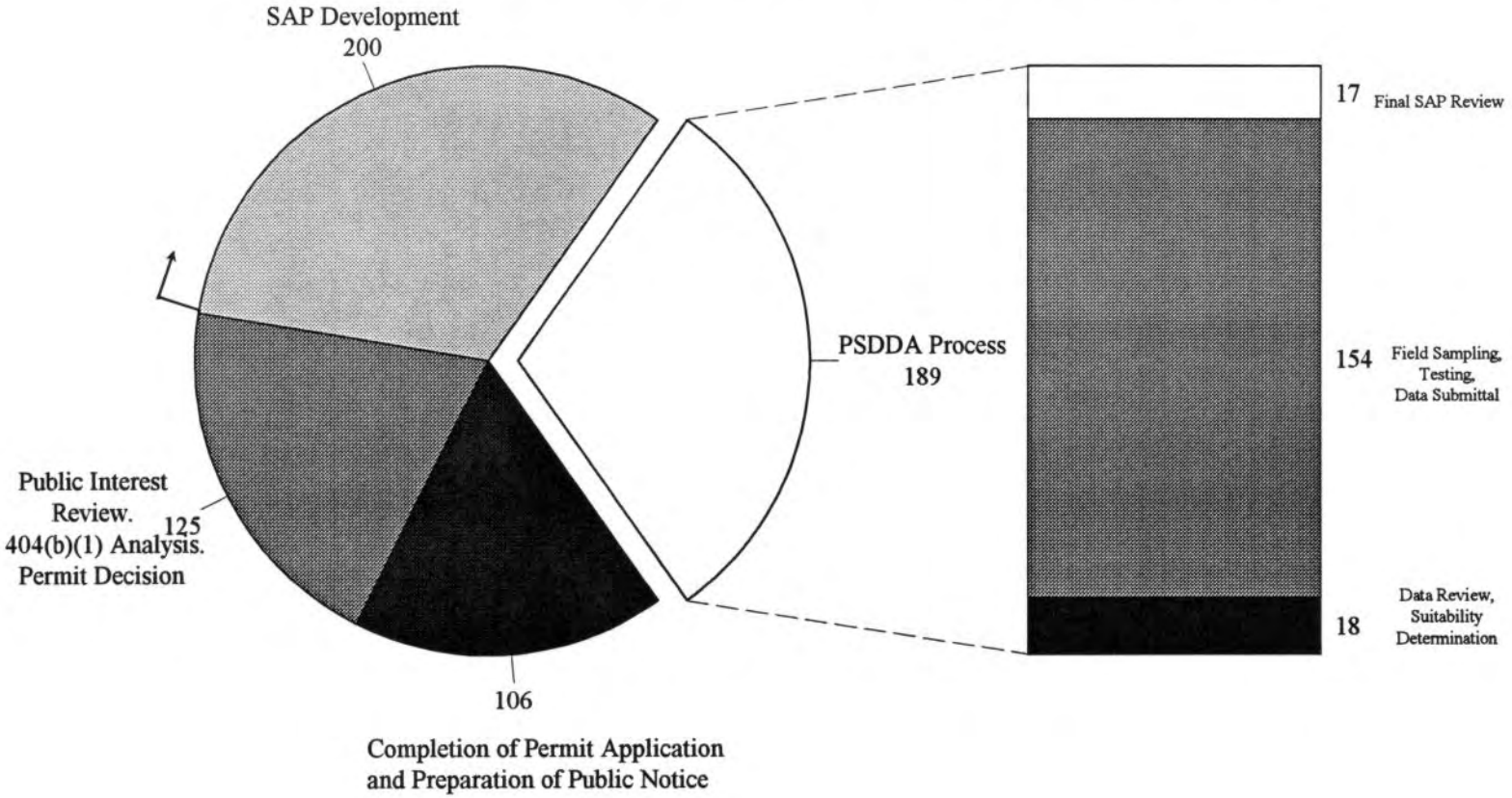


FIGURE 1-5a. Regulatory Processing Time

Means for DY94/DY95 Projects

FIGURE 1-5b. PSDDA PROCESSING TIME

Means for DY94/DY95 Projects (days)



Cost Analysis

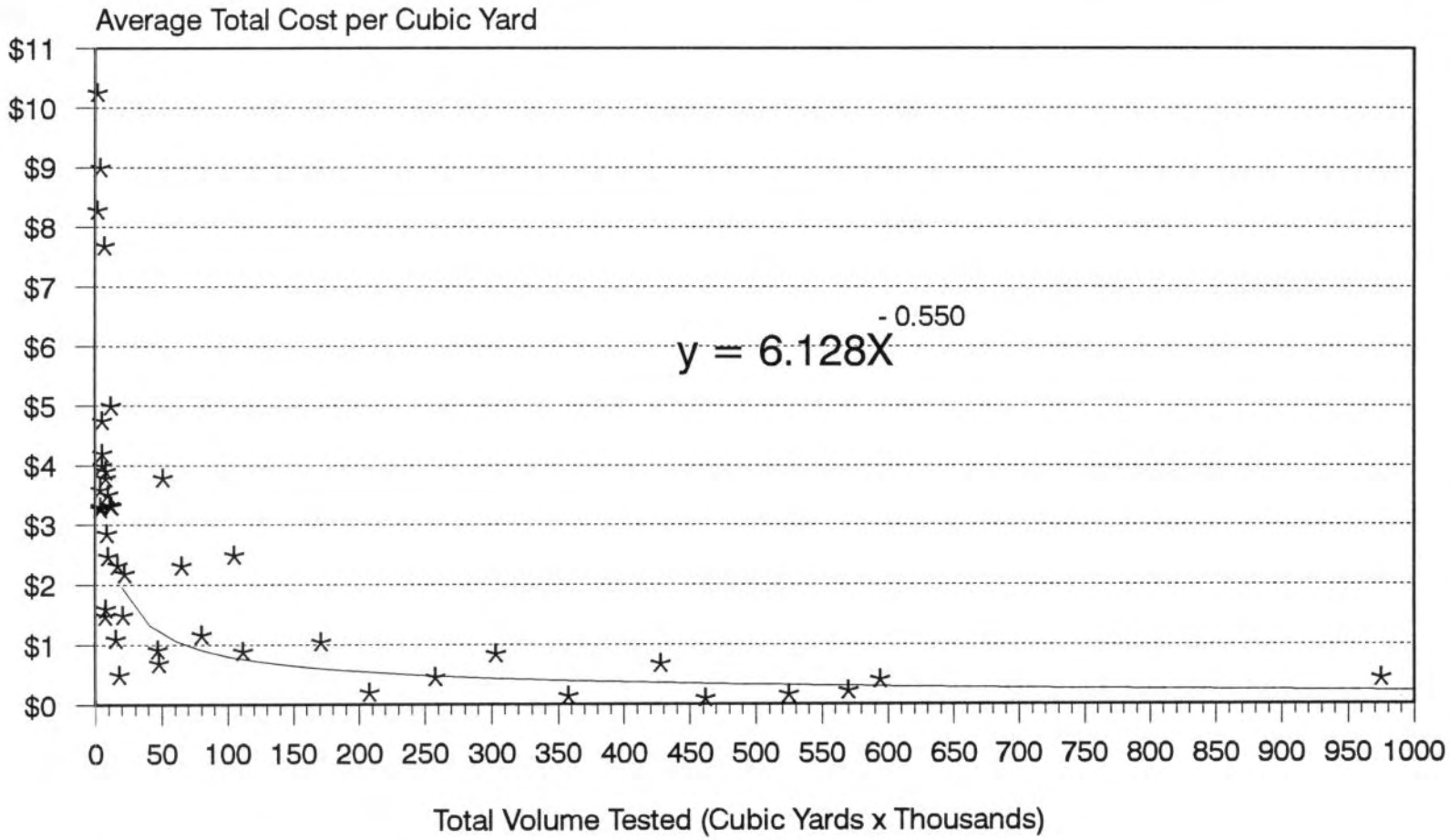
Total Costs. Total sampling and testing costs are generally related to the size of the project and the rank. Larger projects have lower unit costs than smaller projects due to economy of scale. Area rank influences costs by requiring larger numbers of analyses (DMMU) relative to lower ranked projects (see Figure 1-4a-c). Figure 1-6 shows the relationship of average total cost per cubic yard to the total volume tested for all PSDDA projects submitting data from DY90 to DY95. The regression of these two variables resulted in a significant ($p<0.001$) correlation and regression equation noted in Figure 1-6, which can be used to estimate testing cost given the project size. Figure 1-8 relates the average cost per cubic yard to the rank. Both figures verify the general relationships expected. Total PSDDA sampling and testing costs reported for DY94/95 were $1,191,216, which were about 46% of the cumulative testing costs reported for DY92/93. These costs include sampling plan development, sampling, chemical and biological testing, reporting, and other miscellaneous costs. The total volume of proposed dredged material handled under PSDDA evaluation guidelines was 1,399,580 cubic yards (1,283,100 cubic yards excluding projects not reporting testing costs). This included one project where no testing was required. The average weighted unit cost for all DY94/95 projects was $0.93 per cubic yard, and reflected the higher number of high and moderate ranked projects. The 1994/1995 average unit cost of $0.93/cy, is comparable to those observed for dredging years 1992/93 ($0.67/cy), 1991($0.38/cy), 1990 ($0.49/cy), and 1989 ($0.62/cy).

Sampling Costs. The costs associated with each of the constituent activities shown in Figure 1-3 (sampling, chemistry, biological testing, miscellaneous) varied widely. Sampling costs, in particular, exhibited high variability and no discernible patterns. An analysis of sampling costs relative to maximum sampling depth, and mean sampling depth failed to find any discernible pattern, although these do influence project sampling costs. Total sampling size was significantly correlated with total sampling costs.

Testing Costs. Chemical testing costs are generally the most straightforward and readily discernible costs. Analytical laboratories performing PSDDA analyses will provide quotes on unit costs. Average unit chemical testing costs (including QA/QC) for the past five years are depicted in Figure 1-8 as a function of the number of analyses. The scatter plot depicted shows that as the number of analyses increases beyond three the unit costs drop sharply and steadily decrease for the most part to a low of around $1500 per analysis. Projects with one or two analyses are especially costly, as the QA/QC costs cannot be distributed over several samples. Eight projects depicted in Figure 1-8 incurred additional chemical costs for either tributyltin or dioxin, which significantly increased the unit analysis costs.

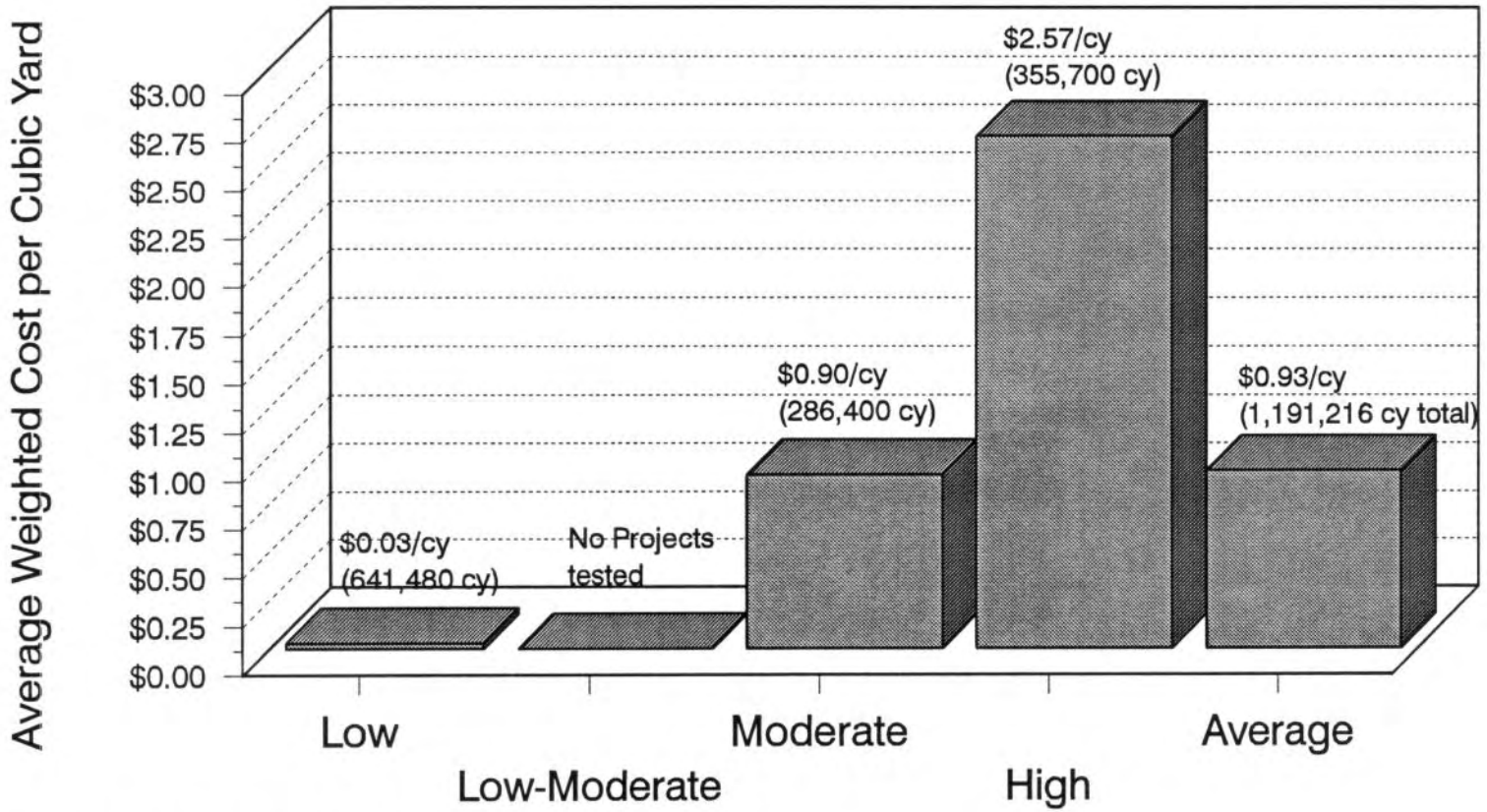
Unit costs for bioassays related well to the total number of analyses, as shown in Figure 1-9. There was a tremendous range in unit costs for projects with only one analysis, whereas the variability in unit costs dropped sharply with additional analyses.

Figure 1-6. Project Size versus Unit Testing Cost



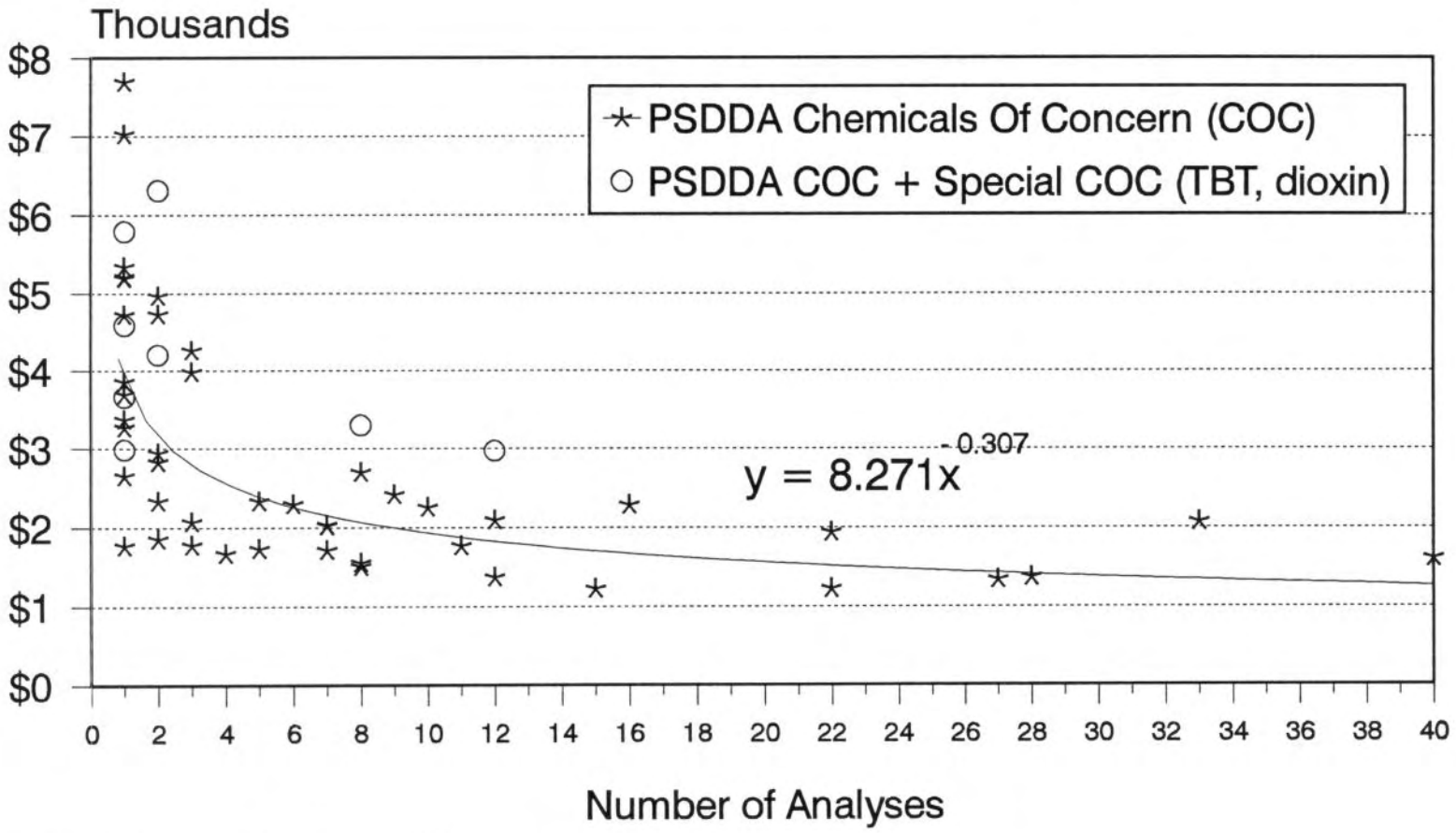
r=-0.51 (n=43, p<0.001)

Figure 1-7. Rank versus Unit Testing Cost Dredging Years 1994 and 1995*



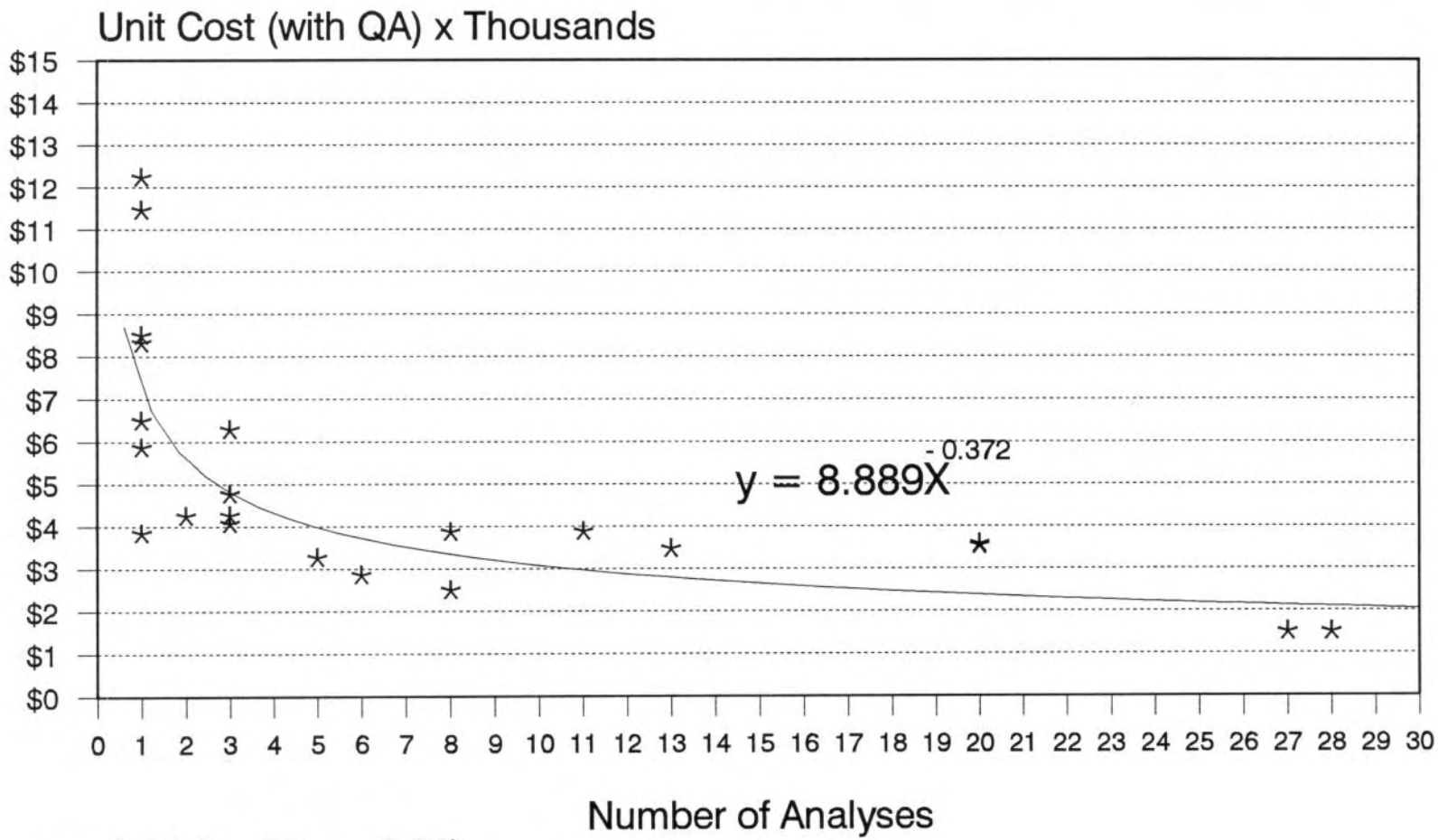
* For dredging projects submitting cost data

Figure 1-8. Chemistry Unit Cost



r = -0.51 (n=45, p<0.001)

Figure 1-9. Bioassay Suite Unit Cost Analysis



r = -0.61 (n=22, p<0.01)

CHAPTER 2

DISPOSAL SITE USE AND MONITORING

A. DISPOSAL ACTIVITY AND SITE USE

The Washington Department of Natural Resources (DNR) issues site-use authorizations to project proponents who wish to dispose of dredged material at PSDDA open-water disposal sites. These authorizations are issued for sediments which are: 1) suitable for open-water disposal as determined by the PSDDA evaluation process; and 2) associated with dredging projects which have received all required regulatory permits (e.g. CWA 404/401 permits). This section of the report describes PSDDA disposal activity for DY 1994 and 1995. This information is discussed by year and by individual disposal site.

Dredging Year 1994

In DY94, a total of 426,529 cubic yards (cy) of dredged material were disposed at PSDDA open-water disposal sites (Table 2-1). Three of the eight sites, Elliott Bay, Port Gardner, and Rosario Strait, were used. The Port Gardner site received most of the material, 236,749 cy, with 132,770 cy going to Elliott Bay and 57,010 cy going to Rosario Strait (Figure 2-1). Table 2-2 provides the project-by-project breakdown of disposal activity in DY94.

Table 2-1. Disposal Site Activity Summary - DY94

Disposal Site	# of Projects	Total Volume (cubic yards)
Port Gardner	1	236,749
Elliott Bay	3	132,770
Rosario Strait	1	57,010
All Sites Combined	5	426,529

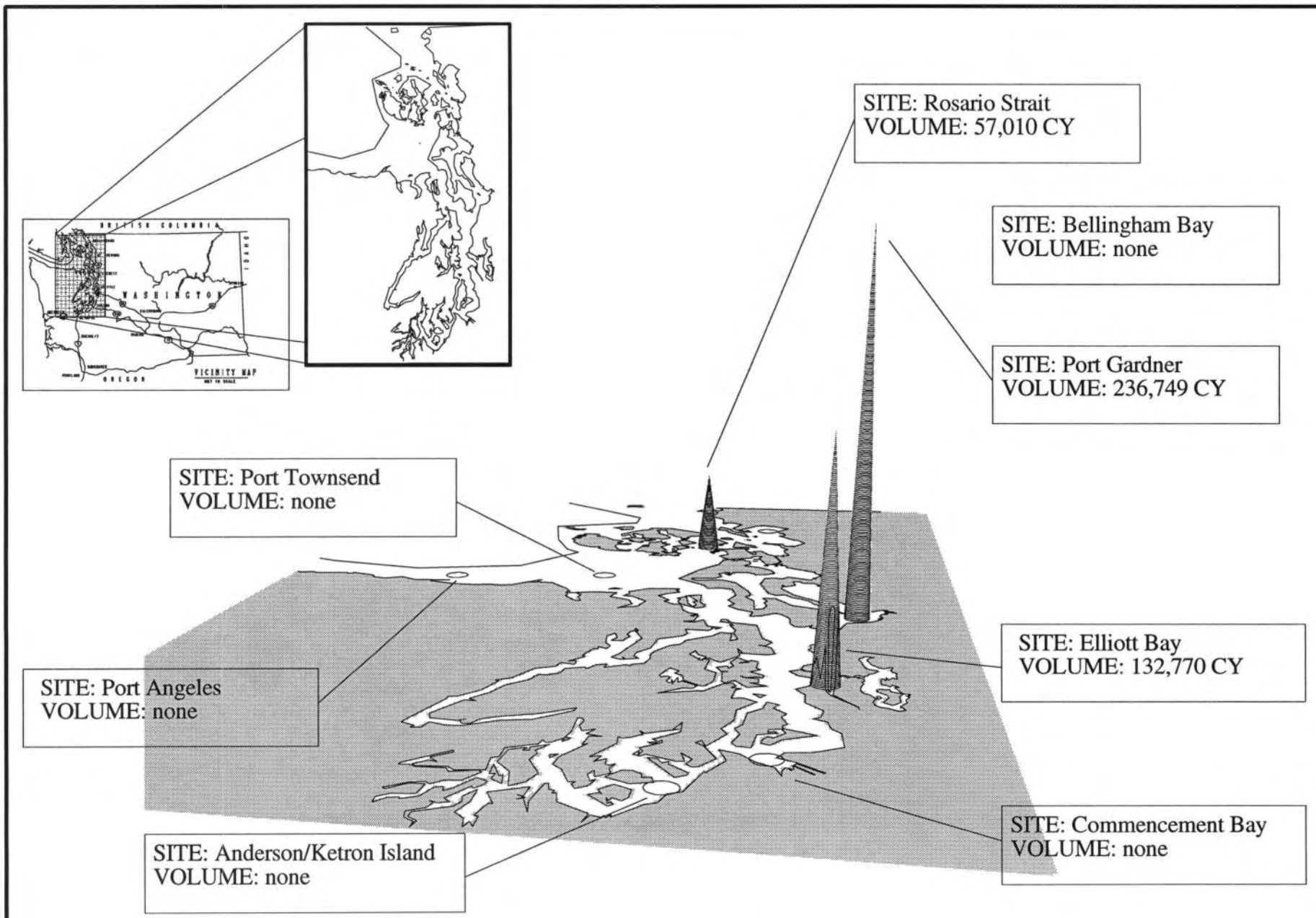


Figure 2-1. Dredging Year 1994 Disposal Volumes

Table 2-2. Summary of DY94 Disposal Projects

Site	Proponent	Dredging Contractor	Disposal Volumes, cy	# Barge Loads	Off Site[1]	Disposal Dates
Elliott Bay	City of Renton	A.H. Powers	84,820	49	No	07/07/93 to 09/16/93
Elliott Bay	Port of Silverdale	General Construction	3,844	4	No	08/10/93 to 08/17/93
Elliott Bay	U.S. Army Corps of Engineers (no local sponsor)	A.H. Powers	44,106	24[2]	No	03/07/94 to 03/28/94
Port Gardner	U.S. Army Corps of Engineers (local sponsor = Port of Everett)	American Construction	236,749[3]	141	No	09/25/93 to 03/14/94
Rosario Strait	Port of Skagit County	A.H. Powers	57,010	32	No	10/27/93 to 03/02/94

[1] Offsite indicates disposal outside of disposal site target zone

[2] An additional 6 barge loads disposed at Port of Seattle's Pier 64/65 Capping Project.

[3] An additional 275,000 cy of material from this project were placed at the East Harbor Operable Unit in Eagle Harbor as part of a EPA superfund removal action.

Dredging Year 1995

In DY95, a total of 561,706 cy of dredged material were disposed at five PSDDA sites (Table 2-3). The Commencement Bay, Port Gardner, Elliott Bay, Rosario Strait, and Anderson/Ketron sites were used. The Commencement Bay and Port Gardner sites received the majority of the material, 290,857 cy and 143,510 cy, respectively. Figure 2-2 illustrates the pattern of site use in DY95. Table 2-4 provides a project-by-project summary of the disposal activity.

Table 2-3. Disposal Site Activity Summary - DY95

Disposal Site	# of Projects	Total Volume (cubic yards)
Commencement Bay	3	290,857
Port Gardner	2	143,510
Elliott Bay	6	93,412
Rosario Strait	1	25,250
Anderson/Ketron Island	1	8,677
All Sites Combined	13	561,709

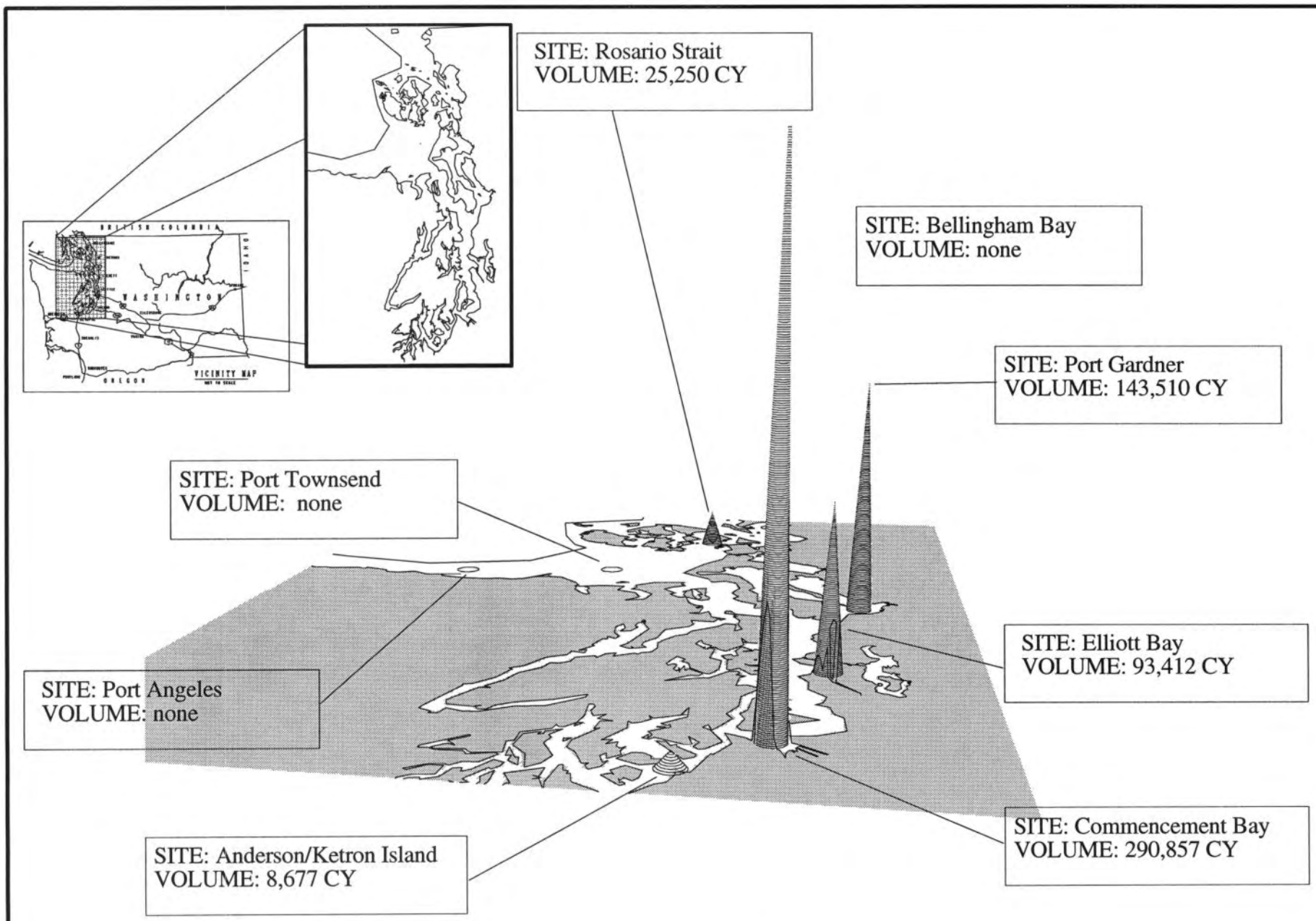


Figure 2-2. Dredging Year 1995 Disposal Volumes

Table 2-4. Summary of DY95 Disposal Projects

Site	Proponent	Dredging Contractor	Disposal Volumes, cy	# Barge Loads	Off Site[1]	Disposal Dates
Anderson/ Ketron Island	Harstene Pointe Maintenance Association	A.H. Powers	8,677	4	No	01/20/95 to 03/15/95
Commencement Bay	Port of Tacoma Blair Waterway	Manson Construction	281,943	383	No	09/07/94 to 03/14/95
Commencement Bay	City of Des Moines Marina	American Construction	5,616	4	No	09/19/94 to 09/23/94
Commencement Bay	Lone Star Northwest	Fletcher General Construction	3,298	3	No	09/03/94 to 09/04/94
Elliott Bay	US Navy Bremerton	A.H. Powers	45,050	25	No	12/06/94 to 02/24/95
Elliott Bay	Port of Seattle	Fletcher General Construction	19,300	18	No	01/06/95 to 01/18/95
Elliott Bay	King County Department of Public Works	A.H. Powers	16,342	17	No	07/26/94 to 08/18/94
Elliott Bay	Port of Brownsville	A.H. Powers	10,550	7	No	07/09/94 to 07/21/94
Elliott Bay	Port of Seattle	American Construction	1675	1	No	12/22/94
Elliott Bay	Lake Forest Park Civic Club (Nyman Marine Construction)	Manson Construction	495	2	Yes	03/27/95 to 03/28/95
Port Gardner	US Navy Everett	Manson Construction	138,851	180	No	07/06/94 to 08/22/94
Port Gardner	US Navy Bangor	A.H. Powers	4,659	4	No	06/18/94 to 06/28/94
Rosario Strait	Port of Skagit County	A.H. Powers	25,250	14	No	09/10/94 to 01/11/95

[1] Offsite indicates disposal outside of disposal site target zone

Summary of Disposal Activity by Site

Port Gardner. During DY94, the Port Gardner disposal site received 236,749 cy of material from one project, the U.S. Army Corps of Engineers/Port of Everett Snohomish River channel maintenance dredging project (Table 2-1). All disposal occurred in the disposal site target area.

An additional 275,000 cy of clean sandy maintenance project material from the lower Snohomish River were placed over a 21.4 hectare area in Eagle Harbor as part of EPA's East Harbor Operable Unit Removal Action.The maintenance dredging was accomplished by hydraulic dredge. Table 2-2 provides information on specific project volumes and site-use dates.

In DY95, a total volume of 143,510 cy from two projects was disposed at the Port Gardner site (Table 2-3). All disposal occurred in the target area, and all dredging was accomplished by clamshell dredge. Project details are included in Table 2-4.

Elliott Bay. The Elliott Bay site received 132,770 cy from three projects in DY94 (Table 2-1). All disposal occurred on site. A clamshell dredge was used for all three projects. Table 2-2 provides additional details regarding these projects.

During DY95, the Elliott Bay site received 93,412 cy of material from six projects (Table 2-3). According to US Coast Guard radar, the disposal of 495 cy of dredged material during the Lake Forest Park Civic Club (Nyman Marine Construction) project occurred off-site; all other projects disposed in the target area. All dredging was accomplished by clamshell dredge. There was a slight overage reported on the Port of Brownsville project. The suitability determination was for 10,000 cy; the amount dredged was 10,550 cy. Project details are included in Table 2-4.

Rosario Strait. The Rosario Strait site received 57,010 cy of material from one project during DY94 (Table 2-1). This project was initiated by the Port of Skagit County in DY94 and was concluded in DY95. Dredged material was disposed on site, and a combination of hydraulic and clamshell dredging was used. Table 2-2 provides additional information.

In DY95, the Port of Skagit County project was concluded with the disposal of 25,250 cy of material at the Rosario Strait site. All material was disposed in the target area, and as in DY94, a combination of hydraulic and clamshell dredging was used. Project details are included in Table 2-4.

Commencement Bay. During DY95, the Commencement Bay site received 290,857 cy from three projects (Table 2-3). All material was disposed on site, and all projects were accomplished by clamshell dredging. The amount disposed during the Port of Tacoma Blair Waterway project exceeded by 31,943 cy the amount authorized in the DNR use authorization. However, the suitability determination and all required permits included the excess amount. Table 2-4 provides additional information regarding these projects.

Anderson/Ketron. In DY95, the Anderson/Ketron site received 8,677 cy from one project (Table 2-3). All material was disposed on site. The majority of material was dredged hydraulically. A small amount of material was removed using a clamshell dredge. The DNR site-use authorization allowed for the disposal of 8,000 cy of material; there was an overage of 677 cy. This excess amount was, however, found suitable by the PSDDA agencies, as documented in an

adjustment from 8,000 cy to 9,600 cy in the suitability determination. Additional details regarding this project are provided in Table 2-4.

B. PSDDA Disposal Site Monitoring

Overview

Environmental monitoring is the primary tool in the management of the PSDDA non-dispersive disposal sites. The objective of disposal site monitoring is to determine whether the disposed dredged material is producing unanticipated adverse effects at the sites. Environmental monitoring can include physical, chemical, and biological assessment of the sediments and biological resources in and adjacent to the disposal sites. The PSDDA monitoring program is designed to compare the post-disposal monitoring results to "baseline" values. Baseline values of key environmental parameters, such as sediment chemistry, toxicity, and biological community structure, were determined for each PSDDA site and at various benchmark stations prior to the first use of the sites (PTI, 1988, 1989).

Post-disposal site monitoring surveys, such as those described below for DY94 and DY95, address three major questions:

1. Is the dredged material deposited on site?

2. Is the deposited dredged material producing chemical and/or biological conditions on site beyond the "minor adverse effects" levels allowed for by the PSDDA Site Management Plan?

3. Is the dredged material causing any adverse impacts to biological resources beyond the disposal site boundaries?

Full PSDDA monitoring is designed to address all three questions; partial PSDDA monitoring only addresses questions 1 and 2. In a cost saving measure, the PSDDA agencies elected to tier monitoring investigations in DY94 to collect all samples necessary under a full monitoring investigation, but only analyze data to initially answer the first two questions. Analyses of archived samples to address the third monitoring question were contingent on results from the first two data analysis objectives. This modified tiered-full monitoring approach is being recommended for adoption for future monitoring following the 1994 survey at the Port Gardner site.

DNR and the Corps are responsible for the physical (Corps), and chemical/biological (DNR) monitoring of the PSDDA non-dispersive disposal sites. This environmental monitoring is conducted, at irregular intervals, based on the "pattern" of disposal site use since the previous monitoring event. This pattern encompasses several important elements, such as the volume and

characteristics of the material disposed at a given site, the nature and recency of previous site monitoring data, and site-specific environmental concerns. Each spring, PSDDA technical staff review the previous year's disposal activity and reach consensus on which site(s) if any will be monitored and at what intensity.

The following sections summarize the results of two tiered-full PSDDA nondispersive disposal site monitoring surveys which were conducted in DY94 and DY95.

Dispersive site monitoring is generally limited to bathymetric surveys to insure that no significant mounding of dredged material is occurring and that sites are sufficiently dispersive. Bathymetry monitoring conducted at the Rosario Straits dispersive site in DY94 is discussed below. A special side-scan sonar survey of the Elliott Bay site was conducted in DY95 and is discussed.

DY94 - Port Gardner - Tiered-Full Monitoring

Site Use and Monitoring History. A baseline (pre-disposal) survey of the Port Gardner disposal site was conducted by the Department of Ecology in 1988 (PTI, 1988). In DY90 approximately 1,033,423 cy (most of it from the U.S. Navy Everett Homeport project) were placed at the Port Gardner disposal site, triggering a full monitoring survey (SAIC, 1991a). From DY91 through DY94, a total of 500,498 cy were disposed at the Port Gardner disposal site, triggering a second monitoring survey in DY94. These monitoring results were discussed at the 1995 Sediment Management Annual Review Meeting (SMARM), and are summarized below.

1994 Tiered-Full Monitoring Results. In May/June 1994, a tiered-full monitoring survey was conducted at the Port Gardner disposal site. Five types of samples were collected during this monitoring survey: physical mapping (sediment vertical profile imagery), sediment chemistry, sediment toxicity (bioassays), benthic community structure (archived), benthic infaunal tissue (Sea cucumber: *Molpadia intermedia*; archived). The last two sample types were archived pending analysis results addressing monitoring questions 1 and 2. The major findings of this survey follow, organized according to the major monitoring questions.

1) Does the dredged material stay on-site?

The sediment-profile camera survey confirmed that all of the recently deposited dredged material was confined within the disposal site perimeter boundary (Figure 2-3). Dredged material was thickest in the target zone, with deposits thinning outward from there. At the site boundary deposits were less than the 5 cm, which is the site management trigger for concern at the perimeter boundary. While some of the material extended out of the site boundary, none extended past the perimeter line. Therefore, the PSDDA site management objective of less than 3 cm at the perimeter was met.

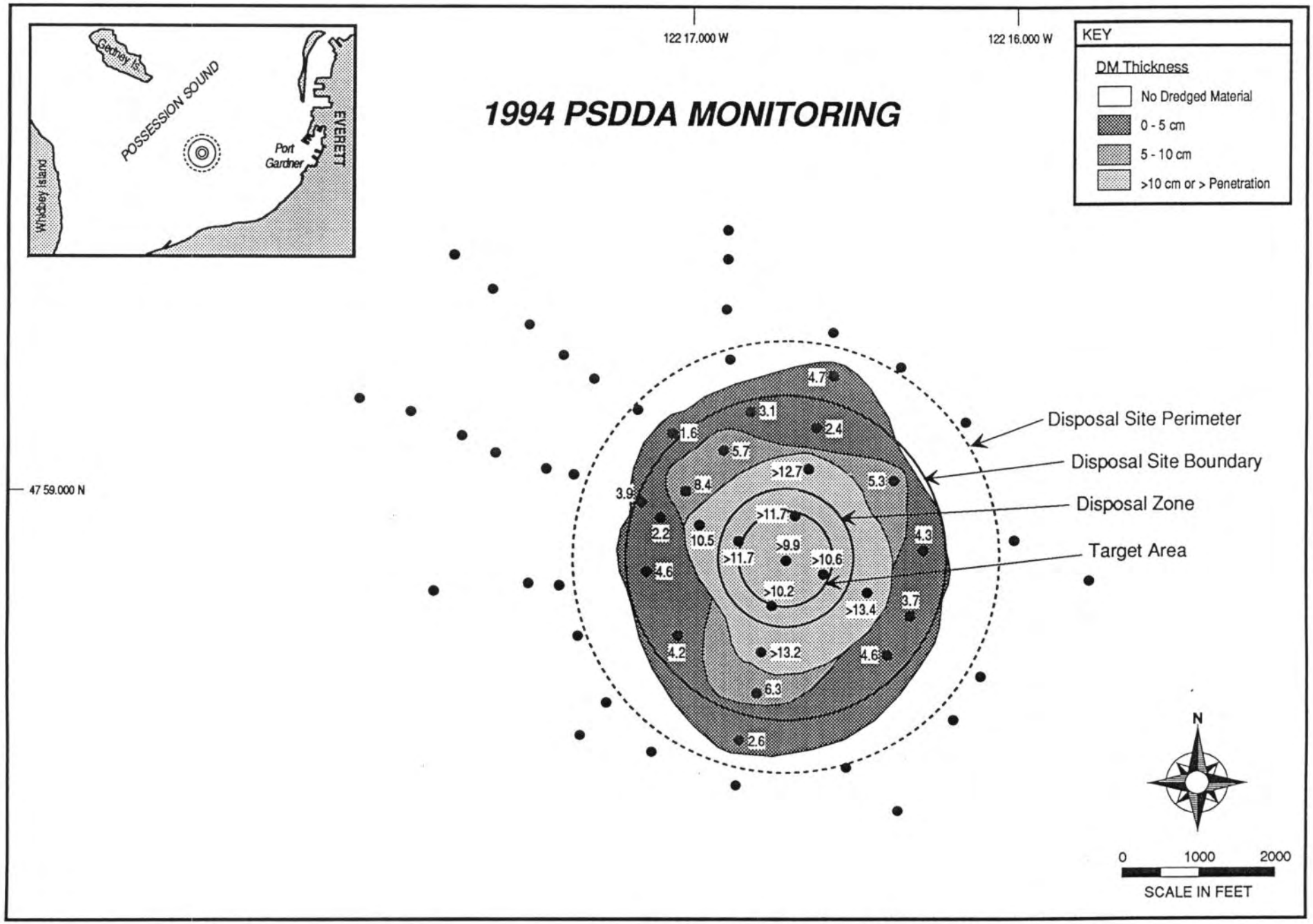


Figure 2-3. The distribution and thickness of dredged material at the Port Gardner disposal site as mapped by SVPS.

Chemical data collected along the site's perimeter indicated some minor chemical exceedances of the derived chemical guideline values (125% of baseline metal concentrations, and 147% of baseline organic concentrations). The guideline values represent 80% confidence intervals, where 20% exceedances of guideline values are expected by chance. The metals exceeding guideline values were antimony, lead, silver and mercury. All metals were generally measured below the PSDDA SL and all were below State sediment quality standards (SQS) values, except one replicate, where mercury was detected at 0.25 ppm (guideline value = 0.2 ppm). However, the mercury levels among the other replicates at this station were below the guideline value, as was the average for all the replicates at this location.

Five organic chemicals exceeding the perimeter guideline values were fluoranthene, benzo(a)anthracene, chrysene, bis(2-ethylhexyl)phthalate, and phenol. The guideline values for these compounds were low because these compounds were either undetected or detected at extremely low levels in baseline chemical evaluations. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant and is generally ubiquitous in Puget Sound. All the organic compounds exceeding guidelines except phenol were well below both PSDDA SLs and State SQS criteria. Phenol showed a relatively large increase at some perimeter stations compared to the baseline. An examination of phenol concentrations at archived benchmark stations showed a similar trend and suggested that phenol increases were due to some area wide environmental factor unrelated to dredged material disposal. Benchmark stations are located in the bay, but away from the potential influence of dredged material disposal.

The results of the chemistry investigations indicated that guideline exceedances fell below the 20 percent expected by chance (11% for metals, and 15% for organics). All concentrations measured at the perimeter stations were well below Washington State SQS criteria and, therefore, well below concentrations expected to cause adverse biological effects. Overall, the data analysis suggests that guideline exceedances were not caused by the movement of dredged material offsite.

2) Is the dredged material causing biological effects beyond the "minor adverse effects" allowed for at the PSDDA site?

On-site chemistry and bioassay data show sediment quality to be well within the allowable "minor adverse effects" levels. No PSDDA ML exceedances were observed and the bioassay results (amphipod: *Ampelisca abdita*; sediment larval: *Dendraster excentricus*; *Neanthes*-20-day growth) all passed non-dispersive site guidelines. In general, sediment chemical levels were all below PSDDA SLs for detected analytes, except phenol, which measured 200 ppb, 16.7% of the ML value. The elevated phenol concentration was tied to a baywide increase. Therefore, the data showed conclusively that the "minor adverse effects" site management objective for chemistry and biological effects was not exceeded at the disposal site.

3) Is the dredged material causing adverse impacts to biological resources outside the disposal site?

Because site monitoring questions 1 and 2 were answered successfully, site question 3 was not addressed under the tiered-full monitoring approach. Therefore, the archived benthic infaunal benthic samples and *Molpadia* tissue samples were not analyzed.

DY94- Rosario Strait Bathymetry Monitoring

Site Use and Monitoring History.

Baseline bathymetry monitoring of the Rosario Strait dispersive site was conducted by the Corps in August 1989. Approximately 566,700 cubic yards were disposed at the site in DY90 and DY91. Bathymetry monitoring of the site was performed by the Corps in August 1991. This survey showed no accumulation of dredged material and demonstrated the highly dispersive nature of the site. Cumulative disposal volumes since the 1991 monitoring event of 274,040 cubic yards triggered the 1994 bathymetry monitoring of the Rosario Strait site. These monitoring results are discussed below.

1994 Bathymetry Monitoring Results.

1) Is the material mounding at the disposal site, or is it being dispersed?

The Corps of Engineers' survey boat "Shoalhunter" conducted a bathymetry survey in June 1994 at the Rosario Strait disposal site. The same survey lanes from the initial predisposal baseline and postdisposal 1991 surveys were revisited. The 1994 results were similar to the 1991 survey results. All the dredged material disposed at this site was rapidly dispersed, and there was no accumulation of dredged material observed along any of the transect lanes. The results indicated that there has been no net change in bathymetry observed at the site since the 1989 baseline survey.

DY95 - Commencement Bay - Tiered-Full Monitoring

Site Use and Monitoring History. The baseline survey of the Commencement Bay disposal site was conducted by the Department of Ecology in 1988 (PTI, 1988). The Commencement Bay site had received a cumulative volume of 325,953 cubic yards since opening in 1989. The 1995 tiered-full monitoring results are summarized below (SAIC, 1995a), and will be discussed at the 1996 SMARM.

1995 Tiered-Full Monitoring Results. In June 1995, a tiered-full monitoring survey was conducted at the Commencement Bay disposal site. Five types of samples were collected during this monitoring survey: physical mapping (sediment vertical profile imagery), sediment chemistry, sediment toxicity (bioassays), benthic community structure (archived), benthic infaunal tissue (Sea cucumber; *Molpadia intermedia*; archived). The last two sample types were archived pending analysis results addressing monitoring questions 1 and 2. The major findings of this survey follow, organized according to the major monitoring questions.

1) Does the dredged material stay on-site? A total of 167 images were taken at the 61 SVPS stations. The survey showed the dredged material footprint was roughly ovoid in shape with the major axis oriented northwest to southeast as depicted in Figure 2-4. The SVPS imagery confirmed that all recently deposited dredged material was confined within the disposal site perimeter. All measured SVPS parameters, including optical signature, grain-size distribution, RPD (redox-potential-discontinuity), and OSI (organism-sediment index) were all in agreement as to the general distribution of the dredged material.

Comparative perimeter station guideline chemistry values are set at 125% of 1988 baseline concentrations for metals and 147% for organics, and have an expected false positive rate of 20% (SAIC, 1991). One important conclusion of the 1988 baseline studies was that several perimeter stations represented contaminated dredged material deposited prior to baseline studies and PSDDA disposal (PTI, 1988). These stations warranted additional study, and five additional field replicates were analyzed at each of the two stations and resulted in mean baseline and guideline values at these stations being revised (PTI, 1989). The major conclusions from the 1995 post disposal perimeter chemistry results were:

- An analysis of the 1995 monitoring results showed that all chemicals were below Washington State SQS and PSDDA SLs.

- Guideline values were exceeded at all four perimeter stations. However, the relatively low level magnitude of the exceedances at three of the perimeter stations, suggest that the exceedances noted at three of the four perimeter stations were not due to dredged material disposal.

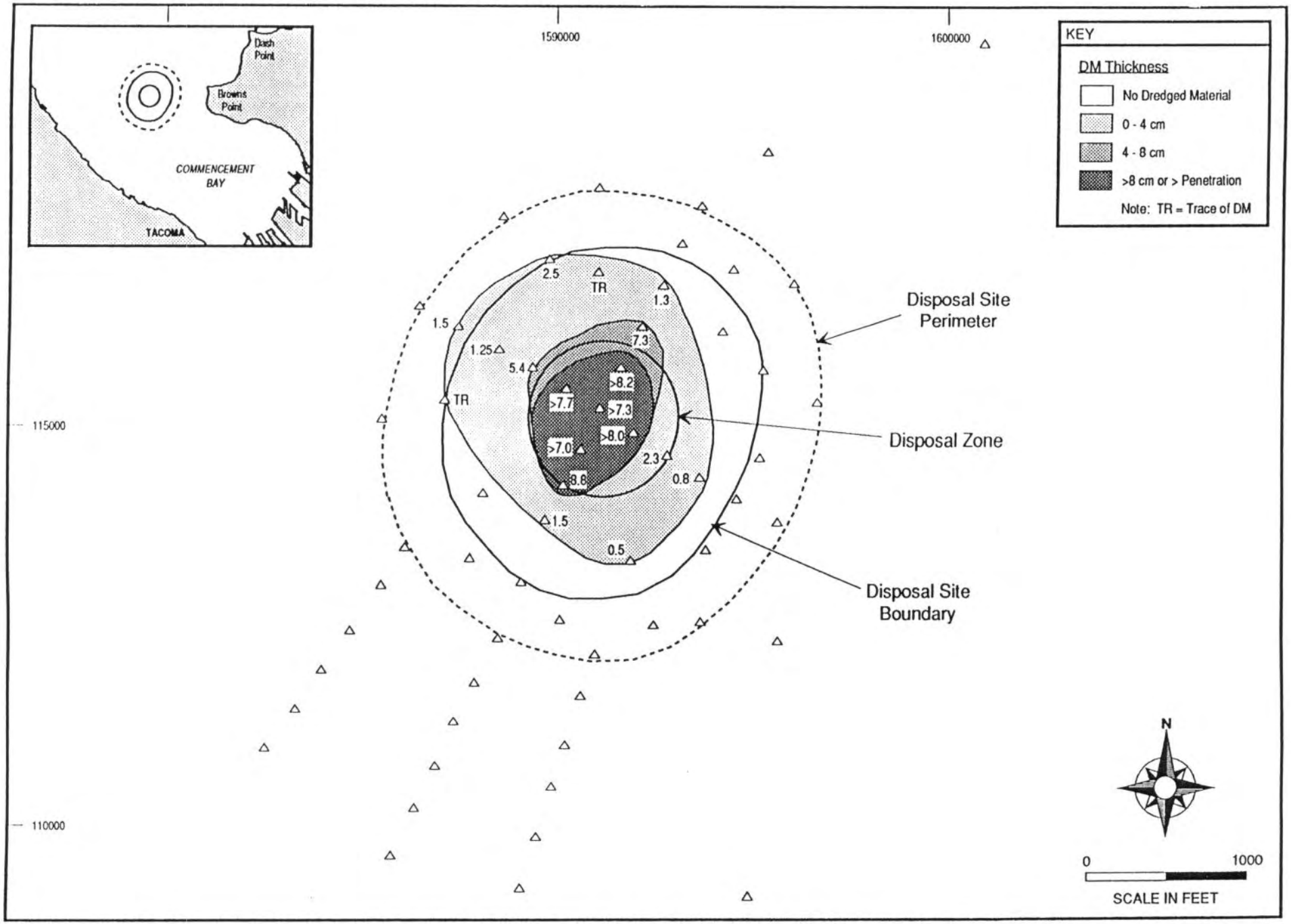


Figure 2-4. The distribution and thickness of dredged material at the Commencement Bay disposal site as mapped by SVPS.

- The fourth perimeter station, located near the south site boundary, was more problematic. At this location six of the nine metals exceeded guideline values and were statistically different from the 1989 baseline values. Metal levels on-site were similar to metals measured at this perimeter station. Organic analyses indicated that eight of the nine measured HPAHs and total HPAH in one of three replicates exceeded the 1989 mean concentration, but all were either slightly over (benzo(a)pyrene, chrysene, benzo(a)anthracene, indeno(1,2,3-cd)pyrene) or within the maximum baseline values previously observed. Comparative analysis of grain size data indicate that there has been a relative increase in percent fines since 1988 at this location.

- There appears to be an apparent upward shift in percent fines at the southern end of the site, with some corresponding increases in PSDDA metals, although HPAH observed generally appear to be related to pre-existing conditions, predating PSDDA disposal activities.

In summary, the SVPS results indicated that the dredged material remained on-site, as did the perimeter chemistry results with the exception of the southern perimeter station. At the southern perimeter there was evidence for increases in some of the metals and HPAHs, although concentrations were well below PSDDA SLs and Washington State SQS. Uncertainty about movement of fines toward the south resulted in analysis of archived sediments to address the third monitoring question.

2) Is the dredged material causing biological effects beyond the "minor adverse effects" allowed for at the PSDDA site?

Onsite chemistry measurements indicated that there were no exceedances of PSDDA SLs. Therefore, no onsite chemicals exceeded biological effects concern levels (screening level concentrations). Therefore, the chemical site management objective was not exceeded (all chemicals less than ML).

The suite of PSDDA bioassays evaluated onsite conditions at three locations, relative to PSDDA guidelines for nondispersive sites. All three onsite stations passed the PSDDA bioassay interpretive guidelines for nondispersive sites. Therefore, the biological effects management guideline ("minor adverse impacts") for nondispersive sites was not exceeded.

3) Is the dredged material causing adverse impacts to biological resources outside the disposal site?

Under the tiered-full monitoring approach, the south perimeter station guideline exceedances of metals and the apparent shift in grain sizes from coarser to finer grained sediments, warranted an evaluation of the third monitoring question. The results of these analyses are discussed below.

Comparison of 1995 and 1988 *Molpadia* tissue data indicated that there were no detected exceedances of any tissue guidelines except bis(2-ethylhexyl)phthalate (BEHP). BEHP is a common laboratory contaminant and was the sole organic chemical detected at two of the three transect stations. Therefore, it is likely that detected tissue BEHP measurements were a laboratory artifact and not derived from field transect stations. The conclusion from these data indicate there was no demonstrated increase in *Molpadia* tissue levels attributable to dredged material disposal.

Comparison of 1988 baseline benthic infaunal abundances at transect stations with 1995 infaunal abundances were evaluated relative to site management objectives (guideline exceeded when there is a $\geq$ 50% statistically significant decrease in any of the major taxa; polychaetes, mollusca, crustacea, and miscellaneous taxa). The data indicated that there was no decrease in polychaete, crustacean, or miscellaneous taxa abundance at any of the three transect stations. Molluscan taxa showed no decrease at two of the transect stations, but did show a significant decrease at the station further most from the site. Based on this exceedance, benchmark station analyses of infaunal abundance are normally required. The PSDDA agencies concluded that examination of benchmark infaunal abundances was not necessary based on the following information.

- The two transect stations nearest the disposal site did not show any significant decrease in infaunal abundances. Dredged material disposal impacts would be expected to show up near the site first and not far field.

- SVPS data indicated that all dredged material remained onsite. There was no indication of dredged material at any of the transect stations.

- All onsite and perimeter chemistry measurements were below biological effects levels (PSDDA SLs and Washington State SQS). Likewise, there was no toxicity expressed from onsite sediment bioassay exposures.

- There were no apparent *Molpadia* tissue accumulations of chemicals of concern at transect stations.

Special Studies. The PSDDA agencies also conducted two special studies to assess 1) the presence of butyltins in on-site and perimeter stations, and 2) examination of simultaneously extractable metals (SEM) and acid volatile sulfide relationship (AVS) in on-site and perimeter stations.

Butyltins. The analyses of tributyltins and their derivatives (di- and monobutyltin) in the 1988 baseline survey indicated they were present at all stations in low concentrations below the PSDDA SL (0.03 ppm). Analyses of butyltins in 1995 indicated all were undetected at the on-site and perimeter stations, with detection limits well below the SL. The conclusion is that butyltins are not a concern at the Commencement Bay site at this time.

SEM/AVS Study. DiToro et al (1990) have proposed that metal toxicity in sediment may be predicted by examining the relationship between the simultaneously extractable metals (SEM) and the acid volatile sulfides (AVS). EPA laboratory experiments have provided sufficient support to this theory that EPA has proposed formulating national sediment quality criteria for metals based upon this relationship. Recent reviews of the scientific basis and the status of proposed federal sediment quality criteria are provided in Ankley et al (1994), and by EPA's Science Advisory Board (1994).

The relationship between metals and AVS is as follows. AVS is defined as that fraction of sulfide in sediments that exists in natural sediments primarily as iron sulfide complexes (Ankley et al, 1994). Cationic metals of concern (cadmium, copper, lead, nickel and zinc) displace iron from the monosulfide, and the synthesized heavy metal salt renders the ion biologically unavailable. When the concentration of heavy metals exceeds the sulfide salt-forming capacity of the sediment, the cations then become biologically available, and the toxicity of the sediment can be predicted.

Interpretation of the results from a SEM/AVS analysis rests upon the derivation of total molar concentrations of the SEM and AVS. When the ratio of the sum of molar-expressed SEM to the molar AVS is less than or equal to 1, the metals are considered to be biologically unavailable, and the sediment is not acutely toxic to benthic organisms. When the ratio is greater than one, metals may be available, although total organic carbon, cation exchange capacity of the sediment, and the relative oxidation or reduction state of the sediments can also affect bioavailability. The SEM/AVS relationship breaks down in aerobic sediments (e.g., sand) and biologically active sediments where AVS is readily oxidized (Ankley et al. 1994).

Results for Commencement Bay indicated that the SEM/AVS ratio was significantly greater than one. While the SEM/AVS ratios were relatively high (5.6 -13.8), the residual μM SEM concentrations (SEM - AVS) were relatively small (0.315 - 0.9 μM/gm) and represent toxicologically insignificant amounts of metals. EPA-Narragansett reviewed the data and concluded that given the relatively low levels of AVS, coupled with the well-bioturbated sediments, metals bioavailability at the disposal site is more likely governed by TOC or other geophysical factors. Based on these results, it can be concluded that SEM/AVS analyses are not appropriate at the Commencement Bay disposal site.

DY95 - Elliott Bay - de minimis debris (rip rap) disposal verification with Side Scan Sonar Survey.

The PSDDA agencies recently agreed to allow 200-300 cy of rip rap to be disposed at the Elliott Bay disposal site as a policy evaluation test case. For the purposes of this rip rap disposal, the PSDDA agencies considered it to be a "de minimis" discharge. Only rip rap passing through a 24" by 24" steel grid screen was allowed to be disposed at the Elliott Bay site. Physical monitoring of the Elliott Bay disposal site was required to document the presence and the potential impacts of rip rap placed at the Elliott Bay nondispersive disposal site. The Corps of

Engineers is responsible for conducting physical monitoring at each of the eight disposal sites when required.

The existing sediment quality in Elliott Bay is degraded, although comparative anaysis of PSDDA monitoring data has demonstrated that onsite postdisposal sediment quality has generally improved over predisposal sediment quality (see Chapter 2 of 1994 PSDDA Biennial Report). Therefore, onsite exposures to contaminants of concern should actually be less than offsite exposures.

There was also a concern that rip rap disposal at the Elliott Bay disposal site might act as an "attractive nuisance" for fish and invertebrates. The side scan survey of the Elliott Bay site was conducted following the debris disposal (Port of Seattle T-30 project) in part to evaluate this concern.

The purpose of this survey was to ascertain whether the rip rap was discernible on site, and its specific distribution and relative amount within the dump zone/target area, relative to two historical ship wrecks. The two ship wrecks are located outside the dump zone within the boundary of the disposal site. A qualitative determination of rip rap significance within the target area was made following the survey. The results from this survey are described below (SAIC, 1995b).

The side-scan survey was conducted by SAIC in February 1995. It utilized an EG&G Model 260 graphic recorder and Model 272-T tow fish loaned to Seattle District by Portland District Corps of Engineers (SAIC, 1995b). The system was capable of detecting bottom features to a resolution of less than 1 meter with a target towdepth of 10 meters above the bottom.

The results indicated that targets possibly representing rip rap were in evidence near the center of the site, but could not be distinguished from other wood debris. Other features were also observed, such as concentric rings representing broad mounds or accumulations of dredged material. These were likely indicative of distinct and repetitive disposal events. Other signatures including likely log debris were observed within the dredged material footprint near the center of the site, some projecting above the sea floor up to 0.4 meters. Lastly, there were also distinct anchor scars observed within the disposal site boundary, which were located on the west and south flanks of the observed dredged material footprint (Figure 2-5).

The survey located the historical ship wrecks identified as the A.J. FULLER and the MULTINOMA. Both these shipwrecks are of archeological importance and were observed in the survey to ascertain likely impacts from disposal attributable to rip rap. Both shipwrecks are located within the disposal site, southeast and northeast of the disposal zone respectively. The signatures of the two wrecks were very sharp, indicating that there was no evidence for any appreciable accumulation of dredged material or impacts from “de minimis” rip rap disposal.

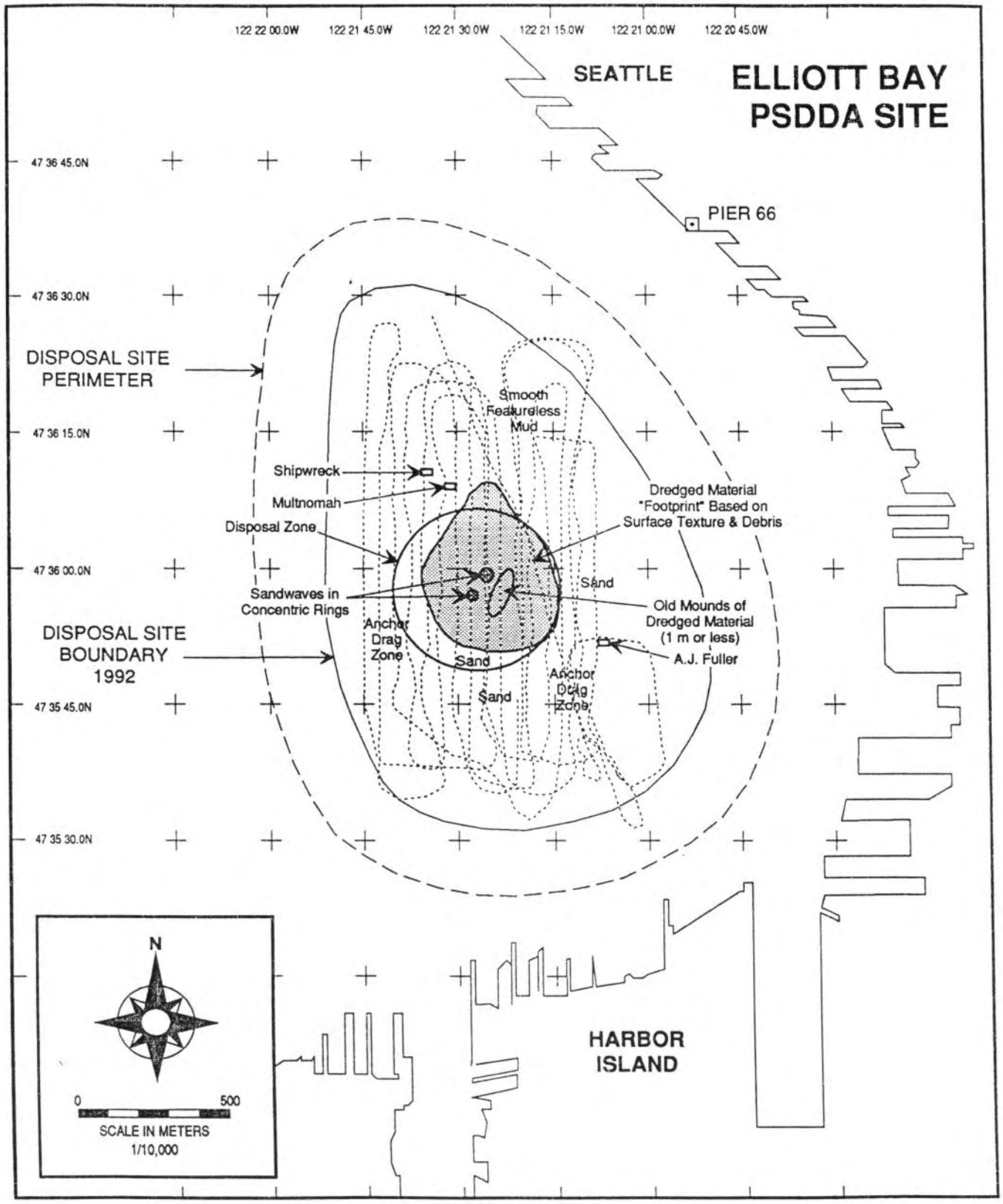


Figure 2-5.. Map of Elliott Bay disposal site based on side-scan sonar survey. Dredged material footprint is depicted based on side-scan sonar records. All shipwrecks were easily identifiable. No large rocks were apparent, although numerous log-like debris images were observed in the disposal zone.

Summary: PSDDA disposal site use and monitoring since program implementation

The cumulative dredged material volumes disposed at each PSDDA site are shown in Table 2-5 and Figure 2-6. Seven of the eight disposal sites have been used. The large volumes disposed at Port Gardner reflect several major DY94/95 dredging projects, including the U.S. Army Corps of Engineers/Port of Everett maintenance dredging of the Snohomish River (236,749 cy) and the US Navy Everett Homeport Element II project (138,851 cy). Numerous smaller projects utilized the Elliott Bay site, adding to the amount disposed primarily as a result of the USACE Duwamish O&M project in DY92, and the Commencement Bay site received a large quantity of material from the Port of Tacoma Blair Waterway project (281,943 cy).

Table 2-5. Cumulative Site use summary (DY89-95).

Disposal Site	Dredging Years Used	Cumulative Volumes Disposed (cubic yards)
Port Gardner (ND)	90, 91, 93, 94, 95	1,499,094
Rosario Strait (D)	91, 92, 93, 94, 95	869,290
Elliott Bay (ND)	90, 91, 92, 93, 94, 95	615,247
Commencement Bay (ND)	89, 91, 95	308,405
Bellingham Bay (ND)	93	32,883
Port Townsend (D)	93	22,642
Anderson/Ketron (ND)	93, 95	18,874
Port Angeles (D)	not used	0
Total cumulative volume		3,366,435

Legend: ND = nondispersive; D = dispersive

Table 2-6 lists the completed and scheduled PSDDA disposal site monitoring events at the nondispersive and dispersive sites. To date, the PSDDA agencies have conducted six post-disposal monitoring surveys at nondispersive sites - 2 full, 2 partial, and 2 tiered-full monitoring events. Four of the five nondispersive sites have been surveyed. The only nondispersive site not yet monitored is the Ketron/Anderson Island site, which has received relatively little use to date. No monitoring at the Ketron/Anderson Island site is anticipated in DY96. The PSDDA agencies anticipate conducting a partial monitoring survey at the Commencement Bay site in 1996 due to anticipated disposal of material from the Port of Tacoma's West Blair Terminal Development Project.

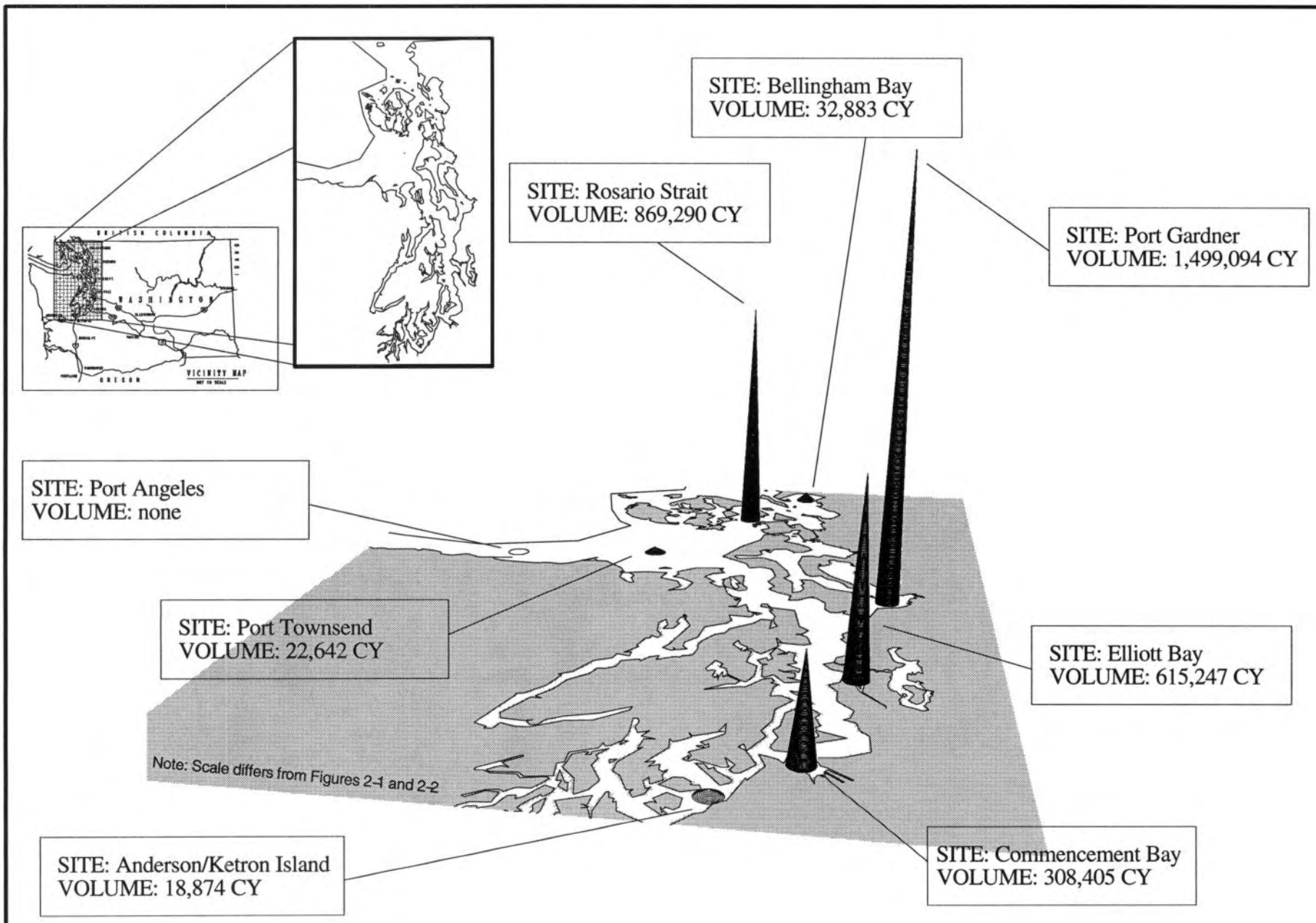


Figure 2-6. Cumulative Disposal Volumes (Dredging Years 1989-1995)

Table 2-6. PSDDA Disposal Site Monitoring Surveys.

Year	Disposal Site	Type of Survey
1990 (completed)	Port Gardner	Full Monitoring
1990 (completed)	Elliott Bay	Partial Monitoring
1992 (completed)	Elliott Bay	Full Monitoring
1993 (completed)	Bellingham Bay	Partial Monitoring
1994 (completed)	Port Gardner	Tiered-Full Monitoring
1995 (completed)	Commencement Bay	Tiered-Full Monitoring
1996 (scheduled)	Commencement Bay	Partial (plus) Monitoring[1]

[1/] Perimeter chemistry stations would be replicated as in a Full Monitoring Survey.

Based on PSDDA site monitoring data collected to date (including physical mapping, on and offsite sediment chemistry, sediment toxicity, offsite infaunal bioaccumulation, and offsite benthic community structure data), dredged material disposal is not causing adverse impacts at or adjacent to the non-dispersive sites. PSDDA evaluation procedures appear to adequately protect the environmental conditions at the disposal sites.

The overall goal of the PSDDA site monitoring program is to insure that the PSDDA prescribed disposal site conditions are maintained and verify that PSDDA dredged material evaluation procedures adequately protect the environment. Monitoring surveys provide feedback to verify the adequacy of the PSDDA dredged material management process. Annual review meetings provide a forum to report findings of post-disposal surveys conducted during any given dredging year and adjustments to management plan.

The PSDDA Management Plan Reports (MPR, 1988, 1989) recognized that intensive post-disposal monitoring surveys would be required early in the program implementation to gather data on the adequacy of the evaluation procedures to meet the site management objectives. Six monitoring events to date have not detected unexpected adverse impacts at any of the four nondispersive sites that have been monitored. In accordance with the management plan, the PSDDA agencies are proposing to reduce the frequency and scope of monitoring based on past documented compliance with the site management objectives. The proposed modification to the management plan are to formally incorporate tiered-full monitoring into the management plan, and to initiate monitoring when cumulative volumes approach or exceed 300,000 cubic yards since the last monitoring event (see Chapter 3 Issue Paper). The PSDDA agencies are continuing their assessment of the proposed perimeter chemistry evaluation approach recommended at the 1995

SMARM (SMARM minutes, 1995) for future adoption. The results of this assessment as applied to the 1995 Commencement Bay monitoring data will be discussed at the 1996 SMARM.

As noted in Table 2-5 above, two of the five nondispersive sites show a relatively low frequency and volume of material disposed since implementing the PSDDA program., which are the Anderson/Ketron Island and Bellingham bay sites. Therefore, the PSDDA agencies will give special consideration to conduct periodic monitoring as necessary at both of these relatively low use sites in the future.

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CHAPTER 3

PSDDA, SMS, AND JOINT PROGRAM REVIEW: CLARIFICATION, STATUS REPORTS AND ISSUES PAPERS

The purpose of this chapter is to present the various topics discussed by the PSDDA agencies during dredging years (DY) 1994-1995 which have implications to the PSDDA Management Plans. These issues have been identified by the agencies for consideration or discussion during the annual review process. Issues of joint concern to the PSDDA program, as well as the Sediment Management Program are also presented. In addition, papers pertaining strictly to the SMS annual review process are presented. These topics warrant further discussion during the sediment management annual review process, either in this report or at the May, 8, 1996 Sediment Management Annual Review Meeting (SMARM).

Under the PSDDA program, a discussion topic may be presented as a clarification, status report or issue paper. Clarifications are minor adjustments to existing PSDDA requirements. They are not usually presented during the annual review process unless specifically requested by public comment. Status reports present the progress made to date on important projects or areas of work. They may be given orally at the SMARM. Issue papers propose significant changes to the PSDDA management plan requirements and warrant more extensive discussion through the annual review process. This classification applies to the joint PSDDA/SMS discussion topics.

PSDDA Annual Review Topics

Clarification Papers

- Dredged Material Volume Estimates
- Small Dredging Projects at Outfalls
- Sediment Bioaccumulation Testing Refinements: Sample Volume Requirements, Simultaneous Co-Testing of Two Species within a Single Aquaria, and Species Substitution
- DGPS as Navigational Standard

Issue Paper

- Adjustments to Site Monitoring

Joint PSDDA/SMS Topics

Clarification Paper

- Neanthes 20-Day Growth Bioassay - Further Clarifications on Negative Control Growth Standard, Initial Size, and Feeding Protocol
- Statistical Evaluation of Bioassay Results

Status Reports

- Beneficial Uses of Dredged Material Work Group
- Puget Sound Multiuser Disposal Site (MUDS) Study
- Sediment Cleanup Strategy: An Interagency Overview
- Human Health-Based Sediment Criteria for Puget Sound
- Re-evaluating Puget Sound Apparent Effects Thresholds (AETs): An Update

SMS Annual Review and Status

- Sediment Management Standards (SMS) Triennial Review

PSDDA PROGRAM REVIEW

CLARIFICATION

STATUS REPORTS

ISSUE PAPERS

CLARIFICATION PAPER

DREDGED MATERIAL VOLUME ESTIMATES

Prepared by Hiram Arden (Corps of Engineers, 206/764-3401), David Fox (Corps of Engineers, 206/764-6550) and Ted Benson (DNR, 360/902-1083) for the PSDDA agencies.

INTRODUCTION

In a PSDDA sediment sampling and analysis plan, the project proponent provides a dredged material volume estimate that is used to determine sampling and testing requirements. This volume estimate is based on bathymetric data for the site and on the dredging prism needed to meet depth requirements for navigation.

Once sampling and testing have been completed, a suitability determination for open-water disposal is signed by all four PSDDA agencies. The suitability determination identifies the portions of the estimated volume that are suitable and unsuitable for disposal at a PSDDA site. The volume suitable for open-water disposal is then incorporated into the Corps section 10/404 permit, DNR site-use authorization, and Ecology water quality certification as an upper limit on the quantity of material authorized for disposal at a PSDDA site.

PROBLEM IDENTIFICATION

Differences can occur between the permitted volume and the volume that is actually dredged. Exceedances of permitted volumes are considered violations by the regulatory agencies and can result in additional workload for the agencies and penalties for the project proponent. There are numerous factors which can contribute to exceedances of permitted volumes:

Uncertainty in the presampling bathymetric data;
- Uncertainty from the volume estimation process;
- Shoaling that occurs between the pre-sampling survey and time of dredging;
- Failure to include overdepth material, sideslopes or "non-pay" volume;
- Uncertainty associated with barge measurements;
- Inadequate communication with agencies;
- Actual in-situ dredged volumes can only be calculated after dredging is complete.

The level of uncertainty in the bathymetric data depends on the instrumentation used, the accuracy of tide measurements, and weather conditions at the time of the survey. Therefore, volume estimates are based on bathymetric data that include some inherent error.

There is also error associated with the various methods used to calculate volumes from the bathymetric data, including the double-end-area method and the surface-to-surface (tin) method. Double-end-area accuracy depends on the spacing of cross-sections; the greater the spacing the greater the error. The accuracy of the tin method depends upon the density of the

bathymetric data. Greater density allows better contouring of the surface and less error in volume estimates.

The presampling bathymetric survey may take place long before the project is actually dredged. This time delay may range from six months to more than two years, being dependent on such factors as project complexity and resolution of habitat issues. Some additional shoaling may occur between sampling and dredging, the quantity of which depends upon local sedimentation rates, storm events and the time that has passed since the presampling survey. This additional sediment is not included in the original volume estimate and may not be reflected in the public notice or permits unless the dredging proponent has included this contingency in project planning.

A dredging project is designed to achieve required navigational depths. However, because dredging is a relatively imprecise technology, one or two feet of allowable overdepth are normally included in a dredging contract to ensure that design depths are achieved. Payment is made for the allowable overdepth actually dredged, thus providing compensation to the dredger for removing sufficient material to provide the design depth over the entire project footprint. Failure to include overdepth in volume calculations can lead to serious underestimates.

Box cuts in unconsolidated or uncohesive sediment usually result in sloughing of material to form a sideslope around the perimeter of the project. Professional judgment is required to determine the angle of repose that will result. This can be particularly difficult under piers where pilings and other structural elements can restrain sediment that would ordinarily slough. Sideslope material has been included historically in PSDDA volume estimates but overdepth for sideslopes has generally not been included. However, box cuts are often made just beyond the perimeter of the design prism so that slough material will fill the box cut without extending into the design prism. Therefore, the concept of overdepth should apply to sideslopes as well as to project depths.

Another minor contribution to dredged volume that is typically not included in estimates is "non-pay" volume. Dredging contracts are set up to compensate the dredger for any allowable overdepth that is removed. Therefore, the dredger may choose to maximize earnings by setting the dredging depth slightly below the allowable overdepth. This is usually on the order of a few tenths of a foot, and although the dredger is not compensated for this small amount of "non-pay" material, this strategy maximizes the quantity of paid overdepth removed.

A practical consideration that has not been explicitly addressed in the past is the bulking of sediment that occurs due to structural disruption and entrainment of water during dredging. The amount of bulking varies with the type of sediment and the method of dredging (mechanical or hydraulic). Because of the uncertainty introduced by bulking, pay quantities in a dredging contract are most often determined by finding the difference between pre- and post-dredge surveys, rather than relying on bulked barge estimates. In contrast, daily

dredging logs and progress report volumes submitted by the dredging contractor to DNR and the Corps are based on barge estimates, which can easily exceed the permitted volume due to bulking, even if the in-situ volume calculation is correct.

Because removed in-situ volumes cannot be determined until a post-dredge survey is conducted, and because bulked barge volumes can easily exceed permitted in-situ volumes, it may be difficult to determine during dredging whether permitted volumes will be exceeded. Therefore, dredgers have not always contacted DNR or the Corps when their tallied barge estimates have exceeded the permitted volume in the belief that sediment bulking alone is responsible for the increase in volume. However, given the uncertainty in both volume and bulking estimates, it is possible that the in-situ volume removed will be greater than that permitted. Failure to notify regulatory agencies in advance about a possible volume exceedance may result in a permit violation.

PROPOSED ACTION/MODIFICATION

Project proponents have generally incorporated contingencies into their sampling and analysis plans to address potential problems with volume estimates. As a result, exceedances of permitted volumes have been relatively uncommon. To further reduce the incidence of permit violations, the following guidelines are provided:

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

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

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

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

The suitability determination for open-water disposal will be based on the adjusted, tested volume, as will the volume in the Corps permit, DNR authorization and Ecology certification.

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

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

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

A description of the procedures to ensure vertical and horizontal dredging control must be included in the dredging and disposal plan. Such procedures prevent dredging of unreasonable non-pay volume.

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

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

As dredging proceeds, the contractor must closely monitor dredging progress and notify the agencies as soon as possible if an exceedance of the permitted volume appears likely. Revision of the permits will be made as necessary. Dredging must stop when the sum of the daily barge estimates, corrected for bulking using the revised bulking factor, reaches the permitted in-situ volume. DNR and the Corps must be notified at this time. If the dredging has not been completed, a determination will be made as to the cause of the impending volume exceedance and permit volumes revised as appropriate. It must be

stressed that, given the contingencies incorporated into the above process, the probability of a dredging contractor being required to stop dredging is small. Good project management and prompt communication with the regulatory agencies will prevent this from occurring.

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

No penalties will be imposed by the PSDDA agencies and any quantity beyond the permitted volume will be charged by DNR at the standard rate (currently $0.45 per cubic yard) if: 1) the process outlined in this paper is followed; 2) no unreasonable dredging has occurred outside the permitted dredge prism; and 3) all other permit conditions have been met.

NOTE: The Swinomish Channel and the settling basins in the Duwamish and Snohomish Rivers are prone to rapid shoaling. Pay quantities are frequently determined from barge measurements and not all of the above guidance will apply to these projects. Also, in cases where contaminated sediment is adjacent to sediment that is being dredged for open-water disposal, more stringent dredging controls must be instituted to ensure that unsuitable material is not dredged and disposed at a PSDDA site. Damages resulting from dredging and disposal of unsuitable material are not addressed by this clarification paper.

CLARIFICATION PAPER

SMALL DREDGING PROJECTS AT OUTFALLS

Prepared by David Fox (Corps of Engineers, 206/764-6550) and Stephanie Stirling (Corps of Engineers, 206/764-6945) for the PSDDA agencies.

INTRODUCTION

In the PSDDA Management Plan Report-Phase II, rankings were applied to general geographic areas, some specific project locations and to certain types of facilities. These rankings were based on the number and kinds of contaminant sources (existing or historic) and the available information on chemical and biological response characteristics of the sediments.

The PSDDA guidelines include "no-test" provisions for small projects ranked low, low-moderate or moderate. No testing is required in low-ranked areas for projects of less than 8,000 cubic yards, while in low-moderate and moderate-ranked areas, no testing is required for projects of less than 1,000 cubic yards. In contrast, testing is always required for high-ranked projects, regardless of the size of the project.

PROBLEM IDENTIFICATION

Some small dredging projects consist of the removal of sediment discharged from an outfall, or located directly adjacent to an outfall, yet fall within a general geographic area ranked low, low-moderate or moderate. Under the "no-test" guidelines, testing is not required for these projects, subject to the volume limitations identified in the introduction. However, it is possible that these sediments contain chemicals at a level of concern far greater than the area in general. Failure to test this material could result in unsuitable material being disposed at a PSDDA site.

PROPOSED ACTION/MODIFICATION

Small projects removing sediments discharged from an outfall, or located directly adjacent to an outfall, may be given a "high" rank by the PSDDA agencies regardless of the rank of the general area. This decision will be made on a case-by-case basis, with consideration given to the type and size of the outfall, the shoaling pattern relative to the outfall, and any other relevant information available to the project proponent. Other information might include catch basin and particulate data associated with the outfall. For small dredging projects at outfalls that are ranked high by the PSDDA agencies, small project testing guidelines established in MPR-Phase II (as modified at the second PSDDA annual review meeting to include two acute bioassays for biological testing) will be followed.

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CLARIFICATION PAPER

SEDIMENT BIOACCUMULATION TESTING RFINEMENTS: SAMPLE VOLUME REQUIREMENTS, SIMULTANEOUS CO-TESTING OF TWO SPECIES WITHIN A SINGLE AQUARIA, AND SPECIES SUBSTITUTION

David Kendall (Corps of Engineers, 206/764-3768) for the PSDDA agencies.

INTRODUCTION

To be consitent with Environmental Protection Agency / U.S. Army Corps of Engineers Guidance contained in the 1994 draft "Inland Testing Manual" (EPA/COE, 1994), the PSDDA program adopted bioaccumulation testing with two species (ARM, 1994 Issue paper). The two species must represent different trophic niches: a suspension-feeding/filter-feeding organism and a burrowing deposit-feeding organism. A test exposure of 28 days is followed by tissue analysis for chemicals of human health and ecological effects concern following the EPA protocol (Lee et.al., 1993; ASTM, 1995). Ecological effects are evaluated through a statistical comparison with a reference area sediment.

A bioaccumulation test will 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. A bioaccumulation test using two species is required if any one of twenty-nine identified chemicals of concern are shown to have concentrations exceeding the bioaccumulation trigger value established under the PSDDA program (Table 1). Following the Tier II evaluation of chemicals of concern, bioaccumulation testing with both species is required when any of the 29 bioaccumulation trigger values established under the PSDDA program is exceeded (see Table 1). These values establish the "reason to believe" levels for chemicals likely to bioaccumulate in marine organisms. Organic compounds with octanol / water partition coefficients (K_{OW}) greater than 5.5 are considered much more likely to bioaccumulate in tissues than less hydrophobic chemicals (Table 1).

PROBLEM IDENTIFICATION

Sediment volume requirements. There has been some confusion concerning the amount of sediment needed to conduct the bioaccumulation test. The PSDDA program generally requires applicants to address contingencies for exceedances of biological testing triggers including bioaccumulation testing in their sampling and analysis plan. In high concern areas, PSDDA agencies generally recommend archiving sufficient sample for potential biological testing (acute/chronic bioassays and bioaccumulation tests) requirements. Sediment archival requirements necessary to conduct the 28-day bioaccumulation test are quite onerous as depicted in Table 2 below. Depending on the species selected, the total test sediment volume requirement can exceed 32.5 liters for each dredged material management unit (DMMU) if each of the two required species are tested separately. A similar volume must also be collected and archived for the

Table 1. Sediment chemistry trigger values for bioaccumulation testing.

CHEMICAL	log K_{OW}[1]	CONCENTRATION[2]
METALS (ppm dry weight basis)	NA	
Antimony	NA	146
Arsenic	NA	507.1
Mercury	NA	1.5
Nickel	NA	1,022
Silver	NA	4.6
ORGANIC COMPOUNDS (ppb dry weight basis)		
Fluoranthene	5.5	4,600
Benzo(a)pyrene	6.0	4,964
1,2-Dichlorobenzene	3.4	37
1,3-Dichlorobenzene	3.4	1,241[3]
1,4-Dichlorobenzene	3.5	190
Dimethyl phthalate	1.6	1,168[3]
Di-n-butyl phthalate	5.1	10,220[2]
Bis(2-ethylhexyl) phthalate	4.2	13,870[3]
Hexachlorethane	3.9	10,220
Hexachlorobutadiene	4.3	212
Phenol	1.5	876
Pentachloropenol	5.0	504
Ethylbenzene	3.1	27
N-Nitrosodiphenylamine	3.1	161
Hexachorobenzene	5.2	168
Tributyltin	--	219[3]
Trichloroethene	3.9	1,168
Tetrachloroethene	2.4	10[3]
Total DDT	(5.7 - 6.0)[5]	50
Aldrin	3.0	37[3]
Chlordane	6.0	37[3]
Dieldrin	5.5	37[3]
Heptachlor	5.4	37[3]
Total PCBs	(4.0 - 6.9)[5]	38[4]

1/ Octanol / Water Partition Coefficients (log K_{OW}) for organic chemicals of concern in Puget Sound.
2/ Concentration = 0.7 * (ML-SL) + SL; When the concentration of any chemical is above this value, a bioaccumulation test must be performed.
3/ These chemicals do not have an ML value. Therefore, the concentration = ((10SL-SL) * 0.7) + SL = 7.3 * 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 judgement after reviewing the Tier II data.

reference sediment and negative control sediment. Large projects can become unmanageable with respect to sampling volumes and storage requirements needed[1].

Table 2. Species specific testing volume requirements.

Species	Tested Sediment Volume Requirements
Macoma nasuta	>250 mL/beaker x 10 beakers/8 L-aquarium[1] = 2.5 L/aquarium 5 replicate aquaria = **>12.5-20 liters**
Nereis virens	200 mL per worm x 20 worms per 20 gallon aquarium[1] = 4 L/aquarium 5 replicate aquaria = **>20 liters**
Arenicola marina or Abarenicola sp.	>500 mL per beaker x 4 beakers per 8 L-aquarium[1] = 2 L/aquarium 5 replicate aquaria = **>10 liters**
Co-testing: *Macoma/Nephthys*	3.87 L per 37.8 liter aquarium (10 gallon)[2] 5 replicate aquaria = **>20 liters**

[1/] Volume specifications stipulated in "Inland Testing Manual (EPA/COE, 1994).
[2/] Volume specification from Battelle, 1992.

Because of the prohibitively high volumes of material needed to conduct this test with two species, dredging applicants may elect not to archive material necessary to conduct the bioaccumulation test against the risk of exceeding a chemical bioaccumulation trigger. If a bioaccumulation trigger is exceeded for one or more of the twenty-nine chemicals of concern, an applicant must remobilize to collect the sediment needed to conduct the bioaccumulation test.

In the event resampling is necessary the sediment sample must be reanalyzed for the chemical(s) exceeding bioaccumulation triggers to properly assess the actual test exposure levels. A recent experience where resampling was necessary resulted in a five-fold difference between the initial and resampled sediment chemical concentration. In the this case, the agencies, utilizing best professional judgement, adjusted the bioaccumulation tissue concentrations proportionally upward based on the ratio between the first and second round sediment chemical concentrations.

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[1] Sediment must be stored at 4°C. in Nitrogen atmosphere until testing.

Species substitution/Co-testing of two species. The current PSDDA testing protocol calls for conducting a 28-day bioaccumulation test with a facultative deposit/suspension-feeding adult bivalve (*Macoma nasuta*) and a deposit-feeding adult polychaete (i.e., either *Nereis virens* or *Arenicola marina/Abarenicola sp.*). Conducting bioaccumulation tests with either of the aforementioned adult polychaete species will generally require conducting separate tests (e.g., adult bivalve and adult polychaete tests).

The "Green Book" (EPA/COE, 1991) also recognizes *Nephthys sp.* as an approved adult polychaete species suitable for evaluating acute toxicity and bioaccumulation concerns in dredged material for ocean disposal. *Nephthys* sp. may be cotested in aquaria with *Macoma nasuta*. The PSDDA agencies recently conducted a successful bioaccumulation test co-testing *Macoma nasuta* and *Nephthys caecoides* within the same aquaria following the protocol developed by Battelle (1992). This reduced sediment testing volume requirements and set up costs. The general co-testing setup volume requirements are noted in Table 2.

PROPOSED ACTION/MODIFICATION

To provide flexibility and enable co-testing of two species in a single testing chamber (aquarium), the PSDDA program will allow the substitution of *Nephthys* sp. in place of either *Nereis virens* or *Arenicola/Abarenicola* sp. when conducting the bioaccumulation test. Applicants proposing to co-test species within the same aquaria should follow the Battelle (1992) protocol, and must articulate their bioaccumulation testing approach in a PSDDA approved sampling and analysis plan.

Applicants electing not to archive samples for potential bioaccumulation testing, and where resampling is necessary to accomplish bioaccumulation testing, will be required to reanalyze the targeted chemical(s) triggering the bioaccumulation testing.

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CLARIFICATION PAPER

DGPS AS NAVIGATIONAL STANDARD

Prepared by Ted Benson (Department of Natural Resources, 360/902-1083) for the PSDDA agencies.

INTRODUCTION

Due to its ability to provide a repeatable accuracy of +/- 2 meters, microwave navigation is identified in the Management Plan Technical Appendix - Phase I (p.I-13), as the positioning method to be used for PSDDA encvienomental site monitoring. The disadvantages of this system are that it requires a system operator on shore, has many complex system parts, and requires substantial operator training.

Recent advances in the Geographical Positioning System (GPS), and Differential Geographic Positioning System (DGPS) have supplanted microwave technology, and can provide an accuracy of +/- 2 meters, with a real-time readout aboard ship. This technology is replacing other, more traditional, methods of navigation and positioning as the navigational standard, and is increasingly becoming the method of choice.

PROBLEM IDENTIFICATION

As the present microwave positioning systems become outdated, they will become more difficult to use and maintain. It is quite possible that this positioning method, specified in the PSDDA documentation will no longer be available for use in the near future.

PROPOSED ACTION/MODIFICATION

Concurrent use of microwave and DGPS methods will be specified for environmental site monitorings at each site for the next monitoring. This will provide data for any needed correction factors of historic project data. DGPS will be used exclusively after one monitoring event at each site.

REFERENCES

PSDDA. 1988. Management Plan Technical Appendix - Phase I (Central Puget Sound). Prepared jointly by Seattle District Corps of Engineers, Washington State Department of Natural Resources, Washington State Department of Ecology, and U.S. Environmental Protection Agency, Region 10.

ISSUE PAPER

ADJUSTMENTS TO SITE MONITORING

Prepared by Ted Benson (Department of Natural Resources, 360/902-1083) for the PSDDA agencies.

INTRODUCTION

The PSDDA site environmental monitoring plan is designed to verify that no unacceptable adverse effects have occurred within or beyond the disposal site as a result of dredged material disposal and to ensure that dredged material disposed at the sites remains within the disposal site boundary. The environmental monitoring data forms the basis for the annual review of the need for changes in the evaluation procedures and site management plans. Two types of post-disposal monitoring efforts are described in the Management Plan Reports and the Management Plan Technical Appendix: full surveys and partial surveys.

A full monitoring survey addresses three major questions:

1. Was the dredged material deposited on site?

2. Is the deposited dredged material producing chemical and/or biological conditions on site beyond the "minor adverse effects" levels allowed by the PSDDA Site Management Plan?

3. Is the dredged material causing any adverse impacts to biological resources beyond the disposal site boundaries?

Full PSDDA monitoring is designed to address all three questions, whereas partial PSDDA monitoring only addresses questions 1 and 2. In a cost saving measure, the PSDDA agencies elected to tier the monitoring investigations in 1994 at the Port Gardner disposal site to collect all samples necessary under a full monitoring investigation, but only analyze data to initially answer the first two questions. Analyses of archived samples to address the third monitoring question were contingent on answers to the first two questions. This modified "tiered-full" monitoring approach was succesful at Port Gardner and was subsequently used at Commencement Bay in 1995.

The purpose of monitoring is to show compliance with the site management objectives, and demonstrate that no unexpected conditions have developed due to dredged material disposal. The PSDDA FEIS and supporting technical appendices (MPR, 1988; MPR, 1989; MPTA, 1988) envisioned an eventual reduction in post-disposal environmental monitoring once these monitoring events verified the effectiveness of the pre-dredging evaluation procedures in meeting the site management objectives. The monitoring data for the past six years have confirmed the adequacy of the dredged material evaluation and disposal procedures.

Therefore, a reduction in the level and frequency of post-disposal monitoring is justified at this time.

PAST MONITORING HISTORY

Six monitoring surveys have been conducted over the past seven years of PSDDA implementation (1989 - 1995) and have documented that the chemical and biological effects site management objective (only "minor adverse effects" on site and no adverse effects offsite) has been met (Table 1). In recognition that the PSDDA evaluation procedures have been successful in meeting site management objectives the PSDDA agencies recommend formally adopting a reduction in the frequency and level of monitoring necessary at the nondispersive disposal sites. The tiered-full monitoring approach successfully applied on a trial basis at both the Port Gardner and Commencement Bay disposal sites have resulted in cost savings. Therefore, tiered-full surveys are recommended for adoption as a permanent change to the monitoring plan as an adjunct to the full and partial monitoring surveys.

Table 1. PSDDA Disposal Site Monitoring Surveys.

Disposal Site	Year	Type of Survey	Monitoring Questions Addressed
Port Gardner	1990	Full Monitoring	1, 2, 3
Port Gardner	1994	Tiered-Full Monitoring	1, 2
Elliott Bay	1990	Partial Monitoring	1, 2
Elliott Bay	1992	Full Monitoring	1, 2, 3
Commencement Bay	1995	Tiered-Full Monitoring	1, 2, 3
Bellingham Bay	1993	Partial Monitoring	1, 2

The three Central Puget Sound nondispersive sites (Port Gardner, Elliott Bay, and Commencement Bay) have been the most frequently used sites, whereas the Bellingham Bay site in northern Puget Sound and the Anderson / Ketron Island site in south Puget Sound have only been relatively low use sites to date (Table 2). Reducing monitoring frequency at the three central Puget Sound disposal sites is justified based on the success of all previous

monitoring results (PBR, 1994; SMARM, 1995). Therefore, the PSDDA agencies recommend setting a cumulative volume trigger at the three central Puget Sound sites of 300,000 cubic yards for future site monitoring. The monitoring trigger volume proposed would not apply to the remaining two nondispersive sites (i.e., Bellingham Bay and Anderson / Ketron Island) because of the relatively low volumes and frequency of use.

Table 2. Cumulative Nondispersive Site use summary (DY89-95).

Disposal Site	Dredging Years Used	Cumulative Volumes Disposed (cubic yards)
Port Gardner (ND)	90, 91, 93, 94, 95	1,499,094
Elliott Bay (ND)	90, 91, 92, 93, 94, 95	615,247
Commencement Bay (ND)	89, 91, 95	308,405
Bellingham Bay (ND)	93	32,883
Anderson/Ketron (ND)	93, 95	18,874
Total cumulative volume: nondispersive sites (nondispersive + dispersive)		2,474,503 (3,366,435)

Legend: ND = nondispersive; D = dispersive

PROPOSED ACTION/MODIFICATION

The PSDDA agencies propose the following changes to the disposal site management plan.

- Tiered-full monitoring will be adopted into the site use management plan as an adjunct survey method to "full" and "partial" monitoring. The PSDDA agencies will review the site use history preceding any monitoring event, and may elect to conduct either full site monitoring, partial monitoring or tiered-full monitoring depending on the circumstances.

- Initiate monitoring when cumulative volumes approach or exceed 300,000 cubic yards since the last monitoring event at the central Puget Sound nondispersive sites (Port Gardner, Elliott Bay, and Commencement Bay). This volume trigger will not apply to the remaining two nondispersive sites (i.e., Bellingham Bay and Anderson / Ketron Island). Therefore, the PSDDA agencies will give special consideration to conduct periodic monitoring as necessary at both of these relatively low use sites in the future.

REFERENCES

FEIS. 1988. Final Environmental Impact Statement - Unconfined Open-Water Disposal Sites for Dredged Material, Phase I (Central Puget Sound). Prepared jointly by Seattle District Corps of Engineers, Washington State Department of Natural Resources, Washington State Department of Ecology, and U.S. Environmental Protection Agency, Region 10.

MPR. 1988. Management Plan Report; Unconfined Open-Water Disposal of Dredged Material, Phase I (Central Puget Sound). Prepared jointly by Seattle District Corps of Engineers, Washington State Department of Natural Resources, Washington State Department of Ecology, and U.S. Environmental Protection Agency, Region 10.

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JOINT PSDDA/SMS TOPICS

CLARIFICATION

STATUS REPORTS

ISSUE PAPERS

PSDDA/SMS CLARIFICATION PAPER

NEANTHES 20-DAY GROWTH BIOASSAY - FURTHER CLARIFICATIONS ON NEGATIVE CONTROL GROWTH STANDARD, INITIAL SIZE, AND FEEDING PROTOCOL

Prepared by David Kendall (Corps of Engineers, 206/764-3768) for the PSDDA/SMS agencies.

INTRODUCTION

The PSDDA agencies implemented the 20-day biomass (growth) test at the beginning of Dredging Year 1993 (June 16, 1992). The latest bioassay protocol updates (PSEP 1995) reflect the PSDDA/SMS program bioassay protocol modifications through July 1995. Since that time a number of additional protocol issues have surfaced. This clarification summarizes those updates enacted by the PSDDA program on an interim basis in a letter sent to bioassay laboratory practitioners in November 1995.

The *Neanthes* test is also one of the chronic bioassays used in the SMS cleanup and source control programs. These programs also rely on the PSEP protocols and modifications made to these protocols at annual review meetings. Consistency in bioassay protocols between the SMS and PSDDA programs is highly desirable and will reduce confusion among laboratories and regulated parties. The following proposed modifications to the PSEP protocols are therefore also applicable to sediment bioassays conducted under SMS.

PROBLEM IDENTIFICATION

Interim Control Performance Standard. A 1995 PSDDA clarification paper established an interim minimum control performance guideline for mean individual growth rate at ≥ 0.72 mg/individual/day, which was the mean growth rate for control sediments up to that time (1995 SMARM minutes). The PSDDA program data on which this guideline was established exhibited one standard deviation around the mean equal to ± 0.34 mg/individual/day. The performance guideline did not reflect the observed variability in laboratory performance noted around the mean performance.

Initial Worm Size. In 1993, the PSDDA agencies clarified the initial starting size requirements for the *Neanthes* test. The protocol clarification established a minimum worm size of 0.5 mg (dry weight). Since implementing this as a PSDDA and SMS program requirement, it has come to light that many labs are having difficulty meeting the 0.5 mg initial weight size, although the PSDDA agencies have generally applied the initial starting worm size as a **guideline** rather than as an absolute standard.

Feeding Protocol. An additional *Neanthes* growth test issue concerns the feeding protocol. The July 1995 PSEP protocol revision (page 68, fourth paragraph, last sentence) states "During the holding period, ... If the entire amount of food provided is being eaten, then an increase in the food ration might be appropriate.". The feeding protocol stipulates a feeding ration of Tetra Marin® of 8 mg/individual every two days. However, deviations from a strict feeding protocol may introduce variability in the test results, given the documented effect of feeding on growth (Johns and Ginn, 1990; Moore and Dillon, 1993).

PROPOSED ACTION/MODIFICATION

Control Performance Standard. Recent data submitted to the PSDDA program after the control growth performance guideline was implemented (August 1995) suggest that bioassay laboratories can routinely achieve control growth rates > 0.72 mg/ind/day. Therefore, the PSDDA and SMS programs reaffirm the interim control performance guideline of ≥ 0.72 mg/ind/day as a target. However, **control growth rates below 0.38 mg/ind/day[2] will be considered a QA/QC failure**. Laboratories failing to achieve a control growth rate ≥ 0.38 mg/ind/day may be required to retest.

The PSDDA agencies will continue to closely monitor the performance of this test and may adjust the control performance guideline in the future. This performance standard was adopted in the December 1995 SMS update.

Initial Worm Size. An evaluation of three years of PSDDA/SMS program data regarding initial starting size suggests that there is much more variability in the control and reference growth exhibited over the 20-day exposure period when average initial worm sizes are less than 0.25 mg (dry weight). The results suggest that worms larger than 0.25 mg (dry weight) exhibit similar growth rates to worms larger than 0.5 mg (dry weight). The PSDDA and SMS programs reaffirm the 0.5 mg (dry weight) initial growth weight as a **guideline target**, and may consider tests initiated with **worms smaller than 0.25 mg (dry weight) as a QA/QC failure**.

Feeding Protocol. Under no circumstances should the feeding be increased over the 8 mg/individual ration (Tetra Marin®) every two days. **Deviations from strict protocol feeding requirements will make the test results invalid for PSDDA/SMS regulatory decision making**.

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[2] This lower limit reflects adjustments to the PSDDA/SMS control performance guideline accounting for the observed variability exhibited by the laboratories performing the test (0.72 - 0.34 = 0.38), where the lower limit of observed control growth (≥ 0.38 mg/ind/day) expresses one standard deviation of the mean.

REFERENCES

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PSDDA CLARIFICATION PAPER
SMS TECHNICAL INFORMATION MEMORANDUM

STATISTICAL EVALUATION OF BIOASSAY RESULTS

Prepared by Dr. Teresa Michelsen (Washington Department of Ecology) and Travis C. Shaw (U.S. Army Corps of Engineers) for the PSDDA/SMS agencies.

INTRODUCTION

Sediment bioassays are an integral part of sediment management programs in Washington State. Under the Puget Sound Dredged Disposal Analysis (PSDDA) program and the Washington Sediment Management Standards (SMS), sediment bioassays may be used to determine whether sediments are suitable for open-water disposal, whether sediments require cleanup, and in determining the need for source control to protect sediment quality near a discharge. The interpretation of bioassay results under these programs requires two evaluations:

- A comparison of the response (e.g., mortality) observed in a sample to a threshold value (absolute or relative to a reference response) established by the agencies, and
- An evaluation of whether the adverse effect observed in the sample is statistically significant and greater than the effect observed at a reference station.

The discussion below provides guidance on the determination of statistical significance under these two regulatory programs.

Draft PSDDA Clarification Papers and SMS Technical Information Memoranda are available for public and agency review through the SMARM process, and will be finalized once public comments have been received. The final PSDDA Clarification Paper/SMS Technical Information Memorandum will be distributed to all SMARM participants and to the mailing list for the SMS Source Control and Sediment Cleanup Users' Manuals.

PROBLEM IDENTIFICATION

Regarding the determination of significance, the SMS rule provides that a t-test, $p \leq 0.05$, be used to determine whether the mean of the site station is statistically different from the mean of the reference station. This statement alone does not provide enough detail to ensure that the regulated community and agency staff consistently produce the same results when analyzing data sets. However, WAC 173-204-130(4) provides authority for Ecology to propose technical methods that replace and/or enhance methods provided for in the rule, providing public review is conducted and the decision to use an alternate technical method is documented in the public record.

The PSDDA Phase II Management Plan Report does provide additional guidance on data transformations and statistical tests to be used, discussed in the sections below. The PSDDA guidance further provides a null hypothesis (similar to text in the SMS rule) that the mean of the site and reference stations are not statistically different; however, this null hypothesis is not appropriate for the one-tailed t-tests recommended for use in SMS and PSDDA regulatory programs.

Agency staff and the regulated community have requested further clarification under SMS and PSDDA on the specific form of the t-test to be used, appropriate hypothesis testing, recommended data transformations, and recommended tests for normality and homogeneity of variances. In addition, the agencies have been asked whether Dunnett's test or other alternative tests could be used in place of the t-test. Finally, questions have arisen over the use of multiple reference stations for comparisons under these programs. The discussion below provides guidance on each of these topics.

DISCUSSION AND TECHNICAL BACKGROUND

Hypothesis Testing

In conducting statistical comparisons for sediment management programs, the only concern is whether adverse effects in the sample being tested are greater than adverse effects in a reference sediment (one-tailed hypothesis). The correct null (H_0) and alternate (H_1) hypotheses for comparing the mean response of the test sediment with the reference sediment are:

H_0: Mean test response (e.g., mortality) is less than or equal to mean reference response at $\alpha = 0.05$

or, H_0: $\mu_{sample} \leq \mu_{reference}$

H_1: Mean test response is greater than the mean reference response at $\alpha = 0.05$

or, H_1: $\mu_{sample} > \mu_{reference}$

Note that, for the larval bioassays, the alpha level should be increased to 0.1 to account for historically high variances in these tests (see PSDDA clarification paper *Interim Revised Performance Standards for the Sediment Larval Bioassay*, finalized November 10, 1994 and the Draft SMS Technical Information Memorandum *Quality Assurance Guidelines for the Sediment Larval Bioassay* presented with this paper at the 1996 SMARM).

The statement of hypothesis should be revised for effects endpoints where the adverse effect being measured results in a test response lower than the reference (e.g., growth endpoint for *Neanthes*). The correct hypotheses in these cases are:

H_0: Mean test response (e.g., growth rate) is greater than or equal to the reference response at $\alpha = 0.05$.

or, H_0: $\mu_{sample} \geq \mu_{reference}$

H_1: Mean test response is less than reference response at $\alpha = 0.05$.

or, H_1: $\mu_{sample} < \mu_{reference}$

In either case, if the null hypothesis is rejected, then we accept the alternate hypothesis that a statistically significant adverse effect is indicated, with a 5% probability of a Type I error (misidentification of an unimpacted station as impacted). If we fail to reject the null hypothesis, we determine that no significant adverse effect has been identified.

The direction of the inequality in the statement of hypothesis affects the comparison of the calculated t statistic with the t table value for a given significance level. The proper relationship between the hypothesis and critical region used in decisions about the hypothesis is presented below:

Type of Test	Null Hypothesis	Alt. Hypothesis	Critical Region
1-tailed	$\mu_{test} \leq \mu_{ref}$	$\mu_{test} > \mu_{ref}$	$t_{calc} > t_{table}$
1-tailed	$\mu_{test} \geq \mu_{ref}$	$\mu_{test} < \mu_{ref}$	$t_{calc} < -t_{table}$

Data Transformations

As noted above, use of the t-test requires that the data are normal and variances are homogeneous. Data derived from bioassay tests are often expressed in terms of percent (mortality or other endpoint). An arcsine-square root transformation should be performed to stabilize the variances and improve the normality of data sets expressed in percent. The arcsine-square root transform is provided below:

$$y = \arcsin \sqrt{x}$$

where x is the percentage expressed as a decimal (e.g., 0.80 instead of 80%). This transformation should not be used with bioassay data that are not expressed in percentages, such as growth rate or biomass.

If heterogeneous variances are encountered with biomass data, a $\log_{10}$ transformation may be applied to stabilize the variances. This transformation is typically used for environmental data for which the variance increases as the mean increases (as may be the case for data related to the growth of organisms), and is often successful in making the variance independent of the mean (Sokal and Rohlf, 1969).

Tests for Normality and Homogeneity of Variances

The theoretical basis for the t-test assumes that both samples being tested come from a normal population with equal variances. Violation of these assumptions reduces confidence in the Type I error rate. As a result, tests for homogeneity of variances and normality should be conducted after applying appropriate data transformations and before conducting the t-test.

To test the null hypothesis "the data have been drawn from a normally distributed population", the Wilk-Shapiro statistic (or W test) should be used. A Cochran's test (or F test of variances) should be used to determine whether the variances are homogeneous or heterogeneous.

Form of t-Test

This section affirms that the one-tailed Student's t-test referred to in PSDDA guidance should normally be used in evaluating sediment bioassay data under SMS cleanup and source control programs. This consistency between programs will support cross-comparisons between data sets and reduce the potential for confusion among parties regulated by both programs. Use of the Student's t-test is contingent upon an assumption that the data set is normal and variances are homogeneous. If these conditions are not met following appropriate transformations, the Mann-Whitney test for statistical significance should be used in place of a t-test or approximate t-test.

Use of Multiple Comparison Tests

Several consultants and regulated parties have suggested that the agencies address whether multiple comparison tests (such as ANOVA and Dunnett's) could be used in place of the t-test. Concerns have been raised that the use of multiple pair-wise tests in a single project could increase the Type I error rate for that project. Acceptable Type I error rates have typically been set by the agencies at 5%. However, if a multisample test design is used with a t-test, the Type I error rate increases with each additional station added to the comparison. For example, the null hypothesis tested in a multisample test might be "the mean of sample 1 is the same as the mean of sample 2, which are both the same as the mean of the reference station", or in mathematical terms:

$$H_0: \mu_1=\mu_2=\mu_{reference}$$

While a true multisample comparison approach would control Type I error for the above hypothesis at 5%, multiple t-tests used for the same number of comparisons would have a Type I error rate of 13% (Zar, 1984).

However, this null hypothesis addresses the relationship of each station not only to the reference station, but to other test stations being evaluated. Under PSDDA and SMS bioassay evaluation procedures, this type of evaluation is not conducted. Under PSDDA, dredged

material management units (DMMUs) are being evaluated individually for disposal; each may be dredged and disposed of independently of the others. This relationship can be expressed mathematically as:

$$H_0: \mu_1 \leq \mu_{reference}$$

and

$$H_0: \mu_2 \leq \mu_{reference}$$

For each comparison, the Type I error rate remains at 5%. Under SMS, a similar comparison is conducted; each station is compared individually to a single reference station to determine whether a regulatory level is exceeded at that station. Stations are not compared to each other to determine if they are the same or different. Once all stations have been independently tested against a reference station, the agencies evaluate the number of stations with exceedances and the magnitude of these exceedances to determine the need for cleanup or source control. Therefore, under both programs, the pairwise comparison of the t-test is appropriate to the evaluation procedures that have been adopted.

Multiple comparison tests have also been suggested using the five lab replicates from each station as a distribution. Under this approach, the Dunnett's or ANOVA test would be used to determine whether the distributions of data at the test site and reference station were statistically different, rather than comparing the means using a t-test. However, this is not an appropriate use of these tests because the "replicate" data for laboratory bioassays are only lab replicates, or subsamples, of a homogenized mixture of sediment taken from a single station (Hurlbert, 1984). They do not represent a true distribution of data representative of environmental variability in the field (for example, a number of independent samples from an area being tested). Replicates for benthic abundance analysis are field replicates, rather than lab replicates. However, benthic endpoints and data analysis techniques are currently being revised and are outside the scope of this paper.

Use of Multiple Reference Stations

For some projects, samples from multiple reference stations are being collected. This is often done to increase the chances that at least one reference station will meet performance standards, or to collect reference samples representative of different grain size regimes present at the site. In addition, field replicates are sometimes collected to assess sediment heterogeneity or variation due to sampling procedures. Because the SMS rule and PSDDA evaluation procedures were written assuming a single reference station, there has been some uncertainty in how to perform comparisons to reference when there are data for more than one acceptable reference station. The following guidance is provided on assessing bioassay results with multiple reference stations:

- As discussed above, pair-wise comparisons are currently being used in both the PSDDA and SMS programs. Multiple comparison tests that compare the distribution of data at the project location to the distribution of data at a reference area are not appropriate for

PSDDA because of the need to treat each individual DMMU separately. The SMS decision process is not structured to allow this type of comparison, and additional development work would need to be done on evaluation procedures if this were contemplated. Therefore, for each site station, a single reference station must be selected for the regulatory comparison.

- If field replicates have been collected at any of the reference stations, the following procedure should be used for statistical tests. Determine the mean response of the lab replicates for each field replicate. Then find the average of the means of all the field replicates and compare this average to the performance standards. This determines whether the station as a whole passes performance standards. An individual field replicate may be excluded or rejected if, in the agency's discretion, it was adversely affected by a sampling, handling, or laboratory problem not representative of environmental conditions at the station.

- For subsequent statistical testing, all field replicate data at a reference station may be pooled, or a representative field replicate may be selected for each station. In selecting a representative replicate, consideration should be given to the degree of variability as well as absolute response. Treatment of field replicate data for statistical analysis should be discussed in the SAP and approved in advance by the lead agency.

- In cases where grain size varies widely at the site, multiple reference stations may be collected to allow comparison of site stations to the acceptable reference station that most closely matches it in grain size. This is particularly appropriate when the bioassay organism used is known to be affected by grain size (e.g., *Rhepoxynius* or *Ampelisca*). Reference stations that do not meet performance standards should be eliminated from the evaluation and each site station compared to the remaining reference station with the closest percent fines.

- If grain size is not an issue, the performance of multiple reference stations should be evaluated with respect to all three bioassays being conducted, and any reference stations eliminated that do not meet performance standards for all three bioassays. If more than one reference station remains that meets all performance standards, a station should be recommended by the project proponent and approved by the lead regulatory agency prior to conducting the statistical analysis. Criteria for selecting an appropriate station could include selection of a station that best represents the overall habitat at the site (e.g., water depth, grain size, TOC), or a station could be selected that is representative of the range of responses (considering both magnitude and variability of the response) seen at the reference area.

- Tables reporting bioassay results should clearly identify which reference station was used for each comparison.

PROPOSED CLARIFICATIONS AND MODIFICATIONS

In summary, the following guidance is provided for the PSDDA and SMS programs:

- A null hypothesis shall be selected that reflects the one-tailed t-test approach and the type of endpoint being evaluated. Appropriate null hypotheses are provided above.
- All bioassay data expressed in percent should be transformed prior to statistical testing using the arcsine-square root transform. No other data transformations should be applied, and this data transformation should not be used for endpoints not expressed in percent (e.g., growth, biomass).
- Bioassay data should then be tested for normality and homogeneity of variances, using the Wilks-Shapiro test (W test) and Cochran's test (F test for variances), respectively.
- Bioassay data passing both tests should be tested for statistical difference using a one-tailed Student's t-test. Bioassay data failing one or both of these tests should be tested for statistical difference using the nonparametric Mann-Whitney test.
- Use of multiple comparison tests (e.g., ANOVA, Dunnett's) is not allowed under either SMS or PSDDA.
- If field replicates are collected at reference stations, and/or multiple reference stations are available that pass performance standards, guidance provided above should be followed in using these data for statistical tests.

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PSDDA/SMS STATUS REPORT

BENEFICIAL USES OF DREDGED MATERIAL WORK GROUP

Prepared by Justine Barton (Environmental Protection Agency, 206/553-4974) for the PSDDA agencies.

INTRODUCTION

> Definition: Beneficial use of dredged material is the placement or use of dredged material for some productive purpose.

A cooperative interagency Sediment Management Agreement was signed in May 1994 by three state and two federal agencies (Washington Departments of Ecology and Natural Resources, the Puget Sound Water Quality Authority, the U.S. Environmental Protection Agency, and the U.S. Army Corps of Engineers). Among other things the agreement directed the agencies to examine policies and procedures affecting beneficial uses of dredged material, and attempt to facilitiate those uses in the context of existing agency authorities and programs, including PSDDA.

Specific key tasks are:

1. compile agency policies and procedures affecting beneficial uses
2. identify common and different policies and procedures
3. prepare a common set of policies (resolve differences, if possible)
4. recommend an integrated procedure for agency review and approval of beneficial uses projects, and
5. identify implementation methods and any unresolved issues.

EPA has been responsible for convening the work group, which has been meeting since April 1995. Agency staff along with representives from the ports, tribes, and local governments have been meeting and working to accomplish the key tasks listed above. Work group meetings are open to anyone interested.

STATUS OF WORK

The work group has had lively discussions on a variety of topics. Relevent agency policies and procedures from Washington Departments of Ecology, Natural Resources, and Fish and Wildlife, along with the Environmental Protection Agency and Army Corps of Engineers, have been compiled and discussed. A working list of regional definitions has been drafted. In an effort to make information more available to prospective project proponents, two information matrices have been drafted, one detailing locations and schedules of available dredged material, and one identifying past beneficial uses projects in the Pacific Northwest. The timeline for completion of work tasks has been extended due to agency furloughs in 1995/96.

Issues to be addressed in spring 1996 include prioritization of competing beneficial uses projects, and development of guidance on necessary levels of characterization. The work group will ultimately produce two short reports; an executive summary (policy) for directors of agencies and other staff, and a guide for project implementers. Anyone interested in participating in the work group is encouraged to contact Justine Barton at (206) 553-4974 or Anne Robinson at (206) 553-6219.

PSDDA/SMS STATUS REPORT

PUGET SOUND MULTIUSER DISPOSAL SITE (MUDS) STUDY

Prepared by Steven Babcock (Corps of Engineers, 206/764-3651) for the PSDDA agencies.

INTRODUCTION

The Corps of Engineers, Department of Ecology, Department of Natural Resources, Environmental Protection Agency, Washington Public Ports Association, and Puget Sound Water Quality Authority are jointly conducting a study to develop a program to site, construct, and operate one or more multiuser sites for the disposal of contaminated sediments dredged from Puget Sound.

PROBLEM IDENTIFICATION

The overall objective of the study is to find an effective solution to the contaminated sediment disposal problem by ultimately establishing one or more multiuser sites for the safe disposal of contaminated sediments derived from Puget Sound, Washington. The study has thus far reaffirmed findings by Ecology that there is a significant need for the establishment of one or more multiuser sites for the disposal of contaminated sediments. These sediments will result from navigation dredging, environmental cleanup, and habitat restoration actions.

STATUS OF WORK

An interagency reconnaissance study is underway and will be completed in 1996. A draft federal reconnaissance report has been completed by the Corps of Engineers for use in the decision process regarding the extent of participation by the Corps in the proposed detailed feasibility study. Other reconnaissance study outputs include a disposal facility siting process study, a contingency management strategy, and programmatic EIS scoping. The interagency study team is presently developing a plan of study, including a task analysis, cost estimate and schedule for the feasibility study. This study scoping effort will be completed by late Spring 1996 and submitted for review and approval by the agency heads. The agencies expect to initiate the cost shared feasibility study in the summer of 1996.

PSDDA/SMS STATUS REPORT

SEDIMENT CLEANUP STRATEGY: AN INTERAGENCY OVERVIEW

Prepared by Rachel Friedman-Thomas (Washington Department of Ecology, (360/407-6909) for the PSDDA agencies.

INTRODUCTION

An Interagency/Intergovernmental Agreement (IAG) was signed in May 1994 by three state and two federal agencies (Washington Departments of Ecology and Natural Resources, the Puget Sound Water Quality Authority, the U.S. Environmental Protection Agency, and the U.S. Army Corps of Engineers). The IAG created a Sediment Cleanup Work Group to recommend ways to make progress with sediment cleanup in Washington State. The Work Group was composed of representatives of industry, tribes, environmental groups, ports, and federal, state and local governments. In December 1994, the Work Group developed seven consensus recommendations which were put before the five agencies for immediate action.

The Work Group acknowledged that the recommendations would require reordering priorities within the sediment, water, and cleanup arenas, and would warrant dropping some activities. The following recommendations were intended to be considered cumulatively rather than individually:

1. The top priority is to manage sediment loading (from point and nonpoint sources) to prevent contamination and recontamination of sediments.

2. All five agencies must work cooperatively and in a coordinated fashion on sediment cleanup issues.

3. Separate, ranked and prioritized sediment site lists for each major bay in Puget Sound should be immediately established.

4. Agencies should institute a baywide approach to source control, sediment cleanup, dredging/disposal, and habitat restoration.

5. Agencies should focus on "hotspot" cleanups to accelerate cleanup at the worst sites.

6. Barriers should be reduced and incentives should be provided for voluntary cleanups.

7. Agencies should see that a multi-user disposal site(s) is built.

Staff from the five agencies and the Washington Department of Transportation, responsed to the Work Group recommendations by developing a strategy for a collective course of action to move sediment cleanup forward over the next few years. In addition, a summary of

commitments for action on each of the consensus recommendations was developed.

RECENT DEVELOPMENTS

In an effort to see real improvements in the quality of aquatic sediments in Puget Sound, a new approach embracing shared leadership of both sediment cleanup and source control will be attempted. Three goals have been outlined which address the need to take a programmatic versus project-by-project approach, as well as share meager agency resources. The following goals are intended to shift resources from litigation to actual cleanup:

Goal 1: New Interagency Cleanup Program

- Produce several collaborative technical and policy work products to advance our effectiveness/efficiency of sediment management.

- Develop a Unified Position that defines the collective government position/program. Each agency will bring their own areas of expertise to the effort.

- Establish an Interagency Technical Assistance Team to focus on prioritized, transactional (construction and real estate transactions) cleanups.

Goal 2: Demonstration Pilot Project

- Develop a "place-based" project where agencies enter into partnerships with local interests and provide grant funding and/or administrative discretion to participants.

- Establish and implement priority actions related to sediments and the aquatic habitat.

- Institutionalize agreements via an Areawide Plan/Environmental Impact Statement for decision-making, including general or streamlined permits for implementation of the areawide plan, and agency resource and responsibility allocations for priority actions.

Goal 3: Flexible and Creative Models for State and Non-State Funding for Cleanup

- Pursue a supplemental budget appropriation during the 1996 State Legislative session to initiate the new sediment strategy.

- Identify new mechanisms for public and private financial contribution to cleanup.

FORTHCOMING ACTION

The six agencies have been working to implement many of the elements of the Sediment Cleanup Strategy. Local governments have been contacted regarding partnering for the demonstration pilot project. An area will be chosen as the first location to conduct the pilot project, based on local interest and financial resources. A budget appropriation was requested from the state legislature for use by the local governments for staffing needs, technical studies, database system development, and/or prioritization process facilitation. In addition, a number of technical and/or policy guidance documents are under development. Their status and an update of the pilot project will be provided at the PSDDA/SMS Annual Review Meeting.

REFERENCES

U.S. Army Corps of Engineers, Washington Department of Ecology, Washington Department of Natural Resources, U.S. Environmental Protection Agency (Region X), and Puget Sound Water Quality Authority. 1994. Interagency Option Papers on Sediment Management Issues.

Sediment Cleanup Work Group. 1994. Final Report. Submitted to the Directors of the Washington Department of Ecology, Washington Department of Natural Resources, U.S. Environmental Protection Agency (Region X), U.S. Army Corps of Engineers, and Puget Sound Water Quality Authority.

Washington Department of Ecology, Washington Department of Natural Resources, Puget Sound Water Quality Authority, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency (Region X). 1995. Sediment Cleanup Strategy: An Interagency Overview.

PSDDA/SMS STATUS REPORT

HUMAN HEALTH-BASED SEDIMENT CRITERIA FOR PUGET SOUND

Prepared by Laura B. Weiss, M.P.H. (Washington Department of Ecology, (360/ 407-7446) for the PSDDA/SMS agencies.

INTRODUCTION

The Department of Ecology's Sediment Management Unit has been conducting and managing the technical and policy development work needed to propose health-based criteria for sediments in Puget Sound. These criteria are being developed using standard risk assessment methodology in conjunction with empirically-derived biota-sediment accumulation factors (BSAFs). More detail on the technical background for the approach can be found in the Department of Health's Tier I Report (DOH, 1995).

BACKGROUND

It is anticipated that human health sediment criteria will be implemented within the current structure of the Sediment Management Standards (SMS). This includes the following basic features:

Criteria: Two levels of criteria are specified in the SMS for regulatory decisionmaking. The Sediment Quality Standards (SQS) are sediment concentrations that are expected to have "no adverse effects...and no significant health risk to humans" and are considered to be the goal of the sediment regulations. The regulatory limit (RL) criteria are less stringent and represent "minor adverse effects". They are upper limits of concentrations that would be allowed under the regulation. Regulatory decisions are made within the range between the two levels (SQS and RL) and take into account cost, technical feasibility and net environmental effects.

Weight of Evidence: The SMS ecological standards allow for two weights of evidence: chemical and confirmatory biological testing. Chemical testing involves comparison of sediment chemical concentrations to table values. The test is intended to provide a reasonably quick and inexpensive means for decision making. With respect to human health criteria, Ecology's proposed construct relies on a tiered approach, with "Tier I" representing an initial evaluation to determine if sediment chemical concentrations pose a significant human health risk. The option to conduct a site-specific analysis would then be available ("Tier II") to verify the results of the Tier I analysis. Ecology is considering other approaches which incorporate fish tissue testing as a step in the Tier I/Tier II framework.

Types of Activities: The SMS establishes requirements for two types of activities: cleanup and source control. In addition, dredging decisions are made so as to meet the requirements of the SMS. Once adopted into the rule, human health criteria will be used in conjunction with the existing ecological criteria to make cleanup, source control and dredging decisions.

IMPLEMENTATION OPTIONS

Within this overall framework, there are several approaches for implementation of human health sediment criteria. Ecology has identified a number of key issues where any of a number of approaches is possible in the design of human health criteria. Those issue areas can be summarized by the following key questions:

What is the Role of Fish Tissue Analysis in Identifying Contaminated Sediment Sites?

Should Sediment Quality Values (SQS, CSL, SIZmax) for Human Health be Expressed as Numerical Values or a Formula?

How Should Background/Reference Area Concentrations be Factored into the Decision-Making Process when Health-Based Values are Lower?

How Should Ecology Factor in Chemicals of Concern Without BSAFs?

How Should Ecology Take into Account that Fish Home Ranges Usually Extend Beyond Individual Source Control of Sediment Cleanup Sites (Use of Surface Area Weighting)?

How Should Ecology Take into Consideration Natural Degradation Processes?

How Should Ecology Account for Background Risks?

Ecology staff have been discussing these questions with interested groups, including the PSDDA agencies, in an effort to develop a workable system for implementation of human health criteria. Additional information on these topics, as well as the connections with the PSDDA program, will be discussed in more detail at the Annual Review Meeting in May.

TIER II FRAMEWORK

While Tier I SQC are intended to provide an efficient and cost effective means of determining where potential risks to human health exist, Tier II is intended to "fine tune" some of the assumptions inherent in the Tier I criteria. One of the key issues for implementing Tier II assessments involves identifying which parameters from the Tier I equation will be open for review. Those parameters include the following:

- Risk Level
- Body Weight
- Exposure Duration
- Averaging Time
- Toxicity Factor
- Ingestion Frequency
- Fish Lipid
- BSAF

Ideally, Tier II assessments will allow for the incorporation of site-specific data or new scientific information. There are policy, as well as scientific, decisions inherent in most of the above parameters. For example, the choice of an appropriate risk level is based entirely on policy and does not lend itself well to site-specific alterations. Conversely, calculation of a site-specific BSAF is largely a scientific decision and would be a very appropriate parameter to alter based on site-specific data.

Due to site-specific variations, parameters and values used to calculate Tier II SQC may be variable. Applicants will be given the flexibility to choose which data to collect and incorporate into their Tier II evaluation, within certain bounds established by Ecology. The rationale for selection of particular site-specific values will need to be well documented by the applicant. Additional information on the details associated with a Tier II analysis will be available at the Annual Review Meeting in May.

REFERENCES

Washington State Department of Health, Tier I Report: Development of Sediment Quality Criteria for the Protection of Human Health, June 1995.

PSDDA/SMS STATUS REPORT

RE-EVALUATING PUGET SOUND APPARENT EFFECTS THRESHOLDS (AETs): AN UPDATE

Prepared by Tom Gries (Washington Department of Ecology, 206/407-7536) for the PSDDA agencies.

INTRODUCTION

Most of the current PSDDA Maximum Level (ML) and Screening Level (SL) guidelines [1] are based on 1986 or 1988 Apparent Effects Threshold (AET) values for Puget Sound sediments [2,3]. The PSDDA agencies began re-evaluating AETs and guidelines in mid-1992, in part to incorporate more recent biological effects data. Initial re-evaluation efforts focused on following the previous approach and analytical methods [2,3] to revise the amphipod AETs and calculate new sediment larval AETs [4]. Preliminary results were presented at the PSDDA annual review meetings (ARMs) and regional Society for Environmental Toxicology And Chemistry conferences [5,6,7,8].

Benthic experts present at those meetings recommended the agencies derive larval AETs based on tests using echinoderm species alone. This recommendation was based on 1) the likelihood that echinoderm species would exhibit different adverse effects from exposure to sediment contaminants than would bivalve larvae, 2) a growing preference for using echinoderms as test organisms, and 3) the lack of enough new bivalve data to warrant pursuing separate bivalve larval AETs. Thus, the task of calculating sediment larval AETs shifted toward deriving echinoderm larval AETs using two separate endpoints: abnormality (alone) and effective mortality (abnormality plus mortality).

At the 1994 ARM, the PSDDA agencies identified some remaining technical tasks and policy determinations needed before recommending changes to ML or SL values. These were to:

- complete calculations of sediment larval effective mortality AETs
- calculate important predictive reliability values for new AETs and PSDDA guidelines
- assess the cost of any proposed ML/SL changes to the dredging community
- assess the regulatory implications for PSDDA of any proposed ML/SL changes
- describe the overall process and judgment criteria for adopting new guidelines
- convene a "Regulatory Work Group" (RWG)

The first of these tasks was completed by 1995. PSDDA agencies reported that echinoderm larval abnormality AETs predicted adverse effects more accurately than values based on the effective mortality endpoint. They also presented additional AET reliability results and proposed a process for reviewing, recommending and adopting new guideline values. The agencies still needed to:

- incorporate peer review comments into a draft AET Report (Volume I) for release to the public

- address public comments in a final AET Report (Volume I)
- draft and finalize a second AET Report (Volume II) detailing the final reliability of the new AETs and proposed guidelines, and implications of using new guidelines in the PSDDA /SMS programs, and the overall re-evaluation process
- convene the RWG to recommend how AETs should be used in sediment regulatory programs

After the 1995 Sediment Management Annual Review Meeting (SMARM), PSDDA agencies solicited and received additional technical comments on the draft "Progress Re-Evaluating Puget Sound Apparent Effects Thresholds (AETs), Volume I (March 1995)." The revised Volume I Report was released for public review in April of this year.

PROBLEM IDENTIFICATION

Nearly all technical comments were addressed in the draft report now undergoing public review. However, it was difficult or impossible to reconcile some remarks with the needs and resources of the PSDDA agencies. A few commenters suggested the agencies expand the AET database by re-introducing the large number of samples excluded from the 1993-1994 calculations. Other reviewers recommended interpreting and incorporating additional synoptic data. However, the agencies could not justify either action. The first suggestion would open the re-evaluation effort to criticism for using inconsistent methods and poor quality data. Many bioassay samples were excluded because they lacked adequate controls or reference samples for interpretation. The second recommendation to incorporate newly-available, high-quality synoptic data was valid, but the time associated with gathering and reviewing new data would have greatly delayed the re-evaluation process. Given limited resources, the PSDDA agencies preferred moving forward. Additional new synoptic data will be incorporated in the next comprehensive re-evaluation.

PSDDA agencies originally conceived of a RWG to make key policy decisions about final phases of thise AET re-evaluation. Work on some of the items identified at the 1994 and 1995 ARMs could therefore not proceed until the RWG's members, mission, goals and objectives were defined, and applicable policy decisions were made.

STATUS OF WORK

A third draft of the AET re-evaluation report (Volume I) was released for public review in April and will be available at the upcoming Sediment Management ARM (May 8, 1996). It will contain a new executive summary, but the detailed discussion of reliability values and the overall re-evaluation "process" ill be included in a separate Volume II of the report. In addition to these elements, Volume II will present estimates of the cost and regulatory implications of changing specific guidelines.

Members of the RWG have been tentatively identified and will be invited to participate in an initial meeting, likely scheduled for June. The agencies have also drafted specific goals and objectives for the RWG, as well as a timeline for making key policy decisions. The RWG will attempt to reach consensus recommendations on how new AETs should be used to revise the PSDDA guideline values, and possibly the SMS criteria. PSDDA agencies will consider the RWG's recommendations and propose changes in the standard issue paper format at the 1997 SMARM. Ecology's Sediment Management Program may also review the RWG's recommendations and consider changes at that time.

REFERENCES

1. PSDDA. 1989. Management Plan Report. Unconfined Open-Water Disposal of Dredged Material, Phases I and II.
2. PSDDA. 1986. Development of Sediment Quality Values for Puget Sound. Prepared for PSDDA by Tetra Tech.
3. PSEP. 1988. Sediment Quality Values Refinement, Volume I. Update and Evaluation of Puget Sound AET. Prepared for the U.S. EPA Region 10 by PTI Environmental Services, Inc.
4. PSDDA. 1993. Minutes to the Annual Review Meeting for Dredging Year 1992. Prepared by the U.S. Army Corps of Engineers - Seattle District.
5. PSDDA. 1994. Minutes to the Annual Review Meeting for Dredging Year 1993. Prepared by the U.S. Army Corps of Engineers - Seattle District.
6. PSDDA. 1995. Minutes to the First Sediment Management Annual Review Meeting. Prepared by the U.S. Army Corps of Engineers - Seattle District.
7. Gries, T.H. and K.H. Waldow. 1993. Presentation at the 2nd Annual Meeting of the Pacific Northwest Chapter of the Society for Environmental Toxicology And Chemistry (SETAC). May 1993.
8. Gries, T.H. 1994. Presentation at the 3rd Annual Meeting of the Pacific Northwest Chapter of the Society for Environmental Toxicology And Chemistry (SETAC). May 1994.

SEDIMENT MANAGEMENT STANDARDS

(CHAPTER 173-204 WAC)

ANNUAL REVIEW AND STATUS

STATUS PAPER

SEDIMENT MANAGEMENT STANDARDS (SMS) TRIENNIAL REVIEW

Prepared by Pamela Sparks-McConkey for the Sediment Management Standards Program, Washington Department of Ecology (360/ 407-6491).

INTRODUCTION

In compliance with the Sediment Management Standards (SMS), Chapter 173-204-130(6)-(8) WAC, the Washington State Department of Ecology (Ecology) initiated the triennial review of the SMS rule at the May 1995 Sediment Management Annual Review Meeting (SMARM), a jointly sponsored Puget Sound Dredged Disposal Agencies (PSDDA) and SMS program conference. As part of the SMS triennial review process, Ecology provided the public opportunity to submit oral or written comments on technical, policy, and regulatory issues. This paper identifies the improvements/revisons that were adopted under the SMS rule in December 29, 1995.

BACKGROUND

At the May 1995 SMARM, Ecology presented triennial review papers on proposed modifications to the SMS rule based on previous PSDDA studies, revisions of the Puget Sound Estuary Program (PSEP) protocols, and/or recommendations from Ecology's ongoing technical development activities. The public was given full opportunity to comment on presentations and/or to recommend revisions to the SMS rule narrative, regulatory language or requirements, technical or policy issues during the SMARM conference. Additionally, Ecology conducted three public hearings and provided a written comment period on proposed modifications to the SMS rule. The department also met with stakeholders on an individual basis to discuss recent scientific results concerning environmental sediment effects associated with chemicals of concern.

REVISIONS TO SMS RULE

Ecology adopted the proposed modifications to the SMS rule on December 29, 1995, and these amendments became effective on January 29, 1996. The fifty plus revisions in the amended SMS rule are based on technical research and scientific knowledge, conclusions from the 1995 SMARM conference presentations, and include minor editorial changes to clarify the intent of the SMS regulations.

In incorporating the revisions to the SMS requirements, fourteen sections were modified in the SMS rule. The primary focus of the rule amendments were to adopt sediment quality standards for allowable sediment effects attributed to a Marine Finfish Rearing Facility discharge, RCW 90.48.220. Additionally, other revisions resulted in the following:

- Incorporating latest scientific methodologies and/or results for consistency between current sediment management programs/protocols,

- Merging public recommendations/comments for improving the implementation of rule requirements and its goal, and

- Correcting typographical and grammatical errors for improving text readability.

These revisions result from using a consultative rule development process i.e., Ecology working with three broad-based advisory committees over a twenty-two month period to ensure that the results from the evaluation of recent technical information was used to identify and clarify issues, regulatory requirements, and potential overlap or redundancy between local, state, or federal regulations and jurisdictions.

An attachment of the list of changes or revisions to the amended SMS rule has been provided to give the reader a perspective of the modifications that supersede the earlier SMS rule.

REFERENCES

Ecology. 1995. Washington State Department of Ecology. Sediment Management Standards. Chapter 173-204 Washington Administrative Code, amended December 1995.

Ecology. 1995. Washington State Department of Ecology. Triennial review papers: Sediment Management Standards Program. Triennial review papers prepared for the jointly sponsored conference, Sediment Management Annual Review Meeting (SMARM).

Puget Sound Estuary Program. 1995. Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments. (July 1995 revisions). Prepared for the U.S. Environmental Protection Agency, Region 10 Office of Puget Sound by the Washington State Puget Sound Water Quality Authority.

Revisions to Sediment Management Standards
Chapter 173-204

As Finally Adopted on December 29, 1995

TABLE OF CONTENTS

1. Inserted new section: WAC 173-204-412 Marine finfish rearing facilities

WAC 173-204-100 AUTHORITY & PURPOSE

2. Inserted a statement to identify cleanup screening levels for identification of sediment cleanup sites, under **WAC 173-204-100 (7)**.

3. Updated the note section to identify Ecology's new mailing address under **WAC 173-204-100 (8)**.

WAC 173-204-130 ADMINISTRATIVE POLICIES

4. Corrected typographical errors (2) for number referencing the annual review process under WAC 173-204-130 (8); References to (7) corrected to (6).

WAC 173-204-200 Definitions

5. Inserted the following two species under the definition for "amphipod" in WAC 173-204-200 (2) *Ampelisca abdita* and *Eohaustorius estuarius*.

6. Inserted a definition for "Marine finfish rearing facilities" under WAC 173-204-200 (13).

7. Modified the definition for "Puget Sound Protocols:" Deleted term "updated in 1989" and replaced with "As amended."

WAC 173-204-315 CONFIRMATORY MARINE SEDIMENT BIOLOGICAL TESTS

8. Inserted *Ampelisca abdita* and *Eohaustorius estuarius* as examples of Amphipod under WAC 173-204-315 (1)(a)(i).

9. For consistency with respect to current scientific taxonomic nomenclature, replaced *Mytilus edulis* with *Mytilus (edulis) galloprovincialis*.

10. Added *Strongylocentrotus droebachiensis*, i.e., Green sea urchin as a larval bioassay organism to be used in the sediment larval bioassay tests under WAC 173-204-315 (1)(a)(ii)(D).

11. For taxonomic clarification purposes inserted the classification terms Class, Class, and Phylum before Crustacea, Polychaeta, and Mollusca respectively under WAC 173-204-315 (1)(b)(i)..

12. Replaced the word "biomass" with "growth rate" to describe endpoint for Juvenile polychaete under WAC 173-204-315 (1)(b)(ii).

13. For consistency with respect to current scientific taxonomic nomenclature replaced *Photobacterium phosphoreum* with *Vibrio fisheri* under WAC 173-204-315(1)(b)(iii).

14. Replaced the first fifty and second fifty with thirty and seventy respectively for Larval seawater control performance under WAC 173-204-315 (2)(b).

15. Under WAC 173-204-315 (2)(d), included a Juvenile polychaete control growth performance standard of .72 mg/ind/day (i.e., mean individual growth) for acceptable control sediments. Additionally, replaced the term "biomass" with "individual growth rate." Restated the juvenile polychaete performance standard to clarify a range of mean individual growth rate.

WAC 173-204-320 Marine Sediment Quality Standards

16. Removed footnotes of Table 1, Marine Sediment Quality Standards--Chemical Criteria and placed them under subsection (2) of WAC 173-204-320.

17. In Table 1, deleted superfluous "chemical parameter" heading.

18. Restated the footnote 1 -- detection limit criteria for consistency with current scientific methods under WAC 173-204-320(2)(a).

19. Restated footnotes 3 and 4 LPAH and HPAH summing procedures respectively for clarity and consistency with current scientific methods under WAC 173-204-320(2)(b)(i) and (ii).

20. For taxonomic clarification purposes inserted the classification terms Class, Class, and Phylum before Crustacea, Polychaeta, and Mollusca respectively under WAC 173-204-320 (3)(c).

21. Replaced the first and second biomass terms with individual growth rate. Additionally, replaced the third and fourth biomass terms with mean individual growth rate under WAC 173-204-320 (3)((d).

WAC 173-204-400 General Considerations

22. Replaced WAC 173-201 with WAC 173-201A under WAC 173-204-400 (11).

WAC 173-204-410 Sediment quality goal and sediment impact zone applicability

23. Omitted the following sentence, "The sediment impact zone maximum criteria of WAC 173-204-420 shall not be applicable during the approved time schedule authorized by the department" under WAC 173-204-410 (6)(d)(i).

INSERTED NEW SECTION: WAC 173-204-412 Marine finfish rearing facilities.

24. Revised the applicability subsection to clarify that the 100 foot perimeter is included within the sediment impact zone by rule under 173-204-412(2).

25. Revised the title of the table and headers to reflect scientific methods under 173-204-412(3)(b).

26. Replaced "antibiotics" with "antibacterials" for consistency with respect to scientific terminology and usage under 173-204-412(3)(d).

27. Restated the applicability of the sediment impact zone by rule to include the 100 foot perimeter and replaced "physical boundary of the rearing facility" with "outer edge of the marine finfish rearing facility structure" for clarity purposes under 173-204-412(4).

28. Clarified the requirement to use a reference benthic infaunal abundance sediment sample that is either a baseline sediment sample or reference sediment sample in compliance with WAC 173-204-200(21) under 173-2040412(4)(a)(i).

29. Inserted verb "be" for proper english usage under 173-2040412(4)(a)(ii).

WAC 173-204-415 Sediment impact zones

30. Corrected typographical error from 5 to 4 under WAC 173-204-415 (1)(f) to correctly reference the design requirements subsection of section 415.

31. Included "PLUMES" as a sediment modelling tool and eliminated the number 4 after WASP under WAC 173-204-415 (4).

32. Included "PLUMES" as a sediment modelling tool and eliminated the number 4 after WASP under WAC 173-204-415 (4)(a)(iii).

33. Included "PLUMES" as a sediment modelling tool and eliminated the number 4 after WASP under WAC 173-204-415 (4)(b).

34. Included "PLUMES" as a sediment modelling tool and eliminated the number 4 after WASP under WAC 173-204-415 (5)(c)(i).

WAC 173-204-420 Sediment impact zone maximum criteria

35. Removed footnotes of Table II, Puget Sound Marine Sediment Impact Zones Maximum Criteria and placed them under subsection (2) of this section.

36. In Table II, deleted superfluous chemical parameter header.

37. Restated the footnote 1 - detection limit criteria for consistency with current scientific methods under WAC 173-204-420(2)(a).

38. Restated footnotes 3 and 4 LPAH and HPAH summing procedures respectively, for clarity and consistency with current scientific methods under WAC 173-204-420(2)(b)(i) and (ii).

39. Restated the Amphipod performance standard to clarify the exceedance level between the test and reference sediments under WAC 173-204-420 (3)(c)(i).

40. For taxonomic clarification purposes inserted the classification terms Class, Class, and Phylum before Crustacea, Polychaeta, and Mollusca respectively under WAC 173-204-420 (3)(c)(iii).

41. Replaced the first and second biomass terms with individual growth rate. Additionally, replaced the third and fourth biomass terms with mean individual growth rate under WAC 173-204-420 (3)(c)(iv).

WAC 173-204-510 Screening sediment station clusters of potential concern

42. Replaced the term "contiguous" with "spatially and chemically similar" under WAC 173-204-510 (2).

WAC 173-204-520 Cleanup screening levels criteria

43. Removed footnotes in Table III, Puget Sound Marine Sediment Cleanup Screening Levels & Minimum Cleanup Levels -- Chemical Criteria and placed the footnotes under subsection (2) of this section.

44. In Table III deleted superfluous "chemical parameter" header.

45. Restated the footnote 1 -- detection limit criteria for consistency with respect to scientific methods under WAC 173-204-520(2)(a).

46. Restated footnotes 3 and 4 LPAH and HPAH summing procedures respectively, for clarity and consistency with current scientific methods under WAC 173-204-520(2)(b)(i) and (ii).

47. Restated the sentence to clarify the Amphipod performance standard between the test and reference test sediments under WAC 173-204-520 (3)(d)(i).

48. For taxonomic clarification purposes inserted the classification terms Class, Class, and Phylum before Crustacea, Polychaeta, and Mollusca respectively under WAC 173-204-520 (3)(d)(iii).

49. Replaced the first and second biomass terms with individual growth rate. Additionally, replaced the third and fourth biomass terms with mean individual growth rate for the Juvenile polychaete test under WAC 173-204-520 (3)(d)(iv).

WAC 173-204-530 Hazard assessment.

50. Inserted the phrase "and site identification" after assessment in the title, **WAC 173-204-530 Hazard assessment.**

51. Replaced "Identifying and characterizing" with "identify and characterize" under WAC 173-204-530 (2)(b).

52. Replaced "Identifying" with "identify" under WAC 173-204-530 (2)(c).

53. Replaced "Identifying" with "identify" under WAC 173-204-530 (2)(d).

54. Replaced "Providing" with "provide" under WAC 173-204-530 (2)(e).

WAC 173-204-560 Cleanup study.

55. Replaced "Properties" with "recontamination potential" under WAC 173-204-560 (4)(c)(i).

56. Inserted reference to use of Ecology's recommended sediment recovery zone computer models "CORMIX," "PLUMES," and/or "WASP," or an alternate sediment recovery zone model(s) approved by the department under WAC 173-204-560 (4)(f)(ii)(A).

WAC 173-204-590 Sediment recovery zones.

57. Inserted reference to use of Ecology's recommended sediment recovery zone computer models "CORMIX," "PLUMES," and/or "WASP," or an alternate sediment recovery zone model(s) approved by the department under WAC 173-204-590 (2)(a).

APPENDIX A

The following discussion includes those projects requiring explanation beyond the summaries provided in Chapter 1 for ranking, sampling plan development, chemical testing, biological testing, or those for which the PSDDA agencies used best professional judgment as part of the decision-making process.

Dredging Year 1994

Konoike-Pacific Terminals, Commencement Bay. The Konoike-Pacific Tacoma Terminals, Inc. (K-Pac) is located on the high-ranked Blair Waterway. The project proposed dredging of 10,500 cubic yards of material from the berthing area. Characterization was conducted for three DMMUs. The material characterized included 4,800 cubic yards in the immediate dredging area and approximately 5,800 cubic yards of material up-slope, which was expected to slump into the dredging area following dredging.

One of the DMMUs had twenty-five SL exceedances, two BT exceedances and two ML exceedances. The two ML exceedances made this DMMU unsuitable for unconfined open-water disposal in the absence of a Tier IV evaluation (e.g., chronic/sublethal testing and potential human health/ecological risk assessment) and no further testing was conducted.

Chemical analyses for the other two DMMUs resulted in several SL exceedances, but no BT or ML exceedances. Biological testing was necessary to complete the decision-making process for these DMMUs. However, due to an error in summing the Aroclors[1] for total PCBs by the applicant, it was mistakenly assumed that the BT was exceeded for one of the DMMU, and the applicant elected not to proceed with routine acute bioassay testing. When the error was discovered the holding times for the sediments had been exceeded and resampling would have been necessary to proceed with these analyses.

For the single DMMU tested the *Neanthes* 20-day biomass test and saline Microtox test results showed no hits. Biological testing results were equivocal for the other two bioassays. For the amphipod bioassay (*Ampelisca abdita*), the results indicated that both the negative control sediment survival standard (90%) and the reference standard ($\leq$ 20% over control) were exceeded. West Beach was utilized as a negative control sediment and is not considered an appropriate control sediment for *Ampelisca abdita*, which had 18% mortality in this sediment. The Carr Inlet reference sediment showed 85% mortality. The test termination protocol used for the sediment larval test (*Strongylocentrotus purpuratus*) followed the ASTM test termination method and not the PSDDA test termination method. The reference sediment also failed to meet the PSDDA reference performance guidelines for this test.

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[1] The PSDDA program convention for summing detected and undetected values for total LPAH, HPAH, DDT, and PCBs is as follows: only detected values are summed for a total value; if all values are undetected, the highest detection limit is reported for the total.

The results of the amphipod and sediment larval tests could not be used to make a suitability determination. Resampling and retesting for both the amphipod and sediment larval bioassays was deemed necessary to complete the decision-making process. The applicant elected not to pursue additional testing and subsequently withdrew the application for dredging.

Lone Star Northwest/Taylor Way Facility. This project is located within a Federal Superfund site. The dredged material was aggregate which had accumulated in the waterway during off-loading operations. The sampling plan for this project required extensive revision, and was returned for revision prior to acceptance by the PSDDA agencies. The agencies required that the surface to remain exposed after dredging be characterized to determine if it met state sediment quality standards.

Port of Seattle - Terminal 30 Apron, Elliott Bay. The purpose of the proposed 30,000 cy dredging project was to rehabilitate a 400 ft by 114 ft section of concrete apron at the Terminal-30 (T-30) container loading facility located on the East Waterway. This project was ranked high for full characterization.

The full characterization plan included sampling at six locations for one uncomposited and two composited surface DMMUs, and two composited subsurface DMMUs. The surface DMMUs extended to 5.3 ft below the mud line to capture an observed visual horizon noted during earlier sampling. During sampling for one of the subsurface composites, it was observed that structural fill predominated at two stations, whereas the third station consisted predominately of sand. A decision was made to analyze the structural fill as a composited DMMU and keep the sand fraction separate as an uncomposited DMMU.

The results of the chemical analyses showed that one surface DMMU and two subsurface DMMUs had no SL exceedances and required no biological testing. The other two surface DMMUs both exceeded the BT for PCBs and one of these also had four ML exceedances. The multiple ML exceedances made this DMMU unsuitable for unconfined open-water disposal in the absence of a Tier IV evaluation (e.g., chronic/sublethal testing and potential human health/ecological risk assessment) and no further testing was conducted. In addition, the Port of Seattle elected not to perform the necessary biological testing for the other DMMU, which would have required the standard suite of PSDDA bioassays plus a 28-day bioaccumulation assessment for PCBs. Therefore, this DMMU was also considered unsuitable for UCOWD.

Biological testing was performed to evaluate the suitability of the one subsurface DMMU with only SL exceedances. In the amphipod test, one of the five West Beach control replicates exhibited 100% mortality at test termination. The replicate was believed to be an outlier, because the other four replicates exhibited low mortalities. Therefore, the anomalous replicate was dropped, and regulatory decision-making was based on the four remaining replicates. There were no hits for any of the bioassays and this DMMU was found suitable for disposal at the Elliott Bay nondispersive site.

The agencies concluded that two of the six DMMUs tested, representing a total of 5,640 cubic yards, were unsuitable for unconfined open-water disposal. The remaining four DMMUs, comprising 24,360 cubic yards of dredged material, were suitable for unconfined disposal at a nondispersive open-water disposal site.

The surface DMMUs contained an estimated 5,000 cubic yards of rip rap. The agencies required that the rip rap located in the single surface DMMU that passed PSDDA testing be separated from the suitable dredged material prior to disposal at the Elliott Bay site. This was accomplished by passing the dredged material through a 24" x 24" steel mesh grid mounted on the disposal barge. The Port of Seattle acknowledged that there were approximately 200-300 cubic yards of rip rap that would pass through the grid and be disposed at the PSDDA site. The PSDDA agencies agreed to allow this disposal as a policy evaluation test case. Physical monitoring of the Elliott Bay disposal site was required to document the presence and the potential impacts of the rip rap. The results of this monitoring are discussed in Chapter 2.

US Navy Pier D (Round 2). This high-ranked project underwent initial characterization in April 1991. PSDDA recency guidelines specify that full characterization data in a high concern area are suitable for up to two years. Concerns expressed during the permit review resulted in delays and the two-year recency guideline was exceeded. Therefore, retesting was deemed necessary. Also contributing to the decision to retest was increased concern for degraded sediment quality throughout Sinclair Inlet and the resulting designation of Sinclair Inlet as a Superfund site. There were also ongoing MTCA cleanup actions on the uplands adjacent to Pier D. The second round of characterization was performed in DY94.

The second round characterization consisted of sampling a redesigned and smaller proposed dredging project of 105,100 cy. Seventeen boring locations were occupied resulting in seventeen uncomposited surface DMMUs and five composited subsurface DMMUs, each consisting of three field samples. Additional sampling for SMS evaluation of sediment quality outside the proposed dredging footprint was also conducted by the Navy to assess potential cleanup requirements by Ecology.

The results of the chemical analyses showed that all seventeen surface DMMUs had quantitated or detection limit exceedances of PSDDA SLs. One DMMU also exceeded the ML and BT for total PCBs. Another DMMU exceeded the mercury BT. Of the five subsurface composite samples analyzed, two DMMUs had no quantitated SL exceedances, and three DMMUs each had single chemical exceedances of SL. The Navy elected to conduct concurrent bioassay testing on all twenty-two DMMUs and bioaccumulation testing for the DMMUs with BT exceedances. Results of biological testing are summarized below.

Amphipod. *Rhepoxynius abronius* was used when the percent fines fraction in the test sediment was less than 60 percent. Six DMMUs were tested with *Rhepoxynius* in two testing rounds. The remaining sixteen DMMUs were assessed in two rounds of testing with *Ampelisca*

abdita. The test sediments utilizing this species contained percentages of fines higher than 60 percent (PSDDA 1993 ARM Clarification). A single DMMU was tested with both amphipod species, and had a fines fraction of 41.5 percent. Amphipod control and reference sediment used for both species met performance standards and the results were considered acceptable for decision making. There were no hits for DMMUs tested with *Rhepoxynius*, whereas there were four double hits and one single-hit failure for DMMUs tested with *Ampelisca*.

Sediment Larval. Sediment larval testing was conducted in three testing rounds utilizing the sand dollar (*Dendraster excentricus*). Additional blind QA/QC analyses were conducted concurrently by an independent laboratory on six DMMUs. A number of problems were encountered in conducting the sediment larval test. The normal spawning cycle for this species extends from April to December. Animals induced to spawn toward the end of the spawning cycle (October to December) produce fewer gametes and exhibit lower viability and are subject to increased performance failures in this test. The seawater controls generally met the PSDDA performance requirements, except in round two testing where the abnormality standard of 10% was exceeded at 13.7%. A retest was authorized for those samples. During the third testing round, the seawater control abnormality standard was slightly exceeded at 11%. This exceedance of the abnormality performance standard was not brought to the attention of the PSDDA agencies until after testing had been completed. The PSDDA agencies did not deem this to be a significant QC issue.

The Carr Inlet reference tested with 57% fines exceeded PSDDA performance guidelines with 23.7% mortality during round one testing, and therefore was not used in decision-making. Because of the round one reference performance failure, a second test was conducted using a Carr reference with 81% fines. No reference performance problems were encountered during round two testing. One of the two references slightly exceeded PSDDA performance guidelines at 20.3% during round three. This exceedance was not significant and both references were deemed suitable for decision-making.

Of serious concern however, was the wide range in positive control (EC50) responses ($CdCl_2$) observed among the three rounds of testing conducted by the primary bioassay testing laboratory. EC50s of 17.9 mg/l, 0.1 mg/l, and 224 mg/l as Cd were reported for rounds one, two and three respectively. This demonstrated a wide range in apparent larval sensitivity among testing rounds. The positive control for the QA/QC analyses conducted by the outside QA/QC laboratory was 8.62 mg/l (Cd) in comparison.

The sediment larval test results indicated that 7 DMMUs passed bioassay interpretative guidelines, 8 exhibited single-hit failures under nondispersive interpretive guidelines, and 7 DMMUs had hits under the two-hit rule (a DMMU double-hit response must be confirmed by another hit to be judged unsuitable). Initial round one testing for one DMMU showed high mortalities that appeared to be associated with high concentrations of sulfides in the overlying water (6.2 mg/l). This was brought to the attention of the PSDDA agencies and a retest was authorized. The retested DMMU passed the nondispersive site suitability guidelines, as did a blind sample analyzed by the outside QA/QC laboratory.

Five of the six DMMUs tested by the QA/QC laboratory passed nondispersive site interpretative guidelines, whereas one exhibited a double-hit failure. The between-laboratory comparisons indicated that results were similar for four of the six samples, but differed for two samples. The primary testing laboratory found single-hit failures for two samples, which were not confirmed by the QA/QC laboratory subsamples of the same material. The QA/QC lab found no toxicity in the same two subsamples. The double hit observed in one DMMU was confirmed by the QA/QC laboratory. A review of the QA/QC data from the primary and QA/QC laboratory failed to provide a reason for the equivocal test outcomes for the two DMMUs. The high variability in laboratory positive control responses may have contributed to this discrepancy. The uncertainties in the positive control data, however, were not sufficient to set aside these results, and the primary bioassay laboratory results were used in regulatory decision-making.

Neanthes Biomass. The *Neanthes* test was conducted in one testing round. The West Beach negative control sediment met the performance standard (i.e., <10% mortality) with 8% mortality. Both reference sediments from Carr Inlet (48%, 57% fines) out- performed the control sediment with average individual biomass of 113% and 135% of the West Beach control, respectively. There were some test inoculation irregularities noted among 5 of the 22 test sediments and one reference sediment, where one of the five replicate beakers was over inoculated (6 or 7 individuals instead of 5 as called for in the protocol). This deviation from the protocol was a concern, but most likely did not have a demonstrable effect on the test outcomes.

Statistical comparison of one of the DMMUs was problematic due to high within-replicate variability in the reference sediment. Currently, there is no performance standard for within-replicate variability for reference sediments for this bioassay, although the PSDDA agencies recognize this as an issue needing future clarification. An analysis conducted on this statistical comparison showed low power and corresponding high beta (power = 0.2 and beta = 0.8)[2]. Because of the low power and high beta exhibited by these sediments, the PSDDA agencies elected to exercise BPJ and considered the DMMU a hit under the double-hit guidelines.

Saline Microtox. The saline Microtox test was conducted in three testing rounds. The two Carr Inlet reference sediments both demonstrated light enhancement as did all twenty-two test sediments. The reference sediments were all run in a single batch, which is a departure from PSDDA testing guidelines requiring comparative reference and test sediments be analyzed within a batch. Given the positive light enhancement exhibited in all tested sediments,

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[2] In the statistical hypothesis testing of two means, low power of a test indicates that there is a high probability of accepting the null hypothesis that the two sample means (test and reference) are equal, when in fact they are different (Type I error), or alternatively when beta is high of not rejecting the null hypothesis that the two sample means are equal, when in fact the alternative hypothesis is true (Type II error).

this deviation from testing protocol would not have changed the test interpretation outcome. The results from all 22 saline Microtox tests showed light enhancement, which is considered a non-toxic response.

Standard Bioassay Testing Summary. The overall DMMU suitability determination relative to these bioassay test results indicated that 11 of 22 DMMUs were unsuitable for UCOWD. The remaining DMMUs passed standard bioassay tests, but one of these was required to undergo additional bioaccumulation testing due to exceedance of the PCB BT.

Bioaccumulation Testing Summary. The 56-day holding time was exceeded by two days for the bioaccumulation test. The two-day exceedance was necessary in order to allow the test animals (*Macoma nasuta*) to acclimate to laboratory conditions (4 to 7 days) as called for by the EPA protocol (Lee et. al., 1989). This issue was brought to the attention of the PSDDA agencies and allowance for the holding time exceedance was documented in a DMMO letter to the contractor/applicant. The bioaccumulation test was conducted on one DMMU over a 28-day exposure period to assess PCB bioaccumulation potential. The results of this test demonstrated a significant uptake of Aroclor 1254 in *Macoma nasuta* tissue from the tested DMMU sediment as compared to the reference sediment. No other Aroclors were quantitated in the tissue samples. Tissue analyses from Carr Inlet reference sediment exposures failed to detect any Aroclors.

Interpretation guidelines for evaluating bioaccumulation data involve a comparison of test results with Food and Drug Administration (FDA) guidelines. The results indicated that the wet-weight tissue concentrations (0.506 mg/kg wet-weight) were below the established 2.0 mg/kg (wet weight) FDA guideline for PCBs. An approximate *t*-test comparison (nonparametric approximate *t*-test utilized due to nonhomogeneous variances) of the DMMU exposures and reference exposures demonstrated a significant difference, and test:reference tissue ratios were 72 when expressed at the Aroclor 1254 detection limit for the undetected reference; the ratio was 145 if the undetected reference values are expressed as half the detection limit. The corresponding dry weight tissue:sediment ratio for the DMMU was 0.92. The accumulation factor (AF) for *Macoma* was calculated from the formula:

$$AF = \frac{\dfrac{C_i(organism)}{\text{Lipid Content}}}{\dfrac{C_i(sediment)}{TOC}}$$

C_i(organism) = *Macoma* tissue concentration (4486 ppb Aroclor 1254 = Total PCBs)
Lipid Content = *Macoma* lipid content (0.053 %)
C_i(sediment) = Sediment concentration for tested DMMU (4900 ppb Total PCBs)
TOC = Total Organic Carbon for tested DMMU (1.0 %)

The calculated AF = 1.9, was 2.3 times the AF derived for *Macoma* in an experimental evaluation of PCB uptake in three marine organisms (*Macoma*, *Palaemonetes*, and *Nereis*) by

Pruell *et al.* (1990). An AF of 1.9 indicated there was a pronounced bioaccumulation potential from material represented by this DMMU. Given the high tissue uptake of PCBs observed, there was a significant concern for the ecological health of marine communities exposed to these sediments. The sediments represented by this DMMU were therefore determined to be unsuitable for UCOWD.

The following discussion addresses the need to analyze archived samples (Z samples) underlying two subsurface DMMUs that failed PSDDA bioassay disposal guidelines for UCOWD. The requirement to characterize samples representing the post-dredging surface is deemed necessary when there is a reason to believe that the newly exposed sediments are of concern (Phase II MPR, page 5-34, paragraph 5.7). In this case, the surface DMMU sediment chemistry overlying these two subsurface DMMUs was notably higher than the subsurface sediment quality. Two of the surface DMMUs overlying one of the subsurface DMMUs passed PSDDA disposal guidelines, but exhibited chemical COC concentrations that were either equal to or higher than the underlying DMMU. All four surface DMMUs overlying the second DMMU failed PSDDA disposal guidelines and exhibited markedly higher chemical values than the underlying DMMU, which had no SL exceedances. In the case of this subsurface DMMU, it failed PSDDA disposal guidelines based on a single hit from the sediment larval bioassay. However, a separate QA/QC sediment larval analysis of the same DMMU by an independent testing lab failed to confirm the toxicity for this bioassay. Therefore, the PSDDA agencies determined that analysis of archived Z samples would not be required based on the pattern of contamination and chemical levels.

The following discussion compares the 1993 retest results with the initial 1991 test results. Most of the chemicals exceeding guidelines in 1991 were also quantitated during the 1993 retest. However, the concentrations were widely different. For example, the initial 1991 characterization noted total DDT exceedances in 16 of 28 DMMUs, with 5 exceeding BT, 5 exceeding ML, and a high concentration of 829 ppb. Corresponding 1993 chemical retesting results only showed a single detected and undetected exceedance of DDT SL.

An analysis of the distribution of suitable/unsuitable DMMU between 1991 and 1993 sampling events was made. As noted previously, the 1993 proposed dredging footprint is smaller at 105,100 cubic yards compared with the 171,400 cubic yard footprint initially characterized. Therefore, the DMMU sampling locations are not exactly comparable between sampling events, but DMMU boundaries are roughly comparable for DMMUs on the west side of the Pier. High DDT levels noted in many of the 1991 DMMUs at these locations were not found in 1993, and the general sediment quality appeared to be substantially improved by comparison. It is not known whether the differences noted were due to any real improvement in sediment quality, or whether sediment heterogeneity is a more likely explanation. Similar discrepancies were noted for the east side of Pier D as well.

The following discussion compares the PSDDA retest results with SMS characterization results for surface (top 10 cm) stations surrounding the dredging prism at 20 locations, to assess the potential recontamination of the dredging prism area from surrounding

sediments. The chemical testing results generally agreed with results from the PSDDA retest, depicting an assortment of metals (mercury, copper, and zinc exceeded either SQS or MCL criteria) and organic contamination (bis(2-ethylhexyl)phthalate and total PCBs exceeded either SQS or MCL criteria) dispersed throughout and extending immediately outside the dredging area. The SMS chemical characterization did not evaluate total DDT as a chemical of concern, so the distribution of this chemical outside the immediate dredging prism remains unknown.

Two additional stations exceeded MCL for bis(2-ethylhexyl)phthalate and copper, respectively, and likely would also be included within the listed areas of sediment contamination in accordance with WAC 173-204-510. The PSDDA agencies recognize that this dredging area lies within a larger MTCA/CERCLA cleanup area. The PSDDA agencies recommend that all dredging and any future post dredging testing be coordinated with these ongoing cleanup efforts. The distribution of 7 of the 10 stations likely exceeding SMS concern criteria are distributed around the unsuitable DMMU on the east side of the pier at 7 SMS stations. Of concern are two SMS stations adjacent to two DMMUs, where both DMMUs were found suitable for UCOWD based on the 1993 retest. These two DMMUs were previously found to be unsuitable in 1991 SDM. Therefore, it is likely that some recontamination of the post-dredging footprint area may occur based on the surrounding SMS sediment quality data reviewed.

All 20 SMS samples underwent concurrent bioassay testing with the amphipod (*Rhepoxynius* or *Ampelisca*), sediment larval *(Dendraster excentricus*), and 20-day *Neanthes* biomass tests. The results from these biological tests indicated that 8 of the 20 SMS samples likely exceeded the biological effects criteria of the SMS.

As a condition to the Section 404 permit, a requirement to develop an agency approved dredging plan for this complex dredging project was instituted. The plan included technology and methodology, which was technically adequate to separate suitable from unsuitable material.

US Navy Norton Terminal. Based on site history information and data from previous dredging projects in the area, this project was down-ranked from moderate to low-moderate. Initial testing was for 115,000 cubic yards, but the project was redesigned to dredge 82,000 cubic yards. The project has not yet been dredged.

Warren Avenue CSO. Sampling and testing for this project were completed without the prior knowledge and approval of the PSDDA agencies. The project came to agency attention at the point where bioassays were required. It appeared that sampling had been adequate to characterize the material, so bioassays were allowed to go forward. The agencies required that the project applicant complete a sampling and analysis plan and submit it part of the data report. The data were deemed adequate for decision-making, and the sediment was found suitable for open-water disposal.

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Lake Forest Park Civic Club. This small project involved the dredging of 480 cubic yards of sediment from an area near a boat dock at the north end of Lake Washington. The area is ranked moderate under PSDDA guidelines. No testing is required for projects less than 500 cubic yards in moderate ranked areas, so no testing was required for this project.

Port of Everett South Terminal Full Characterization. The PSDDA agencies applied differential rankings to wood/silt (moderate rank) and wood/sand (low-moderate rank) fractions based on the results of a partial characterization. Data from the partial characterization also indicated that native sands underlying post-industrial sediments were suitable for open-water disposal and did not require further investigation during the full characterization. However, the sampling plan required that the "contact layer" separating underlying sands from post-industrial sediments be located at each sampling location. Only the post-industrial sediments were tested chemically and biologically.

Because of the mix of fine wood debris and silt comprising much of the post-industrial sediments, the Port of Everett elected to run two species of amphipods side-by-side. *Rhepoxynius abronius* is known to be sensitive to fine-grained sediments while *Ampelisca abdita* is not. As anticipated *R. abronius* performed poorly while *A. abdita* survival was acceptable for all test sediments. The PSDDA agencies agreed to use the *A. abdita* results in lieu of *R. abronius.*

Strongylocentrotus purpuratus was used in the larval test but performed poorly for the reference sediments. Therefore, *Dendraster excentricus* was used in a retest. A retest was also required for one DMMU in the Microtox test. The retests for the larval and Microtox bioassays provided adequate data for decision-making by the PSDDA agencies.

Port of Everett Piers 1 & 3. Due to the proximity to the South Terminal project with its fine woody debris, the Port of Everett elected to run two species of amphipods side-by-side, as was done for South Terminal. However, in the case of Piers 1 and 3, woody debris was not encountered and *Rhepoxynius abronius* and *Ampelisca abdita* exhibited exactly the same pattern of hits for the DMMUs. Therefore, both species resulted in the same interpretation for open-water disposal and it became irrelevant which species was used for decision-making.

The same QA/QC problems encountered in the South Terminal project were also encountered in this project. *Strongylocentrotus purpuratus* was used in the larval test but performed poorly for the reference sediments. Therefore, *Dendraster excentricus* was used in a retest. A retest was also required for one DMMU in the Microtox test. The retests for the larval and Microtox bioassays provided adequate data for decision-making by the PSDDA agencies.

Port of Tacoma, Blair Bridge. This project includes dredging associated with the removal of the 11th Street Bridge over the Blair Waterway. Surface sediments were

characterized. Samples were taken of subsurface sediments, composed of native material. The sediments were to be analyzed if any surface sediments were unsuitable for open-water disposal. Since both surface DMMUs had no screening level exceedances, the subsurface sediments were not characterized.

Port of Tacoma - West Blair Terminal Development. The project design called for widening the existing Blair Waterway by 88-feet along 2,000 feet of 2H:1V sloped shoreline. The upland portion of the site was a MTCA cleanup site slated for cleanup prior to PSDDA excavation/dredging. The waterward portion of the site was part of a CERCLA cleanup site. The northeast portion of the site lies next to the Port of Tacoma's Blair Waterway dredging project (characterization documented in SDM dated 21 August 1991). Blair deepening, while not a CERCLA cleanup, is being administered by CERCLA as part of the Sitcum Waterway problem area remediation. The PSDDA agencies required additional confirmation sampling of the dredged material surface exposed following the MTCA cleanup and the waterward side slopes along the Blair Waterway being administered by CERCLA, before a final determination of suitability could be completed.

The PSDDA project was ranked "high" for the 10' of dredged fill underlying the approximately 3-feet of MTCA cleanup material composed of arsenic slag deposits. Seven borings (hollow-stem auger drilling rig) were collected approximately 250 feet apart to depths of between 13 and 24 feet below the ground surface. Samples were collected vertically within each boring location from the tidal marsh fill sediment layer for seven uncomposited analyses. Underlying material below the tidal marsh fill layer representing native soil was collected from each of the seven boring locations and composited for two analyses. No additional analyses were required from the "native soil" layer by the agencies, although additional material underlying the "native soil" sampling layer was collected, composite and archived.

Verification of the side slopes following the CERCLA cleanup included collecting and analyzing samples from two vertical horizons along the side slope as follows. From the +17 to 0 feet MLLW horizon, two analyses for arsenic only were required, each consisting of a composite sample from three Van Veen grab samples. From the 0 to -20 feet MLLW, three analyses composited from nine samples were required for the full PSDDA chemical suite. Results of all five side slope analyses showed no chemicals exceeded the PSDDA screening level.

Verification sampling for the MTCA upland cleanup of arsenic slag deposits consisted of excavating 21 test pits ranging from 2.35 to 4 feet below the ground surface using a backhoe. Soil encountered in the test pits consisted of compacted fill extending from the ground surface to a depth of around 3.5 feet below the ground surface. Dredged material was encountered below the compacted fill layer at depths ranging from 0.5 to 4.0 feet below the ground surface. Three test pits were excavated in each of the seven DMMUs and samples were collected for analysis within each test pit at depth intervals of 0-6 inches, 6-12 inches, 12-24 inches, 24 inches to the base of the test pit. All samples were analyzed for arsenic. No arsenic was detected at levels exceeding the screening level (57 mg/kg) 12 inches below the

surface. Therefore, MTCA, in accordance with the guidelines in the former Murray Pacific Logyard No. 2 Consent Decree, required excavating to a minimum depth of 2 feet along the shoreline. The removal of this material was completed prior to any dredging activities.

The confirmation sampling of the side slopes, the upland verification sampling, and the supplemental sampling all collectively supported the conclusion that the 525,000 cy of excavated dredged material was suitable for unconfined open-water disposal. A public notice was issued for this project and indicated that 80,000 cy of dredged material was slated for project mitigation, leaving 445,000 cy for disposal at the Commencement Bay site.

USACE and Port of Bellingham, Squalicum Waterway. Characterization of 258,000 cubic yards of maintenance dredged material (210,000 cy federal, 44,000 cy nonfederal) focused on the Squalicum Creek Waterway, which was previously characterized in 1991/1992, and partially dredged in 1992. Most of the waterway, from the entrance channel to near the head, was ranked moderate. DMMUs located at the head of the waterway were ranked high based on previous testing results. Of a total of 20 DMMUs, only eight had SL exceedances and required bioassays.

Biological testing was accomplished on the eight DMMUs with chemical SL exceedances. *Neanthes* growth bioassay results indicated all eight were suitable for either nondispersive or dispersive site disposal. Six of the eight DMMUs utilized *Ampelisca abdita* due to finer grain sizes, whereas the remaining two were tested with *Rhepoxynius abronius*. All eight DMMUs passed amphipod disposal guidelines for nondispersive sites, whereas three DMMUs failed to pass the more restrictive dispersive site guidelines. Saline Microtox test results, although not used for decision making, confirmed the amphipod and *Neanthes* results, and no toxicity was observed.

Sediment larval bioassay tests utilized the purple sea urchin (*Strongylocentrotus purpuratus*), but test results were rejected for regulatory decision-making because the laboratory failed to follow the PSDDA/PSEP temperature requirements of 15 ± 1^{0}C. The test was run at 12 ± 1^{0}C. The lower temperature resulted in a slower rate of development to the 4-arm pluteus larval stage at test termination. The lower temperatures may have influenced abnormality observations, whereby organisms scored as abnormal may have been normal larvae that had not yet reached the 4-arm pluteus larval stage. Additionally, the number of normals in the seawater control was unacceptable, thereby invalidating the results for decision making. By the time the PSDDA agencies were notified of the test performance problems, the holding time had been exceeded by four weeks, thereby making a retest unfeasible.

Given the marginal exceedances of SLs, the PSDDA agencies set aside the results of the sediment larval test and utilized the remaining bioassay results for decision-making. The suitability determination indicated that of the total 258,000 cy, 44,000 cy was suitable only for nondispersive site disposal, whereas the remaining 214,000 cy was suitable for both dispersive and nondispersive site disposal.

APPENDIX B - DY94/95 GUIDELINE VALUES (CHEMISTRY)

CHEMICAL	SL	BT	ML	(SL+ML)/2
METALS (ppm dry wgt):				
Antimony	20	146	200	110
Arsenic	57	507.1	700	378.5
Cadmium	0.96		9.6	5.3
Copper	81		810	445.5
Lead	66		660	363
Mercury	0.21	1.5	2.1	1.2
Nickel	140	1,022		
Silver	1.2	4.6	6.1	3.7
Zinc	160		1,600	880
ORGANIC CHEMICALS (ppb dry wgt):				
LPAH				
2-Methylnaphthalene	67		670	368.5
Acenaphthene	63		630	346.5
Acenaphthylene	64		640	352
Anthracene	130		1,300	715
Fluorene	64		640	352
Naphthalene	210		2,100	1,155
Phenanthrene	320		3,200	1,760
Total LPAH	610		6,100	3,355
HPAH				
Benzo(a)anthracene	450		4,500	2,475
Benzo(a)pyrene	680	4,964	6,800	3,740
Benzo(g,h,i)perylene	540		5,400	2,970
Benzofluoranthenes	800		8,000	4,400
Chrysene	670		6,700	3,685
Dibenzo(a,h)anthracene	120		1,200	660
Fluoranthene	630	4,600	6,300	3,465
Indeno(1,2,3-c,d)pyrene	69		5,200	2,634.5
Pyrene	430		7,300	3,865
Total HPAH	1,800		51,000	26,400
CHLORINATED HYDROCARBONS				
1,2,4-Trichlorobenzene	13		64	38.5
1,2-Dichlorobenzene	19	37	350	184.5
1,3-Dichlorobenzene	170	1,241		
1,4-Dichlorobenzene	26	190	260	143
Hexachlorobenzene	23	168	230	126.5

APPENDIX B - DY94/95 GUIDELINE VALUES (CHEMISTRY)

CHEMICAL	SL	BT	ML	(SL+ML)/2
PHTHALATES				
Bis(2-ethylhexyl) phthalate	3,100	13,870		
Butyl benzyl phthalate	470			
Di-n-butyl phthalate	1,400	10,220		
Di-n-octyl phthalate	6,200			
Diethyl Phthalate	97			
Dimethyl Phthalate	160	1,168		
PHENOLS				
2-Methylphenol	20		72	46
2-4-Dimethylphenol	29		50	39.5
4-Methylphenol	120		1,200	660
Pentachlorophenol	100	504	690	395.0
Phenol	120	876	1,200	660
MISCELLANEOUS EXTRACTABLES				
Benzoic Acid	400		690	545
Benzyl Alcohol	25		73	49
Dibenzofuran	54		540	297
Hexachlorobutadiene	29	212	290	159.5
Hexachloroethane	1,400	10,220	14,000	
N-Nitrosodiphenylamine	28	161	220	124
VOLATILE ORGANICS				
Ethylbenzene	10	27	50	30
Tetrachloroethene	14	102	210	112
Total Xylene	12		160	86
Trichloroethene	160	1,168	1,600	880
PESTICIDES and PCBs				
Aldrin	10	37		
Chlordane	10	37		
Dieldrin	10	37		
Heptachlor	10	37		
Lindane	10	37		
Total DDT	6.9	50	69	38
Total PCBs	130	38*	2,500	1,315

* Value in ppm normalized to Total Organic Carbon

APPENDIX B - DY94/95 PSDDA EVALUATION GUIDELINES (BIOASSAYS)

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

M = mortality, N = normals, I = initial count, MIG = mean individual growth rate, BLD = blank-corrected light decrease
SD = statistically different, NOCN = no other conditions necessary, N/A = not applicable
Subscripts: R = reference sediment, C = negative control, T = test sediment

APPENDIX C - LEGEND

S	=	reported concentration exceeds screening level
B	=	reported concentration exceeds bioaccumulation trigger
M	=	reported concentration exceeds maximum level
BM	=	reported concentration exceeds bioaccumulation trigger and maximum level
u	=	detection limit exceeds screening level
b	=	analyte detected in corresponding blank
d	=	quantitation performed on a diluted sample
e	=	estimate
j	=	detected between the SDL and the CRDL
L	=	the highest reported concentration was below SL
LM	=	the highest reported concentration was between SL and (SL + ML)/2
M	=	the highest reported concentration was between (SL + ML)/2 and ML
H	=	the highest reported concentration exceeded ML
H*	=	the sediment rank is based on biological testing results
(1)	=	no bioaccumulation trigger exists for this analyte
(2)	=	no maximum level exists for this analyte
(3)	=	no bioaccumulation trigger or maximum level exists for this analyte
X	=	a hit under the two-hit rule
XX	=	a hit under the single-hit rule
X(X)	=	a hit under the two-hit rule for nondispersive sites; a hit under the single-hit rule for dispersive sites
QC	=	bioassay results were set aside due to QA/QC problems
P	=	test sediment passed PSDDA guidelines for open-water unconfined disposal
F	=	test sediment failed PSDDA guidelines for open-water unconfined disposal
P(F)	=	passes nondispersive guidelines; fails dispersive guidelines
F(C)	=	DMMU found unsuitable for open-water disposal in the absence of bioaccumulation and/or Tier IV testing data
-	=	this test was not done

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	Indian Cove	Konoike-Pacific			POS Terminal 30			US Navy Pier D		
	C1	C1	C2	C3	C2	C4	S1	C1	C4	C5
METALS										
Mercury			S	S	S	S	S			
Antimony			S	B						
Arsenic				S						
Cadmium (1)					S		S		S	S
Copper (1)			S	M			S			
Lead (1)				S	S		S	S		
Nickel (2)										
Silver							S			
Zinc (1)			S	S	S		S			
LPAH										
2-Methylnaphthalene (1)				S	S					
Acenaphthene (1)				S	M					
Acenaphthylene (1)										
Anthracene (1)		S		S	S		S			
Fluorene (1)				S	M		S			
Naphthalene (1)				S	S					
Phenanthrene (1)		S		S	S		S			
Total LPAH (1)		S		S	M		S			
HPAH										
Benzo(a)anthracene (1)		S		S	S		S			
Benzo(a)pyrene				S			S			
Benzofluoranthenes (1)		S		S			S			
Chrysene (1)				S			S			
Dibenzo(a,h)anthracene (1)							S			
Fluoranthene		S	S	S	S		S			
Indeno(1,2,3-c,d)pyrene (1)		S	S	S	S		S			
Pyrene (1)		S	S	S	S		S			
Total HPAH (1)		S	S	S	S		S			
CHLORINATED HYDROCARBONS										
1,2,4-Trichlorobenzene (1)										
Hexachlorobenzene										

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APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	Indian Cove	Konoike-Pacific			POS Terminal 30			US Navy Pier D		
	C1	C1	C2	C3	C2	C4	S1	C1	C4	C5
PHTHALATES										
Bis(2-ethylhexyl) phthalate (2)				S						
Diethyl phthalate (3)										
PHENOLS										
2 Methylphenol (1)										
2,4-Dimethylphenol (1)										
4 Methylphenol (1)										
Pentachlorophenol										
Phenol	S									
MISCELLANEOUS EXTRACTABLES										
Benzoic acid (1)										
Benzyl alcohol (1)				S						
Dibenzofuran (1)					M					
Hexachlorobutadiene							S u			
N-Nitrosodiphenylamine										
PESTICIDES AND PCBs										
Aldrin (2)					S		S			
Dieldrin (2)					S		B			
Heptachlor (2)							S			
Lindane (2)										S u
Total DDT				S u	S		S			
Total PCBs			S	BM	B		B			
BIOASSAYS										
Amphipod		-		-	-		-			
Sediment Larval		-		-	-		-	X	X	XX
Juvenile Infaunal Biomass		-		-	-		-			
Microtox		-	-	-	-		-			
PASS/FAIL	P	AW	AW	AW	F(C)	P	F(C)	P	P	F
HIGHEST RANKING:	LM	LM	LM	H	H	LM	M	LM	LM	H*

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	US Navy Pier D (continued)									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
METALS										
Mercury	S	S		S	S	S	S	B	S	S
Antimony		S					BM			
Arsenic										
Cadmium (1)		S		S	S		S	S	S	S
Copper (1)	S	S			S	S	S	S		
Lead (1)	S	S					S	S		
Nickel (2)										
Silver										
Zinc (1)	S	S					S	S		
LPAH										
2-Methylnaphthalene (1)										
Acenaphthene (1)										
Acenaphthylene (1)										
Anthracene (1)										
Fluorene (1)										
Naphthalene (1)										
Phenanthrene (1)										
Total LPAH (1)										
HPAH										
Benzo(a)anthracene (1)										
Benzo(a)pyrene										
Benzofluoranthenes (1)	S									
Chrysene (1)										
Dibenzo(a,h)anthracene (1)										
Fluoranthene										
Indeno(1,2,3-c,d)pyrene (1)	S	S					S	S		S
Pyrene (1)	S	S					S	S		
Total HPAH (1)	S	S					S	S		S
CHLORINATED HYDROCARBONS										
1,2,4-Trichlorobenzene (1)										
Hexachlorobenzene										

(Continued on facing page)

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	US Navy Pier D (continued)									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
PHTHALATES										
Bis(2-ethylhexyl) phthalate (2)							S			
Diethyl phthalate (3)										
PHENOLS										
2 Methylphenol (1)										
2,4-Dimethylphenol (1)										
4 Methylphenol (1)										
Pentachlorophenol										
Phenol										
MISCELLANEOUS EXTRACTABLE										
Benzoic acid (1)										
Benzyl alcohol (1)										
Dibenzofuran (1)										
Hexachlorobutadiene						S u	S u			
N-Nitrosodiphenylamine										
PESTICIDES AND PCBs										
Aldrin (2)										
Dieldrin (2)										
Heptachlor (2)										
Lindane (2)										
Total DDT							S u		S	
Total PCBs		S	BM				S	S		S
BIOASSAYS										
Amphipod				X		X	X	XX		
Sediment Larval		XX		XX	XX	XX	XX		XX	
Juvenile Infaunal Biomass										
Microtox										
PASS/FAIL	P	F	F(B)	F	F	F	F	F	F	P
HIGHEST RANKING:	LM	H*	H	H*	H*	H*	H	H*	H*	LM

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	US Navy Pier D (continued)							US Navy Norton Terminal		Warren Ave. CSO
	S11	S12	S13	S14	S15	S16	S17	C3	C4	C1
METALS										
Mercury	S	S	S			S	S			S
Antimony										
Arsenic										
Cadmium (1)	S	S		S	S	S	S			
Copper (1)	S	S				S	S			
Lead (1)	S									
Nickel (2)										
Silver										
Zinc (1)	S	S				S	S			
LPAH										
2-Methylnaphthalene (1)										
Acenaphthene (1)										
Acenaphthylene (1)										
Anthracene (1)									S	
Fluorene (1)										
Naphthalene (1)										
Phenanthrene (1)										
Total LPAH (1)										
HPAH										
Benzo(a)anthracene (1)										
Benzo(a)pyrene										
Benzofluoranthenes (1)										
Chrysene (1)										
Dibenzo(a,h)anthracene (1)										
Fluoranthene		S								
Indeno(1,2,3-c,d)pyrene (1)	S	S								S
Pyrene (1)	S	S								S
Total HPAH (1)	S	S								S
CHLORINATED HYDROCARBONS										
1,2,4-Trichlorobenzene (1)										
Hexachlorobenzene								S u	S u	

(Continued on facing page)

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	US Navy Pier D (continued)							US Navy Norton Terminal		Warren Ave. CSO
	S11	S12	S13	S14	S15	S16	S17	C3	C4	C1
PHTHALATES										
Bis(2-ethylhexyl) phthalate (2)										
Diethyl phthalate (3)										
PHENOLS										
2 Methylphenol (1)										
2,4-Dimethylphenol (1)										
4 Methylphenol (1)										S
Pentachlorophenol										
Phenol										S
MISCELLANEOUS EXTRACTABLE										
Benzoic acid (1)										
Benzyl alcohol (1)										
Dibenzofuran (1)										
Hexachlorobutadiene	S u					S u				
N-Nitrosodiphenylamine										
PESTICIDES AND PCBs										
Aldrin (2)										
Dieldrin (2)										
Heptachlor (2)										
Lindane (2)										
Total DDT										
Total PCBs	S						S			B u
BIOASSAYS										
Amphipod								-		
Sediment Larval		X		XX	X	X	X	-		
Juvenile Infaunal Biomass						X		-		
Microtox								-		
PASS/FAIL	P	P	P	F	P	F	P	P	P	P
HIGHEST RANKING:	LM	LM	LM	H*	LM	H*	LM	LM	LM	M

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	Warren Ave. CSO (continued)	USACE Bellingham							POS Terminal 5 Extension
	C2	C1	C3	C5	C16	C17	C18	C19	C1
METALS									
Mercury						S	S		
Antimony									
Arsenic									
Cadmium (1)									
Copper (1)								S	
Lead (1)		S							
Nickel (2)		S	S	S					
Silver									S
Zinc (1)	S								
LPAH									
2-Methylnaphthalene (1)									
Acenaphthene (1)									
Acenaphthylene (1)									
Anthracene (1)									S
Fluorene (1)									
Naphthalene (1)									
Phenanthrene (1)									
Total LPAH (1)									
HPAH									
Benzo(a)anthracene (1)									
Benzo(a)pyrene									
Benzofluoranthenes (1)									
Chrysene (1)									
Dibenzo(a,h)anthracene (1)									
Fluoranthene									
Indeno(1,2,3-c,d)pyrene (1)					S				
Pyrene (1)									
Total HPAH (1)									
CHLORINATED HYDROCARBONS									
1,2,4-Trichlorobenzene (1)									
Hexachlorobenzene									

(Continued on facing page)

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	Warren Ave. CSO (continued)	USACE Bellingham							POS Terminal 5 Extension
	C2	C1	C3	C5	C16	C17	C18	C19	C1
PHTHALATES									
Bis(2-ethylhexyl) phthalate (2)									
Diethyl phthalate (3)									
PHENOLS									
2 Methylphenol (1)									
2,4-Dimethylphenol (1)									
4 Methylphenol (1)									
Pentachlorophenol									
Phenol									
MISCELLANEOUS EXTRACTABLE									
Benzoic acid (1)									
Benzyl alcohol (1)									
Dibenzofuran (1)									
Hexachlorobutadiene									
N-Nitrosodiphenylamine									
PESTICIDES AND PCBs									
Aldrin (2)									
Dieldrin (2)									
Heptachlor (2)									
Lindane (2)									
Total DDT						S			
Total PCBs	B u								
BIOASSAYS									
Amphipod		X(X)	X(X)						
Sediment Larval		QC	QC						
Juvenile Infaunal Biomass									
Microtox									
PASS/FAIL	P	P(F)	P(F)	P	P	P	P	P(F)	
HIGHEST RANKING:	LM	LM	LM	LM	LM	LM	LM	LM	LM

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	POE South Terminal FC								POE Piers 1 & 3	
	C1	C2	C3	C4	C5	C6	C7	C8	C1	S1
METALS										
Mercury										
Antimony										
Arsenic										
Cadmium (1)				S	S	S	S			
Copper (1)					S		S			S
Lead (1)				S						S
Nickel (2)										
Silver										
Zinc (1)			S							
LPAH										
2-Methylnaphthalene (1)	S u			S u		S	S		S	
Acenaphthene (1)	S			S u	S	S	S		M	S
Acenaphthylene (1)	S u			S u		S	S u		S u	
Anthracene (1)	S					S	S		S	S
Fluorene (1)	S			S u	S	S	S		M	S
Naphthalene (1)	S					S	S		S	
Phenanthrene (1)	S					S	S		S	S
Total LPAH (1)	S				S	S	S		S	S
HPAH										
Benzo(a)anthracene (1)										
Benzo(a)pyrene										
Benzofluoranthenes (1)										
Chrysene (1)									S	
Dibenzo(a,h)anthracene (1)				S u						
Fluoranthene	S					S	S		S	
Indeno(1,2,3-c,d)pyrene (1)	S			S	S	S	S		S	
Pyrene (1)	S					S	S		S	
Total HPAH (1)	S			S	S	S	S		S	
CHLORINATED HYDROCARBONS										
1,2,4-Trichlorobenzene (1)				S u	S u					
Hexachlorobenzene	S u			S u	S u	S u	S u		S u	

(Continued on facing page)

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	POE South Terminal FC								POE Piers 1 & 3	
	C1	C2	C3	C4	C5	C6	C7	C8	C1	S1
PHTHALATES										
Bis(2-ethylhexyl) phthalate (2)										
Diethyl phthalate (3)				S u		S u				
PHENOLS										
2 Methylphenol (1)	S u			S u	S u	S u	S u		S u	
2,4-Dimethylphenol (1)	S u			S u		S u	S u			
4 Methylphenol (1)	S			S u		S	S			
Pentachlorophenol	S u			S u	S u	S u	S u		S u	
Phenol				S u						
MISCELLANEOUS EXTRACTABLE										
Benzoic acid (1)	M u			S u	S u		S u		S u	
Benzyl alcohol (1)	S u	S u	S u	S u	S u	S u	S u	S u	S u	
Dibenzofuran (1)	S			S u	S	S	S		M	S
Hexachlorobutadiene	S u			S u	S u	S u	S u		S u	
N-Nitrosodiphenylamine	S u			S u	S u	S u	S u		S u	
PESTICIDES AND PCBs										
Aldrin (2)										
Dieldrin (2)										
Heptachlor (2)										
Lindane (2)										
Total DDT				S u						
Total PCBs				S u						
BIOASSAYS										
Amphipod										
Sediment Larval	X									XX
Juvenile Infaunal Biomass					X				XX	X
Microtox			X					X		
PASS/FAIL	P	P	P	P	P	P	P	P	F	F
HIGHEST RANKING:	H?	LM	LM	M	M	M	M	LM	H	H*

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	POE Piers 1 & 3 (continued)						
	S2	S3	S4	S5	S6	S7	S8
METALS							
Mercury							
Antimony							
Arsenic							
Cadmium (1)	S	S	S	S	S	S	S
Copper (1)	S	S				S	
Lead (1)	S	S	S			S	
Nickel (2)							
Silver							
Zinc (1)		S		S			
LPAH							
2-Methylnaphthalene (1)		S	S		S	S	S u
Acenaphthene (1)	S	S	S		S	S	S u
Acenaphthylene (1)		S	S u			S	S u
Anthracene (1)	S	M	S		S	S	
Fluorene (1)	S	M	S		S	S	S u
Naphthalene (1)		S	S		S	S	
Phenanthrene (1)	S	S	S		S	S	
Total LPAH (1)	S	S	S		S	S	
HPAH							
Benzo(a)anthracene (1)	S	S				S	
Benzo(a)pyrene		S					
Benzofluoranthenes (1)		S				S	
Chrysene (1)		S				S	
Dibenzo(a,h)anthracene (1)		S					
Fluoranthene	S	B	S		S	S	
Indeno(1,2,3-c,d)pyrene (1)	S	S	S		S	S	S
Pyrene (1)	S	S	S		S	S	
Total HPAH (1)	S	S	S		S	S	S
CHLORINATED HYDROCARBONS							
1,2,4-Trichlorobenzene (1)							
Hexachlorobenzene	S u	S u	S u			S u	S u

(Continued on facing page)

APPENDIX C -DY94/95 EVALUATION GUIDELINE EXCEEDANCES

Project:	POE Piers 1 & 3 (continued)													
	S2		S3		S4		S5		S6		S7		S8	
PHTHALATES														
Bis(2-ethylhexyl) phthalate (2)														
Diethyl phthalate (3)														
PHENOLS														
2 Methylphenol (1)	S	u	S	u	S	u					S	u	S	u
2,4-Dimethylphenol (1)	S	u	M	u	S	u					S	u	S	u
4 Methylphenol (1)	S				S						S			
Pentachlorophenol	S	u	S	u	S	u					S	u	S	u
Phenol														
MISCELLANEOUS EXTRACTABLE														
Benzoic acid (1)	S	u	S	u							S	u	S	u
Benzyl alcohol (1)	S	u	S	u	S	u			S	u	S	u	S	u
Dibenzofuran (1)	S		S		S				S		S		S	u
Hexachlorobutadiene	S	u	S	u	S	u					S	u	S	u
N-Nitrosodiphenylamine	S	u	S	u	S	u					S	u	S	u
PESTICIDES AND PCBs														
Aldrin (2)														
Dieldrin (2)														
Heptachlor (2)														
Lindane (2)														
Total DDT	S													
Total PCBs	S													
BIOASSAYS														
Amphipod			-						XX		XX			
Sediment Larval	QC		-				XX		QC		QC		QC	
Juvenile Infaunal Biomass	X		-		XX		X		X		XX		XX	
Microtox	X		-				QC				QC		X	
PASS/FAIL	F		F(C)		F		F		F		F		F	
HIGHEST RANKING:	H*		H		H*		H*		H*		H*		H*	