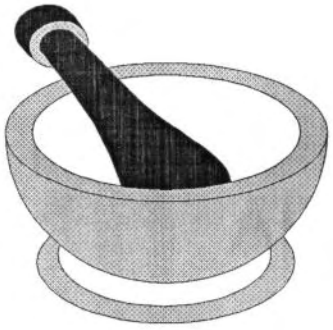
DREDGED MATERIAL EVALUATION APPLICATION REPORT

(Dredging Year 1990)



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FINAL REPORT
January 1991

Dredged Material Management Office
Seattle District
U.S. Army Corps of Engineers

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LIST OF ACRONYMS

ARM = Annual Review Meeting
ASTM = American Society for Testing Materials
B/A = Bioaccumulation
BPJ = Best Professional Judgement as allowed in EPTA/MPR
BT = Bioaccumulation Trigger Values established by PSDDA in EPTA/MPR's
CI = 95 % Confidence Interval
CLP = Contract Lab Program, EPA Scope of Work
COC = Chemical of Concern
COV = Coefficient of Variation
CRM = Certified Reference Material
CSO = Confined Sewer Outfall
CY = Cubic Yards (volume measurement used to express quantity of dredged material)
DAIS = Dredged Analysis Information System
DDT = (Dichloro-diphenyl-trichloro-ethane) Water-insoluble crystalline insecticide on the PSDDA COC list
DMEAR = Dredged Material Evaluation Application Report
DNR = Department of Natural Resources (Washington)
DO = Dissolved Oxygen
DY = Dredging Year (DY 90: June 16, 1989 - June 15, 1990)
EC50 = Effective Concentration with 50 percent nonlethal response (abnormality)
EPA = Environmental Protection Agency
EPTA = Evaluation Procedures Technical Appendix
FC = Full Characterization
FEIS = Final Environmental Impact Statements (PSDDA Phases I and II)
H = High Rank as described by EPTA and MPR's for sampling/analysis requirements
HPA = Hydraulic Project Approval (issued by Washington Department of Fisheries)
HPAH = High Molecular Weight Polycyclic Aromatic Hydrocarbons
L = Low Rank as described by EPTA/MPR's for sampling/analysis requirements
LC50 = Concentration that results in 50 percent mortality
LM = Low-Moderate Rank as described by EPTA/MPR's for sampling/analysis requirements, also used in Pattern Analysis Section to denote response range between SL and (SL+ML)/2
LOD = Limit of Detection
LOQ = Limit of Quantitation
LPAH = Low Molecular Weight Polycyclic Aromatic Hydrocarbons
M = Moderate Rank as described by EPTA and MPR's for sampling/analysis requirements.
ML = Maximum Level Guideline Chemical Values per EPTA/MPR's
MLLW = Mean Lower Low Water (datum for water depth)
MPAR = Management Plan Assessment Report
MPR = Management Plan Reports (Phase I and II)
OCW = Office of Coastal Waters (EPA), formerly PSEP
O&M = Operations and Maintenance Dredging/Disposal
PAH = Polycyclic Aromatic Hydrocarbons
PC = Partial Characterization
PCB = Polychlorinated Biphenols
PCP = Pentachlorophenol
PPB = Parts per Billion (micrograms/kilogram)

PPM = Parts per Million (milligrams/kilogram)
PSEP = Puget Sound Estuary Program (EPA)
PSDDA = Puget Sound Dredged Disposal Analysis
QA1 = Quality Assurance review of Data conducted by PSDDA agencies before Suitability Decision
QA = Quality Assurance
QC = Quality Control
U = Undetected, normally expressed as a measurement of the limits of detection.
ROD = Record of Decision
RPD = Relative Percent Difference
SAP = Sampling and Analysis Plan
Section 10 = Corps permit issued under Section 10 of Rivers and Harbors Act of 1899.
Section 404 = Corps permit issued under Section 404 of the Clean Water Act.
SD = Suitability Decision
SL = Screening Level Guideline Chemical Values per EPTA/MPR's
SS = Statistical Significance (t-Test; $p<.05$)
TOC = Total Organic Carbon
TVS = Total Volatile Solids
UCOWD = Unconfined Openwater Disposal
USACE = United States Army Corps of Engineers
USCG = United States Coast Guard
USN = United States Navy
WPPA = Washington Public Ports Association

DREDGED MATERIAL EVALUATION APPLICATION REPORT
(January 1991)

I. INTRODUCTION.

This is the second annual report prepared by the Seattle District Corps of Engineers pursuant to requirements established in the 1988-1989 PSDDA Phase I and II Management Plan Reports (MPR) to summarize dredged material sampling, testing, and disposal guidelines results for all projects tested during each dredging year. This report will be used by the Department of Ecology in preparing their annual Management Plan Assessment Report, and to present preliminary recommendations of issues for discussion and resolution at the PSDDA Annual Review Meeting to be held the following year.

With the completion of the PSDDA Phase I Final Environmental Impact Statement (FEIS) in June 1988 and the filing of the Record of Decision (ROD) in December 1988, implementation of PSDDA commenced in the Phase I area. The Port Gardner disposal site was opened on September 30, 1988, followed by the Commencement Bay site on October 1, 1988, and the Elliott Bay site on February 5, 1989. The PSDDA Phase II FEIS was completed in September 1989, and the ROD was filed on December 12, 1989, thereby completing the PSDDA study. Of the five designated disposal sites in the Phase II areas, three sites opened during the period covered by this report. The Bellingham Bay site was opened on November 5, 1989, followed by the Port Townsend dispersive site on March 2, 1990, and the Rosario Straits dispersive site on April 5, 1990. Shoreline permits for the two remaining sites were recently issued with the Port Angeles dispersive site opening on April 6, 1990, and the Ketron Island nondispersive site opening on October 9, 1990.

Through the period called the Dredged Material Management Year 1990 (DY 90) covered by this report (June 16, 1989 - June 15, 1990) 129,542 cubic yards of dredged material were disposed of at the Elliott Bay disposal site and 992,074 cubic yards of dredged material were disposed of at the Port Gardner site. Upon reopening of the sites following the fishery closure period (March 15-June 15) 1,664 cubic yards of dredged material were disposed of at the Elliott Bay site from the Lonestar Northwest project (DY 91). No disposal of dredged material took place at any of the Phase II sites during DY 90, and through October 1990.

II. PROPOSED DREDGING PROJECTS TESTED DURING 1990 DREDGING YEAR (June 16, 1989 - June 15, 1990).

Projects tested under the PSDDA program during DY 90 covered by this report include nine Section 10/404 permit applications, a single Federal navigation channel maintenance project, and one planning feasibility study. Quality assurance reviews (QA1) of test data were completed for all projects, which provided the technical basis for subsequent PSDDA agency decisions on the suitability of the dredged material for disposal at PSDDA unconfined open-water disposal sites.

Information for the nine Section 10/404 projects, which had QA1 reviews and suitability decisions completed prior to June 15, 1990, are summarized in Table 1. Also included are two permitted projects for which suitability decisions had been completed in DY 89 but which had disposal actions in DY 90, and one project in DY 90 which required no testing under the provisions established in the MPR.

TABLE 1. PROJECTS UNDERGOING TESTING, AND/OR DISPOSAL BETWEEN JUNE 16, 1989 AND JUNE 15, 1990.

PROJECT NAME	SUITABILITY DECISION DY[a]	AREA RANK	VOLUME TESTED (CY)	VOLUME FAILING (CY)	PERCENT FAILING	PSDDA DISPOSAL SITE	VOLUME DISPOSED (CY)
Duwamish Yacht Club	1989	H	(17,000)	(3,000)	(18 %)	EB	22,275
Port of Everett Marina	1989	M	(64,600)	(4,300)	(7 %)	PG	41,349
Lone Star Northwest	1990	H	1,600	0	0 %	EB	(1,664)[b]
Morton Marine	1990	H	4,000	0	0 %	EB	PENDING
U.S. Coast Guard Pier 35	1990	H	5,100	2,400	47 %	EB	CANCELED
Port of Skagit County/La Conner	1990	L	6,600	N/A	N/A	RS	PENDING
Pope and Talbot Inc.	1990	M	11,100	4,700	42 %	EB	PENDING
METRO (Emergency By Pass Outfall)	1990	M	48,775	0	0 %	EB	CANCELED
METRO (Denny Way Capping/beneficial uses)[c]	1990	M	(14,890)	0	0 %	N/A	N/A
Duwamish Operations and Maintenance	1990	M/H	126,332	16,000	13 %	EB	107,267
U.S. Navy Manchester Fuel Pier	1990	LM/H	181,830	0	0 %	EB	PENDING
Port of Bellingham/Blaine Marina	1990	LM	358,000	0	0 %	RS	PENDING
U.S. Navy Homeport Everett/Element I	1990	L/LM/ M	975,000	0	0 %	PG	950,725
Port Townsend - Harbor Expansion Study	1990	M	(300,000)	N/A	N/A	N/A	N/A
DY 1990 TOTALS:			1,718,337	23,100	1.3 %		1,121,616

[a] projects within a given dredged material management year (DY) with completed QA1 review and suitability decision.

[b] disposal occurred on June 24, 1990 during DY 91.

[c] METRO Denny Way Capping Project was cost shared (Seattle District) beneficial uses project utilizing Duwamish River upper turning basin sediments to cap Denny Way CSO. Chemical characterizations conducted were included in the Duwamish River maintenance data set.

LEGEND:
EB = Elliott Bay
PG = Port Gardner
RS = Rosario Straits
N/A = not applicable
L = Low
LM = Low-Moderate
M = Moderate
H = High
( ) = values not included in testing or disposal totals for DY 90.

A single Corps of Engineers' navigation maintenance dredging project was tested during the 1990 dredging year. This was for maintenance of the Duwamish River between the turning basin and the mouth of the Duwamish River. Dredging and disposal for this project took place during DY 90. Sediments characterized in the turning basin were cost shared by the Corps and METRO, for beneficial use as capping material for the METRO Denny Way Capping Project. Information for these projects is summarized in Table 1. (Another current Corps maintenance project is the disposal at the Rosario Straits dispersive disposal site of approximately 93,000 cubic yards of material tested for maintenance dredging in the Swinomish Channel during DY 89. Disposal commenced in December 1990. This project is not included in Table 1 as no action took place during DY 90).

The Port Townsend Harbor Expansion Project Feasibility Study conducted limited sediment characterization during DY 90 and is summarized in Table 1.

A. Dredging Area Ranking/Sampling and Testing Requirements for Partial and Full characterization.

1. Area 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 to establish an initial area ranking based on a "reason to believe" that chemicals of concern may or may not be in the project area. PSDDA has generally ranked areas based on existing sediment data or awareness that sources of contamination are known to exist, thereby establishing a "reason to believe" that an area is likely to be clean or contaminated. If data are absent, regulatory personnel from the Corps, Washington State Departments of Ecology and Natural Resources, and the Environmental Protection Agency establish an initial ranking that is generally on the conservative side 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 the dredger/applicant conducts a partial characterization (PC) as described in EPTA (pages II-63 to II-65) to survey surface sediments in the project area for the PSDDA chemicals of concern (COC). 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 sampling may be reduced during the full characterization (FC) commensurate with the revised ranking requirements. Of the eleven projects discussed in this report, only one, the U.S. Navy Homeport Project at Everett, Washington conducted a PC for the purposes of downranking consideration for full characterization. The Port Townsend Feasibility study conducted a PC as a planning study to evaluate future harbor expansion alternatives.

Six of the projects tested were in "high" ranked areas, whereas three were in "moderate" ranked areas. The U.S. Navy Homeport Project was variably ranked from "moderate" to "low" based in part on the partial characterization data and other considerations contained in a "settlement agreement" between the U.S. Navy and six environmental groups (Friends of the Earth et al.). Several conditions followed by the Navy were beyond the PSDDA requirements. Based on PC data, the Navy Homeport

project would have been ranked "low-moderate" to "low" for normal PSDDA sediment characterization.

A single project, the Port of Skagit at La Conner, Washington, in the Swinomish Channel, was ranked "low", and qualified for "no testing" required under the Small Project PSDDA testing guidelines (Phase II MPR, pages A-12 to A-14).

2. Sampling.

a. Section 404 Permit Applications. Project-specific sampling methods for collecting sediment samples are depicted in Table 2. PC sampling methods consisted of four-foot diver collected cores for the U.S. Navy Homeport Project and van-veen grab collected samples for the Port Townsend harbor expansion study. FC sampling for dredging projects with relatively shallow dredging prisms of 4 feet or less, utilized hammer-driven stainless steel 1" diameter tubes and a hand operated stainless steel tube. A vibracore sampler was used to collect sediment samples for the Duwamish River maintenance dredging project, where actual dredging depths were limited to 5 feet or less to maintain the project depth of -15 feet $\pm$ 2 feet MLLW. Barge mounted drilling rigs were utilized for seven of the projects, with hollow stem auger drills and split spoon samplers used for deeper dredging prisms, extending to a maximum depth of 40 feet for the Navy Homeport Project.

Area rankings established in the Phase I and II documents range from low to high for the eleven project areas discussed for DY 1990. Areas ranking high generally require one sample and one analysis for every four thousand cubic yards for the upper four feet of the dredging cut. Several projects with "high" rankings, notably Lone Star Northwest and Morton Marine had shallow dredging prisms with proposed dredging over an expansive area and volumes under 4,000 cubic yards. Therefore, compositing was deemed appropriate to insure that the dredging area was properly characterized. Sediment characterization of the "high" ranked area at the U.S. Coast Guard Pier 35 Slip necessitated a departure from the existing testing guidelines in order to characterize separately the degree of contamination in surface material and the subsurface fraction. Normal PSDDA testing would have called for a single uncomposited sample and analysis, which would have limited the dredging alternatives available to the applicant. Therefore, the U.S. Coast Guard elected to do three analyses, and treated the entire surface area as one composited analysis of three samples, and separating out the seaward and landward subsurface fractions into two composited analyses. The remainder of the projects followed the area ranking specific guidelines for sampling and analysis (see Table 2 for project-specific summary).

b. Corps Operations and Maintenance Dredging Projects. Sampling for the fiscal year 1990 Duwamish River operations and maintenance dredging was accomplished during ongoing maintenance dredging of the channel during April 1989 and upstream areas were reoccupied in October 1989 to resample for bioassays failing QA/QC during initial testing. Additional sampling was necessary during January 1990 to conduct some additional sediment characterization, after winter storms and resulting freshets had moved significant quantities of new material down the Duwamish River into the turning basin and upper navigation channel. Area ranking for the Duwamish River was "high" except in the vicinity of the turning basin, where a "moderate" rank was assigned. Approximately 15,000 cubic yards of this material was characterized to assess its acceptability as cap material for the METRO Denny Way CSO capping project. This was a cost shared beneficial uses project between METRO and Seattle District, with METRO conducting organic chemical analyses on five samples collected to

TABLE 2. PROJECT SPECIFIC PSDDA SAMPLING/ANALYSIS GUIDELINES REQUIREMENTS[a]

PROJECT NAME	AREA RANK	VOLUME TESTED	SAMPLING EQUIPMENT	# SAMPLES/ # CHEMICAL ANALYSES	DREDGING DEPTH (FT)	# BIOASSAY ANALYSES	REFERENCE AREA
Lone Star Northwest[b]	H	1,600	hammer-driven stainless steel 1" diameter tube	2/1	4	1	West Beach
Morton Marine[b]	H	4,000	hand operated stainless steel tube	3/1	2	1	Carr Inlet
U.S. Coast Guard Pier 35	H	5,100	barge mounted drill rig equipped w/hollow stem auger & Dames & Moore sampler	17/3	25	3	West Beach
Port of Skagit County/La Conner	L	6,600	N/A	N/A	4	N/A	N/A
Pope and Talbot Inc.	M	11,100	barge mounted mobile 4-inch hollow stem auger drill rig	8/2	17	none	N/A
METRO (Denny Way Capping)[c]	H	(14,890)	collected by vibracore sampler during Duwamish River maintenace sampling	(13/5)	5	none	N/A
METRO (Emergency By Pass Outfall)	M	48,775	barge mounted hollow stem auger drill rig/split spoon samplers	13/7	24	7	Samish Bay
Duwamish Operations & Maintenance	M/H	126,332	vibracore sampler	39/18	5	12	Carr Inlet
U.S. Navy Manchester Fuel Pier	LM/H	181,830	barge mounted split spoon sampler	33/15	15	15	Samish Bay
Port of Bellingham/Blaine Marina	LM	358,000	Muskox B-51 drilling rig w/4-inch I.D. hollow stem auger/split spoon samplers	21/9	21	none	N/A
U.S. Navy Homeport Everett/Element I	L/LM/M	975,000	diver collected cores (PC); drill rig/piston corer/impact corer/hollow stem auger (FC)	9/9 (PC) 153/31 (FC)	4 (PC) 40 (FC)	none (PC) 31 (FC)	N/A (PC) Samish Bay & Jetty Island (FC)
Port Townsend - Harbor Expansion Study	M	(300,000)	Van Veen grab	9/3 (PC)	2 (PC)	3 (Microtox only)	None
DY 1990 TOTALS:		1,718,337		307/99		73	

[a] projects within a given dredged material management year (DY) with completed QA1 review and suitability decision.

[b] reduced testing requirements based on Phase II MPR (page A-14) requiring only single acute amphipod bioassay. Post Annual Review Meeting clarification subsequently stipulated that the saline Microtox bioassay will be required in addition to the amphipod test.

[c] METRO Denny Way Capping project was cost shared (Seattle District) beneficial uses project utilizing Duwamish River upper turning basin sediments to cap sediments near Denny Way CSO. Chemical characterization data was included in Duwamish River maintenance dredging data set.

LEGEND:
= number
N/A = not applicable
L = Low
LM = Low-Moderate
M = Moderate
H = High
( ) = values within parenthesis not included in dredging and/or disposal totals for DY 90

characterize the material from the upper turning basin. All testing data pertaining to the METRO Denny Way Capping project are, for purposes of this report, treated as Duwamish River maintenance project data.

c. Planning Studies. Partial characterization sampling for the Port Townsend Harbor Expansion Study was conducted to assess dredging alternatives as a planning exercise. The characterization data provided sufficient data to consider reranking the project area from "moderate" to "low-moderate" for future full characterization sampling/analyses for dredging/disposal alternative assessment.

3. Chemical Characterization.

The following discussion references screening level (SL), bioaccumulation trigger level (BT), and maximum level (ML). For a full description of these terms see Phase II Management Plan Report (pages A-23 to A-24; pages A-19 to A-21, Table A.7; page A-27, Table A.8). Table 3 summarizes the DY 90 chemistry analyses performed among the eleven projects and 99 analyses. Analyses of these data relative to the PSDDA chemical guidelines showed 49 COC exceeded the SL and 11 exceeded the ML, with 3 exceedances of the BT. Notably, all exceedances of the BT and ML were from a single project, the U.S. Coast Guard Pier 35 slip area. Detection limit exceedences of PSDDA chemical guidelines are noted in Table 3, and showed 21 chemical exceedences of SL, 6 chemical exceedences of BT, and 8 chemical exceedences of ML. All detection limit exceedences of BT and ML were also from a single project, the U.S. Coast Guard Pier 35 project. Detected chemicals most commonly exceeding PSDDA SL's were high molecular weight polycyclic aromatic hydrocarbons [HPAH's: indeno(1,2,3-c,d)pyrene (25/99 analyses for 7 projects), fluoranthene (15/99 analyses for 6 projects), and benzofluoranthenes (7/99 analyses for 5 projects)], and total PCB's (13/99 analyses for 3 projects). Of the 99 analyses conducted during DY 1990, 44 analyses either had quantitated values or detection limits exceeding the PSDDA chemical guideline values.

Laboratories following the Puget Sound Estuary Program's (PSEP) Recommended Protocols Guidelines, continue to have difficulty in achieving PSEP recommended and PSDDA required detection limits (i.e., < SL) for some of the organic compounds on the PSDDA COC list (see Phase II MPR, pages 5-27-29; Table 5.3). Generally, detection limits set at the PSDDA SL were not a problem for metals and polycyclic aromatic hydrocarbons (PAH's), volatile organic compounds, and pesticides and polychlorinated biphenyls (PCB's), but were a problem for some projects relative to chlorinated hydrocarbons, phthalates, phenols, and miscellaneous extractables. Chemicals most frequently failing to meet PSDDA detection limits were 1,2,4-trichlorobenzene, 2,4-dimethylphenol, 2 methylphenol, and benzyl alcohol. As noted above, failure to achieve PSDDA required detection limits at the SL level were noted for eight of the eleven projects undergoing testing. Chemical results for the U.S. Coast Guard project contained the bulk of the PSDDA guideline exceedences, including all the detection limit exceedences of BT and ML. Those chemicals undetected above the PSDDA SL are noted in Table 3. For those projects, where detected or undetected exceedences of COC SLs occurred, bioassays were required, and were generally run concurrently with chemical analyses for higher ranked projects tested.

TABLE 3 - PSDDA CHEMICAL TESTING SUMMARY

	D>SL	PROJECT FREQUENCY	D>BT	PROJECT FREQUENCY	D>ML	PROJECT FREQUENCY	U>SL	PROJECT FREQUENCY	U>BT	PROJECT FREQUENCY	U>ML	PROJECT FREQUENCY
METALS												
Antimony	1	1										
Cadmium (1)	5	2										
Copper (1)	2	1										
Lead (1)	3	2										
Mercury	1	1										
Silver	1	1										
Zinc (1)	4	2										
LPAH												
2-Methylnaphthalene (1)	5	3			1	1						
Acenaphthene (1)	3	2			1	1						
Acenaphthylene (1)	1	1					2	1				
Anthracene (1)	6	4			2	1						
Fluorene (1)	3	2			1	1						
Naphthalene (1)	2	1			1	1						
Phenanthrene (1)	6	4			1	1						
Total LPAH (1)	6	4			2	1						
HPAH												
Benzo(a)anthracene (1)	6	5										
Benzo(a)pyrene	3	2										
Benzo(g,h,i)perylene (1)	3	2										
Benzofluoranthenes (1)	7	5										
Chrysene (1)	5	4										
Dibenzo(a,h)anthracene (1)	6	3										
Fluoranthene	15	6	2	1	1	1						
Indeno(1,2,3-c,d)pyrene (1)	25	7										
Pyrene (1)												
Total HPAH (1)	8	5										
CHLORINATED HYDROCARBONS												
1,2,4-Trichlorobenzene (1)	1	1					21	3			1	1
1,2-Dichlorobenzene							15	2	2	1		
1,3-Dichlorobenzene (2)							2	1				
1,4-Dichlorobenzene							13	2	2	1	1	1
Hexachlorobenzene							4	2	2	1	1	1
PHTHALATES												
Butyl benzyl phthalate (3)	1	1										
Diethyl Phthalate (3)							2	1				
Dimethyl Phthalate (2)	1	1					2	1				
PHENOLS												
2 Methylphenol (1)							21	4			2	1
2,4-Dimethyl phenol (1)							22	5			2	1
4 Methylphenol (1)							2	1				
Pentachlorophenol							5	3	2	1	2	1
Phenol	2	1					2	1	1	1		
MISCELLANEOUS EXTRACTABLES												
Benzoic Acid (1)							3	2			2	1
Benzyl Alcohol (1)	1	1					22	5			2	1
Dibenzofuran (1)	3	2			1	1						
Hexachlorobutadiene							13	4	1	1		
N-Nitrosodiphenylamine	1	1					3	2				
VOLATILE ORGANICS												
Ethylbenzene	1	1	1	1	1	1						
Tetrachloroethene							1	1				
PESTICIDES AND PCBs												
Aldrin (2)							1	1				
Lindane (2)							1	1				
Total DDT	3	2	1	1	1	1						
Total PCBs	13	3					4	1				

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

Chemistry laboratories generally performed better during the DY 90 than during DY 89 in adhering to the PSEP protocols and PSDDA detection limits. The PSDDA agencies are continuing to work with the labs to resolve quality assurance and quality control (QA/QC) problems. 1989 SL adjustments for pentachlorophenol (PCP), for example, dropped the SL from 140 ppb to 69 ppb. Data submittals for projects undergoing testing indicated that laboratories could not routinely meet the 69 ppb SL, and the SL was subsequently raised to 100 ppb on an interim basis after a full PSDDA agency review of the problem. This included a sensitivity and reliability analysis (i.e., ability of higher SL to predict biological effects) conducted by Ecology using the Sediment Quality Data Base, which showed that raising the SL to 100 ppb would not measurably decrease the predictability of the higher SL. The interim SL adjustment in PCP was subsequently adopted following the second PSDDA annual review meeting.

a. Specific Project Discussion. The following summary discusses project-specific exceedances of PSDDA chemical guidelines noted during DY 90, and does not elaborate on the biological testing tier required, when chemical guidelines are exceeded. Biological testing required for the projects with exceedances noted are discussed in the following section of this report.

Of the thirty-one composited analyses tested for the U.S. Navy Homeport Project at Everett, Washington, two had detected chemicals exceeding SL for lead, zinc, indeno(1,2,3-c,d)pyrene, and Total HPAH, and five analyses had detection limits above the PSDDA SL. All thirty-one analyses underwent concurrent bioassay testing with no sediments failing the nondispersive disposal guidelines.

Seven of fifteen analyses conducted for the U.S. Navy Manchester Fuel Pier project had detected SL exceedences of cadmium, PAH's, and phenol, and all fifteen exceeded SL detection limits for 1,2,4-trichlorobenzene, phenols (2-methylphenol, 2,4-dimethylphenol) and benzyl alcohol. Concurrent bioassays were run on all fifteen samples and all passed the nondispersive disposal site guidelines.

Eleven of eighteen chemical analyses conducted on Duwamish River maintenance dredging material had chemicals exceeding SL (e.g., PAH's and PCB's), with detection limit exceedences of SL for two chemicals (1,2-dichlorobenzene, and 1,4-dichlorobenzene) noted.

Two small projects tested under the small project testing guidelines for "high" concern areas were Lonestar Northwest and Morton Marine. Both had chemistry detected/undetected exceedences of SL, the former with PAH's, phenols, and miscellaneous extractables, whereas the later was limited to pesticides and PCB's. Single bioassays (amphipod) were performed for each of these projects in accordance with established PSDDA evaluation procedures (EPTA and MPR).

The METRO Emergency Bypass project had four of seven analyses with chemical exceedences of PSDDA SL guidelines, two with detected exceedences (PAH's), and all four had undetected exceedences of PCBs.

The Port of Bellingham Blaine Marina project had no chemical exceedences of any PSDDA guidelines.

4. Biological Testing.

Biological testing was carried out in eight of eleven projects (note that all METRO Denny Way Capping data are included in the Duwamish River maintenance data set) in DY 90. Table 4 presents general information related to biological testing for these projects.

During DY 90 there were changes instituted by the PSDDA agencies which varied the biological testing requirements for projects undergoing sediment characterization during the year. Between June 16, 1989 and January 11, 1990, PSDDA required three bioassays for all projects requiring biological testing (except those which qualified for reduced small project testing). These were the 10-day amphipod mortality test, the acute toxicity sediment larval test and the Microtox bioassay. Requirements to do the juvenile infaunal mortality test had been suspended (see minutes of the PSDDA First Annual Review Meeting) due to problems with the specified organism, the geoduck (Panope generosa). On December 12, 1989 the ROD for the PSDDA Phase II Final EIS and the Phase II MPR was signed instituting, 30 days afterward, the 10-day Neanthes acute mortality test as the juvenile infaunal bioassay. Projects with sampling commencing after January 11, 1990 were required to include this bioassay. (Only one such project occurred during DY 90.)

Protocol and interpretation guidelines used for the PSDDA bioassays are found in the EPA Puget Sound Estuary Program Recommended Protocols (1986) as modified by the draft changes published in Spring, 1990[1] and the changes discussed in the PSDDA EPTA (June 1988) and the PSDDA Phase II MPR (September 1989). Additional protocol and interpretation changes were made during the DY 89 annual review process and were adopted during the second PSDDA Annual Review Meeting (ARM)(see minutes of the Second Annual Review Meeting). The 1990 draft Recommended Protocols was in open review during the latter part of DY 90 but had very little influence on that dredging year's testing. PSDDA ARM/MPR changes are generally within, or are clarifications to, the draft 1990 Recommended Protocols.

The amphipod test was carried out in seven of the projects undergoing biological testing during DY 90. Two projects, Lonestar Northwest and Morton Marine, qualified as small projects. Under PSDDA guidelines in effect at the time of sampling and testing for these two projects, only the amphipod bioassay was required for full characterization. (Subsequent to testing for these two projects the small project reduced testing requirements were changed to include both the amphipod and Microtox tests. This change was adopted during the second ARM.)

The sediment larval test was conducted in five of the projects undergoing biological testing. Lonestar and Morton Marine did not undergo sediment larval testing due to their small-project status. In addition, the Corps' Port Townsend planning study did not include the sediment larval test. The Echinoderm, Dendraster excentricus, was selected for all but one of the analyses.

Microtox was run for all projects requiring biological testing except the two projects tested under the small project testing guidelines. PSDDA protocol and interpretation guidelines in effect at the time of testing for these projects called for doing a dilution series and testing for dose-responsiveness.

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[1] This document and the office from which it originates have both changed names. It is now the EPA Office of Coastal Waters, and the document has substituted the name "Guidelines" for "Protocols" as of December, 1990.

TABLE 4 - BIOLOGICAL TESTING DATA SUMMARY

PROJECT	Number of Biological Analyses	Number of Analyses Failing	Number Undergoing Concurrent Testing	Number Undergoing Tiered Testing	Bioassays Conducted (X = Yes)				Sediment Larval Species	Juvenile Infaunal Species	Control Sediment Location	Reference Sediment Location
					Amphipod (8)	Sediment Larval	Microtox (9)	Juvenile Infaunal				
Lonestar Northwest (1)	1	-	1	-	X	-	-	-	-	-	Whidbey Island West Beach	Whidbey Island West Beach
Metro Emergency Bypass	7	-	7	-	X	X	X	NI	*Dendraster excentricus*	NI	Whidbey Island West Beach	Samish Bay
Morton Marine (1)	1	-	1	-	X	-	-	-	-	-	Whidbey Island West Beach	Carr Inlet
USCG Pier 35	3	2	3	-	X	X	X	NI	*Dendraster excentricus*	NI	Whidbey Island West Beach	Whidbey Island West Beach
USACE Port Townsend (2)	3	NA	3	-	-	-	X	-	-	-	-	-
USACE Duwamish O&M Round 1	11	retest required	-	11	X	X	X	NI	*Dendraster excentricus*	NI	Whidbey Island West Beach	Carr Inlet
USACE Duwamish O&M (3) Round 2	11	4	-	11	X	X	X	NI	*Dendraster excentricus*	NI	Yaquina Bay Oregon	Carr Inlet
USACE Duwamish O&M (4) Round 3	1	-	1	-	X	X	X	X	*Strongylocentrotus purpuratus*	*Neanthes arenaceodentata*	Whidbey Island West Beach	Carr Inlet
USN Manchester	15	-	15	-	X	X	X	NI	*Dendraster excentricus*	NI	Whidbey Island West Beach	Samish Bay
USN Homeport FC (5)	31	-	31	-	X	X	X	X	*Dendraster excentricus*	*Panope generosa*	Whidbey Island West Beach	Samish Bay & Jetty Island
USN Homeport PC (6)	-	-	-	-	-	-	-	-	-	-	-	-
Blaine Marina (7)	-	-	-	-	-	-	-	-	-	-	-	-
Pope & Talbot (7)	-	-	-	-	-	-	-	-	-	-	-	-

(1) Tested under guidelines for small projects
(2) Planning study; dilution series run for Microtox without reference sediment
(3) Retest of sediments from Round 1
(4) Testing of material accumulated subsequent to Rounds 1 and 2
(5) Juvenile infaunal test run as part of the Settlement Agreement; not required by PSDDA
(6) Bioassays not required for partial characterization
(7) No exceedances of screening levels; bioassays not required

NA = Not applicable; full characterization not undertaken
NI = requirement not instituted at time of testing

(8) *Rhepoxynius abronius*
(9) *Photobacterium phosphoreum*

If dose-responsiveness existed, then five replicates at the highest concentration were compared between the test and reference sediments using a t-test comparison. Because of the log transformation required in using the data to test dose-responsiveness, negative light diminution data (light enhancement) could not be used in calculations, often resulting in an inability to determine dose-responsiveness. Consequently, comparison of five replicates at the highest concentration was not carried out for many of the projects. (Because of this technical problem with the Microtox bioassay, clarifications were made at the second ARM. Comparisons of five replicates at the highest concentration are now mandatory whether dose-responsiveness can be determined or not.)

The Neanthes 10-day mortality test was instituted as the PSDDA juvenile infaunal bioassay with the signing of the ROD for the Phase II EIS. Only one sample, Duwamish channel maintenance material, was tested with Neanthes. This was the only project (with the exception of Morton Marine) from DY 90 which had bioassays performed after the change. There were no problems associated with this test. (Several projects have subsequently been tested in DY 91 using Neanthes with no performance problems.) Although not required by PSDDA, the geoduck was used as a juvenile infaunal test during US Navy Homeport-Element I biological testing because of Settlement Agreement requirements. Results from this bioassay are discussed below.

a. Specific Project Discussion. Quality control was acceptable for the majority of bioassays performed. Reference and control sediments for most projects performed within the performance criteria established by PSDDA. Water quality monitoring demonstrated that most parameters were generally within the recommended ranges. Three projects experienced some degree of difficulty running bioassays, however. The Samish Bay reference sediment failed to meet performance standards for the Metro Emergency Bypass amphipod test. This result was inconsequential from a regulatory perspective however, because none of the test sediments exceeded the control sediment mortality by more than twenty percent, a condition which must exist before a cogent comparison to the reference sediment can be made. Biological testing for the Corps of Engineers' Duwamish O&M had to be repeated due to reference sediment failures, water quality parameter deviations from recommended ranges and protocol problems. During US Navy Homeport biological testing there was a reference sediment failure in the juvenile infaunal test and bioassay hits in the sediment larval bioassay thought to be related to ammonia. Details for the Duwamish River maintenance dredging and Navy Homeport projects follow.

(1) Duwamish River Maintenance Dredging

Round 1: Duwamish River maintenance sediments were sampled and tested in the spring of 1989. All three bioassays required at the time of testing experienced difficulties:

Microtox: Dilution series were run for all test sediments and the reference sediment. Additional replicates for t-test comparisons were run for the reference sediment on the same day the dilution series were run. The extracts on which the additional replicates at the highest extract concentration were performed for the test sediments were held refrigerated overnight and exhibited significantly less light diminution than the two replicates at the highest extract concentration conducted the previous day as part of the dilution series. The Microtox test data were deemed unacceptable due to the variability in response noted above, and the bioassay was rerun in Round 2.

(As a result of this situation, the PSDDA agencies adopted at the second ARM a change in the Microtox protocols which calls for testing a reference sediment within each batch of Microtox test sediments. A batch was defined as tests run using rehydrated bacteria from the same vial. The useful life of rehydrated bacteria was limited to two hours. In addition, sediment extracts may not be held longer than two hours.)

Amphipods: The Carr Inlet reference sediment mean mortality was 55 percent, which was outside the performance standard of 20 percent over control (control sediment mortality was 1 percent). The reference sediment had a high percentage of fines (88%) and the high mortality may have been related to this parameter (see MPR-Phase II pp. 5-32 to 5-34). The measured temperatures (8.5°to 19°C) exceeded recommended range of 14° to 16°C in 90 out of 110 recorded measurements). The exceedance of the recommended temperatures was suspected of having influenced response sensitivity. As a result the amphipod test was set aside as a QA failure and this bioassay was rerun.

Sediment Larval Test: Ten of eleven lab samples failed the sediment larval test under the "single-hit" rule with mortalities greater than 30 percent over, and significantly different from, reference. One sample had a hit under the "two-hit" rule (statistical significance from reference and 20% over control with a confirmation hit from another bioassay required for failure). High ammonia concentrations measured in test beakers during testing were highly correlated with both mortality and abnormality, and may have contributed to hits (both Pearson product-moment correlations = 0.83, $p < 0.01$). Therefore, the test was rerun.

Round 2: In the fall of 1989, Duwamish River maintenance sediments were resampled for a second round of biological testing. Samples were taken from the same sampling locations used during Round 1. All three bioassays in use at the time were run.

Amphipods: No problems with water quality were experienced during Round 2 and the amphipod results were deemed acceptable.

Sediment Larval Test: As in Round 1 the reference sediment failed to meet performance standards with reference mortality exceeding control mortality by 51 percent. High concentrations of ammonia, similar to those in Round 1, were reported. Spearman's rank statistic was used to assess correlation of mortality with ammonia concentrations. No significant correlation was found although data points in the low and midranges of concentrations were limited to one point each. Twenty-three of 26 ammonia levels measured were above the water quality criteria for ammonia-nitrogen of 0.59 mg/l established by EPA in 1989. The sediment larval test data were not used in making the suitability decision for open-water disposal due to the failure of the reference sediment relative to performance standards.

Microtox: No problems were identified during Round 2 of testing and the Microtox results were used in making a regulatory decision.

Round 3: An additional volume of material was deposited by winter floods subsequent to Round 1 and 2 testing. This additional volume was characterized under PSDDA sampling and analysis guidelines by two chemistry analyses and one biological analysis. Sampling and testing took place in January of 1990. By this time the requirement to do the acute toxicity juvenile infaunal test had been

instituted with Neanthes arenaceodentata used as the test species. No problems were experienced with this test nor the amphipod and Microtox bioassays. The suitability decision for this additional material was made using the results from these three bioassays. The sediment larval test again experienced difficulties with the reference sediment exhibiting 47 percent mortality greater than control. The results were set aside, and not used to make the suitability decision.

(2) US Navy Homeport-Element I Full Characterization

Sediment Larval Test: There were hits for two of the test sediments under the "two-hit" rule. These two test sediments also had the highest concentrations of bulk ammonia found in this project (35.2 and 46.0 mg/l). This correlation between mortality and ammonia concentration made the data suspect and the results from the sediment larval bioassay for these two test sediments were set aside using Best Professional Judgement as provided for in the MPR, and were not used to make the suitability decision. These results alerted the PSDDA agencies that water quality monitoring of ammonia and sulfide at the beginning and end of the test run for all bioassays except Microtox, would provide PSDDA agencies a means to assess this influence on bioassay performance. A recommendation to add ammonia and sulfide monitoring of bioassays at the second annual review meeting was adopted and this is now a requirement.

Juvenile Infaunal: The geoduck test was conducted as the juvenile infaunal bioassay. This was not an approved PSDDA bioassay but was conducted under terms of the settlement agreement between the Navy and the Sierra Club Legal Defense Fund. Two reference sediments were used for comparison. One was from an approved PSDDA reference area in Samish Bay. This reference sediment was a poor match for the high silt content found in the Homeport material. There was no PSDDA-recommended reference area at the time which provided a better match. A second reference sediment was taken from Jetty Island. This sediment did match better the grain-size characteristics of the test sediments. During geoduck testing the Samish Bay reference sediment failed to pass the performance criterion of 20% over reference established by PSDDA for one of the two batches run. Comparisons for this bioassay only were made with the Jetty Island reference. Twelve of seventeen test sediments in the first batch failed. The poor performance of the Samish Bay reference sediment coupled with the large number of test sediment exceedances over control cast serious doubt on the validity of the batch 1 test results relative to a determination of a significant toxic response directly attributable to any of the chemicals of concern and/or polar compounds quantitated in the Element I study area. These results are not inconsistent with previous unsuccessful experiences with the geoduck test. The results were not set aside but given the ammonia hits in the sediment larval test for two of these same test sediments, these sediments were not failed.

B. Partial And Full Characterization Sampling and Testing Costs.

Many factors influenced the cost of sampling and testing, including the size (volume tested) of the project, dredging depth, and area ranking. Figure 1(a) illustrates the effect of project size relative to normalized sampling/testing cost (average cost per cubic yard). Small dredging volumes incurred a greater relative sampling/testing cost due to higher relative contributions by analytical QA/QC. Average sampling/testing costs decrease with increasing size of the dredging volume tested. Average sampling/testing costs per cubic yard ranged from a high of $8.29 per cubic yard to a low of $0.15 per cubic yard. Sampling costs increased substantially when the depth of the dredging cut increased as illustrated in Figure 1(b). For two projects illustrated, sampling costs were the single largest cost relative to testing costs. Area rank had a dramatic effect on the sampling and testing costs as

illustrated by Figure 1(c) where "low" ranked projects had a minimal sampling/testing cost of $0.06/cubic yard, compared to $3.11/cubic yard for "high" ranked projects, averaging $1.64/cubic yard for all projects tested for DY's 1989 and 1990. Figure 1(d) shows the average unit sampling/analysis costs for nine projects tested during the 1990 dredging year. Average unit costs ranged from a low of $4,347 to $17,750 per analysis. The major components contributing to the costs are also shown and illustrate the high degree of variability among the projects tested. Miscellaneous costs included all costs not included in bioassay, chemistry, and sampling cost, such as sampling/analysis plan development, cost of inputting data to DAIS spreadsheets, and administrative costs. The major components contributing to these costs are discussed in detail below.

1. Sampling costs.

Comparative unit sampling costs generally accounted for the largest absolute difference in total costs between projects as depicted in Figure 1(d), ranging from a low of $862 per uncomposited surface (< 5 ft) sample for the Duwamish River maintenance dredging project to a high of $12,500 per composited sample for the Pope and Talbot, Inc. project, where the sampling depth extended to 17 feet. Costs for sampling to the dredging cut depth of 24 feet for the METRO Emergency By-Pass project resulted in commensurately high sampling costs of $11,429 per analysis. Costs for sampling sediment cores extending 40 feet in the U.S. Navy Homeport project Element I area were also high at $7,150 per composited analysis. The remaining project sampling costs ranged from $1,135 to $2,601 per analysis. Costs associated with taking core samples appear to be highly variable and dependent on equipment used, the total project size, dredging prism depth, and area rank.

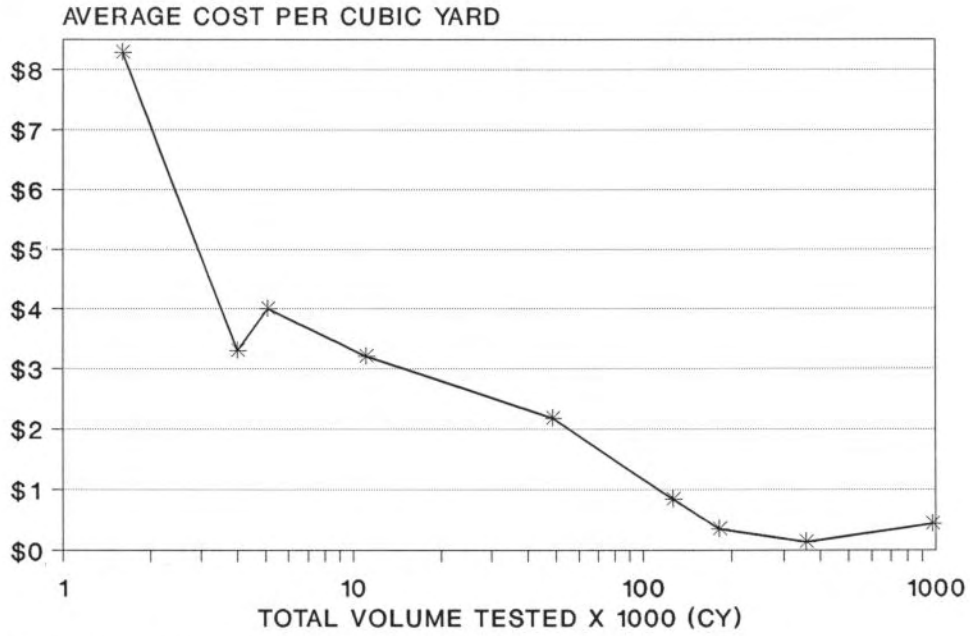
2. Chemical testing costs.

The total costs for conducting chemical analysis on sediments for the 6 sediment conventional parameters (i.e., total organic carbon, total volatile solids, percent solids, grain size, total sulfides, and ammonia), 9 metals and 49 organic chemicals (including total LPAH's and HPAH's) ranged from a low of $844 per analysis (including QA, but excluding pesticides, volatiles, and PCB's based on "no reason to believe" for USN Manchester) to a high of $7,701 per analysis with associated QA/QC data required by the PSDDA program. As shown by Figure 1(e) the average per analysis cost (with QA) is greatly influenced by the number of analyses. With two or more analyses, average chemistry costs ranged from a low of $1,611 per analyses to a high of $2,289 per analysis, averaging $1,991 per analysis. For projects with a single analysis the unit costs were much higher. These costs were in the range of those summarized in the 1989 application report, although the average is somewhat higher. Six of the projects tested during 1990 were in areas with a high ranking. Matrix interference problems causing multiple cleanup steps to be implemented in order to achieve the PSDDA required detection limits probably contributed to the higher costs observed. Chemistry costs are driven by organic analysis costs, with metals and sediment conventionals only contributing a relatively small portion to the total cost. As shown in Figure 1(d) chemistry generally was a significant portion of the overall sampling and testing costs for only two projects, Lonestar Northwest, and Morton Marine, which were small projects of less than 4,000 cubic yards total with only one analysis each.

3. Biological testing costs.

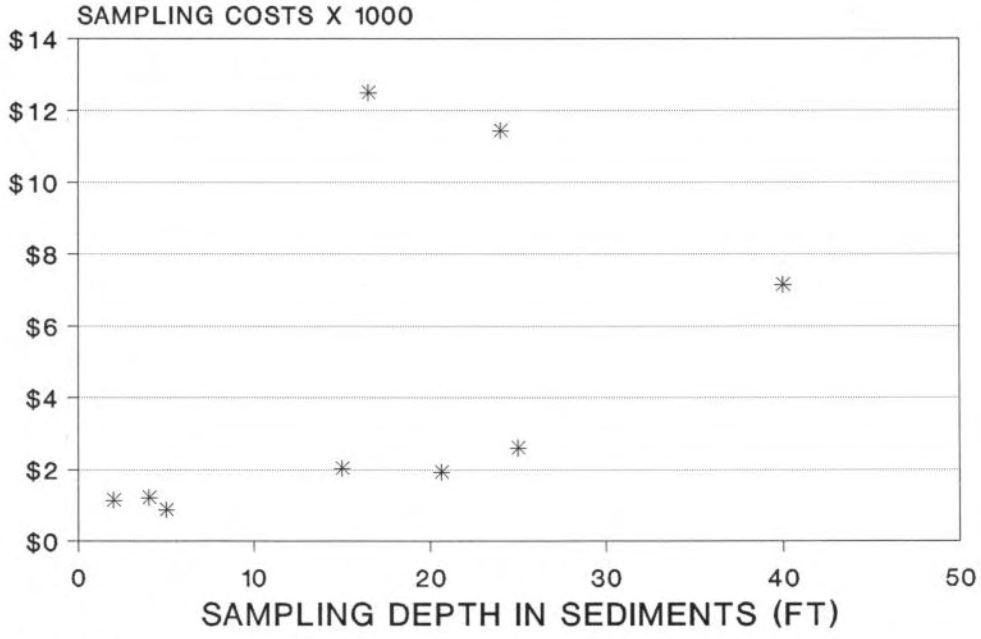
Figure 1(f) depicts the average per analysis cost for the three PSDDA prescribed bioassays (the Neanthes juvenile infaunal bioassay was not implemented at the time of this testing) during the 1990 dredging year by the number of analyses conducted. Actual total costs per sample for doing the three

FIGURE 1. COST ANALYSIS*
(a) PROJECT SIZE VERSUS UNIT COST



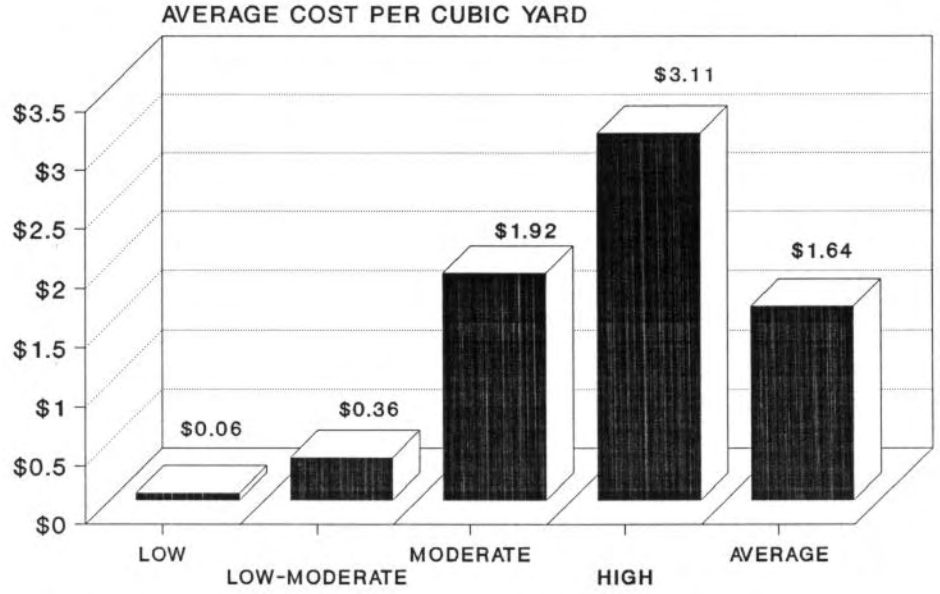
* SAMPLING AND TESTING COSTS

(b) SAMPLING COSTS* VERSUS TEST DEPTH



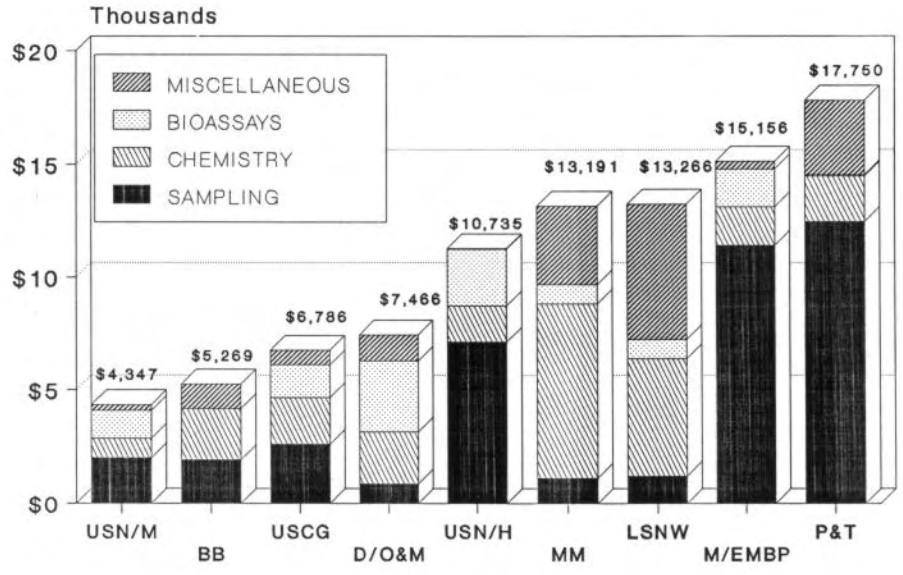
* per analysis

(c) AREA RANK VERSUS UNIT TESTING COSTS*



*DATA COMBINED FROM DY's 1989 AND 1990

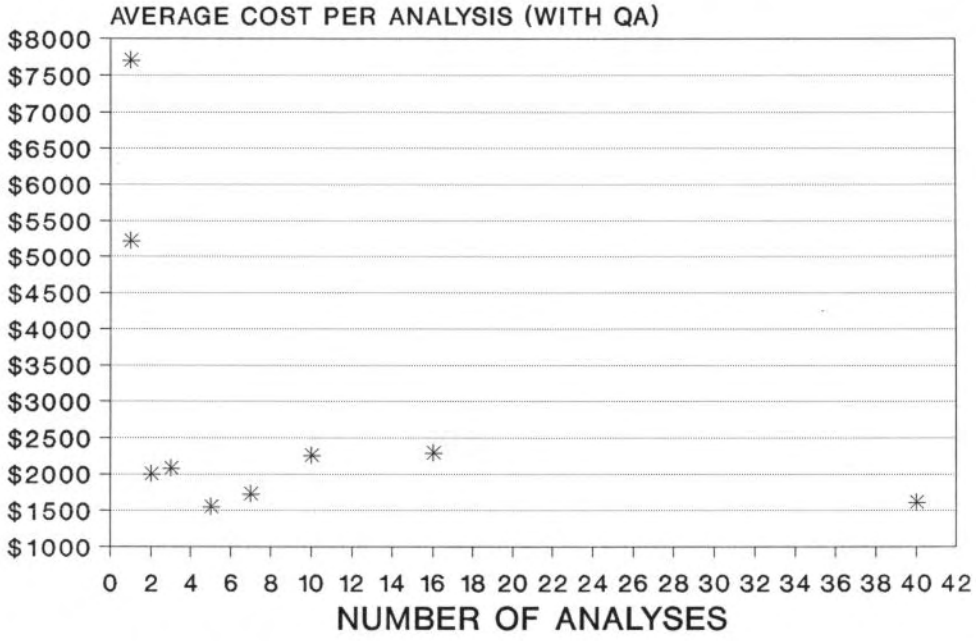
(d) AVERAGE SAMPLING/ANALYSIS COST*



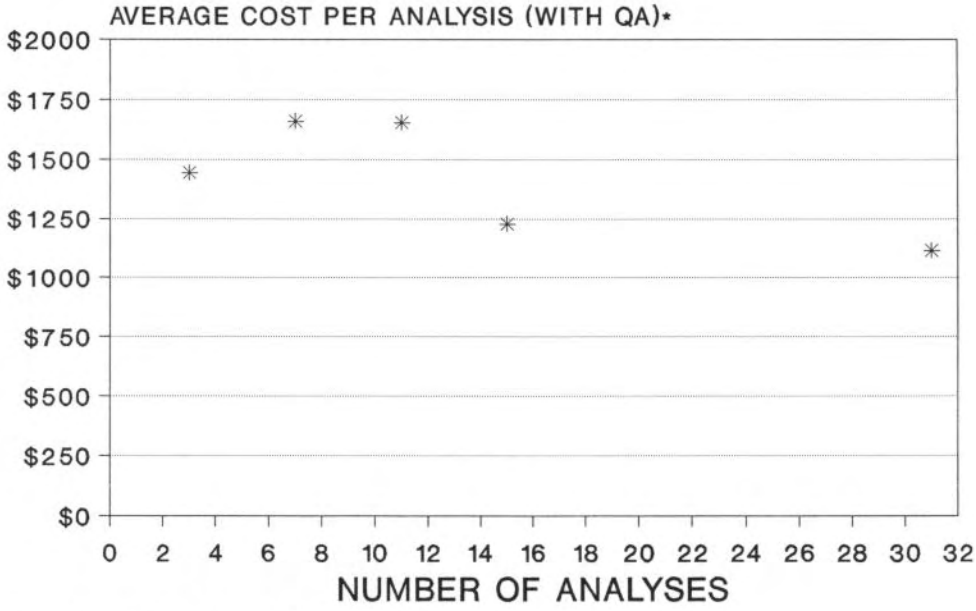
*PER PROJECT ANALYSIS COSTS: DY 1990

LEGEND: USN/M - Navy Manchester; BB - Blaine Marina; USCG - US Coast Guard Pier 35; D/O&M - Duwamish Maint. Dredging; USN/H - Navy Homeport; MM - Morton Marine; LSNW - Lonestar NW; M/EMBP - Metro Emerg.Bypass; P&T - Pope & Talbot, Inc.

(e) CHEMISTRY COST ANALYSIS



(f) BIOASSAY COST ANALYSIS



* AVERAGE TOTAL INCLUDES AMPHIPOD + ECHINODERM LARVAE + MICROTOX BIOASSAY

PSDDA required bioassays (Microtox, amphipod, and sediment larval) ranged from $1,115 to $1,657/sample, averaging $1,419/sample. These costs compare favorably with EPTA estimates ($1,300/sample for the same 3 bioassay tests).

Of the three PSDDA required bioassays, the saline Microtox test was the lowest in cost ranging between $162 and $243 per test. The echinoderm larval bioassay was generally similar in cost to the amphipod test with a range from $465 to $550/sample except for one reported high unit cost of $810/sample. The amphipod bioassay costs ranged from $450 to $650 for projects with more than one analysis. The unit cost reported for a single test however, increased to $810/sample with associated QA/QC required (reference/control sediments). The cost of running the non-PSDDA required geoduck bioassays for the U.S. Navy Homeporting project was $1,400/sample.

Water quality monitoring of ammonia and sulfides at the beginning and end of the test was proposed to be added at the April 1990 PSDDA ARM, and was subsequently adopted following the meeting as a required test commencing with DY 91 (June 16, 1990). Three projects tested during DY 90 elected to perform ammonia/sulfide water quality monitoring of bioassay test beakers on a voluntary basis. There appeared to be a relatively wide disparity in costs among the three projects with the unit sample cost reported at $70, $90, and $228 for monitoring the amphipod and echinoderm larvae bioassays collectively. These costs are expected to drop with the use of ion-specific electrochemical ammonia and sulfide probes.

III. OVERALL ASSESSMENT OF DREDGING YEAR 1990'S TESTING RESULTS.

A. Area Sediment Quality Trends and Reranking Considerations.

Data were reviewed during the 1990 dredging year to evaluate limited project area specific sediment quality trends and reranking considerations. Eighty-three chemical analyses were performed for the nine Section 10/404 permit applications. The sixteen analyses performed for the Duwamish River maintenance project included chemistry data for the Denny Way CSO Capping project, which were characterized as part of the Duwamish River maintenance dredging data set. The Port Townsend Harbor Expansion Feasibility Study conducted 3 analyses.

Of the 99 management units characterized among the projects, six were found to be unacceptable for unconfined open-water disposal (UCOWD), due to bioassay testing failures exceeding PSDDA disposal guidelines for nondispersive sites. These failures collectively constituted 18,400 cubic yards of material. An additional 4,700 cubic yards of material from the Pope and Talbot Project were found to be unacceptable for UCOWD due to high levels of wood chips (greater than 50 percent, which is the maximum allowed by Ecology), although chemical tests indicated no PSDDA chemical guideline exceedances.

Table 3 summarizes the number of COC specific exceedances of PSDDA SL, BT, and ML guidelines among the eleven projects and 99 total analyses (see Appendix III for project and station specific chemistry and bioassay summaries for all analyses exceeding PSDDA guidelines). The number of COC exceeding the (SL + ML)/2 is also used as a qualitative check on area ranking considerations (EPTA, pages II-64) for PC guidelines (see Appendix I of this report for 1989 guidelines).

Table 5 illustrates the qualitative check used to evaluate the project specific chemistry data for all 99 analyses conducted during DY 90. After evaluating the chemistry data, the bioassay responses relative to PSDDA disposal guidelines mediate the chemistry reranking evaluation if

TABLE 5. EPTA RANKING GUIDELINES

AREA RANK	DATA EVALUATION ALGORITHM
HIGH	ANY COC GREATER THAN ML
MODERATE	ONE OR MORE COC GREATER THAN (SL + ML)/2 AND LESS THAN ML
LOW-MODERATE	ONE OR MORE COC GREATER THAN SL AND LESS THAN (SL + ML)/2
LOW	ALL COC BELOW SL

(and only if) bioassay results do not indicate suitability for UCOWD. (Should bioassays fail a management unit, the area designated by that analysis is assigned a "high" rank)

Table 6 summarizes the project-specific analysis rankings for surface and subsurface samples (see Appendix IV for chemical-specific ranking for each analysis and biological testing results). The data summarized generally support the previously assigned conservative ranking of each project.

Neither Lone Star Northwest or Morton Marine project areas provide sufficient data to consider reranking at this time due to the limited data provided from a small area. However, data suggest that these areas may be downranked at least one level in the future.

Chemistry data from the Pope and Talbot project support a lower ranking, although the presence of large quantities of woodchips makes this material qualitatively unacceptable for UCOWD except where they represent a volumetrically insignificant part of the sediments.

No change in ranking is indicated for the U.S. Coast Guard Pier 35 area based on the high number of exceedances of PSDDA COC guidelines and bioassay responses. Multiple exceedences of SL, BT, and ML for two of the three analyses conducted for the U.S. Coast Guard Pier 35 project were corroborated by the bioassay results, resulting in two dredged material management units being judged unacceptable for UCOWD, and thereby confirmed the "high" ranking assigned. There is evidence that contamination of subsurface sediments extends deeper than 4 feet (Appendix III).

Data for the METRO Emergency Bypass Outfall supported a low-moderate ranking for future testing in this area.

Likewise, data for the Port of Bellingham Blaine marina project support lowering the ranking from low-moderate to low for future testing purposes.

Extensive testing from the U.S. Navy Homeport's Element I project area showed the sediments generally support a low-moderate ranking for surface sediments and a low ranking for subsurface sediments.

Sediment testing data for the U.S. Navy Manchester Fuel Pier project area generally supported maintaining a low-moderate rank for the project area east of the fuel pier area and a moderate rank for the sediments surrounding the existing and proposed pier.

B. Sampling and Testing Costs.

Costs associated with sampling and testing sediment samples for dredged material disposal suitability decisions appear to be generally within the cost ranges estimated by PSDDA. Costs are closely related to area ranking, project size and dredging depth, as discussed previously relative to the eleven projects analyzed under the PSDDA guidelines (see Figures 1(c-d)). Total average costs for sampling and testing on a per sample basis were highly variable, indicating that there is a relatively wide latitude in the costs various laboratories and engineering firms charge for these services (Figure 1(d)). There is a preliminary indication that the higher chemistry analysis costs did not result in fewer QA problems and/or exceedances of PSDDA detection limits for detected samples relative to the other projects tested.

TABLE 6. SUMMARY OF TESTING DATA FOR RERANKING CONSIDERATION*

PROJECT	PRETESTING ASSIGNED RANK	TESTING DEPTH	AREA RANKS CORRESPONDING TO TEST DATA			
			LOW	LOW-MODERATE	MODERATE	HIGH
LONE STAR NORTHWEST:	H	SURFACE			1	
MORTON MARINE:	H	SURFACE		1		
U.S. COAST GUARD/PIER 35:	H	SURFACE				1
		SUBSURFACE		1		1
POPE AND TALBOT, INC.:	M	SURFACE	3			
METRO (EMERGENCY BY PASS OUTFALL):	M	SURFACE	1	3		
		SUBSURFACE	2	1		
DUWAMISH OPERATIONS AND MAINTENANCE:	M/H	SURFACE	4	8		4
PORT OF BELLINGHAM/BLAINE MARINA:	LM	SURFACE	3			
		SUBSURFACE	6			
U.S. NAVY HOMEPORT EVERETT/ELEMENT I:	L/LM/M	SURFACE	3	6		
		SUBSURFACE	22			
PORT TOWNSEND - HARBOR EXPANSION STUDY:	M	SURFACE	2	1		
U.S. NAVY MANCHESTER:	LM/H	SURFACE		8	1	
		SUBSURFACE		6		

* NUMBER OF ANALYSES MEETING RANKING CONSIDERATIONS PER EPTA PAGE II-64 TO II-66.

C. Chemicals greater than PSDDA Guidelines.

Table 3 depicts the 49 chemicals exceeding PSDDA guideline (i.e., SL, BT, ML) values cumulatively among the eleven projects tested during the 1990 dredging year. Appendix II compares the sample/analysis specific PSDDA guideline exceedances of the 49 observed COC among the eleven projects tested. This appendix also provides bioassay performance results relative to the PSDDA disposal guidelines.

In summary, for the detected metals, only cadmium, zinc, lead, and copper exceeded SL guidelines more than once among the 99 analyses. High and low molecular weight PAH's (LPAH's, and HPAH's) exceeded PSDDA sediment quality guidelines more frequently among projects than any other group of chemicals, with seven of the eleven projects showing at least one PSDDA guideline exceedance from this group.

Sediments from the U.S. Coast Guard Pier 35 Slip were the only ones with detected BT and ML exceedances among the eleven projects tested. Seven LPAH's, one HPAH, dibenzofuran, ethylbenzene, and total DDT exceeded ML in two of the three analyses for this project. The chemistry results alone generally indicated these two dredged material management units were unacceptable for unconfined openwater disposal. Moreover, bioassays run concurrently on these two samples corroborated the chemistry results when all three bioassays showed "hits" for the two management units.

Detected levels of total PCBs exceeded SL in 13 of the 99 total analyses among three projects tested in Elliott Bay and the Duwamish River (Morton Marine, U.S. Coast Guard Pier 35, and Duwamish maintenance dredging). There were no detected/undetected exceedences of either BT or ML for this suite of chemicals. PCB and HPAH exceedances of SL in four dredged material management units for the Duwamish maintenance dredging project may have contributed to the bioassay hits resulting in PSDDA nondispersive disposal guideline failures (see pattern analysis discussion of COC associations with bioassay responses; pages 26 to 34).

Failure to achieve PSDDA required limits of detection (LOD's) occurred in two of the three Section 10/404 permit projects tested as shown in Table 3. PSDDA detection limits were not a problem for metals. Twenty one organic chemicals on the COC list among six projects demonstrated problems in achieving PSDDA detection limits (i.e., concentrations measured as undetected above the PSDDA SL's). Most were previously documented as problem chemicals for achieving PSDDA prescribed LOD's[2] using EPA CLP and modified CLP methods (see Phase II MPR, pages 5-27 to 5-29)(Table 4). Laboratories are required to achieve LOD's below the SL's for all chemicals on the PSDDA COC list, or else biological testing (or chemical reanalysis) is necessary prior to a suitability decision. Fourteen organic chemicals had undetected but no detected LOD's above the PSDDA SL's, and they were primarily among the chlorinated hydrocarbons (e.g., 1,2-dichlorobenzene, 1,4-dichlorobenzene), phenols (e.g., 2-methylphenol, 2,4-dimethylphenol), and miscellaneous extractables (e.g., hexachlorobutadiene). Nine organic chemicals and two metals (arsenic, nickel) on the COC list

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[2]The PSDDA Phase II MPR, in a footnote on page 5-27, notes that the Puget Sound Estuarine Program's Recommended Protocols Guidelines defines a "required quantitation limit" that is equivalent to "limit of detection" used in the 1986 Recommended Protocols and all PSDDA documents.

never exceeded PSDDA guidelines in any of the eleven projects (METRO Denny Way Capping and Duwamish River Maintenance Projects combined) and 99 analyses. Experience to date suggests that labs generally improved their LOD performance in DY 90.

A detailed discussion of other QA/QC issues relative to PSDDA testing requirements are found in pages 41-50. A thorough review (QA1) of all testing data submitted by applicants/dredgers is conducted by the Corps Dredged Material Management Office in concert with the other PSDDA agencies prior to making a suitability decision for each project.

Sediment holding times compiled among the eleven projects tested during DY 1990 were compared with PSEP/PSDDA requirements for various chemical analyses, and are summarized in Table 7. These data demonstrated that PSDDA specified holding times were generally met, except for a single project (U.S. Coast Guard Pier 35) exceedance of the mercury 28 day holding time.

TABLE 7. SEDIMENT HOLDING TIMES FOR CHEMICAL ANALYSES[a]

	Metals	Mercury	Semivolatile Organics	Volatile Organics	Pesticides/ PCBs
PSEP/PSDDA Requirements	182 Days	28 Days	365 Days	14 Days	365 Days
Observed Range Among Projects	4-40 Days	5-36 Days	3-31 Days	6-12 Days	3-19 Days
Number of Projects Exceeding Holding Time	0	1/11	0	0	0
Mode Among Projects	20 Days	15 Days	12 Days	9 Days	9 Days

[a] Numbers depict batch specific holding times in days between sample collection and analysis.

D. Bioassay performance.

In general, the performances of the amphipod bioassay, the sediment larval echinoderm bioassay and saline microtox bioassay were satisfactory and provided data sufficient for regulatory decisions on the suitability of the dredged material for unconfined open-water disposal, except as noted previously for project specific problems (see pages 11-13). In the few instances where the data was set aside, there remained a sufficient weight of evidence to make a suitability decision from the remaining tests or from a resampling and/or retesting event.

The amphipod bioassay continues to be a reliable bioassay and posed few problems during DY 90 testing, except one instance of exceedance of temperature guidelines requiring a retest for those samples (see discussion on page 12).

The sediment larval test provided consistent and interpretable results for most projects tested during DY 90. The echinoderm larval bioassay, utilizing Dendraster excentricus, was utilized for all six projects where the full suite of PSDDA bioassays were required (Strongylocentrotus purpuratus was used for Round 3 of the Duwamish testing). This organism is increasingly being selected over the oyster larvae test by labs doing PSDDA bioassay testing. After making clarifications and adjustments in the protocol for the echinoderm embryo test, this test now appears to be working properly, and is showing itself to be a sensitive PSDDA bioassay. This test appears to be sensitive to high ammonia levels and possibly sulfide levels, and these were implicated in several QA/QC failures for the Duwamish River maintenance material tested during DY 90, and two hits during the Navy Homeport Element I sediment characterization. A bioassay workshop held on July 10, 1990, identified a number of protocol issues which have been forwarded to PSEP for review and adoption in the revised bioassay protocol document to be released during Spring 1991. These issues are summarized below as protocol clarifications to be finalized at the next annual review meeting.

The saline microtox bioassay performance was less satisfactory due to ongoing adjustments and clarifications to the protocol used during DY 90 for PSDDA testing. Recent clarifications to the saline microtox bioassay protocol were implemented following the second annual review meeting and none of the DY 90 projects utilized the revised protocol (see discussion on pages 9-11). The saline microtox bioassay was recently added as a required biological test for Small Projects requiring biological testing (see Phase II MPR, pages A-7)

The Phase II changes to testing requirements added the Neanthes 10-day acute bioassay. However, only a single bioassay utilizing this species test was run during DY 90. It is too soon to evaluate its performance, although preliminary indications, from DY 91 data indicate there are no significant performance problems with this test.

A summary of bioassay holding time performance among the eight projects undergoing bioassay testing is depicted in Table 8. They were all within the PSDDA mandated maximum holding time of 42 days.

TABLE 8. SEDIMENT HOLDING TIMES FOR PSDDA BIOASSAYS[a]

	AMPHIPOD	SEDIMENT LARVAE	MICROTOX	NEANTHES 10-DAY ACUTE TEST
PSDDA Requirements	42	42	42	42
Observed Range Among Projects	6-21 Days	7-21 Days	8-31 Days	5
Number Exceeding Holding Time	0	0	0	0
Mode Among Projects	15 Days	8 Days	16 Days	5 Days

[a] Numbers depict batch specific holding times in days between sample collection and analysis.

Positive controls are run in bioassays to give an idea of comparative performance among different testing runs. In general, a 100 percent variation in response can be expected. Table 9 provides a summary of positive control responses observed during DY 90 bioassay testing. It shows that for the amphipod bioassay the positive control responses for cadmium chloride were always lower than the reported LC50 value (environmental concentration that results in 50 percent mortality), and in some instances was markedly lower ranging between 0.1 and 1.51 mg/l. Sodium pentachlorophenol was only used once during DY 90 testing and was also lower than the reported LC50 value. This suggests that amphipods tested during DY 90 are more sensitive than those used to establish the reported sensitivity levels.

No positive control LC50 levels for cadmium chloride are available for the echinoderm larval sediment bioassay. LC50 values reported during DY 90 ranged between 10.8 and 22.9 mg/l. A single lab used sodium dodecyl sulfate as a positive control toxicant, and reported a LC50 response at 1.8 mg/l and a EC50 response (effective concentration with 50 percent abnormality) for abnormality at 3.0 mg/l.

No EC50 positive control levels are available to compare the saline Microtox test responses with, but observed responses ranged from 0.01 to 0.45 mg/l for ethanol and 14 to 20.5 mg/l for phenol.

No LC50 value was reported for the single Neanthes bioassay run during DY 90, nor are there any specifications for reference toxicants in the draft final PSEP bioassay protocols.

TABLE 9. SUMMARY OF POSITIVE CONTROL RESPONSES FOR PSDDA BIOASSAYS DURING DREDGING YEAR 1990

BIOASSAY TYPE	AMPHIPOD (LC50)		SEDIMENT ECHINODERM LARVAE (LC50)		SALINE MICROTOX (EC50)	
REFERENCE TOXICANT:	**REPORTED VALUE**	**TESTED VALUE**	**REPORTED VALUE**	**TESTED VALUE**	**REPORTED VALUE**	**TESTED VALUE**
$CdCl_2$ (mg/l) (probit)	1.61	mean = 0.68 range = 0.1-1.51	3.81[a]	mean = 18.5 range= 10.8-22.9	NS	--
NaPCP (mg/l)	0.3-0.39	0.19	--	--	NS	--
SDS (mg/l) (Data Observation)	--	--	(EC50 = 0.91)[b]	1.8 (EC50 = 3.0)	NS	--
ETHANOL (mg/l)	--	--	--	--	NS	mean = 0.23 range = 0.01-0.45
PHENOL (mg/l) (moving average)	--	--	--	--	NS	mean = 16.8 range = 14-20.5

[a] reported LC50 value for oyster larvae bioassay (Cardwell, et.al., 1977)

[b] reported EC50 value for oyster larvae bioassay (Calabrese, 1973)

LEGEND:
LC50 = LETHAL CONCENTRATION 50 PERCENT
EC50 = EFFECTIVE CONCENTRATION 50 PERCENT RESPONSE
NS = NONE SPECIFIED
SDS = SODIUM DODECYL SULFATE
-- = NOT APPLICABLE

E. Chemical/Biological Pattern Analysis.

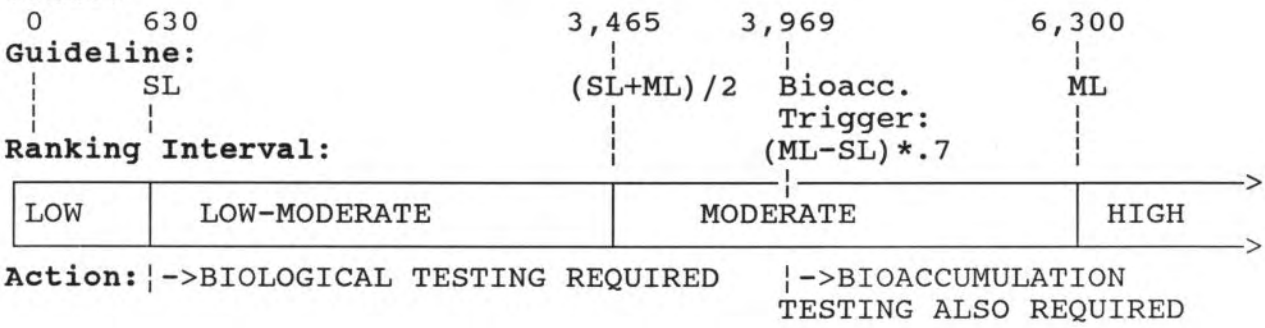
1. Introduction. The PSDDA agencies will evaluate yearly/multiyearly data with an eye to discernment of patterns that suggest potential modifications of dredged material evaluation guidelines. It should be noted, however, that the agencies also recognize that it may take several years of data to be able to meaningfully evaluate the programmatic guidelines. For this reason, it is likely that the establishment of a methodology for discerning patterns will be the principal focus for the next several years in the program.

In the first two Annual Review Meetings, the Washington Public Ports Association (WPPA) stressed its desire to see pattern or trend analyses and to participate in the pattern analysis. It stated particular interest in circumstances when chemicals of concern in dredged material exceeds SL but shows no biological "hits" or failures under the one- and two-hit rules, and asked that the PSDDA agencies display the results with this in mind. During Dredging Years 90 and 91, meetings of the PSDDA agencies and WPPA occurred to further define what kinds of assessments would be most informative.

In appendix IV, some methodologies and analyses are presented that examine trends in the DY 90 data set; the data for all testing during this dredging year are summarized in Appendices II and III, and a values table is available that includes all testing values recovered. The following sections summarize the information in the appendix.

2. Chemical Exceedances and Biological Responses, Part 1. PSDDA DY 90 data are presented in the Appendix II and III summary tables as SL exceedances, ML exceedances, bioaccumulation trigger exceedances and as ranking intervals. All of these intervals are illustrated below for the compound fluoranthene:

Figure 2. PSDDA Value Intervals for the Compound Fluoranthene. The values are in parts per billion; the screening level and the relationship to the ranking are shown.



The PSDDA agencies determined that chemical levels in sediment greater than the PSDDA SL could be associated with biological effects on the basis of a large data set on Puget Sound chemicals and concomitant biological testing. Between SL and ML it was not deemed possible to predict with certainty the level of effect. In this "gray area," biological testing would be needed. (The PSDDA Phase II MPR, pages 5-2 ff. discusses this more fully.)

There are several ways in which to view the data set:

- qualitatively or quantitatively by all chemicals (for example, by number of exceedances of a particular guideline) versus biological effects; or
- quantitatively by single chemical value and associated biological effects.
- use larger Ecology sediment quality data base instead of yearly dredging data.

This section deals with analyses under the first bullet, and the next one addresses the second bullet. For the present analysis, stations that exceeded ML for any chemical are excluded because the focus is on the SL to ML interval. Also, the influence of realized detection limits above the SL will be examined, since this is a recurring problem in PSDDA testing. The appendix also displays all biological hits and failures in respect to numbers of guideline exceedances.

Figure 3. Biological Responses by Test Organism and Intensity of Response (e.g., Hit, Failure) versus Low Moderate Values. See text for interpretation.

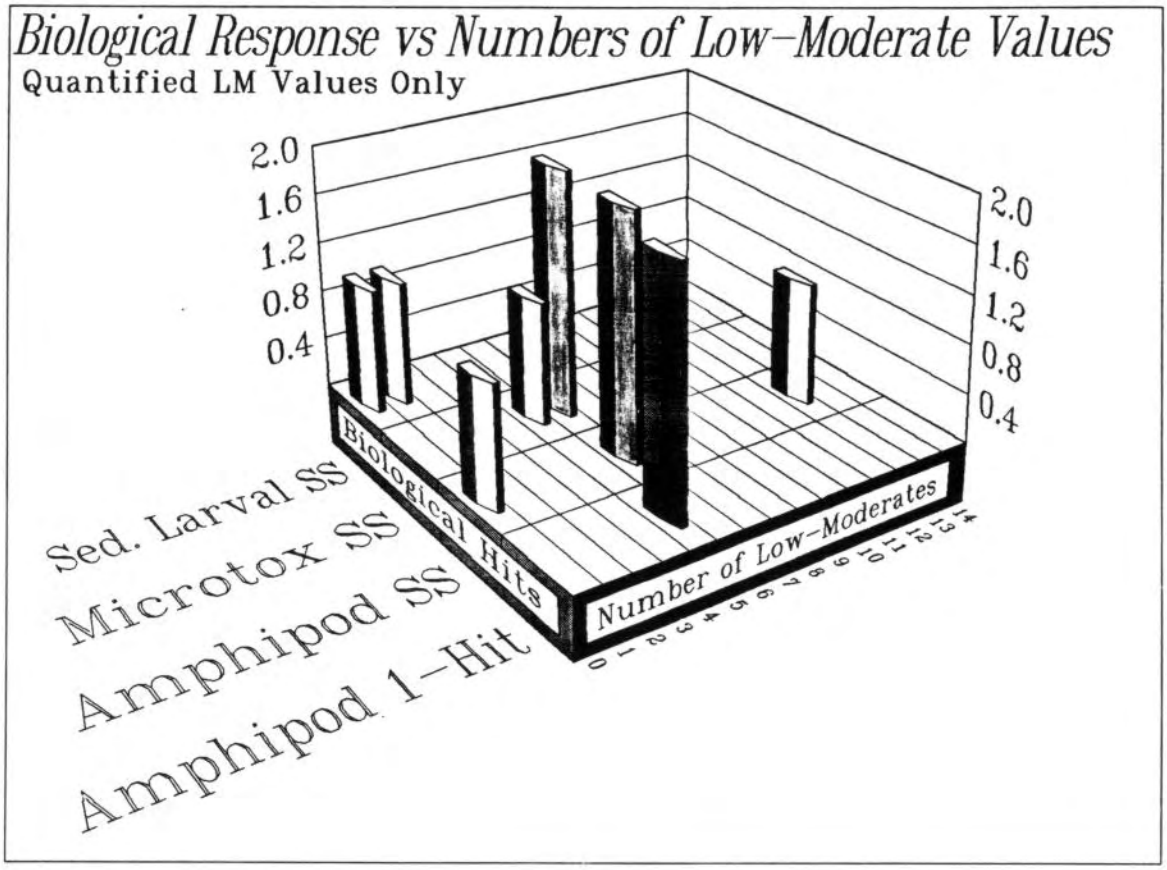


Figure 3 shows all the biological responses that occurred in DY 90, on an axis of increasing numbers of exceedances in the range SL to (SL+ML)/2 (the low-moderate range shown in figure 2). Discussion in Appendix IV indicates that all of the hits or failures occurred in this range during this DY, so this is the same as the numbers of SL exceedances. The amphipod single-hit response (shown in the figure as a dark bar) occurred in two samples at 5 LMs or SL exceedances, and accounted for 2 of the 4 management units that had chemistry between the SL and ML and failed the nondispersive guideline. There were two double-hit failures (shaded in the figure), both with amphipod and microtox responses that were statistically significant (SS in Figure 3) and 20% over control. All of the rest of the biological responses met the nondispersive guideline. Note that the acute Neanthes test had no biological hits observed during its single application in DY 90.

It is evident that it is possible to exceed more than one SL and still pass the guideline, and this information will be of interest to dredgers who have to make a decision on whether to invest in biological testing based on their chemistry results. The analysis poses some management questions for the PSDDA agencies, shown in table 10.

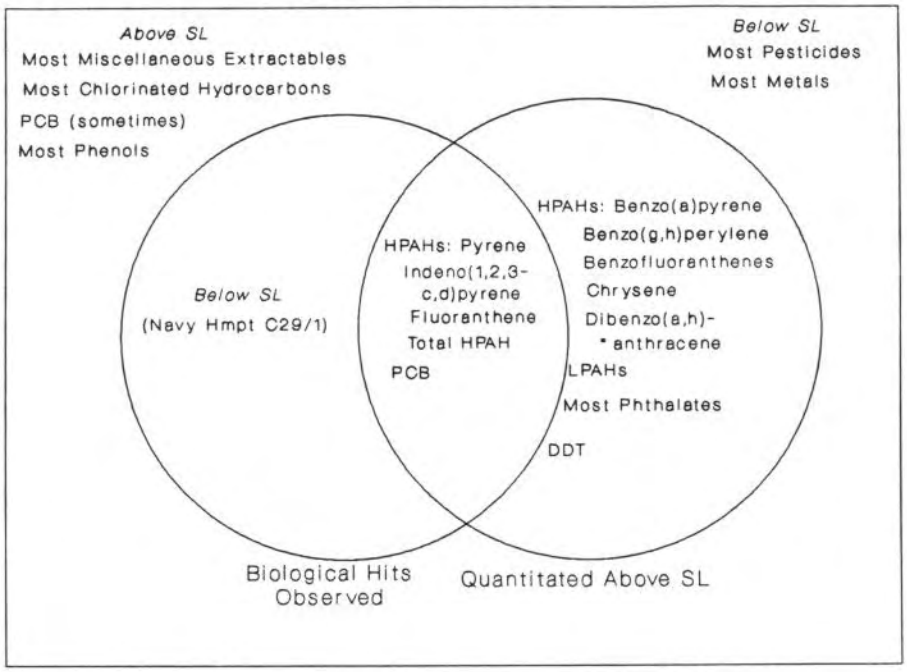
Table 10. Summary of Results of Analysis of Chemical Intervals and Biological Results.

Principal Question	Result assuming that undetected values indicate chemicals are present below SL (or other value).	Result assuming undetected values are present at detection limits.
What is the maximum number of SL exceedances that occur without material failure?	3	5
What is the minimum number of SL exceedances required to predict all biological failures?	5	7
What is the minimum number of occurrences of values between SL and (SL+ML)/2 that are required to predict all biological failures?	5	7
What is the minimum number of occurrences above (SL+ML)/2 that are required to predict all biological failures?	0 (All were predicted in the preceding block)	0 (All were predicted in the preceding block)

The fact that several exceedances of SL may occur is consistent with the PSDDA program for the "gray area," and the agencies have not agreed at this time to try to "optimize" the SL in such a manner that fewer SLs exceedances would serve to predict all of the failues.

Also, numerous compounds of concern were detected or quantitated above the SL but were not associated with biological hits or failures during this dredging year. WPPA representatives have asked that these be displayed quantitatively to determine whether the SL is too conservative for these compounds, but there have not been sufficient data in this dredging year and the development of DAIS does not yet permit this to be done in an automated manner. The following figure characterizes the data set qualitatively.

Figure 4. Chemical and Biological Summary
DY 90 Data Set



(Only amphipod, microtox, sed. larval tests used)

The figure is a Venn diagram, in which the box represents all samples that were analyzed for both chemistry and biology during DY 90. The circle on the right represents the samples that had chemicals of concern quantitated above the SL. The circle on the left comprises the subset of the samples that had biological hits observed. The remainder of the box includes all samples with no COCs quantitated above the SL. These comprise: samples that were quantitated below the SL (in the upper right hand corner - e.g., metals and pesticides) and those that were often reported as undetected with detection limits above the SL value for some of the chemicals of concern (in the upper left hand corner - e.g., phenols). This latter condition is very important, because the PSDDA agencies have made an administrative decision (described in the Phase II MPR) to treat these nondetected values as though the compounds were present above the SL. Accordingly, biological testing is required. The circles' intersection specifies those compounds that have both quantitated SL exceedances and biological effects observed. The compounds inscribed in that portion of the right-hand circle that does not intersect the circle on the left are the primary concern of WPPA.

There are several important points in this diagram for the PSDDA agencies. First, there are evident quantification problems represented by the groups of chemicals in the upper left corner of the box. These are the compounds that have been responsible for the greater number of SL exceedances or LM levels that are required to predict all of the failures (see table 10). The PSDDA agencies are currently working with the contract labs to discover what may be done to improve this. Second, while the compounds of concern to WPPA have been identified from this data set, next dredging year's data may tell a different story. (As of this writing, a good many more failures of material are being reported during DY 91.) The PSDDA agencies will determine a priority and a time frame for looking at these compounds when they judge that there is sufficient and stable information on their behavior. Then, it would be logical to use the Ecology data base to access and

consider a greater amount of information, perhaps applying the "sensitivity" test[3] to raised SLs. Third, the compounds in the circles' intersection deserve a closer look to assure that the SLs are protective once the agencies deem that there are sufficient data. (A first look is given in the next section of this report.)

Tentative conclusions from the analyses described in this section include:

- Several SL exceedances appear to be needed to predict failure of a dredged material sample. This is not inconsistent with the PSDDA management approach. Moreover, this data set is too small to suggest a modification of SLs at this time. Biological hits that did not represent material failures occurred below 3 cumulative quantified SL exceedances.

- All of the biological failures occurred between SL and (SL+ML)/2.

- It is probably too soon to determine whether SLs are in need of revision. In future years' analyses, when there are more biological responses registered, it may be fruitful to examine chemicals that frequently occur above SL and are not associated with biological responses.

- Influence of undetected values above the SL is very noticeable on the ability to predict failures, and should be a priority for the PSDDA agencies to address.

No management decisions based on the analysis are recommended for this year's Annual Review Meeting. It should be noted additionally that, in the subject DY, only the nondispersive guideline was applied.

3. Chemical Exceedances and Biological Responses, Part 2. The following describes the results of biological testing versus levels of individual chemicals that appear to be associated with biological failures. The chemicals or suites of chemicals that appeared to be correlated with failures were indeno(1,2,3-c,d)pyrene, pyrene, total HPAHs, total PCBs, and fluoranthene.

The comparison asks the question: for those compounds associated with material failures, where do failures occur? (This question is principally keyed to the SL - ML interval, but for this analysis, the failures above ML have been added to the data set considered. This is why the number of raw failures that occur in the following figures is greater than the number in the previous section.) It was necessary to normalize the SL to ML scale for the comparison because several of the chemicals had MLs that do not follow the usual rule of ML = 10 X SL, so that scales would have differed for them. The normalization is shown in figure 5.

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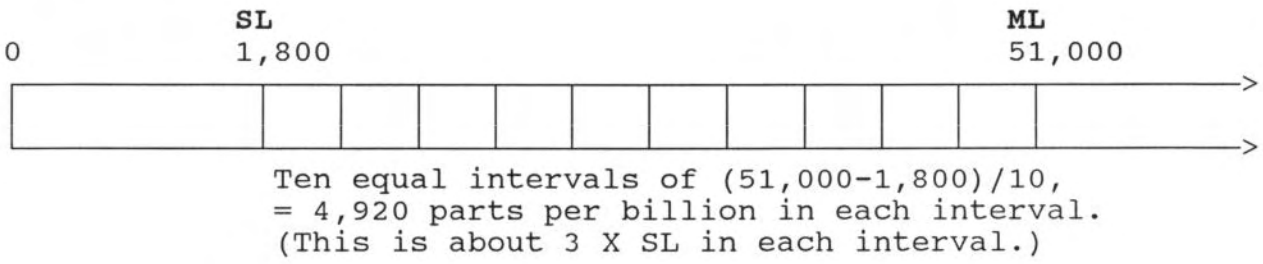
[3] Barrick, R., L. Brown, and S. Becker. 1988. Sediment Quality Values Refinement: Volume II--Evaluation of PSDDA Sediment Quality Values. Report prepared by PTI Environmental Services EPA's Office of Puget Sound (now Office of Coastal Waters).

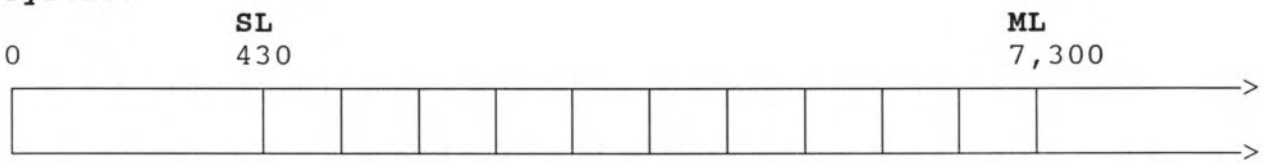
Figure 5. Examples of normalized SL-ML intervals.

Total HPAHs:



Ten equal intervals of (51,000-1,800)/10,
= 4,920 parts per billion in each interval.
(This is about 3 X SL in each interval.)

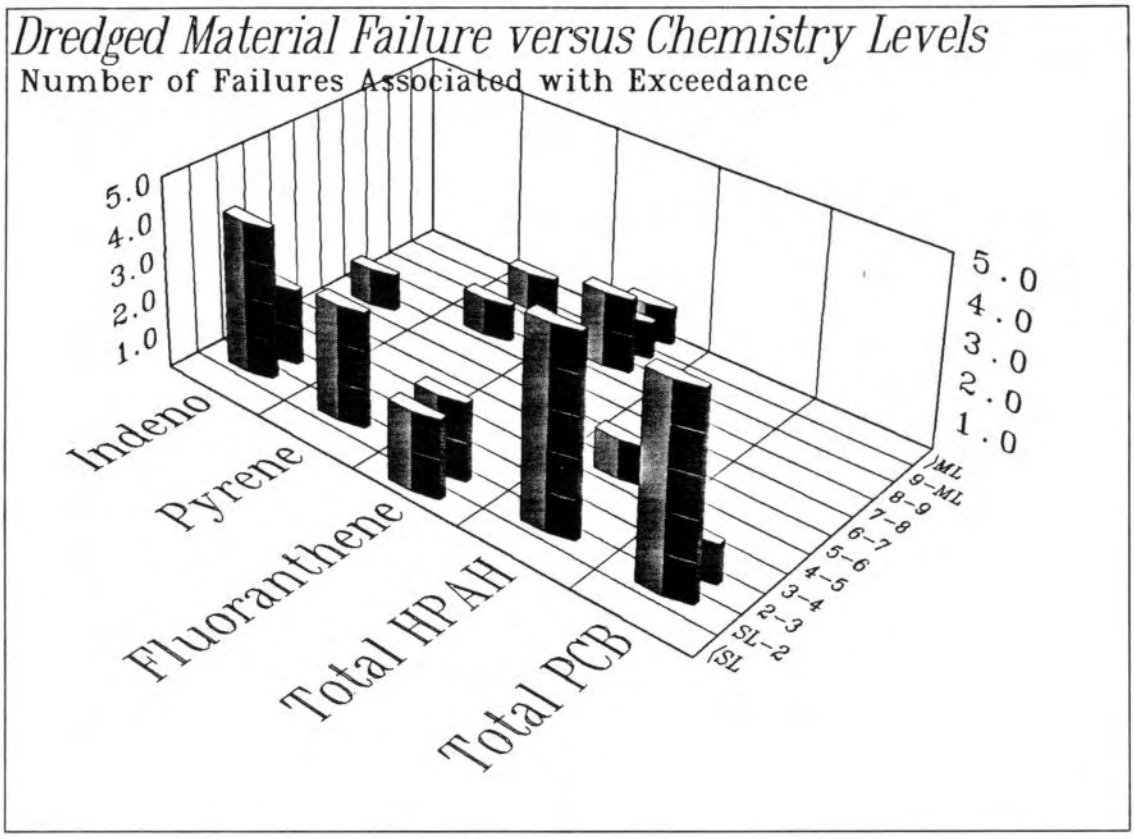
Pyrene:



Ten equal intervals of (7,300-430)/10,
= 687 parts per billion in each interval.
(This is about 1.6 X SL in each interval.)

Figure 6, below, displays the biological failures ordinated on an SL-to-ML scale.

FIGURE 6.



For these compounds, many of the failures occurred close to the SL end of the range. The SLs appear to be protective: the results of all except 2 failures (fluoranthene) were seen above SL. The fluoranthene failures were predicted by other SL exceedances in co-occurring compounds. Nonetheless, these compounds may need to be watched in future to assure that this pattern persists. If a converse pattern had been noted, with most failures occurring near the ML and few or none near the SL, it might suggest a review to determine whether the SLs are set artificially low.

It is important to note that the observed pattern in the figure could come about for reasons other than strict observance of the SL - ML interval:

- in DY 90, there are more samples with SL exceedances in the low range than in the high range, which gives more opportunity for failures near the SL; and

- the compounds in the table often occur together (and total HPAHs includes fluoranthene, pyrene, and indeno(1,2,3,-c,d)pyrene), so the compounds are probably not acting independently, and could influence the patterns seen in the data. This would improve with a greater number of sediments.

Despite these shortcomings, visualizing performance provides a possible means of looking at future years' data. However, due to the limitations in the data, no management decisions based on this analysis are recommended for this year's Annual Review Meeting. Ongoing changes to tests or to chemical screening levels are also likely to influence the interpretations and patterns in the data. Because these analyses at present are labor intensive and have not been automated, it is recommended that the PSDDA agencies reconsider the need to perform them on an annual basis. Ecology's sediment quality data base can perform automated sensitivity tests, accordingly, it is recommended that it be used preferentially to perform these types of analyses.

F. Volumes tested failing disposal guidelines at each PSDDA Disposal Site.

Table 11 summarizes the dredging volumes tested for each disposal site, volume failing the PSDDA disposal guidelines, and volume disposed of at each site. A total of 1,718,337 cubic yards of dredged material was tested under the PSDDA disposal guidelines during DY 90 for unconfined open-water disposal. See Table 1 for a project specific summary on testing and disposal.

TABLE 11. DISPOSAL SITE SUMMARY OF TESTED/DISPOSED VOLUMES FOR DREDGING YEAR 1990.

DISPOSAL SITE	VOLUME TESTED (CY)	VOLUME FAILING (CY)	PERCENT FAILING	VOLUME DISPOSED (CY)
Elliott Bay	378,737	23,100	6.1 %	129,542
Port Gardner	975,000 (64,600)[a]	0	0 %	992,074
Rosario Straits	364,600 (93,000)[b]	0	0 %	0
DY 1990 TOTAL:	1,718,337	23,100	1.3 %	1,121,616

[a] tested during DY 1989 with 41,349 cubic yards being disposed during DY 1990, and an additional 20,000 cubic yards disposed during November 1990 (DY 91).

[b] tested during DY 1989 for the Swinomish Channel maintenance dredging project, with dredging/disposal commencing during December 1990 (not included in total).

Of the 378,737 cubic yards tested for disposal in Elliott Bay, two projects (METRO Emergency Bypass Outfall and U.S. Coast Guard Pier 35) totalling 53,875 cubic yards have been canceled, while a third project, the U.S. Navy Manchester Fuel Pier Project has been reduced in scope from 181,830 cubic yards to 80,000 cubic yards. The Section 10/404 permit to do the dredging and pier construction for the Navy Manchester Fuel Pier Project has recently been issued. While collectively only 6.1 percent of the material tested for disposal at the Elliott Bay site failed the disposal guidelines for UCOWD, project specific test results showed that 13 percent of the material tested for maintenance dredging from the upper Duwamish River failed, whereas 47 percent of the U.S. Coast Guard material failed, and 42 percent of the Pope and Talbot material failed PSDDA disposal guidelines. All the Navy Manchester Fuel Pier dredged material was found to be suitable for UCOWD.

The bulk of the material tested for the year came from one project, the U.S. Navy Homeporting Project at Everett, Washington, with 950,725 cubic yards of material going to the Port Gardner site. One additional project, the Port of Everett Marina Project contributed 41,349 cubic yards to the DY 1990 total (note that this project underwent testing during DY 1989). All the Navy material passed the UCOWD nondispersive guidelines.

The Section 10/404 permits for the two projects proposing to dispose their material at the Rosario Straits disposal site are still in review, but passed the more rigorous disposal guidelines for dispersive sites.

G. PSDDA Processing of Non-Corps Dredging Projects.

There is a sequence of steps in the regulatory process through which dredging projects must move before receiving a permit under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. These are as follows:

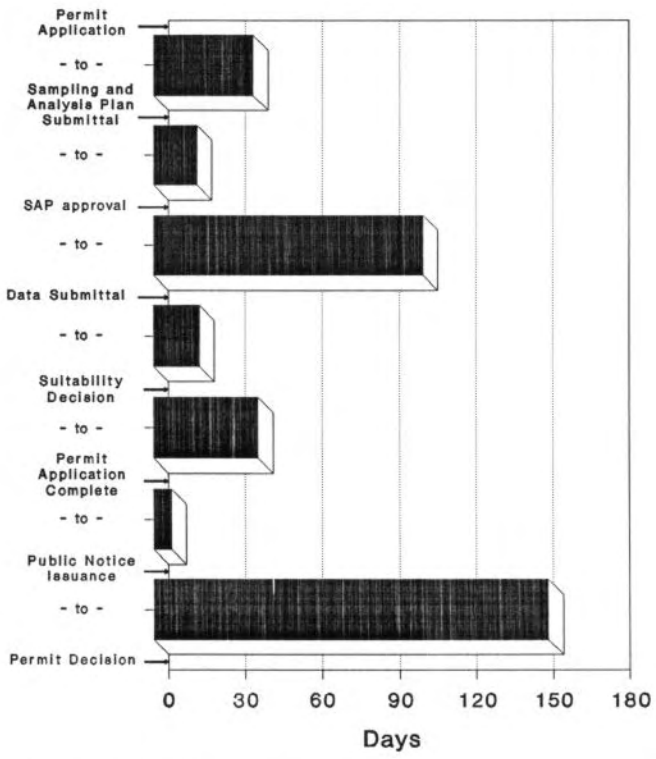
(1) Submit application for permit.
(2) Prepare sampling and analysis plan for characterization of proposed dredged material.
(3) Receive approval of sampling and analysis plan from PSDDA agencies.
(4) Perform sampling and chemical/biological analysis.
(5) Submit testing results.
(6) Receive suitability decision 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 Figure 7, which was constructed using data from DY 90 dredging projects.

1. 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 Corps' Dredged Material Management Office begins review of information relevant to the proposed dredging.

Time Elapsing For Each Regulatory Stage:



PSDDA Processing Time:

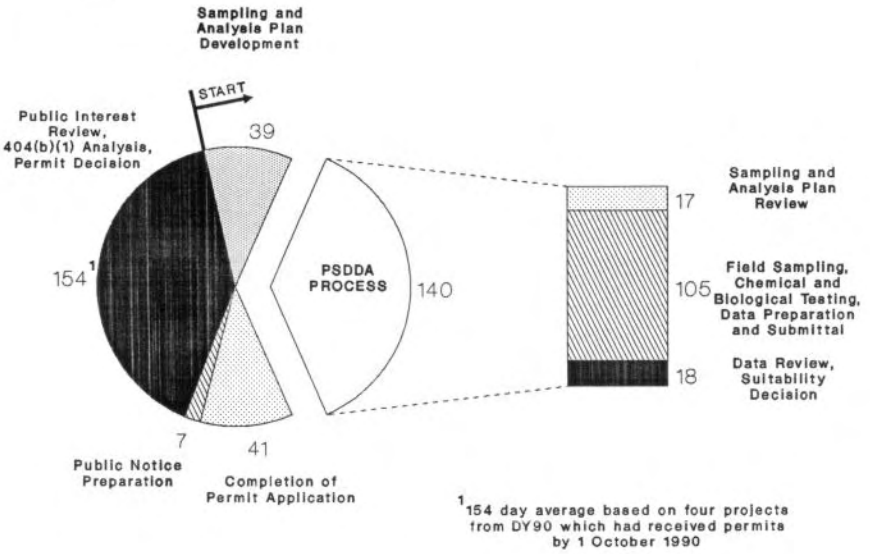


FIGURE 7 - REGULATORY PROCESSING TIME

Averages for DY90 Projects

2. Sampling and Analysis Plan (SAP) Development.

A plan for characterization of the proposed dredged material must be developed. This may include a review of historical data for ranking considerations, dredging volume computations with a field sampling plan adequately characterizing that volume, division of the dredging volume into dredgeable management units, a chemical analysis plan including adequate QA/QC, contingencies for biological analysis and reporting requirements, among other important elements. The SAP may be submitted at the time of permit application. Dredging consultants are required to submit plans which are complete and fully adequate to characterize the proposed dredged material. During DY90, considerable time and effort were invested in improving the quality of SAP's submitted.

3. Sampling Plan Approval.

Once a complete sampling plan has been submitted, the Dredged Material Management Office coordinates review of the SAP with the other PSDDA agencies: the Environmental Protection Agency and State of Washington Departments of Ecology and Natural Resources. PSDDA-agency comments are forwarded to the dredging consultant. If substantial issues need to be addressed, resubmittal of the SAP is required. Otherwise, an approval letter is sent which includes minor comments and corrections to the SAP. At this point, sampling and analysis may proceed. It is the goal of the Dredged Material Management Office to complete the review of SAP's within three weeks. During DY 90 the average time from submittal of the final SAP for a project to SAP approval was 17 days.

4. Sampling and Analysis.

During this phase field sampling and chemical/biological analysis are completed following the protocols laid down in the approved SAP. Data is compiled and submitted both in a hard-copy report and on the Corps' DAIS spreadsheets. Sampling and characterization consume a substantial portion of the PSDDA Process time budget, averaging 105 days during DY 90. There was also a high degree of variation in this phase with projects ranging from 41 to 210 days for DY 90.

5. Data Review.

Once a full set of chemical/biological testing data is submitted along with a sampling report, the Dredged Material Management Office coordinates 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 decision reached on the suitability/unsuitability of each of the dredged management units defined in the approved SAP. Once again, the goal of the Dredged Material Management Office is to complete this review within 3 weeks of data submittal. In DY 90 the average time required was 18 days.

6. Complete Application Permit.

When the suitability decision has been made, the Dredged Material Management Office informs the Regulatory Branch project manager and preparations are made to go out to public notice. At the time of original application, construction details may not have been known for the project. Alternatively, construction plans may be altered due to the suitability decision reached. In these cases

new drawings may be required of the applicant along with any other information pertinent to the preparation of the Public Notice for the project.

Often times the local shorelines decision runs concurrent to PSDDA testing. The decision may be made to wait to go to public notice until the local shorelines jurisdiction has issued a permit. In this case there may be a time lapse between the suitability decision and the public notice.

For DY 1990, processing took an average of 41 days to finalize the permit application before a public notice could be prepared with times ranging from 2 to 119 days.

7. Public Notice Preparation.

By regulation, the Regulatory Branch must issue a public notice within 15 days of completion of the permit application. For DY 1990 the average time for Public Notice preparation was 7 days.

8. Public Interest Review and Permit Decision.

A PSDDA dredging 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 usually 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 times only part of complex projects. Other elements may be involved, such as wetland fills or eelgrass bed impacts or development of appropriate mitigation. Resolution of these and other controversial issues may consume additional time after the PSDDA suitability decision has been made. To improve regulatory response time, the Washington Department of Ecology recommends that applicants seek an hydraulic project approval (HPA) from the Department of Fisheries and resolve other problems (e.g., wetlands-related) earlier in the permit process. Pre-application meetings could serve to improve some turn-around times and could themselves be held earlier in the process.

This stage required more time than any other during DY 90, averaging 154 days per project and ranging from 77 to 261 days. Analysis for this stage was based on the four projects from DY 1990 which received permits prior to October 1, 1990: Lonestar Northwest, Metro Denny Way Capping, US Navy Homeport-Element I and US Navy Manchester Fuel Pier Replacement.

9. PSDDA Processing Time.

PSDDA processing time, as depicted in the lower part of Figure 7, includes sampling and analysis plan review and approval, field sampling and analysis, data review and suitability decision-making. This took an average of 140 days per project for DY 1990, with the majority of that time taken up by actual sampling, analysis and data preparation. Sampling and analysis plan preparation, although part of the PSDDA process, was not included due to the wide variation in time which can elapse between permit application and sampling and analysis plan submittal. This is largely outside the control of the PSDDA agencies.

IV. CONCLUSIONS AND RECOMMENDATIONS.

A. PSDDA Guideline Applications.

Projects tested during the 1990 dredging year covered by this report generally complied with PSDDA sampling and testing guidelines, which allow for best professional judgement in interpreting test data (EPTA, page II-106; Phase I MPR, pages A-17 and A-25).

1. Summary Comparison of 1989/1990 Applications.

In general, a comparison of the performance for chemistry and biological testing conducted showed that applicants/agents/laboratories have improved during the 1990 dredging year. The improvements in QA/QC performance between DY 1989 and 1990 were encouraging, and are expected to improve through ongoing coordination with dredgers/applicants and laboratories through workshops, and the annual review process. A workshop is scheduled for January 24, 1991 with chemistry laboratory chemists to discuss detection limit problems and QA/QC requirements relative to the PSDDA program. The PSDDA User Manual is expected to be in a draft-final form in January 1991 and will be made readily available to dredgers/applicants and laboratories conducting PSDDA testing.

2. Topics of Special Concern.

The following topics surfaced during the 1990 dredging year and are discussed below.

a. Bioaccumulation Trigger for PCB. With the finalization of the PSDDA study, a change to the total PCBs human health bioaccumulation trigger value specification was made that is described in the Phase II MPR, pages 5-14 through 5-16. The trigger value was increased from 1,789 ppb (dry weight sediment basis) to 38,000 ppb (dry weight, total organic carbon [TOC] basis).[4] As explained in the cited text, the change better characterizes the biological availability of the compounds in the aquatic environment, and is equivalent to the former value at about 70% solids (30% water) and 3% TOC in the sediment and a 3% lipid value in the organism.

The change did not affect any of the suitability decisions on projects during DY 90. What follows is a discussion that is not reflected in the summary tables and appendices because of the rules change. Several projects during this period, for which suitability decisions were made prior to rule change, would have exceeded the current bioaccumulation trigger due either to high detection/quantitation limits or to very low reported values of TOC. The discussion also suggests updates for the values used in the theoretical bioaccumulation calculation that could be used for a better specification.

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[4] Please note that the value in table A.8 on page A-27 of the Phase II MPR erroneously states 38 ppb, not 38,000 ppb. The correct value of 38 ppm (38,000 ppb) is given on page 5-16. A change page has been issued to correct the error.

The current SL for total PCBs is 130 ppb, and this is the required detection/quantitation limit specified by the PSDDA agencies in the Phase II MPR. According to the PSEP Recommended Protocols Guidelines, the achievable detection/quantitation limit for total PCBs is in the range of 10-50 ppb; and the precision of the TOC measurement is to the nearest 0.01g in a 50g minimum sample size, or 0.02+/-0.01%.

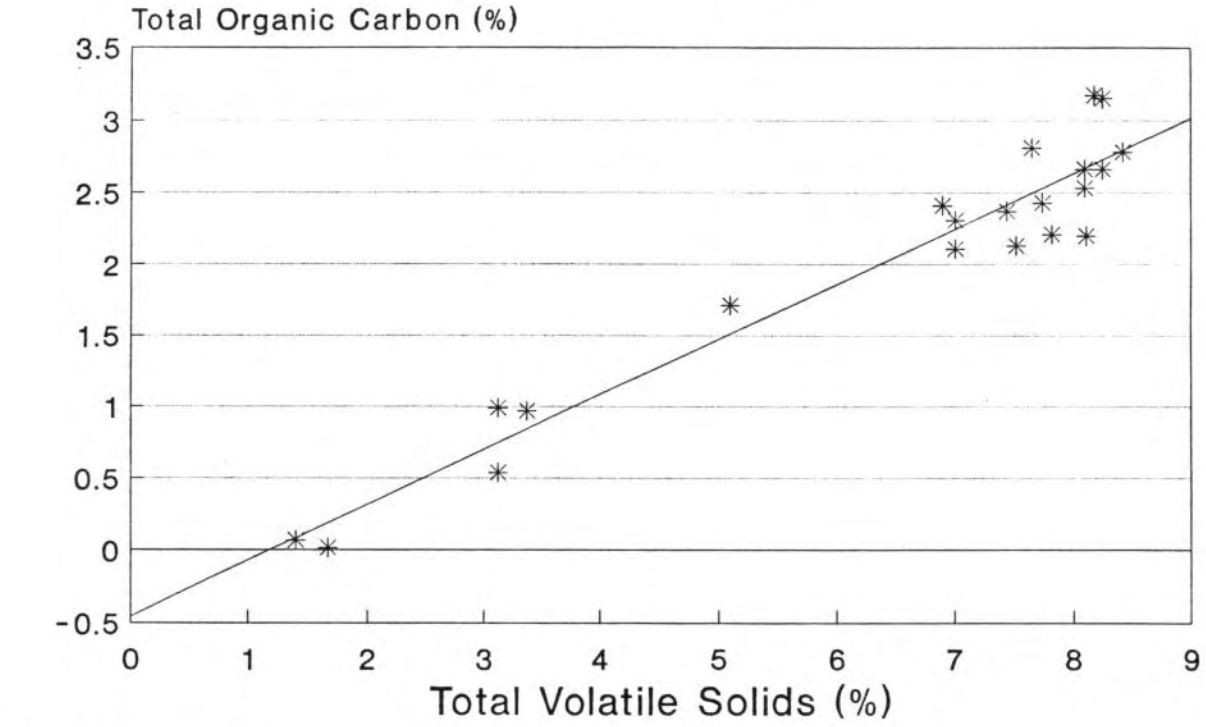
TABLE 12 indicates the samples that would have shown problems according to these specifications.

Sample--Composite	PCB,ppb	TOC,%	PCB/TOC	Problem
Duwamish--C1/1	9.6 U	0.013	73,846	Low TOC
METRO Emerg Byp C1/1	100 U	0.05	200,000	Low TOC, High U Value
METRO Emerg Byp C2/1	100 U	0.05	200,000	Low TOC, High U Value
METRO Emerg Byp S1/1	126	0.07	180,000	Low TOC
METRO Emerg Byp S2/1	200 U	0.08	250,000	Low TOC High U Value
METRO Emerg Byp S3/1	200 U	0.09	222,222	Low TOC, High U Value
METRO Emerg Byp S4/1	200 U	0.39	51,282	High U Value

The Duwamish O&M sample C1/1 showed an undetected value of 9.6 ppb (satisfactory according to the stated PSEP range) but a very low reported value of 0.0013% TOC. This value was determined to be reasonable but not significantly different from zero by linear least-squares regression of TOC on total volatile solids (Figure 8). Clearly, since division by zero is undefined and the TOC-normalized PCB value increases very rapidly as zero is approached, the theoretical model does not apply very well with very low TOC.

The Computerized Risk Assessment Bioaccumulation System (CRABS), an expert system authored by Henry Lee II and Bruce Boese, was consulted to discern whether the results of the calculation are reasonable. CRABS provides reasonable choices for the other required parameters depending on bioaccumulation organism selected, and compares bioaccumulation calculations to tissue values reported in the literature. In the present instance, Macoma nasuta, the bioaccumulation organism specified in PSDDA and recommended in the 1990 EPA/Corps "Draft Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters" was selected. Values from the literature for this species were used: an accumulation factor of 4 (more than twice the value of 1.72 used in the PSDDA Phase II MPR) and a lipid value of 5.5%, wet-weight basis. CRABS reported the resulting value of 15,990 ppb to be well out of range of the reported values (5,400 ppb is the 99th percentile reported in NOAA, 1988). Thus, there is further reason to believe that the model is not adequate at this low level of TOC.

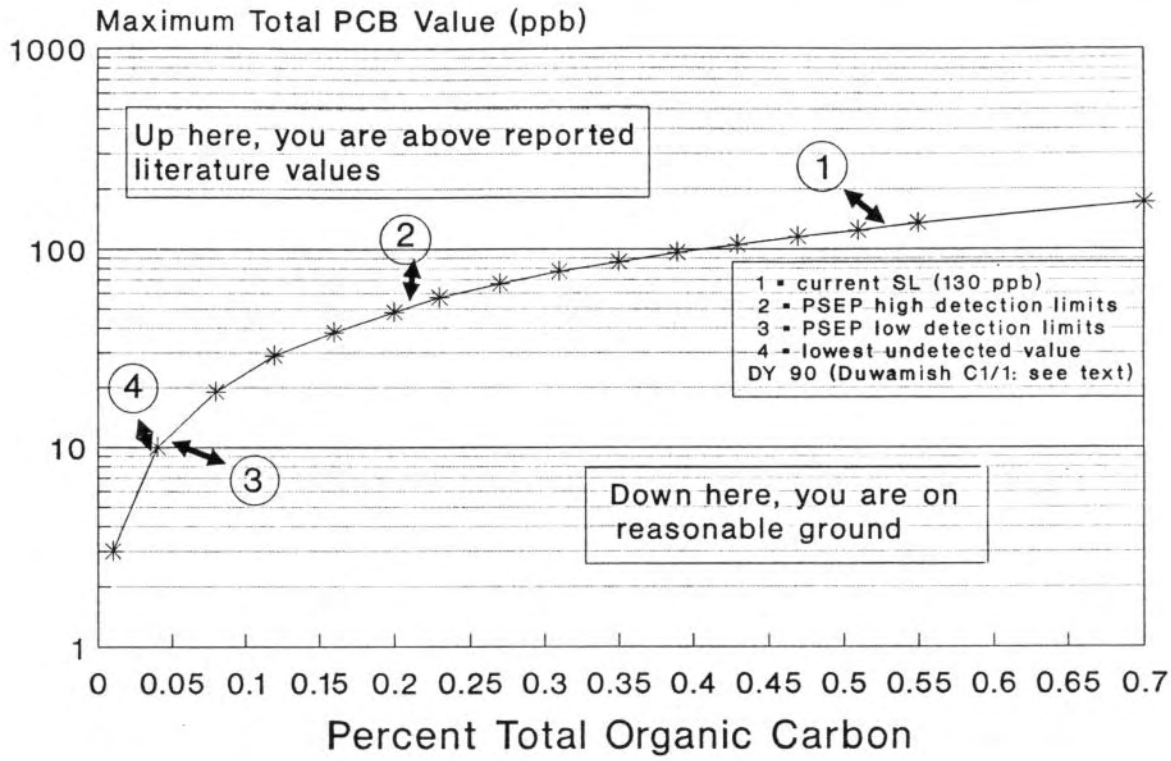
Figure 8. Duwamish O&M Conventionals Regression of TOC on TVS



All but one of the calculations reported above would be tagged as "out of range." Figure 9 shows a graphical solution of the greater-than-the-99th-percentile-out-of-range problem, with various values illustrated for comparison. The figure illustrates that theoretical bioaccumulation calculations are not reliable at low concentrations of TOC. Best professional judgement should be applied in determining whether the bioaccumulation trigger for PCB has been exceeded, when TOC levels are at 0.5% or lower. Careful consideration must be given to the interpretation difficulties that would result from doing bioaccumulation testing when TOC is low enough to produce unreasonable theoretical values (as compared to literature values). Also, calculations indicate (not shown on this graph), that the PSDDA total PCB SL of 130 ppb is higher than the PSDDA bioaccumulation trigger value at TOC values below about 0.18%. These TOC values are very low compared to the "average" Puget Sound value discussed in the Phase II MPR. Work is ongoing to determine the frequency that Puget Sound dredged sediments might fall into this low range. The PSDDA agencies should provide information to prospective dredgers that these low levels of TOC require particular attention to the precision of the conventionals testing as well as the PCB analysis.

Of the 7 total PCB values reported in Table 12, 3 are undetected above the SL, and would require retesting currently. These values, if they are appropriate to use for the bioaccumulation calculation, would necessitate bioaccumulation testing to take place. The PSDDA agencies need to make certain that reasonable detection limits for PCBs are attained.

FIG. 9. Graphical Solution of Bioaccumualation Where Theoretical B/A Goes Bad!



b. Chemistry Quality Assurance/Quality Control Conclusions and Recommendations. The following is a description of performance during DY 90.

(1) Overview. For DY 90, QA/QC for chemical analyses was generally very good. Quality control for chemical testing was analyzed for all eleven projects. No major problems were encountered in any of these projects. Accuracy was evaluated as a function of reference material, matrix spike and surrogate spike recoveries. For metals, certified reference materials and matrix spikes were utilized in tandem for most projects and provided a solid basis for accuracy determinations. For organics, there were minor problems with matrix spike recovery, but poor matrix spike performance alone is not taken as a sufficient basis for rejecting chemical testing results. Low matrix spike recoveries may result from matrix interferences in the sample. Surrogate spike recovery, which is the only QA/QC check performed for every sample, is deferred to when matrix spike recoveries are questionable. Only about five percent of surrogate-spiked samples exceeded PSDDA warning limits while none at all exceeded EPA CLP control limits. Precision, as measured by replicate analyses, was excellent for all projects. Method blanks detected no major problems with laboratory contamination.

In the details which follow, an objective analysis of both chemical testing results and PSDDA performance limits was performed with the use of a secondary set of standards. Analytical results were compared to the Environmental Protection Agency's Contract Lab Program (EPA CLP) control limits to provide an inter-standard evaluation of quality control.

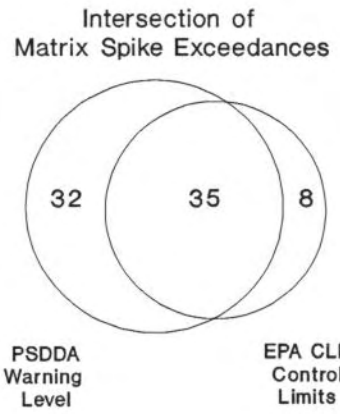
(a) Matrix Spikes. Matrix spikes were utilized in all projects. All projects had exceedances of the PSDDA warning limits and nine also showed exceedances of the EPA CLP control limits. In all there were 640 analyses of matrix spikes. Of these, 79 exceeded PSDDA warning limits.

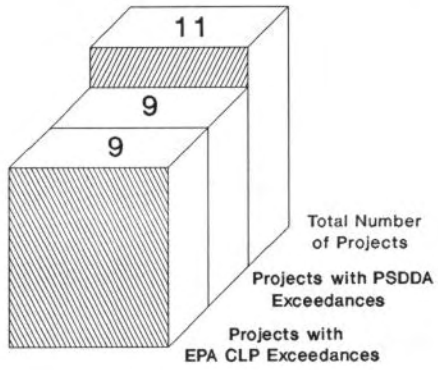
Of the 58 PSDDA chemicals-of-concern there are 21 with corresponding CLP limits. There are an additional ten chemicals with CLP limits which are routinely used by testing labs doing PSDDA work. There were 491 matrix spike analyses of 30 of these analytes (endrin was the only CLP chemical not used). Of these analyses, 67 exceeded PSDDA warning limits while 43 of these exceeded CLP limits. See Figure 10 for a graphical comparison. The intersection of these exceedances can also be seen in the figure. Of the total number of exceedances 35 were common between the PSDDA and CLP limits. In 32 cases, the PSDDA warning limit was more restrictive than the CLP control limits, while in only 8 cases was the CLP limit more restrictive. This is as expected since the PSDDA standard is a warning limit which should be triggered more often than an analytical control limit.

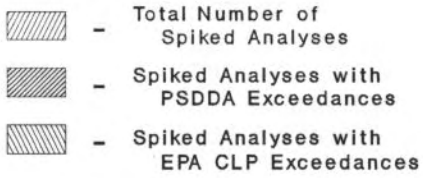
Of the metals, the analytes exceeding both PSDDA and CLP limits most frequently were antimony, arsenic and silver with 3 projects exceeding each. Extremes in ranges (in % recovery) were seen for arsenic (23-108), silver (65-179) and zinc (10-172). Only cadmium and lead had no exceedances.

For the organics, lindane and heptachlor had the most numerous projects with exceedances of CLP limits at three each. PSDDA limits were exceeded by projects most often for 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, heptachlor, pentachlorophenol, phenol and 4,4'-DDT, the first three with four exceedances and the last three with three exceedances each. The extreme ranges were for 1,2,4-Trichlorobenzene (34-74), pyrene (0-336), 1,4-Dichlorobenzene (14-75), pentachlorophenol (30-110), phenol (28-130), lindane (31-133), heptachlor (0-120), aldrin (25-131), dieldrin (27-120) and 4,4'-DDT (23-115). The volatiles were the most consistent in terms of recovery, with no exceedances of either PSDDA or CLP limits.

For matrix spikes the PSDDA warning limits seem to be at reasonable levels, being triggered more often on average than CLP limits and providing a quick check of data. In all cases in DY 90 in which CLP limits were triggered while PSDDA limits were not, the recovery was greater than 100%. Recoveries greater than 100% correspond to reported concentrations for those and similar analytes being higher than those actually existing in the test sediment. PSDDA has had no upper limit for matrix spike recovery. The minimum recovery under PSDDA warning limits is 50%. Only in the case of volatiles is the lower end of the CLP range more restrictive than PSDDA with minimum recovery requirements of 59-66%. PSDDA should change its minimum recovery to 70% for volatiles to ensure detecting recoveries outside the CLP control limits. For DY 90 this would still have resulted in no exceedances of the PSDDA warning limits. For all organics PSDDA should adopt the Puget Sound Estuary Program's (PSEP) upper limit of 150% for recovery. There were several instances in DY 90 of recovery much higher than 100% for which no CLP limits existed as a double-check on matrix spike recovery adequacy.







Exceedances are of PSDDA warning levels
and EPA CLP control levels

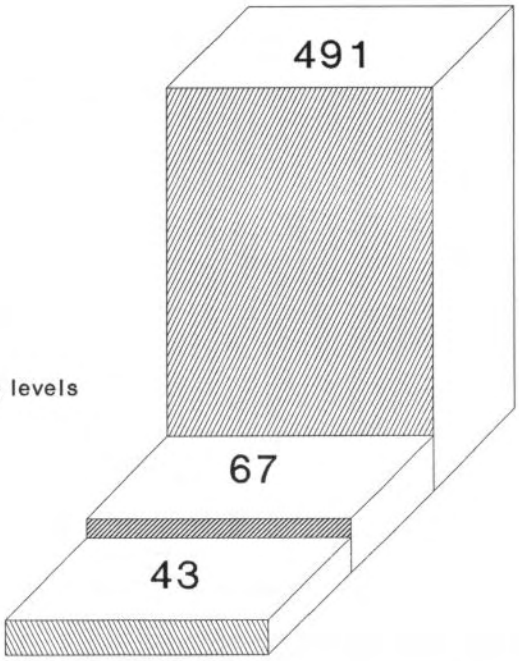


FIGURE 10 - MATRIX SPIKE RECOVERY

(b) Surrogate Spikes. Surrogate spikes were utilized in all eleven projects. Of those, eight showed exceedances of the PSDDA warning limits while there were no exceedances of the EPA CLP control limits. In all there were 1196 analyses of surrogate spikes (for test sediments only). Of these, 59 exceeded PSDDA warning limits.

There are 13 surrogates with CLP limits. Nine of these were used in at least one project during DY 90. An additional two chemicals without CLP limits were used routinely as surrogates as well. There were 939 surrogate spike analyses of the nine chemicals with CLP limits. Of these, 54 exceeded PSDDA warning limits while none of these exceeded CLP limits. While there were numerous exceedances of the PSDDA warning limits there was not a single exceedance of the CLP control limits. See Figure 11 for a graphical comparison.

Of all the surrogates, nitrobenzene-d5 and phenol-d5 had the most projects with exceedances of PSDDA warning limits with five projects apiece. 2-fluorophenol had four projects with exceedances while 2-fluorobiphenyl and 2,4,6-tribromophenol each had three projects with exceedances.

As was the case for matrix spikes, volatiles were the most consistent in terms of recovery with no exceedances of either PSDDA or CLP limits. Pesticides performed well also with only two project exceedances combined for three different surrogates used.

For surrogate spikes the PSDDA warning limits seem to be at reasonable levels, being triggered more often on average than CLP limits and providing a quick check of data. Only in the case of volatiles and pesticides is the lower end of the CLP limits more restrictive than the 50% standard set by PSDDA, with minimum required CLP recovery of 59-84%. PSDDA could change the lower end of its recovery limit to 85% for volatiles and 60% for pesticides to better screen these groups of chemicals. PSEP has adopted CLP control limits as action limits and PSDDA could do the same. Automated QA/QC evaluations by DAIS will make the use of chemical-specific limits feasible.

Noteworthy was the fact that neither of the two pesticide/PCB surrogates currently on the CLP list were used in any of the projects. Tetrachlorometaxylene and decachlorobiphenyl both are recent additions to the CLP list and have advisory limits only. During DY 90 the three pesticide surrogates employed were dibutylchlorendate (formerly on the CLP list), hexabromobenzene and isodrin. None of these three surrogates currently have CLP control limits established for them.

(c) Method Blanks. Of the 58 chemicals of concern, 14 were detected in method blanks in at least one of the projects. Six of these were metals and eight were organics (see Figure 12). For the metals, zinc occurred most frequently with five projects reporting detected concentrations ranging from 0.003-5.8 ppm. Lead, nickel and silver each were reported twice with maximum concentrations of 5, 6, and 0.11 ppm respectively. Of the organics, phthalates accounted for five of eight chemicals reported in blanks. Bis(2-ethylhexyl)phthalate, a common organic contaminant, was reported in the blanks of four projects with concentrations ranging from 6-370 ppb. The SL for bis(2-ethylhexyl)phthalate is 3100 ppb so the highest blank concentration represents only slightly more than 10% of the SL. The other three organics were each reported in one project only and at negligible concentrations.

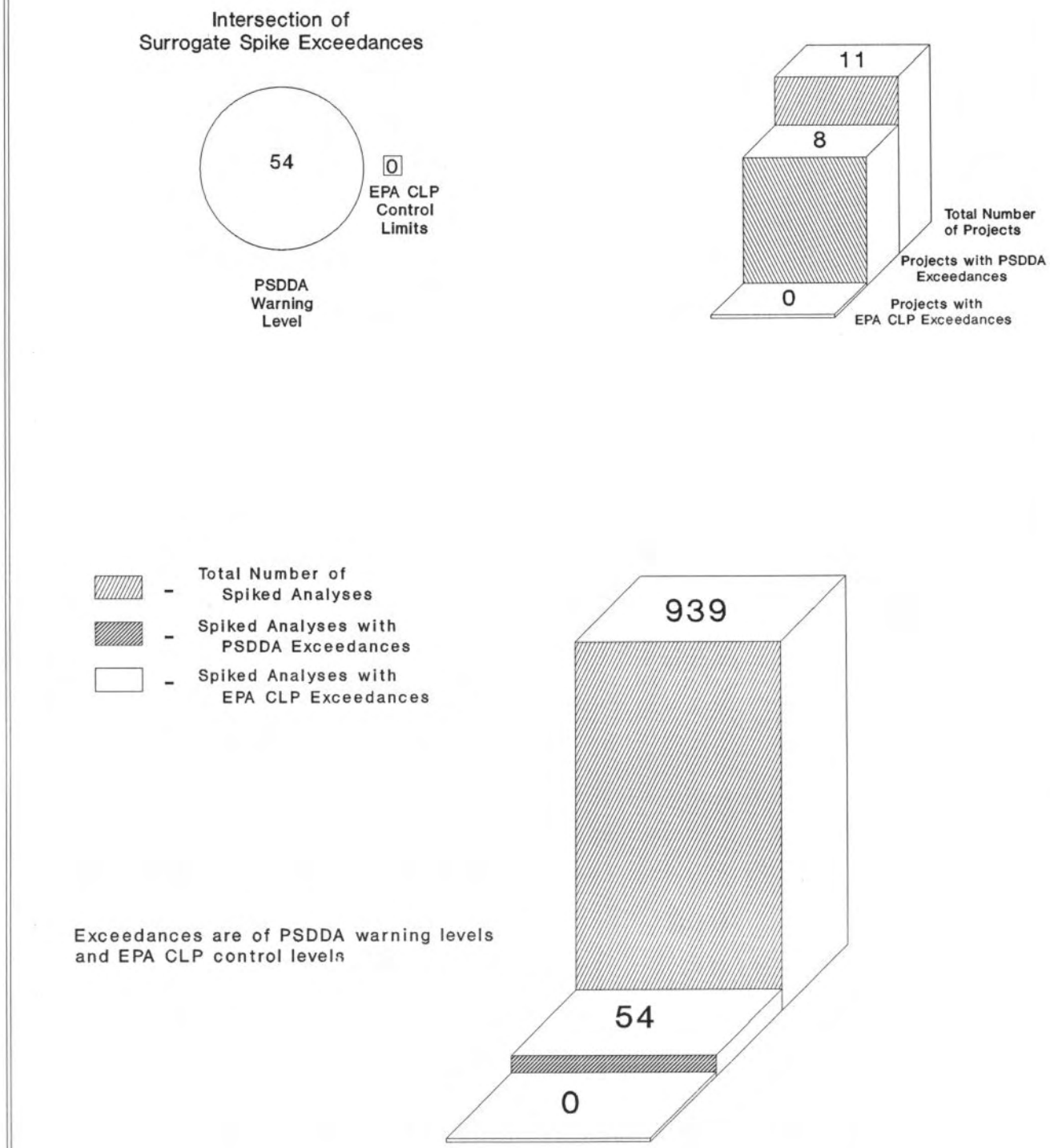


FIGURE 11 - SURROGATE SPIKE RECOVERY

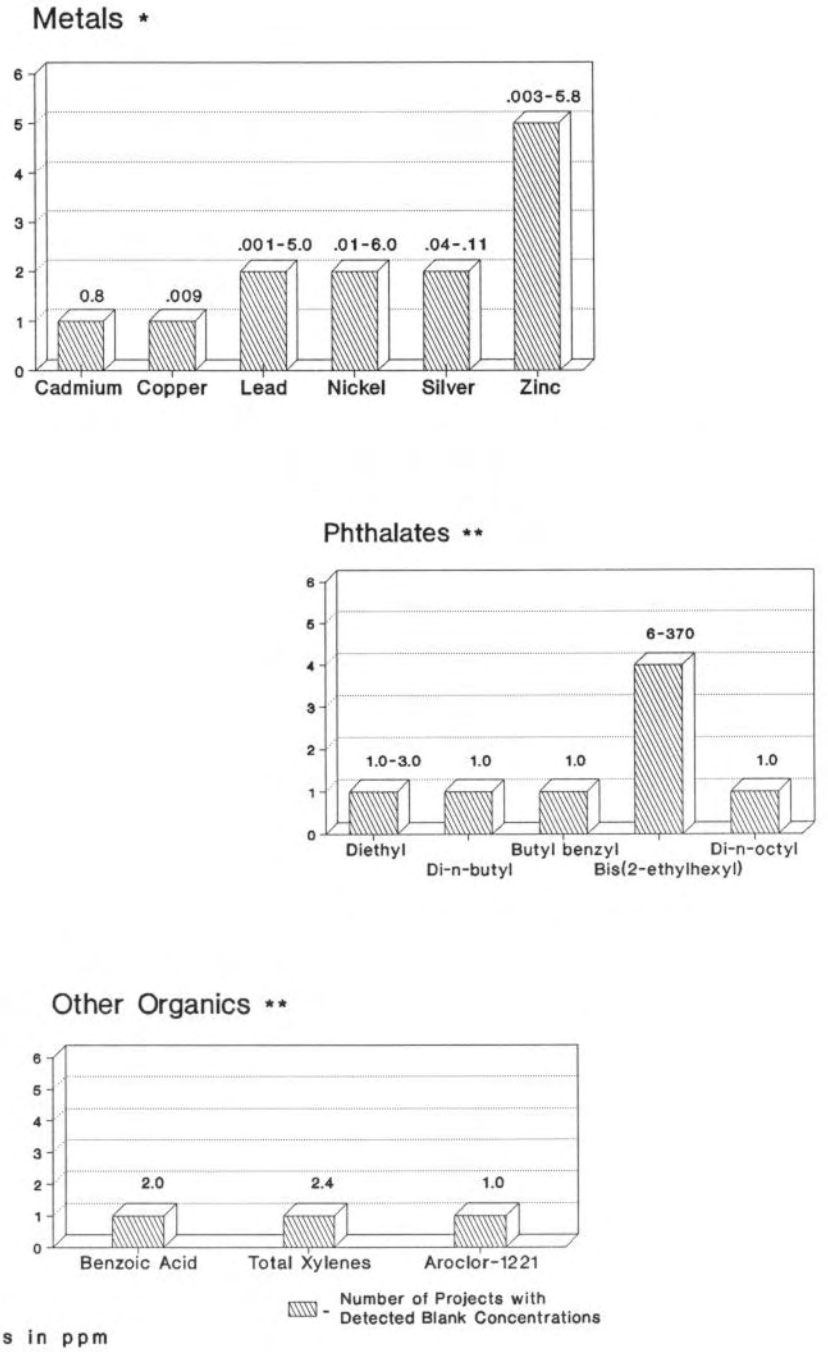


FIGURE 12 - METHOD BLANKS

(d) Certified Reference Materials. For certified reference materials (CRMs) the PSDDA warning limits are 80-120% for metals and within the 95% confidence interval (CI) for organics. In DY 90 nine projects performed CRMs for metals for which 95% CIs were also reported. For organics there were no CRMs with 95% CIs used. PSEP's Sequim Bay Reference material was analyzed in two projects while Canada's National Research Council's HS-3 was used for one project. Neither of these have interlaboratory certified 95% CIs.

For the metals, of the nine projects with reported 95% CIs, seven had exceedances of PSDDA warning limits while seven also had concentrations outside the 95% CI. There were a total of 99 analyses for metals with corresponding 95% CIs. Of these, 21 exceeded the PSDDA warning limit while 28 had concentrations outside the 95% CI (see Figure 13). Only 11 of the exceedances were shared in common which means that in 10 cases the PSDDA warning limit was more restrictive than the 95% CI while in 17 cases the 95% CI was more restrictive.

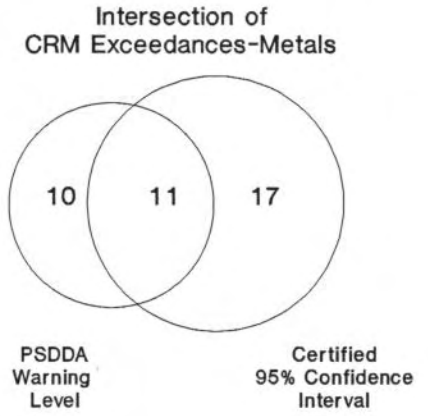
The metals with the most projects having PSDDA warning limit exceedances were nickel with five and antimony with four exceedances. Comparisons to 95% CIs yielded six projects with CRM values outside the 95% CIs for zinc, 5 for antimony, 4 for arsenic and nickel, and 3 for copper and mercury. In the case of CRMs for metals the PSDDA warning limits are not screening the data adequately with the 95% CIs being triggered more frequently than the warning limits. PSDDA should adopt the 95% confidence intervals associated with certified reference materials as action limits when these are available.

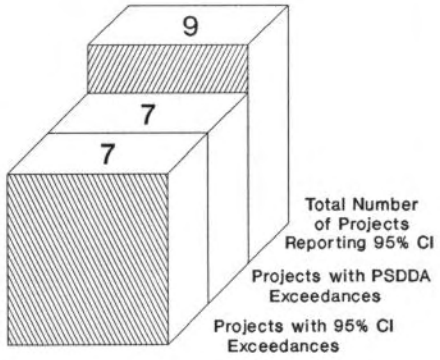
(e) Precision. For precision, the PSDDA warning limits are 20% Relative Percent Difference (RPD) or Coefficient of Variation (COV) for metals and 100% for organics. CLP limits are also 20% for metals. For organics CLP has established limits for those chemicals which are used for matrix spikes. These have been established on a chemical-specific basis.

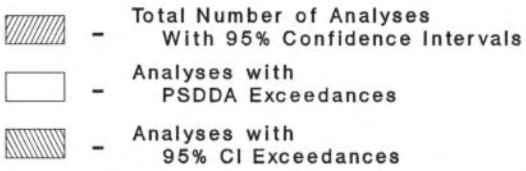
There were a total of 799 chemical replicate analyses performed. Of these 353 had corresponding CLP limits. Of those chemicals with CLP limits 10 exceedances of the PSDDA warning limit occurred. There were 19 exceedances of CLP limits (see Figure 14). All 10 PSDDA exceedances occurred for metals. Because PSDDA and CLP limits are the same for metals there were also 10 exceedances of CLP limits for metals. The other 9 exceedances of CLP limits occurred for organics in which no case is the PSDDA warning limit more restrictive than CLP limits. There were relatively few problems with precision. Only arsenic, silver, acenaphthene and pyrene had more than one exceedance of CLP control limits, with two apiece.

In general, the PSDDA warning limit for organics does not appear to function well as a screening tool. For DY 90 the highest RPD reported was 71.3% with only 3 analyses being reported in exceedance of 50%. The warning limit established by PSEP of 35% could be adopted as a better indication of when precision is moving out of control. The PSEP action limit, a difference of no more than a factor of 2 for duplicates or 50% COV among replicates, should also be adopted. When QA/QC checking is automated, the warning limits could be set at the CLP advisory limits for matrix spike duplicates for those chemicals covered by CLP.

Also at issue is the large number of precision analyses for which the RPD could not be calculated because at least one of the replicates was reported as undetected. This occurred in 313 out of the 799 total analyses. The use of matrix spike duplicates or the selection of the sample with the highest estimated concentrations of chemicals-of-concern would help eliminate this problem.







Exceedance are of PSDDA warning levels
and Certified 95% Confidence Intervals

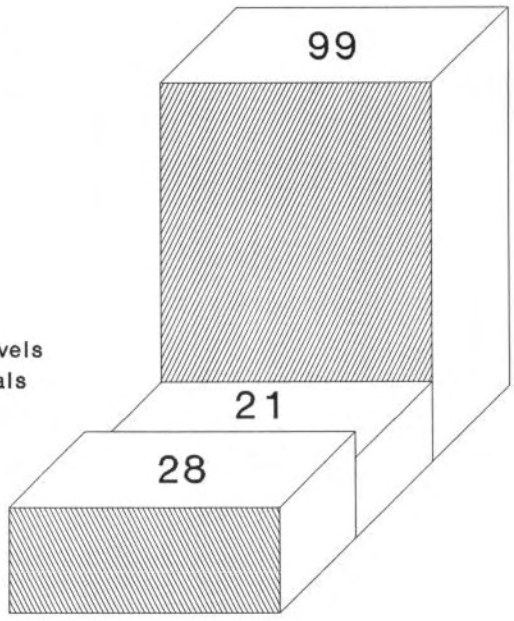
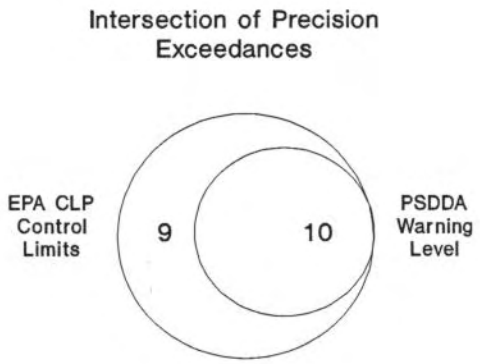
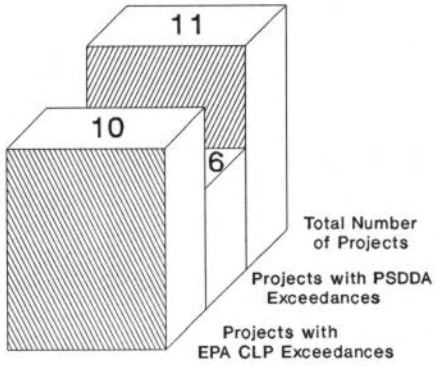
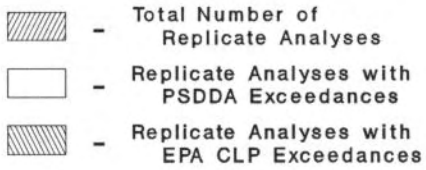


FIG. 13 - CERTIFIED REFERENCE MATERIALS
METALS







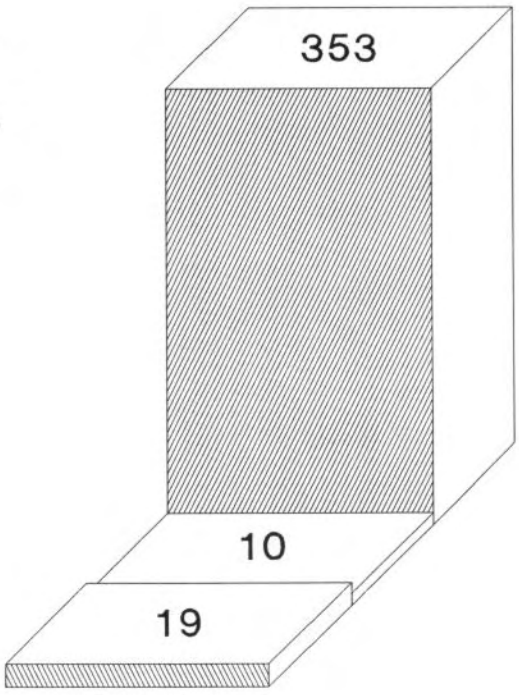


FIGURE 14 - PRECISION

(2) Recommendations. PSEP defines warning limits as "numerical criteria that serve to alert data reviewers and users to possible problems with the analytical system. When a warning limit is exceeded, the laboratory is not obligated to halt analyses, but the reported data may be qualified during subsequent QA/QC review." Action limits are "numerical criteria that, when exceeded, require specific action by the laboratory before data may be reported." Warning limits provide a quick check on data while action limits serve as analytical controls.

To be effective, warning limits should be consistently more conservative than action, or control, limits. This ensures that the warning limits do just that: warn the QA reviewer that certain data need closer scrutiny and that further comparison to action limits is necessary. With the advent of automated QA/QC evaluations with DAIS, the use of certain warning limits will become unnecessary because time-consuming comparisons to chemical-specific CLP control limits will become feasible. For manual reviews of data sets however, and for those QA/QC elements without action limits, warning limits would still be needed.

Table 13 contains recommended warning and action limits for use by PSDDA data reviewers. PSEP guidelines have been followed for all action limits. Some PSEP warning limits have been adjusted to levels which make them better screening tools, being consistently more stringent than CLP control limits and providing a quick check on when chemistry analyses are moving out of control.

c. Streamlining the Sampling and Evaluation Process. The Corps, in coordination with the PSDDA agencies, will be setting up a meeting/workshop on January 24, 1991 with environmental chemists/consultants/engineers/ agents/dredgers engaged in PSDDA project sampling and testing to explore ways of improving the PSDDA permitting/sampling/testing process. Discussion items which should be explored are methods and problems of sampling deep sediments, collecting sufficient deep sediment volumes, field time, and sample holding times. Testing methodologies and QA/QC requirements will also be the focus of a separate session of the January 24, 1991 workshop. The workshop/meeting participants will explore all aspects of the PSDDA process to make it more efficient, less timely, and more cost efficient. Workshop recommendations may become issues for discussion at the third Annual Review Meeting.

Table 13. PSDDA Warning and Action Limit Recommendations

QA Element	Warning Limits	Action Limits
Precision:		
Metals:	none	20% RPD or COV
Organics:	35% RPD or COV	50% COV or a factor of 2 for duplicates
Matrix Spikes:		
Metals:	none	75-125% recovery
Organics: [1]		none (zero percent recovery may be cause for data rejection however) [2]
Volatiles:	70-150%	
Semivolatiles and Pesticides:	50-150%	
Reference Materials:		
Metals:	none	95% CI if specified for a particular CRM; 80-120% recovery if not.
Organics:	none	95% CI for CRMs. No action limit for uncertified RMs.
Surrogate Spikes:		
Organics:		EPA CLP chemical-specific recovery limits
Volatiles:	85% minimum recovery	
Pesticides:	60% minimum recovery	
Semi-volatiles:	50% minimum recovery	

[1] When QA/QC becomes automated, the warning limits used within DAIS should be set at the CLP advisory limits for matrix spike duplicates for those chemicals covered under CLP.

[2] Rigorous control limits are not recommended due to possible matrix effects and interferences.

d. Project Planning for Application of PSDDA Bioassays. For those applicants who opt for tiered testing the following recommendations should be followed to avoid violation of holding time limits for bioassays:

Microtox - Requires minimum lead time and advanced coordination. Shelf-available freeze-dried bacteria are used and the test itself is not time-intensive.

Amphipods - Because these organisms are collected from wave-exposed subtidal locations (West Beach, Whidbey Island or the Oregon coast) it is suggested that the biological testing lab be given a minimum lead time of two weeks during good summer months and three weeks during winter months. This is a 10-day test. Ideally, if the possibility for doing a rerun of the test is to remain open, without resampling, then chemical results should be in hand within 18 days of testing during good weather and 11 days in poor weather.

Sediment Larval Test - Intertidal or shallow subtidal populations of field-collected echinoderms or bivalves are used. Tides make a difference as do season and "ripeness" in determining the viability of a particular species as a test organism. This may translate to a need for pre-testing populations to determine their likelihood of success by doing fertilization experiments and "wet runs" to assure that survivorship in seawater controls will be sufficient. Sufficient lead time for this is three weeks if there is a question about sources, particularly during the "off season" (Nov-Jan). Two weeks should be the minimum lead.

Neanthes - Cultured Neanthes worms are obtained from Dr. Don Reish in California. These worms are available on request with a certain amount of lead time. Four weeks of lead time should be allowed for delivery of the size of juveniles that are used in the 10-day acute test. At a nominal cost of approximately one dollar per worm it is probably cheaper to order worms that are not needed than to suffer the consequences of not having worms available.

e. Objective Review of Bioassay Tests. As indicated in the DY 89 Ecology Management Plan Assessment Report (MPAR), the PSDDA agencies are in the process of conducting a review of the suitability of the Microtox and the sediment larval tests for dredged material evaluation. The review will consider the test results developed in the PSDDA program and other current information, and will distinguish between endpoints (measurements made in the laboratory) and field predictions (significance of the information developed from the tests to the weight of evidence approach used by PSDDA to forecast possible biological effects such as toxicity of disposed sediments).

Issues that were stated in the MPAR regarding Microtox follow:

- Clarify the information value of the endpoint of decreased bacterial luminosity relative to toxicity of disposed sediments, in particular, when Microtox shows responses that are not correlated with other test species or shows no response when other test species do; and

- Consider whether a saline or an organic sediment extract should be used.

Questions that were stated in the MPAR regarding the sediment larval test follow:

- Clarify the information value of the mortality and/or abnormality endpoints of water column organisms to potential field effects at a disposal site;

- Clarify whether observed problems due to presence of sediment in the solid phase or in suspension in the test beakers obscuring toxic response to chemicals with a "nontoxic" or physical response by the test organisms.

Should the tests appear, on the basis of the review, to be inadequate, other appropriately sensitive test species would be considered.

(1) Summarize Test Results. The current DMEAR report has presented the test results from all bioassays conducted during DY 90 (Sections II.A.4, III.d and III.e). It is evident that too few biological results were generated during this time to draw any firm conclusions based on test performance alone. Also, in this period, the PSDDA agencies have instituted numerous changes during the period that modify the tests to improve test performance and interpretation. PSDDA Phase II changes to the Microtox and sediment larval test conditions took effect for only 5 months of DY 90; changes to the Microtox test introduced at the Second Annual Review Meeting did not affect DY 90 results; and clarifications to both Microtox and sediment larval test conditions as a result of the July 1990 Bioassay Workshop (Section IV.A.1 and IV.B.) also did not affect DY 90 results or procedures. The first full year of data according to the collective PSDDA refinements will be DY 91, reviewed at the Fourth Annual Review Meeting in April 1992. The PSDDA agencies will accordingly continue the objective review of testing results of all tests (not merely the Microtox and sediment larval tests) during the next DY when additional data will be available to support conclusions on whether the tests should be retained in the program.

(2) Consider Current Information on Bioassay Testing. The PSDDA agencies updated the current information on biological testing before the Second Annual Review Meeting, and made available at the meeting a synopsis of the bibliographic review. In addition, during DY90, a report entitled "Annotated Bibliography of Bioassays Related to Sediment Toxicity in Washington State" was compiled for PSDDA by Dr. Paul Dinnel of the Fisheries Research Institute at the University of Washington. This report is available on request. Results of these literature surveys will be considered by the agencies prior to the next Annual Review Meeting. Also, during this time, the Puget Sound Estuarine Program draft revisions of the Bioassay Protocols for the Recommended Puget Sound Protocols Guidelines have been circulated in the region and nationally for comment. The sediment and water column larval test protocols for the bivalve and echinoderm are currently being considered by the American Society for Testing Materials (ASTM), and a PSDDA representative is involved in the review and voting. Currently, no "fatal flaw" papers have been found regarding either the Microtox or the sediment larval test, and the agencies are expected to continue to update this analysis also for the DY 91 Annual Review Meeting.

f. Sample Collection and Preparation for Volatile Organic Analysis. If analysis of volatile compounds is required, volatile subsamples should be removed from one randomly chosen core representing each composite. For example, for a composite consisting of 6 core samples, one of the 6 would be chosen (using a random numbers table) for volatiles subsampling prior to processing. Volatile samples should be taken from the representative sampling core section immediately upon

opening and splitting that section, prior to sulfides subsampling. Subsamples should be taken along the entire length of the representative core section.

Two separate 40-ml glass containers should be completely filled with sample sediment. No headspace should remain in either container. Two samples are collected to ensure that an acceptable sample with no headspace is submitted to the laboratory for analysis. The containers, screw caps, and cap septa (silicone vapor barriers) should be washed with detergent, rinsed once with tap water, rinsed at least twice with distilled water, and dried at $>105°C$. A solvent rinse should be avoided because it may interfere with the analysis. Samples for analysis of volatile organic compounds should be taken directly from the representative core section prior to any subsampling for other analyses. Many of the volatile compounds of interest could be lost while compositing.

To avoid leaving headspace in the containers, sample containers can be filled in one of two ways. If there is adequate water in the sediment, the vial should be filled to overflowing so that a convex meniscus forms at the top. Once sealed, the bottle should be inverted to verify the seal by demonstrating the absence of air bubbles. If there is little or no water in the sediment, jars should be filled as tightly as possible, eliminating obvious air pockets. With the cap liner's PTFE (teflon) side down, the cap should be carefully placed on the opening of the vial, displacing any excess material. Sediment samples collected for analysis of volatile organic compounds should not be frozen.

g. Dredged Analysis Information System (DAIS) Update and Status. In the past year the complex data model which defines the structure of the database has been completed along with the various input modules and reporting modules utilized in this report, which are described below. The data model includes submodels consisting of station positioning and lab analysis coding, sediment conventionals, chemistry, standard bioassay and bioaccumulation data. All QA/QC data relevant to making suitability decisions for open-water disposal are included in the data model.

Input modules have been completed for all but the bioaccumulation submodel. These input modules take data from data spreadsheets submitted by permit applicants, perform a preliminary quality control check on the data and enter the data in the database. The balance of the input modules are under development. For DY 90, nine of eleven project applicants submitted data on DAIS spreadsheets. The other two projects submitted data before the requirement to submit data disks was instituted. These latter two data sets were entered by Corps personnel. The sediment guideline exceedance table and the ranking table in this report were printed from data in the DAIS database using DAIS reporting modules.

By the first part of calendar year 1991, other reporting modules will become operational. An automated summary report for each set of project data will be able to be produced. This will provide a standard reporting format which should facilitate data reviews. Another reporting module will provide a more comprehensive QA/QC review of PSDDA data to ensure that the quality-assured data is used in regulatory decision-making and stored in the DAIS database or uploaded to the Department of Ecology database.

A future development (Phase II) includes interfacing DAIS with a Geographical Information System (GIS) which will further enhance reporting and query capabilities. It is anticipated that the GIS utilized will be ArcInfo compatible to insure maximum utility among other agencies and programs.

3. PSEP/PSDDA Protocol Issues/Clarifications.

Protocol clarifications which were implemented during the course of the 1990 dredging year are summarized below. Issues surfacing during the dredging year, which need to be discussed and resolved at the PSDDA Annual Review Meeting are discussed separately.

a. Sediment Larval Test Specifications and Termination. A bioassay workshop was conducted on July 10, 1990 to discuss PSDDA bioassay protocols and clarify interlaboratory differences in interpreting and applying the protocols. A major discussion topic which surfaced was the need to standardize test specification requirements and test termination protocols for the sediment larval test. It was apparent that test specifications for aeration and temperature were not clearly specified, and needed to be standardized. Labs indicated varing approaches were being followed to terminating the sediment larval test, and it was evident that PSDDA should standardize the test termination protocol. What follows is the general recommendation of Dr. Paul Dinnel and is tentatively adopted as a PSDDA requirement until formally adopted at the next Annual Review meeting.

(1) Aeration. The PSEP protocol for the oyster larval test specifies aeration of all test beakers within a batch is required if dissolved oxygen (DO) drops below 5 ppm in any given test beaker (EPTA inaccurately states 4 ppm). The PSEP protocol specification will now extend to all sediment larval bioassay species including the echinoderm larval test.

(2) Temperature and Test Duration. An exposure temperature of 15 degrees Celsius is now specified for the Sediment Larval test with echinoderm species to insure development of pluteus larvae within 48-96 hours. A minimum test duration of 48 hours is also specified for the PSDDA sediment larval bioassay. Test length may exceed 96 hours however.

(3) Test endpoints: abnormality. Seawater controls should be carefully monitored for the degree of development of its larvae. The test should be allowed to run until at least 90 percent (preferably more) of the pluteus larvae are well developed with deeply invaginated preoral arms in the seawater control. The test should be allowed to run for a minimum of 48 hours.

(4) Test Termination. To terminate the sediment larval test the water should be carefully stirred (gently) within each test beaker to insure larvae are suspended in the water without disturbing the sediment. The water is then carefully decanted, to between 80-95 percent, leaving the sediment in the test beaker. The decanted water is then thoroughly mixed to insure uniform distribution of larvae prior to removing up to three 10 ml aliquots, each of which is fixed with buffered formalin. One 10 ml aliquot is then counted, while the other two are archived until counts are assured to be adequate for characterizing test replicates.

B. PSDDA Annual Review Meeting Issues.

Several issues that need to be discussed and resolved at the next annual review meeting are discussed below.

1. Amphipod Reburial.

The current revision of the PSEP amphipod protocol to be released during February 1991 specifies a dual endpoint of mortality and the number of amphipods failing to rebury after 1 hour. The PSDDA interpretation of the amphipod test currently does not utilize the amphipod reburial data, nor does it require its collection. In order to be consistent with the revised PSEP protocol, PSDDA should require the collection of amphipod reburial data. Whether or not PSDDA needs to reevaluate its endpoint determination to incorporate this information is an issue which needs discussion and resolution at the next annual review meeting.

2. Aeration of test beakers.

PSDDA should adopt a standard approach when DO drops below 5 ppm water quality guideline for sediment larval bioassay/echinoderm larval test (see discussion above). PSDDA should specify that aeration of all test beakers within a batch will commence when/if dissolved oxygen drops below 5 ppm in accordance with general practice for the other PSEP bioassays.

3. Dilution Series for Microtox Bioassay.

At the bioassay workshop on July 10, 1990, much discussion ensued as to the need to do the dilution series, when the regulatory "suitability" decision is based solely on the comparison of the five replicates at the highest dilution for each test and reference sediments. PSDDA currently requires running the dilution series in order to be consistent with the PSEP protocol and to allow data comparability with other programs using the standard EC50 endpoint. It was suggested that the dilution series should only be run on test samples demonstrating a statistically significant response relative to the reference sample. This would require running the five replicates at the highest dilution first, and only running the dilution series if the test sediment response is found to be statistically significant (t-test, $p < .05$) from the reference sediment. This recommendation should be reviewed as a protocol clarification at the next annual review meeting.

4. Total carbon normalized chemical values.

Prior to organic normalization of any further PSDDA chemicals of concern, the potential negative influence of low TOC on achievable limits of detection and quantitation should be thoroughly analyzed as it relates to the regulatory decision making.

5. Objective Review of Bioassay Tests

The PSDDA agencies should continue to conduct an objective review of all bioassays during DY 91, which will be concluded by the Fourth ARM (April 1992).

V. REFERENCES

Calabrese, A., R.S. Collier, D.A. Nelson and J.R. MacInnes. 1973. The toxicity of heavy metals to embryos of the American oyster Crassostrea virginica. Marine Biology 18:162-166.

Cardwell, R.D., C.E. Woelke, M.I. Carr and E.W. Sanborn. 1977. Appraisal of a reference toxicant for estimating the quality of oyster larvae. Bull. Environ. Contam. Toxicol. 18(6):719-725.

EPTA, 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Technical Appendix - Evaluation Procedures. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region X, and the Washington State Departments of Ecology and Natural Resources.

FEIS, 1988. Puget Sound Dredged Disposal Analysis Final Environmental Impact Statement, Unconfined open-water disposal for Dredged Material, Phase I (Central Puget Sound). NEPA/SEPA. Prepared by Seattle District Corps of Engineers, Environmental Protection Agency, and Washington State Departments of Ecology and Natural Resources.

FEIS, 1989. Puget Sound Dredged Disposal Analysis Final Environmental Impact Statement, Unconfined open-water disposal for Dredged Material, Phase II (North and South Puget Sound). NEPA/SEPA. Prepared by Seattle District Corps of Engineers, Environmental Protection Agency, and Washington State Departments of Ecology and Natural Resources.

MPR, 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Phase I (Central Puget Sound) Management Plan Report. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region X, and the Washington State Departments of Ecology and Natural Resources.

MPR, 1989. Puget Sound Dredged Disposal Analysis (PSDDA) Phase II (North and South Puget Sound) Management Plan Report. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region X, and the Washington State Departments of Ecology and Natural Resources.

NOAA, 1988. A summary of selected data on chemical contaminants in sediments collected during 1984, 1985, 1986, and 1987. Progress Report for Marine Environmental Quality. NS&T Program. NOAA Technical Memorandum NOS OMA 44. Rockville, MD. 15pp. + appendices.

Tetra Tech, 1986. Recommended Protocols for Sampling and Testing in Puget Sound. Prepared for Environmental Protection Agency, Region X, Office of Puget Sound.

VI. APPENDICES

APPENDIX I - PSDDA SEDIMENT GUIDELINE VALUES

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	6.4		64	35.2
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
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	10		72	41
2-4-Dimethylphenol	10		50	30
4-Methylphenol	120		1,200	660
Pentachlorophenol	100	504	690	379.5
Phenol	120	876	1,200	660
MISCELLANEOUS EXTRACTABLES				
Benzoic Acid	216		690	453
Benzyl Alcohol	10		73	41.5
Dibenzofuran	54		540	297
Hexachlorobutadiene	29	212	290	159.5
Hexachloroethane	1,400	10,220	14,000	
N-Nitrosodiphenylamine	22	161	220	121
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 II - SEDIMENT GUIDELINE EXCEEDANCES AND BIOASSAY RESULTS

In this appendix, all those samples from DY 90 which had exceedances of the PSDDA sediment guideline values (detected and undetected) or bioassay hits (including QA hits) have been tabulated. A brief project-specific summary follows which discusses the data as it relates to PSDDA interpretation. Although the data set is limited any discernible patterns will be highlighted.

As expected, the most highly contaminated sediments also had the most bioassay hits. See, for example, the analyses at the US Coast Guard Pier 35 project. In two instances several maximum levels and bioaccumulation triggers were exceeded and biological testing confirmed chemical contamination with hits for all three bioassays conducted.

For the Lonestar Northwest project a single composite, C1, was analyzed in duplicate (C1/1 and C1/2) with some discrepancies appearing between the two replicates in terms of the number and kind of screening level exceedances. Results from both chemical analysis replicates are displayed in the table. There were 13 detected exceedances of SL (PAHs and dibenzofuran) combined between the two replicates and there was one hit under the two-hit rule for the amphipod test.

For the Metro Emergency Bypass project the results present an anomaly relative to the pattern expected, linking more chemically contaminated sediments and bioassay hits. One test sediment (S4) had 14 detected exceedances of SL (all PAHs) yet sustained no hits during biological testing. Another test sediment (C3) had no detected exceedances of SL yet scored one hit under the two-hit rule for the sediment larval bioassay. This is consistent with burden-of-proof testing under which exceedances of chemical screening level values must be supported by corroborating biological testing evidence before a sediment is deemed unsuitable for open-water disposal. Situations such as this demonstrate the viability of PSDDA interpretation guidelines.

The Corps of Engineers' Port Townsend planning study (the purpose of which was to partially characterize the proposed dredged sediment, not to determine its suitability for unconfined open-water disposal) had 7 detected exceedances of SL (all HPAHs) for sample C1 and a Microtox hit.

The Corps' Duwamish O&M project had four failed sediments based on biological testing. These four sediments had four or five detected exceedances of SL (PAHs and PCBs). There is no discernible pattern in the chemistry SL exceedances which would mark these sediments as different from other sediments with SL exceedances. The table does not consider actual concentrations of those chemicals exceeding SL. For a more in-depth look at pattern analysis see pages 26 to 34.

The test sediments from the US Navy Manchester project which had exceedances of SL ranged from one to twelve in number of exceedances (mostly PAHs along with cadmium and phenol). All of these sediments passed biological testing with no hits in any bioassays. This would seem to suggest, for this project, that additivity in SL exceedances does not appear to be important.

The Navy Homeport Element I Full Characterization biological testing results reflect the low concentrations of chemistry found. Very few SLs were exceeded and there was only a single hit for the amphipod test, two hits for the sediment larval test which were correlated with high ammonia levels, and a series of hits on the juvenile infaunal geoduck test which were concluded to reflect a general problem with the geoduck test unrelated to the composition of the test sediments.

The Morton Marine project had detected exceedances of the SL for DDT and PCBs but no hit for the single amphipod test conducted.

APPENDIX II-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	=	undetected at the concentration reported
e	=	estimated concentration
j	=	the analyte was detected at a concentration greater than the SDL, but less than the CRDL. The value reported should be considered an estimate
(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
QC	=	bioassay results were set aside due to QA/QC problems
AC	=	hits correlated with high ammonia concentrations
SA	=	non-PSDDA bioassay run as part of the US Navy/Friends of the Earth settlement agreement
P	=	test sediment passed PSDDA guidelines for open-water unconfined disposal
F	=	test sediment failed PSDDA guidelines for open-water unconfined disposal
NA	=	not applicable; this test sediment was included in a partial characterization or planning study; no suitability decision was made for this test sediment
-	=	this test was not done

Project:	US ARMY CORPS OF ENGINEERS DUWAMISH O&M											
Sample ID/Replicate Number:	C5/1	C6/1	S10/1	S11/1	S2/1	S4/1	S5/1	S6/1	S7/1	S8/1	S9/1	C8/1
METALS												
Antimony												-
Cadmium (1)												-
Copper (1)												-
Lead (1)												-
Mercury												-
Silver												-
Zinc (1)												-
LPAH												
2-Methylnaphthalene (1)					S						S	
Acenaphthene (1)												
Acenaphthylene (1)												
Anthracene (1)												
Fluorene (1)												
Naphthalene (1)												
Phenanthrene (1)												
Total LPAH (1)												
HPAH												
Benzo(a)anthracene (1)												
Benzo(a)pyrene												
Benzo(g,h,i)perylene (1)												
Benzofluoranthenes (1)												
Chrysene (1)												
Dibenzo(a,h)anthracene (1)												
Fluoranthene	S	S					S	S	S	S		
Indeno(1,2,3-c,d)pyrene (1)	S	S	S	S	S	S	S	S	S	S	S	
Pyrene (1)	S	S	S	S		S	S	S	S	S		
Total HPAH (1)	S	S	S	S		S	S	S	S	S	S	
CHLORINATED HYDROCARBONS												
1,2,4-Trichlorobenzene (1)												
1,2-Dichlorobenzene	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	
1,3-Dichlorobenzene (2)												
1,4-Dichlorobenzene	S u	S u	S u	S u		S u		S u	S u	S u	S u	
Hexachlorobenzene												
PHTHALATES												
Butyl benzyl phthalate (3)												
Diethyl Phthalate (3)												
Dimethyl Phthalate (2)							S					
PHENOLS												
2 Methylphenol (1)												
2,4-Dimethyl phenol (1)												
4 Methylphenol (1)												
Pentachlorophenol												
Phenol												
MISCELLANEOUS EXTRACTABLES												
Benzoic Acid (1)												
Benzyl Alcohol (1)					S							
Dibenzofuran (1)												
Hexachlorobutadiene												
N-Nitrosodiphenylamine							S					
VOLATILE ORGANICS												
Ethylbenzene												
Tetrachloroethene												
PESTICIDES AND PCBs												
Aldrin (2)												-
Lindane (2)												-
Total DDT												-
Total PCBs	S	S	S	S	S		S	S	S	S	S	-
BIOASSAYS												
Amphipod			XX					X	X	X	XX	
Sediment Larvae	QC	QC	QC	QC	QC	QC	QC	QC	QC	QC	QC	QC
Juvenile Infaunal	-	-	-	-	-	-	-	-	-	-	-	
Microtox								X	X		X	
PASS/FAIL	P	P	F	P	P	P	P	F	F	P	F	P

Project:	LONESTAR NORTHWEST		METRO EMERGENCY BYPASS				MORTON MARINE	US COAST GUARD PIER 35			USACE PORT TOWNSEND
Sample ID/Replicate Number:	C1/1	C1/2	S2/1	S3/1	S4/1	C3/1	C1/1	C1/1	C2/1	C3/1	C1/1
METALS											
Antimony								S			
Cadmium (1)								S		S	
Copper (1)								S		S	
Lead (1)								S		S	
Mercury										S	
Silver										S	
Zinc (1)								S		S	
LPAH											
2-Methylnaphthalene (1)	S							S j		M	
Acenaphthene (1)	S	S						S		M	
Acenaphthylene (1)					S			S u		S u	
Anthracene (1)	S				S			M		M	
Fluorene (1)	S	S						S		M	
Naphthalene (1)								S		M	
Phenanthrene (1)	S	S			S			S		M	
Total LPAH (1)	S	S			S			M		M	
HPAH											
Benzo(a)anthracene (1)	S				S			S		S	S
Benzo(a)pyrene					S			S		S	
Benzo(g,h,i)perylene (1)					S			S		S	
Benzofluoranthenes (1)		S			S			S		S	S
Chrysene (1)					S			S		S	S
Dibenzo(a,h)anthracene (1)					S			S		S j	
Fluoranthene	S	S			S			B		BM	S
Indeno(1,2,3-c,d)pyrene (1)	S			S	S			S		S	S
Pyrene (1)	S	S			S			S		S	S
Total HPAH (1)	S	S			S			S		S	S
CHLORINATED HYDROCARBONS											
1,2,4-Trichlorobenzene (1)								S u		M u	
1,2-Dichlorobenzene								B u		B u	
1,3-Dichlorobenzene (2)								S u		S u	
1,4-Dichlorobenzene								B u		BM u	
Hexachlorobenzene					S u			BM u	S u	BM u	
PHTHALATES											
Butyl benzyl phthalate (3)								S			
Diethyl Phthalate (3)								S u		S u	
Dimethyl Phthalate (2)								S u		S u	
PHENOLS											
2 Methylphenol (1)	S u	S u						M u		M u	
2,4-Dimethyl phenol (1)	S u	S u			S u			M u		M u	
4 Methylphenol (1)								S u		S u	
Pentachlorophenol	S u	S u			S u			BM u	S u	BM u	
Phenol								S u		B u	
MISCELLANEOUS EXTRACTABLES											
Benzoic Acid (1)	S u	S u						M u		M u	
Benzyl Alcohol (1)	S u	S u			S u			M u	S u	M u	
Dibenzofuran (1)	S	S						S		M	
Hexachlorobutadiene					S u			S u		B u	
N-Nitrosodiphenylamine					S u			S u		S u	
VOLATILE ORGANICS											
Ethylbenzene										BM e	
Tetrachloroethene										S u	
PESTICIDES AND PCBs											
Aldrin (2)							S u				
Lindane (2)							S u				
Total DDT							S	S		BM	
Total PCBs			S u	S u	S u	S u	S	S		S	
BIOASSAYS											
Amphipod	X	-					-	X		XX	-
Sediment Larvae	-	-				X	-	X		X	-
Juvenile Infaunal	-	-	-	-	-	-	-	-	-	-	-
Microtox	-	-						X		X	X*
PASS/FAIL	P	-	P	P	P	P	P	F	P	F	NA

Project:	US NAVY MANCHESTER												
Sample ID/Replicate Number:	**C1/1**	**C2/1**	**C3/1**	**C4/1**	**C5/1**	**C6/1**	**C7/1**	**S1/1**	**S2/1**	**S3/1**	**S4/1**	**S5/1**	**S6/1**
METALS													
Antimony													
Cadmium (1)					S				S	S			
Copper (1)													
Lead (1)													
Mercury													
Silver													
Zinc (1)													
LPAH													
2-Methylnaphthalene (1)													
Acenaphthene (1)													
Acenaphthylene (1)													
Anthracene (1)										S		S	
Fluorene (1)													
Naphthalene (1)													
Phenanthrene (1)										S		S	
Total LPAH (1)										S		S	
HPAH													
Benzo(a)anthracene (1)										S			
Benzo(a)pyrene													
Benzo(g,h,i)perylene (1)													
Benzofluoranthenes (1)										S	S		
Chrysene (1)										S			
Dibenzo(a,h)anthracene (1)										S	S	S	
Fluoranthene										S		S	
Indeno(1,2,3-c,d)pyrene (1)					S				S	S	S	S	
Pyrene (1)										S	S	S	
Total HPAH (1)										S	S	S	
CHLORINATED HYDROCARBONS													
1,2,4-Trichlorobenzene (1)	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u
1,2-Dichlorobenzene													
1,3-Dichlorobenzene (2)													
1,4-Dichlorobenzene													
Hexachlorobenzene													
PHTHALATES													
Butyl benzyl phthalate (3)													
Diethyl Phthalate (3)													
Dimethyl Phthalate (2)													
PHENOLS													
2 Methylphenol (1)	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u
2,4-Dimethyl phenol (1)	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u
4 Methylphenol (1)													
Pentachlorophenol													
Phenol			S					S					
MISCELLANEOUS EXTRACTABLES													
Benzoic Acid (1)													
Benzyl Alcohol (1)	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u	S u
Dibenzofuran (1)													
Hexachlorobutadiene	S u	S u							S u	S u			S u
N-Nitrosodiphenylamine													
VOLATILE ORGANICS													
Ethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	-	-	-	-	-	-	-	-	-	-	-	-	-
PESTICIDES AND PCBs													
Aldrin (2)	-	-	-	-	-	-	-	-	-	-	-	-	-
Lindane (2)	-	-	-	-	-	-	-	-	-	-	-	-	-
Total DDT	-	-	-	-	-	-	-	-	-	-	-	-	-
Total PCBs	-	-	-	-	-	-	-	-	-	-	-	-	-
BIOASSAYS													
Amphipod													
Sediment Larvae													
Juvenile Infaunal	-	-	-	-	-	-	-	-	-	-	-	-	-
Microtox													
PASS/FAIL	P	P	P	P	P	P	P	P	P	P	P	P	P

Project:	US NAVY MANCHESTER (continued)		US NAVY HOMEPORT ELEMENT I-FC									US NAVY HOMEPORT ELEMENT I-PC
Sample ID/Replicate Number:	S7/1	S8/1	C1/1	C2/1	C3/1	C4/1	C5/1	C8/1	C17/1	C27/1	C29/1	S5/1
METALS												
Antimony												
Cadmium (1)												
Copper (1)												
Lead (1)			S									
Mercury												
Silver												
Zinc (1)			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												
Benzo(g,h,i)perylene (1)												
Benzofluoranthenes (1)												
Chrysene (1)												
Dibenzo(a,h)anthracene (1)												
Fluoranthene												
Indeno(1,2,3-c,d)pyrene (1)			S									
Pyrene (1)												
Total HPAH (1)			S									
CHLORINATED HYDROCARBONS												
1,2,4-Trichlorobenzene (1)	S u	S u										S
1,2-Dichlorobenzene												
1,3-Dichlorobenzene (2)												
1,4-Dichlorobenzene												
Hexachlorobenzene												
PHTHALATES												
Butyl benzyl phthalate (3)												
Diethyl Phthalate (3)												
Dimethyl Phthalate (2)												
PHENOLS												
2 Methylphenol (1)	S u	S u										
2,4-Dimethyl phenol (1)	S u	S u										
4 Methylphenol (1)												
Pentachlorophenol												
Phenol												
MISCELLANEOUS EXTRACTABLES												
Benzoic Acid (1)												
Benzyl Alcohol (1)	S u	S u										
Dibenzofuran (1)												
Hexachlorobutadiene			S u	S u		S u	S u	S u				
N-Nitrosodiphenylamine												
VOLATILE ORGANICS												
Ethylbenzene	-	-					-	-				
Tetrachloroethene	-	-					-	-				
PESTICIDES AND PCBs												
Aldrin (2)	-	-										
Lindane (2)	-	-										
Total DDT	-	-										
Total PCBs	-	-					-	-				
BIOASSAYS												
Amphipod											X	-
Sediment Larvae									AC	AC		-
Juvenile Infaunal	-	-	SA	SA	SA	SA	SA	SA	SA	SA	SA	-
Microtox												-
PASS/FAIL	P	P	P	P	P	P	P	P	P	P	P	NA

APPENDIX III - RANKING ANALYSIS

In this appendix, the ranking of each analysis appearing in Appendix II has been calculated. The comparative rank for each chemical-of-concern is based on the concentration of that chemical. Rankings were calculated using the partial characterization reranking formulas found in EPTA, page II-64. These formulas appear on page 19 of this report. The highest calculated rank for each analysis is indicated and biological testing results are included.

LEGEND

L	=	reported concentration was below SL
LM	=	reported concentration was between SL and (SL + ML)/2
M	=	reported concentration was between (SL + ML)/2 and ML
H	=	reported concentration exceeds ML
u	=	undetected at the concentration reported
e	=	estimated concentration
j	=	the analyte was detected at a concentration greater than the SDL, but less than the CRDL. The value reported should be considered an estimate
(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
P	=	test sediment passed PSDDA guidelines for open-water unconfined disposal
F	=	test sediment failed PSDDA guidelines for open-water unconfined disposal
NA	=	not applicable; this test sediment was included in a partial characterization or planning study; no suitability decision was made for this test sediment
-	=	this test was not done
*	=	no ML exists for this analyte; comparative rank determined by setting ML = 10 x SL
H*	=	overall sediment rank based on biological testing results

Project:	LONESTAR NORTHWEST		METRO EMERGENCY BYPASS				MORTON MARINE	US COAST GUARD PIER 35			USACE PORT TOWNSEND
Sample ID/Replicate Number:	C1/1	C1/2	S2/1	S3/1	S4/1	C3/1	C1/1	C1/1	C2/1	C3/1	C1/1
METALS											
Antimony	L u	L u	L u	L u	L u	L u	L u	LM	L u	L	L e
Cadmium (1)	L u	L	L u	L u	L	L u	L u	LM	L	LM	L
Copper (1)	L	L	L	L	L	L	L	LM	L	LM	L
Lead (1)	L	L	L u	L u	L u	L u	L	M	L	M	L
Mercury	L u	L u	L	L	L	L	L	L	L u	LM	L u
Silver	L u	L u	L u	L u	L u	L u	L u	L	L	LM	L
Zinc (1)	L	L	L	L	L	L	L	LM	L	LM	L
LPAH											
2-Methylnaphthalene (1)	LM	L	L u	L u	L u	L u	L	LM j	L u	H	L e
Acenaphthene (1)	LM	LM	L u	L u	L u	L u	L m	M	L u	H	L e
Acenaphthylene (1)	L	L u	L u	L u	LM	L u	L u	LM u	L u	LM u	L
Anthracene (1)	LM	L	L u	L u	LM	L u	L	H	L u	H	L
Fluorene (1)	M	LM	L u	L u	L	L u	L	M	L u	H	L
Naphthalene (1)	L	L	L u	L u	L	L u	L m	M	L u	H	L u
Phenanthrene (1)	M	LM	L u	L	LM	L u	L	M	L j	H	L
Total LPAH (1)	LM	LM	L u	L	LM	L u	L	H	L u	H	L
HPAH											
Benzo(a)anthracene (1)	LM	L	L u	L	LM	L u	L	LM	L u	LM	LM
Benzo(a)pyrene	L	L	L u	L	LM	L u	L	LM	L u	LM	L
Benzo(g,h,i)perylene (1)	L	L	L u	L	LM	L u	L u	LM	L u	LM	L
Benzofluoranthenes (1)	L	LM	L u	L	LM	L u	L	LM	L u	LM	LM
Chrysene (1)	L	L	L u	L	LM	L u	L	LM	L e	LM	LM
Dibenzo(a,h)anthracene (1)	L u	L u	L u	L u	LM	L u	L u	LM	L u	LM j	L
Fluoranthene	LM	LM	L u	L	LM	L u	L	M	L j	H	LM
Indeno(1,2,3-c,d)pyrene (1)	LM	L	L u	LM	LM	L u	L u	LM	L u	LM	LM
Pyrene (1)	LM	LM	L u	L	LM	L u	L	M	L j	M	LM
Total HPAH (1)	LM	LM	L u	L	LM	L u	L	LM	L u	LM	LM
CHLORINATED HYDROCARBONS											
1,2,4-Trichlorobenzene (1)	L u	L u	L u	L u	L u	L u	L u	M u	L u	H u	L u
1,2-Dichlorobenzene	L u	L u	L u	L u	L u	L u	L u	LM u	L u	LM u	L u
1,3-Dichlorobenzene (2)	L u	L u	L u	L u	L u	L u	L u	LM u*	L u	LM u*	L u
1,4-Dichlorobenzene	L u	L u	L u	L u	L u	L u	L u	M u	L u	H u	L u
Hexachlorobenzene	L u	L u	L u	L u	LM u	L u	L u	H u	LM u	H u	L u
PHTHALATES											
Butyl benzyl phthalate (3)	L u	L	L u	L u	L u	L u	L u	LM *	L u	L u	L e
Diethyl Phthalate (3)	L u	L u	L u	L u	L u	L u	L u	LM u*	L u	LM u*	L u
Dimethyl Phthalate (2)	L u	L u	L u	L u	L u	L u	L u	LM u*	L u	LM u*	L
PHENOLS											
2 Methylphenol (1)	LM u	LM u	L u	L u	L u	L u	L u	H u	L u	H u	L u
2,4-Dimethyl phenol (1)	LM u	LM u	L u	L u	LM u	L u	L u	H u	L u	H u	L u
4 Methylphenol (1)	L u	L u	L u	L u	L u	L u	L u	LM u	L u	LM u	L u
Pentachlorophenol	LM u	LM u	L u	L u	LM u	L u	L u	H u	LM u	H u	L u
Phenol	L u	L u	L u	L u	L u	L u	L u	LM u	L u	M u	L e
MISCELLANEOUS EXTRACTABLES											
Benzoic Acid (1)	LM u	LM u	L u	L u	L u	L u	L u	H u	L u	H u	L u
Benzyl Alcohol (1)	LM u	LM u	L u	L u	LM u	L u	L u	H u	LM u	H u	L u
Dibenzofuran (1)	LM	LM	L u	L u	L u	L u	L	M	L u	H	L e
Hexachlorobutadiene	L u	L u	L u	L u	LM u	L u	L u	M u	L u	M u	L u
N-Nitrosodiphenylamine	L u	L u	L u	L u	LM u	L u	L u	LM u	L u	LM u	L u
VOLATILE ORGANICS											
Ethylbenzene	L u	L u	L u	L u	L u	L u	L u	L	L u	H e	L u
Tetrachloroethene	L u	L u	L u	L u	L u	L u	L u	L u	L u	LM u	L u
PESTICIDES AND PCBs											
Aldrin (2)	L u	L u	L u	L u	L u	L u	LM u*	L u	L u	L u	L u
Lindane (2)	L u	L u	L u	L u	L u	L u	LM u*	L u	L u	L u	L u
Total DDT	L u	L u	L u	L u	L u	L u	LM	LM	L u	H	L u
Total PCB's	L	L	LM u	LM u	LM u	LM u	LM	LM	L u	LM	L u
Bioassay Pass/Fail	P	-	P	P	P	P	P	F	P	F	NA
HIGHEST RANKING:	M	LM	LM	LM	LM	LM	LM	H	LM	H	LM

Project:	US ARMY CORPS OF ENGINEERS DUWAMISH O&M											
Sample ID/Replicate Number:	C5/1	C6/1	S10/1	S11/1	S2/1	S4/1	S5/1	S6/1	S7/1	S8/1	S9/1	C8/1
METALS												
Antimony	L	L	L	L	L	L	L	L	L	L	L	-
Cadmium (1)	L	L	L	L	L	L	L	L	L	L	L	-
Copper (1)	L	L	L	L	L	L	L	L	L	L	L	-
Lead (1)	L	L	L	L	L	L	L	L	L	L	L	-
Mercury	L	L	L	L	L	L	L	L	L	L	L	-
Silver	L	L	L	L	L	L	L	L	L	L	L	-
Zinc (1)	L	L	L	L	L	L	L	L	L	L	L	-
LPAH												
2-Methylnaphthalene (1)	L	L	L	L	LM	L	L	L	L	L	LM	L u
Acenaphthene (1)	L	L	L	L	L	L	L	L	L	L	L	L u
Acenaphthylene (1)	L	L u	L u	L	L u	L u	L	L u	L	L	L u	L u
Anthracene (1)	L	L	L	L	L	L	L	L	L	L	L	L e
Fluorene (1)	L	L	L	L	L	L	L	L	L	L	L	L u
Naphthalene (1)	L	L	L	L	L	L	L	L	L	L	L	L u
Phenanthrene (1)	L	L	L	L	L	L	L	L	L	L	L	L
Total LPAH (1)	L	L	L	L	L	L	L	L	L	L	L	L
HPAH												
Benzo(a)anthracene (1)	L	L	L	L	L	L	L	L	L	L	L	L
Benzo(a)pyrene	L	L	L	L	L	L	L	L	L	L	L	L
Benzo(g,h,i)perylene (1)	L	L	L	L	L	L	L	L	L	L	L	L e
Benzofluoranthenes (1)	L	L	L	L	L	L	L	L	L	L	L	L
Chrysene (1)	L	L	L	L	L	L	L	L	L	L	L	L
Dibenzo(a,h)anthracene (1)	L	L	L	L	L	L	L	L	L	L	L	L e
Fluoranthene	LM	LM	L	L	L	L	LM	LM	LM	LM	L	L
Indeno(1,2,3-c,d)pyrene (1)	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	L e
Pyrene (1)	LM	LM	LM	LM	L	LM	LM	LM	LM	LM	L	L
Total HPAH (1)	LM	LM	LM	LM	L	LM	LM	LM	LM	LM	LM	L
CHLORINATED HYDROCARBONS												
1,2,4-Trichlorobenzene (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
1,2-Dichlorobenzene	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	L u
1,3-Dichlorobenzene (2)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
1,4-Dichlorobenzene	LM u	LM u	LM u	LM u	L u	LM u	L u	LM u	LM u	LM u	LM u	L u
Hexachlorobenzene	L	L	L u	L u	L	L	L	L	L	L u	L u	L u
PHTHALATES												
Butyl benzyl phthalate (3)	L	L	L	L	L	L	L	L	L	L	L	L u
Diethyl Phthalate (3)	L	L	L	L	L	L	L	L	L	L	L	L u
Dimethyl Phthalate (2)	L	L	L	L	L	L	LM •	L	L	L	L	L u
PHENOLS												
2 Methylphenol (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
2,4-Dimethyl phenol (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
4 Methylphenol (1)	L	L	L u	L u	L	L	L	L	L	L	L u	L u
Pentachlorophenol	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Phenol	L	L	L	L	L	L	L	L	L	L	L	L u
MISCELLANEOUS EXTRACTABLES												
Benzoic Acid (1)	L	L	L	L	L	L	L	L	L	L	L	L u
Benzyl Alcohol (1)	L u	L u	L u	L u	LM	L u	L u	L u	L u	L u	L u	L u
Dibenzofuran (1)	L	L	L	L	L	L	L	L	L	L	L	L u
Hexachlorobutadiene	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
N-Nitrosodiphenylamine	L u	L	L u	L u	L u	L u	LM	L	L u	L u	L u	L u
VOLATILE ORGANICS												
Ethylbenzene	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Tetrachloroethene	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
PESTICIDES AND PCBs												
Aldrin (2)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	-
Lindane (2)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	-
Total DDT	L	L	L	L	L	L	L	L	L	L	L	-
Total PCB's	LM	LM	LM	LM	LM	L	LM	LM	LM	LM	LM	-
Bioassay Pass/Fail	P	P	F	P	P	P	P	F	F	P	F	P
HIGHEST RANKING:	LM	LM	H•	LM	LM	LM	LM	H•	H•	LM	H•	L

Project:	US NAVY MANCHESTER												
Sample ID/Replicate Number:	C1/1	C2/1	C3/1	C4/1	C5/1	C6/1	C7/1	S1/1	S2/1	S3/1	S4/1	S5/1	S6/1
METALS													
Antimony	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L	L u
Cadmium (1)	L	L	L	L	LM	L	L	L	LM	LM	L u	L	L
Copper (1)	L	L	L	L	L	L	L	L	L	L	L	L	L
Lead (1)	L	L	L	L u	L	L	L u	L	L	L	L	L	L
Mercury	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L	L	L u
Silver	L	L	L	L	L	L	L u	L	L	L	L	L	L
Zinc (1)	L	L	L	L	L	L	L	L	L	L	L	L	L
LPAH													
2-Methylnaphthalene (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L j	L j	L j	L u
Acenaphthene (1)	L u	L u	L u	L u	L j	L u	L u	L u	L u	L	L	L	L u
Acenaphthylene (1)	L u	L u	L u	L u	L e	L u	L u	L u	L u	L	L	L	L u
Anthracene (1)	L u	L u	L j	L u	L	L u	L u	L u	L	LM	L	LM	L
Fluorene (1)	L u	L u	L u	L u	L j	L u	L u	L u	L u	L	L	L	L u
Naphthalene (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L j	L	L	L u
Phenanthrene (1)	L u	L u	L	L u	L	L	L u	L e	L	LM	L	LM	L
Total LPAH (1)	L u	L u	L	L u	L	L	L u	L u	L	LM	L	LM	L
HPAH													
Benzo(a)anthracene (1)	L u	L e	L	L u	L	L	L j	L u	L	LM	L	L	L
Benzo(a)pyrene	L u	L u	L	L u	L	L	L e	L u	L	L	L	L	L
Benzo(g,h,i)perylene (1)	L u	L u	L u	L u	L	L u	L u	L u	L	L	L	L	L
Benzofluoranthenes (1)	L u	L u	L	L u	L	L	L j	L u	L	LM	LM	L	L
Chrysene (1)	L u	L j	L	L u	L	L	L j	L u	L	LM	L	L	L
Dibenzo(a,h)anthracene (1)	L u	L u	L u	L u	L	L u	L u	L u	L	LM	LM	LM	L e
Fluoranthene	L u	L j	L	L u	L	L	L j	L j	L	LM	L	LM	L
Indeno(1,2,3-c,d)pyrene (1)	L u	L u	L u	L u	LM	L u	L u	L u	LM	LM	LM	LM	L
Pyrene (1)	L u	L j	L	L u	L	L	L	L e	L	LM	LM	LM	L
Total HPAH (1)	L u	L	L	L u	L	L	L	L	L	LM	LM	LM	L
CHLORINATED HYDROCARBONS													
1,2,4-Trichlorobenzene (1)	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u
1,2-Dichlorobenzene	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
1,3-Dichlorobenzene (2)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
1,4-Dichlorobenzene	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Hexachlorobenzene	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
PHTHALATES													
Butyl benzyl phthalate (3)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Diethyl Phthalate (3)	L u	L u	L	L u	L u	L u	L u	L u	L u	L u	L u	L u	L
Dimethyl Phthalate (2)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
PHENOLS													
2 Methylphenol (1)	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u
2,4-Dimethyl phenol (1)	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	M u	LM u	LM u	LM u	LM u
4 Methylphenol (1)	L u	L u	L u	L u	L u	L u	L u	L	L u	L u	L u	L u	L u
Pentachlorophenol	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Phenol	L u	L u	LM	L u	L u	L u	L u	LM	L u	L u	L u	L e	L u
MISCELLANEOUS EXTRACTABLES													
Benzoic Acid (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Benzyl Alcohol (1)	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u	LM u
Dibenzofuran (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L j	L j	L	L u
Hexachlorobutadiene	LM u	LM u	L u	L u	L u	L u	L u	L u	LM u	LM u	L u	L u	LM u
N-Nitrosodiphenylamine	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
VOLATILE ORGANICS													
Ethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	-	-	-	-	-	-	-	-	-	-	-	-	-
PESTICIDES AND PCBs													
Aldrin (2)	-	-	-	-	-	-	-	-	-	-	-	-	-
Lindane (2)	-	-	-	-	-	-	-	-	-	-	-	-	-
Total DDT	-	-	-	-	-	-	-	-	-	-	-	-	-
Total PCB's	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioassay Pass/Fail	P	P	P	P	P	P	P	P	P	P	P	P	P
HIGHEST RANKING:	LM	LM	LM	LM	LM	LM	LM	LM	M	LM	LM	LM	LM

Project:	US NAVY MANCHESTER (continued)		US NAVY HOMEPORT ELEMENT I-FC									US NAVY HOMEPORT ELEMENT I-PC
Sample ID/Replicate Number:	S7/1	S8/1	C1/1	C2/1	C3/1	C4/1	C5/1	C8/1	C17/1	C27/1	C29/1	S5/1
METALS												
Antimony	L u	L u	L u	L	L	L u	L	L u	L	L u	L	L u
Cadmium (1)	L	L	L	L	L	L	L	L	L	L	L	L
Copper (1)	L	L	L	L	L	L	L	L	L	L	L	L
Lead (1)	L u	L	LM	L	L	L	L	L	L	L	L	L
Mercury	L u	L u	L	L	L	L	L	L	L	L	L	L
Silver	L u	L	L	L	L	L	L	L	L	L	L	L
Zinc (1)	L	L	LM	L	LM	L	L	L	L	L	L	L
LPAH												
2-Methylnaphthalene (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Acenaphthene (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Acenaphthylene (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Anthracene (1)	L u	L	L	L u	L u	L u	L u	L u	L u	L u	L u	L u
Fluorene (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Naphthalene (1)	L u	L u	L u	L	L	L u	L u	L u	L u	L u	L u	L u
Phenanthrene (1)	L	L	L	L	L	L u	L u	L u	L u	L u	L u	L u
Total LPAH (1)	L	L	L e	L e	L e	L u	L u	L u	L u	L u	L u	L u
HPAH												
Benzo(a)anthracene (1)	L	L	L	L	L	L	L	L	L	L u	L u	L
Benzo(a)pyrene	L	L	L	L u	L	L	L u	L	L	L u	L u	L u
Benzo(g,h,i)perylene (1)	L u	L	L	L	L u	L u	L u	L u	L	L u	L u	L u
Benzofluoranthenes (1)	L	L	L	L u	L	L e	L u	L	L u	L u	L u	L u
Chrysene (1)	L	L	L	L	L	L	L	L	L	L u	L u	L
Dibenzo(a,h)anthracene (1)	L u	L	L	L u	L u	L u	L u	L u	L u	L u	L u	L u
Fluoranthene	L	L	L	L	L	L	L	L	L u	L u	L u	L
Indeno(1,2,3-c,d)pyrene (1)	L u	L	LM	L	L u	L u	L u	L u	L	L u	L u	L u
Pyrene (1)	L	L	L	L	L	L	L	L	L	L	L u	L
Total HPAH (1)	L	L	LM	L e	L e	L e	L e	L e	L e	L e	L u	L
CHLORINATED HYDROCARBONS												
1,2,4-Trichlorobenzene (1)	LM u	LM u	L u	L u	L u	L u	L u	L u	L u	L u	L u	LM
1,2-Dichlorobenzene	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
1,3-Dichlorobenzene (2)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
1,4-Dichlorobenzene	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Hexachlorobenzene	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
PHTHALATES												
Butyl benzyl phthalate (3)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Diethyl Phthalate (3)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L	L u	L u
Dimethyl Phthalate (2)	L u	L u	L u	L u	L u	L u	L u	L u	L	L u	L u	L u
PHENOLS												
2 Methylphenol (1)	LM u	LM u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
2,4-Dimethyl phenol (1)	LM u	LM u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
4 Methylphenol (1)	L u	L u	L u	L	L u	L u	L u	L u	L u	L u	L u	L u
Pentachlorophenol	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Phenol	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
MISCELLANEOUS EXTRACTABLES												
Benzoic Acid (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Benzyl Alcohol (1)	LM u	LM u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Dibenzofuran (1)	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Hexachlorobutadiene	L u	L u	LM u	LM u	L u	LM u	LM u	LM u	L u	L u	L u	L u
N-Nitrosodiphenylamine	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
VOLATILE ORGANICS												
Ethylbenzene	-	-	L u	L u	L u	L u	-	-	-	-	-	L u
Tetrachloroethene	-	-	L u	L u	L u	L u	-	-	-	-	-	L u
PESTICIDES AND PCBs												
Aldrin (2)	-	-	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Lindane (2)	-	-	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Total DDT	-	-	L u	L u	L u	L u	L u	L u	L u	L u	L u	L u
Total PCB's	-	-	L u	L u	L u	L u	-	-	-	-	-	L u
Bioassay Pass/Fail	P	P	P	P	P	P	P	P	P	P	P	NA
HIGHEST RANKING:	LM	LM	LM	LM	LM	LM	LM	LM	L	L	L	LM

DDD

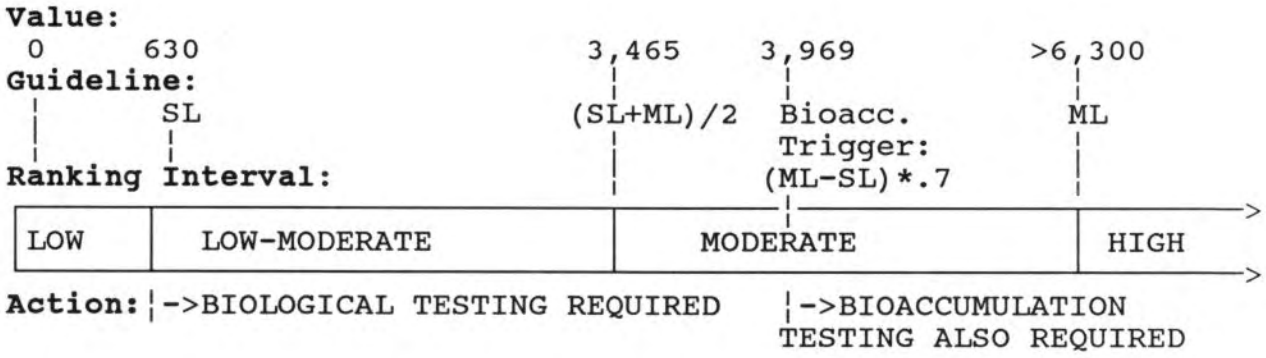
APPENDIX IV.

Chemical and Biological Pattern Analysis.

1. Introduction and Background. The PSDDA agencies will evaluate yearly/multiyearly data to discern patterns that suggest potential modifications of evaluation guidelines. In the first two Annual Review Meetings, the Washington Public Ports Association (WPPA) stressed its desire to see such analyses as they are developed and to participate in the pattern analysis. During the subject dredging year, the PSDDA agencies and WPPA met to further define what kinds of assessments would be most informative.

The data for all testing during this dredging year are summarized in Appendixes II and III, as well as in a values table containing all the chemical levels, which is available on request. (The latter table was too bulky to include in this report.) The PSDDA DY 90 data consist of (1) SL exceedances, (2) ML exceedances, (3) bioaccumulation trigger exceedances and (4) as ranking intervals (low, low-moderate, moderate, and high). The figure below illustrates these concepts using the compound fluoranthene:

Figure IV-1. PSDDA Value Intervals for the Compound Fluoranthene. The values are in parts per billion; the screening level and the relationship to the ranking are shown.



The PSDDA agencies established that chemical levels in sediment greater than the PSDDA SL could be associated with biological effects on the basis of a large data set on Puget Sound chemicals and concomitant biological testing. The agencies concluded that between SL and ML it was not possible to predict with certainty the level of effect. In this "gray area," biological testing would be needed. They also concluded that it was likely that adverse biological effects would be associated with chemical levels greater than the ML a great deal of the time.
The SL is used as a "reason to believe" adverse biological effects could occur and its exceedance triggers a PSDDA requirement for biological testing.

A possible management question (and one that is directed to the PSDDA agencies by the WPPA) is whether it is appropriate to try to optimize or adjust the SL such that it is usually only exceeded when there is a high likelihood of prediction of biological effects. PSDDA did not set out to treat the SL in this way, but instead relied on the confirmatory information from the Puget Sound data set. SL and ML values are values of a single chemical that for the most part are derived from the Puget Sound data set via the Apparent Effects Threshold approach. (Through the use of this

approach these values also incorporate the effects of chemicals which may interact in a multiple fashion in sediments.) Using recent updates to this large data set, the SL and ML values have been shown to be efficient and sensitive predictors for biological effects in sediments (reference: pages 5-4 and following in the PSDDA Phase II MPR). The principal management questions that occur in this analysis follow.

- How often does exceedance of the SL occur with no biological effects? (Also, add to this exceedance of Low-Moderate level, which is 50% of the way between SL and ML.)

- What is the influence of chemical quantitation (i.e., higher than desirable detection limits or quantitation limits) on the preceding question? (Chemicals of concern that remain undetected above the SL[1] are treated by the PSDDA agencies as SL exceedances. The contribution of chemicals undetected above the SL may have a significant influence on biological effects predictions which is related more to the performance of the analytical laboratory than to the actual value of SL.)

- Is it possible to revisit individual chemicals to assure that their SL is not set too low or too high? For example, are biological effects occurring most often in the region just above the SL, suggesting that it doesn't delimit the gray area with adequate protection; or are all of them occurring at levels near the ML, suggesting that the SL may be set too low?

To accomplish the analysis, one may view the data set in either qualitatively or quantitatively by all chemicals (for example, by number of exceedances of a particular guideline) versus biological effects or quantitatively by single chemical value and associated biological effects.
The paragraphs which follow deal with analyses which consider multiple chemical exceedances of PSDDA guidelines and the next section deals with individual chemicals versus biological responses. For the current section, stations that exceeded ML for any chemical are excluded because the focus is on the SL to ML interval. Also, the influence of realized detection limits above the SL will be examined, since this is a recurring problem in PSDDA testing.

The evaluation of data according to either approach should be qualified:

- The amount of data qualifying for the assessment is smaller than is desirable to institute management changes in the program. For example, only 42 synoptic chemical and biological test samples exist in this year's data set compared to the 400+ in the Puget Sound data base;

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[1] The Phase II MPR, in a footnote on page 5-27, notes that the Puget Sound Estuarine Program Recommended Protocols and Guidelines defines a "required quantitation limit" that is the equivalent of "detected value" in the PSEP 1986 documents and PSDDA documents.

- The PSDDA agencies have not made a management decision at this time to "optimize" or recalibrate the SLs such that they reliably predict all biological effects.[2] The "gray area" is expected to remain somewhat gray.

2. Analysis by Multiple Chemicals. It was desirable to create a display method that would not be sensitive to the volumes of "clean" or "contaminated" material tested in a particular year or period, but which would show biological responses (hits or failures) against guideline exceedances. A diagram which shows cumulative exceedances is not volume-dependent and serves the purpose. Accordingly, the analysis in this section places biological effects results on an axis of cumulative numbers of exceedances of chemistry threshold levels. The principal question posed is: how well would an unbiased individual predict the biological results from only the numbers of chemicals concern that exceed guidelines. This prediction is the basis for the tiered testing approach in PSDDA. (Note that an individual that knew the numerical level and thus the intensity of exceedance would have more information--this is considered by looking at intervals between the SL and ML, such as the low-moderate/moderate intervals, in a subsequent analysis.) The analysis also discusses individual compounds that have exceeded SL with no biological effects observed.

The samples evaluated in the cumulative analysis fall in the subset of DY 90 data that fit the following criteria: co-occurring chemical and biological test results and maximum chemical levels falling between the SL and the ML. This is because the focus is the gray area; and although values greater than the ML do not fail a sample automatically, the prediction is deemed to be considerably more certain. In DY90, both stations with ML exceedances, the US Coast Guard C1/1 and C3/1, also failed.[3]

a. SL Exceedances and Biological Failure of Material for Unconfined, Open-Water Disposal. If SLs always predict a biological response that is sufficiently intense to cause failure of dredged material, then the example Figure IV-2 "picket fence diagram" would be true. This figure shows 100% of biological failures (the histogram bars or pickets) being predicted correctly with only 1 SL exceedance. Note also the cumulative distribution of the samples according to numbers of SL exceedances is displayed as a line. This is to say that, for the 20% of the total number of samples (which contain 1 or fewer SL exceedances), all of the biological failures would be correctly predicted by the unbiased observer, without regard to how much the exceedance was.

It is important to realize that, in this example, 100% failure does not mean that all samples with more than one SL exceedance failed, but instead that 100% of total failures were accounted for by one SL exceedance. It was expected by the PSDDA agencies that the SL would not predict all failures, which is to say that more than one SL exceedance (or a very intense SL exceedance) would

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[2] In this regard, it should be noted that organic carbon normalization of neutrophilic organic chemicals' Sls and MLs are proposed for discussion at the Third PSDDA Annual Review Meeting. Such a change would better reflect the bioavailability of the compounds; it would also invalidate the basis for the values used in the present analysis, although the approach may still be valuable.

[3] The conditions exclude the following data: (1) Lonestar Northwest C1/2, Port Townsend, and Navy Homeport Element 1 Partial Characterization did not have biological data associated; and (2) the referenced US Coast Guard station exceeded the ML.

probably be need to realize material failure. Thus, the pickets would be expected to be displaced to the right (or higher) number of exceedances. Administratively, this is due to incorporation of a degree of environmental protection into the SL; operationally, this is due to such things as: the situation not all SL exceedances may be strong exceedances (so that 4 SL exceedances at a low level might be less influential than 1 at a high level), and undetected/unquantified values above the SL.

Figure IV-2.

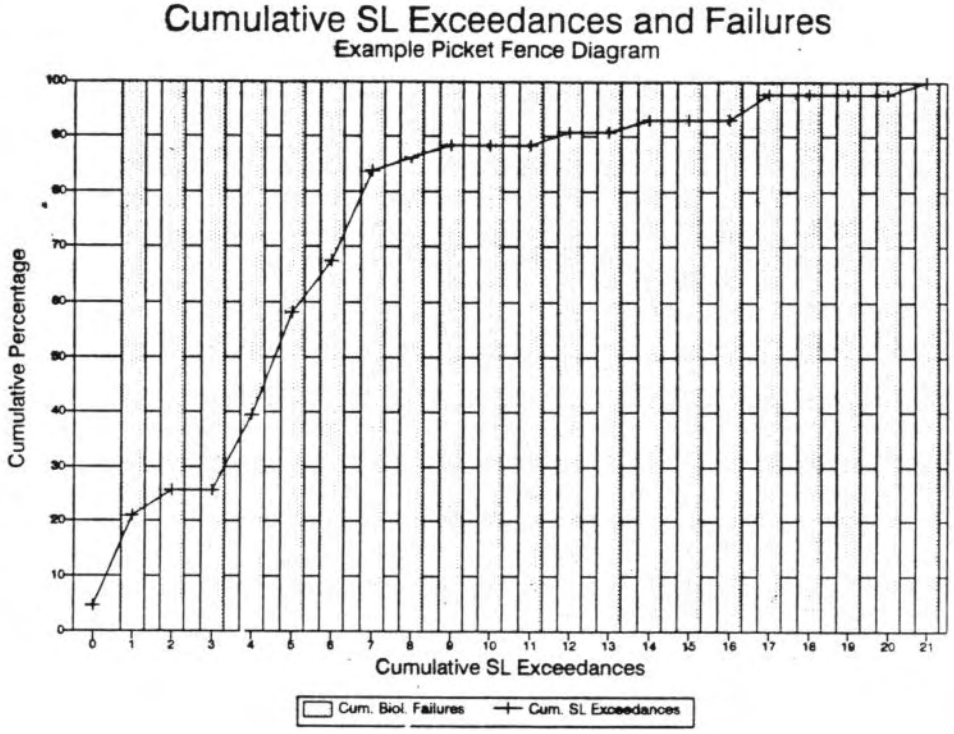


Figure IV-3 is a picket fence diagram using DY 90 data that shows detected values and detection limits for compounds undetected above the SL. A value of 6 on the X axis denotes approximately 67% of the samples had 6 or fewer SL exceedances, and they predicted 50% of the biological failures, while at 83% of the population, or 7 SL exceedances, 100% of the failures were predicted. This suggests that 5 or fewer values of chemicals of concern greater than SL did not predict any failures under the nondispersive guideline. (It should be noted that there were statistically significant bioassay responses in some samples with 5 or fewer SL exceedances, however.) A later section discusses the individual biological test results.

Figure IV-4 removes the values that were reported as undetected above the SL, and shows only quantified values. The pickets are shifted to the left by 2: 3 SL exceedances is the maximum number that is associated with no failures, and 5 predicts 100% of failures. This clearly shows the merit of improving contract laboratory chemical quantification to fit program requirements.

Figure IV-3.

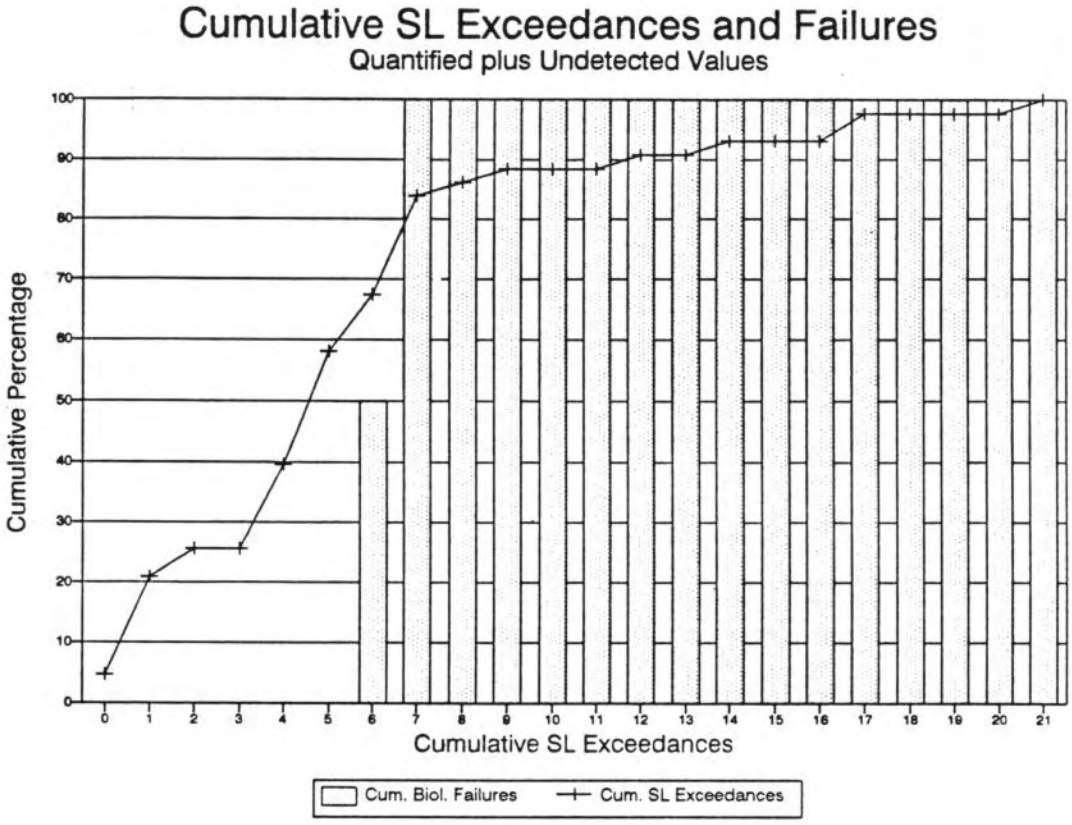
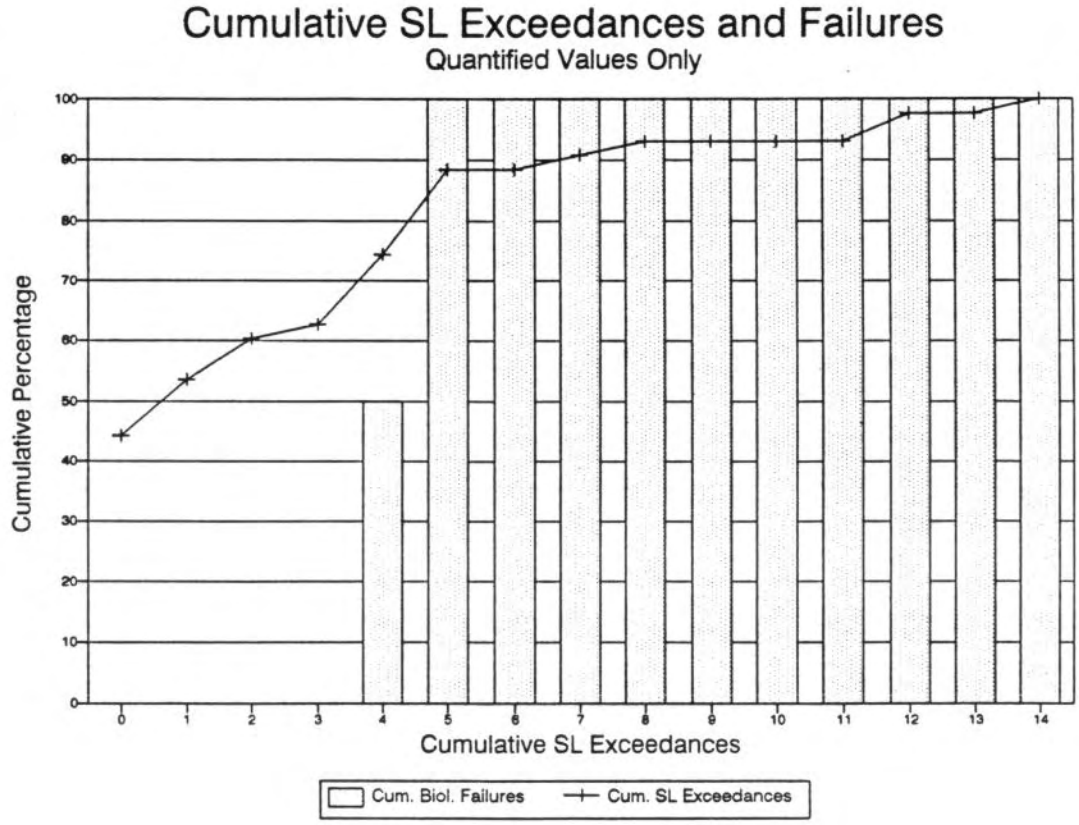


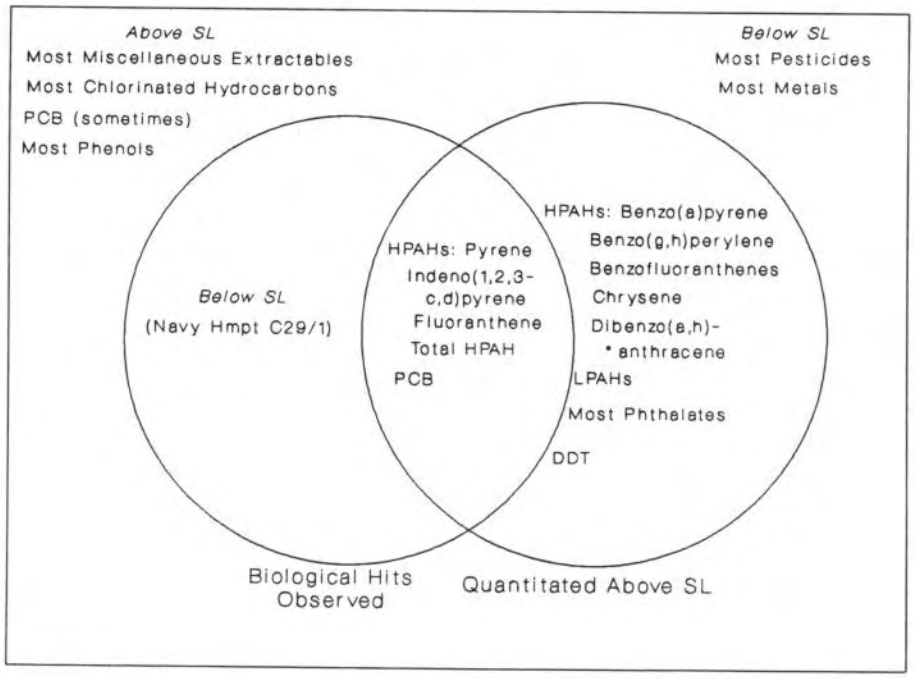
Figure IV-4.



Numerous compounds were detected or quantitated above the SL but were not associated with biological hits or failures during this dredging year. Figure IV-5 summarizes the data in this manner. The figure is a Venn diagram, in which the box represents all samples that were analyzed for both chemistry and biology during DY 90. The right circle represents the samples that had chemicals of concern quantitated above the SL. The remainder of the box includes all samples not quantitated above the SL. These comprise: samples that were quantitated below the SL (e.g., metals and pesticides) and those that were often not detected or quantitated above the SL value for some of the chemicals of concern (e.g., phenols). This latter condition is very important, because the PSDDA agencies have made an administrative decision (described in the Phase II MPR) to treat these nondetected values as though the compounds were present above the SL. Accordingly, biological testing is required. The left circle comprises the subset of the samples that had biological hits observed. The circles' intersection specifies those compounds that have both quantitated SL exceedances and biological effects observed. The compounds inscribed in that portion of the right circle that does not intersect the left circle are the primary concern of WPPA.

Figure IV-5. Chemical and Biological Summary of DY 90 Data

Figure IV-5. Chemical and Biological Summary
DY 90 Data Set



(Only amphipod, microtox, sed. larval tests used)

There are several important points in this diagram for the PSDDA agencies. First, there are evident quantitation problems represented by the groups of chemicals in the upper left corner of the box. These are the compounds that have been responsible for the greater number of SL exceedances or LM levels that are required to predict all of the failures. The PSDDA agencies are currently working with the contract labs to discover what may be done to improve this. Second, while the compounds of concern to WPPA have been identified from this data set, next dredging year's data may tell a different story. (As of this writing, a good many more failures of material are being reported during DY 91.) The PSDDA agencies will determine a priority and a time frame for looking at these compounds when they judge that there is sufficient and stable information on their behavior. Then, it would be logical to use the Ecology data base to access and consider a greater amount of information, perhaps applying the "sensitivity" test[4] to raised SLs. Third, the compounds in the circles' intersection deserve a closer look to assure that the SLs are protective once the agencies deem that there are sufficient data. Accordingly, this means of viewing the data suggests PSDDA priorities and actions: improvement of quantitation for those groups of compounds that are often unquantitated appears to be first priority.

b. Low-Moderate and Moderate Ranking Intervals. The PSDDA convention of assigning values of "low," "low-moderate," "moderate," or "high" to areas on the basis of SL and ML exceedances offers an opportunity to zoom in on intervals or intensities of exceedance. The analysis considers compounds in those categories. In the population of samples considered here, only one, US Navy Manchester S2/1, returned a value of moderate; this result was not associated with a biological failure nor any biological hits. The values that returned LM (with either detected on undetected values above SL) are displayed in the two figures on the next page in a fashion similar to the SL exceedances in previous figures. These results resemble the previous SL exceedance information because, as noted, the moderate interval did not contribute to the results. The drop from 7 LM exceedances (quantified plus undetected) to 5 LM exceedances (quantified only) suggests that primarily chemicals or combinations of chemicals between SL and (SL+ML)/2 are implicated in the biological effects interpreted in the guideline. Again, since unquantified values above SL are numerous in the data tables in this years' report they have a strong influence on the ability to predict failures.

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[4] Barrick, R., L. Brown, and S. Becker. 1988. Sediment Quality Values Refinement: Volume II--Evaluation of PSDDA Sediment Quality Values. Report prepared by PTI Environmental Services EPA's Office of Puget Sound (now Office of Coastal Waters).

Figure IV-5.

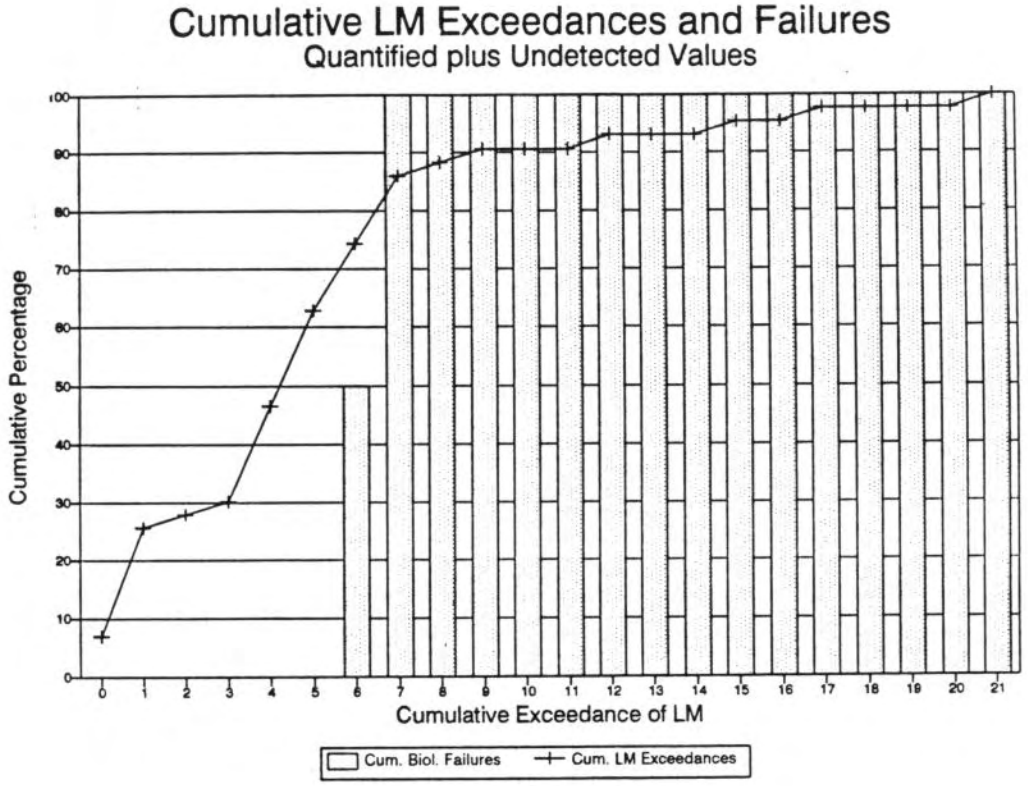
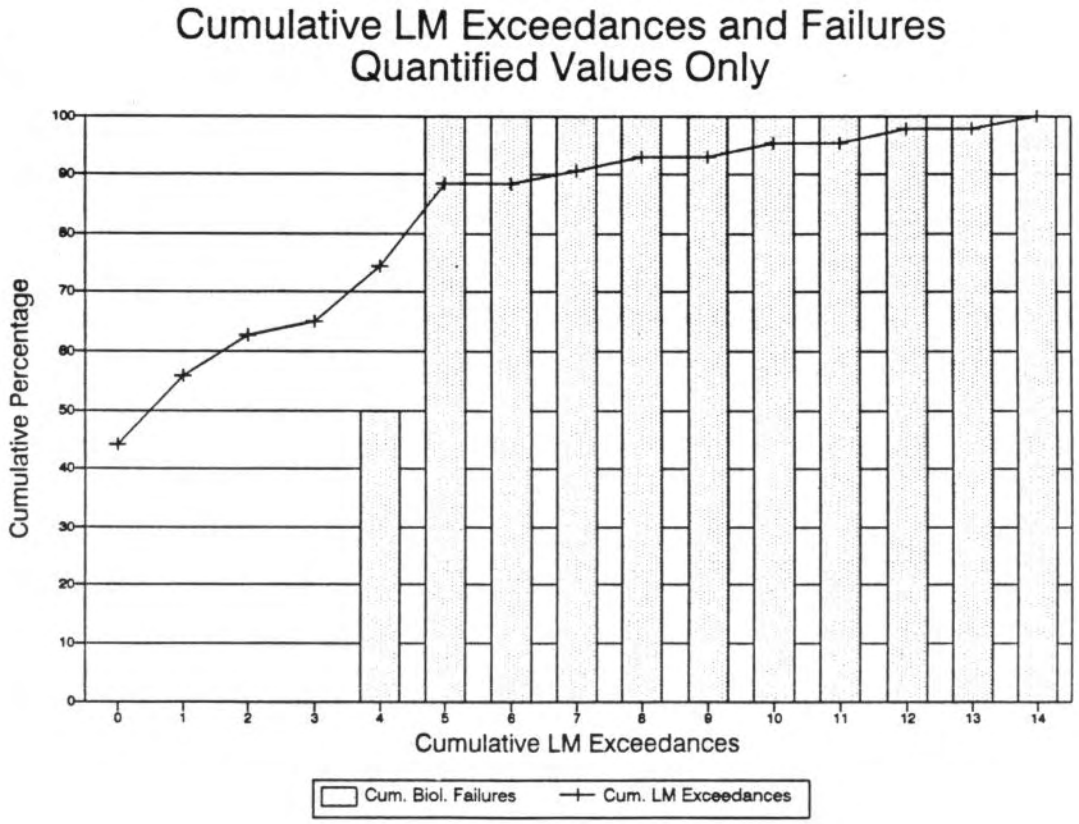


Figure IV-6.



The table below summarizes results of the SL exceedance and Low-Moderate analyses as possible management questions.

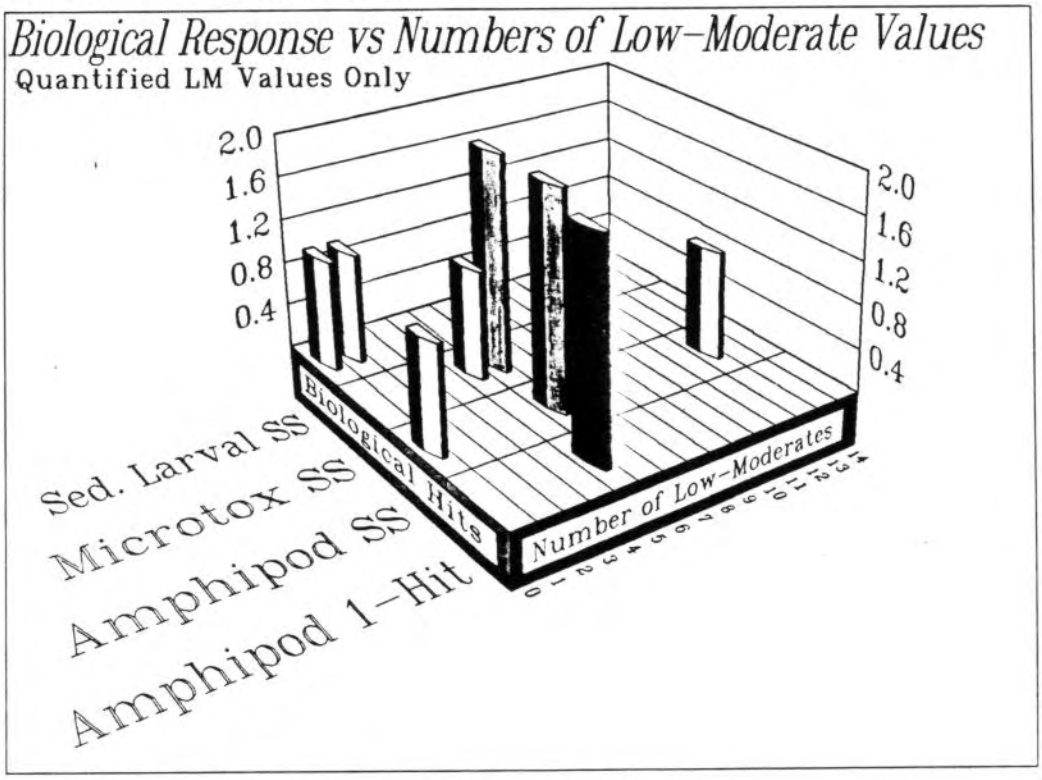
Table IV-1. Summary of Results of Analysis of Chemical Intervals versus Biological Response

Principal Question	Result assuming that undetected values indicate chemicals are present below SL (or other value).	Result assuming undetected values are present at detection limits.
What is the maximum number of SL exceedances that occur without material failure?	3	5
What is the minimum number of SL exceedances required to predict all biological failures?	5	7
What is the minimum number of occurrences of values between SL and (SL+ML)/2 that are required to predict all biological failures?	5	7
What is the minimum number of occurrences above (SL+ML)/2 that are required to predict all biological failures?	0 (All were predicted in the preceding block)	0 (All were predicted in the preceding block)

c. Consideration of Individual Test Results versus Numbers of Low Moderate Values.

Figure IV-7 shows all the biological responses that occurred in DY 90, on an axis of increasing numbers of exceedances in the range SL to (SL+ML)/2 (the low-moderate range shown in figure IV-1). The amphipod single-hit response (shown in the figure as a dark bar) occurred in two samples at 5 LMs or SL exceedances, and accounted for 2 of the 4 management units that had chemistry between the SL an ML and failed the nondispersive guideline. There were two double-hit failures, both with amphipod and microtox responses that were statistically significant and 20% over control. All of the rest of the biological responses met the nondispersive guideline.

Figure IV-7. Biological Responses by Test Organism and Intensity of Response (e.g., Hit, Failure) versus Low Moderate Values. See text for interpretation.



d. Tentative Conclusions from the Analyses in this Section.

- Several SL exceedances appear to be needed to predict failure of a dredged material sample. This is not inconsistent with the PSDDA management approach. Moreover, this data set is too small to suggest a modification of Sls at this time. Biological hits that did not represent material failures occurred below 3 cumulative quantified SL exceedances.

- All of the biological failures occurred between SL and (SL+ML)/2. This small data set tends to support the environmental protectiveness of the PSDDA SLs.

- It is probably too soon to determine whether SLs are in need of revision based on this limited data set. In future years' analyses, when there are more biological responses registered, it may be fruitful to examine chemicals that frequently occur above SL and are not associated with biological responses.

- Influence of undetected values above the SL is very noticeable on the ability to predict failures.

No management decisions based on the analysis are recommended for this year's Annual Review Meeting. It should be noted additionally that, in the subject DY, only the nondispersive guideline was applied; in future years, the dispersive guidelines--which are more restrictive--will make analysis more difficult.

3. Analysis by Individual Chemicals. In the preceding analyses, multiple chemicals were considered as they relate to the observed biological responses. This section considers individual chemicals that are associated with hits and failures. All the 4 failing samples had detected values of SL exceedance in common for:

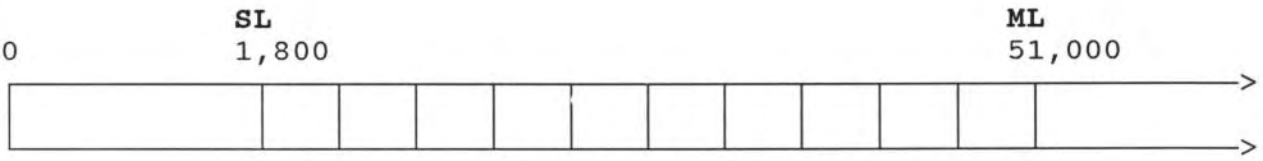
- indeno(1,2,3-c,d)pyrene
- pyrene
- total HPAH
- total PCBs

Two of them also had exceedances of the fluoranthene SL. None of the Duwamish samples had exceedances of metals SLs. All of the samples have analytical problems with detecting the compounds 1,2- and 1,4-dichlorobenzene, and the values reported exceeded the SL.

The analysis asks the following question: for those compounds associated with material failures, where do failures occur between SL and ML? It was necessary to normalize the SL to ML scale for the comparison because several of the chemicals had MLs that do not follow the usual rule of ML = 10xSL, so that scales would have differed for them. The normalization is displayed on pertinent graphs in Appendix V, and two examples are shown below.

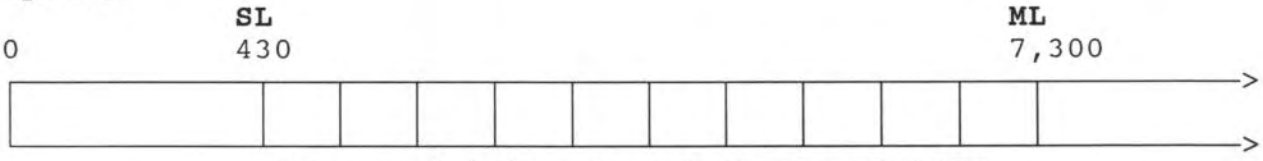
Figure IV-8. Examples of normalized SL-ML intervals.

Total HPAHs:



Ten equal intervals of (51,000-1,800)/10,
= 4,920 parts per billion in each interval.
(This is about 3 X SL in each interval.)

Pyrene:

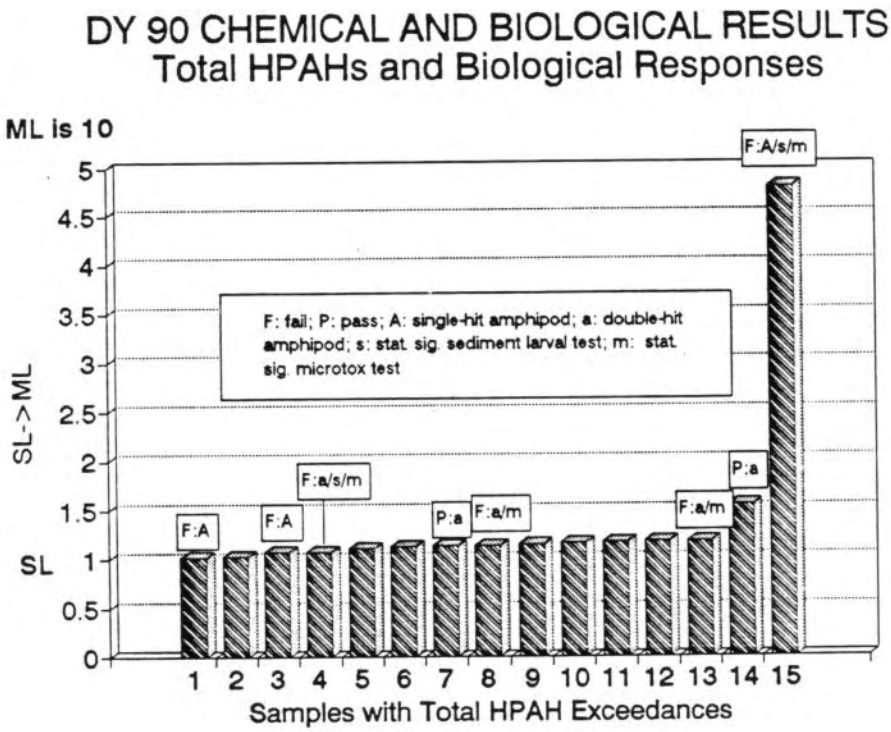


Ten equal intervals of (7,300-430)/10,
= 687 parts per billion in each interval.
(This is about 1.6 X SL in each interval.)

For this analysis, there are several differences from the preceding ones. First, the samples in most cases deal with chemicals such as HPAHs and PCBs for which the ML is more than 10 times

the SL. Normalization is done as indicated on this and ensuing figures to make the intervals from SL to ML into 10ths for comparability to those chemicals that have an ML = 10*SL. Second, the samples are ranked in order of increasing normalized values in order to make visual interpretation easier. (Previous charts had cumulative exceedances; for these charts, each bar represents a sample. Because the samples are ranked for each chemical, the X axis sample numbers do not represent the same sample in different figures.)

Figure IV-9.

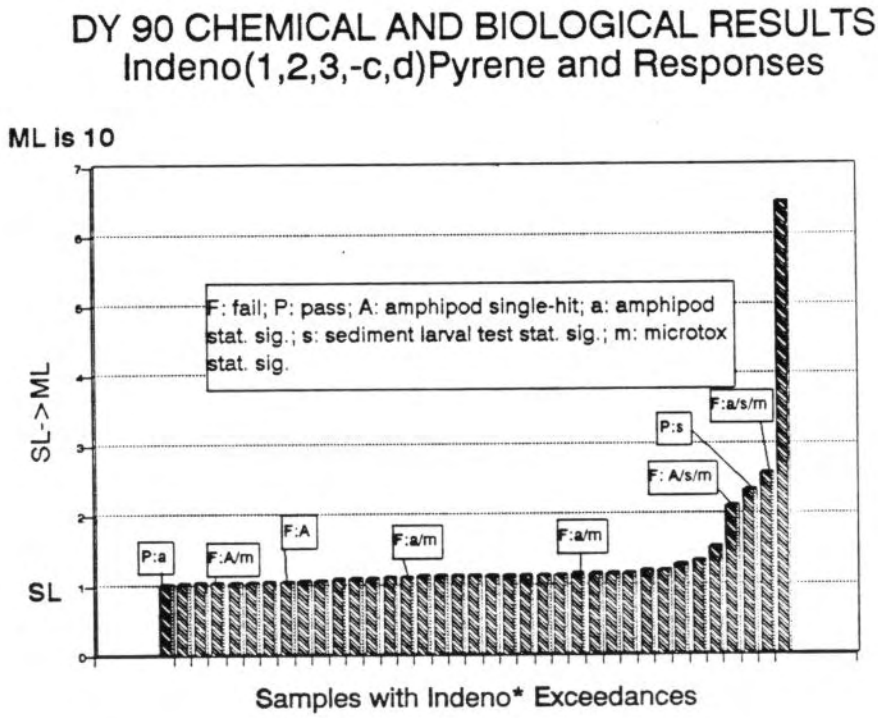


a. Total HPAHs. Figure IV-9 depicts samples that had total HPAHs at or above the SL. As indicated in the legend, F means failed and P means passed, and the following letters identify the biological tests that showed hits. A double letter such as "aa" denotes an intense response, a "single hit" failure in the amphipod test (at 30% over reference, statistically significant from reference, and 20% or over above control response. A single letter denotes statistical significance from reference, a response less than the guideline for single hit, and 20% over control response. No data box above the depicted sample means no biological response was observed in any of the bioassays for the sample with that level of chemistry.

For total HPAHs, it is clear that all but one normalized value were within the range of 1-1.6. Other than that, a definite pattern is difficult to discern. A strong (single-hit, A) amphipod response occurred both at the low and the high end of the range, and numerous double hits occurred throughout the range. The highest total HPAH sample showed a single hit response in the amphipod and confirmatory lower-level hits in both of the other two tests that were used. Another sample (number 4) also had statistically distinct (and 20% over control) responses in all 3 tests, but the amphipod response was less than the highest HPAH sample.

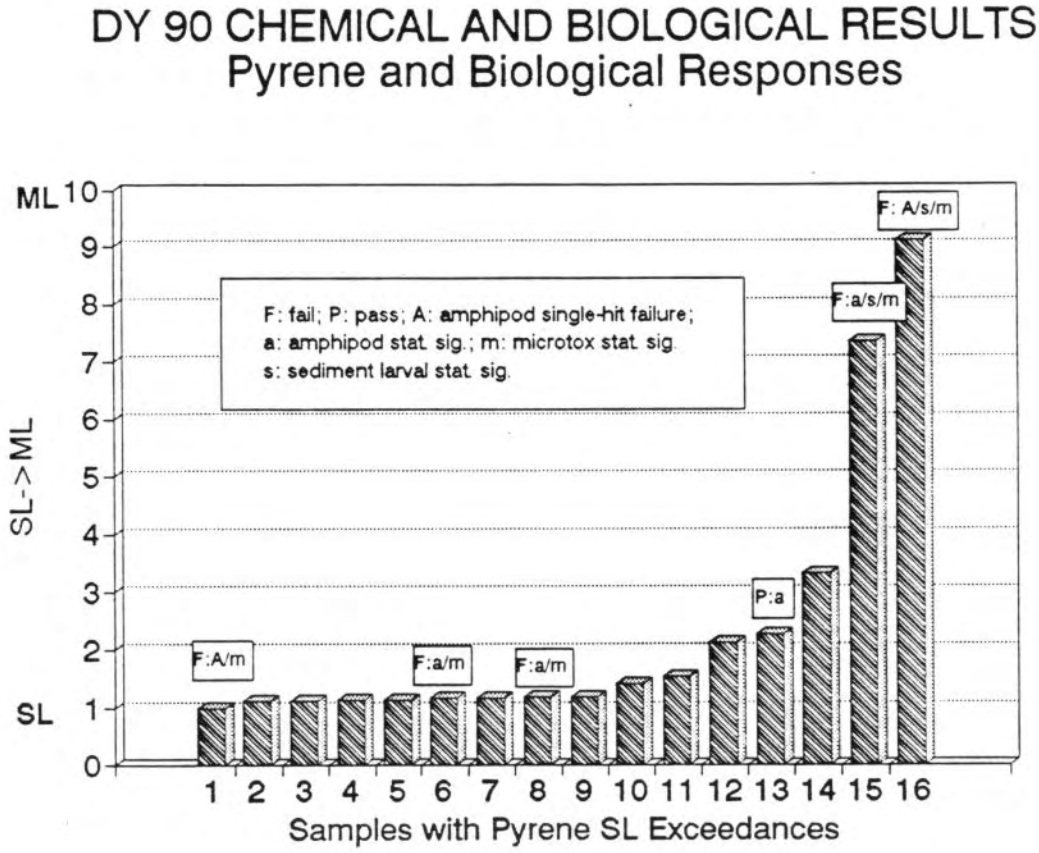
b. Indeno(1,2,3-c,d)pyrene. In Figure IV-10, below, there were more total exceedances than in the preceding total HPAH figure, and many of the values are near the SL. However, there are more intermediate (normalized value of 2 and above) values than in the total HPAHs. As before, however, a pattern seems to be lacking. Several test sediments (e.g., sample 35) pass at higher levels than those that fail with more intense biological response (e.g., samples 4, 8, 15, and 25). The highest value showed no biological response.

Figure IV-10.



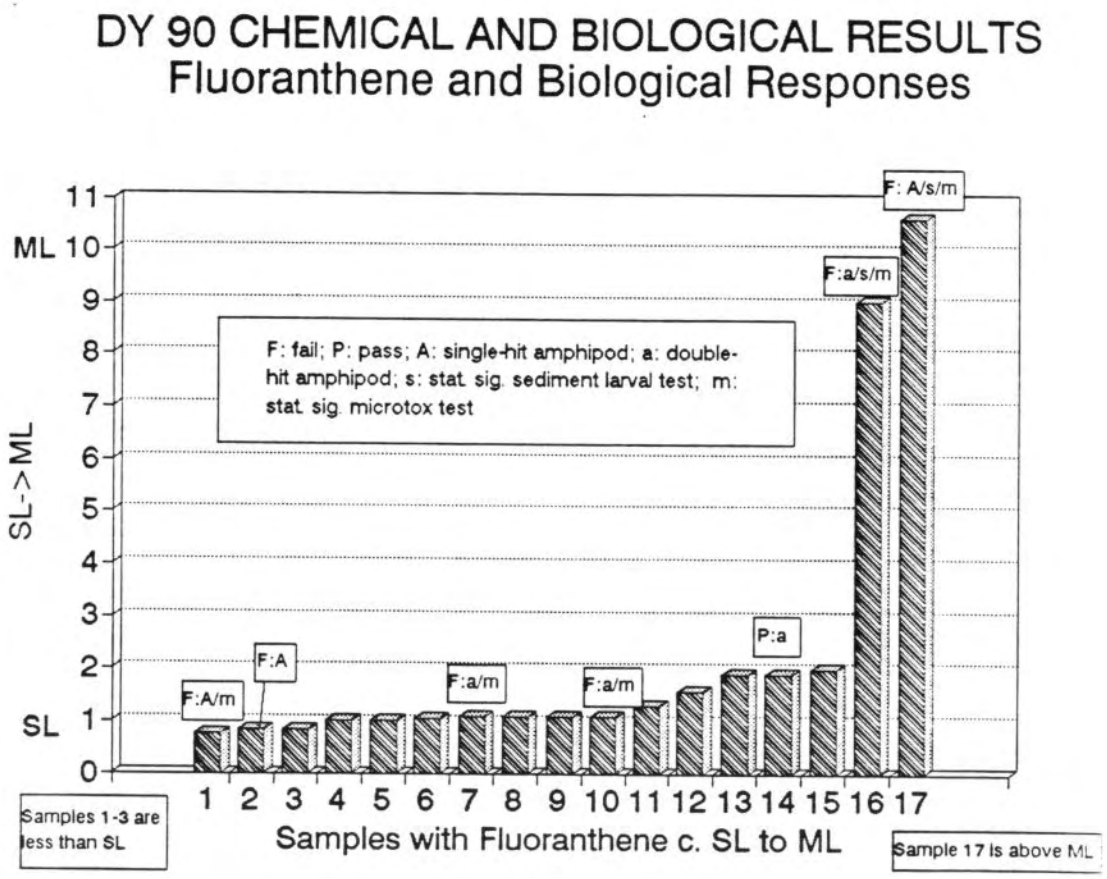
c. Pyrene. Figure IV-11 illustrates the situation for pyrene, another HPAH. As in the preceding analyses, single-hit and statistically significant responses occur without pattern at the lower end of the range, from 1 to 3. In this instance, however, the 2 highest values (which are 2 to 3 greater than the lower range) had single-hit or two-hit responses with confirmation by the other tests.

Figure IV-11.



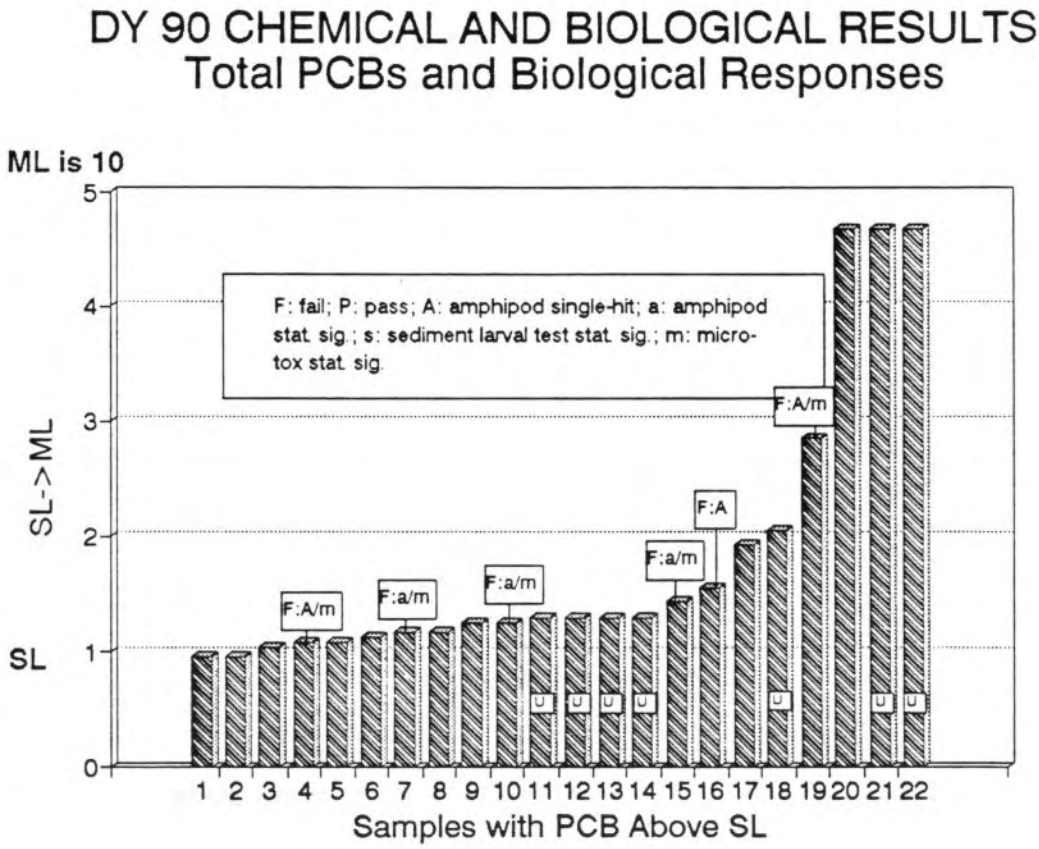
d. Fluoranthene. Figure IV-12 presents the final pattern for the HPAHs, fluoranthene. In this case, 3 values are shown that occurred near but slightly below the SL that have associated biological effects. (Fluoranthene SL exceedances were only associated with four of the six failures during DY 90.) With this exception, the pattern is similar to that for pyrene, above.

Figure IV-12.



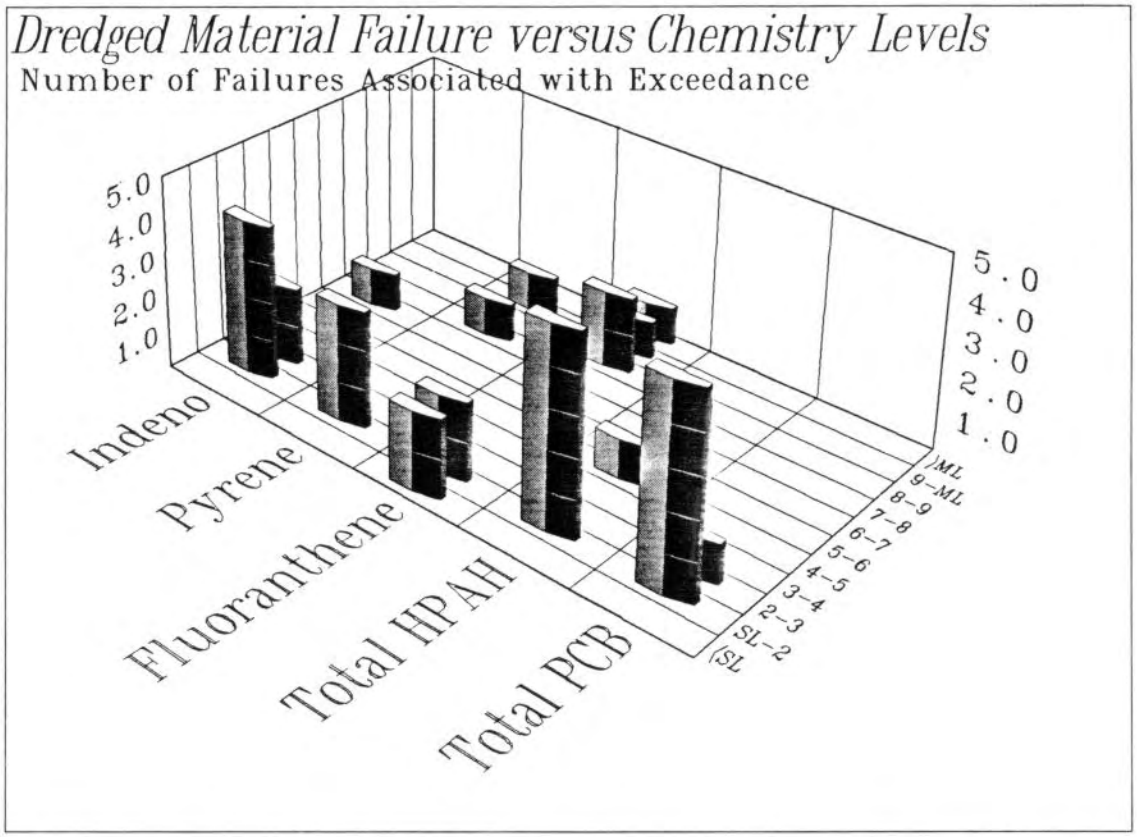
e. Total PCBs. Total PCBs were also examined. Figure IV-13 has the same legends as the preceding figures, but also shows a "U" on the histogram when the values that were reported were "undetected" values driven by the detection or quantitation limits in the analytical laboratories. However, none of the undetected values were found to be associated with bioassay responses in this dataset. Results of the display of total PCBs resemble those of the HPAHs presented above: it is difficult to find a pattern of increasing response with increasing level of the chemicals.

Figure IV-13.



f. Distribution of Failure by SL-ML Interval. Figure IV-14 displays the data set by numbers of failures without regard to the test or test that caused the failures. This summary format is thought to be among the most useful visual analytic methods in this year's report because it lends itself directly to addressing the management question regarding protectiveness and predictiveness of SLs and MLs.

Figure IV-14.



For these compounds, many of the failures occurred close to the SL end of the range. The SLs appear to be protective: the results of all except 2 failures (fluoranthene) were seen above SL. The fluoranthene failures were predicted by other SL exceedances in co-occurring compounds. Nonetheless, these compounds may need to be watched in future to assure that this pattern persists. If a converse pattern had been noted, with most failures occurring near the ML and few or none near the SL, it might suggest a review to determine whether the SLs are set artificially low.

It is important to note that the observed pattern in the figure could come about for reasons other than strict observance of the SL - ML interval:

- in DY 90, there are more samples with SL exceedances in the low range than in the high range, which gives more opportunity for failures near the SL; and

- the compounds in the table often occur together (and total HPAHs includes fluoranthene, pyrene, and indeno(1,2,3,-c,d)pyrene), so the compounds are probably

not acting independently, and could influence the patterns seen in the data. This would improve with a greater number of sediments.

g. Conclusions from the Comparison of Individual Chemical Levels. Despite the stated shortcomings, the last (summary) method of visualizing performance appears to provide the most promising means of looking at future years' data on individual compounds. However, due to the limitations in the data, no management decisions based on this analysis are recommended for this year's Annual Review Meeting. Ongoing changes to tests (which, for example, added the Neanthes acute test late in DY 90) or to chemical screening levels (e.g., the adjustment of the SL for pentachlorophenol from 69 to 100 ppb and the Ecology-proposed normalization of organic SLs and MLs to Total Organic Carbon) are also likely to influence the interpretations and patterns in the data.