SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING MINUTES

May 7, 1997

EPA
Region 10

WASHINGTON STATE DEPARTMENT OF ECOLOGY

US Army Corps of Engineers
Seattle District

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Jennifer M. Belcher - Commissioner of Public Lands
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LIST OF ACRONYMS

AET	Apparent Effects Thresholds
ARM	Annual Review Meeting
CSL	Cleanup Screening Level
CSMP	Cooperative Sediment Management Program
CSO	Combined Sewer Outfall
DMMO	Dredged Material Management Office
DMMP	Dredged Material Management Progam
DMMU	Dredged Material Management Units
DNR	Washington State Department of Natural Resources
Ecology	Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
LAET	Lower Apparent Effects Threshold
ML	Maximum Level
MTCA	Model Toxics Control Act
MUDS	Multiuser Confined Disposal Site
NPDES	National Pollution Discharge Elimination System
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PSDDA	Puget Sound Dredged Disposal Analysis
ROD	Record of Decision
RPD	Redox Potential Discontinuity
SAP	Sampling and Analysis Plan
SCUM1	Sediment Cleanup User's Manual Volume I
SCUM2	Sediment Cleanup User's Manual Volume II
SEDQUAL	Ecology's Sediment Quality Database
SL	Screening Level
SMARM	Sediment Management Annual Review Meeting
SMS	Sediment Management Standards
SQS	Sediment Quality Standard
TBT	Tributyltin
TMDL	Total Maximum Daily Loads
TOC	Total organic carbon
USACE	U.S. Army Corps of Engineers

SMARM MINUTES

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING MINUTES

The Cooperative Sediment Management Program (CSMP) held it annual review of dredging/disposal and sediment management issues on May 7, 1997. This Sediment Management Annual Review Meeting (SMARM) was hosted by the U.S. Army Corps of Engineers (USACE), Seattle District at the North Joint Use Auditorium at Federal Center South, Seattle, Washington. The SMARM combined both the Dredged Material Management Program (DMMP) annual review meeting and the Department of Ecology's Sediment Management Standards (SMS) annual review process. The DMMP is an interagency cooperative program for dredged material management that began with the Puget Sound Dredged Disposal Analysis Program (PSDDA) and has expanded to other regions of Washington State. The meeting agenda is provided as Attachment 1, and the list of attendees is provided as Attachment 2.

Morning Session

1. Brian Applebury. Chief, Operations Division, USACE, Seattle District gave opening remarks and introduced Colonel Donald T. Wynn, Commander, Seattle District Corps of Engineers.

2. Colonel Wynn welcomed the participants. He discussed the accomplishment of the agencies in cooperating in putting together and enacting protocols and guidelines for sediment management in the state of Washington. He spoke of how Washington's cooperative program is setting an example for the rest of the nation, which still has a long way to go in sediment management. He commended everyone on the progress that has been made, and urged them to continue forward with the work. As an example of how the program is continuing forward, Colonel Wynn pointed out that the agencies would soon meet on cost sharing to initiate the study to ultimately establish one or more multi-user disposal site (MUDS).

3. Brian Applebury introduced the panel of agency representatives: David Kendall, USACE, Seattle District; John Malek, Environmental Protection Agency (EPA), Region 10; Dave Bradley, Washington Department of Ecology (Ecology); and Craig Partridge, Washington Department of Natural Resources (DNR). Ann Essko, DNR, replaced Craig Partridge after the morning break.

4. Brian Applebury reviewed the objectives of the meeting and the topics of discussion, including overviews of DMMP and SMS programs, various agency and public issue papers, and DMMP/SMS clarification topics. Some of the clarification papers and status reports would not be presented during the meeting, but there would be time set aside during the meeting for comments on these papers. He also pointed out that there were comment sheets and boxes provided in the back for anyone who had

comments for discussion during the meeting or at the agencies post-SMARM meeting.

Ovrhd 1-1.	Sediment Management Annual Review Meeting
Ovrhd 1-2.	SMARM Sponsors and Host
Ovrhd 1-3.	Meeting Objectives and Purpose
Ovrhd 1-4.	Dredged Material Management Program Overview
Ovrhd 1-5.	SMS Group Overview
Ovrhd 1-6.	PSDDA Clarification Papers (presented)
Ovrhd 1-7.	Issue Papers (DMMP)
Ovrhd 1-8.	Public Issue Papers
Ovrhd 1-9.	Clarification Papers (not presented)
Ovrhd 1-10.	Status Reports (not presented)
Ovrhd 1-11.	Summary and Closing

5. David Kendall summarized the agency response actions to the 1996 SMARM. He indicated that the assessment of tributyltin (TBT) sensitivity in amphipod species was not accomplished in the past year due in part to funding constraints. However, in the near future they expect to assess TBT sensitivity of the amphipod *Leptocheirus plumulosus* in the 28-day chronic/sublethal test. He informed the attendees that the final TBT issue paper removed all references to a regulatory maximum level upper limit for TBT, and there currently is no established TBT upper limit for regulatory decision making. The agencies have also adopted the interstitial TBT DMMP screening level of 0.15 ppb as the bioaccumulation trigger. In addition, the DMMP and SMS have established an interim tissue TBT action level of 2 ppm wet weight. The agencies have also suspended conducting acute bioassays based on TBT alone.

Dr. Kendall also discussed the agencies' responses to bioassay testing issues. The agencies currently do not have the resources to assess sulfur and sulfide effects on the saline extract and solid phase Microtox bioassays, although sulfur and sulfide effects may be studied in the future. The agencies have re-examined and re-affirmed the initial weight standard of >0.25 mg/individual and 0.5 mg/individual (as target) for the *Neanthes* 20-day growth bioassay. The negative control growth rate standard (>0.38 mg/individual/day; 0.72 mg/individual/day as target) for the *Neanthes* bioassay has also been re-affirmed. The EPA/Corps ammonia purging protocol was utilized for the Port of Seattle, Terminal 18 dredging project, and found to reduce ammonia levels to acceptable levels (<20 mg/L). Dr. Kendall indicated that, for those interested, the Port of Seattle/EVS report on the effects of ammonia purging on contaminant concentrations in sediment interstitial water was provided in the back of the room.

During the 1996 SMARM, the public and ports had raised several issues concerning apparent effects threshold (AET) recalculations. Dr. Kendall indicated that the outcome of the deliberations were summarized in an issue paper that would be presented during the SMARM meeting and in a clarification paper, both of which were included in the SMARM meeting package. In addition, the interagency Bellingham Pilot demonstration project was initiated in September 1996, and the status of this project was also included in the SMARM meeting package mailed out to the public.

Ovrhd 2-1. Summary Agency Response Actions to May 1996 SMARM
Ovrhd 2-2. Joint PSDDA/SMS Issues (TBT Issues)
Ovrhd 2-3. DMMP/SMS Issues
Ovrhd 2-4. DMMP/SMS Issues (cont'd)
Ovrhd 2-5. DMMP Issues
Ovrhd 2-6. CSMP Issues

6. Substituting for Stephanie Stirling, David Fox (USACE) gave an overview of PSDDA, Grays Harbor, and Lower Columbia River project testing activities and DMMP evaluation procedures. He provided an update on the DMMP project volumes and the number of dredged material management units (DMMUs) for which chemistry, bioassay, and bioaccumulation analyses were conducted. He summarized the testing results including the number of PSDDA screening level, bioaccumulation trigger, and maximum level exceedances, bioassay hits, bioaccumulation failures, and the proportion of suitable and unsuitable material determined over all projects. The total volume dredged was 2,230,550 cubic yards, of which 84% were found suitable for unconfined-open-water disposal.

Ovrhd 3-1. DY96/97 Projects: Overview of PSDDA, Grays Harbor, and Lower Columbia River Evaluation Procedures
Ovrhd 3-2. DY96/97 Project Volumes: Puget Sound
Ovrhd 3-3. Chemical and Biological Testing
Ovrhd 3-4. Chemical and Biological Testing (cont'd)
Ovrhd 3-5. Suitable/Unsuitable Dredged Material
Ovrhd 3-6. Chemistry Testing Summary
Ovrhd 3-7. Bioassay Hits
Ovrhd 3-8. Bioaccumulation Testing
Ovrhd 3-9. Project Volumes: Grays Harbor
Ovrhd 3-10. Project Volumes: Columbia River
Ovrhd 3-11. Total Volume

7. Mr. Fox then gave a presentation on the use of the internet for disseminating sediment management information. He listed the Seattle District Corps of Engineer's home page address (http://www.nws.usace.army.mil), and the existing and future contents of the home page. The existing content includes email addresses for the Dredged Material Management Office (DMMO) staff, links to other DMMP agency home pages, and changes that have been made to PSDDA via the Annual Review Meeting (ARM) process and public workshops since 1989. The USACE will soon add Sampling and Analysis Plan (SAP) examples for both large and small projects, and the PSDDA Users Manual. The PSDDA Users Manual consolidates and condenses guidance found in PSDDA documents, workshop proceedings and annual review minutes into the essential nuts and bolts of the program, and will be updated every year. In the future, the USACE hopes to add biennial reports, posting of draft

SMARM papers, SMARM minutes, and updated DMMP manuals to the system. He thanked those involved in creating the Web site and entering the PSDDA updates.

Ovrhd 4-1.	Use of the Internet
Ovrhd 4-2.	Seattle District's Home Page Address
Ovrhd 4-3.	Existing Content
Ovrhd 4-4.	Soon-to-be-Existing Content
Ovrhd 4-5.	Future Use
Ovrhd 4-6.	Special Thanks

8. Ted Benson, DNR, presented an overview the PSDDA disposal site monitoring efforts. He reviewed the monitoring framework, monitoring tools, and modifications for the 1996 monitoring program at the Commencement Bay disposal site. He discussed the chemical tracking system that was used in the 1996 program to calculate time trends in single chemicals and groups of chemicals. The system is able to handle non-detected data and avoids "false alarms" due to random variation and analysis of many chemicals. He provided a flow chart on how the chemical tracking system works, and gave examples of fitted time trends in chemical concentrations in Commencement Bay from 1988-1996. The power to detect real trends using this system depends on the number of chemicals considered, variability, correlation among chemicals, number of samples per year, number of years, and the magnitude of the real trend. He also discussed how it is important to detect and handle outliers when calculating time trends.

Mr. Benson then summarized the findings of the 1995 monitoring survey and benchmark sediment and tissue chemistry analyses. He discussed the 1996 monitoring results, compared them to the 1995 survey, and evaluated the monitoring data. He provided recommendations to the monitoring program that included 1) compile and publish a disposal site monitoring plan which includes the numerous programmatic changes, field and analytical changes, transect biological analysis changes, and bioassay procedure and interpretation changes and 2) present future monitoring reports and appendices on a CD-ROM. Mr. Benson indicated that there would be no PSDDA disposal site monitoring for 1997.

Ovrhd 5-1.	Presentation Agenda
Ovrhd 5-2.	PSDDA Monitoring Framework
Ovrhd 5-3.	PSDDA Monitoring Tools
Ovrhd 5-4.	Modifications for the 1996 Monitoring Program
Ovrhd 5-5.	Chemical Tracking System
Ovrhd 5-6.	Raw Data - Examples from CBP01, Commencement Bay
Ovrhd 5-7.	False Alarms. Hypothetical Example.
Ovrhd 5-8.	Correlations Among Chemicals Varies and Affects Analysis and Conclusions
Ovrhd 5-9.	Chemical Tracking System (flowchart)
Ovrhd 5-10.	Fitted Time Trends in Chemical Concentrations
Ovrhd 5-11.	Power to Detect Real Trends Depends On...

Ovrhd 5-12. Power Curves (Simplified Examples)
Ovrhd 5-13. Outliers Affect Estimated Trend. Hypothetical Example
Ovrhd 5-14. What Else Can Help Determine if Chemicals are on the Move?
Ovrhd 5-15. Findings
Ovrhd 5-16. Summary of 1995 Conditions
Ovrhd 5-17. Summary of 1995 Conditions (cont'd)
Ovrhd 5-18. 1995 Benchmark Sediment and Tissue Chemistry
Ovrhd 5-19. 1995 Benchmark Sediment and Tissue Chemistry (cont'd)
Ovrhd 5-20. Sediment Vertical Profile System (SVPS)
Ovrhd 5-21. Commencement Bay Stations
Ovrhd 5-22. Distribution of Infaunal Successional Stages in 1996
Ovrhd 5-23. Surficial Footprint of Silt-clay Dredged Material in 1996
Ovrhd 5-24. Distribution of Grain Size Major Mode in 1996
Ovrhd 5-25. Distribution of Apparent RPD Depths in 1996
Ovrhd 5-26. Dredged Material Footprint at Commencement Bay Site in 1996
Ovrhd 5-27. Distribution of Dredged Material at the Commencement Bay Site
Ovrhd 5-28. Distribution of Organism-Sediment Indices in 1996
Ovrhd 5-29. Sediment Chemistry
Ovrhd 5-30. Sediment Bioassays
Ovrhd 5-31. Evaluation of 1996 Monitoring Data
Ovrhd 5-32. Evaluation of 1996 Monitoring Data (cont'd)
Ovrhd 5-33. Chemical Tracking System Output for Commencement Bay Station CBP01
Ovrhd 5-34. Maximum Likelihood Results for Commencement Bay Perimeter Stations.
Ovrhd 5-35. Chemical Tracking System Output for Commencement Bay Station CBP03.
Ovrhd 5-36. Evaluation of 1996 Monitoring Data
Ovrhd 5-37. Evaluation of 1996 Monitoring Data
Ovrhd 5-38. Recommendations

9. <u>Public Comments and Questions</u>

Carl Kassebaum, Hartman Consulting Corporation, mentioned to Ted Benson that there was a 1984 study done in Commencement Bay before the PSDDA effort was conducted. During the 1984 study, those conducting the survey could not distinguish the Commencement Bay site from the surrounding area. He believed that there might be a lot of natural cadmium present at the site. He suggested that Ted Benson might want to look at the 1984 data to see if a trend is observed.

Ted Benson said that he would be interested in seeing the report.

Tom Gries, Ecology, commented that according to the data Ted Benson presented, there were no trends in chemistry concentrations at the Commencement Bay disposal site. Based on conversations with Tim Thompson, he thought there was a slight trend in chemistry levels.

Tim Thompson, Remedial Technologies Inc., responded that in the original analysis there was no overall increase in all site contaminants. However, a mathematical error was detected when spreadsheets were reviewed again. The analysis was rerun, and the results indicated that polycyclic aromatic hydrocarbons (PAHs) had decreased significantly since the original monitoring. There were some modest increases in some of the metals. This will be in the revised PSDDA report SAIC will submit to DNR.

**** MORNING BREAK****

10. Brian Applebury introduced the next topic, the SMS group overview, including SMS activities and annual review, regional cleanup activities, and triennial review status.

11. Rachel Friedman-Thomas, Ecology, discussed the SMS sediment activities including sediment program implementation, coordination, and the importance of maintaining a scientific and technical foundation. For sediment source control, activities to date have focused on point sources. Sediment data for areas adjacent to 38 NPDES discharges showed 18 areas with sediment impacts (some are due to historic discharges). Contaminants of concern included metals, phthalates, PAHs, PCBs, and phenols. She indicated that Brendan McFarland is the point of contact for discharge information.

Ms. Friedman-Thomas said that for sediment cleanup implementation, Ecology has published a contaminated sediment site list. Ecology has also participated in the Bellingham Bay demonstration project, and provided technical assistance and coordination with regional cleanup staff on site work. The point of contact for sediment cleanup is Michelle Wilcox.

Ecology is developing a new in-house graphical version of SEDQUAL which can be linked to ArcView GIS systems. It should be available to the public approximately in the fall of 1997. Ecology will be able to use the system for criteria comparisons and AET calculation. Martin Payne is the point of contact.

Ms. Friedman-Thomas also spoke of future sediment program laboratory accreditation requirements. Ecology will revise the SMS to require laboratory accreditation (Chapter 173-50 WAC, Accreditation of Environmental Laboratories). Kathy Bragdon-Cook is the point of contact for laboratory accreditation.

Ms. Friedman-Thomas concluded with the sediment program challenges such as addressing stormwater and nonpoint sources of sediment contamination, developing sediment-based total maximum daily loads (TMDLs), updating discharge assessment tools, emphasizing sediment quality in watershed planning, updating the contaminated sediment site list, and continuing to promote consistent data quality. She provided the Ecology sediment internet site as: http://www.wa.gov/ecology/cp/sediment.html. She notified the attendees that order forms for Sediment Source Control Users Manual and

Sediment Cleanup Users Manual (SCUM I and SCUM II, respectively) documents will be available on the homepage. Ecology is conducting annual review of the SMS rule between May 7 - June 7, and she asked the public to submit any comments on the SMS rule during this timeframe.

- Ovrhd 6-1. SMS Sediment Activities
- Ovrhd 6-2. Sediment Program Implementation (Sediment Source Control)
- Ovrhd 6-3. Sediment Program Implementation (Sediment Cleanup)
- Ovrhd 6-4. Sediment Program Implementation (Information Management and Lab Accreditation)
- Ovrhd 6-5. Sediment Program Challenges (Sediment Source Control)
- Ovrhd 6-6. Sediment Program Challenges

12. Teresa Michelsen, Ecology, discussed the regional cleanup activities. She presented the status of sediment cleanup sites. Approximately one third of the sites are in the cleanup phase, while another third are in the remedial investigation/feasibility phase, and the final third are either in the initial investigation or work has not begun. She stated that there are large challenges ahead, including source control at some of the sites. The site list presented was for Puget Sound. There are others addressing issues in other parts of Washington, including Eastern Washington. She said there is still much work to be done, but that good progress is being made.

Dr. Michelsen listed the program accomplishments. She indicated that no new orders to accomplish cleanup have been issued, they have provided a model for technical assistance and interagency cooperation, and waterfront redevelopment has provided opportunities for collaborative, cost-effective projects. Staff training has been completed. Ecology has also collaborated with the University of Wisconsin to offer training courses in understanding marine sediment analysis and interpretation, and cleaning contaminated marine sediment. These courses will be offered in Seattle in mid-July. The program has also developed agency guidance for TBT, wood waste, and bioassay statistics.

Dr. Michelsen then summarized the cleanup decisions and decision factors for several contaminated sites. Four sites (Southwest Harbor Project, Duwamish/Diagonal CSO, Cascade Pole, and Eagle Harbor) required cleanup to cleanup screening levels (CSL) due to proximity to other sites, recontamination potential, cost and technical feasibility, or cost/benefit analysis. The Norfolk combined sewer outfall (CSO) required cleanup to sediment quality standards (SQS), which is a more stringent cleanup, but had smaller additional costs. Cleanup standards selected in pre-SMS Records of Decision (RODs) were used for St. Paul and Sitcum Waterways. Cleanup was performance-based for Everett Piers 1&3, which were dredged to native sediment. Cleanup standards for 5 other sites (see overhead, Appendix C) were based on bioaccumulation or human health risks.

- Ovrhd 7-1. Status of Sediment Cleanup Sites
- Ovrhd 7-2. Program Accomplishments
- Ovrhd 7-3. Cleanup Decision Summary

13. Dave Bradley, Ecology, gave a status report on the SMS triennial review. He provided a background on the triennial review process, summarized triennial review issues, described the next steps toward completing the triennial review, and identified key challenges to complete the triennial review. He spoke of the Draft Responsiveness Summary for sediment management standards, which included recommended rule revisions, issues requiring more discussion, and issues recommended for no further action. Some of the triennial review issues included sediment cleanup, sediment quality criteria, test methods, and human health sediment quality values. The next steps toward completing the triennial review included distribution of the Draft Responsiveness Summary (May 1997), implementation committee discussions (summer 1997), coordination with other regulatory programs (summer 1997), and preparation of recommended SMS rule amendments (fall 1997). Challenges in completing the review were to re-engage stakeholder groups, resolving technical issues, meeting commitments, and finding a regulatory balance.

Ovrhd 8-1. SMS Triennial Review
Ovrhd 8-2. Triennial Review Background
Ovrhd 8-3. Triennial Review Draft Responsiveness Summary
Ovrhd 8-4. Triennial Review Issues
Ovrhd 8-5. Triennial Review Issues (cont'd)
Ovrhd 8-6. Triennial Review Next Steps
Ovrhd 8-7. Triennial Review Challenges

14. Public Comments and Questions

Scott Mickelson, King County Environmental Laboratory, asked Rachel Friedman-Thomas if Dale Norton's group was the appropriate contact for sediment trap information.

She responded that he was correct.

Kris Holm, Northwest Pulp and Paper Industry, asked when the draft wood waste guidance document would be available, or whether it was in the SMARM mail out. She wondered how it fit in with Governor Locke's regulatory reform order issued in March regarding guidance documents. It required analysis by all state government agencies regarding guidance and rules put forth. She mentioned that there is a sometimes subtle distinction between guidance and rule.

Teresa Michelsen responded that Kris Holm's question was a question the agencies struggled with when writing the guidance. Dr. Michelsen said that the document was included in the SMARM mail out, and it will be presented today. She said the guidance did not require new rule language. The agencies applied what was written in the rule for wood waste guidance. They are also looking for ways proponents can save money in addressing wood waste at their sites. She said that Kris Holm's question was a very important question. However, for this particular guidance, the regulatory reform order did not apply because the existing rule approach was used.

Kris Holm said that if followed up in the executive order, the guidance should be completed in consultation with the Attorney General's Office. She wondered if that had been done in this case.

Dr. Michelsen responded that the requirement to consult with the Attorney General did not apply since the wood waste guidance was not a new rule. However, the agencies did coordinate with the Attorney General's Office.

Kris Holm asked if the wood waste guidance issue would be on the agenda for the next sediment implementation committee meeting. She wondered if the committee would be given the opportunity to review the guidance document before it would become official. She would also like to look at the issue of rule vs. guidance during the committee meeting.

Dave Bradley added that he thought it was a broader issue than just wood waste. Ecology has a number of existing documents that fit with the regulatory reform guidelines, but it is a broader issue.

Kris Holm agreed. She felt that if there is going to be formal guidance issued by Ecology, the public needs to know how the rule would be implemented.

Dave Bradley said that her point was well taken.

** LUNCH BREAK **

Afternoon Session

15. Justine Barton, EPA, discussed guidelines for beneficial use of dredged material. She indicated that there was an interagency/intergovernmental agreement to compile agency policies and procedures, identify similarities and differences, prepare a common set of policies, recommend an integrated procedure for agency review and approval, and identify implementation methods and unresolved issues. A user manual for project proponents is currently under agency review, and will be open for public review during June. An executive summary has been prepared for agency directors. Agency representatives involved are Vernice Santee (Ecology), Ted Benson (DNR), Justine Barton (EPA), and Stephanie Stirling (USACE). She said to contact her if interested in reviewing the User's Manual in June.

For pre-application for material for beneficial use, she indicated the DNR or Corps representative should be contacted early. They will present the project at the interagency CSMP monthly meeting. The proponent may be asked to prepare a brief presentation or write-up. Some of the conflicts which may need to be resolved depend on the type of beneficial use proposed, project readiness, costs, logistics, material ownership, public trusts, volume required, urgency to resolve the problem, and the agency authority. Physical, chemical, and biological characteristics of the material will be considered. These characteristics are usually compared to SQS and CSL. Should chemical and biological character be greater than the SQS, but less than the CSL, the material may be appropriate on a case-by-case basis due to site specific considerations. In some instances, a PSDDA suitability determination may be conducted for sediments slated for unconfined, open-water disposal at a designated disposal site, and the material is later considered for beneficial use. In these cases, the results need to be repackaged and compared to SMS in order to be considered for beneficial use. She indicated that if project sediments (chemistry and bioassays) are less than or equal to SQS, the suitability determination will indicate that the material is generally acceptable for beneficial use. However, the suitability determination is not a permit. Best professional judgement may also be necessary when determining if the material may be used for beneficial purposes.

Ovrhd 9-1.	Beneficial Use of Dredged Material
Ovrhd 9-2.	Interagency/Intergovernmental Agreement
Ovrhd 9-3.	Products
Ovrhd 9-4.	Pre-Application for Material
Ovrhd 9-5.	Resolving Conflicts
Ovrhd 9-6.	Resolving Conflicts (cont'd)
Ovrhd 9-7.	Sediment Characterization
Ovrhd 9-8.	Sediment Characterization (cont'd)
Ovrhd 9-9.	PSDDA Comparisons
Ovrhd 9-10.	Suitability Determination Process
Ovrhd 9-11.	Suitability Determination Process (cont'd)

16. Teresa Michelsen and David Kendall presented the clarification paper on the management of wood waste. Dr. Michelsen gave the SMS approach to cleanup sites, and Dr. Kendall discussed how it would be managed in the PSDDA program. Dr. Michelsen described the impacts of wood waste on the surrounding environment, such as increasing the biological oxygen demand, causing sediments to become anaerobic, causing a build-up of ammonia and sulfides (or methane), introducing toxic chemicals as the wood waste breaks down, smothering benthic organisms, and altering the benthic substrate. Wood waste accumulations can persist for decades. In addition, the impacts are quite variable depending on the type of sediment, surrounding environment, benthic community present, type and size of wood, salinity, and flushing rates. For example, large pieces of wood debris could provide habitat, while small shredded material could smother the organisms present.

Teresa Michelsen then discussed wood waste characterization and cleanup. She indicated that it is not possible to develop a single criterion that would predict the impacts of wood waste. Existing biological standards and regulatory authorities such as the Water Pollution Control Act, Model Toxics Control Act (MTCA), and SMS would apply. Sediments with wood waste mixed in would follow SMS criteria. For evaluating in-situ toxicity, the agencies do not recommend bioassay purging. If the sediment containing wood waste will be moved to another environment (e.g., dredged), purging may be acceptable. They encourage studying benthic effects (chronic tests), although this is not part of the required testing. Solid waste regulations may also apply. The rule currently does not indicate where solid waste applies, although if the material is 100 percent wood waste, it would be treated as solid waste.

Wood waste characterization and screening tools include sediment vertical profile imaging, video surveys, and other remote sensing techniques. In addition, TOC and depth of the aerobic layer in sediments with wood waste would be compared to reference area sediments. Dr. Michelsen encouraged beneficial reuse of wood waste such as for soil amendments and fuel. She encouraged the public to submit suggestions for other possible ways of reusing the material.

Ovrhd 10-1. Wood Waste Impacts
Ovrhd 10-2. Wood Waste Characterization and Cleanup

17. Dr. Kendall then discussed proposed DMMP actions for wood waste. These included conducting a visual assessment of the material, selectively removing debris greater than 24" by 24", and analyzing material less than 24" by 24". The analysis would include conducting weight-specific analysis methods (e.g., Modified Volatile Solids) and converting the weight-specific fraction (dry weight) to volume basis by multiplying by two. Estimated sample volumes greater than 50 percent (e.g., >25 percent by weight) would require biological testing. Sample volumes less than 50 percent would be suitable for unconfined open-water disposal without biological testing unless other chemicals of concern exceeded screening levels. Recommendations for improving bioassay performance for wood waste samples included monitoring interstitial ammonia levels, and when levels exceed 20 mg/L, the agencies recommended the use of the ammonia purging protocol (EPA/Corps) to reduce ammonia levels below 20 mg/L. The agencies also recommended analysis of the organic-free sample for particle size distribution and to use it in conjunction with the conventional particle size analysis to select the appropriate amphipod species and reference sediment.

Ovrhd 11-1. Proposed DMMP Actions
Ovrhd 11-2. Proposed DMMP Actions (cont'd)

18. Public Comments and Questions

Allan Chartrand, Muckleshoot Tribe, indicated that he was confused about the recommendation for bioassay purging. Teresa Michelsen had said that it was not recommended for wood waste, and Dr. Kendall had indicated that it was recommended when ammonia levels exceed 20 mg/L.

David Kendall clarified that purging is acceptable for dredging projects.

Allan Chartrand said that he thought that even for dredging projects, ammonia could contribute to the toxicity.

Dr. Kendall replied that when picking up sediment and moving it to another location, the agencies have found that ammonia is a transient problem, but not a persistent problem at disposal sites. Therefore, they feel ammonia purging is appropriate.

Tim Thompson, ReTec, mentioned that during a recent project, the bioassay laboratory indicated there was a high degree of predatory epifauna on the wood waste. Mr. Thompson commented that this could be a confounding feature that one should be aware of when conducting bioassays.

Doug Hotchkiss, Port of Seattle, wanted to point out that the 20 mg/L ammonia level in the overlying water used to determine whether purging is required is inconsistent with the protocol they have used for purging. He said that it is the ammonia in the interstitial water that determines when purging is necessary (for the amphipod test). He thought the agencies should look at this issue.

Kris Holm commented on Teresa Michelsen's discussion of beneficial uses for wood waste. She said that it would not be beneficial to burn salt laden wood waste due to its effect on air quality during the combustion process.

Dr. Michelsen concurred, and said wood waste from freshwater locations potentially would be used for this purpose. She acknowledged that this would need to be clarified.

Kris Holm mentioned that there was no discussion of source control for wood waste. She wondered if the guidance document prepared by the agencies would address source control issues.

Dr. Michelsen responded that they had discussed it among the agencies, but will not be addressing source control during this meeting or in the guidance document. The reason for not including it was primarily due to log rafting issues that would be best addressed in other venues.

Kris Holm surmised that Ecology would not be adding wood waste sites to the site cleanup list for 1997.

Dr. Michelsen said that they would not.

Carl Stivers, Parametrix, commented that the definition of when wood waste is a solid waste needs to be more specific. He asked when the agencies would have another policy paper saying when wood waste material is and is not a solid waste.

Teresa Michelsen responded that they may be able to integrate it into the paper they presented, depending on when they receive comments and when they receive the solid waste program's definition of wood waste and its beneficial uses. She was uncertain if they will have the information in time to integrate it into the paper for the SMARM minutes.

Carl Stivers added that it is critical to know ahead of time how the agencies will deal with the wood waste (e.g., whether it will be treated as a solid waste). A lot of money can be spent on a project characterizing the wood waste.

Teresa Michelsen said that they have identified some wood waste sites where they decided not to focus money for characterization on areas where they knew wood waste was a problem. She said that it is difficult to pick a number as to when certain amounts of coverage should be treated as a solid waste. For example, some sediments which have 50 percent wood waste coverage appear to be fine. As a result, the agencies have been deliberately vague with their definition. She commented that what they could do now is sit down with proponents, identify areas where wood waste is clearly a problem, and focus the money on the fringe areas.

Carl Stivers added that when dealing with the vertical extent of wood waste, one may end up with less percent coverage. For example, for locations that have 6 cm of coverage and the rest mud, there really is not a high percentage of wood waste.

Teresa Michelsen agreed that some cores may be necessary to characterize the site. Sediment vertical profile imaging helps to some extent. She asked Carl Stivers to put his comments in writing so that she could be sure to address them.

19. Ted Benson discussed verification methods for dredging of material unsuitable for open water disposal. Projects may be comprised of both suitable and unsuitable material, and only suitable material may be place at DMMP disposal sites. There is an increasing number of projects which have both suitable and unsuitable dredged material management units (DMMUs) in the dredge prism. Therefore, dredge sequencing and DMMU tracking is necessary in order to ensure that chemical guidelines are not exceeded at the disposal sites. The DMMP agencies may require more documentation than has been the case when only suitable material will be disposed. This may require additional bathymetric surveys and phased dredging (e.g., removing unsuitable material before the suitable material is dredged). For these projects, dredging methodology needs to be addressed in the dredging plan. For more complex projects, the dredging issue should be addressed early.

Mr. Benson also passed on a message from Hiram Arden, USACE. Hiram Arden said that coordination of offset distances have been helpful. This can be incorporated into the dredging plan, including dredge cut angles.

Ovrhd 12-1.	Verification of Methods for Dredging of Materia Unsuitable for Open Water Disposal
Ovrhd 12-2.	Introduction
Ovrhd 12-3.	Problem Identification

Ovrhd 12-4. Problem Identification (cont'd)
Ovrhd 12-5. Proposed Action
Ovrhd 12-6. Proposed Action (cont'd)

20. Tom Gries, Ecology, discussed revisions to DMMP screening and maximum level guidelines. He reviewed the background for the revisions including calculation of 1994 amphipod and echinoderm AETs, requirement of a QA2 level review for surveys setting new AETs, formation of a regulatory work group (RWG), and analysis of implications of changing guideline values.

The comments they received during the 1996 SMARM created the impetus to move forward and create the RWG. The objectives of the work group were to re-evaluate assumptions underlying AETs, recommend revisions to guidelines, and recommend ways to streamline processes. The work group consisted of technical experts, policy makers, and stakeholders who met five times from November 1996 to February 1997. The members agreed to provide their individual expertise and work together, and to not attempt to represent their particular agency or organization. Work group recommendations were made by consensus. Short term (for the 1997 SMARM), medium term (for the SMARM 1998), and long term (for the SMARM 1999) recommendations set forth by the work group are provided in Tom Gries' presentation overheads included in Appendix C. The issue paper addresses only short-term recommendations.

The DMMP agencies agreed with all but two of the recommended short-term changes. The agencies will not use 1994 echinoderm AETs to set lower apparent effects thresholds (LAETs) or screening levels (SLs), primarily because more work needs to be done on assessing different sensitivities among the species used for the test. They recommended suspending the use of echinoderm AETs until the agencies are certain of the numbers. Therefore, the amphipod, benthic, oyster, and Microtox AETs will be used. In addition, the agencies disagreed with the work group that SLs should only increase in value.

Tom Gries displayed a figure that compared 307 sediment stations to 1994 and 1997 SLs (many now TOC normalized). For the 1997 SLs, there were fewer stations, samples, and chemicals that exceeded screening levels. This could represent a cost saving in handling and testing these sediments. However, more stations, samples, and chemicals exceeded the 1997 maximum levels (ML) than 1994 MLs. While some of the proposed MLs in 1997, more MLs were exceeded, perhaps as a result of carbon normalizing the data (compared to dry weight). Certain key chemicals drove these results. Analytes for which the ML increased include cadmium and mercury (slight increase), chrysene (2X), dibenzo(a,h)anthracene (2X), and bis(2-ethylhexyl)phthalate (2.7X). Conclusions of the work group were that there is an adequate scientific and programmatic basis for changes to SL and ML values, and the proposed changes have significant positive cost implications without significant added environmental risk. The agencies need to revisit proposed maximum levels to see if carbon normalizing them creates more exceedances. .

Ovrhd 13-1. Revisions to DMMP Screening and Maximum Level Guidelines

Ovrhd 13-2. Revisions to DMMP Guidelines - Background
Ovrhd 13-3. Revisions to DMMP Guidelines - Regulatory Work Group
Ovrhd 13-4. Revisions to DMMP Guidelines - Regulatory Work Group (Cont.)
Ovrhd 13-5. Revisions to DMMP Guidelines - RWG Recommendations
Ovrhd 13-6. Revisions to DMMP Guidelines - Medium-term Recommendations
Ovrhd 13-7. Revisions to DMMP Guidelines - Long-term Recommendations
Ovrhd 13-8. Revisions to DMMP Guidelines - Short-term Recommendations
Ovrhd 13-9 Revisions to DMMP Guidelines - DMMP Response
Ovrhd 13-10. Revisions to DMMP Guidelines - 1994 vs 1997 SL Exceedances
Ovrhd 13-11. Revisions to DMMP Guidelines - 1994 vs 1997 ML Exceedances
Ovrhd 13-12. ML Chemicals Which Bioaccumulate
Ovrhd 13-13. Revisions to DMMP Guidelines - Conclusions

21. Public Comments and Questions

Teresa Michelsen said that in some cleanup program cases TOC normalization is not done below a certain level. She wondered how their analysis was conducted (dry weight vs. TOC normalized). Tom Gries replied that it was a preliminary analysis using PSDDA projects only. He suspected that Mike John's point was true - that a number of the samples were below the 0.5% threshold, and could have caused many of the exceedances. He indicated that Ecology would be examining this in more detail.

Teresa Michelsen said that it would be interesting to see what the results would be if they applied a similar threshold to normalize the data.

Tom Gries added that it would also be useful to not just look at the PSDDA projects, but a much larger data set collected from throughout Puget Sound.

Carl Kassebaum pointed out that it is important to consider what is happening at the disposal sites. If the biological community is doing well and in some cases, the site is self-cleaning, then it doesn't make sense to get stricter standards. If what they are doing at the disposal sites is working, standards should be relaxed if anything. The criteria to be more strict should be based on the actual impact seen at the site.

**** AFTERNOON BREAK ****

22. Brian Applebury introduced the presentations of issue papers by the public.

23. Doug Hotchkiss, Port of Seattle, indicated that the Port of Seattle is committed to working with the agencies on sediment management issues. The Port has been providing input to the agencies for a long time and are committed to continue to work with them. He mentioned the success of the AET calculation meetings (once emotional aspects were resolved). He introduced the issue papers for which the Port was involved.

24. Mike Johns, EVS Consultants, discussed progress made in developing a Puget

Sound AET for the *Neanthes* 20-day biomass/growth endpoint. He reviewed how AET values have previously been determined. An AET is generally set by the sample with the highest chemical concentration of a potential toxicant that does not exhibit a significant adverse biological effect. He then discussed each AET calculation step including data acquisition, quality assurance of sediment chemistry and bioassay data, data processing, data analysis, and AET calculation.

Data used for the AET calculations included the USACE's Dredged Analysis Information System (DAIS) database, Ecology's SEDQUAL database, EVS Consultants data, and additional data from regional consulting and engineering firms. They looked at various surveys in Puget Sound with 20-day *Neanthes* biomass growth data. These surveys had a wide range in sediment quality. For each data set, they determined whether chemistry and bioassay analyses met quality assurance requirements, and whether bioassay test performance standards for the control, reference, and initial biomass were met. For example, the initial weight used to winnow out the data was 1 mg. Data in varying formats were compiled and processed into a FoxPro database.

Once the varying data sets were in the database, data were analyzed. Test stations were paired with reference stations based on sediment grain size. Growth data were assessed for normality, and rankit transformations were applied to data that failed the test for normality. One-tailed t-tests were used to test for significant adverse effects. Because there was concern about the method used to identify outliers for the original AET calculation, "no-hit" samples that were statistical outliers for any chemical were identified. Rosner's test was used to identify the outliers. In addition, the matrix type was also considered when determining outliers. Some of the data was included among the outliers due to the unusual matrix type (e.g., slag). Dr. Johns emphasized that it is important to go through a statistical process to calculate outliers before calculating AETs.

Dr. Johns then presented recalculated AET values for chemicals of concern for each bioassay including both dry weight and TOC normalized AETs (refer to Appendix C). Future steps include evaluating chemically anomalous stations, and conducting reliability, sensitivity, and efficiency evaluations.

Ovrhd 14-1. Progress in Developing a Puget Sound AET for the *Neanthes* Biomass/Growth Endpoint
Ovrhd 14-2. Scope
Ovrhd 14-3. Fig. 1 - Determination of an Apparent Effects Threshold Value
Ovrhd 14-4. AET Calculation Steps
Ovrhd 14-5. Data Acquisition
Ovrhd 14-6. Surveys from the Puget Sound Region...
Ovrhd 14-7. Quality Assurance of Sediment Chemistry and Bioassay Data
Ovrhd 14-8. Summary of Screening Results for Studies...
Ovrhd 14-9. Data Processing
Ovrhd 14-10. Data Compilation Process
Ovrhd 14-11. Data Analysis

Ovrhd 14-12. Simulated Normal Distribution
Ovrhd 14-13. Arsenic
Ovrhd 14-14. Total DDD, DDE, and DDT
Ovrhd 14-15. Chromium
Ovrhd 14-16. Dry Weight-Normalized AET Values
Ovrhd 14-17. Dry Weight-Normalized AET Values (cont'd)
Ovrhd 14-18. TOC-Normalized AET Values
Ovrhd 14-19. TOC-Normalized AET Values (cont'd)
Ovrhd 14-20. Future Steps

25. Lawrence McCrone, PTI, discussed the potential for grain size effects in larval sediment bioassays. Available larval bioassay species include oysters, mussels, sea urchins, and sand dollars. Oysters are not recommended for fine-grained sediments. For tests on the fine-grained sediments, the sand dollar is recommended. However, there were no recommendations regarding grain size effects for the mussel or sea urchin. He discussed some of the supporting investigations for grain size effects on test species, but indicated that he hadn't seen studies on mussels and urchins.

The results for a recent investigation on fine-grained sediments (85 to 98 percent fines) that had no SQS exceedances for any chemical, showed no exceedances of SQS biological criteria for the amphipod and *Neanthes* test, but exhibited effects for the mussel and sea urchin bioassay. Combined effects (mortality/abnormality) for the mussel bioassay were 76 to 87 percent, and for the sea urchin bioassay were 51 to 68 percent. Dr. McCrone suggested that the effects observed in the larval bioassays may have been due to the fine grain size. He said that the combined effects may not be linearly correlated with percent fines. He hypothesized that the very fine particles that remain in suspension and approximate the size of phytoplankton (small silt and clay particles), may be ingested by the larvae and block their gut.

Dr. McCrone indicated that there was not a lot of data available for support or guidance concerning fine-grained sediments on these two species. He proposed that all matched larval bioassay and grain size data collected to date be reviewed. If there was insufficient data for sediments with high proportions of fine-grained sediments, then a well-designed laboratory investigation should be conducted to see if there are physical effects on the species. Should unacceptable high grain size effects be observed, it may not be wise to run the larval test on very fine-grained sediments.

Ovrhd 15-1. Potential for Grain-Size Effects on Larval Sediment Bioassays
Ovrhd 15-2. Available Larval Bioassay Species
Ovrhd 15-3. Supporting Investigations
Ovrhd 15-4. Results of Recent Investigation
Ovrhd 15-5. Combined Effect May Not be Linearly Correlated w/Percent Fines
Ovrhd 15-6. Proposed Actions

26. Spryos Pavlou, URS Greiner, discussed a report by the National Research Council

on strategies and technologies for contaminated sediments management. Dr. Pavlou said that the sediment management programs for Washington and Puget Sound are quite advanced on a national perspective. He reviewed the tasks and activities of the National Research Council's committee on contaminated marine sediments, and provided a conceptual overview of contaminated sediment management. He presented the committee's conclusions on issues concerning decision making, technology costs, remediation technology options, and project implementation, and recommendations to address these issues. He pointed out that careful problem formulation and good information can provide the foundation for good decisions. Incremental improvements can be made in decision-making, remediation technologies, and project implementation. (Details of his presentation are provided in Appendix C overheads).

Ovrhd 16-1. Strategies & Technologies for Contaminated Sediment Management
Ovrhd 16-2. Statement of Task
Ovrhd 16-3. Activities
Ovrhd 16-4. Conceptual Overview of Contaminated Sediment Management
Ovrhd 16-5. Containment, Disposal, & Natural Recovery Technologies
Ovrhd 16-6. Conclusions: Decision Making
Ovrhd 16-7. Recommendations: Decision Making
Ovrhd 16-8. Conclusions: Technology Costs
Ovrhd 16-9. Conclusions: Remediation Technology Options
Ovrhd 16-10. Conclusions: Remediation Technology Options (cont'd)
Ovrhd 16-11. Conclusions: Remediation Technology Options (cont'd)
Ovrhd 16-12. Recommendations: Remediation Technologies
Ovrhd 16-13. Conclusions: Project Implementation
Ovrhd 16-14. Recommendations: Project Implementation
Ovrhd 16-15. Summary

27. Lincoln Loehr, of Heller, Ehrman, White, & McAuliffe, discussed issues concerning sediment cleanup. He indicated that the sediment cleanup workgroup endorsed focusing cleanup efforts on hotspots. He presented a hypothetical site that did not require cleanup and the same site in which 3 sediments stations exceeded the CSL so that the whole site required cleanup. He suggested that if cleanup was conducted on the hotspot where the sediments exceeded the CSL, the whole site would no longer be considered a cleanup site (i.e. the remaining stations would not require cleanup). He indicated that the agencies agreed to not consider the stations inbetween zones as contaminated and requiring cleanup. However, he said the agencies have not consistently followed this line of reasoning. He asked that they re-evaluate their cleanup decisions.

Mr. Loehr's other issue concerned in-place dilution cleanup. He acknowledged that dilution is not necessarily the solution to pollution. However, under the PSDDA program, dredging allows for composite samples. He felt that if in-place mixing were allowed, contaminated material could be diluted with clean material and then disposed of should the composite meet regulatory standards. He suggested that this method would be less costly, and yet sediment management standards could still be met.

Ovrhd 17-1. Figures 1-3
Ovrhd 17-2. Contaminated Sediment Cleanup Decision Process
Ovrhd 17-3. Development of Cleanup Standards for a Site or Site Unit

28. Public Comments and Questions

Tim Thompson, ReTec, complimented Spyros Pavlou on the book on contaminated marine sediments the Natural Research Council committee put together. He felt that our region has an excellent program for defining when sediment is or is not contaminated. However, there is no guidance in the region for remediation. For example, what is an appropriate dredge to use in given situations? He suggested that the agencies should be spending more time on what we can to remediate contaminated sites.

Clay Patmont, Hart-Crowser, mentioned that in work Hart-Crowser has done, they have seen an increasing trend in concentration of chemicals thought to be oddball contaminants (e.g., phenols). Attempts have been made to focus on what sources are involved in the increase in the contaminants. Increases appear to be diffuse, although they have also occurred near discharge areas. He also mentioned that he hoped the evaluation of the AETs could be sped up, as it may pose problems for plans underway for current projects should values change significantly.

Teresa Michelsen has also noted the elevated phenols. She added that Jim Cubbage observed elevated phenols in Bellingham storm drains. The phenols appeared to have an upland source.

Dr. Kendall added that phenols were elevated at benchmark stations in Port Gardner. This would indicate an area wide increase and not a result of dredged material disposal.

Paul Dinnel, Dinnel Marine Research, commented on Lawrence McCrone's presentation. He said that the during 48- to 96-hour larval test, it is improbable that the larvae are ingesting the sediment. He added that perhaps they may be ingesting sediment during the late part of the test. He said that there were initially routine failures of the larval test, which they thought was due to burial. The four-hour settling period significantly reduced the mortality. He suggested that experimental work could be done on allowing a longer settling period for the mussel and sea urchin larval tests.

Allan Chartrand, Muckleshoot Tribe, mentioned some research in which larva were suspended in a tube with a screen that helped reduce fine grain size effects. He said they also didn't see predation by epifauna using this method.

29. Brian Applebury indicated that those who had questions or comments on the clarification papers and status reports that were included in the SMARM mailing (but not presented during the meeting) could comment at this time.

30. Public Comments and Questions

Desi Turner, Striplin Environmental Associates, asked if the TBT interstitial criteria of 0.05 µg/L was an SQS or a CSL.

Teresa Michelsen replied that the work group agreed 0.05 µg/L levels was similar to no adverse effects. It is a scientific judgement, but has not been adopted as a standard. An upper number has not been selected. The agencies have not agreed on a level equivalent to a CSL. Until they are forced to set a site-specific standard, they may not spend a lot of effort on it. She pointed out that for PSDDA the value is different (0.15 µg/L). The lower SQS number is important for cleanup. It is important to have a low enough number for shellfish fisheries. This is not as much of a problem concerning impacts to bivalves at PSDDA disposal sites.

31. David Fox requested all who had comments during the meeting to fill out the forms provided and place them in the comment box so that the agencies can be sure to address all issues.

32. Dave Bradley summarized some of the SMARM issues that will be addressed by the DMMP and SMS group before the next annual review meeting. Some of the issues included looking at how changes in guidelines apply to the Administration Procedures Act, looking at remediation technologies, speeding up the AET process, and looking at how source control fits in with cleanup. Refer to Appendix A for public comments and issues, and agency responses to comments.

33. Brian Applebury closed the meeting and reminded participants that comments on the SMARM should be submitted by May 21, 1997 for consideration. Written comments submitted for the SMS annual review should be submitted by June 7, 1997. He thanked everyone for their participation.

ATTACHMENT 1

Agenda

Sediment Management Annual Review Meeting (SMARM):
Cooperative Sediment Management Program (CSMP)
Dredged Material Management Program (DMMP)
and the
Department of Ecology / Sediment Management Standards (SMS) Program

Location: Federal Center South/North Joint Use Auditorium, Seattle, WA

May 7, 1997

Final Agenda

MORNING SESSION

8:30 Coffee

9:00 Introduction and Overview

Greeting: Colonel Donald T. Wynn, Commander, Seattle District Corps of Engineers

Meeting Objectives: Brian Applebury, Chief, Operations Division, Seattle District

9:30 DMMP Dredging/Disposal Overview

Summary actions of 1996 SMARM (David Kendall, Corps)

Overview of DMMP project/testing activities (Stephanie Stirling, Corps)

DMMO Homepage / Use of Internet for Communication (David Fox, Corps)

Disposal site monitoring overview (Ted Benson, DNR)

10:00 Discussion and Public Comment on above topics

10:15 Break

10:30 SMS Overview

SMS activities and annual review (Rachel Friedman-Thomas, Ecology)

Regional cleanup activities (Teresa Michelsen, Ecology)

Triennial Review Status (Dave Bradley, Ecology)

11:15 Discussion and Public Comment on above topics

11:30 Lunch

AFTERNOON SESSION

12:30 Presentations of DMMP Clarification Paper (CP), DMMP/SMS Clarification Paper & DMMP Issue Papers (IP)

CP: Beneficial uses guidelines (Justine Barton, EPA)

CP: Management of Woodwaste (Teresa Michelsen, Ecology / David Kendall, Corps)

IP: Verification methods for dredging of unsuitable material (Ted Benson, DNR)

IP: Regulatory Workgroup Recommendations: Short-term SL and ML adjustments (Tom Gries, Ecology)

1:30 Discussion and Public Comment on above topics

1:45 Break

2:00 Presentation of Issue Papers by the Public:

DMMP/SMS:

- Progress in developing a Puget Sound AET for the Neanthes biomass/growth endpoint (Dr. Mike Johns, EVS Consultants)
- Potential for grain-size effects on larval sediment bioassays (Dr. Lawrence McCrone, PTI Environmental Services)
- Strategies and technologies for contaminated sediments management: Report by National Resources Council (Dr. Spryos P. Pavlou, URS Greiner)

SMS:

- Sediment cleanups should focus only on those stations exceeding the cleanup screening levels of the sediment management standards (SMS) (Lincoln Loehr, Heller, Ehrman, White, & McAuliffe)
- Inplace dilution cleanup (Lincoln Loehr, Heller, Ehrman, White, & McAuliffe)

3:00 Discussion on Public Issue Papers

3:30 Public Comment on the draft Clarification Papers and Status Reports **mailed out to public with SMARM invitation**

4:30 Summary and Closing (Brian Applebury, Corps)

Public Issues Summary (Agencies will convene a post-SMARM meeting to review and prioritize these items for DMMP action. The DMMP decision will be posted on the DMMO website and published in the minutes.)

SMS Issues Summary.

Written comments may be submitted on the SMARM proceedings, but must be submitted to the DMMP agencies by May 21, 1997 for consideration. Written comments may be submitted for SMS annual review for consideration by June 7, 1997.

ATTACHMENT 2

List of Attendees

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING
LIST OF ATTENDEES

Name	Organization	Phone #	FAX #	E-Mail Address
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APPENDIX A

Agency Responses:

Public Issue Papers presented at the SMARM

Public Issue Papers not presented at the SMARM, but disseminated at the meeting

Post-SMARM Comment Letters

Public Issue Papers presented at the SMARM

1. Progress in Developing a Puget Sound AET for the Neanthes Biomass/Growth Endpoint (D. Michael Johns, Ph.D[1].; Lorraine B. Read[1]; Daniel P. Hennessy[1]; Carolyn J. Soetrisno[1]; and Douglas Hotchkiss[2].

2. Potential for grain-size effects on larval sediment bioassays (Lawrence McCrone, PTI Environmental Services).

3. Strategies and technologies for cleaning up contaminated sediments in the nation's waterways: A study by the National Research Council (Spyros P. Pavlou[3] and Louis Thibodeaux[4]).

4. Sediment cleanups should focus only on those stations exceeding the cleanup screening levels of the Sediment Management Standards (Lincoln Loehr, Heller, Ehrman, White and McAuliffe).

5. In-place dilution cleanup (Lincoln Loehr, Heller, Ehrman, White and McAuliffe).

6. Recent observations of increasing Phenol and 4-Methylphenol concentrations in Puget Sound sediments (Clay Patmont, Hart Crowser, Inc.).

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[1] EVS Consultants, Inc.
[2] Port of Seattle
[3] URS Greiner Inc.
[4] Louisiana State University, Baton Rouge, LA

SMARM Public Issue Papers: Agency responses

Papers presented at the SMARM:

1. Progress in Developing a Puget Sound AET for the Neanthes Biomass/Growth Endpoint (D. Michael Johns, Ph.D[1].; Lorraine B. Read[1]; Daniel P. Hennessy[1]; Carolyn J. Soetrisno[1]; and Douglas Hotchkiss[2].

Response: (Tom Gries) We commend the Port of Seattle and EVS on the *Neanthes* AET issue paper presented at the 1997 Sediment Management Annual Review Meeting (D. Michael Johns, et al, 1997). The paper presents draft AET values which generally reflect sound methods (PTI, 1988 and the Regulatory Work Group, 1997) applied to a more-than-adequate synoptic database. The agencies believe the success of this paper was due to early coordination with the regulatory agencies and careful attention to detail on the part of the authors.

The Regulatory Work Group (RWG) recommended that the DMMP agencies work with the Port of Seattle to finalize the list of *Neanthes* AETs by the 1998 SMARM (RWG, 1997). We agree and consider this task a high priority. However, we need clarification on some points. For example, were all the samples used to calculate *Neanthes* AETs truly synoptic? Did all chemistry and bioassay data undergo appropriate and complete quality assurance review? Were AET calculations performed using data only for chemicals of regulatory concern or for a more extensive list of chemicals? Were samples found to be statistical outliers excluded from AET calculations? Can EVS submit a more detailed analysis of data outliers and anomalous *Neanthes* samples?

We expect discussions with the Port of Seattle, EVS and others will answer the above questions, and look forward to working with them over the next six months. When we receive a copy of the *Neanthes* AET database, we will independently verify the AET calculations, determine the predictive reliability of the new AETs, and evaluate their possible implications to regulatory programs. We will then draft and present an issue paper describing final, technically defensible, Neanthes AET values at the next SMARM.

2. Potential for grain-size effects on larval sediment bioassays (Lawrence McCrone, PTI Environmental Services).

Response: (Tom Gries) The DMMP/SMS agencies have reviewed and carefully considered this issue paper. We concur that there is not much information available on the performance of the 48-96 hour sediment larval bioassay for reference area samples exhibiting a high percentage of clay or fines. And, as the paper points out, settling of clay particles in toxicity test chambers may not be complete after only four hours. Furthermore, while we currently do

[1] EVS Consultants, Inc.
[2] Port of Seattle

not know whether or not the clay particles remaining in suspension have significant adverse effects on larval bioassay results, we agree more investigation may be worthwhile.

The author proposes the agencies take a two-phased approach to investigate a possible relationship between grain-size and the "effective mortality" observed for the various larval species used in sediment toxicity testing (McCrone, L., 1997). Initially, the agencies should cooperatively review and analyze existing larval reference data. If the data prove inadequate, then they should design and conduct appropriate laboratory experiments to reveal such a relationship.

The agencies will respond to these proposals *within the constraints of available resources and priorities*. Currently, we consider numerous other issues and recommendations made by the Regulatory Work Group and public to be higher priority for action and resources (**see the DMMO web site for agency priorities at: http://www.nws.usace.army.mil and select "Dredged Material Testing Requirements"**). We do not anticipate responding to the second proposal -- to conduct a laboratory study of grain-size effects on larval toxicity test results -- during the next six or eight months. However, it may prove feasible to examine current sediment quality databases for a relationship between the reference sample grain-size distribution and observed larval toxicity.

3. Strategies and technologies for cleaning up contaminated sediments in the nation's waterways: A study by the National Research Council (Spyros P. Pavlou[3] and Louis Thibodeaux[4]).

<u>Response:</u> (Rachel Friedman-Thomas) The DMMP agencies applaud the efforts of the Marine Board for the publication of "Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies". The report will provide useful information to agency decision makers on topics ranging from remedial action alternatives to assessing trade-offs at sediment cleanup sites. Presently, there are a number of ongoing activities, namely the siting of a multi-user confined disposal site and the Bellingham Bay Demonstration Pilot Project, which will be looking very closely at the report and making use of its recommendations.

4. Sediment cleanups should focus only on those stations exceeding the cleanup screening levels of the Sediment Management Standards (Lincoln Loehr, Heller, Ehrman, White and McAuliffe).

<u>Response:</u> (SMU: Rachel Friedman-Thomas) Ecology agrees with the general concept of focusing cleanup efforts on the most highly contaminated sediments (e.g. hotspots) in order to accelerate cleanup at the worst sites. This concept is consistent with recommendations from the Sediment Cleanup Work Group which was formed in 1994 to advise the Agency Directors (Ecology, DNR, COE, EPA Region 10, PSWQA) on ways to expedite sediment cleanup (among other issues). The Workgroup's final report recommends that "...agencies should

[3] URS Greiner Inc.

[4] Louisiana State University, Baton Rouge, LA

focus on 'hotspot' cleanups to accelerate cleanup at the worst sites..." where hot spots are defined as "...the area that exceeds the MCUL (cleanup trigger)..." The Work Group also recommended that "...[i]n the lesser contaminated portions of a site, rely on source control, natural recovery, voluntary cleanup, and monitoring..." (Sediment Cleanup Work Group, 1994).

This general concept is also reflected in the Agency Directors response to the Workgroup's hot spot recommendation:

The agencies agree. To accomplish this, Ecology will modify how it currently implements the sediment cleanup process outlined in the SMS rule. Some of these modifications will be incorporated into the rule during the triennial review process.

Ecology will implement the hotspot approach at the point in the process where a formal ranked site list is published for each bay. Prior to that point, Ecology will continue to conduct the early public notice/hazard assessment on all areas which exceed the sediment quality standards in order to receive all available sediment data.

Sites will include only those adjacent sediment stations that exceed the SMS regulatory trigger ("cleanup screening level" - CSL). Those areas which are not defined as hotspot sites yet pose potential concern (*i.e.*, exceed the sediment quality standards but not the CSL) will be tracked for future monitoring and additional characterization (Ecology et. al., 1995).

Discussions with Ecology site managers indicate that final decisions on most sediment cleanup sites are generally consistent with this approach. However, Ecology recognizes that the regulated community believes that additional guidance/rule revisions are needed to fully implement this approach in a manner that increases regulatory certainty and predictability. Ecology also understands the ongoing concerns expressed by environmental groups and tribal representatives for continued progress and accountability for the cleanup of contaminated sediments.

Ecology intends to work with the SMS Implementation Committee to identify and evaluate rule revisions/guidance that will serve to accelerate cleanup of hotspot areas. Based on our review of the SMS triennial review comments and implementation experience, there are several key issues that will need to be evaluated prior to identifying specific revisions to the SMS rule and/or guidance. These include:

⇒ Degree of site investigation required to characterize the active cleanup and natural recovery areas;

⇒ Procedures for establishing site-specific cleanup standards;

⇒ Measures needed to ensure the long-term effectiveness of hotspot cleanup actions; and

⇒ Responsibilities and requirements for monitoring natural recovery/source control effectiveness.

5. In-place dilution cleanup (Lincoln Loehr, Heller, Ehrman, White and McAuliffe).

<u>**Response:**</u> (SMU: Rachel Friedman-Thomas) The Department of Ecology (Ecology) is a proponent of both natural recovery and enhanced natural recovery. The intent of the Sediment Management Standards (Chapter 173-204, WAC) (SMS) is to reduce and ultimately eliminate contaminants that would pose an adverse effect on the biological resources. Stirring sediments, as a form of dilution, has the purpose of spreading the contamination deeper into the sediment and the potential to physically transport contaminants into the water column. Both of these actions would expose greater numbers of organisms to the bioavailable contaminants. While dilution strategies may be cost and time effective, they do not inherently meet the antidegradation intent of the SMS.

Until we can assess the implications of in-place dilution, Ecology will not be making changes to the SMS rule. At this time, Ecology's ability to conduct pilot research is very limited due to workload priorities and resource constraints.

6. Recent observations of increasing Phenol and 4-Methylphenol concentrations in Puget Sound sediments (Clay Patmont, Hart Crowser, Inc.).

<u>**Response:**</u> (Tom Gries) Analysis of Ecology's Sediment Quality Database (SEDQUAL) reveals the fraction of all samples equaling or exceeding the sediment quality standard (SQS) for phenol was 193/3763, or about 5%. Approximately 4% of all 4-methyl phenol results (141/3419) equaled or exceeded the corresponding SQS. In most cases, the samples exceeding either SQS were collected 6-12 years ago. We do not observe an obvious increase in either of these two chemicals of concern (COC) over time, based on data available in SEDQUAL. However, we are very interested in obtaining and reviewing the specific information that led to this issue being raised at the SMARM.

Public Issue Papers not presented at the SMARM, but disseminated at the meeting

1. Dredger's Option: Possible Tier IV Testing Strategies for PSDDA Decision Making (D. Michael Johns[1] Chris M. Boudreau[1], Jack Q. Word[2], Douglas Hotchkiss[3]).

2. Effect of the USEPA/USACE ammonia purging protocol on contaminant concentrations in sediment interstitial water (Kenneth R. Seeley[1], Tim J. Hammermeister[1], D. Michael Johns[1], Alice Sheely[4], Douglas Hotchkiss[3]).

3. Analysis of regulatory approach to evaluating the quality of sediments contaminated with TBT. (Chris M. Boudreau[1], D. Michael Johns[1], Jack Q. Word[2], Douglas Hotchkiss[3]).

4. Proposed Tributyltin Testing Scheme and Protocols. (Chris M. Boudreau[1], D. Michael Johns[1], Jack Q. Word[2], Charles Boatman[10], Douglas A. Hotchkiss[3]).

5. A response to "PSDDA/SMS Issue Paper. Critique of PSDDA draft issue paper on testing, reporting, and evaluation of tributyltin in PSDDA and SMS programs" by Seeley et. al., 1996 (Jim Meador, NOAA).

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[1] EVS Consultants, Inc.
[2] Battelle Pacific Northwest Division
[3] Port of Seattle
[4] TerraStat Consulting Group
[10] Aura Nova Consultants, Inc.

Public Issue Papers not presented at SMARM, but disseminated at the meeting.

1. Dredger's Option: Possible Tier IV Testing Strategies for PSDDA Decision Making (D. Michael Johns[1] Chris M. Boudreau[1], Jack Q. Word[2], Douglas Hotchkiss[3]).

<u>Response:</u> (David Kendall) The DMMP agencies appreciate the efforts on behalf of the Port of Seattle and their contractors to develop a potential framework for conducting Tier IV (Dredger's Option) analyses. This is a programmatic issue on the DMMP agencies to-do list, which the agencies prioritized for action. It received a higher priority and will be worked on as soon as agency resources permit. On a project specific basis, the substantive requirements for Tier IV are being assessed for the Port of Seattle's Terminal 18 project by the Port of Seattle and DMMP agencies. Any framework developed for this project will be assessed by the agencies for possible implementation as part of the programmatic issue assessment.

2. Effect of the USEPA/USACE ammonia purging protocol on contaminant concentrations in sediment interstitial water (Kenneth R. Seeley[1] , Tim J. Hammermeister[1] , D. Michael Johns[1], Alice Sheely[4] , Douglas Hotchkiss[3])

<u>Response:</u> (Tom Gries) The DMMP agencies thank the Port of Seattle and their consultants for conducting the study referenced above to assess potential contaminant losses as a result of applying the USEPA/USACE ammonia purging protocol. The agencies have reviewed this paper in detail. While the Port of Seattle concludes that the ammonia purging protocol does not result in the loss of specific trace metals from the interstitial water, we believe that there are design flaws in this study that are sufficient to question both the conclusions themselves and their general applicability to other sediments/contaminants. The DMMP agencies will continue to selectively allow the use of the USEPA/USACE protocol on a project by project basis when interstitial / overlying ammonia levels (e.g., > 20 mg/liter) indicate their may be a potential toxicity problem attributable to ammonia.

3. Analysis of regulatory approach to evaluating the quality of sediments contaminated with TBT. (Chris M. Boudreau[1], D. Michael Johns[1], Jack Q. Word[2] , Douglas Hotchkiss[3])

<u>Response:</u> (Teresa Michelsen/David Kendall) The information provided in the paper has been superseded by the final 1996 DMMP/SMS Issue Paper/Technical Information Memorandum (TIM). The guidance stipulated in the Public Issue Paper was developed to resolve TBT concerns for the Port of Seattle's T-18 project before the TBT Issue paper/TIM was finalized. Therefore, the evaluation process followed for this project have been replaced by the guidance in the issue paper/TIM.

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[1] EVS Consultants, Inc.
[2] Battelle Pacific Northwest Division
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[4] TerraStat Consulting Group

4. Proposed Tributyltin Testing Scheme and Protocols. (Chris M. Boudreau[1], D. Michael Johns[1], Jack Q. Word[2], Charles Boatman[5], Douglas A. Hotchkiss[3])

Response: (Teresa Michelsen/David Kendall) The proposed testing scheme and protocols were developed for the Port of Seattle's T-18 project before the TBT Issue paper/TIM was finalzed. Therefore, the evaluation process followed for this project for TBT testing have been replaced by the guidance in the Final (October 1996) Issue Paper/TIM.

5. A response to "PSDDA/SMS Issue Paper. Critique of PSDDA draft issue paper on testing, reporting, and evaluation of tributyltin in PSDDA and SMS programs" by Seeley et. al., 1996 (Jim Meador, NOAA)

Response: (David Kendall) Please also see SMARM invitation mailout: Enclosure 5 (Omissions from the 1996 SMARM minutes) for PSDDA/SMS response to the above referenced paper. Dr. Meador responds to the critique of his methods for TBT analyses from the Draft TBT Issue Paper/TIM.

[5] Aura Nova Consultants, Inc.

Post-SMARM Comment Letters

1. Lawrence McCrone, Ph.D. (PTI Environmental Services). Comment letter on the following two SMARM papers on behalf of the Weyerhaeuser Company.

   (1) Joint DMMP clarification paper and Technical Information Memorandum: Selection of negative control sediments and use of control sediments as reference sediments.

   (2) Joint DMMP Issue Paper and SMS Technical Information Memorandum: Management of wood waste under Dredged Material Management Program and the Sediment Management Standards Cleanup Program.

2. Timothy J. Hall (National Council of the Paper Industry for Air and Stream Improvement, Inc.) (NCASI).

3. Eric Johnson (Washington Public Ports Association), and Douglas Hotchkiss, Thomas Newlon (Port of Seattle). Comment letter addressing a number of DMMP/SMS program SMARM papers.

4. Mike Salazar (Applied Biomonitoring): *Environmental Significance of Laboratory Tests of Toxicity and Bioaccumulation*. Comment letter raises a number of issues relative to the existing DMMP approach for assessment and interpretation of bioaccumulation potential.

5. Richard S. Caldwell, Ph.D. (Northwest Aquatic Sciences): DMMP clarification paper: Standardization of Reference Toxicant Tests.

6. Richard S. Caldwell, Ph.D. (Northwest Aquatic Sciences): Comment relating to SMARM Issue Paper submitted by Dr. Lawrence McCrone.

7. Douglas Hotchkiss, Thomas Newlon (Port of Seattle). Comment letter regarding: "Ninth Annual Sediment Management Annual Review Meeting (SMARM) - Follow-up Comments on SMS Annual Review".

DMMP/SMS Agencies Responsiveness Summary to Post-SMARM Comment Letters

1. Lawrence McCrone, Ph.D. (PTI Environmental Services). Comment letter on the following two SMARM papers on behalf of the Weyerhaeuser Company.

   (1) Joint DMMP clarification paper and Technical Information Memorandum: Selection of negative control sediments and use of control sediments as reference sediments.

   1a. Comment: Use of negative control sediments in larval bioassay tests.

   Response: (Teresa Michelson) Reporting of negative control sediment data for larval bioassay tests provides valuable information useful in interpreting QA/QC failures, even though it is not required by the PSEP protocols. If performance standards for reference sediments are failed, the negative control data can be useful in determining whether a testing problem caused the failure or whether the reference site was inappropriate. A negative control sediment may pick up laboratory problems that a seawater control cannot address, such as sieving problems. Therefore, running and reporting sediment control data for larval tests is encouraged, though not required.

   If reference station performance standards are failed, and negative controls show no problems with the test, there is no reason why the negative sediment control should not be available as one possible substitute for the reference station, assuming the grain size is appropriate for comparison with the site stations. Not allowing use of the negative control sediment in this situation removes a cost-effective option for interpretation of the data. The only alternative in many situations may be resampling. The CSMP agencies will retain the option to use the sediment control data in lieu of reference station data as an alternative to costly resampling and retesting. Therefore, it will generally be to the project proponent's advantage to include a negative control sediment in running a larval bioassay.

   1b. Comment: Recommendation to use a percentage difference in TOC in comparing reference vs. site stations.

   Response: (Teresa Michelson) The final paper will incorporate a revised method.

   (2) Joint DMMP Issue Paper and SMS Technical Information Memorandum: Management of wood waste under Dredged Material Management Program and the Sediment Management Standards Cleanup Program.

(A) <u>**Comment:**</u> The SMARM agenda specifies this paper as a clarification paper, whereas the SMARM mailout specifies the paper as an issue paper. The intent of the paper should be clarified.

Response: (David Kendall) We regret the confusion that was generated by the inadvertent error in the classification of the paper. The agenda was in fact correct and this paper is a DMMP and SMS clarification paper and not an issue paper. The guidance contained therein only clarifies existing guidance on the procedures / process for quantifying woodwaste in dredged material to assess its suitability for unconfined open-water disposal, and to identify potential problem areas that may require cleanup. It does not establish a new policy and only clarifies minor changes to the methods for quantifying woodwaste that will lead to unequivocal regulatory determinations on dredged material and at cleanup sites with significant quantities of woodwaste.

(B) **Comment:** The method for determining moisture content using method ASTM D-2974C needs specification.

Response: (David Kendall) The method specified for determining moisture content using method ASTM D-2974C should follow method A) which involves drying the material in an oven at 105 ^{o}C.

(C) **Comment:** The author questions the validity of utilizing the ash-free-sediment from the modified total volatile solids analysis in conjunction with the conventional grain size analysis results to help select appropriate amphipod species and reference sediments for bioassay testing of material with TOC contents greater than 25%. The difficulty in identifying an appropriate reference sediment will only be compounded by the absence of more detailed guidance on these issues. The author therefore urges the DMMP agencies to give further consideration to these issues before requiring biological testing of sediments with significant fractions of woody material/debris.

Response: (David Kendall) A comparison of the ash-free sediment with results from the conventional grain size analysis are necessary to select the appropriate amphipod species for testing and to aid in the selection of a suitable reference sediment. It is necessary to get rid of the woody debris to assess the fine grained sediment fraction. The proposed guidance was formulated during a recent Port of Everett project to facilitate meaningful comparisons of test sediments with reference sediments allowing unequivocal regulatory interpretations for the amphipod bioassay. The method specified worked well and enabled sediment quality to be properly evaluated by the regulatory agencies. The applicant and testing lab must closely coordinate results from these analyses with the Dredged Material Management Office for agency review and input before final selection of species and reference sediment is accomplished. Therefore, the DMMP agencies feel that this guidance does provide sufficient detail to enable dredging applicants with sediments with significant woody material fractions (e.g., >50% by volume, and/or >25% by weight) to proceed and accomplish the required testing. Applicants may also choose not to conduct biological testing and accept the regulatory decision that the material is unsuitable for unconfined open-water disposal. The DMMP agencies will continue to monitor this issue, and will provide additional guidance as needed in the future.

(D) **Comment:** The author expresses concern for the potentially confounding influences of physical effects (e.g., non-treatment effects) on the bioassay testing results for sediments with significant amounts of woody material/debris. The author therefore requests additional research on the potential influences of these variables on the bioassay outcomes, before applying bioassay testing requirements under the DMMP and SMS cleanup program to these kinds of sediments.

Response: (Teresa Michelson, David Kendall) The potential for non-treatment effects on bioassay testing results is acknowledged. That is why when conducting a DMMP evaluation the EPA/COE ammonia purging protocol may be utilized to address elevated ammonia levels. As for addressing the physical effects of woody debris on the biological responses demonstrated by the specific bioassays, we feel that any such effects occurring would also likely occur at the disposal site, and are a legitimate outcome of the bioassays. As stated in the clarification paper, recent experience in one dredging project where sediments with high volumes of woodwaste (>50% by volume) were subjected to biological testing, the bioassays successfully sorted out suitable/unsuitable dredged material. The guidance stipulated in the draft clarification paper provides an opportunity for applicants with dredged material containing woody material in excess of 50% by volume (25% by weight) to test sediments using the standard suite of bioassays. Otherwise, the only option left to an applicant is to accept the regulatory agencies decision that all material with wood waste volumes greater than 50% will be deemed unsuitable for unconfined open-water disposal. We will continue to monitor the success of bioassays to differentiate suitable from unsuitable material with high amounts of woodwaste.

2. Timothy J. Hall (National Council of the Paper Industry for Air and Stream Improvement, Inc.) (NCASI).

   Comment: Comment letter in support of grain size effects issue raised in public issue paper presented by Lawrence McCrone on "Potential for Grain-Size Effects on Larval Sediment Bioassays".

Response: Comment noted.

3. Eric Johnson (Washington Public Ports Association), and Douglas Hotchkiss, Thomas Newlon (Port of Seattle). Comment letter addressing the following DMMP/SMS program SMARM papers.

(1) DMMP Screening and Maximum Level Guideline Revisions.

A) **Comment:** *"The Port of Seattle and WPPA strongly urge the DMMP agencies to follow the Regulatory Work Group's recommendation and use combined oyster and echinoderm larval data for calculating SLs."*

Response: (Tom Gries) Prior to the 1997 SMARM, we weighed the Regulatory Work Group's rationale for the recommendation that sediment larval AETs should be based on bivalve and echinoderm species "lumped" together. We offer the following responses.

We generally concur with the RWG's determination that the 1994 AETs are technically defensible, but that maintaining 1994 larval AETs based solely on echinoderm effects, and revising SLs accordingly, might not be. However, we do not agree that there is adequate scientific evidence to justify a single group of sediment larval AETs based on several larval test species -- that the various larval test species are identical in their responses to environmental toxicants. The comparative sensitivity of various larval species to a large number of contaminants in Puget Sound sediments cannot be determined by examining their response to a single reference toxicant (Johns, et al, Minutes to the 1996 SMARM). Arithmetically combining 1986 oyster and 1994 echinoderm AETs, and considering the greater of two to be the new value (as recommended by the RWG), could easily mask any differential sensitivities to groups of chemicals which the larval species might possess.

Furthermore, an underlying reason for "lumping" all larval species results into one group of AETs seems to be that doing so minimizes the potential number of changes to SLs and Sediment Quality Standards (SQS) criteria.

For these reasons, we elect to postpone our decision to revise SLs based on 1994 "echinoderm" AETs, whether used separately or in combination with 1986 oyster AET values.

B) **Comment:** *"The dissenting vote in the RWG on the "bundling" issue was not based on the scientific validity of treating the tests as functionally equivalent, but was instead based on concerns regarding the statistical validity of combining bioassays run with slightly different procedures ... "*

Response: (Tom Gries) We understand another reason cited for not "bundling" larval species together into a single group of AETs was because the comparisons of responses to a known toxicant (positive controls) were equivocal (Johns, et al, Minutes to the 1996 SMARM).

C) **Comment:** *"The agencies' primary objection to combining echinoderm and oyster data, that there is no proof that the tests are identical in their sensitivity to contaminants, does not appear to be supported by the evidence. In particular, there is no evidence that echinoderm and oyster larval data are significantly different from each other in terms of sensitivity." " ... there may be as or more difference within a given phyla (sic) ... as there is between phyla. ... Johns, et al's 1996 paper examined reference toxicant data ... and concluded that the data were inconclusive as to differences in sensitivity among the larval bioassays."*

Response: (Tom Gries) There is evidence both for and against calculating a single group of sediment larval AETs based on all larval effects data. The evidence lies in responses to a single known toxicant and the AET values calculated in 1994. We believe neither line of evidence is conclusive. Please see our other responses.

D) **Comment:** *" .. the evidence which the agencies believe demonstrates the differential sensitivity of the tests is more likely a result of the source of the data than true differences in sensitivity." " ... the differences in AET could be as much an issue associated with the size of the data set and the range of contaminant concentrations observed in the data set as an indicator of true differential sensitivity."*

Response: (Tom Gries) The Port's assertion is true in theory but perhaps not in fact. We believe that the 1994 echinoderm AET values were calculated using a more extensive and likely more representative database than the one used in 1986. There were over 200 echinoderm toxicity test sample results which were carefully interpreted and classified for adverse effects ("Hit"/"No Hit") and used in 1994 AET calculations. These included samples from several projects located in contaminated areas (e.g., Pier "D", Sitcum Waterway). In contrast, 1986 oyster AETs were based on 50 samples collected from Commencement Bay alone.

E) **Comment:** *"Apparent AET differences could also reflect the variability of the individual AETs, which combine both chemical and bioassay variability." "The only way that AETs could be used to validly assess test sensitivity is if the data sets used for the bioassay comparisons were substantially similar, ... " "We recommend that any evaluation to determine sensitivity differences be consistent across classes of contaminants, and that observed differences must be greater than a factor of two before the larval tests are considered to warrant separate AETs."*

Response: (Tom Gries) We do not agree with the Port or RWG that 1994 echinoderm AET values are so obviously similar to 1986 oyster AETs that they should be combined without further investigation and discussion. According to the "1988 Update and Evaluation of Puget Sound AET" (1988), sixteen dry weight-normalized LAETs were co-established by 1986 oyster and 1986 Microtox® AET values. Only the LAET for phenol was set by the 1986 oyster AET alone. In contrast, twenty-two LAETs were uniquely set by 1994 echinoderm AET values. In addition, the 1994 dry weight-normalized echinoderm AETs for

PAHs appear to be consistently lower than other groups of AETs. These facts do not imply cause and effect. However, they do provide evidence that the probability of observing significant adverse effects among the two larval groups in certain sediment samples may differ. We note the Port's other comment and recommendation.

F) **Comment:** " ... *the Port of Seattle and WPPA are very concerned about the agencies' use of a so-called "weight of evidence" rule to disqualify an AET proposal that all agree has technical merit. This sounds like 'no matter what the science says, if we don't like the numbers we won't use them.' The Port of Seattle and WPPA would like assurances that such an interpretation is not what the DMMP agencies mean." "The sediment larval toxicity testing workshop should also be convened."*

Response: (Tom Gries) DMMP agencies believe that the RWG, the process used to arrive at consensus recommendations, and the final recommendations themselves are all very credible. We are in the process of adopting all but two of the RWG's short-term recommendations, and have prioritized many of the medium-term recommendations for action during the upcoming year. However, not everyone agrees on the technical merit of calculating only a single group of AETs based all bivalve and echinoderm test results lumped together. DMMP staff do not agree evidence from comparing toxicant control response data is adequate justification for the recommendation. Neither is a cursory comparison of the two existing groups of AET values.

The decision whether or not to lump sediment bivalve and echinoderm larval AET groups together is controversial because its ramifications are significant. The DMMP agencies have no predisposition on this matter -- we simply do not believe either decision can be based on unequivocal evidence at this time. Thus, it is prudent to seek the knowledge and professional opinions of additional regional/national experts before deciding a course of action regarding the use of larval AET values in revising DMMP guidelines.

We assure the Port and others that the underlying science and technical merit of any RWG recommendation or SMARM issue paper proposal is of utmost importance to us. It is not a case of *"no matter what the science says, if we don't like the numbers we won't use them."* In fact, we are somewhat surprised at this assertion given the efforts of the Port and WPPA to publicly undermine 1994 AETs which the RWG later determined were sufficiently valid for use in revising SLs and MLs.

The DMMP recognizes that the professional opinions of RWG members, and the recommendations of the RWG as a body, carry more weight than a single party testifying for or against a particular proposal. However, the Port should recall that opinions among experts on the RWG often differed. And, issues which have far-reaching consequences should perhaps be reviewed and evaluated by an even more experienced body.

The DMMP agencies will convene a sediment larval workshop in the fall. The topics to be discussed will include whether AETs based on bivalve and echinoderm test species should be separate or "lumped," and which test endpoints are most appropriate for guidelines/criteria vs.

regulatory use. We look forward to having the Port and the WPPA attend in the workshop, and together listening to the scientific community present current knowledge and express professional opinions. After weighing a greater body of evidence and opinion, we may very well agree at the 1998 SMARM that there are no compelling reasons to maintain separate larval AET groups.

G) **<u>Comment:</u>** *The DMMP " ... agencies reluctance to combine the echinoderm and oyster data is inconsistent with prior administrative treatment of the tests." "Administratively, these (larval) tests have always been treated as functionally equivalent in the DMMP/PSDDA program and we have no statistical evidence to indicate that this is inappropriate. The results of any one of the (larval) tests will be as protective in decision making as any of the other tests."*

<u>Response:</u> (Tom Gries) Sediment larval toxicity tests provide information on biological effects which, when combined with other physical, chemical and biological evidence, form the basis for regulatory decisions on the suitability of dredged material for open water disposal. However, because biological testing is triggered by exceedance of screening level values, the technical basis for SLs may legitimately differ from the regulatory interpretive guidelines. Hence, it may be reasonable use echinoderm AETs to establish SLs, if those values prove quite sensitive for example, but base regulatory decisions on effects data from either group of larval species and different test endpoints.

H) **<u>Comment:</u>** *The DMMP agencies should " ... thoroughly review the validity of and the continued use of Microtox data." "These facts surrounding the Microtox® test call into question the validity of the data set currently used to generate the Microtox® AET." " ... inclusion of the Microtox® AET is no longer appropriate ... "*

<u>Response:</u> (Tom Gries) Concerning Microtox® AETs, the RWG determined that the 1986 values " ... remain valid despite relatively minor protocol differences from newer Microtox® data." and should be included in the suite of AETs used to determine both LAET and highest AET (HAET). The Microtox® test results which formed the basis of the 1986 AETs did not exhibit the same degree of enhanced luminescence that was observed in early PSDDA samples (see below). They are quite sensitive predictors of the potential for significant adverse biological effects and are therefore useful in deriving screening values in regulatory programs. In addition they show a good degree of concordance with other groups of AETs. Thus, we can find no technical basis for simply discarding 1986 Microtox® AETs without a similarly sensitive and practical substitute. The Port's comments appear inconsistent with the evidence and the RWG recommendations.

Early use of the 15 minute saline extract Microtox® test in the PSDDA program, however, revealed an increasing number of sediment samples which exhibited enhanced luminescence. The agencies clarified this would be interpreted as "no significant adverse effect." (Minutes to the 1991? ARM). The agencies later discontinued routine use of the Microtox® test on an interim basis, because the actual physiological or ecological significance of enhanced luminescence was not known (Minutes to the 1992? ARM). We still believe these were appropriate actions.

Subsequently, we investigated the potential for substituting a newer, solid-phase, Microtox® test. Unfortunately, we have not found convincing data about the comparative utility of this alternative. Thus, we have remained "on hold" until more side-by-side comparisons can be conducted or until there is evidence that another appropriate test can be substituted for the Microtox® test.

The Regulatory Work Group did recommend the DMMP agencies agree to the next steps needed to decide on the fate of continued use of Microtox® AETs and the saline toxicity test in regulatory programs. We have decided to meet during the next six months to determine our course of action regarding both the Microtox® AETs and the continued use of the saline Microtox® test.

I) <u>**Comment:**</u> *"Development and inclusion of a* Neanthes *AET is appropriate ... "*

<u>**Response:**</u> (Tom Gries) It is very important to pursue finalization of the *Neanthes* AET work begun by the Port of Seattle, and we are committed to doing so during the next six months.

J) <u>**Comment:**</u> *"Including a Neanthes AET and removing the Microtox® AET would not alter the basic number of AETs used to calculate the HAETs and the LAETs. This is important because increasing the number of AET groups would generally result in a lowering of the LAETs and in a raising of the HAETs."*

<u>**Response:**</u> (Tom Gries) There are, no doubt, several alternative approaches which the CSMP might take to integrate *Neanthes* AET values into the suite of Puget Sound AETs. We agree with the Port that one option would be to substitute them for the 1986 Microtox® AETs. However, we wish to assert that there is no "magic" number of AET groups which can be used to establish DMMP guidelines or SMS criteria. We agree with the Port that adding a new AET group to the current suite of Puget Sound AETs could lower LAETs and raise HAETs. But we find neither outcome to be technically indefensible, inherently undesirable or necessarily onerous.

K) <u>**Comments on Proposed New SL and ML Values:**</u> " ... *we are very interested in the comparison of TOC normalized numbers to the bulk dry weight numbers. ... It will be very important to meet and discuss this issue as soon as we receive and can evaluate the results of the organic carbon normalized AETs (with the less than 0.5% TOC removed following the most recent PSEP guidance for TOC analysis").*

<u>**Response:**</u> (Tom Gries) We intend to openly report the apparent implications of adopting the proposed new TOC-normalized SLs and MLs with the Port of Seattle and the public.

L) __Comments on Updating 1988 and 1994 AETs:__ *" ... a current and updated AET database is a critical component of the DMMP sediment management scheme ... the agencies have historically committed to reviewing AETs in light of new information. The Clarification Paper points out some of the methodological steps, including establishment of DRVs, necessary to accomplish this task ... discussion of these steps lacks a strong commitment to promptly undertake AET recalculation ... We trust that this does not reflect a change in policy ... "*

"We are concerned about the apparent lack of commitment to complete AET recalculations prior to the 1998 SMARM ... " " ... the DMMP agencies (are encouraged) to follow through on the Regulatory Work Group's recommendations to complete AET recalculations prior to the 1998 SMARM and to establish DRVs prior to the recalculation to allow incorporation of older data."

__Response:__ (Tom Gries) The DMMP agencies believe they will be able to propose default reference values (DRVs) be adopted for use in reintroducing data into AET calculations at the 1998 SMARM. We hope to be able to use them in advance of the 1998 SMARM to calculate new bivalve AETs, as well as to recalculate amphipod and echinoderm AETs. However, as stated at the 1997 SMARM, we must carefully evaluate overall program priorities and balance them against limited resources. There is a long list of tasks we consider to be mandatory, to which we must consider adding a final draft of the draft 1994 AET report, finalizing 1997 *Neanthes* AETs, using DRVs and new protocols to reintroduce data to 1994 AET calculations, incorporating key new data sets into AET calculations, convening a sediment larval workshop, deciding a course of action for the Microtox® AETs and toxicity testing, etc. The perception that we lack commitment appears to be based on our reluctance to state publicly we will accomplish more than we are able. If we are unable to act on all the RWG's medium-term recommendations before the 1998 SMARM, then we will likely attempt to do so during the following year.

M) __Comments on AET Methodology:__ *" ... the DMMP agencies (are strongly encouraged) to commit to following the RWG recommendation that only truly anomalous data, as opposed to all statistical outliers, will be excluded from the AET data set." "We are concerned about ... (the) potential exclusion from the AET data of statistical outliers that are not anomalous."*

" ... we are concerned with the Clarification Paper's failure to squarely address the inclusion of non-anomalous statistical outliers in the AET calculations. One of our consistent concerns is that data should not be excluded from the AET calculations simply because the data set is incomplete in its upper ranges. This is especially true for chemicals (such as antimony) that are not commonly found in Puget Sound sediments at levels that would be expected to result in toxicity. If data are not anomalous, they should be included in AET calculations, regardless of whether they are statistical outliers

Response. (Tom Gries) The RWG recommended that the DMMP "adopt a three-step process for identifying possibly anomalous samples ... " (RWG, 1997). These included statistically identifying outliers among biological effects data, reviewing data for possible explanation for the apparent outliers, and deciding whether to use the data or exclude them as anomalous (using best professional judgment). They also recommended clearly documenting the final decision on each outlier. We agree with those recommendations and intend to comply with them.

N) General Comment:

"The DMMP agencies (should) promptly reconvene the Regulatory Work Group ... to address these issues over the next year."

Response: (Tom Gries) The agencies intend to re-convene the Regulatory Work Group, or its equivalent, in order to continue the highly productive policy and technical dialog on development of sediment quality guidelines and dredged material management issues which it exemplified. We hope to meet again in September, and will work with the Port and other parties to choose the agenda topics to be discussed.

(2) Verification Methods:

Comment:*"The Port of Seattle and WPPA strongly recommend that the DMMP agencies avoid instituting the costly verification procedures discussed in the Issue Paper as a means of remedying what to date has proven not to be a problem".*

Response: (Ted Benson) The PSDDA agencies appreciate the comments received from the Port of Seattle and the Washington Public Ports Association regarding the establishment of requirements to verify that material from dredged material management units that have been not been found to be suitable for open water disposal is not disposed of at PSDDA open-water disposal sites. We understand that this requirement places an additional cost burden upon some projects and increases the complexity of these projects. However, due care requires that if a problem can be reasonably foreseen, reasonable action must be taken. Due care is not likely to have been satisfied if we fail to act when it is reasonably likely that action would have been effective; i.e., now.

It should also be pointed out that material unsuitability can also arise due to legal status as well as from chemical contamination. In any event, if the PSDDA process has not determined that a certain volume of material is suitable for open-water disposal it is incumbent upon the PSDDA agencies to ensure that the material is not, in fact, deposited at a PSDDA open-water disposal site. The requirements discussed in the issue paper are an attempt to secure a cooperative effort to demonstrate that only material found suitable through the PSDDA process is disposed at these sites.

In the SMARM presentation of this paper, it was stressed that this verification of unsuitable material disposal would be project specific, and that dredging proponents and contractors were advised to address this issue in their dredge plans. DNR and the other PSDDA agencies are willing to work with the dredging proponents to find the most cost-effective means of accomplishing this verification. The DMMP agencies, as well, support a phased dredging approach, as this would seem to be one of the most cost effective approach. However, the DMMP agencies did not wish to preclude other methods.

While spot checking is an excellent idea, the adoption of either an expensive, all-encompassing oversight program or a random spot-check program with incentives for correct behavior would be a financial burden that would, in the final analysis, be borne by the dredging community, and thus should be avoided. The dredging community has voiced opposition to additional administrative fees, and the PSDDA agencies have no wish to increase present fees.

The PSDDA agencies would be quite happy to consider any suggestions that would eliminate or reduce the requirement for buffers on units dredged separately. However, it should be remembered that the concept driving this is the requirement that no material from a dredged material management unit that has not been found suitable for open water disposal is disposed at any such site.

While it is agreed that mid-project surveys are an additional expense and can raise many technical issues, such surveys will be required only when other methods of verification are not available. As to the issue of potential ambiguity or erroneous results, this should present no problem. If survey results are erroneous or ambiguous then the survey needs to be redone. This eventuality should be addressed in the contract. As long as the specifications provide for verification of survey accuracy, there should be no problem verifying the accuracy of the data. It may, however, be advisable to look to the American Congress on Surveying and Mapping (ACSM), and possibly NOAA, for development of specifications and requirements.

Early communication and coordination by the dredging proponent with the PSDDA agencies is recommended to accomplish the required level of protection to ensure that disposal of material not found to be suitable for open-water does not occur. It is realized, and has been publicly stated, that requirements will be project specific. The PSDDA agencies are willing to work with dredging sponsors and the dredging community to keep the verification methods at the least restrictive level possible while still ensuring that the proper level of care and oversight has been accomplished.

(3) TBT Testing, Reporting and Data Evaluation (DMMP/SMS):

Comment: *"As an additional comment to the original Issue Paper, the Port of Seattle and WPPA dispute the conclusions that the current suite of Puget Sound bioassays are insensitive to TBT at concentrations that are of environmental concern, and recommend deletion of the statement until stronger evidence supports such a conclusion."*

Response: (Tom Gries/David Kendall) The DMMP agencies are currently negotiating a study to be conducted by Dr. Ted DeWitt (Battelle NW) to assess TBT sensitivity in the *Leptocheirus plumulosus* 28-day chronic/sublethal bioassay relative to our existing test suite. It is expected that these studies along with other recently completed assessments will provide the necessary data to fully evaluate TBT sensitivity in our current test suite.

(4) Negative Control Sediment Selection and Using Control Sediments as Reference Sediments (DMMP/SMS)

A) **Comment:** *"The Port of Seattle and WPPA recommend that the DMMP and SMS agencies provide additional guidance on appropriate control sediments for individual test species, particularly Ampelisca."*

Response: (David Fox) In response to the request from the Port of Seattle and WPPA for evidence suggesting that *Ampelisca abdita* performance has been poor in West Beach sand, amphipod data residing in the Dredged Analysis Information System (DAIS) was reviewed. Nine dredging projects to date have used *Ampelisca abdita* to assess the suitability of dredged material for open-water disposal (see accompanying table). In eight of the nine projects, negative control sediment was collected from the same location as the test organisms. The mean mortality was 8.1 percent in those cases and only one control exceeded the 10 percent limit on mortality. Conversely, in the single case where West Beach sediment was used, the negative control exhibited 18 percent mortality and failed to meet the performance standard. While the data set is not large, it does suggest that *Ampelisca abdita* performance in West Beach sand may be poorer than performance in sediment from test organism collection locations.

The clarification paper entitled *Selection of Negative Control Sediments and Use of Control Sediments as Reference Sediments* concluded that "[t]he best way to ensure a good negative control [for the amphipod bioassay] is to collect the control sediment from the same location at which the test organisms are collected". Given the relatively minor additional expense of shipping native sediment along with the test organisms, it makes good sense to continue to collect control sediment from the collection site of the test organism.

Project	Dredging Year	Control Sediment Location	mean mortality (%)
Weyerhaeuser - Bay City	1992	Dillon Beach, CA	6.0
Weyerhaeuser - Bay City	1993	Dillon Beach, CA	11.5
Port of Everett - South Terminal	1995	Narragansett Bay, RI	10.0
Port of Everett Piers 1 and 3	1995	Narragansett Bay, RI	9.0
Corps of Engineers - Duwamish River	1997	Narragansett Bay, RI	7.0
US Navy Bremerton - Pier D	1994	Narrow River, RI	9.0
Corps of Engineers - Squalicum Waterway	1995	Narrow River, RI	2.0
Corps of Engineers - Grays Harbor	1996	Narrow River, RI	10.0
Konoike Pacific Terminals	1994	**West Beach, WA**	**18.0**

B) <u>Commment:</u> *"If a toxicity test meets all of the QA/QC performance criteria (e.g., water quality, control performance) then the test is a valid test. The fact that the reference fails to meet performance standards does not justify deeming a test series invalid."*

"To deny this (blocking for nontreatment factors) by refusing to accept reference data is to deny that organisms respond to nontreatment factors."

<u>Response:</u> (Tom Gries) The DMMP agencies require collection and testing of a grain-size matched reference sample because we believe organisms do respond to nontreatment factors. We agree with the Port of Seattle that test sediment samples should not be automatically considered invalid if the corresponding reference sediment sample response exceeds the performance standard (e.g., 20% mortality in the 10-day amphipod toxicity test). However, such a reference response complicates interpretation of test samples results because it is quite unusual. It may be a statistical outlier and indicate the presence of atypical nontreatment factors.

We do not believe it is credible for regulatory agencies to make decisions by comparing test sediments to atypical references. In the absence of a typical, grain-size matched reference sample, we allow comparison of a test sample to a control sediment sample. While not technically ideal, it is a more conservative interpretive guideline which may preclude having to remobilize and collect a new reference sample.

C) <u>Comment:</u> *"One method (of accepting failed reference data) would be to look at the standard deviation of the failed reference and determine whether the variation overlaps with the performance standard."*

<u>Response:</u> (Tom Gries) The DMMP agencies believe the suggested comparison can be made once default reference values are established based on a large number of reference

responses. We request clarification, however, on how the standard deviation of a failed reference response can be used to compare the reference's absolute response to a performance standard whose statistical basis is not known.

D) **Comment:** *"Maximum acceptable standard deviations could be established, similar to the method Tom Gries used when calculating the 1994 AETs."*

Response: (Tom Gries) It is difficult to show a significantly different toxic response between test and reference sediment samples if the reference exhibits high variability caused by one unusual replicate, incomplete homogenization or unknown reasons (statistical outlier). Thus, for calculating 1994 AETs, we established reference performance standards based on the variability of toxic responses among lab replicates. Performance standards based on variability (e.g., maximum standard deviation) could be routinely used as an additional quality assurance measure for toxicity tests.

E) **Comment:** *"Alternatively, ... a `Puget Sound-wide' (default reference) value could be substituted for the statistical comparisons if the reference sediment fails the performance standards. This was the Regulatory Work Group's (RWG) recommendation ... "*

Response: (Tom Gries) The RWG recommended that default reference values (DRV) be established to reintroduce certain synoptic sample data into AET calculations. We generally agree with that recommendation and hope to establish DRVs for various sediment toxicity tests. However, this use of DRVs should be distinguished from potential regulatory uses. The RWG made no deliberation on the validity or desirability of using DRVs for interpreting toxicity test data that would be used to make regulatory decisions. We believe this application of DRVs may prove defensible, but that further study and discussion are needed.

(5) Wood Waste Management (DMMP/SMS):

Comment: *"If Wood wastes in the marine environment are to be managed, they should be managed exclusively through the DMMP and SMS programs and not through the State's Solid Waste Management Program. Given the potentially far reaching effect of managing wood wastes in the marine environment, Ecology should propose specific rule revisions to address wood waste as was done in the case of net pens several years ago."*

Response: (Teresa Michelson) The DMMP and SMS programs and regulations are intended to address clean and contaminated sediments in the aquatic environment, and are not designed to address waste materials that have been dumped or have come to be located in the aquatic environment. When large accumulations of waste materials are encountered during dredging or cleanup operations, alternative regulatory authorities and approaches may be more relevant. In general, waste materials are not allowed to be discharged into the water, and should be removed from that environment when encountered.

The specific relationship between the Solid Waste regulations and the Sediment Management Standards with respect to wood waste is still being defined, and the relevant portion of the Solid Waste Regulations is being revised. Until this process is complete, it may not be possible to specifically define whether and how the Solid Waste regulations apply to wood wastes in the aquatic environment. A special section of the SMS rule to address wood waste is not being contemplated at this time. During development of the clarification paper, a number of possible approaches to sediments contaminated with wood waste were discussed, and the approach that was selected was to rely on the existing tools already in the SMS regulations (e.g., marine confirmatory bioassays). Therefore, there is no need for a special section addressing wood waste.

4. Mike Salazar (Applied Biomonitoring): *Environmental Significance of Laboratory Tests of Toxicity and Bioaccumulation*. Comment letter raises a number of issues relative to the existing DMMP approach for assessment and interpretation of bioaccumulation potential.

    (1) **Comment:** **Sensitivity**. "[Caged] mussels [exposed in the field] are more sensitive than amphipods [tested in the laboratory] because the exposure period is much longer (84 days vs. 10) and the measurement endpoints are generally more sensitive (growth vs. mortality)."

    Response: (David Kendall/David Fox) We agree that growth is a more sensitive endpoint than mortality. That is why the agencies replaced the *Neanthes* 10-day mortality test with the *Neanthes* 20-day growth bioassay in 1992. In fact, of the three tests in the standard suite of bioassays, only the amphipod bioassay has an acute mortality endpoint. The larval bioassay assesses both lethal and developmental effects and the 20-day test assesses effects on growth. Nationally, the Corps and EPA are developing improved chronic/sublethal tests, such as the 28-day *Leptocheirus plumulosus* bioassay (also see response to 3(3) above), which may ultimately be incorporated into our existing test suite.

    In evaluating dredged material we use a suite of bioassay organisms comprised of different taxa and ecological niches as surrogates for resources we are trying to protect. We feel that on balance the standard bioassays do a satisfactory job of identifying contaminated sediments. We have serious reservations about requiring caged mussel assessments at dredging sites on a routine basis. Routine use of caged mussels in lieu of the standard amphipod test would be cost-prohibitive.

    (2) **Comment:** **Test Duration.** "The PSDDA agencies should consider extending the test duration of both the amphipod test and the polychaete worm test to approach steady state conditions [for TBT] and equivalent tissue burdens among species."

    Response: The agencies no longer use the amphipod and *Neanthes* tests to assess the toxicity of TBT. Bioaccumulation testing of dredged material with porewater concentrations greater than 0.15 ug/L has been standard procedure since it was approved by the DMMP agency heads/directors following the 1996 SMARM.

(3) Bioaccumulation potential.

(a) Comment: "The PSDDA agencies should consider returning to the assessment philosophy of testing every sediment for bioaccumulation potential or at least those sediments that contain chemicals of concern known to take longer to reach chemical equilibrium and exhibit more chronic effects in nature such as TBT, PCBs, DDT, dioxins, and furans."

Response: (David Kendall/David Fox) We do not agree that we should change our assessment philosophy to require bioaccumulation testing on every sample. Bioaccumulation testing is very expensive and must be used judiciously. We believe that bioaccumulation testing is warranted only for dredged material in which concentrations of bioaccumulative chemicals are high enough to create a potential problem at the disposal site from a human health or ecorisk perspective.

(b) Comment: "By measuring tissue weights, percent lipids, and percent water at the beginning of the test on a surrogate sample of test animals, and again at the end of the test, multiple metrics could be used to estimate animal health. This would increase the value of the bioaccumulation data and give the PSDDA agencies more confidence in their regulatory decisions."

Response: (David Kendall/David Fox) We agree that it would be useful to modify the bioaccumulation protocol to include additional metrics to assess the health of the animal.

(4) Comment: PSDDA data interpretation. Mike Salazar questions the ecological protection afforded by the tissue effects guideline of 2 µg TBT/g (wet weight) used in a recent PSDDA project.

Response: (David Fox/David Kendall) It is important to remember that PSDDA adopted "Site Condition II" as a management objective at the disposal sites. Following is a discussion on Site Condition II taken from the PSDDA Evaluation Procedures Technical Appendix, Phase I (1988):

"The biological testing guidelines for Site Condition II, which allow for minor significant effects in the laboratory tests, suggest that some biological effects may be expected at the disposal site. The severity and extent of biological effects are not expected to be great because the majority of the species found at the preferred disposal sites are not known to be acutely sensitive to chemicals of concern. Effects associated with Site Condition II will include sublethal effects and, potentially, an increase in the mortality of the more sensitive but less abundant crustacean species. Cumulative effects are expected to consist of a reduction in population and community biomass and an increase in the tissue concentration levels of chemicals of concern."

In reviewing the available data, the agencies focused on marine organisms and endpoints that were the same or similar to endpoints used in the PSDDA suite of bioassays (mortality and growth). Much less emphasis was given to molecular, cellular, behavioral and morphological effects whose ecological relevance could not be determined. While the agencies understand that scientific advances may demonstrate the ecological importance of such effects, it was not possible at this time to evaluate them in the context of Site Condition II.

(5) **Comment:** **Other interpretation examples.** "The PSDDA agencies should consider re-evaluating the concept of assessing bioaccumulation potential from the trigger approach, to the way the tests are conducted, to the way the data are interpreted."

Response: (David Kendall/David Fox) National guidance on bioaccumulation testing procedures and interpretation is currently being re-evaluated by EPA and the Corps and bioaccumulation has been the focus of two recent national workshops (Denver 1995, Baltimore 1996). On a programmatic level, the DMMP agencies this year will assess the approach used to address bioaccumulation potential and effects associated with the uptake of bioaccumulative chemicals. As part of this effort the agencies propose conducting one or more workshops related to bioaccumulation. All stakeholders will be invited and encouraged to attend.

(6) **Comment:** **Costs vs. Utility.** "[I]t would be conceptually sound to conduct more tests with meaningful measurement endpoints that are appropriately sensitive, have exposure periods that approach steady state conditions, and provide a credible scientific approach for evaluating sediments that are contaminated with all chemicals, but particularly those that are extremely hydrophobic and require longer times periods to reach steady state and exposures that are potentially toxic. If the ultimate issue is cost, and it is not feasible to conduct all the tests in a meaningful way, I suggest that the number of tests be reduced and the quality of each test be improved."

Response: (David Kendall/David Fox) The DMMP agencies recognize the balance that must be struck between cost and regulatory certainty. The agencies also recognize the difficulties inherent in assessing potential effects of extremely hydrophobic chemicals, especially the need to consider longer exposure times necessary to approach steady state during bioaccumulation testing (also see response to comment 4(4) above). Nationally, the Corps and EPA are developing improved chronic/sublethal tests, such as the 28-day *Leptocheirus plumulosus* bioassay (also see response to 3(3) above), which may ultimately be incorporated into our existing test suite. In addition, a reassessment of bioaccumulation testing is underway nationally and will soon commence within the DMMP. The DMMP agencies also will be conducting some side by side comparative testing to evaluate sensitivity and response at 3 labs (part of a national Round Robin to evaluate the WES protocol) later this summer utilizing a 28-day *Neanthes* growth test protocol (e.g., developed at the Waterways Experiment Station protocol) versus the current PSEP 20-day *Neanthes* bioassay protocol utilized by DMMP and SMS.

5. **Comment:** Richard S. Caldwell, Ph.D. (Northwest Aquatic Sciences): DMMP clarification paper: Standardization of Reference Toxicant Tests. Comment letter opposes implementation of proposed clarification paper, and states that the regulatory agencies are trying to micromanage the bioassay laboratories.

Response: (David Fox) The DMMP agencies drafted the clarification paper "Standardization of Reference Toxicant Tests" in response to recommendations by the Northwest Toxicity Assessment Group, which includes representatives from a majority of the toxicology laboratories performing bioassays for dredged material assessment. In so doing, the objective of the agencies was not to micromanage toxicology laboratories, but to be responsive to concerns expressed by professional toxicologists.

Dr. Caldwell raised a number of important issues regarding the use of reference toxicants by testing laboratories. The DMMP agencies have carefully evaluated Dr. Caldwell's objections to standardization of reference toxicant testing and understand how the draft clarification could be perceived as a case of "micromanagement". Therefore, the DMMP agencies formally withdraw the clarification paper and recommend that the Northwest Toxicity Assessment Group develop reference toxicant guidelines for use by its members.

6. **Comment:** Richard S. Caldwell, Ph.D. (Northwest Aquatic Sciences): Comment relating to SMARM Issue Paper submitted by Dr. Lawrence McCrone. Generally agrees that fine grained sediments may result in "high mortality and/or poor recovery (mortality) compared with coarser sediments, but that there are many other reasons, mostly related to swimming behaviors, that may significantly affect the recovery (read mortality) of test organisms in the PSEP larval tests." He suggests that research is needed to assess some of these issues relative to the current method. He recommends that both DMMP and SMS programs reconsider the use of the larval test on a pass/fail basis at this time, given the issues raised that can confound the results.

Response: (David Kendall, Teresa Michelson) We investigated the potential effects of grain size on echinoderm larval mortalities (primarily *Dendraster excentricus*) and found no apparent relationship to either percent fines (silts + clays) or percent clay (Fox, 1993 ARM). Additionally, a comparative EPA (SAIC, 1993) study also showed that there was no apparent adverse response of *Dendraster excentricus* to increasing silts/clays, although the same study documented that *Crassostrea gigas* larvae did appear to be sensitive to sediments with a high proportion of clays and silts. There has been very little use of the oyster (*Crassostrea gigas*) larval bioassay collectively in the DMMP and SMS programs. We have encountered very little evidence of grain size effects for the echinoderm larval bioassay in either program, except the one case Dr. McCrone referenced, and in that case due to QA./QC problems with the test (e.g., inappropriate selection of reference sediments), not enough information has been provided to determine whether a grain size effect is occurring. The test is being rerun to address these issues.

We appreciate the observations that Dr. Caldwell has brought to our attention concerning the potential impacts of swimming behaviors of larval species on the test results. This is an issue that needs to be addressed in the upcoming sediment larval workshop. However, we do not feel there is a compelling reason to suspend the use of this test as a pass/fail test in the SMS/DMMP programs at this time. We will continue to monitor the larval test performance so that potential problems in test outcomes can be addressed as needed by the agencies.

7. **Comment:** Douglas Hotchkiss, Thomas Newlon (Port of Seattle). Comment letter regarding: "Ninth Annual Sediment Management Annual Review Meeting (SMARM) - Follow-up Comments on SMS Annual Review"

Response: (Brett Betts) As part of the SMS Triennial Review, the Washington Department of Ecology will respond separately to the Port of Seattle on each of the follow-up comments noted in their letter.

APPENDIX B

Public Issue Papers presented at the SMARM

Public Issue Papers not presented at the SMARM, but disseminated at the meeting

Post-SMARM Comment Letters

Public Issue Papers presented at the SMARM

1. Progress in Developing a Puget Sound AET for the Neanthes Biomass/Growth Endpoint (D. Michael Johns, Ph.D[6].; Lorraine B. Read[1]; Daniel P. Hennessy[1]; Carolyn J. Soetrisno[1]; and Douglas Hotchkiss[7].

2. Potential for grain-size effects on larval sediment bioassays (Lawrence McCrone, PTI Environmental Services).

3. Strategies and technologies for cleaning up contaminated sediments in the nation's waterways: A study by the National Research Council (Spyros P. Pavlou[8] and Louis Thibodeaux[9]).

4. Sediment cleanups should focus only on those stations exceeding the cleanup screening levels of the Sediment Management Standards (Lincoln Loehr, Heller, Ehrman, White and McAuliffe).

5. In-place dilution cleanup (Lincoln Loehr, Heller, Ehrman, White and McAuliffe).

6. Recent observations of increasing Phenol and 4-Methylphenol concentrations in Puget Sound sediments (Clay Patmont, Hart Crowser, Inc.).

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[7] Port of Seattle
[8] URS Greiner Inc.
[9] Louisiana State University, Baton Rouge, LA

Progress in Developing a Puget Sound AET for the *Neanthes* Biomass/Growth Endpoint

Prepared by
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Douglas A. Hotchkiss • Port of Seattle

Introduction

The Apparent Effects Threshold (AET) approach has been used by Puget Sound regulatory agencies to establish sediment quality guideline concentrations. AETs are used in the Puget Sound Dredged Disposal Analysis (PSDDA) program to establish both the maximum level (ML) and the screening level (SL) concentrations. Washington Department of Ecology (Ecology) has also used AETs to establish various sediment quality concentrations for their Sediment Management Standards (SMS) program.

AETs have been determined for almost all of the biological test endpoints used for assessing sediment quality in Puget Sound, including most standardized sediment toxicity tests, as well as a measure of benthic community status. AETs exist for the toxicity tests most frequently used (e.g., the 10-day amphipod test, and bivalve and echinoderm larval tests), as well as for less-used tests (e.g., Microtox®). However, no AET has been developed for toxicity tests in which the juvenile stage of the polychaete, *Neanthes arenaceodentata*, is used as the test organism. The purpose of this paper is to present an AET for the *Neanthes* 20-day biomass/growth endpoint.

Problem Identification

A *Neanthes* biomass/growth AET has not been developed to date primarily because of resource constraints within Ecology and the other PSDDA agencies. Convening of the Regulatory Work Group (RWG) provided a mechanism for the Port of Seattle to offer technical assistance in calculating a "near final" *Neanthes* AET. Among other issues discussed by the RWG was a review of the AET calculation procedures (Gries 1997). Following discussions with RWG members, the Port of Seattle volunteered to compile available synoptic data (i.e., biomass/growth and sediment chemistry data) from Puget Sound studies for the purpose of calculating a *Neanthes* biomass/growth AET.

Technical Background and Discussion

Under the direction of the Port of Seattle, EVS Consultants (EVS) undertook the calculation task, following the quality assurance, biological effects interpretation, AET, and reliability calculation methods utilized by Ecology (Gries and Waldow 1996; Gries 1997). One difference in the procedures used in calculating a *Neanthes* AET was that a top-down approach to checking data quality was taken rather than the bottom-up method, in that only the data setting the AET values were fully checked for fulfillment of QA/QC requirements (i.e., were subjected to a QA2-type assessment: see Ecology [1989a] for the definition of QA2). This method allowed for the same confidence in the AET results, but reduced the intensive effort that would have been necessary to perform a QA check for all of the data prior to the AET determination. Figure 1 presents the steps taken in the calculation of the AET values for the *Neanthes* biomass endpoint and outlines the following discussion.

Data Acquisition

EVS staff compiled an extensive inventory of matching chemistry and *Neanthes* 20-day biomass/growth endpoint data based on sediment samples collected from the Puget Sound region. Since the initial goal for this effort was to compile as much synoptic data as possible in a short period of time, data already in electronic form were preferred. Surveys were primarily acquired from the US Army Corps of Engineers, Seattle District, DAIS database and the Ecology SEDQUAL database. The in-house database at EVS Consultants was also used and provided data from recent sediment evaluation studies at Harbor Island and Commencement Bay.

The synoptic *Neanthes* 20-day biomass/growth and chemistry data acquired represents sediments from 380 stations in five major Puget Sound regions: Commencement Bay, Elliott Bay, Bremerton, Everett/Central Puget Sound, and Bellingham. Data from Commencement Bay are provided by seven surveys and comprise the largest number of stations at 159. Eleven surveys of Elliott Bay contained data from 150 stations. Six surveys in the Everett/Central Puget Sound region provided data from 37 stations. Two surveys each from the Bremerton area and Bellingham Bay provided 24 stations and nine stations, respectively. Table 1 presents the Puget Sound surveys and sources of data obtained by EVS.

Initial Data QA Review

An initial screening process compared survey data to PSSDA evaluation guidelines. Laboratory replication and negative controls were required for inclusion of data. Bioassay series with control mortality greater than 10 percent and reference growth/biomass less than 80 percent of the control were excluded. The initial biomass of *Neanthes* worms was evaluated for all bioassay test series. Test series were deemed acceptable if the animals had an initial biomass between 0.125 mg and 1.5 mg and grew by at least an order of magnitude over the 20-day test duration. Nontoxic stations with high variance among the bioassay replicates resulting in low power for the statistical tests were excluded as statistically inconclusive. Chemistry QA/QC summaries were evaluated when available and data failing to pass QA1 requirements were excluded (see Ecology [1989b] for the definition of QA1). However, because of the effort required to validate chemistry QA requirements, only surveys and stations setting the AET values will be evaluated for QA2 requirements. Table 2 summarizes the screening results for chemistry QA, laboratory replication, negative controls, reference stations, and statistical inconclusiveness. Table 3 presents the initial biomass measurements, the lowest mean biomass among the reference stations used in a survey, the magnitude of growth in the lowest mean biomass reference station, and the decision regarding acceptance of the test series.

Data Processing

Data processing consisted of reformatting the data, comparing it to the original source when hardcopy reports were available, and cross-checking bioassay and chemistry files. Most data acquired through DAIS were in electronic form and hardcopy reports were not available. Data that were hand-entered were 100 percent verified by EVS personnel. The data compilation process consisted of the following steps:

1. Receive data in text (ASCII), XLS, or .DBF format
2. Check for data consistency
3. Import into FoxPro®
4. Format data to correspond with database structures
   - Translate compound names into codes
   - Include only chemicals of concern
   - Standardize units
   - Sum DDTs, LPAHs, HPAHs, and PCBs — sum of all detected values or highest undetected value
5. Establish the relation between BIOASSAY.DBF and CHEM.DBF.
6. Delete samples without corresponding chemistry
7. Calculate normalized values (mg/kg-oc)
8. Repeat the above steps for every new survey or groups of surveys added.

   Data are stored in the EVS database in a format that is consistent with SEDQUAL and DAIS.

Data Analysis

Bioassay test and reference stations were paired based on the closest match of percent fines observed in the sediment samples. Once the appropriate reference and test stations were determined, bioassay data were assessed for normality and equality of variance. The tests of these assumptions were performed on the station residuals (the individual observation minus the station mean) on a survey-by-survey basis. Normality was checked using Shapiro-Wilk's test ($\alpha = 0.01$) and normal probability plots. A low α-level was used for the Shapiro-Wilk's test because of the sensitivity of this test when sample sizes are large. For very large sample sizes ($n > 200$), non-normality had to be confirmed by the normal probability plots. In some cases, non-normality was due to one or two stations with extreme values. In these cases, the individual stations were culled from their survey and transformed. The remaining stations in the survey were reassessed for normality. Equality of variances between the paired test of reference stations was assessed using Levene's test ($\alpha = 0.05$). Statistical evaluation of adverse effects was made using a one-tail Student's *t*-test ($\alpha = 0.05$) on raw data or rankit-transformed data if distributions were found to be significantly different from normal. When variances were found to be significantly different, an approximate *t*-test using separate variance estimates was performed. Test stations that were found to be significantly different from reference stations were considered hits.

Evaluation of the variability among bioassay replicates followed the procedures used by Gries and Waldow (1995). The no-hit samples with variance exceeding the 80th percentile of the distribution of variances for all samples were identified. The statistical power of the comparisons involving these samples were calculated, and labeled statistically inconclusive if the power was less than 0.6. Samples with low power result in questionable no-hit status; it is uncertain whether the station is a no hit because of adequate growth or because the statistical test had inadequate power. Stations which were found to have excessive variability were permanently removed from the AET database. Note that the method for determining statistically inconclusive samples will change pending a future clarification paper on this subject.

The distribution of non-toxic samples for each compound was evaluated for one or more outliers using Rosner's test. It is possible that the sample with the highest concentration may not be an outlier because it was masked by another outlier. In this way the highest concentration may be found not to be an outlier, but the second and third highest samples might be. Rosner's test allows for the detection of up to ten outliers. Nontoxic samples identified as statistical outliers due to elevated chemistry for one or more chemicals were identified. Table 4 shows the concentrations for all samples found to be statistical outliers, and also for all samples with concentrations greater than the outlier; those samples may have been masked by the outlier samples. Data is also shown for the next lowest sample relative to the outlier; this sample would set the AET if all outlying samples were excluded from the database. Available information was insufficient to indicate whether these samples were anomalous due to unusual matrix effects. This set of outliers was reserved for further investigation to determine whether these are anomalous samples, e.g., high chemical concentrations due to an atypical sediment matrix that is not representative of Puget Sound sediments.

AET Calculation

After data analysis and the determination of hit and no hit stations, and the exclusion of statistically inconclusive and chemically anomalous stations, stations were ranked by chemical concentration for the 64 chemicals of concern represented in the database. Based on these rankings, the highest no hit concentrations were identified as the AET values. Tables 5 and 6 present the dry-weight normalized and organic carbon normalized AET values, respectively.

Tables 5 and 6 also provide AETs for other bioassays and the benthic community. Comparison of the *Neanthes* AET to the other AETs indicates that the *Neanthes* AET is for the most part similar to the other AETs. Among dry weight-normalized AETs, the *Neanthes* AET sets the high AET for only 11 chemicals of concern. The majority of the high AETs are associated with pesticides. The most notable high AET is for total PCBs. Among TOC-normalized AETs, the *Neanthes* AET sets the high AET for only 8 COCs. In addition to potentially establishing some new high AETs, the *Neanthes* AET would establish new low AETs. Among the dry weight-normalized AETs, 14 low AETs are established by *Neanthes*, and 15 low AETs are established by *Neanthes* for the TOC-normalized AETs.

Finally, there has been some speculation since the development of the *Neanthes* 20-

day biomass/growth test that the test species and endpoint were insensitive to contaminants relative to the other bioassays used in Puget Sound. The similarity in AETs among all of the bioassays indicates that the sensitivity of the test is on par with the other bioassays. Many of the high AET concentrations identified with the *Neanthes* test are set by stations that have not been included in the AET re-calculations conducted by Ecology. At many of these stations, all three bioassays passed, indicating that a recalculation process for all tests, which included all of the surveys used in the *Neanthes* AET calculations, would result in increasing the AETs to the concentration represented by the *Neanthes* AET.

Proposed Action

A "near-final" set of AET concentrations resulted from the work directed by the Port of Seattle. The next step in the process, refinement of the *Neanthes* AET, should continue to be a partnership effort among the Port and government regulatory agencies. This partnership effort should be further explored and formalized. The focus of the calculation effort has been to provide a full analysis of a *Neanthes* biomass/growth AET for the purpose of incorporating the AET concentrations into regulatory decision making as part of the 1998 SMARM.

REFERENCES

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Ecology. 1989b. Data validation guidance manual for selected sediment viables. Ecology contract C0089018. Prepared by PTI Environmental Services, Bellevue, WA. Washington Department of Ecology, Olympia, WA.

Gries, T.H. and K.H. Waldow. 1996. Progress re-evaluating Puget Sound apparent effects thresholds (AETs), Volume I: 1994 amphipod and echinoderm larval AETs. Draft Report. Washington Department of Ecology, Olympia, WA.

Gries, T.H. 1997. AET Methodology: clarification and minor revisions, a clarification paper. Prepared for the 1997 SMARM. Washington Department of Ecology, Olympia, WA.

Data Acquisition

Scope

- *Neanthes arenaceodentata* (juvenile Polychaete) 20-day bioassay (biomass measurement endpoint)
- Corresponding sediment chemistry data (dry weight and TOC normalized)
- Puget Sound region

Sources

- U.S. Army Corps of Engineers – DAIS (Dredged Analysis Information System)
- Washington Department of Ecology – SEDQUAL
- EVS Consultants
- Other (Additional)
  - Regional consulting and engineering firms

Quality Assurance of Sediment Chemistry and Bioassay Data

- Determine whether bioassays meet test performance (control, reference, initial biomass) and quality assurance requirements
- Determine whether sediment chemistry meets quality assurance requirements

Data Processing

- Report, spreadsheet, database sources
- Reformat data into Microsoft FoxPro® database
- Compare data to original source

Data Analysis

- Pair reference stations with test stations based on sediment grain size
- Assess growth data for normality (using Shapiro-Wilk's test and normal probability plots) and equality of variance (using Levene's test)
- Apply a rankit transformation to data failing test for normality
- Test for significant adverse effects (using one-tail *t*-test, $\alpha = 0.05$; "approximate" *t*-test when data fail test for equal variances)
- Exclude no-hit samples which are statistically inconclusive from AET calculations
- Identify no-hit samples which are statistical outliers for any chemical

AET Calculation

Figure 1. The calculation of *Neanthes* sublethal AET values

Table 1. Surveys from the Puget Sound region with *Neanthes* 20-d biomass/growth data

Survey Name	Survey ID	Number of Stations	Data Source
Port of Seattle - Terminal 18 Phase 1, 1996	T18_P1	86	EVS
Sitcum Waterway - Pentec 1991	SITCUMRI	79	SEDQUAL
Hylebos Waterway - Striplin 1994	1A CORES	46	EVS
Harbor Island RI, 1995	HIRI95	35	EVS
Hylebos Waterway - NOAA - DAC 1994	DAC-HY94	28	EVS
US Navy Bremerton Pier D, Round 2, DY94	USNPD1CF072	22	DAIS
Weyerhaeuser Everett - PTI 1994	EVEWEY94	15	SEDQUAL
Port of Seattle - Terminal 18 Phase 2, 1996	T18_P2	14	EVS
Port of Everett - Piers 1 and 3, DY95	POE131BF079	9	DAIS
Port of Everett - South Terminal FC, DY95	POEST1BF081	8	DAIS
Squalicum Waterway Sediment Characterization, DY92	SQUAL1BF103	8	DAIS
Sound Refining	SNDREF92	3	SEDQUAL
Port of Seattle - Terminal 5, 1996	T5-1996	3	EVS
Duwamish Waterway, DY93	DUWA71BF107	3	DAIS
Monitoring - Elliott Bay Full, DY92	MONEB4BF061	3	DAIS
USACE Everett Downstream Settling Basin FC, DY93	EVEDS1BF063	3	DAIS
City of Bremerton - Warren Ave Basin CSO, DY94	WACSO1BF078	2	DAIS
Port of Seattle - Terminal 115, DY93	PS1151BF065	2	DAIS
Neanthes Sublethal Test Demonstration - PTI 1988	PTISTD88	2	EVS
Konioke-Pacific - Striplin 1993	KONPAC93	1	SEDQUAL
Bellingham Bay Partial Monitoring, DY93	MONBB4DP099	1	DAIS
Indian Cove Moorage, DY94	ICOVM1BF077	1	DAIS
King County Sammamish River, DY93	KCSAM1BF059	1	DAIS
Konoike-Pacific Tacoma Terminals, DY94	KPACT1BF068	1	DAIS
Port of Seattle - Terminal 30, DY94	PST301BF076	1	DAIS
Port of Seattle - Terminal 5 Pier Extension, DY92	PS0051BF100	1	DAIS
US Navy Everett Norton Terminal, DY94	USNNT1BF067	1	DAIS
Weyerhaeuser Bay City Dock, DY92	WEYER1BF056	1	DAIS
TOTALS	**28**	**380**	

Note: All data obtained from databases as noted; listed source documents not directly accessed

Table 2. Summary of screening results for studies containing matched *Neanthes* 20-d bioassay and sediment chemistry data

Survey Name	Survey ID	Number of Stations	Data Source	Chemical QA	Lab Replicates	Negative Control	Reference	Statistically Inconclusive
Port of Seattle - Terminal 18 phase 1, 1996	**T18_P1**	**86**	**EVS**	**QA2**	✔	✔	✔	**2 Stations Excluded**
Sitcum Waterway - Pentec 1991	*SITCUMRI*	*79*	*SEDQUAL*	-	✔	✔	✔	-
Hylebos Waterway - Striplin 1994	***1A CORES***	***46***	***EVS***	***QA1***	✔	✔	***Suitability TBD***	***11 Stations Excluded***
Harbor Island RI, 1995	HIRI95	35	EVS	QA1	✔	✔	✔	1 Station Excluded
Hylebos Waterway - NOAA - DAC 1994	DAC-HY94	28	EVS	QA1	✔	✔	✔	
US Navy Bremerton Pier D, round 2, DY94	USNPD1CF072	22	DAIS	TBD	✔	✔	✔	4 Stations Excluded
Weyerhaeuser Everett - PTI 1994	EVEWEY94	15	SEDQUAL	TBD	✔	✔	Suitability TBD	✔
Port of Seattle - Terminal 18 phase 2, 1996	T18_P2	14	EVS	QA2	✔	✔	✔	
Port of Everett - Piers 1 and 3, DY95	POE131BF079	9	DAIS	-	✔	✔	✔	3 Stations Excluded
Port of Everett - South Terminal FC, DY95	POEST1BF081	8	DAIS	TBD	✔	✔	✔	1 Station Excluded
Squalicum Waterway Sediment **Characterization, DY92**	SQUAL1BF103	8	DAIS	TBD	✔	✔	✔	✔
Sound Refining	*SNDREF92*	*3*	*SEDQUAL*	-	✔	✔	✔	✔
Port of Seattle - Terminal 5, 1996	T5-1996	3'	EVS	-	✔	✔	✔	✔
Duwamish Waterway, DY93	DUWA71BF107	3	DAIS	-	✔	✔	✔	2 Stations Excluded
Monitoring - Elliott Bay Full, DY92	MONEB4BF061	3	DAIS	-	✔	✔	✔	✔
USACE Everett Downstream Settling Basin FC, DY93	EVEDS1BF063	3	DAIS	-	✔	✔	✔	✔

Table 2. continued

Survey Name	Survey ID	Number of Stations	Data Source	Chemical QA	Lab Replicates	Negative Control	Reference	Statistically Inconclusive
City of Bremerton - Warren Ave Basin CSO, DY94	*WACSO1BF078*	*2*	*DAIS*	-	✔	✔	✔	✔
Port of Seattle - Terminal 115, DY93	PS1151BF065	2	DAIS	-	✔	✔	✔	✔
Neanthes sublethal test demonstration - PTI 1988	PTISTD88	2	EVS	-	✔	✔	✔	✔
Konioke-Pacific - Striplin 1993	**KONPAC93**	**1**	**SEDQUAL**	**TBD**	✔	✔	✔	✔
Bellingham Bay partial monitoring, DY93	MONBB4DP099	1	DAIS	-	✔	✔	✔	✔
Indian Cove Moorage, DY94	ICOVM1BF077	1	DAIS	-	✔	✔	✔	✔
King County Sammamish River, DY93	KCSAM1BF059	1	DAIS	-	✔	✔	✔	✔
Konoike-Pacific Tacoma Terminals, DY94	*KPACT1BF068*	*1*	*DAIS*	-	✔	✔	✔	✔
Port of Seattle - Terminal 30, DY94	*PST301BF076*	*1*	*DAIS*	-	✔	✔	✔	✔
Port of Seattle - Terminal 5 Pier Extension, DY92	*PS0051BF100*	*1*	*DAIS*	-	✔	✔	✔	✔
US Navy Everett Norton Terminal, DY94	USNNT1BF067	1	DAIS	-	✔	✔	✔	✔
Weyerhaeuser Bay City Dock, DY92	WEYER1BF056	1	DAIS	-	✔	✔	✔	✔
TOTALS	28	379						

NOTE: **Bold text** indicates surveys with stations setting AET values
Italic text indicates surveys with stations failing initial screening
TBD - to be determined

Table 3. Summary of initial biomass screening decision

Survey Name	Survey ID	Bioassay Series	Mean Initial Biomass (IBM)	Lowest Reference Station Mean (REF)	Growth Magnitude (REF/IBM)	Decision
Port of Seattle - Terminal 18 Phase 1, 1996	T18_P1	S1:	0.40	11.67	29.18	PASS
		S2:	0.36	10.16	28.23	PASS
		S3:	0.44	11.24	25.55	PASS
		S4:	0.40	10.22	25.56	PASS
		S5:	0.37	10.44	28.21	PASS
Sitcum Waterway - Pentec 1991	SITCUMRI	S1:	6.60	8.2	1.24	FAIL
		S2:	0.10	6.8	68.00	FAIL
Hylebos Waterway - Striplin 1994	1A CORES	S1:	0.67	18.86	28.02	PASS
		S2.	0.65	6.22	9.61	FAIL
		S3:	0.73	20.42	28.13	PASS
		S4:	0.76	6.78	8.96	FAIL
		S5:	0.55	15.06	27.23	PASS
Harbor Island RI, 1995	HIRI95	S1:	0.43	10.60	24.82	PASS
		S2:	0.56	12.13	21.66	PASS
		S3:	0.44	8.92	20.27	PASS
Hylebos Waterway - NOAA - DAC 1994	DAC-HY94	S1:	0.13	9.01	67.59	PASS
US Navy Bremerton Pier D, Round 2, DY94	USNPD1CF072	S1:	0.50	7.98	15.96	PASS
Weyerhaeuser Everett - PTI 1994	EVEWEY94	S1:	0.17	8.90	52.34	PASS
Port of Seattle - Terminal 18 Phase 2, 1996	T18_P2	S1:	1.06	12.22	11.52	PASS
Port of Everett - Piers 1 and 3, DY95	POE131BF079	S1:	0.53	11.92	22.62	PASS
Port of Everett - South Terminal FC, DY95	POEST1BF081	S1:	0.50	7.75	15.40	PASS
		S2:	0.38	8.42	22.16	PASS
Squalicum Waterway Sediment Characterization, DY92	SQUAL1BF103	S1:	0.58	19.75	34.35	PASS
Sound Refining	SNDREF92	S1:	3.87	2.32	0.60	FAIL

Table 3. continued

Survey Name	Survey ID	Bioassay Series	Mean Initial Biomass (IBM)	Lowest Reference Station Mean (REF)	Growth Magnitude (REF/IBM)	Decision
Port of Seattle - Terminal 5, 1996	T5-1996	S1:	NA	10.85	NA	NA
Duwamish Waterway, DY93	DUWA71BF107	S1:	0.62	16.72	27.14	PASS
Monitoring - Elliott Bay Full, DY92	MONE84BF061	S1:	0 17	8.42	48.97	PASS
USACE Everett Downstream Settling Basin FC, DY93	EVEDS1BF063	S1:	0 17	3.83	22.96	PASS
City of Bremerton - Warren Ave Basin CSO, DY94	WACSO1BF078	S1:	1.39	4 00	2.88	FAIL
Port of Seattle - Terminal 115, DY93	PS1151BF065	S1:	0.17	6.21	37.19	PASS
Neanthes Sublethal Test Demonstration - PTI, 1988	PTIS1D88	S1:	0 60	14 12	23.53	PASS
Konioke-Pacific - Striplin 1993	KONPAC93	S1.	0.37	13 1	35.22	PASS
Bellingham Bay Partial Monitoring, DY93	MONBB4DP099	S1:	0 20	2 88	14 40	PASS
Indian Cove Moorage, DY94	ICOVM1BF077	S1	0.98	18 86	19.24	PASS
King County Sammamish River, DY93	KCSAM1BF059	S1:	0.52	11.91	22.90	PASS
Konoike-Pacific Tacoma Terminals, DY94	KPACT1BF068	S1:	0.07	15.19	205.27	FAIL
Port of Seattle - Terminal 30, DY94	PST301BF076	S1'	1 87	20 2	10.80	FAIL
Port of Seattle - Terminal 5 Pier Extension, DY92	PS0051BF100	S1.	1.02	5 53	5.43	FAIL
US Navy Everett Norton Terminal, DY94	USNNT1BF067	S1:	0.28	14.89	53.16	PASS

NOTE Decision Criteria - IBM between 0.125-1 5 mg and Growth Magnitude>10

Table 4. Nontoxic samples identified as statistical outliers by Rosner's test

Chemical	Survey ID	Station ID	Sample ID	Concentration	Outlier[a]
Dry weight concentrations					
Metals (ppm)					
Chromium	HIRI95	WW-18	18	240	✔
	HIRI95	WW-18B	18B	160	
	1A CORES	4107	4107A	110	✔
	HIRI95	WW-13	13	94	
Nickel	SQUAL1BF103	C3	C3	150	
	SQUAL1BF103	C1	C1	150	✔
	MONBB4DP099	S1	S1	150	✔
	SQUAL1BF103	C18	C18	140	✔
	SQUAL1BF103	C19	C19	95	
Zinc	HIRI95	WW-23	23	2300	✔
	HIRI95	WW-18	18	1200	
Organic compounds (ppb)					
Acenaphthene	T18_P1	1C42	1C42	3400	✔
	1A CORES	4106	4106A	1000	
Fluorene	T18_P1	1C42	1C42	1600	✔
	1A CORES	4106	4106A	660	
Dibenzofuran	T18_P1	1C42	1C42	630	✔
	POEST1BF081	C6	C6	310	
4-Methylphenol	EVEWEY94	WE021	WE021	880	
	EVEWEY94	WE009	WE009	790	
	POEST1BF081	C7	C7	670	✔
	POEST1BF081	C1	C1	410	✔
	POEST1BF081	C6	C6	300	✔
	EVEDS1BF063	C8	C8	150	
Pentachlorophenol	DAC-HY94	HY-09	9	790	✔
	DAC-HY94	HY-10	10	180	
Butylbenzyl phthalate	DAC-HY94	HY-23	23	580	✔
	USNPD1CF072	S3	S3	170	
Pesticides (ppb)					
Total DDD+DDE+DDT	1A CORES	2106	2106A	390	✔
	T18_P1	1C03	1C03	71	
p.p.DDT	1A CORES	2106	2106A	320	✔
	DAC-HY94	HY-21	21	19	

Table 4. continued

CHEMICAL	SURVEY ID	STATION ID	SAMPLE ID	CONCENTRATION	OUTLIER[a]
Organic carbon-normalized concentrations					
Organic compounds (ppb)					
Acenaphthene	T18_P1	1C42	1C42	240	✔
	T18_P1	1C30	1C30	46	
Fluorene	T18_P1	1C42	1C42	110	✔
	T18_P1	1C06	1C06	27	
Dibenzofuran	T18_P1	1C42	1C42	45	✔
	T18_P1	1C06	1C06	18	
4-Methylpnenol	EVEWEY94	WE021	WE021	73	✔
	POEST1BF081	C7	C7	15	
Pentachlorophenol	DAC-HY94	HY-09	9	39	✔
	DAC-HY94	HY-10	10	8.8	
Butylbenzyl phthalate	USNPD1CF072	S3	S3	17	
	DAC-HY94	HY-23	23	15	✔
	T18_P1	1C03	1C03	7.0	
Pesticides (ppb)					
Total DDD+DDE+DDT	1A CORES	2106	2106A	16	✔
	T18_P1	1C03	1C03	5.5	
p.p.DDT	1A CORES	2106	2106A	13	✔
	T18_P1	1C13	1C13	1.2	

[a] Outliers are samples identified as statistical outliers using Rosner's test (α = 0.05). The highest concentrations may not have been identified as an outlier because they were masked by samples with the same or slightly lower concentrations (e.g., in nickel or 4-methylphenol). For comparison, the highest concentration below the outlier samples is also shown.

Table 5. Dry weight-normalized AET values

CHEMICAL GROUP/ CHEMICAL OF CONCERN	AMPHIPOD AET	LARVAL AET	BENTHIC AET	MICROTOX AET	*NEANTHES* AET
Metals (mg/kg or ppm)					
Antimony	200	9.3	150	NA	38
Arsenic	450	700	57	700	99
Cadmium	14	10	5.1	9.6	*3.0*
Chromium	>1,100	>96	260	NA	>240
Copper	1,300	390	530	390	390
Lead	1,200	660	450	530	650
Mercury	2.3	1.4	2.1	0.41	2.2
Nickel	>370	110	>140	NA	150
Silver	6.1	8.4	>6.1	>0.56	3.3
Zinc	3,800	1,600	410	1,600	2,300
Organic compounds (g/kg or ppb)					
Low molecular weight PAH					
LPAH	29,000	5,200	13,000	5,200	11,000
2-Methylnaphthalene	1,900	670	1,400	670	*200*
Acenaphthene	2,000	500	730	500	3,400
Acenaphtylene	1,300	>560	1,300	>560	*>160*
Anthracene	13,000	960	4,400	960	1,700
Fluorene	3,600	540	1,000	540	1,600
Napthalene	2,400	2,100	2,700	2,100	*1,300*
Phenanthrene	21,000	1,500	5,400	1,500	3,400
High molecular weight PAH					
HPAH	69,000	17,000	6,900	12,000	39,000
Benz(a)anthracene	5,100	1,600	5,100	1,300	3,300
Benzo(a)pyrene	3,500	1,600	3,600	1,600	2,200
Benzo(g,h,i)perylene	3,200	920	2,600	670	1,400
Benzofluoranthenes	9,100	3,600	9,900	3,200	8,200
Chrysene	21,000	2,800	9,200	1,400	10,000
Dibenz(a,h)anthracene	1,900	240	970	230	560
Fluoranthene	30,000	2,500	24,000	1,700	10,000
Indeno(1,2,3-c,d)pyrene	4,400	760	2,600	600	1,300
Pyrene	16,000	3,300	16,000	2,600	9,600
Chlorinated organic compounds					
1,2,4-trichlorobenzene	51	64	NA	31	110
1,2-dichlorobenzene	>110	50	50	35	*13*
1,3-dichlorobenzene	>170	>170	>170	>170	*21*
1,4-dichlorobenzene	120	120	110	110	*97*
Hexachlorobenzene	130	230	22	70	120

Table 5. continued

Chemical Group/ Chemical of Concern	Amphipod AET	Larval AET	Benthic AET	Microtox AET	*Neanthes* AET
Phthalates					
Bis(2-ethylhexyl)phthalate	>8,300	1,900	1,300	1,900	2,000
Butyl benzyl phthalate	970	>470	900	63	>580
Di-*n*-butyl phthalate	1,400	1,400	>5,100	1,400	*76*
Di-*n*-octyl phthalate	>2,100	>420	6,200	NA	*61*
Diethyl phthalate	>1,200	>73	200	>48	NC
Dimethyl phthalate	>1,400	160	>1,400	71	75
Phenols					
2-methyl phenol	77	63	72	>72	*23*
2,4-dimethyl phenol	77	55	210	29	*18*
4-methyl phenol	3,600	670	1,800	670	**>880**
Pentachlorophenol	400	150	690	>140	**790**
Phenol	1,200	420	1,200	1,200	*340*
Miscellaneous extractables					
Benzyl alcohol	73	73	870	57	>150
Benzoic acid	760	650	650	650	*88*
Dibenzofuran	1,700	540	700	540	630
Hexachlorobutadiene	180	270	11	120	260
Hexachloroethane	140	NA	NA	NA	NC
N-nitrosodiphenylamine	48	130	28	40	NC
Volatile organics					
Ethylbenzene	50	37	10	33 -	NC
Tetrachloroethene	>210	140	57	140	130
Xylene, total	160	120	40	100	*80*
Pesticides and PCBs					
Aldrin	9.5	9.5	NA	NA	**21**
Chlordane	2.8	>4.5	NA	NA	**14**
Dieldrin	3.5	1.9	NA	NA	**34**
Heptachlor	1.5	2.0	NA	NA	**>4.1**
p,p'-DDD	63	28	16	NA	**68**
p,p'-DDE	62	9.3	9.0	NA	**46**
p,p'-DDT	>270	12	34	NA	**>320**
Total DDT	24	37	NA	NA	**390**
Total PCBs	3,100	1,100	1,000	130	**4,900**

NOTE: **Bold** - Values greater than established AETs
Italic - Values less than established AETs
NA - not available
NC - value not calculated
- Identified as a potential outlier (see Table 4)

Table 6. TOC-normalized AET values

Chemical Group/ Chemical of Concern	Amphipod AET	Larval AET	Benthic AET	Microtox AET	*Neanthes* AET
Nonionizable organic compounds (mg/kg TOC; ppm)					
Low molecular weight PAH					
LPAH	2,200	370	780	>530	770
2-Methylnaphthalene	>120	>53	64	NA	*13*
Acenaphthene	200	>110	57	>57	**>240**
Acenaphtylene	66	>27	66	>27	*>9.3*
Anthracene	1,200	93	220	>79	120
Fluorene	360	73	79	>71	110
Napthalene	220	>190	170	>170	*39*
Phenanthrene	840	140	480	>160	240
High molecular weight PAH					
HPAH	5,300	960	7,600	1,500	2,100
Benz(a)anthracene	270	170	650	>160	190
Benzo(a)pyrene	210	230	>1,000	>140	*140*
Benzo(g,h,i)perylene	100	>240	>1,200	>67	100
Benzofluoranthenes	450	310	1,500	>430	340
Chrysene	840	220	850	>200	420
Dibenz(a,h)anthracene	50	120	89	33	*24*
Fluoranthene	3,000	320	1,200	>190	710
Indeno(1,2,3-c,d)pyrene	120	>190	900	>87	*79*
Pyrene	1,000	520	1,400	>210	690
Chlorinated organic compounds					
1,2,4-trichlorobenzene	1.8	2.7	NA	0.81	**5.4**
1,2-dichlorobenzene	>5.8	2.3	2.3	2.3	*0.64*
1,3-dichlorobenzene	>15	>15	>15	>15	*0.81*
1,4-dichlorobenzene	9.0	3.1	16	>16	4.2
Hexachlorobenzene	4.5	9.6	0.38	2.3	5.9
Phthalates					
Bis(2-ethylhexyl)phthalate	>550	130	60	47	87
Butyl benzyl phthalate	49	>9.2	64	4.9	>17
Di-*n*-butyl phthalate	260	260	1,700	220	*4.8*
Di-*n*-octyl phthalate	58	>57	4,500	NA	3.2
Diethyl phthalate	>110	>5.3	61	>5.3	NC
Dimethyl phthalate	53	>22	53	>19	2.3

Table 6. continued

Chemical Group/ Chemical of Concern	Amphipod AET	Larval AET	Benthic AET	Microtox AET	*Neanthes* AET
Miscellaneous extractables					
Dibenzofuran	>170	57	58	>58	*45*
Hexachlorobutadiene	6.2	11	6.9	3.9	**15.0**
Hexachloroethane	2.7	NA	NA	NA	NC
N-nitrosodiphenylamine	>11	>11	11	>11	NC
Volatile organics					
Ethylbenzene	>3.8	>3.8	>3.8	>3.8	NC
Tetrachloroethene	>22	>22	>22	>22	*2.1*
Xylene, total	>12	>12	>12	>12	*0.40*
Pesticides and PCBs					
Aldrin	0.56	>0.56	NA	NA	**1.9**
Chlordane	0.16	>0.26	NA	NA	**1.1**
Dieldrin	0.13	0.28	NA	NA	**2.6**
Heptachlor	>0.11	>0.40	NA	NA	>0.23
p,p'-DDD	3.1	1.6	1.0	NA	2.8
p,p'-DDE	6.0	>7.3	0.31	NA	>3.5
p,p'-DDT	16	>0.71	3.7	NA	>13
Total DDT	1.4	8.8	NA	NA	**>16**
Total PCBs	190	>46	65	12	**>490**
Ionizable inorganic compounds (mk/kg TOC or ppm)					
Phenols					
2-methyl phenol	3.1	3.1	10	>10	*1.2*
2,4-dimethyl phenol	6.5	>1.3	2.6	0.63	0.88
4-methyl phenol	780	37	250	81	>73
Pentachlorophenol	24	>11	66	>11	**39**
Phenol	>440	>39	>140	33	*17*
Miscellaneous Extractables					
Benzyl alcohol	5.0	5.0	>73	5.0	>16
Benzoic acid	>170	>170	>170	>170	*3.2*

NOTE: **Bold** - values greater than established AETs
Italic - values less than established AETs
NA - not available
NC - value not calculated
- identified as a potential outlier (see Table 4)

POTENTIAL FOR GRAIN-SIZE EFFECTS ON LARVAL SEDIMENT BIOASSAYS

SMARM ISSUE PAPER

Prepared by Lawrence McCrone (PTI Environmental Services) on behalf of the Weyerhaeuser Company

INTRODUCTION

Larval sediment bioassays conducted under the Sediment Management Standards (SMS) and the Dredged Material Management Program (DMMP) may use any of several bivalve and echinoderm species (e.g., oyster, mussel, sea urchin, sand dollar). The regulatory agencies have indicated that oyster larvae may be susceptible to high combined mortality and abnormality in sediments known to have a high proportion of silt- and clay-sized particles, even in the absence of chemical contamination (U.S. EPA 1993; Ecology 1995). Alternatively, the regulatory agencies have suggested that sand dollar embryos are recommended as the test species when sediment samples have a high proportion of silt- and clay-sized particles. Two studies have been cited as the basis for these recommendations.

Science Applications International Corporation (SAIC) tested oyster larvae and sand dollar embryos in four reference area sediment samples with a range of percent fines (i.e. the combined silt- and clay-sized fractions) (U.S EPA 1993). Those four sediment samples had fine fractions of 6, 28, 51, and 87 percent. Unacceptably high combined mortality and abnormality was found for the oyster larvae exposed to the sediment sample with 87 percent fines. Under the aerated conditions normally used in these bioassays, sand dollar embryos did not exhibit unacceptably high combined mortality and abnormality (i.e., greater than 35 percent, the reference area performance standard) when exposed to any of these sediment samples.

PTI (1991) tested oyster larvae and sand dollar embryos in 21 sediment samples from three reference areas. Those 21 sediment samples had fine fractions ranging from 3.2 to 96 percent. Combined mortality and abnormality was found to be significantly correlated with higher percentages of both fine-grained particles and total organic carbon for both species tested. However, all of the sediments tested exhibited combined mortality and abnormality for the oyster larvae that was higher than the reference area performance standard (35 percent), while all of the sediments tested were below that standard for the sand dollar embryos.

We are not aware of similar studies having been conducted of possible grain-size effects for mussel larvae or sea urchin embryos.

PROBLEM IDENTIFICATION

In a recent investigation designed to assess compliance with the SMS, sediment samples were chemically analyzed and subjected to amphipod, juvenile polychaete, mussel, and sea urchin bioassays. In one area that had been identified as potentially being of concern, sediment samples from three stations exhibited no exceedances of sediment quality standards (SQS) for any chemical, and there were no significant "hits" for either the amphipod or juvenile polychaete bioassays. Excessively high combined mortality and abnormality in reference area samples for both the mussel and sea urchin bioassays precluded a definitive assessment of the results. Nevertheless, the combined mortality and abnormality in the test sediment samples was noted to be rather high (76 to 87 percent for the mussel, with a corresponding range in the fine-grained fraction of 85 to 95 percent and in total organic carbon of 3.1 to 3 6 percent; 51 to 68 percent for the sea urchin, with a corresponding range in the fine-grained fraction of 95 to 98 percent and in total organic carbon of 2.8 to 4.6 percent). In the absence of any evidence of chemical toxicity, even among chemicals for which there are no SQS, we believe that the fine-grained nature of these sediments alone may account for the high combined effects.

Although another round of testing is now planned for this area using sand dollar embryos, we believe that the very limited experience to date with sediments having very high proportions of silt and clay particles precludes definitive conclusions regarding the lack of a grain-size effect for all of the larval test organisms Among the 25 reference area sediment samples subjected to oyster larvae and sand dollar bioassays by SAIC (U S. EPA 1993) and PTI (1991), only four had a fine-grained fraction of greater than 80 percent. Mussel larvae and sea urchin embryos have apparently not been subjected to similar tests of grain-size effects under controlled conditions Extrapolation of bioassay results for a broad range of particle sizes to samples with very high proportions of fine-grained sediments is not necessarily valid both because the observed correlations are rather poor (PTI 1991), and because there is no reason to believe that the effect would be linear at extremely high proportions of fine-grained sediments

In experiments conducted nearly four decades ago, Davis (1960) demonstrated marked reductions in the normal development of clam larvae as the concentration of suspended silt particles in the experimental chambers was increased, while increasing concentrations of suspended clay particles were shown to inhibit growth. Davis (1960) suggested that the smaller inorganic particles, which approximate the size of the small phytoplankton cells that the larvae normally feed upon, were ingested by the larvae, resulting in blockage of their digestive tracts. If Davis (1960) is correct, a grain-size effect would not be expected until a significant concentration of the very finest grain sizes was reached, because larger particles could not be ingested by the larvae. Therefore, adverse effects on the larvae would not be linearly correlated with grain size over a wide range of sediment types

The particle settling behavior of silt- and clay-sized particles could also be a reason that effects observed at high proportions of fine-grained sediments would be non-linear. At the initiation of the larval bioassays, the sediment sample is mixed with seawater and allowed to settle for 4 hours prior to introduction of the test organisms. SAIC demonstrated through an analysis of particle settling rates that in a static environment virtually all sediment particles greater than 1.9 μm in diameter would settle to the bottom of a 15-cm test chamber within 4 hours, leaving only the finer clay-sized particles in suspension (U.S. EPA 1993). Aeration of the test chambers, as normally conducted for the larval bioassays, would likely create turbulence in the chambers, allowing some of the finer grain-sized particles to remain in suspension for a longer time. It would be unlikely, however, that particles coarser than silt would be kept in suspension. Observations by laboratory personnel confirm that when samples with a high proportion of fine-grained sediments are subjected to larval bioassays, the water may remain cloudy for the duration of the test. Therefore, if fine-grained particles indeed have a strictly physical effect on the survival and development of the test organisms, it may not be observed until the test sediment has a high proportion of such particles.

PROPOSED ACTIONS

Relatively few locations in Puget Sound have sediments with as high a proportion of fine-grained sediments as the area of concern discussed above. Nevertheless, such areas do exist (e.g., river deltas, deep basins, quiescent embayments or sloughs) Because of the relative rarity of such high proportions of fine-grained sediments in areas that have typically been the focus of sediment investigations conducted to date, we suggest that the issue of the applicability of the larval sediment bioassays to such sediments has not been adequately addressed. In the absence of a more detailed analysis of this issue, we suggest that it would be inappropriate to conclude that high combined mortality and abnormality is necessarily indicative of chemical toxicity.

We therefore request the regulatory agencies to pursue the following two-phased investigation:

- A considerable number of Puget Sound sediment investigations have been conducted to date in which both larval bioassays and grain-size analyses have been conducted, but the data have never been analyzed to address this issue. Therefore, all matched larval bioassay and sediment grain-size data already in the possession of the regulatory agencies should be assembled. The data for each larval test organism (i.e., oyster, mussel, sea urchin, sand dollar) should be evaluated independently. Attention should be focused on samples with a high proportion (e.g., > 85 percent) of fine-grained sediments, and especially on samples with low concentrations of potentially toxic chemicals, which would likely be from reference areas. If a sufficient number of such samples already exist, an assessment should then be made of whether the combined mortality and abnormality in those samples is sufficiently high to suggest that these bioassays may not be relied upon as indicators of chemical toxicity for such fine-grained sediments.

- If, in the absence of sufficient historical data to perform such an assessment for one or more of the larval test species, the regulatory agencies should then sponsor a well-designed laboratory investigation to address this issue. A panel of larval bioassay experts should be convened to design the investigation, and the services of several of the recognized toxicity testing laboratories in the area should be enlisted. The goal should be to provide definitive proof of whether any of the existing larval bioassay species can reliably provide evidence of chemical toxicity in sediments, and not be confounded by potential physical effects of grain size alone.

If, as a result of the suggested investigation, it can be demonstrated that the results of larval bioassays for all of the available test species are confounded by the physical effects of grain size alone, it may be necessary to forego testing of sediment samples with a high proportion of fine-grained particles. In such cases, the only viable alternative may be to rely on a preponderance of evidence (e.g., sediment chemistry and the results of the other sediment bioassays) to make a regulatory decision for such sediments.

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STRATEGIES AND TECHNOLOGIES FOR CLEANING UP CONTAMINATED SEDIMENTS IN THE NATION'S WATERWAYS: A STUDY BY THE NATIONAL RESEARCH COUNCIL [1]

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[1] Presented at the National Conference on Management and Treatment of Contaminated Sediments. Cincinnati, OH, May 13-14, 1997.

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INTRODUCTION

This presentation is an overview of a study performed by the National Research Council (NRC) Marine Board Committee on Contaminated Marine Sediments. The fifteen-member committee included national experts from academia, industry, and the professional services sector. The committee was established in the spring of 1993 and completed its work in the summer of 1996. The committee's deliberations were published in a report released by the NRC in March 1997.

The committee's activities were sponsored through the NRC by the US Environmental Protection Agency (USEPA), the US Army Corps of Engineers (USACE), the US Navy, the National Marine Fisheries Service of the US Department of Commerce, the Maritime Administration of the US Department of Transportation, and the US Geological Survey.

THE CHALLENGE

Contaminated marine sediments pose a threat to ecosystems, marine resources, and human health. Sediment contamination also interferes with shipping activities and growth of trade resulting from delays in dredging and/or the inability to dredge the nation's harbors due to controversies over risks and costs of sediment management. Given that approximately 95% of total US trade passes through dredged ports, potential economic impacts due to sediment contamination may be severe.

The management of contaminated sediments is a complex and difficult process. The factors that contribute to the complexity are multiple and, in combination, exacerbate the problem. In summary, these are:

- High public expectations for protecting human health and the environment
- Multiple stakeholder interests and priorities
- Conflicting and overlapping jurisdictions of federal, state, and local regulatory authorities
- Relatively low levels of contamination
- Large quantities of affected sediments
- Uncertainty in quantifying and managing risk
- Limitations of handling and treatment technologies

All of the above factors may result in non-cost-effective management actions with controversial outcomes and marginal benefits.

CONCEPTUAL FRAMEWORK FOR CONTAMINATED SEDIMENT MANAGEMENT

The committee recognized the challenges associated with contaminated sediment management and developed a risk-based framework for making management decisions and for selecting remediation technologies. This framework provides the basis for a systematic and consistent approach to contaminated sediment management, including dredging and disposal.

It must be emphasized here that the approach appears similar to existing decision-making frameworks developed by USEPA and USACE. One of these decision-making frameworks was developed by USEPA for evaluating alternatives for remediation in Superfund projects. The other was developed jointly by USEPA and USACE for evaluating alternatives for the disposal of dredged material associated with navigation projects. While the committee recognized the utility of these formal decision-making approaches, this schematic representation has a different purpose. It was developed as a generic overview of the contaminated sediment management process to assist the committee members in addressing the various decision components in a logical sequence of evaluations.

SCOPE OF THE STUDY AND APPROACH

The committee's charge was to: (1) assess best management practices and emerging technologies for reducing adverse environmental impacts; (2) appraise interim control measures for use at contaminated sediment sites; (3) address how information about risks, costs, and benefits can be used and communicated to guide decision making and; (4) assess existing knowledge and identify research needs for enhancing contaminated sediment remediation technology.

Technical information was reviewed and assessed. Committee members interacted closely with researchers, regulators, stakeholders, engineers and operators. Six case studies of contaminated sediment remediation were evaluated and one sediment remediation project site was visited. In addition, the committee conducted workshops on interim controls and long-term technologies, summarized site assessment methods, and evaluated the application of decision tools to the contaminated sediment management process.

The results obtained from the above tasks were then assembled and organized under three major categories: decision making, remediation technologies, and project implementation. Opportunities for improvement were identified in all categories. The discussion that follows summarizes the committee's conclusions and recommendations.

CONCLUSIONS AND RECOMMENDATIONS

Improving Decision Making

Factors influencing decision making include regulatory realities, stakeholder interests, site-specific characteristics and data uncertainty, and availability of remediation technologies. The committee examined all of the above factors in making the following conclusions and recommendations:

- Stakeholder involvement early in the decision process is important in heading off disagreements and building consensus among all parties involved. In situations where decisions are complex and divisive, obtaining consensus among stakeholders can be facilitated by using formal analytical tools; e.g., decision analysis.

- The trade-off evaluation of risks, costs and benefits and the characterization of their associated uncertainties in selecting a preferred management alternative offers the best chance for effective management and communication of the decision-making process to stakeholders.

- Risk analysis is an effective method for selecting and evaluating management alternatives and remediation technologies. More extensive use of appropriate methods for cost-benefit analysis has the potential to improve decision making.

- The USEPA and USACE should sponsor research to quantify the relationship between contaminant availability and corresponding human health and ecological risks. The main goal is to evaluate projects using performance-based standards, i.e., risk reduction from in-place sediments, disturbed sediments and sediments under a variety of containment, disposal and treatment scenarios. This information is critical to the successful trade-off evaluations of risks, costs, and benefits to make technically defensible decisions in selecting a preferred management alternative.

- The use of systems engineering can strengthen project cost effectiveness and acceptability In choosing a remediation technology, systems engineering can help ensure that the solution meets all removal, containment, transport, and placement requirements while satisfying environmental, social and legal demands.

- Federal, state, and local agencies should work together with appropriate private sector stakeholders to interpret statutes, policies, and regulations in a constructive manner so that negotiations can move forward and sound solutions are not blocked or obstructed.

- The USEPA and USACE should continue to develop uniform or parallel procedures to address human health and environmental risks associated with freshwater, marine, and land-based disposal, containment, or beneficial reuse of contaminated sediments.

- The USEPA and USACE should develop and disseminate information to stakeholders regarding: the availability and applicability of decision analytical tools; appropriate risk analysis techniques to be used throughout the management process, including the selection and evaluation of remedial alternatives; and the demonstration and appropriate use of decision analysis in an actual contaminated sediment remediation case.

- The USACE should modify their cost-benefit analysis guidelines and practices to ensure comprehensiveness and uniformity in method application.

Improving Remediation Technologies

Technologies were identified and grouped into four categories: interim control, in-situ management, sediment removal and transportation, and ex-situ management. Technologies were compared qualitatively in terms of state of maturity, frequency of usage, scale of application, cost per cubic yard, and use limitations. The technologies were then scored according to four criteria: effectiveness, feasibility, practicality, and cost. Based on the latter information, technologies were ranked according to preference factors. Other topics addressed included technology cost issues across all categories and the need for remediation technology research, development, testing, and demonstration.

Technology Costs

- Capping, containment and natural recovery are effective management methods for most contaminated sediments. Where remediation is necessary, high-volume low-cost technologies are the first choice, assuming they are feasible and succeed in attaining the required risk reduction for protecting human health and the environment. Because treatment is expensive, reducing volume is important.

- Treatment is usually justified only for relatively small volumes of highly contaminated sediments. Advanced treatment is too costly in the majority of cases, which typically involve low-level contamination.

- Cost data for full scale remediation systems must be improved to allow for fair overall comparisons and development of benchmarks for R&D and systems design. The USEPA and USACE should develop guidelines for calculating costs of remediation systems, including technologies and management methods. The agencies should maintain a database on the costs of systems that have actually been used.

In-Situ Controls

- Natural recovery is viable and can be considered as an optimum remediation solution when contaminant concentrations are low. If natural recovery is not feasible, capping may be appropriate to reduce bioavailability. Monitoring is required to test the efficacy of capping. The use of capping might be advanced if it were viewed as a permanent remedy under Superfund.

- In-situ chemical treatment has conceptual advantages but considerable R&D will be needed before successful application can be demonstrated. Similarly, using bioremediation to treat in-place sediments requires further R&D to resolve microbial, geochemical, and hydrological issues.

Sediment Removal Technologies

The high costs of ex-situ treatment relative to dredging calls for improvement of dredging technologies to enable sediment removal at near in-situ densities and precise removal of contaminated sediments to limit the capture of clean sediments and water. In this manner, the volume of dredged material requiring containment or treatment can be reduced.

Ex-Situ Controls

- Research is needed to improve control of contaminant releases, long-term monitoring methods, and techniques for preserving the capacity of existing confined disposal facilities (CDFs).

- The potential for acceptability of constructing contained aquatic disposal (CAD) facilities on or near contaminated sites must be explored fully. The USEPA and USACE should support research to improve design tools for preventing containment failure, improve monitoring methods for assessing long-term performance, control contaminant loss, and determine risk-reduction effectiveness through contaminant isolation.

- The USEPA and USACE should support research for promoting the reuse of CDFs and CADs and for improving tools for the design and evaluation of their long-term stability and effectiveness.

- R&D on ex situ treatment technologies is warranted in the search for cost-effective treatment of large sediment volumes. Bench- and pilot-cale testing of ex-situ treatment technologies, and eventually full-scale demonstrations in marine systems, are needed to improve cost estimates, resolve technical problems, and improve treatment effectiveness.

Technology Innovation

Additional R&D and demonstration projects are needed to improve existing technologies and reduce risks associated with developing and implementing innovative approaches. The advancement of cost-effective and innovative technologies could be facilitated by peer review of R&D proposals and side-by-side demonstrations of new and current technologies. The USEPA and USACE should develop a program to support such R&D and demonstration projects.

Improving Project Implementation

Although improvements in decision-making and remediation technologies would contribute to cost-effective contaminated sediment management, a variety of practical issues must be addressed to remove constraints in project implementation. These include responsibility for source control, site characterization needs and technologies, interim controls, and promotion of beneficial uses. The committee's conclusions and recommendations regarding these issues are presented below.

- As ports currently bear an unfair share of the responsibility for remediation and placement of contaminated sediments, project implementation would be facilitated by transferring the burden for source control to states and polluters. Federal and state regulators, together with the ports, should investigate the use of appropriate legal and enforcement tools to require the upstream contributors to the contamination to share equitably in the cleanup costs.

- New and improved techniques are needed to reduce the costs and enhance the precision of site assessments. The use of remote sensing technologies, including rapid and accurate sensors may accomplish this goal. The USEPA and USACE should jointly support R&D to advance the state of science in site assessment technologies. Objectives should include the identification and development of advanced survey approaches and new and improved chemical sensors for surveying and monitoring.

- In cases where sediment contamination poses an imminent danger, administrative and engineering or structural controls can be used to reduce risks to potential human and ecological receptors from exposure to contaminated sediments over a short term until a more permanent remedy can be implemented.

- Beneficial uses of dredged contaminated material can provide disposal alternatives that are socially acceptable These may include creation of islands for seabird nesting, landfills for urban development, beach nourishment, wetlands, shoreline stabilization, topsoil for landfill covers, and other potential marketable uses of the material. The USACE should revise its policies to allow for placement strategies that incorporate the beneficial use of contaminated sediments even if they are not the lowest cost alternatives. Regulatory agencies involved in contaminated sediment disposal should develop incentives for and encourage implementation of beneficial use alternatives. Funding should be continued for R&D of innovative beneficial uses of contaminated sediments and the development of technical guidance and procedures for environmentally acceptable beneficial reuse.

SUMMARY

There is no simple solution to the problems created by contaminated marine sediments. However, the NRC Marine Board study summarized in this presentation indicates that careful problem formulation and good information provide the foundation for good decisions in managing contaminated sediments. Incremental improvements can be made in decision making, remediation technologies, and project implementation that may result in cost-effective, socially acceptable, and environmentally sound solutions.

SMS ISSUE PAPER

SEDIMENT CLEANUPS SHOULD FOCUS ONLY ON THOSE STATIONS EXCEEDING THE CLEANUP SCREENING LEVELS OF THE SEDIMENT MANAGEMENT STANDARDS

Prepared by Lincoln Loehr (206 / 389-6219) (Heller, Ehrman, White & McAuliffe)

INTRODUCTION

A cleanup approach that emphasized just cleaning up the stations that exceed the Cleanup Screening Level ("CSL") of the Sediment Management Standards ("SMS") was proposed to the Sediment Cleanup Work Group ("SCWG") in 1994. This approach was endorsed by that advisory group which in turn recommended the approach to the directors of the five state and federal agencies that had convened the advisory group. In 1995 this approach was endorsed by the directors of those agencies. The CSL is also known as the "minor adverse effects level". By focussing cleanup efforts on those stations exceeding the CSL, remaining sediments would not exceed the minor adverse effects level and, consistent with the SMS, would not necessitate additional cleanup.

PROBLEM IDENTIFICATION

Although the directors of the five agencies endorsed the SCWG's approach in 1995 as a means to speed up sediment cleanup, the reality is that EPA and Department of Ecology staff have deliberately resisted implementing it. Agency staff have held out for costly cleanup of sediments that did not exceed the CSL and this in turn has delayed sediment cleanup. Agency staff have essentially said that they were not compelled to follow the approach that their directors had signed onto.

DISCUSSION

In the summer of 1994, five agencies, including the Department of Ecology, Department of Natural Resources, Environmental Protection Agency, Army Corps of Engineers, and the Puget Sound Water Quality Authority, chartered a multiparty Sediment Cleanup Work Group to give agency directors their collective best ideas on how to make progress with sediment cleanup in Washington. The recommendations of the SCWG were presented to the five agency directors on December 20, 1994. In August 1995, the five agency directors signed on to the Sediment Cleanup Strategy: An Interagency Overview which formally endorsed the implementation of the recommendations of the SCWG.

One of the endorsed SCWG recommendations dealt with focussing on cleanup of "hot spots". "Hot spots" meant only those stations that exceed the CSL. In May 1996, Ecology published the Contaminated Sediments Site List, stating:

> "As party to the Sediment Cleanup Workgroup recommendations of December 1994, to expedite cleanup efforts Ecology's site list contains sites composed solely of stations exceeding the cleanup screening level."

This is what the SCWG intended in its recommendation. It was specifically intended to prevent the phenomenon of the "exploding cleanup sites" that the sediment management standards created. It was intended to show that sediments exceeding the sediment quality standard but not exceeding the CSL, were sediments of low concern, and not cleanup sites.

To understand what is meant by "exploding cleanup sites", refer to the following figures. Figure 1 represents a collection of sediment stations which includes 13 stations that exceed the SQS, but none that exceed the CSL. Under the SMS, this is not a site and it does not require remediation. The 13 stations within the bounded area in Figure 1 are sediments of low concern. Figure 2 is the same as Figure 1, except that now three stations exceed the CSL. Under the SMS, the small area exceeding the CSL results in all 13 of the stations in the entire bounded area being a contaminated sediment site, necessitating considerable regulatory process and cleanup. However, by simply cleaning up those three stations that exceed the CSL, the resulting condition is shown in Figure 3. Figure 3 is actually cleaner than Figure 1 and the bounded area is not a contaminated sediment site and does not require remediation. When the SCWG discussed this aspect of the SMS, the term "exploding cleanup sites" was created and understood by all the participants. All the participants understood that focussing on cleanups of those stations exceeding the CSL and then re-evaluating solved the dilemma of the "exploding cleanup sites".

For unknown, unexplained reasons, the principle agencies have deliberately ignored the CSL cleanup recommendation of the SCWG and the endorsement by their directors in favor of continuation of the exploding cleanup sites approach. In receiving the recommendations of the SCWG, Chuck Clark, EPA Region X director stated:

> "Hope this group stays committed to keeping us on the ropes with these seven recommendations."

This issue paper is intended to do just that.

PROPOSED ACTION

Implement the CSL cleanup approach the way it was intended. If areas exceeding the CSL are cleaned up, then the remaining sediments are not a site under the rule. The purpose of the SCWG's recommendations was to speed up cleanups. The CSL cleanup approach avoids wasteful expenditures of resources on areas of low concern.

The report back to the SMARM on this issue next year should simply state that beginning on May 8, 1997, the agencies uniformly implemented the CSL cleanup approach to only require cleanup of those stations that exceed cleanup screening levels.

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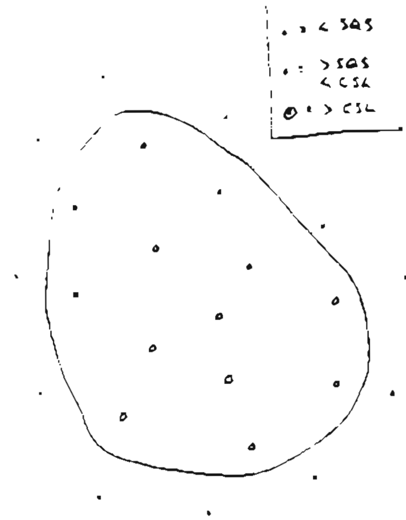

Figure 1: Area of low concern.
Not a contaminated sediment site.
No cleanup needed.

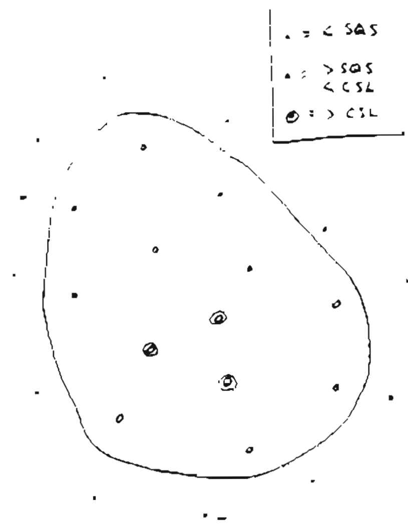

Figure 2: All the bounded area
is a contaminated sediment site.
Cleanup needed.

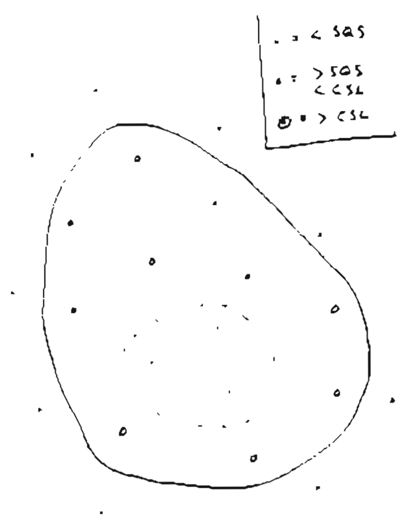

Figure 3: Following only a CSL
cleanup. Area of low concern.
Not a contaminated sediment site.
No cleanup needed.

SMS ISSUE PAPER

IN-PLACE DILUTION CLEANUP

Prepared by Lincoln Loehr (206 / 389-6219) (Heller, Ehrman, White & McAuliffe)

INTRODUCTION

Stirring of sediments to achieve a mixture in the upper four feet, can result in sediment concentrations that meet PSDDA open water disposal criteria, meet the Cleanup Screening Levels (CSL) and perhaps even meet the Sediment Quality Standards. If sediments do not need to be moved for maintenance dredging, this in-place dilution strategy is less costly and more environmentally friendly than dredging and disposal at another site.

PROBLEM IDENTIFICATION

The problem is the built in regulatory reluctance to consider "dilution as a solution to pollution". The sound byte carries a lot of impact. Never-the-less, to deny the use and viability of dilution strategies is to impose additional costs and delays in favor of cleanup strategies that may be significantly more harmful and may even waste scarce confined disposal site capacity. In-place dilution is a viable tool for cleanup that should be added to the assortment of cleanup strategies available. In-place dilution should qualify as a form of enhanced natural recovery.

DISCUSSION

The PSDDA process actually recognizes the significance of dilution. Dredging takes big bites, which, coupled with open water disposal results in a mixing of sediments. Sediments with surface contamination requiring cleanup could still qualify for PSDDA open water disposal because, following dredging, they will be mixed with cleaner sediments, to acceptable levels.[1] The analysis of four foot composites under PSDDA is a recognition of the power of dilution.

Sediment cleanup on the other hand is driven by just the contamination in the biologically active zone. Dredging may be

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[1] the PSDDA acceptable levels are biologically comparable to the Sediment Management Standards Cleanup Screening Level. Under the hot spot cleanup strategy that the agencies are supposed to be using, stations not exceeding the cleanup screening level should not require further cleanup.

necessary or at least an option for a sediment cleanup. Dilution with deeper sediments will occur.

Even though the PSDDA analysis may indicate that the sediments can be disposed of in open water sites, the disposal itself is not benign and results in a smothering of organisms in the disposal area, just as the dredging itself results in death to organisms in the dredged area. In-place dilution however, would result in sediments no longer requiring a cleanup, with the added benefit of not killing organisms at a disposal site.

PROPOSED ACTION

As a bold move, the agencies present here today should allow one or more pilot studies to demonstrate in-place mixing as a viable cleanup alternative. Once such a demonstration is made, then the agencies need to examine what regulatory changes (if any) may be necessary to allow and even encourage in-place dilution. If changes are needed, the Department of Ecology should then adopt an emergency rule to allow in-place dilution, and simultaneously go through full rule-making to allow it, extending the emergency rule as necessary until the formal rule-making is complete. Obviously, a PSDDA style characterization would be important when assessing the suitability of an in-place dilution cleanup.

Note that experience gained with the in-place dilution cleanup option may provide beneficial, cost-effective options applicable elsewhere in our country and in the world. This provides the potential to speed up environmental benefits from sediment cleanups on a large scale. The opportunity exists for this region to provide a significantly beneficial example on a grand scale.

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RECENT OBSERVATIONS OF INCREASING PHENOL AND 4-METHYLPHENOL CONCENTRATIONS IN PUGET SOUND SEDIMENTS

Clay Patmont
Hart Crowser, Inc.
May 7, 1997

Issue: Phenol and 4-methylphenol concentrations in surface sediments in at least several urban embayments in Puget Sound appear to be increasing, apparently because of increasing stormwater loadings associated with diffuse, non-point sources of these compounds. In at least three of these embayments (inner Bellingham Bay, Everett Harbor, and central Seattle waterfront), surface concentrations are now above SMS cleanup screening levels (CSLs), and pose a potential complication to ongoing sediment cleanup efforts in these areas. In addition, sediments containing concentrations of both phenol and 4-methylphenol above the CSL were found to have no adverse effects in PSEP sediment bioassays. Prompt evaluation by the PSDDA/SMS agencies of potential AET updates for these compounds is requested. Pending the results of the ongoing AET re-evaluation, it may also be advisable to initiate and coordinate a regional source evaluation and source control effort targeted towards phenol and 4-methylphenol.

Background: For several urban embayments in Puget Sound now being evaluated for sediment cleanup, surface sediment concentrations of phenol and/or 4-methylphenol are currently elevated relative to deeper sediment samples. Recent surface sediment concentrations of phenolics are also elevated relative to previous (i.e., historical) surface sampling results collected in the same area. In addition, concurrent sediment traps deployed within at least two of these embayments have detected phenol and 4-methylphenol at even greater concentrations.

The available sediment quality data imply an increasing, ongoing source of phenol and 4-methylphenol to these urban embayments. In one instance (inner Bellingham Bay), recent watershed source sampling by Ecology has also identified elevated concentrations of phenol and 4-methylphenol in urban stormwater (i.e., storm drain) runoff sediments. The relatively widespread distribution of phenolic compounds in the Bellingham Bay watershed is suggestive of a diffuse, non-point source. However, specific sources for these compounds have not yet been determined.

In several urban embayments, confirmatory bioassay tests have been undertaken to verify or refute toxicity predicted on the basis of elevated phenolic concentrations. Relatively high concentrations of phenol and 4-methylphenol have frequently not resulted in toxicity to species including *Eohaustorius estuarius, Neanthes arenaceodentata, and Mytilus edulis*. These results, along with literature reviews of phenol and 4-methylphenol toxicity, suggest that the current SMS and PSDDA standards for these chemicals may be overly stringent.

Public Issue Papers not presented at the SMARM, but disseminated at the meeting

1. Dredger's Option: Possible Tier IV Testing Strategies for PSDDA Decision Making (D. Michael Johns[1] Chris M. Boudreau[1], Jack Q. Word[2], Douglas Hotchkiss[3]).

2. Effect of the USEPA/USACE ammonia purging protocol on contaminant concentrations in sediment interstitial water (Kenneth R. Seeley[1] , Tim J. Hammermeister[1] , D. Michael Johns[1], Alice Sheely[4] , Douglas Hotchkiss[3]).

3. Analysis of regulatory approach to evaluating the quality of sediments contaminated with TBT. (Chris M. Boudreau[1], D. Michael Johns[1], Jack Q. Word[2] , Douglas Hotchkiss[3]).

4. Proposed Tributyltin Testing Scheme and Protocols. (Chris M. Boudreau[1], D. Michael Johns[1], Jack Q. Word[2], Charles Boatman[5], Douglas A. Hotchkiss[3]).

5. A response to "PSDDA/SMS Issue Paper. Critique of PSDDA draft issue paper on testing, reporting, and evaluation of tributyltin in PSDDA and SMS programs" by Seeley et. al., 1996 (Jim Meador, NOAA)

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Dredger's Option: Possible Tier IV Testing Strategies for PSDDA Decision Making

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Introduction

Puget Sound Dredged Disposal Analysis (PSDDA) evaluation procedures require that sediments with concentrations of contaminants of concern (COCs) that exceed screening level (SL) concentrations undergo biological testing. The objective of this testing is to determine whether the material to be dredged is suitable for unconfined, open-water disposal. The standard tests consist of five acute and sublethal toxicity tests plus bioaccumulation tests using a bivalve and a deposit feeder. In addition to the SL, PSDDA has established a second, higher concentration for COCs that is termed the maximum level (ML). If COCs in the sediments are found to be at concentrations above the ML, the material will not be considered suitable for unconfined, open-water disposal, even if the sediments pass the routine biological tests. Material with COCs above the ML may be considered for open-water disposal only if, in addition to passing the routine biological tests, it undergoes further biological tests using specialized test procedures. PSDDA terms the use of these specialized test procedures Tier IV testing or Dredger's Option. To date, no dredging proponents have exercised this option. Appearing to believe that the potential for passing all standard biological testing requirements plus specialized testing is low, they have opted instead to use other disposal options, e.g., upland disposal.

The ML concentration was originally established using data generated from the Apparent Effects Threshold (AET) approach. The ML was set at the highest available AET concentration (termed the high AET), meaning that in past studies all standard Puget Sound bioassays had resulted in statistically significant failures when the concentration of the COC was higher than this AET value. For samples failing a ML criterion, the possibility of passing even the standard biological toxicity tests appeared remote, let alone the specialized testing. This "likelihood of failure" concept has apparently discouraged dredging project proponents from pursuing Tier IV testing. However, the results of recent studies in Puget Sound have included a number of sediment samples in which the concentrations of one or more COCs were above the high AET, but the sample passed all standard biological toxicity tests.

Passing sediments using Tier IV testing and approving them for open-water disposal of the dredged material management unit (DMMU) could reduce overall dredging project costs, since the cost of disposal at the open-water site is substantially less than the cost of any other available disposal option. Cost savings from successful Tier IV testing would be greater than the additional assessment costs of conducting Tier IV tests, given the large cost differential between open-water and upland disposal. The purpose of this paper is to present an approach to Tier IV testing that could be used in the future by dredging project proponents.

Problem Identification

Tier IV or Dredger's Option requires expanded toxicity and bioaccumulation testing (PSDDA 1988). The purposes of the tiered testing approach are to further characterize the sediments and to ascertain whether disposing of the sediment at an open-water site will result in COCs exceeding Site Condition II, which is an unaccepatable risk to the environment. By its nature, Tier IV testing requirements will be dictated primarily by site-specific conditions, since Tier IV testing is intended to address problems associated with a specific subset of COCs located within the dredging area.

Ultimately, the PSDDA agencies are concerned with making the most appropriate disposal decision for project DMMUs. Sediments with COC concentrations above the ML which have passed the standard bioassays must be fully characterized to identify any toxicological or bioaccumulative concerns and to determine the most suitable disposal option. The need to better define sediment quality raises two questions that should be addressed by the agencies in making decisions concerning DMMUs with COCs above the ML:

1) Do the COC concentrations pose unacceptable risks?

2) Which test types are the best suited to identify the risks associated with the specific COCs present at concentrations above the ML?

The intent of this paper is to provide ideas for both dredging proponents and PSDDA agency staff to consider when evaluating the appropriateness of Tier IV testing.

Discussion

Undertaking a Tier IV evaluation requires careful consideration and assessment of sediment characteristics. Dredging proponents should consider both the types of COCs that exceeded the ML and the absolute concentration of the ML exceedance. Depending on the sediment matrix being tested, it is possible that the COC exceeding the ML is not biologically available, making it likely that Tier IV testing will demonstrate that the sediments are acceptable for open-water disposal. Other factors being equal, COCs only slightly exceeding the ML are less toxic than COCs exceeding the ML more widely.

Dredging proponents should also evaluate the toxicity profile of the COCs. Available literature may indicate that sediment COC concentrations are so close to lethal concentration that the likelihood of passing toxicity tests with longer exposure periods and more sensitive endpoints is low. The results from the standardized toxicity tests already conducted should be reviewed to determine whether the response of the test organisms provides any insight into the potential for passing tests with longer exposure periods and more sensitive endpoints. Both the absolute toxicity response of each bioassay and the variability in replicate response should be evaluated. Sediment samples that were toxic, but within the limits of PSDDA evaluation criteria, are more likely to fail Tier IV tests than sediments showing little or no toxicity. Finally, project proponents should consider the bioaccumulative potential of COCs that exceed the ML. Since human health concerns associated with bioaccumulation are addressed during routine testing, the primary concern during Tier IV testing is with ecological bioaccumulation risks such as impacts on species that utilize the disposal site or species within the local aquatic food web.

The national dredged material testing guidance developed by the U. S. Army Corps of Engineers (U.S. ACOE) and the U.S. Environmental Protection Agency (U.S. EPA) provides some guidance on conducting Tier IV testing (U.S. EPA 1991; U.S. EPA 1994). The Ocean Disposal Manual (U.S. EPA 1991) states that Tier IV tests should consist of toxicity and bioaccumulation tests which will show the long-term effects of exposure to dredged material, and that the tests should be carefully selected to address the specific issues relevant to the project in question. Toxicity tests should:

- Measure sensitive indicators of long-term effects of clear ecological importance, such as survival and reproduction

- Be of longer exposure periods than used in the routine tests

- Maximize exposure to sediment-associated contaminants by focusing on infaunal organisms

In addition, relevant guidance from the Ocean Disposal Manual (U.S. EPA 1991) on bioaccumulation states that for Tier IV testing, it may be more appropriate to expose test organisms until tissue accumulation steady-state is achieved than to use a standard 28-day exposure period. The manual also provides some guidance on interpreting tissue residue data, stating that concern over potential adverse impacts increases with:

- Number of species in which bioaccumulation from the dredged material is statistically greater than bioaccumulation from a reference material

- Number of COCs for which bioaccumulation from the dredged material is statistically greater than bioaccumulation from a reference material

- Magnitude by which bioaccumulation from the dredged material exceeds bioaccumulation from a reference material

- Toxicological importance of the COCs

- Propensity of the COCs with statistically significant bioaccumulation to biomagnify within aquatic food webs

Both toxicity and bioaccumulation strategies that are consistent with national guidance are available for conducting a Tier IV analysis of Puget Sound sediment. At least one of the toxicity test organisms currently used in routine PSDDA testing (*Neanthes arenaceodentata*) can be used to investigate the potential for impacts associated with long-term exposures to COCs. Research conducted by Johns and Ginn (1990) and Johns et al. (1991) for the PSDDA agencies demonstrated the possibility of conducting studies on the effects of life-cycle exposures (>120 days) on reproductive success. Several measures of reproductive success, including time to sexual maturity, percent of females laying eggs, fecundity, and egg viability were found to be responsive endpoints to exposure to COCs. This testing protocol, and ones similar in design, have been used to investigate the effects of exposure to individual contaminants (EVS 1994) and field-collected sediment (EVS 1994; Moore and Dillon 1993).

Another toxicity test procedure using the amphipod species *Leptocheirus plumulosus* could also be used. Testing protocols are available for conducting 28-day tests with test endpoints that include survival, growth, and the production of juveniles (DeWitt et al. 1992). It is also possible to calculate population growth indices using the data obtained from the tests. Test protocols are currently undergoing additional refinement under U.S. EPA sponsorship.

An example of the type of bioaccumulation test that might be conducted as part of a Tier IV evaluation was undertaken during the recent Port of Seattle Terminal 18 project. As part of the dredged material suitability evaluation process, the PSDDA agencies raised concerns about the availability of tributyltin (TBT). To address these concerns, the Port conducted bioaccumulation testing to determine the extent to which TBT might accumulate in the tissues of two benthic invertebrates. Unlike the tests for most Puget Sound dredging projects, in which the tissue residue data are used to address human health concerns (PSDDA 1988), the bioaccumulation tests for TBT were intended to address potential ecological impacts. Test exposure was extended to 45 days to better approximate tissue residue steady-state conditions. Resulting tissue residues were statistically compared to the residues accumulated through exposure to reference sediments as recommended in the national testing guidance documents (U.S. EPA 1991, 1994). Prior to testing, to better address whether measured tissue TBT concentrations represented an exceedance of Site Condition II, the Port searched the literature for data that related biological effects of TBT to tissue residue concentrations. Their findings were used to establish an effects/tissue residue concentration of 2 ppm (wet weight) to evaluate sediment suitability for open-water disposal. Tissue concentrations exceeding this benchmark would indicate sediment not suitable for open-water disposal.

Proposed Actions or Modifications

Recent testing experience with Puget Sound sediments indicates that the ML may be exceeded without failing subsequent toxicity and bioaccumulation tests. Tier IV testing could in these cases be used to determine whether the sediments are suitable for open-water disposal. Whether Tier IV testing is appropriate and practical will have to be evaluated on a case-by-case basis. Factors such as the number of COCs that exceed the ML, the absolute exceedance of the ML, and the toxicity profile (including bioaccumulation and biomagnification potential) of the COCs that exceed the ML should be taken into account in deciding whether or not Tier IV testing is warranted. In addition, dredging proponents should review other Puget Sound bioassay data relating to the same COCs and take those data into account in deciding whether or not to go forward with Tier IV testing. Before undertaking Tier IV testing, a dredging proponent should, at a minimum:

- Understand the behavior (e.g., toxicity and bioaccumulation potential) of the COC

- Understand the likely toxic effect of the COC (e.g., long-term mortality, impaired growth or reproductive potential, behavior or central nervous system changes)

- Evaluate the available toxicity tests to assure that the test endpoint matches the expected toxic effect

- Negotiate an agreement with the PSDDA agencies on the interpretive criteria that will be used on any test data generated for Tier IV

If the dredging proponent determines that Tier IV testing is warranted, then both toxicity tests and bioaccumulation testing protocols are available to address ecological issues that might be raised by the PSDDA agencies.

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The Effect of the USEPA/USACE Ammonia Purging Protocol on Contaminant Concentrations in Sediment Interstitial Water

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Introduction

In conducting amphipod bioassays, a number of laboratories have experienced problems replicating test results. These problems have been attributed in part to high concentrations of ammonia in sediment interstitial water, some of which occurs naturally as a by-product of normal sediment chemistry (Sims and Moore 1995, Whiteman et al. 1996). In certain cases, such as evaluations of dredged material proposed for open-water disposal, ammonia-related toxicity may be of less concern than toxicity due to more persistent anthropogenic contaminants. In response, the U.S. Environmental Protection Agency (USEPA) and the United States Army Corps of Engineers (USACE) have jointly issued guidance on purging ammonia from sediment samples prior to toxicity testing (USEPA/USACE 1993).

According to the USEPA/USACE guidance, ammonia purging should be conducted when interstitial water concentrations of ammonia exceed 20 mg/L (although it may be necessary to vary this criterion depending on the test species employed), and if ammonia is not a chemical of concern at the intended disposal site. The guidance document recommends purging ammonia by aerating samples to saturation and replacing overlying water in test chambers at a rate of two volumes per day. When the interstitial ammonia concentrations fall below 20 mg/L, test organisms can be introduced to the test chambers and tests can be initiated. During the course of the bioassay, interstitial ammonia concentrations should be monitored regularly to ensure that they do not exceed 20 mg/L, and water changes should be continued at a rate of two volumes per day if the ammonia concentrations are found to exceed 20 mg/L (USEPA/USACE 1993). The ammonia purging protocols have been shown to be effective at reducing interstitial ammonia concentrations to below no-effects levels prior to testing (Pinza et al. in press).

Problem Identification

Despite its demonstrated effectiveness at reducing interstitial ammonia concentrations, this ammonia purging protocol has a number of potential disadvantages. It increases sample volume, laboratory space, and labor requirements, and may cause sample holding times to be exceeded. The most important disadvantage associated with this protocol, however, is the possibility that concentrations of contaminants of concern may also be purged from the interstitial water. Thus, there is concern that the observed reductions in toxicity could be the result of reduced concentrations of toxicants other than ammonia, or the result of reduced concentrations of both ammonia and other toxicants. To the best of our knowledge, no attempts have been made to determine the effects of ammonia purging on interstitial water concentrations of other contaminants.

Technical Background and Discussion

Experiments were conducted in support of dredged material evaluations which were being conducted for Terminal 18 of the Port of Seattle, to evaluate whether the ammonia purging protocol affects only ammonia concentrations in interstitial and surface water, or whether the concentrations of other contaminants are also affected. The methods and results of these experiments are described below.

Materials and Methods

Sediment collection and manipulation

Surface sediments from the top 10 cm of the sediment horizon were collected from three locations (Figure 1) near Harbor Island, Seattle, Washington, on April 4, 1996, using a van Veen grab sampler. All sampling locations had been shown in previous investigations to have elevated concentrations of various metals and polycyclic aromatic hydrocarbons (PAHs) (EVS 1996). Sampling locations had also been shown in previous investigations to have similar grain-size distributions, although sediments from Sampling Location C had a moderately higher sand content compared to the other two locations. Sediments were stored at 4°C until processed in the laboratory on April 29, 1996, at the initiation of the tests.

Immediately prior to the initiation of the tests, sediment samples from each location were individually homogenized in order to ensure an even distribution of contaminants. Subsamples (approximately 500 grams) of each sediment sample were collected for bulk chemical analyses for PAHs, Hg, Pb, and Zn. Samples were shipped overnight at 4°C to Columbia Analytical Laboratory (Kelso, Washington), where they were immediately processed for analysis.

Test Chambers

Test chambers were prepared by adding approximately 200 mL of sediments to one liter, certified-clean glass jars (Environmental Sampling Supply, Oakland, California). A total of 36 test chambers were prepared for each sampling location (Figure 2a). Sand-filtered seawater, obtained from Elliot Bay, Seattle, Washington, was added to the jars to bring the total volume in each up to 1 liter. Fresh seawater for test chamber water changes was collected from Elliot Bay on a daily basis throughout the course of the experiment.

Experimental Design

Each treatment was performed in triplicate for each sampling location. To obtain sufficient sample volume for chemical analyses, each replicate sample was composed of three separate test chambers which were composited following the experiment. Once prepared, test chambers were randomly assigned to one of two treatment groups, consisting of "purged" samples designated to undergo the ammonia purging protocol, or "non-purged" samples, designated to receive no treatment (Figure 2a). All test chambers were placed into two gravity fed water baths maintained at 20°C. Half of the chambers were placed into a water bath reserved for purged samples, while the other half were placed into a water bath reserved for non-purged samples.

Each test chamber was continuously aerated throughout the duration of the test (a control test chamber, connected to the aeration system and containing only seawater, was included as a control for possible contamination from the aeration system). Test chambers were allowed to equilibrate for 24 hours before testing was initiated (Figure 2b). The 24-hour equilibration period is similar to the test initiation protocol used for sediment toxicity tests (ASTM 1995).

Following the 24-hour equilibration period, one-half of the test chambers assigned to the non-purged group were sampled for chemical analyses, and the remaining samples were maintained in the water bath for an additional 10-day period, the duration of a standard amphipod bioassay commonly used in dredged-material toxicity evaluations (ASTM 1995). Thus, interstitial and overlying water concentrations were determined at the initiation ("Day-0") and termination ("Day-10") of a standard bioassay test period (Figure 2b).

For the test chambers assigned to the purged group, overlying water was exchanged twice daily (at approximately 12-hour intervals) for seven days. A 7-day purging period was chosen for this study because it represented the average period of purging normally required for sediment samples taken near Harbor Island. Interstitial ammonia concentrations were not determined in this study, as we were primarily concerned with the effects of the ammonia purging protocol on the concentrations of other contaminants.

The procedure for exchanging overlying water involved removing (via siphon) approximately 600 mL of overlying water. A small amount of overlying water (less than 200 mL) was left in order to minimize disturbance at the sediment-water interface. Test chambers were immediately replenished with fresh seawater by slowly pouring the water down the side of the chamber to avoid disturbing the sediments. After 7 days of twice-daily water exchanges, half of the test chambers were sampled for chemical analyses ("Day-0")(Figure 2b). The remaining test chambers were maintained in the water bath for an additional 10 days as described above ("Day-10"). Control seawater samples were immediately shipped at 4°C to Columbia Analytical Laboratory for chemical analyses on Day 0 for each treatment (purged and non-purged).

Sample Collection and Analytical Methods

On Days 0 and 10 for each treatment group, overlying and interstitial water were sampled for chemical analyses from one half of the test chambers, chosen at random. First, overlying water from the 3 test chambers comprising an individual sample was collected using a sterile pipette and composited in a certified clean amber glass bottle (Environmental Sampling Supply, Oakland, California). Interstitial water was collected by centrifuging a composited sediment sample prepared from the same 3 test chambers at 1300 x g for 45 minutes.

Sediments were composited by removing samples from the test chambers with a chemically-cleaned stainless steel spoon and mixing them directly in the centrifuge jars. Following centrifugation, supernatants were removed from the centrifuge jars with sterile pipettes and placed in certified clean amber glass bottles (samples designated for metals analyses were fixed with nitric acid) for immediate shipment to the analytical laboratory.

All analyses were performed by Columbia Analytical Services, Inc., Kelso, Washington. USEPA methods (USEPA 1983, 1986) used for determining analyte concentrations were as follows:

Analyte	Sample Matrix	USEPA Method
lead, zinc	sediment	200.8
mercury	sediment	7471
lead	water	7421
mercury	water	7470
zinc	water	6010A
PAHs	sediment	3540B/8310
PAHs	water	3520/8310

Data Analysis

Although sediments at the three sampling locations selected for this study were found to have elevated concentrations of PAHs, lead, zinc, and mercury, most water samples contained non-detectable levels of these contaminants. As a result, data analysis was limited to lead and zinc concentrations in interstitial water and lead concentrations in overlying water. Day 0 and Day 10 samples were analyzed separately, resulting in six analyses of variance (ANOVAs). The primary factor of interest is purging, but location must be taken into account as a blocking factor. Preliminary data explorations determined that variance is not homogeneous across locations; higher mean concentrations relate to higher variance. The rankit transformation (Conover 1980, p. 317) was performed, and the transformed data conformed to the assumptions of ANOVA. Statistical power analysis for ANOVA based on non-transformed data was performed, assuming an alpha-level of 0.05 and a desired power of at least 75 percent. Statistical power is the probability of detecting a difference between sample means, given the population mean difference and variance. Population variance was estimated using two levels of sample variance. Although statistical power analysis was not conducted on transformed data, it was likely to be higher than with the untransformed data, since the untransformed data do not conform to the assumptions of ANOVA.

At the lowest observed sample variances (observed for overlying water concentrations and Day 10 interstitial water concentrations), a difference in population means in purged and non-purged samples of 1.5 μg/L would be sufficient to attain power greater than 85 percent. For the highest observed sample variances (observed for Day 0 interstitial concentrations), a difference in population means of 55 to 80 μg/L is required to attain the desired 75 percent power. For this reason, we set the alpha level at 0.10 for Day 0 interstitial concentrations, still requiring a population difference in the 48-70 μg/L range for 75 percent power.

Results

Bulk Sediment Concentrations

As stated above, previous investigations have shown that concentrations of low molecular weight PAHs and metals were elevated in sediments at the sampling locations selected for this study. Analyses of bulk sediments showed that samples collected for this study were similar to those collected previously (Table 1).

Tables 2, 3, and 4 display the observed concentrations of metals and PAHs. Statistical comparisons were limited to the contaminants present in detectable concentrations. Of the contaminants analyzed for in overlying water samples in this study, only lead was present in detectable concentrations. In the interstitial water samples, only lead and zinc were present in detectable concentrations. No contaminants of concern were detected in the seawater control sample. The histograms in Figure 3 display the difference in sample means for purged and non-purged samples for the six ANOVA endpoints.

Results of the statistical analysis are displayed in Table 5. Location (the blocking factor) was statistically significant in five of the six ANOVAs, reflecting the higher concentrations at location B. Purging was not significant in most cases, with the exception of Day 0 lead concentrations in overlying water (p=.001). For this case, the sample mean lead concentration for non-purged Day 0 overlying water is 4.9 μg/L greater than that for purged samples. Interaction was also significant for Day 0 lead concentrations in overlying water (p=.037), apparently due to the fact that there was no difference in mean level (in purged vs. non-purged samples) at location C.

Due to the low statistical power for the Day 0 interstitial tests, we should note that the mean interstitial lead concentration for the Day 0 purged samples is 24 μg/L lower than the mean for the Day 0 non-purged samples. For zinc, the mean for purged samples is 15.6 μg/L lower. Neither of these differences is statistically significant.

Discussion

Numerous studies have shown that naturally-occurring ammonia in freshwater or marine sediments can be responsible for toxicity in these sediments (Whiteman et al. 1996).Thus, when conducting dredged-material evaluations, it may be desirable either to reduce interstitial ammonia concentrations before beginning bioassays (USEPA/USACE 1993), or to measure ammonia-related toxicity separately from that caused by other contaminants present in the sediments (Whiteman et al. 1996).

In this study, we have evaluated the effects of a recommended ammonia purging protocol (USEPA/USACE 1993) on concentrations of contaminants other than ammonia in interstitial and overlying water. Our results show no evidence that ammonia purging decreases the level of lead or zinc in interstitial or overlying water after the 10-day period of a bioassay test. In fact, the mean of the purged samples at Day 10 was higher in most cases. There is some evidence that concentrations of lead and zinc immediately following purging (Day 0) may be lower in the purged samples. For overlying water, purged samples had significantly lower lead concentrations than non-purged samples at Day 0 (a difference of 4.9 μg/L). The concentrations in interstitial water at Day 0 were also lower for purged than for non-purged samples, but the differences were not statistically significant.

Lower concentrations of contaminants in the purged samples at Day 0 may be the result of relatively rapid dilution during the purging process. Contaminant concentrations in the non-purged samples were ultimately (after 10 days) similar to levels observed in the purged samples, possibly due to resorption of lead and zinc from the water back into the bulk sediments. This explanation is consistent with our current understanding of the relative masses and mobilities of contaminants in Puget Sound sediments; most lead contamination is bound up in the sediments, and is rarely affected by changes in the overlying water column. In fact, benthic flux measurements taken by other investigators near the sampling sites used in this investigation have shown that sediments act as a sink for dissolved lead in the overlying water (Boatman and Devol 1995).

This study was hampered by low concentrations of most contaminants in the water column. Also, high variability in initial concentrations of contaminants in interstitial water resulted in low statistical power for some comparisons. However, the Day 10 results for lead and zinc in interstitial water and lead in overlying water are clear. There is no evidence that the ammonia purging protocol has significant long-term effects on these contaminants in the water column.

Proposed Actions or Modifications

The results described above show no evidence that the application of the ammonia purging protocol results in significant alterations of concentrations of metals (lead and zinc) in overlying or interstitial water in solid-phase bioassay samples. This study provided no evidence to suggest that the ammonia purging protocol should be discontinued or modified in those dredged material evaluation bioassays for which it is indicated by interstitial ammonia concentrations exceeding established guidelines.

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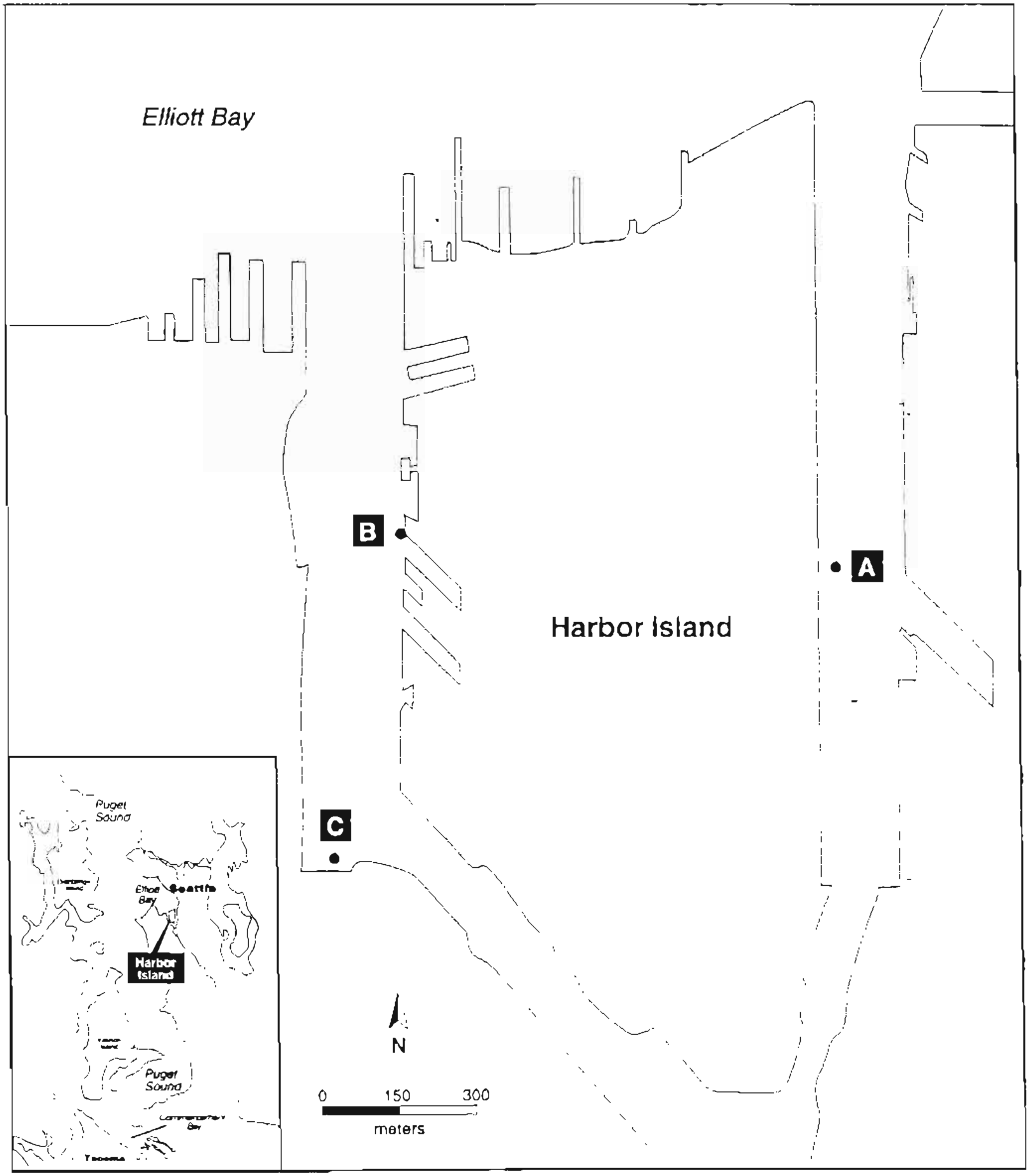

Figure 1. Harbor Island sampling locations

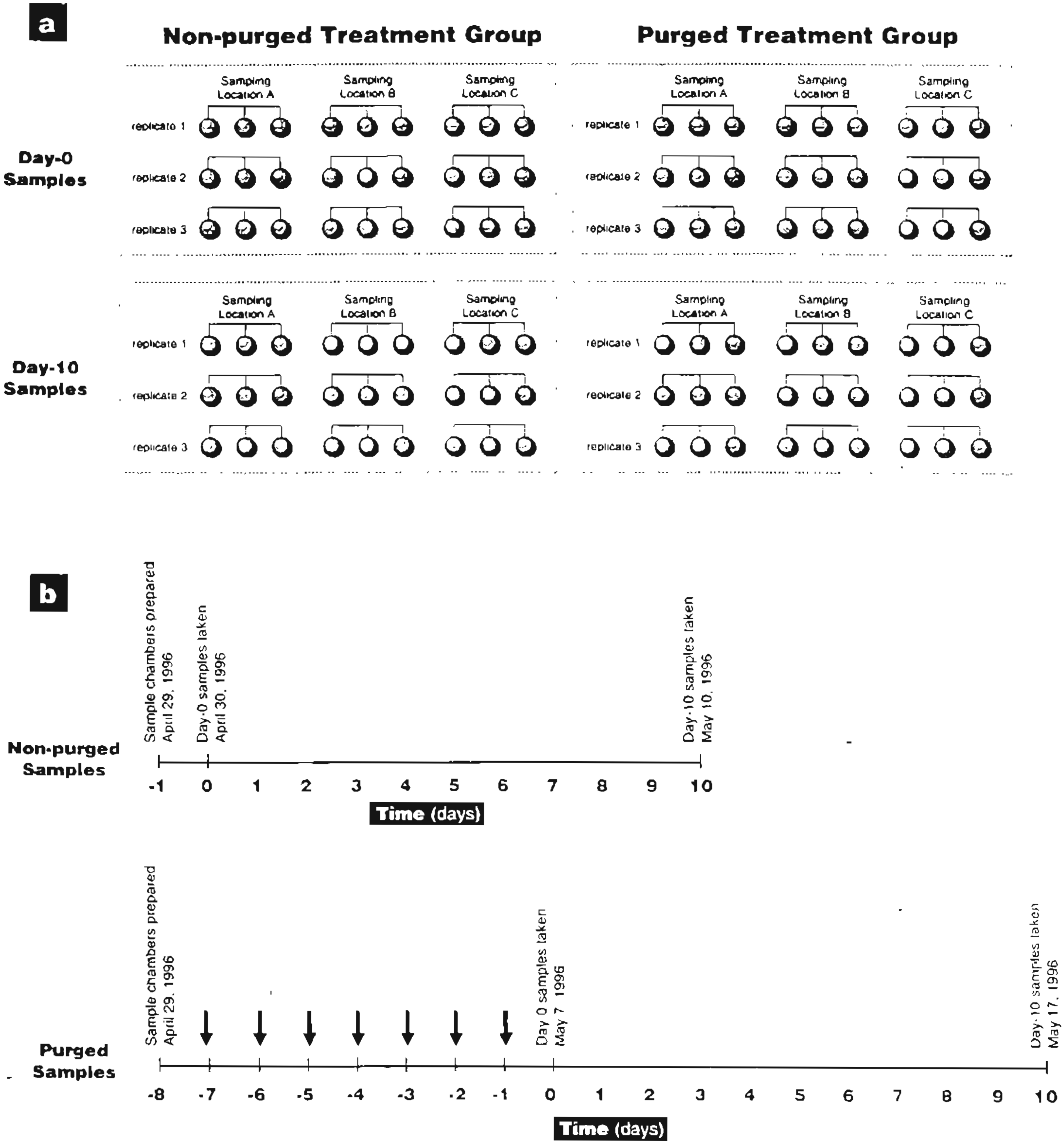

Figure 2. Experimental design. a). Treatment groups used in experiment b). Timeline for handling purged and non-purged samples. Arrows indicate days in which water changes occurred.

Table 1. Bulk concentrations (mg/kg) of various contaminants in unmanipulated sediment samples

ANALYTE	SAMPLE A	SAMPLE B	SAMPLE C
Metals			
Lead	154	570	39.3
Mercury	0.6	0.7	0.3
Zinc	229	1040	89.5
Polycyclic Aromatic Hydrocarbons			
Naphthalene	< 0.2	< 0.2	< 0.2
Acenaphthylene	1.7	2.6	0.7
Acenaphthene	< 0.2	< 0.2	< 0.2
Fluorene	0.08	0.09	0.09
Phenanthrene	0.36	0.57	0.35
Anthracene	0.17	0.28	0.13
Fluoranthene	0.56	0.96	0.58
Pyrene	1.7	1.1	0.99
Benz(a)anthracene	0.29	0.53	0.21
Chrysene	0.64	1	0.35
Benzo(b)fluoranthene	0.66	0.86	0.37
Benzo(k)fluoranthene	0.22	0.38	0.16
Benzo(a)pyrene	< 0.61	< 0.76	< 0.32
Dibenz(a,h)anthracene	0.05	0.07	< 0.03
Benzo(g,h,i)perylene	0.11	0.17	0.05
Indeno(1,2,3-c,d)pyrene	0.12	0.23	0.07

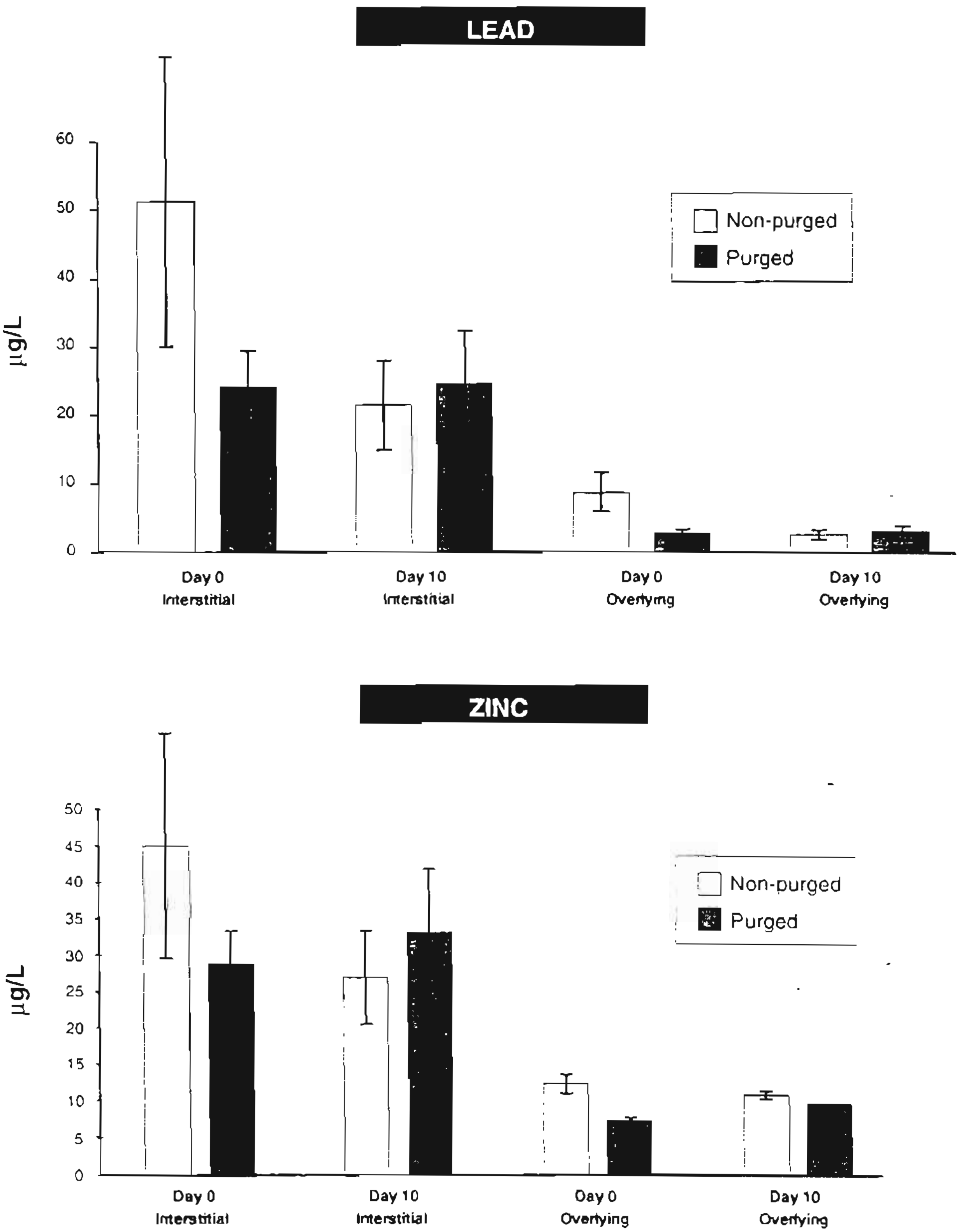

Figure 3. Concentrations of lead and zinc in interstitial and overlying water in purged and non-purged samples, at Day-0 and Day-10 (bars represent standard error of the mean, n=9)

Table 2. Concentrations of lead, zinc, and mercury (in $\mu g/L$) in purged and non-purged interstitial and overlying water samples

	Day 0									Day 10								
Analyte	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**
a) Non-purged interstitial water																		
Lead	44	9	11	204	81	72	9	10	24	12	10	14	49	51	43	7	8	8
Zinc	53	<10	10	157	56	63	14	14	32	14	12	12	54	52	57	17	14	16
Mercury	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
b) Purged interstitial water																		
Lead	20	14	9	36	52	46	11	15	18	12	10	6	55	61	51	14	5	10
Zinc	28	20	13	36	48	52	18	22	27	13	14	<10	67	66	67	27	13	26
Mercury	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
c) Non-purged overlying water																		
Lead	4	3	8	12	27	11	2	2	2	2	2	2	2	2	7	2	2	2
Zinc	<10	<10	14	13	16	<10	21	10	<10	<10	<10	<10	12	12	16	<10	<10	<10
Mercury	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
d) Purged overlying water																		
Lead	3	2	2	5	6	3	2	2	2	2	2	2	2	3	3	2	8	2
Zinc	<10	<10	<10	10	12	12	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Mercury	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 3. Concentrations of low molecular weight polycyclic aromatic hydrocarbons (in μg/L) in purged and non-purged interstitial water samples

Analyte	Day 0 A1	Day 0 A2	Day 0 A3	Day 0 B1	Day 0 B2	Day 0 B3	Day 0 C1	Day 0 C2	Day 0 C3	Day 10 A1	Day 10 A2	Day 10 A3	Day 10 B1	Day 10 B2	Day 10 B3	Day 10 C1	Day 10 C2	Day 10 C3
a) Non-purged Interstitial water																		
Naphthalene	<20	<20	<20	<20	<100	<100	<100	<100	<100	<10	<10	<10	<10	<10	<10	<25	<30	<30
Acenaphthylene	<20	<20	<20	<20	<100	<100	<100	<100	<100	<10	<10	<10	<10	<10	<10	<25	<30	<30
Acenaphthene	<20	<20	<20	<20	<100	<100	<100	<100	<100	<10	<10	<10	<10	<10	<10	<25	<30	<30
Fluorene	<4	<4	<4	<4	<20	<20	<20	<20	<20	<2	<2	<2	<2	<2	<3	<5	<6	<6
Phenanthrene	<2	<2	<2	<2	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1.5	<2.5	<3	<3
Anthracene	<2	<2	<2	<2	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1.5	<2.5	<3	<3
Fluoranthene	<4	<4	<4	<4	<20	<20	<20	<20	<20	<2	<2	<2	<2	<2	<3	<5	<6	<6
Pyrene	<4	<4	<4	<4	<20	<20	<20	<20	<20	<2	<2	<2	<2	<2	<3	<5	<6	<6
Benz(a)anthracene	<2	<2	<2	<2	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1.5	<2.5	<3	<3
Chrysene	<2	<2	<2	<2	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1.5	<2.5	<3	<3
Benzo(b)fluoranthene	<4	<4	<4	<4	<20	<20	<20	<20	<20	<2	<2	<2	<2	<2	<3	<5	<3	<6
Benzo(k)fluoranthene	<2	<2	<2	<2	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1.5	<2.5	<3	<3
Benzo(a)pyrene	<2	<2	<2	<2	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1.5	<2.5	<3	<3
Dibenz(a,h)anthracene	<2	<2	<2	<2	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1.5	<2.5	<3	<3
Benz(g,h,i)anthracene	<4	<4	<4	<4	<20	<20	<20	<20	<20	<2	<2	<2	<2	<2	<3	<5	<6	<6
Indeno(1,2,3-c,d)pyrene	<2	<2	<2	<2	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1.5	<2.5	<3	<3
b) Purged Interstitial water																		
Naphthalene	<10	<10	<10	<10	<10	<10	<30	<30	<30	<15	<10	<10	<10	<10	<15	<30	<30	<40
Acenaphthylene	<10	<10	<10	<10	<10	<10	<30	<30	<30	<15	<10	<10	<10	<10	<15	<30	<30	<40
Acenaphthene	<10	<10	<10	<10	<10	<10	<30	<30	<30	<15	<10	<10	<10	<10	<15	<30	<30	<40
Fluorene	<2	<2	<2	<2	<2	<2	<6	<6	<6	<3	<2	<2	<2	<2	<3	<6	<6	<8
Phenanthrene	<1	<1	<1	<1	<1	<1	<3	<3	<3	<1.5	<1	<1	<1	<1	<1.5	<3	<3	<4
Anthracene	<1	<1	<1	<1	<1	<1	<3	<3	<3	<1.5	<1	<1	<1	<1	<1.5	<3	<3	<4
Fluoranthene	<2	<2	<2	<2	<2	<2	<6	<6	<6	<3	<2	<2	<2	<2	<3	<6	<6	<8
Pyrene	<2	<2	<2	<2	<2	<2	<6	<6	<6	<3	<2	<2	<2	<2	<3	<6	<6	<8
Benz(a)anthracene	<1	<1	<1	<1	<1	<1	<3	<3	<3	<1.5	<1	<1	<1	<1	<1.5	<3	<3	<4
Chrysene	<1	<1	<1	<1	<1	<1	<3	<3	<3	<1.5	<1	<1	<1	<1	<1.5	<3	<3	<4
Benzo(b)fluoranthene	<2	<2	<2	<2	<2	<2	<6	<6	<6	<3	<2	<2	<2	<2	<3	<6	<6	<8
Benzo(k)fluoranthene	<1	<1	<1	<1	<1	<1	<3	<3	<3	<1.5	<1	<1	<1	<1	<1.5	<3	<3	<4
Benzo(a)pyrene	<1	<1	<1	<1	<1	<1	<3	<3	<3	<1.5	<1	<1	<1	<1	<1.5	<3	<3	<4
Dibenz(a,h)anthracene	<1	<1	<1	<1	<1	<1	<3	<3	<3	<1.5	<1	<1	<1	<1	<1.5	<3	<3	<4
Benz(g,h,i)anthracene	<2	<2	<2	<2	<2	<2	<6	<6	<6	<3	<2	<2	<2	<2	<3	<6	<6	<8
Indeno(1,2,3-c,d)pyrene	<1	<1	<1	<1	<1	<1	<3	<3	<3	<1.5	<1	<1	<1	<1	<1.5	<3	<3	<4

Table 4. Concentrations of low molecular weight polycyclic aromatic hydrocarbons (in μg/L) in purged and non-purged overlying water samples

Analyte	Day 0									Day 10								
	A1	A2	A3	B1	B2	B3	C1	C2	C3	A1	A2	A3	B1	B2	B3	C1	C2	C3
a) Non-purged interstitial water																		
Naphthalene	<20	<20	<20	<20	<20	<20	<20	<20	<20	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenapthylene	<20	<20	<20	<20	<20	<20	<20	<20	<20	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthene	<20	<20	<20	<20	<20	<20	<20	<20	<20	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluorene	<4	<4	<4	<4	<4	<4	<4	<4	<4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Phenanthrene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	<4	<4	<4	<4	<4	<4	<4	<4	<4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Pyrene	<4	<4	<4	<4	<4	<4	<4	<4	<4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Benz(a)anthracene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b)fluoranthene	<4	<4	<4	<4	<4	<4	<4	<4	<4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(k)fluoranthene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenz(a,h)anthracene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benz(g,h,i)anthracene	<4	<4	<4	<4	<4	<4	<4	<4	<4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Indeno(1,2,3-c,d)pyrene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
b) Purged interstitial water																		
Naphthalene	<1	<1	<1	<1	<1	<1	<1	<1	<4	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthylene	<1	<1	<1	<1	<1	<1	<1	<1	<4	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthene	<1	<1	<1	<1	<1	<1	<1	<1	<4	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluorene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Phenanthrene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Pyrene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Benz(a)anthracene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b)fluoranthene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(k)fluoranthene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenz(a,h)anthracene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benz(g,h,i)anthracene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Indeno(1,2,3-c,d)pyrene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 5. ANOVA Results

	Degrees of Freedom	Sum of Square	Mean Square	F Value	P-value
a. Interstitial Water, Lead Concentrations, Day 0					
Location	2	9.0854	4.5427	11.8527	0.0014*
Purge	1	0.1158	0.1158	0.3023	0.5926
Loc:purge	2	1.0403	0.5202	1.3572	0.2942
Residuals	12	4.5992	0.3833		
b. Interstitial Water, Zinc Concentrations, Day 0					
Location	2	8.4616	4.2308	8.8131	0.0044*
Purge	1	0.0827	0.0827	0.1723	0.6854
Loc:purge	2	1.3512	0.6756	1.4074	0.2824
Residuals	12	5.7607	0.4801		
c. Overlying Water, Lead Concentrations, Day 0					
Location	2	8.3414	4.1707	40.2932	0.0000*
Purge	1	1.8044	1.8044	17.4325	0.0013*
Loc:purge	2	0.9096	0.4548	4.3937	0.0370*
Residuals	12	1.2421	0.1035		
d. Interstitial Water, Lead Concentrations, Day 10					
Location	2	10.3110	5.1555	15.2866	0.0005*
Purge	1	0.0615	0.0615	0.1823	0.6769
Loc:purge	2	1.1233	0.5616	1.6653	0.2300
Residuals	12	4.0471	0.3373		
e. Interstitial Water, Zinc Concentrations, Day 10					
Location	2	11.7068	5.8534	26.4840	0.0000*
Purge	1	0.2457	0.2457	1.1115	0.3125
Loc:purge	2	0.5234	0.2617	1.1841	0.3394
Residuals	12	2.6522	0.2210		
f. Overlying Water, Lead Concentrations, Day 10					
Location	2	1.3875	0.6938	1.4594	0.2708
Purge	1	0.4769	0.4769	1.0033	0.3363
Loc:purge	2	0.3728	0.1864	0.3922	0.6839
Residuals	12	5.7044	0.4754		

NOTE * Indicates significant effect ($\alpha = 0.10$)

Analysis of Regulatory Approach to Evaluating the Quality of Sediments Contaminated with TBT

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Introduction

Determining the suitability of dredged material for unconfined, open-water disposal in the Puget Sound Dredged Disposal Analysis (PSDDA) program is based on the concentration of contaminants of concern (COCs) and the outcome of sediment toxicity and bioaccumulation testing. Toxicity testing of dredged material samples is required when COC concentrations exceed the Screening Level (SL) concentration; bioaccumulation testing is required when selected COC concentrations exceed the bioaccumulation trigger (BT) concentrations (PSDDA 1988). For some proposed dredging projects, COCs have been found for which there are no established PSDDA tests. In most cases, evaluation of the sediments contaminated with the COCs is adequately addressed by the existing testing program, since toxicity contributed by these COCs would be identified during routine toxicity testing. For some potential COCs, however, the toxicity tests currently required by PSDDA may not adequately address all biological threats associated with the contaminant. Determining the suitability of the material for open-water disposal requires additional testing.

The PSDDA process gives the agencies flexibility in addressing COCs without criteria in determining dredged-material quality. This issue paper outlines the process used to evaluate dredged material that contained tributyltin (TBT) from the Port of Seattle's (Port's) Terminal 18 (T-18) project, and presents recommendations for refining the PSDDA process for evaluating non-routine COCs and for future decision making concerning TBT.

Problem Identification

During the development of the PSDDA program, TBT was not identified as a COC. TBT has been analyzed only when there was reason to believe it was potentially present, primarily in sediments in marinas and near shipyards. In 1988, the PSDDA agencies determined that TBT was a chemical of concern, and established a SL for TBT in sediment of 30 ppb as tin and a BT of 219 ppb as tin based upon available information (PSDDA 1989). As with other PSDDA COCs, if the concentration of TBT in sediment exceeded the SL, then toxicity testing was required to determine the suitability of dredged material for open-water disposal.

Additional concerns about the potential environmental impacts of sediment-associated TBT were raised in the period prior to the initiation of the T-18 project. Agency workgroups were formed to address contamination issues and to assess TBT's mobility, toxicity, and bioavailability in aquatic environments. Superfund studies conducted in Commencement Bay and Elliott Bay observed high concentrations of TBT, which prompted further investigations and a reevaluation of TBT as a chemical of concern. In the Elliott Bay study near Harbor Island, no toxicity was observed in sediments using three standardized Puget Sound bioassay tests (the 10-day amphipod test, the bivalve larval test, and the 20-day polychaete growth test) even though the sediments contained TBT at concentrations as high as 3,060 μg/kg (EVS and Hart Crowser 1996). U.S. EPA (1996) presented data from researchers which indicated that sediment-associated TBT should be toxic at concentrations considerably lower than the concentrations observed in Harbor Island sediments. Based on the U.S. EPA report, PSDDA agency staff concluded that the standard toxicity tests used in Puget Sound may not be sufficiently sensitive to exhibit toxicity associated with TBT. Regulatory agencies determined that effects could be measured more accurately if based on the concentration in interstitial water (IW), rather than the concentration in bulk sediment.

Uncertainties raised regarding commonly used Puget Sound assessment techniques for evaluating TBT prompted PSDDA agency staff to identify the following issues that needed to be resolved to determine the suitability of T-18 material for open-water disposal:

- Establish threshold concentrations for IW concentrations of TBT analogous to the PSDDA SL which would trigger additional testing requirements

- Identify testing procedures which can appropriately evaluate toxicity and other adverse effects due to TBT

- Establish data interpretation criteria which evaluate the potential significance of TBT concentrations measured in IW or tissue

Technical Background and Discussion

Technical Approach

The PSDDA agencies requested that the Port undertake non-routine testing to evaluate environmental concerns associated with the disposal of TBT-contaminated sediments at the Elliott Bay PSDDA disposal site. The testing and evaluation procedures proposed by the PSDDA agencies were based, in part, on the results of an interagency workgroup study which proposed options for managing TBT-contaminated sediment. The recommended approach for establishing TBT cleanup concentrations for Superfund sites in Puget Sound was based on IW concentrations. IW concentrations can be calculated using an equilibrium partitioning model, which estimates the IW concentration of TBT based on the bulk sediment concentration (reported in dry weight) and the percent total organic carbon (TOC) present in the sediment. The equilibrium partitioning model was used to determine whether the calculated IW concentration of TBT in test sediments was above a threshold concentration of 0.15 μg/L TBT_{ion}. If so, further biological testing was required. The TBT IW criterion was based on an analysis of TBT concentrations in tissues that were associated with biological effects, the results of which were then used to calculate backwards to a probable IW concentration. The proposed TBT IW criterion was used in a manner analogous to an SL. As with the existing PSDDA testing paradigm, sediments with IW concentrations greater than 0.15 μg/L TBT_{ion} could be subjected to biological testing to show they were suitable for open-water disposal.

Because the Port needed to proceed with sampling at T-18 before the PSDDA agency review of the TBT characterization approaches was complete, the Port and the PSDDA agencies negotiated an agreement for a two-step process to determine whether IW concentrations of TBT were high enough to warrant biological testing. The first step applied the equilibrium model, using bulk TBT and TOC concentrations measured during an initial sediment collection, to calculate whether sediments from any dredged material management unit (DMMU) potentially exceeded the proposed IW criterion of 0.15 μg/L TBT_{ion}. The model was chosen as the first step in order to take advantage of the fact that bulk sediment data were available that could be used to estimate IW TBT contamination. The equilibrium model used to estimate IW concentrations is presented in Equation 1. The partitioning coefficient of 25,000 liter/kg_{oc} used was chosen based upon research conducted by Meador (1996), in which test sediments were spiked with pure TBT compound.

$$\text{Equation 1} \quad [TBT]_{IW} = \frac{\left(\dfrac{[TBT]_{sed}}{TOC\ \%\ /\ 100}\right)}{K_{OC}}$$

Where K_{OC} = 25,000, from Meador (1996)
[IW] = interstitial water
and sed = sediment

If the calculated IW TBT concentration was less than 0.15 μg/L, then sediments from that DMMU were considered suitable for unconfined, open-water disposal relative to TBT. If the calculated IW TBT concentration was greater than 0.15μg/L, then biological testing would be required to determine whether the sediments were suitable for open-water disposal. Aliquots of sediments from the first collection in which the calculated IW TBT concentration was greater than 0.15 μg/L were centrifuged to collect a sufficient volume of IW, which was then analyzed for TBT.

During discussions with the PSDDA agencies, the Port commented that the equilibrium model would represent the maximum potential TBT in IW for two reasons:

1) The Unger et al. (1986) method used for determining bulk sediment TBT concentrations uses the organic solvent methylene chloride to extract TBT. Regardless of matrix, TBT within the sediments is extracted and reported as a concentration. Thus, reported TBT concentrations within the sediments will over-estimate calculated IW concentrations, since they include TBT bound with sediment particles, and TBT associated with other matrices such as paint chips.

2) The partitioning coefficient used in the model was calculated from laboratory experiments in which pure TBT compound was spiked into field-collected sediments. In this particular study, sediments from three different locations were spiked with a concentrated solution of TBT

in acetone. Calculations of K_{oc} were based on the assumption that all partitioning was associated with TOC and not influenced by other factors such as the presence of organisms or the contribution of other sediment matrices such as particulate matter (e.g., paint chips). For example, Meador (1996) reported that $\log_{10} K_{oc}$ values were higher for samples with organisms than those without. Thus, the K_{oc} used within this model may be lower than what naturally occurs in Puget Sound sediments.

While the Port considered it unlikely that the source of TBT in sediments within the T-18 project was pure TBT, but rather from products that may contain TBT, e.g., agricultural pesticides, wood, textiles, paper, leather preservatives, and paint chips, the equilibrium model was an acceptable interim method of estimating IW TBT concentrations. However, for those samples that exceeded the 0.15μg/L TBT_{ion} concentration based on model calculations, the Port proposed directly measuring IW concentrations of TBT in sediments from the second collection to determine whether biological testing would be required, using the same proposed IW threshold concentration. IW was collected by centrifuging sediment samples. The collected supernatant was filtered through a 0.45 μm polycarbonate filter, then analyzed.

Sediments in which the measured IW concentration of TBT exceeded 0.15μg/L TBT_{ion} were tested using bioaccumulation tests. As discussed previously, PSDDA agency staff expressed concern that the standard sediment toxicity tests used in Puget Sound were not sensitive to TBT. The alternative was to use bioaccumulation tests in which the action concentration for determining whether tissue residue concentrations were of concern was based on data that related tissue residue concentrations to measured biological effects. Using available data, the PSDDA agencies established the tissue residue action concentration at 2.0 mg/kg wet weight (Fox pers. comm. 1996; Johns pers. comm. 1996 a,b). The mean for the five bioaccumulation replicates from each DMMU tested for TBT was statistically compared to the tissue residue action concentration following the guidance presented in the 1994 draft version of the U.S. EPA/ACOE Inland Testing Manual (U.S. EPA and ACOE 1994).

Terminal 18 Results

Equilibrium model calculations for each of the 86 DMMUs associated with the T-18 project, identified only 28 DMMUs with calculated IW concentrations that exceeded the criterion of 0.15μg/L TBT_{ion}. Calculated IW concentrations are presented in Tables 1 and 2 and range from 0.483 μg/L to 3.213 μg/L. When IW was extracted from sediments from each of these 28 DMMU's and measured, only two DMMUs, 1C4 and 1C5, had measured IW concentrations of TBT that were greater than 0.15μg/L TBT_{ion} (Table 1). DMMU 1C4, which had the highest calculated IW concentration (3.213 μg/L) had a measured IW concentration of 0.207μg/L in the first collection phase. DMMU 1C5 had a calculated IW concentration of 1.427 μg/L and a measured IW concentration of 0.209 μg/L in the first collection phase. In all cases, the equilibrium model calculations significantly overestimated the concentration of TBT when compared with concentrations actually measured in the IW (Figure 1 and

Table 3). The ratio of measured to calculated IW TBT ranged from 0.03 to 0.146, which corresponds to measured concentrations of IW ranging from only 3 percent to 15 percent of the theoretical calculation.

Of the two DMMUs requiring bioaccumulation testing, one exceeded the tissue residue trigger value of 2 ppm wet weight.

Discussion

The overall process used to develop both analytical and decision-making approaches for evaluating TBT worked well, considering that many of the agency decisions were made in "real time" during the actual T-18 sediment assessment process. The level of teamwork among the PSDDA agency staff and the degree of cooperation with the Port is reflective of the PSDDA process. Given the time frame for decision making, agency staff consistently applied the best available data to guide the process of defining decision criteria for TBT. This process used by the agencies in addressing TBT is a good model for dealing with future uncertainties regarding COCs.

The results of the T-18 sediment evaluation suggest several modifications for addressing concerns about TBT. These include:

- **TBT IW equilibrium model** — The data generated for T-18 project sediments suggest that the equilibrium model overestimates the concentration of TBT that will be measured in IW (at least for the Harbor Island sediment matrix). As discussed previously, this is not surprising considering that the partitioning coefficient used in the model was derived from laboratory experiments in which pure TBT product was spiked into sediments. Sources of TBT in Puget Sound sediments are likely to be associated with a matrix (e.g., colloidal matter, ligands, organismal influences, paint chips) in which the TBT is more tightly bound and does not equilibrate as predicted using the partitioning coefficient developed by Meador et al (1996). The partitioning coefficients (K_{oc}) for TBT in the 15 samples collected for the T-18 project ranged from 171,000 to 802,000, with a mean value of approximately 391,700 (Table 4). These K_{oc} values represent a range of values that are between 6.8 and 32 times higher than the value reported by Meador et al. (1996) which was used in the T-18 equilibrium model. Higher K_{oc} values indicate that the partitioning equilibrium favors the solid phase matrix. The range of K_{oc} values from the measured IW samples indicates that the equilibrium model is extremely conservative when a K_{oc} value of 25,000 is used. The current PSDDA agency approach with new dredging projects will require a direct measurement of IW TBT concentrations without the initial step of using the model to estimate IW concentrations from bulk sediment concentrations. If the model is used in the future to estimate IW concentrations, one approach to making it more predictive would be for the agencies to adopt a Puget Sound-specific K_{oc} value. Such a value can be derived from the T-18 data and from the Hylebos Waterway data, when the latter become available. As the equilibrium model is meant to estimate potential TBT availability conservatively, a K_{oc} value that is between the average value reported for Puget Sound sediments and that calculated by Meador et al. (1996) would represent a more realistic approximation that is still conservative considering the probable partitioning behavior of TBT in Puget Sound sediments.

- **Tissue residue trigger concentrations**— Establish a tissue concentration action criterion to determine when the tissue residue concentrations at the disposal site result in effects that exceed the Site Condition II definition for managing PSDDA open-water disposal sites. At the present time, there is little matched tissue residue and biological effects data for establishing suitable action levels for bioaccumulation testing. The action level selected should consider the Site Condition II definition and should address the toxicological importance of the COC and the COC's potential to biomagnify within aquatic food webs. During the T-18 project, the Port analyzed all available matched tissue residue and biological effects data for various life stages (principally data identified in Fent [1996], Meador et al. [1996], and Moore et al. [1991]) and identified tissue residue concentrations that were related to varying degrees of biological effects. In their analysis, no observed effects concentrations (NOECs) were found to range from 0.54 to 9.9 ppm wet weight, sublethal effects were found to range from 0.01 to 12.6 ppm wet weight, and lethal effects were found to range from 4.4 to 40 ppm wet weight. Based on this analysis (especially as it related to the data presented by Meador et al. [1996]) for amphipods and a Puget Sound polychaete, the Port suggested that a tissue residue trigger value of 2 ppm wet weight best represented the Site Condition II definition.

- **Toxicity test species sensitivity** — The primary reason for developing an alternative approach for assessing TBT was that only marginal toxicity had been observed in Puget Sound sediments (principally around Harbor Island and the Hylebos Waterway), even though the bulk sediment concentrations were in the ppm range in some samples. One initial agency requirement was that *Eohaustorius estuarius* rather than *Rhepoxynius abronius* be used as the amphipod test species in the 10-day acute test. This requirement was based on the results of Meador et al. (1996), noting up to a 20-fold difference in sensitivity between the two genera. However, even the differences noted between the two genera in the Meador et al. (1996) study did not explain the lack of toxicity observed in previous tests conducted with Puget Sound sediments. Sediments from T-18 with concentrations as high 1.1 ppm dry weight were not toxic to *Eohaustorius*. An alternative explanation is that the TBT present in Puget Sound sediments tested to date is not as bioavailable as the TBT in the other tests. Both the IW data and the toxicity data generated for T-18 support this explanation. The results of the IW analysis indicate that only a small fraction of the TBT associated with sediments is actually present in the IW in a dissolved form, with typically less than 0.1 percent of the bulk TBT present in dissolved form in the IW.

Proposed Actions or Modifications

When characterizing quality of sediments contaminated with TBT for dredging purposes, the following procedures should be implemented:

1) A sufficient volume of sediment should be collected to ensure that IW can be collected and analyzed following the procedures used for the T-18 project.

2) If bioaccumulation testing is implemented, the resulting tissue concentrations should be compared to effects-related data. Based on analysis of the available tissue residue/effects data, we conclude that a tissue residue trigger value of at least 2 ppm wet weight meets the Site Condition II definition.

3) Although the agencies opted to require a bioaccumulation test as the biological criterion for TBT, this was not meant to suggest that the standard sediment toxicity tests available in the PSDDA program are not sensitive to TBT. It is more likely that the majority of TBT present is not in a bioavailable form. It would be beneficial if additional research were conducted to investigate this hypothesis.

4) If IW TBT concentrations are going to be calculated rather than measured, then the partitioning coefficient used in the equilibrium model should be adjusted to reflect the relationship between bulk TBT concentrations and IW on a site-specific basis if data are available.

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Table 1. TBT IW calculated, measured, and predicted concentrations

DMMU	TOC	TBT BULK SEDIMENT (TIN) (µg/kg)	TBT IW CALCULATED[a] TBT (TIN) (µg/L)	TBT IW CALCULATED[a] TBT (ION)[b] (µg/L)	TBT IW MEASURED TBT (ION) (µg/L)	TBT IW PREDICTED TBT (ION) (0.146 x IW CALC) (µg/L)
1C 3	1.3	275	0.846	2.065	0.105	
1C 4	1.4	461	1.317	3.214	0.207	
1C 5	0.93	136	0.585	1.427	0.209	
1C 6	0.95	126	0.531	1.294	0.060	
1C 7	1.7	3.91	0.009	0.022		
1C 8	1.2	0.482	0.002	0.004		
1C 9	0.83	86.8	0.418	1.021	0.084	
1C 10	1.2	105	0.350	0.854	0.084	
1C 11	1.6	48.7	0.122	0.297		0.043
1C 12	1.7	42.8	0.101	0.246		0.036
1C 13	0.84	167	0.795	1.940	0.059	
1C 14	1.8	27.7	0.062	0.150		0 022
1C 15	0.92	84	0.365	0.891	0.031	
1C 16	1.9	16.7	0.035	0.086		
1C 17	2.6	27.2	0.042	0.102		
1C 18	0.96	48.8	0.203	0.496	0.039	
1C 19	2.5	23.7	0.038	0.093		
1C 20	2.3	38.9	0.068	0.165		0.024
1C 21	1.9	7.31	0.015	0.038		
1C 22	2	16.3	0.033	0.080		
1C 23	1.7	146	0.344	0.838	0.081	
1C 24	2.1	3.61	0.007	0.017		
1C 25	2.8	12.8	0.018	0.045		
1C 26	1.2	1.54	0.005	0.013		
1C 27	2.8	25	0.036	0.087		
1C 28	0.67	50	0.299	0.728	0.059	
1C 29	1.5	25.3	0.067	0.165		0 024
1C 30	1.2	14.6	0.049	0.119		-
1C 31	3.2	33.6	0.042	0.102		
1C 32	3.7	64.8	0.070	0.071		0.025
1C 33	3.9	56	0.057	0.000		
1C 34	1 2	59.4	0.198	0.483	0 046	
1C 35	1.4	27.7	0.079	0.193		0 028
1C 36	2.6	34.7	0.053	0.130		
1C 37	2.3	47.9	0.083	0.203		0 030
1C 38	3.3	54.1	0.066	0.160		0 023
1C 39	4.8	39.6	0.033	0.081		
1C 40	1	59.5	0.238	0.581	0.037	
1C 41	0.52	17.7	0.136	0.332		0 049

Table 1. continued.

DMMU	TOC	TBT BULK SEDIMENT (TIN) (μg/kg)	TBT IW CALCULATED[a] TBT (TIN) (μg/L)	TBT IW CALCULATED[a] TBT (ION)[b] (μg/L)	TBT IW MEASURED TBT (ION) (μg/L)	TBT IW PREDICTED TBT (ION) (0.146 x IW CALC) (μg/L)
1C 42	1.4	19.6	0.056	0.137		
1C 43	2.3	36.5	0.063	0.155		0.023
1C 44	3.6	163	0.181	0.442	0.030	
1C 45	5.4	46.4	0.034	0.084		
1C 46	1 1	61.7	0.224	0.547	0.041	
1C 47	1.3	45.6	0.140	0.342		0.050
1C 48	1.6	19.6	0.049	0.120		
1C 49	2.2	55.1	0.100	0.244		0.036
1C 49Y	1.3	0.59	0.002	0.004		
1C 50	1 5	13.3	0.035	0.087		
1C 51	3.5	33.3	0.038	0.093		
1C 53	1.5	0.53	0.001	0.003		
1C 54	1.7	0.6	0.001	0.003		
1C 55	1 7	3.8	0.009	0.022		
1C 56	1.7	1.3	0.003	0.007		
1C 57	1	0.482	0.002	0.005		

NOTE: [box] - calculated values exceed 0.15μg/L (ion)
Bold measured values exceed 0.15μg/L (ion)

[a] Calculated TBT IW based on equation #1
[b] TBT(ion) = TBT(tin) x 2.44.

Table 2. TBT IW calculated and predicted concentrations

DMMU	TOC	TBT BULK SEDIMENT (TIN) (μg/kg)	TBT IW CALCULATED[a] TBT (TIN) (μg/L)	TBT (ION)[b] (μg/L)	TBT IW PREDICTED TBT (ION) (0.146 x IW CALC) (μg/L)
2C 1	0.78	4.05	0.021	0.051	
2C 2	1.9	2.78	0.006	0.014	
2C 3	1.16	0.482	0.002	0.004	
2C 4	1.2	27.9	0.093	0.227	0.033
2C 5	1.3	2.98	0.009	0.022	
2C 6	1.8	1.63	0.004	0.009	
2C 7	2.2	74.6	0.136	0.331	0.048
2C 8	1.6	35.8	0.090	0.218	0.032
2C 9	2.6	30.4	0.047	0.114	
2C 10	2.4	53.6	0.089	0.218	0.032
2C 11	3.6	65.5	0.073	0.178	0.026
2C 12	1.9	26.9	0.057	0.138	
2C 13	1.9	13.4	0.028	0.069	
2C 14	4 7	38.9	0.033	0.081	
2C 15	4.2	79.6	0.076	0.185	0.027
2C 16	3.6	81.9	0.091	0.222	0.032
2C 17	5.2	15.8	0.012	0.030	
2C 18	4.2	12.5	0.012	0.029	
2C 19	1.3	6.3	0.019	0.047	
2C 20	2	35.7	0.071	0.174	0.025
2C 21	1.2	0.482	0.002	0.004	
2C 22	1 1	0.482	0.002	0.004	
2C 23	3.6	8.77	0.010	0.024	
2C 24	0.84	0.482	0.002	0.006	
3C 1	1.3	3.91	0.012	0.029	
3C 2	1 3	3.88	0.012	0.029	
3C 3	0 63	5.65	0.036	0.088	
3C 4	0.81	4.04	0.020	0.049	
3C 5	2	19.5	0.039	0.095	
3C 6	0.98	9.42	0.038	0.094	
3C 7	1.1	0.482	0.002	0.004	
4C 1	2	59.5	0.119	0.290	

NOTE: [ ] - calculated values exceed 0.15μg/L (ion)

[a] Calculated TBT IW based on equation #1.
[b] TBT(ion) = TBT(tin) x 2.44.

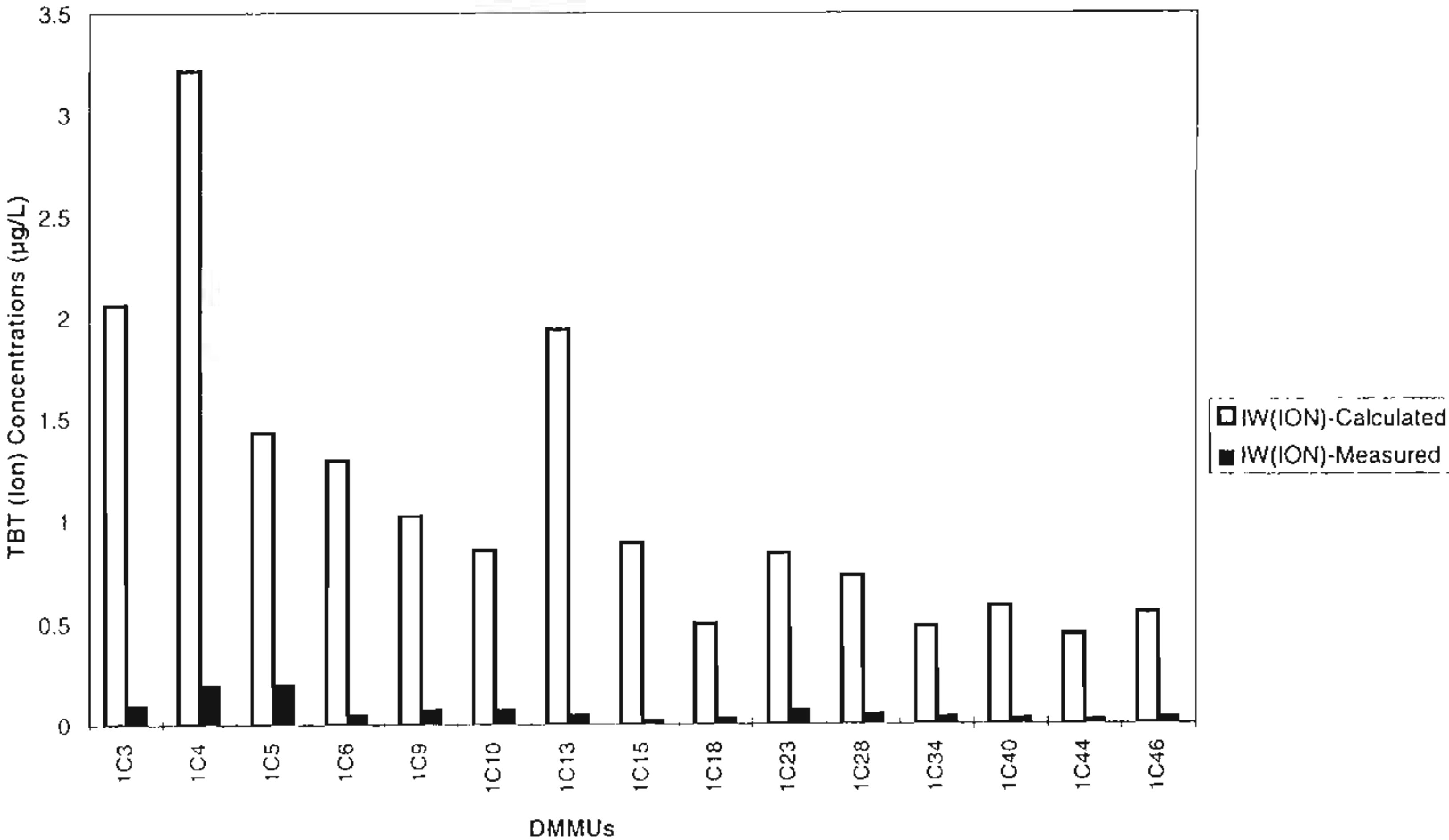

Figure 1. TBT (ion) concentrations in interstitial water C calculated vs. measured values

Table 3. TBT concentrations for Phase I selected DMMUs at Terminal 18

DMMU	TBT BULK SEDIMENT (TIN) (ng/kg)	TBT IW CALCULATED[a] TBT (TIN) (ng/L)	TBT (ION)[b] (ng/L)	TBT IW MEASURED TBT (ION) (ng/L)	RATIO MEASURED/ CALCULATED
1C3	275,000	846	2064.24	105	0.051
1C4	461,430	1317	3213.48	207	0.064
1C5	136,450	585	1427.4	209	0.146
1C6	126,000	531	1295.64	59.7	0.046
1C9	86,800	418	1019.92	84.2	0.083
1C10	105,000	350	854	83.7	0.098
1C13	167,000	795	1939.8	59.0	0.030
1C15	84,020	365	890.6	30.5	0.034
1C18	48,750	203	495.32	38.6	0.078
1C23	145,500	342	834.48	81.2	0.097
1C28	50,000	300	732	58.6	0.080
1C34	59,400	198	483.12	45.7	0.095
1C40	59,500	238	580.72	36.6	0.063
1C44	163,000	181	441.64	30.3	0.069
1C46	61,700	224	546.56	41 1	0.075

[a] Calculated TBT IW based on equation #1.
[b] TBT(ion) = TBT(tin) x 2.44.

Table 4. TBT partition coefficients for Phase I selected DMMUs at Terminal 18

DMMU	TBT BULK SEDIMENT (TIN) (ng/kg)	TBT MEASURED IN INTERSTITIAL WATER (TIN) (ng/L)	% TOC	K_p (unrounded)	K_p	K_{oc} (unrounded)	K_{oc}
1C3	275,000	43	1.3	6,395	6,400	491,950	492,000
1C4	461,430	84.6	1.4	5,454	5,450	389,590	390,000
1C5	136,450	85.8	0.93	1,590	1,590	171,003	171,000
1C6	126,000	24.5	0.95	5,143	5,140	541,353	541,000
1C9	86,800	34.5	0.83	2,516	2,520	303,126	303,000
1C10	105,000	34.3	1.2	3,061	3,060	255,102	255,000
1C13	167,000	24.8	0.84	6,734	6,730	801,651	802,000
1C15	84,020	12.8	0.92	6,564	6,560	713,485	714,000
1C18	48,750	15.8	0.96	3,085	3,080	321,400	321,000
1C23	145,500	33.3	1.7	4,369	4,370	257,022	257,000
1C28	50,000	24	0.67	2,083	2,080	310,945	311,000
1C34	59,400	18.7	1.2	3,176	3,180	264,706	265,000
1C40	59,500	16.3	1	3,650	3,650	365,031	365,000
1C44	163,000	12.7	3.6	12,835	12,800	356,518	357,000
1C46	61,700	16.9	1.1	3,651	3,650	331,899	332,000

[a] $$K_p = \frac{\text{TBT bulk sediment concentration}}{\text{TBT measured interstitial water concentration}}$$

[b] $$K_{oc} = \frac{K_p}{\%\ \text{TOC}/100}$$

Proposed Tributyltin Testing Scheme and Protocols

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Introduction

Tributyltin (TBT) has received considerable attention from both regulatory agencies and dredging proponents along the west coast of the United States. Agency workgroups have been formed to develop guidelines for establishing toxicological and bioaccumulative assessment endpoints which will define TBT concentrations protective of both the environment and human health. Superfund studies conducted in Commencement Bay (Hylebos Waterway) and Elliott Bay (Harbor Island), in which elevated concentrations of TBT were found, have prompted reevaluation of methods used to establish appropriate levels of concern for this compound.

The Puget Sound Dredged Disposal Analysis (PSDDA) process bases initial sediment evaluations of potential toxicity on the bulk concentration of contaminants of concern (COCs) in the sediment. Further biological testing of dredged material samples is required when the concentration of COCs exceeds either a Screening Level (SL) concentration, or a bioaccumulation trigger (BT) concentration (PSDDA 1989). In 1989 PSDDA established an SL of 30 ppb and a BT of 219 ppb for sediment concentrations of TBT (PSDDA 1989). Recently, U.S. EPA (1996) published "Recommendations for Screening Values for Tributyltin in Sediments at Superfund Sites in Puget Sound," in which it is suggested that bulk sediment concentrations may be poor predictors of the bioavailable fraction of a contaminant because of the complex partitioning behavior of TBT. In addition, the document suggests that the current suite of bioassays used in Puget Sound to assess sediment quality may not be sensitive to TBT.

Based in part on the this report, one conclusion by some of the PSDDA agency staff states that an alternative approach may be necessary to determine the suitability of sediments containing TBT for open-water disposal. Since the major route of uptake and exposure for sediment-dwelling organisms is likely to be from interstitial water (IW), the PSDDA agency staff have focused on directly measuring IW concentrations for comparisons with toxicity endpoints.

During the Port of Seattle's Terminal 18 (T-18) Project, PSDDA agency staff proposed an IW threshold concentration criterion of 0.15 μg/L (TBT_{ion}) to determine when further biological testing would be required. This concentration is low enough to prevent 95 percent of the effects of TBT_{ion} observed in the laboratory and field for water-only exposures to TBT_{ion} (U.S. EPA 1996).

The purpose of this paper is to present a proposed PSDDA decision scheme for analyzing IW concentrations of TBT and an outline of recommended IW sample collection and analytical methods, based on the Port of Seattle's T-18 project experience. Currently, there are no regional or national standardized methods for sampling, processing, or analyzing IW. Analytical methods, processing protocols, and guidelines for data interpretation are all needed to provide consistency within a regulatory framework.

Problem Formulation

Traditionally, agencies have required dredging proponents to collect bulk sediments, analyze it for TBT concentrations, and compare these concentrations to a sediment SL and BT. As previously stated, because of the issues raised concerning the current approaches to evaluating TBT, ongoing projects are now required to evaluate IW concentrations of TBT. Since the requirement to test IW for TBT is new, there is no previous experience on which to base a testing approach. Two issues arise from the new agency requirements for addressing TBT:

1) What are the appropriate protocols for extracting and analyzing IW for TBT analysis?

2) What type of testing scheme should be implemented to measure IW concentrations of TBT and evaluate its biological significance?

Technical Background and Discussion

During the T-18 project, an interim testing scheme was developed to guide agencies in deciding when further biological testing was required based upon IW concentrations of TBT. Since bulk sediment had already been analyzed for TBT (dry weight basis), the decision scheme included both the application of the equilibrium partitioning model as proposed by U.S. EPA (1996) and, when indicated by model calculations, direct measurement of TBT concentrations in IW (Figure 1). An initial screening of IW TBT concentrations was made using the equilibrium partitioning model. Calculated IW concentrations were compared to the IW criterion of 0.15 μg/L TBT_{ion}. For those dredged material management units (DMMUs) with calculated IW TBT concentrations that exceeded this criteria, archived sediment was centrifuged and the IW was analyzed for butyltins. Initially, in order to decrease costs associated with butyltin analyses, the Port proposed that the IW first be analyzed for total tin (Sn), with total Sn acting as a conservative surrogate measure of Sn as TBT. If IW total Sn concentrations exceeded 0.0615 μg/L TBT as Sn (converted from 0.15 μg TBT_{ion}/L), the remaining IW would be analyzed for butyltins. However, due to an insufficient volume of sediment for most of the DMMUs, the total Sn analyses were bypassed and only butyltins were analyzed.

Once it was determined which DMMUs had calculated IW concentrations that exceeded the proposed IW criterion, archived sediments were retrieved to obtain an adequate volume of IW for chemical analyses. There is currently no published Puget Sound standard protocol for extracting IW. Different procedures have been used in the past by various researchers; the procedure chosen was largely dependent upon the analysis to be performed. Required volumes of IW for analysis are dependent on the desired detection limit and the type of analysis (i.e., total Sn or TBT as Sn). When analyzing for total Sn, approximately 50 grams of sediment are centrifuged at 740 G for 10 minutes to obtain approximately 10 mL of IW. In contrast, butyltin analysis requires approximately 1000 grams of sediment to extract the required 150 to 250 mL of IW to attain a detection limit of 0.05 μg/L. For T-18, approximately 800 mL of sediment were centrifuged to obtain interstitial water for analysis.

After centrifuging, the collected supernatant was filtered to remove particles greater than 0.45 μm using polycarbonate filters. The choice of filters was based upon the recommendation of Carter et al. (1989), which demonstrated that polycarbonate filters exhibited the lowest adsorption of all the materials tested (i.e., waxed glass, perspex, polypropylene, teflon, and glass). Filtering IW is necessary because the literature shows that there is a strong correlation of sediment TBT with fines and very strong binding with clay minerals which exist as colloidal aggregates in seawater. Colloidal aggregates can be easily disaggregated during sample handling and preparation, releasing colloidal particulates into the IW, which then have to be physically removed by filtering. Filtering to 0.4 or 0.45 μm is the accepted operational limit for dissolved metals according to U.S. EPA and PSEP protocols.

Filtered samples were analyzed for TBT using the method described by Unger et al. (1986). This method was chosen over the Matthias method referenced in Puget Sound Estuary Program (PSEP 1996) for several reasons. There are a number of areas where the Matthias method could result in complications, such as attempts to separate small volumes of organic solvent (5 mL of methylene chloride) from the water being extracted. Also, when dealing with seawater, especially IW, significant emulsions may form which will make the extraction process difficult. Additionally with the Matthias method, the detection limits reported in PSEP (1996) are not realistically achieved in a routine laboratory setting using the standard capillary gas chromatography (GC) technology employed by most laboratories today. Data generated by the Unger et al. (1996) method were then compared to the IW SL. Samples having a concentration greater than the SL were then subjected to bioaccumulation testing. Boudreau et al. (1997) present the results of the tiered analysis conducted for the T-18 project.

Proposed Actions and Modifications

The following actions are proposed based on the experience gained through the T-18 project:

- **Tiered Approach to Analysis**: A tiered approach for the collection, processing, and analysis of IW concentrations is recommended. The reason for tiering the analysis is to identify, in a cost-effective manner, DMMUs that may require biological testing for TBT. Figure 2 presents a flow chart of the tiered approach and identifies decision points. The tiered approach, as outlined, will allow for the determination of suitability based on TBT at a number of different steps, depending on the estimated concentration of IW TBT. To meet the analytical scheme presented in Figure 2, we recommend that at least

3 to 4 liters of sediment be collected for those DMMUs in which a further analysis of TBT is expected. This will provide a sufficient sample to run multiple analyses.

- **Decision concentrations for TBT as Sn**: Based on the PSDDA SL of 0.15 μg/L TBT_{ion}, a concentration of total Sn greater than 0.0615 μg/L TBT as Sn would require further analysis.

- **Decision concentrations for TBT as organotin**: In addition to the analytical steps outlined in Figure 2, it is also possible to measure the concentration of organotin. Measuring organotin would serve as an intermediate analytical step between the measurement of total Sn and butyltin. Assuming that organotin comprises 10 percent of the total Sn in seawater (Crecelius pers. comm. 1996), and that approximately only 50 percent of the organotin is TBT, a screening concentration of 0.3 μg/L TBT as organotin would be an appropriate decision concentration.

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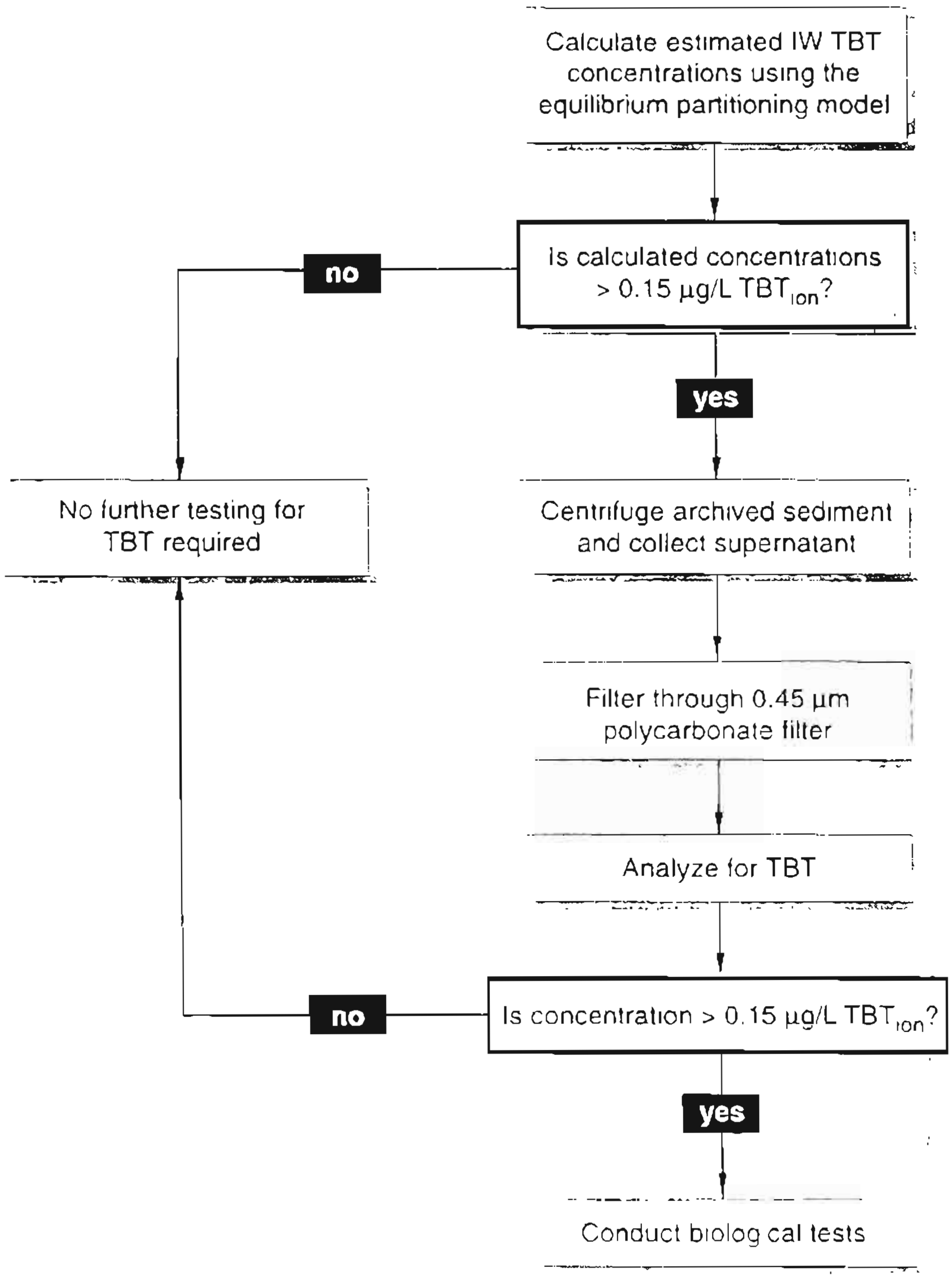
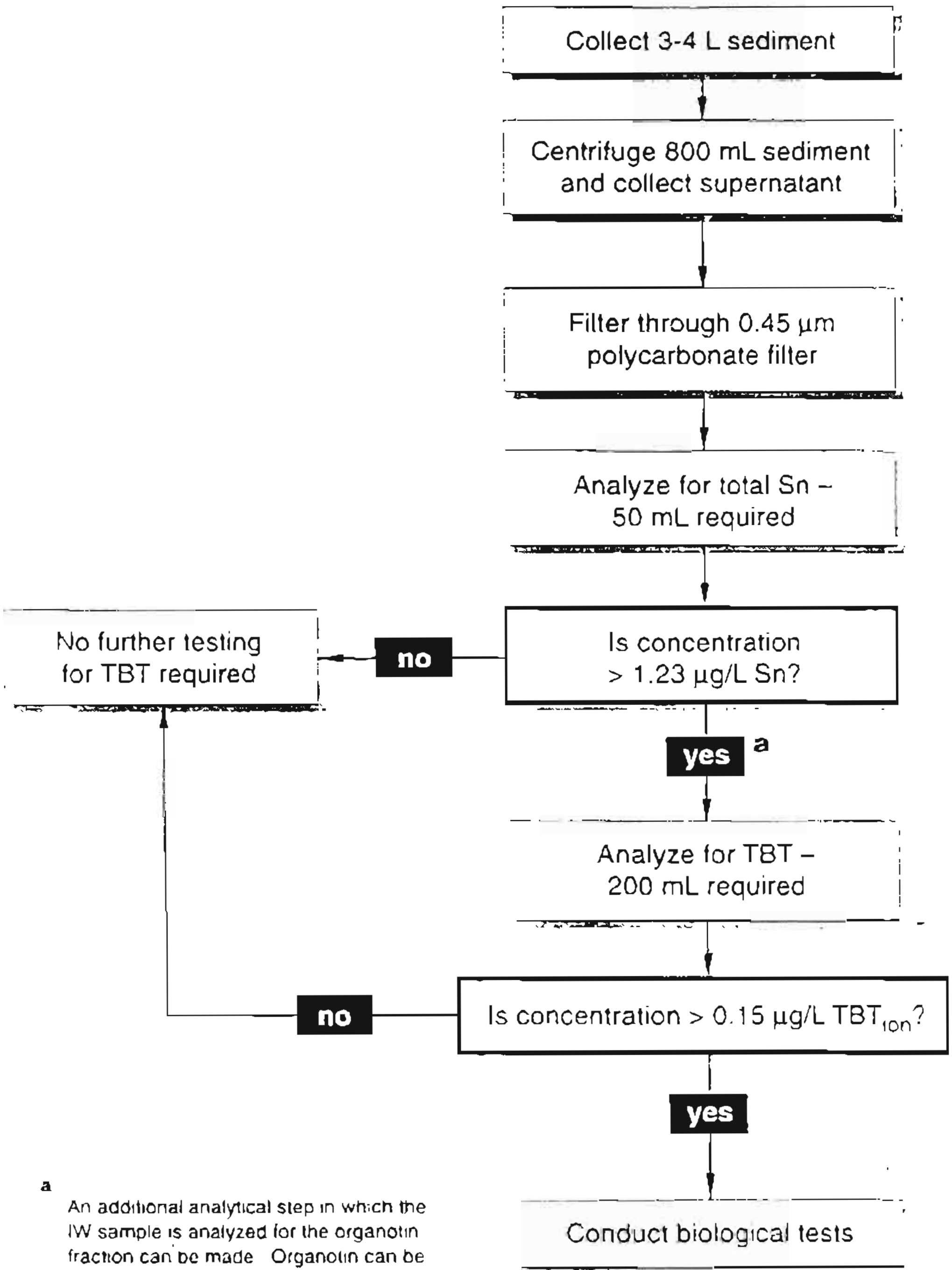


Figure 1. Terminal 18 project tiered IW TBT assessment approach



[a] An additional analytical step in which the IW sample is analyzed for the organotin fraction can be made. Organotin can be extracted from the IW sample using methylene chloride.

Figure 2. Tiered IW TBT assessment approach

A response to "PSDDA/SMS Issue Paper. Critique of PSDDA draft issue paper on testing, reporting, and evaluation of tributyltin in PSDDA and SMS programs" by Seeley et al. (1996)

J. Meador
10 March 1997

Below is my response to the review by Seeley et al. (1996) on results presented in Meador et al. (1997). Seeley et al. (1996) raise a number of issues, which can be grouped into three main categories: 1) the use of tissue residues to assess toxicity, 2) the validity of K_{OC} values, and 3) the differences in response among species to environmental concentrations of tributyltin (TBT). The following response also applies to the comments made by Bergquist et al. (1996), which are redundant (and repeated verbatim) with those in Seeley et al. (1996), and those raised by M. Johns and D. Hotchkiss on pages 11-13 in the Sediment Management Annual Review Meetings Minutes (1996), which are also the same as those made by Seeley et al. (1996). Specific comments follow the general response for each of the three categories, with specific comments made by Seeley et al. (1996) in italics.

I would like to point out that the hypotheses and objectives of Meador et al. (1997) were not intended to match the regulatory needs for determining sediment quality guidelines for tributyltin. Criticism of a peer-reviewed publication for failing to meet those goals was not warranted.

1. *Tissue residues*

Concerned was expressed about using tissue residues to determine "screening levels". While Seeley et al. (1996) are correct that it is difficult to determine a lethal tissue residue based on an administered dose because of variable assimilation efficiency and metabolism, they failed to recognized that LD50s can be determined with the acquired dose. Because of these uncertainties mentioned above with the administered dose, assessment of dose-response relationships with the actual tissue residues is the preferred method. As stated in the methods section for Meador et al (1997), we used the acquired dose to determine LD50s. Because of the confusion over the use of acquired and administered dose for LD50s, I have introduced the term LR50, for lethal residue, to help clarify this concept (Meador 1997).

Seeley et al. (1996) also question the validity of the "LD50s" in Meador et al. (1997). I would like to point out that a new paper, Meador (1997), also shows very consistent LR50s in 5 species. Other studies (Borgmann et al. 1997, Tas 1993) have also found LR50s that were very similar to those reported in Meador et al. (1993, 1997) and Meador (1993), confirming the utility of the tissue residue approach for TBT toxicity assessment.

I would also like to comment on the statement by Seeley et al. (1996) that we should rely on "bioassay-based determinations of LC50s" made on page 5 paragraph 1. I think there is ample evidence and support in the literature for assessing toxicity based on tissue residues because of their value in field surveys and because they reduce variability in our assessments. Large uncertainty exists today in aquatic toxicology because of the attitude of relying on LC50 values.

p. 4 para 5. *Animals may have been unnoticed for 1-2 days.* As stated in the Meador et al. (1997) paper, dead animals were removed daily. When these infaunal species are exposed to high levels of TBT, they come to the surface for a day or two before dying. Because of this characteristic, accurate daily assessment of dead animals could be made.

p. 4 para 5. *Purging of live animals may have affected LD50 values.* Individuals were purged for 6 hours. Also supplied in the Meador et al. (1997) paper were the k_2 values, which can be used to determine the half-life of TBT in each species. The fastest k_2 (*Rhepoxynius abronius)* indicates that the half-life of TBT is predicted to be 3.8 days. Consequently, the 6 hour purge would not have had a significant effect on tissue residues.

p. 4 para 5. *Without purging, it is difficult to predict actual tissue concentrations for dead animals.* Because the animals come to the surface and do not die for a day or two, they are not feeding and may be purging any sediment they may contain. Also, based on the high BAFs, a small amount of sediment in the gut will have only a minor effect on tissue residues. *Armandia brevis*, which displayed higher LR50s for sediment exposure versus water only exposure, may have had some sediment-associated TBT in their gut; however, considering the 95% CIs, these differences in LR50 values were not large.

p. 4. last sentence. The small size of amphipods for bioaccumulation is not a limitation if one knows how to balance acceptable detection limits with sample size.

p. 4 para 5. There was no uncertainty in estimating the dose because acquired dose was measured. Also, the small size of individuals has nothing to do with the assessment of contaminant uptake. By using more individuals to increase biomass per sample, an accurate determination of toxicokinetic parameters can be made.

2. *Partition chemistry*

Seeley et al. (1996) also raised questions regarding the determination of K_{oc} values in Meador et al. (1997). I agree that regulatory decisions should not be made on the results from one study. Until more research is done, I would like to see a lower K_{oc} used. This lower K_{oc} would be more conservative for the environment, i.e., more TBT in IW for a given sediment concentration and TOC.

The results on K_{oc} determination in Meador et al. (1997) are well supported. These sediments were manipulated to achieve variable TOC for a constant grain size to test for the influence of organic carbon on partitioning and toxicity. As pointed out in that paper, only 8 of the 31 treatments had ratios of added TOC to natural TOC that were greater than 0.9 (i.e., ≈ 1:1 ratio, or half from added TOC and half natural TOC). Also, all 7 TBT treatments for *E. washingtonianus* used sediment having no added TOC. Because the K_{OC}s were all relatively close (mean (sd) 25,100 (5,500)) for all treatments where organisms were absent for most of the test, the added TOC did not appear to affect the outcome.

Seeley et al. (1996) also made references (bottom of page 6) to equilibrium partitioning theory (EqP). There is no *a' priori* reason to expect that TBT behaves according to EqP. Partitioning between sediment and water is certainly not according to EqP and the partitioning between water and tissue may or may not be controlled by lipid and is difficult to assess because of metabolism. If one believes that TBT behaves according to the principles of EqP, then the K_{OW} should be used as a default for the K_{OC}.

p. 5 para 2. *It was not likely that equilibrium was established among TBT concentrations.* Equilibrium between water and sediment is reported to occur very rapidly (within hours) (Unger et al. 1988).

p5 para 2. *Overlying water was manipulated.* Pouring water gently was done to minimize particle sorting, a serious confounding factor in sediment bioassays. There is no research to show that this method of overlying water addition would affect equilibrium between IW and sediment. Reason suggests that this method would be more appropriate than adding water violently, which would create severe particle sorting and heterogeneity within the beaker.

p. 6. *Reported K_{ow} values range from 200 to 7,000.* The K_{OW} determined by Laughlin (1986), is the one that is generally accepted because of his methods.

p. 6 para 4. *EqP is not applicable at TOC < 0.5%.* Di Toro et al. (1991) state that organic carbon normalization is valid for TOC >0.2%. In Meador et al. (1997), 27 out of 31 treatments in had TOC values greater than 0.2%.

p. 6 para 4. *Meador et al. (1997) focused on sediments with very low TOC.* Even though TOCs in the range of 0.5 to 1.0% are very common on the West Coast of the U.S. (Meador et al. 1994), they are low for some areas of Puget Sound.

p. 7 para 3. *Pore water methods were different.* Different methods were intended to show different ways to collect porewater. Because of the relatively consistent K_{OC} (mean (sd) 25,100 (5,500), it can be concluded that the method of collection had little effect on IW determinations.

p. 7 para 3. *Freezing of porewater.* Freezing of porewater is an acceptable procedure and is documented in the literature. As far as we know, freezing does not alter TBT in solution.

3. *Differential species sensitivity*

The differential sensitivity of amphipods (*Rhepoxynius abronius* and *Eohaustorius* spp.) to TBT is very clear. Large differences in these species' response to environmental concentrations had been demonstrated previously in Meador et al. (1993) and Meador (1993) (and more recently in Meador 1997). These studies show conclusively that these species have widely differing responses to environmental concentrations of TBT. The study of Meador et al. (1997) was designed to show differences in species response to sediment-associated TBT. The results on species sensitivity to environmental exposure to TBT exposure in that study were consistent with the previous studies with water-only exposures.

Seeley et al. (1996) also implied that collecting sediment and animals at different locations and times was not appropriate (p. 7 para 4). The concern by Seeley et al. (1996) regarding the collection of sediments from different locations was not warranted. The point, which was clearly stated in the paper, was to vary TOC and hold grain size constant. This was an experiment designed to control variables for inference, not a site-specific test. The only difference between sediments in these experiments was the TOC content and each TOC treatment had a corresponding control.

In Meador et al. (1997), the main comparison was between *R. abronius* and *A. brevis*. The other amphipod, *E. washingtonianus*, was included to show the response of a sensitive species to sediment-associated TBT. Also, collecting animals at different times for toxicity testing is advantageous when attempting to characterized a species response. If one doesn't know the variability in LC50s over season, then you are never sure about the results. Examination of my other papers (Meador et al. 1993, Meador 1993, Meador 1997) will show that LC50 tests were conducted at various times (usually winter and summer) indicating that season does not appear to have an effect on LC50 for these species.

p. 7 para 3. LC50s were adjusted by adding the number of mortalities in the acetone control to the number of survivors. This <u>increased</u> the number of survivors in the treatments and raised the LC50, not lowered it. As stated in the paper, the LC50s with and without this adjustment were not statistically different. It should be noted that this method is more conservative than Abbott's formula.

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Post-SMARM Public Comment Letters

1. Lawrence McCrone, Ph.D. (PTI Environmental Services). Comment letter on the following two SMARM papers on behalf of the Weyerhaeuser Company.

   (1) Joint DMMP clarification paper and Technical Information Memorandum: Selection of negative control sediments and use of control sediments as reference sediments.

   (2) Joint DMMP Issue Paper and SMS Technical Information Memorandum: Management of wood waste under Dredged Material Management Program and the Sediment Management Standards Cleanup Program.

2. Timothy J. Hall (National Council of the Paper Industry for Air and Stream Improvement, Inc.) (NCASI).

3. Eric Johnson (Washington Public Ports Association), and Douglas Hotchkiss, Thomas Newlon (Port of Seattle). Comment letter addressing a number of DMMP/SMS program SMARM papers.

4. Mike Salazar (Applied Biomonitoring): *Environmental Significance of Laboratory Tests of Toxicity and Bioaccumulation*. Comment letter raises a number of issues relative to the existing DMMP approach for assessment and interpretation of bioaccumulation potential.

5. Richard S. Caldwell, Ph.D. (Northwest Aquatic Sciences): DMMP clarification paper: Standardization of Reference Toxicant Tests.

6. Richard S. Caldwell, Ph.D. (Northwest Aquatic Sciences): Comment relating to SMARM Issue Paper submitted by Dr. Lawrence McCrone.

7. Douglas Hotchkiss, Thomas Newlon (Port of Seattle). Comment letter regarding: "Ninth Annual Sediment Management Annual Review Meeting (SMARM) - Follow-up Comments on SMS Annual Review".

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May 16, 1997

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Subject: Comments on SMARM Papers

Dear Friends:

On behalf of the Weyerhaeuser Company, I am submitting the enclosed comments on the following papers included in the information package for the May 7, 1997 Sediment Management Annual Review Meeting (SMARM)

- Joint DMMP Clarification Paper and SMS Draft Technical Information Memorandum titled. "*Selection of negative control sediments and use of control sediments as reference sediments*"
- Joint DMMP Issue Paper and SMS Draft Technical Information Memorandum titled "*Management of wood waste under Dredged Material Management Programs (DMMP) and the Sediment Management Standards (SMS) Cleanup Program*"

The Weyerhaeuser Company and PTI Environmental Services appreciate the opportunity to comment on these important papers

Sincerely,

Lawrence E. McCrone, Ph.D
Principal Ecologist

Enclosures

cc: Jennifer Strachan, Weyerhaeuser, w/enclosures
Ken Johnson, Weyerhaeuser, w/enclosures
Chris Mann, Weyerhaeuser, w/enclosures

COMMENTS ON THE JOINT DMMP ISSUE PAPER AND SMS DRAFT TECHNICAL INFORMATION MEMORANDUM TITLED: *"MANAGEMENT OF WOOD WASTE UNDER DREDGED MATERIAL MANAGEMENT PROGRAMS (DMMP) AND THE SEDIMENT MANAGEMENT STANDARDS (SMS) CLEANUP PROGRAM"*

Comments prepared by Lawrence McCrone (PTI Environmental Services)
on behalf of the Weyerhaeuser Company

The subject paper is described in both the cover letter for the Sediment Management Annual Review Meeting (SMARM) information package and in the draft agenda for the SMARM as being a joint DMMP clarification paper and SMS technical information memorandum. However, the paper itself refers to it as a DMMP issue paper/SMS technical information memorandum. The difference between an issue paper and a clarification paper is important, and the intent of this paper should be clarified. Although public comments are invited on both, an issue paper addresses significant changes in the program and will presumably be the subject of further deliberations by the regulatory agencies after the SMARM, while a clarification paper addresses minor adjustments to the program that are proposed for immediate implementation following the SMARM. The issues raised in the subject paper have significant implications for the management of sediments, and should not be implemented immediately without consideration of public comments and further examination of the issues

The subject paper states that, in the past, the Washington State Department of Ecology (Ecology) generally considered dredged material having woody debris volumes of greater than 50 percent as being unsuitable for unconfined, open-water disposal The proposed guidance stipulates that dredged material containing significant amounts of woody material/debris will now be tested to quantify the organic fraction If the dredged material contains an organic fraction greater than 25 percent (dry weight), it will be required to undergo biological testing to assess the suitability of the material for unconfined, open-water disposal Dredged material containing an organic fraction less than 25 percent (dry weight) will be considered suitable for unconfined, open-water disposal without biological testing unless one or more chemicals of concern exceed chemical screening levels

Although applicants may propose other methods for quantifying the organic fraction of the dredged material, one method (ASTM D-2974C) is said to have been applied recently for a proposed dredging project. That method offers two alternatives for determining the moisture content of the material, and then offers two alternatives for determining the organic content of the dried sample The subject paper does not recommend which method should be used for determining the moisture content. The first alternative (method A) involves drying the material in an oven at 105° C. The second alternative (method B) removes the total moisture in two steps: 1) the material is first air-dried to a constant weight at room temperature; and 2) a representative sample of the air-dried material is ground for 1–2 minutes in a high-speed blender and then subjected to drying at 105° C in an oven as in the first alternative For determining the organic content of the dried sample, the subject paper recommends the first of two available methods (method C), in which the oven-dried material from either method A or method B is ignited in a muffle furnace at 440° C, the ash content is determined, and the organic content is calculated by difference.

The suggested methods may very well be appropriate for determining the organic fraction of the material. However, the subject paper goes on to say that because sediment grain size is an important consideration in selecting the bioassay species and in choosing a reference sediment, applicants should analyze the grain size of the residue (i.e., the ash) left from the aforementioned method C. According to the subject paper, the organic-free particle size distribution should then be used in conjunction with the conventional particle size distribution in selecting the appropriate bioassay species and in choosing a reference sediment. We question the relevance of the particle size distribution of the ash left after igniting the material in a muffle furnace for these purposes. Our concern applies to both the method A and method B alternatives for determining the moisture content, but especially to method B, in which the air-dried material is ground in a high-speed blender prior to igniting it in a muffle furnace. The combination of grinding the material and then igniting it in a muffle furnace likely renders the material completely different in its physical characteristics from the original sample. In addition, the subject paper offers no guidance on how the organic-free particle size distribution should be used "*in conjunction with*" the conventional particle size distribution in selecting the appropriate bioassay species and in choosing a reference sediment. A further complication is that no mention is made of considering the organic content of the material in choosing a reference sediment. Given the lack of similarity between sediments containing a high content of woody material/debris and the sediments commonly found in Puget Sound reference areas, it will be difficult to identify an appropriate reference sediment for use in sediment toxicity tests. The difficulty in identifying an appropriate reference sediment will only be compounded by the absence of more detailed guidance on these issues. We therefore urge the regulatory agencies to give further consideration to these issues before requiring the biological testing of sediments containing significant amounts of woody material/debris.

The stated intent of the regulatory agencies to require biological testing of sediments with a high content of woody material/debris for evaluation under the DMMP and SMS cleanup program is also cause for concern. There is sufficient experience with the sediment toxicity tests routinely applied under the two programs to support the notion that adverse effects demonstrated in these tests are associated with toxic chemicals in the sediments. Less well known are the effects that physical characteristics alone may have on the outcome of these tests. The physical characteristics of a sediment having a high content of woody material/debris are likely to be substantially different from those of a sediment with a much lower content of such material. However, there has been little research into the effect such differences may have on the test organisms. Consequently, guidance is not currently available on selecting among the available test species on the basis of the wood content of the sediments. Moreover, the ecological relevance of an adverse effect of such sediments on any of the available test species is not apparent. The test species in routine use under the DMMP and SMS cleanup program were selected in part because they can be used to test a wide variety of sediments commonly found in Puget Sound. Sediments with a high content of woody material/debris represent an extreme case, however, and the ability of these organisms to survive when exposed to such sediments may be a poor predictor of the effect these sediments might have on other species better adapted to such conditions. Just because the survival of the test species may be adversely affected does not necessarily imply that alternative ecological communities cannot survive or even thrive in the presence of large amounts of woody material/debris. We suggest that additional research on these issues is necessary before the sediment toxicity tests currently applied under the DMMP and SMS cleanup program can be recommended for testing sediments with a high content of woody material/debris

COMMENTS ON THE JOINT DMMP CLARIFICATION PAPER AND SMS DRAFT TECHNICAL INFORMATION MEMORANDUM TITLED: "*SELECTION OF NEGATIVE CONTROL SEDIMENTS AND USE OF CONTROL SEDIMENTS AS REFERENCE SEDIMENTS*"

Comments prepared by Lawrence McCrone (PTI Environmental Services) on behalf of the Weyerhaeuser Company

The subject paper refers to the required use of negative control sediments to provide an estimate of the general health of the test organisms in both the amphipod mortality and *Neanthes* growth bioassays The paper also notes that a clean seawater control is used for this purpose in larval sediment bioassays. However, the paper fails to mention that some toxicity testing laboratories routinely run a negative control sediment in conjunction with larval sediment bioassays, even though such practice is not required by the Puget Sound Protocols. Such use of negative control sediments may provide an additional check on the laboratory's performance of the bioassay, but the combined mortality and abnormality results for negative control sediments should never be used as a substitute for the results from appropriate reference area sediments in comparisons with test sediment results In our experience, this would be especially unwarranted because there may have been no attempt to match the sediment characteristics (e.g , grain size, total organic carbon (TOC) content) of the negative control sediment with the test sediments If the negative control sediment had been selected on the basis of these characteristics, then it would simply represent another reference area sediment Therefore, the paper should specifically state that even if results are reported by the laboratory for negative control sediments in the larval bioassays, they should not be used in lieu of appropriate reference area sediments in comparisons with test sediment results.

The subject paper also indicates that sediments proposed for use as negative controls in the amphipod mortality and *Neanthes* growth bioassays must be approved by the regulatory agencies before the bioassays commence Furthermore, if an area "without a proven track record" is proposed for the collection of negative control sediment, "sufficient data" (e g , grain size, TOC content, chemical data, bioassay results) must be submitted before its use can be approved by the regulatory agencies. Further guidance is required regarding what would constitute "sufficient data" (e.g., number of samples, proximity of the proposed sampling location to historical stations, recency of the data).

The subject paper also suggests criteria for determining whether a negative control sediment "is substantially dissimilar to the site stations and a failed reference station in its physical characteristics." Those criteria are 1) a difference in the fine-grained sediment fraction of greater than 25 percent, and 2) a difference of 1 percent TOC when the TOC content is 2 percent or less, or of 2 percent when the TOC content is greater than 2 percent The suggested TOC criteria do not make sense. By these criteria, if the TOC content of the test sediment was 2.1 percent, it could be matched with a negative control sediment having a TOC content between 0 1 and 4.1 percent. However, if the TOC content of the test sediment was 1.9 percent. it could only be matched with a negative control sediment having a TOC content between 0 9 and 2 9 percent.

It may be preferable to specify an allowable relative percentage difference in TOC content instead of an absolute percentage difference. For example, the negative control sediment could be required to have a TOC content within 50 percent of the TOC content of the test sediment (i.e., for a test sediment with a TOC content of 2 percent, the allowable range in TOC content for the negative control sediment would be 1 to 3 percent; for a test sediment with a TOC content of 4 percent, the allowable range in TOC content for the negative control sediment would be 2 to 6 percent).

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NATIONAL COUNCIL OF THE PAPER INDUSTRY FOR AIR AND STREAM IMPROVEMENT, INC.

May 19, 1997

Dredged Material Management Office
Seattle District
Army Corps of Engineers
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I recently had the opportunity to review an Issue Paper (Potential for Grain-Size Effects on Larval Sediment Bioassays) which was subsequently presented at the May 7 SMARM meeting. The issue pertained to whether or not there were sufficient data available to judge the potential effects of very high amounts of fine sediments on the echinoderm embyro/larval sediment bioassay. Part of our laboratory function is to perform technical evaluations of various bioassay methods used in state and federal regulatory programs. These technical evaluations have focused on procedures used for both effluent and sediment testing. Part of this technical evaluation has been to identify and understand method variables that can influence test results. The issue of fine sediment effects has been identified by others being an important variable for several sediment bioassays, including those with *Chironomus tentans* (freshwater), several of the marine amphipods, and embryo/larval tests with bivalves.

The above examples illustrate the possible importance of fine sediments and provide a support for further fine sediment evaluations with the echinoderm embryo/larval test if there are situations where the test is being used which exceed the range represented at the reference stations used to validate the. The SMARM Issue Paper prepared by Lawrence McCrone addresses the need for validating whether or not fine sediments can have an adverse effect on echinoderm embryo/larval tests at very high fine sediment concentrations (e.g >90%). Apparently this level of fine sediments exceeds most if not all of the reference stations. The approach suggested, which begins with an analysis of existing Ecology data and then proceeds with the generation of new data if necessary, appears to be logical and efficient If this proposal proceeds to a laboratory testing phase we would be pleased to participate in any experimental design discussions. We function as a non-profit technical support group for the forest products industry and our laboratory has had extensive experience with the experimental design and conduct of various inter and intralaboratory studies directed at bioassay protocol issues. In the past we have worked with EPA, Ecology, and the California Water Resources Control Board on such studies.

Thank you for your consideration of our comments

Yours truly,

Timothy J. Hall
Aquatic Biology Program Manager
Principal Research Scientist

Port of Seattle

May 21, 1997

VIA FACSIMILE: ORIGINAL TO BE MAILED

Brian R. Applebury, P.E.
Chief, Operations Division
Seattle District Corps of Engineers
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Re: Ninth Annual Sediment Management Annual Review Meeting (SMARM) – Follow-up Comments

Dear Mr. Applebury:

Once again, on behalf of the Port of Seattle (the Port) and the Washington Public Ports Association (WPPA) we appreciate the opportunity to participate in the Sediment Management Annual Review Meeting (SMARM), the activities that led up to it, and those that will follow.

This year we are particularly encouraged with the progress made by the Dredged Material Management Programs' (DMMP) Regulatory Work Group. When agency staff, the regulated community and other interested parties sit down together early on to discuss technical and policy issues we can make significant progress toward workable solutions to difficult problems. The Work Group's success clearly demonstrates the utility of engaging in an open and spirited dialogue early on in the technical and policy formation process.

We encourage the DMMP agencies to follow through on the Work Group's many recommendations. Participating in the Work Group requires a significant contribution of time and resources by both individuals and institutions. In recognition of this contribution, and in recognition of the high quality of the Work Group's final report, the DMMP agencies should follow through on and implement the Work Group's short and medium-term recommendations over the coming year. Doing so will not only advance the DMMP process, it will also encourage participation in similar efforts in the future.

What follow are our comments on a few outstanding issues raised during the 1997 SMARM process. In general, the comments respond to and are associated with specific Issue papers, Clarification Papers or Technical Information Memoranda. Given the

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significance of some of the issues raised during the SMARM and discussed further below, we strongly encourage the DMMP agencies to promptly reconvene the Regulatory Work Group, or similar agency/stakeholder/expert technical working group, to address these outstanding issues in a timely and meaningful way.

DMMP ISSUES

<u>DMMP Screening and Maximum Level Guideline Revisions</u>
(DMMP Issue Paper)

> *The Port of Seattle and WPPA strongly urge the DMMP agencies to follow the Regulatory Work Group's recommendation and use combined oyster and echinoderm larval data for calculating SLs. The Port of Seattle and WPPA also strongly urge the DMMP agencies to thoroughly review the validity of and the continued use of Microtox data.*
>
> *Given the importance and technical complexity of these issues, the Port of Seattle and WPPA strongly urge the DMMP agencies to promptly reconvene the Regulatory Work Group or a similar agency/stakeholder/expert technical working group to address these issues over the next year. The sediment larval toxicity testing workshop should also be convened within the coming year to ensure that the treatment of larval bioassays does not delay the AET recalculation effort.*

The Port of Seattle and WPPA commend the DMMP agencies' commitment to adopt many of the Regulatory Work Group's recommendations regarding Screening and Maximum Level guidelines revisions. The Work Group's recommendations are a step in the right direction on the critical issue of regularly updating Apparent Effects Thresholds (AETs) using the most complete and appropriate data sets. The 1994 AET recalculations, although limited by the exclusion of significant data and confused by the questionable decision to split the larval bioassay AETs, were likewise a step in the right direction.

The Port of Seattle and WPPA encourage the DMMP agencies to follow up on the recently-adopted recommendations, to do so in a timely fashion, and to include RWG participants such as the Port of Seattle and WPPA in the early stages of analysis of the remaining issues. As we have seen over the last year, a technical work group such as the RWG brings significant experience and resources to the table. We look forward to continued participation in developing and conducting the analyses outlined in the Issue Paper, debating the echinoderm/oyster larval data issue, developing a *Neanthes* AET, carefully reviewing the continued use of Microtox data, and discussing other DMMP issues as they arise.

Echinoderm/Oyster Larval Data

Our primary concern with the DMMP agencies' current position is the decision not to adopt the RWG recommendation to combine echinoderm and oyster larval data when calculating AETs (RWG Recommendations 1e and 2b). The agencies' current position is that they will temporarily forego use of the echinoderm AET and rely exclusively on the bivalve data for setting the larval AET and any SL for which the larval data represents the LAET. The agencies intend to convene a workshop during 1997 for larval sediments experts to address the issue. While we understand the decision to seek further expert opinion on the issue, and expect to participate actively in that discussion, the following aspects of the debate warrant comment at this time.

First, the agencies' reluctance to combine the echinoderm and oyster data is inconsistent with prior administrative treatment of the tests. Administratively, these tests have always been treated as functionally equivalent in the PSDDA/DMMP program and we have no statistical evidence to indicate that this is inappropriate. The results of any one of the tests will be as protective in decision making as any of the other tests. Accordingly, the RWG strongly endorsed the philosophy of treating the tests as functionally equivalent. The dissenting vote in the RWG on the "bundling" issue was not based on the scientific validity of treating the tests as functionally equivalent, but was instead based on concerns regarding the statistical validity of combining bioassays run with slightly different procedures (e.g., the early Commencement Bay mussel larval set and the later echinoderm larval tests).

Second, the agencies' primary objection to combining echinoderm and oyster data, that there is no proof that the tests are identical in their sensitivity to contaminants, does not appear to be supported by the evidence. In particular, there is no evidence that echinoderm and oyster larval data are significantly different from each other in terms of sensitivity. While the agencies state that phylum separation of echinoderms from bivalves may result in differences in sensitivity, data available to the Port of Seattle suggests that there may be as much or more difference within a given phyla (e.g., differences in sensitivity between different species of echinoderms or between different species of mollusks) as there is between phyla (e.g., differences between echinoderms and mollusks). Johns et al.'s 1996 paper, presented at the 1996 SMARM, examined available reference toxicant data on species sensitivity from laboratories that conduct these tests in Puget Sound and concluded that the data were inconclusive as to differences in sensitivity among the larval bioassays.

Third, the evidence which the agencies believe demonstrates the differential sensitivity of the tests is more likely a result of the source of the data than true differences in sensitivity. The two larval tests were rarely, if ever, conducted on the same sediment sample. Therefore, the data set used to calculate the AET for each larval test is different and the differences in AET could be as much an issue associated with the size of the data set and the range of contaminant concentrations observed in the data set as an indicator of true differential sensitivity. Apparent AET differences could also reflect the variability of individual AETs, which combine both chemical variability and bioassay variability.

The only way that AETs could be used to validly assess test sensitivity is if the data sets used for the bioassay comparisons were substantially similar, in which case you would be left with only AET variability. For example, when calculating the *Neanthes* AET we find a number of contaminants in which a new HAET would be established. One potential conclusion from this is that the tests and species are not as sensitive as other toxicity tests. However, when you evaluate the station setting these individual AETs you find that the other bioassays also passed, and that once these data are included in a new AET recalculation, then the AET for all of the tests used will increase. For all of the above reasons, absent some clear indication that echinoderm and oyster larval tests are differentially sensitive to contaminants, the DMMP agencies should follow past administrative practice of treating the tests as functionally equivalent and follow the RWG recommendation to combine the data when calculating larval AETs.

Recognizing that the DMMP agencies may choose not to change their position on bundling at this time, the Port of Seattle and WPPA agree that it would be appropriate to convene an experts group sometime between now and the 1998 SMARM to address the issue of larval test sensitivity. However, the side-by-side comparison issue discussed above and the absence of an appropriate data set may make it difficult for the group to resolve the issue. As was attempted by Johns et al. (1996), it may be possible to use the reference toxicant data from all laboratories to determine if relevant sensitivity differences exist. We recommend that any evaluation of sensitivity differences be consistent across classes of contaminants, and that observed differences must be greater than a factor of two before the larval tests are considered to warrant separate AETs.

<u>*Neanthes*/Microtox</u>

When considering which AETs are used to set the HAET and the LAET, the most obvious areas that need adjustment in the DMMP/SMS programs are the lack of a *Neanthes* AET and the continued inclusion of the Microtox AET. Development and inclusion of a *Neanthes* AET is appropriate because (1) the 20-day *Neanthes* toxicity test is currently used in both the DMMP and SMS programs to make regulatory decisions, and (2) a *Neanthes* AET will directly reflect a chronic/sublethal endpoint. On the other hand, inclusion of the Microtox AET is no longer appropriate because it is based on numbers generated from a test that we no longer use because of its inability to give us reasonably consistent end points and for which there appears to be a potential for substantial interferences in anaerobic sediments. These facts surrounding the Microtox test call into question the validity of the data set currently used to generate the Microtox

AET. Including a *Neanthes* AET and removing the Microtox AET would not alter the basic number of AETs used to calculate the HAETs and the LAETs. This is important because increasing the number of AET groups would generally result in a lowering of the LAETs and in a raising of the HAETs.

Regulatory Use of Recalculated AETs

Finally, the Port of Seattle and WPPA are very concerned about the agencies' use of a so-called "weight of evidence" rule to disqualify an AET proposal that all agree has technical merit. This sounds like "no matter what the science says, if we don't like the numbers we won't use them." The Port of Seattle and WPPA would like assurances that such an interpretation is not what the DMMP agencies mean. We trust that the DMMP agencies will continue to keep us and the other RWG members involved in examining the potential regulatory implications of any changes in the AETs and the manner in which the DMMP agencies will streamline the AET recalculation process.

Along these lines, we are very interested in the comparison of TOC normalized numbers to the bulk dry weight numbers. Based on the presentation by Tom Gries at the SMARM on May 7th this change could potentially cause a much greater impact than the RWG members anticipated. It will be very important to meet and discuss this issue as soon as we receive and can evaluate the results of the organic carbon normalized AETs (with the less than 0.5 % TOC removed following the most recent PSEP guidance for TOC analysis).

AET Methodology Clarification and Revisions
(DMMP Clarification Paper)

> *The Port of Seattle and WPPA strongly encourage the DMMP agencies to follow through on the Regulatory Work Group's recommendations to complete AET recalculations prior to the 1998 SMARM and to establish DRVs prior to the recalculation to allow incorporation of older data*
>
> *The Port of Seattle and WPPA also strongly encourage the DMMP agencies to commit to following the RWG recommendation that only truly anomalous data, as opposed to all statistical outliers, will be excluded from the AET data set.*

The Port of Seattle and WPPA generally support the direction the DMMP agencies are taking on the AET methodology issues discussed in the Clarification Paper. However, we are concerned about the apparent lack of agency commitment to complete

AET recalculations prior to the 1998 SMARM. We also continue to be concerned about the potential exclusion from the AET data set of statistical outliers that are not anomalous.

As participants in and observers of the PSDDA/DMMP process have recognized from the outset, a current and updated AET database is a critical component of the DMMP sediment management scheme. Assuring that AETs are as accurate as possible is essential to assuring that sediment management decisions are fair and reasonable in light of the best available information. Recognizing the importance of keeping the data set current, the agencies have historically committed to reviewing AETs in light of new information. The Clarification Paper points out some of the methodological steps, including establishment of DRVs, necessary to accomplish this task. However, the Clarification Paper's discussion of these steps lacks a strong commitment to promptly undertake AET recalculation ("If we are able to undertake DY 1998 AET calculations . . . "). We trust that this comment does not reflect a change in policy, and encourage the agencies in the strongest of terms to fulfill the commitment to review and revise the AETs on a regular and timely basis in keeping with the RWG's recommendations.

On a more technical note, we are concerned with the Clarification Paper's failure to squarely address the inclusion of non-anomalous statistical outliers in the AET calculations. One of our consistent concerns is that data should not be excluded from the AET calculations simply because the data set is incomplete in its upper ranges. This is especially true for chemicals (such as antimony) that are not commonly found in Puget Sound sediments at levels that would be expected to result in toxicity. If data are not anomalous, they should be included in AET calculations, regardless of whether they are statistical outliers. Again, we encourage the agencies to follow the RWG recommendations on this issue, distinguish between anomalous data and outliers, and recalculate AETs using non-anomalous data.

<u>Verification Methods</u>
(DMMP Issue Paper)

The Port of Seattle and WPPA strongly recommend that the DMMP agencies avoid instituting the costly verification procedures discussed in the Issue Paper as a means of remedying what to date has proven not to be a problem.

The focus of the Issue Paper is identifying appropriate mechanisms for ensuring that unsuitable materials are not introduced into open water disposal sites. The Port of Seattle and WPPA appreciate the Department of Natural Resources' obligation, as DMMP site manager, to diligently monitor this aspect of dredged material disposal.

However, as noted in the Issue Paper, monitoring data indicates that disposal of unsuitable materials in the open water disposal sites has not been a problem to date.

The Port of Seattle and WPPA therefore recommend caution in establishing procedures for segregating suitable from unsuitable materials at mixed dredge sites and keeping the unsuitable materials out of open water disposal sites. Any such procedures should only be established after consultation with the regulated community to determine the least costly way to achieve a reasonable level of protection against disposal of unsuitable materials. Proposed procedures should also provide the flexibility necessary to accommodate the different needs of different projects by allowing selection of a project-appropriate approach from among several options. In the interim, as the monitoring data indicates, the current practice appears to be adequately protective of the open water disposal sites. To the extent that any additional measures are required in the short term, we recommend phased dredging of unsuitable and suitable materials where possible. We also recommend that the agencies perform random spot checks to assess the extent to which there actually is a problem and to provide an incentive to the dredging community to avoid commingling of suitable and unsuitable materials. Another straight forward step to investigate would be for the dredge contractor to detail in the Plan of Operation, a quality control plan for separation of suitable vs. unsuitable including daily logs of operation that are to be turned in to DNR at the completion of the unsuitable dredging.

Many of the solutions discussed in the Issue Paper and at the SMARM, such as buffer offsets and additional surveys between unsuitable and suitable dredging phases, may appear to be simple but are in fact very costly for the dredging proponents and therefore are not justified by the limited nature of the problem. A good example of this is the potential addition of buffer offsets to unsuitable DMMU dredge prisms, the cost of which would be tremendous. A 1 foot buffer on the sides and bottom of a 4,000 cy surface DMMU would add approximately $90,450 to the project cost (1 foot buffer generates 1,206 cy of additional material requiring confined disposal with additional handling and upland disposal costs of $75 per cubic yard).

The suggestion of requiring surveys between dredging stages is likewise expensive and may not be justified by the nature of the problem. Shutting down dredging for even 3 to 4 days in order to conduct a survey and generate required data would add about $15,000 to project costs. Any time needed for the DMMP agencies to review the data prior to authorizing the next stage of dredging would add still more costs to the project. While mid-project surveys would be less costly than buffer offsets, and may be the most cost effective approach for large projects, they would still add substantial costs and do not appear likely to result in significant environmental benefits. Further, mid-project surveys would raise a host of technical issues that would have to be resolved before such surveys were required. These include:

- Establishing required survey accuracy in all XYZ coordinates (though recorded in 0.1 ft increments, the repeatability between surveys is often around 1 ft or more);
- Accommodating the effects of weather on survey repeatability (when dredging equipment is on standby, surveyors will not be able to wait for optimal weather conditions for conducting surveys);
- Determining whether results will be averaged over entire DMMUs;
- If results are not averaged over entire DMMUs, determining how much of a vertical or horizontal divergence from pre-dredging surveys will be tolerated before requiring re-dredging and re-surveying;
- Determining whether the degree of contamination and the location of a divergence will be taken into account in deciding whether to re-dredge and re-survey;
- Determining whether contractors may re-survey if the first survey generates potentially ambiguous or erroneous results;
- Determining how tight a survey grid will be required; and
- Determining how to account for the difficulties of surveying slopes (small XY coordinate errors make for large depth (Z) errors).

While none of these technical issues are irresolvable, they suggest the level of effort and complexity involved in instituting an additional mid-project surveying requirement.

As noted above, before instituting either of the costly procedures discussed above, the Port of Seattle and WPPA recommend consultation with the dredging community to determine what, if any, measures are needed to ensure DNR and the public that unsuitable materials will not be disposed at open water disposal sites and that the sites will not exceed Site Criteria II. When considering what, if any, additional control measures are appropriate, it is imperative that consideration be given to the impact of different project conditions (i.e., differences in the areal extent of dredging, and in the location and cost of confined disposal) on the choice of project-appropriate control measures.

ISSUES AFFECTING BOTH DMMP AND SMS

<u>TBT Testing, Reporting and Data Evaluation</u>
(Comments and Responses from 1996 SMARM)

As an additional comment to the original Issue Paper, the Port of Seattle and WPPA dispute the conclusion that the current suite of Puget Sound bioassays are insensitive to TBT at concentrations that are of environmental concern and *recommend deletion of the statement until stronger evidence supports such a conclusion.*

In general, the Port of Seattle and WPPA find that the DMMP and SMS agencies' approach to addressing TBT is acceptable. The tissue residue interpretive concentration of 2 ppm (wet weight) is acceptable. Further, provided that the extraction techniques used are those used for the Port of Seattle's Terminal 18 project (i.e., centrifuging and filtering), it is appropriate to use interstitial water to determine the TBT trigger concentration. However, if these extraction techniques are not used, then the Port of Seattle and WPPA stand by their earlier significant criticism, based on the binding affinity of TBT to fine clay particles, regarding interstitial water concentration interpretation and its relevance to available TBT.

The Port of Seattle and WPPA do, however, have an additional comment on the bioassay testing portion of the original TBT Issue Paper. The Paper states that the current suite of bioassays used in Puget Sound are not sensitive enough to detect TBT at concentrations that are relevant for species that are to be protected. The primary basis for this conclusion is that there were no toxicity test failures in Harbor Island sediment even though some samples contained high bulk concentrations of TBT. The Paper's authors cite data from Commencement Bay, Harbor Island, the Puget Sound Naval Shipyard, and Coos Bay that purportedly shows impacts associated with TBT and suggests that Puget Sound bioassays are insensitive.

We have reviewed the data from the referenced studies and find very little evidence to support the conclusion that Puget Sound toxicity tests are insensitive to TBT. As an initial matter, the data from these other studies are not well suited to determining the effects of TBT. Very little of the data from these studies were collected synoptically. In some cases the toxicity test and benthic data were collected years apart. In other cases the sediment for the toxicity tests was not collected from the same station as the benthic data. More significant even than these data quality issues, benthic impacts did not appear to change with changes in TBT concentration. In fact, in some cases no benthic impacts were observed at stations with the highest TBT concentrations.

Finally, in all of the sites studied, the sediments were contaminated with multiple contaminants and there is no evidence that the observed benthic impacts were due to TBT rather than to other contaminants (i.e., the data does not demonstrate a cause-effect relationship). The Port of Seattle and WPPA therefore recommend deleting the Issue Paper's conclusions regarding the current suite of Puget Sound bioassays' insensitivity to TBT at concentrations of environmental concern.

Negative Control Sediment Selection and Using Control Sediments as Reference Sediments

(DMMP Clarification Paper / SMS Draft Technical Information Memorandum)

The Port of Seattle and WPPA recommend that the DMMP and SMS agencies provide additional guidance on appropriate control sediments for individual test species, particularly Ampelisca.

The Port of Seattle and WPPA also recommend that the agencies consider additional alternatives for interpreting test results when reference sediment fails to meet performance standards.

This Issue Paper addresses two facets of biological testing under DMMP and SMS: 1) selection of appropriate control sediment for specific test species, and 2) test interpretation procedures when reference sediment fails to meet performance standards.

Selecting the Appropriate Control Sediment

The agencies should provide additional guidance on appropriate sediment for use as controls for each test species, and should provide guidance on where the sediment can be collected. The main test species of concern is the amphipod *Ampelisca* that apparently requires sediments with a grain size distribution that includes a higher percentage of fines than is present in West Beach sand. The agencies should first present any evidence they have suggesting that *Ampelisca* performance has been poor in West Beach sand. If *Ampelisca* meet the performance criteria for controls when placed in West Beach sand, then the agencies should justify any requirement for an alternate source of control sediment. If *Ampelisca* do require an alternate source of control sediment, the agencies should provide information on grain size distributions that are more appropriate for *Ampelisca*.

Test Interpretation Procedures for Failed Reference Sediments

The Issue Paper also provides guidance on how to interpret sediment toxicity data when the reference sediment fails to meet established performance standards. The agencies propose a number of possibilities for test interpretation. These include using the reference sediment that is the next closest in grain size distribution to the failed reference sediment, or, if no other reference sediment exists, using the control sediment. The agencies end the Issue Paper by stating that, if no other reference sediments were run with the test series, the only acceptable method is to use the control sediment, no matter how different it is from the test sediment in grain size distribution or percent TOC, as the reference sediment for statistical comparisons. In this situation, the agencies provide only two possibilities, either use the control or "Otherwise, the data will be considered uninterpretable and the bioassay(s) in question will need to be rerun."

The agencies' position fails to take into account other less costly and less potentially disruptive alternatives than the one proposed. Requiring a test rerun because of a failed reference test is not the only valid alternative. If a toxicity test meets all of the QA/QC performance criteria (e.g., water quality, control performance) then the test is a valid test. The fact that the reference fails to meet performance standards does not justify deeming a test series invalid.

As stated in the Issue Paper, the reference sediment is intended "to address nontreatment effects from physical factors such as grain size." Mortality observed in a reference sediment, assuming that the sediment was collected from an accepted site (i.e., a site historically used for collecting reference sediment with data showing that the area is acceptable for collecting reference sediment) is a direct measure of the nontreatment factors. The reason that reference sediments are used at all is because there is evidence that toxicity test organisms respond negatively to a wide variety of factors, including natural sediment characteristics. The reference sediment is used to block for those factors, or at least to provide evidence of their effect. To deny this by refusing to accept reference data is to deny the fact that organisms respond negatively to nontreatment factors.

Unlike control sediment performance standards, which assess test organism health, reference sediment performance standards were established to prevent the situation where a test sediment is truly a risk, but is not found to be statistically different from the reference sediment because of a high negative response in reference. While the DMMP and SMS agencies should be concerned about this situation, they must also recognize that a majority of the reference sediment performance standards were set imperfectly, without the benefit of a large data set to define what should be expected in a test organism subject to varying nontreatment factors.

Given the imperfect nature of the current reference sediment performance standards, the Port of Seattle and WPPA recommend that the agencies consider the following alternatives, in addition to those outlined in the Issue Paper, for situations where reference sediment fails performance standards:

- If the reference sediment test data are within a few percentage points of meeting the performance standards, and the nontreatment factors that are being blocked are a factor in the test sediment (e.g., blocking for high percent fines and the reference sediment contains high percent fines), then the reference sediment could be acceptable for statistical comparisons. One method would be to look at the standard deviation of the failed reference and determine whether the variation overlaps with the performance standard. Maximum acceptable standard deviations could be established, similar to the method Tom Gries used when calculating the 1994 AETs.

- Alternatively, as Tom Gries discussed in his 1997 SMARM paper covering default reference values (DRVs), a "Puget Sound-wide" value could be substituted for the statistical comparisons if the reference sediment fails the performance standards. This was essentially the Regulatory Work Group's (RWG) recommendation regarding how to handle data in AET calculations when the reference fails the performance standards. This should be an acceptable approach given that the existing Puget Sound toxicity test performance standards are based on what is considered an acceptable level of response. Two options for providing standardized reference values came out of the RWG recommendations: (1) use the existing reference performance standard as the constant and compare it to test data using appropriate statistical procedures (e.g., one sample one-tail t-test), and (2) develop a Puget Sound value (e.g., the 80th percentile of the distribution of mean reference performance), stratified by the important nontreatment factors and compare it to test data as in (1). Either method would be acceptable from a statistical point of view and, in terms of accomplishing the intent of the reference test, would be far superior to and more technically appropriate than using control sediments as reference sediments.

Wood Waste Management
(DMMP Issue Paper / SMS Draft Technical Information Memorandum)

If wood wastes in the marine environment are to be managed, they should be managed exclusively through the DMMP and SMS programs and not through the State's Solid Waste Management program. Given the potentially far reaching effect of managing wood wastes in the marine environment, Ecology should propose specific rule revisions to address wood wastes as was done in the case of net pens several years ago.

As discussed in the Issue Paper (identified in the SMARM Final Agenda as a Clarification Paper), several statutory authorities appear to support regulation of wood wastes in the marine environment and remediation of significant environmental degradation that may be associated with those wastes. These authorities may be implemented through the DMMP and SMS programs – programs with significant combined experience studying and managing marine sediments and related environmental issues. Given these existing programs, regulating wood wastes in the marine environment as a solid waste would be both unnecessary and unwise. Instead, if Ecology determines that regulating wood wastes in the marine environment is appropriate, it should propose specific revisions to the Sediment Management Standards to address wood wastes as was done in the case of net pens several years ago.

In its closing paragraph, the Issue Paper inexplicably ignores the DMMP and SMS programs and suggests that if wood wastes are present in "sufficient quantities" they may be classified and regulated as solid wastes rather than sediments. The Issue Paper goes on to state that, having been so classified, Ecology might then require removal of the wastes and disposal in a permitted solid waste facility *"even when toxicity to aquatic life is low."* By focusing on the origin of the materials rather than their effect, the statements are a striking example of placing form over substance. They also appear to demonstrate a surprising departure from common sense, from the goals of existing sediment management programs, and from current principles of regulatory reform.

Wood wastes in the marine environment should only be regulated as solid wastes if, under existing regulatory programs, it is determined that the wastes must be removed from the marine environment and treated using upland disposal. The state's solid waste regulations should not be used as another set of criteria for determining whether removal is necessary in the first place. The current solid waste regulations, which expressly exclude from coverage dredged material that is regulated under section 404 of the Clean Water Act, reflect this common sense allocation of regulatory authority.

CONCLUSIONS

Again, the Port of Seattle and WPPA commend the DMMP and SMS agencies on the progress made over the last year, particularly in the context of the Regulatory Work Group. The Port of Seattle and WPPA also commend the DMMP agencies for adopting many of the RWG's recommendations and urge the DMMP agencies to implement these recommendations over the coming year. With regard to RWG recommendations not yet adopted, the Port of Seattle and WPPA look forward to continued open and constructive dialogue between the agencies and the regulated community.

The Port of Seattle and WPPA also encourage the DMMP and SMS agencies to look to the successes of the past year as a model for addressing issues currently on the table and those that will inevitably arise in the future. The likelihood of resolving these issues in a way that is responsive to the agencies' regulatory obligations, scientifically sound, and fair and reasonable for the regulated community increases tremendously when stakeholders and experts are brought into the discussion at the earliest stages and consulted throughout the decision making process. The Port of Seattle and WPPA welcome the agencies' apparent commitment to this ongoing dialogue and commit themselves to participate as well.

Finally, the Port of Seattle and WPPA encourage the DMMP and SMS agencies to diligently pursue a process that will allow regular and frequent AET recalculation. As we have repeatedly stated, accurate AETs based on all available data are essential to a sound sediment management program in Washington State.

Sincerely,

Port of Seattle

Douglas A. Hotchkiss
Thomas A. Newlon

Washington Public Ports Association

Eric Johnson by TN

Eric Johnson

DAH:mdw

cc: David Bradley, Department of Ecology
Ann Essko, Department of Natural Resources
David Kendall, U.S. Army Corps of Engineers
John Malek, Environmental Protection Agency
Konrad Liegel, Preston Gates & Ellis LLP
D. Michael Johns, EVS Consultants

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ENVIRONMENTAL SIGNIFICANCE OF LABORATORY TESTS OF TOXICITY AND BIOACCUMULATION. Michael H. Salazar, Applied Biomonitoring, May 20, 1997.

It has been over 10 years since I first discussed the environmental significance and interpretation of tributyltin (TBT) bioassays (Salazar, 1986). Many of these issues were addressed again last year, in response to questions regarding the regulation of TBT- contaminated sediments by the PSDDA agencies (Salazar, 1996). The problem however, is much more generic than just TBT and revolves around our lack of understanding the biological availability of sediment-sorbed chemicals like TBT, PCBs, DDT, dioxins, and furans. Similarly, specific issues have arisen in this regard concerning the sensitivity of test animals, test duration, assessments of bioaccumulation potential, data interpretation, the purpose, cost, and utility of laboratory assessments in evaluating contaminated sediment, particularly with respect to strongly hydrophobic chemicals like the ones mentioned above. The following will summarize basis for these issues and explore possible solutions.

1. SENSITIVITY. Many opinions have been expressed regarding the relative sensitivity of test animals commonly used in the PSDDA suite. Last year I made a presentation to the PSDDA agencies titled "Are mussels more sensitive to TBT than amphipods?" On a tissue residue basis the mussel growth endpoint of 4 ug TBT/g dry wt. (Salazar & Salazar, 1996, in review) is about an order of magnitude more sensitive than the mortality endpoint of 40 ug TBT/g dry wt. used by Meador (Meador et al., 1996; Meador, 1997). This is not really surprising since sublethal endpoints like growth are generally about an order of magnitude below mortality endpoints. Further, one would expect an 84-day exposure period to elicit a more sensitive endpoint than a 10-day exposure. One would also expect that these results are more environmentally realistic because the exposures occurred in the field and previous studies (Henderson and Salazar, 1996; Salazar et al., 1987; Salazar and Salazar, 1995a, 1996) have shown that steady state is reached after an exposure period of about 60 days.

There are several other important points made in the two Meador (Meador et al., 1996; Meador, 1997) papers that have been missed however: (1) It takes about 45 days to reach steady state between TBT in amphipod tissues and TBT in sediments: and (2) There was little difference in sensitivity on a tissue residue basis between three different amphipod species, a worm, and a flatfish. At steady state, there was little difference in species sensitivity on a tissue residue basis. The answer to the question regarding relative sensitivity of amphipods and mussels should really be related to the exposure period and the endpoints being measured. The way the tests are conducted, mussels are more sensitive than amphipods because the exposure period is much longer (84 days vs 10) and the measurement endpoints are generally more sensitive (growth vs mortality). It should be acknowledged however, that if the endpoints are based on the exposure concentration, then the differences will remain.

2. TEST DURATION. It should not be surprising therefore, that there was a lack of concordance in sediment quality triad evaluations of TBT-contaminated sediment that included sediment chemistry, laboratory bioassays, and benthic community structure. Since the amphipod exposures in the laboratory were not in a steady-state condition, one would not expect to see the same effects as community alterations that were in steady state. This can also be used to explain the differential sensitivity between Rhepoxynius and Eohaustorius previously reported by Meador et al. (1993). These tests were only conducted for 10 days, the animals were not in steady state, and Eohaustorius was more sensitive than Rhepoxynius. At steady state however, Meador has recently shown that on a tissue residue basis, there is no difference in sensitivity between the two species. Nevertheless, at steady state, the differences between Rhepoxynius abronius and Eohaustorius washingtonianus are even larger when based on the exposure concentration.

In their study of chronic toxicity of TBT to the marine polychaete worm, Neanthes arenaceodentata, Moore et al. (1991) demonstrate chronic effects on growth and reproduction after a 70-day exposure period. While the main purpose for selecting the 70-day exposure period was to include the reproduction, it seems likely that these animals were also in steady-state. If the time to reach steady state for TBT in Neanthes tissues is similar to that for some amphipods (Meador et al., 1996; Meador, 1997) and mussels (Salazar and Salazar, 1995a), 45-60 days is probably a reasonable estimate and suggests that the 20-day Neanthes exposures are not adequate to reach steady state with TBT in sediment and to reflect effects that would be found in nature. Although Rhepoxynius abronius approaches steady state after only 16 days, it takes approximately 45 days for Eohaustorius to reach the same conditions. The PSDDA agencies should consider extending the test duration of both the amphipod test and the polychaete worm test to approach steady state conditions and equivalent tissue burdens among species.

3. BIOACCUMULATION POTENTIAL. When the original guidance for conducting dredge material bioassays came out in 1977, there was a requirement for assessing the bioaccumulation potential for every sediment of concern. The rationale was that chemicals could be accumulated that might have long-term effects not measured in short-term laboratory exposures. This appears to be what happened in the TBT- contaminated sediments that produced apparently anomalous results. Based on the arguments presented above, it is not surprising that there was this lack of concordance. From a programmatic standpoint, the PSDDA agencies should consider returning to the assessment philosophy of testing every sediment for bioaccumulation potential or at least those that sediments that contain chemicals of concern known to take longer to reach chemical equilibrium and exhibit more chronic effects in nature such as TBT, PCBs, DDT, dioxins, and furans. We also routinely measure percent lipid and percent water as another estimate of animal health. In many cases this would be done anyway to present the data on a lipid-normalized basis. The percent lipid also provides information on general animal health since healthier animals have a higher percentage of lipids. Animals under stress, whether from lack of food or chemicals tend to utilize those lipid reserves and the percentage of lipids decreases. The percent water is routinely used to present data from particular sites on a dry-weight basis. As animals utilize lipids and other chemical reserves the percent water in their tissues also tends to increase. These measurements are usually inversely related. These measurements therefore, could be used an another indicator of health in the Macoma bioaccumulation test. By measuring tissue weights, percent lipids, and percent water at the beginning of the test on a surrogate sample of test animals, and again at the end of the test multiple metrics could be used to estimate animal health. This would increase the value of the bioaccumulation data and give the PSDDA agencies more confidence in their regulatory decisions.

Another generic problem is that there is no requirement to assess animal health in the Macoma bioaccumulation test other than mortality. Since mortality is not a very sensitive endpoint, particularly for bivalves like Macoma, another endpoint needs to be used. The first choice would be to measure whole animal wet-weights and lengths as we do in our mussel deployments as an estimate of growth. Unfortunately, there will probably not be much growth in a 20-day laboratory exposure so the second choice should be to estimate tissue weights at the beginning of the test. We routinely do this as a standard operating procedure by measuring as many animals as there are in each replicate for each treatment. Since normally use 100 animals per replicate and 3 replicates per site, this would be a total of 300 tissue measurements at the beginning of the test. In the case of the laboratory Macoma test this could be represented by 20 animals per replicate and 5 replicates per treatment or a total of 100 measurements at the beginning of the test.

This approach would also provide another way to calibrate measured concentrations of chemicals of concern. Since tissue concentrations are calculated by the ratio of chemical content per gram of tissue mass, tissue mass has a large bearing on the resulting measurements. Another way to interpret bioaccumulation potential is to compare the total chemical content on a per animal basis (ug of chemical) to eliminate the effects of growth dilution or degrowth magnification. This would help to reduce the effects of growth on interpreting the tissue data. The other information that this provides is a more quantitative and sensitive estimate of animal health. If there is not a significant decrease in tissue weights, one could assume that the animals are in reasonably good health. Other endpoints that could assist in determining animal health are measurements of percent water and percent lipids at the beginning and end of the test as described above.

4. PSDDA DATA INTERPRETATION. The PSDDA agencies have emphasized that laboratory tests of toxicity and bioaccumulation are not intended to be exact simulations of nature. Nevertheless, there should be some common scientific thread that brings together issues related to species sensitivity, test duration, and bioaccumulation potential in order to properly interpret the results and use them in a meaningful way to regulate contaminated sediments. There have been a number of negative comments on

the Meador papers (Meador et al., 1996; Meador, 1997) and suggestions that the use of tissue residues to predict effects is invalid. Nevertheless, there is an increasing number of papers supporting the tissue residue approach for predicting environmental effects and using the information in a regulatory context in the scientific literature. I believe that it is one method to bring together the results of laboratory sediment chemistry, laboratory bioassays and benthic community assemblages and we have proposed an exposure-dose-response triad that emphasizes the utility of this approach (Salazar and Salazar, 1995b, in review). Furthermore, both EPA and the Corps of Engineers are developing tissue residue effects databases for this purpose and project that they will be on-line, on the Internet in August, 1997.

Recently, the ecological effects guideline of 2 ug TBT/g tissue (wet wt.) was used as the most conservative of three guidelines (FDA, PSDDA human health, and ecological effects) for interpreting bioaccumulation test data. I believe that this is a dangerous precedent and that it is not a realistic guideline for protection against potential ecological effects. Although Widdows and Page (1993) are cited as one of the references for this threshold effects number, they (Page and Widdows, 1993; Widdows and Page 1991) suggest that effects are possible near 2 ug TBT/g (dry wt.). For marine organisms like amphipods, polychaete worms, and mussels that are generally between 80-90% water, this translates to multiplication factors between roughly 5-10. This means that suggested screening level would be between 10-20 ug TBT/g (dry wt.). Clearly this screening level is not conservative, in terms of environmental protection, since sublethal effects have been measured in a variety of species at concentrations far below 10-20 ug TBT/g (dry wt.). Moore et al. (1991) found reductions in survival at concentrations >17 ug TBT/g (dry wt.). Although our own work has suggested no adverse effects on mussel growth at tissue concentrations <2.5 ug TBT/g (dry wt.), mussel growth is not the most sensitive measurement endpoint and the imposex phenomenon has been reported at concentrations of < 1 ug TBT/g (dry wt.). For this reason the PSDDA agencies should consider a screening level concentration in the same range, depending on the purpose of the screening concentration and the rationale for selecting a conservative versus a non-conservative concentration.

After rereading the suitability determination and the decision of the PSDDA agencies it appears that I have misunderstood your use of the term "conservative". It was my understanding that when the PSDDA agencies made a conservative determination they erred on the side of the environment, not on the side of the applicant. It appears in this case that the PSDDA agencies have disregarded the preponderance of evidence and become conservative with respect to the project rather than the environment. Given the language used in the MEMORANDUM FOR RECORD dated March 17, 1997, it appeared that this document was prepared by an applicant rather than the PSDDA agencies. John Widdows is a world-renowned scientist who does not appear to be particularly pro-environment or pro industry and has pioneered the use of scope for growth in bivalves as a measurement endpoint. My guess is that he probably presented an unbiased interpretation of his data. Because of the size of the error bars in his study, I understand why you may have used the higher number of 10 ug TBT/g dry weight to be absolutely sure of the suitability determination. However, I still believe that you have become conservative in the wrong direction. Furthermore, you have also disregarded the preponderance of evidence suggesting effects at tissue concentrations <10 ug TBT/g (dry wt.), including our own work. Attachment 19A (Beaverson et al., 1996) cites 14 different studies that show adverse effects.

While the regulations apparently allow some effects at the disposal site, I suggest that the effects that could occur based on the 14 studies cited above would be highly significant. If you carefully examine the 9 experiments we conducted in the most TBT- contaminated yacht basin in San Diego Bay, you will find that the surface site ranged in water concentrations from 72-530 ng TBT/L (mean = 188 ng TBT/L) and the corresponding tissue concentrations ranged from 4.2-15.8 ug TBT/g dry wt. (mean = 9.9 ug TBT/g dry wt.). Your criteria then suggest that tissue burdens measured for a very highly contaminated area, adjacent to ship hulls that were allowed to use TBT antifouling coatings at the time, would be acceptable. Remember that these coatings have now been banned on small vessels in sheltered marinas for this reason. Then compare the growth rates at that particular site with all of San Diego Bay and you will see that they were the lowest in each of the experiments between 1987-1990.

The real problem however, is that your screening level of 2 ug TBT/g wet wt. is approaching levels that associated with mortalities. The Moore et al. (1991) study suggests chronic effects on growth and reproduction between 3-6 ug TBT/g dry wt. and acute effects at tissue concentrations >17 ug/g dry wt. Assuming 84% water (range in Neanthes % water = 82.0%-85.4%), this translates to lethal effects in Neanthes at concentrations above 2.72 ug TBT/g wet wt. Although this is above your suggested trigger it is very close. Given the errors associated with their prediction it is likely that there could be mortalities in Neanthes at the concentration that you have suggested as a reference for evaluating bioaccumulation potential. Although I was not present at the meetings of the TBT working group, Jim Meador told me yesterday that he was under the impression that the group had recommended a trigger in the low ppm level (1-3 ug TBT dry wt.) on a dry weight basis. It appears that there has been another shift in policy or that the PSDDA agencies decided to reject the recommendation of the group as they have the Widdows data and the 14 other studies cited in Attachment 19A. These papers all suggest effects at tissue concentrations of TBT below the suggested reference concentration for evaluating bioaccumulation potential. More importantly, you are permitting tissue burdens that are among the highest ever reported in surviving animals from the most contaminated yacht basin in San Diego Bay that are no longer permitted due to the ban on the use of TBT in those situations. It is surprising that you would permit those concentrations at the disposal site. Perhaps the site condition criteria should also be re-evaluated, particularly those that apparently allow mortality at the disposal site.

5. OTHER INTERPRETATION EXAMPLES. I will now cite two recent examples where interpretation of results from laboratory exposures of Macoma to estimate bioaccumulation potential have been problematic. In the first, the PSDDA agencies recognized that 28 days may not have been sufficient to reach chemical equilibrium between tissue burdens and sediment burdens for the chemicals of concern. Since both chemicals are extremely hydrophobic and take longer to reach chemical equilibrium, it was decided to conduct the exposures for 45 days instead of the usual 28. The problem is that this extended exposure period created other experimental artifacts that compromised the utility of the data.

The results from this evaluation show that the experiment was terminated after 44 days instead of 45 because of increasing mortality rates at the end of the test. Since mortality is not really a very sensitive endpoint, particularly for bivalves like Macoma, the data suggests that tissue weights probably started to decrease several weeks before the increases in mortality became apparent. The real problem is that since changing tissue weights can either under- or over-estimate bioaccumulation potential (depending on whether the chemicals of concern remain behind or are lost with the withering tissues). The PSDDA agencies should give serious consideration to changing their protocols to assess animal health by using tissue weights, percent lipids, and percent water as part of the test protocols to assist in data interpretation. Furthermore, there should be a more quantitative method for estimating steady state than simply extrapolating between log Kow values and approximate times to reach steady state. More guidance for improving animal husbandry can be found in U.S. EPA (1993). They caution against extending the test duration beyond 28 days without a complete change of sediment in the test chambers. Since Macoma is not really sensitive in terms of mortality to these chemicals (this is why they are used to test bioaccumulation potential) it seems unlikely that observed mortalities can be attributed to chemicals of concern. It is much more likely that animals died due to starvation because their supply of nutrition was not renewed. U.S. EPA (1993) give two reasons for changing the test sediment: (1) to provide additional nutrition beyond 28 days; and (2) to prevent dilution of the chemicals of concern in the test sediment. They also suggest rejecting test results if Macoma survival is less than 90%.

In another set of experiments in the vicinity of a pulp and paper mill (Salazar et al., 1997), caged mussels accumulated high concentrations of dioxins and furans in the water column while Macoma exposed to contaminated sediments from the area accumulated very little. Mussels not only accumulated much higher concentrations but their tissues exhibited a much better correlation with Macoma exposed directly to that sediment in laboratory exposures. Proponents of the laboratory exposure method could argue that the dioxins and furans in the sediment were not biologically available. While this is possible, it seems more likely that the test animals in the laboratory test tanks were under stress. They may have remained closed for extended periods of time to avoid chemical exposure, the chemicals could have had some adverse effect and been lost as the tissue mass decreased, or they could have been under severe nutritive stress due to remaining closed or a low food supply in the test sediment. This is another reason for quantifying animal health during the test with some endpoint more sensitive than mortality.

From a conceptual standpoint, this study concluded that the caged bivalve bioassay provided a more realistic assessment of bioaccumulation potential and potential effects because it was conducted in the field, there was a correlation between tissue burdens and growth rate, and the growth endpoint was more sensitive in distinguishing differences among sites than the mortality endpoint. The PSDDA agencies should consider re-evaluating the concept of assessing bioaccumulation potential from the trigger approach, to the way the tests are conducted, to the way the data are interpreted.

5. COSTS vs UTILITY. Costs have always been a significant issue and have been a primary driving force in developing test protocols and the application of those protocols. Nevertheless, it would be conceptually sound to conduct more tests with meaningful measurement endpoints that are appropriately sensitive, have exposure periods that approach steady state conditions, and provide a credible scientific approach for evaluating sediments that are contaminated with all chemicals, but particularly those that are extremely hydrophobic and require longer time periods to reach steady state and exposures that are potentially toxic. If the ultimate issue is cost, and it is not feasible to conduct all the tests in a meaningful way, I suggest that the number of tests be reduced and the quality of each test be improved. For example, just as the PSDDA agencies have suspended the use of the Microtox test for a number of reasons, perhaps it is time to consider a similar approach, particularly for those hydrophobic chemicals mentioned previously. Last year I suggested increasing the exposure period of the Neanthes test and including both growth and reproductive endpoints. This would certainly be a step in the right direction. This test has been used successfully to evaluate TBT-contaminated sediments for example. More recently, long-term tests with amphipods have been used to evaluate sediments contaminated with DDT and PCBs. The PSDDA agencies could also consider site-specific evaluations with caged bivalves. A balance needs to be achieved between the quality and costs of the data. In the final analysis, it could be that the most expensive approach could be the most cost-effective in terms of providing useful information for regulating contaminated sediments.

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NORTHWESTERN AQUATIC SCIENCES

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FAX TRANSMISSION

TO: Dr. David Fox, U.S. Army Corps of Engineers, Seattle District, P.O. box 3755, Seattle, WA 98124-2255. Tel: 206-764-6550; Fax: 206-764-6602.

FROM: Richard S. Caldwell, Northwestern Aquatic Sciences, 334 SW 7th St., P.O. Box 1437, Newport, OR 97365. Tel: 541-265-7225; Fax: 541-265-2799

DATE: May 27, 1997

SUBJECT: Standardization of Reference Toxicant Tests--DMMP Clarification Paper

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Dear Dr. Fox:

We at Northwestern Aquatic Sciences (NAS), wish to express our position as opposing the above referenced proposal for the reasons given below. We realize that DMMP has its own perspective and reasons for wanting these changes. However, we would like the chance to give our laboratory's perspective on the issue.

Although the proposal will have limited effects on our operation, largely just requiring our changing test concentrations, we are opposed in principal to the constantly increasing level of micromanagement of environmental laboratory operations by the regulatory agencies that this proposal perpetuates. That is not to say that we do not fully agree and understand that the regulatory agencies, through an evolutionary process, have the responsibility of defining the testing protocols that they require for carrying out their regulatory obligations. My concern is that the constant revision of minor details by the DMMP regulatory agencies along with similar efforts by other national and regional regulatory entities is largely unecessary, expensive, and, I believe, actually has negative effects on the quality of work in the long run.

Specifically regarding the above proposal, changing test concentrations alone means modifying written procedures, and changing reference toxicants requires establishing new control charts (a minimum of five tests before the data should be considered useable). The latter process, by the way, will probably require laboratories to perform side-by-side reference toxicant testing until their new control charts are sufficienctly developed. Since we are not convinced that the justifications for the proposed changes are meaningfull, we believe that they represent an unnecessary added workload and expense. Experienced aquatic toxicology laboratories have been, for some time, using reference toxicant testing as an in-house QA/QC measure (long ago mandated by EPA). A laboratory's existing records of this testing program, including all of the raw data and the resultant control charts, are readily available for review by any client or agency wishing to investigate the qualifications of a laboratory. Since it seems that the above proposal is at least in part, if not exclusively, a response to concerns about laboratory qualifications, I contend that the DMMP agencies already have ample criteria, including required laboratory participation in accreditation programs, for making laboratory qualifications judgments.

NAS, and other laboratories, provide bioassay testing services to many entities in addition to DMMP (NPDES effluent and sediment testing, hazardous waste testing, risk assessment work, chemical compound testing for manufacturers, TIE investigations, as well as other types of toxicity testing).

We try to use one reference toxicant for each organism that we test, regardless of the type of testing or agency requiring the testing. This is the only way a laboratory can maintain quality data at competitive prices. We provide these services to clients in any of the 50 states and for innumerable agencies (federal, state, county, municipal, etc.) in addition to testing for clients internationally. If every agency requires reference toxicant tests to fit their own rigid specifications, each laboratory will have to maintain several control charts. The usefulness of any one in-house reference toxicant database will be reduced since the number of points will be reduced.

As I have already suggested, some of the specific concerns your paper identifies to justify the proposed actions appear insignificant. For example, the concern that "often two or more partial esponses in the 20-80% range have not occurred" deserves a comment. Most experienced aquatic toxicologists would agree that a good reference toxicant test can be performed using a minimum of five or six concentrations in a 50% dilution series such that at least one concentration results in zero response and one concentration results in a full or 100% response. At least two partial responses will not be uncommon for most toxicant-species combinations under these conditions. Also, while desirable, it is not at all essential for two partial responses to be within the 20-80% range. If probit analysis cannot be used, trimmed Spearman-Karber can and will give a response very similar to probit in most instances we have seen.

The use of higher dilution series such as 70% is also unecessary in my opinion. Any improvement in the accuracy of the point estimate will usually be minimal, and unless addtional concentrations are employed, the chance of not having zero or 100% responses is significantly increased. We have routinely employed 50% dilutions in nearly all of our testing for years and find it almost always acceptable for computing good point estimates (e.g. LC50s, EC50s). This is also the univerally recommended dilution series used by EPA in its testing manuals.

The switching of reference toxicant from cadmium, due to the health issue, is a worthy goal and one that our laboratory has been considering and exploring. However, the suggestion that the toxicant must be copper as copper chloride is again locking laboratories into an unecessary mandated situation. We intend to do our own research into toxicants before changing our program, especially given our extensive existing database with our current reference toxicants and the problems of working with toxicants and disposal of wastes. Again, unless there is some very good regulatory reason, we are generally opposed to being told in minute detail how to conduct the business in which we feel we are experienced professionals, as well as having each agency impose different, specific requirements that add to our cost to do the work.

In summary, I believe that the justifications for this additional proposed micromanagement of testing laboratory operations are not convincing. While benefits appear questionable, added costs and complexity of laboratory operations will occur and will lead to increased costs of studies. I hope you will reconsider this proposal.

Sincerely,

Richard S. Caldwell, Ph.D.

Principal Scientist

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FAX TRANS

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TO: Mr. Dave Bradley, Section Chief, SMS Pr[...] WA. Tel: 360-407-6000; Fax: 360-407-6[...]

FROM: Richard S. Caldwell, Northwestern Aquatic Sciences, 334 SW 7th St., P.O. Box 1437, Newport, OR 97365. Tel: 541-265-7225; Fax: 541-265-2799

DATE: June 6, 1997

SUBJECT: Comment relating to SMARM Issue Paper submitted by Dr. Lawrence McCrone

PAGE 1 OF 2

Dear Mr. Bradley:

At the 1997 SMARM meeting held on May 7, 1997 in Seattle, an Issue Paper was presented by Dr. Lawrence McCrone of PTI entitled *Potential for Grain-Size Effects on Larval Sediment Bioassays*. The contention of this paper was that sediments with a very high proportion of silts and clays (e.g. ≥ 85-90%) may result in high mortality or combined mortality and abnormality of the organisms in the absence of any apparent chemical toxicants. Furthermore, it was suggested that insufficient research results are available, or that available data in the Puget Sound data files have not yet been sufficiently analyzed, to confirm or deny this contention. One of the problems is that testing with fine grained reference site sediments may lead to failure to meet the reference area performance standard of NCMA ≤ 35% and data sets are, therefore, not usable. McCrone proposes in his paper that the extensive existing Puget Sound data files be analyzed and/or appropriate studies be designed and performed to identify and document any grain-size effects on the larval sediment bioassays.

Two attendees at the meeting, Paul Dinnel and Alan Chartrand, gave comments bearing on the McCrone paper. Dinnel's comments were that for sediments with high fines contents, it might be anticipated that the non-swimming embryos, added after the protocol-specified four hour settling period, could be smothered by a continuing settlement of fines and that this might cause early mortalities. His recommendation was that a longer, perhaps overnight, settling period be employed before addition of embryos. Chartrand cited recent methods employed in California studies in which larval organisms are confined in a screen cage and thus prevented from direct contact with the bottom sediments, and suggested that this approach might provide a solution to the high mortalities often observed in the larval tests.

Our laboratory has had extensive experience performing these tests for many clients over nearly ten years with all four of the protocol species (two bivalves, two echinoderms). Based on this experience, it is clear to us that there are many potential, difficult to control, situations that are capable of altering the results of a larval test based on the PSEP protocols. We certainly agree that sediments with high fines contents settle more slowly and that this slow settling almost certainly results in a covering of the embryos leading to unknown effects on their survival. The embryos of all four recommended species do not swim at the time of inoculation in the tests and rapidly settle onto, or into, the sediments.

It should also be kept in mind that the PSEP larval tests are really very much "recovery" tests. In other words, the endpoint we are actually observing is a count of recovered larvae, both normal and abnormal. The procedure followed is to carefully decant or siphon the overlying water to separate it from the sediments on the bottom of the test vessel, then to quantitatively count a subsample of the aqueous phase. The problem is that many normal larvae may be lost in the sediments, and the proportion of lost larvae may be easily influenced in a number of ways, most of which are directly related to the swimming behavior of the normal larvae at the time of test termination. Clearly each species may be expected to differ in at least some of these swimming behaviors; therefore each species may be expected to show a different response in the test regardless of any differences in sensitivity to available toxicants.

Some, but certainly not all, of the factors that may influence the larval swimming behavior at the time of test termination include: suspended fines or other particulates, phototactic responses, geotactic responses, diurnal rhythms, and general condition or health of the culture. Phototactic and geotactic responses, which are known to change during different stages of larval development in many species, would have a very important influence on the proportion of swimming larvae at the time of test termination. We have no idea, as far as I am aware, if any changes in tactic responses occur, for the species we employ, around the normal test termination times. If there are diurnal cycles in swimming behavior, should we be terminating tests at a particular time of day? Responses encouraging normal larvae to swim or stay near or on the bottom will result in much poorer recovery (read mortality) than if the larvae stayed in the water column.

We think it is very possible that the fineness of the sediments may also influence recovery of normal larvae since during decanting of the overlying water fine sediments often tend to collapse on themselves more so than do coarser sediments. It may be the inconsistency of such events from beaker to beaker that causes sometimes high variability between replicates.

Another conclusion we have often heard (and seen in our studies) is that bivalves seem to perform less well than echinoderms in terms of meeting reference area performance standards, and in overall survival in test sediments. We have, over many years, consistently observed in test vessels that do not contain sediments (e.g. in effluent tests or PSEP controls) that normal bivalve larvae tend to be found on the bottom of the vessel, often to one side. These larvae appear to be morphologically completely normal and are usually found actively moving in an upright position along the bottom. Their presence on the bottom may be a positive geotactic response or may possibly be due to a negative phototactic response to the overhead laboratory lights. The latter may be especially indicated by our observation that the larvae are usually mostly on one side of the beaker bottom. Is this the side furthest from the lights? Clearly this behavior of apparently normal and healthy organisms can be expected to result in very poor recovery (read high mortality) in test and reference area sediments.

In summary, not only do I agree, for reasons given above, that it is possible that fine sediments could result in high mortality and/or poor recovery (read mortality) compared with coarser sediments, but that there are many other reasons, mostly related to swimming behaviors, that may significantly affect the recovery (read mortality) of test organisms in the PSEP larval tests. Almost all of the problems stem from the potentially very variable and unquantifiable loss of organisms in the sediments. If this type of protocol is to be used despite the poor recovery problem, then it is important for us to better understand specific swimming behaviors of the selected test organisms, especially near the time of test termination.

Let me be clear that I am not suggesting that we discontinue regulatory use of the larval tests. We have known for decades that these larval organisms are important toxicology surrogates for the thousands of marine species that employ free swimming larval dispersal stages and I encourage their use whenever appropriate. What I am suggesting is that research aimed at solving some of the obvious problems with the method might be long overdue. Furthermore, I would encourage the DMMP and SMS Programs to consider that use of the larval protocol on a pass/fail basis at this time may represent questionable judgement considering the issues discussed above.

Sincerely,

Richard S. Caldwell, Ph.D.
Director, Technical Programs

cc: Dr. Teresa Michelsen, WDOE, Bellevue
Dr. David Kendall, COE, Seattle
Dr. Justine Barton, EPA, Seattle
Dr. Lawrence McCrone, PTI, Bellevue

Port of Seattle

June 6, 1997

VIA FACSIMILE: ORIGINAL TO BE MAILED

Brian R. Applebury, P.E.
Chief, Operations Division
Seattle District Corps of Engineers
P.O. Box 3755
Seattle, WA 98124-2255

David Bradley
Washington Department of Ecology
MS PV-11
P.O. Box 47600
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Re: Ninth Annual Sediment Management Annual Review Meeting (SMARM) – Follow-up Comments on SMS Annual Review

Dear Mr. Applebury and Mr. Bradley:

On behalf of the Port of Seattle, we appreciate the opportunity to participate in the Sediment Management Annual Review Meeting (SMARM), the activities that led up to it, and those that will follow. We have only a few comments to the Washington Department of Ecology (Ecology) for SMS annual review beyond those that have already been provided in our earlier SMS triennial review correspondence (dated August 15, 1995 and May 22, 1996).

Triennial Review

We are very pleased to see Ecology begin to meet with the SMS Implementation Committee to discuss priority issues for review and revision of the SMS Rule. We remain prepared and willing to work with Ecology in this endeavor, and to assist Ecology in fleshing out recommendations for rule revisions into specific rule language, so long as Ecology keeps the process focused and moving along without undue delay.

Recalculation of the sediment criteria based upon updated AET values is fundamental to this rule revision effort. As you know, the Dredged Material Management Program (DMMP) convened a Regulatory Work Group to address appropriate changes to AET methodology and DMMP regulatory guidelines. This Work Group produced a high quality final report to the DMMP agencies within a relatively short period of time (three months). Ecology should seek to reconvene this Work Group, or an appropriate subset of it, in early or mid-summer to discuss how to apply its recommendations to revision of the SMS Rule. The Port of Seattle participated in the

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earlier Work Group, and would be willing and interested in participating again in a Work Group focused on producing timely recommendations for revision of AETs and sediment criteria numbers in the SMS Rule.

Review of SMS Rule Under Executive Order 97-02

In March 1997, Governor Gary Locke signed Executive Order 97-02 directing each state agency to begin a review of its rules that have significant effects on business, labor, consumers, and the environment. Agencies are directed, in part, to concentrate their regulatory review on rules or portions of a rule that have been the source of complaints, concerns, or other difficulties that relate to matters other than the specific mandates of the statute on which the rule is based. Each rule identified for review must be reviewed under the following criteria: need; effectiveness and efficiency; clarity; intent and statutory authority; coordination; cost; and fairness. Agencies must determine if the rule should be retained in its current form, or amended or repealed if it does not meet the above review criteria.

The SMS Rule should be among the rules prioritized for review by Ecology under this Executive Order. In 1991 Washington State was the first state in the country to adopt a rule with specific pass/fail sediment criteria, and apparently remains the only state with a specific management standards rule for sediments. The Rule was promulgated under very general statutory authorities and does not have a specific statutory mandate. Since its adoption, the Rule has been the source of complaints, concerns and other difficulties, evidenced by the regulatory work groups formed to address specific SMS Rule implementation issues (e.g., Stormwater and Sediment Liability Discussion Group [1992-1993] and Sediment Cleanup Work Group [1994]) and the numerous comments received during annual and triennial reviews.

As currently drafted, the SMS Rule appears to fail at least some of the review criteria identified in the Executive Order:

- *Need* -- There are inconsistencies between the SMS and MTCA Rules. Placing the sediment cleanup standards portion of the SMS Rule into the MTCA Rules would serve to reduce existing inconsistencies and redundancies between the rules and generally serve the interests of regulatory reform.

- *Effectiveness and Efficiency* -- There is broad consensus among many in the regulated community and state government that the SMS Rule is not providing the results that it was originally designed to achieve in a reasonable or timely manner. Our understanding is that Ecology has not authorized any sediment impact zones as yet except by rule in the case of net pens. Most cleanups have occurred as part of CERCLA cleanups or incidental to in-water development projects and maintenance dredging operations, and could be addressed under existing programs (MTCA and DMMP).

- *Clarity* -- The SMS Rule is not written and organized in a clear and concise manner so that it can be readily understood by those to whom it applies.

- *Intent and Statutory Authority* -- As noted above, many aspects of the SMS Rule do not stem directly from enabling statutory authority. The Rule could be revised to focus on those areas with specific legislative authorization.

In consultation with the Sediment Implementation Committee, Ecology should determine how the SMS Rule should be amended (or possibly repealed) to meet the rule review criteria specified in Executive Order 97-02. This review should be coordinated with Ecology's ongoing triennial review and sediment criteria recalculation effort, and should be completed by the end of 1997.

Human Health Sediment Criteria Development

As the Port has repeatedly indicated, given the significant methodological and practical impediments to doing so, and given the regulatory reform principles outlined in Executive Order 97-02, it is not appropriate to adopt or impose human health sediment criteria at this time. Some of the methodological problems with developing human health criteria along the lines proposed by Ecology are discussed in Appendix A to this comment letter. Practical and policy problems are discussed below.

The ongoing discussions regarding AET recalculation exemplify one of the primary practical impediments to developing human health sediment criteria at this time -- the difficulty of updating sediment criteria after initial adoption. When adopted, a principle underlying the SMS rule was that, as the rule was based on an evolving science, the rule would be regularly revised to incorporate new science and new data. In practice, despite significant new information, the rule has proved particularly resilient to much-needed updating. Given this history, and given the significant technical uncertainties that underlie human health sediment criteria (see Appendix A), the Port has little confidence that any such regulatory regime, whether based on biota accumulation factors (BSAFs) or otherwise, would be flexible enough to incorporate rapidly evolving information.

Finally, consistent with the regulatory reform principles outlined in Executive Order 97-02, Ecology should ensure that its existing SMS rule is performing well and as intended before adopting a new rule involving human health sediment criteria. From a policy perspective, fixing an existing regulatory regime that is not working very well before adding new and uncertain regulatory requirements to that regime is simply using common sense. As discussed above, much work is needed on the existing SMS rule to improve its clarity, effectiveness and efficiency.

Conclusion

We thank you for the opportunity to comment on the SMS Rule, and look forward to working with Ecology in seeing the triennial review and sediment criteria recalculation process through to a timely conclusion. Please call us if you have any questions concerning the comments provided in this letter.

Sincerely,

Port of Seattle

Douglas A. Hotchkiss   Thomas A. Newlon

DAH:mdw

cc: Dan Silver, Washington State Department of Ecology
Eric Johnson, Washington Public Ports Association (WPPA)
Konrad Liegel, Preston Gates & Ellis LLP
D. Michael Johns, EVS Consultants

APPENDIX A TO PORT OF SEATTLE JUNE 6, 1997 SMS ANNUAL REVIEW COMMENT LETTER

HUMAN HEALTH SEDIMENT CRITERIA DEVELOPMENT

In their 1996 SMARM follow-up comment letter, the Port of Seattle (Port) and the Washington Public Ports Association suggested that Ecology further pursue ways to use fish tissue data should Ecology move forward with developing human health sediment criteria. In response, Ecology put forth several possible ways to use fish tissue data and requested further comment on the approaches outlined and on other possible approaches. The following is the Port's response to Ecology's request for a more detailed discussion of the issues surrounding human health sediment criteria development and possible approaches to the same using fish tissue data.

The Port continues to have significant reservations about the technical approach being used by Ecology to establish human health concerns associated with the consumption of seafood. Should Ecology move forward with developing human health sediment criteria, which the Port does not advise at this time for the reasons provided in the cover letter, the Port believes Ecology should consider an alternative approach to human health criteria -- an approach that first uses a screening tissue concentration to determine if a human health risk problem exists, and, if so, a more realistic, site-specific assessment of the risk.

The current Ecology criteria development model uses both human health risk assessment approaches and equilibrium partitioning theory to derive sediment contaminant concentrations that are protective of human health. Ecology assumes that a set of sediment quality concentrations can be established that adequately protect human health. These sediment quality concentrations are intended to achieve regulatory simplicity in that no data, other than sediment chemical concentrations, are needed to make decisions to protect human health. However, as demonstrated in Ecology's previous developmental work on this topic, the model can lead to interpretations about sediment contamination that are highly misleading and that undermine the regulatory simplicity apparently achieved through sediment quality concentrations. For example, the model predicts that sediment concentrations of PCBs, total PAH, as well as a number of PAH compounds, in virtually all of Puget Sound exceed the concentration at which human health would be compromised by the consumption of seafood. This raises several possibilities, including the following:

- there is a potential crisis in Puget Sound from consuming seafood due to the contaminants associated with the sediments; or

- the model is simply overstating the human health risks because of errors in the translation of seafood tissue to sediment concentrations using biota sediment accumulation factors (BSAFs).

After analyzing the model being developed by Ecology, it is our opinion that too much uncertainty (i.e., variability) accompanies the translation of seafood tissue residue concentrations to sediment contaminant concentrations using BSAFs to make BSAFs a useful regulatory tool. For instance, PTI (*Analysis of BSAF Values for Nonpolar Organic Compounds in Finfish and Shellfish,* 1995) performed non-linear regression analyses to try to find relationships between BSAFs and $\log(K_{ow})$ values. While they found some highly significant regressions that could be used to estimate mean BSAF values based on the K_{ow}, the variability of a specific BSAF for a given K_{ow} spanned several orders of magnitude. The significance of the regressions comes primarily from the fact that the sample sizes are so large (one of the regressions recommended for use had a sample size of 1,532, a $p < 0.001$, and an R^2 of 0.139); consequently confidence in the mean BSAF was relatively high. PTI noted that caution should be used when drawing conclusions, that is only that "the mean BSAF can be predicted with greater confidence than an individual BSAF value." If BSAFs are to be used, and Ecology is going to use the regression equations developed in the PTI report to establish the K_{ow}-specific BASF, then the valid comparison for sediment chemical concentrations resulting from the model calculations would be mean sediment concentrations from the study area (or fish species home range), and not the upper percentile values being considered currently by Ecology, since the average sediment concentration is consistent with a mean BSAF generated using regression analysis.

The uncertainty surrounding establishing contaminant-specific BSAFs is compounded by the uncertainty associated with the conservative exposure assumptions employed in the human health fish tissue consumption model. In particular, three exposure assumptions have the most uncertainty: (1) ingestion rates -- the ingestion rate of 420 g/day is based on Tulalip and Squaxin Indian tribe finfish consumption rates and not necessarily the exposed population at the site of contamination; (2) fraction ingested --the assumption that the exposed population consumes fish only from the contaminated source and no other fish (of any type) from any other location; and (3) exposure frequency and duration -- the period of time that an exposed population consumes fish from the contaminated source is assumed to be 365 days a year for 30 years. All three of these assumptions may lead to significant overestimates in true risks.

Also, Ecology has assumed to date that tissue residue concentrations found in aquatic organisms arise from direct exposure to sediment. As you are aware, the accumulation of contaminants can also occur through the food chain or from the water column. At any given site, these factors may be of more significance than direct exposure to sediment.

Therefore, because of the unacceptable uncertainties associated with the use of BSAFs in regulatory decisionmaking and the issue of what exposure pathways are contributing to seafood tissue residue levels, the Port has, along with others, recommended that, if Ecology is going to pursue human health criteria development, it at least consider adopting a different model for criteria development that provides a direct focus on tissue residue concentrations as the most immediate regulatory endpoint. The reasons for such a recommendation are obvious and well stated in James W. Male's regulatory options draft concerning the use of fish tissue criteria (prepared for Ecology in 1994): (1) seafood tissue residue concentrations, when applied in a human health consumption model, provide a direct estimate of the potential risks; (2) the uncertainties accompanying use of BSAFs are eliminated; and (3) sampling can be specific to those fish consumed.[1]

Ecology outlined in the 1996 SMARM meeting minutes some approaches to use of fish tissue residue concentrations and asked the Port to respond. The first alternative would use tissue residue data as an override to Tier I human health sediment criteria, similar to the biological override currently used with SMS sediment quality criteria. The other two alternatives outlined by Ecology would be used as part of the site-specific Tier II analysis. One approach proposed using fish tissue and associated sediment data to calculate site-specific BSAFs, while the second approach proposed using fish tissue data to make bay- or river-wide cleanup and source control decisions based on exceedence factors. The second approach relies on calculating an exceedence factor based on tissue levels in a specific bay or river as compared to target human health-based tissue levels, and then conducting cleanup in the most contaminated areas until the bay- or river-wide sediment concentrations are reduced by the same exceedence factor.

The Port believes that all of the approaches outlined by Ecology that utilize sediment concentrations to signify potential health threats to humans through the consumption of fish are fatally flawed. They still rely on the use of BSAFs to set Tier I sediment quality concentrations. Using BSAFs to set Tier I sediment quality concentrations is improper for the reasons discussed above. Using BSAFs to set Tier I

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[1] Establishment of fish tissue criteria is not problem free. As noted by Male (1994), it is difficult to determine in general if sediment, as opposed to the water column or the food chain, was the avenue by which seafood was contaminated. This problem, however, is inherent in the development of any human health sediment criteria, whether based on BSAFs or fish tissue residue concentrations, and calls into question the appropriateness of developing "one number fits all" human health sediment criteria in the first place. In the end, because of these complexities, removing and containing a lot of sediment based on human health sediment criteria may have little effect on actually lowering human health risks associated with seafood consumption.

sediment quality concentrations is also impractical in that the resulting concentrations will be so low that virtually any sediment in Puget Sound will trigger site-specific Tier II testing.

An alternative to a BSAF-based approach would be to modify Ecology's second "Tier II" approach to use seafood tissue concentrations that are related to human health concerns as the primary screen in the Tier I analysis for human health concerns at a site or within a watershed. The tissue levels would be based on a conservative assessment that is protective of the segment of population at greater risk for consumption of those fish that have the majority of their contaminant uptake from a benthic food chain. If tissue concentrations from a site are below this value, then Ecology can be confident that the consumption of benthic associated seafood collected from the site does not pose a risk. This would be analogous to the SL under the Dredged Material Management Program, which essentially meets a "reason to believe" analysis concerning the risks posed by seafood consumption. The tissue residue concentrations would not be based at background concentrations, but rather would be representative of the lower range of contamination that does not result in risks from consumption.

Using this approach, Tier II analysis would be required if the fish tissue concentrations at a site exceed Tier I levels. By necessity, both the level of testing effort required and the source control/cleanup actions undertaken would be based on site-specific conditions. Determining the type of fish consumed (may be different from Tier I), who consumes seafood from the study area (or the area which includes the home range of the species being consumed) and the amount of food of that species from that area consumed, could be among the factors to be considered in the Tier II analysis. These factors play a significant role in calculating risk, and should better reflect site conditions that are different than predicted from the risk calculations developed for the Tier I "reason to believe" assessment. Other factors that should be taken into account include the home range of the seafood species of concern relative to overall exposure. These factors and others have been discussed by Ecology in their *Alternative Decision-Making Frameworks Document*. The ultimate goal of the analysis would be to determine if there is a human health risk, and, if there is, what source control/cleanup actions could be taken that would effectively reduce the human health risk to an acceptable level.

Given our comments in the cover letter and these technical comments, the Port believes that it is not appropriate to adopt or impose human sediment criteria at this time. Should Ecology persist in this endeavor, however, we recommend to Ecology that their human health criteria development efforts be refocused to: (1) developing Tier I tissue residue concentrations that are analogous to the PSDDA SL; and (2) developing a guidance document that both identifies and discusses the factors for consideration in a Tier II analysis and presents an approach for doing the Tier II analysis itself (using case study examples). Doing so will provide guidance to both Ecology field staff responsible for project-level decision making and to project proponents on how best to address site-specific issues. This alternative approach provides a better method for evaluating the primary concerns (i.e., is there a human health risk associated with the consumption of seafood?) and places much of the emphasis for addressing potential concerns at the site-specific level where focused assessments can be made concerning Tier I seafood consumption assumptions, species home range and exposure pathways. If following the Tier II assessment, an unacceptable human health risk exists, then site specific sediment cleanup plans may need to be developed in which target cleanup goals (using BSAF and other approaches) will be established.

The Port would be pleased to meet with Ecology staff to discuss further the approach to use of seafood tissue concentrations outlined above. Please give us a call if you wish to arrange such a meeting.

APPENDIX C

SMARM Overheads

LIST OF OVERHEADS

Ted Benson

Ovrhd 5-1.	Presentation Agenda
Ovrhd 5-2.	PSDDA Monitoring Framework
Ovrhd 5-3.	PSDDA Monitoring Tools
Ovrhd 5-4.	Modifications for the 1996 Monitoring Program
Ovrhd 5-5	Chemical Tracking System
Ovrhd 5-6.	Raw Data - Examples from CBP01, Commencement Bay
Ovrhd 5-7	False Alarms. Hypothetical Example
Ovrhd 5-8	Correlations Among Chemicals Varies and Affects Analysis and Conclusions
Ovrhd 5-9.	Chemical Tracking System (flowchart)
Ovrhd 5-10.	Fitted Time Trends in Chemical Concentrations
Ovrhd 5-11.	Power to Detect Real Trends Depends On...
Ovrhd 5-12.	Power Curves (Simplified Examples)
Ovrhd 5-13.	Outliers Affect Estimated Trend. Hypothetical Example
Ovrhd 5-14	What Else Can Help Determine if Chemicals are on the Move?
Ovrhd 5-15	Findings
Ovrhd 5-16.	Summary of 1995 Conditions
Ovrhd 5-17.	Summary of 1995 Conditions (cont'd)
Ovrhd 5-18.	1995 Benchmark Sediment and Tissue Chemistry
Ovrhd 5-19	1995 Benchmark Sediment and Tissue Chemistry (cont'd)
Ovrhd 5-20	Sediment Vertical Profile System (SVPS)
Ovrhd 5-21.	Commencement Bay Stations
Ovrhd 5-22.	Distribution of Infaunal Successional Stages in 1996
Ovrhd 5-23	Surficial Footprint of Silt-clay Dredged Material in 1996
Ovrhd 5-24	Distribution of Grain Size Major Mode in 1996
Ovrhd 5-25	Distribution of Apparent RPD Depths in 1996
Ovrhd 5-26.	Dredged Material Footprint at Commencement Bay Site in 1996
Ovrhd 5-27	Distribution of Dredged Material at the Commencement Bay Site
Ovrhd 5-28	Distribution of Organism-Sediment Indices in 1996
Ovrhd 5-29	Sediment Chemistry
Ovrhd 5-30.	Sediment Bioassays
Ovrhd 5-31	Evaluation of 1996 Monitoring Data
Ovrhd 5-32	Evaluation of 1996 Monitoring Data (cont'd)
Ovrhd 5-33	Chemical Tracking System Output for Commencement Bay Station CBP01
Ovrhd 5-34	Maximum Likelihood Results for Commencement Bay Perimeter Stations.
Ovrhd 5-35	Chemical Tracking System Output for Commencement Bay Station CBP03
Ovrhd 5-36.	Evaluation of 1996 Monitoring Data
Ovrhd 5-37	Evaluation of 1996 Monitoring Data
Ovrhd 5-38	Recommendations

Rachel Friedman-Thomas

Ovrhd 6-1	SMS Sediment Activities
Ovrhd 6-2.	Sediment Program Implementation (Sediment Source Control)
Ovrhd 6-3.	Sediment Program Implementation (Sediment Cleanup)
Ovrhd 6-4	Sediment Program Implementation (Information Management and Lab Accreditation)
Ovrhd 6-5	Sediment Program Challenges (Sediment Source Control)
Ovrhd 6-6	Sediment Program Challenges

Teresa Michelson

Ovrhd 7-1	Status of Sediment Cleanup Sites
Ovrhd 7-2.	Program Accomplishments
Ovrhd 7-3	Cleanup Decision Summary

Dave Bradley

Ovrhd 8-1	SMS Triennial Review
Ovrhd 8-2.	Triennial Review Background
Ovrhd 8-3.	Triennial Review Draft Responsiveness Summary
Ovrhd 8-4	Triennial Review Issues
Ovrhd 8-5	Triennial Review Issues (cont'd)
Ovrhd 8-6.	Triennial Review Next Steps
Ovrhd 8-7	Triennial Review Challenges

Justine Barton

Ovrhd 9-1	Beneficial Use of Dredged Material
Ovrhd 9-2	Interagency/Intergovernmental Agreement
Ovrhd 9-3.	Products
Ovrhd 9-4	Pre-Application for Material
Ovrhd 9-5	Resolving Conflicts
Ovrhd 9-6	Resolving Conflicts (cont'd)
Ovrhd 9-7.	Sediment Characterization
Ovrhd 9-8.	Sediment Characterization (cont'd)
Ovrhd 9-9.	PSDDA Comparisons
Ovrhd 9-10	Suitability Determination Process
Ovrhd 9-11.	Suitability Determination Process (cont'd)

Teresa Michelson

Ovrhd 10-1	Wood Waste Impacts
Ovrhd 10-2	Wood Waste Characterization and Cleanup

David Kendall

Ovrhd 11-1.	Proposed DMMP Actions
Ovrhd 11-2.	Proposed DMMP Actions (cont'd)

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING

Ovrhd 1-1. Sediment Management Annual Review Meeting

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING

Jointly Sponsored
by the
PSDDA Program and SMS Group

Seattle District Joint Use North Auditorium
Seattle, WA

May 7, 1997

Hosted by Seattle District, Corps of Engineers

Ovrhd 1-2. SMARM Sponsors and Host

MEETING OBJECTIVES AND PURPOSE

- Obtain public input on proposed changes to the Dredged Material Management Program (DMMP) Management Plans per Issue Papers and Clarification Papers mailed out with the Sediment Management Annual Review Meeting announcement.
- Discuss disposal site management actions and changes.
- Presentation and discussion of Public Issue Papers.
- Comments and discussion on Status Reports of ongoing actions of DMMP and SMS Group.

Ovrhd 1-3. Meeting Objectives and Purpose

Dredged Material Management Program Overview

- Summary actions of previous Annual Review Meeting
- Summary of DMMP project / testing activities
- DMMP Homepage / Use of Internet for Communication
- Disposal site monitoring

Ovrhd 1-4. Dredged Material Management Program Overview

SMS Group Overview

- SMS activities and Annual Review
- Regional cleanup activities
- Triennial Review Status

Ovrhd 1-5. SMS Group Overview

PSDDA Clarification Papers (presented)

DMMP:

- Beneficial uses guidelines

DMMP / SMS:

- Management of Woodwaste

Ovrhd 1-6. PSDDA Clarification Papers (presented)

Issue Papers (DMMP)

- Verification methods for dredging of unsuitable material

- Regulatory Workgroup Recommendations: Short-term Screening Level (SL) and Maximum Level (ML) adjustments

Ovrhd 1-7 Issue Papers (DMMP)

Public Issue Papers

DMMP/SMS:

- Progress in developing a Puget Sound AET for the *Neanthes* biomass/growth endpoint (Mike Johns, EVS)
- Potential for grain-size effects on larval sediment bioassays (Lawrence McCrone, PTI)
- Strategies and technologies for contaminated sediments management: Report by National Resources Council (Spyros Pavlou, URS Greiner)

SMS:

- Sediment cleanups should focus only on those stations exceeding cleanup screening levels of the sediment management standards (Lincoln Loehr, Heller, Ehrman, White, & McAuliffe)
- Inplace dilution cleanup as a concept (Lincoln Loehr, Heller, Ehrman, White, & McAuliffe)

Ovrhd 1-8. Public Issue Papers

Clarification Papers (not presented)

DMMP:

- Revisions to site guidelines for chemistry

DMMP / SMS TIM*

- Negative controls in bioassays
- Standardization of Reference toxicants

* TIM = Technical Information Memorandum

Ovrhd 1-9. Clarification Papers (not presented)

Status Reports (not presented)

- Bellingham Pilot Project
- SMS Triennial Review
- Human Health Criteria
- Columbia River Evaluation Framework
- Designating Sediment Impact Zones for Disposal Sites
- Bioassay Statistics
- AET Methodology: Clarification and Minor Revisions

Ovrhd 1-10. Status Reports (not presented)

Summary and Closing

- Public Issues Summary (Agencies will convene a post-SMARM meeting on May 15 to review and prioritize public issues for DMMP action. The DMMP prioritization decision will be posted on the DMMO homepage and published in the minutes.)
- SMS Issues Summary
- Written comments may be submitted on the SMARM proceedings, but must be submitted to the DMMP agencies by May 21, 1997 for consideration. Written comments may be submitted for SMS annual review consideration by June 7, 1997.

Ovrhd 1-11. Summary and Closing

SUMMARY AGENCY RESPONSE ACTIONS TO MAY 1996 SMARM

Ovrhd 2-1. Summary Agency Response Actions to May 1996 SMARM

Joint PSDDA/SMS Issues

TBT Issues:

- Assessment of TBT sensitivity in amphipod species was not accomplished during the past year due in part due to funding constraints, and because current TBT regulatory and cleanup guidance (DMMP/SMS) requires bioaccumulation testing in lieu of acute bioassay testing. However, the DMMP agencies are finalizing a scope of work to assess TBT sensitivity in the *Leptocheirus plumulosus* (amphipod) chronic/sublethal 28-day test. As part of this effort comparative sensitivity of *Leptocheirus plumulosus* to *Eohaustorius* will also be assessed.

- The final TBT issue paper removed all references to a regulatory maximum level (ML) upper limit for TBT. There currently is no established TBT upper limit for regulatory decision making for either dredging/disposal and cleanup.

- The interstitial TBT level adopted as the DMMP screening level (SL), 0.15 ppb was also adopted as the bioaccumulation trigger.

- DMMP and SMS established an interim tissue TBT action level of 2 ppm (wet weight), which was used to evaluate bioaccumulation data for the Port of Seattle/ T-18 project.

Ovrhd 2-2. Joint PSDDA/SMS Issues (TBT Issues)

DMMP / SMS Issues

- The DMMP and SMS agencies do not have the resources to assess sulfur and sulfide effects on the saline microtox and solid phase microtox bioassay. Microtox testing has been suspended for dredged material evaluations since 1994 due to its apparent lack of sensitivity and non-concordance with the other bioassays in the DMMP test suite.

- The DMMP and SMS agencies re-examined and reaffirmed the initial weight standard (>0.25 mg/individual; 0.5 mg/individual as target) and negative control growth rate standard (> 0.38 mg/individual/day; 0.72 mg/individual/day as target) for the *Neanthes* 20-day growth bioassay.

Ovrhd 2-3. DMMP/SMS Issues

DMMP / SMS Issues

- The EPA/Corps ammonia purging protocol was utilized for one large dredging project (Port of Seattle/T-18), and was found to satisfactorily reduce ammonia levels to acceptable levels (< 20 mg/liter). The Port of Seattle/EVS investigated the effects of ammonia purging on contaminant concentrations in sediment interstitial water. The results of these investigations are available at the back table for those interested.

Ovrhd 2-4. DMMP/SMS Issues (Continued)

DMMP Issues

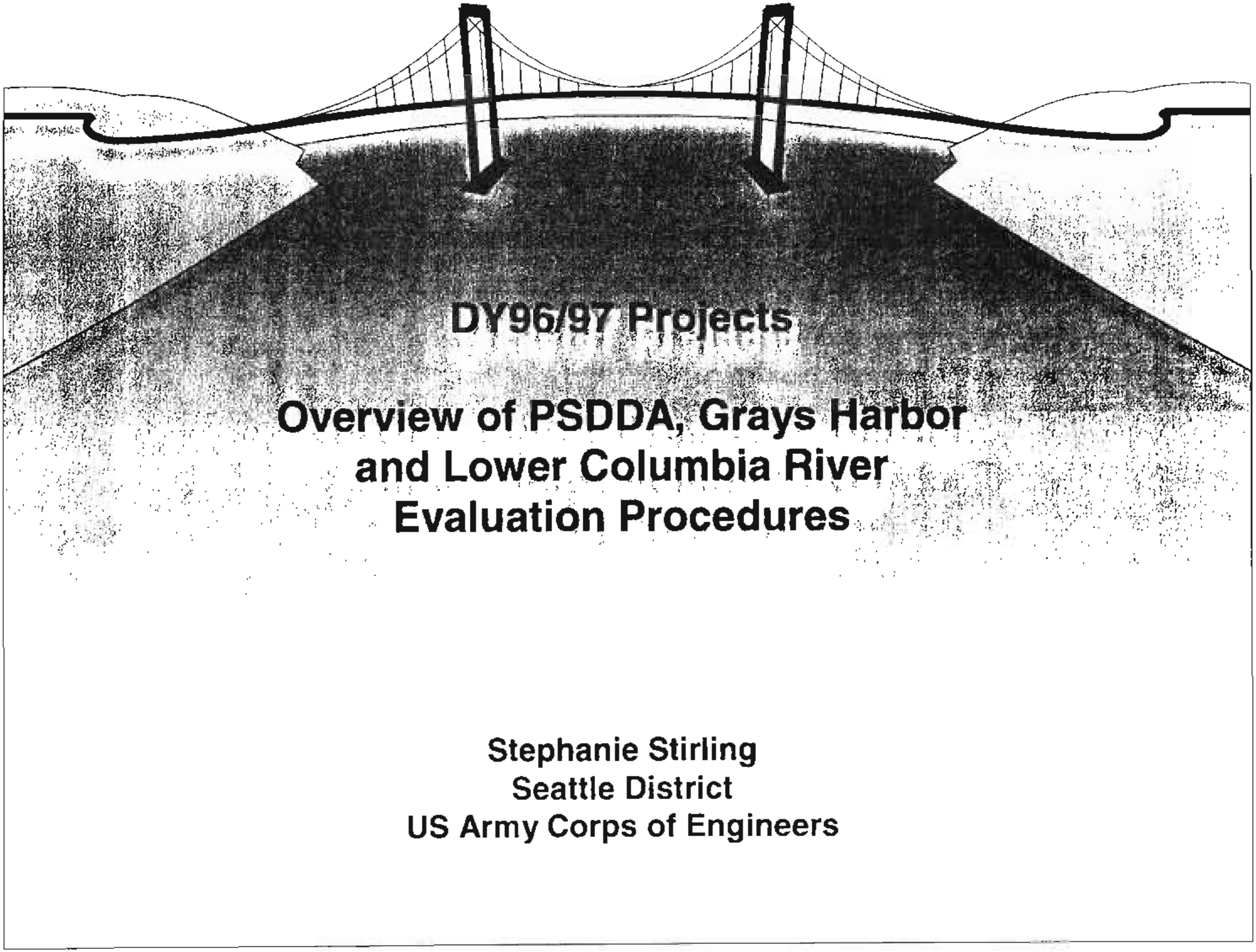
- Ecology convened a Regulatory Workgroup under the DMMP to address substantive issues raised by the public and ports at the 1996 SMARM concerning AET recalculations. The outcome of these deliberations are summarized in an issue paper that will be presented this afternoon and a status report, both of which were mailed out as part of the SMARM meeting package.

Ovrhd 2-5. DMMP Issues

CSMP Issues

- The interagency Bellingham Pilot demonstration project was initiated in September 1996 by the CSMP agencies (see SMARM mailout for a status summary).

Ovrhd 2-6. CSMP Issues



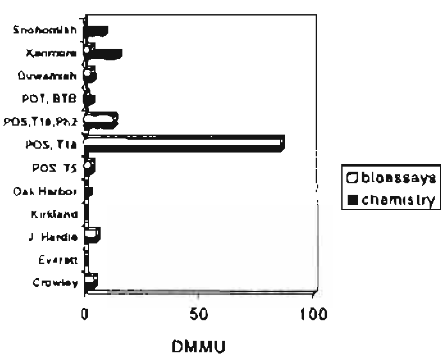
Ovrhd 3-1. DY96/97 Projects: Overview of PSDDA, Grays Harbor, and Lower Columbia River Evaluation Procedures

DY96/97 Project Volumes: Puget Sound

• Crowley Marine	13,000
• Port of Everett NCD/Berth	370,000
• James Hardie Gypsum	18,000
• City of Kirkland	800
• Oak Harbor Marina	27,000
• Port of Seattle, T5	36,000
• Port of Seattle, T18	538,350
• Port of Tacoma, Blair TB	755,000
• USACE Duwamish	112,000
• USACE Kenmore	60,000
• USACE Snohomish	300,400
TOTAL	2,230,550

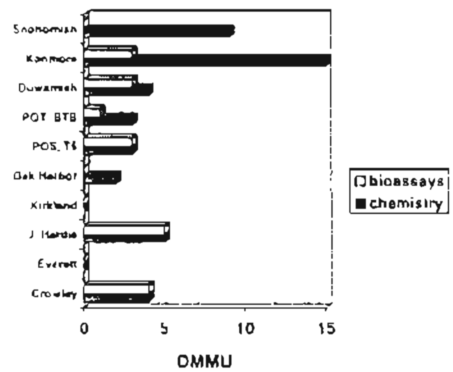
Ovrhd 3-2. DY96/97 Project Volumes: Puget Sound

Chemical and Biological Testing



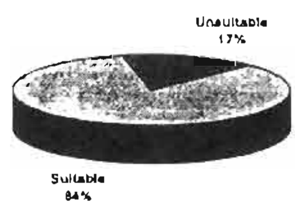
Ovrhd 3-3. Chemical and Biological Testing

Chemical and Biological
Testing



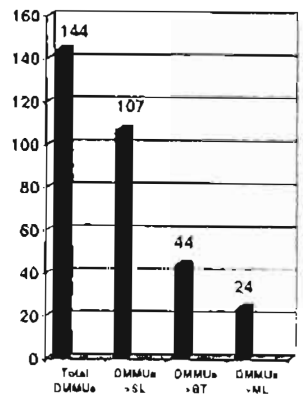
Ovrhd 3-4. Chemical and Biological Testing (Continued)

Suitable/Unsuitable
Dredged Material



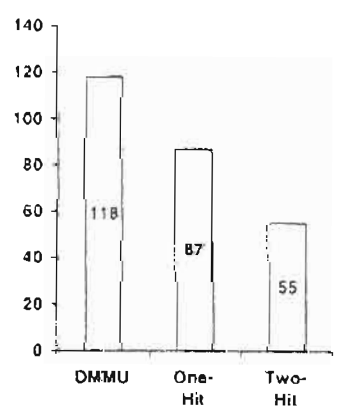
Ovrhd 3-5. Suitable/Unsuitable Dredged Material

Chemistry Testing Summary



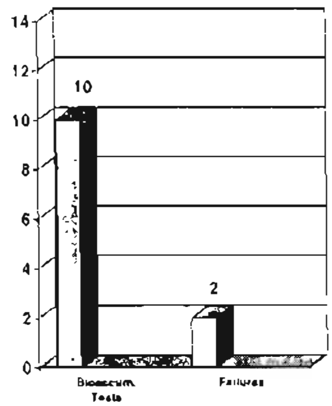
Ovrhd 3-6. Chemistry Testing Summary

Bioassay Hits



Ovrhd 3-7. Bioassay Hits

BioaccumulationTesting



Ovrhd 3-8. Bioaccumulation Testing

Project Volumes: Grays Harbor

Terminal 2	15,000
Rayonier	20,000
Bay City	20,000

Ovrhd 3-9. Project Volumes: Grays Harbor

Project Volumes:
Columbia River

- High Cascade/Stevenson 20,000
- Mt. Coffin Channel 200,000

Ovrhd 3-10. Project Volumes: Columbia River

Total Volume

2,605,550 cubic yards

Ovrhd 3-11. Total Volume

Use of the Internet

1997

Sediment Management Annual
Review Meeting

Ovrhd 4-1. Use of the Internet

Seattle District's Home Page Address

http://www.nps.usace.army.mil

select

"Dredged Material Testing Requirements"

to get to DMMO's home page

Ovrhd 4-2. Seattle District's Home Page Address

Existing Content:

- email addresses for DMMO staff
- links to other DMMP agency homepages
- changes that have been made to PSDDA via the ARM process and public workshops since 1989 (listed both chronologically and by topic)

http://www nps.usace.army.mil

1997 Sediment Management Annual Review Meeting

Ovrhd 4-3. Existing Content

Soon-to-be-Existing Content:

- SAP examples
  - large projects
  - small projects
- PSDDA Users Manual

http://www.nps.usace.army.mil

1997 Sediment Management Annual Review Meeting

Ovrhd 4-4. Soon-to-be-Existing Content

Future Use:

- biennial reports
- posting of draft SMARM papers
- SMARM minutes
- updated DMMP manuals

http://www.nps.usace.army.mil

1997 Sediment Management Annual Review Meeting

Ovrhd 4-5. Future Use

Special Thanks!

★ Lori Danielson
  - Web Manager

★ Theresa Bauccio
  - PSDDA updates

http://www.nps.usace.army.mil

1997 Sediment Management Annual Review Meeting

Ovrhd 4-6. Special Thanks

PRESENTATION AGENDA

- PSDDA Monitoring Tools
- Modifications to the 1996 Partial Monitoring Approach
- *Chemical Tracking System*
- 1996 Findings
- 1996 Evaluations
- Monitoring Modification Recommendations

Ovrhd 5-1. Presentation Agenda

PSDDA MONITORING FRAMEWORK

- 1. Dredged material remain onsite?
  - Sediment Vertical Profile System
  - Sediment Chemistry
- 2. Biological effects conditions exceeded?
  - Sediment Chemistry
  - Sediment Bioassays
- 3. Adverse effects to offsite biological resources?
  - Tissue Chemistry
  - Infaunal Community Structure

Ovrhd 5-2. PSDDA Monitoring Framework

PSDDA MONITORING TOOLS

PSDDA disposal site station types and monitoring tools.

Station	SVPS	Sediment Chemistry	Bioassays	Benthic Infauna	Tissue Chemistry
Zone (Z)	●	●	●		
Site (S)	●	○	○		
Perimeter (P)	●	●			
Transect (T)	●			○	○
Benchmark (B)		●(A)	●(A)	○(A)	○(A)
Central Transect (C)	●				
Reference (R)			●		

○ Monitoring tools used for an intensive full monitoring program
● Monitoring tools used for a partial monitoring or full monitoring program
(A) Archived

Ovrhd 5-3. PSDDA Monitoring Tools

MODIFICATIONS FOR THE 1996 MONITORING PROGRAM

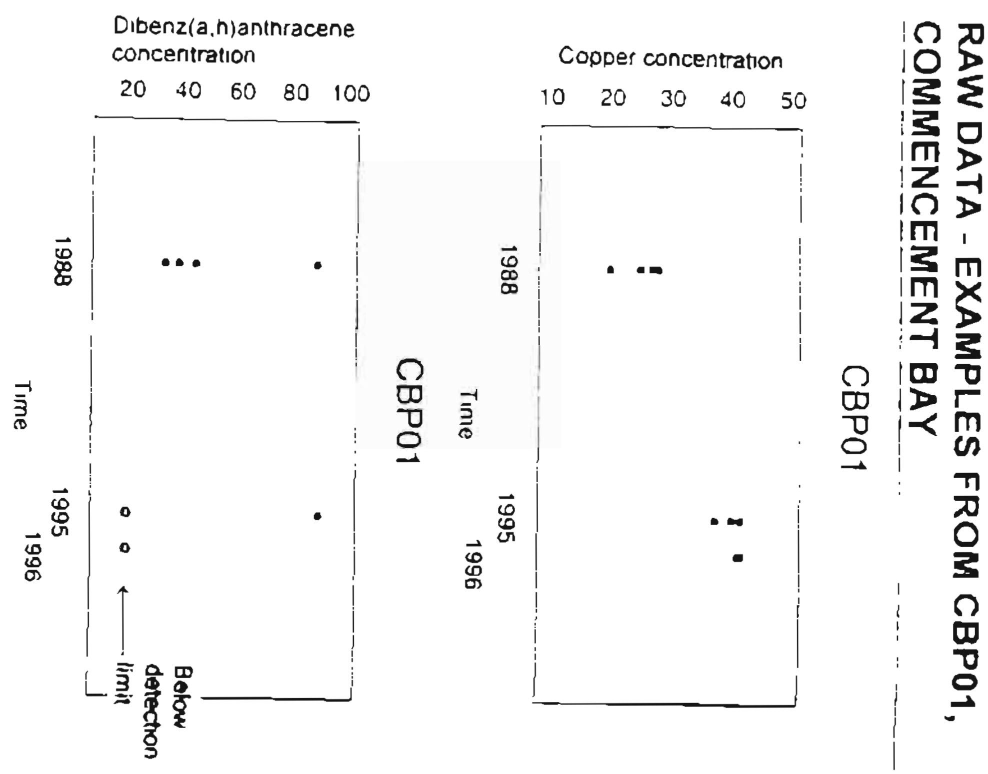
- Programmatic Change
  - Hypothesis 2 - Using the SQS as triggers instead of Guideline Values
  - Application of *CTS* to perimeter chemistry results
- Technical Change
  - Use of DGPS instead of microwave navigation

Ovrhd 5-4 Modifications for the 1996 Monitoring Program

CHEMICAL TRACKING SYSTEM

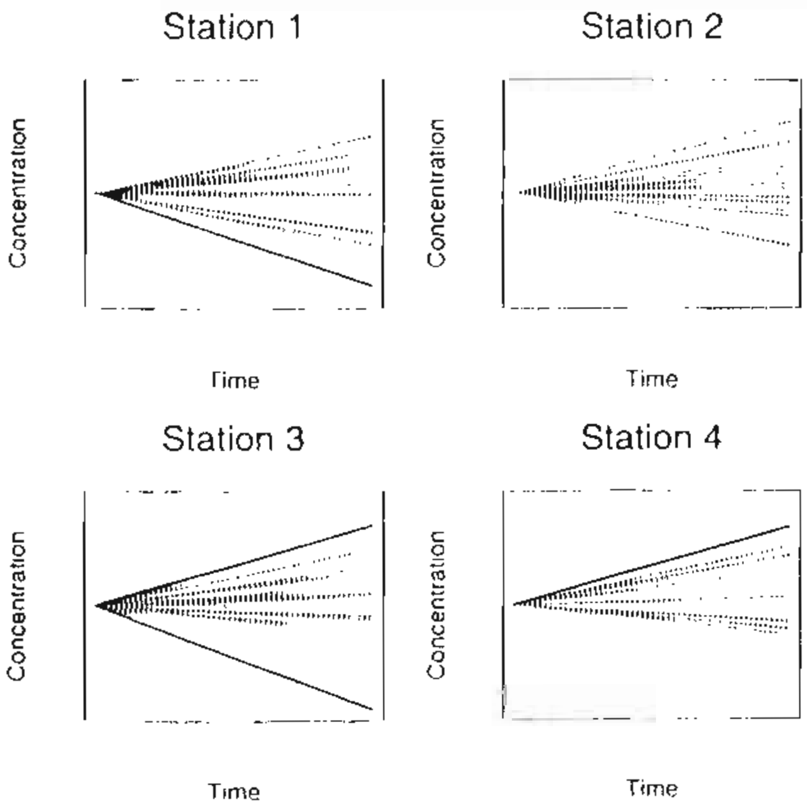
- Calculates time trends in single chemicals and groups of chemicals.
- Handles non-detected data.
- Avoids "false alarms" due to random variation and analysis of many chemicals.

Ovrhd 5-5. Chemical Tracking System



Ovrhd 5-6 Raw Data - Examples from CBP01. Commencement Bay

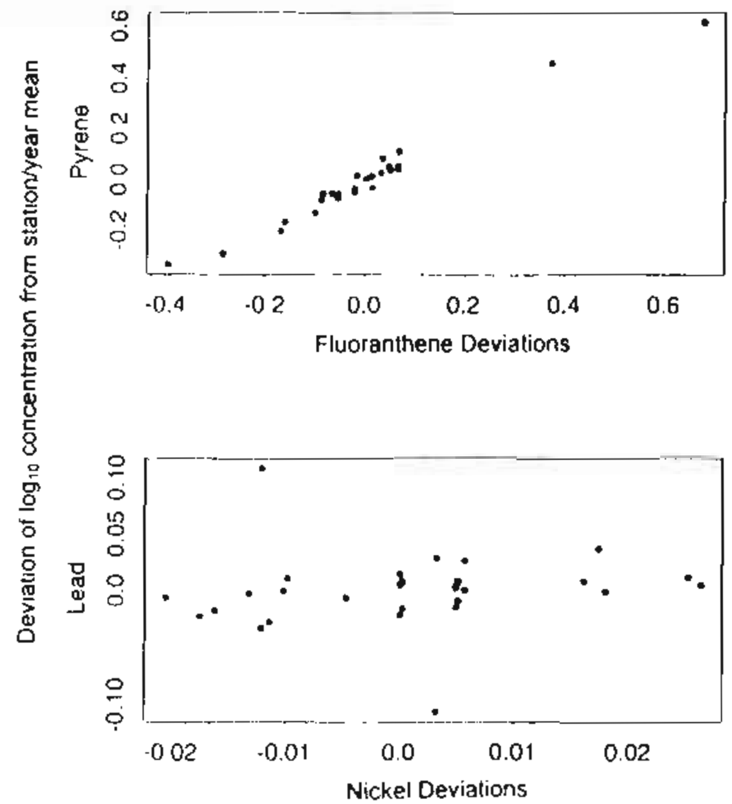
FALSE ALARMS OCCUR WHEN MANY CHEMICALS AND MULTIPLE STATIONS ARE ANALYZED. HYPOTHETICAL EXAMPLE.



25 chemicals at each of four stations. Solid lines: "statistically significant" trends (P< 05). Data were randomly generated with true trend = 0

Ovrhd 5-7 False Alarms. Hypothetical Example.

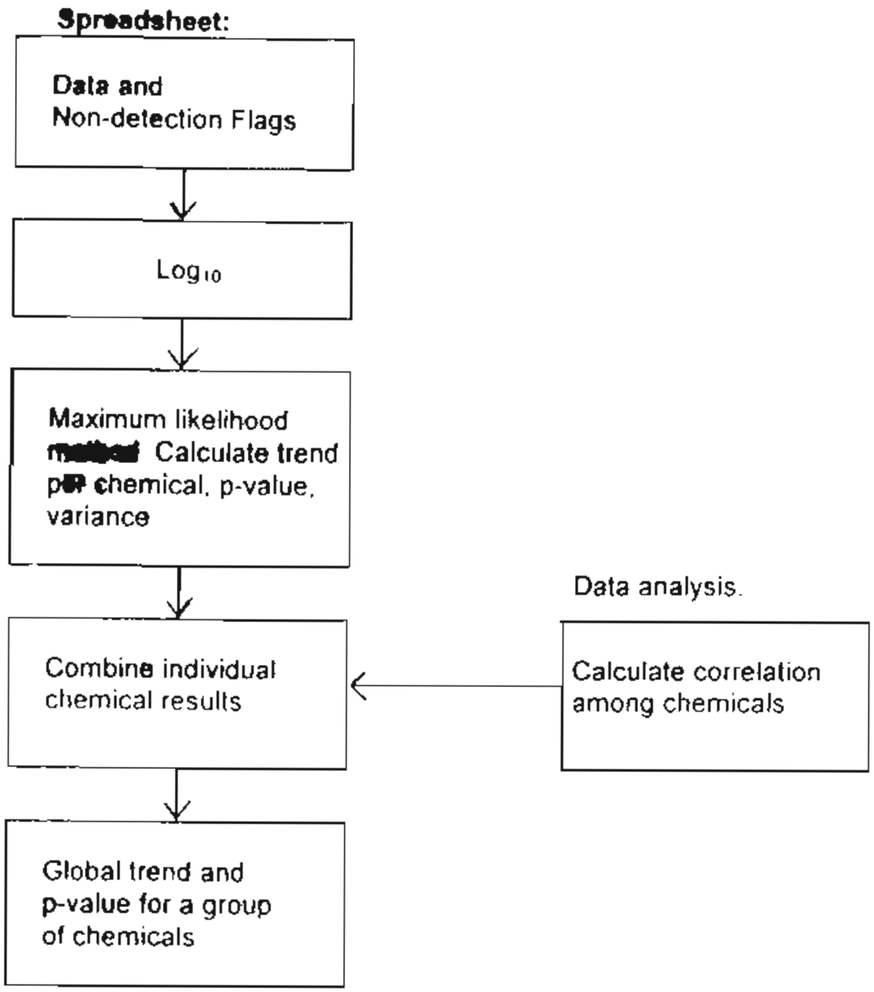
CORRELATION AMONG CHEMICALS VARIES AND AFFECTS THE ANALYSIS AND CONCLUSIONS



Commencement Bay, 1988-96,
CBP01, 03, 07, 11

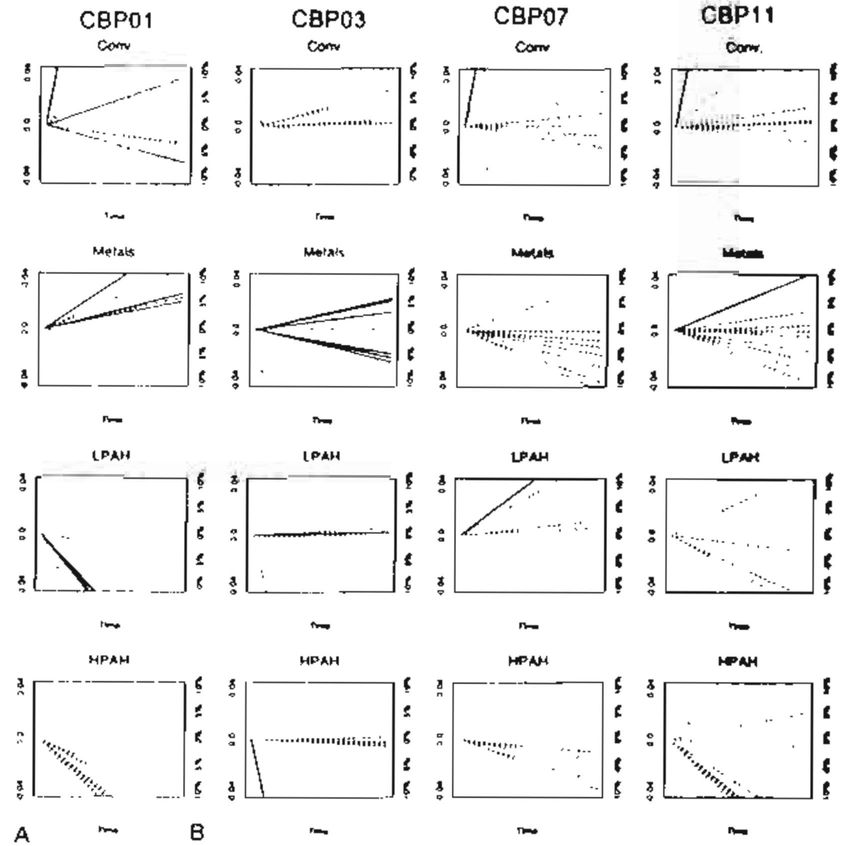
Ovrhd 5-8. Correlations Among Chemicals Varies and Affects Analysis and Conclusions

CHEMICAL TRACKING SYSTEM



Ovrhd 5-9. Chemical Tracking System (flowchart)

Fitted Time Trends in Chemical Concentrations, Commencement Bay, 1988 - 96*



Scale A Deviation of $\log_{10}$ concentration from baseline
Scale B Percent change in concentration per year

*Draft results, based on partial data for some stations

Ovrhd 5-10. Fitted Time Trends in Chemical Concentrations

POWER TO DETECT REAL TRENDS DEPENDS ON . . .

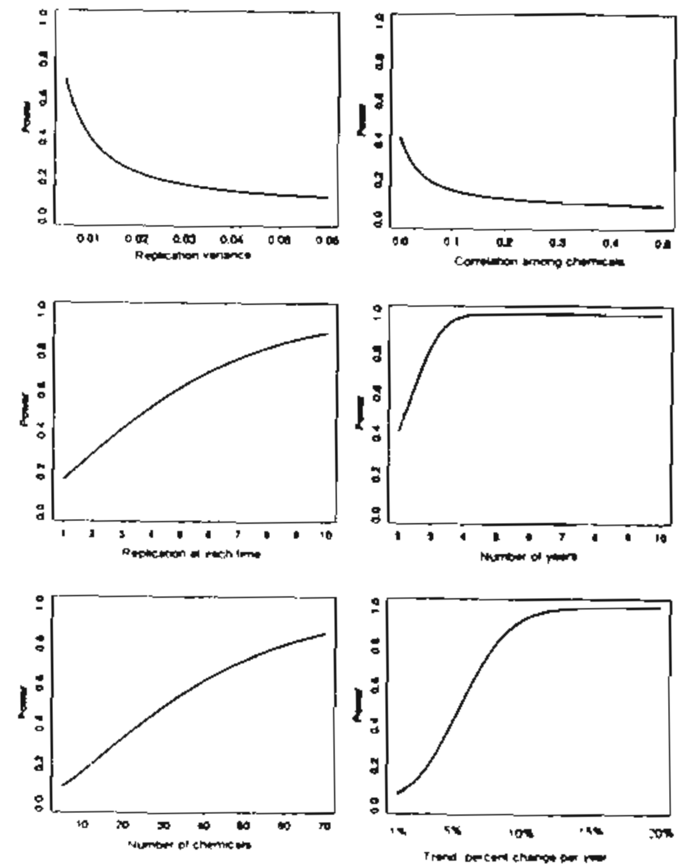
- Number of chemicals considered
- Variability (random "noise")
- Correlation among chemicals
- Number of samples per year
- Number of years
- Magnitude of the real trend

Examples

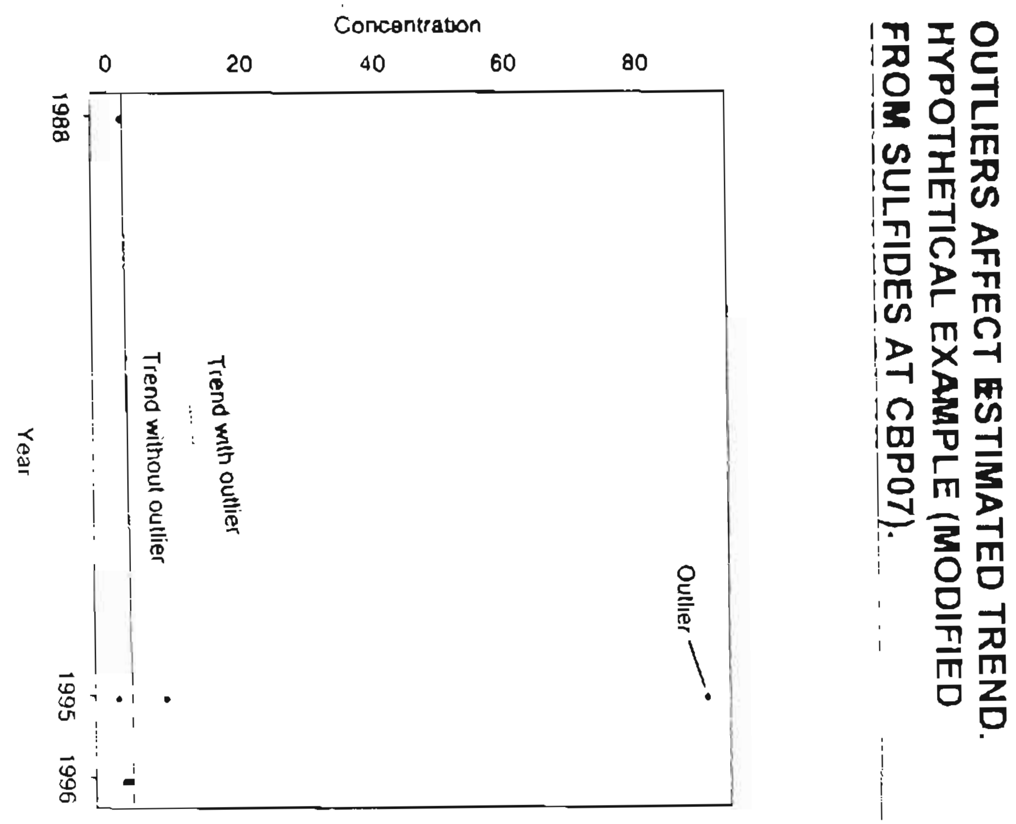
No. of Chemicals	Variability	Correlation	Samples per Year	No. of Years	Power to detect a 5% per year increase
10	high	weak, but not zero	3	2	6%
25	medium	zero	3	2	41%
25	low	zero	3	5	~100%

Ovrhd 5-11. Power to Detect Real Trends Depends On...

POWER CURVES
(Simplified examples)



Ovrhd 5-12. Power Curves (Simplified Examples)



Ovrhd 5-13 Outliers Affect Estimated Trend. Hypothetical Example

WHAT ELSE CAN HELP DETERMINE IF CHEMICALS ARE ON THE MOVE?

- Detect and handle outliers
- Consider other indications of movement besides the "one slope" model
- Compare chemical trends to chemical signature of deposited material
- (Cautiously) Combine trends for two or more stations
- Nonparametric analysis or "bootstrap" for unusual distributions and many outliers.

Ovrhd 5-14. What Else Can Help Determine if Chemicals are on the Move?

FINDINGS

- 1995 Benchmark Chemistry
- SVPS
- Site Chemistry
- Site Bioassays

Ovrhd 5-15. Findings

SUMMARY OF 1995 CONDITIONS

- SVPS
  - Dredged material deposit contained within site perimeter
- Chemistry
  - Metals
    - No exceedance of SL, ML, or SQS at any station
  - Volatile Organics
    - Undetected at all stations
  - Semivolatile Organics
    - No SQS or ML exceedances
    - SL exceedance for PAHs at on replicate of CBP01
- Bioassays
  - No PSDDA Guideline exceedances

Ovrhd 5-16 Summary of 1995 Conditions

SUMMARY OF 1995 CONDITIONS

- Butyltins
  - No detections at any station
- Organics
  - Volatile Organics
    - No detected exceedances
    - 1,2,4-trichlorobenzene DL > SL & SQS
  - Semivolatile Organics
    - No SQS or ML exceedances
    - SL exceedance for PAHs at one replicate of perimeter station PO1

Ovrhd 5-17. Summary of 1995 Conditions (Continued)

1995 Benchmark Sediment and Tissue Chemistry

- Analyzed to complete 1995 Baseline chemistry
  - Volatile organics, mercury, total sulfides analyzed in '95.
- Conventionals
  - Qualified as estimates as these were analyzed 6 months after holding times.
- Metals
  - No exceedance of SL except for lead
    - exceeded SL for all benchmark samples
- Butyltins
  - No detection at any stations
    - DL exceeded PSDDA interim SL for one replicate at CBB02 due to small sample size.

Ovrhd 5-18 1995 Benchmark Sediment and Tissue Chemistry

1995 Benchmark Sediment and Tissue Chemistry

- Semivolatile Organics
  - Pesticides/PCBs were undetected
  - All detected PAHs below SL except indeno(1,2,3-c,d)pyrene
  - 4-methlphenol, benzyl alcohol, and benzoic acid exceeded SL at CBB02.
  - DL for several semivolatile organics were greater than the SL at CBB02
- Tissue Chemistry
  - Metals detected at low levels
  - Organics and butyltins not detected

Ovrhd 5-19. 1995 Benchmark Sediment and Tissue Chemistry (Continued)

SEDIMENT VERTICAL PROFILE SYSTEM (SVPS)

- Recent dredged material footprint
  - Thin deposit at perimeter stations CBP10, P11, and P12
- Fine-grained deposit present at the site center.
  - Dredged material or ambient?
- Effect of dredged material on other measurements
  - Grain-size
  - RPD
  - Successional stages
- Organism Sediment Index (OSI)
  - OSI distribution suggests a resilient benthic habitat

Ovrhd 5-20 Sediment Vertical Profile System (SVPS)

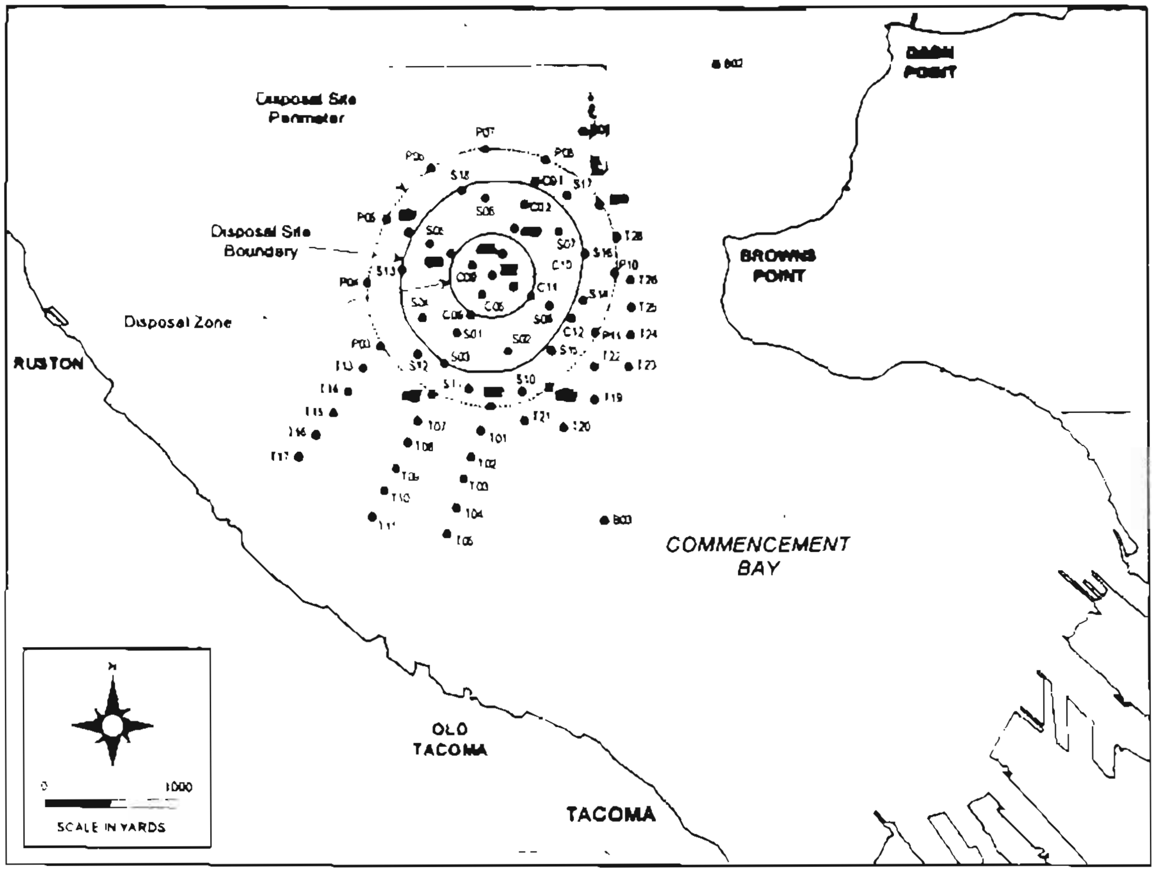


Figure 3-1 Commencement Bay stations

Ovrhd 5-21. Commencement Bay Stations

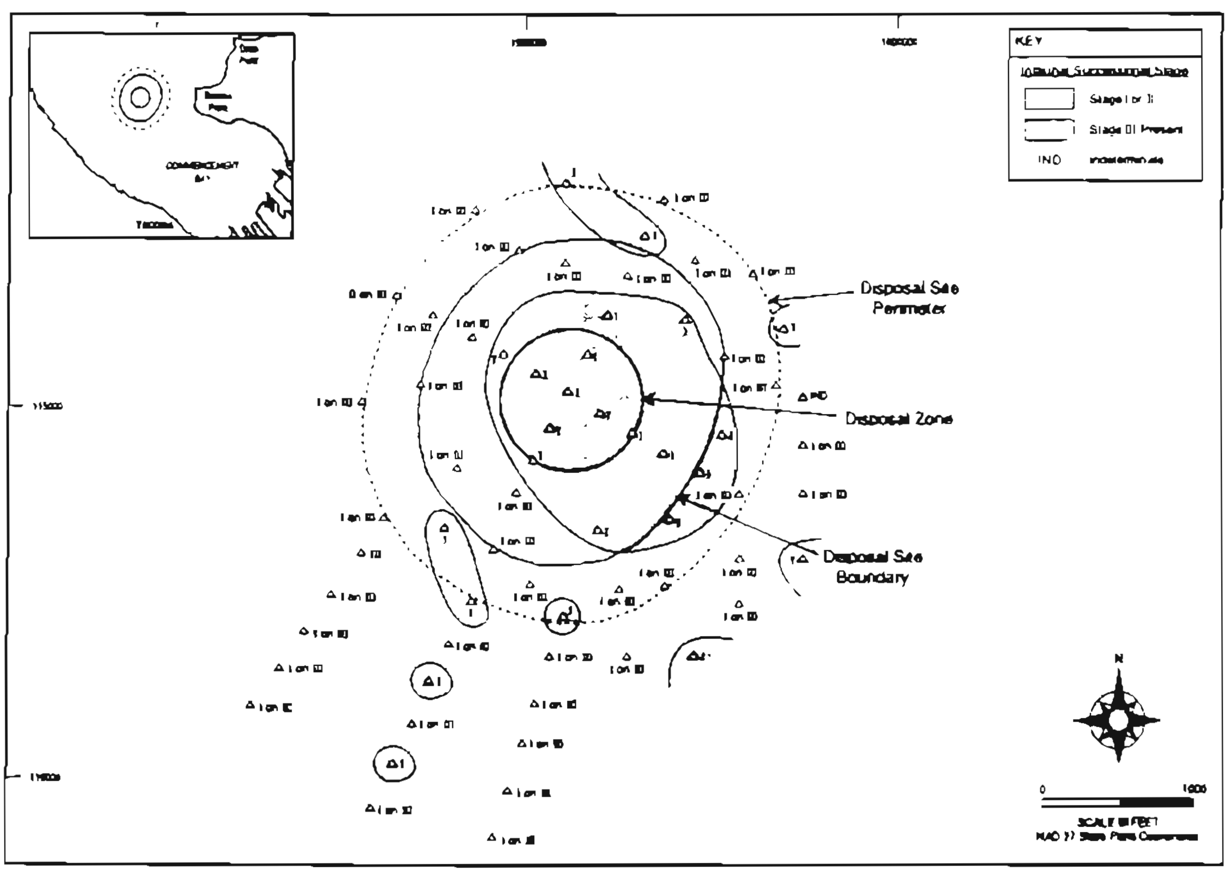


Figure 4-10. Distribution of infaunal successional stages during the 1996 partial monitoring of the Commencement Bay PSDDA disposal site

Ovrhd 5-22. Distribution of Infaunal Successional Stages in 1996

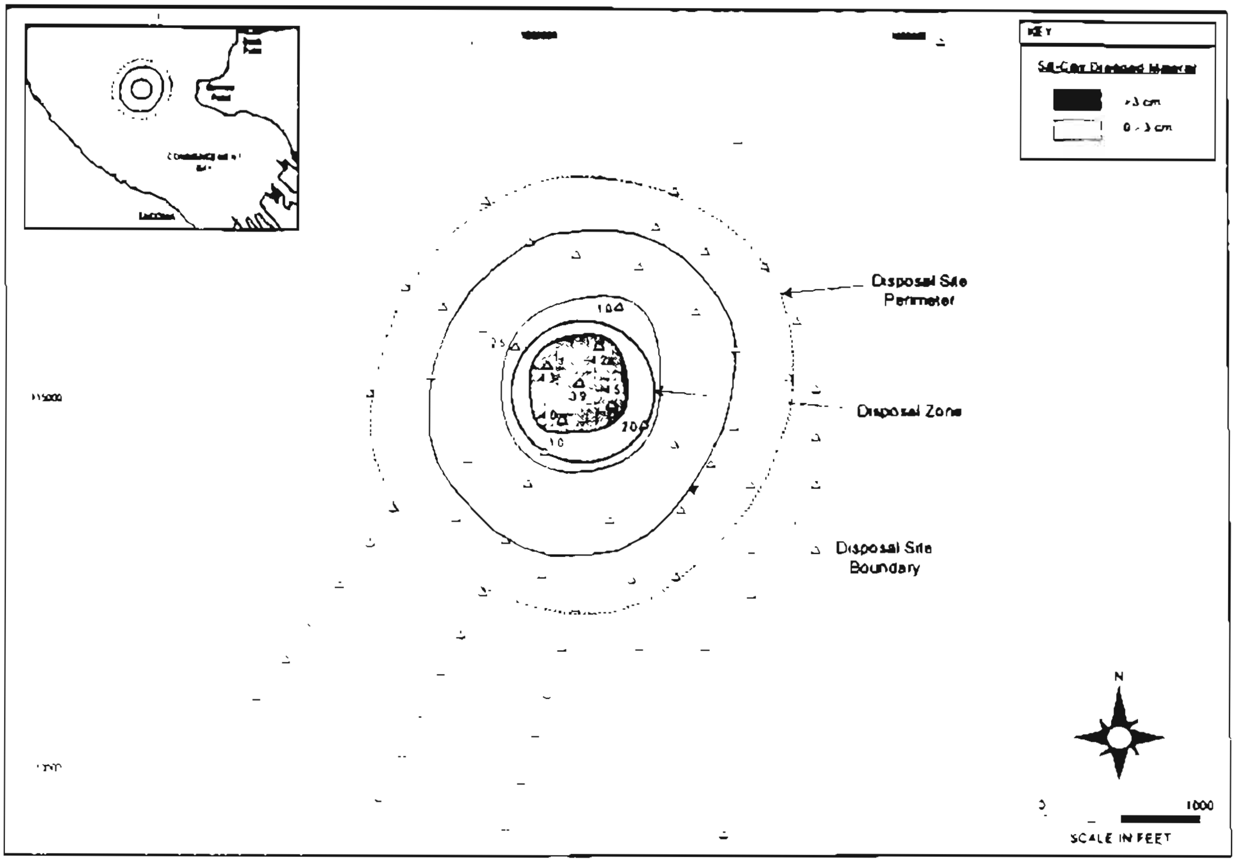


Figure 4-6 Surficial footprint of silt-clay dredged material measured at the Commencement Bay PSDDA disposal site in 1996. The silt-clay deposit overlies the fine sand component of the dredged material deposit. Thickness is measured in centimeters.

Ovrhd 5-23. Surficial Footprint of Silt-clay Dredged Material in 1996

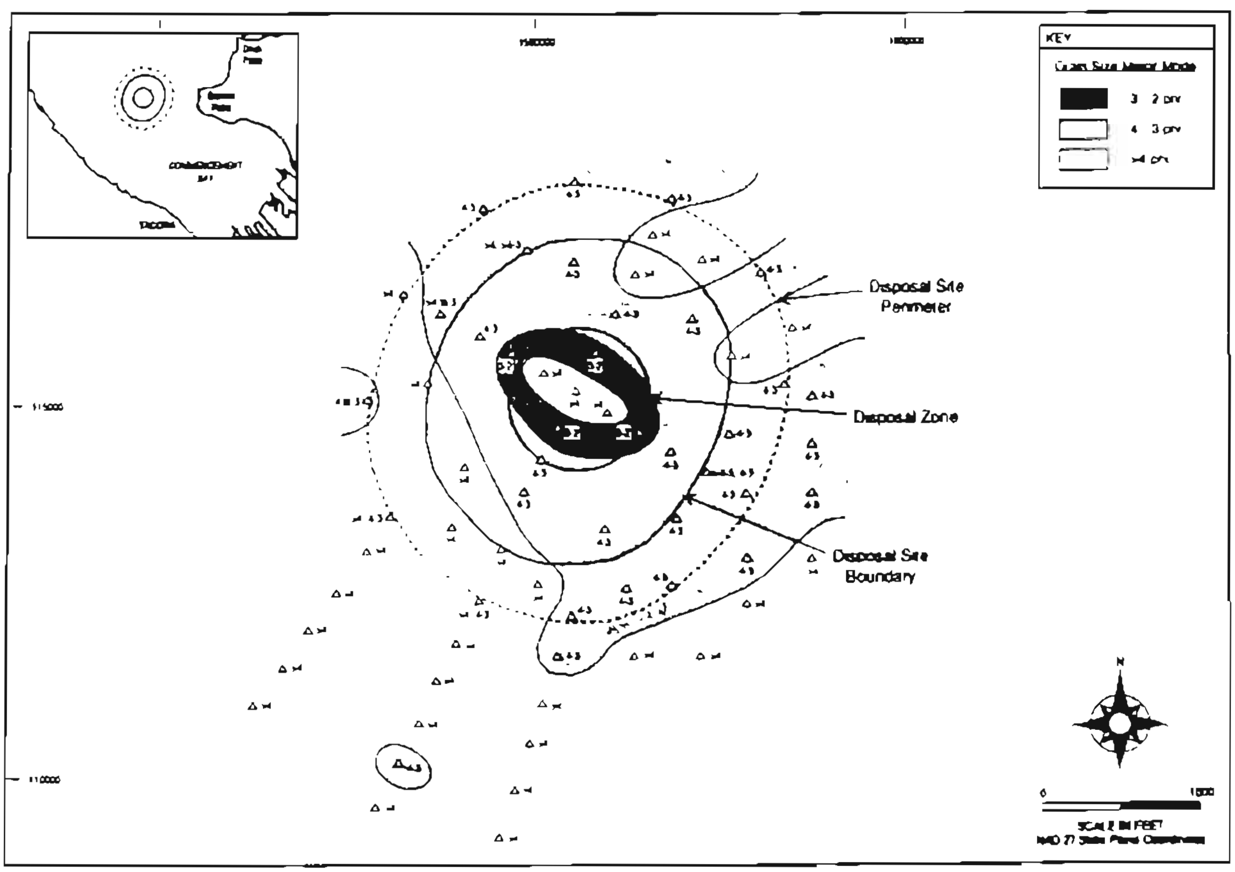


Figure 4-7. Distribution of grain size major mode in phi measured during the 1996 SVPS survey at the Commencement Bay PSDDA disposal site

Ovrhd 5-24 Distribution of Grain Size Major Mode in 1996

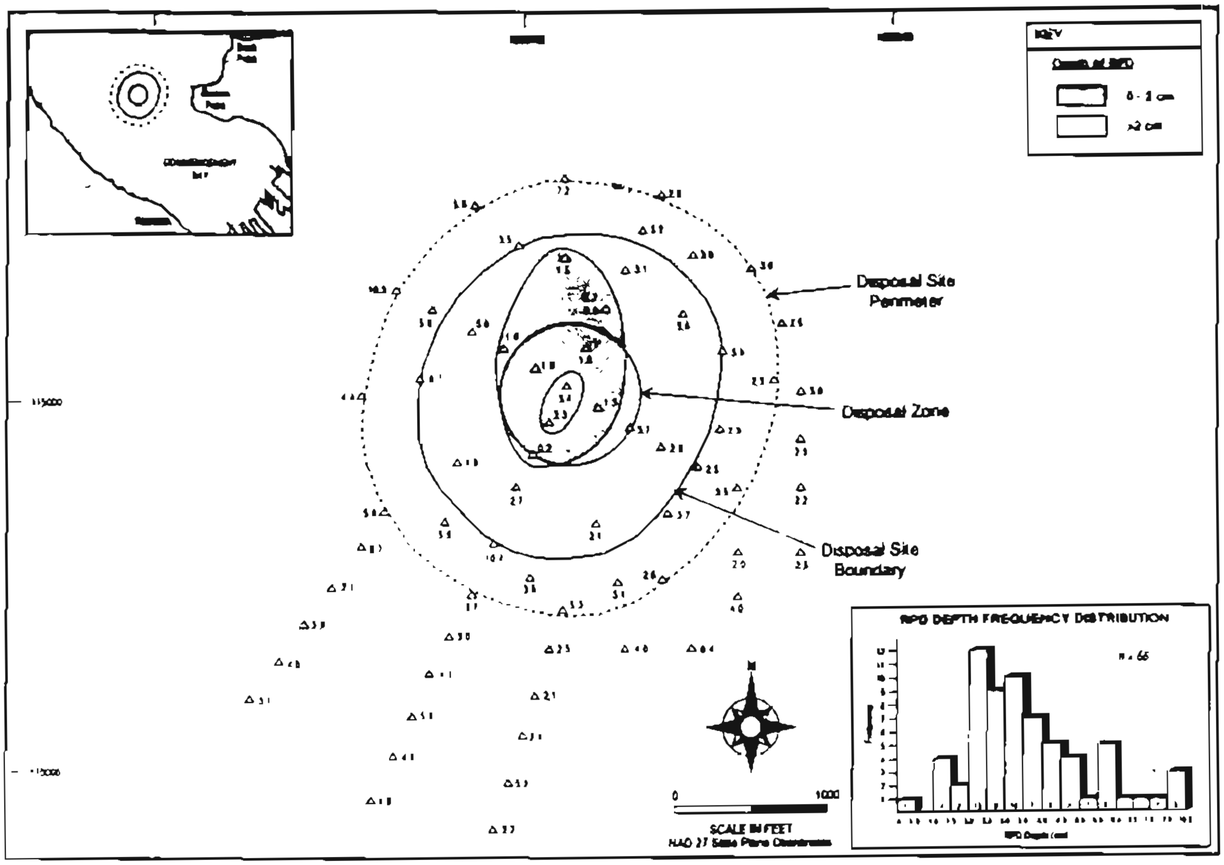


Figure 4-9. Distribution of apparent RPD depths during the 1996 partial monitoring of the Commencement Bay PSDDA disposal site. RPD depths are in centimeters.

Ovrhd 5-25. Distribution of Apparent RPD Depths in 1996

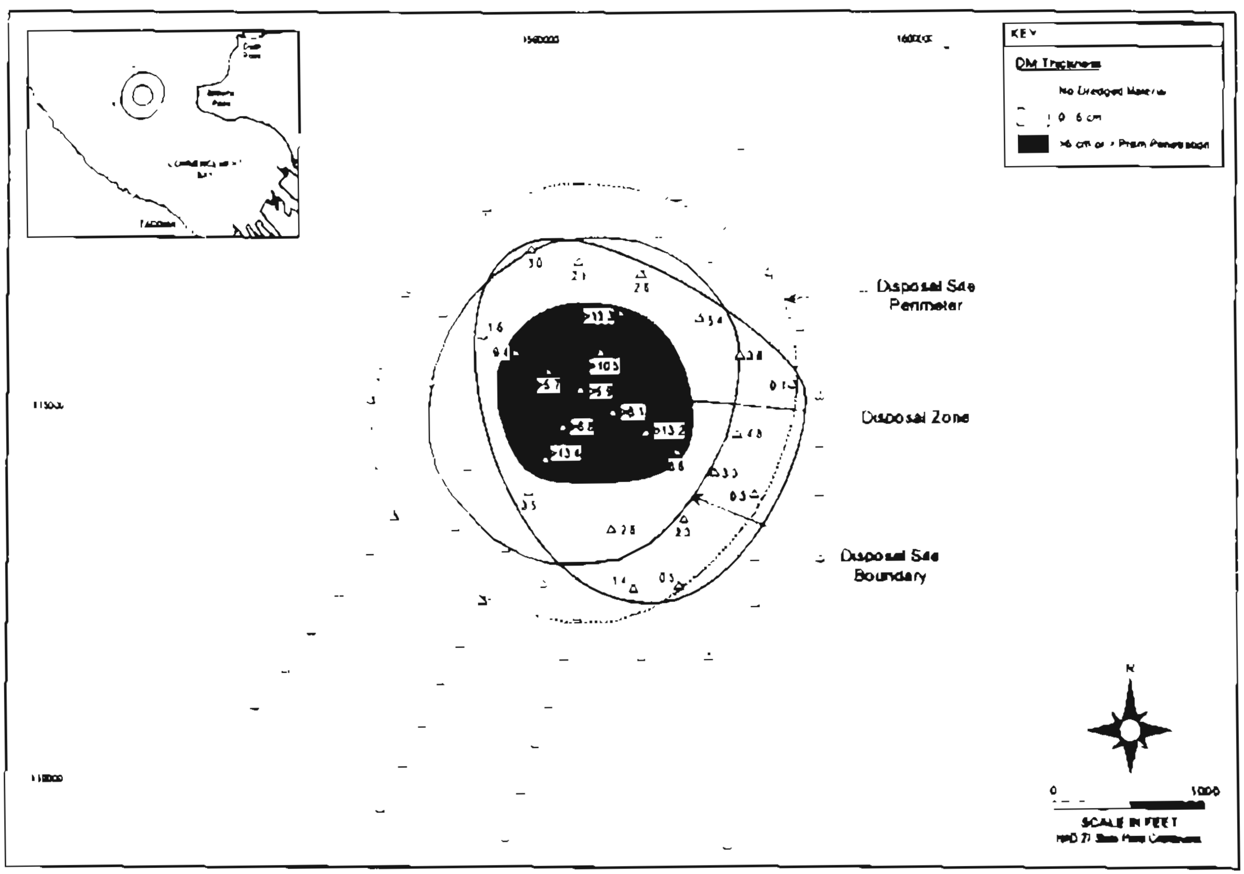


Figure 4-1. Dredged material (DM) footprint measured at the Commencement Bay PSDDA disposal site in 1996. Thickness is measured in centimeters.

Ovrhd 5-26 Dredged Material Footprint at Commencement Bay Site in 1996

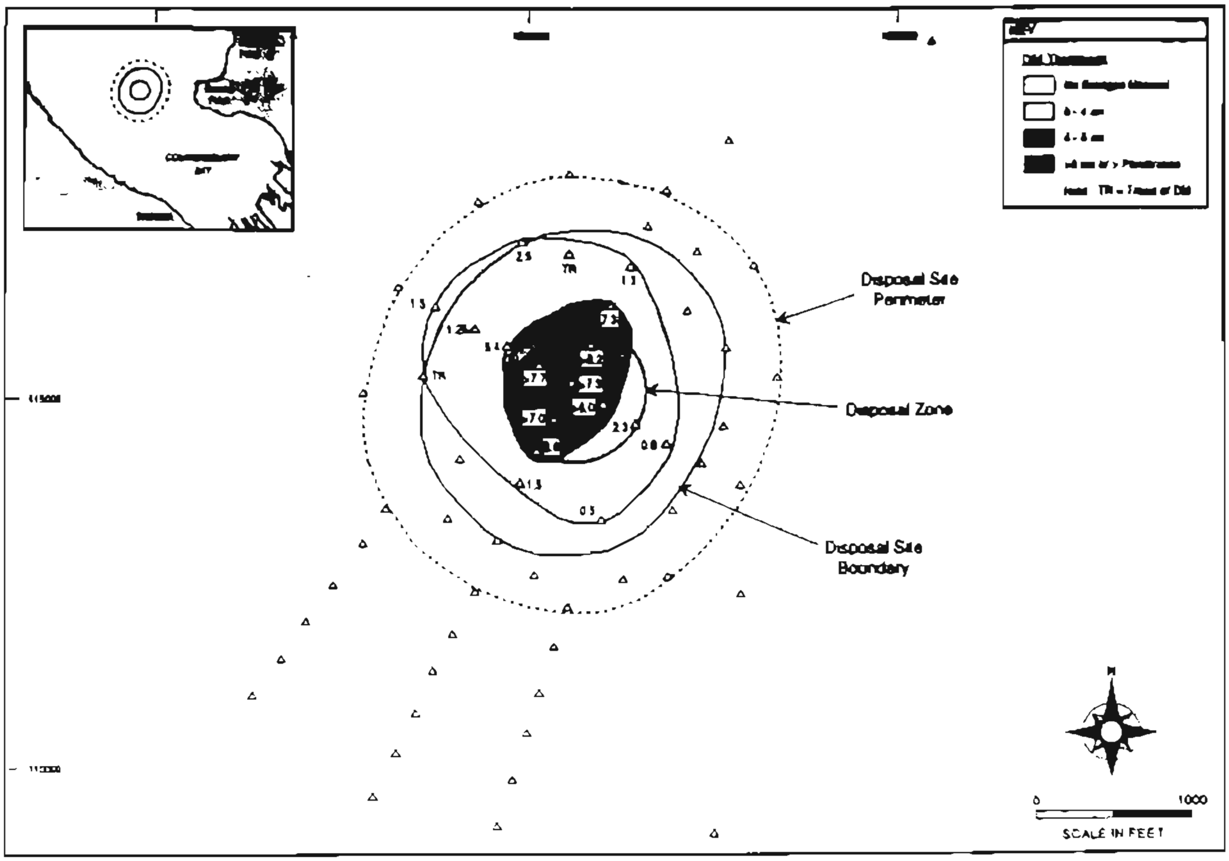


Figure 4-4. Distribution of dredged material (DM) at the Commencement Bay PSDDA disposal site. Thickness is measured in centimeters.

Ovrhd 5-27. Distribution of Dredged Material at the Commencement Bay Site

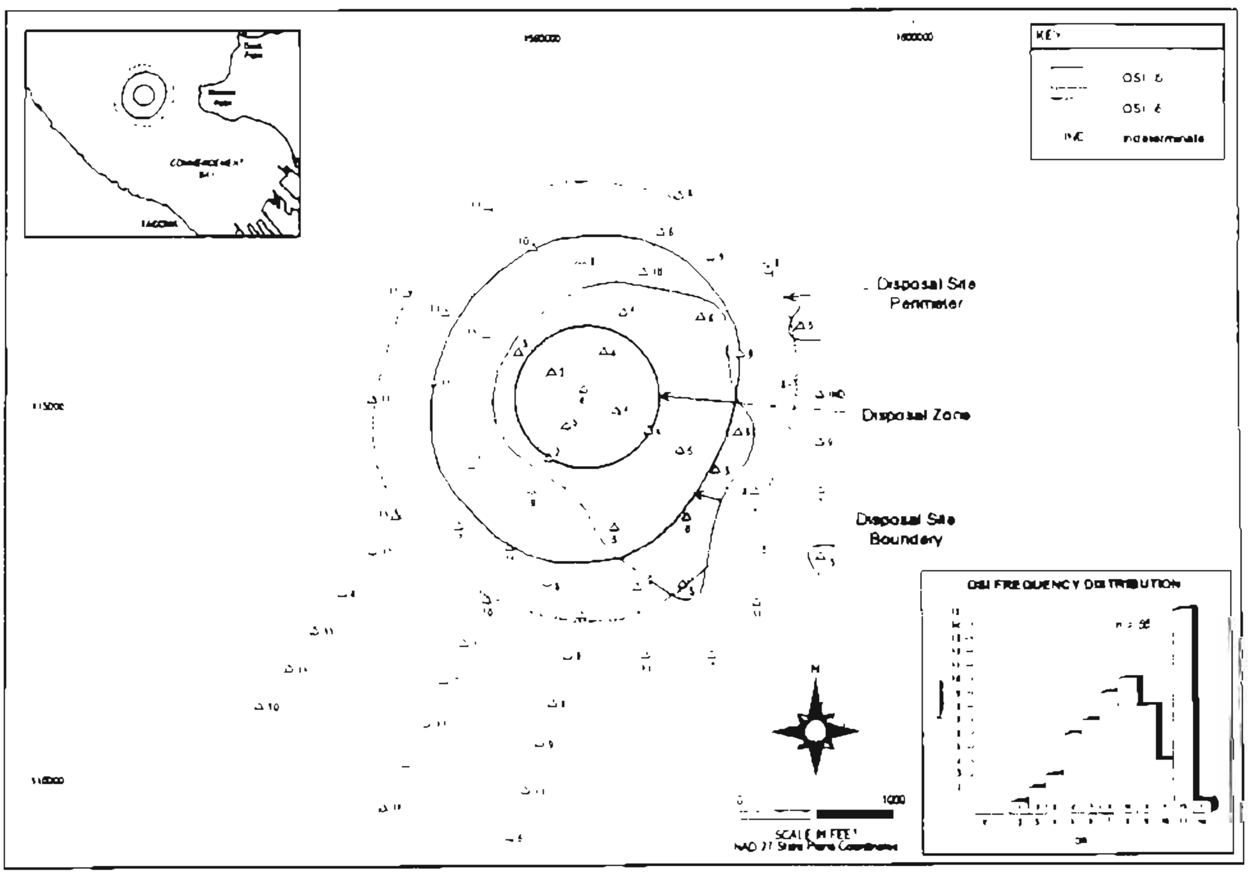


Figure 4-11. Distribution of organism-sediment indices (OSI) during the 1996 partial monitoring of the Commencement Bay PSDDA disposal site. The OSI is a general measure of sediment habitat quality ranging from a minimum quality value of -4 to a maximum quality value of +11.

Ovrhd 5-28. Distribution of Organism-Sediment Indices in 1996

SEDIMENT CHEMISTRY

- Conventionals
  - Perimeter grain size shows a shift to fine-grained material compared to 1995
- Metals
  - No exceedance of SL, ML, or SQS, except for lead
    - One replicate each from P03 and P07 exceeded the lead SL
- Organics
  - Chlorinated aromatics, volatile organics, and PCBs were undetected
  - DL for 2-methylphenol and 1,2,4-trichlorobenzene > SL
  - DL for hexachlorobenzene > SQS but < SL

Ovrhd 5-29 Sediment Chemistry

SEDIMENT BIOASSAYS

- All bioassays met QA/QC requirements
  - Two sets of controls run for amphipod, echinoderms, and *Neanthes*
    - All controls met PSDDA standards
    - Most conservative control results used for data evaluation
- No exceedances of biological effects criteria in bioassay results

Ovrhd 5-30 Sediment Bioassays

EVALUATION OF 1996 MONITORING DATA

- Question 1: Does dredged material remain onsite?
  - Hypothesis 1: Dredged material within site boundary.
    - Thin dredged material deposit at perimeter stations P10, P11, and P12 < 3 cm
    - SVPS data confirms hypothesis

Ovrhd 5-31. Evaluation of 1996 Monitoring Data

EVALUATION OF 1996 MONITORING DATA

- Question 1: Does dredged material remain onsite?
  - Hypothesis 2: Chemical concentrations offsite do not increase over time due to dredged disposal.
    - SQS not exceeded at perimeter stations.
    - There are no significant increases in chemicals over time
    - At CBP01, indications are that PAHs are declining
    - Re-evaluations will be forthcoming on P03, P07, and P12.

Ovrhd 5-32 Evaluation of 1996 Monitoring Data (Continued)

Table 5-2. Chemical Tracking System output for Commencement Bay station CBP01

Per Chemical Results:	Slope		P-Value	Intercept				Slope as %
	beta	SE(beta)		alpha	SE(alpha)	sigma	SE(sigma)	change/year
Conventionals								
Total Organic Carbon	0.0371	0.0061	0.0061	-0.7681	0.1381	0.0761	0.0421	8.8301
Total Sulfides	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Ammonia	0.0781	0.0761	0.3581	-1.3661	1.8061	0.0831	0.0891	19.7911
TVS	0.3721	0.0251	0.0001	-10.1471	0.5821	0.3081	0.1691	272.8401
Total Solids	-0.0261	0.0031	0.0001	2.3481	0.0861	0.0361	0.0201	-6.3041
Percent Gravel (>/=2.0 mm)	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Percent Sand (2.0 mm - 0.06 mm)	0.1181	0.0281	0.0061	-1.6461	0.7001	0.1991	0.1371	31.3191
Percent Silt (0.06 mm - 0.004 mm)	-0.0131	0.0131	0.3651	1.9611	0.3251	0.0921	0.0631	-2.9291
Percent Fines (<0.06 mm)	-0.0151	0.0081	0.1201	2.2491	0.2021	0.0571	0.0391	-3.4211
Percent Clay (<0.004 mm)	-0.0191	0.0031	0.0021	1.9571	0.0771	0.0221	0.0151	-4.1821
Metals								
Antimony	0.0251	0.0201	0.2391	-0.7111	0.4571	0.2511	0.1371	5.9871
Arsenic	0.0491	0.0141	0.0081	-0.2831	0.3121	0.1711	0.0941	11.9331
Cadmium	-0.0201	0.0131	0.0651	-0.1891	0.3021	0.1661	0.0911	-4.1951
Copper	0.0281	0.0041	0.0001	0.8741	0.0901	0.0641	0.0301	6.7361
Lead	0.0731	0.0071	0.0001	-0.1981	0.1491	0.0821	0.0451	18.3471
Mercury	0.0401	0.0241	0.1311	-1.9831	0.5501	0.3021	0.1651	[illegible]
Nickel	-0.0021	0.0021	0.2251	1.5011	0.0391	0.0211	0.0121	-0.5101
Silver	0.0251	0.0151	0.1221	-1.3811	0.3381	0.1841	0.1011	5.9571
Zinc	0.0221	0.0041	0.0011	1.3101	0.1021	0.0561	0.0311	5.2621
LPAH								
Naphthalene	-0.1241	0.0161	0.0001	4.6361	0.3671	0.1951	0.1111	-24.9231
Acenaphthylene	-0.2171	5.9301	0.9721	5.4431	109.1931	0.2831	0.7301	-39.3151
Acenaphthene	-0.1321	0.0151	0.0001	4.6361	0.3171	0.1451	0.1031	-26.2621
Fluorene	-0.1181	0.0181	0.0001	4.2661	0.3901	0.2001	0.1361	-23.4211
Phenanthrene	-0.1111	0.0141	0.0001	4.7461	0.3291	0.1811	0.0991	-22.5661
Anthracene	-0.1141	0.0471	0.0391	4.5281	1.0471	0.5431	0.2961	-23.0141
2-Methylnaphthalene	-0.0151	0.0111	0.2171	1.7651	0.2521	0.1381	0.0761	3.3221
HPAH								
Fluoranthene	-0.1181	0.0421	0.0221	5.0681	0.9701	0.5311	0.2911	-23.7061
Pyrene	-0.0921	0.0401	0.0461	4.4331	0.9101	0.4991	0.2731	19.1071
Benzo(a)anthracene	-0.1051	0.0511	0.0681	4.4271	1.1401	0.6081	0.2681	-21.4671
Chrysene	-0.0991	0.0431	0.0471	4.4171	0.9651	0.5401	0.2961	-20.4451
Total fluoranthenes	-0.0631	0.0361	0.0601	4.1381	0.8761	0.4811	0.2641	17.3361
Benzo(a)pyrene	-0.0681	0.0521	0.1251	3.9531	1.1691	0.6061	0.2711	-18.4101
Indeno(1,2,3-cd)pyrene	-0.0611	0.0411	0.1721	3.0771	0.9161	0.4781	0.2251	-13.0931
Dibenz(a,h)anthracene	-0.0451	0.0391	0.2711	2.4621	0.8421	0.4171	0.2541	-9.8871
Benzo(g,h,i)perylene	-0.0551	0.0361	0.1651	2.9331	0.8091	0.4211	0.1931	-11.8511
Phthalate Esters								
bis(2-Ethylhexyl)phthalate	0.0481	0.0321	0.1651	0.3191	0.7261	0.3991	0.2191	11.7231
Phenols								
Phenol	excluded	excluded	excluded	excluded	excluded	excluded	excluded	excluded

Ovrhd 5-33. Chemical Tracking System Output for Commencement Bay Station CBP01

Table 5-1 Maximum likelihood results for Commencement Bay perimeter stations

	SLOPE AND SIGNIFICANCE (Log10)								PERCENT CHANGE/YEAR		
	Mean	Max	Min	Median	S.E.	95% LCL	95% UCL	P-Value	Mean	95% LCL	95% UCL
CBP01											
Global	-0.0166	0.5716	-0.2169	-0.0232	0.1749	-0.3720	0.3389	0.9252	-3.74	-67.54	118.22
Conventionals	0.0913	0.5716	-0.0283	0.0121	0.0108	0.0665	0.1162	0.0000	23.41	16.55	30.67
Metals	0.0259	0.0732	0.0278	0.0253	0.0062	0.0118	0.0400	0.0024	6.15	2.76	9.64
LPAH	-0.1020	-0.0147	-0.1323	-0.1147	0.0156	-0.1401	-0.0639	0.0006	20.93	-27.58	-13.68
HPAH	0.0829	0.0452	-0.1175	-0.0884	0.0403	0.1740	0.0082	0.0697	-17.37	-33.01	1.91
CBP03											
Global	0.0354	0.3043	0.6143	-0.0007	0.0657	-0.1693	0.0986	0.5940	-7.82	32.28	25.47
Conventionals	0.0545	0.2782	-0.0954	0.0585	0.0156	0.0186	0.0904	0.0081	13.37	4.38	23.13
Metals	-0.0439	0.3043	-0.6143	0.0125	0.0502	-0.1573	0.0696	0.4046	-9.61	30.39	17.38
LPAH	-0.0824	0.0664	-0.4275	0.0007	0.0800	-0.2880	0.1232	0.3501	-17.29	-48.48	32.80
HPAH	0.1000	0.0132	-0.4584	0.0556	0.2141	0.5936	0.3937	0.6529	-20.57	-74.51	147.55
CBP07											
Global	0.0198	0.5568	0.1984	0.0067	0.0199	-0.0209	0.0604	0.3278	4.66	-4.69	14.93
Conventionals	0.0754	0.5568	-0.1984	0.0020	0.0466	-0.0302	0.1809	0.1406	18.95	-6.71	51.67
Metals	0.0126	0.0364	-0.0477	-0.0110	0.0301	-0.0796	0.0545	0.6847	-2.86	-16.75	13.36
LPAH	0.0318	0.0816	-0.0010	0.0116	0.0578	0.1167	0.1803	0.6058	7.59	23.56	51.46
HPAH	0.0200	0.0816	-0.0010	0.0116	0.0445	0.1253	0.0854	0.6674	-4.50	25.07	21.72
CBP11											
Global	0.0015	0.5134	-0.1097	-0.0053	0.0149	-0.0289	0.0319	0.9197	0.35	-6.44	7.63
Conventionals	0.0774	0.5134	-0.0109	0.0051	0.0084	0.0580	0.0968	0.0000	19.50	14.28	24.86
Metals	-0.0059	0.0453	-0.0410	-0.0046	0.0175	-0.0455	0.0337	0.7449	-1.34	-9.94	8.08
LPAH	0.0166	0.0626	0.0577	-0.0304	0.0151	0.0583	0.0253	0.3353	-3.72	-12.55	8.00
HPAH	0.0658	0.0214	-0.1097	-0.0865	0.0485	-0.1777	0.0460	0.2118	-14.07	-33.58	11.18

Ovrhd 5-34. Maximum Likelihood Results for Commencement Bay Perimeter Stations.

Table 5-3. Chemical Tracking System Output for Commencement Bay station CBP03

Per Chemical Results:

	Slope		P-Value	Intercept				Slope as % change/year
	beta	SE(beta)		alpha	SE(alpha)	sigma	SE(sigma)	
Conventionals								
Total Organic Carbon	0.077	0.023	0.028	-1.710	0.580	0.028	0.021	19.285
Total Sulfides	insd data	insd data	insd data	insd data	insd data	insd data	insd data	insd data
Ammonia	-0.095	0.022	0.007	3.370	0.547	0.154	0.108	-19.715
TVS	0.043	0.018	0.076	3.096	0.487	0.022	0.016	10.367
Total Solids	0.101	0.011	0.000	-1.029	0.271	0.078	0.052	26.160
Percent Gravel (>/=2.0 mm)	insd data	insd data	insd data	insd data	insd data	insd data	insd data	insd data
Percent Sand (2.0 mm - 0.06 mm)	0.278	0.082	0.020	-8.015	2.058	0.580	0.396	89.774
Percent Silt (0.06 mm - 0.004 mm)	0.074	0.006	0.000	-0.234	0.161	0.045	0.031	18.614
Percent Fines (<0.06 mm)	0.026	0.010	0.043	1.226	0.240	0.066	0.047	6.167
Percent Clay (<0.004 mm)	-0.067	0.085	0.461	3.080	2.117	0.597	0.410	-14.302
Metals								
Antimony	-0.814	0.116	0.006	15.796	3.006	0.142	0.106	-75.604
Arsenic	0.175	0.017	0.000	-3.578	0.424	0.120	0.115	49.667
Cadmium	-0.237	0.017	0.000	5.422	0.413	0.116	0.112	-42.070
Copper	0.304	0.033	0.000	-6.750	0.833	0.236	0.227	101.516
Lead	0.012	0.017	0.327	1.431	0.286	0.081	0.078	2.949
Mercury	-0.326	0.012	0.000	7.544	0.310	0.087	0.064	-52.820
Nickel	0.276	0.036	0.001	5.750	0.949	0.268	0.258	88.978
Silver	-0.280	0.010	0.000	6.600	0.255	0.072	0.069	-47.559
Zinc	0.295	0.039	0.001	5.765	0.980	0.278	0.267	97.172
LPAH								
Naphthalene	-0.427	0.303	0.231	12.513	7.699	0.027	0.029	-62.629
Acenaphthylene	insd data	insd data	insd data	insd data	insd data	insd data	insd data	insd data
Acenaphthene	0.028	0.004	0.001	0.572	0.107	0.029	0.026	6.607
Fluorene	insd data	insd data	insd data	insd data	insd data	insd data	insd data	insd data
Phenanthrene	0.066	0.033	0.102	0.070	0.831	0.234	0.159	16.526
Anthracene	-0.078	0.032	0.080	3.446	0.794	0.217	0.152	16.471
2-Methylnaphthalene	-0.001	0.004	0.864	1.527	0.091	0.026	0.015	-0.152
HPAH								
Fluoranthene	-0.458	0.045	0.001	13.710	1.174	0.056	0.041	-65.196
Pyrene	-0.033	0.047	0.506	2.680	1.170	0.330	0.227	7.364
Benzo(a)anthracene	-0.082	0.051	0.187	3.817	1.242	0.338	0.223	17.126
Chrysene	-0.040	0.039	0.381	2.648	0.987	0.278	0.191	8.727
Total fluoranthenes	-0.050	0.062	0.456	2.935	1.555	0.438	0.301	-10.907
Benzo(a)pyrene	-0.089	0.055	0.169	3.830	1.364	0.371	0.243	16.555
Indeno(1,2,3-cd)pyrene	-0.061	0.028	0.061	3.003	0.687	0.187	0.122	-13.101
Dibenz(a,h)anthracene	insd data	insd data	insd data	insd data	insd data	insd data	insd data	insd data
Benzo(g,h,i)perylene	0.013	0.047	0.768	1.102	1.145	0.311	0.204	3.092
Phthalate Esters								
bis(2-Ethylhexyl)phthalate	0.075	0.018	0.008	-0.391	0.439	0.124	0.085	18.726
Phenols								
Phenol	excluded	excluded	excluded	excluded	excluded	excluded	excluded	excluded

Ovrhd 5-35. Chemical Tracking System Output for Commencement Bay Station CBP03.

EVALUATION OF 1996 MONITORING DATA

- Question 2: Biological effects conditions exceeded?
  - Hypothesis 3: PSDDA Site Condition II for sediment chemistry.
    - No ML exceedance, hypothesis is not rejected
  - Hypothesis 4: PSDDA Site Condition II for sediment bioassays.
    - No bioassay exceedance; hypothesis is not rejected

Ovrhd 5-36 Evaluation of 1996 Monitoring Data

EVALUATION OF 1996 MONITORING DATA

- Question 3: Adverse effects to offsite biological resources?
  - Hypothesis 5: No increase in tissue body burden.
    - Not adressed
  - Hypothesis 6: No decrease in infaunal major taxa abundance with time.
    - Not adressed

Ovrhd 5-37. Evaluation of 1996 Monitoring Data

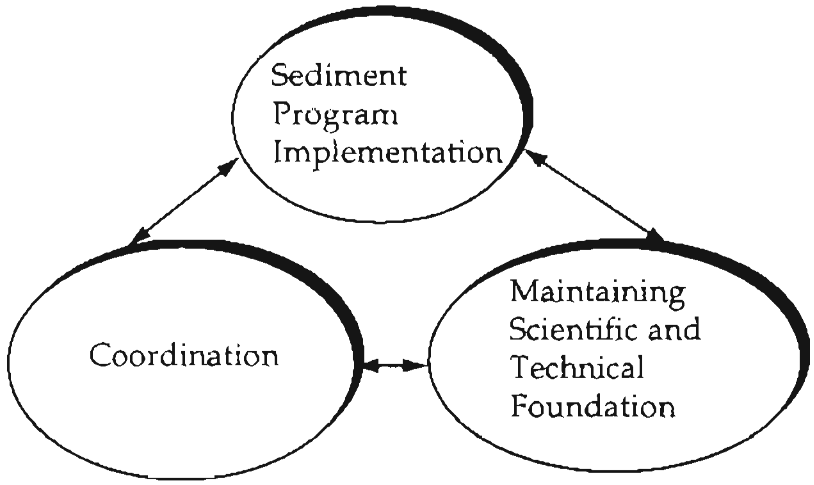
RECOMMENDATIONS

- Compile and publish disposal site monitoring plan.
  - Numerous programmatic changes
  - Field and analytical changes
  - Transect biological analysis changes
  - Bioassay procedure and interpretation changes

- Present future monitoring reports and appendicies on a CD-ROM.
  - SAIC internal goal for 1997 report.

Ovrhd 5-38. Recommendations

SMS SEDIMENT ACTIVITIES - Rachel Friedman-Thomas



Ovrhd 6-1. SMS Sediment Activities

SEDIMENT PROGRAM IMPLEMENTATION

- **Sediment Source Control**
  - Activities to-date have focused on point sources
  - Sediment data for areas adjacent to 38 NPDES dischargers shown 18 with sediment impacts
  - Contaminants of concern include:
    - » Metals - most common contaminants
    - » Phthalates, PAHs, PCBs - also common
    - » Phenols - seen at more than one site

Ovrhd 6-2. Sediment Program Implementation (Sediment Source Control)

SEDIMENT PROGRAM IMPLEMENTATION

- **Sediment Cleanup**
  - Published Contaminated Sediment Site List
  - Participating in Bellingham Bay Demonstration Pilot Project
  - Provide technical assistance/coordinate with regional cleanup staff on site work

Ovrhd 6-3. Sediment Program Implementation (Sediment Cleanup)

SEDIMENT PROGRAM IMPLEMENTATION

- **Information Management**
  - New SEDQUAL
    - Access database with a Visual Basic user interface linked to ArcView GIS stations file
    - Functions: criteria comparisons, AET calculation
- **Lab Accreditation**
  - Sediment category currently in WAC 173-50, Accreditation of Environmental Laboratories
  - Future sediment program accreditation reqmt's

Ovrhd 6-4. Sediment Program Implementation (Information Management and Lab Accreditation)

SEDIMENT PROGRAM CHALLENGES

- **Sediment Source Control**
  - Addressing stormwater and nonpoint sources of sediment contamination
  - Updating discharge assessment tools
  - Additional emphasis on sediment quality in watershed planning
  - Developing sediment-based TMDLs

Ovrhd 6-5. Sediment Program Challenges (Sediment Source Control)

SEDIMENT PROGRAM CHALLENGES

- Quickly update the contaminated sediment site list
- Continue to promote consistent data quality
- Balance workload against expectations
- Ecology sediment internet site
  - http://www.wa.gov/ecology/cp/sediment.html

Ovrhd 6-6. Sediment Program Challenges

Status of Sediment Cleanup Sites

Type of Cleanup	Not Started	II	RI	FS	Cleanup	No Further Action	Totals
MTCA	1	4	4	3	5	4	**21**
CERCLA	0	0	1	8	7	4	**20**
CWA	3	1	1	1	1	3	**10**
Other	0	0	1	2	1	1	**5**
Not Assigned	9	7	6	0	0	2	**24**
Totals	**13**	**12**	**13**	**14**	**14**	**14**	**80**

Ovrhd 7-1. Status of Sediment Cleanup Sites

Program Accomplishments

- ***Significant progress on cleanup in four years of work***

  - No new orders have been issued to accomplish cleanup

  - Providing a model for technical assistance and interagency coordination

  - Waterfront redevelopment is providing opportunities for collaborative, cost-effective projects

- ***Completed staff training***

  - Two new sediment staff

  - Interagency training (federal, state, local)

  - Collaboration with University of Wisconsin

- ***Development of agency guidance***

  - TBT guidance

  - Wood waste guidance

  - Bioassay/statistics guidance

Cleanup Decision Summary

Cleanup to CSL	**Decision Factors**
Southwest Harbor Project	Proximity to other sites, recontamination potential
Duwamish/Diagonal CSO	Proximity to other sites, recontamination potential
Cascade Pole	Cost and technical feasibility
Eagle Harbor	Cost/benefit analysis
Cleanup to SQS	
Norfolk CSO	NRDA cleanup Human health risks/PCBs Small additional cost
Other Cleanup Standards	
St. Paul and Sitcum Waterways	Cleanup standards selected in pre-SMS ROD
Performance-Based	
Everett Piers 1&3	Dredge to native material

Cleanup Standards based on Bioaccumulation or Human Health Risks

- Harbor Island
- Boeing Plant 2
- Georgia-Pacific (?)
- Manchester Annex
- Hylebos Waterway

Ovrhd 7-3. Cleanup Decision Summary

[redacted]

SMS TRIENNIAL REVIEW
-Presentation Outline-

- Provide background on the Triennial Review process
- Summarize Triennial Review issues
- Describe the next steps toward completing Triennial Review
- Identify key challenges to complete Triennial Review

Ovrhd 8-1. SMS Triennial Review

[redacted]

TRIENNIAL REVIEW
- Background-

- **SMS Rule Review Requirements:**
  - Public comments
  - New scientific and technical information
  - Implementation experience
  - New federal or state rules
- **Triennial Review Started In 1995.**
- **Three Phases:**
  - Issues identification
  - Issues evaluation/resolution
  - Rule amendments/guidance development

Ovrhd 8-2. Triennial Review Background

TRIENNIAL REVIEW
-Draft Responsiveness Summary-

- Recommended SMS Rule Revisions
- Issues Requiring More Discussion to Identify Specific Rule Revisions
- Issues Recommended for No Further Action

Ovrhd 8-3. Triennial Review Draft Responsiveness Summary

TRIENNIAL REVIEW
-Issues-

- **Sediment Cleanup**
  - SMS/MTCA Consistency
  - Types of Cleanup Actions
  - Implementation of Hotspot Approach
- **Sediment Quality Criteria**
  - Port of Seattle AET Recommendations
  - Updating SMS Rule based on 94 AETs
  - Chemical/Biological Criteria for Other Marine Sediments

Ovrhd 8-4. Triennial Review Issues

TRIENNIAL REVIEW
-Issues-

- **Test Methods**
  - Role of Benthic Assessments
  - Artifact Toxicity
  - Protocol revision process
- **Human Health Sediment Quality Values**
  - Continuation/Schedule of Rulemaking
  - BSAF Values (Uncertainty/Variability)
  - Implementation Issues/Impacts

Ovrhd 8-5. Triennial Review Issues (Continued)

TRIENNIAL REVIEW
-Next Steps-

- **Distribute Draft Responsiveness Summary..................................May 1997**
- **Implementation Committee Discussions.......................Summer 1997**
- **Coordination with other regulatory programs............................Summer 1997**
- **Prepare Recommended SMS Rule Amendments..............................Fall 1997**

Ovrhd 8-6. Triennial Review Next Steps

[redacted]

TRIENNIAL REVIEW
-Challenges-

- Re-engage stakeholder groups
- Finding regulatory balance
- Resolving technical issues
- Meeting commitments

Ovrhd 8-7. Triennial Review Challenges

Beneficial Use of Dredged Material

DMMP Clarification Paper
SMARM 1997

Ovrhd 9-1. Beneficial Use of Dredged Material

Interagency/Intergovernmental Agreement

- Compile agency policies & procedures -- EPA, Corps, Ecology, WDNR, WDFW
- Identify common & different policies and procedures
- Prepare common set of policies (resolve differences, if possible)
- Recommend integrated procedure for agency review & approval
- Identify implementation methods and unresolved issues

Ovrhd 9-2. Interagency/Intergovernmental Agreement

Products

- User Manual for project proponents
- Executive Summary for agency directors

Ovrhd 9-3. Products

Pre-Application for Material

- Contact WDNR and/or Corps DMMO representative early
- Project presented by WDNR or Corps at the monthly interagency Cooperative Sediment Management Program meeting
- Proponent may be asked for brief presentation or write up
- Conflicts for material -- likely separate meeting to resolve

Ovrhd 9-4. Pre-Application for Material

Resolving Conflicts

- Type of beneficial use proposed
- Project readiness
- Project logistics, esp. effects on Corps O&M activity
- Material ownership
- Urgency of need to resolve problem
- Public trust requirements
- "Value" of the project, incl. ability to pay for material

Ovrhd 9-5. Resolving Conflicts

Resolving Conflicts (con't)

- Agency authorities
- Volume required

Ovrhd 9-6. Resolving Conflicts (cont'd)

Sediment Characterization

- Case-specific characterization required to determine whether dredged material is suitable for the proposed reuse
- Physical, chemical, biological
- Unconfined, aquatic projects -- material is compared to numeric and narrative SMS
- Material <= SQS (incl. bioassays) is appropriate for most project uses

Ovrhd 9-7. Sediment Characterization

Sediment Characterization (con't)

- Material > SQS but less than CSL may be appropriate on a case-by-case basis due to site specific considerations

Ovrhd 9-8. Sediment Characterization (cont'd)

PSDDA Comparisons

- Suitability of dredged material for unconfined, open-water disposal at designated open-water sites is documented in signed "Suitability Determination"
- Specific analysis and comparison of testing results to SMS must be performed (Repackaging)

Ovrhd 9-9. PSDDA Comparisons

Suitability Determination Process

- Utilize existing Corps DMMO coordination and suitability determination process for aquatic projects
- Ensure data collected to allow repackaging
- If projects sediments are <= SQS suitability determination will indicate generally OK for exposed aquatic beneficial use

Ovrhd 9-10. Suitability Determination Process

Suitability Determination Process (con't)

- Suitability determination is not a permit
- Use of best professional judgement (detection limits, TOC normalization, COC's, etc.)

Ovrhd 9-11. Suitability Determination Process (cont'd)

Wood Waste Impacts

Conventionals:

- Increases biological oxygen demand
- May produce anaerobic sediments
- Build-up of ammonia, sulfides, and/or methane
- Limits biodegradation of contaminants

Chemical Impacts:

- Some natural breakdown products are toxic
- Some toxic chemicals leach from bark and wood
- Phenol, methylphenol, terpenes, tropolones, benzoic acid, benzyl alcohol
- Not all of these chemicals have SMS criteria

Physical Impacts:

- Smothering of benthic organisms
- Alteration of benthic substrate
- Large accumulations may persist for decades

Impacts from wood waste are highly variable, and depend on the surrounding environment, the type of sediment, the type of wood and its particle size, the natural benthic community, salinity, and flushing rates. Uncontaminated woody debris can be beneficial under some circumstances.

Ovrhd 10-1. Wood Waste Impacts

Wood Waste Characterization and Cleanup

Regulatory Authorities:

- Water Pollution Control Act (Chapter 90.48 RCW)
- Model Toxics Control Act (Chapter 70.105D RCW)
- Sediment Management Standards (Chapter 173-204 WAC) "other deleterious substances"

Overall Approach is Effects-Based:

- A chemical criterion will not be developed
- Existing biological standards will apply
- Bioassay purging not recommended
- Benthic effects should be emphasized
- Solid waste regulations may also apply

Characterization/Screening Tools:

- Sediment Vertical Profile Imaging (SVPI)
- Qualitative benthic evaluations
- Remote sensing techniques
- Video surveys, visual sample characterization
- Comparison of TOC and/or depth of the aerobic layer to reference area sediments

Beneficial Reuse Encouraged:

- Soil amendments
- Fuel

Proposed DMMP actions:

- Conduct visual assessment
- Selective debris removal (> 24" x 24")
- Laboratory analysis of material < 24" x 24"
  - Weight-specific analysis method (e.g., Modified Volatile Solids)
  - Convert weight-specific fraction (dry weight) to volume basis by multiplying by two.
- Estimated sample volumes > 50% (e.g., >25% by weight) require biological testing
- Estimated sample volumes < 50% (e.g., <25% by weight) suitable for unconfined open-water disposal without biological testing unless other chemicals-of-concern have chemicals exceeding SLs.

Ovrhd 11-1. Proposed DMMP Actions

proposed DMMP actions:

Recommendations for improving bioassay performance.

- Monitor interstitial ammonia levels (e.g., recommended for high woodwaste samples)
- When total ammonia levels exceed 20 mg/liter (overlying water) use ammonia purging protocol (EPA/Corps) to reduce ammonia levels below 20 mg/liter.
- Analyze the organic-free sample (e.g., residue from modified TVS analysis) for particle size distribution and use in conjunction with the conventional grain-size analysis to select the appropriate amphipod species and reference sediment.

Ovrhd 11-2. Proposed DMMP Actions (Continued)

Verification Methods for Dredging of Material Unsuitable for Open Water Disposal

A DMMP Issue Paper

Ovrhd 12-1. Verification of Methods for Dredging of Materia Unsuitable for Open Water Disposal

Introduction

- A project may be comprised of both "suitable" and "unsuitable" material.
- Only "suitable" material may be placed at the DMMP disposal sites.
- This can occur with both surface and subsurface units.

Ovrhd 12-2. Introduction

Problem Identification

Increased Complexity of Projects

- There is a larger number of projects with both suitable and unsuitable DMMUs in the dredge prism.
- Dredge sequencing and DMMU tracking required to ensure Site Condition II is not exceeded.

Ovrhd 12-3. Problem Identification

Problem Identification

Continued

- Also required to demonstrate appropriate degree of diligence and to limit increased public exposure to liability.
- Past practice was monitoring of total volumes disposed only.

Ovrhd 12-4. Problem Identification (Continued)

Proposed Action

For Projects with Suitable and Unsuitable DMMUs

- The DMMP agencies may require additional documentation that only suitable material is being disposed.
- This may result in requirement for additional bathymetric surveys.
- May also require phased dredging (unsuitable material first).

Ovrhd 12-5. Proposed Action

Proposed Action

Continued

- Methodology will be addressed in dredging plan.
- DMMP agencies will be flexible in requirements.
- For more complex projects, this issue should be addressed as early as possible.

Ovrhd 12-6. Proposed Action (Continued)

Revisions to DMMP Screening and Maximum Level Guidelines

Ovrhd 13-1. Revisions to DMMP Screening and Maximum Level Guidelines

Revisions to DMMP Guidelines -Background-

- Calculated 1994 amphipod and echinoderm AETs
- "QA2" level review required for surveys setting new AETs
- Agreed to convene an independent Regulatory Work Group (RWG)
- Agreed to analyze implications of changing guideline values

Ovrhd 13-2. Revisions to DMMP Guidelines - Background

Revisions to DMMP Guidelines
-Regulatory Work Group-

- **Purposes**
  - Establish feedback loop to evaluate reliability of SLs
  - Establish process for evaluating data affecting MLs
- **Objectives**
  - Re-evaluate assumptions underlying AETs
  - Recommend revisions to guidelines
  - Recommend ways to streamline process

Ovrhd 13-3. Revisions to DMMP Guidelines - Regulatory Work Group

Revisions to DMMP Guidelines
-Regulatory Work Group-

- **Composition of RWG**
  - 12 to 15 consistent members
  - Technical experts, policy makers, stakeholders
- **Meetings**
  - Five meetings; Nov '96 to February '97
  - Members provided individual expertise
  - Prioritized 13 issues
  - Made recommendations by consensus

Ovrhd 13-4. Revisions to DMMP Guidelines - Regulatory Work Group (Cont.)

Revisions to DMMP Guidelines
-RWG Recommendations-

- **Short-term:**
  - For changes proposed at the 1997 SMARM
- **Medium-term:**
  - For changes proposed at the 1998 SMARM
- **Long-term:**
  - For changes proposed at the 1999 SMARM

Ovrhd 13-5. Revisions to DMMP Guidelines - RWG Recommendations

Revisions to DMMP Guidelines
-RWG Recommendations-

- **Medium-term:**
  - Reintroduce data excluded in 1994 and examine "borderline" data
  - Streamline re-evaluation process
  - Calculate new bivalve and new *Neanthes* AETs
  - Conduct trend analysis of remaining disposal sites
  - Microtox

Ovrhd 13-6. Revisions to DMMP Guidelines - Medium-term Recommendations

Revisions to DMMP Guidelines
-RWG Recommendations-

- **Long-term:**
  - Examine definition and use of MLs
  - Establish default reference values for AET work
  - Sponsor larval workshop
  - Modify bioassay protocols to minimize effect of ammonia and sulfides
  - Microtox
  - Annual calculation of AETs

Ovrhd 13-7. Revisions to DMMP Guidelines - Long-term Recommendations

Revisions to DMMP Guidelines
-RWG Recommendations-

- **Short-term:**
  - Set SLs equal to LAETs
  - Do not lower SL guidelines
  - Analysis of disposal sites for increasing trends
  - Set MLs equal to HAETs
  - Check increasing MLs for capacity to bioaccumulate/biomagnify
  - TOC normalize non-polar organics

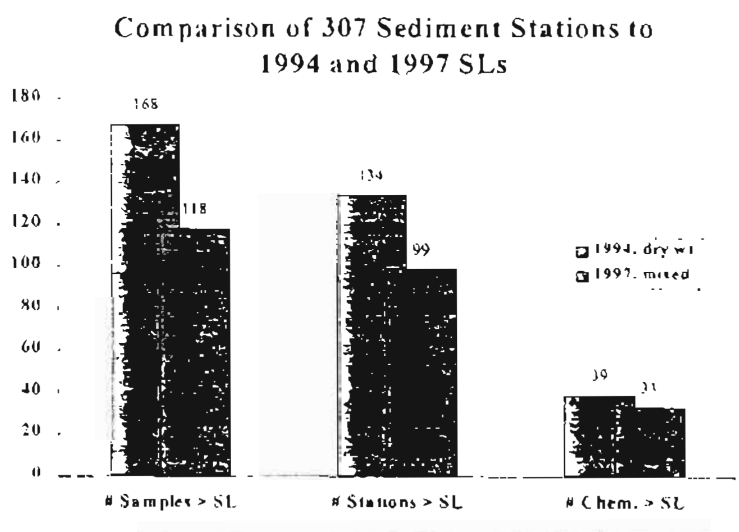
Ovrhd 13-8. Revisions to DMMP Guidelines - Short-term Recommendations

Revisions to DMMP Guidelines
-DMMP Response-

- The agencies agree with all but two recommended short-term changes
- On an interim basis only, the agencies will not use 1994 echinoderm AETs to set LAETs or SLs
- The agencies disagreed with the RWG that SLs should only increase in value
- Proposed new SLs/MLs in Tables 1 & 2

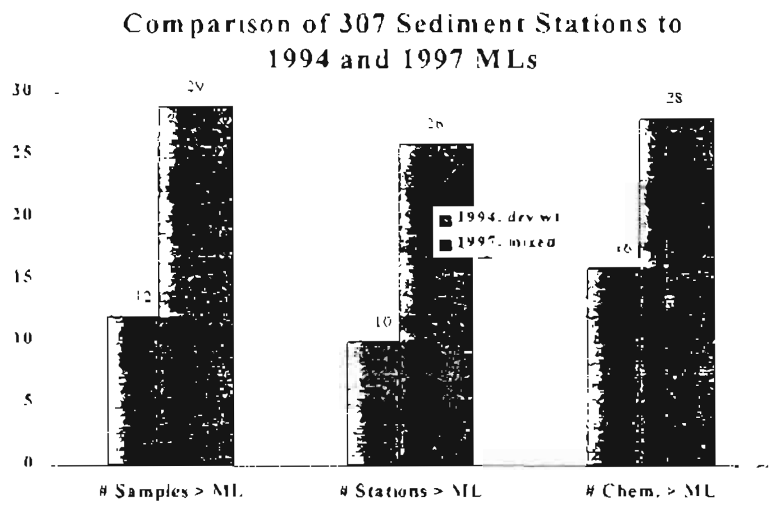
Ovrhd 13-9 Revisions to DMMP Guidelines - DMMP Response

Revisions to DMMP Guidelines



Ovrhd 13-10. Revisions to DMMP Guidelines - 1994 vs 1997 SL Exceedances

Revisions to DMMP Guidelines



Ovrhd 13-11. Revisions to DMMP Guidelines - 1994 vs 1997 ML Exceedances

Revisions to DMMP Guidelines
-ML Chemicals Which Bioaccumulate-

- **Metals**:
  - Cadmium and mercury increase slightly
- **Organics**:
  - Chrysene increases two-fold (2X)
  - Dibenzo(a,h)anthracene (2X)
  - Bis(2ethylhexyl)phthalate (2.7X)

Ovrhd 13-12. ML Chemicals Which Bioaccumulate

Revisions to DMMP Guidelines
-Conclusions-

- Adequate scientific and programmatic basis for changes to SL and ML values
- DMMP agencies are still evaluating proposed ML changes
- The proposed changes have significant positive cost implications without significant added environmental risk

Ovrhd 13-13. Revisions to DMMP Guidelines - Conclusions

Progress in Developing a Puget Sound AET for the Neanthes *Biomass/ Growth Endpoint*

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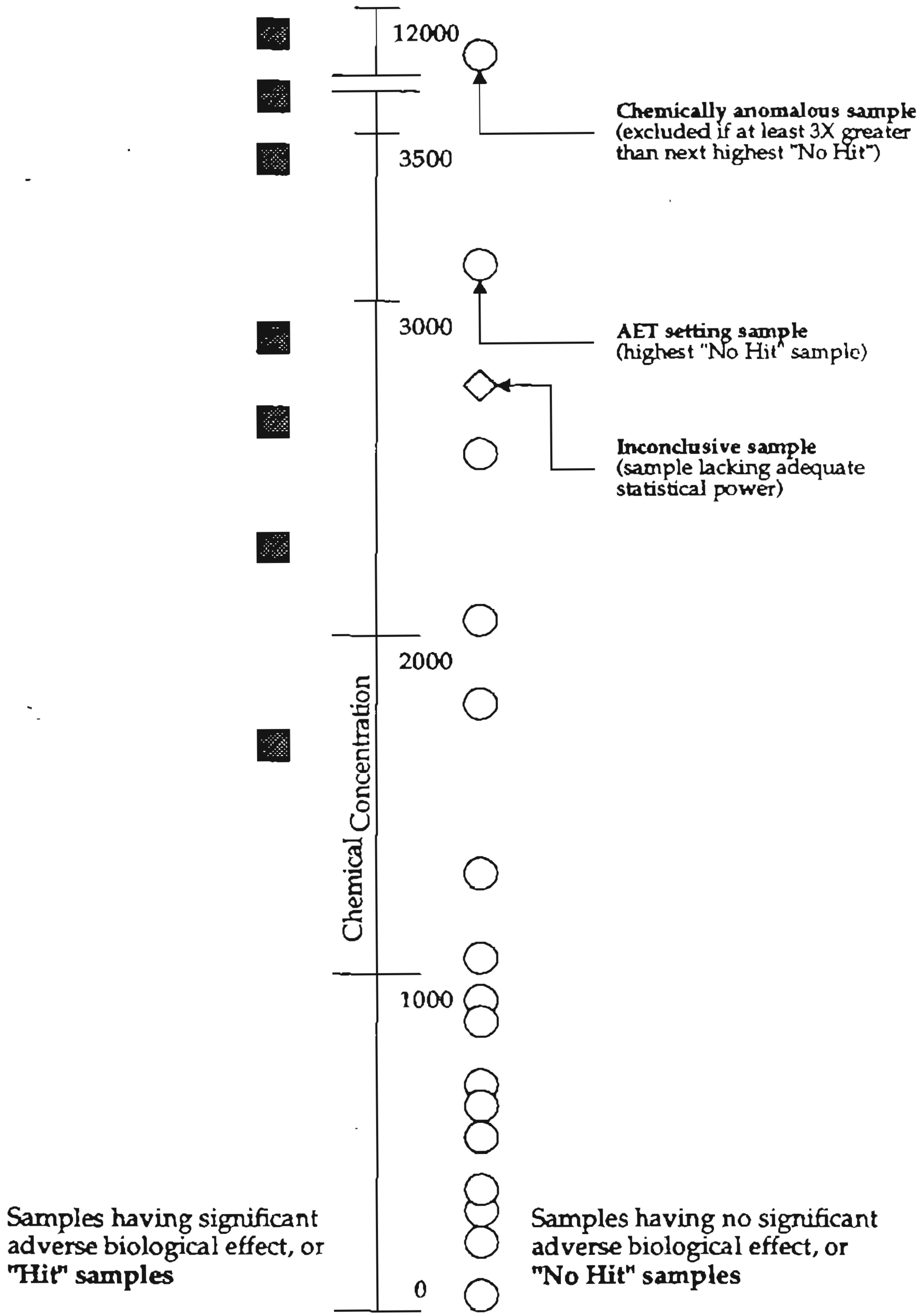
Ovrhd 14-1 Progress in Developing a Puget Sound AET for the *Neanthes* Biomass/Growth Endpoint

Scope

- *Neanthes arenaceodentata* (juvenile Polychaete) 20-day bioassay (biomass/growth measurement endpoint)
- Corresponding sediment chemistry data (dry weight basis, TOC-normalized)
- Puget Sound region

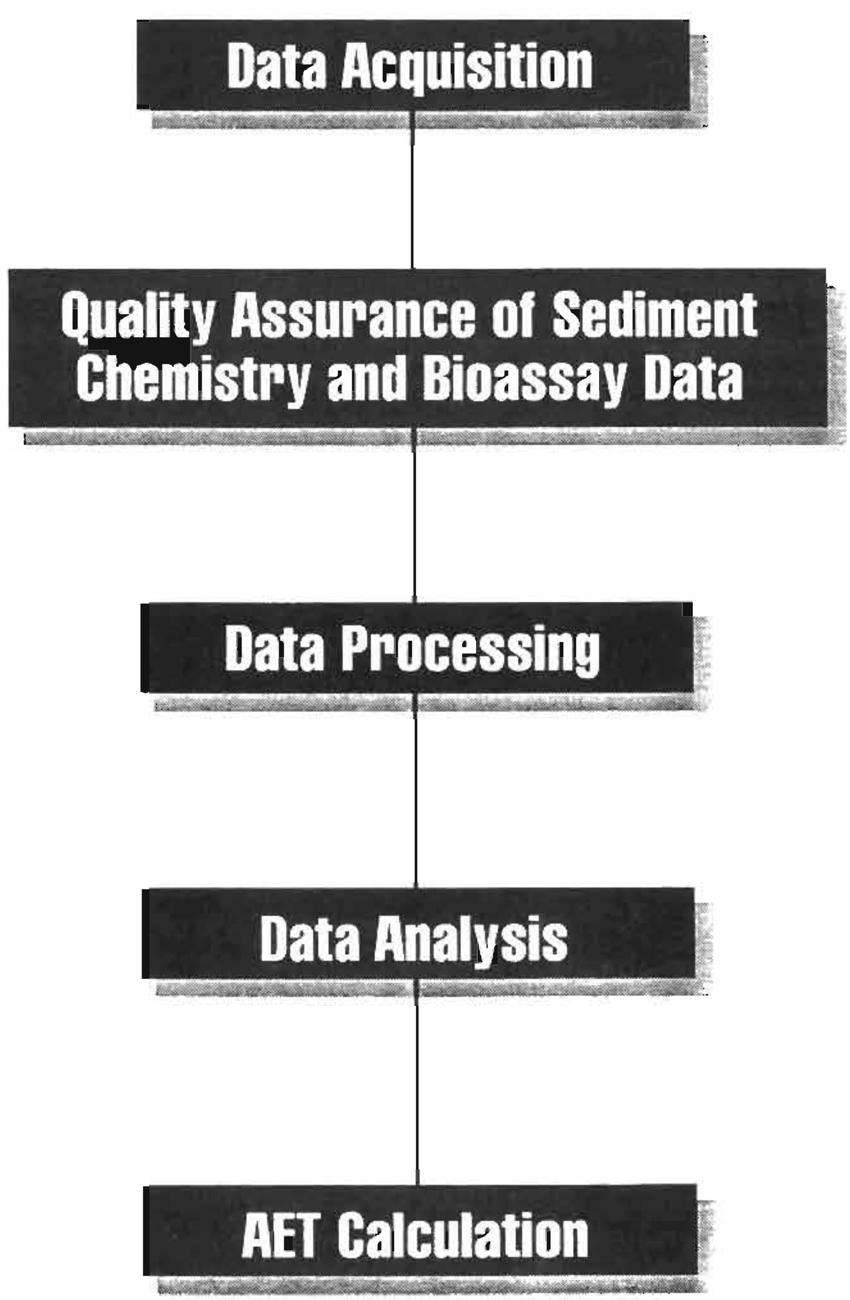
Ovrhd 14-2 Scope

Figure 1. Determination of an Apparent Effects Threshold (AET) value.
An AET is generally set by the sample with the highest chemical concentration of a potential toxicant which does not exhibit a significant adverse biological effect ("No Hit"). The AET is qualified as a minimal value using a "G" or a ">" symbol if no "Hit" sample exceeds it. Note: Any units of measure or means of normalization may apply.



Ovrhd 14-3 Fig. 1 - Determination of an Apparent Effects Threshold Value

AET Calculation Steps

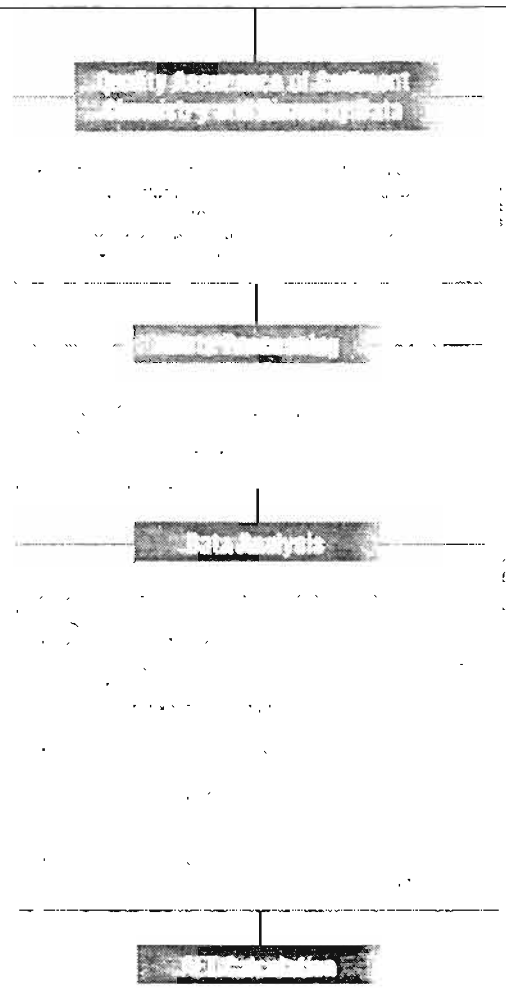


Ovrhd 14-4 AET Calculation Steps

Data Acquisition

Sources

- U.S. Army Corps of Engineers – DAIS (Dredged Analysis Information System)
- Washington Department of Ecology – SEDQUAL
- EVS Consultants
- Other (Additional)
  - Regional consulting and engineering firms



Surveys from the Puget Sound region with Neanthes *20-d biomass/growth data*

SURVEY NAME	SURVEY ID	NUMBER OF STATIONS	DATA SOURCE
Port of Seattle - Terminal 18 Phase 1, 1996	T18_P1	86	EVS
Sitcum Waterway - Pentec 1991	SITCUMRI	79	SEDQUAL
Hylebos Waterway - Striplin 1994	1A CORES	46	EVS
Harbor Island RI, 1995	HIRI95	35	EVS
Hylebos Waterway - NOAA - DAC 1994	DAC-HY94	28	EVS
US Navy Bremerton Pier D, Round 2, DY94	USNPD1CF072	22	DAIS
Weyerhaeuser Everett - PTI 1994	EVEWEY94	15	SEDQUAL
Port of Seattle - Terminal 18 Phase 2, 1996	T18_P2	14	EVS
Port of Everett - Piers 1 and 3, DY95	POE131BF079	9	DAIS
Port of Everett - South Terminal FC, DY95	POEST1BF081	8	DAIS
Squalicum Waterway Sediment Characterization, DY92	SQUAL1BF103	8	DAIS
Sound Refining	SNDREF92	3	SEDQUAL
Port of Seattle - Terminal 5, 1996	T5-1996	3	EVS
Duwamish Waterway, DY93	DUWA71BF107	3	DAIS
Monitoring - Elliott Bay Full, DY92	MONEB4BF061	3	DAIS
USACE Everett Downstream Settling Basin FC, DY93	EVEDS1BF063	3	DAIS
City of Bremerton - Warren Ave Basin CSO, DY94	WACSO1BF078	2	DAIS
Port of Seattle - Terminal 115, DY93	PS1151BF065	2	DAIS
Neanthes Sublethal Test Demonstration - PTI 1988	PTISTD88	2	EVS
Konioke-Pacific - Striplin 1993	KONPAC93	1	SEDQUAL
Bellingham Bay Partial Monitoring, DY93	MONBB4DP099	1	DAIS
Indian Cove Moorage, DY94	ICOVM1BF077	1	DAIS
King County Sammamish River, DY93	KCSAM1BF059	1	DAIS
Konoike-Pacific Tacoma Terminals, DY94	KPACT1BF068	1	DAIS
Port of Seattle - Terminal 30, DY94	PST301BF076	1	DAIS
Port of Seattle - Terminal 5 Pier Extension, DY92	PS0051BF100	1	DAIS
US Navy Everett Norton Terminal, DY94	USNNT1BF067	1	DAIS
Weyerhaeuser Bay City Dock, DY92	WEYER1BF056	1	DAIS
TOTALS	**28**	**380**	

Ovrhd 14-6 Surveys from the Puget Sound Region.

Data Acquisition

Scope

Sources

Quality Assurance of Sediment Chemistry and Bioassay Data

- Determine whether bioassays meet test performance (control, reference, initial biomass) and quality assurance requirements
- Determine whether sediment chemistry meets quality assurance requirements

Data Processing

Data Analysis

AET Calculation

Ovrhd 14-7. Quality Assurance of Sediment Chemistry and Bioassay Data

Summary of screening results for studies containing matched Neanthes *20-d bioassay and sediment chemistry data*

Survey Name	Number of Stations	Chemical QA	Lab Replicates	Negative Control	Reference	Initial Biomass
Port of Seattle - Terminal 18 phase 1, 1996	**86**	**QA2**	✔	✔	✔	**P**
Sitcum Waterway - Pentec 1991	*79*	-	✔	✔	✔	*F*
Hylebos Waterway - Striplin 1994	***46***	***QA1***	✔	✔	✔	***P-F***
Harbor Island RI, 1995	**35**	**QA1**	✔	✔	✔	**P**
Hylebos Waterway - NOAA - DAC 1994	**28**	**QA1**	✔	✔	✔	**P**
US Navy Bremerton Pier D, round 2, DY94	**22**	**TBD**	✔	✔	✔	**P**
Weyerhaeuser Everett - PTI 1994	**15**	**TBD**	✔	✔	✔	**P**
Port of Seattle - Terminal 18 phase 2, 1996	14	QA2	✔	✔	✔	P
Port of Everett - Piers 1 and 3, DY95	9	-	✔	✔	✔	P
Port of Everett - South Terminal FC, DY95	**8**	**TBD**	✔	✔	✔	**P**
Squalicum Waterway Sediment Characterization, DY92	**8**	**TBD**	✔	✔	✔	**P**
Sound Refining	*3*	-	✔	✔	✔	*P*
Port of Seattle - Terminal 5, 1996	3	-	✔	✔	✔	F
Duwamish Waterway, DY93	3	-	✔	✔	✔	NA
Monitoring - Elliott Bay Full, DY92	3	-	✔	✔	✔	P
USACE Everett Downstream Settling Basin FC, DY93	3	-	✔	✔	✔	P
City of Bremerton - Warren Ave Basin CSO, DY94	*2*	-	✔	✔	✔	*F*
Port of Seattle - Terminal 115, DY93	2	-	✔	✔	✔	P
Neanthes sublethal test demonstration - PTI 1988	2	-	✔	✔	✔	P
Konioke-Pacific - Striplin 1993	**1**	**TBD**	✔	✔	✔	**P**
Bellingham Bay partial monitoring, DY93	1	-	✔	✔	✔	P
Indian Cove Moorage, DY94	1	-	✔	✔	✔	P
King County Sammamish River, DY93	1	-	✔	✔	✔	P
Konoike-Pacific Tacoma Terminals, DY94	*1*	-	✔	✔	✔	*F*
Port of Seattle - Terminal 30, DY94	*1*	-	✔	✔	✔	*F*
Port of Seattle - Terminal 5 Pier Extension, DY92	*1*	-	✔	✔	✔	*F*
US Navy Everett Norton Terminal, DY94	1	-	✔	✔	✔	P
Weyerhaeuser Bay City Dock, DY92	1	-	✔	✔	✔	P

NOTE: Bold text indicates surveys with stations setting AET values
Italic text indicates surveys with stations failing initial screening
TBD - to be determined
✔ - passed screening criteria

Data Processing

- Report, spreadsheet, database sources
- Reformat data into Microsoft FoxPro® database
- Compare data to original source

Ovrhd 14-9 Data Processing

Data Compilation Process

1) Receive data in text (ASCII), .XLS, or .DBF format

2) Check for data consistency

3) Import into FoxPro®

4) Format data to correspond with database structures

   - Translate compound names into codes
   - Include only chemicals of concern
   - Standardize units
   - Sum DDTs, LPAHs, HPAHs, and PCBs — Sum of all detected values or highest undetected value

5) Establish the relationship between BIOASSAY.DBF and CHEM.DBF.

6) Delete samples without corresponding chemistry

Data Acquisition

Scope

Sources

Quality Assurance of Sediment Chemistry and Bioassay Data

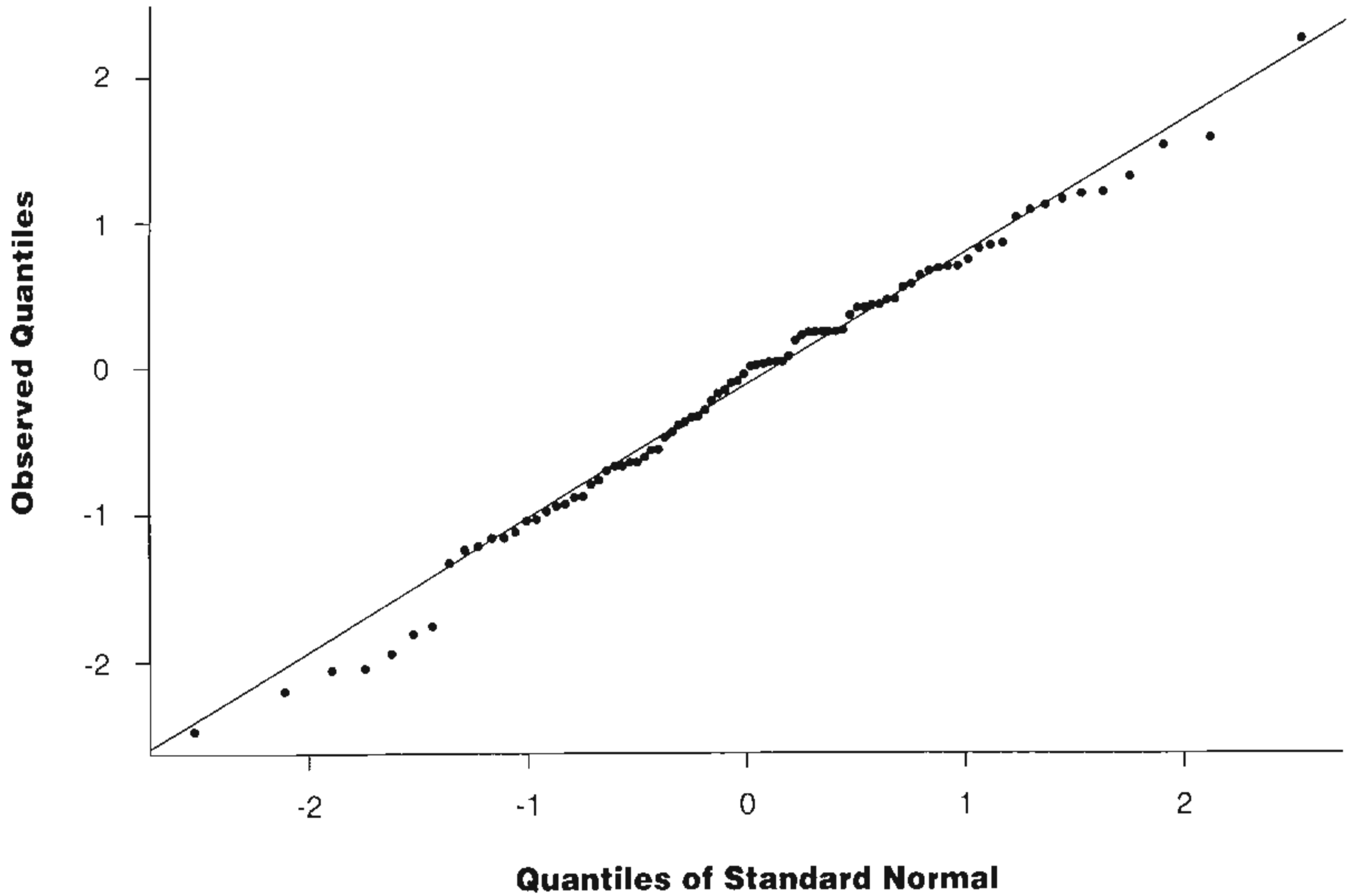
Data Processing

Data Analysis

- Pair reference stations with test stations based on sediment grain size
- Assess growth data for normality (using Shapiro-Wilk's test and normal probability plots) and equality of variance (using Levene's test)
- Apply a rankit transformation to data failing test for normality
- Test for significant adverse effects (using one-tail t-test, $\alpha = 0.05$; "approximate" t-test when data fail test for equal variances)
- Exclude no-hit samples which are statistically inconclusive from AET calculations
- Identify no-hit samples which are statistical outliers for any chemical

Ovrhd 14-11. Data Analysis

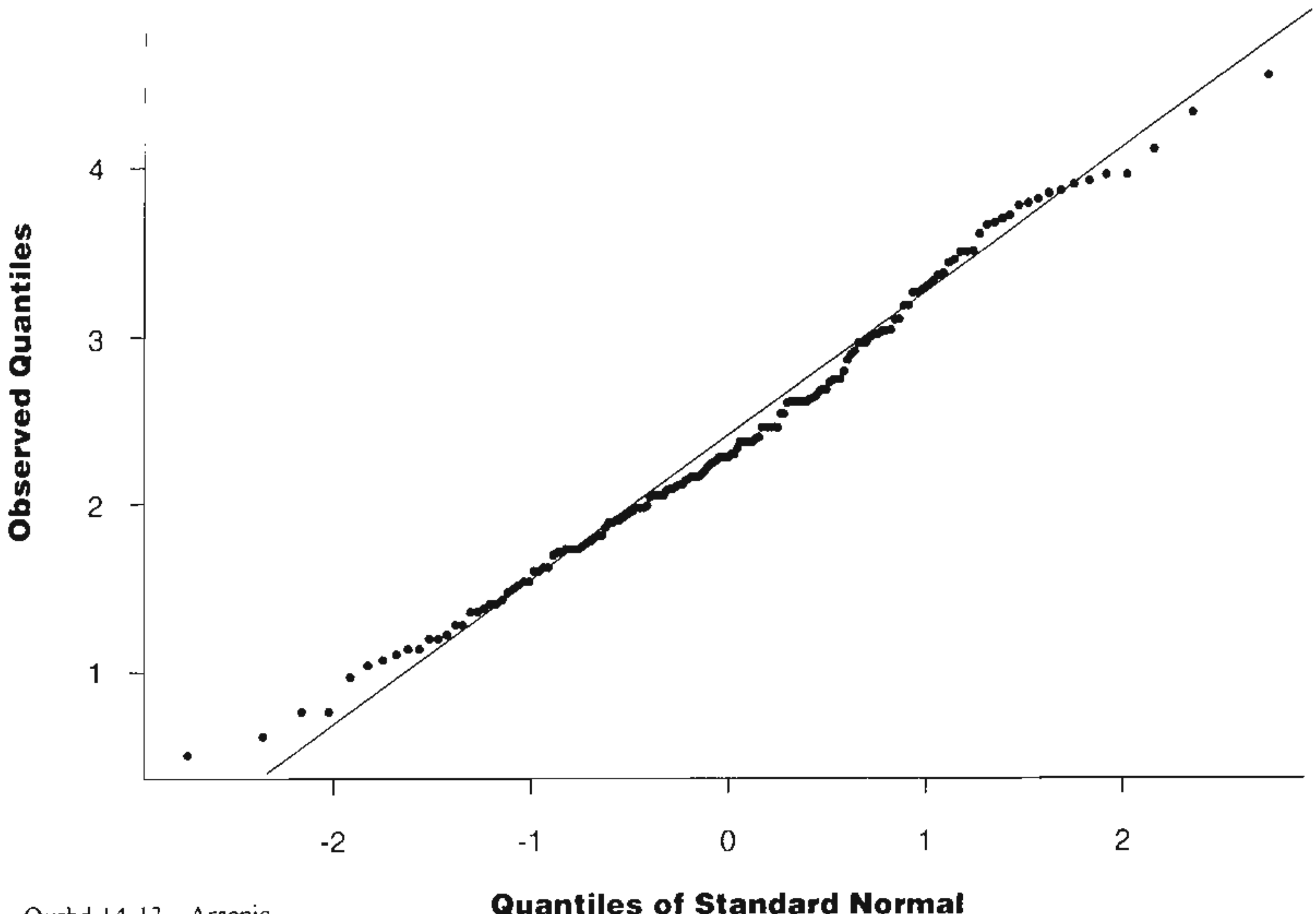
Simulated Normal Distribution



Ovrhd 14-12. Simulated Normal Distribution

Arsenic

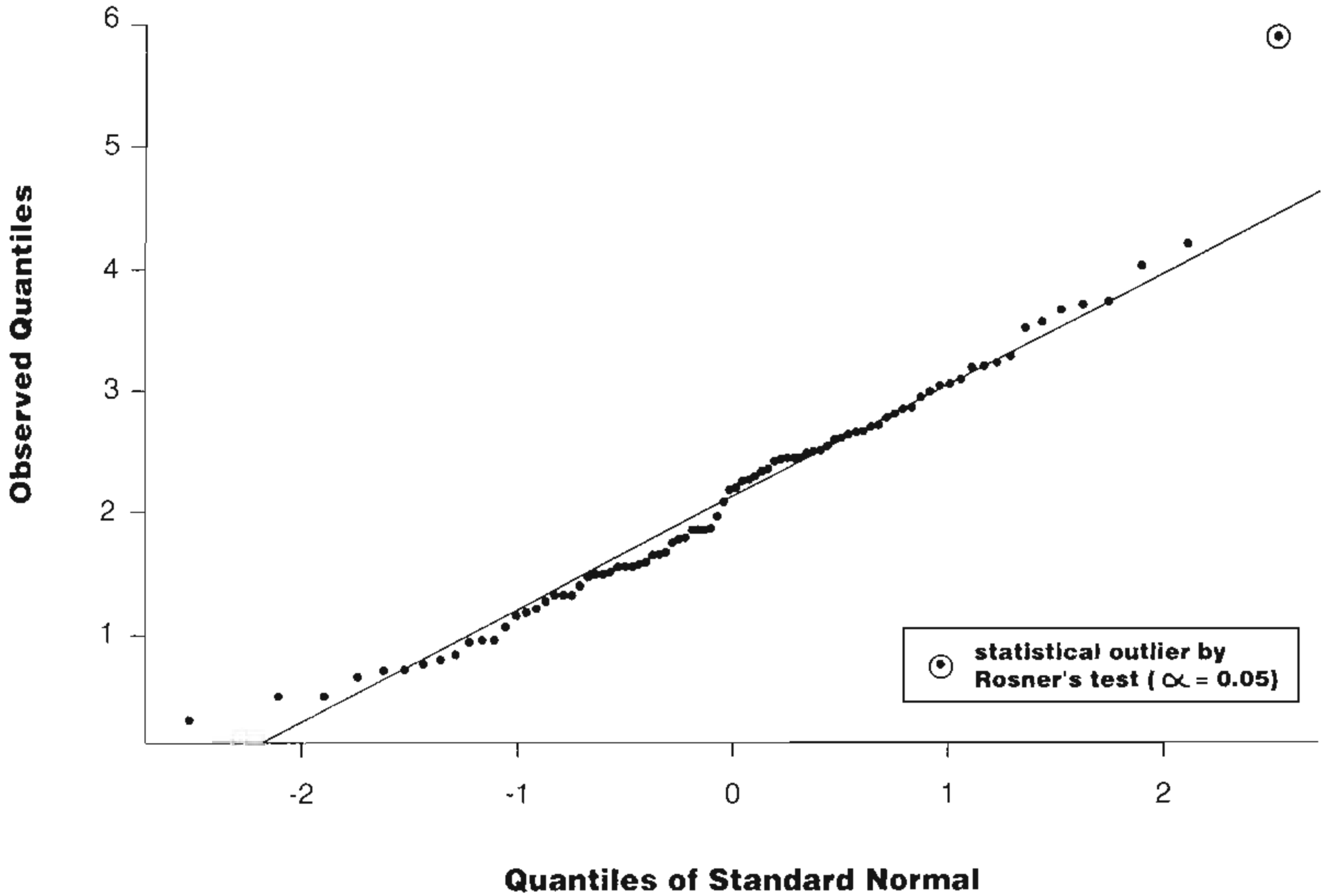
(log-transformed dry weight concentrations)



Ovrhd 14-13. Arsenic

Total DDD, DDE, and DDT

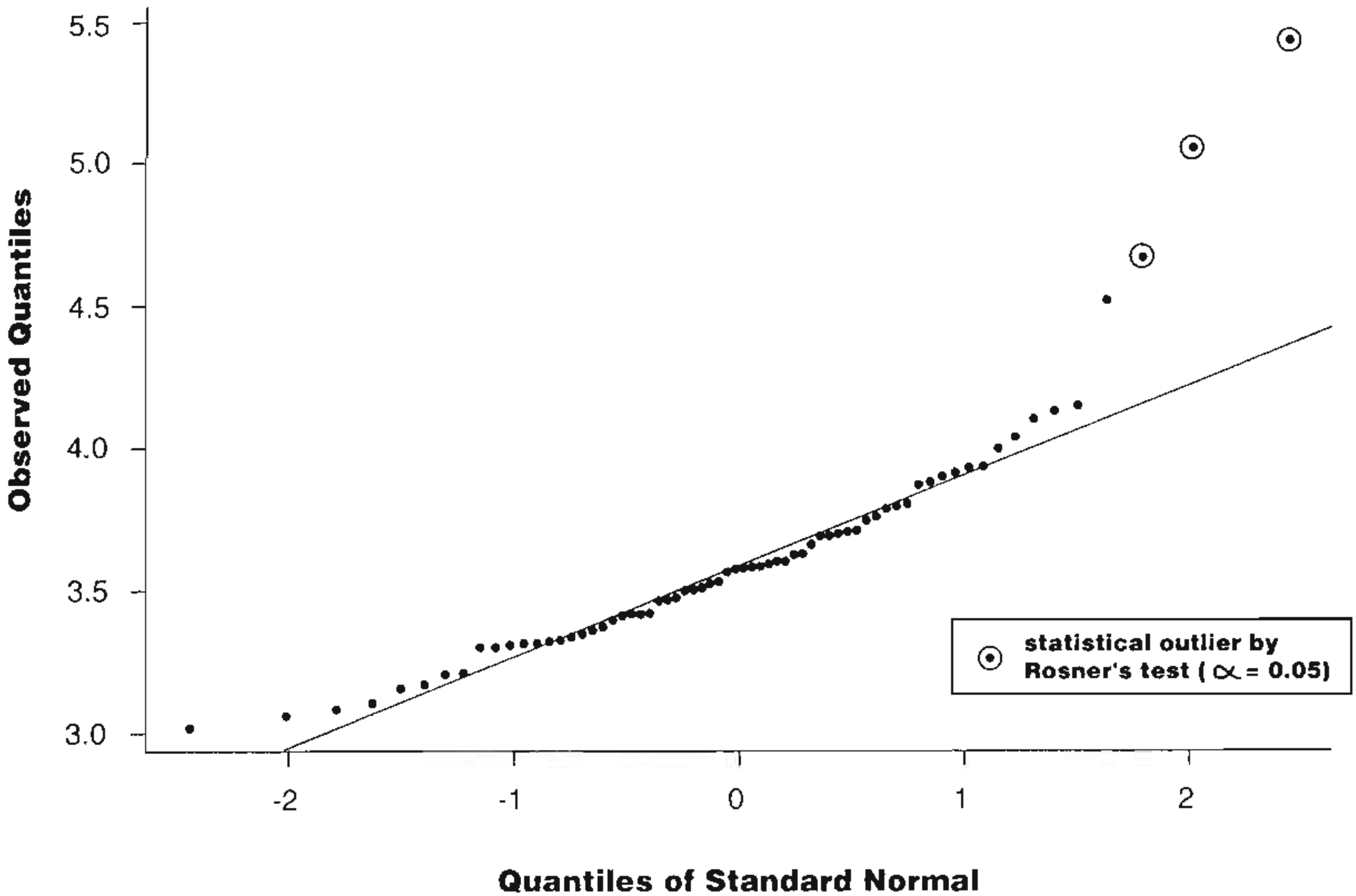
(log-transformed dry weight concentrations)



Ovrhd 14-14 Total DDD, DDE, and DDT

Chromium

(log-transformed dry weight concentrations)



Ovrhd 14-15 Chromium

Dry weight-normalized AET values

Chemical Group/ Chemical of Concern	Amphipod AET	Larval AET	Benthic AET	Microtox AET	*Neanthes* AET
Metals (mg/kg or ppm)					
Antimony	200	9.3	150	NA	38
Arsenic	450	700	57	700	99
Cadmium	14	10	5.1	9.6	*3.0*
Chromium	>1,100	>96	260	NA	>240
Copper	1,300	390	530	390	390
Lead	1,200	660	450	530	650
Mercury	2.3	1.4	2.1	0.41	2.2
Nickel	>370	110	>140	NA	150
Silver	6.1	8.4	>6.1	>0.56	3.3
Zinc	3,800	1,600	410	1,600	2,300
Organic compounds (g/kg or ppb)					
Low molecular weight PAH					
LPAH	29,000	5,200	13,000	5,200	11,000
2-Methylnaphthalene	1,900	670	1,400	670	*200*
Acenaphthene	2,000	500	730	500	**3,400**
Acenaphtylene	1,300	>560	1,300	>560	*>160*
Anthracene	13,000	960	4,400	960	1,700
Fluorene	3,600	540	1,000	540	1,600
Napthalene	2,400	2,100	2,700	2,100	*1,300*
Phenanthrene	21,000	1,500	5,400	1,500	3,400
High molecular weight PAH					
HPAH	69,000	17,000	6,900	12,000	39,000
Benz(a)anthracene	5,100	1,600	5,100	1,300	3,300
Benzo(a)pyrene	3,500	1,600	3,600	1,600	2,200
Benzo(g,h,i)perylene	3,200	920	2,600	670	1,400
Benzofluoranthenes	9,100	3,600	9,900	3,200	8,200
Chrysene	21,000	2,800	9,200	1,400	10,000
Dibenz(a,h)anthracene	1,900	240	970	230	560
Fluoranthene	30,000	2,500	24,000	1,700	10,000
Indeno(1,2,3-c,d)pyrene	4,400	760	2,600	600	1,300
Pyrene	16,000	3,300	16,000	2,600	9,600
Chlorinated organic compounds					
1,2,4-trichlorobenzene	51	64	NA	31	110
1,2-dichlorobenzene	>110	50	50	35	*13*
1,3-dichlorobenzene	>170	>170	>170	>170	*21*
1,4-dichlorobenzene	120	120	110	110	*97*

Ovrhd 14-16 Dry Weight-Normalized AET Values

Dry weight-normalized AET values. cont.

Chemical Group/ Chemical of Concern	Amphipod AET	Larval AET	Benthic AET	Microtox AET	*Neanthes* AET
Hexachlorobenzene	130	230	22	70	120
Phthalates					
Bis(2-ethylhexyl)phthalate	>8,300	1,900	1,300	1,900	2,000
Butyl benzyl phthalate	970	>470	900	63	**>580**
Di-*n*-butyl phthalate	1,400	1,400	>5,100	1,400	*76*
Di-*n*-octyl phthalate	>2,100	>420	6,200	NA	*61*
Diethyl phthalate	>1,200	>73	200	>48	NC
Dimethyl phthalate	>1,400	160	>1,400	71	75
Phenols					
2-methyl phenol	77	63	72	>72	*23*
2,4-dimethyl phenol	77	55	210	29	*18*
4-methyl phenol	3,600	670	1,800	670	**>880**
Pentachlorophenol	400	150	690	>140	**790**
Phenol	1,200	420	1,200	1,200	*340*
Miscellaneous extractables					
Benzyl alcohol	73	73	870	57	>150
Benzoic acid	760	650	650	650	*88*
Dibenzofuran	1,700	540	700	540	630
Hexachlorobutadiene	180	270	11	120	260
Hexachloroethane	140	NA	NA	NA	NC
N-nitrosodiphenylamine	48	130	28	40	NC
Volatile organics					
Ethylbenzene	50	37	10	33	NC
Tetrachloroethene	>210	140	57	140	130
Xylene, total	160	120	40	100	*8.0*
Pesticides and PCBs					
Aldrin	9.5	9.5	NA	NA	**21**
Chlordane	2.8	>4.5	NA	NA	**14**
Dieldrin	3.5	1.9	NA	NA	**34**
Heptachlor	1.5	2.0	NA	NA	**>4.1**
p,p'-DDD	63	28	16	NA	**68**
p,p'-DDE	62	9.3	9.0	NA	46
p,p'-DDT	>270	12	34	NA	**>320**
Total DDT	24	37	NA	NA	**390**
Total PCBs	3,100	1,100	1,000	130	**4,900**

NOTE: **Bold** - Values greater than established AETs
Italic - Values less than established AETs
NA - not available
NC - value not calculated
- Identified as a potential outlier

Ovrhd 14-17 Dry Weight-Normalized AET Values (cont'd)

TOC-normalized AET values

CHEMICAL GROUP/ CHEMICAL OF CONCERN	AMPHIPOD AET	LARVAL AET	BENTHIC AET	MICROTOX AET	*NEANTHES* AET
Nonionizable organic compounds (mg/kg TOC; ppm)					
Low molecular weight PAH					
LPAH	2,200	370	780	>530	770
2-Methylnaphthalene	>120	>53	64	NA	*13*
Acenaphthene	200	>110	57	>57	**>240**
Acenaphtylene	66	>27	66	>27	*>9.3*
Anthracene	1,200	93	220	>79	120
Fluorene	360	73	79	>71	110
Napthalene	220	>190	170	>170	*39*
Phenanthrene	840	140	480	>160	240
High molecular weight PAH					
HPAH	5,300	960	7,600	1,500	2,100
Benz(a)anthracene	270	170	650	>160	190
Benzo(a)pyrene	210	230	>1,000	>140	*140*
Benzo(g,h,i)perylene	100	>240	>1,200	>67	100
Benzofluoranthenes	450	310	1,500	>430	340
Chrysene	840	220	850	>200	420
Dibenz(a,h)anthracene	50	120	89	33	*24*
Fluoranthene	3,000	320	1,200	>190	710
Indeno(1,2,3-c,d)pyrene	120	>190	900	>87	*79*
Pyrene	1,000	520	1,400	>210	690
Chlorinated organic compounds					
1,2,4-trichlorobenzene	1.8	2.7	NA	0.81	**5.4**
1,2-dichlorobenzene	>5.8	2.3	2.3	2.3	*0.64*
1,3-dichlorobenzene	>15	>15	>15	>15	*0.81*
1,4-dichlorobenzene	9.0	3.1	16	>16	4.2
Hexachlorobenzene	4.5	9.6	0.38	2.3	5.9
Phthalates					
Bis(2-ethylhexyl)phthalate	>550	130	60	47	87
Butyl benzyl phthalate	49	>9.2	64	4.9	>17
Di-*n*-butyl phthalate	260	260	1,700	220	*4.8*
Di-*n*-octyl phthalate	58	>57	4,500	NA	3.2
Diethyl phthalate	>110	>5.3	61	>5.3	NC
Dimethyl phthalate	53	>22	53	>19	2.3

TOC-normalized AET values. continued

Chemical Group/ Chemical of Concern	Amphipod AET	Larval AET	Benthic AET	Microtox AET	*Neanthes* AET
Miscellaneous extractables					
Dibenzofuran	>170	57	58	>58	*45*
Hexachlorobutadiene	6.2	11	6.9	3.9	**15.0**
Hexachloroethane	2.7	NA	NA	NA	NC
N-nitrosodiphenylamine	>11	>11	11	>11	NC
Volatile organics					
Ethylbenzene	>3.8	>3.8	>3.8	>3.8	NC
Tetrachloroethene	>22	>22	>22	>22	*2.1*
Xylene, total	>12	>12	>12	>12	*0.40*
Pesticides and PCBs					
Aldrin	0.56	>0.56	NA	NA	**1.9**
Chlordane	0.16	>0.26	NA	NA	**1.1**
Dieldrin	0.13	0.28	NA	NA	**2.6**
Heptachlor	>0.11	>0.40	NA	NA	>0.23
p,p'-DDD	3.1	1.6	1.0	NA	2.8
p,p'-DDE	6.0	>7.3	0.31	NA	>3.5
p,p'-DDT	16	>0.71	3.7	NA	>13
Total DDT	1.4	8.8	NA	NA	**>16**
Total PCBs	190	>46	65	12	**>490**
Ionizable Inorganic compounds (mk/kg TOC or ppm)					
Phenols					
2-methyl phenol	3.1	3.1	10	>10	*1.2*
2,4-dimethyl phenol	6.5	>1.3	2.6	0.63	0.88
4-methyl phenol	780	37	250	81	>73
Pentachlorophenol	24	>11	66	>11	39
Phenol	>440	>39	>140	33	*17*
Miscellaneous Extractables					
Benzyl alcohol	5.0	5.0	>73	5.0	>16
Benzoic acid	>170	>170	>170	>170	*3.2*

NOTE: **Bold** - Values greater than established AETs
Italic - Values less than established AETs
NA - not available
NC - value not calculated
- Identified as a potential outlier

Ovrhd 14-19. TOC-Normalized AET Values (cont'd)

Future Steps

- Evaluate chemically anomalous stations

- Conduct reliability, sensitivity, and efficiency evaluation (Ecology?)

Ovrhd 14-20. Future Steps

Potential for Grain-Size Effects on Larval Sediment Bioassays

Lawrence McCrone, Ph.D.

PTI ENVIRONMENTAL SERVICES

Ovrhd 15-1. Potential for Grain-Size Effects on Larval Sediment Bioassays

Available Larval Bioassay Species

Bivalve Larvae

- Oyster (not recommended for fine-grained sediments)
- Mussel (?)

Echinoderm Embryos

- Sea urchin (?)
- Sand dollar (recommended for fine-grained sediments)

PTI

Ovrhd 15-2. Available Larval Bioassay Species

Supporting Investigations

Refinements of Current PSDDA Bioassays
(U.S. EPA 1993)

– Tested four Carr Inlet reference area samples with 6, 28, 51, and 87 percent fines

Reference Area Performance Standards for Puget Sound
(PTI 1991)

– Tested 21 reference area samples with 3.2 to 96 percent fines

PTI

Ovrhd 15-3. Supporting Investigations

Results of Recent Investigation

- Three stations in area of concern with 85 to 98 percent fines, 2.8 to 4.6 percent TOC
- No exceedances of SQS for any chemical
- No exceedances of SQS biological effects criteria for amphipod or ***Neanthes*** bioassays
- Combined effects in mussel bioassay of 76 to 87 percent
- Combined effects in sea urchin bioassay of 51 to 68 percent

PTI

Combined Effect May Not Be Linearly Correlated With Percent Fines

- Very fine particles (small silt and clay particles) approximate the size of phytoplankton and may be ingested by the larvae

- Only the very fine particles would remain in suspension in the experimental chambers

PTI

Proposed Actions

- Review of all matched larval bioassay and sediment grain-size data collected to date

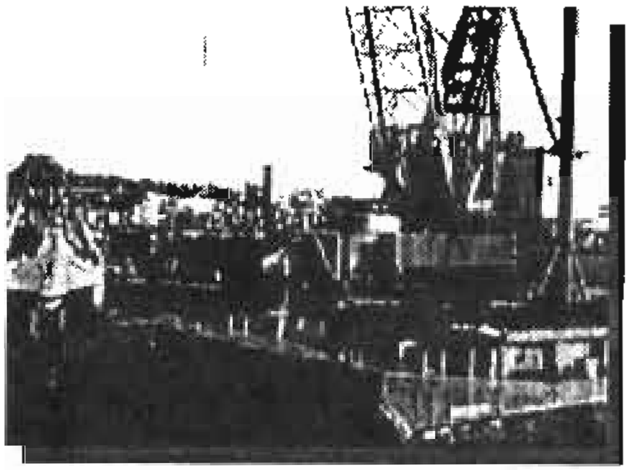
- If insufficient data currently exist for sediments with high proportions of fine-grained sediments, conduct a well-designed laboratory investigation

- If there is an unacceptably high combined effect resulting from grain-size alone, rely on a preponderance of evidence to make regulatory decisions for fine-grained sediments

PTI

Ovrhd 15-6. Proposed Actions

Marine Board
National Research Council
Committee on Contaminated Marine Sediments



STRATEGIES AND TECHNOLOGIES FOR CONTAMINATED SEDIMENT MANAGEMENT: A Report by the National Research Council

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URS Greiner

Sediment Management Annual Review Meeting

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Committee on Contaminated Marine Sediments: Statement of Task

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- Assess best management practices and emerging technologies for reducing adverse environmental impacts
- Appraise interim control measures for use at contaminated sediment sites
- Address how information about risks, costs, and benefits can be used and communicated to guide decision making
- Assess existing knowledge and identify research needs critical for enhancing existing technology

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Committee on Contaminated Marine Sediments: Activities

- Reviewed and assesed technical information
- Interacted closely with researchers, regulators, stakeholders, engineers/operators
- Evaluated six case studies and conducted one site visit
- Conducted workshops on interim controls and long-term technologies
- Summarized site assessment methods
- Evaluated application of decision tools to management process

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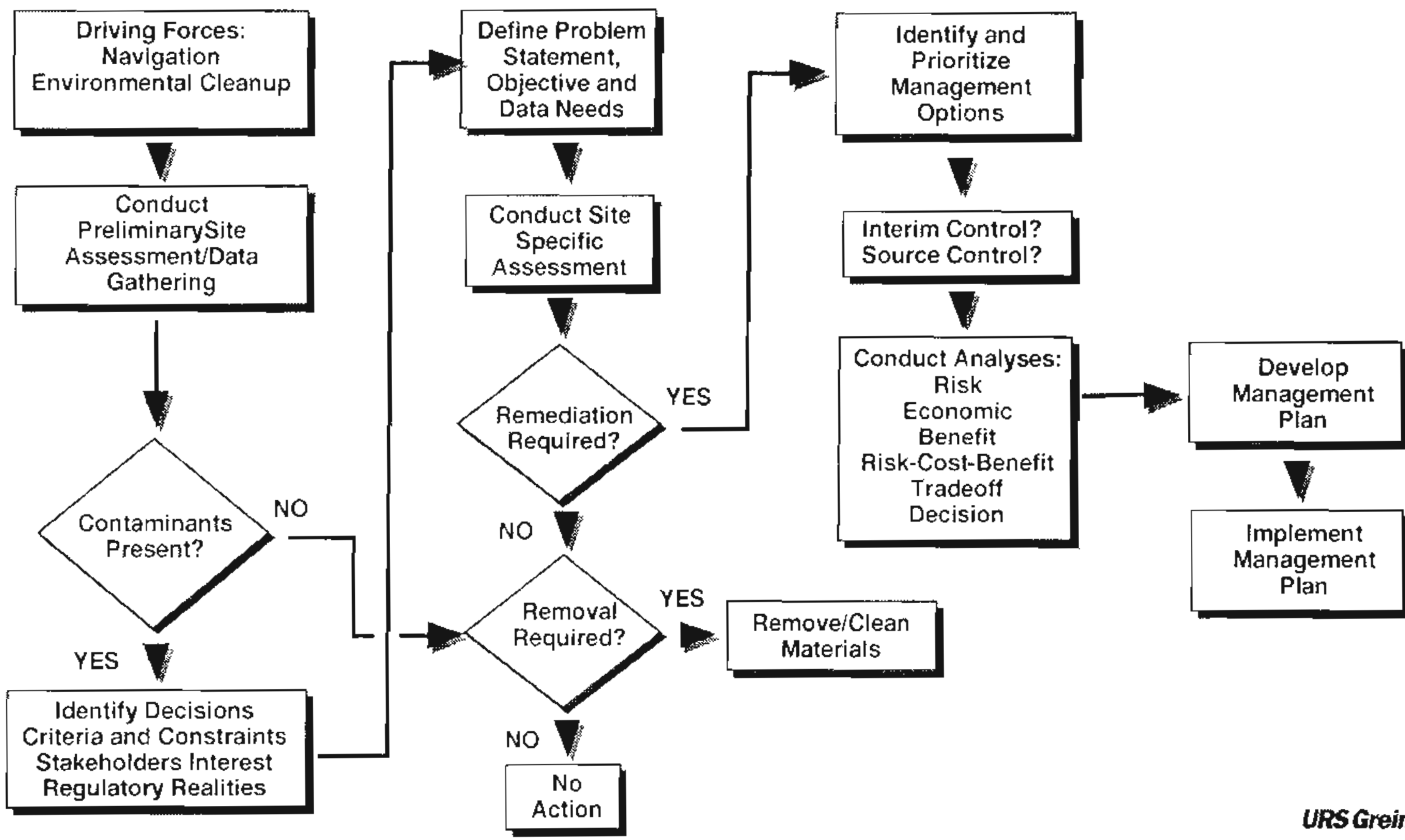
Conceptual Overview of Contaminated Sediment Management



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Ovrhd 16-4. Conceptual Overview of Contaminated Sediment Management

Containment, Disposal, and Natural Recovery Technologies

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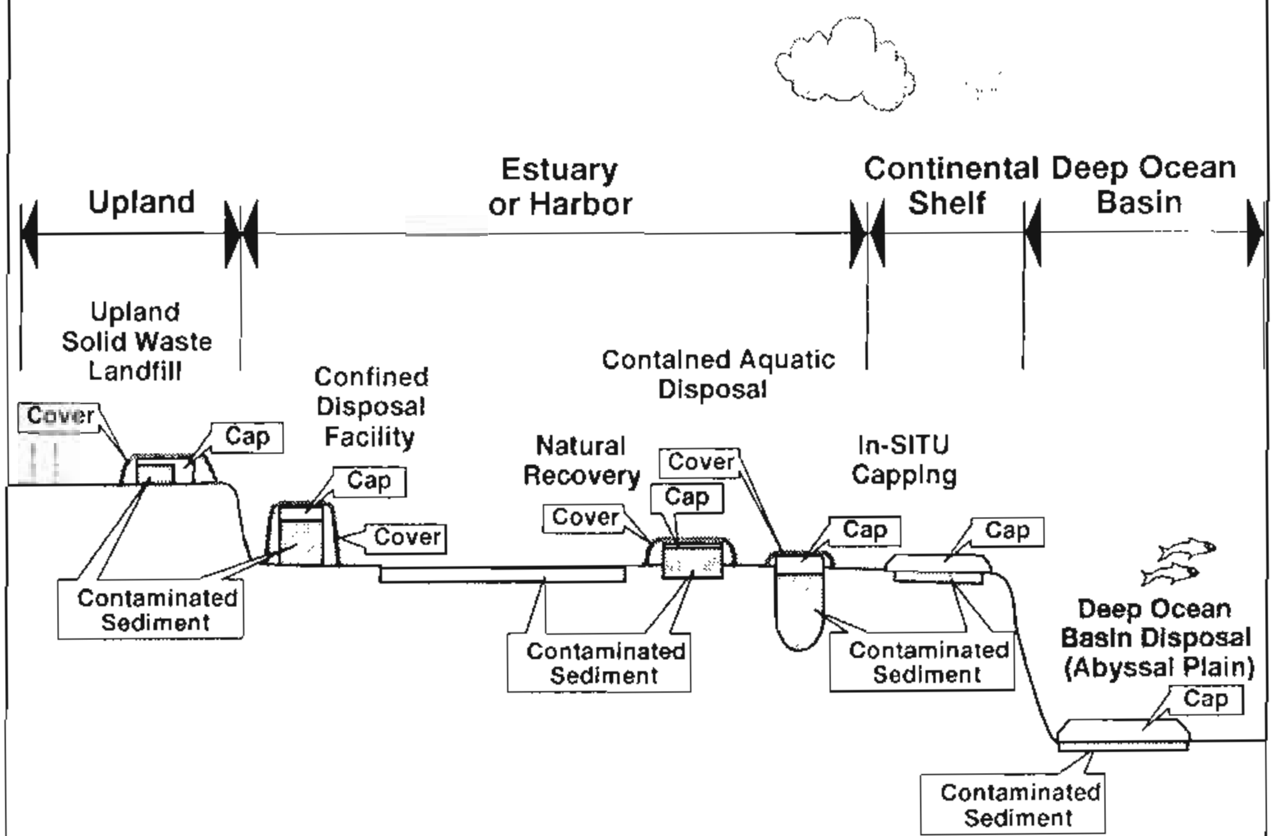

Adapted from Mike R. Palermo, USAE, Vicksburg, Mississippi

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Conclusions: Decision Making

- Stakeholder/involvement early in the decision process is important in heading off disagreements and building consensus
- Systematic risk-based approach offers the best chance for cost-effective management
- Risk analysis effective in selecting and evaluating management alternatives and remediation technologies
- Consistent cost sharing and cost benefit analysis approaches may enhance cost-effectiveness of dredging and disposal.
- Systems engineering strengthens project cost effectiveness and acceptability
- Beneficial uses of contaminated sediments may resolve complex disposal decisions

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Recommendations: Decision Making

- USEPA/USACE: sponsor research to quantify relationship between contaminant availability and risk; evaluate projects using performance-based standards
- USEPA/USACE: develop uniform or parallel procedures to address human health and environmental risks associated with disposal, containment, or beneficial reuse of contaminated sediment
- USEPA: disseminate information to stakeholders on state of the science of decision analytical tools and risk analysis techniques; support pilot projects to demonstrate the use of trade-off analysis and decision analysis in an actual contaminated sediment remediation case
- USACE: modify cost-benefit analysis guidelines and practices to ensure comprehensiveness and uniformity in method application

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Conclusions: Technology Costs

- Natural recovery, capping and containment are effective methods for contaminated sediment management
- High-volume/low-cost technologies are cost effective for contaminated sediment remediation
- Advanced treatment justified for relatively small volumes of highly contaminated sediments; unit costs unlikely to become competitive with less expensive technologies
- Cost data of full scale remediation technologies could be enhanced

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Conclusions: Remediation Technology Options

In Situ Controls

- Natural recovery is a viable and optimum remediation solution when contaminant concentrations are low; if natural recovery is not sufficient, capping may be appropriate
- In situ chemical treatment has conceptual advantages, but needs R&D
- Bioremediation needs R&D to resolve microbial, geochemical, and hydrological issues

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Conclusions: Remediation Technology Options (continued)

Ex Situ Controls

- Improve control of contaminant releases and apply long-term monitoring methods
- Develop methods to preserve capacity of existing CDFs
- Explore acceptability potential for CADs on or near contaminated sites
- R&D for improved design and long-term monitoring methods to control containment loss
- R&D for ex situ technologies for cost effective treatment of large sediment volumes; bench and pilot scale investigations for demonstrating effectiveness of technologies

Conclusions: Remediation Technology Options (continued)

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Sediment Removal

- Precise dredging at near in situ densities may limit capture of clean sediments and water and hence reduce volume of material

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Recommendations: Remediation Technologies

- USEPA/USACE: develop guidelines for calculating costs of remediation systems, including technologies and management methods; maintain database on costs of systems that have already been used.

- USEPA/USACE: support research for promoting reuse of CDFs and CADs, and for improving tools for design and evaluation of long-term stability and effectiveness.

- USEPA/USACE: support R&D for improving existing technologies and reducing risks associated with innovative approaches; encourage peer review of R&D proposals and side-by-side demonstrations of new and current technologies.

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Conclusions: Project Implementation

- Cost sharing for source control, sediment remediation and disposal
- Precision of site assessments; potential application of remote sensing technologies (acoustic coring)
- Combining of institutional controls with natural recovery
- Beneficial uses of contaminated sediments (e.g. islands for seabird nesting, landfills for urban developments, beach nourishment, wetlands, shoreline stabilization, top-soil for landfill covers)

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Recommendations: Project Implementation

- USEPA/USACE: jointly support R&D for the advancement of site assessment technologies (advanced survey methods, chemical sensors for surveying and monitoring)

- USACE: revise policies to allow for placement strategies that incorporate beneficial uses *even if they are not the lowest cost alternatives*; develop and encourage the implementation of beneficial-use alternatives with the help of other regulatory agencies

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Summary

- Careful problem formulation and good information provide the foundation for good decisions
- No silver bullet solution
- Incremental improvements can be made in:
  - Decision-making
  - Remediation Technologies
  - Project Implementation

Figure 1: Area of low concern. Not a contaminated sediment site. No cleanup needed.

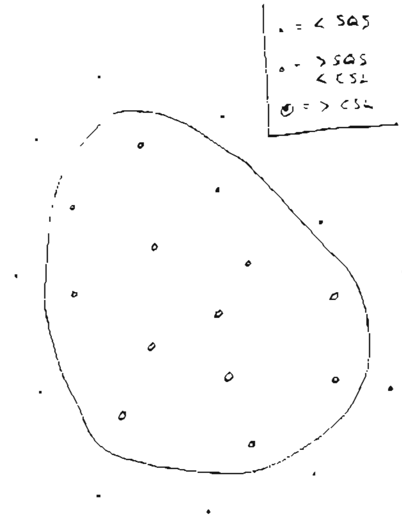


Figure 2: All the bounded area is a contaminated sediment site. Cleanup needed.

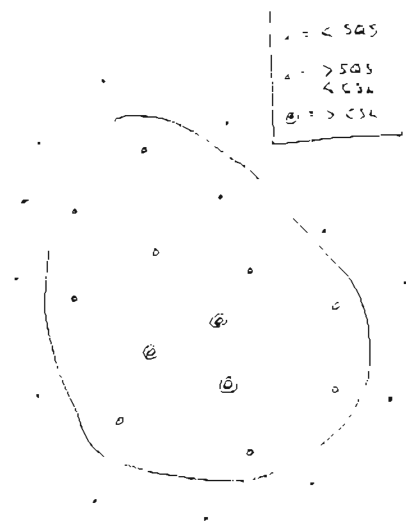
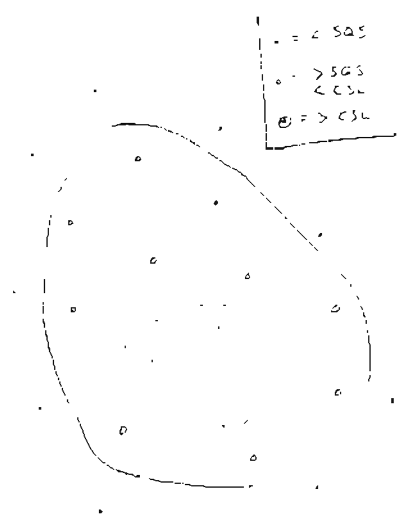
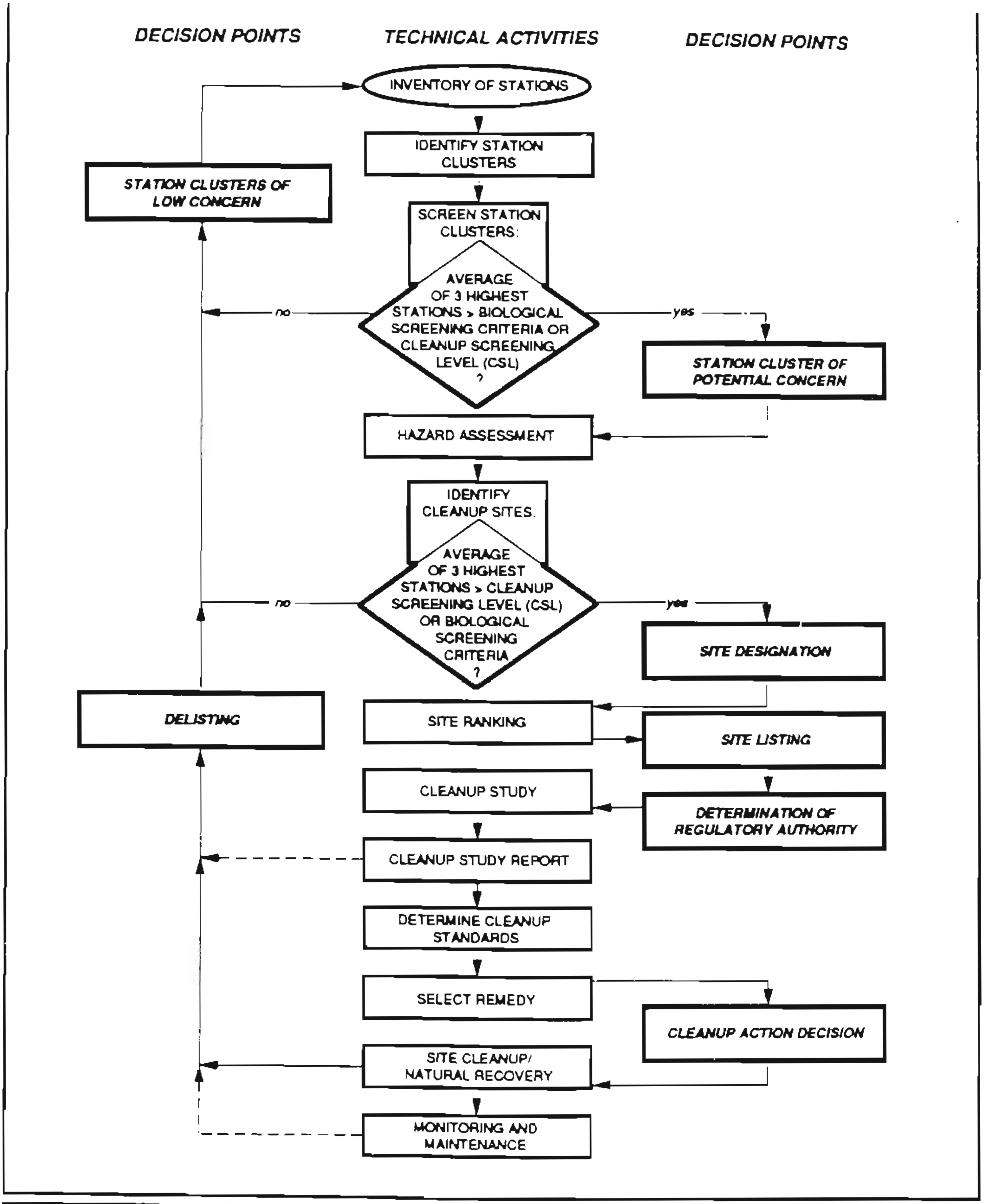


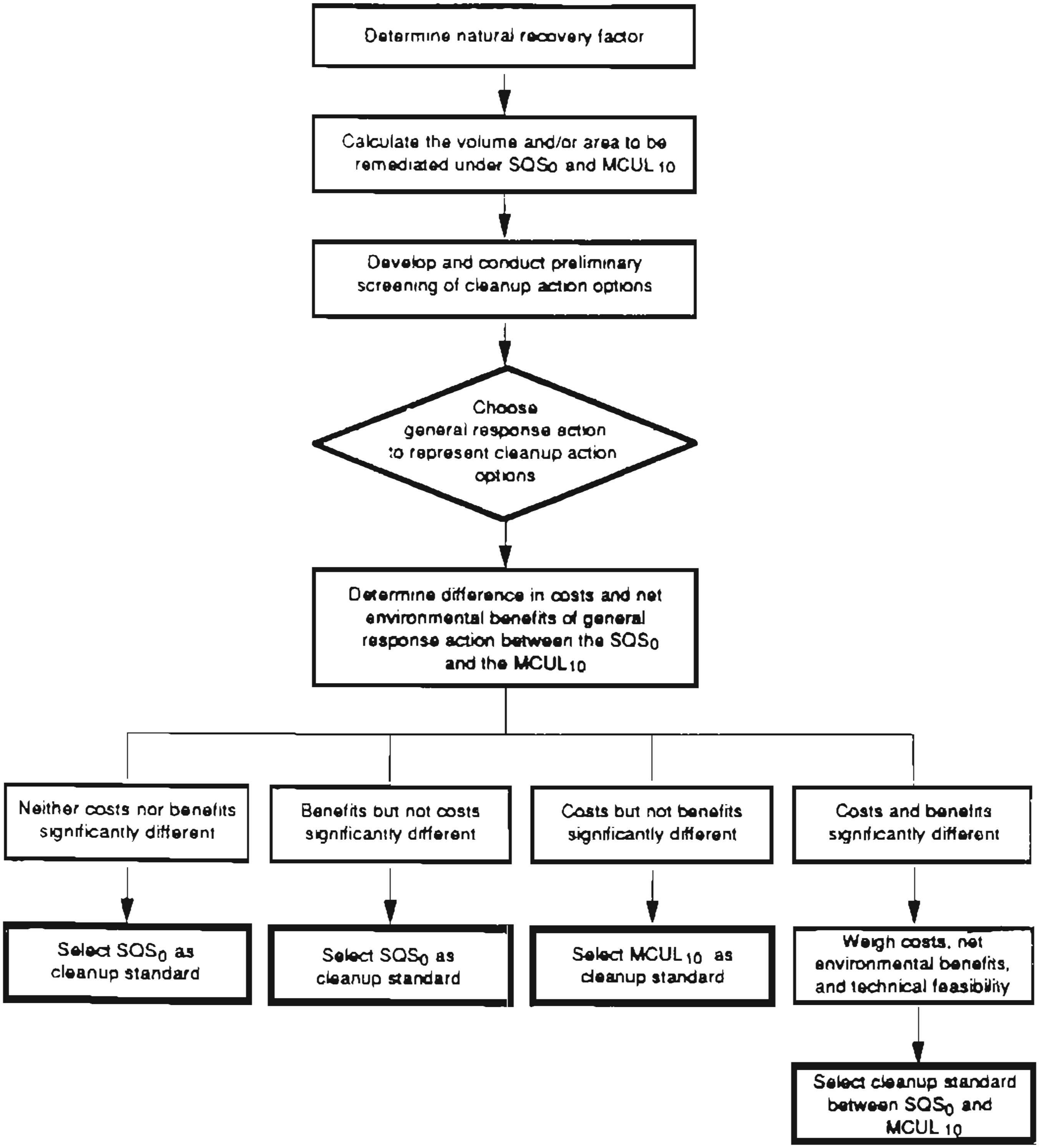
Figure 3: Following only a CSL cleanup. Area of low concern. Not a contaminated sediment site. No cleanup needed.





Contaminated sediments cleanup decision process.

Ovrhd 17-2. Contaminated Sediment Cleanup Decision Process



Development of cleanup standards for a site or site unit.

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Ovrhd 17-3. Development of Cleanup Standards for a Site or Site Unit