SEDIMENT MANAGEMENT
ANNUAL REVIEW MEETING MINUTES

May 8, 1996

Prepared for:

Washington State Department of Natural Resources
Division of Aquatic Lands
Olympia, Washington 98504

Prepared by

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REPLY TO
ATTENTION OF

Operations Division
Dredged Material Mangement Office

Dear Interested Party:

We would like to thank you for your interest and participation in the Sediment Management Annual Review Meeting (SMARM) held on May 8, 1996. This meeting combined the Puget Sound Dredged Disposal Analysis (PSDDA) program annual review meeting with the Department of Ecology's Sediment Management Standards (SMS) Annual Review process. The SMARM was hosted this year by the Washington State Department of Natural Resources. Interaction with the public is vital to the success of both the PSDDA program and SMS process. Programmatic changes to the PSDDA program are finalized and implemented only after the public has had an opportunity for involvement through the annual review process.

This letter transmits to you:

1) a summary of PSDDA program changes
2) the minutes of the SMARM
3) SMARM agenda (Attachment 1)
4) a list of SMARM participants (Attachment 2)
5) post-SMARM comments and responses (Appendix A)
6) SMARM Public Issue Papers and Post SMARM Comment Letters (Appendix B)
7) overheads from SMARM oral presentations (Appendix C)
8) final PSDDA program issue/clarification papers

Thank you for your interest and involvement in the PSDDA and SMS review processes. If you have questions, or need additional copies of the SMARM minutes, please contact the Corps of Engineers' Dredged Material Management Office at (206) 764-3768 or the Department of Ecology at (360) 407-6914 for assistance.

Sincerely,

Brian R. Applebury, P.E.
Chief, Operations Division
Seattle District Corps of Engineers

D.J. Patin
Assistant Director
Central Programs & Enforcement Division
Washington State Department of Ecology

Enclosures

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SMARM Overheads

LIST OF ACRONYMS

AET	Apparent Effects Thresholds
AVS	Acid Volatile Sulfides
BSAF	Biosediment Accumulation Factor
CSLs	Cleanup Screening Levels
DGPS	Differential Global Positioning Systems
DMMU	Dredged Material Management Units
DNR	Washington State Department of Natural Resources
Ecology	Washington Department of Ecology
EIS	Environmental Impact Statement
GMA	Growth Management Act
Koc	Organic carbon partitioning coefficient
LTMS	Long Term Management Strategy
MTCA	Model Toxics Control Act
MUDS	Multiuser Confined Disposal Site
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
PSQWA	Puget Sound Water Quality Authority
QA/QC	Quality Assurance/Quality Control
RI/FS	Remedial Investigation/Feasibility Study
SCUM1	Sediment Cleanup User's Manual Volume I
SCUM2	Sediment Cleanup User's Manual Volume II
SEM	Simultaneously Extractable Metals
SEPA	State Environmental Policy Act
SMA	Shoreline Management Act
SMARM	Sediment Management Annual Review Meeting
SMS	Sediment Management Standards
SQSs	Sediment Quality Standards
TBT	Tributyltin
USACE	U.S. Army Corps of Engineers
WPPA	Washington Public Ports Association

SMARM MINUTES

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING
MINUTES

The Sediment Management Annual Review Meeting (SMARM) was held on 8 May 1996 at the Saint Helens Conference Center, Tacoma, Washington. The SMARM combined both the Puget Sound Dredged Disposal Analysis (PSDDA) Annual Review Meeting and the Department of Ecology's Sediment Management Standards (SMS) Annual Review process. The meeting was hosted by the Washington State Department of Natural Resources (DNR), and was facilitated by the U.S. Army Corps of Engineers (USACE) and the Washington Department of Ecology (Ecology). The meeting agenda and list of attendees are provided as Attachments 1 and 2, respectively.

Morning Session

1. Brian Applebury, Chief, Operations Division, USACE, Seattle District gave opening remarks and introduced Stan Biles, Deputy Supervisor, DNR.

2. Stan Biles greeted the participants on behalf of Jennifer Belcher, Commissioner, DNR. He discussed the approaching tenth anniversary of the PSDDA program, and congratulated everyone on the success of the program. PSDDA is an example of partnerships of several levels of government which have been able to communicate, analyze, and implement various projects throughout the Sound, and the word on the successes of PSDDA is being passed around to other states such as San Francisco and the East coast. He spoke of the increasing population, economy, and development in Seattle and Washington State, which has created a foundation and need for the PSDDA program for sediment management and dredging projects.

Mr. Biles stated that DNR has given tremendous support to the PSDDA program. He spoke of the need to promote healthy ecosystems in appropriate places and public access to these ecosystems, while allowing for continued economic development. He mentioned that creating habitats in urban areas may not be appropriate for a successful restoration project. The agencies also need to consider whether capping contaminated sediments on state owned land and tidelands is the best management method to use in the long run. He concluded by welcoming everyone and wishing them a good meeting.

3. Brian Applebury reviewed the objectives of the meeting and the various topics of discussion, including overviews of the PSDDA and SMS programs, various agency and public issue papers, status reports, and PSDDA/SMS clarification topics. The panel of agency representatives included Ann Essko, DNR; David Kendall, USACE, Seattle District; Dave Bradley, Ecology; and John Malek, U.S. Environmental Protection Agency (EPA).

Ovrhd 1-1. Sediment Management Annual Review Meeting
Ovrhd 1-2. Meeting Objectives and Purpose

Ovrhd 1-3.	PSDDA Program Overview
Ovrhd 1-4.	SMS Group Overview
Ovrhd 1-5.	Issue Papers
Ovrhd 1-6.	Public Issue Papers
Ovrhd 1-7.	Public Issue Papers (Cont.)
Ovrhd 1-8.	Status Reports
Ovrhd 1-9.	PSDDA Clarification
Ovrhd 1-10.	PSDDA/SMS Clarification Papers
Ovrhd 1-11.	Summary and Closing

4. Brian Ross, EPA Region IX, San Francisco, briefly spoke of dredged material management in the San Francisco Bay area, including beneficial uses of dredged material and management of contaminated sediments. He indicated they are making progress, but do not yet have a system of reviewing and fine-tuning the program in their area on a year to year basis, as Washington does with the SMARM. They are still developing cooperation among the various agencies in the Bay area. He stressed that the PSDDA and SMS programs and cooperation among the agencies in Washington should not be taken for granted. He provided copies of the Long Term Management Strategy (LTMS) Environmental Impact Statement (EIS) to the various agencies, which are available to others upon request. He also provided various fliers describing the San Francisco LTMS program for those interested. Mr. Ross also mentioned several other people from San Francisco agencies present at this meeting who could provide information about their program and answer any questions. These individuals were Tom Gansbury, Regional Water Quality Control Board; Eric Larson, San Francisco Bay Conservation Development Commission; and Erika Hoffman and Allan Ota, EPA Region IX.

5. David Kendall, USACE, discussed that due to time constraints, the clarification papers mentioned by Brian Applebury would not be discussed during the meeting. However, the papers were provided in the biennial review report and at this meeting in order to allow for public review and comments during the appropriate time and place set aside during the SMARM. Dr. Kendall then gave a summary of actions taken in response to comments and requests by the public of the 1995 PSDDA SMARM. This included both PSDDA and joint PSDDA/SMS issues such as clarification of water temperatures at which echinoderm tests should be run, analysis of interstitial ammonia and sulfides if warranted, further refinements to the *Neanthes* 20-day growth test, and dropping the PSDDA requirement for analysis for 2-methylnaphthalene in order to be consistent with the SMS program. In response to AET issues, the PSDDA/SMS agencies would be mailing out an AET draft report the following week, and that a regulatory work group would be established to determine whether or not to implement the recalculated AETs. The final AET report will be issued during the summer. Volume II of the AET report is expected to be completed in January 1997. Guidelines have been drafted for the State Environmental Policy Act/Growth Management Act (SEPA/GMA) Shoreline Management Act using PSDDA language. This will be expected to be adopted as a pilot rule for one year in December 1996. The PSDDA agencies are also evaluating statistical power using the perimeter guidelines approach presented at the SMARM last year, and using Commencement Bay monitoring data. This work is still in progress, but will be included with the SMARM minutes and presented next year.

Ovrhd 2-1.	Summary of May 1995 SMARM
Ovrhd 2-2.	PSDDA Issues
Ovrhd 2-3.	PSDDA Issues (Cont.)
Ovrhd 2-4.	PSDDA/SMS Issues
Ovrhd 2-5.	PSDDA/SMS Issues (Cont.)
Ovrhd 2-6.	PSDDA Agencies Response to AET Issues
Ovrhd 2-7.	PSDDA Agencies Response to AET Issues (Cont.)

6. David Fox, USACE, gave an overview of the PSDDA project testing activities and applications of PSDDA evaluation procedures. He provided an update of the 1995 PSDDA projects; the volumes dredged; the number of dredged material management units (DMMUs) tested for chemistry and bioassays; a summary of both chemistry screening level, bioaccumulation trigger, and maximum level exceedances; bioassay hits, and the suitability determinations for these projects. The volume of suitable material dredged in 1995 was slightly above the average volume dredged from 1989 to 1995. He also discussed sampling and testing costs, and compared costs from years 1988 through 1995. He acknowledged that costs were escalating, but that the percent of high-ranked sediments slated to be dredged had also increased.

Ovrhd 3-1.	DY95 PSDDA Projects
Ovrhd 3-2.	DY95 Project Volumes
Ovrhd 3-3.	DY95 Chemical and Biological Testing
Ovrhd 3-4.	DY95 Suitability Determinations
Ovrhd 3-5.	DY95 Chemistry Testing Summary
Ovrhd 3-6.	DY95 Bioassay Hits
Ovrhd 3-7.	PSDDA Suitability DY89-95
Ovrhd 3-8.	DY94/95 Testing Costs
Ovrhd 3-9.	Cost Comparison DY89-95

7. Ted Benson, DNR, presented an overview of the PSDDA disposal site monitoring efforts, and concluded that there have been no adverse impacts to PSDDA dispersive disposal sites to date. He reviewed the PSDDA monitoring framework, monitoring tools, and modifications for the 1995 monitoring program at the Commencement Bay disposal site. The results of the sediment chemistry and tissue analyses, bioassay tests, benthic infaunal analyses, and the evaluation of the monitoring data were presented. He expressed the difficulties in comparing the baseline (1988) chemistry and benthic infaunal data with current data due to differences in sample chemistry analysis methods, and to the lack of full identifications (to lowest taxon possible) for benthic infauna species collected in 1988 (infauna were listed as major taxa only). Therefore, the recommendation was to use the 1995 Commencement Bay data as a baseline for future monitoring efforts. He provided recommendations to the monitoring program that included 1) the substitution of differential global positioning systems (DGPS) for microwave positioning systems, 2) to exclude simultaneously extractable metals/acid volatile sulfides (SEM/AVS) analyses from the monitoring program and 3) to compile and publish a disposal site monitoring plan, which would incorporate all programmatic, field sampling, analytical, transect biological

analysis, and bioassay procedure and interpretation changes to the disposal site monitoring program into one document.

Ovrhd 4-1.	Presentation Agenda
Ovrhd 4-2.	PSDDA Monitoring Framework
Ovrhd 4-3.	PSDDA Monitoring Tools
Ovrhd 4-4.	Map of Commencement Bay Disposal Site and Station Locations
Ovrhd 4-5.	Modifications for the 1995 Monitoring Program
Ovrhd 4-6.	Distribution of Dredged Material at the Commencement Bay Disposal Site
Ovrhd 4-7.	Sediment Chemistry Conventionals and Metals
Ovrhd 4-8.	Sediment Chemistry Organics, Butyltins, and SEM/AVS
Ovrhd 4-9.	Sediment Bioassays
Ovrhd 4-10.	Tissue Analysis
Ovrhd 4-11.	Benthic Infauna
Ovrhd 4-12.	Evaluation of 1994 Monitoring Data - Does dredged material remain onsite? (SVPS)
Ovrhd 4-13.	Evaluation of 1994 Monitoring Data - Does dredged material remain onsite? (Chemistry)
Ovrhd 4-14.	Evaluation of 1994 Monitoring Data - Biological effects conditions exceeded?
Ovrhd 4-15.	Evaluation of 1994 Monitoring Data - Adverse effects to offsite biological resources? (Tissue body burden)
Ovrhd 4-16	Evaluation of 1994 Monitoring Data - Adverse effects to offsite biological resources? (Infaunal abundance)
Ovrhd 4-17.	Evaluation of 1994 Monitoring Data - Adverse effects to offsite biological resources? (Cont.)
Ovrhd 4-18.	Special Studies
Ovrhd 4-19.	Recommendations (DGPS)
Ovrhd 4-20.	Recommendations (SEM/AVS)
Ovrhd 4-21.	Recommendations (Use of 1995 data as baseline)
Ovrhd 4-22.	Recommendations (Disposal Site Monitoring Plan)

8. Public Comments and Questions

No comments.

MORNING BREAK

9. Pamela Sparks-McConkey, Ecology, gave the annual review of the status of SMS program activities. She discussed the SMS Rule background (WAC 173-204) including sediment quality criteria, implementation of source control and cleanup, public involvement and support

concerning technical and policy issues, guidance and training documents, and alternative technologies. She outlined the causes for the revisions in the 1995 rule. For example, revisions to Puget Sound Estuary Program (PSEP) protocols, latest scientific methodologies, clarification of the summing of chemical criteria, use of alternative biological effects criteria, removing the stormwater exemption, and adding a new section to the rule concerning marine finfish rearing facilities (RCW 90.48.220). She indicated that the SMS Rule adopted in December 1995 has some outstanding issues that need to be addressed. In addition, a draft of the triennial responsiveness summary will be issued during the summer of 1996. The presentation reviewed changes to PSEP protocols, SEDQUAL redevelopment, and the preparation of technical development documents concerning bioassay procedures, evaluation of using alternative infaunal assessments, and development of reference ranges. She reviewed the ongoing regional and national policy concerning human health and freshwater criteria, and cooperative sediment management programs (multi-user disposal site, cleanup strategy demonstration, and beneficial uses projects). She identified that the Puget Sound Contaminated Sediment Site List would become available for public distribution this summer, and those interested should sign a list provided at the SMARM. She concluded by welcoming comments, and she identified the process that the comments would be responded in; public comments on papers and technical memorandums that were presented at the SMARM would be handled under the joint PSDDA/SMS summary of meeting minutes document, and public comments on revisions to policy, criteria, and administrative text in the SMS rule would be addressed under the Ecology's Triennial review Responsiveness Summary document.

Ovrhd 5-1.	SMS Rule Background - WAC 173-204
Ovrhd 5-2.	SMS Rule Background (Cont.)
Ovrhd 5-3.	1995 Activities: Rule Revisions
Ovrhd 5-4.	1995 Activities: SMS Rule, Triennial Responsiveness Summary, Draft Triennial Responsiveness
Ovrhd 5-5.	1995 Activities: Changes to PSEP Protocols, SEDQUAL Redevelopment, Technical Development Documents
Ovrhd 5-6.	1995 Activities: Regional/National Policy, Cooperative Sediment Management Program, Contaminated Site List
Ovrhd 5-7.	Post SMARM SMS Activities

10. Russ McMillan, Ecology Southwest Regional Office, gave an overview of the SMS regional cleanup activities. The sediment cleanup implementation is undertaken within the toxics cleanup program, and he introduced two new Ecology sediment site managers, Martha Turvey (Northwest Regional Office) and Marian Abbett (Headquarters for toxics cleanup program). Some of the projects and issues the program has been involved with the past year included training programs, TBT and sediment larval bioassay technical memos, and statistical issues as applied to the SMS. Ecology is also working on a model sampling and analysis plan, which would be an appendix to the Sediment Cleanup User's Manual, Volumes I and II (SCUM1 and SCUM2) documents. Current site activities included the Seattle waterfront recontamination study, completion of the Seattle Colman ferry dock remedial investigation, the Model Toxics

Control Act (MTCA) order with Georgia Pacific in Bellingham for cleanup of Whatcom and I&J Waterways (through RI/FS stage and into cleanup), the Lake Hills Metro sewage treatment plant cleanup and habitat restoration of wetlands that have been contaminated by polychlorinated biphenyls (PCBs) sludge, Eagle Harbor cap monitoring, signing of the Navy Subase Bangor Record of Decision for a 5 year sediment monitoring program, MTCA orders for a PCB and phthalate contaminated site on the Hylebos Waterway and other sites on the Thea Foss Waterway. Future actions for SMS implementation include a baywide demonstration project for sediment cleanup, continued internal and interagency training, completion of the sampling and analysis plan appendix, and other sediment issues.

Ovrhd 6-1.	Sediment Cleanup Program Implementation Activities
Ovrhd 6-2.	Current Site Activities
Ovrhd 6-3.	Significant Milestones
Ovrhd 6-4.	Significant Milestones (Cont.)
Ovrhd 6-5.	Future Actions for SMS Implementation

11. Brenden McFarland, Ecology, presented an update on sediment source control activities. Sediment source control is implemented through National Pollution Discharge Elimination System (NPDES) discharge permits, and the current approach for source control is based on available discharge data. Data is available primarily for treated wastewater (point discharge) as opposed to stormwater (nonpoint). He gave an overview of the general process involved in source control, which begins with a screening evaluation to assess potential for sediment impacts from which permit conditions can be determined. Depending upon the findings, a more detailed analysis could then be conducted that include monitoring and modeling. The SCUM1 document provides details on the process, and can be ordered by calling 360-407-6908 for an order form. Mr. McFarland presented general results of the sediment source control reviews, which showed 15 out of 33 NPDES discharges having sediment impacts. Contaminants included metals, polycyclic aromatic hydrocarbons (PAHs), phthalates, and PCBs. He described revisions to the screening evaluation and the need for a new step between initial screening and site-specific modeling. He presented three effluent screening equations: current screening equation, which does not take enough into account; a more complex loading and natural deposition equation, which is too unwieldy; and a new proposed equation. The next steps for the sediment source control group is to include the screening equation revisions into the Permit Writer's Manual, and SCUM1 document, to provide further sampling and analysis plan guidance, to further permit manager sediment training, to incorporate sediment contaminant modeling as a permit requirement, to provide a more comprehensive sediment source control approach, and to address stormwater discharges for source control.

Ovrhd 7-1.	Sediment Source Control Activities
Ovrhd 7-2.	Sediment Source Control Implemented through NPDES Permits
Ovrhd 7-3.	General Process Overview
Ovrhd 7-4.	Results of Sediment Source Control Reviews
Ovrhd 7-5.	Revision of Screening Evaluation
Ovrhd 7-6.	Screening Equation 1 (current screening)

Ovrhd 7-7.	Screening Equation 2 (loading and natural deposition)
Ovrhd 7-8.	Screening Equation 3 (proposed)
Ovrhd 7-9.	What next?
Ovrhd 7-10.	What next? (Cont.)

12. Public Comments and Questions

Eric Johnson, Washington Public Ports Association (WPPA), stated that he will have questions later, and that although he does not have any at this time, it does not mean that he is completely satisfied.

A question was posed from the audience concerning sediment impact zone authorizations.

Brenden McFarland replied that there have been no sediment impact zones authorized to date. There are two locations they are considering, but he was unable to project a date as to when an impact zone will be authorized.

Scott Mickelson, King County Environmental Laboratory, asked if there was a proposed date for when the Sampling and Analysis Plan Appendix (SAPA) will be available?

Brenden McFarland estimated a final sometime in the fall of 1996, with a draft available during summer 1996.

A question was posed asking whether sediment loading in grams/year as used in the third screening equation, is a reasonable unit to use, and asked how one may measure it.

Brenden McFarland replied that there are data available for background sedimentation in Puget Sound through sediment trap work. From the sediment trap information, sediment accumulation rates can be determined.

A follow-on question was how one determines that for a specific compound or analyte?

Brenden McFarland indicated that the amount of a specific compound or analyte can be calculated from a given discharge. The equation is essentially more of a mass loading equation.

Doug Hotchkiss, Port of Seattle, asked if the SAPA (or SAP guidance) will be available for public review.

Brenden McFarland indicated the SAPA is updated as more information becomes available. They could possibly circulate a draft product to him to comment before it is finalized, or send out the finalized version and revise it later based on public input. He will consider this question (public review of the SAPA), but does not have a response at this time.

Doug Hotchkiss indicated that he would prefer to see the SAPA while it is a draft.

Brenden McFarland noted the comment.

[Draft SAPA was circulated to SMS implementation committee with comment period ending July 31, 1996. Still no target dates for final. Draft currently being used.]
Rachel Friedman-Thomas stated that there are four additional sections to the SAP, which are currently being drafted by an intergovernmental group. There will be an opportunity to amend the SAP, because these sections will need to be added. When these sections are added there will be a much faster turnaround for the SAP.

A question was asked concerning cost benefit analysis associated with human health criteria, and what opportunity there was for public intervention? [Could not discern the full question on the tapes. Request PSDDA contact Laura Weiss for clarification.]

Laura Weiss indicated that they are required to do a cost benefit analysis. [Could not hear the response.]

Jack Word, Batelle, wondered how sediment loading is being factored into the equation. [Could not hear his question well during the meeting or on tape.]

Brenden McFarland clarified that the screening process determines whether a discharge has the potential to be a problem, not how far contaminants get downstream and where it will end up in the receiving environment.

Jack Word stated the depositional rate or how fast the sedimentation occurs can be altered in an effluent treatment system, so that the settlement pattern can be minimized. He felt that right now they are using a general settlement regime for a general deposition rate for Puget Sound in the screening equation. He wondered if there was thought to go back to one of the treatment scenarios which minimizes settlement (by removing large chunks), so that they would not need to deal with the sediment contamination load.

Brenden McFarland indicated that it was something to take into consideration, although it will come into later analyses of the discharge (e.g. modeling phase). He is not certain how this could be incorporated into the screening phase at this time.

Todd Thornburg, Hart-Crowser, asked if there was any thought of incorporating chemical partitioning in the screening process, so that one can account for some of the less hydrophobic compounds, which are less likely to absorb to particles in the deposit.

Brenden McFarland replied that they can incorporate these into equations between the screening and modeling phase, but that this is not part of the screening phase at this time.

Todd Thornburg asked if it was included as part of the modeling effort.

Brenden McFarland indicated there have been discussions as to what partitioning coefficients should be included in modeling efforts so that it is included at some phase.

Todd Thornburg indicated that he understood it would not be part of the screening phase.

Brenden McFarland acknowledged that it would not be part of the screening phase.

Andrew Noch, Golder Associates, wondered what Brenden McFarland's views were on stormwater and industrial discharges with respect to regulating discharges such as lead, which is pervasive in our environment. He wondered how Mr. McFarland accounts for nonpoint discharges such as Interstate 5, which according to the SCUM1 guidance would be a source control problem. Industrial dischargers, which have the same ambient dust properties in their stormwater, under the existing program have to clean that stormwater or have to perform discharge observational work. Large areas of public land are probably receiving more nonpoint discharges to the ambient water, which are not regulated under the existing program. There has to be a resolution.

Brenden McFarland replied that it was a good problem statement, and that he does not have a good answer at this point. Stormwater is a trickier issue for them than dealing with processed wastewater. The source control program is considerably more advanced for wastewater than it is for stormwater. They have a problem dealing with water quality with stormwater issues and with sediment source control for the same discharges. Water quality is the mechanism they are using to deal with sediment source control.

13. Ted Benson discussed adjustments to the PSDDA site monitoring. He briefly reviewed the questions and hypotheses addressed by the full monitoring program. He indicated that the PSDDA agencies elected to tier the tests at Port Gardner and Commencement Bay as a cost savings. The monitoring surveys at these two disposal sites were used to verify the effectiveness of the evaluation and disposal. The agencies found that it was justified to reduce the monitoring efforts. He then presented the various PSDDA disposal site monitoring surveys and the cumulative non-dispersive site use summary.

Ovrhd 8-1.	PSDDA Disposal Site Monitoring Surveys
Ovrhd 8-2.	Cumulative Non-Dispersive Site Use Summary

***** LUNCH BREAK *****

Afternoon Session

14. John Malek, EPA, presented the PSDDA/SMS issue paper on tributyltin. He pointed out that the issue paper on tributyltin should be considered a draft. There has been further discussions with the Port and various consultants, who had suggestions and concerns which the agencies would like to consider for revising the issue paper. He described the highlights of the testing, reporting, and evaluation of tributyltin in the PSDDA and SMS programs, and reviewed

the history of analysis for tributyltin in these programs. He indicated that, until recently, tributyltins were not routinely analyzed as a chemical of concern, but were analyzed based on a "reason to believe" it may be present (e.g., near marinas and shipyards where ship painting occurred). The scope of what constituted a "reason to believe" tributyltin may be present, has been limited. In 1988, TBT was considered a potential chemical of concern, and the agencies went through a process of establishing a screening level for TBT in sediments, expressed as tin (based on equilibrium partitioning model, but focusing on the sediment associated chemical). They established a bioaccumulation trigger as 219 ppb.

Today tributyltin is found in varying levels all over, ranging from very low to what may be considered high levels in certain sediments. To complicate matters, the toxicity and bioaccumulation potential are affected by various factors, such as pH, salinity, and organic carbon, more so than many other chemicals of concern. These factors can change the form of the TBT chemical, and hence change the toxicity or bioavailability of the chemical. Butyltin is often released into the environment in different forms such as paint chips, as a direct liquid, non-point source discharges for such items as Tylex, and in wood preservatives. The scope is broadening. As a result, an interagency work group has been set up to deal with tributyltin contamination issues and to decide what need for remediation should occur. The need for this work group was also triggered by high TBT contamination in superfund sites located in Commencement Bay. To date, the work group's attempts to develop AETs has failed, due to insufficient information and other complications (such as effects of pH, salinity, and organic carbon). The work group determined that an AET approach may not be appropriate. The focus, regulatorily, is generally on evidence of effects, and these effects could be measured and more strongly documented by focusing on the amount of TBT in the interstitial waters, as opposed to the sediment concentrations.

Future actions for tributyltin issues include a need for standardization of methods used to measure tributyltin and of reporting TBT values (reported as TBT vs. as tin). The focus is to look more at TBT in the interstitial waters and in tissues. For requiring TBT analysis, the agencies will continue with a "reason to believe" approach, but the scope has expanded. They are recommending that for "no test" requirement for TBT, there should be evidence that TBT is either not present at the area of concern, or evidence that levels are below those which would trigger concern. They are developing a new tiered testing strategy, and plan to de-emphasize bulk chemistry testing in favor of using the interstitial or pore water approach. He realized that the process of changing over to using interstitial water testing may not be easy, because there are many projects which have only tributyltin sediment chemistry data. However, there is a formula (based on theoretical partitioning) for converting the sediment chemistry data for TBT to an interstitial water concentration. The testing strategy will include a biological component, which could override the chemical criteria. In addition, the agencies want to look at refocusing from the standard bioassays, which test for acute toxicity, to looking at bioaccumulation to measure potential effects (e.g., the work by Jim Meador at NOAA). The endpoint for the bioaccumulation remains an application of acute and chronic toxicity based on the research information. The bioaccumulation test is not looking at a human health endpoint, but at acute and chronic effects on organisms.

The new PSDDA screening levels for TBT in pore waters were presented. If the concentration of TBT in pore waters is above 0.15 μg TBT/liter, biological testing will be required. Based on the literature, the maximum level is proposed as 0.7 μg TBT/liter. He cautioned that because the SMS process goes through more formal procedures, these values should not be considered as sediment quality standards (SQSs) and CSLs. There is a need for a standardized pore water extraction method that all the agencies agree upon, and which methods should be used under specific circumstances. They also need to identify the appropriate species to use in the bioaccumulation tests, the protocols for performing the tests, and the length of the test. The test will either have to be very long (longer than the standard 28 days) or they may also consider modeling the effects forward based on results from a more standard length test. He concluded by informing the participants that there will be a TBT meeting on May 20th at EPA in the 7th floor conference room (10:00 am), which will allow for further discussion of TBT issues.

Ovrhd 9-1.	Testing, Reporting and Evaluation of Tributyltin in PSDDA and SMS Programs
Ovrhd 9-2.	Tributyltin Past
Ovrhd 9-3.	Tributyltin Past (Cont.)
Ovrhd 9-4.	Tributyltin Present
Ovrhd 9-5.	Tributyltin Present (Cont.)
Ovrhd 9-6.	Tributyltin Future: Standardization
Ovrhd 9-7.	Tributyltin Future: Proposed Actions
Ovrhd 9-8.	Tributyltin Future: Proposed Actions (Cont.)
Ovrhd 9-9.	Tributyltin Future: Proposed Actions (Cont.)
Ovrhd 9-10.	Tributyltin Future: Proposed Actions (Cont.)
Ovrhd 9-11.	Tributyltin Future: Proposed Actions (Cont.)

15. Doug Hotchkiss, Port of Seattle, presented a critique of the PSDDA/SMS draft issue paper on the testing, reporting, and evaluation of TBT data in the PSDDA and SMS programs. He outlined some of the recent developments concerning TBT, and identified problems the Port and others had with the PSDDA/SMS issue paper on TBT. He indicated that initially referenced information in the issue paper was not readily available for them to review. In addition, much of the work in the draft seemed to be based on recent work by Jim Meador and colleagues at NOAA, which was still in process. There was some concern that the information from this work was inadequate to fully support the conclusions presented in the PSDDA/SMS draft. He felt it was inappropriate to base policy recommendations on work that is not yet finalized, and for which they have some technical concerns.

Mr. Hotchkiss discussed some of the recent developments, which have raised some concerns. With respect to measuring TBT concentrations in interstitial waters, there were some concerns that interstitial concentrations will be all that they will get. They have a problem with the way tissue concentrations in the literature, which were used to support regulatory levels in the draft paper, were obtained. In addition, they did not feel there was sufficient science involved to make the regulatory levels hard and fast. They also had problems with the screening levels for TBT. They felt the screening levels were a reasonable way to start, but there was insufficient data to

support these levels to be used for regulatory purposes. The Port was also concerned about abandoning the bioassay tests for TBT effects, and felt that the agencies jumped too soon at concluding the test organisms were not being responsive. It may have been that the elevated TBT observed in some of the sediments were not bioavailable, and that the levels of TBT present in the interstitial waters were not sufficient to be toxic to the organisms. He felt there should be more work done in examining the standard bioassay tests before abandoning them for regulatory purposes. They agree that moving ahead with the bioaccumulation testing is not an unreasonable approach, but that they want to see more work done on the bioassay tests.

Mr. Hotchkiss then reviewed some of the problems concerning the methods used to calculate the lethal doses (LD50s) of TBT to test organisms. For example, the LD50s were based on a combination of dead animals, and living which had been depurated. In addition, the small size of the organisms would make it difficult to accurately assess the concentrations in the tissues. He then listed some more detailed problems with the bioassay testing (e.g. too many parameters varied, different methods used in obtaining pore waters, etc.). Specific problems the Port has with the proposed PSDDA screening level for TBT in interstitial water include the Koc (organic carbon partitioning coefficient) value used, which probably was not accurate, the need for additional investigations to determine the partitioning coefficient, and the reliance placed on the single Koc values. He indicated that the 0.15 μg TBT/L level was not unreasonable for a screening level, but that it would not be appropriate to consider 0.7 μg TBT/L as a maximum level. It would be more appropriate as a cleanup screening level, CSL.

Ovrhd 10-1.	PSDDA/SMS Issue Paper: Tributyltin Draft Issue Paper Critique
Ovrhd 10-2.	Recent Developments Concerning TBT
Ovrhd 10-3.	Problem Identification
Ovrhd 10-4.	Discussion of Recent Developments
Ovrhd 10-5.	Tissue Concentrations
Ovrhd 10-6.	Bioassay Testing
Ovrhd 10-7.	Proposed PSDDA Screening Level for TBT in Interstitial Water
Ovrhd 10-8.	Conclusions

16. Mike Johns, EVS Environmental Consultants, discussed the sensitivity of amphipod species to TBT in sediment and porewater. He indicated that the genesis of this issue paper for the Port of Seattle was a Harbor Island project in which there were high concentrations of TBT in the sediment, although there were no corresponding failures in the bioassay tests (amphipod, sediment larval, and *Neanthes* bioassays). The agencies expressed the concern that the bioassay tests used were not sensitive. At about that time, Jim Meador's paper came out concerning sensitivity of amphipods to TBT, and an apparent differential sensitivity to TBT between *Rhepoxynius* and *Eohaustorius*. As a result, the agencies began to request that the amphipod *Eohaustorius* be used for testing TBT effects. Since then, the agencies have concluded that neither species is sufficiently sensitive, and have moved on to include other tests such as bioaccumulation tests and in some cases, *in situ* benthic community analysis.

He indicated that there were some technical issues with respect to the methods used and conclusions derived from the study in which these differences in amphipod sensitivities were observed (Meador's paper). The study in itself was not designed to test whether one species was more sensitive than the other to TBT. He felt the sensitivity analysis was inconclusive, and emphasized that it was a single study. In addition, a number of parameters were varied, and different methods were used to obtain pore water. The same chemical analysis was not used, nor were bioassays analyzed during the same time of year. The spiked sediments used in the analyses compared were not collected from the same location. All these variables made it difficult to conclude whether one species was more sensitive than the other. There was also uncertainty in the way the LC50 values were calculated.

Mike Johns then proposed that another study be conducted, which is designed to evaluate the sensitivity of *Eohaustorius* vs. *Rhepoxynius*. Test sediments used should be spiked TBT concentrations that are representative of the range of TBT concentrations observed throughout Puget Sound (focusing on the interstitial water concentrations). Because acetone used in spiking sediments could cause unequal pools of TBT in pore waters, the acetone would need to evaporate fully when used to spike TBT. Acetone is a toxicant and can cause mortality if it is not fully evaporated, which would affect the interpretation of the bioassay test results. A reference sediment should be run and all tests should be conducted at the same time. The data uses would be to determine whether there is a differential sensitivity among species, whether species are sensitive to levels of TBT found throughout Puget Sound, and to provide some basis for regulatory decision making.

Ovrhd 11-1.	Sensitivity of Amphipods Species to TBT in Sediment and Porewater
Ovrhd 11-2.	Introduction
Ovrhd 11-3.	Problem Identification
Ovrhd 11-4.	Proposed Actions
Ovrhd 11-5.	Data Uses

17. Public Comments and Questions

Teresa Michelsen, Ecology, responded to the issue papers presented by Doug Hotchkiss and Mike Johns. She agreed that many of their comments were valid, but that there have been some misperceptions about how the numbers presented in the draft TBT issue paper were developed. She indicated that the sensitivity of the bioassay tests were questioned because different patterns in TBT test results were observed. For example, high sediment concentrations, benthic community impacts and bioaccumulation in tissues occurred, yet no bioassay test failures occurred. Bioaccumulation in the tissues indicated that TBT was bioavailable, and yet there was no response in the bioassay tests. Meador's paper offered one possible explanation for why the bioassay test results had no failures. They did not rely on Meador's paper in developing the interstitial water concentrations that are in the proposal. A compilation of interstitial concentrations that resulted in effects levels was developed (paper by Roy F. Weston Consultants). They selected from among those percentages of acute and chronic effects that were relevant for organisms found in Puget Sound. The interstitial water values came directly out of

the literature. They did not perform any back calculations using Koc values. With respect to the bioaccumulation ranges presented in the paper, there was not much information available at the time the paper was put out. However, in revising the paper, she has collected much more information. She said based on the information she has gathered or been given, the effects levels in tissues for species common in Puget Sound were in the order of 2-12 mg/kg dry weight, which were close to the range they reported for chronic effects in the paper (3-9 mg/kg). Ranges observed in studies on *Neanthes* were on the order of 4-6 mg/kg. With more data coming in, they will be able to review the ranges and make the numbers more robust. She was very interested in the proposal for the bioassays test studies presented by Mike Johns.

18. Eric Johnson, WPPA, gave a presentation on the Sediment Management Standards Triennial Review process. He expressed that it was appropriate for annual reviews of both the PSDDA and SMS programs to be conducted at the same time, because so much of the sediment regulatory work arose out of the early PSDDA work and the need for defensible disposal standards that lead to methodology given us in the SMS. He discussed the comments the Ports have about the SMS triennial review process, which can be summed as "When all is said and done, more is said than done". The standards have been on the books or in development for several years. He acknowledged that Washington State has been and still is on the leading edge of development in this field (sediment management), but with that comes the responsibility to continue to validate and incorporate new scientific information into the process. The agencies vowed to make this process work, and to incorporate new scientific information into the management standards. However, the process has not completely worked, although in some areas, such as the PSDDA program, it has worked well.

The Port of Seattle recommended a series of issues during the triennial review process last year (examples listed on the second page of the issue paper). One issue was to recalculate the AETs using newly obtained data, which could change the way the standards are interpreted. In some cases, the AET numbers may increase. The Port of Seattle obtained abundant data (e.g. Harbor Island), which indicated the need for some changes. The Port presented the agencies with this data, but the data has not been incorporated. They want the AETs recalculated, among a few other issues concerning bioassays, which will be discussed later during the meeting. Their views on the triennial review were that it is a good process, but that it has not done enough. The Ports would like to get cleanups accomplished, and to determine what they can do to move cleanups forward. The Ports are hoping to work with the agencies in order to get these cleanups completed.

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

Lincoln Loehr from Heller, Ehrman, White, and McAuliffe, agreed with Eric Johnson. He wanted to note there is not a reference to a Sediment Management Standards <u>final</u> rule for the rule that is "passed off" as a triennial review of SMS adopted in December (appearing in Federal Register on January 17). He felt that this did not accomplish a triennial review of the sediment management standards.

20. Jack Word, Battelle Marine Science Laboratory, gave a presentation on reducing the uncertainties in the interpretation of sediment toxicity tests and benthic community effects. He stated that Battelle has been working on a variety of bioassays and trying to understand benthic community impacts for a number of years. There are many things that can cause an organism to die or a community to change, and they have been trying to study the various chemicals of concern to evaluate if the response observed was related to one of the chemicals. That is how the Apparent Effects Threshold values were determined. One problem is that what is observed in the Puget Sound environment may not apply in another environment (for example the effects based criteria do not respond in the same way).

He discussed how studies throughout the country tried to relate effects observed in a benthic community to contaminant effects. Although there may or may not be a cause and effect relationship, the tendency is to continue to try to associate a cause and effect relationship between effects observed and contaminant levels present. He discussed how a number of variables, in addition to contaminant concentrations, can cause toxicity effects or changes in the benthic community. This can include grain size, ammonia and/or hydrogen sulfide concentrations, organic matter, salinity, and various other factors. When information on these variables is not available, those evaluating the data tend to attribute impacts to what ever is being studied or measured, such as various chemicals of concern. It is not fully possible to go back in time and review sediment toxicity test results to eliminate these variables, because these variables (e.g. ammonia and sulfides) were not always measured. One can test to see if predictions about potential effects based on the chemistry hold up. If not, then possibly one of the other variables such as grain size or ammonia concentrations are influencing the results.

He indicated that there are a couple questions we should be considering. One is whether or not there is a sediment toxicity response or community change occurring at a site, such as a Superfund site, and whether they need to do anything with the sediment. The other question is when you move the material to another site, the effects you see *in situ* may vary from what you would see if you place it at another site, because the equilibrium will have been disrupted. This is important for dredged material evaluations; we need to deal with protocols that deal with these kinds of questions. When conducting sediment toxicity tests, one needs to consider whether the evaluation is for sediments that will remain in place (in which case sediment disturbance can become a problem in the test), or whether it will be moved to another location, so that sediment manipulation during the tests would not be a problem. In fact, during toxicity testing for sediments that will be dredged, the test sediments should be manipulated in order to be more representative of the disturbance that occurs during dredging, transport, and disposal of the dredged material.

Much of the work done on sediment toxicity tests have been related to ammonia effects. Ammonia is very toxic to the organisms, and levels in interstitial waters of sediments evaluated can be quite high. They have observed toxicity associated with ammonia concentrations in the tests conducted. In the past, they may have attributed some of those effects to concentrations of certain contaminants in the sediment, and not to ammonia concentrations that were there. When observing absence of effects when one would expect them to occur based on the AETs, it may

not be that the experimental procedures are wrong. It may be indicating that when work was done in the past, there may not have been enough information to evaluate the results appropriately. As more information about varying procedures and contributors to toxicity are learned, these variables can be eliminated. In other words, we do not want to attribute toxicity effects observed in a sediment which contains PCBs, when the toxicity observed is actually due to high levels of ammonia present.

Ovrhd 12-1.	Reducing Uncertainties in the Interpretation of Sediment Toxicity and Benthic Community Effects
Ovrhd 12-2.	Table of Recommended Protocol Modifications to Minimize False Positives (Relocating Contaminated Sediment)
Ovrhd 12-3.	Table of Recommended Protocol Modifications to Minimize False Positives (Contaminated In-Situ Sediment)

21. Public Comments and Questions

Mike Johns stated that the issue of ammonia is important and needs continued study. EVS is working now on samples which have high ammonia concentrations (up to 300 mg/L). So far they have determined an approximate "no effects" level of 18 mg/L of ammonia in the interstitial waters. Therefore, the results of their toxicity tests on those sediments could be affected by the ammonia concentrations. In order to mitigate the effects of ammonia on these tests, they have gotten the approval of the PSDDA agencies to allow them to adopt the New York process of exchanging the water twice a day if the interstitial levels of ammonia were greater than 18 mg/L. The agencies raised the issue as to whether or not contaminants are lost with the exchange of water, which may reduce the toxicity. They are testing the issue by studying the interstitial and overlying water for tests which are run according to PSEP protocols, in comparison to those in which the water is exchanged twice daily. They hope the results of the comparisons will give them some insight as to whether they can use exchanges of water to mitigate the effects of ammonia.

A question was posed from the audience asking if EVS is testing for contaminants in water when studying the comparison of tests.

Mike Johns clarified that the issue raised by the PSDDA agencies was whether or not they were exchanging the exposure environment in the interstitial waters, so they were not looking at the cumulative loss of contaminants. With the *Neanthes* bioassay, they did measure contaminants and found there was very little contaminant loss (in bulk concentration) through the water that was exchanged out. This is different from the agencies question of whether there is a substantial difference in the interstitial exposure concentration, so they were not measuring the loss in the exchange water for this study. They do however have bulk chemistry of the sediments at the beginning of the test and can compare it to bulk chemistry at the end of the test to get an idea of what may have been exchanged.

Jack Word added that last year Battelle also ran a study as to whether different numbers of water exchanges (2, 6, or no exchange) until you get a "no effects" ammonia level, would result in a difference in the toxicity to the organisms that were being exposed to it. They found they got the same response for each type of exchange, although it took longer to get to a "no effects" ammonia level in the no exchange test. There was essentially no response by these organisms in sediments where only ammonia was causing the hit. They also had a test sediment which had contaminants present, and they observed a similar effect all the way through the system, which was not being driven by the ammonia toxicity. He stated that which ever procedure was used (2 exchange, 6 exchange or none), gave them the same answer if it was only ammonia driving the toxicity.

Brian Ross, EPA, San Francisco, said that they are working on the ammonia issues as well, and have seen some hits which could be attributed to ammonia toxicity. They have found that the process of two water exchanges per day, without disturbing the sediments, has helped eliminate the problem, and helped with their decision process.

Jack Word added that the important thing is that if a problem with ammonia (or another variable) is suspected, which may affect the outcome of the tests, these concerns should be discussed with the agencies up front. In conjunction with the agencies, the decision may be made to adjust the test (e.g. water exchanges) to mitigate the effects of ammonia (or some other factor). If the concerns are not discussed up front, a situation may occur where one may attempt to explain away toxic effects observed in the test. It is a much easier decision process if attempts to eliminate toxic effects from variables other than the contaminants present in the sediment are made.

Paul Dinnel, Dinnel Marine Research, stated that one problem he has noted lately is that many people are recording total ammonia values for toxicity tests. He said the toxic component of the ammonia is the unionized component. For typical Puget Sound temperatures and salinities, the unionized component is only about 1-2%. If a test is run at 20°C and at a pH over 8, higher levels (5-10%) of the unionized component may be approached. He felt we need to report the unionized component for the test. There are unionized values given for the *Neanthes* and sediment larval tests in PSEP 1995, but they seem to be lacking for the amphipod test.

Jack Word indicated that they actually are not lacking for the amphipod test. He said that the unionized fraction based on the salinity, temperature, and pH has been calculated since the tests were developed. They found that when temperature and salinity were controlled (pH did not vary greatly in seawater environments with sediment in them), they got the same concordance of information when either total ammonia or unionized ammonia were recorded. There was not a big difference between the two. He stressed the unionized fraction is a calculated value vs. a measured value.

Paul Dinnel would like to suggest that at least in the overlying water, pH varies more than Jack Word suggested.

Jack Word replied that he was referring to interstitial water, and not overlying water.

Paul Dinnel said he understood what Jack Word was conveying, but still felt the unionized values should be reported.

Jack Word said that it was interesting, because in one of the first papers they completed, they reported both unionized an total ammonia values. However, the reviewers had them remove the unionized values because it did not make a difference.

Doug Hotchkiss added a comment that we should take a serious look at these issues (possible ammonia toxicity) up front.

22. Jack Word discussed confounding issues associated with the Microtox bioassays. He discussed recent work by Jacobs et al. (1992), which was done on the solvent extract test, but which we may want to consider for the saline extract test. The recent work by Jacobs looked at sulfur effects on the solvent extract Microtox test. They found dose response effects due to sulfur. If they added copper, the sulfur effects were reduced or eliminated. He said that it was uncertain if saline extracts would produce the concentrations of sulfur for which toxic effects were observed (25 ppb). However, the more toxic sulfide forms were present in the saline extracts. The agencies may want to consider assessing the potential for sulfur (sulfides) to produce Microtox toxicity in the saline extract tests. It may be good to review the AETs for butylbenzphthalate and PCBs, which had substantially lower AET responses in the Microtox test than in any of the other biological tests. It was possible that sulfides were responsible for driving those values.

Ovrhd 13-1. Confounding Issues in Microtox Bioassays

23. Public Comments and Questions

Chuck Boatman, Aura-Nova Consultants, said that for the past couple of years they have been measuring sulfur species in pore waters and in extracts. They measured colloidal sulfur, sulfides, and polysulfides. They consistently found elemental sulfur both in the pore waters and in the leachates.

Jack Word asked if he knew what the concentrations were.

Chuck Boatman responded that he did not know the exact numbers.

Jack Word asked if they were on the order of PCB levels.

Chuck Boatman replied that they were higher. He added that there is quite a bit of literature concerning sulfides in pore waters, and in most cases when polysulfides and sulfides were present, elemental sulfur was also be present.

Lincoln Loehr said that Jack Word mentioned 13 of 47 AET values were set using the Microtox response, and he assumed that was for sediment quality standards. He asked how many additional cleanup screening levels were set by the Microtox response.

Jack Word replied that he did not know the answer, but that could be a problem as well.

Doug Hotchkiss added that before setting the standards, the agencies should consider these Microtox issues as well.

24. Mike Johns gave an evaluation of the Puget Sound Apparent Effects Thresholds (AETs). He said that because AETs are the foundation for making regulatory decisions, it is necessary to have confidence in the numbers. He defined AETs as the concentration above which adverse or toxic effects always occur to biological organisms. The AETs were recalculated in 1994. He felt that some of the criteria used to reject data for inclusion in the AET calculations had some problems. The three criteria of concern used to reject some of the data included reference failures, the handling of statistically inclusive data, and chemically anomalous data. He then reviewed how much data was rejected using inconclusive criteria.

For example, much of the data which passed the QA2 process was rejected due to reference station failure. He felt that good quality data was rejected. One suggested alternative was that if a reference station failed, a default value based on historical data could be examined and used to evaluate the tests results. For the inconclusive data he felt that statistical methods used for rejecting the data were not always the most appropriate methods. The statistical tools used to evaluate the data should be updated and the appropriate method used. For chemically anomalous data, he felt there was a subjective nature in some of the reanalysis and decisions to consider a result anomalous. He indicated that a more rigorous statistical method of determining the outlier should be employed. In addition, some of the AETs were based on samples that were not the highest "no hit" concentration. He suggested that all valid data (i.e., have passed QA/QC guidelines) should be used for AET recalculations. If apparent outlier results were for sediments which had an anomalous substrate type, then data may not be comparable. As a result these data should be excluded from the recalculations.

Ovrhd 14-1.	1994 Recalculation of Apparent Effects Thresholds (AETs)
Ovrhd 14-2.	Data Excluded for 1994 AET Recalculations
Ovrhd 14-3.	Reference Station Performance
Ovrhd 14-4.	Statistically Inconclusive Data
Ovrhd 14-5.	Chemically Anomalous Data
Ovrhd 14-6.	Overall Recommendations

25. Tom Gries, Ecology, responded to the AET issues presented by Mike Johns. He acknowledged that the PSDDA agencies have always recognized imperfections with the 1988 AET calculation methods. However, a policy decision was made in 1992 to continue to adhere to those methods, partly because revisiting the AET calculations, reanalyzing the statistics, and potentially changing the methods would be a lengthy process, and perhaps have more discontent

than using the established numbers. However, peer review and input from the public would help their technical work.

He then discussed the data which were excluded. He began by discussing data which were excluded because of "reference sediment failures". For most of these tests, a reference sediment was not tested. As a result, test sediments were statistically compared to the negative control. The result was that many of the test sediments exhibited toxic effects based on comparison to the control, when there may not have been toxic effects had there been a reference sediment tested for comparison. Therefore, the decision was to exclude these data from the calculations. He thought the proposal presented by Mike Johns to use "default" reference sediment results may be a viable option. In 1988, they had considered using standard reference data (or default data) for those tests which lacked a reference or for which the reference had failed. However, at that time they felt there was insufficient data to determine standard reference data. There may now be sufficient reference data to reconsider this.

With respect to the statistically inconclusive data, they may be able to review the data. He commented that the trigger level used to perform the power analysis resulted in relatively few inconclusive data that should be excluded. He was not certain if that was in agreement with the criticism presented at this meeting, but that it was worth reviewing and justifying the numbers.

Mr. Gries stated the chemical anomalies have the greatest potential to affect the AET levels set. As an example, he presented an overhead for amphipod mortalities for specific chemicals such as antimony. Values shaded exhibited adverse effects ("hit" samples). While there was a "no hit" with a concentration of 1370, the next highest concentration for which there was a "no hit" was at 199 ppm. Based on best professional judgement, the sample result of "no hit" with a concentration of 1370 appears to be anomalous. The criteria of excluding data which was three times higher than the next highest "no hit" sample was used. He showed a similar example using benzyl alcohol. He then gave an example for 2-methylphenol, where two "no hit" samples of similar concentrations (370 and 350), had concentrations which were much higher than all other "no hit" samples. If the highest "no hit" concentration (370) was compared to the next highest "no hit" concentration (350), then the "3 times" exclusion criteria would indicate these were not anomalous data. However, when these two results were compared to the rest of the data, they appeared to be anomalous data and were more than three times the next highest data. He gave similar examples for 2,4-dimethylphenol and silver, where there were more than one "no hit" data results determined to be anomalous. If these data were included in the AET calculations, the AETs would be five to ten times higher than the 1988 AETs. When excluding data, they did not keep raising the AETs in mind, they used the exclusion criteria established in 1988 and best professional judgement based on comparison to the bulk of the other samples. They need to go back at look at using statistical tests to determine if these samples are really outliers. His gut feeling was that they were.

Mr. Gries' recommendations were to proceed with the current criteria and make them as scientifically valid and sound as possible, and to determine what they can do in the near term to improve what they have. They should then push into the second part of the process using a

regulatory work group to determine how to use the numbers and whether they should use them, and to create a parallel work group which would start looking toward the next round of work: reviewing the concepts, methods, organisms used, etc.

Ovrhd 15-1.	Apparent Effects Thresholds
Ovrhd 15-2.	Apparent Effects Thresholds: Exclusion of Useful Synoptic Data
Ovrhd 15-3.	Apparent Effects Thresholds: Comments and Responses
Ovrhd 15-4.	Apparent Effects Thresholds: Recommendations
Ovrhd 15-5.	Chemically Anomalous Amphipod Mortality Samples: Benzyl Alcohol
Ovrhd 15-6.	Chemically Anomalous Amphipod Mortality Samples: Antimony
Ovrhd 15-7.	Chemically Anomalous Amphipod Mortality Samples: 2-Methylphenol
Ovrhd 15-8.	Chemically Anomalous Amphipod Mortality Samples: 2,4-Dimethylphenol
Ovrhd 15-9.	Chemically Anomalous Amphipod Mortality Samples: Silver

26. Public Comments and Questions

Lincoln Loehr asked if Tom Gries could put up one of his overheads. He wondered if some of the large gaps between some of the hits could be due to some other parameters (besides the specific chemical of concern). If those "hits" which could be attributed to other factors could be identified, it may make those working with the AET calculations more comfortable in accepting a "no hit" value at a higher level.

Tom Gries responded that the AET method does not allow for drawing conclusions about cause and effect for a specific analyte.

The statement was made from the audience that Mr. Gries was drawing a cause and effect conclusion with the examples he gave.

Tom Gries indicated that they were not showing cause and effect. There was something in those samples that caused them to be adversely affected. It was not necessarily the antimony, for example.

A follow-on question was asked on what basis the model was programmed?

Tom Gries responded that this was a probablistic model. The definition says the highest concentration of no effects is the concentration above which "hits", from whatever cause in that sample, always occur.

Mike Johns stated that he views AETs as a research tool as much as a tool for driving and generating regulatory values. The more information that is in that research tool, the better contamination effects will be understood. How data is translated is up to the agencies and their programs. However, we should allow the AETs to float based on the data we are generating.

We should not be afraid of chemically anomalous data; it tells us something. We may find in the next three years that it is truly anomalous data, although we may also find that there are multiple stations which have "anomalous" data. He agreed that they are not dealing with cause and effect, but are correlating the values. The AET values were generated on data collected before 1988. The purpose of recalculating the AETs with more recent data taken into account allows us to determine if the values change.

Teresa Michelsen, Ecology, added that we need to look at all the AETs together and assess their reliability. When considering outliers, if they are indeed outliers, excluding them from the AET calculation will result in more reliable AETs.

Les Williams, EA Science and Engineering, Inc., stated that he had difficulty in seeing what is anomalous about the chemistry data. He mentioned they are talking about a statistical distribution. The real issue is what the tail end of the distribution looks like for the sample size you have. AET values should not be set unless you have a certain number of hits at the end of that distribution.

Tom Gries responded that what Les Williams suggested is quite reasonable for considering for their next round of efforts. Right now they need to focus on finishing the work they have done as best as possible, and looking hard at improving methodology.

Les Williams said they could try looking at it now using a Monte Carlo Bootstrap Simulation, and determining how the anomalous data behave.

Tom Gries also responded to Mike Johns idea that there are no truly anomalous data or that you have to know more about the sediment substrate to be able to say they are anomalous. Based on the limited information that they get in their programs, they can QA the data and see what may be anomalies. They can consider them anomalous either by a subjective method similar to the one they use now, by some statistical test, or by best professional judgement. As regulatory agencies, they want to prevent Type II errors where they are predicting no effects when there really is a toxic situation. If these outliers were included, the AETs would be driven high enough that the ability to predict a contaminated site accurately would be much reduced.

27. Mike Johns discussed AET issues related to the larval bioassay sensitivity assessment. In the 1994 calculations there was a break out in calculations of AETs using bivalves and echinoderm tests. The results of the AET recalculation suggested there was a difference in sensitivity to specific toxicants (metals and PAHs) between the two phyla (echinoderms were more sensitive). Due to seasonal availability of larvae, current PSDDA guidelines allow for five different test species. PSDDA testing procedures also allow for use of any of the five species based on the determination that they have similar sensitivities to contaminants of concern. Therefore, any of the five species could be used for suitability determinations. If the species' sensitivities were different, this could create limits on the species used and the dredging proponent's options, and could slow the decision making process. Mike Johns recommended looking at whether there really is a difference in sensitivity among these species.

EVS performed a study to investigate whether the larvae of four of the test species (*Dendraster excentricus*, *Strongylocentrotus purpuratus*, *Crassostrea gigas*, and *Mytilus edulis*) differed in sensitivity to toxicants (specifically to reference toxicants). They gathered and compared data on EC50 values for the positive controls of bioassays run at various laboratories, over a number of years, using the different species. The assumption was that if the different species varied in sensitivity to the reference toxicants, they may also have different sensitivities to contaminants present in samples tested.

The results of the study showed that there were differences in sensitivity among the four species to specific reference toxicants. However, there was not a clear direction in sensitivity for any one species, or for the two phyla for all reference toxicants. Statistical results concerning differences in sensitivity between the species and phyla were inconclusive. Mike Johns recommended that PSDDA continue to allow for use of the different species, and that the agencies should retain the combined echinoderm/bivalve AET values for now. He suggested conducting experiments designed to test the sensitivity of the species. It may not be possible to conduct the tests side by side due to the seasonal availability of the larva, but they could look to find ways to make the tests as robust as possible. He suggested using water only, and using cadmium, mercury, and naphthalene as the toxicants. These toxicants were recommended based on the results of the 1994 AET recalculations which showed a difference in sensitivity between the two phyla for these toxicants. Echinoderms were apparently more sensitive to cadmium and naphthalene, and bivalves were more sensitive to mercury.

Ovrhd 16-1. Problem Identification
Ovrhd 16-2. Larval Toxicity Tests
Ovrhd 16-3. EC50 Values by Reference Toxicant and Species
Ovrhd 16-4. Distribution of EC50 Values, with Sample Sizes
Ovrhd 16-5. Recommendations

28. Public Comments and Questions

Teresa Michelsen commented that the final conclusions of Mike Johns' report seemed incompatible with the analysis. For example, in the report it was stated that the differences among the species and phyla were highly significant, yet the conclusions indicated that the results were inconclusive. She speculated that he is arguing that since the results were not always going one way, they were inconclusive. She added that AETs were calculated on a chemical by chemical basis, so that it would not matter if the sensitivities varied for the different toxicants.

Mike Johns responded that then there needs to be enough confidence to develop a manual which indicates in which cases echinoderms should be used and in which case bivalves should be used. In fact, what they saw in the case of cadmium was that one species of echinoderms was the most sensitive to cadmium, while the least sensitive species was another echinoderm (less sensitive than the bivalves), although the AET calculations implied that all echinoderms were more sensitive than the bivalves. The relationship between sensitivities or perceived sensitivities they observed based on the AET calculations was not observed for water only measurements for that

contaminant. The point he was trying to make was that when AETs for the different species of phyla were generated, there was a perceived sensitivity. He suggested that AET calculations should not be used to determine if there is a sensitivity between bioassays (using different species). Water only tests using a specific contaminant should be used to determine whether there are sensitivities (i.e. run some experiments).

Teresa Michelsen understood, but pointed out that he still seemed to be downplaying the significant differences observed.

Mike Johns responded that one factor was that the sample size was small. The other was that the data was variable.

Teresa Michelsen also questioned why he proposed to run tests for species' sensitivity for water only. Since these species interact with the sediments, she questioned why the tests would not be run with sediments as well.

Mike Johns said the question she asked was whether or not the contaminants that get in the water column were causing toxicity in the larval test. The purest way of testing that is to put the contaminant directly in the water column and eliminate the confounding factor of sediment. Then a side by side comparison may be conducted to determine whether or not the responses to the toxicant are the same. They have a difficult time in taking a sediment, which has multiple contaminants, and determining whether or not one species is more sensitive than another, because they can not tell which contaminant is causing the effect or what the interactions among the contaminants are. They would have to use a sediment that is spiked with one contaminant or a larval exposure (e.g. the water test) in which the one factor being tested that relates to species sensitivity, is controlled.

Teresa Michelsen still felt that they should also include sediment tests in addition to the water only tests.

Mike Johns asked Paul Dinnel whether his perceptions on the route of exposure for echinoderm larva in the tests have strong sediment larval interactions.

Paul Dinnel commented that the larval tests are primarily a water exposure. They can be affected by the sediments (contaminants can be in the pore waters), but that it is primarily a water exposure.

29. Jack Word, Battelle, presented an evaluation of the benthic criterion for PCB AETs. He indicated that there were several inconsistencies in AET support documentation which influenced the benthic AET value for PCBs. He said that there seemed to be errors in the information that was used to derive the SMS AET (Tetra Tech document). He presented a table from the report and pointed out the apparent errors in the table or errors in determining the AET. He stressed that due to these errors, the raw data needs to be reviewed thoroughly. It may have just been an error in the documentation. He then discussed his concerns about apparent effects thresholds

compared to apparent effects clusters. He felt that when working with apparent effects clusters, clusters of data can be thrown out of the analysis as more information becomes available.

Ovrhd 17-1.	Benthic Community AET for PCBs
Ovrhd 17-2.	Data used for PCB Benthic AET Determination

30. Public Comments and Questions

Chuck Boatman asked what Jack Word proposes to do next for the evaluation of the benthic criterion.

Jack Word replied that we should go back to the original information, determine what references were used, determine whether or not there was a statistical difference, and recalculate the AETs for the PCBs if warranted, based on the review.

31. Rachel Friedman-Thomas, Ecology, discussed the cooperative sediment management program including the status of technical/policy guidelines and the demonstration pilot. She first reviewed the history of the sediment cleanup strategy and discussed the work group that was convened to develop the strategy. The charges and recommendations of the work group included defining agency roles and funding, facilitating cleanups, developing strategies for cleanups, and determining whether the legal framework needs to be changed. The workgroup defined a need to reprioritize and balance their work. Some of the recommendations included focusing on "hotspots", instituting a baywide approach, and reducing barriers for voluntary cleanup. She gave an overview of the sediment cleanup strategy, which was a phased strategy for collective action. The first phase is a federally led effort to produce program guidelines, and the second phase is a state led effort to test ways of coordinating and expediting sediment cleanup, source control, disposal, and habitat restoration. She reviewed the premise and approach to the demonstration pilot project, including coordinating multiple objectives, incorporating local priorities, linking economic and environmental benefits, pursuing existing and new funding sources, and offering regulatory discretion. To date, three to four candidate bays have been suggested for the pilot project, and Ecology has appropriated funding for various aspects of the project. The selection of the demonstration bay is expected to occur by June 28, 1996. They anticipate a 6-18 month process to develop a scope of work and begin implementation of the study.

Ovrhd 18-1.	Cooperative Sediment Management Program and Status of Sediment Cleanup Strategy
Ovrhd 18-2.	History
Ovrhd 18-3.	Work Group Charges and Consensus Recommendations
Ovrhd 18-4.	Sediment Cleanup Strategy: An Interagency Overview
Ovrhd 18-5.	Demonstration Pilot Project Premise/Approach
Ovrhd 18-6.	Demonstration Pilot Project Status
Ovrhd 18-7.	Demonstration Pilot Project Status (Cont.)

32. Justine Barton, EPA Region 10, gave a status report on the beneficial uses workgroup. The work group was convened based on an interagency/intergovernmental agreement to promote and facilitate projects involving beneficial uses of dredged material. The workgroup was convened in April of 1995, and met eight or nine times to try and define beneficial uses, and develop a glossary of terms. Other work included identifying policy conflicts and limitations, prioritizing a scheme for projects, discussing technical considerations such as sediment characterization and suitability determinations, and developing a permitting process. The products the work group has completed include an executive summary for agency directors and a user manual for project proponents. They expect the draft products to be completed in July 1996, and final products to be completed in October 1996.

Ovrhd 19-1.	Beneficial Uses Work Group: Tasks
Ovrhd 19-2.	Beneficial Uses Work Group: Products

33. John Malek gave an update of the Multiuser Confined Disposal Site (MUDS) study. He presented a map of the Puget Sound MUDS sites and discussed the Puget Sound confined disposal site reconnaissance phase study and report. He indicated the likely sponsors for the feasibility study, including the Army Corps of Engineers, Ecology, Puget Sound Water Quality Authority (PSQWA), DNR, and the Washington Public Ports Association. The EPA would be a cooperating agency. The remaining phases for the confined disposal site study would include the feasibility study, a draft programmatic EIS, siting criteria and programmatic disposal. Decisions concerning the MUDS site would be made by the end of fiscal year 1999, and they expect to start on cleanup between the years 2000 and 2002.

Ovrhd 20-1.	Multiuser Confined Disposal Site (MUDS)
Ovrhd 20-2.	Agencies Involved
Ovrhd 20-3.	Map of Puget Sound MUDS Sites
Ovrhd 20-4.	Puget Sound Confined Disposal Site Study
Ovrhd 20-5.	Feasibility Study
Ovrhd 20-6.	Puget Sound Confined Disposal Site Study
Ovrhd 20-7.	Puget Sound Confined Disposal Site Study: Feasibility Phase Study/Implementation Study

34. Laura Weiss, Ecology, gave an update on developments with the Human Health Criteria. She mentioned the information she discussed at the 1995 SMARM, and said that although Ecology predicted a final rule to be completed by now, it has not been finalized. She discussed the need for Human Health Criteria (health risks based on levels of contaminants in fish and shellfish). New technical developments with respect to Human Health Criteria including a Tier 1 report were reviewed. This includes distributional analysis for cancer potency factors, bioaccumulation factor approach for metals and organics analysis, and analysis of BSAF values for nonpolar organic compounds in finfish and shellfish. The Tier I report was finalized in the summer of 1995, and included background concentrations, chemicals of concern, BSAF development, and fish consumption review. The numbers calculated by the Department of Health presented in the report should be considered a point of reference only, because there was some

information that the Department of Health used which Ecology may or may not use in the development process. When using the numbers, one should be aware of the assumptions used in determining the numbers.

Ms. Weiss then discussed their policy and implementation development, including an alternative decision making framework paper. This paper included how they may incorporate fish tissue testing into the process of developing new Human Health Criteria, issues related to numbers vs. formulas, background reference concentrations and how they might drive the criteria for certain chemicals, issues concerning chemicals (certain metals) with no BSAFs, and approaches to surface area weighing (related to use of fish tissue in the equations).

Laura Weiss then reviewed some of the issues and concerns raised about the Human Health Criteria, such as the consistency between Ecology programs, the technical and scientific methods used, liability and statutory authority, and source control. The revised approach is to do case studies, and determine how the rule may be influenced or changed. The schedule is to document the rule framework, to conduct case studies in the summer, present the results in the fall, and request input and comments concerning the results. Ecology is continuing to work on the development of Human Health Criteria, and is still making decisions on a case-by-case basis. They want the direction of Human Health Criteria to be efficient and cost effective. They also want to be responsive to the concerns of various parties interested in the development of the Human Health Criteria.

Ovrhd 21-1.	Human Health Sediment Criteria
Ovrhd 21-2.	1995 SMARM (Review)
Ovrhd 21-3.	Why Develop Health-Based Sediment Criteria?
Ovrhd 21-4.	Conceptual Model
Ovrhd 21-5.	New Technical Developments
Ovrhd 21-6.	Tier I Report (DOH, 1995)
Ovrhd 21-7.	Policy and Implementation Development
Ovrhd 21-8.	Issues and Concerns Raised
Ovrhd 21-9.	Revised Approach: Case Studies
Ovrhd 21-10.	Schedule
Ovrhd 21-11.	Case Study Building Blocks

35. Public Comments and Questions

Jack Word asked whether Ecology was planning to use reference and control sites in the case studies to determine what the calculated Human Health risk might be when using their numbers at an unaffected site.

Laura Weiss indicated that as she understood it, using reference sites with respect to human health is part of the process.

Jack Word said he was thinking of some examples such as a reference bay approach that was developed a while ago to look at different reference bays within Puget Sound, which includes sediment and fish tissue values. If one looked at some of the sediment values and sediment human health standards presented there, there would be an expected human health risk if you calculated it on a number of the reference bays that have no industrial activity or influences. It may be valuable to ground truth the human health numbers Ecology develops with the reference bays.

Laura Weiss responded that they have taken reference and background concentrations into consideration, particularly with PCBs, before they reached the case study phase. For example, the numbers developed for PCBs based on health risk only were lower than the background concentrations. Therefore, they defaulted to the background concentrations for development of health risk for PCBs, particularly for cleanup.

Jack Word also pointed out that there are certain metals (e.g. arsenic and mercury) which are not bioavailable because they are tied up in a rock matrix. This could affect how risk is calculated for these compounds (especially when there really is no risk associated with these compounds).

Laura Weiss stated that this is where fish tissue concentrations are considered.

Jack Word agreed that it would be better to determine the calculations based on fish tissue concentrations than concentrations within the sediment for those compounds which are not bioavailable.

Laura Weiss indicated that they were also looking at background concentrations in fish, and considering those concentrations in the development of the criteria.

Dr. Kok-Leng Tay, Environment Canada, wondered if Ecology has sediment bacteria contamination criteria for shellfish.

Laura Weiss responded that for this process, they are not looking at bacteria. The State Department of Human Health looks at bacteria in shellfish and determines shellfish regulations on levels. They also regulate areas where acute problems are observed.

Doug Hotchkiss stated that the Port was concerned about the Human Health Criteria, and whether the criteria were based on solid science, including the appropriate methods and approach for BSAF development. The wide scatter in the numbers indicate that there is much to be worked on and understood. He felt Ecology should be looking more at ground truthing the levels that occur in Puget Sound, and how those levels compare with other regulatory decisions made on PCBs and other contaminants. They should look at a regulatory continuity across different levels that regulate the contaminants, such as in the marketplace. They would like to see a number that regulates all aspects of fish consumption, and that can be applied to both human consumption and cleanup levels. He speculated whether the vectors from which the contaminants

are passed from the mud to fish consumed by humans are really understood. Before public funds are spent in an attempt to rectify a situation, it should be known if a specific end will be achieved before the funds are spent. He wanted to make certain the money is applied appropriately.

Laura Weiss noted the comment. She added that there are uncertainties around the BSAFs, and they are dealing with that. They are focusing on chemicals for which the uncertainties are the smallest, for which the Department of Health has recommended Ecology to regulate, and on those for which they have the best information. They are planning on some reanalysis of some of the BSAFs to deal with the uncertainties.

Eric Johnson asked if the case studies she referenced were different from the pilot studies for the sediment management strategy.

Laura Weiss responded that they are different. The demonstration bay he referred to is happening concurrently with the case studies for human health, which they hope will occur faster. The focus will be on what has been done on human health in the field, and how the human health rule could affect those sites. They are considering conducting the case studies at four sites scattered around Puget Sound. There may or may not be overlapping of the sites that are picked for the case studies and that which is ultimately picked for the demonstration bay.

Doug Hotchkiss asked if the case studies are currently ongoing.

Laura Weiss indicated that the sites have been picked.

Doug Hotchkiss inquired as to the locations.

Laura Weiss listed the sites as Boeing Plant II, the Puget Sound Naval Shipyard, Cascade Pole, and Whatcom Waterway. She said these sites differ in terms of chemicals of concern, locations within the Sound, decisions that were made concerning human health, and in terms of questions they want to ask about the sites. These were picked based on the range of information and situations they want to consider. Results and findings of the studies will be compiled into a report, describing what was done at each site and recommendations for rule modifications based on what they have found at each of the sites.

36. Christine Psyk, EPA, reviewed the lessons learned from the Superfund sediment program. She mentioned the various Superfund sites, and presented a map of locations. She discussed the division of labor among EPA and Ecology, including intra-site cooperation (where one agency may be the lead on source control and the other may be the lead on sediment cleanup) and inter-site control (one of the other agencies have full responsibility for a whole site). The status of the various Superfund sites in Puget Sound, including the site size and type, volume of sediment involved, agency lead, the phase of cleanup, and projects completed was presented. She stressed that Superfund is a driven program to attain certain goals and milestones, with a design of remediation. There is a great deal of pressure to get the Superfund sites cleaned up.

Approximately one third of the sites have been completed. One of the reasons the agencies have gotten together to work on the sites is a need for "closure" for TBT issues for cleanup of a Superfund site. The agencies wish to respond to issues on both a technical and programmatic level. One of the lessons learned is that the cooperation of Ecology and EPA on Superfund sites allows them to cover a broader area and enables them to prevent duplication of efforts.

Ovrhd 22-1.	Map of Superfund Sites
Ovrhd 22-2.	EPA Region 10 Superfund Site Categories
Ovrhd 22-3.	Table of EPA Region 10 Superfund Sites
Ovrhd 22-4.	Table of EPA Region 10 Superfund Sites (Cont.)
Ovrhd 22-5.	Table of EPA Region 10 Superfund Sites (Cont.)

36. Brian Applebury presented a list of clarification papers mailed to the public with the meeting invitation. These included both PSDDA and PSDDA/SMS clarification papers. He then gave an opportunity for the public to respond to these papers and to comment on the previous status paper presentations.

37. Public Comments and Questions

No comments.

38. David Kendall discussed the various issues to which the PSDDA agencies and SMS group would respond before the next annual review meeting. The agencies propose to recommend a study to assess TBT sensitivity among 3 amphipod species, to reassess the TBT maximum level, to consider alternative TBT screening approaches, to evaluate cleanup versus dredging questions, to consider *a priori* analysis of ammonia in interstitial water, and to assess sulfur and sulfide effects on the Microtox tests. The AET issues to which the agencies plan to respond in the following year include re-evaluating the method of tagging anomalous data for AET calculations, considering using default reference data when quality control is good but there is a reference problem or no reference data, and reassessing the 1986 PCB AET for benthos.

Ovrhd 23-1. PSDDA/SMS Issues

39. Dave Bradley, Ecology, discussed the issues to which the SMS group would respond. They will continue to move forward on the triennial review process, and continue to respond to issues raised. The SCUM1 and SCUM2 SAP appendix will be coordinated with an SMS implementation committee before finalizing the appendix. Human Health Criteria for Puget Sound and specific BSAFs will continue to be reviewed and numbers checked. Similarly, they will continue to review AETs, including the benthic PCB AETs, and data screening issues. They also plan on finalizing the report for the benthic endpoint. They will also review issues concerning the discharge equations and other stormwater issues.

40. Public Comments and Questions

Sharon Metcalf asked if Dave Bradley was proposing that the water quality standards sediment performance will be amended this year.

Dave Bradley responded that the SMS group is moving ahead to complete the rule, addressing a broader range of issues. There may be additional review before fully completing the rule.

41. Brian Applebury closed the meeting, and thanked the participants for coming to the meeting.

ATTACHMENT 1

Agenda

Sediment Management Annual Review Meeting
Puget Sound Dredged Disposal Analysis (PSDDA) Program
and the
Department of Ecology-Sediment Management Standards (SMS) Program

Location: Saint Helens Conference Center, Tacoma, WA

May 8, 1996

Final Agenda

MORNING SESSION

Coffee (8:30-9:00am):

Introduction and Overview (9:00-9:30am):

Greeting: Stan Biles, Deputy Supervisor, Department of Natural Resources

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

PSDDA Program Overview (9:30-10:15am)

- Summary actions of 1995 PSDDA SMARM (Dr. David Kendall, Corps)
- Overview of PSDDA project/testing activities (David Fox, Corps)
- Disposal site monitoring overview (Ted Benson, DNR)

Discussion and Public Comment on above topics (10:15-10:30am)

Break (10:30-10:45am)

SMS Overview (10:45-11:30am):

- SMS activities and annual review (Pamela Sparks-McConkey)
- Regional cleanup activities (Russ McMillan)
- Source control activities (Brenden McFarland)

Discussion and Public Comment on above topics (11:30-11:45am)

Presentation of PSDDA Issue Paper (11:45-12:00pm)

- Adjustments to PSDDA site monitoring (Ted Benson, DNR)

Lunch (12:00-1:00pm):

AFTERNOON SESSION

Presentation of TBT Issues: Joint PSDDA/SMS and Public Issue Papers (1:00-1:45pm)

☞ Tributyltin (TBT): PSDDA/SMS issues (John Malek, EPA)

☞ Critique of PSDDA/SMS draft issue paper on testing, reporting, and evaluation of TBT data in PSDDA and SMS programs (Doug Hotchkiss, Port of Seattle)

☞ Sensitivity of amphipod species to TBT in sediment and porewater (Dr. D. Michael Johns, EVS Environmental Consultants for the Port of Seattle)

Discussion and Public Comment on above topics (1:45-2:00pm)

Presentation of Issue Papers by the Public (2:00-3:30pm)

Process: SMS Triennial Review Process (Eric Johnson, Washington Public Ports Association)

General Issues with AET implications:

☞ Reducing uncertainties in the interpretation of sediment toxicity tests and benthic community effects (Dr. Jack Word, Battelle Marine Science Laboratory)

☞ Confounding issues in Microtox bioassays (Dr. Jack Word, Battelle Marine Science Laboratory)

AET issues:

☞ Evaluation of Puget Sound Apparent Effects Thresholds (Dr. D. Michael Johns, EVS Environmental Consultants for the Port of Seattle)

☞ Larval bioassay sensitivity assessment (Dr. D. Michael Johns, EVS Environmental Consultants for the Port of Seattle)

☞ Evaluation of the benthic criterion for PCB AETs (Dr. D. Michael Johns, EVS Environmental Consultants for the Port of Seattle)

Discussion on Public Issue Papers (3:30-3:45pm)

Presentation of PSDDA / SMS Status Papers (3:45-5:00pm)

☞ Cooperative Sediment Management Program: status of technical/policy guidelines and demonstration pilot (Rachel Friedman-Thomas, Ecology)

☞ Beneficial uses workgroup status report (Justine Barton, EPA)

- Multiuser confined disposal study (MUDS) update (John Malek, EPA)
- Superfund sediment program: lessons learned (Christine Psyk, EPA)
- Human health sediment criteria (Laura Weiss, Ecology)

Discussion and Public Comment on above topics (5:00-5:15pm)

Public Comment on the PSDDA Clarification Papers mailed out to public with meeting invitation (5:15-5:30pm)

Summary and Closing (5:30-5:45pm)(Brian Applebury, Corps)

- Issues to which PSDDA agencies will respond before the next annual review meeting.
- Issues to which SMS group will respond before the next annual review meeting.
- Written comments may be submitted on the SMARM proceedings, but must be submitted to the PSDDA agencies and SMS group by May 22, 1996 for consideration.

ATTACHMENT 2

List of Attendees

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING
Attendee List

Name	Organization
Marian Abbett	Department of Ecology
Tammy Allen	Department of Natural Resources
Helle Andersen	Beak Consultants
Brian Applebury	Corps of Engineers
Gail Arnold	City of Seattle
Justine Barton	Environmental Protection Agency, Region X
Dave Beach	Corps of Engineers, Portland District
Ted Benson	Department of Natural Resources
Brett Betts	Department of Ecology
Stan Biles	Department of Natural Resources
Pamela Blake	Oregon Department of Environmental Quality
Chuck Boatman	Aura-Nova Consultants
Dave Bradley	Department of Ecology
Eric Braun	Corps of Engineers, Portland District
Diane Brothers	Environment Canada
Sharon Brown	Department of Ecology
Sandy Browning	Striplin Environmental Associates
Lee Carfioly	North Creek Analytical
Yip Chun	Hart Crowser
Linda Cox	Corps of Engineers
Tad Deshler	Tetra Tech
Paul Dinnel	Dinnel Marine Research
John Dunn	Aquatic Research
Jerry Erickson	Beak Consultants
Ann Essko	Department of Natural Resources

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING
Attendee List (Continued)

Name	Organization
Sally Fisher	GeoEngineers
Teri Floyd	Eco Chem, Inc.
David Fox	Corps of Engineers
Rachel Friedman-Thomas	Department of Ecology
Mark Fugiel	Amtest, Inc.
Paul Fuglevand	Dalton, Olmsted & Fuglevand
Taku Fuji	Hart Crowser
Tom Gansbury	Regional Water Quality Control Board
William Gardiner	Battelle Marine Sciences Lab
Mike Gaul	Port of Coos Bay
Kathleen Goodman	Enviros, Inc.
Tom Gries	Department of Ecology
Rick Haley	NCASI
Tim Hammermeister	EVS Consultants
Grant Haskins	Enviros, Inc.
Mary Henley	City of Tacoma
Phil Hertzog	Department Natural Resources
John Hicks	Analytical Resources, Inc.
Allison Hiltnere	Environmental Protection Agency
Erika Hoffman	Environmental Protection Agency, Region IX
Craig Homan	King County Water Pollution Control Division
Doug Hotchkiss	Port of Seattle
Dena Hughes	Ray F. Weston
Mike Johns	EVS Consultants
Eric Johnson	Washington Public Ports Association

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING
Attendee List (Continued)

Name	Organization
Cheryl Karmera	King County Environmental Lab
Carl Kasselman	Hartman Associates
Karen Keeley	Environmental Protection Agency
David Kendall	Corps of Engineers
Kay Kim	Environment Canada
Karen Kochenbach	Corps of Engineers
Mark Larsen	RETEC
Eric Larson	San Francisco Bay Conservation Development Commission
Brent Lebl	Tetra Tech
Deanna Lee	B.C. Ministry of Environment
Lisa Lefrovitz	Battelle Marine Sciences Lab
Konrad Liegel	Preston Gates & Ellis/Port of Seattle
Lincoln Loehr	Heller, Ehrman, White, and McAuliffe Attorneys
John Malek	Environmental Protection Agency
Ricardo Marroquin	North Creek Analytical
Julie McCallister	Kennedy/Jenks Consultants
Bruce McDonald	Black and Veatch
Brenden McFarland	Department of Ecology
Russ McMillan	Department of Ecology
Mark Mertz	TEG Ocean Services
Sharon Metcalf	Seattle City Attorney
Teresa Michelsen	Department of Ecology
Scott Mickelson	King County Environmental Lab
David Mitchell	Analytical Resources. Inc.

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING
Attendee List (Continued)

Name	Organization
Nancy Musgrove	Ray F. Weston
Tom Newlon	Port of Seattle
Andrew Noch	Golder Associates
Allan Ota	Environmental Protection Agency, Region IX
Cheryl Paston	Seattle Engineering Department
Maria Peeler	Department of Ecology
George Perry	King County
Christine Psyk	Environmental Protection Agency
Jerry Ramsden	Ogden Beeman & Associates
Lorraine Read	EVS Consultants
Carole Richmond	Department Natural Resources
Lisa Roach	Science Applications International Corp.
Robin Roek	Marten & Brown
Pat Romberg	King County Water Pollution Control Division
Keith Rose	Environmental Protection Agency, Region X
Brian Ross	Environmental Protection Agency, Region IX
Pete Rude	Landau Associates, Inc.
Allan Rumbaugh	Port of Coos Bay
Bruce Rummel	URS Consultants
Steve Ryan	Boeing
Mike Salazar	Applied Biomonitoring
Carol Sanders	Sanders Associates, Inc.
Marilyn Schwartz	Ogden Environmental
Ken Seeley	EVS Consultants
Travis Shaw	Corps of Engineers

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING
Attendee List (Continued)

Name	Organization
Mark Siipola	Corps of Engineers, Portland District
David Slater	Maxim Analytical Sciences
Robin Smith	Geraghty & Miller, Inc.
Pamela Sparks-McConkey	Department of Ecology
Kevin Stigile	EFA Northwest - Navy
Stephanie Stirling	Corps of Engineers
Carl Stivers	Parametrix, Inc.
Mike Stoner	Port of Bellingham
Peter Striplin	Striplin Environmental Associates
Dixie Sullivan	Environment Canada
Alex Sumeri	Corps of Engineers
Fran Sweeney	Department Natural Resources
Kok-Leng Tay	Environment Canada
David Templeton	Hart Crowser
Tim Thompson	Science Applications International Corp.
Todd Thornburg	Hart Crowser
Ula Trangue	Sound Analytical Services
Desi Turner	Striplin Environmental Associates
Martha Turvey	Department of Ecology
Laura Weiss	Department of Ecology
Patty White	Battelle Marine Sciences Lab
Cliff Whitmus	Pentec Environmental
Les Williams	EA Science and Engineering
Don Wilson	Boateng & Associates
Nancy Winters	Puget Sound Water Quality Authority/SAIC

SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING
Attendee List (Continued)

Name	Organization
Charles Wisdom	Parametrix, Inc.
Chris Woelfel	City of Seattle
Jack Word	Battelle Marine Sciences Lab
Greg Zenther	City of Tacoma

APPENDIX A

Post-SMARM Comments and Responses

Response to comments concerning *Neanthes* 20-day growth. Use of 0.25 mg/individual (initial wgt) as QA/QC failure.
Prepared by Dr. Dave Kendall (Corps of Engineers 206/764-3768).

The PSDDA/SMS agencies re-examined the initial weight standard to see if it was reasonable and achievable given recent laboratory performances. The data from PSDDA projects indicate the labs are complying with the initial weight standard (>0.25 mg/individual). Projects where the initial weight standard was exceeded resulted in relatively high negative control final biomasses and calculated growth rates well above the QA/QC flag (greater than 0.38 mg/individual/day). After considering the issue both the PSDDA and SMS programs consider the initial weight standard and negative control performance guideline to be reasonable and readily achievable by laboratories performing this test. Past experience indicated that laboratories initiating tests with smaller worms (<0.25 mg) resulted in an increasing likelihood of equivocal test results due to lower biomass and calculated growth rates at test termination. Therefore, both the initial weight and negative control QA/QC Red Flag will remain in effect until further notice. The PSDDA/SMS programs will normally consider exceedances of these standards as grounds for retesting, but have the ability to exercise best professional judgement when/if special circumstances warrant. The PSDDA/SMS programs will continue to monitor the laboratory performance for the *Neanthes* Growth bioassay, and will provide future modifications to these QA/QC guidelines as deemed appropriate.

Response to Comments raised by the Port of Seattle Concerning the SMS Triennial Review. "Consistent with Ecology's commitment to undertake thorough triennial review of the rule, the Port of Seattle is enclosing by separate letter to Dave Bradley of Ecology proposed SMS rule revisions. ...The Port of Seattle and WPPA urge Ecology to seriously consider and adopt these revisions in order to create a more efficient, more workable rule, and one that is in the end, more likely to provide real improvements to Washington's environment."

Ecology proposes to review the Port of Seattle's letter to Dave Bradley and provide responses in a draft Annual/Triennial Review Responsiveness Summary to the SMS Implementation Committee by the beginning of September 1996. Ecology proposes to use the SMS Implementation Committee as the forum to review and consider all annual/triennial review comments received by Ecology. After the SMS Implementation Committee has completed review and comment on the preliminary draft of the Annual/Triennial Review Responsiveness Summary, Ecology plans to finalize the document by the end of December 1996. The final Responsiveness Summary will identify Ecology's proposed changes to the SMS rule based on review of all annual/triennial comments received.

Response to comments raised by the Port of Seattle concerning SMS Guidance for Sampling and Analysis Plans: "Before this guidance is finalized, however, we believe that it should be reviewed by the SMS Implementation Committee".

Ecology agrees and has provided a copy of the draft final Sampling and Analysis Plan Appendix

(SAPA) to Implementation Committee stakeholders. Ecology has asked that comments on the SAPA be provided to Ecology by July 31, 1996.

Response to comments by Carl Kassebaum on the clarification paper - Dredged Material Volume Estimates

Mr. Carl Kassebaum, of Hartman Associates, proposed changes to the clarification paper on dredged material volume. Mr. Kassebaum suggested that when daily barge estimates, corrected for bulking, reaches the permitted in-situ volume, dredging must stop unless the DMMO is immediately notified, and that such notification include certain information.

However, the multi-agency make-up of PSDDA is such that a call to the DMMO will not suffice to alter the authorized disposal volume. The volume of dredged material that can be disposed at a PSDDA site is governed by a combination of permits and authorizations. The final authorization for disposal comes from the Department of Natural Resources, and this authorization can only be for the minimum amount of material as specified in any of the applicable permits. Additionally, all of these permits and authorizations are independent, although coordinated through the JARPA, and each agency must be able to internally review and modify these permits and authorizations.

As dredging proceeds, the contractor must closely monitor dredging progress and notify the agencies as soon as possible if an exceedance of the permitted volume appears likely. A decision will be made at this time, based upon an estimate of the probable permitted volume exceedance, as to whether dredging and disposal can continue. Revision of the permits will be made as necessary. If notification of the agencies does not occur, dredging must stop when the sum of the daily barge estimates, corrected for bulking using the revised bulking factor, reaches the permitted in-situ volume. DNR and the Corps must be notified at this time of the status of the project. If the dredging has not been completed, a determination will be made as to the cause of the impending volume exceedance and permit volumes revised as appropriate.

Response to comments by Mike Salazar (Applied Biomonitoring) concerning site monitoring adjustments, site evaluation procedures and "rush to judgement".

The PSDDA site monitoring plan was carefully crafted with full agency and interested public participation and input. At the time it was finalized by the evaluation procedures technical workgroup it reflected the best monitoring approach available balancing environmental concerns with economic cost considerations. The response provided herein deal with the generic aspects of PSDDA site monitoring, and TBT specific issues are dealt with separately in comment/response. The PSDDA agencies feel strongly that the physical/chemical/ biological testing approach used in monitoring the sites generally provides satisfactory feedback to evaluate onsite and offsite impacts of dredged material disposal. Evaluation of potential offsite impacts includes down current analyses at transect stations of infaunal abundance and selected infaunal (e.g., *Molpadia intermedia* and/or *Compsomyax subdiaphana*) tissue levels of chemicals of concern. These data have conclusively demonstrated that PSDDA disposal at all nondispersive sites monitored have not resulted in offsite benthic infaunal impacts or elevated tissue levels of chemicals of concern in infaunal organisms monitored.In 1990, the PSDDA agencies also conducted a laboratory

bioaccumulation test with onsite postdisposal material from the Port Gardner disposal site to evaluate tissue levels of chemicals of concern in *Macoma nasuta*. Results from this evaluation failed to document any accumulation of chemicals of concern attributable to dredged material disposal.

Moreover, evaluation of onsite sediment chemistry attributable to disposal of dredged material has generally shown that chemicals of concern rarely exceed the screening levels or biological effects levels (eg., PSDDA SL and SMS SQS). Corresponding toxicity evaluations of onsite material have not shown any evidence of toxicity to date among the four biological effects tests.

Response to comments raised by Mike Salazar concerning inconsistencies in approach to larval bioassays: "If there are significant differences in the results of larval testing from different species, it is not clear why the Department of Ecology is requiring bivalve bioassays at pulp and paper mills in Puget Sound"

Whole effluent toxicity testing is a requirement of state and federal regulations to evaluate potential ecological impacts from discharges. Given specific conditions that must be met, all discharges are subject to requirements of Whole Effluent Toxicity testing (WET). Ecology contracted the study, "*West Coast Marine Species Chronic Protocol Variability Study. February 1994. Prepared for Washington Department of Ecology prepared by PTI Environmental Services* to address a number of issues concerning selection of appropriate species and protocols. We understand after reading this study that the larval protocols used are essential the same as sediment protocols, but without sediment. Additionally, we believe both echinoderm and bivalve species, and other invertebrates, fish and plants are acceptable organisms for these tests. Interestingly, the above study found: that the protocols used for bivalve and echinoderm tests yielded EC50 estimates with relatively low variability among laboratories (inter- and intralaboratory results). Lastly, the study concluded that it was apparent that several of the laboratories had more difficulty in conducting the echinoderm test than the bivalve test.

Response to comments concerning the need to assess sulfur and sulfide effects on saline microtox and solid phase microtox.

The PSDDA/SMS programs acknowledge the need to address non-treatment factors that can affect the test outcome, leading to potential false positive responses in toxicity tests. However, the current and near future funding/staffing scenario appears bleak and is not expected to improve within the foreseeable future. The PSDDA/SMS programs will address this worthwhile issue when staff and resources become available. It should be noted that the PSDDA program no longer requires applicants to run the saline microtox test because of apparent past lack of sensitivity and concordance with toxicity responses of the three other bioassays in the testing suite. The PSDDA program has not made a final decision on whether or not the solid phase microtox test should be adopted to replace the saline microtox test, or whether the saline microtox test should be dropped in favor of some other "yet to be determined" test. Given the current staffing/funding levels, PSDDA does not know when we will have the necessary resources to complete this task.

Response to comments: Demonstration Pilot Project
Prepared by Rachael Friedman Thomas (Washington Department of Ecology, 360/407-6909)

Question. The Demonstration Pilot Project should be used as an opportunity to test supplementary monitoring tools and evaluate the sensitivity of existing tools. (Mike Salazar, Applied Biomonitoring)

Response. The Demonstration Pilot Project, an effort to coordinate at the local level and develop a comprehensive, prioritized plan for sediment management, is part of a larger effort to develop a Cooperative Sediment Management Program (CSMP). Both the pilot project and the CSMP will afford the opportunity, within existing and future resource constraints, to address outstanding technical and policy issues. Scientific investigations in the pilot bay will be driven by the need to fill data gaps, characterize prioritized projects, and develop the technical basis for permit streamlining. State and local participants will be employing an adaptive management approach, thus will remain flexible to implement alternate methodologies as appropriate.

Question. Use of the Demonstration Pilot Project to test the Maritime Administration/U.S. Department of Transportation's (MARAD) decision model for dredged material management. (Dr. Spyros Pavlou, Ogden Environmental and Energy Services)

Response. There are currently three joint intergovernmental initiatives operating under the umbrella of the Cooperative Sediment Management Program. The three efforts, Beneficial Uses Policy Development, Multiuser Confined Disposal Siting, and Sediment Cleanup Strategy, do not represent the entire universe of sediment management issues facing the State of Washington. There are other activities, such as the development of a Regional Dredging Team and Regional Dredging Manual for the Columbia River. The MARAD Phase-1 study findings may have applicability in a number of the aforementioned venues. The sediment management agencies will evaluate the information and consider incorporation as appropriate.

Response to comments received concerning Human Health Criteria Development
Prepared by Laura Weiss.

Port of Seattle/WPPA Comments

Comment: *"... BSAFs for individual chemicals vary as much as five orders of magnitude... Any BSAF-based approach introduces such a tremendous amount of variability into the standard-setting process as to call into question the validity of any standards that result."*

Response: In order to calculate health-based criteria for sediments, a factor that quantitatively relates sediment concentrations to tissue concentrations is needed. That factor is commonly known as a Biota-Sediment Accumulation Factor (BSAF). In the Tier I Report, the Washington State Department of Health describes the technical basis for BSAFs and calculates recommended BSAFs based on empirically-derived data collected from the literature.

Ecology recognizes that there are uncertainties associated with the use of BSAFs. However, Ecology does not consider the variability to be nearly as great as is implied in the Port's comments. For example, the BSAFs calculated by DOH for PCBs with K_{ow}s between 6.0 and 7.0 (which includes most Aroclors seen in the aquatic environment) range from a median of 1.5 to a 90th percentile of 12.1, which is less than an order of magnitude.

In addition, Ecology contracted with PTI Environmental Services to conduct an additional analysis of the data collected and analyzed by DOH. In that November 1995 report, entitled "*Analysis of BSAF Values for Nonpolar Organic Compounds in Finfish and Shellfish*," PTI used regression analysis to calculate BSAFs for PCBs, dioxins/furans, PAHs and pesticides. Highly significant regressions of BSAF on K_{ow} were obtained for PCBs and dioxins in finfish, and for PAHs and PCBs in shellfish. PTI calculated confidence limits of BSAFs, which showed very little variability between the 0.5 and 0.95 confidence limits for PCBs and dioxins. PTI further concluded that "the mean regression line is generally well defined for PCBs, dioxins and PAHs -- that is, it has considerably less uncertainty, and the mean BSAF can be predicted with greater confidence than an individual BSAF value."

Additional support for BSAFs can be found in a recent article published in the Archives of Environmental Contamination and Toxicology by Tracey and Hansen. The authors concluded that BSAFs do not differ as a function of feeding type or habitat of benthic species. They confirmed that BSAFs are dependent on K_{ow}, and that if one limits the K_{ow} range under consideration, the BSAF range is quite small.

BSAFs calculated by Tracey and Hansen are in the same range as those calculated by DOH and PTI. Tracey and Hansen reported about an order of magnitude difference in BSAFs between the 50th percentile and 99th percentile for PAHs, PCBs and pesticides.

Ecology's construct for human health criteria includes 2 tiers. The first tier is intended to allow for an initial evaluation to determine if sediment chemical concentrations pose a significant human health risk. The second tier allows for additional, site-specific analysis.

BSAFs are necessary for the calculation of the Tier I criteria, and the uncertainties associated with BSAFs can be more fully evaluated during the Tier II analysis.

Comment: *Preliminary standards derived for the DOH Tier I Report indicate that vast areas of Puget Sound are grossly contaminated. "This conclusion simply does not make sense."*

Response: As noted in Ecology's cover memo to the Tier I Report, the assumptions used to develop the criteria values listed in Table 6 of the Tier I Report (Appendix C) may be altered during the rule development process, which would ultimately change the final criteria values proposed by Ecology.

For example, DOH used a risk level of 1 in a million (10^{-6}) to calculate the criteria values in Appendix C. Ecology has previously explained its intention to use a risk level of 1 in a million in setting the lower SQS and a risk level of 1 in a 100,000 (10^{-5}) for calculating the CSL.

In addition, as the Tier I Report explains and as Ecology has also identified as an important consideration, background concentrations of certain ubiqitous, anthropogenic compounds are expected to play a role in the development of health-based criteria. Ecology recognizes the need to allow for non-health-based criteria to drive cleanup decisions in certain situations, especially where health-based levels are well below background concentrations.

Comment: *"Ecology sediment management should provide direction to its regional offices indicating that the June 1995 DOH Tier I Report is not a valid basis for making regulatory determinations in exercising best professional judgement in regulatory case-by-case decision making."*

Response: Ecology regional staff rely on many tools to make case-by-case decisions. The Tier I Report is one of those tools available. It includes valuable information about toxicity values, background concentrations, chemicals of concern and BSAFs. Regional sediment cleanup staff are aware of the regulatory and legal limitations associated with the use of the criteria values listed in Appendix C for case-by-case decision-making. We are not aware of any situations where values listed in Table 6 have been applied directly at sites.

Comment: *"Ecology should further pursue ways to use fish tissue data. A much simpler and more effective approach would be to define fish tissue levels that would serve as triggers for concern, and only move forward with site-specific inquiries on the need for sediment cleanup in those areas where fish monitoring defines a valid concern for human health."*

Response: Ecology is interested in how the Ports envision this proposal working in more detail. Ecology has given a lot of consideration to the use of fish tissue testing, especially in the development of site-specific human health criteria. There are a number of approaches associated with fish tissue testing that Ecology has considered. The three bullets below,

divided according to whether the approach fits within a Tier I or II approach, describe those approaches.

Options for incorporating fish tissue data in the decision-making for sediment cleanup and/or source control:

Tier I

- Include fish tissue regulatory levels in Tier I. Those levels could be used like a biological override -- if sediment levels exceed Tier I human health sediment criteria but tissue levels are below "tissue criteria," then no regulatory action would be required. However, if tissue levels were found to exceed "tissue criteria," while sediment concentrations were below levels of concern, then there is a question about the appropriate regulatory action.

This also brings up issues related to adequacy and completeness of sampling and analysis and the costs and benefits associated with false negatives and false positives. By allowing tissue concentrations to override sediment chemistry, one is more likely to end up with a false negative; that is, assuming that the site is clean when in fact it is "dirty." This might occur if the species collected bioaccumulates contaminants to a lesser degree than another species that are being consumed by people Or it might occur if the fish sampled were not representative of exposures by most fish.

Tier II

- Use fish tissue data to calculate a site-specific BSAF, which is then used to calculate a site-specific human health criteria.

x

- Use fish tissue testing to make cleanup and source control decisions, based on an exceedence factor approach. For example, in the Duwamish Waterway, consideration is being given to a river-wide approach for making cleanup decisions that is an alternative approach to a BSAF-based criteria. The river-wide approach relies on calculating an exceedence factor based on tissue levels in the river as compared to target, health-based tissue levels, and then conducting cleanup in the most contaminated areas until the river-wide sediment concentrations is reduced by the same exceedence factor.

If the Ports have another approach in mind that is not captured here, Ecology would like to be made aware of that approach in more detail.

Salazar Comments

Comments: *(a) There are problems associated with using chemical analysis of fish tissue (thier mobility, for example). (b) DOE and DOH have proposed that "caged fish or bivalves be used to develop site-specific biota-sediment accumulation factors."*

(c) Use of caged bivalves would provide a link between human health assessments and ecological assessments by utilizing species that were adaptable to both programs. There is also the additional link between consumption of bivalves and tissue residues measured in the field.

Response: In response to the second comment above (b), it is not true that DOE and DOH have proposed that "caged fish or bivalves be used to develop site-specific biota-sediment accumulation factors." In fact, DOH has recommended against it in the Tier II Report, based on concerns about equilibrium, exposure pathway and cost.

Ecology has also heard concerns that the accumulation of contaminants in caged species may overestimate exposure from a human health perspective and may be more reflective of water column concentrations, rather than sediment concentrations.

Nonetheless, Ecology does occasionally use caged mussels at cleanup sites to asses bioaccumulation potential. It is likely that the Tier II approach will allow for the use of caged mussels (or other caged species) as a component of site-specific bioaccumulation assessment. It is not likely that we would rely solely on caged mussel studies to make decisions about human health risks.

Response to Comments on Criteria for Screening New Data for AET Calculations
Prepared by T.H. Gries for the Cooperative Sediment Management Program (CSMP)

Background

Mr. Tom Newlon, representing the Port of Seattle, submitted a letter dated May 22, 1996, to the Corps of Engineers commenting on issues discussed at the Sediment Management Annual Review Meeting (SMARM) held two weeks before. One of the issues affecting both the PSDDA and SMS programs was how AETs had been recalculated. The Port urged the CSMP agencies to reconsider the criteria used to screen newer data. They found the concept and exclusion of "chemically anomalous" samples particularly "troublesome."

General Response

The agencies could have responded more easily and completely to the concerns expressed in the Port's letter and issue papers had those concerns been raised earlier in the overall process of re-evaluating AETs. Methods for screening newer synoptic data and recalculating AETs were presented to the public as early as the spring of 1993 *(1)*. They were again summarized in the spring of 1994 *(2)* and detailed in a draft report released to a select group of technical experts *(3)*. Yet no participant in the early phases of recalculating AETs, or reviewer of early AET results, objected to recalculations which followed the 1988 methods. Those methods included screening for and excluding chemically anomalous sample data *(4)*.

Nevertheless, the Port raises some valid concerns in their letter and related issue papers. The agencies are reconsidering several of the screening and calculation methods used. We intend to make our findings available during upcoming Regulatory Work Group meetings in order to facilitate recommendations on how AETs should be used, particularly in the PSDDA program. Findings will also be discussed in the final AET Re-evaluation Report and in any proposals to formally adopt new guidelines or criteria.

We greatly appreciate the comments forwarded by the Port and welcome any additional ones the Port may have. We want to encourage their active participation in the remaining phases of re-evaluating AETs. Their input at Regulatory Work Group (RWG) meetings will be invaluable, especially for analyzing the potential implications of new Screening and Maximum Level (SL/ML) values. We also strongly support the Port's early involvement in the agencies' next comprehensive re-evaluation of AETs, which will feature at least some of the following:

- incorporating biological effects data from numerous additional synoptic surveys, including ones conducted by the Port
- changing the concept and calculation of AET values, including screening methods, interpretation endpoints, statistical methods
- calculating new types of AETs, including ones based on reduction in benthic richness, adverse effects to a combination of all bivalve and echinoderm larval species, inhibition of *Neanthes* growth

changing how AETs are used in regulatory programs

Specific Responses

Statement

The Port states in the opening paragraph of its comment letter that an individual AET, by definition, represents *"a threshold value, not a mean or clustered value." "The AET values do not describe direct cause and effect relationships between a given contaminant and biological effects." "The data is associational ... ." "As more and more data is collected, AET values will rise,"* which is an *"honest recognition of the meaning of AET data."*

Response

The agencies agree with these statements.

Statement

"New AET data cannot and should not be reviewed with the intention of preventing AETs from rising or the presumption that any data resulting in higher AETs is automatically suspect or will lead to a less protective rule."

Response

We are in complete agreement. Absolutely no data were reviewed or excluded from 1994 AET recalculations in order to prevent values from rising or becoming less environmentally protective. Please note that several amphipod mortality AETs did increase and that some represent potentially higher PSDDA ML values.

Statement

"The 'chemically anomalous' screen, is particularly troublesome because it specifically excludes valid data that should be included unless some atypical mechanism for a lack of toxicity is demonstrated ... ."

Response

Identification of "chemically anomalous" samples was a generally accepted part of the 1988 AET calculation methods which yielded the values used in current regulatory guidelines and criteria *(4)*. Of course, this does not mean that generally accepted methods should never be reviewed and improved. Indeed, the agencies did consider identifying chemically anomalous samples using a method appearing less arbitrary than "any 'No Hit' sample having a chemical concentration three times greater than the next highest 'No Hit' sample" *(4)*. But largely ignored alternative approaches after assuming that 1) following the existing method would result in less controversy, and 2) the results obtained using a different method would be similar. The

agencies are now in the process of re-examining those assumptions.

The Port states that it may be acceptable to exclude valid data if *"some atypical mechanism for a lack of toxicity is demonstrable."* However, having AET values for a large number of chemicals of concern which predict significant adverse biological effects does not mean the chemical or chemicals causing the effect are known or which one(s) caused the effect. Nor can we discern the mechanism of inaction in samples predicted to exhibit adverse effects but which do not. Thus, if under the current scheme of testing we never know what the exact cause or mechanism of sediment toxicity is, then why must we know the actual mechanism of inaction in order to exclude a "No Hit" sample which is an apparent outlier?

Nature seldom reveals to us exactly how or why an event occurs, just that it does and how frequently it occurs (if we're lucky). For this reason, the agencies identify outliers as rare "events," "events" which occur much more frequently than expected, or "events" which exhibit properties outside the probability distribution for our observations. These "events" are "chemically anomalous" when they are "No Hit" samples exhibiting a chemical concentration at least three times greater than the next sample showing no significant adverse effects. We do not presume to know cause for lack of an adverse effect when we identify an anomalous sample. But we are searching for a more scientifically defensible tool to identify outlier samples than the admittedly simple one currently used.

Statement
"Excluding a data point solely because it is higher than others presumes that a cause and effect relationship exists between the current AET value and toxicity in the environment."

Response
No. The only presumption the agencies make is that the data point lies on the extreme high end of the concentration range, and so is not representative of the normal distribution of chemical concentrations for "No Hit" samples.

Statement
"A good example of the problems associated with the 'chemically anomalous' screening tool is the antimony data mentioned at the SMARM. The data point that was rejected would have raised the AET value considerably."

Response

We agree. The "No Hit" sample considered to be chemically anomalous for antimony would have set the AET at 1370 ppm (Table 1). This value is 6.9 times higher than the next greatest "No Hit" sample ***(5, Appendix B)***. We consider this an outlier from the standpoint of probability because, among a total of 273 synoptic samples with detected concentrations of antimony, no other "No Hit" sample was observed above 199 ppm (Figure 1).

We believe that one of the problems associated with allowing a highly unusual sample to set the AET value -- reducing the ability to accurately predict areas of legitimate contamination --

outweighs the ones to which the Port alludes. The AET will increase if new data for antimony collected over the next few years reveals more "No Hit" samples associated with higher concentrations. Sample WW-14 will no longer be rare, occur more frequently than expected, or exhibit properties outside the probability distribution of observations.

Statement

" ... in comparison to arsenic, the AET calculation initially produced an antimony value approximately 500 times lower than what one might expect if one regarded the AETs as generating cause and effect values."

Response

The agencies do not regard the AETs as *"generating cause and effect values,"* so we do not expect the same relative proportionality between antimony and arsenic AETs as is exhibited by the marine chronic criteria.

Statement

" ... an increase of considerably more than one order of magnitude in a second round calculation should not be surprising or cause regulatory concern."

Response

The agencies did not know to what extent 1994 AETs might increase. We found that most of the 1994 AETs which increased did so to a modest degree. For example, the 1994 dry-weight normalized amphipod mortality AETs which increased since 1988 did so by little more than a factor of two *(5)*. In retrospect, then, *"an increase of considerably more than one order of magnitude"* would have been surprising. It might also have been cause for regulatory concern due to the likely loss of predictive sensitivity.

Statement

"The process (for screening new data) cannot be an arbitrary one, though, and should not be designed in such a way that it is inherently prejudiced against data suggesting higher AETs."

Response

As already stated, the screening process was not designed to include any prejudice. If the method used to identify chemically anomalous samples was designed to prejudice certain data, then perhaps the Port should discuss this its contractors -- the same ones who developed the 1988 method.

References

1. PSDDA. 1993. Minutes of the 1993 Annual Review Meeting. Presentations by K.H. Waldow and T.H. Gries.
2. PSDDA. 1994. Minutes of the 1994 Annual Review Meeting. Presentation by T.H.

Gries.

3. Gries, T.H. and K.H. Waldow. 1994. Re-evaluation of Some Puget Sound Apparent Effects Thresholds. Draft report prepared by the Department of Ecology for the PSDDA agencies, November 1993

4. Barrick, R., L. Brown, and S. Becker. 1988. Sediment Quality Values Refinement, Volume I; 1988 Update and Evaluation of Puget Sound AET. Prepared by PTI Environmental Services for the U.S. Environmental Protection Agency Region 10, Office of Puget Sound. PTI Environmental Services, Bellevue, WA.

5. Gries, T.H. and K.H. Waldow. 1996. Progress Re-evaluating Puget Sound Apparent Effects Thresholds (AETs), Volume I. Draft report prepared by the Department of Ecology for the CSMP agencies, April 1996.

RESPONSES TO COMMENTS ON: **July 25, 1996**
STATISTICAL EVALUATION OF BIOASSAY RESULTS (Michelsen, Shaw)

Comments 1-4 are excerpted from a memorandum prepared by Lorraine Read of EVS for the Port of Seattle, dated May 21, 1996, attached to a comment letter from Doug Hotchkiss, Port of Seattle and Eric Johnson, Washington Public Ports Assn., to Brian Applebury, Corps of Engineers and D.J. Patin, Dept. of Ecology, dated May 22, 1996.

C1. Transformations should not automatically be made on data without consideration of their untransformed distribution. Zar (1996) states that transformation is unwarranted unless the largest sample size is more than 5 times greater than the smaller sample size, and the smaller variance is associated with the smaller sample. In the case of bioassay results, the sample sizes are generally equal, eliminating the need for this transformation. If one concludes that the original data do not meet the assumptions of the t-test, then the transformations suggested may be used to resolve the problems with the data (i.e., non-normality or different variances).

R1. The decision to transform all data was made to streamline the analysis procedure for project proponents and is unlikely to impact the results of the analysis. However, we agree that this approach is technically more appropriate and will revise this section of the paper to read "An arcsine square root transformation ***may*** *be performed* ***if required*** *to stabilize variances etc..."*

C2. It should be noted that the arcsine square root transformation is only appropriate for percentages bounded by 0 and 100 (e.g., mortality or abnormality); it would not apply to percent change, as these values could be greater than 100%.

R2. Agreed; it will be clarified that this transformation should not be applied to, for example, Microtox results where percent values could be greater or less than 100%.

C3. Checking the assumptions on which statistical tests are based is important in order that the results from these tests be properly interpreted. However, many studies have been done on the performance of the t-test under varying conditions of non-normality and non-homogeneous variances. The conclusions are that the t-test is quite robust to deviations from both assumptions, particularly when the sample sizes are equal (as is generally the case in bioassay results). Deviations only become important when they are severe, and especially when extreme values are present.

R3. Generally, it is true that the Student's t-test is robust to deviations from the underlying assumptions of the statistic. However, the one-tailed test prescribed by the clarification paper is not as robust as the two-tailed version. Specifically, the one-tailed t-test is more susceptible to increased type I error or reduced power if the underlying population is not normal or is skewed. (Zar, 1984). This is particularly true when sample size is small.

C4. The hypothesis tests for normality and homogeneity of variances are less robust to deviations from their assumptions than is the t-test. The Shapiro-Wilks test (W test) for normality is adversely affected by tied data. The F-test for equal variances is strongly affected by deviations

from normality (much more so than the t-test). Rather than run the data through statistical tests which have limited power because of small sample size, it would be better to assess the basic symmetry of the distributions and check for extreme values using graphical measures, such as box plots or Quantile-Quantile plots.

R4. We agree that the tests for normality may be problematic, however, the use of graphical examinations alone to make determinations regarding normality is too subjective. One goal in providing statistical guidance is to make use of tests that are widely available in standard statistical packages and are straight-forward to interpret. The Wilk-Shapiro test provides at least some objective measure of a data set's normalcy, particularly after the data have been transformed. Another goal is to standardize the statistical analysis procedures; due to widely varying degrees of statistical familiarity among regulated parties and agency staff, it may be less important to select the most mathematically robust alternative than to select a widely available, consistent approach with reasonably low error rates. However, several alternative tests are under discussion, including the Brown-Forsythe procedure and Levene's test, and these approaches may be presented at the next SMARM if they appear to offer significant advantages in reducing error rates and increasing power.

The following comments arose out of interagency statistics discussions which took place on May 1, 1996 at Ecology and May 2, 1996 at EPA.

C5. Substantial discussion took place regarding whether ANOVA/Dunnett's could or should be substituted for the t-test under various conditions (e.g., when multiple comparisons to a single reference station are being made), out of concern that the Type I error increases with each comparison.

R5. The PSDDA agencies make separate regulatory decisions about each individual DMMU based on a comparison of a single sample to a reference station. Thus the Type I error for each regulatory decision remains at 5% and the approach described in the SMARM paper is appropriate.

Likewise, under SMS, each station is considered individually, and may or may not be compared to the same reference station as another. A hit/no-hit designation is made for each separate site station, and the Type I error for each individual station remains at 5%. An argument was made that the overall Type I error rate increases with each additional comparison. However, the agencies are not concerned with this "overall" error rate, since it is not likely to affect the overall regulatory decision. When there is a 5% chance of error at each station, it is obvious that as you make hit/no-hit decisions for a number of stations the overall chance of making one incorrect decision somewhere within that area increases. However, one incorrect assignment, or even a few more, are not likely to make a significant regulatory difference at cleanup site where 30 or more stations may have been sampled. It is the overall number, pattern, and magnitude of hits that drive cleanup decisions, along with a wide variety of additional types of evidence.

In addition, the agencies are less concerned with a type I error (the chance that a clean station

would be designated as dirty) than the type II error (the chance that a dirty station would be designated clean), since it is the latter that determines the power or ability of an agency to detect a contaminated site. At the alpha level set by the SMS, use of the ANOVA/Dunnett's procedure decreases the power, resulting in fewer detections of contaminated sites. In order to get the same power as the t-test, the alpha level or type I error rate would also have to be increased. Thus it is not obvious that the ANOVA/Dunnett's procedure offers better performance than the existing method.

C6. If replicate data are available for either a site or reference station, the number of data points for one station may be different from the station it is compared to. A discussion was held of the best statistical procedure for handling this situation. It was suggested that the Mann-Whitney test (a nonparametric test suggested in the SMARM paper as an alternative to the t-test when t-test assumptions are not met) is relatively insensitive to unequal data set sizes, and would be a good choice in this situation.

R6. This suggestion will be added to the alternatives for dealing with replicate data at reference stations.

Response to "Evaluation of the Benthic Criterion for PCB AETs"

Prepared by T.H. Gries for the Cooperative Sediment Management Program (CSMP)

Background

Battelle and EVS, acting on behalf of the Port of Seattle, reviewed the original benthic AET development work *(1)* and developed the above issue paper for the 1996 Sediment Management Annual Review Meeting (SMARM). They compiled a small portion of the synoptic sample results used to calculate benthic AETs in Table 1 of the issue paper. Sample WP-09-2082 had the highest detected PCB concentration among those assigned an "N" in the "Hit" column ("No Hit") and a "1" in the "Benthic Code" column ("no statistically significant reduction in abundance in any major taxonomic group"). That sample set the current AET for PCBs at 65 mg /kg TOC *(2)*.

However, results for two other samples listed in Table 1 raised some questions. Sample WP-08-2083 was listed as a "Hit" but also assigned a "Benthic Code" indicative of a "No Hit" sample. This inconsistency was notable because the sample contained 270 mg PCBs/kg TOC. If WP-08-2083 was listed as a "Hit" incorrectly, then perhaps the AET for PCBs should have been set much higher than it was. The second sample, WP-07-1812, was listed as a "No Hit" but was also assigned a "0" in the "Benthic Code" column, meaning that it was not used in final benthic AET calculations . If sample WP-07-1812 had been used, then perhaps the AET should have been set at 83 mg PCBs/kg TOC. It was not immediately clear why the sample was not used.

Battelle and EVS also noted that most of the original benthic "Hit" samples collected from Elliott Bay came from the vicinity of the Denny Way CSO. This area likely had high levels of organic enrichment which might have contributed to false positive "Hit" classifications.

Proposed Actions

"The raw data used to determine the Benthic AET for total PCBs should be reevaluated to check for inappropriate classifications and possible inconsistencies."

"Station locations for the Benthic AET for total PCBs should be evaluated for the possibility of confounding factors, such as heavy organic enrichment. Supplementation of the existing database should also be considered."

Response to Proposed Action #1

The CSMP agencies (henceforth "the agencies") are reviewing detailed results for the original benthic AET samples, but have yet to verify inappropriate "Hit" classifications or inconsistencies identified in the issue paper. We will continue working to determine whether WP-08-2083 was correctly classified as a "Hit" sample and why WP-07-1812 was not used in the original AET development work.

At the time of this response, the agencies believe there are two possible explanations why sample WP-08-2083 did not set the benthic AET for PCBs at 270 mg/kg TOC. The 1986 AET document may have assigned an incorrect "Benthic Code" to the "Hit" sample WP-08-2083. Alternatively, sample WP-08-2083 was excluded from 1988 AET calculations for being three times greater than the next highest "No Hit" sample; it was considered "chemically anomalous," *(2, Appendix C)*.

In regard to sample WP-07-1812 (83 mg PCBs/kg TOC), the agencies believe it was one of the 23 stations in the TPPS3AB survey which apparently lacked " ... appropriate biological reference stations ... " *(1, Page C-1)*. The benthic effects exhibited by these samples could not be interpreted and so were not used to calculate AETs. The remaining 29 synoptic benthic samples were used *(2)*.

Response to Proposed Action #2

The agencies have long recognized that factors other than anthropogenic contaminants can affect species abundance, as well as other measures of benthic community health. High levels of organic enrichment in the vicinity of sewage treatment plant outfalls, for example, could have caused misclassification of some of the original benthic effects samples. Unfortunately, there is no practical means of assessing the direct influence of organic enrichment alone, as measured by percent TOC, on community health represented by ten year old benthic samples. Even if a relationship between TOC and reduced species abundance could be demonstrated, the causative nature of that relationship could not.

This stated, we did briefly examine the original benthic effects database for such a relationship. They compared the mean TOC concentration among all benthic "Hit" samples to the mean TOC among all benthic "No Hit" samples *(2)* and found the former was significantly greater than the latter ($p<0.01$). This appeared to be caused by the relatively greater number of "Hit" samples having more than 2.0 percent TOC (Figure 1). There was no significant difference between mean TOC in "Hit" and "No Hit" samples having 2.0 percent TOC or less.

We conclude that there may be need to distinguish between "High TOC" and "Low TOC" samples in future interpretations of benthic community health. We may study the relationship further, realizing it cannot be used to imply a cause and effect relationship between high TOC and false-positive "Hit" classifications.

The agencies agree with the recommendation to expand our benthic indicators database. Our limited resources, however, are currently devoted to completing definition of benthic reference sample performance standards *(3, 4)* which will aid in interpreting benthic sample results. An expanded database and new reference performance standards could form the basis for beginning a lengthy process of re-evaluating the 1986/1988 benthic AETs. Other requisite steps would include:

- negotiating new benthic interpretation endpoints and guidelines
- interpreting all benthic sample results in the expanded Sound-wide database

considering adverse effects caused by factors other than anthropogenic contaminants in those interpretations
calculating new benthic AETs
assessing the implications of new benthic AETs on regulatory programs

References

1. Beller, H., R. Barrick, and S. Becker. 1986. Development of Sediment Quality Values for Puget Sound, Volume I. A report prepared by Tetra Tech, Inc. for the U.S. Army Corps of Engineers for Puget Sound Dredged Disposal Analysis program. Tetra Tech, Inc., Bellevue, WA.
2. Barrick, R., L. Brown, and S. Becker. 1988. Sediment Quality Values Refinement, Volume I; 1988 Update and Evaluation of Puget Sound AET. Prepared by PTI Environmental Services for the U.S. Environmental Protection Agency Region 10, Office of Puget Sound. PTI Environmental Services, Bellevue, WA.
3. CSMP. 1995. Minutes to the 1995 Sediment Management Annual Review Meeting (SMARM), Appendix C. Status Report of Benthic Infauna Studies, prepared by P. Sparks-McConkey.
4. Striplin Environmental Associates, Inc. 1996. Development of Reference Value Ranges for Benthic Infauna Assessment Endpoints in Puget Sound. Prepared for the Department of Ecology.

	A	B	C	D	E	F
1	09/06/96					
2	Survey	Station	Date	Sample	FieldRep	SubSamp
3						
4	TPPS3AB	WP-08	07/15/82	2083		
5	EBCHEM	MG-04	09/26/85	MG-04		
6	EBCHEM	MG-03	09/26/85	MG-03		
7	EVCHEM	NG-02	10/02/86	NG-02G	NG02	
8	TPPS3AB	WP-03	07/15/82	2090		
9	EVCHEM	NG-03	10/02/86	NG-03G	NG03	
10	EBCHEM	MG-01	09/26/85	MG-01		
11	EBCHEM	MG-02	09/26/85	MG-02		
12	EVCHEM	SD-01	10/09/86	SD-01G	SD01	
13	CBMSQS	RS-20	01/01/84	RS-20		
14	EVCHEM	NG-04	10/02/86	NG-04G	NG04	
15	EBCHEM	AB-03	09/26/85	AB-03		
16	TPPS3AB	EB-35	07/15/82	2079		
17	EBCHEM	KG-11	10/01/85	KG-11		
18	EBCHEM	WW-01	10/01/85	WW-01		
19	EHCHEM	EH-03	06/01/85	V6		
20	CBMSQS	RS-19	01/01/84	RS-19		
21	TPPS3AB	EB-33	07/15/82	2080		
22	TPPS3AB	EB-36	03/15/82	1776		
23	TPPS3AB	EB-36	07/15/82	2072		
24	EBCHEM	NH-11	10/15/85	NH-11		
25	EBCHEM	WW-03	10/01/85	WW-03		
26	TPPS3AB	EB-35	03/15/82	1775		
27	EHCHEM	EH-08	06/01/85	V1		
28	TPPS3AB	EB-33	03/15/82	1779		
29	EBCHEM	NS-06	09/27/85	NS-06		
30	EBCHEM	NH-01	10/15/85	NH-01		
31	EBCHEM	WW-04	10/01/85	WW-04		
32	EBCHEM	WW-20	10/03/85	WW-20		
33	EHCHEM	EH-15	06/01/85	V1		
34	TPPS3AB	EB-38	07/15/82	2074		
35	EBCHEM	WW-05	10/01/85	WW-05		
36	EBCHEM	NS-08	09/26/85	NS-08		
37	EBCHEM	WW-19	10/03/85	WW-19		
38	TPPS3AB	EB-38	03/15/82	1778		
39	TPPS3AB	WP-16	03/15/82	1816		
40	EBCHEM	WW-18	10/03/85	WW-18		
41	CBMSQS	SP-16	01/01/84	SP-16		
42	CBMSQS	SI-12	01/01/84	SI-12		
43	EBCHEM	WW-16	10/02/85	WW-16		
44	EBCHEM	KG-06	09/30/85	KG-06		
45	EBCHEM	KG-08	10/01/85	KG-08		
46	EVCHEM	SR-08	10/03/86	SR-08G	SR08	
47	EBCHEM	NH-02	10/15/85	NH-02		
48	EHCHEM	EH-05	06/01/85	V1		
49	CBMSQS	HY-47	01/01/84	HY-47		
50	EHCHEM	EH-06	06/01/85	V6		
51	EBCHEM	EW-04	10/14/85	EW-04		
52	EBCHEM	NH-08	10/16/85	NH-08		

	G	H	I	J	K	L
1						
2	PCBS		TOC		Hit?	Anomalous?
3						
4	160		0.06		Y	
5	200	U	0.16	E	Y	
6	150	U	0.18	E	Y	
7	5	U	0.18		Y	
8	25		0.18		Y	
9	5	U	0.19		Y	
10	100	U	0.2	E	Y	
11	160	U	0.21	E	Y	
12	5	U	0.24		Y	
13	4		0.28		Y	
14	5	U	0.28		Y	
15	160	U	0.29	E	Y	
16	970		0.44		Y	
17	180	E	0.45	E	Y	
18	160	E	0.48	E	Y	
19	5	U	0.5		Y	
20	14		0.58		Y	
21	2300		0.6		Y	
22	4000		0.6		Y	
23	490		0.62		Y	
24	300	E	0.63	E	Y	
25	460	U	0.72	E	Y	
26	3900		0.77		Y	
27	5	U	0.9		Y	
28	1100		0.9		Y	
29	380	U	0.96	E	Y	
30	160	E	0.99	E	Y	
31	500	E	1	E	Y	
32	160	E	1.07	E	Y	
33	24	E	1.1		Y	
34	320		1.2		Y	
35	1200	E	1.23	E	Y	
36	280	U	1.26	E	Y	
37	320	E	1.27	E	Y	
38	730		1.3		Y	
39	280		1.3		Y	
40	270	E	1.35	E	Y	
41	90		1.47		Y	
42	18		1.56		Y	
43	650	LM	1.61	LM	Y	
44	3100	E	1.64	E	Y	
45	190	E	1.7	E	Y	
46	1	U	1.71		Y	
47	190	E	1.78	E	Y	
48	30	U	1.8		Y	
49			1.84		Y	
50	45	E	1.9		Y	
51	430	E	1.96	E	Y	
52	1300	E	1.96	E	Y	

	M	N	O	P
1				
2	**"N", Mean, StDev, Var**	**Different?**		
3	**Hit/No Hit TOC**	**(t-test)**		
4	**107**			
5	**3.34**	**3.26**	See S&R, p227	
6	**4.47**	1.982	Crit. t value	
7	**19.95**			
8				
9			"Hits"	
10	0.49	15	15	24
11	0.99	27	12	40
12	1.99	49	22	64
13	2.99	71	22	77
14	3.99	82	11	79
15	4.99	88	6	82
16	7.49	96	8	85
17	9.99	100	4	86
18	19.99	105	5	87
19	29.99	107	2	87
20				
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9	"No Hits"
10	24
11	16
12	24
13	13
14	2
15	3
16	3
17	1
18	1
19	0
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	A	B	C	D	E	F
53	EBCHEM	WW-08	10/01/85	WW-08		
54	EBCHEM	NH-04	10/15/85	NH-04		
55	EBCHEM	WW-17	10/03/85	WW-17		
56	CBMSQS	SP-15	01/01/84	SP-15		
57	EBCHEM	WW-10	10/02/85	WW-10		
58	CBMSQS	SI-11	01/01/84	SI-11		
59	EBCHEM	EW-07	10/14/85	EW-07		
60	EBCHEM	SS-03	10/04/85	SS-03		
61	EVCHEM	EW-12	10/01/86	EW-12G	EW12	
62	EBCHEM	EW-09	10/14/85	EW-09		
63	CBMSQS	HY-42	01/01/84	HY-42		
64	EBCHEM	EW-02	10/04/85	EW-02		
65	EBCHEM	EW-08	10/14/85	EW-08		
66	EHCHEM	EH-02	06/01/85	B1		
67	EBCHEM	WW-06	10/01/85	WW-06	2	
68	EBCHEM	WW-12	10/02/85	WW-12		
69	CBMSQS	HY-37	01/01/84	HY-37		
70	EBCHEM	WW-14	10/02/85	WW-14		
71	EBCHEM	NH-05	10/15/85	NH-05		
72	EBCHEM	KG-07	09/30/85	KG-07		
73	EBCHEM	WW-09	10/02/85	WW-09		
74	CBMSQS	HY-43	01/01/84	HY-43		
75	EBCHEM	NH-03	10/16/85	NH-03		
76	CBMSQS	HY-28	01/01/84	HY-28		
77	EBCHEM	KG-01	09/25/85	KG-01		
78	EBCHEM	WW-06	10/01/85	WW-06	1	
79	EHCHEM	EH-16	06/01/85	V1		
80	EVCHEM	SR-07	10/03/86	SR-07G	SR07	
81	ALKI	AP-04	05/25/84	AP-04		
82	EBCHEM	EW-11	10/14/85	EW-11		
83	CBMSQS	SP-11	01/01/84	SP-11		
84	EBCHEM	KG-05	09/30/85	KG-05		
85	CBMSQS	HY-23	01/01/84	HY-23		
86	CBMSQS	HY-32	01/01/84	HY-32		
87	CBMSQS	MD-12	01/01/84	MD-12		
88	EBCHEM	EW-06	10/04/85	EW-06		
89	EBCHEM	NH-06	10/16/85	NH-06		
90	CBMSQS	HY-22	01/01/84	HY-22		
91	CBMSQS	HY-14	01/01/84	HY-14		
92	EVCHEM	EW-14	10/01/86	EW-14G	EW14	
93	CBMSQS	HY-24	01/01/84	HY-24		
94	EBCHEM	WW-11	10/02/85	WW-11		
95	CBMSQS	HY-17	01/01/84	HY-17		
96	CBMSQS	CI-17	01/01/84	CI-17		
97	EBCHEM	EW-05	10/14/85	EW-05	2	
98	EVCHEM	EW-07	09/30/86	EW-07G	EW07	
99	CBMSQS	CI-13	01/01/84	CI-13		
100	EBCHEM	SS-04	10/04/85	SS-04		
101	EBCHEM	SS-06	10/03/85	SS-06		
102	CBMSQS	RS-18	01/01/84	RS-18		
103	CBMSQS	CI-11	01/01/84	CI-11		
104	EBCHEM	EW-05	10/14/85	EW-05	1	

	G	H	I	J	K	L
53	620	E	2.03	E	Y	
54	160	E	2.04	E	Y	
55	360	E	2.04	E	Y	
56	90	U	2.06		Y	
57	300	E	2.06	GM	Y	
58	20		2.1		Y	
59	370	E	2.1	E	Y	
60	570	E	2.14	E	Y	
61	5	U	2.23		Y	
62	530	E	2.27	E	Y	
63	1100		2.39		Y	
64	980	E	2.4	E	Y	
65	540	E	2.4	GM	Y	
66	26		2.4		Y	
67	710	U	2.44	E	Y	
68	410	E	2.45	E	Y	
69	420		2.48		Y	
70	380	E	2.52	E	Y	
71	500	E	2.55	E	Y	
72	500	U	2.62	E	Y	
73	1500	E	2.8	GM	Y	
74	100	U	2.89		Y	
75	3300	E	3.01	E	Y	
76	120		3.1		Y	Count
77	490	E	3.13	E	Y	Mean
78	610	E	3.14	E	Y	StDev
79	52	E	3.2		Y	
80	50	U	3.24	LM	Y	
81	34				Y	
82	950	E	3.43	E	Y	
83	90	U	3.5		Y	
84	180	E	3.74	E	Y	
85	1500		3.78		Y	
86	130		3.83		Y	
87	130		4.04		Y	
88	1500	E	4.09	E	Y	
89	600	E	4.14	E	Y	
90	2000		4.44		Y	
91	85		4.51		Y	
92	50	U	4.66		Y	
93	250		5.12		Y	
94	470	E	5.19	E	Y	
95	170		5.22		Y	
96	75		5.64		Y	
97	2900	LM	5.68	LM	Y	
98	87	LM	6.1	LM	Y	
99	140		6.5		Y	
100	1600	E	6.83	E	Y	
101	570	E	8.52	E	Y	
102	26		8.83		Y	
103	15		8.86		Y	
104	2200	E	9.1	E	Y	

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75	"Hits" <2.0% TOC			
76	**49**			
77	**0.93**			
78	**0.59**			
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	A	B	C	D	E	F
105	EBCHEM	SS-09	09/27/85	SS-09		
106	EVCHEM	EW-01	10/07/86	EW-01G	EW01	
107	CBMSQS	CI-16	01/01/84	CI-16		
108	EVCHEM	EW-10	10/01/86	EW-10G	EW10	
109	CBMSQS	SP-14	01/01/84	SP-14		
110	EBCHEM	SS-08	09/27/85	SS-08		
111	EVCHEM	EW-04	09/30/86	EW-04G	EW04	
112	TPPS3AB	WP-10	07/15/82	2076		
113	TPPS3AB	WP-01	07/15/82	2088		
114	TPPS3AB	WP-05	07/15/82	2092		
115	TPPS3AB	WP-04	07/15/82	2091		
116	CBMSQS	CR-13	01/01/84	CR-13		
117	EVCHEM	NG-01	10/02/86	NG-01G	NG01	
118	TPPS3AB	WP-09	07/15/82	2082		
119	CBMSQS	CR-12	01/01/84	CR-12		
120	CBMSQS	HY-44	01/01/84	HY-44		
121	EVCHEM	PS-04	10/10/86	PS-04G	PS04	
122	TPPS3AB	WP-13	07/15/82	2070		
123	TPPS3AB	WP-02	07/15/82	2089		
124	TPPS3AB	WP-07	07/15/82	2093		
125	TPPS3AB	WP-06	07/15/82	2084		
126	CBMSQS	CR-11	01/01/84	CR-11		
127	EVCHEM	PS-03	10/13/86	PS-03G	PS03	
128	EBCHEM	PS-03	10/12/85	PS-03		
129	EVCHEM	NG-06	10/08/86	NG-06G	NG06	
130	EBCHEM	PS-04	10/12/85	PS-04		
131	EBCHEM	SS-01	10/16/85	SS-01		
132	EVCHEM	PS-02	10/13/86	PS-02G	PS02	
133	CBMSQS	CR-14	01/01/84	CR-14		
134	EBCHEM	AB-04	09/26/85	AB-04		
135	TPPS3AB	WP-15	07/15/82	2094		
136	EVCHEM	SD-02	10/07/86	SD-02G	SD02	
137	TPPS3AB	WP-14	07/15/82	2085		
138	TPPS3AB	WP-11	03/15/82	1789		
139	CBMSQS	RS-13	01/01/84	RS-13		
140	TPPS3AB	WP-12	07/15/82	2069		
141	EVCHEM	NG-10	10/03/86	NG-10G	NG10	
142	EBCHEM	NS-03	10/04/85	NS-03		
143	CBBLAIR	B09	06/01/84	B09		
144	CBMSQS	BL-28	01/01/84	BL-28		
145	TPPS3AB	WP-14	03/15/82	1785		
146	TPPS3AB	WP-16	07/15/82	2086		
147	TPPS3AB	WP-15	03/15/82	1817		
148	EBCHEM	NS-05	10/04/85	NS-05		
149	EBCHEM	PS-02	10/12/85	PS-02		
150	TPPS3AB	WP-13	03/15/82	1784		
151	TPPS3AB	WP-12	03/15/82	1786		
152	EHCHEM	EH-01	06/01/85	B1		
153	EBCHEM	EW-16	10/15/85	EW-16		
154	CBMSQS	BL-31	01/01/84	BL-31		
155	EBCHEM	NH-09	10/16/85	NH-09		
156	CBMSQS	BL-21	01/01/84	BL-21		

	G	H	I	J	K	L
105	3300	E	10.3	E	Y	
106	5	U	10.7		Y	
107	36		10.9		Y	
108	13	E	11.8		Y	
109	180	U	16		Y	
110	2400	U	26.6	E	Y	
111	9600	E	29.4		Y	
112	41		0.08		N	
113	15		0.14		N	
114	0.5	U	0.15		N	
115	68		0.16		N	
116	7	U	0.19		N	
117	1	U	0.2		N	
118	130		0.2		N	
119	7	U	0.26		N	
120	65	U	0.26		N	
121	50	U	0.26	LM	N	
122	87		0.26		N	
123	150		0.27		N	
124	130		0.27		N	
125	70		0.28		N	
126	7	U	0.35		N	
127	50	U	0.36		N	
128	140	U	0.39	E	N	
129	5	U	0.39		N	
130	120	U	0.4	E	N	
131	380	U	0.4	E	N	
132	50	U	0.4		N	
133	7	U	0.43		N	
134	180	U	0.45	E	N	
135	220		0.45		N	
136	5	U	0.54		N	
137	150		0.59		N	Anom.
138	1100		0.6		N	Anom.
139	14		0.69		N	
140	110		0.7		N	
141	50	U	0.71		N	
142	310	E	0.72	E	N	
143	5	U	0.73		N	
144	84		0.73		N	
145			0.75		N	
146	76		0.75		N	
147	150		0.76		N	
148	200	E	0.83	E	N	
149	150	U	0.84	E	N	
150	480		0.9		N	
151	100		0.95		N	
152	7	E	1		N	
153	59	E	1.04	E	N	
154	3		1.09		N	
155	280	E	1.11	E	N	
156	6.7		1.14		N	

	M	N	O	P
105	87			
106	1.65			
107	2.06			
108	4.24			
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	A	B	C	D	E	F
157	EBCHEM	EW-12	10/15/85	EW-12		
158	CBMSQS	CI-22	01/01/84	CI-22		
159	EBCHEM	AB-02	09/26/85	AB-02		
160	CBMSQS	BL-11	01/01/84	BL-11		
161	EHCHEM	BH-01	06/01/85	B1		
162	CBBLAIR	B10	06/01/84	B10		
163	CBBLAIR	B12	06/01/84	B12		
164	CBMSQS	BL-25	01/01/84	BL-25		
165	CBBLAIR	B15	06/01/84	B15		
166	EBCHEM	AB-01	09/26/85	AB-01		
167	EBCHEM	PS-01	10/12/85	PS-01	1	
168	EBCHEM	PS-01	10/12/85	PS-01	2	
169	CBMSQS	MI-15	01/01/84	MI-15		
170	EBCHEM	EW-13	10/15/85	EW-13		
171	EBCHEM	NS-02	09/27/85	NS-02		
172	CBBLAIR	B04	06/01/84	B04		
173	EBCHEM	KG-09	10/01/85	KG-09		
174	EBCHEM	WW-13	10/02/85	WW-13		
175	EBCHEM	EW-14	10/15/85	EW-14		
176	EHCHEM	BH-02	06/01/85	B1		
177	CBMSQS	BL-13	01/01/84	BL-13		
178	CBMSQS	MI-13	01/01/84	MI-13		
179	CBBLAIR	B03	06/01/84	B03		
180	CBMSQS	HY-50	01/01/84	HY-50		
181	EBCHEM	NS-07	10/04/85	NS-07		
182	CBMSQS	MI-11	01/01/84	MI-11		
183	CBMSQS	SI-15	01/01/84	SI-15		
184	EBCHEM	KG-03	09/25/85	KG-03		
185	EBCHEM	EW-10	10/14/85	EW-10		
186	CBMSQS	RS-12	01/01/84	RS-12		
187	EBCHEM	EW-03	10/04/85	EW-03		
188	EBCHEM	EW-15	10/15/85	EW-15		
189	EBCHEM	SS-12	09/27/85	SS-12		
190	EBCHEM	SS-10	09/27/85	SS-10		
191	CBMSQS	CI-20	01/01/84	CI-20		
192	CBMSQS	SP-12	01/01/84	SP-12		
193	EBCHEM	SS-05	10/03/85	SS-05	SS19	
194	EBCHEM	SS-05	10/03/85	SS-05	SS18	
195	EBCHEM	SS-11	09/27/85	SS-11		
196	CBMSQS	HY-12	01/01/84	HY-12		
197	EBCHEM	SS-07	10/03/85	SS-07		
198	CBMSQS	RS-14	01/01/84	RS-14		
199	ALKI	AP-01	05/25/84	AP-01		
200	ALKI	AP-02	05/25/84	AP-02		
201	ALKI	AP-03	05/25/84	AP-03		
202	ALKI	AP-05	05/25/84	AP-05		
203	ALKI	AP-06	05/25/84	AP-06		
204	ALKI	AP-07	05/25/84	AP-07		
205	ALKI	PW-01	05/26/84	PW-01		
206	ALKI	PW-02	05/26/84	PW-02		
207	ALKI	PW-03	05/26/84	PW-03		
208	ALKI	PW-04	05/26/84	PW-04		

	G	H	I	J	K	L
157	140	E	1.2	GM	N	
158	32		1.21		N	
159	97	E	1.27	E	N	
160	17		1.29		N	
161	5	E	1.3		N	
162			1.32		N	
163			1.41		N	
164	38		1.47		N	
165			1.48		N	
166	130	E	1.49	E	N	Anom.
167	220	U	1.49	E	N	
168	170	U	1.5	LM	N	
169	16		1.52		N	
170	450	E	1.65	GM	N	
171	510	U	1.66	E	N	
172			1.67		N	
173	280	E	1.76	E	N	
174	500	U	1.9	GM	N	
175	340	E	1.98	E	N	
176	5	U	2		N	
177	22		2.03		N	
178	13		2.17		N	
179			2.18		N	
180	33		2.25		N	
181	330	E	2.28	E	N	
182	35		2.3		N	
183	16		2.46		N	
184	300	E	2.47	E	N	Count
185	500	E	2.52	E	N	Mean
186	16		2.57		N	StDev
187	1000	E	2.66	E	N	
188	130	E	2.73	E	N	
189	220	E	3	E	N	
190	790	U	3.99	E	N	Anom.
191	19		4.59		N	
192	100	U	4.67		N	
193	610	E	4.79	E	N	
194	580	LM	5.1	LM	N	
195	260	E	5.1	E	N	
196	110		5.72		N	
197	460	E	8	E	N	
198	17		15.1		N	
199	18				N	
200	19				N	
201	29				N	
202	14				N	
203	6.6				N	
204	11				N	
205	13				N	
206	8.6				N	
207	5.6				N	
208	25				N	

	M	N	O	P
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183	"No Hits" <2.0% TOC	**(t-test)**		
184	**64**	**1.01**	See S&R, p227	
185	**0.82**	1.982	Crit. t value	
186	**0.52**			
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APPENDIX B

SMARM Public Issue Papers
and
Technical Information Memoranda

SMS TECHNICAL INFORMATION MEMORANDUM **7/25/96**

QUALITY ASSURANCE GUIDELINES FOR THE SEDIMENT LARVAL BIOASSAY

Prepared by Dr. Teresa Michelsen (Washington Department of Ecology, 206/649-7257).

INTRODUCTION

The larval bioassay is one of the bioassays used under the Sediment Management Standards (SMS) to evaluate the need for sediment cleanup and source control. It is also one of the tests used by the PSDDA program to evaluate the suitability of dredged material for open-water disposal. Over the last five years, the PSDDA/SMS agencies have had the opportunity to evaluate a large number of larval bioassay tests and have made various modifications to the performance standards for the larval bioassay.

On June 16, 1994, a final PSDDA Clarification Paper took effect providing a number of modifications to the larval performance standards, including:

Decreasing the seawater control performance standard to 30% effective mortality
Establishing a reference sediment performance standard of 35% effective mortality (seawater normalized)
Increasing the alpha level for the test of statistical significance to 0.1 to account for typical replicate variability.

The reader is referred to the 1994 PSDDA clarification paper for a detailed explanation of the rationale behind these changes. In general, these changes were implemented to increase the statistical validity of the tests, provide greater environmental protectiveness, and reduce the number of retests required.

At the 1995 SMARM (May, 1995) a draft SMS triennial review paper was presented that proposed changing the seawater control performance standard in the SMS rule, and further study to determine whether the additional PSDDA modifications should also be adopted as technical guidance for the SMS program. Following public review, the seawater control performance standard was revised to 30% in the 1995 update of the PSEP bioassay protocols and was also adopted in the December 1995 revisions to the SMS rule.

This Technical Information Memorandum discusses the additional PSDDA guidance for the larval bioassay and confirms that these technical guidelines are appropriate for use under the SMS program.

PROBLEM STATEMENT

The SMS cleanup program has been implemented over the last three years. Experience during this time has shown that critical site decisions may depend on the results of bioassay evaluations, which override chemical data under the rule. Often the results of the bioassay evaluations are dependent on QA evaluations, which include review of a wide variety of data types in addition to the few performance standards listed in the rule. For example, positive and negative control performance, reference station performance, water quality parameters, holding times, and larval viability may all be reviewed during a QA review. Each of these factors may affect data usability and subsequent interpretation of the results. WAC 173-204-130(9) requires determinations regarding sediment quality to be made in consideration of an appropriate QA/QC program, as determined by Ecology.

Evaluation of the reference station performance is critical to decisions about the site, since the Sediment Quality Standard (SQS) for the larval bioassay is defined as 15% effective mortality plus the effective mortality of the reference station, and the Cleanup Screening Level (CSL) is defined as 30% effective mortality plus the effective mortality of the reference station. Thus, the effective mortality at the reference station defines the SQS and CSL for this bioassay, and may significantly impact decisions regarding the need for cleanup and source control at the site or discharge location. In both the PSDDA and SMS programs, reference stations are expected to be collected from approved reference areas with little or no chemical contamination.

The lack of a defined performance standard for the larval bioassay has led to a general expectation among regulated parties that any level of effective mortality at the reference station is acceptable. However, WAC 173-204-200(22) states that reference sediment samples "cannot exceed the applicable Sediment Quality Standards" (SQS) listed in WAC 173-204-320 through 340. SQS levels are further defined in §320 as levels that result in "no acute or chronic adverse effects". At some sites, reference stations have been submitted for approval that exceeded 60% effective mortality. If this were considered acceptable, then the SQS would be set at 75% effective mortality and the CSL at 90% effective mortality. These levels far exceed the narrative definitions of the reference station (below no adverse effects levels), SQS (no adverse effects), and CSL (minor adverse effects), and are not consistent with the intent of the rule.

In addition, the replicate variability is generally high enough at these levels of adverse effects that it may not be possible to exceed the CSL. This occurs because the definition of the CSL includes not only comparison to a numerical effects level but a demonstration of statistical difference from the reference station. For these reasons, a performance standard for the reference station is needed to define a level that meets the narrative definition of a reference station in the rule. In addition, tools are needed to address the higher level of replicate variability sometimes observed in this test.

QUALITY ASSURANCE GUIDELINES

This paper affirms that, during the normal QA review of bioassay data, Ecology may reject data for reasons other than the basic performance standards listed in the rule if, in our judgment, the data do not meet data quality objectives and cannot be used for regulatory decision-making. Authority for this determination, and for setting appropriate QA/QC objectives, is provided by WAC 173-204-130(9).

Ecology will rely on publicly-reviewed PSEP and PSDDA guidance in making these decisions. For the larval bioassay in particular, the 1994 PSDDA clarification paper will be used as additional guidance to assess the acceptability of the bioassay data. In summary, that paper recommends:

A reference sediment performance standard (seawater-normalized) of 35% effective mortality
An increase in the alpha level to 0.1
A power analysis to evaluate the power of the data if the standard deviation of reference and/or test sediments exceeds 20%

It should be noted that the reference area performance standard is *normalized to the sea-water control.* In other words, once the seawater control is determined to be acceptable, the number of normal survivors (as opposed to the total number of organisms) in the seawater control is used as the benchmark for comparison to the reference and site data. Thus, the reference sediment must have at least 65% of the number of normal survivors in the seawater control.

PSDDA CLARIFICATION PAPER **7/25/96**
SMS TECHNICAL INFORMATION MEMORANDUM

STATISTICAL EVALUATION OF BIOASSAY RESULTS

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

INTRODUCTION

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

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

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

PROBLEM IDENTIFICATION

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

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

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

DISCUSSION AND TECHNICAL BACKGROUND

Hypothesis Testing

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Data Transformations

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

$$y = \text{arcsine}\sqrt{x}$$

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

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

Tests for Normality and Homogeneity of Variances

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

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

Form of t-Test

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

Use of Multiple Comparison Tests

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

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

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

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

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

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

and

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

For each comparison, the Type I error rate remains at 5%. Likewise, under SMS, each station is considered individually, and may or may not be compared to the same reference station as another. A hit/no-hit designation is made for each separate site station, and the Type I error for each individual station remains at 5%. Stations are not compared to each other to determine if they are the same or different. Once all stations have been independently tested against an appropriate reference station, the agencies evaluate the number of stations with exceedances and the magnitude of these exceedances to determine the need for cleanup or source control.

An argument was made that the "overall" Type I error rate increases with each additional comparison. However, the agencies are not concerned with this overall error rate, since it is not likely to affect the final regulatory decision. When there is a 5% chance of error at each station, it is clear that as you make hit/no-hit decisions for a number of stations the overall chance of making one incorrect decision somewhere within that area increases. However, one incorrect assignment, or even several, are not likely to make a significant regulatory difference at cleanup site where 30 or more stations may have been sampled. It is the overall number, pattern, and magnitude of hits that drive cleanup decisions, along with a wide variety of additional types of evidence.

In addition, the agencies are less concerned with a type I error (the chance that a clean station would be designated as dirty) than the type II error (the chance that a dirty station would be designated clean), since it is the latter that determines the power or ability of an agency to detect a contaminated site. At the alpha level set by the SMS, use of the ANOVA/Dunnett's procedure decreases the power, resulting in fewer detections of contaminated sites. In order to get the same power as the t-test, the alpha level or type I error rate would also have to be increased. Thus it is not obvious that the ANOVA/ Dunnett's procedure offers better performance than the existing method. Therefore, under both programs, the pairwise comparison of the t-test is appropriate to the evaluation procedures that have been adopted.

Use of Multiple Reference Stations

For some projects, samples from multiple reference stations are being collected. This is often done to increase the chances that at least one reference station will meet performance standards, or to collect reference samples representative of different grain size regimes present at the site. In addition, field replicates are sometimes collected to assess sediment heterogeneity or variation due to sampling procedures. Because the SMS

rule and PSDDA evaluation procedures were written assuming a single reference station, there has been some uncertainty in how to perform comparisons to reference when there are data for more than one acceptable reference station. The following guidance is provided on assessing bioassay results with multiple reference stations:

- As discussed above, pair-wise comparisons are currently being used in both the PSDDA and SMS programs. Multiple comparison tests that compare the distribution of data at the project location to the distribution of data at a reference area are not appropriate for PSDDA because of the need to treat each individual DMMU separately. The SMS decision process is not structured to allow this type of comparison, and additional development work would need to be done on evaluation procedures if this were contemplated. Therefore, for each site station, a single reference station must be selected for the regulatory comparison.

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

- For subsequent statistical testing, all field replicate data at a reference station may be pooled, or a representative field replicate may be selected for each station. Pooled data should be analyzed using the nonparametric Mann-Whitney test, since the number of replicate data at the site station will be different from the reference station. In selecting a representative replicate, consideration should be given to the degree of variability as well as absolute response. Treatment of field replicate data for statistical analysis should be discussed in the SAP and approved in advance by the lead agency.

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

- If grain size is not an issue, the performance of multiple reference stations should be evaluated with respect to all bioassays being conducted, and any reference stations eliminated that do not meet performance standards for all bioassays. If more than one reference station remains that meets all performance standards, a station should be recommended by the project proponent and approved by the lead regulatory agency prior to conducting the statistical analysis. Criteria for selecting an appropriate station

could include selection of a station that best represents the overall habitat at the site (e.g., water depth, grain size, TOC), or a station could be selected that is representative of the range of responses (considering both magnitude and variability of the response) seen at the reference area.

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

PROPOSED CLARIFICATIONS AND MODIFICATIONS

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

- A null hypothesis shall be selected that reflects the one-tailed t-test approach and the type of endpoint being evaluated. Appropriate null hypotheses are provided above.
- Bioassay data expressed in percent should be transformed prior to statistical testing using the arcsine-square root transform. This data transformation should not be used for endpoints not expressed in percent (e.g., growth, biomass). A $\log_{10}$ transformation may be used with growth or biomass data.
- Bioassay data should then be tested for normality and homogeneity of variances, using the Wilks-Shapiro test (W test) and Cochran's test (F test for variances), respectively.
- Bioassay data passing both tests should be tested for statistical difference using a one-tailed Student's t-test. Bioassay data failing one or both of these tests should be tested for statistical difference using the nonparametric Mann-Whitney test.
- Multiple comparison tests (e.g., ANOVA, Dunnett's) are not used under either SMS or PSDDA.
- If field replicates are collected at reference stations, and/or multiple reference stations are available that pass performance standards, guidance provided above should be followed in using these data for statistical tests.

REFERENCES

Sokal, R.R. and F.J. Rohlf. 1969. Biometry: The principles and practice of statistics in biological research. W.H. Freeman and Co, San Francisco, CA.

Zar, J.H. 1984. Biostatistical Analysis, 2nd Ed. Simon & Schuster Co., Englewood Cliffs, NJ.

PSDDA ISSUE PAPER **10/96**
SMS TECHNICAL INFORMATION MEMORANDUM

TESTING, REPORTING, AND EVALUATION OF TRIBUTYLTIN DATA IN PSDDA AND SMS PROGRAMS

Dr. Teresa Michelsen (Washington Department of Ecology, 206/649-7257), Travis C. Shaw (Corps of Engineers, 206/764-3600), and Stephanie Stirling (Corps of Engineers, 206/764-6945) for the PSDDA/SMS agencies.

INTRODUCTION

Tributyltin (TBT) is a special chemical of concern under the PSDDA program and is classified as a deleterious substance under the SMS rule. Testing for this chemical in areas where it is likely to be found (e.g., marinas, ship repair facilities, shipping lanes) may be required under both programs. In 1988, the PSDDA agencies conducted a study on the presence of TBT in marinas in Puget Sound, and funded a risk assessment of TBT (Cardwell, 1989). In 1988, the PSDDA agencies developed a screening level (SL) and bioaccumulation trigger (BT) for use in the PSDDA program, based on the best available knowledge of this chemical and its properties.

In the past year, additional information has come to light on TBT, its distribution in Puget Sound, and its effects on the environment that support a change in the way the agencies approach evaluation of TBT in sediments. Most recently, an interagency work group was convened by EPA to develop a site-specific screening value for the Commencement Bay Nearshore/Tideflats and Harbor Island Superfund sites (see EPA, 1996). This paper discusses some of the issues raised by this new information and modifications to the PSDDA and SMS programs to address these issues.

Authority to develop testing programs, interpretation guidelines, and regulatory levels for deleterious substances (substances that currently do not have standards) under SMS is provided by WAC 173-204-110(6) and WAC 173-204-310(3). This technical memorandum was circulated for public review and comment in conjunction with the 1996 Sediment Management Annual Review Meeting. Many comments were received and a substantial number of revisions and additions to this memorandum have been made.

PROBLEM IDENTIFICATION

Worldwide information documenting TBT's adverse impact on the aquatic environment is extensive. In addition to direct mortality, adverse impacts on a wide variety of aquatic organisms include reduced larval growth, sexual abnormalities, reproductive failure, gross morphological abnormalities, immune system dysfunction, nervous system disorders, and skin and eye disorders. TBT has a strong inhibitory effect on the cytochrome P450 system, reducing the ability of the organism to metabolize and detoxify environmental pollutants, and on ATP synthesis, reducing the ability of the organism

to produce energy. These effects are generalized enough to occur in many organisms (including invertebrates, fish, and mammals). Available evidence indicates that serious chronic effects resulting in population declines occur at water concentrations in the parts per trillion (ng/L) to parts per billion (μg/L) range, depending on the species (Fent, 1996; EPA, 1991).

The available literature indicates that the toxicity and bioaccumulation of TBT are affected by a variety of factors, including organic carbon in sediment and water, pH, salinity, clay fraction, and the presence of inorganic constituents such as iron oxides. TBT partitioning is further complicated by the fact that it occurs in several forms, including TBT^{+}, TBTCl, and TBTOH, and may interconvert among these forms with fluctuations in salinity and pH (Fent, 1996; EPA, 1991). Finally, TBT has been released into the environment in a variety of forms, including leaching directly from vessel hull paints (the most toxic and bioavailable form) and in the form of paint wastes from sandblasting (which may be less bioavailable but may represent a long-term source of the contaminant).

Sediment sampling in Puget Sound and elsewhere indicates that sediments in areas with vessel activity (e.g., marinas, harbors, boatyards, shipyards) are a significant reservoir of TBT (Parametrix, 1995). Worldwide, TBT-contaminated sediments adversely impact benthic organisms and contribute to water column concentrations that continue to be toxic to aquatic life (Fent, 1996). Very high, widespread TBT sediment concentrations have been found in the waterways of Commencement Bay, Elliott Bay (Harbor Island), and the Salmon Bay/Ship Canal area. Additional ongoing sources include domestic vessels that are still allowed to use TBT paints and shipping traffic from countries without TBT regulations.

Efforts to interpret environmental data in Puget Sound have been frustrated by the complexity of TBT partitioning in the environment and uncertainty over appropriate effects levels, testing strategies, and interpretive criteria. Recent data provided by NOAA suggest that the bioassay tests routinely used in the PSDDA and SMS program may not be of long enough duration to accurately reflect *in situ* effects due to TBT, and that other approaches may be more appropriate to the types of toxicity exhibited by this chemical (Meador *et al.*, 1996 in press).

TECHNICAL BACKGROUND AND DISCUSSION

Analytical Methods

Analytical methods and detection limits for TBT are provided in the 1996 PSEP Organics Protocol, Appendix A (PSWQA, 1996). The recommended method involves reaction with sodium borohydride, methylene chloride extraction and analysis by GC/MS (Matthias *et al.*, 1986). However, this method is somewhat experimental and is not available at most commercial laboratories. Alternative methods involve methylene chloride extraction, followed by Grignard derivatization and analyzed by GC/MS (Krone et al., 1989) or GC/FPD (Unger et al., 1986).

Reporting Conventions

TBT data have historically been reported in a number of different ways. For example, in the literature TBT may be reported as Sn, TBT, TBTCl, or TBTO. For the same environmental concentration, these reporting conventions result in different numerical values because each of these forms has a different molecular weight. This has resulted in some confusion interpreting the data and in setting standards.

It is important that all data be reported in comparable units, and that any standards or guidance levels also be in those same units. The PSDDA program has used Sn in the past and the existing SL and BT are based in units of Sn. However, much of the analytical and research community recommends reporting TBT as the TBT ion (TBT^+).

A simple conversion based on the ratio of molecular weights can be used to convert older data into these units for comparison with newer data:

To convert TBT reported as:	To:	Multiply By:
mg Sn/kg	mg TBT/kg	2.44
mg TBTCl/kg	mg TBT/kg	0.89
mg TBTO/kg	mg TBT/kg	0.95

The existing PSDDA SL for sediments (30 µg Sn/kg) corresponds to 73 µg TBT/kg.

TBT and Apparent Effects Threshold Values

The interagency work group followed the traditional approach in establishing regulatory thresholds for Puget Sound sediments by attempting to establish apparent effects threshold (AET) values for TBT. This effort was unsuccessful because of the widely varying responses in the bioassay and benthic data reviewed over a wide range of TBT concentrations (EPA, 1996). In some cases, despite extremely high TBT concentrations in sediments, no acute toxicity was exhibited by the standard suite of bioassay organisms. Current research shows that TBT partitioning is highly complex, and the relationship between concentrations and observed effects data is much stronger for interstitial water and tissue concentrations. Therefore, the work group discontinued efforts to develop AET values and instead focused its attention on using effects data associated with interstitial water and tissue concentrations as regulatory endpoints. However, Ecology will evaluate any additional synoptic data that are collected to further explore whether a reliable AET value can be calculated.

Interstitial Water Concentrations

As part of the TBT work group's efforts, an extensive literature review and compilation of effects levels in marine waters was developed for use in setting a site-specific screening value for the Commencement Bay Nearshore/Tideflats Superfund site (EPA, 1996). The reader is referred to this report, which received substantial public and technical review, for a detailed presentation of effects

levels in water. TBT water concentrations that result in acute and chronic adverse effects to a wide range of marine species have been reported in the literature (Fent, 1996; EPA, 1991; EPA, 1996). Chronic effects to aquatic organisms have been reported at concentrations ranging from 0.002 - 74 µg TBT/L, with the majority of species responding below 0.5 µg TBT/L. Acute effects have been reported at concentrations ranging from 0.3 - 200 µg TBT/L.

The consensus of the TBT work group was that an interstitial water concentration of 0.05 µg TBT/L corresponds to a no adverse effects level that would protect most (approximately 95%) of the Puget Sound species that have been tested. This level is conceptually equivalent to the SQS under the Sediment Management Standards, and is consistent with the EPA approach to developing water quality and sediment criteria. For comparison, the EPA proposed draft marine chronic water quality criterion has been set at 0.01 µg TBT/L (EPA, 1991).

A higher adverse effects level was also evaluated by the TBT work group; however, less consensus was achieved on an upper or maximum allowable regulatory level. As one possibility, the work group discussed a value of 0.7 µg TBT/L. This concentration is lower than most of the acute effects levels reported in the literature. However, significant chronic effects are likely at this concentration, particularly to bivalve species present in Puget Sound. On the basis of the work group discussion and an associated report (EPA, 1996), an interstitial water concentration of 0.7 µg TBT/L was selected by EPA as the basis for a site-specific sediment trigger level for cleanup in the Hylebos Waterway (Commencement Bay Nearshore/Tideflats Superfund site). ***This value is not currently proposed as an upper regulatory level for either the PSDDA or SMS programs.*** For comparison, the EPA proposed draft marine acute water quality criterion has been set at 0.36 µg TBT/L (EPA, 1991).

Tissue Concentrations

In contrast to toxicity levels based on TBT water concentrations, which range over several orders of magnitude for various species, recent studies on tissue concentrations in Puget Sound organisms indicate that a much narrower range of tissue concentrations is associated with adverse effects to these organisms (see citations below). Different species have widely varying uptake, metabolic, and elimination rates for TBT, in part explaining the widely varying sediment and water concentrations that yield similar tissue concentrations and associated effects.

This finding provides an opportunity to develop tissue TBT concentrations that are directly correlated with observed effects in a wide range of ecologically relevant species. Meador *et al.* (1993; 1996 in press) have reported acute toxicity (LD_{50}s) for *Rhepoxynius abronius*, *Eohaustorius washingtonianus* and *Armandia brevis* at concentrations ranging from 34 - 89 mg TBT/kg body weight (dry weight). Tissue concentrations within or above this range would represent a severe adverse effect and sediments associated with these levels would exceed the level at which cleanup would be required, and would also be inappropriate for open-water disposal.

However, PSDDA and SMS require consideration of both acute and chronic effects. Chronic effects levels for species of concern in Puget Sound can be found in the literature (Salazar and Salazar, 1992,

1995; Moore et al, 1991; Davies et al., 1987, 1988; Page and Widdows, 1991; Widdows and Page, 1993; Thain et al., 1987; Waldock et al., 1992; Waldock and Thain, 1983; Meador *et al.*, in press; Minchin et al., 1987; Alzieu and Heral; these values typically fall within a range of 2-12 mg TBT/kg body weight (dry weight), with a median value of about 4.

Direct measurements of TBT in tissues of biota collected from the site and *in situ* bioaccumulation studies are considered promising methods for assessing TBT toxicity, and may be recommended by the agencies to support sediment management decisions. The ranges discussed above provide a starting point for interpretation of bioaccumulation data from dredging projects or cleanup sites.

PSDDA Screening Level for TBT

A review of the existing SL was conducted to evaluate its relationship to known effects levels in water. Butyltins were added to the list of chemicals-of-concern for limited areas in the PSDDA Management Plan Report - Phase II (PSDDA, 1989). At the time of the listing, an interim SL for TBT was established at 30 µg/kg (as Sn). This SL was established using the available information on TBT contamination in Puget Sound and an equilibrium partitioning model that estimated interstitial water concentrations of TBT based on TBT sediment concentrations. In addition, the professional judgment of dredged material decision-makers in other regions of the country was sought in selecting the interim SL.

The interstitial water TBT concentration corresponding to the SL can be calculated using an equilibrium partitioning approach and a representative partitioning coefficient of 25,000 ($\sigma = 5{,}500$) derived from Meador *et al.* (1996 in press). Assuming a sediment organic carbon content of 2%, the SL of 30 µg/kg TBT (as Sn) corresponds to an interstitial water concentration of 0.06 µg/L TBT (as Sn) or 0.15 µg/L TBT (as TBT). Because there are many uncertainties associated with the original PSDDA SL and with the partitioning approach described above, this proposed interstitial water level was further evaluated based on a comparison to acute and chronic adverse effects levels compiled by EPA (1996).

This concentration is below approximately 2/3 of the chronic effects levels reported in the literature, and is below the entire range of acute effects levels reported in the literature. PSDDA disposal sites have been carefully sited to avoid sensitive habitat areas (such as shellfish growing areas) and most are sited in deep water. For these reasons, many of the chronic impacts to bivalves and other species that would be predicted at lower concentrations are not expected to occur at the disposal sites. This interstitial water level is therefore expected to be protective of acute and most chronic effects, without being overconservative. Thus, an interstitial water concentration of 0.15 µg/L TBT is appropriate for use as an SL for the PSDDA open-water disposal sites.

Bioassay Testing

Exceedances of the SL for TBT currently trigger the requirement to conduct bioassay testing. The PSDDA bioassays include a 10-day amphipod mortality test, a sediment larval bioassay and the 20-

day *Neanthes* biomass test. Bioassay testing under SMS includes these same bioassays, although Microtox or benthic infaunal analysis can be substituted for the biomass test. However, recent project data and evidence from the scientific literature indicate that most or all of the bioassay tests typically used under SMS and PSDDA may not be appropriate for evaluation of TBT toxicity, particularly with the short testing durations routinely used (Meador *et al.*, in press; Moore et al., 1991; Langston and Burt, 1991; Fent, 1996). Most of the bioassay organisms currently used have been demonstrated to show serious acute and chronic toxicity associated with TBT in sediments, but at much longer exposure periods than employed in the standard PSEP bioassay protocols (EPA, 1996; Salazar and Salazar, 1991, 1996).

Results from recent projects (e.g., Puget Sound Naval Shipyard, Commencement Bay, Coos Bay, Harbor Island) would seem to bear out this prediction. Several sites have shown adverse benthic effects in areas with high TBT sediment concentrations, even when acute and/or chronic bioassays did not show adverse effects. In addition, bioaccumulation of TBT and associated adverse effects has been demonstrated at a number of these sites when short-term laboratory bioassays did not show a response. This may be because the longer-term bioaccumulation studies and *in situ* benthic assemblages better reflect the chronic endpoints with which TBT is associated and include long enough exposure durations for TBT in sediments and water to come into equilibrium with the organisms.

PSDDA Bioaccumulation Testing for TBT

The TBT bioaccumulation trigger was established at 219 µg/kg (as Sn), based on a multiple of the SL (PSDDA, 1989). Bioaccumulation testing is required when this threshold is exceeded. However, using the method described above for the SL, the existing BT corresponds to an interstitial water concentration of 1.07 µg/L (as TBT). This concentration is well above a level considered protective by the PSDDA agencies and the EPA Superfund work group. Based on the evidence provided above, significant bioaccumulation and adverse effects may occur at much lower concentrations. The interstitial water SL (0.15 µg/L TBT) corresponds to a level above which adverse reproductive and population-level effects due to bioaccumulation of TBT have been observed, and will also be used as the BT.

PROPOSED ACTIONS/MODIFICATIONS

Testing Locations

The SMS program and PSDDA agencies have required testing for TBT in marinas, boat maintenance areas, and other locations where TBT is likely to be present. Sediment testing in Commencement Bay (Thea Foss and Hylebos Waterways), in the Duwamish River, and in Salmon Bay and Lake Union Ship Canal have shown TBT to be present throughout the waterways and at levels substantially above the existing sediment SL. These studies show that TBT is more widely distributed, and at higher levels, than previously thought. For this reason, the SMS and PSDDA agencies will require testing

for TBT in areas where past data have demonstrated its presence (particularly urban bays), and at other appropriate project locations where it would be likely to be present, such as marinas, shipyards, boatyards, and in the vicinity of large CSOs or treatment plant outfalls. Persons who have evidence that TBT is not present at their project location can ask to have this requirement waived.

TBT Testing Strategy for PSDDA Projects

The available evidence indicates that neither sediment chemistry screening levels nor the existing PSEP bioassay protocols may be as useful in predicting actual environmental effects as measurement of TBT concentrations in interstitial water and tissues. Therefore, the current tiered testing protocol utilizing bulk sediment chemistry and short-term bioassays is not considered appropriate for evaluating the potential adverse effects of TBT. Because of the complexity of TBT speciation in the aquatic environment (including ionic forms) and because other factors may strongly affect its bioavailability, an alternative testing strategy is proposed.

Measurement of TBT in interstitial water provides a more direct measure of potential bioavailability, and hence toxicity, than bulk sediment concentrations. This approach also avoids the difficulties inherent in extrapolating to a sediment cleanup level, particularly where paint wastes or other less bioavailable forms may be present. Therefore, ***the agencies propose that interstitial water analysis replace bulk sediment analysis*** as the initial step in a tiered assessment of TBT toxicity for PSDDA projects.

TBT should be analyzed using approved methods as described above, and reported as TBT. A standard method for collection of interstitial water has not yet been determined, though several techniques are available. Recommendations for a standardized method will be developed over the next year and discussed at the 1997 SMARM.

If the TBT concentration in the interstitial water is above 0.15 µg TBT/L, bioaccumulation testing of project sediments must be conducted using the PSDDA bioaccumulation guidelines in effect at the time of testing. Acute bioassay testing will not be required[1]. If unacceptable tissue concentrations are measured at the end of the bioaccumulation test, the sediment will be found unsuitable for open-water disposal.

TBT Testing for SMS Cleanup Sites

Although specific regulatory levels corresponding to the SQS and CSL have not yet been promulgated, a similar conceptual approach will be used for evaluation of TBT toxicity at SMS sites. As is typical of cleanup sites, a preponderance of evidence approach may be used rather than a strict tiered testing approach. However, interstitial water data and bioaccumulation (tissue) data will be given more weight in evaluating potential ecological effects than sediment concentrations or short-term bioassay results. Either laboratory or *in situ* bioaccumulation tests may be employed.

Other chemicals of concern may trigger acute toxicity testing.

At many sites, bioassay testing will be conducted to evaluate the ecological effects of other chemicals in sediments. To evaluate ecological effects of TBT at these sites, longer-term bioassay/bioaccumulation studies could be considered as alternative chronic tests to those listed in SMS. Such alternative testing approaches may be particularly appropriate when other chemicals are also present that are slow to reach equilibrium in the laboratory, such as dioxins/furans and pesticides. Biological tests that measure both bioaccumulation and associated effects endpoints are recommended to assess the significance of measured tissue concentrations.

At sites where these alternative approaches are used to assess the effects of TBT, site-specific cleanup standards will need to be set based on the interstitial water and tissue effects ranges described in this paper. Consistent with the narrative standards set forth in WAC 173-204-100(3) and (7), site-specific cleanup standards shall include consideration of acute and chronic effects to aquatic organisms and human health, and shall range between no adverse effects and minor adverse effects levels. With respect to TBT, the presence of natural or cultured bivalve growing or collection areas shall be given special consideration in setting protective cleanup standards, since very low levels of TBT in water and sediments are known to adversely affect reproduction and growth of these culturally and economically important resources.

Further Development of Bioassay/Bioaccumulation Tests

Public comments recommended a wide variety of possible bioassay and bioaccumulation test strategies. Recommendations included side-by-side testing of amphipod species to determine relative sensitivity to TBT; use of a 60-day *Neanthes* bioassay with growth and reproduction endpoints; use of a 20-day *Macoma nasuta* test with bioaccumulation, tissue growth, and shell growth as endpoints; field-validation of laboratory bioaccumulation tests; use of longer-term larval tests with sensitive organisms such as oysters, mysids, and the copepod *Acartia tonsa*; and interstitial water bioassays. Although it is not currently within the PSDDA budget to conduct such studies, it may be possible to conduct some studies as part of large cleanup projects or through academic or agency research projects. The PSDDA agencies welcome and will carefully consider any information that is useful in better defining appropriate chronic tests for assessment of TBT and other compounds for which existing short-term bioassays may be inadequate to predict chronic effects.

REFERENCES

Alzieu, C. and M. Heral. 1984. Ecotoxicological effects of organotin compounds on oyster culture. In: Ecotoxicological Testing for the Marine Environment, Vol. 2. G. Persoone, E. Jaspers, and C. Claus, Eds. State University of Ghent, Belgium. 588 pp.

Cardwell, R. 1989. Aquatic ecological and human health risk assessment of tributyltin in Puget Sound and Lake Washington sediments. Prepared by the National Marine Fisheries Service for the PSDDA agencies.

Davies, I.M., J. Drinkwater, and J.C. McKie. 1988. Effects of tributyltin compounds from antifoulants on Pacific oysters (*Crassostrea gigas*) in Scottish sea lochs. Aquaculture 74:319-330.

Davies, I.M., J. Drinkwater, J.C. McKie, and P. Balls. 1987. Effects of the use of tributyltin antifoulants in mariculture. In: Proceedings of Oceans '87, International Organotin Symposium 4:1477-1481.

EPA. 1991. Ambient aquatic life water quality criteria for tributyltin. Draft Report. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratories, Duluth, MN and Narragansett, RI.

EPA. 1996. Recommendations for screening values for tributyltin in sediments at Superfund sites in Puget Sound, Washington. Prepared for EPA Region 10, Superfund, by Roy F. Weston, Seattle WA.

EPA/USACE. 1994. Evaluation of dredged material proposed for discharge in waters of the U.S.-testing manual (draft). U.S. Environmental Protection Agency, U.S. Army Corps of Engineers.

Fent, K., and J.J. Stegeman. 1993. Effects of tributyltin *in vivo* on hepatic cytochrome P450 forms in marine fish. Aquatic Toxicology 24:219.

Fent, K. 1996. Ecotoxicology of organotin compounds. Critical Reviews in Toxicology 26:1.

Krone, C.A., D.W. Brown, D.G. Burrows, R.G. Bogar, S.-L. Chan, and U. Varanasi. 1989. A method for analysis of butyltin species in measurement of butyltins in sediment and English sole livers from Puget Sound. Marine Environmental Research 27:1-18.

Langston, W.J. and G.R. Burt. 1991. Bioavailability and effects of sediment-bound TBT in deposit-feeding clams, *Scrobicularia plana*. Marine Environmental Research 32:61-77.

Matthias, C.L., J.M. Bellama, and F.E. Brinckman. 1986. Comprehensive method for determination of aquatic butyltin and butylmethyltin species at ultratrace levels using simultaneous hybridization/extraction with GC/FPD detection. Environ. Sci. Tech. 20:609-615.

Meador, J.P., U. Varanasi, and C.A. Krone. 1993. Differential sensitivity of marine infaunal amphipods to tributyltin. Marine Biology 116:231-239.

Meador, J.P., C.A. Krone, D.W. Dyer, and U. Varanasi. 1996 (in press). Toxicity of sediment-associated tributyltin to infaunal invertebrates: Species comparison and the role of organic carbon. Marine Environmental Research.

Minchin, D., C.B. Duggan, and W. King. 1987. Possible effects of organotins on scallop recruitment. Marine Pollution Bulletin 18(11):604-608.

Moore, D.W., T.M. Dillon, and B.C. Suedel. 1991. Chronic toxicity of tributyltin to the marine polychaete worm, *Neanthes arenaceodentata*. Aquat. Toxic. 21:181-198.

Page, D.S. and J. Widdows. 1991. Temporal and spatial variations in levels of alkyltins in mussel tissues: A toxicological interpretation of field data. Marine Environmental Research 32:113-129.

Parametrix. 1995. Long-term national monitoring program for tributyltin and its primary intermediates, Annual Report: Year 3, 1994-1995. Prepared for Elf Atochem North America, Inc. and Witco Corporation by Parametrix, Seattle, WA.

PSDDA. 1988. Evaluation procedures technical appendix, Phase I. U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region X; Washington State Department of Natural Resources; Washington State Department of Ecology.

PSDDA. 1989. Management plan report. Unconfined open-water disposal of dredged material, Phase II. U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region X; Washington State Department of Natural Resources; Washington State Department of Ecology.

PSWQA. 1996. Recommended guidelines for measuring organic compounds in Puget Sound water, sediment, and tissue samples. Prepared by King County Water Pollution Control Division Environmental Laboratory for the Puget Sound Water Quality Authority, Lacey, WA.

Salazar, M.H. and S.M. Salazar. 1996 (in press). Mussels as bioindicators: Effects of TBT on survival, bioaccumulation and growth under natural conditions. In: Tributyltin: Environmental Fate and Effects. M.A. Champ and P.F. Seliman, Eds. Elsevier.

Salazar, M.H. and S.M. Salazar. 1995. *In situ* bioassays using transplanted mussels: I. Estimating chemical exposure and bioeffects with bioaccumulation and growth. In: Environmental Toxicology and Risk Assessment, 3rd. Vol. J.S. Hughes, G.R. Biddinger and E. Mones (Eds.). ASTM STP 1218. American Society for Testing and Materials, Philadelphia, PA. pp. 216-241.

Salazar, M.H. and S.M. Salazar. 1992. Mussel field studies: Mortality, growth, and

bioaccumulation. In: Tributyltin - Environmental Fate and Effects, Part III. M.A. Champ and P.F. Seligman, Eds. Elsevier.

Salazar, M.H. and S.M. Salazar. 1991. Assessing site-specific effects of TBT contamination with mussel growth rates. Marine Environmental Research 32:131-150.

Thain, J.E., M.J. Waldock, and M.E. Waite. 1987. Toxicity and degradation studies of tributyltin (TBT) and dibutyltin (DBT) in the aquatic environment. In: Proceedings of Oceans '87, Organotin Symposium, 4:1306-1313.

Unger, M.A., W.G. McIntyre, J. Greaves, and R.J. Huggett. 1986. GC determination of butyltins in natural waters by flame photometric detection of hexyl derivatives with mass spectrometric confirmation. Chemosphere 15:461.

Unger, M.A., W.G. McIntyre, and R.J. Huggett. 1987. Equilibrium sorption of tributyltin chloride by Chesapeake Bay sediments. Proceedings of Oceans '87, Organotin Symposium 4:1381-1385. Marine Technology Society, Washington D.C.

Waldock, M.J. and J.E. Thain. 1983. Shell thickening in *Crassostrea gigas*: Organotin antifouling or sediment induced? Marine Pollution Bulletin 14:411-415.

Waldock, M.J., M.E. Waite, J.E. Thain, and V. Hart. 1992. Improvements in bioindicator performance in UK estuaries following the control of the use of antifouling paints. International Council for Exploration of the Sea, CM1992/E:32.

Widdows, J. and D.S. Page. 1993. Effects of tributyltin and dibutyltin on the physiological energetics of the mussel, *Mytilus edulis*. Mar. Environ. Res. 35:233-249.

PSDDA/SMS ISSUE PAPER

CRITIQUE OF PSDDA DRAFT ISSUE PAPER ON TESTING, REPORTING, AND EVALUATION OF TRIBUTYLTIN DATA IN PSDDA AND SMS PROGRAMS

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INTRODUCTION

The Puget Sound Dredge Disposal Analysis (PSDDA) and Sediment Management Standards (SMS) Agencies have prepared a draft issue paper on the testing, reporting, and evaluation of tributyltin (TBT) data in PSDDA and SMS programs. The focus of this issue paper is the fact that new information on TBT has come to light in recent years, requiring that regulatory agencies reconsider their approach to evaluating TBT in sediments. According to the PSDDA/SMS issue paper, the new information on TBT falls into a number of categories, including its chemical behavior in the environment, its effects on aquatic organisms, and its distribution in Puget Sound.

Specifically, the authors of the PSDDA/SMS issue paper argue the following points:

1). Analytical Methods

The recommended method for TBT analysis involves reaction with sodium borohydride, methylene chloride extraction, and analysis by GC/MS.

2). Reporting Conventions

Comparable units should be used when reporting TBT concentrations, and any standards or guidance levels should also be stated in the same units. TBT should be reported in units of TBT ion, rather than in units of Sn, TBTCl, or TBTO. The authors of the PSDDA/SMS issue paper list factors to be used when converting older data from units of Sn, TBTO, or TBTCl into units of the TBT ion.

3). TBT and Apparent Effects Thresholds (AETs)

Current research indicates that TBT partitioning is highly complex, and the relationship between biological effects and tissue concentrations or interstitial water concentrations appears to be stronger than the relationship between effects and bulk sediment TBT concentrations. As a result, the authors of the PSDDA/SMS issue paper believe that attention should be focused on interstitial water and tissue concentrations rather AETs as regulatory endpoints.

4). Interstitial Water Concentrations

The authors report that an interstitial water concentration of 0.05 μg TBT/L (stated as TBT) corresponds to a no adverse effects level that would be protective of approximately 95 percent of the species tested in Puget Sound. Additionally, an interstitial water concentration of 0.7 μg TBT/L has been chosen by U.S. EPA as a site-specific sediment remediation "trigger " concentration for the Hylebos Waterway. This remediation trigger will also serve as an upper regulatory limit when determining whether or not dredge material is suitable for open-water disposal.

5). Tissue Concentrations

The authors believe that direct measurement of TBT concentrations in biota may be a useful indicator of TBT toxicity, and such measurements may be recommended by the PSDDA agencies for the evaluation of dredging projects. Based on toxicity tests results reported by Meador *et al.* (in prep.) for *Rhepoxynius abronius, Eohaustorius washingtonianus*, and *Armandia brevis*, the authors state that acute (9 or 10 day) LD50s for TBT should range from 34 to 89 mg TBT/kg dry body weight (as TBT). By applying an acute:chronic ratio of 10, the authors have concluded that chronic LD50s should range from 3 to 9 mg TBT/kg body weight. Data from Moore (1989) also support this sublethal endpoint using *Neanthes* tests where he determined that effects occurred above 5 mg TBT/kg body weight.

6). PSDDA Screening Level for TBT

An interim screening level (SL) of 30 μg/kg for TBT (reported as Sn) in bulk sediment was established in 1989 (PSDDA, 1989). The authors have calculated an interstitial water SL using an equilibrium partitioning approach derived from Meador *et al.* (in prep.). Using a partitioning coefficient of 25,000, and assuming a sediment organic carbon content of 2 percent, the authors state that the existing SL of 30 μg/kg corresponds to an interstitial water concentration of 0.06 μg/L TBT (as Sn) or 0.15 μg/L TBT (as TBT).

7). Bioassay Testing

The authors have concluded that bioassay test species currently employed under SMS and PSDDA are not appropriate for the evaluation of TBT toxicity. This is based on the apparent lack of toxicity at locations with sediment TBT concentrations that are assumed to have toxic interstitial water concentrations. For example, the authors state that the amphipod *Rhepoxynius abronius* is not affected by TBT at concentrations found in Puget Sound. Other species have been shown to exhibit toxic responses following acute and chronic TBT exposures, but only after much longer exposure periods than those used in standard (i.e., 10-day) bioassays.

On the other hand, the authors cite studies conducted by Meador *et al.* (in prep.) which purportedly have shown that two other amphipod species, *Eohaustorius estuarius* and *Eohaustorius washingtonianus* are more sensitive to TBT than *R. abronius* during a 10-day exposure period. However, it is not clear from the authors' discussion whether they are recommending the use of these species in dredge material evaluations.

8). PSDDA Bioaccumulation Testing for TBT

A TBT bioaccumulation trigger was originally established at 219 μg/kg wet weight (as Sn) for bulk sediment (PSDDA, 1989). This value corresponds to an interstitial water concentration of 1.07 μg/L (as TBT), based on a partitioning coefficient of 25,000 (Meador *et al.* (in prep.). This concentration is well above the recently established 0.7 μg/L upper regulatory level, and according to the authors, significant bioaccumulation and toxic effects may occur at much lower interstitial water concentrations. As a result, the authors recommend that the existing interstitial water SL of 0.15 μg/L also be used as a bioaccumulation trigger.

Finally, the authors of the PSDDA/SMS issue paper propose an alternate strategy for evaluating TBT-contaminated dredge material. They suggest that chemical analysis of bulk sediments and short-term bioassays are not appropriate means of evaluating the potential effects of TBT, and recommend that direct measurement of TBT in interstitial water be conducted instead. Acute bioassay testing would not be required under this new strategy, although interstitial water concentrations above 0.15 μg TBT/L (as TBT) would trigger bioaccumulation testing. An exceedance of 0.7 μg TBT/L in interstitial water would render sediments unsuitable for open-water disposal, unless dredgers choose to conduct more in-depth investigations, potentially including chronic sub-lethal bioassays and/or risk assessments.

PROBLEM IDENTIFICATION

In general, very little supporting information has been included in the PSDDA/SMS issue paper. For example, the authors refer to a compilation of effects associated with interstitial water TBT concentrations produced by Weston (1996). This compilation is currently in draft form, and is not available for general review. The same is true for the work of Meador et al. (in prep.), the text of which has been circulated widely in draft form, although the raw data have not been made available for review. As a result, it is difficult to determine whether or not various assumptions used in developing guidelines are appropriate and reasonable.

Policy recommendations outlined in the PSDDA/SMS issue paper appear to have been largely based on the work of Meador *et al.* (in prep.), particularly with respect to SLs for interstitial water concentrations. The experimental design of the investigation discussed in Meador *et al.* (in prep.) appears to have been inadequate to fully support the conclusions presented in the PSDDA/SMS issue paper (see discussion below). It would

be inappropriate to base policy decisions on technical information that has not completely undergone the peer review process.

DISCUSSION

Of the eight points listed above, three are problematic, and will be discussed below. These three points include: 5) tissue concentrations, 6) proposed PSDDA screening level for TBT in interstitial water, and 7) bioassay testing. While the guidelines presented in the PSDDA/SMS issue paper may ultimately be shown to be reasonable, there is currently some debate as to whether the approaches used to establish them were scientifically sound and appropriate.

Since many of the policy recommendations outlined in the PSDDA/SMS issue paper are based on the work of Meador *et al.* (in prep.), it is important to evaluate the validity of the conclusions presented in that paper. Since the raw data obtained in studies described in Meador *et al.* are not available for evaluation, the following comments are focused primarily on the experimental design employed.

Tissue Concentrations

Accurate estimation of lethal doses to bioassay test organisms can be a relatively complicated process. Unless specified doses are administered directly to the test organisms, the actual dose received can only be inferred through circumstantial evidence. For example, circumstantial evidence of lethal doses could be obtained by determining the relationship between exposure concentrations and tissue concentrations, or by determining the concentration of a toxicant in an animal's tissue at the end of a test or following its death. Neither of these methods will necessarily be able to take into account the effects of metabolic activity, assimilation efficiency, purging, etc.

In Meador *et al.* (in prep.) tissue concentrations of TBT were measured in test organisms, and based on these data LD50s were determined. Dead test organisms were collected and immediately prepared for analysis, while living organisms were allowed to depurate for several hours prior to sacrificing. An inherent assumption in this procedure is that the tissue concentrations measured in dead test animals actually reflected the lethal dose administered. This may not be the case, as dead test animals may have been unnoticed for 1-2 days prior to their removal from the sediments, and their actual tissue concentrations could have changed considerably over this time. Further, without purging the gut contents of dead organisms, it is difficult to predict the actual dose that reaches their tissues. Uncertainty in dosage estimates associated with this issue could be significant. Accurate assessment of contaminant uptake by amphipods is further confounded by their small size, which limits their usefulness as a bioaccumulation test species.

While it may be true that the method used by Meador *et al.* (in prep.) was the only practical means available for determining lethal doses of TBT to test organisms, it does not appear to be a reliable means of accurately assessing LD50s. Because of the inherent difficulties associated with making such a determination, caution should be used when attempting to develop screening levels based on tissue concentrations. Until a more reliable method for evaluating bioaccumulation in small organisms such as amphipods is available, it would be more appropriate to continue relying on established protocols, such as bioassay-based determinations of LC50s.

Proposed PSDDA Screening Level for TBT in Interstitial Water

The proposed PSDDA screening levels for TBT in interstitial water were based on partitioning coefficients derived from studies described in Meador *et al.* (in prep.). These studies were conducted using sediments that had been spiked by adding TBT (dissolved in acetone) directly to sediments, followed by rolling in glass jars for 48 hours. Using this spiking method, it is not likely that equilibrium was established among TBT concentrations in sediment, interstitial water, and overlying water. Also, overlying water was carefully manipulated during these studies (e.g., water was slowly added to test beakers to minimize disturbance of sediments), further decreasing the likelihood that equilibrium was established between interstitial water and overlying water. Thus, the partitioning coefficient presented in Meador *et al.* (in prep.) is probably not accurate, and more rigorous attempts should be made to determine the partitioning coefficient before this policy is promulgated.

The 1989 SL of 30 μg Sn/kg (dw) is based on three lines of reasoning, including environmental concentrations of TBT measured in the Puget Sound, guidelines used in other areas of the country, and U.S. EPA advisory water concentrations linked to sediment concentrations through equilibrium partitioning (PSDDA, 1989).

In 1989, the U.S. EPA TBT advisory level in water was 0.531 μg/L which theoretically protected "95 percent of species." In PSDDA (1989) a sediment concentration was calculated which corresponded to this concentration in water using equilibrium partitioning (Equation 1).

$$Cs = Ciw*Koc*foc \qquad \text{Equation 1}$$

The sediment concentration (Cs) was calculated to be 40 μg/kg, where the interstitial water concentration (Ciw) was the U.S. EPA advisory level of 0.531 μg/L, and the product of the sedimentary carbon partitioning coefficient and the fraction sediment organic carbon (Koc*foc) was 75.3 (this value was determined by back calculation from information given in PSDDA (1989)). If the foc is assumed to be 0.02, then the Koc is assumed to be 3,765. Apparently the final proposed SL was set equal to 30 μg Sn/kg because, based on the above assumptions for Koc*foc, the resulting interstitial water concentration would be lower than the U.S. EPA advisory level, and since one of the

guidelines used throughout the U.S. was to trigger biological testing for sediment concentrations between 30 and 100 μg/kg (PSDDA, 1989).

The new SL proposed in the Michelsen et al. (1996) memo of 0.15 μg TBT/L is derived using the same equilibrium partitioning equation given above but solving for interstitial water concentration with the following assumptions: (1) Cs is 30 μg Sn/kg; (2) Koc is assumed to be 25,000 based on the recent work of Meador et al. (in press); (3) foc is assumed to be 0.02; and (4) Ciw is converted to units of μg TBT/L from μg Sn/L.

The resulting concentration of 0.15 μg TBT/L should be evaluated in terms of its basis and its implications. Its basis is awkward for two reasons. Firstly, it is based on an historic SL which was calculated assuming a Koc value an order of magnitude lower than the one used in the present calculation and using a U.S. EPA advisory level which is no longer in use (the current U.S. EPA proposed draft marine acute and chronic water quality criteria for TBT are 0.36 and 0.01 μg TBT/L, respectively (U.S. EPA, 1991)). If the SL was calculated for sediment today, it would range from 5 to 180 μg TBT/kg rather than 73 μg TBT/kg (corresponding to 30 μg Sn/kg), as follows:

$Cs = 0.01*25{,}000*0.02 = 5$ μg TBT/kg (for chronic effects) Equation 2

$Cs = 0.36*25{,}000*0.02 = 180$ μg TBT/kg (for acute effects) Equation 3

Secondly, the reliance placed on the single Koc value used in the Michelsen et al. (1996) memo is problematic, for the following reasons: Reported Kow values for TBT range from 200 to 7,000 (Laughlin et al., 1986 as cited in Weston, 1996). While Koc and Kow are not necessarily the same, they are generally within an order of magnitude of one another and Koc values are very site specific. Therefore, using a Koc value reported in one paper in which Koc was measured from experiments with highly manipulated sediments, consisting of mixtures of mostly sandy sediment with mud and organic matter from a headbox at a marine station, does not seem a reasonable basis to propose a criteria. In addition, the study (Meador et al., in prep.) focused on sediment mixtures with very low TOC concentrations of 0.1 to 1 percent. The equilibrium partitioning theory is not applicable at TOC concentrations below 0.5 percent. Therefore, using a Koc derived under these conditions is questionable.

If the new SL were calculated using equilibrium partitioning with the same assumptions used previously (specifically Koc = 3765; Cs = 30 μgSn/kg = 73 μgTBT/kg), the proposed SL for interstitial water would be 0.97 μg TBT/L.

$Ciw = 73/(3765*0.02) = 0.97$ μg TBT/L Equation 4

With respect to the implications of a SL of 0.15 μg TBT/L, this concentration can be compared to toxicity data to assess its level of protection. This concentration is lower than the proposed acute criteria (0.36 μgTBT/L) but higher than the proposed chronic

criteria (0.01 μgTBT/L). Toxicological data for acute and chronic endpoints have been summarized in Weston (1996) and are presented in Tables 1 and 2. As shown in Table 1, 0.15 μg TBT/L is less than any of the acute effects concentrations listed. It is between the 25th and 50th percentiles of chronic effects concentrations (Table 2). Therefore, it is a relatively conservative screening level. If the SL were 0.97 μg TBT/L, it would be between the 82nd and 95th percentile of chronic effects and between the 25th and 50th percentile of acute effects. Since the SL is intended as a conservative screen, the resulting value of 0.15 μg TBT/L, although somewhat questionable in its basis, is not unreasonable. Its application, which will require routine analysis in interstitial waters, may prove to be challenging from a logistics perspective.

Furthermore, the recommendation to use 0.7 μg TBT/L as an upper regulatory limit in the PSDDA process would seem inappropriate. This concentration was established as a CSL for the Hylebos Waterway. Currently, ML concentrations are greater than the CSL for Phase I depositional sites. Proposing an equivalent CSL and ML does not coincide with the general PSDDA philosophy. A clear policy statement must be made regarding the degree of protectiveness desired in an ML before the choice of an action limit can be made and justified.

Bioassay Testing

As stated above, there are several technical issues regarding the methods and conclusions discussed in Meador *et al.* (in prep.). While it may be true that different species exhibit differential susceptibility to TBT, too many parameters were varied in Meador et al.'s experiments to state conclusively that variability observed in toxic responses among species was solely the result of differential susceptibility to TBT. For example, pore water was obtained by various methods for different species, and some samples were processed for chemical analysis immediately, while others were frozen prior to analysis. Also, it appears that the LC50s for some but not all species were calculated by adding mortality from a "failed" acetone blank to the test mortality, thereby lowering the LC50 for that species and artificially increasing the differences among species.

Test animals were also collected at different times; *R. abronius* and *E. washingtonianus* were collected from uncontaminated sampling areas in August 1991 and *E. washingtonianus* was collected again in August 1992, while *Armandia brevis* was collected in June 1991. Presumably, the fact that animals were collected at different times would indicate that they were also used in tests at different times. Sediments used for spiking appear to have been collected from different locations. In most cases, tests organisms were apparently exposed to sediments composed primarily of West Beach, WA, sediment, while others were exposed to spiked sediment from Mitchell Bay, San Juan Island, WA. It is not clear from the methods description why sediments from different locations were used.

In general, it appears that the experiments described in Meador *et al.* (in prep.) were an attempt to test multiple hypotheses simultaneously, with the result being that the comparison of TBT sensitivity among species appear to be less than robust.

CONCLUSIONS

In conclusion, it has not been proven conclusively that bioassays are not an effective means of evaluating TBT-contaminated dredge material, or that the organisms currently used in these bioassays are not sufficiently sensitive. Until studies have been conducted that do prove these two arguments, the existing bioassay-based approach to evaluating dredged material should be maintained.

The authors of the PSDDA/SMS issue paper argue that currently used bioassay organisms must be insensitive to TBT, since test organisms exposed to sediments from areas with elevated TBT concentrations and impaired benthic communities do not always fail bioassays. However, this argument is unfounded. Benthic community structure can be altered by a wide range of factors, including differences in physical and chemical characteristics as well as other contaminants. Furthermore, even though elevated TBT can be observed in these sediments, it may not be bioavailable and toxic to test organisms. More rigorous site-specific investigations must be conducted in order to determine the actual cause(s) of observed benthic community impairment.

Finally, the recommendation to adopt a 0.7 μg TBT/L upper regulatory limit represents a radical departure from current evaluation procedures. Before such a limit can be established, more extensive research into the effects of TBT and factors controlling its toxicity in Puget Sound must be conducted. Furthermore, if an entirely new philosophy on dredging policy is to be developed, then it should be based on sound science and enjoy the general support of all stakeholders.

REFERENCES

Meador, J.P., C.A. Krone, D.W. Dyer, and U. Varanashi (in prep.). Toxicity of sediment-associated tributyltin to infaunal invertebrates: species comparison and the role of organic carbon.

Laughlin, R.B., H.E. Guard, and W.M. Coleman. 1986. Tributyltin in seawater: speciation and octanol-water partition coefficient. Environ. Sci. Technol. 20:201-204.

Michelsen, T., C. Travis, and S. Stirling. 1996. Testing, reporting, and evaluation of tributyltin data in PSDDA and SMS programs. Prepared for Puget Sound Dredged Disposal Analysis Program. Washington Department of Ecology and U.S. Army Corps of Engineers.

Moore, D.W., T.M. Dillon, and B.C. Suedel. 1991. Chronic toxicity of tributyltin to the marine polychaete worm, *Neanthes arenaceodentata*. Aquat. Toxic. 21:181-198.

PSDDA (1989). Management plan report. Unconfined open-water disposal of dredged material, Phase II. U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region X; Washington State Department of Natural Resources; Washington State Department of Ecology.

U.S. EPA. 1991. Draft proposed ambient aquatic life water quality criteria for tributyltin. U.S. Environmental Protection Agency.

Weston. 1996. Recommendations for a screening level for tributyltin in Puget Sound sediment. Prepared for U.S. Environmental Protection Agency, Seattle, WA. Roy F. Weston, Inc., Seattle, WA.

Table 1. Summary of acute effects concentrations reported for marine aquatic organisms

TBT ug/L	Species	Endpoint
0.280	*Gammarus oceanus* larvae	Reduced survival and growth
0.292	Mysid shrimp juveniles	96-hr LC50
0.380	*Acartia tonsa*	LC50
0.389	Marine diatoms	72-hr EC50
0.389	*Acartia tonsa*	6-day LC50
0.420	Mysid shrimp	96-hr LC50
0.600	*Eurytemora affinis*	72-hr LC50
0.610	*Acartia tonsa*	96-hr LC50
0.610	*Scorbicularia plana* larvae	48-hr EC50
0.610	*Acanthomysis sculpta* juvenile	LC50
0.778	*Onchorynchus tshawytscha*	96-hr LC50
0.850	*Crassostrea virginica* larvae	LC50
0.900	*Crassostrea virginica*	48-hr LC50
0.940	*Metamysidopsis elongata* (mysid) juvenile	Species mean acute value
0.979	*Mercenaria mercenaria* embryos	48-hr LC50
1.100	*Acartia tonsa*	48-hr LC50
1.250	*Mysidopsis bahia* (mysid) juvenile (a)	
1.300	*Gammarus sp.* juveniles	96-hr LC50
1.320	*Mercenaria mercenaria* larvae	Species mean acute value
1.400	*Onchorynchus tshawytscha* juvenile	LC50
1.500	*Crassostrea gigas* larvae	LC50
1.600	*Eohaustorius washingtonianus*	10-day LC50
1.700	*Homarus americanus* (lobster) larvae	LC50
1.800	*Nitocra spinipes* (copepod)	LC50
2.000	*Eohaustorius estuarius*	10-day LC50
2.200	*Cyprinodon varigatus* (sheepshead minnow)	Species mean acute value
2.200	*Mytilus edulis* larvae	LC50
2.670	*Menidia beryllina* larvae	96-hr LC50
3.400	*Onchorynchus mykiss*	LC50
4.600	*Armandia brevis*	10-day LC50
5.300	*Brevoortia tyrannus* (Atlantic menhaden)	Avoidance
5.350	*Tubifex tubifex*	24-hr LC50
6.600	*Neanthes arenaceodentata* juvenile	LC50
8.000	*Menidia menidia* (Atlantic silverside) (a)	
9.400	*Carcinus maenus* larvae (shore crab)	LC50
14.200	*Orchestia. traskiana* adult (amphipod)	LC50
22.600	*Fundulus heteroclitus*	Species mean acute value
28.000	*Rhepoxynius abronius*	10-day LC50
29.000	*Palaeomonetes. pugio* (shrimp)	No avoidance
33.800	*Rhithropanopeus harrisii* (crab) larvae	Species mean acute value
81.000	*Hemigrapsus nudus*	LC50
198.000	*Ostrea edulis* adults	LC50

480.317 SUM
33.56 95th percentile
5.34 75th percentile
1.55 Median
0.80 25th percentile
0.70 23rd percentile
0.60 15th percentile
0.50 13th percentile
0.38 5th percentile

Note: Acute values for species flagged with (a) interpreted from Cardwell and Meador (1989) Figure 2.
Other sources include 1991Draft Proposed EPA Ambient Aquatic Life Water Quality Criteria for TBT and Fent 1996.

Reference: Roy F. Weston, Inc. 1996

Table 2. Summary of chronic effects concentrations reported for marine aquatic organisms

TBT µg/L	Species	Endpoint
0.002	Dog whelk (*N. lapillus*)	Sterilization
0.010	*Crassostrea gigas* spat	Growth
0.020	*Ostrea sp.* spat	Reduced growth
0.023	*Acartia tonsa nauplii*	6-day decreased survival
0.024	*Mercenaria mercenaria* larvae	14-day reduced growth
0.039	*Mytilus edulis* larvae	15-day LC50
0.050	*Mytilus edulis* larvae	25-day growth
0.090	*Menidia beryllina* larvae	28-day growth
0.097	Marine diatoms	Growth
0.100	*Eurytemora affinis* neonates	21 % suvival, 6-day
0.100	*Neanthes arenaceodentata*	10-week growth
0.120	*Menidia beryllina* (Silverside) (a)	Growth
0.130	Algae (a)	Reduction in photosynthesis
0.178	*Onchorynchus mykiss* larvae	110 day
0.195	*Cnchorynchus mykiss* larvae	10 day
0.200	*Eurytemora affinis* (copepod)	13-day reduced survival
0.240	*Crassostrea gigas* spat	Mortality and reduced growth
0.250	*Crassostrea gigas, Mytilus edulis, Venerupis decussata*	Growth
0.292	*Acartia tonsa*	Death, 144 hr.
0.389	*Mytilus edulis* spat	7-day growth
0.480	*Uca pugilator*	Limb regeneration
0.500	*Menidia beryllina* larvae	28-day growth
0.530	*Gammarus sp.* juveniles	24-day, no lethality
0.584	*Onchorynchus mykiss* adult	Immune function depression
0.600	*Fucus sp.* (brown algae)	Community primary productivity
0.730	*Crassostrea gigas* embryos/spat	Body weight
0.790	*Onchorynchus mykiss*	110-day growth and mortality
0.940	*Mytilus sp.* larvae	15-day LC50
0.970	Bay mussel	66-day LC50
1.720	Grunion embryo	No embryotoxicity
1.750	*Onchorynchus mykiss* larvae	LC100, 12 day
2.500	*Crassostrea virginica* adult	30 day LC50
6.000	*Rhithropanopeus harrisii* (crab) larvae	15-day reduced growth

20.642 SUM
2.05 95th percentile
0.80 82nd percentile (.815)
0.70 77th percentile
0.60 75th percentile
0.50 65th percentile
0.24 Median
0.10 25th percentile
0.02 5th percentile

Note: Chronic values for species flagged with (a) interpreted from Cardwell and Meador (1989) Figure 2.
Other sources include 1991 Draft Proposed EPA Ambient Aquatic Life Water Quality Criteria for TBT and Fent 1996.

Reference: Roy F. Weston, Inc. 1996

PSDDA/SMS ISSUE PAPER

SENSITIVITY OF AMPHIPOD SPECIES TO TBT IN SEDIMENT AND POREWATER

Prepared by Berit Bergquist, Kenneth Seeley, D. Michael Johns (EVS Consultants, 206/217-9337), and William Gardiner (Battelle Laboratories) for the Port of Seattle.

INTRODUCTION

Various regulatory agencies have recently stated that the amphipod *Eohaustorius estuarius* is more sensitive to TBT in sediment and porewater than *Rhepoxynius abronius*, and are therefore requiring certain projects to use this former amphipod in bioassays. The conclusions regarding comparative sensitivities have been based largely on a study conducted by Meador et al. (in review). There are technical issues regarding some methods and conclusions of the aforementioned study, and thus the requirement for using *Eohaustorius*. This paper discusses the technical issues and proposes a study to conduct bioassays with three amphipod species for a comparative analysis of their sensitivity to TBT.

TECHNICAL BACKGROUND AND DISCUSSION

As stated above, there are several technical issues regarding the methods and conclusions discussed in Meador et al. (in review). While it may be true that different species exhibit differential susceptibility to TBT, too many parameters were varied in Meador et al.'s experiments to state conclusively that variability observed in toxic responses among species was solely the result of differential susceptibility to TBT. For example, pore water was obtained by different methods for different species, and some samples were processed for chemical analysis immediately, while others were frozen prior to analysis. Also, it appears that the LC50s for some species (but not all) were calculated by adding mortality from a "failed" acetone blank to the test mortality, thereby lowering the LC50 for that species and artificially increasing the differences among species.

Tests animals were also collected at different times (*R. abronius* and *E. washingtonianus* were collected at from uncontaminated sampling areas in August 1991 and *E. washingtonianus* was collected again in August 1992, while *Armandia brevis* was collected in June 1991). Presumably, the fact that animals were collected at different times would indicate that they were also used in tests at different times. Sediments used for spiking appear to have been collected from different locations. In most cases, tests organisms were apparently exposed to sediments that were primarily composed of sediments taken from West Beach, WA, while others were exposed to spiked sediment from Mitchell Bay, San Juan Island, WA. It is not clear from the methods description why sediments from different locations were used.

In general, it appears that the experiments described in Meador et al. (in review) were designed to test multiple hypotheses, rather than one specific hypothesis. As a consequence, the results of the

comparison of TBT sensitivity among species appear to be less than robust. The study described below has been designed to specifically evaluate TBT susceptibility among amphipod species, while holding all other variables constant.

PROPOSED ACTIONS

It is proposed that a laboratory study be conducted to test the sensitivities of three species of amphipods. A 10-day sediment bioassay is proposed for each amphipod species using sediment collected from the same reference area and spiked with five TBT concentrations. Concentrations of TBT in both sediment and pore water will be measured. Target pore water concentrations will include those used by Meador et al. (in review) as well as those that cover a range of concentrations observed in Puget Sound. The results from this study will be used to determine an LC50 for each amphipod species in both sediment and pore water. These results will then be used in a comparative analysis of the sensitivities of the species.

The proposed methodology for this study is described below. This description is contained in three sections. The first section presents the protocol to be used for spiking sediment with TBT. The study design and methods for the bioassays are described in the second section. The third section discusses chemical analyses to be conducted before and after initiation of the bioassays.

Protocol for Spiking Sediment with Organic Compounds

This protocol describes the gravimetric method used to amend natural sediments with known amounts of organic compounds. These methods are based on procedures outlined in Word et al. (1987), Dewitt et al. (1992) and Ditsworth et al. (1990). This procedure is applicable for amending natural sediments with organic compounds, such as petroleum hydrocarbons, organotins, and pesticides. Also included are methods for sediment and pore water collection for chemical analysis.

Equipment and Glassware Preparation

1. Only glass, Teflon, and stainless steel should contact test sediments or seawater. This restriction is especially true of sediments or solutions containing any of the spiking compounds. The use of more porous materials may result in significant reductions in contaminant concentrations. Glass coated with inert materials, such as Prosil or HMDC, may be used; however, in previous experiments with DDT and TBT these coatings have not sufficiently reduced organic compounds binding onto glass surfaces.

2. All glassware, Teflon, and stainless steel should be washed in hot soapy water and rinsed at least three times with residue-free water. Glassware and teflon should then be soaked in 10% nitric acid for at least 4 h, followed by a complete rinsing with residue-free water. All materials should be solvent rinsed with residue-free acetone.

3. The mixing apparatus consists of three tiers of 6 horizontal neoprene-coated, stainless-steel rollers. The rollers are rotated by a gear and chain assembly, powered by an adjustable speed electric motor. One-gallon jars will rotate at approximately 15 to 30 rpm. The rolling table can accommodate up to 36 jars.

4. Appropriate laboratory safety precautions will be used whenever TBT or TBT-contaminated material is handled.

Sediment Preparation and Spiking

1. Natural substrates for spiking experiments should be collected from an area considered to be free from anthropogenic influences, such as reference sites. All collection apparatus should be precleaned and solvent rinsed.

2. Prior to spiking, sediments should be sieved through a 0.5 mm screen to remove any potential predators or indigenous species that may confound toxicity test results.

3. The chemical stock solution for spiking should be prepared from high purity test compounds. An aluminum weigh boat should be placed on a microbalance, and tared. The pure compound should be weighed in the aluminum weigh boat and the weight should be recorded, as well as the chemical manufacturer, catalog and lot number, the expiration date, and any other pertinent information. A glass funnel should be placed into a glass volumetric flask and the weighed compound poured into the flask. The pan and funnel should be washed with acetone from a teflon bottle. The acetone rinsewater containing the compound should be released into the flask. The compound should be dissolved to volume in the acetone in the flask.

4. The spiking level of the compound is on a dry weight basis. The dry weight concentration is usually determined from an expected LC50 level on either a total organic carbon normalized or interstitial water concentration basis. In both cases the percent solids and bulk density (g wet sediment/mL wet sediment) of the test sediment are needed as well as the wet weight of sediment that will be added to the mixing jars. The amount of stock necessary to spike the sediment at the desired dry weight concentration should be calculated using the following equations:

$$\text{volume of stock solution} = \frac{\text{(target sediment concentration * dry wt mass of sediment)}}{\text{concentration of stock solution}}$$

where: dry wt mass of sediment = mL of wet sediment * bulk density * percent solids

5. The predetermined volume of stock solution should be placed in the glass jars. The jar should be turned on its side and rolled slowly while directing a stream of clean nitrogen gas into the jar until all of the acetone is evaporated and a uniform layer coats the inner surface of the jar. It may be necessary to add acetone to the jar if there is insufficient

volume to coat the jar walls. It is important that all the acetone be evaporated from the jar.

6. The correct weight of sediment should be added to the jar. The jar should be no more than half full. The rim of each jar should be wiped free of particles, sealed with a Teflon-lined lid, and placed on the roller for at least 24 hours. Sediments should be rolled at substantially less than the speed at which the contents would centrifuge.

7. After several minutes of mixing, each jar should be checked for mixing efficiency. Substrate that displays any cohesiveness, agglomeration or balling should be wetted with a small aliquot (~50 mL) amount of 0.45 µm-filtered seawater. Care should be taken not to add so much water that the sediments fail to climb the jar walls and tumble down the substrate mass. Ideally, the wetted sediment should resemble wet brick mortar.

8. Rolling may occur continuously over 24 h, or intermittently (2-, 4-, or 8-h increments) over a 24-h period. Once rolling is complete, the jars should be stored in the dark at 4°C. Spiked sediment should be allowed to equilibrate prior to analysis. Previous studies (Word et al. 1987; Dewitt et al. 1992) have shown that approximately 30 days are necessary for a spiked compound to come to equilibrium in the sediment and interstitial water.

9. Immediately prior to using spiked sediment for analysis, the jars should be placed on the rolling table for at least 2 h to remix the substrate and any interstitial water that may have exuded during settling.

Collection of Sediment and Bulkwater Samples

1. Sediment samples should be collected immediately after remixing. With a solvent rinsed, stainless-steel spatula or spoon, an aliquot of sediment should be removed and placed in a U.S. EPA-certified, prelabeled I-Chem jar.

2. Interstitial water samples should be collected in 500-mL Teflon jars. Approximately 250-mL of remixed sediment should be placed in the teflon jar and securely sealed with a Teflon lid. The sediment sample should be centrifuged for 30 minutes at approximately 1000-times-gravity. The supernatant should be poured into a prelabeled sample jar.

Study Design for Amphipod Bioassays

Bioassays will be conducted with *Rhepoxynius abronius*, *Eohaustorius washingtonianus*, and *Eohaustorius estuarius*. Test animals will be collected from uncontaminated control sites. *R. abronius and E. washingtonianus* will be collected from West Beach, Whidbey Island, Washington. *E. estuarius* will be collected from Yaquina Bay, Newport, Oregon.

Test sediments will also be collected from an uncontaminated control site, and will be selected based on important physical characteristics, such as organic carbon content and grain size. These characteristics will be acceptable for all test species. Total organic carbon and grain size will be measured for the test sediment.

Treatment groups will include the following:

- Negative control sediment -sediment with no other additions.
- Positive control sediment - sediment spiked with an appropriate reference toxicant.
- Acetone blank - sediment without TBT but with the same concentration of acetone used to dissolve TBT incorporated into spiked sediments.
- Spiked sediments - sediments spiked with a range of TBT concentrations. A total of five TBT concentrations will be used, including an approximate LC50 (based on a review of the available literature), two concentrations below the LC50, and two concentrations above it.
- To determine which species are appropriate for bioassay testing when exceedances of the SL for TBT is triggered.

Five replicates will be included for each treatment group. At the initiation of the tests, 20 amphipods will be introduced to each test chamber. Test chambers will consist of 1-L glass beakers, containing test sediments and overlying water. Tests will be static, with no changes of overlying water. Chambers will be aerated. Test animals will not be fed throughout the course of the exposure. At the end of the 10-day exposure period, test animals will be sieved from the sediments, and the survivors will be counted. In addition to determining mortality, a sublethal endpoint (amphipod reburial) will be evaluated throughout the exposure period.

Chemical Analysis

Chemical analysis of sediments will be conducted prior to the initiation of the tests to verify that nominal TBT concentrations were obtained in the spiked sediments. This analysis will consist of measurement of total tin in both bulk sediment and in pore water.

Both sediment and pore water will be analyzed for TBT at the initiation of the bioassays (Day 0) and again at the conclusion of the bioassays (Day 10). Samples will be composited from replicate chambers for each nominal concentration and species.

Data Uses

Results for the designed study can be used for two purposes:

- To establish whether there is differential sensitivity to TBT for the three species tested
- To determine whether the species are sensitive to interstitial water TBT concentrations that are representative of Puget Sound sediments where high bulk concentrations of TBT have been observed

REFERENCES

Dewitt, T.H., M.S. Redmond, J.E. Sewall, R.C. Schwartz. 1992. Development of a chronic sediment toxicity test for marine benthic amphipods. CBP/TRS 89/93. U.S. Environmental Protection Agency, Environmental Research Laboratory, Pacific Ecosystems Branch. Newport, Oregon.

Ditsworth, G.R., D.W. Shults, J.K.P. Jones. 1990. "Preparation of benthic substrates for sediment toxicity testing". Environmental Toxicology and Chemistry 9: 1523-1529.

Meador, J.P., C.A. Krone, D.W. Dyer, and U. Varanasi. Toxicity of sediment-associated tributyltin to infaunal invertebrates: species comparison and the role of organic carbon. In review.

Word, J.Q., J.A. Ward, L.M. Franklin, V.I. Cullinan, S.L. Kiesser. 1987. Evaluation of the equilibrium partitioning theory for estimating the toxicity of the nonpolar compound DDT to the sediment dwelling amphipod Rhepoxynius abronius. Battelle Washington Environmental Program Office. Washington D.C.

SMS ISSUE PAPER

SMS TRIENNIAL REVIEW PROCESS

Prepared by Tom Newlon (206 / 728-3731) and Doug Hotchkiss (206 / 728-3192) (Port of Seattle) and Eric Johnson (Washington Public Ports Association, 360 / 943-0760)

INTRODUCTION

Ecology adopted Washington's Sediment Management Standards (SMS) in 1991. At the time of adoption, Ecology committed to review the SMS Rule on an annual basis and to make necessary revisions every three years. In conducting its annual review and triennial revision, Ecology committed to paying particular attention to new or additional scientific information.

Since 1991, many comments have been submitted regarding the need for significant revisions to the core Rule. Further, a substantial amount of new data regarding the effects of different contaminants has been collected and added to Ecology's sediment database. Despite Ecology's receipt of these comments and new data, Ecology has not adopted any significant revisions to the core Rule since 1991. Ecology has also declined to use the new data to recalculate the Rule's numeric criteria. Ecology's only notable change to the SMS Rule since 1991 is the addition, in 1995, of new sections dealing with fish farming (see Sparks 1996).

PROBLEM IDENTIFICATION

Ecology has failed to conduct a thorough triennial review and revision of the SMS Rule. Ecology has also failed to utilize substantial new scientific information to validate and refine the Rule by recalculating the Rule's many numeric criteria.

DISCUSSION

At the time Ecology adopted the SMS Rule in 1991, the agency explicitly recognized the need for continued review of the SMS Rule, committed itself to identifying the latest scientific knowledge, and committed itself to modifying the SMS Rule accordingly. WAC 173-204-130. One of the Rule's key goals is that it should be based upon methods that accurately reflect the latest scientific knowledge. The Rule seeks to accomplish this by directing Ecology to modify the Rule through ongoing validation and refinement. The Rule further directs Ecology to conduct an annual review of the Rule and to revise the Rule every three years, or as necessary. Finally, the Rule directs Ecology to provide meaningful opportunities for public comment during Rule review and revision.

In keeping with these provisions of the Rule, many interested parties have provided Ecology with proposed Rule revisions. The Port of Seattle, for example, recommended numerous Rule changes

during the course of Ecology's purported triennial review of the Rule in 1995 (Aggerholm, et al., 1995). The Port's recommendations include, among others, the following:

- Recalculate the Rule's chemical criteria using newly obtained data;
- Recognize, and institute procedures to minimize, bioassay false positives that result from other interfering factors;
- Provide greater emphasis on benthic community assessment as a third tier for determining whether sediments exceed regulatory limits;
- Focus active cleanup efforts on "hotspots" to accelerate cleanups at the worst sites;
- Give greater emphasis to source control and natural recovery relative to active cleanup;
- Reduce barriers to, and provide incentives for, voluntary cleanups; and
- Simplify and clarify cleanup study plan and reporting requirements.

Overall, Ecology's response to these comments has been to acknowledge them, and then to take no further action. As noted above, Ecology's only notable Rule revision since 1991 is the 1995 addition of provisions specific to finfish farming (see Sparks 1996).

While some of the Port's proposed Rule revisions entail minor policy shifts, many are based on the Rule's unambiguous mandate that Ecology continually validate and refine the Rule to assure that it is based upon the latest scientific information. The clearest example of this is the Port's recommendation that Ecology recalculate the chemical criteria using newly obtained data. The Rule specifically requires Ecology to consider such data ("new or additional scientific information") when evaluating the Rule for possible revisions. WAC 173-204-130(7). In an area such as sediment management, where the scientific understanding of contamination and its related effects is evolving so rapidly, and where substantial new data is readily available, Ecology's first priority during rule revision should be recalculating the chemical criteria rather than continuing to rely on criteria that were established five years ago using an outdated data set of questionable predictive ability.

Ecology's failure to recalculate the chemical criteria during last year's purported triennial review, and its failure to address the many other issues raised during the review process, requires immediate attention. Ecology should therefore conduct a real triennial review over the coming year, and should commit to doing so every three years thereafter.

Finally, although the Rule does not mandate a specific process for conducting annual Rule review and triennial Rule revision, the Sediment Management Standards Annual Review Meeting (SMARM) process is an appropriate one which Ecology should follow and take full advantage of. SMARM provides a regular opportunity for raising and addressing Rule issues in need of review. It also provides a good mechanism for the public and for stakeholders to participate in Rule revision, and for all interested parties, including Ecology and other agencies, to present their views on the merits of various proposals. Accordingly, the Port of Seattle will be submitting proposed SMS Rule language during the SMARM comment period to follow-up on the proposed amendments to the SMS Rule identified in its August 1995 letter.

PROPOSED ACTION

- Ecology should commit to conducting a thorough review and revision of the SMS Rule over the next year and every three years thereafter. Ecology should also commit to using newly available data in its sediment database to recalculate the Rule's numeric criteria during this and future triennial reviews.

- Ecology should use the SMARM process as the mechanism for identifying areas of the Rule in need of revision and for obtaining public and peer review of proposed revisions to the Rule.

- Ecology should invite SMARM participants to submit proposed amendments to the SMS Rule, including proposed Rule language, during the SMARM comment period.

REFERENCES

Aggerholm, D., Hotchkiss, D., and Newlon, T., 1995. Letter to Brett Betts, Department of Ecology, regarding Triennial Review of State Sediment Management Standards.

Sparks-McConkey, P. (for Ecology), 1996. Status Paper -- Sediment Management Standards (SMS) Triennial Review.

REDUCING UNCERTAINTIES IN THE INTERPRETATION OF SEDIMENT TOXICITY TESTS AND BENTHIC COMMUNITY EFFECTS

Prepared by Jack Word, Theodore Dewitt, and William Gardiner, Battelle Marine Sciences Laboratory, ((360) 683-4151) for the PSDDA/SMS agencies.

INTRODUCTION

Current PSSDA regulations require chemical and biological evaluations to determine whether aquatic sediments are contaminated. The required biological assessments include acute and chronic bioassays and measurements of benthic infaunal abundance. Imbedded in this process is the assumption that the observed effects are a result of priority pollutants. However, physical and chemical factors unrelated to chemical contamination can influence biological responses and therefore result in false-positive conclusions. There exist methods to either account for or eliminate non-contaminant factors; however, it is important to apply these methods in a manner suitable to the specific evaluation being performed.

The purpose of this paper is to: 1) identify non-contaminant factors which can lead to false-positive conclusions or mask effects from contaminants of concern; 2) provide methods that account for or eliminate non-contaminant factors; and 3) distinguish between those methods that are suitable for reducing interferences in evaluations of *in situ* sediment versus those for evaluations of sediment for relocation (ie. dredged-material disposal).

TECHNICAL BACKGROUND AND DISCUSSION

Sediment quality evaluations in the Puget Sound include both chemical and biological components. Observed chemical concentrations in sediments are paired with the results toxicity tests and benthic community analysis to determine the degree of contamination at a given station. This approach implies that the sediment chemistry is responsible for the biological responses.

Recent studies have identified a number of physical and chemical factors which can directly or indirectly influence benthic community structure or biological responses in laboratory bioassays. These interferences can confound the interpretation of biological responses and the attribution of toxicity to chemical contamination in three ways: 1) greater biological effects are observed when chemical contamination is absent or very low (false-positive conclusion); 2) the interfering factor may mask effects caused by low concentrations of contaminants of concern; and 3) a less-than-expected biological response is observed when chemical concentrations are elevated (false-negatives). An interfering, or confounding, factor can interfere with biological analyses by directly affecting organism health or by interacting with chemical contaminant bioavailability.

These confounding factors include, but are not limited to: sediment grain size, salinity, ammonia, hydrogen sulfide, sediment organic matter content. The following discussion reviews some of the confounding factors encountered in biological evaluations (toxicity testing and benthic community analysis). A full presentation is available in Dewitt et al. (1995).

Sediment Grain Size

Toxicity Testing: In benthic-phase toxicity tests, sediment grain size can confound toxicity tests by directly affecting test organism health, although the mechanism is unknown. Benthic infaunal species used in sediment tests move freely among the sediment particles or live in tube-like dwellings. Abrasion of sensitive body parts, clogging of gills, or reduced diffusion of dissolved oxygen into the sediment are possible factors that may be associated with fine grained sediment and contribute to the mortality of test animals.

Bivalve and echinoderm invertebrate larvae are used to evaluate the toxicity of sediment bound contaminants to water-column organisms. In the PSEP/PSDDA protocol for these tests, larvae are exposed for 48-72h to a sediment-water mixture in which sediment is allowed to settle and remainin the test chamber throughout the test. During early development (<12h to 24h) larvae are negatively buoyant and rest on the sediment surface, whereas larvae that are >12h to 24h-old are free-swimming. Developing larvae may become trapped while on the sediment surface or become entrained in settling particles and sink to the bottom. Larvae may then become trapped in the surface sediments or be alive and irretrievable at test termination when only the overlying water is removed to collect the test organisms. Very fine-grained materials that remain in suspension might adhere to the surface of developing embryos and either inhibit the diffusion of oxygen to cells or the action of flagella and cilia, or interfere with cell-surface processes due to interaction with negatively charged clay particles.

Benthos: PSDDA benthic community assessments rely upon a comparison between infaunal abundance at a test site and abundance at a reference site. Benthic community structure is greatly affected by sediment grain size. Sandy habitats are generally characterized by clean, coarse-grained sediments, low in organic material. Relatively large spaces between the sediment particles allow water, chemicals (O_2, H_2S, NH_3, and contaminants), and infauna to move freely throughout the substrate. Silt and clay sediments are characterized by finer, hard particles that are coated with organic carbon. The interstitial spaces are much smaller in these substrates, inhibiting infaunal and water movement. Different lifestyles and feeding habits will allow different species to survive in these two different habitat types. Not only can substrate influence the species that are present in a given area, but also the abundance and richness of a given area. Extreme changes in community profile can be found within small embayments at similar depths. These changes may be largely due to sediment grain size. If the sediment grain size of the reference site differs greatly from that of the test site, false-positive conclusions could be made.

Salinity

Toxicity Testing: Test sediments collected in estuaries or between estuaries and marine waters will often exhibit a wide range of salinities in the sediment porewater (i.e., <1.0‰ to >30‰). This wide range of porewater salinities can cause osmotic stress in stenohaline (i.e., truly marine) test species, which can lead to death. A difference in the salinity internal and external to the organism can lead to 1) dehydration of tissues, if the external salinity exceeds the internal salinity, or 2) cellular swelling and rupture, if the internal salinity exceeds that of the surrounding water. In addition, salinity can alter the bioavailability of dissolved metals, but this form of interference is qualitatively different from salinity's role as a confounding factor. Salinity effects are more likely to be an issue in solid-phase tests than in larval tests, since low salinity interstitial porewater is diluted in seawater during test preparation.

Benthos: Marine water prevails throughout much of Puget Sound; however many nearshore sites receive heavy freshwater influx (from riverine input, estuaries, and surface-water run-off) and can have

relatively low salinity waters (<25‰). Many of the urban embayments in Puget Sound are influenced by river discharge and run-off. Infaunal communities in these areas would tend to feature euryhaline (salinity tolerant) species, rather than the marine species found throughout much of the Sound. As with sediment grain size, selection of a reference site is critical for a valid comparison of the benthic infaunal community. Many of the Puget Sound reference areas feature marine communities and may be invalid points of comparison for euryhaline communities.

Porewater Ammonia

Toxicity Testing: Ammonia in sediment porewater is produced by the microbial metabolism of nitrogenous organic matter, and can be acutely and chronically toxic to test organisms at concentrations observed in field-collected sediments (up to hundreds of mg/L total ammonia). Although ammonia is not considered a chemical of concern in evaluations of sediment contamination, (due to its lack of persistence), it can persist in laboratory test chambers and confound the interpretation of sediment toxicity tests. Burrowing amphipods and polychaetes may be in direct contact with the potentially high ammonia concentrations in interstitial porewater. Other species, such as tube-dwelling amphipods and larval forms, are exposed to more dilute ammonia concentrations in the water overlying the sediment. Ammonia effects are more likely as a result of direct contact with sediment porewater (and higher ammonia concentrations); however, larval species are highly sensitive to ammonia and effects may be seen at concentrations down to 3 mg/L to 5 mg/L total ammonia.

Benthos: Because high ammonia concentrations are usually associated with abiotic, anaerobic sediments, the role of ammonia as an interfering influence in benthic evaluations is tied closely with the influences of dissolved oxygen and hydrogen sulfide. Little is known about the influence of ammonia on benthic communities, but given the sensitivity of toxicity test organisms to ammonia, some toxic effects would be expected if ammonia were present in the sediment.

Other confounding factors

Hydrogen sulfide (H_2S) commonly occurs in marine and estuarine sediments and is produced by sulfate-reducing bacteria as they anaerobically decompose organic matter. H_2S usually occurs under hypoxic or anoxic conditions and is toxic to most marine organisms, with symptoms similar to those of hypoxia. Although H_2S can exist for a short time in the presence of oxygen, both chemical and biological oxidation can reduce H_2S concentrations fairly rapidly. Since most toxicity tests are maintained at dissolved oxygen levels sufficient to reduce H_2S, risks of interference are minimized. However, in static tests with sediments particularly high in H_2S, H_2S-related toxicity could result in false-positive conclusions.

Organic material can influence both toxicity tests and benthic communities. Organic material can act as a food source, alter grain size, and alter contaminant bioavailability. Total organic carbon (TOC) concentrations are generally higher in fine-grained sediments. Some contaminants, such as hydrophobic organics and to a lesser extent metals, preferentially bind to TOC which can alter contaminant bioavailability in toxicity tests and in the benthos. Thus contaminant bioavailability may be different in a coarse-grained sediment relative to a finer-grained sediment, despite similar overall contaminant concentrations. The abundance of many species of invertebrates are dramatically influenced by the quantity and quality of organic enrichment. Certain infaunal species may have optimal ranges for organic matter content. Species that respond to organic enrichment may produce false positives by responding to changes in TOC, rather than to chemical contamination.

PROPOSED ACTIONS OR MODIFICATIONS

Biological data for sediment quality evaluation needs to account for non-contaminant interferences that can lead to erroneous conclusions regardiner pollution impacts. This can be accomplished with the following two proposed actions.

1) Review of current PSEP/PSDDA protocols to ensure that the effects of interfering influences are minimized.

2) Where necessary, modify existing protocols to incorporate available methods that remove or account for interfering factors. A number of methods are currently available to reduce the impact of confounding factors and are summarized in Tables 1 and 2. In some cases, more than one approach is available.

3) Ensure that the methods employed to account for interfering factors are suitable for the type of evaluation being performed. For certain interferences, the techniques used in assessments for sediment relocation (ie. dredged material disposal) may be quite different than those employed for *in situ* evaluations (ie. sediment monitoring). This distinction has been overlooked in some evaluations and can lead to incorrect conclusions. To emphasize these differences the suggested methods are presented separately. A thorough review of these methods is presented in Dewitt et al. (1995).

REFERENCES

DeWitt, T.H., J.Q. Word, L.D. Antrim, N.P. Kohn. 1995 (Draft). "Reducing Uncertainty in the Interpretation of Sediment Toxicity Tests and Benthic Community Effects." Prepared for the Port of Seattle under Contract 21973 by Battelle/Marine Sciences Laboratory, Sequim, Washington; Battelle, Pacific Northwest Laboratories, Richland, Washington.

Table 1. Recommended Protocol Modifications to Minimize False Positives Resulting from Interfering Factors for Tests of the Effects of Relocating Contaminated Sediment

INTERFERENCE	SOLID-PHASE TESTS	LARVAE TOXICITY	BENTHIC
Salinity	Measure interstitial water salinity to determine whether test sediment matches salinity tolerance of test organism	Generally not an issue	Measure interstitial water salinity
	Use test species that are tolerant to salinity of test sediment		Compare to reference sites based on disposal site salinity conditions
	Compare survival to established dose/response curves. Only consider mortalities that are not accounted for by salinity		Compare community changes along salinity only effects gradient.
Ammonia	Measure interstitial water[a] prior to and during test to determine whether test sediment matches ammonia tolerance of test organism.	Measure overlying water in lab prior to and during testing.	Measure interstitial and overlying water in field
	Minimize ammonia production during collection and storage of sediment		
	Conduct ammonia reference toxicant tests with same population at same time as testing, and compare interstitial water ammonia concentrations to dose-response curves to assess impact of interstitial ammonia in test sediment.		Effects on benthos are unknown but expected.
	Manipulate ammonia in interstitial water by EPA approve protocol (2-exchanges/day until NOEC attained.	Allow time to attain NOEC in overlying water.	
		Use more ammonia tolerant species.	
Grain Size	Use species that are likely to occur at disposal site.	Use species which are tolerant of settled sediment.	Compare benthic communities to disposal site reference areas.
	Use established grain size-mortality regression curves to determine influence of grain size of test sediment on survival of test organism	Increase settling time to decrease effects of suspended sediment.	Evaluate changes in community structure along grain size gradients
		Address mortality abnormality introduced due to settled sediment	
	Use test species that are tolerant of range of grain-sizes of test sediments	Use test species that are tolerant of range of grain-sizes of test sediments	
	Compare to reference	Compare to reference	Compare communities to reference values
Organic Matter	Normalize chemical concentration by TOC to predict bioavailability		
	Ascertain whether observed biological effects are due to the quantity or quality of total organic carbon contained in sediment.		
Hydrogen Sulfide	For all tests, analytical difficulties confound separating the effects of sulfide from anoxia. Procedures should be developed to measure hydrogen sulfide and its potential effects in interstitial and overlying water for both toxicity tests and for benthic community evaluations.		
Sediment Manipulation	Manipulation is acceptable		Not an issue
Storage	Test storage should be minimized in order to reduce the potential for introduction of sediment changes that will influence test organisms survival.		Not an issue

(a) All measurement of ammonia shall include measurement of temperature, salinity, and pH in sample.

Table 2. Recommended Protocol Modifications to Minimize False Positives Resulting from Interfering Factors for Tests of the Effects of Contaminated In-Situ Sediment

INTERFERENCE	SOLID-PHASE TESTS	SURFACE TOXICITY	BENTHIC
Salinity	Measure interstitial water salinity to determine whether test sediment matches salinity tolerance of test organism	Generally not an issue	Measure interstitial water salinity
	Use test species that are tolerant to salinity of test sediment		Compare to reference conditions with similar salinity values
	Compare survival to established dose/response curves. Only consider mortalities that are not accounted for by salinity		Compare community changes along salinity only effects gradient.
Ammonia	Measure interstitial water prior to and during test to determine whether test sediment matches ammonia tolerance of test organism.	Measure overlying water in lab prior to and during testing.	Measure interstitial and overlying water in field
	Minimize ammonia production during collection and storage of sediment		
	Manipulate ammonia in interstitial water by EPA approve protocol (2-exchanges/day until NOEC attained.	Allow time to attain ammonia NOEC in overlying water.	Effects on benthos are unknown but expected.
	Conduct ammonia reference toxicant tests with same population at same time as testing, and compare interstitial water ammonia concentrations to dose-response curves to assess impact of interstitial ammonia in test sediment.	Use ammonia tolerant species.	
Grain Size	Use test species that are tolerant of range of grain-sizes of test sediments	Increase settling time to decrease effects of suspended sediment.	Compare community measures along grain size gradients.
		Address mortality abnormality introduced due to settled sediment	
	Use established grain size-mortality regression curves to determine influence of grain size of test sediment on survival of test organism.	Use more tolerant species	
	Compare to reference sediment	Compare to reference	Compare communities to reference values
Organic Matter	Normalize chemical concentration by TOC to predict bioavailability	Normalize chemical concentration by TOC to predict bioavailability	Normalize chemical concentration by TOC to predict bioavailability
			Ascertain whether observed biological effects are due to the quantity or quality of total organic carbon contained in sediment.
Hydrogen Sulfide	For all tests, analytical difficulties confound separating the effects of sulfide from anoxia. Procedures should be developed to measure hydrogen sulfide and its potential effects in interstitial and overlying water for both toxicity tests and for benthic community evaluations.		Not an issue
Sediment Manipulation	Manipulation should be minimized		Not an issue
Storage	Test storage should be minimized in order to reduce the potential for introduction of sediment changes that will influence test organisms survival.		Not an issue

CONFOUNDING ISSUES IN MICROTOX BIOASSAYS

Prepared by Jack Word and William Gardiner, Battelle Marine Sciences Laboratory, (360) 683-4151 for the Port of Seattle.

INTRODUCTION

The Microtox saline extract test is one of five biological tests available for the PSDDA process of sediment evaluation. In this chronic-surrogate test, the marine bacteria, *Photobacterium phosphoreum*, are exposed to sediment extracts, after which luminescence is measured. Decreased luminescence is used to indicate toxicity. Although this test renders a quick estimate of response, the extraction process may alter extract toxicity which can, in turn, lead to false-positive conclusions. Of particular concern is the coextraction of naturally occurring elemental sulfur which can be toxic to *P. phosphoreum*. The purpose of this paper is to evaluate potential confounding influences from the coextraction of sulfur and to review the sediment extraction process.

TECHNICAL BACKGROUND AND DISCUSSION

During the Microtox test, photobacterium are exposed to a liquid sediment extract preparation. The PSDDA methodology requires a seawater extract of the sediment. An alternative extraction process using a solvent, typically acetonitrile, can be toxic to the bacterium, and as a result, the solvent matrix is exchanged to a less toxic solvent, such as ethanol or dimethyl sulfoxide (DMSO). During the chemical analysis of organic pollutants, clean-up procedures are generally performed to remove any coextracted substances which may cause interferences. Microtox studies have, however, skipped this cleanup procedure, potentially resulting in effects related to naturally occurring, non-contaminant coextraction products.

In a recent study, Jacobs et al. (1992) evaluated the Microtox extraction process and the effectiveness of two clean-up procedures: reversed-phase, C_{18} solid-phase extraction columns and the addition of copper powder to the C_{18} column. Treatment of extracts with the C_{18} column removes biogenic compounds and the addition of copper powder removes elemental sulfur. Jacobs et al. concluded that:

1) Acetonitrile extracts of marine sediments without clean-up procedures were toxic when using the light output endpoint of the Microtox assay.

2) Extracts treated with the C_{18}-column cleanup procedure produced no change in the amount of light output and were therefore as toxic as the original extracts.

3) Continued clean up of the C_{18}-column-cleaned extracts using copper powder (purified electrolytic dust) resulted in a significant reduction in toxicity.

4) Elemental sulfur dissolved into acetonitrile using the same procedures as established for the Microtox extraction test resulted in toxicity.

5) C_{18}-column cleanup procedures with the spiked acetonitrile/sulfur extracts resulted in no reduction in toxicity.

6) C_{18}-column cleanup of the spiked extracts with the addition of copper powder reduced toxicity.

7) Toxicity of elemental sulfur in acetonitrile, methylene chloride, and DMSO were not statistically significantly different from each other. The EC_{50} for reduced light output for elemental sulfur in these solvents ranged from 24.7 to 35.8 µg S/L.

Furthermore, Jacobs et al. concluded:

> "This study demonstrated that elemental sulfur dissolved in three organic solvents is highly toxic to *P. phosphoreum* used in Microtox bioassays. Previous chemical evaluation of sediment solvent extracts have utilized some form of sulfur cleanup before analysis, using either activated copper or mercury. Since Microtox bioassays have not included a cleanup step prior to analysis, coextracted sulfur might have been present in some of the crude extracts, thereby contributing to the observed toxicity."..."***the results of the Microtox bioassays of crude extracts containing coextracted sulfur may result in an overestimation of the toxicity of identified sediment pollutants***. Alternatively, the relatively high toxicity of coextracted sulfur in sediment extracts may mask the toxicity of extracted contaminants that are less toxic to Microtox than elemental sulfur. ***The elimination of sulfur in sediment solvent extracts is necessary to evaluate the toxicity of extracted hydrophobic organic pollutants more accurately***."

PROPOSED ACTIONS OR MODIFICATIONS

Currently, 13 of 47 sediment management values in the AET database are determined by the Microtox bioassay. The chemicals in the AET database with the lowest sediment concentrations that are associated with the Microtox test include: copper, mercury, 1,2,4-trichlorobenzene, total PCBs, di-N-butyl phthalate, butylbenzylphthalate, bis(2 ethylhexyl)phthalate, hexachlorobutadiene, 4-methylphenol, 2,4-dimethylphenol, and benzoic acid.

Two issues that need to be addressed are:

1) Assess the potential for elemental sulfur to be included in seawater extracts at concentrations exceeding 25 mg/L.

2) Reassess those AET values that were set by Microtox tests. If the current Microtox SedQual values are potentially affected by false-positives, SedQual values could increase by a factor of 1.3 to 8.6, with the highest increases being associated with butylbenzylphthalate (8.6) and total PCBs (5.4).

REFERENCES

Jacobs, M.W., J.J. Delfino and G. Bitton. 1992. *The Toxicity of Sulfur to Microtox from Acetonitrile Extracts of Contaminated Sediments*. Environmental Toxicology and Chemistry. 11: 1137-1143.

PSDDA/SMS ISSUE PAPER

EVALUATION OF PUGET SOUND APPARENT EFFECTS THRESHOLDS (AETs)

Prepared by Mike Johns, Tim Hammermeister, Lorraine Read, and Kim Magruder (EVS Consultants, 206/217-9337) for the Port of Seattle.

INTRODUCTION

Apparent Effects Thresholds (AETs) are defined as concentrations of specific chemicals of concern in sediment above which significant adverse biological effects always occur. Dredging and disposal guidelines for Puget Sound and sediment management standards used in Washington State are based upon AETs. In 1994, a recalculation of the 1988 Puget Sound AETs was performed by the Washington Department of Ecology utilizing high quality synoptic data collected subsequent to the 1988 calculations. The purpose of this paper is to evaluate the methodology used to exclude data from the calculation of the new AET values.

It is important to use only high quality synoptic data in the calculation of AETs. It is equally important to base decisions on as much information as is available. Establishing relevant AETs is highly dependant on data, the more data the more likely the AET will be predictive of toxic conditions. Criteria established for the exclusion of data from the 1994 recalculation of AETs included, in order of application: 1) not synoptic; 2) failed chemical QA; 3) insufficient lab replicates; 4) negative control sample failure; 5) no reference or reference failure; 6) statistically inconclusive; and 7) chemically anomalous (Gries and Waldow, 1995). The following discussion examines the exclusion of potentially valid, high quality data from the AET calculations when using the last three criteria listed above.

PROBLEM IDENTIFICATION

Reference Station Performance

The emphasis placed on the reference station performance standards resulted in the exclusion of numerous data from the AET calculations that were otherwise of good quality. The present criteria for accepting data for AET calculation requires a negative control and at least one reference sample per bioassay batch. Positive control or reference

toxicant bioassay data are no longer deemed necessary for inclusion in AET calculations. While both the negative control data and reference sample data are important in evaluating toxicity test responses, the performance of negative and positive controls are more critical in determining bioassay data quality. Negative control data provide an indication of test organism health during the exposure period, while the positive control data establish whether the test organisms are sensitive to toxicants. 96-hour LC50 values (48-hour LC50 and EC50 for larval bioassays) determined with reference toxicants are required for the QA2 data requirements, but were dismissed in the recalculation of AETs. There are no reference sediment performance standards specified in the QA2 data requirements (Corps, 1996).

Data should not be excluded from inclusion in the AET calculation because of poor reference station performance, rather a default group of reference samples based on historical reference data should be made available for use in those cases where the study-specific reference data do not meet minimum standards. Reference sample requirements and performance guidelines were the leading factors in rejecting data, resulting in the exclusion of 308 samples containing amphipod data (37% of total amphipod data) and 59 samples containing echinoderm data (19% of total echinoderm data).

Statistically Inconclusive Data

Gries & Waldow (1995) present a five phase process for determining whether significant effects exist between test and reference samples exhibiting high variability. The statistical methods employed to determine the significant effects between test and reference samples are not the most appropriate. As a result, data may be unnecessarily excluded from AET calculations as being statistically inconclusive. Sixteen amphipod (2% of total) and 11 echinoderm (3% of total) samples were excluded from AET calculations after being deemed statistically inconclusive.

Chemically Anomalous "No Hit" Samples

The 1994 re-evaluation of AETs defined a chemically anomalous "No Hit" sample as:

> a sample with a three-fold difference in chemical concentration between it and the next highest adjacent "No Hit" sample, when these samples were ranked according to chemical concentration.

Samples identified as anomalous for dry-weight and TOC normalized chemistry were excluded from AET calculations. Data that have passed all QA/QC guidelines should be considered valid and therefore appropriate for use in AET calculations. The definition of

AETs implies that the highest concentration with a "No Hit" sets the value. If data are to be excluded as being "anomalous," a more rigorous statistical method of determining outlier data should be employed. Eleven AET values were calculated for amphipod mortality based on samples that were not the highest "no hit' concentration. Seven AET values were calculated for echinoderm larvae abnormality based on samples that were not the highest "no-hit" concentration.

TECHNICAL BACKGROUND AND DISCUSSION

Quality Assurance/Quality Control Guidelines

Puget Sound Estuary Program (PSEP) guidelines were followed for the collection, handling, storage, and analysis of sediment samples used for calculating the AETs. Between 1988 and 1994, the Puget Sound Dredged Disposal Analysis (PSDDA) agencies adopted several modifications to the PSEP protocols, which were taken into consideration when selecting sediment data for the 1994 AET recalculations. Modifications to the PSEP protocols included:

- Extension of bioassay holding time from two weeks to six weeks
- Measurement of dissolved total ammonia and sulfides at the initiation and completion of each bioassay
- Monitoring dissolved oxygen (DO) and pH daily
- Aerating the overlying water if DO fell below 60% of saturation, or if high ammonia or total sulfides were present

Sediment data used for calculating the 1988 and 1994 AET values had undergone a rigorous quality assurance (QA) review process. This process is defined in the *Data Validation Guidance Manual for Selected Sediment Variables* (PTI, 1989), which is referred to as the QA2 document in this report. The QA2 data review process is relatively extensive in that it involves verifying the quality of the sample collection efforts as well as the laboratory performance. General QA guidance (based on PSEP protocols) for station positioning, sediment sample collection and storage, and sample handling and document control are provided in the QA2 document. The laboratory performance evaluation involves verifying all documentation provided by the laboratory (i.e., QA sample results and supporting information, original instrumentation printouts [when applicable], original laboratory benchsheets, etc.) for conventional variables, metals, organic compounds, and bioassay results. This documentation is reviewed with respect to the requirements set forth in the original statement of work for the laboratory, which is based on the data quality objectives for the project and PSEP protocol requirements.

Data that meets the QA/QC requirements as described above is considered to be of high quality and defensibly valid. The use of high quality data in the calculation of AETs is paramount to providing the best available knowledge on Puget Sound sediments.

Data excluded due to reference sediment performance

Subsequent to the QA/QC review of Puget Sound sediment data, additional criteria have been used to screen the usefulness of bioassay data in calculating AETs. A phased approach is utilized to determine significant adverse effects for each bioassay, based on reference and test sediment results.

The present reference sediment requirements for bioassay testing include:

- Testing at least one reference sediment per bioassay batch
- Reference sediment had to be collected from recognized reference areas (e.g. Carr Inlet), areas meeting the description in PSEP protocols, or areas identified by recent reference area studies
- Reference sediment performance met ≤20% mean amphipod mortality (≤18% Std. Dev.) and ≤35% mean effective mortality (≤22% Std. Dev.) for sediment larval testing

The assessment of adequate reference sediments for each batch of bioassay test samples is the first tier of significant effect determination. If the test with the reference sediment does not pass QA review, and no alternative reference option is available, then the test samples for those batches with rejected reference sediment results are excluded from the AET analysis. Most of the samples excluded from the 1994 amphipod mortality AET and the echinoderm abnormality AET were excluded because of inadequate reference sediment samples.

According to PSEP, samples are defined as a reference sediment "if it is in fact essentially free of contamination, can provide data that can be used to separate toxicant effects from unrelated effects such as those of sediment grain size." A pool of historical reference samples, stratified by sediment grain size and other factors affecting bioassay variability, should be made available. This historical pool could be used for comparison to test samples when adequate reference data are not available for a given bioassay batch.

A failed reference test does not necessarily indicate laboratory problems; those problems are evaluated by the negative and positive control samples. Operationally, performance of a reference sediment (good or poor) simply reflects the response of the test organisms to native Puget Sound sediment that is minimally contaminated. Providing that the reference sediment has been analyzed for contamination and for other factors (e.g., grain

size, total organic carbon, and ammonia), it is possible to draw an alternative conclusion that the reference test response is due to anything other than a response to natural sediment characteristics. While this sediment should not be used to establish reference area mortality or abnormality, it should not result in throwing out the associated batch of test samples. Establishing a database of all historical reference sample bioassay results, stratified appropriately, is recommended to maximize the amount of data available for calculating AET values.

Data excluded as being statistically inconclusive

Choice of statistical tests

Phase III of the significant effect determination recommends using tests which may not be the most appropriate. The tests selected (t-tests for comparison of means and the F-test for equality of variances) assume that the data are normally distributed. While the t-test is quite robust to deviations from normality, the F-test is not; in both tests, the presence of extreme values can lead to erroneous conclusions. A more robust testing procedure would be one using a nonparametric test which is based on ranks -- this test is not adversely affected by extreme values, nor does it require distributional assumptions. In addition, it results in greater statistical power (i.e., the ability to detect differences when they really exist) under most circumstances. A review of some of the bioassay results and the implications of the proposed testing procedures with respect to increased probability of Type I errors (i.e., erroneously calling a station a "Hit") or Type II errors (i.e., erroneously calling a station a "No-Hit") is recommended.

Statistical power considerations

Phase IV of the evaluation of bioassay data screens test samples by comparing the variability among replicates to a trigger value which is based on a percentile of the observed test sample data set. The logic of screening the test samples for excessive variability is sound (i.e., when the variability of the data is high then there can be less confidence in the observed mean, and consequently less confidence in the observed difference between means). However, the selection of the screening value (the 80th percentile of the test sample data set) is subjective, and not very meaningful with respect to the statistical issues which it presumes to address. By the nature of percentiles, a given percentage of the samples evaluated would automatically be rejected because of high variability, regardless of statistical relevance.

If the intent of this screening is to limit the probability of Type II errors, then a probabilistic approach should be taken. The procedure should be designed to screen out test samples which have excessive variability, consequently resulting in decreased power

to detect a biologically meaningful difference. This approach requires establishing a level of difference between reference and test samples that is biologically meaningful. The screening procedure would then be a power analysis to test whether variability is too high to result in an adequate assessment of significance at this predetermined level of difference.

The issue of statistical power is very important in the bioassay testing procedure and in the establishment of AET values. AET values are based on an observed relationship between the assessed chemical concentrations and significant biological effects. If there is error in either of these assessments, then the reliability of the AET values is seriously affected. Phase IV of the process to determine adverse biological effects advises a post-hoc power analysis which is well-intentioned. However, there has been some discussion in recent scientific literature indicating that a post-hoc power analysis is artificially bounded (ESA, 1995). A post-hoc power analysis using the original data (i.e., the observed difference of means and variance estimates) following a failure to reject the null hypothesis has an upper bound of 50%. Consequently, *any* post-hoc power analysis would result in an "Inconclusive" statistical evaluation by the rules outlined in the phased determination of significant adverse effects (Figure A-4; Gries and Waldow, 1995). *This type of screening will result in a final dataset that is much smaller than it should be based on accurate statistical considerations.* A post-hoc power analysis should be employed using an established "biological meaningful difference" rather than the observed difference of means.

The statistical evaluation procedure for the bioassay data requires some revisions to ensure statistical validity and appropriateness, and biological relevance. The risk of committing Type I and Type II errors may be increased beyond expectation when statistical tests are not applied appropriately. Because the setting of AET values hinges on the collection of "No-Hit" samples, the determination of biological significance should be as rigorous and robust as possible. To generate protective AETs (i.e., values sensitive to the potential for biological effects), we may prefer to err on the conservative side. Statistically, this means accepting a Type I error rate larger than alpha; practically, it means being more aggressive in determining what is called a "Hit." To generate reliable AETs (i.e., values which perform reasonably well at predicting both biological effects and non-effects), we should try to limit the Type II errors (i.e., maximize power). This can be accomplished by screening out highly variable samples which result in a low power test for the meaningful level of difference between reference and tests sediments.

Data excluded as being chemically anomalous

Data were determined to be chemically anomalous if a "No Hit" sample was one with a three-fold difference in chemical concentration between it and the highest adjacent "No-

Hit" sample, when these samples were ranked according to chemical concentration. The use of this methodology is in contrast to the definition of AET; in addition, it is not implemented as stated. For the recalculation of amphipod AETs, three chemicals of concern (2-methylphenol; 2,4-dimethylphenol, and silver) had two samples each regarded as anomalous, resulting in the *third* highest "No Hit" sample concentration setting the AET. The recalculated echinoderm AETS had two chemicals of concern, antimony and total PCBs, with multiple chemically anomalous samples. The echinoderm AET for antimony is based on the *fourth* highest "No Hit" concentration, due to three chemically anomalous samples (two samples were the same value), and the total PCBs AET based on the third highest "No Hit" concentration. In each of these examples of chemically anomalous data, the sample concentrations excluded differed by less than a factor of two from each other.

These samples were considered outliers because they exceed a subjective trigger value. The purpose of this trigger is to keep the AET value low, so that the predictive capacity of the established value is more sensitive. Therefore, the majority of the data with concentrations below the AET value will be "No Hit." However, a normal distribution of contaminant concentrations (and associated biological effects) should not be expected over the entire dataset. The distribution will be truncated at the analytical detection limit and have sporadic frequency at higher concentrations as data from chemically distinctive contaminated sites are collected. In statistical applications, a data point may be legitimately identified as anomalous (i.e. "outlier") for one of two reasons:

1) The accuracy of the data is in question, or there is clearly an error. In the case of the AET database, either the chemistry, the biology, or both may be in error. Consequently, the data points which are unreliable should be excluded from the database. However, the QA/QC guidelines and the laboratory control standards should detect any errors with respect to data quality.

2) The data associated with a particular station may be correct, but the data do not meet the assumptions of the current model. In the case of AETs, high concentrations of contaminants are expected, since most sites investigated are considered to be chemically degraded.

If a station has both very high chemistry and no apparent biological effects, then:

either

a)The biological responses used are insensitive to this level of contamination. In this case the regulations should require a bioassay or suite of bioassays which provide the acceptable level of sensitivity or a positive control

(reference toxicant) bioassay that would indicate insensitivity of a particular test batch,

or

b)The contaminant in question is not toxic in the system being tested or readily bioavailable. This may be a result of the interference of toxicity associated with high concentrations of one compound due to high concentrations of another (antagonistic effects) or the composition of the contaminant.

The AET approach assumes a simplified model of positively correlated biological effects and chemical contamination. The example above describes the situation where a more complex toxicological model is required. If there is evidence that there is interference between certain chemical compounds (either synergistic or antagonistic), then the AET model should not be applied for those compounds. If there is no evidence for an alternative model, then the AET model can represent the null hypothesis and the AET values should be based on all available data which passes QA or laboratory control procedures. There is no reason to assume a valid datapoint with high chemistry and no apparent biological effect is any less accurate than a valid datapoint with moderate chemistry and no apparent biological effect.

An appropriate case for which data can truly be considered chemically anomalous would be when the substrate of a site (e.g., ASARCO slag) are not typical of Puget Sound substrates. Data are not comparable when the substrates are radically different, and therefore such samples should not be included in an AET calculation. However, excluding anomalous data due to non-typical substrate should be decided upon at the beginning of the process when potential datasets are identified, not after reviewing the analytical chemistry/bioassay results.

PROPOSED ACTIONS/MODIFICATIONS

Sediment management decisions should be made based on all of the high quality data (e.g., data that passes a QA2 review) that are available. Only data that have failed to meet QA/QC guidelines, and are therefore considered to be invalid, should be excluded from AET calculations. The following proposed modifications are designed to maximize the inclusion of quality data without compromising the overall integrity of the database and to speed the process by which AETs are recalculated.

The identification of high quality synoptic data sets for inclusion into the AET database should remain essentially the same. Synoptic datasets collected from sites with substrates

typical of Puget Sound should undergo a QA/QC review at a QA2 level for chemistry and bioassays.

1) Inclusion of data with no reference or poor reference performance

As per the QA2 data requirements, assessment of bioassay performance should be based upon reference toxicants and problems that may have influenced data quality (i.e, negative control results). Upon meeting QA/QC requirements, test results are compared to reference data to determine whether the sample is a "Hit" or "No Hit". Presently, a "Hit" is determined when the test sample demonstrates a mean mortality that is 25% or greater than the mean mortality of one or more reference samples. The proposed modification is to identify a pool of historical reference samples, stratified by sediment grain size and other factors affecting bioassay variability, to create a default reference value. The default reference value could be used for comparison to test samples when an adequate reference is not available for a given bioassay batch.

2) Re-evaluate data previously deemed statistically inconclusive

The second proposed modification is to revise the analytical and statistical methods used to assess the significance of biological effects. The revision should include:

a) An evaluation of the appropriateness of the recommended parametric significance tests, and recommendations for alternative non-parametric tests.

b) Application of a probabilistic approach to screen the test samples for excessive variability among replicate observations.

c) Revision of the rule which requires a post-hoc power analysis to use a "biologically meaningful difference," rather than the observed difference of means.

3) Inclusion of data previously deemed chemically anomalous

The final proposed modification is to include all data in the AET database that meet required QA/QC guidelines. Data considered to be valid should be included regardless of how it affects an AET value or the predictive reliability of the resulting AET value. The AET database should contain data representative of all the information collected to date on Puget Sound sediments.

REFERENCES

Corps. 1996. QA2 data requirements. U.S. Army Corps of Engineering DMMO Dredge, Material Management Office, Seattle, WA.

ESA. 1995. Statistical Ecology Section, Spring 1995 newsletter. Ecological Society of America.

Gries, T.H. and K.H. Waldow. 1995. Re-evaluation of some Puget Sound AETs. Prepared for Puget Sound Dredged Disposal Analysis (PSDDA): U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10; Washington Department of Ecology; Washington Department of Natural Resources.

PSEP. 1991. Puget Sound Estuary Program. Recommended guidelines for conducting laboratory bioassays on Puget Sound sediments. Final Report. Prepared by PTI Environmental Services, Inc. For U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, and U.S. Army Corps of Engineers, Seattle District.

PTI. 1989. Data validation guidance manual for selected sediment variables. Prepared for Washington Department of Ecology, Olympia, Washington. PTI Environmental Services, Bellevue, WA.

PSDDA/SMS ISSUE PAPER

LARVAL BIOASSAY SENSITIVITY ASSESSMENT

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INTRODUCTION

Present approaches to evaluating sediment quality rely upon chemical concentration data and biological toxicity data. Toxicity assessments are obtained from a series of bioassays exposing test organisms to environmental sediment samples. The species used in these bioassays may vary; particularly among bivalve larvae (*Crassostrea gigas, Mytilus edulis,* or *M. galloprovincialis*) and echinoderm larvae (*Dendraster excentricus* or *Strongylocentrotus purpuratus*). For the bivalve test, the above five species are considered to be interchangeable in testing Puget Sound sediment for regulatory purposes.

During the 1994 recalculation of the Puget Sound AETs, phylum-specific AETs were developed using the bivalve and the echinoderm species test data. The results of the AET recalculation suggests that there are significant differences between the phyla to toxicants, with the echinoderm species apparently more sensitive to a number of metals and a majority of the polycyclic aromatic hydrocarbon (PAH) compounds commonly tested in Puget Sound sediments.

The purpose of this study is to investigate whether larvae of these four species exhibit different sensitivities (at the phyla level or the individual species level) to reference toxicity materials. The endpoint chosen to measure sensitivity is the EC50 value from the positive controls of bioassay batches run at several labs over several years. The EC50 value is the concentration of reference toxicant which adversely affects 50% of the initial population (these effects are manifested as death or visible abnormality/deformity). If the different species demonstrate a noticeable difference in their sensitivities to any of the toxicants tested, a similar response to the forms of contaminants present in environmental samples could be expected.

PROBLEM IDENTIFICATION

Gries and Waldon (1995) have presented the bivalve and echinoderm AETs separately. From this presentation it can be inferred that in the future there is a potential for individual AETs to be promulgated for echinoderm and bivalve. This issue paper presents data supporting the prudence in keeping the echinoderm and bivalve AETs combined.

To determine if sediment is suitable for unconfined, open-water disposal, PSDDA requires measurements of certain chemicals in the sediment. If the concentration of each contaminant of concern in the sediment is less than their respective screening level (SL), open-water disposal is

allowed. If concentrations of one or more contaminants are greater than the SL, but less than the maximum level (ML), bioassays are required to determine if open-water disposal is appropriate. At this point the dredging project proponent has the option to conduct biological testing or accept the unsuitability of the tested sediment for open-water disposal. If the proponent decides to conduct bioassays, the results of these toxicity test will determine the suitability of the sediment for open-water disposal. Bioassay testing requires the use of three different species, including at least one larval test, to provide phylogenetic diversity that might address the different sensitivities of various taxa to a range of chemicals.

Current PSDDA sediment testing procedures allow for the dredging project proponent to select among five species when conducting the larval toxicity test. The PSDDA agencies have determined that the five species used in the testing have similar sensitivities to contaminants of interest and therefore using any one of the five species provides data sufficient to assess the suitability of material for open water disposal. Seasonal availability of larvae for each of the five test species varies, and having a choice of species ensures that the dredging proponent can choose the most appropriate species for the season. Reducing the number of species available, or placing different degrees on the sensitivity of the species or phylum could significantly reduce a dredging proponent's options in test selection. In addition, these limitations could potentially slow the decision making process regarding the disposal of dredged material from a particular site. The 1994 AET recalculation analysis suggests (based on developing separate AETs for bivalves and echinoderms) that there is a substantial difference in the sensitivity. Prior to a decision by the PSDDA agencies regarding species sensitivity and the development of separate AETs, side-by-side comparisons should be made exposing all five species to a select set of contaminants. The results of these comparisons can be used to assess whether the presence and magnitude of sensitivity differences are significant enough to warrant segregating the test species based on phyla.

This paper offers some preliminary results on the sensitivities of the five species used in larval toxicity tests, to a selected set of contaminants.

TECHNICAL BACKGROUND AND DISCUSSION

Sources of Data

The ideal situation to test for different sensitivities among the identified species would be in an experiment designed for this purpose. In most laboratories, positive controls that use reference toxicity materials are run simultaneously with each bioassay batch. This information has already been generated and can be used for an initial investigation of possible differences in the sensitivity of different larval species to reference toxicants. EC50 data were requested from several laboratories and from the DAIS database of the Seattle Corps of Engineers (COE). The resulting database used in this assessment includes information provided by Battelle Labs (Sequim, Washington), EVS Labs (North Vancouver, B.C.), and various laboratories and studies contributing to the DAIS database.

Measure of Sensitivity

The positive control procedure involves running a series of seawater bioassays at increasing concentrations of a reference toxicant. The series of concentrations (e.g., 0, 2, 4, 8, 16, 32 mg/L) should result in several partial mortalities in order for an EC50 to be adequately estimated. The EC50 value corresponds to the concentration which yields 50% effective mortality. A lower EC50 value indicates a greater sensitivity to the reference toxicant.

Sources of Variability

Much of the data compiled for this paper is historical, and information regarding many of the potential sources of variability is unavailable at this time. Some of the more important sources of variability are: water treatment (flow-through vs. static test chambers); source of water (fresh natural sea water, natural sea water which has been held for several days, or manufactured sea water); measurement of the concentration in the test chamber water or estimation from the original spiking procedure; laboratory conditions and personnel; time of year; source of organisms. Because of the review (rather than experimental) nature of this study, the influence of these sources cannot be separated. Any observed differences in sensitivity, or lack thereof, will have to be considered in light of the multiple sources of variability.

The Data

The queries to the DAIS database and area labs resulted in data generated by seven laboratories over 7 years (1989-1995). These data are summarized in Table 1.

Table 1. EC50 Values by Reference Toxicant and Species

	Bivalve Larvae			Echinoderm Larvae	
Reference Toxicant	*Crassostrea gigas*	*Mytilus edulis*	*Mytilus galloprovincialis*	*Dendraster excentricus*	*Strongylocentrotus purpuratus*
Cadmium (mg/L) median (range) sample size	1.2 (0.42-2.3) n=18	2.0 (0.40-4.3) n=10	3.4 (1.9-5.6) n=5	6.0 (1.9-23) n=30	0.32 (0.03-89) n=8
Copper (mg/L)	10 (8.2-25) n=5	—	7.7 (3.3-15) n=25	17 (15-24) n=10	27 (21-32) n=2
Ammonia (mg/L)	7.1 (6.8-7.6) n=4	—	6.4 (2.2-13) n=13	2.65 (2.4-2.9) n=2	—
Sodium dodecyl sulphate (SDS) (mg/L)	3.6 (2.1-4.2) n=21	3.7 (2.4-5.0) n=20	—	3.1 (2.0-9.1) n=8	6.4 (2.9-8.4) n=12

There is insufficient data to statistically compare all species for all toxicants. However, a graphical display of the distributions of the data by toxicant can illustrate some of the potential differences.

Statistical/Analytical Methods

The data compiled exhibit unequal variances between species for some contaminants (Figure 1). In addition, the distributions are sometimes highly skewed making them poor candidates for an ANOVA model. Based on visual inspection and professional judgment, these data were not expected to meet the assumptions of a parametric ANOVA test. Consequently, a nonparametric ANOVA (Kruskall-Wallis) was used to test for differences in EC50 values among the different species. The nonparametric ANOVA is a robust test for differences in locations (e.g., median) and requires fewer assumptions about the data than the standard parametric ANOVA.

Boxplots (also known as box and whisker plots) are used to visually explore the location, spread, and skewness of a group of data (Figure 1). They are particularly useful when boxplots for several groups are placed side by side for comparison. The information conveyed in the boxplots are the range of values, the 1st, 2nd (median), and 3rd quartiles, along with any suspected "outliers." The "outliers" are values which exceed 1.5 times the interquartile distance (the difference between the 1st and 3rd quartiles) from the median. When these extreme values are present in a boxed group, the whiskers are shown at 1.5 times the interquartile distance from the median. When statistical tests cannot be applied due to highly irregular sample sizes, interpretations can be made from the graphs.

Cadmium

The different species appear to have different responses to cadmium. With the widely different sample sizes it is difficult to clearly say whether the differences are real. However, from the graphical displays, there is evidence that *S. purpuratus* is much more sensitive to cadmium than is *D. excentricus*. [The high value (89) was excluded from the *S. purpuratus* group prior to analysis because of the possibility of a misrepresentation in the units. Other values from this lab were reported in μg/L.] Also, the group of bivalves (*Mytilus* spp. and *C. gigas*) seem to have fairly similar responses, particularly when compared to the values observed within *D. excentricus*. The variability observed in the *D. excentricus* results can be primarily attributed to high intralab variability for one lab in particular (n=17). A Kruskall-Wallis test for the differences among all species was highly significant ($p<<0.01$).

Copper

From the graphical displays, *S. purpuratus* would appear to be less sensitive to copper than the other species (in contrast to the results from the cadmium reference toxicant). However, this conclusion is based on two samples, and is merely suggestive. The differences between

D. excentricus and each of the bivalve species are large enough to suggest real differences. A Kruskall-Wallis test for the differences among all species was highly significant ($p<<0.01$).

Ammonia

For the ammonia results, the sample sizes were too small to make a valid comparison among the species. The results for *M. galloprovincialis* are all from a single lab (Battelle), and aside from a single high value in this group, the values are otherwise quite comparable with the *C. gigas* results.

D. excentricus would appear to have very high sensitivity to ammonia, although results for two samples are insufficient to provide any conclusive evidence. A Kruskall-Wallis test was non-significant ($p=0.69$) for comparisons between the two bivalve species. Comparisons among all species was also non-significant ($p=0.30$).

Sodium dodecyl sulphate (SDS)

The range of responses for each species overlaps considerably; however, the median values vary, with *D. excentricus* exhibiting greatest sensitivity and *S. purpuratus* the lowest. There appears to be less variability in sensitivity between the two bivalve species than between the two echinoderm species. The greatest difference in sensitivities is between *S. purpuratus* and the other species. A Kruskall-Wallis test for comparison of sensitivities across all species was significant ($p<0.01$).

Summary

The results of the above analysis do not indicate a clear direction in differential sensitivity for any one species for all reference toxicants, or for clear differential sensitivity for the two phyla. Differences in sensitivity to reference toxicants are apparent. For example, *D. excentricus* appears to be the least sensitive to cadmium of the five species tested, while *S. purpuratus* appears to have the greatest sensitivity to cadmium. The bivalves are intermediate to the two extremes shown in the echinoderm species. On the other hand, echinoderms appeared to be less sensitive to copper than the bivalves. Echinoderms appear to have sensitivity comparable to the bivalves for SDS, although *S. purpuratus* appears slightly less sensitive. The results for ammonia are the least compelling (because of sample sizes), although they suggest comparable sensitivities within the bivalve group, and slightly increased sensitivity for *D. excentricus*.

The present cadmium AET for bivalve larvae is 9.6 mg/kg dry weight (DW), and that proposed for echinoderm larvae is 2.7 mg/kg DW. The difference in the AETs predicts that echinoderm larvae should be more sensitive to cadmium than are bivalve larvae. In contrast, the results of this analysis indicate that larvae of one species of echinoderm, *D. excentricus*, appears to be less sensitive to cadmium that the bivalve larvae, while the other species of echinoderm, *S. purpuratus*, appears to be more sensitive. The present copper AET for bivalve larvae and

proposed for echinoderm larvae is 390 mg/kg DW. The present analysis indicates that bivalve larvae may be more sensitive to copper than the echinoderm larvae.

There is variability within each phylum as well as between them. In addition, the influence of the other potential sources of variability cannot be discriminated, and so there is the possibility of bias that has an unpredictable effect on the statistics. Comparison of the AETs and the results of this study for cadmium and copper provide an example in which there is not a consistent basis for supporting establishment of separate AETs for the two phyla.

PROPOSED ACTIONS/MODIFICATIONS

This study is based on the results of bioassays that used single, known reference toxicants. Even so, the statistical results concerning differences in sensitivity between larval organisms from bivalve and echinoderm phyla, as well as between species within each phylum, were inconclusive. Consequently, in the interest of facilitating the PSDDA decision making process, it is recommended that the species continue to be used interchangeably in the bioassay tests. Additional, controlled bioassay studies should be conducted using representative compounds from each group of contaminants to investigate differences in sensitivities of different organisms. Results of this type of study would be used to decide whether to establish individual AETs that are either species based or phylum based.

REFERENCES

Gries, T.H. and Waldon, K.H. 1995. Re-evaluation of some Puget Sound AETs. Draft Report. Department of Ecology for Puget Sound Dredged Disposal Analysis (PSDDA). Olympia, WA.

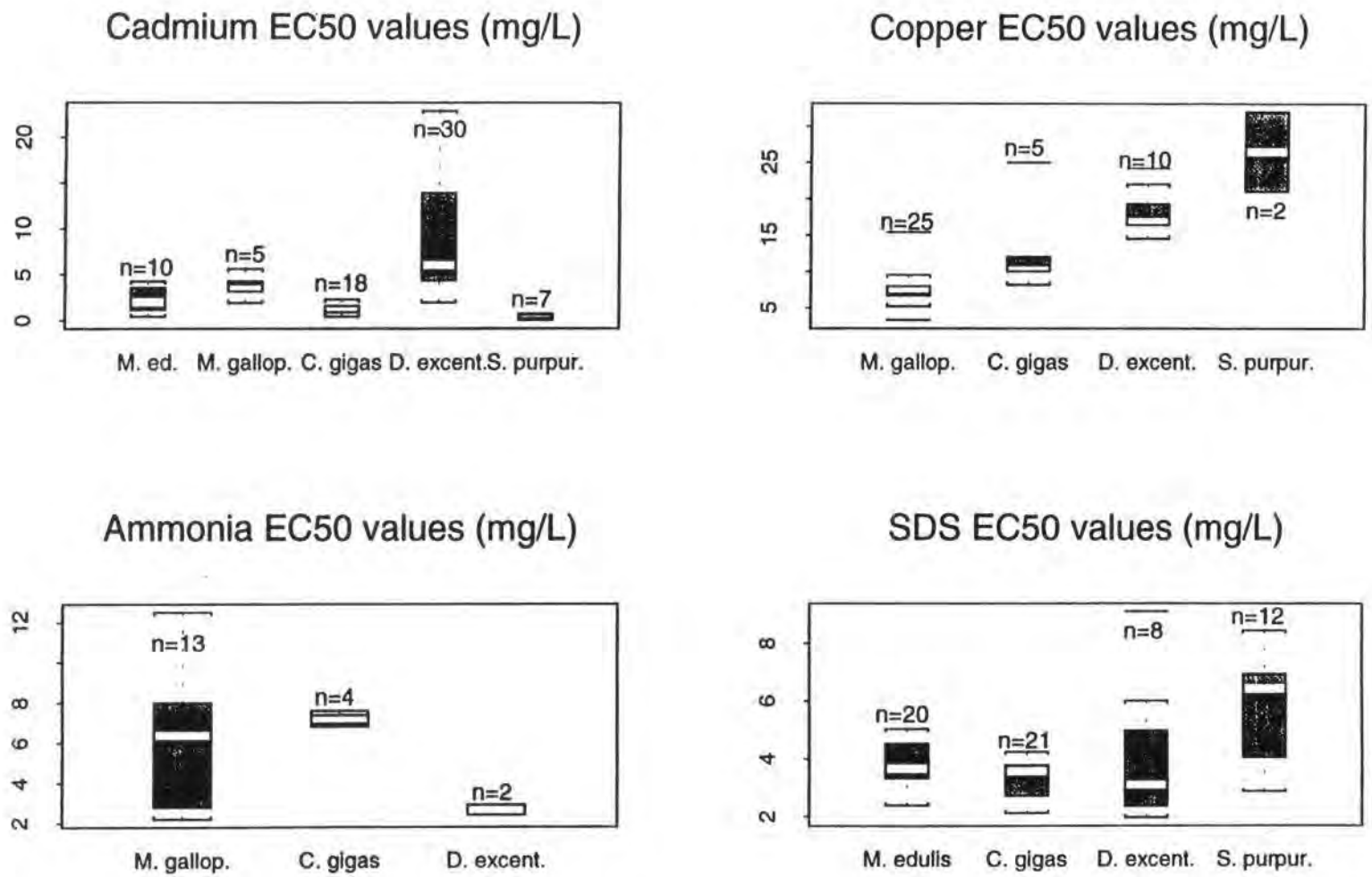

Figure 1. Distribution of EC50 values, with sample sizes

SMS DRAFT TECHNICAL INFORMATION MEMORANDUM 3/7/96

QUALITY ASSURANCE GUIDELINES FOR THE SEDIMENT LARVAL BIOASSAY

Prepared by Dr. Teresa Michelsen (Washington Department of Ecology, 206/649-7257).

INTRODUCTION

The larval bioassay is one of the bioassays used under the Sediment Management Standards (SMS) to evaluate the need for sediment cleanup and source control. It is also one of the tests used by the PSDDA program to evaluate the suitability of dredged material for open-water disposal. Over the last five years, the PSDDA/SMS agencies have had the opportunity to evaluate a large number of larval bioassay tests and have made various modifications to the performance standards for the larval bioassay.

On June 16, 1994, a final PSDDA Clarification Paper took effect providing a number of modifications to the larval performance standards, including:

- Decreasing the seawater control performance standard to 30% effective mortality
- Establishing a reference sediment performance standard of 35% effective mortality (seawater normalized)
- Increasing the alpha level for the test of statistical significance to 0.1 to account for typical replicate variability.

The reader is referred to the 1994 PSDDA clarification paper for a detailed explanation of the rationale behind these changes. In general, these changes were implemented to increase the statistical validity of the tests, provide greater environmental protectiveness, and reduce the number of retests required.

At the 1995 SMARM (May, 1995) a draft SMS triennial review paper was presented that proposed changing the seawater control performance standard in the SMS rule, and further study to determine whether the additional PSDDA modifications should also be adopted as technical guidance for the SMS program. Following public review, the seawater control performance standard was revised to 30% in the 1995 update of the PSEP bioassay protocols and was also adopted in the December 1995 revisions to the SMS rule.

This Technical Information Memorandum discusses the additional PSDDA guidance for the larval bioassay and confirms that these technical guidelines are appropriate for use under the SMS program. Draft SMS Technical Information Memoranda are available for public and agency review through the SMARM process, and will be finalized once public comments have been received. Final Technical Information Memoranda will be distributed to all SMARM participants and to the mailing list for

the SMS Source Control and Sediment Cleanup Users' Manuals.

PROBLEM STATEMENT

The SMS cleanup program has been implemented over the last three years. Experience during this time has shown that critical site decisions may depend on the results of bioassay evaluations, which override chemical data under the rule. Often the results of the bioassay evaluations are dependent on QA evaluations, which include review of a wide variety of data types in addition to the few performance standards listed in the rule. For example, positive and negative control performance, reference station performance, water quality parameters, holding times, and larval viability may all be reviewed during a QA review. Each of these factors may affect data usability and subsequent interpretation of the results. WAC 173-204-130(9) requires determinations regarding sediment quality to be made in consideration of an appropriate QA/QC program, as determined by Ecology.

Evaluation of the reference station performance is critical to decisions about the site, since the Sediment Quality Standard (SQS) for the larval bioassay is defined as 15% effective mortality plus the effective mortality of the reference station, and the Cleanup Screening Level (CSL) is defined as 30% effective mortality plus the effective mortality of the reference station. Thus, the effective mortality at the reference station defines the SQS and CSL for this bioassay, and may significantly impact decisions regarding the need for cleanup and source control at the site or discharge location. In both the PSDDA and SMS programs, reference stations are expected to be collected from approved reference areas with little or no chemical contamination.

The lack of a defined performance standard for the larval bioassay has led to a general expectation among regulated parties that any level of effective mortality at the reference station is acceptable. However, WAC 173-204-200(22) states that reference sediment samples "cannot exceed the applicable Sediment Quality Standards" (SQS) listed in WAC 173-204-320 through 340. SQS levels are further defined in §320 as levels that result in "no acute or chronic adverse effects". At some sites, reference stations have been submitted for approval that exceeded 60% effective mortality. If this were considered acceptable, then the SQS would be set at 75% effective mortality and the CSL at 90% effective mortality. These levels far exceed the narrative definitions of the reference station (below no adverse effects levels), SQS (no adverse effects), and CSL (minor adverse effects), and are not consistent with the intent of the rule.

In addition, the replicate variability is generally high enough at these levels of adverse effects that it may not be possible to exceed the CSL. This occurs because the definition of the CSL includes not only comparison to a numerical effects level but a demonstration of statistical difference from the reference station. For these reasons, a performance standard for the reference station is needed to define a level that meets the narrative definition of a reference station in the rule. In addition, tools are needed

to address the higher level of replicate variability sometimes observed in this test.

QUALITY ASSURANCE GUIDELINES

This paper affirms that, during the normal QA review of bioassay data, Ecology may reject data for reasons other than the basic performance standards listed in the rule if, in our judgment, the data do not meet data quality objectives and cannot be used for regulatory decision-making. Authority for this determination, and for setting appropriate QA/QC objectives, is provided by WAC 173-204-130(9).

Ecology will rely on publicly-reviewed PSEP and PSDDA guidance in making these decisions. For the larval bioassay in particular, the 1994 PSDDA clarification paper will be used as additional guidance to assess the acceptability of the bioassay data. In summary, that paper recommends:

- A reference sediment performance standard (seawater-normalized) of 35% effective mortality
- An increase in the alpha level to 0.1
- A power analysis to evaluate the power of the data if the standard deviation of reference and/or test sediments exceeds 20%

It should be noted that the reference area performance standard is *normalized to the sea-water control.* In other words, once the seawater control is determined to be acceptable, the number of normal survivors (as opposed to the total number of organisms) in the seawater control is used as the benchmark for comparison to the reference and site data. Thus, the reference sediment must have at least 65% of the number of normal survivors in the seawater control.

EVALUATION OF THE BENTHIC CRITERION FOR PCB AETs.

Prepared by Jack Word and William Gardiner, Battelle Marine Sciences Laboratory, (360) 683-4151 and Gary Rosenthal, EVS Environment Consultants for the Port of Seattle.

INTRODUCTION

Chemical-specific sediment quality values have been developed to assess sediment contamination in Puget Sound. These apparent-effects thresholds (AETs) are developed from chemical and biological data collected from stations throughout Puget Sound and are based, in part, on a benthic component. The Benthic AET is defined as that chemical concentration above which a significant depression in benthic faunal abundance, relative to an appropriate reference station, is always expected. The purpose of this paper is to evaluate data used to determine the Benthic AET for PCBs and to identify several inconsistencies in AET support documents which directly influence the Benthic AET value for PCBs.

TECHNICAL BACKGROUND AND DISCUSSION

The AET approach identifies concentrations of contaminants that are associated with sediments having statistically significant biological effects, relative to an appropriate reference. The AET is the *highest* chemical concentration in which *no* biological effects are observed. For the Benthic AET, the measured biological effect is a significant depression in total infaunal abundance or in the abundances of either polychaetes, molluscs, or crustaceans.

Determinations for the Benthic AETs were made from a database including 190 sediment stations sampled under seven different investigations (Tetra Tech 1986). Benthic infaunal abundance was statistically compared to an appropriate reference station and classified using the following benthic codes:

0 = no data available
1 = no statistically significant reduction in abundance of any major taxonomic group
2 = a statistically significant reduction in abundance in one major taxonomic group
3 = a statistically significant reduction in abundance in more than one major taxonomic group.

Stations scoring a "1" were considered unimpacted, with no benthic effect. Stations scoring a "2" or "3" were considered impacted, with a significant depression in infaunal abundance. Stations scoring a "0" were not included in determining a benthic AET because of the lack of appropriate biological or chemical data.

Additionally, stations were scored with the classification codes:

* = station was not used for developing sediment quality values due to a lack of appropriate biological data
E = estimated chemical concentration
U = undetected, concentration at or above the given value
Y = statistically significant reduction in the abundance of one or more taxonomic groups
N = no statistically significant reduction in the abundance of any taxonomic group.

A synopsis of the chemical and benthic data used to determine the Benthic AET for PCBs is presented in Table 1. PCB data in this table are TOC corrected and are presented as mg PCB/kg TOC, where total PCBs are the sum of all analyzed aroclors.

According to the Tetra Tech (1986) document, the Benthic AET concentration for total PCBs is 83 mg/kg TOC. This value was established from data collected at station WP-07-1812. However, according to page A135 of the Tetra Tech document, station WP-07-1812 lacked appropriate biological data, as indicated by an asterisk and a benthic code of "0". This lack of biological data would, therefore, disqualify this station from the Benthic AET determination.

Furthermore, it is unclear what is meant by "appropriate biological data". It is possible that this refers to the lack of an appropriate reference; however, there a several instances where multiple samples are collected from the same site, yet only one sample is classified as "lacking appropriate data".

If station WP-07-1812 were disqualified from the benthic data set, station WP-09-2082 would define the Benthic AET for total PCBs at 65 mg/kg TOC. However, another station, WP-08-2083, with a higher total PCB concentration (270 mg/kg TOC) also received a benthic code of "1", meaning no significant reduction in any major taxonomic group. This station then represents the *"highest* chemical concentration in which *no* biological effects are observed" and by definition should determine the benthic AET for total PCBs. This is more than 3-times higher than the current AET, determined by a station which lacks any appropriate biological data.

Finally, the majority of the data used to determine the Benthic AET for total PCBs was collected from Elliot Bay, with the exception of one station from the Hylebos Waterway. All stations that exceeded the 270 mg/kg TOC value were shallow water Denny Way CSO samples with extensive organic debris. It is possible that the organic debris was responsible for reduced infaunal diversity rather than the PCB concentrations in the sediments.

PROPOSED ACTIONS OR MODIFICATIONS

Two issues need to be addressed:

1) The raw data used to determine the Benthic AET for total PCBs should be reevaluated to check for inappropriate classifications and possible inconsistencies.

2) The station locations for the Benthic AET for total PCBs should be evaluated for the possibility of confounding factors, such as heavy organic enrichment. Supplementation of the existing database should also be considered.

REFERENCES

Tetra-Tech. (1986). *Application of Selected Sediment Quality Value Approaches to Puget Sound Data* (Draft). Report No. TC3090-02. Prepared for the US Army Corps of Engineers, Seattle, Washington.

TABLE 1. Data used for PCB Benthic AET determination (from Tetra Tech 1986).

SURVEY	STATION	SAMPLE	CONCENTRATION MG/KG TOC	HIT	BENTHIC CODE	ORIGINAL STATION	LOCATION
TPPS3AB	EB-36	1776	670	Y	2	1606	DENNY WAY CSO
TPPS3AB	EB-35	1775	510	Y	2	1603	DENNY WAY CSO
TPPS3AB	EB-33	2080	380	Y	3	1406	DENNY WAY CSO
TPPS3AB	WP-08	2083	270	Y	1	810	WEST OF 4-MILE ROCK
TPPS3AB	EB-35	2079	220	Y	2	1603	DENNY WAY CSO
EBCHEM	KG-06	KG-06	E190	Y	NA[a]	NA	NA
EBCHEM	MG-04	MG-04	U130	Y	NA	NA	NA
TPPS3AB	EB-33	1779	120	Y	3	1406	DENNY WAY CSO
EBCHEM	NH-03	NH-03	E110	Y	NA	NA	NA
EBCHEM	WW-05	WW-05	E98	Y	NA	NA	NA
EBCHEM	SS-01	SS-01	U95	N	NA	NA	NA
EBCHEM	MG-03	MG-03	U83	Y	NA	NA	NA
TPPS3AB*	WP-07	1812	83	N	0	730	SW OF WEST POINT
TPPS3AB	EB-36	2072	79	Y	3	1606	DENNY WAY CSO
EBCHEM	MG-02	MG-02	U76	Y	NA	NA	NA
EBCHEM	NH-08	NH-08	E66	Y	NA	NA	NA
TPPS3AB	WP-09	2082	65	N	1	830	4-MILE ROCK
EBCHEM	WW-03	WW-03	U64	Y			
TPPS3AB	EB-38	1778	56	N	1	1706	DENNY WAY CSO
EBCHEM	AB-03	AB-03	U55	T	NA	NA	NA
CBMSQA	HY-47	HY-47	U54	Y	NA	NA	HYLEBOS WATERWAY
TPPS3AB	WP-13	1784	53	N	1	375	BASIN OFF WEST POINT

(a) NA Data not available in Tetra Tech (1986).

SMS DRAFT TECHNICAL INFORMATION MEMORANDUM

SMS LARVAL BIOASSAY REFERENCE SEDIMENT PERFORMANCE STANDARD

Prepared by Pamela Sparks-McConkey (Washington Department of Ecology, (360) 407-6491)

INTRODUCTION

The larval bioassay is one of five bioassays used under the Sediment Management Standards (SMS), Chapter 173-204 WAC to evaluate the need for source control and sediment cleanup. However, to ensure the validity of the bioassay results for use as a sediment decision tool, performance standards and combined mortality and abnormality (effective mortality) results from both negative controls and reference sediments are used. The SMS cleanup program experience has been that larval quality assurance (QA) evaluations and critical sediment decisions are complicated by variable or poor performance of the reference sediments. This technical memorandum is a companion to the SMS technical information memorandum: *Quality Assurance Guidelines for the Sediment Larval Bioassay* (draft 1996), and is intended to provide further justification for these modifications based on analysis of Ecology's Sediment Quality Database (SEDQUAL) data.

Recently, Ecology had the opportunity to evaluate a large number of larval bioassay tests in SEDQUAL, and has proposed to established a reference performance biological standard for the SMS larval bioassay tests. For consistency purposes, Ecology has taken into consideration the current Puget Sound Dredged Disposal Analysis (PSDDA) program guideline on reference sediment seawater-normalized effective mortality (Fox and Littleton, 1994).

PROBLEM STATEMENT

The SMS rule does not specify a reference sediment performance standard for effective mortality. During bioassay data review, a QA review of the reference sediment performance is made to ensure there is an appropriate basis for comparison to test samples. Numerous SMS projects have been received with high effective mortality in reference sediments. When these reference sediments have been used for test interpretation, a very high mortality is required in order to exceed the sediment quality standard (SQS) or cleanup screening level (CSL). Such high reference mortality (e.g. 70 percent) is not consistent with the SMS rule concerning sediment designation determinations using appropriate quality assurance/quality control procedures for biological data (WAC 173-204-130(9)) or with the intent of the reference performance standards narrative to limit

unacceptable high variability (WAC 173-204- 315(2)). Currently, the site project managers use their best professional judgement to meet the intent of these SMS sections in evaluating such data sets.

DISCUSSION

The SMS larval bioassay data in Ecology's SEDQUAL database was used to derive frequency distributions for absolute effective mortality in reference sediments. Frequency distributions for the echinoderm larval bioassay data were derived for absolute effective mortality in reference sediments (Figure 1). The echinoderm test is the most frequently used bioassay test under both PSDDA and SMS programs. The large majority of the larval reference samples had effective mortality below 35 percent. The data below 35 percent suggest a normal distribution such as might be found in natural occurring populations. The distributions in this figure suggest similarities to the PSDDA guideline for reference sediment seawater-normalized effective mortality of thirty-five percent. No significant correlations between absolute effective mortality and sediment grain size particles were established (r=.19).

Frequency distributions for standard deviations associated with the SEDQUAL reference sediment effective mortality means are presented in Figure 2. Review of this figure identifies similar distributions as found in the PSDDA clarification paper (Fox and Littleton, 1994), with the majority of SEDQUAL data exhibiting standard deviations of 18 percent or less. In addition, these results are also similar to previous work conducted in Ecology's Sediment Management Section (Gries and Waldow, 1994). Gries and Waldo identified a standard deviation no greater than 22 percent associated with the replicate sample results of reference sediments when using a 95th percentile as guidance. Review of Figure 2 resulted in the 95th percentile occurring at a standard deviation of 18.4 percent. The reduction in the standard deviation results from the earlier work does seem reasonable because a larger sample of data (n=104) was used in conducting this evaluation.

This evaluation identifies a similar deviation level as the PSDDA 1994 guideline, and therefore the SMS program supports increase of the alpha level to 0.1 (similar to PSDDA) for interpretation of this test.

PROPOSED ACTION/MODIFICATION

Ecology proposes under WAC 173-204-130(4), Administrative policies, to establish an alternate technical method to enhance the application of larval bioassay test data as follows:

A larval reference sediment performance standard will be set at a seawater normalized effective mortality of 35 percent.

An increase in the alpha level to 0.1.

This is consistent with PSDDA guidance and will provide a more reliable sediment larval toxicity test for projects under the SMS program. Please refer to the SMS draft technical information memorandum by Dr. Teresa Michelsen for further discussion.

REFERENCES

Chapter 173-204 WAC, Sediment Management Standards, December 1995.

Fox, D. and T. Littleton. Clarification Paper. PSDDA 1994.

Gries, T. and K. Waldow. 1994. Re-evaluation of Some Puget Sound Apparent Effects Thresholds. Washington Department of Ecology.

Michelsen, Teresa. 1996. SMS draft technical memorandum: Quality Assurance Guidelines for the Sediment Larval Bioassay. Washington Department of Ecolgy.

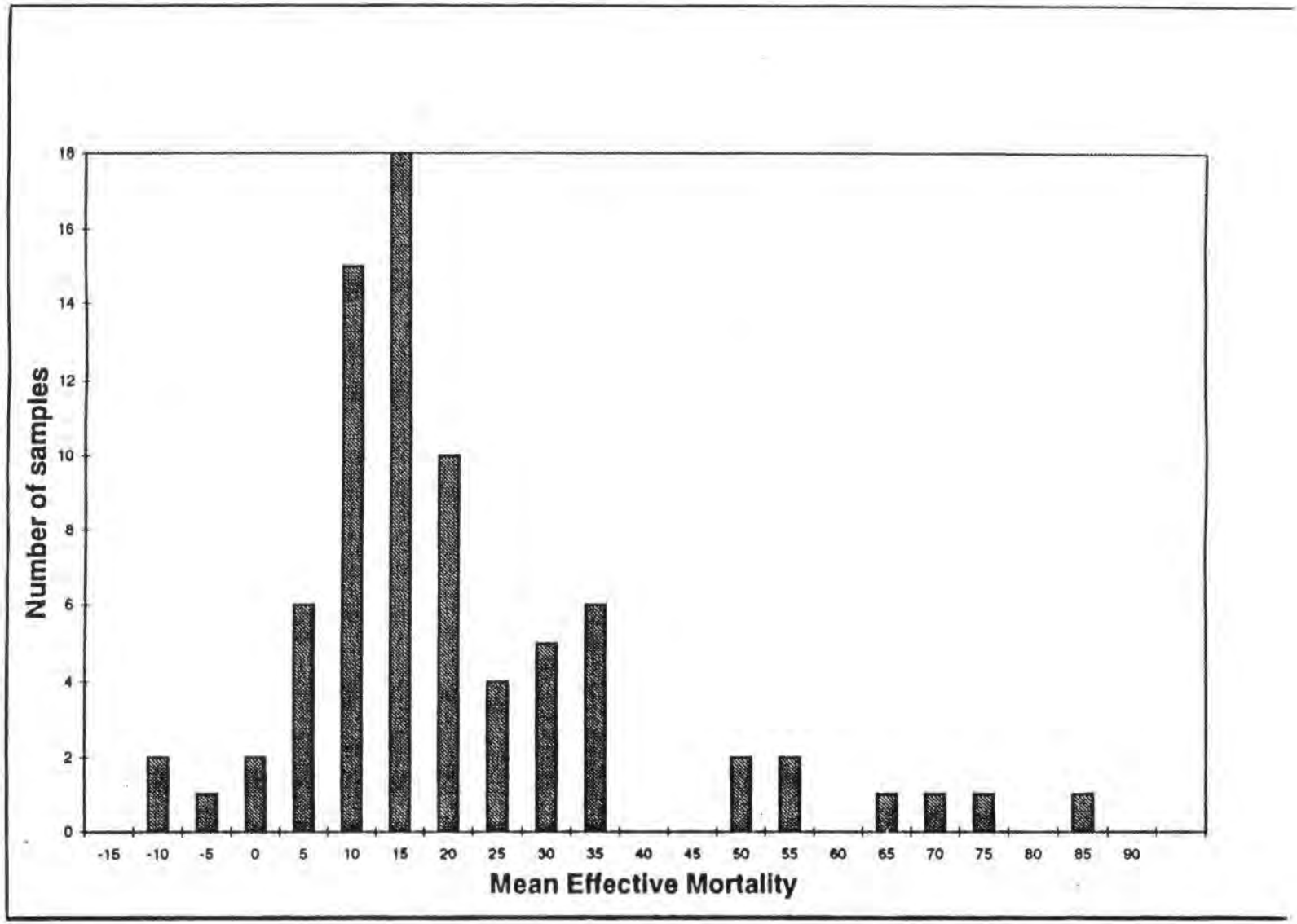

Figure 1. Effective mortality distributions of larval reference sediments.

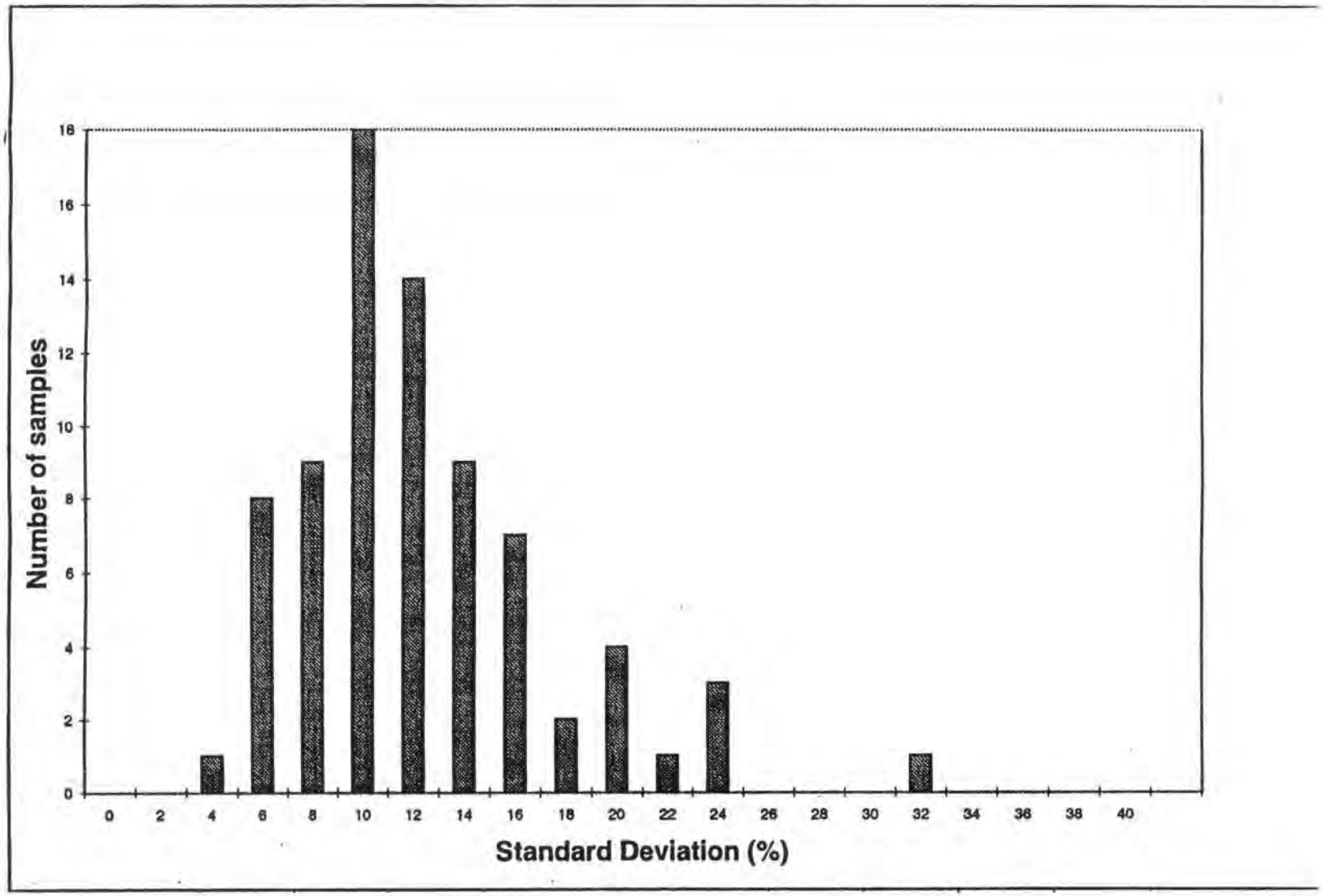

Figure 2. Standard deviation distributions of larval reference area sediments.

APPENDIX C

SMARM Overheads

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David Kendall

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SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING

Jointly Sponsored
by the
PSDDA Program and SMS Group

St. Helens Conference Center, Tacoma, WA

May 8, 1996

Hosted by DNR

MEETING OBJECTIVES AND PURPOSE

- Obtain public input on proposed changes to the PSDDA Management Plan per Issue Papers and Clarification Papers mailed out with the Sediment Management Program Biennial Report and meeting announcement.
- Discuss disposal site management actions and changes.
- Discuss Status Reports on important ongoing actions within the PSDDA program and SMS Group.

PSDDA Program Overview

- Summary actions of previous Annual Review Meeting
- Summary of PSDDA project / testing activities
- Disposal site monitoring

SMS Group Overview

- SMS activities and Annual Review
- Regional cleanup activities
- Source control activities

Issue Papers

- Adjustments to PSDDA site monitoring
- Tributyltin (TBT): PSDDA / SMS issues

Public Issue Papers

- **TBT Issues:**
  - Critque of PSDDA draft issue paper on testing, reporting, and evaluation of Tributyltin data in PSDDA and SMS programs
  - Sensitivity of amphipod species to TBT in sediment and porewater
- **Process: SMS Triennial Review Process**

Public Issue Papers (continued)

- **General Issues with AET implications:**
  - Reducing uncertainties in the interpretation of sediment toxicity tests and benthic community effects
  - Confounding issues in Microtox bioassays
- **AET Issues:**
  - Evaluation of Puget Sound Apparent Effects Thresholds
  - Larval bioassay sensitivity assessment
  - Evaluation of the benthic criterion for PCB AET's

Status Reports

- Cooperative sediment program: status of tech/policy guidelines and demonstration project
- Beneficial uses: definitions, participation
- MUDS study update
- Superfund sediment program: lessons learned
- Human health sediment criteria

PSDDA Clarification Papers

- Dredged material volume estimates
- Small dredging projects at outfalls
- Sediment bioaccumulation testing refinements: sample volume requirements, simultaneous co-testing of two species within a single aquaria, and species substitution
- DGPS as navigational standard

PSDDA/SMS Clarification Papers

- Neanthes 20-day growth bioassay - further clarifications on negative control growth standard, initial size, and feeding protocol
- Statistical evaluation of bioassay results

Summary and Closing

- Issues to which PSDDA agencies will respond before the next annual review meeting
- Issues to which SMS group will respond before the next annual review meeting
- Written comments may be submitted on the SMARM proceedings, but must be submitted to the PSDDA agencies and SMS group by May 22, 1996 for consideration.

SUMMARY OF MAY 1995 SMARM COMMITMENTS AND ACCOMPLISHMENTS

PSDDA Program Issues

Joint PSDDA / SMS Program Issues

Joint PSDDA/SMS Issues

- The PSDDA/SMS water quality monitoring requirements for ammonia and sulfides were clarified relative to the number of replicates to be analyzed. For both PSDDA/SMS bioassays (except Microtox, where no current WQ monitoring is required), one replicate chemistry only beaker (sediments without organisms) is required per sample.
- The PSDDA/SMS programs clarified the temperature regimes for all larval echinoderm species:
  - *Dendraster excentricus* = 15 degrees Celsius $\pm$ 1 degree
  - *Strongylocentrotus purpuratus* = 15 degrees Celsius $\pm$ 1 degree
  - *Strongylocentrotus droebachiensis* = 12 degrees Celsius $\pm$ 1 degree

PSDDA / SMS Issues

- The PSDDA/SMS programs recommend interstitial measurements of ammonia and sulfide at the option of the project proponent for both amphipod and Neanthes growth bioassays.
- The PSDDA agencies were not able to work on the PCB Congener analysis issue paper over the past year due to workload and lack of resources.
- The PSDDA program no longer includes 2-methylnaphthalene in the LPAH Group, which is now consistent with the SMS Rule.

PSDDA Issues

- Local governments are in the drafting phase for the integrating PSDDA guidelines into the SEPA/GMA/Shoreline Management Act. It is expected that they will directly reference the PSDDA guidelines. The draft guidelines are expected to be completed by June, and are to be adopted as pilot rules in December 1996 for one year. The local governments appear to be moving as quickly as time allows to incorporate PSDDA guidelines into their local shoreline master programs, and do not anticipate PSDDA issues slowing things down.
- The PSDDA agencies are conducting an evaluation of statistical power utilizing the perimeter chemistry guidelines approach presented at the 1995 SMARM for the 1995 Commencement bay monitoring data. The results of these analyses are not yet completed and a summary of these analyses will be attached to the SMARM minutes mailout.
- A revised discussion paper of the Northwest Straits National Marine Sactuary Project was jointly published by the Department of Ecology and NOAA on May 3, 1995. The revised paper explicitly states that the Sanctuary Project will not "interfere with the Puget Sound Dredged Disposal Analysis Process".

Joint PSDDA / SMS Issues

- Further refinements/clarifications to the *Neanthes* growth bioassay test are proposed by the PSDDA / SMS programs to improve the performance of the test. A clarification paper documenting these changes which were adopted in November 1995 on an interim basis, can be found in the March 1996 Sediment Management Biennial Report. The proposed changes clarify the following:
  - Control growth rate target $\geq$ 0.72 mg/individual/day; < 0.38 mg/individual/day as QA/QC failure
  - Mean Initial Weight $\geq$ 0.5 mg/individual as target; < 0.25 mg/individual as QA/QC failure
  - There should be no alteration to feeding protocol. Any deviations from the strict protocol will be treated as a QA/QC failure

PSDDA Agencies Response to AET Issues

- PSDDA agencies met in November 1995 to discuss options for AET work relative to existing/available resources.
- AET Report: revised April 1996 draft responded to most peer reviewer comments. Report available in back for those interested in obtaining a copy (please sign up).
- AET report (April 1996 draft) will be mailed next week to interested parties.
- Convening of a Regulatory Work Group (RWG): PSDDA agencies have met several times to discuss RWG members, major tasks to be accomplished by RWG, and ground rules and process.

PSDDA Agencies Response to AET Issues

- Regulatory Work Group: Letters to potential RWG members will be sent out soon. Expect to convene first meeting in June, with recommendation to implement recalculated AETs by November 1996.
- AET report expected to be finalized during the Summer 1996.
- AET report: Volume II (containing final reliability, implications and overall process) will be drafted and finalized by January 1997.

Ovrhd 3-1. DY95 PSDDA Projects

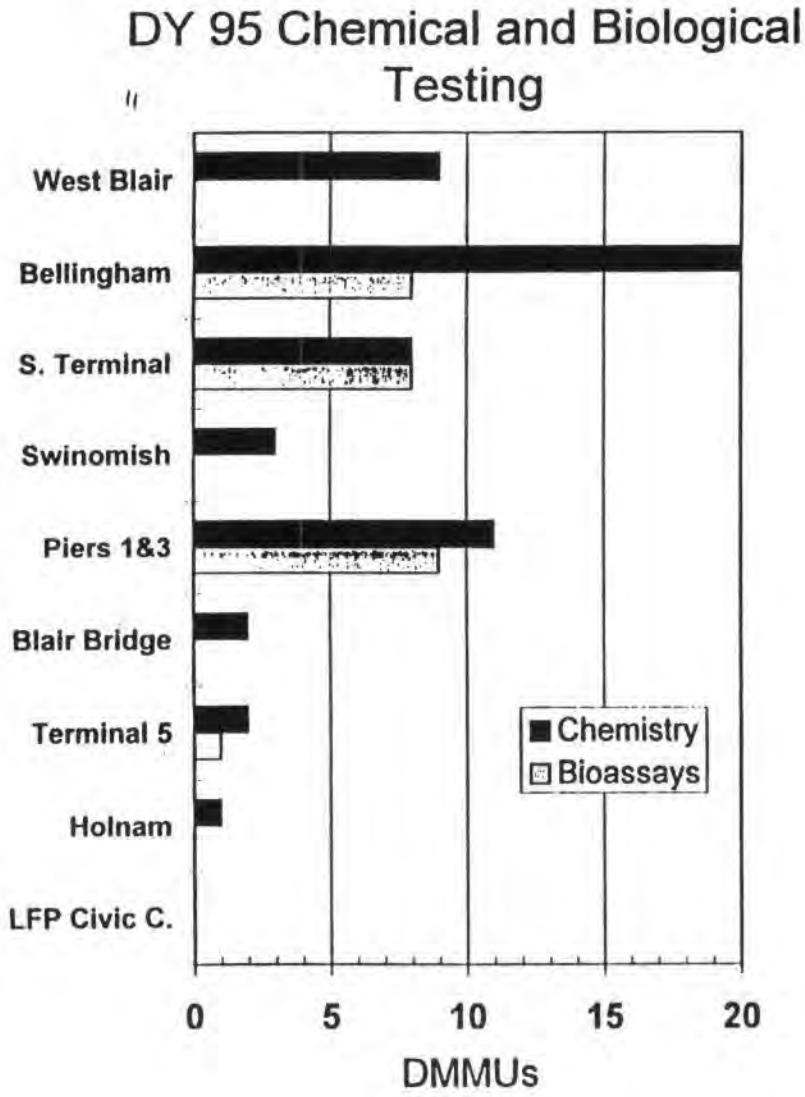
DY95 PSDDA Projects

An overview of the application of PSDDA evaluation procedures

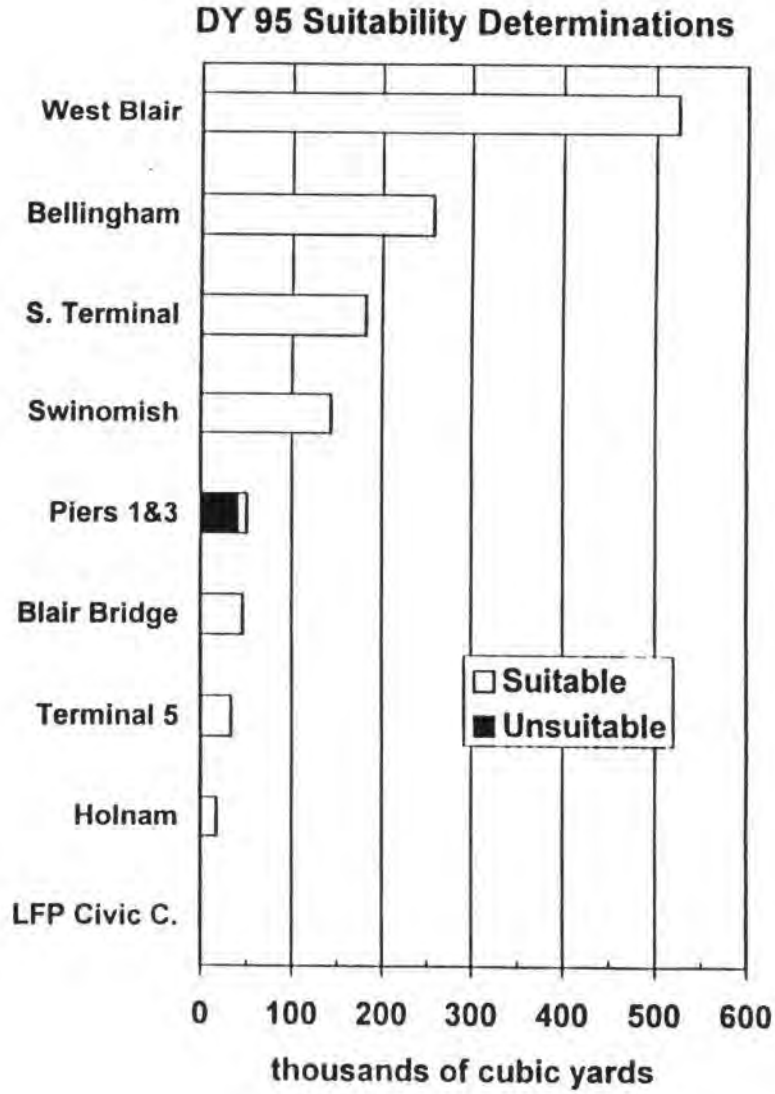
Ovrhd 3-2. DY95 Project Volumes

DY 95 Project Volumes

• Port of Tacoma West Blair	525,000
• USACE/Port of Bellingham	258,000
• Port of Everett South Terminal	183,000
• USACE Swinomish	144,000
• Port of Everett Piers 1 & 3	51,000
• Port of Tacoma Blair Bridge	47,000
• Port of Seattle T5 Pier Extension	34,000
• Holnam Cement	18,200
• Lake Forest Park Civic Club	480
Total Volume:	1,260,680

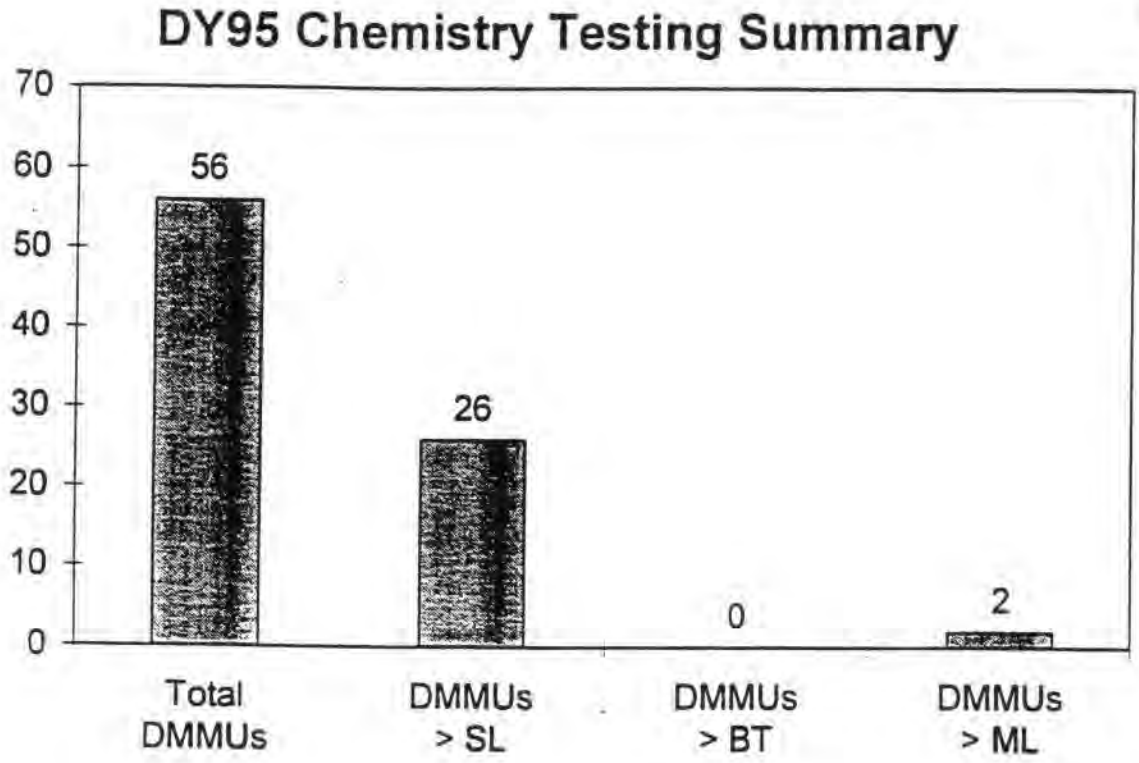


Ovrhd 3-3. DY95 Chemical and Biological Testing

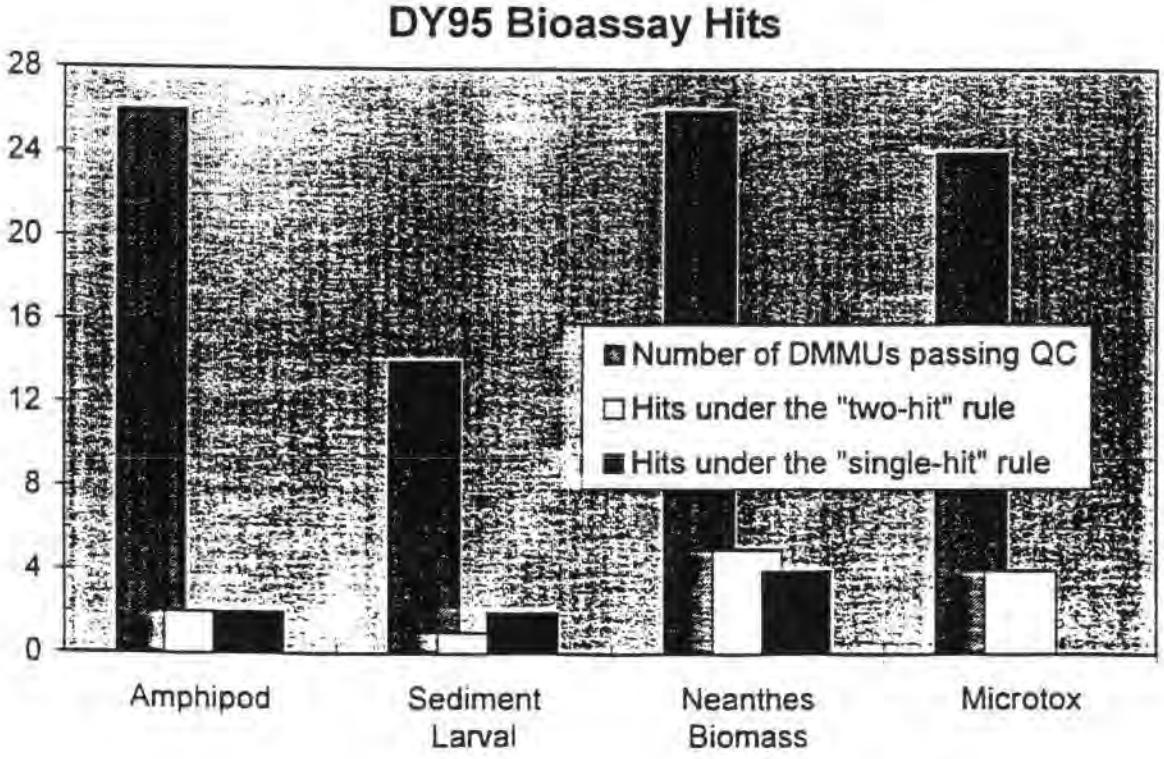


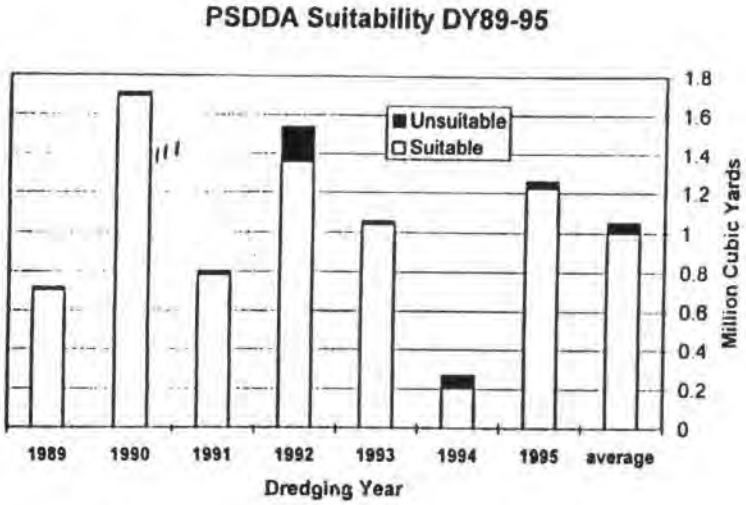
Ovrhd 3-4. DY95 Suitability Determinations

Ovrhd 3-5. DY95 Chemistry Testing Summary

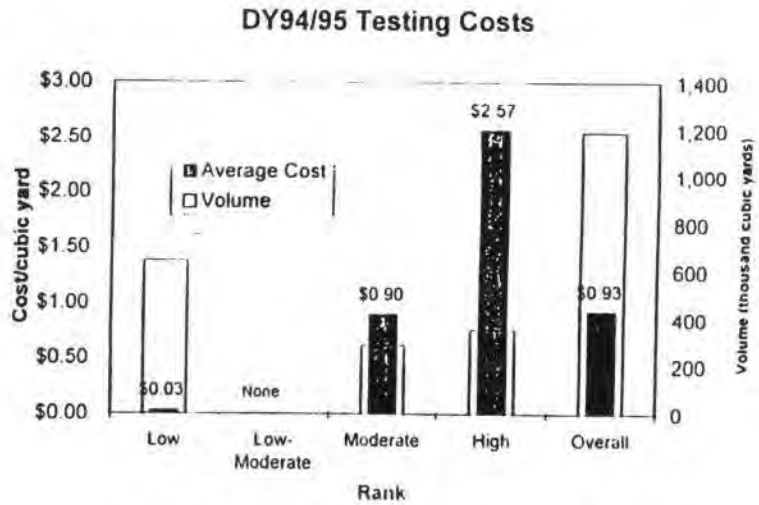


Ovrhd 3-6. DY95 Bioassay Hits

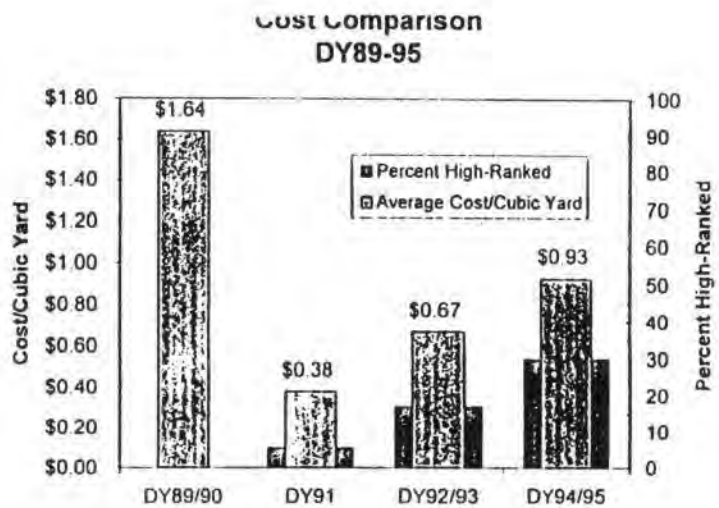




Ovrhd 3-7. PSDDA Suitability DY89-95



Ovrhd 3-8. DY94/95 Testing Costs



Ovrhd 3-9. Cost Comparison DY89-95

PRESENTATION AGENDA

- PSDDA Monitoring Tools
- Modifications to the 1995 Full Monitoring Approach
- Summary of Baseline Conditions
- 1995 Findings
  - SVPS
  - Sediment Chemistry
  - Sediment Bioassays
  - Tissue Analysis
  - Benthic Infaunal Analysis
- 1995 Evaluations
- Monitoring Modification Recommendations

Ovrhd 4-1. 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 4-2. PSDDA Monitoring Framework

PSDDA MONITORING TOOLS

	SVPS	Sediment Chemistry	Benthic Infauna	Bioassays	Tissue Chemistry
Zone Station (Z)	✓	✓		✓	
Site Station (S)	✓	✓		✓	
Perimeter Station (P)	✓	✓			
Transect Station (T)	✓		✓		✓
Benchmark Station (B)		✓(A)	✓(A)	✓(A)	
Cross Station (C)	✓				
Reference Station (R)				✓	

Ovrhd 4-3. PSDDA Monitoring Tools

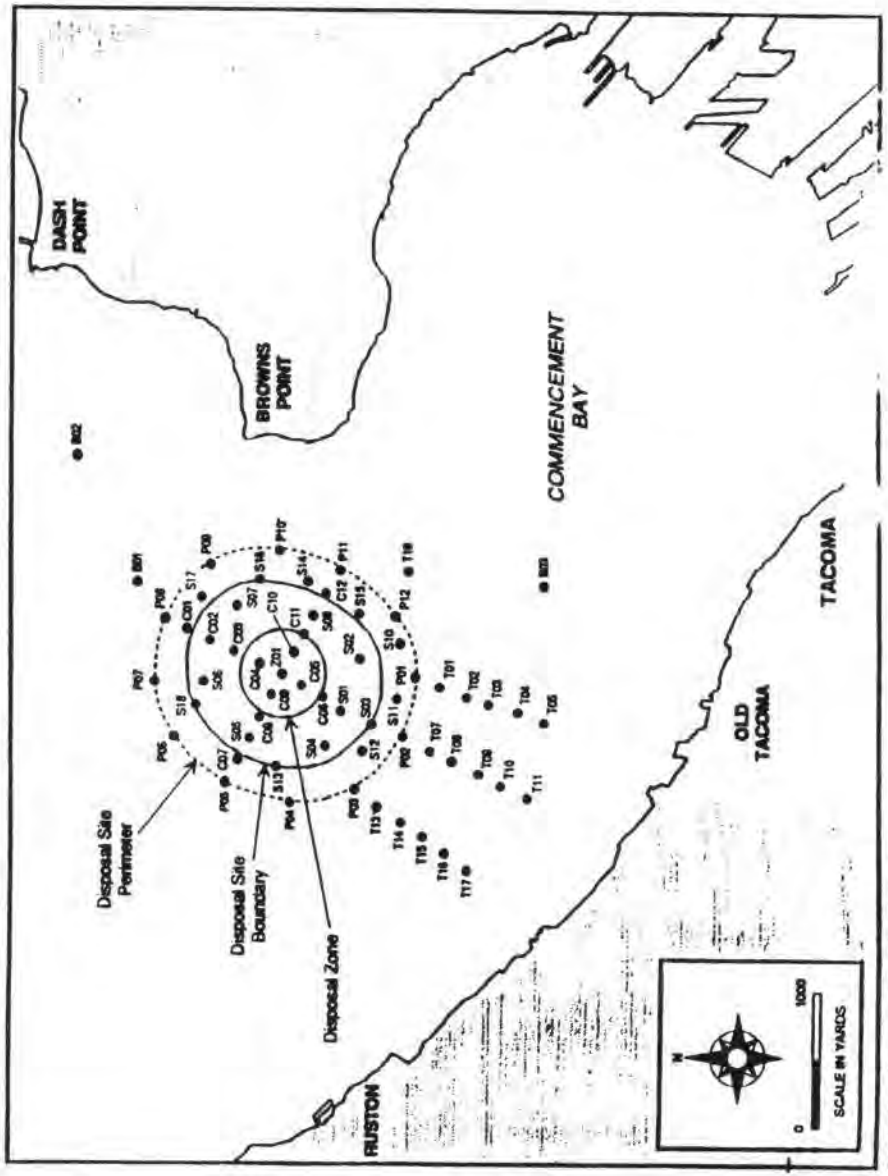


Figure 3-1. Commencement Bay stations.

Ovrhd 4-4. Map of Commencement Bay Disposal Site and Station Locations

MODIFICATIONS FOR THE 1995 MONITORING PROGRAM

- Programmatic Change
  - Hypothesis 2 - Using the SQS as triggers instead of Guideline Values
- Sediment Chemistry
  - SEM/AVS (onsite and perimeter)
  - Tributyltin (onsite and perimeter)
- Bioassays
  - Use of *Neanthes* growth guideline
  - Solid phase Microtox

Ovrhd 4-5. Modifications for the 1995 Monitoring Program

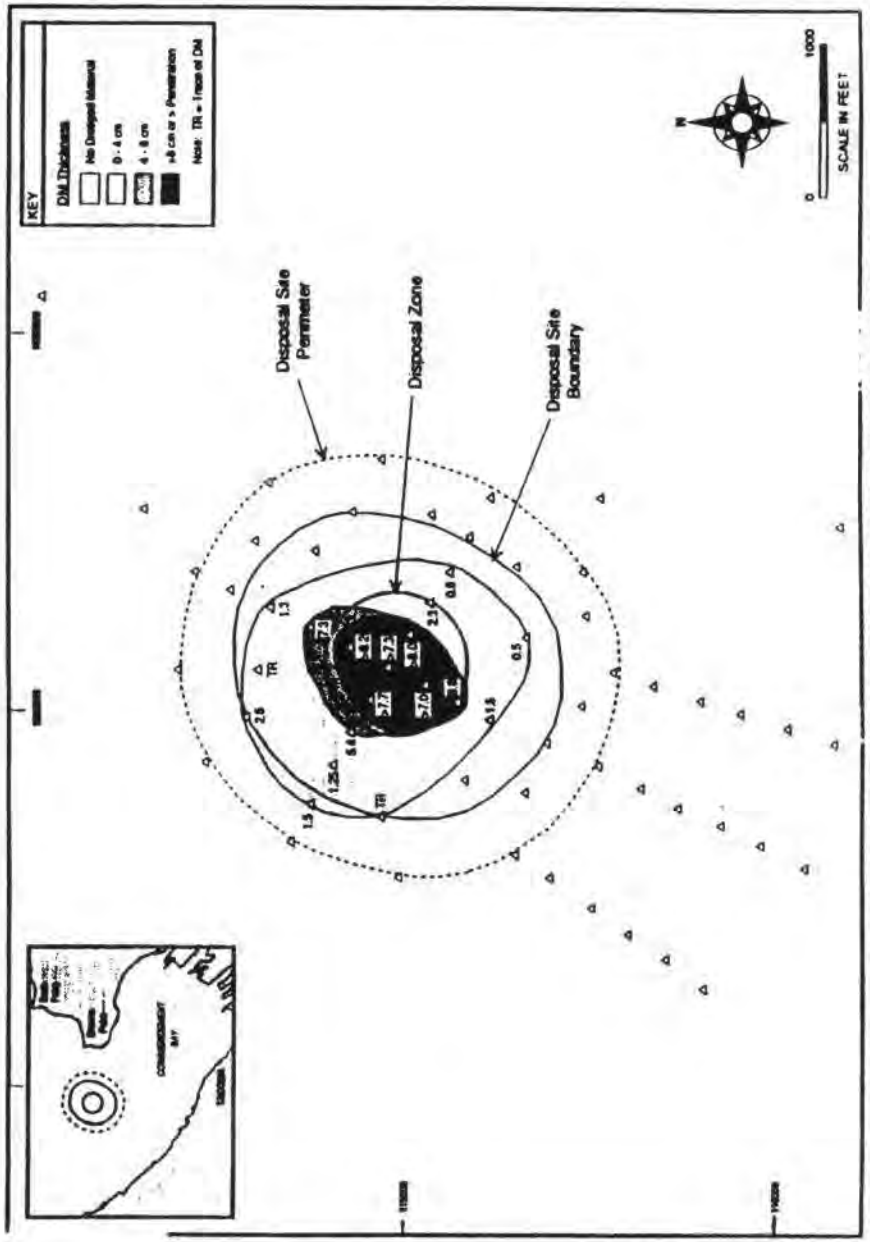


Figure 4-4. Distribution of dredged material (DM) at the Commencement Bay PSDDA disposal site. Thickness is measured in centimeters.

Ovrhd 4-6. Distribution of Dredged Material at the Commencement Bay Disposal Site

SEDIMENT CHEMISTRY

- Conventionals
  - Grain size anomoly - apparent shift to course material
    - Determined that 1988 procedure used hydrogen peroxide.
    - Peroxide breaks up mud clasts, leading to higher reported fines.
- Metals
  - No exceedance of SL, ML, or SQS at any station.

Ovrhd 4-7. Sediment Chemistry Conventionals and Metals

SEDIMENT CHEMISTRY

- 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
- Butyltins
  - No detections at any station
- SEM/AVS

Ovrhd 4-8. Sediment Chemistry Organics, Butyltins, and SEM/AVS

SEDIMENT BIOASSAYS

- All bioassays met QA/QC requirements
  - *Neanthes* exceeded minimum growth requirement
- No exceedances of biological effects criteria in bioassay results

Ovrhd 4-9. Sediment Bioassays

TISSUE ANALYSIS

- Metals detected in low quantities
- Organics not detected
  - Exception is bis-2-ethylhexylphthalate

Ovrhd 4-10. Tissue Analysis

BENTHIC INFAUNA

- Near-site transect stations (T01 and T03) similar in abundance, taxa distribution, and diversity.
- Far site (T05) lower in total abundance, but having higher diversity across major taxonomic groups.
- Top four species the same at all three sites

Ovrhd 4-11. Benthic Infauna

EVALUATION OF 1994 MONITORING DATA

- Question 1: Does dredged material remain onsite?
  - Hypothesis 1: Dredged material within site boundary.
    - SVPS data confirms hypothesis

Ovrhd 4-12. Evaluation of 1994 Monitoring Data - Does dredged material remain onsite? (SVPS)

EVALUATION OF 1994 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.
    - Perimeter station P01 metals were significantly (alpha = 0.2) elevated over baseline chemistry.
    - PAHs are elevated at P01-C, but levels are similar to those observed in baseline.
    - Data suggest confirmation of hypothesis, but warrant further attention in next monitoring period.

Ovrhd 4-13.
Evaluation of 1994 Monitoring Data - Does dredged material remain onsite? (Chemistry)

EVALUATION OF 1994 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 4-14.
Evaluation of 1994 Monitoring Data - Biological effects conditions exceeded?

EVALUATION OF 1994 MONITORING DATA

- Question 3: Adverse effects to offsite biological resources?
  - Hypothesis 5: No increase in tissue body burden.
    - No increase, hypothesis accepted

Ovrhd 4-15.
Evaluation of 1994 Monitoring Data - Adverse effects to offsite biological resources? (Tissue body burden)

EVALUATION OF 1994 MONITORING DATA

- Question 3: Adverse effects to offsite biological resources?
  - Hypothesis 6: No decrease in infaunal major taxa abundance with time.
    - 1988 analyzed P07, P09, P11
    - 1995 analyzed P01, P03, P05

      Elected to compare the near-site (1 vs. 7), mid-distance (3 vs. 9) and distal (5 vs. 11) transect stations.
    - Depths, proximity, physical similarities, and SVPS data suggested that the comparison was likely valid.

Ovrhd 4-16
Evaluation of 1994 Monitoring Data - Adverse effects to offsite biological resources? (Infaunal abundance)

EVALUATION OF 1994 MONITORING DATA

- Question 3: Adverse effects to offsite biological resources?
  - Hypothesis 6: No decrease in infaunal major taxa abundance with time.
    - Comparison of near-site and mid-distance site did not exceed PSDDA guidance
    - Far-field comparisons showed decrease in molluscs.
    - Using weight-of-evidence approach, concluded that far-field impacts were not related to dredge material disposal.

Ovrhd 4-17.
Evaluation of 1994 Monitoring Data - Adverse effects to offsite biological resources? (Cont.)

SPECIAL STUDIES

- Butyltin Analysis
  - Butyltins not detected in any sample
- SEM/AVS
  - SEM/AVS ratios high
    - Range of 5.6 - 13
    - Suggests metal are bioavailable
  - "Free" SEM present in low molar quantities
  - Recent EPA work suggests that in sandy, aerobic environments, AVS not an important factor in SEM regulation.

Conclude that SEM/AVS is generally unimportant consideration for PSDDA Site Monitoring

Ovrhd 4-18. Special Studies

RECOMMENDATIONS

- Future PSDDA site monitoring uses DGPS in place of microwave systems.
  - Cost savings would be significant
  - DNR and Corps possess such systems

Recommend a side-by-side comparison of the two navigation systems during next monitoring event

Ovrhd 4-19. Recommendations (DGPS)

RECOMMENDATIONS

- SEM/AVS
  - SEM/AVS should not be incorporated as a routine component of PSDDA Site Monitoring.
    - Largely sandy deposits at disposal sites precludes AVS importance in control of metals.
  - SEM/AVS may be appropriate in pre-disposal characterization of materials from high fine, anaerobic environments.

Ovrhd 4-20. Recommendations (SEM/AVS)

RECOMMENDATIONS

- Use 1995 Commencement Bay data as baseline for future monitoring.
  - Present baseline data is 8 years old.
  - Methods used in 1988 are not consistant with present PSDDA procedures
    - e.g., analytical methods, bioassays, *Molpadia* collection and processing.
  - 1988 Transect benthic infaunal data is limited to major taxa, whereas current procedure calls for identification to lowest possible taxon.

  Maintain 1988 data for time trends analysis, but use 1995 data for interpretive guidelines.

Ovrhd 4-21. Recommendations (Use of 1995 data as baseline)

RECOMMENDATIONS

- Compile and publish disposal site monitoring plan.
  - Numerous programmatic changes
  - Field and analytical changes
  - Transect biological analysis changes
  - Bioassay procedure and interpretation changes

  These changes are listed in a multitude of PSDDA, Ecology, and SAIC documents since 1988.

  Recommend their collection in one place

Ovrhd 4-22. Recommendations (Disposal Site Monitoring Plan)

Ovrhd 5-1. SMS Rule Background - WAC 173-204

SMS RULE BACKGROUND - WAC 173-204

√ **Sediment Quality Criteria**
- Source Control
- Cleanup

√ **Implementation - Source Control**
- Modelling studies
- User manual

√ **Implementation - Cleanup**
- User manual - SCUM2
- Site list

Ovrhd 5-2. SMS Rule Background (Cont.)

SMS RULE BACKGROUND (Cont'd)

√ **Public Involvement & Support**
- Comment on development needs:
  - Technical Issues
  - Policy Issues

√ **Implementation Support**
- Guidance & training documents

√ **Alternative Technologies**

Ovrhd 5-3. 1995 Activities: Rule Revisions

1995 ACTIVITIES

RULE REVISIONS:

- **Incorporating latest scientific methodologies:**
  Amended Puget Sound Estuary Protocols
  Puget Sound Dredged Disposal Analysis
  In-house studies

- **Merging public recommendations/comments**
  Clarifying summing of chemical criteria
  Revising biological effects criteria
  Removing stormwater exemption

- **Legislative directives -- RCW 90.48.220**
  New section: Marine finfish rearing facilities

Ovrhd 5-4. 1995 Activities: SMS Rule, Triennial Responsiveness Summary, Draft Triennial Responsiveness

1995 ACTIVITIES (Cont'd)

√ SMS RULE: adopted 29th December 1995
effective 29th January 1996

√ TRIENNIAL RESPONSIVENESS SUMMARY
Multi-organizational
Resource availability
Reasonable implementation

√ DRAFT TRIENNIAL RESPONSIVENESS
– Summer 1996

Ovrhd 5-5. 1995 Activities: Changes to PSEP Protocols, SEDQUAL Redevelopment, Technical Development Documents

1995 ACTIVITIES (Cont'd)

√ **REVIEWED CHANGES TO PSEP PROTOCOLS**
QA/QC for data generation & sampling requirements
Metals and Organic compound analyses

√ **SEDQUAL REDEVELOPMENT**
Public Accessibility
GIS Module

√ **TECHNICAL DEVELOPMENT DOCUMENTS**
QA/QC Bioassay Data Deliverables - Stinson
Assessment of Benthic Infaunal Endpoints - Weston
Benthic Infauna Reference Ranges - SEA (forthcoming)

Ovrhd 5-6. 1995 Activities: Regional/National Policy, Cooperative Sediment Management Program, Contaminated Site List

1995 ACTIVITIES (Cont'd)

√ **Review ongoing regional/national policy**
HUMAN HEALTH CRITERIA
FRESHWATER CRITERIA

√ **Cooperative Sediment Management Program**
- MULTI-USER DISPOSAL SITE
- SEDIMENT CLEANUP STRATEGY
  DEMONSTRATION BAY PROJECT
- BENEFICIAL USES

√ **Puget Sound Contaminated Sediment Site List**

Ovrhd 5-7. Post SMARM SMS Activities

POST SMARM SMS ACTIVITIES

- √ **Annual Review - SMARM document**
- √ **Triennial Review - Ecology document**

5-10-96

Ovrhd 7-1. Sediment Source Control Activities

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Sediment Source Control Activities

Sediment Management Annual Review

presented by Brenden McFarland

Ovrhd 7-2. Sediment Source Control Implemented through NPDES Permits

Sediment Source Control Implemented Through NPDES Permits

- For permitted discharges only
- Permit by permit approach
- Approach based on discharge data
- Mostly treated wastewater, not stormwater

Ovrhd 7-3. General Process Overview

General Process Overview

- Screening Evaluation - Assess Potential to Cause Sediment Impacts
- Permit Conditions/Detailed Evaluation
  - Monitoring
  - Modeling
- Permit Conditions - SIZs, Effluent Limits
- For details, see Sediment Source Control Standards User Manual (SCUM1)
  - call 360 407-6908 for an order form

Ovrhd 7-4. Results of Sediment Source Control Reviews

Results of Sediment Source Control Reviews

- Involvement with 56 dischargers
  - Screening evaluations, Permits/Factsheets, SAPs, Data Reports, Modeling
  - Includes marine and freshwater
- Received Sediment Data for 33 NPDES dischargers
  - 15 discharges show sediment impacts
  - Chemicals of concern include metals, PAHs, phthalates, and PCBs

Ovrhd 7-5. Revision of Screening Evaluation

Revision of Screening Evaluation

- First step in linking effluent quality with sediment quality, via a screening equation
- Process as originally envisioned included 3 steps
  - screening evaluation
  - general model
  - site-specific model
- General model has remained elusive and new step between initial screening and site-specific modeling is needed

Ovrhd 7-6. Screening Equation 1 (current screening)

Screening Equation 1 (current screening)

$$\frac{C_t}{TSS} \times 10^6 = C_p$$

- C_p = Concentration of contaminant associated with suspended solids in effluent (mg/kg dry weight)
- C_t = Total concentration of contaminant in effluent (mg/L)
- TSS = Total suspended solids in effluent (mg/L)
- 10^6 = Conversion factor (mg/kg)

Ovrhd 7-7. Screening Equation 2 (loading and natural deposition)

Screening Equation 2 (loading and natural deposition)

$$\frac{(C_p \times TSS \times Q) + (C_b \times Dep \times Area \times Conv1)}{(TSS \times Q \times Conv2) + (Dep \times Area)} = C_s$$

- C_p = Concentration of contaminant associated with suspended solids in effluent (mg/kg dry weight)
- TSS = Total suspended solids in effluent (kg/L)
- Q = Discharge rate (L/yr)
- C_b = Background concentration in sediments (mg/kg dry weight)
- Dep = Natural sediment deposition rate (mg/cm^2-yr)
- Area = Size of problem area (cm^2)
- Conv1 = Conversion factor (1×10^{-6} kg/mg)
- Conv2 = Conversion factor (1×10^{6} mg/kg)
- C_s = Sediment Concentration (mg/kg dry weight)

Ovrhd 7-8. Screening Equation 3 (proposed)

Screening Equation 3 (proposed)

$$\frac{E_c}{E_{sed} + B_{sed}} = C_{sed}$$

- E_c = Effluent Contaminant Loading, mass of chemical of concern in effluent (gm/yr)
- E_{sed} = Effluent Sediment Loading, mass of solids from effluent (gm/yr)
- B_{sed} = Background Sediment Loading, mass of solids from background sedimentation in area of concern (gm/yr)
- C_{sed} = Sediment Contaminant Concentration, the value to be compared to sediment quality criteria (unitless before use of conversion factor)

Ovrhd 7-9. What next?

What next?

- Screening Equation revisions
  - Permit Writer's Manual
  - Sediment Source Control Standards User Manual (SCUM1)
- Sampling and Analysis Plan Guidance
  - finalize appendix to SCUM1 and SCUM2
- WQ Permit Manager Sediment Training

Ovrhd 7-10. What next? (Cont.)

What next? (cont.)

- Sediment Contaminant Modeling as permit requirement
- More comprehensive Sediment Source Control Approach
  - via "Watershed" or other geographic unit
  - Prioritize actions through a ranking process
- Include stormwater

PSDDA Disposal Site Monitoring Surveys

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

Ovrhd 8-2. Cumulative Non-Dispersive Site Use Summary

CUMULATIVE NON-DISPERSIVE SITE USE SUMMARY

Disposal Site	Dredging Years Used	Cumulative Volumes
Port Gardner	90, 91, 93, 94, 95	1,499,094
Elliott Bay	90, 91, 92, 93, 94, 95	615,247
Commencement Bay	89, 91, 95	308,405
Bellingham Bay	93	32,883
Anderson/Ketron	93, 95	18,874
Cumulative Volume		2,474,503
Total Cumulative	(Non-Disp.+ Disp)	3,366,435

Ovrhd 8-1. PSDDA Disposal Site Monitoring Surveys

Ovrhd 10-1. PSDDA/SMS Issue Paper: Tributyltin Draft Issue Paper Critique

PSDDA/SMS Issue Paper

Critique of PSDDA draft issue paper on testing, reporting, and evaluation of tributyltin data in PSDDA and SMS programs

Prepared by Kenneth R. Seeley, Chris M. Boudreau,
Kathy B. Godtfredsen, and D. Michael Johns
(EVS Consultants, 206/217-9337)
Douglas A. Hotchkiss (Port of Seattle 206/782-3192)

Prepared for the Port of Seattle

Ovrhd 10-2. Recent Developments Concerning TBT

Recent Developments concerning TBT

- Analytical methods
- Reporting conventions
- TBT and Apparent Effects Thresholds (AETs)
- Interstitial water concentrations
- Tissue concentrations
- PSDDA screening level for TBT
- Bioassay testing
- PSDDA bioaccumulation testing for TBT

Ovrhd 10-3. Problem Identification

Problem Identification

- Referenced information was not easily accessible
- Policy recommendations appear to have been largely based on the work of Meador et al. (in prep.)
  - Meador et al. (in prep.) appears to have been inadequate to fully support the conclusions presented in the PSDDA/SMS issue paper
- It would be inappropriate to base policy decisions on technical information that has not completely undergone the peer review process

Ovrhd 10-4. Discussion of Recent Developments

Discussion of Recent Developments

- Interstitial Water Concentrations
- Tissue concentrations
- Proposed PSDDA screening level for TBT in interstitial water
- Bioassay testing

Ovrhd 10-5. Tissue Concentrations

Tissue Concentrations

- LD50s based on test organisms tissue concentrations of TBT
  - dead test organisms used
  - living organisms depurate
- Bioaccumulation and LD50s for amphipods difficult and subject to numerous measurement errors
- Rely on established protocols (LC50s)

Ovrhd 10-6. Bioassay Testing

Bioassay Testing

- Too many parameters were varied
- Pore water was obtained by various methods for different species
- The LC50s for some but not all species were calculated by adding blank mortality to test mortality
- Test animals were also collected at different times
- Test sediments collected from different locations.
- Experiments described in Meador et al. (in prep.) appear to have been an attempt to test multiple hypotheses simultaneously

Proposed PSDDA Screening Level for TBT in Interstitial Water

- Koc used is probably not accurate
  - spiked sediment
  - not likely that equilibrium was established
- Additional investigations to determine the partitioning coefficient
- Proposed screening level: 0.15 µg TBT/L
  - original Koc value an order of magnitude lower than the one used in the present calculation
- Reliance placed on the single Koc value
- The resulting value of 0.15 µg TBT/L is not unreasonable as SL
- 0.7 g TBT/L is not unreasonable as CSL
- 0.7 g TBT/L as an ML would seem inappropriate

Ovrhd 10-7.
Proposed PSDDA Screening Level for TBT in Interstitial Water

Conclusions

- Existing bioassay-based approach should be maintained
  - It has not been proven conclusively that current bioassay organisms are not sufficiently sensitive
- Benthic community structure can be altered by a wide range of factors
  - TBT may not be bioavailable and toxic to test organisms
  - physical and chemical characteristics
  - other contaminants
  - more rigorous site-specific investigations must be conducted in order to determine the actual cause(s) of observed benthic community impairment
- 0.7 µg TBT/L as an upper regulatory limit represents a radical departure from current evaluation procedures

Ovrhd 10-8. **Conclusions**

Sensitivity of Amphipod Species to TBT in Sediment and Porewater

Prepared by Berit Bergquist, Kenneth R. Seeley, D. Michael Johns
(EVS Consultants, 206/217-9337)
William Gardiner (Battelle Laboratories)

Prepared for the Port of Seattle

Ovrhd 11-1. **Sensitivity of Amphipods Species to TBT in Sediment and Porewater**

Introduction

- Amphipod *Eohaustorius estuarius* may be more sensitive to TBT in sediment and porewater than *Rhepoxynius abronius*

- PSDDA agencies are considering including other test species or favor bioaccumulation tests and *in situ* benthic community surveys

Ovrhd 11-2. Introduction

Problem Identification

- Species sensitivity analysis is inconclusive
- Parameters varied
  - different methods were used to obtain pore water samples
  - pore water samples were not all processed for chemical analysis using the same method
  - test animals were collected at different times (as much as one year apart)
  - TBT-spiked sediments not collected from same locations

Ovrhd 11-3. Problem Identification

Proposed Actions

- Conduct study to evaluate the sensitivity of three amphipod species (*Rhepoxynius abronius*, *Eohaustorius estuarius*, and *Eohaustorius washingtonianus*) to TBT

- Study design
  - test sediment samples from uncontaminated reference location
  - test animals will be tested at same time
  - sediment characteristics (e.g., grain size and TOC) will be held constant
  - sediments spiked with a range of TBT concentrations consistent with Puget Sound

Ovrhd 11-4. Proposed Actions

Data Uses

- Establish differential sensitivity to TBT between the three species tested
- Determine whether species are sensitive to interstitial water TBT concentrations representative of Puget Sound sediments
- Provide data for regulatory decision making and defining evaluation procedures

Ovrhd 11-5. Data Uses

II

REDUCING UNCERTAINTIES IN THE INTERPRETATION OF SEDIMENT TOXICITY AND BENTHIC COMMUNITY EFFECTS

BACKGROUND

SEDIMENT QUALITY EVALUATIONS IN PUGET SOUND INCLUDE BOTH CHEMICAL AND BIOLOGICAL COMPONENTS.

ORIGINAL ASSOCIATIONS BETWEEN CHEMICAL CONTAMINANTS OF CONCERN (COC) AND OBSERVED BIOLOGICAL EFFECTS PROVIDED PROVISIONAL APPARENT EFFECTS THRESHOLD VALUES FOR THESE COC'S.

SINCE THAT TIME CERTAIN FACTORS THAT WERE NOT INCLUDED HAVE BEEN SHOWN TO RESULT IN BIOLOGICAL EFFECTS. SOME OF THESE FACTORS INCLUDE: (SEDIMENT GRAIN SIZE, SALINITY, AMMONIA, HYDROGEN SULFIDE, SULFUR, ORGANIC MATTER CONTENT AND QUALITY, ETC.).

PROBLEM

WHILE ALL OF THESE FACTORS RESULT IN TOXICITY AND MAN BE INCLUDED AS A COC, THEY CONFUSE THE ISSUE OF TOXICITY RELATIVE TO THE ORIGINAL COC'S THAT WE WISH TO REGULATE ON.

OBVIOUSLY WE DO NOT WISH TO REGULATE THE CONCENTRATION OF PAH'S IF THE OBSERVED TOXICITY IS REALLY DUE TO INTERSTITIAL WATER SALINITY.

PROPOSED ACTION

IMPLEMENT PROCEDURES TO MINIMIZE UNCERTAINTIES IN TOXICITY AND BENTHIC COMMUNITY ANALYSES BASED UPON ONE OF TWO TYPES OF ASSESSMENTS. (SHOW TABLES OF SUGGESTED PROCEDURES).

THE TWO TYPES OF ASSESSMENTS INCLUDE:

DETERMINING WHETHER THE EFFECTS OF IN-SITU CONTAMINATION ARE CAUSING BIOLOGICAL EFFECTS.

OR

DETERMINING WHETHER THE TRANSPORT OF SEDIMENTS TO A NEW PLACE OF STORAGE OR RESIDENCE WILL RESULT IN UNACCEPTABLE BIOLOGICAL EFFECTS DUE TO THE COC'S

Ovrhd 12-1.
Reducing Uncertainties in the Interpretation of Sediment Toxicity and Benthic Community Effects

Table 1. Recommended Protocol Modifications to Minimize False Positives Resulting from Interfering Factors for Tests of the Effects of Relocating Contaminated Sediment

INTERFERENCE	SOLID-PHASE TESTS	LARVAL TOXICITY	BENTHIC
Salinity	Measure interstitial water salinity to determine whether test sediment matches salinity tolerance of test organism	Generally not an issue	Measure interstitial water salinity
	Use test species that are tolerant to salinity of test sediment		Compare to reference sites based on disposal site salinity conditions
	Compare survival to established dose/response curves. Only consider mortalities that are not accounted for by salinity		Compare community changes along salinity only effects gradient
Ammonia	Measure interstitial water[a] prior to and during test to determine whether test sediment matches ammonia tolerance of test organism.	Measure overlying water in lab prior to and during testing.	Measure interstitial and overlying water in field
	Minimize ammonia production during collection and storage of sediment		
	Conduct ammonia reference toxicant tests with same population at same time as testing, and compare interstitial water ammonia concentrations to dose-response curves to assess impact of interstitial ammonia in test sediment.		Effects on benthos are unknown but expected.
	Manipulate ammonia in interstitial water by EPA approve protocol (2-exchanges/day until NOEC attained	Allow time to attain NOEC in overlying water.	
		Use more ammonia tolerant species.	
Grain Size	Use species that are likely to occur at disposal site.	Use species which are tolerant of settled sediment.	Compare benthic communities to disposal site reference areas
	Use established grain size-mortality regression curves to determine influence of grain size of test sediment on survival of test organism	Increase settling time to decrease effects of suspended sediment.	Evaluate changes in community structure along grain size gradients
		Address mortality abnormality introduced due to settled sediment	
	Use test species that are tolerant of range of grain-sizes of test sediments	Use test species that are tolerant of range of grain-sizes of test sediments	
	Compare to reference	Compare to reference	Compare communities to reference values
Organic Matter	Normalize chemical concentration by TOC to predict bioavailability		
	Ascertain whether observed biological effects are due to the quantity or quality of total organic carbon contained in sediment		
Hydrogen Sulfide	For all tests, analytical difficulties confound separating the effects of sulfide from anoxia. Procedures should be developed to measure hydrogen sulfide and its potential effects in interstitial and overlying water for both toxicity tests and for benthic community evaluations.		
Sediment Manipulation	Manipulation is acceptable		Not an issue
Storage	Test storage should be minimized in order to reduce the potential for introduction of sediment changes that will influence test organisms survival.		Not an issue

(a) All measurement of ammonia shall include measurement of temperature, salinity, and pH in sample.

Ovrhd 12-2.
Table of Recommended Protocol Modifications to Minimize False Positives (Relocating Contaminated Sediment)

Table 2. Recommended Protocol Modifications to Minimize False Positives Resulting from Interfering Factors for Tests of the Effects of Contaminated In-Situ Sediment

INTERFERENCE	SOLID-PHASE TESTS	LARVAL TOXICITY	BENTHIC
Salinity	Measure interstitial water salinity to determine whether test sediment matches salinity tolerance of test organism	Generally not an issue	Measure interstitial water salinity
	Use test species that are tolerant to salinity of test sediment		Compare to reference conditions with similar salinity values
	Compare survival to established dose/response curves. Only consider mortalities that are not accounted for by salinity		Compare community changes along salinity only effects gradient.
Ammonia	Measure interstitial water prior to and during test to determine whether test sediment matches ammonia tolerance of test organism.	Measure overlying water in lab prior to and during testing.	Measure interstitial and overlying water in field
	Minimize ammonia production during collection and storage of sediment		
	Manipulate ammonia in interstitial water by EPA approve protocol (2-exchanges/day until NOEC attained.	Allow time to attain ammonia NOEC in overlying water.	Effects on benthos are unknown but expected.
	Conduct ammonia reference toxicant tests with same population at same time as testing, and compare interstitial water ammonia concentrations to dose-response curves to assess impact of interstitial ammonia in test sediment.	Use ammonia tolerant species.	
Grain Size	Use test species that are tolerant of range of grain-sizes of test sediments	Increase settling time to decrease effects of suspended sediment.	Compare community measures along grain size gradients.
		Address mortality abnormality introduced due to settled sediment	
	Use established grain size-mortality regression curves to determine influence of grain size of test sediment on survival of test organism.	Use more tolerant species	
	Compare to reference sediment	Compare to reference	Compare communities to reference values
Organic Matter	Normalize chemical concentration by TOC to predict bioavailability	Normalize chemical concentration by TOC to predict bioavailability	Normalize chemical concentration by TOC to predict bioavailability
			Ascertain whether observed biological effects are due to the quantity or quality of total organic carbon contained in sediment.
Hydrogen Sulfide	For all tests, analytical difficulties confound separating the effects of sulfide from anoxia Procedures should be developed to measure hydrogen sulfide and its potential effects in interstitial and overlying water for both toxicity tests and for benthic community evaluations.		Not an issue
Sediment Manipulation	Manipulation should be minimized		Not an issue
Storage	Test storage should be minimized in order to reduce the potential for introduction of sediment changes that will influence test organisms survival.		Not an issue

Ovrhd 12-3. **Table of Recommended Protocol Modifications to Minimize False Positives (Contaminated In-Situ Sediment)**

CONFOUNDING ISSUES IN MICROTOX BIOASSAYS

BACKGROUND

THE MICROTOX SALINE EXTRACT TEST OF SEDIMENTS IS ONE OF THE ACCEPTABLE BIOASSAYS FOR THE PSDDA PROCESS AND FOR DETERMINING CHEMICAL SPECIFIC VALUES FOR USE IN ASSIGNING SEDIMENT MANAGEMENT STANDARDS.

PSDDA HAS SUSPENDED CONCLUSIONS BASED THAT ARE BASED ONLY ON RESPONSES BY MICROTOX ORGANISMS TO SALINE EXTRACTS OF SEDIMENTS.

13 OF 47 SEDIMENT MANAGEMENT VALUES IN THE AET DATA BASE ARE ESTABLISHED USING THE MICROTOX RESPONSE; 2 OF THESE (BUTYLBENZYLPHTHALATE AND TOTAL PCB'S) HAVE SUBSTANTIALLY LOWER AET RESPONSES THAN ANY OF THE OTHER BIOLOGICAL TESTS.

PROBLEM

RECENT WORK BY JACOBS ET AL.(1992). HAS SHOWN THAT ELEMENTAL SULFUR IN SOLVENT EXTRACTS IS TOXIC TO MICROTOX AT CONCENTRATIONS OF 24.7 TO 35.8 μg S/L.

IT IS UNKNOWN IF SALINE EXTRACTS OF SEDIMENT WOULD PRODUCE THESE CONCENTRATIONS OF SULFUR. IT IS KNOWN THAT THE MORE TOXIC SULFIDE FORMS ARE SOLUBLE IN SALINE EXTRACTS.

IT IS ALSO UNKNOWN IF FALSE POSITIVE RESPONSES BY MICROTOX OCCURRED IN THE DEVELOPMENT OF AET AND ITS APPLICATION TO SEDIMENT MANAGEMENT STANDARDS.

PROPOSED ACTIONS

ASSESS THE POTENTIAL FOR SULFUR (SULFIDES) TO PRODUCE MICROTOX TOXICITY IN SALINE EXTRACTS OF SEDIMENTS.

REASSESS AET VALUES THAT ARE SET BY MICROTOX RESPONSES; ESPECIALLY THOSE VALUES THAT ARE VERY DISSIMILAR TO OTHER BIOLOGICAL EFFECTS RESPONSE CRITERIA.

Ovrhd 13-1. Confounding Issues in Microtox Bioassays

1994 Recalculation of Apparent Effects Thresholds (AETs)

Definition:

concentrations above which significant adverse biological effects always occur

Criteria established for the exclusion of data:

1) not synoptic
2) failed chemical QA
3) insufficient lab replicates
4) negative control sample failure
5) no reference or reference failure
6) statistically inconclusive
7) chemically anomalous

Ovrhd 14-1. 1994 Recalculation of Apparent Effects Thresholds (AETs)

Data Excluded from 1994 AET Recalculations

Reason for Exclusion	Amphipod Data (# of samples)	Echinoderm Data (# of samples)
Failed Chemical QA	76	0
Insufficient Replicates	1	1
Negative Control Sample Failure	50	25
No Reference or Reference Failure	305	59
Statistically Inconclusive	13	11
Chemically Anomalous	13	8
Total Data Excluded	458	104
Percent Excluded	40.4%	32.9%
Total 1994 Data Inventory	1134	316

Ovrhd 14-2. Data Excluded for 1994 AET Recalculations

Reference Station Performance

- Problem identification
  - exclusion of good quality data
- Discussion
  - poor reference station performance does not indicate laboratory problems
  - negative and positive controls determine bioassay data quality
  - QA2 data requirements include reference toxicant data
- Suggested alternative
  - use default reference values when a reference station fails
  - default reference values based on historical data

Ovrhd 14-3. Reference Station Performance

Statistically Inconclusive Data

- Problem identification
  - the statistical methods are not the most appropriate
- Discussion
  - data may not be normally distributed
  - variance screening value is subjective
  - post-hoc power analysis is inappropriate as applied
- Suggested alternative
  - alternative non-parametric tests
  - probabilistic approach to screen for excessive variability
  - post-hoc power analysis using "biologically meaningful difference"

Ovrhd 14-4. Statistically Inconclusive Data

Chemically Anomalous Data

- Problem Identification
  - three-fold difference in chemical concentration considered chemically anomalous
- Discussion
  - subjective trigger value
  - QA/QC should detect any errors in data accuracy
  - high concentrations are expected
  - atypical Puget Sound substrates
- Suggested Alternative
  - include all valid data in the AET database
  - identify anomalous substrate type (i.e., ASARCO slag)

Ovrhd 14-5. Chemically Anomalous Data

Overall Recommendations

- Maximize data used in calculating AETs
  - use QA2 as primary data acceptance screening tool
  - find alternative method for failed reference samples
  - incorporate current statisitical methods in dealing with high variance data
  - include all data passing QA2

Ovrhd 14-6. Overall Recommendations

Ovrhd 15-1. Apparent Effects Thresholds

Apparent Effects Thresholds

- PSDDA recognized imperfections in 1988 AET methods
- Discussed decision to follow 1988 methods at 1992 Annual Review Meeting
- Revisiting AET concepts and methods lengthy, more contentious
- Dialog and feedback on methods being used will improve final AET re-evaluation
- Port of Seattle issue paper focuses on exclusion of useful data

Ovrhd 15-2. Apparent Effects Thresholds: Exclusion of Useful Synoptic Data

Apparent Effects Thresholds

- Exclusion of useful synoptic data
  - 160+ samples lacked bioassay reference, 80+ references failed performance standards
  - "post hoc" power analysis inappropriate, but relatively few samples found statistically inconclusive
  - relatively few chemically anomalous samples may have greatest effect on AET values (examples of anomalous samples)

Ovrhd 15-3. Apparent Effects Thresholds: Comments and Responses

Apparent Effects Thresholds

- PSDDA agencies will group comments and responses at post SMARM meeting:
  - valid comments, will address in near-term
  - valid comments, inadequate resources to address in near-term, will try to address in future re-evaluation
  - comments unlikely to trigger future action

Ovrhd 15-4. Apparent Effects Thresholds: Recommendations

Apparent Effects Thresholds

- Proceed with current AET effort, responding to as many comments as possible
- Establish Regulatory Work Group (RWG), define tasks, process and timeline, start series of meetings
- Propose separate "Technical Advisory Group" to be simultaneously reviewing AET concept, new tests or endpoints, statistical methods, etc

Table . Chemically anomalous amphipod mortaility samples, 1994.

Survey	Station	Sample	FR	SS	Benzyl alcohol
EBCHEM	WW-02	WW-02			8800
EBCHEM	SS-03	SS-03			1300
EBCHEM	EW-12	EW-12			870
EVCHEM	EW-04	EW-04G	EW04		810
CBMSQS	CI-11	CI-11			140
EBCHEM	WW-08	WW-08			140
CBMSQS	SP-16	SP-16			130
CBMSQS	HY-50	HY-50			73
CBMSQS	SP-12	SP-12			61
CBMSQS	BL-21	BL-21			57
CBMSQS	BL-25	BL-25			42
CBMSQS	HY-23	HY-23			41
CBMSQS	RS-12	RS-12			35
CBMSQS	HY-24	HY-24			33
CBMSQS	MI-15	MI-15			31
CBMSQS	MD-12	MD-12			29
CBMSQS	CI-22	CI-22			29
CBMSQS	HY-32	HY-32			29
CBMSQS	CI-13	CI-13			25
CBMSQS	MI-11	MI-11			25

Ovrhd 15-5.
Chemically Anomalous Amphipod Mortality Samples:
Benzyl Alcohol

Table . Chemically anomalous amphipod mortaility samples, 1994.

Survey	Station	Sample	FR	SS	Antimony
EBCHEM	WW-14	WW-14			1370
EBCHEM	WW-12	WW-12			1160
EBCHEM	SS-03	SS-03			690
EBCHEM	SS-09	SS-09			680
EBCHEM	NH-04	NH-04			504
CBMSQS	RS-18	RS-18			420
EBCHEM	NH-03	NH-03			249
EBCHEM	WW-18	WW-18			199
EBCHEM	KG-06	KG-06			192
EBCHEM	WW-19	WW-19			189
EBCHEM	WW-16	WW-16			184
EBCHEM	WW-06	WW-06	2		176
EBCHEM	WW-20	WW-20			163
EBCHEM	WW-11	WW-11			153
EBCHEM	EW-15	EW-15			150
EBCHEM	WW-09	WW-09			140
EBCHEM	KG-07	KG-07			128
EBCHEM	SS-06	SS-06			126
EBCHEM	WW-17	WW-17			114

Ovrhd 15-6.
Chemically Anomalous Amphipod Mortality Samples:
Antimony

Table . Chemically anomalous amphipod mortality samples, 1994.

Survey	Station	Sample	FR	SS	2-Methylphenol
EVCHEM	EW-04	EW-04G	EW04		1200
EVCHEM	EW-07	EW-07G	EW07		580
SITCUMRI	NC-S5	300043NCS5	1	1	370
SITCUMRI	NC-S6	300042NCS6	1	1	350
EBCHEM	DR-25	DR-25			280
EBCHEM	NH-04	NH-04			240
SITCUMRI	NC-S4	300048NCS4			77
SITCUMRI	NC-S2	300050NCS2			74
CBMSQS	RS-13	RS-13			72
CBMSQS	RS-18	RS-18			71
SITCUMRI	NC-S1	300051NCS1			71
SITCUMRI	NC-S3	300049NCS3			68
SITCUMRI	NC-I11	300079NCI11			64
CBMSQS	MD-12	MD-12			63
SITCUMRI	NC-I1	300092NCI1			55
SITCUMRI	NC-I3	300090NCI3			55
SITCUMRI	NC-I12	300078NCI12			55
SITCUMRI	NC-I2	300091NCI2			54

Ovrhd 15-7.
Chemically Anomalous Amphipod Mortality Samples: 2-Methylphenol

Table . Chemically anomalous amphipod mortality samples, 1994.

Survey	Station	Sample	FR	SS	2,4-Dimethylphenol
EVCHEM	EW-04	EW-04G	EW04		520
SITCUMRI	NC-S5	300043NCS5	1	1	370
SITCUMRI	NC-S6	300042NCS6	1	1	350
EBCHEM	SS-07	SS-07			210
EVCHEM	EW-07	EW-07G	EW07		130
SITCUMRI	NC-S4	300048NCS4			77
SITCUMRI	NC-S2	300050NCS2			74
EHCHEM	EH-08	V1			74
EHCHEM	EH-15	V1			72
SITCUMRI	NC-S1	300051NCS1			71
SITCUMRI	NC-S3	300049NCS3			68
SITCUMRI	NC-I11	300079NCI11			64
EHCHEM	EH-05	V1			59
SITCUMRI	NC-I1	300092NCI1			55
SITCUMRI	NC-I3	300090NCI3			55
SITCUMRI	NC-I12	300078NCI12			55
SITCUMRI	NC-I2	300091NCI2			54
SITCUMRI	NC-I6	300086NCI6			53

Ovrhd 15-8.
Chemically Anomalous Amphipod Mortality Samples: 2,4-Dimethylphenol

Table . Chemically anomalous amphipod mortaility samples, 1994.

Survey	Station	Sample	FR	SS	Silver
SITCUMRI	NS-D4	300098NSD4			33.4
SITCUMRI	NS-D6	300095NSD6	1	1	29.7
SITCUMRI	NS-D5	300099NSD5			24.1
SITCUMRI	NS-D6	300095ANSI	1	1	19.3
SITCUMRI	NS-D2	300083NSD2	1	1	12.2
SITCUMRI	NS-B1	300018NSB1			8.4
EBCHEM	NS-01	NS-01			8.27
EBCHEM	SS-05	SS-05	SS18		6.12
EBCHEM	SS-07	SS-07			5.85
SITCUMRI	NS-E1A	300097NSE1A			5.8
EBCHEM	SS-05	SS-05	SS19		5.58
SITCUMRI	NS-A2	300047NSA2			5.3
EBCHEM	SS-12	SS-12			4.98
EBCHEM	SS-06	SS-06			4.72
EBCHEM	EW-05	EW-05	2		4.6
SITCUMRI	NS-E4	300106NS34			4.5
EBCHEM	SS-11	SS-11			4.31
SITCUMRI	NS-E5	300094ANSE	1	1	4
SITCUMRI	NS-E5	300094NSE5	1	1	4
EIGHTBAY	SC-06	SC-06			3.7

Ovrhd 15-9. Chemically Anomalous Amphipod Mortality Samples: Silver

Problem Identification

- 1994 Recalculation of Apparent Effects Threshold Values (AETs)
  - separate phyla AETs for larval toxicity tests
  - apparent differences in sensitivity --> *inconclusive*
  - no-action by agencies
- Investigate differences in sensitivities
  - available EC50 data
  - 5 species
  - 4 reference toxicants
  - water only
  - trends in species or phyla differences?

Ovrhd 16-1. **Problem Identification**

Larval Toxicity Tests

- Echinoderm
  - *Dendraster excentricus* (June-September)
  - *Strongylocentrotus purpuratus* (December-March)

- Bivalve
  - *Crassostrea gigas* (May - October)
  - *Mytilus edulis* or *M. galloprovincialis* (December-April)

Ovrhd 16-2. Larval Toxicity Tests

EC50 Values by Reference Toxicant and Species

	Bivalve Larvae			Echinoderm Larvae	
Reference Toxicant	*Crassostrea gigas*	*Mytilus edulis*	*Mytilus galloprovincialis*	*Dendraster excentricus*	*Strongylocentrotus purpuratus*
Cadmium (mg/L) **median** (range) sample size	**1.2** (0.42-2.3) n=18	**2.0** (0.40-4.3) n=10	**3.4** (1.9-5.6) n=5	**6.0** (1.9-23) n=30	**0.32** (0.03-89) n=8
Copper (mg/L)	**10** (8.2-25) n=5	–	**7.7** (3.3-15) n=25	**17** (15-24) n=10	**27** (21-32) n=2
Ammonia (mg/L)	**7.1** (6.8-7.6) n=4	–	**6.4** (2.2-13) n=13	**2.65** (2.4-2.9) n=2	–
Sodium dodecyl sulphate (SDS) (mg/L)	**3.6** (2.1-4.2) n=21	**3.7** (2.4-5.0) n=20	–	**3.1** (2.0-9.1) n=8	**6.4** (2.9-8.4) n=12

Ovrhd 16-3. EC50 Values by Reference Toxicant and Species

Distribution of EC50 Values, With Sample Sizes

Cadmium

Copper

Ammonia

SDS

Ovrhd 16-4. Distribution of EC50 Values, with Sample Sizes

Recommendations

- Retain combined echinoderm/bivalve AET
  - accommodates variable sensitivities
  - flexible
  - seasonal appropriateness

- Design an experiment to test sensitivity differences
  - side by side tests, 5 species
  - water only
  - selected contaminants: cadmium, mercury, naphthalene

Ovrhd 16-5. Recommendations

BENTHIC COMMUNITY AET FOR PCB'S

BACKGROUND

THE MAXIMUM CHEMICAL CONCENTRATION LEVELS THAT MAY BE ALLOWED WITHIN AN AUTHORIZED IMPACT ZONE AND THE MINIMUM CLEANUP LEVELS FOR TOTAL PCB'S IS 65 PPM ORGANIC CARBON.

THE AET VALUE THAT ESTABLISHED THIS CRITERIA WAS THE BENTHIC RESPONSE BASED ON A REDUCTION OF 50% OF ONE OF THREE MAJOR TAXONOMIC GROUPS.

PROBLEM

THE DATA USED TO ESTABLISH THIS RELATIONSHIP AND PRESENTED IN THE ORIGINAL DOCUMENTS (TETRA TECH 1986) HAD APPARENT TYPOGRAPHICAL ERRORS.

THE COMMUNITIES OF ORGANISMS WITH APPARENT RESPONSES AT SEDIMENT CONCENTRATIONS ABOVE THESE VALUES ARE ALSO ALL FROM HEAVILY ORGANICALLY ENRICHED SEDIMENTS AT THE DENNY WAY CSO.

PROPOSED ACTIONS

THE RAW DATA USED TO DETERMINE THE BENTHIC AET FOR TOTAL PCB'S SHOULD BE REEVALUATED TO CHECK FOR INAPPROPRIATE CLASSIFICATION AND POSSIBLE INCONSISTENCIES.

THE INFLUENCE OF HEAVY ORGANIC ENRICHMENT ON BENTHIC AET VALUES NEEDS TO BE ASSESSED BY COMPARING AREAS WITH COMPARABLE ORGANIC ENRICHMENT AND MUCH DIFFERENT CONTAMINATION LEVELS.

Ovrhd 17-1. Benthic Community AET for PCBs

TABLE 1. Data used for PCB Benthic AET determination (from Tetra Tech 1986).

SURVEY	STATION	SAMPLE	CONCENTRATION MG/KG TOC	HIT	BENTHIC CODE	ORIGINAL STATION	LOCATION
TPPS3AB	EB-36	1776	670	Y	2	1606	DENNY WAY CSO
TPPS3AB	EB-35	1775	510	Y	2	1603	DENNY WAY CSO
TPPS3AB	EB-33	2080	380	Y	3	1406	DENNY WAY CSO
TPPS3AB	WP-08	2083	270	Y	1	810	WEST OF 4-MILE ROCK
TPPS3AB	EB-35	2079	220	Y	3	1603	DENNY WAY CSO
EBCHEM	KG-06	KG-06	E190	Y	NA[a]	NA	NA
EBCHEM	MG-04	MG-04	U130	Y	NA	NA	NA
TPPS3AB	EB-33	1779	120	Y	3	1406	DENNY WAY CSO
EBCHEM	NH-03	NH-03	E110	Y	NA	NA	NA
EBCHEM	WW-05	WW-05	E98	Y	NA	NA	NA
EBCHEM	SS-01	SS-01	U95	N	NA	NA	NA
EBCHEM	MG-03	MG-03	U83	Y	NA	NA	NA
TPPS3AB*	WP-07	1812	83	N	0	730	SW OF WEST POINT
TPPS3AB	EB-36	2072	79	Y	3	1606	DENNY WAY CSO
EBCHEM	MG-02	MG-02	U76	Y	NA	NA	NA
EBCHEM	NH-08	NH-08	E66	Y	NA	NA	NA
TPPS3AB	WP-09	2082	65	N	1	830	4-MILE ROCK
EBCHEM	WW-03	WW-03	U64	Y			
TPPS3AB	EB-38	1778	56	N	1	1706	DENNY WAY CSO
EBCHEM	AB-03	AB-03	U55	Y	NA	NA	NA
CBMSQA	HY-47	HY-47	U54	Y	NA	NA	HYLEBOS WATERWAY
TPPS3AB	WP-13	1784	53	N	1	375	BASIN OFF WEST POINT

(a) NA Data not available in Tetra Tech (1986)

Ovrhd 17-2. Data used for PCB Benthic AET Determination

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Cooperative Sediment Management Program and Status of Sediment Cleanup Strategy

presented by

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Ovrhd 18-1. Cooperative Sediment Management Program and Status of Sediment Cleanup Strategy

Ovrhd 18-2. History

History

- Premise: Interest in use of PSDDA model of cooperative decisionmaking for sediment challenges
- Interagency/Intergovernmental Agreement signed by five agencies in May 1994
- Initiate joint actions:
  - Sediment Cleanup Strategy
  - Multiuser Confined Disposal siting
  - Beneficial Uses Work Group
- Sediment Cleanup Work Group convened to develop strategy

Ovrhd 18-3. Work Group Charges and Consensus Recommendations

Work Group Charges and Consensus Recommendations

CHARGES

- Facilitate cleanup under existing legal framework
- Strategy for urban sediment cleanups
- Agency roles and funding sources
- Possibilities for changing legal scheme

RECOMMENDATIONS

- Manage sediment loading
- Agencies work cooperatively
- Publish ranked list of contaminated sites
- Institute a baywide approach
- Focus on 'hotspots"
- Reduce barriers for voluntary cleanups
- Build a MUDS

Ovrhd 18-4. Sediment Cleanup Strategy: An Interagency Overview

Sediment Cleanup Strategy: An Interagency Overview

- Responded to recommendations and described a phased strategy for collective action
  - Phase 1: Federal lead effort to produce needed program guidelines for immediate use and establishment of a technical assistance team
  - Phase 2: State lead effort to test ways of coordinating and expediting sediment cleanup, source control, disposal, and habitat restoration at a local level

Ovrhd 18-5. Demonstration Pilot Project Premise/Approach

Demonstration Pilot Project Premise/Approach

- Coordinate multiple objectives
- Incorporate local priorities through equal participation
- Link economic and ecological/human health benefits
- Pursue existing and new funding sources
- Offer regulatory discretion

Ovrhd 18-6. Demonstration Pilot Project Status

Demonstration Pilot Project Status

- Four candidate bays have been contacted regarding partnering for the project
- Department of Ecology has appropriated $700,000 for local government partner use for staffing, technical studies, database development, and/or prioritization process
- Selection of the demonstration bay will be June 28, 1996

Ovrhd 18-7. Demonstration Pilot Project Status (Cont.)

Demonstration Pilot Project Status Cont'd

- Anticipate 6 - 18 month process to develop a scope of work and begin implementation:
  - identify specific objectives
  - fill data gaps
  - prioritize actions
  - develop funding mechanism
  - complete implementing agreements/SEPA
  - conduct priority actions
  - evaluate success of pilot

BENEFICIAL USES WORK GROUP

Interagency/Intergovernmental Agreement

Tasks:

1. **Compile agency policies and procedures EPA, Corps, Ecology, DNR, WDFW**
2. **Identify common and different policies and procedures**
3. **Prepare common set of policies (resolve differences, if possible)**
4. **Recommend integrated procedure for agency review and approval**
5. **Identify implementation methods and unresolved issues**

...Develop regional guidelines to facilitate projects involving beneficial uses of dredged material...

Ovrhd 19-1. Beneficial Uses Work Group: Tasks

BENEFICIAL USES WORK GROUP

Convened April 1995

To date:

- **Definition of "beneficial uses"; glossary of terms**
- **Identification of policy conflicts and limitations**
- **Prioritization scheme for projects**
- **Technical considerations, e.g., characterization, PSDDA suitability determinations, project specific factors**
- **Permitting process**

Products: **(1) Executive Summary for agency directors**
(2) User Manual for project proponents

Draft products: **July 1996**
Final products: **October 1996**

Ovrhd 19-2. Beneficial Uses Work Group: Products

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Human Health Sediment Criteria Development

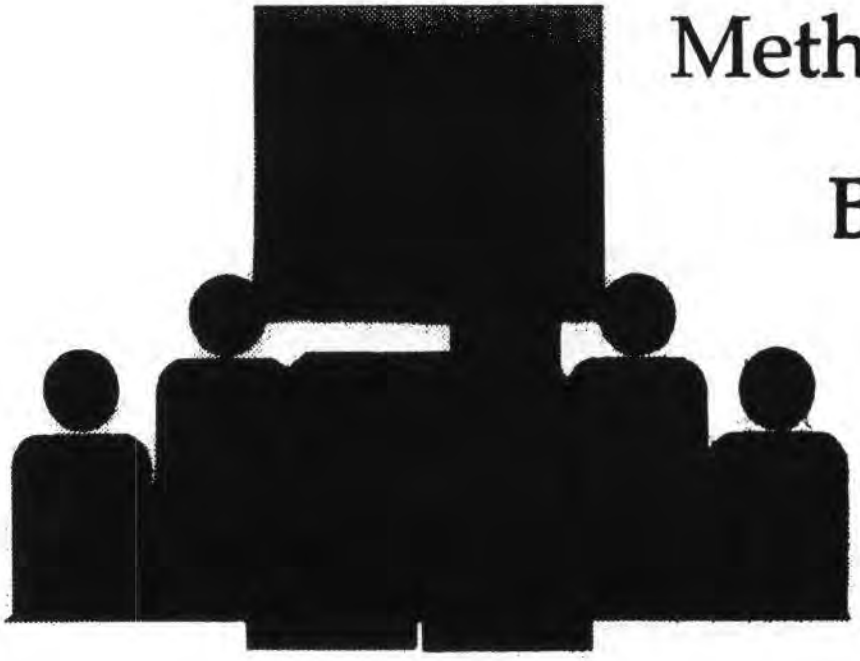
Sediment Management Annual Review

Laura B. Weiss, M.P.H.
(360) 407-7446

1995 SMARM

Background - Why, What and Where

Chemicals of Concern



Methodology for Tier I

BSAF Development

Schedule

Why Develop Health-Based Sediment Criteria?

Reasons for Concern

- *Elevated health risks in urban bays*
- *Ensure safe fish/shellfish for future generations*
- *Lack of certainty and consistency under case-by-case approach*
- *Allow for more timely decision-making*

Mandates

- *Water Pollution Control Act (RCW 90.48)*
- *Model Toxics Control Act (RCW 70.105D)*
- *Puget Sound Water Quality Act (RCW 90.70)*

Conceptual Model

Humans

Risk = Exposure x Toxicity

Fish/Shellfish

Biota-Sediment Accumulation Factor (BSAF)

Sediment

New Technical Developments

- Tier I Report finalized (DOH)
- Technical Review of Distributional Analysis for Cancer Potency Factors
- Bioaccumulation Factor Approach Analysis for Metals and Polar Organic Compounds
- Analysis of BSAF Values for Nonpolar Organic Compounds in Finfish and Shellfish

Tier I Report (DOH, 1995)

- Finalized in Summer 1995
- Included:
  - Determination of background concentrations
  - List of chemicals of concern (3 groups)
  - BSAF development
  - Fish consumption review and recommendations
- SQC calculated based on DOH recommendations

Policy/Implementation

- Alternative Decision-Making Frameworks: Options Paper discussed with Implementation Committee
- Key Issues Discussed:
  - Role of fish tissue testing
  - Use of numerical vs. formula-based criteria
  - Background/reference area concentrations
  - Chemicals with no available BSAFs
  - Role of surface area weighting
  - Background risk

Issues/Concerns Raised

- Technical/scientific methods
- Consistency between Ecology programs
- Liability and cost associated with cleanup
- Statutory authority
- Implications for source control
- Environmental equity
- Speed of rule development
- Protection of resource and future generations

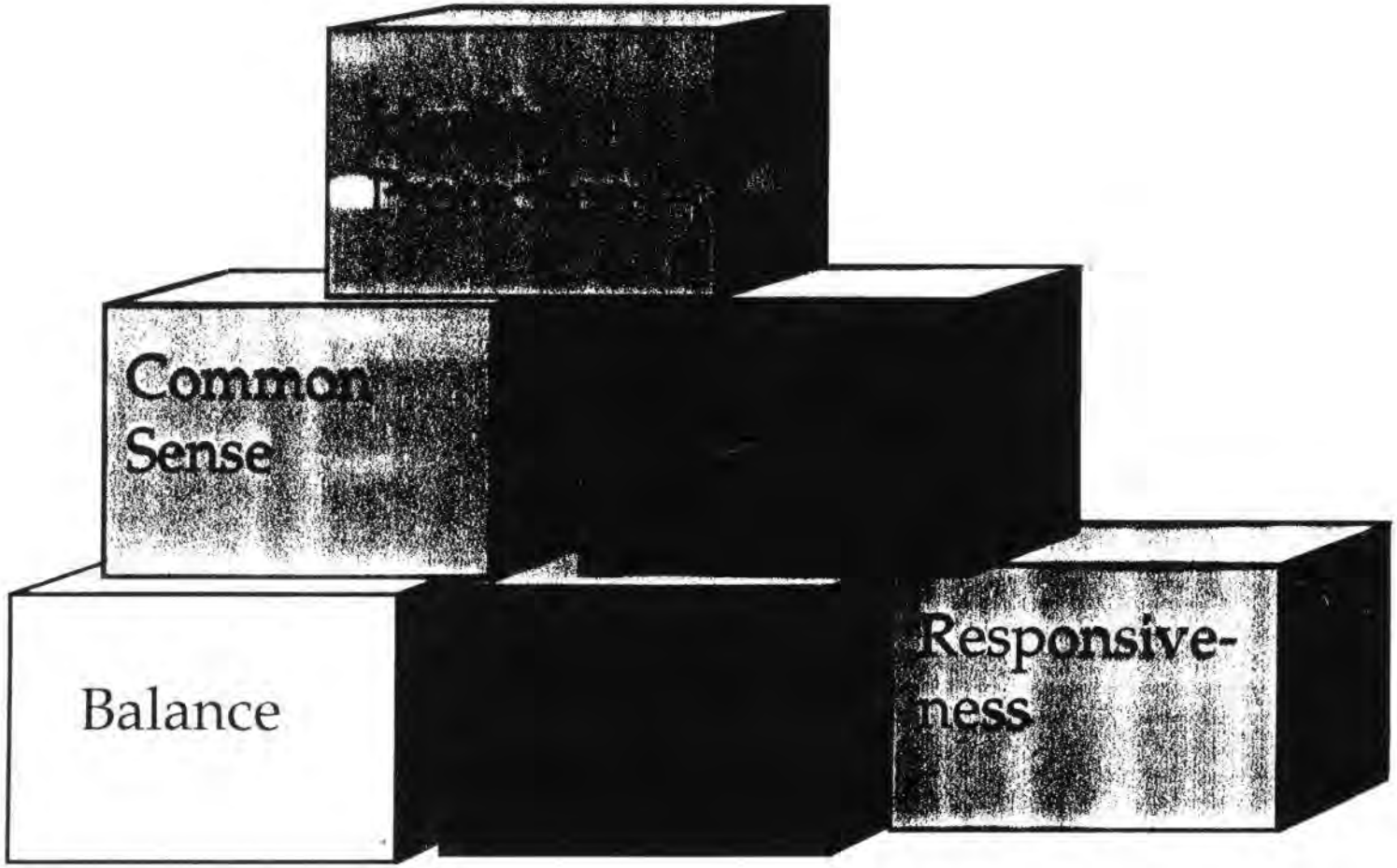
Revised Approach: Case Studies

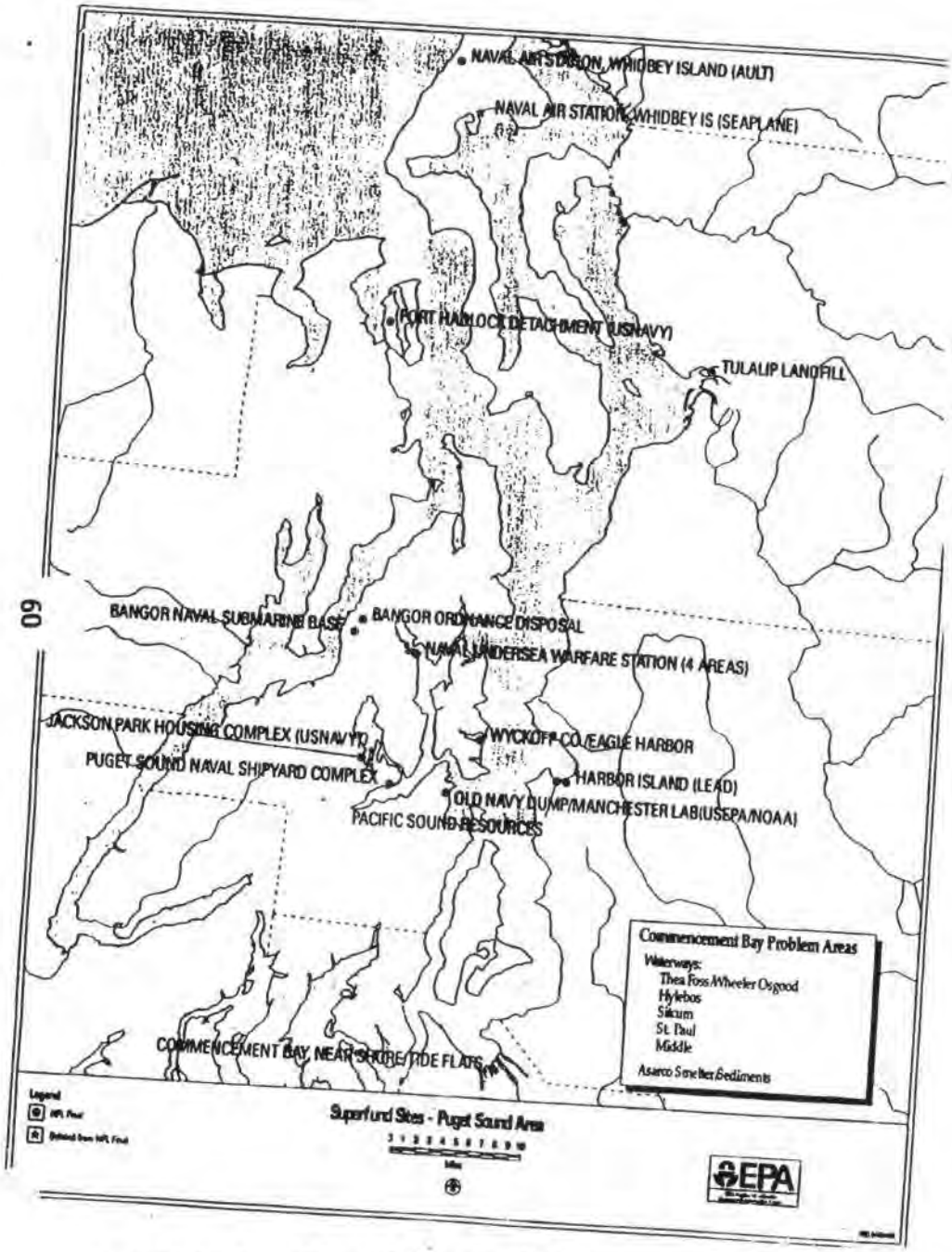
- ✓ What are current approaches/ methods?
- ✓ How can we improve efficiency of case-by-case decision-making?
- ✓ How will rule affect existing sites?
- ✓ How will rule affect source control decisions?
- ✓ What lessons from the field can we use to improve HHSQC rule and guidance?

Schedule

May '96	Document rule framework
June '96	Develop site manager questionnaire
July/Aug	Case studies
Sept '96	Document results
Oct '96	Distribute case study results

Case Study Building Blocks





Ovrhd 22-1. Map of Superfund Sites

EPA REGION 10 SUPERFUND SITE CATEGORIES

- **EPA/Ecology Division of Labor**

  Intra-Site: EPA and Ecology divide responsibilities where each agency focuses on a certain aspect of the problem (i.e., at Commencement Bay Ecology is lead on source control while EPA is lead on sediment cleanup).

  Inter-Site: EPA or Ecology take responsibility for the whole site.

- **Financing of Sites**

  Fund Financed

  PRP Financed

  Federal Facility Financed

Ovrhd 22-2. EPA Region 10 Superfund Site Categories

EPA Region 10 Superfund Sites in Puget Sound								
Site	Size		Type of Site	Agency Lead	Phase Cleanup			
	# Areas	Sediments			Investig.	Decision	Design	Action
Commencement Bay	6							
Thea Foss Wheeler-Osgood		600,000* cy	Multiple commercial industrial sources	Ecology lead on source control; EPA lead on sediment cleanup	x	x	x	
Hylebos		1,200,000* cy	Multiple commercial industrial sources	Ecology lead on source control; EPA lead on sediment cleanup	x	x	x	
Middle Waterway		63,000* cy	Multiple commercial industrial sources	Ecology lead on source control; EPA lead on sediment cleanup	x	x	x	
Sitcum		2,400,000 cy	Multiple commercial industrial sources	Ecology lead, source control; EPA lead, sediment cleanup and long-term monitoring	x	x	x	Cleanup completed 1994
St. Paul		17-acre sediment cap	Pulp and paper mill	Ecology lead, source control and sediment cleanup; EPA lead, long-term monitoring	x	x	x	Cleanup completed 1988
Asarco (Sediments)		168,000*** cy	Arsenic smelter	EPA lead	x			
Pacific Sound Resources	2		Wood treater	EPA				
Upland	25 acres non sediment				x			Early action
Offshore		10 acres (50,000-150,000*** cy)			x			

Ovrhd 22-3. Table of EPA Region 10 Superfund Sites

Site	Size		Type of Site	Agency Lead	Phase Cleanup			
	# Areas	Sediments			Investig.	Decision	Design	Action
Harbor Island	2	325** acres	Shipyard and other industrial sources	EPA				
Todd & Lockheed Shipyards		150,000*** cy; 29 acres			x	x		
Remainder of sites		296** acres			x			Early action
Wyckoff/Eagle Harbor	4		Wood treater/shipyard	EPA				
East Harbor		200** acres 50*** acres 50**** acres			x	x		Early action
West Harbor		10*** acres			x	x	x	
Wyckoff Facility					x			Early action
Wyckoff Facility GW					x	x		
Tulalip	2		Landfill	EPA				
Landfill	150 acres non-sediments				x	x		
Off-Source Area		~200** acres			x			
Old Navy Dump	1	~50**acres	Navy disposal site	EPA lead oversight; COE lead doing work	x			

Ovrhd 22-4. Table of EPA Region 10 Superfund Sites (Cont.)

Site	Size		Type of Site	Agency Lead	Phase Cleanup			
	# Areas	Sediments			Investig.	Decision	Design	Action
Naval Air Station Whidbey (Ault Field)	5 ~8000 acres	Sampling of marine & fresh-water sediments	Naval air station	EPA/lead; Navy lead doing work	x	x	x	Final actions
Naval Air Station Whidbey (Seaplane Base)	1	Sampling of marine sediments & bioassays	Naval Seaplane Base; fuel storage area	EPA/Ecology lead; Navy lead doing work	x	x	x	Deleted from NPL
Puget Sound Naval Shipyard	4	340** acres	Naval Shipyard	Ecology lead; EPA support; Navy doing the work	x			Some up-land early actions
Bangor Ordnance Disposal	2	Some marine & freshwater sedi-ment & bioassay sampling	Naval Ordnance Base	Ecology lead; Navy doing the work	x	x	x	x
Bangor Naval Submarine Base	7	Marine sediment & bioassay sampling (Hood Canal)	Naval Submarine Base	Ecology lead; Navy doing the work	x	x	x	x
Naval Undersea Warfare Station	2	Marine sediment & bioassay sampling	Torpedo chrome plating/landfill	Ecology lead; Navy doing the work				
Upland					x	x	x	x
Landfill					x			
Jackson Park Housing Complex	1	Marine sediment & bioassay sampling	Navy Munitions storage/Navy housing complex	Ecology lead; Navy doing the work	x			
Port Hadlock	1	~100**acres	Navy facility/port	Ecology lead; Navy doing the work	x	x	x	

* Estimated volume of contaminated sediments
** Estimated acres/cy under study or studied in RI/FS
***Estimated acres/cy subject to cleanup
****Estimated acres needing further remediation

Ovrhd 22-5. Table of EPA Region 10 Superfund Sites (Cont.)

PSDDA/SMS ISSUES

1. TBT

   A. Keep current biological testing approach until bioassays are demonstrated to be insensitive to TBT. Recommend a study of 3 amphipod species (*Rhepoxynius*, *Eohaustorius estuarius* and *Eohaustorius washingtonius*) to assess TBT sensitivity, flocculation for sediment grain sizes, and the spiking of the sediment with TBT at Puget Sound ranges.

   B. The Maximum level proposal is not reasonable, and needs to be reassessed.

   C. PSDDA needs to consider alternative screening approaches (Organotin) to reduce costs and onerous testing requirements.

2. PSDDA needs to evaluate cleanup versus dredging questions, and these questions should be assessed *a priori* to reduce false positives.

3. *A priori* analysis of ammonia in interstitial water is needed to assess the need to purge to reduce false positives, rather than *a postori* analyses.

4. There is a need to assess sulfur and sulfide effects on saline Microtox and solid phase Microtox.

5. AETs

   A. The AET's issue of tagging data as anomalies needs to be re-evaluated.

   B. PSDDA needs to consider using reference defaults for bioassays where QA is okay, but there are no references or there is a reference problem.

   C. The 1986 AET for PCB (benthos) needs to be reassessed.

Ovrhd 23-1. PSDDA/SMS Issues