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EPA

AN SAB REPORT: EVALUATION OF A TESTING MANUAL FOR DREDGED MATERIAL PROPOSED FOR DISCHARGE IN INLAND AND NEAR COASTAL WATERS

PREPARED BY THE SEDIMENT QUALITY SUBCOMMITTEE OF THE ECOLOGICAL PROCESSES AND EFFECTS COMMITTEE

EPA-SAB-EPEC-94-007

February 1, 1994

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Subject: Review of the Draft Testing Manual for Dredged Material Proposed for Discharge in Inland and Near Coastal Waters

Dear Ms. Browner:

On July 7-8, 1993, the Sediment Quality Subcommittee of the Ecological Processes and Effects Committee met to review the Agency's draft document, *Evaluation of Dredged Material Proposed for Discharge in Inland and Near Coastal Waters: Testing Manual*. The testing manual provides test methods for evaluating the potential ecological and human health impacts of contaminants in dredged material proposed for discharge under section 404 of the Clean Water Act. At the request of the Office of Water, we reviewed the manual to determine whether it provides an appropriate testing framework, and in particular, to evaluate: 1) the chemical and physical analyses; 2) the types of bioassays and species selected for toxicity and bioaccumulation tests; 3) the scope of the Tier IV (case-specific) studies; 4) the statistical methods used to compare dredged material to reference sediment; and 5) the use of the mixing zone model (STFATE) in a variety of shallow-water conditions.

In 1991, the Science Advisory Board reviewed the companion testing manual for evaluating dredged material proposed for disposal in ocean waters. We were pleased to see that many of the recommendations of that review have been addressed in the testing manual for inland and near coastal waters. Overall, the proposed test methods in the manual are validated and appropriate for use at this time. Although we have recommended a number of specific changes to the test procedures, the primary focus of our report is on issues which are not well addressed in the draft manual. Several of our broader recommendations are relevant to the Agency's overall approach to contaminated sediments. Our principle recommendations are as follows:

a) The assessment of risks from discharge of dredged material in inland and near coastal waters should be conducted in accordance with the Agency's *Framework for Ecological Risk Assessment*, considering the full range of risks (including those from resuspension of pathogenic microorganisms in dredged material) and the risks associated with alternative disposal options.

b) The toxicity of dredged material should be determined relative to known clean sediments, rather than relative to reference sediments which may themselves be causing contaminant-related impacts.

c) The manual should include plant bioassays to be conducted in conjunction with animal tests in cases where the dredged material discharge site will be vegetated (e.g. beneficial uses of dredged material for creation of wetlands, submerged aquatic vegetation beds, and beach renourishment).

d) The development and implementation of a continuous release model for dredged material discharge, to supplement the instantaneous discharge model (STFATE), should be accelerated and included in the final manual.

e) Guidance on sampling design, field collection of samples, and statistical analysis of data should be expanded.

We appreciate the opportunity to review this important document, and we hope that our recommendations will be helpful to the Agency and the U.S. Army Corps of Engineers in implementing section 404 of the Clean Water Act. The Sediment Quality Subcommittee has reviewed a number of scientific issues and methodologies over the past years which are the stepping stones to the development of sediment quality criteria and an overall contaminated sediment strategy. We encourage the Agency to continue this interaction with the Board as subsequent sediment technical documents are developed.

Sincerely,

/signed/

Dr. Genevieve M. Matanoski, Chair
Executive Committee

/signed/
Dr. Kenneth L. Dickson, Chair
Ecological Processes and
Effects Committee

/signed/
Dr. Robert J. Huggett, Chair
Sediment Quality Subcommittee

U.S. Environmental Protection Agency

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ABSTRACT

On July 7-8, 1993, the Sediment Quality Subcommittee of the Ecological Processes and Effects Committee met to review the draft document, *Evaluation of Dredged Material Proposed for Discharge in Inland and Near Coastal Waters: Testing Manual*, to determine whether it provides an appropriate testing framework to evaluate potential ecological and human health impacts of proposed discharges of dredged material under section 404 of the Clean Water Act. Overall, the Subcommittee concluded that the tests were validated and appropriate for use at this time. However, the Subcommittee questioned the premise of comparing contaminant-related risks from dredged material to those from reference material which might itself be causing adverse biological effects. Rather, the Subcommittee recommended that the toxicity of dredged material be determined relative to known clean sediments. The Subcommittee felt that the assessment of risks from discharge of dredged material in inland and near coastal waters should be conducted in accordance with the Agency's *Framework for Ecological Risk Assessment*, considering the full range of risks (including those from resuspension of pathogenic microorganisms in dredged material) and risks associated with alternative disposal options. In assessing risks to human health from bioaccumulating substances, the Subcommittee agreed that FDA action levels are the appropriate benchmarks for comparison, as long as the tests are made on edible portions of food organisms; bioaccumulation factors (BAFs) determined in amphipods or aquatic insects are not appropriate for such a comparison. The panel also recommended that plant bioassays be conducted in conjunction with animal tests in cases where the dredged material discharge site will be vegetated (e.g., beneficial uses of dredged material for creation of wetlands, submerged aquatic vegetation beds, and beach nourishment).

KEYWORDS: dredged material, ecological risk assessment, bioaccumulation, toxicity

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SCIENCE ADVISORY BOARD
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SEDIMENT QUALITY SUBCOMMITTEE

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1. EXECUTIVE SUMMARY

The Sediment Quality Subcommittee of the Ecological Processes and Effects Committee has reviewed the draft document, *Evaluation of Dredged Material Proposed for Discharge in Inland and Near Coastal Waters: Testing Manual* (May 1993), to determine whether it provides an appropriate testing framework to evaluate potential ecological and human health impacts of proposed discharges of dredged material under section 404 of the Clean Water Act. Overall, the proposed test methods in the manual are validated and appropriate for use at this time. However, since this is a rapidly advancing field, we encourage both EPA and the U.S. Army Corps of Engineers to maintain active research programs to identify, develop, validate and apply new approaches for assessing environmental and human health risks related to disposal of dredged material. Our comments and recommendations are summarized as follows:

a) **We recommend that the toxicity of dredged material be determined relative to known clean sediments.** The manual currently requires that the determination of contaminant-related impacts be based on statistical comparisons between tests with proposed dredged material and reference sediment. However, the criteria for selection of reference sites are vague and subjective. If the chosen reference site sediments contain contaminants that elicit the same level of effects as those in the dredged material, then discharge could be approved even if significant mortality of test organisms occurred in both. We disagree with the underlying assumption that discharge of toxic dredged material at already-contaminated sites will not cause additional degradation, since: 1) natural deposition may remove in-place contamination from the biologically active zone if the source of contamination is removed, and 2) the substance(s) causing the adverse biological effects in the dredged material may have a different degradation half-life than those in the reference sediments.

b) **The manual should incorporate elements of EPA's *Framework for Ecological Risk Assessment* and relate the test procedures in the manual to the overall assessment of risks associated with various disposal options, including discharge into coastal and inland waters.**

c) **The manual should address the full range of risks from discharge of dredged material into coastal and inland waters, including those related to pathogenic microorganisms.** Currently, the manual focuses primarily on risks from chemical contaminants that bioaccumulate and would, therefore, be transmitted to humans through consumption of food exposed at the site. However, the 28-day "bioavailability" test in the manual has several limitations: 1) one cannot assume that an equilibrium has been reached after 28 days, especially in the case of macromolecules, and 2) results of bioavailability tests must be evaluated in conjunction with information on the extent of uptake and storage of a contaminant in the organisms.

The manual does not adequately address the most likely human health risk from discharge of dredged material in inland and near-shore environments, namely the resuspension of pathogenic microorganisms which have accumulated in sediments, e.g., near sewage treatment plant outfalls. The testing manual should include greater detail on the analytical methods available for assessing the extent of microbial contamination, their strengths and weaknesses, and appropriate uses.

d) **Where plants may become part of the ecosystem developing on the deposited dredged material, plant bioassays should be conducted in conjunction with animal tests.** Although the manual specifically states that the tests apply to dredged material to be used for beneficial uses, most of which (wetlands, submerged aquatic vegetation beds, and beaches) will be vegetated, no plant toxicity tests are required. Animals, no matter how carefully chosen, cannot serve as surrogates for plants. For example, responses to herbicides, sulfides, pH, sediment texture and fertility cannot be evaluated across kingdoms.

e) **We recommend a number of specific changes to test procedures in the manual**, for example: 1) elutriate for chemical analyses and toxicity testing should be prepared using water which mimics the salinity and ionic composition of the water at the proposed discharge site rather than the dredging site; and 2) consideration should be given to conducting sediment bioassays on core segments since homogenizing sediment samples may result in over or under-estimation of ecological risks from contaminated sediment.

f) **Sublethal chronic tests are very important in assessing sediment toxicity and such assays should be incorporated into Tier III as soon as they have reached an acceptable level of development.** Another source of information on longer-term contaminant related impacts is analysis of benthic community structure and bioaccumulation in indigenous infauna at proposed dredging and reference sites.

g) **The STFATE mixing zone model appears to be competently implemented and useful for instantaneous discharges of dredged material, although the manual should include greater detail on the model's limitations, intended uses, and governing equations. However, since most estuarine and near-shore dredging is by means of pipe dredges with continuous discharge dredged material release, we recommend that development/implementation of a continuous release model be accelerated and included in the final manual.**

h) **We recommend that guidance on sampling design, field collection and statistical analysis of data be expanded in the final manual.**

2. INTRODUCTION

2.1 Background

Under section 404 of the Clean Water Act, the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE) share responsibility for managing disposal of dredged material. The COE regulates non-federal dredging and dredged material discharge activities through a permit program, and conducts federal dredging and dredged material activities through its Civil Works Program. EPA is responsible for developing guidelines for designating dredged material disposal sites. The statute requires that these 404(b)(1) guidelines be comparable to criteria established under the Marine Protection, Research and Sanctuaries Act (MPRSA) for disposal of dredged material into ocean waters.

In 1991, the Science Advisory Board reviewed the *Testing Manual for Evaluation of Dredged Material Proposed for Ocean Disposal* (Ocean Testing Manual), which addresses dredged material disposal governed by section 103 of the MPRSA (EPA-SAB-EPEC-92-014). Like the Ocean Testing Manual, the document titled *Evaluation of Dredged Material Proposed for Discharge in Inland and Near Coastal Waters: Testing Manual* is intended to form the basis for the assessment of contaminant-related environmental impacts from proposed discharge of dredged material. Test results are evaluated along with consideration of physical impacts, disposal alternatives, etc. prior to a final decision.

2.2 Charge to the Subcommittee

On July 7-8, 1993, the Sediment Quality Subcommittee of the Science Advisory Board's Ecological Processes and Effects Committee met to review the draft document, *Evaluation of Dredged Material Proposed for Discharge in Inland and Near Coastal Waters: Testing Manual* (Inland Testing Manual). The Office of Science and Technology in the Office of Water requested that the Subcommittee review the draft testing manual to determine whether it provides an appropriate testing framework to evaluate potential ecological and human health impacts of proposed discharges of dredged material under section 404 of the Clean Water Act, and, in particular, to evaluate 1) the chemical and physical analyses; 2) the types of bioassays and species selected for toxicity and bioaccumulation tests; 3) the scope of the Tier IV studies; 4) the statistical methods used to compare dredged material to reference sediment; and 5) the use of the mixing zone model (STFATE) in a variety of shallow-water conditions.

3. GENERAL COMMENTS

3.1 Test Methods

The Subcommittee commends the authors of the Inland Testing Manual in that many of the recommendations made by the SAB on the Ocean Testing Manual have been addressed here. For example, a major concern with the Ocean Testing Manual involved the selection of toxicity test organisms and the tests themselves. With the exception of plant bioassays, which were not a consideration for the Ocean Testing Manual, most of these concerns have been alleviated in this draft of the Inland Testing Manual. The test methods in the manual are validated and appropriate for use at this time. However, since this is a rapidly advancing field, we encourage both EPA and the COE to maintain active research programs to identify, develop, validate and apply new approaches for assessing environmental and human health risks related to disposal of dredged material (e.g., cell culture bioassays, biomarkers, and molecular measures). Of particular importance would be to take advantage of scientific developments occurring in other federal agencies (U.S. Fish and Wildlife Service, U.S. Department of Agriculture, Air Force, etc.) and in other countries, particularly Canada and Western Europe.

3.2 Comparison to Reference Sediment

The Inland Testing Manual describes a testing strategy wherein toxic effects of proposed dredged material are compared to reference sediment and control sediment. Reference sediment is defined in the manual as sediment obtained from the proposed disposal site (but outside the footprint of any past disposal), and control sediment is characteristic of the test organisms' collection site or laboratory-rearing environment. Survival of test organisms in the control is used only to verify that the test procedures themselves are not resulting in unacceptable mortality, and statistical comparisons are only done between tests with proposed dredged material and reference sediment.

If the chosen reference site sediments contain contaminants that elicit the same level of effects as those in the dredged material, then discharge could be approved even if significant mortality of test organisms had occurred in both. This leads to the possibility that the limiting factor(s) governing whether or not a dredged material is suitable for overboard disposal is not its toxicity but rather the toxicities of the suite of potential reference sites. The Subcommittee believes this to be inconsistent with optimum protection of coastal and inland waters since the criteria for selection of reference sites are much too vague and subjective.

The underlying assumption that discharge of toxic dredged material at already-contaminated sites will not cause additional degradation of the aquatic environment is often, if not usually, false. One reason is that when in-place contaminated sediments are in depositional areas, sedimentation will remove them from the biologically active zone if the source of contamination is removed (e.g., as seen with Kepone contamination in the James River, Virginia). Discharge of contaminated materials on top of in-place contaminated sediments constitutes a continuation of the pollution source and may result in additional degradation of coastal and inland waters. Another concern is that there is usually no assurance that the substance(s) causing the adverse biological effects in the dredged material are the same as those in the reference sediments. One only knows that the biological responses were nearly the same. For example, if the contaminants in the dredged material had a longer degradation half-life than those in the reference sediment, then that discharge would constitute increased or additional degradation.

A more logical approach would be to consider the "control sediments", now used in the testing protocol, the same way that reference site sediments are in the present document. In other words, determine the toxicity of the dredged material relative to known clean sediments. This information can then be considered, along with information on other potential dredging/disposal impacts, in a risk management context.

3.3 Risk Assessment vs. Risk Management

The assessment of contaminant-related impacts from discharge of dredged material (e.g., determination of chemical content, dilution requirements, bioaccumulation potentials, toxicities, etc.) is considered in the "Analysis" and "Risk Characterization" sections of the Agency's *Framework for Ecological Risk Assessment* (EPA/630/R-92/001). However, the decision on whether or not to dispose of contaminated sediments on or near other contaminated sediments is a risk management decision. In this case, risk management includes consideration not only of the relative toxicities of the dredged material and sediment from the proposed disposal site, but also whether or not it is prudent to dispose of a material in coastal or inland waters if it contains hazardous materials in toxic amounts, and other available management options.

We recommend that the Inland Testing Manual incorporate elements of the *Framework for Ecological Risk Assessment*, and relate the test procedures in the manual to the overall assessment of risks associated with various disposal options, including discharge into coastal and inland waters. It appears that most, if not all, of the analyses needed are already required; it is only the thought process and data treatment and integration that differ.

3.4 Protection of Human Health

The Inland Testing Manual suggests that protection of human health from impacts associated with discharge of dredged materials is a major goal. However, the manual addresses human health risks mainly for chemical contaminants that bioaccumulate and would, therefore, be transmitted to humans through consumption of food exposed at the disposal site. Several concerns are not addressed by this approach:

a) The links between exposure of fish and shellfish to dredged material, subsequent bioaccumulation of chemicals in aquatic organisms, and transfer to humans in amounts sufficient to cause adverse health effects are not clear.

b) Exposure of human populations to chemical contaminants through direct water contact, i.e., swimming and recreational use, is not addressed at all.

c) Health risks from exposure to pathogenic microorganisms resuspended by dredging and discharge activities are not adequately addressed.

3.4.1 Bioaccumulation

The bioaccumulation of chemicals from sediments is of potential concern to the accumulating organisms and to the consumers of such organisms. The Inland Testing Manual relies heavily on a 28-day "bioavailability" test for the assessment of bioaccumulation. Bioavailability is defined as the ability of a substance to be taken up by an organism. This definition of bioavailability includes practically everything except very large macromolecules and solids. Thus, the simple question of whether a substance is bioavailable is not very useful. It is the extent of the uptake and storage that is important, and that requires estimates of equilibrium concentrations in the bioaccumulating organism relative to the concentration of the chemical in water, sediment and food materials. Alternatively, the extent of bioaccumulation can be estimated from a knowledge of uptake rates, metabolism and excretion rates, and the storage compartments in the organism. To discern whether an equilibrium has been attained requires repetitive sampling. One cannot assume that an equilibrium has been reached after 28 days, especially in the case of macromolecules and substances with a high octanol-water partitioning coefficient (K_{ow}).

Furthermore, it is inherently difficult to determine whether an equilibrium has been attained by inspection of bioaccumulation curves alone. Shallow slopes in a bioaccumulation curve combined with variabilities in the data often lead to visual estimates that underestimate the true equilibrium concentration. Even if accurate determinations of the equilibrium and bioaccumulation coefficient have been made, these cannot account for any biomagnification in higher trophic levels. The manual is correct in pointing out that the phenomenon of biomagnification appears to be applicable only to a limited set of chemicals.

The major stated purpose in the manual for determining the degree of bioaccumulation of chemicals in sediments is the protection of human health. The Food and Drug Administration (FDA) action levels are the benchmarks against which the extent of bioaccumulation are compared. This is appropriate, as long as the comparisons are made on edible portions of food organisms. In other words, bioaccumulation factors (BAFs) in mussels, oysters or edible parts of fish can be used in conjunction with FDA guidelines as part of a risk assessment process for the protection of human health. BAFs determined in amphipods or aquatic insects are not appropriate for such a procedure, although such BAFs are potentially useful for the development of exposure guidelines for the protection of organisms that consume amphipods or aquatic insects.

Neither the use of excess cancer risk slope factors (which is often at variance with FDA action levels) nor the "computerized risk and bioaccumulation system" expert system were evaluated by the Subcommittee because insufficient detail was provided.

3.4.2 Microbiological Concerns

The most likely human health risk, and, in some cases, perhaps the greatest overall adverse effect from discharge of dredged material in inland and near-shore environments, is the resuspension of pathogenic microorganisms which have accumulated in sediments, e.g., near sewage treatment plant outfalls. Following resuspension during dredging and discharge, the redeposition of these very small particles may be very slow, spread over a large area, and not be well predicted by the mixing zone model designed for different purposes. Human exposure to these pathogens can occur via the three pathways described in section 4.2.1 of the Inland Testing Manual: 1) through consumption of contaminated seafood, 2) direct contact, and 3) through contamination of drinking water supplies.

Although discharge of dredged material must be in compliance with state water quality standards (i.e., standards must not be exceeded outside the mixing zone), we question whether dredging operations routinely include any measurement of pathogens or indicator organisms. In addition, current microbial water quality standards, especially the total coliform standard for shellfish, are in dispute and widely acknowledged to not be protective for viral disease.

In section 4.2.1, the manual does include a brief discussion of microbiological concerns related to dredging and discharge of sediments and provides literature references where more detail can be found. However, while it may be beyond the scope of this manual to address all of these issues comprehensively, the manual should include greater detail on the analytical methods available for assessing the extent of microbial contamination, their strengths and weaknesses, and appropriate uses.

4. BIOASSAY PROCEDURES AND TEST SPECIES

4.1 Need for Plant Bioassays

In the Ocean Testing Manual, potential contaminant effects on plants were not considered because the only plant communities exposed to the dredged material were the phytoplankton communities during the time the dredged material dropped through the photic zone to the aphotic sea bottom. In estuarine and inland settings, however, the photic zone frequently extends to the bottom of the open water where benthic micro- and macroalgal communities develop. These benthic micro-algae are often the source of much of the phytoplankton as they are suspended by natural or human-induced turbulence. In addition, the Inland Testing Manual states in section 2.3 (page 23) that the tests apply to dredged materials to be used for beneficial uses, most of which (wetlands, submerged aquatic vegetation--SAV--beds, and beaches), will be vegetated (both angiosperm and algae). Wetlands obviously have angiosperm and algal bases to their food webs, as do SAV beds. In human-assisted beach nourishment, the dredged material may end up in the intertidal area where benthic micro flora grow on and between the sand grains. These organisms play a stabilizing role as well as serving as a food source for invertebrates which in turn are eaten by surf-zone fish and shore birds. Some of the deposited material is often used to form a primary dune which is planted with beach grass, such as *Amophila*. The point is that plant communities must be considered.

Animals, no matter how carefully chosen, cannot serve as surrogates for plants. For example, responses to herbicides, sulfides, pH, sediment texture and fertility cannot be evaluated across kingdoms. Where plants may become part of the ecosystem developing on the deposited dredged material, plant bioassays should be conducted in conjunction with animal tests. Candidate plant assays which could be incorporated in the manual would include tests involving root elongation, seed germination, and chlorophyll content. Plant considerations should be integrated throughout the manual in order that the user be aware of their primary importance in new ecosystems developing on the deposited dredged material.

4.2 Bioassay Test Conditions

The proposed bioassay testing techniques for dredged material currently use standardized EPA protocols. However, these protocols may not be representative of the salinity and temperature conditions at the proposed disposal site. Salinity and temperature affect not only the physiology of the test organism, but also can modify contaminant toxicity, bioavailability, and reactivity (e.g., salinity may influence metal speciation and bioavailability). For these reasons, we recommend that the water used in elutriate testing should mimic the salinity and ionic composition of the water at the proposed discharge (vs. dredging) site. The manual should require that, in addition to bioassays conducted using standard protocols, parallel bioassays be conducted under conditions of salinity and temperature that are representative of the discharge site. Such modifications of the testing procedure should give a more realistic estimate of sediment toxicity for specific disposal sites. Of course, care must be taken not to exceed the thermal or salinity tolerances of the test organisms and we recommend that additional freshwater test species be added to Tables 9 and 10 of the manual.

4.3 Test Sediments

The sediment bioassay procedures call for homogenizing the sediments prior to introduction of test animals. In the normal benthic environment, the sediment profile is quite important in that the macro-benthic organisms are exposed only to the top several centimeters of sediments, and it is the toxicity of these sediments that is of greatest concern. While dredging and discharge operations will tend to homogenize the sediments, upon discharge the dredged material will settle at different rates. Lighter, smaller particles will settle out more slowly than heavier particles, forming a surface layer of sediments which newly settling larvae will contact. Since these smaller particles are more likely to have greater contamination, due to their greater surface area per unit mass, the process of sediment homogenization prior to a bioassay will likely expose test organisms to a less toxic environment than had the original sediment profile been retained. Conversely, at reference sites where clean sediment has accumulated on top of contaminated sediment, homogenization of reference sediment may result in greater toxicity to test organisms than the undisturbed sediment.

Therefore, it may be appropriate to require that analyses (chemical and bioassay) be done with the top two centimeters of sediment cores if they are fine grained (less than 63 microns) since this is the material most likely to be mobilized in dredging/disposal operations. Since mixing the sediment cores may result in an over or under estimation of ecological risks, consideration should be given to conducting some tests on core segments, e.g., 0-2 cm, 8-10 cm, etc.

In any case, substrates which have been collected for toxicity testing from control, reference and dredging sites need to be closely matched for those physical and chemical characteristics that are required to support the growth and survival of the test organisms. Otherwise, the tests are likely to measure deviations from basic growth requirements rather than impacts of any contaminants in the sediments.

4.4 Sampling Indigenous Infauna

The diversity of the benthic community is a clear indication of the habitability of the sediments at a given site. In locations that are not dredged too frequently, and where vessel traffic is not too great, it may be possible to do benthic community analysis in order to supplement information obtained from sediment bioassays. Identification of organisms sieved from the sediments prior to sample processing would allow a first order assessment of community diversity at the proposed dredging site relative to that at a reference site. In addition, organisms collected from the dredging site could be analyzed for body burden of contaminants of concern to supplement the bioaccumulation tests (for which various chemicals may not reach steady state by 28 days). This will give a truer indication of long term steady-state bioaccumulation.

5. TIER IV SUBLETHAL CHRONIC TESTS

Sublethal chronic tests are very important in assessing the toxicity of a sediment and such assays should be incorporated into Tier III as soon as they have reached an acceptable degree of development. Such tests include *Neanthes* growth, and reproduction in the amphipod *Leptocheirus*. Development of sexual maturation in Mysids may also be a good test, despite the epibenthic nature of these animals.

Tier IV guidelines are envisioned for the most complex situations. It is not possible to write detailed directives for the investigation of such situations. However, it must be recognized that environmental toxicological testing is open ended and there are always additional tests that can be conducted that could provide useful data. Therefore, it is critical that there be a process for negotiating which questions are of concern in each case.

6. USE OF THE STFATE MIXING ZONE MODEL

The Inland Testing Manual details the use of a numerical simulation model to determine the "instantaneous discharges from barges or scows and sequential discharges from hopper dredges." The model is the COE's STFATE (Short-Term Fate of Dredged Material Disposal in Open Water Model). Since most estuarine and near-shore dredging is by means of pipe dredges with continuous discharge dredged material release, we recommend that development/implementation of a continuous release model be accelerated and included in the final manual.

STFATE appears to be a competently implemented and useful instantaneous discharge model. The STFATE program, which is provided on PC-based diskettes with the manual, is easy to use. However, since the documents on which this model are based were not available in advance of our review meeting, we have not attempted to review the technical aspects of the model. Rather, our comments center on the way in which the model is presented in the document.

In general, the description of STFATE, both in the body of the manual and in Appendix C, should be more detailed. The model's limitations, intended uses, and governing equations should be clearly stated in the manual. We recommend that the manual be revised to include the following:

a) The STFATE model should be introduced as an instantaneous discharge model by name in section 2.8.

b) The basic conceptual approach of the STFATE model and its application to water column testing should be included in section 10.1. This how-to-do section should clearly specify the intended applications and inherent limitations of the model. For example, the model is intended for short-term (1-2 hours) and shallow-water (without vertical density stratification) applications.

c) Full theoretical and technical details of STFATE should be presented in Appendix C, including governing equations, all model assumptions, some details of the solution techniques, capabilities, limitations, and calibration and validation procedures. The original published documentation of the model should be referenced.

Once a continuous dredged material discharge model is completed, it should be presented in a similar fashion, with PC-compatible diskettes supplied with the document. Note, however, that for continuous discharge of dredged material into tidal waters, it will become necessary to discuss and account for the oscillatory nature of the currents and the associated tidal dispersion. This will not prove to be as simple as the application of the STFATE model.

7. FIELD DATA COLLECTION AND STATISTICAL METHODS

Field data collection is primarily discussed in Chapter 8, and statistical methods are discussed in Appendix D. In addition, these topics are also referred to in many sections throughout the document. We recommend that these sections be expanded. The document should include practical advice on the design of sampling, how, where and when to collect the field data, and how to analyze the data statistically. In the case of bottom sediment sampling, the manual should specify how deep the sediment samples should be. The information should be very specific, including the answers to what, how, when, and where to collect the data, advice on the number of samples and replicates, a holistic discussion of the overall sampling design and strategy, and guidance on data analysis following sampling. This would best be accomplished in Chapter 8.

8. TECHNICAL CORRECTIONS

In addition to the comments provided in previous sections of this report, we would like to note the following technical corrections which should be incorporated into the final Inland Testing Manual:

a) The document currently contains a mixture of units, encompassing the SI, the cgs, the MKS, and the English systems. In conformance with conventional and national scientific standards, metric units should be used throughout the document and equations that use English units should be reformulated. As the engineering community still in part uses English units, it would be appropriate to specify the English-unit equivalents within parentheses, in addition to metric units.

b) In several places in the document (pp. 107, 113, 122), estuarine salinity is referred to as varying from 1 to 25 ppt and the near coastal salinity as exceeding 25 ppt. We realize that the purpose of specifying salinity ranges is to suggest the range of salinity tolerances of the various test species. However, the commonly accepted salinity range for estuaries is 1-35 ppt and near coastal salinity is usually greater than 30 ppt.

c) The title of Part III of the document is "Data Generation." Although numerical modelers often refer to the output of simulation models as data, and thus modeling as generation of data, this is confusing and a controversial practice. We recommend that this title be changed and that Chapter 8 be retitled "Field Sampling."

d) Footnote "b" of Table 9 (p. 107) should refer to Echinoderms as having pluteus larvae--veliger larvae belong to mollusks.

e) Any reference to determining population or community effects from results of single species bioassays should be deleted from the manual. For example, section 6.0 of the manual on Tier III Evaluation (p. 51) includes the statement, "laboratory toxicity tests, as used in dredging assessments, are generally only intended to be indicative of possible impacts to community structure, <u>not</u> to specific individual species". The current state-of-the-science concerning the natural parameters that control population and community structure does not usually allow extrapolation from single species bioassays to population or community effects.

f) The definition of "biomagnification" given on p.5 of the draft manual should be amended to include the condition that organisms at higher trophic levels will have higher body burdens than those at lower trophic levels.

g) Page 65 of the manual includes the statement, "Contaminants have a greater affinity for clay and silt than for sand." To ensure that sandy sediments are not automatically excluded from sampling and testing, it would be helpful to include a statement that, while contaminants may be present in lesser concentrations, they may be more **bioavailable** from sandy sediments.

h) It should be noted in the section dealing with toxic equivalency factors (p. 89 of the draft manual) that these factors have been derived for human health purposes, and that for aquatic organisms the relative toxicities of different PCB congeners and dioxins are likely to be quite different.

i) While it may be true that EPA has not published Agency-approved analytical methods for analysis of saline water (as stated in 9.4.2 of the manual), widely accepted methods for chemical analysis of estuarine and ocean waters do exist and should be referenced in the testing manual (e.g., Strickland and Parsons, 1972; Grasshoff et al., 1983)

j) The manual states that water column concentrations outside the mixing zone which exceed 0.01 of the toxic (LC50 or EC50) concentration are deemed to be acutely toxic to water column organisms. The origin of the 0.01 factor should be explained (i.e., the factor originated as an "application factor" to relate acute to chronic toxicity and was largely a matter of judgement).

k) The manual includes procedures for assessing ammonia toxicity in dredged material (Appendix F of the manual). The toxicity of sulfides should receive similar consideration.

9. REFERENCES CITED

Grasshoff, K., M. Ehrhardt, and K. Kremling. 1983. Methods of sea water analysis. 2nd, revised and extended edition. Verlag Chemie, Weinheim. 419p.

Strickland, J.D.H. and T. R. Parsons. 1972. A practical handbook of sea water analysis. Bulletin of the Fisheries Research Board of Canada 122:1-172.