

US EPA ARCHIVE DOCUMENT

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Summary Report

Peer Review of “Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Marine Waters”

I. Introduction

This document contains the peer review comments on the document *Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Marine Waters* released in October 2001. The comments and recommendation from the five reviewers have been combined and organized as follows:

- Charge to the peer reviewers:
- General comments;
- Response to charge;
- Specific comments by page number referenced by commenters; and
- Additional references recommended by the reviewers.

Please note that paragraph number 1 refers to the first section on that page, regardless of whether it was carried over from the previous page. The EPA response to comments is written in bold.

Peer reviewers included:

Thomas Brosnan, National Oceanic and Atmospheric Administration

W. Michael Kemp, Horn Point Environmental Lab, University of Maryland

Hassan Mirsajadi, Delaware Department of Natural Resources and Environmental Control

Jonathan Pennock, Dauphin Island Sea Lab and University of Alabama

David Tomasko, Southwest Florida Management District

II. Charge to the Peer Reviewers:

See section IV where specific charges are presented.

III. General Comments:

Background Perspective:

Several reviewers acknowledged that estuaries and coastal shelf waters are complex ecosystems, involve a wide diversity of types when the entire coast of the 48

contiguous states are considered, and these systems represent a wide range in their susceptibility to nutrient over-enrichment. Most reviewer's stated either explicitly or implicitly that the writing of such a manual was challenging and the need for clarity would require careful diligence. These features may well help explain the diverse opinions expressed by the reviewers. Some commonality was noted in the reviewer's general comments but their specific comments were often specific to each reviewer. This necessitated a more lengthy response than had their been more convergence in the comments.

Summary of General Comments:

Reviewers comments varied in their generality and specificity. Four of the five reviewers commented that the manual was worthwhile. Other general comments stated that the manual made a reasonable first cut at a very difficult problem and contained much useful and relevant information. In general, reviewers felt the manual was stronger in the background information (e.g., scientific descriptions) provided than the actual procedural guidance. While numerous positive comments were offered, the reviewers expressed a number of general concerns that made the manual less effective than it might be. Comments ranged from editorial problems (e.g., lack of clarity, structural/organizational problems), weakness in relating response variables such as chlorophyll *a* and dissolved oxygen deficiency to changes in living resources such as fish and seagrass abundance, redundancy, over-all excessive length, and an inordinate faith in the use of mechanistic models (i.e., process-based) versus empirical modeling (e.g., comparative regression models). One reviewer expressed the view that the supporting chapters (e.g., 2, 3, 5, and 9 could more effectively be moved to the back of the document and move the procedural guidance forward (e.g., 4, 6, 7, and 8).

EPA Response: EPA felt that these general criticisms had merit and an effort was made to address them in the October 2001 revised version. For example, efforts were made to clarify ambiguous phrasing which was usually identified in specific written comments or comments made directly on the reviewer's copy of the text. A new section was added to Chapter 2 (e.g., beginning on page 2-28) that provided examples of effects of nutrient over-enrichment on seagrasses, finfish, oysters, and benthic macroinvertebrates with additional citations, many provided by the reviewers. A new section in Chapter 9 was added that discussed the merits of empirical and computer-based mechanistic models.

The issue of redundancy was a problem that EPA acknowledged. However, it was felt that some redundancy was important because some users of the manual may well not read the entire volume and some brief summary information by chapter was included at the end of Chapter 1. However, there was an effort to reduce the volume of some of the redundant information in several places. Some information was moved from the primary chapters (i.e., Chapters 1-9) to appendices in response to concerns expressed about the over-all length of the document.

EPA did not agree to move the procedural guidance forward. Although such movement was acknowledged to have some merit, it was felt that reviewers of the *Lakes and Reservoirs and Rivers and Streams Nutrient Guidance Manuals* did not make this recommendation and

some consistency among manuals was important to maintain for users for cross reference purposes.

IV. Response to Charge:

1. Does the manual properly strike a balance between discussions of scientific information and practical resource management?

The response to this question was mixed but several reviewers felt the manual, in general, struck a reasonable balance between science and practical management. One reviewer answered with a “no” and recommended more examples of how to apply the science to management issues of nutrient enrichment. Another reviewer found the science to be adequate, except Chapter 4 which focused too much on oceanic sources of information with inadequate nutrient information on different classes of estuaries to help local managers, and inadequate information on how to link nutrient enrichment processes to designated uses. One reviewer felt that too much emphasis in Chapter 4 was devoted to ammonia toxicity.

EPA Response: EPA recognized this to be a difficult issue, in part, because there was no clear consensus on the problem or actual examples offered as a solution. More information was provided on linkages between nutrient relationships between the primary causal (e.g., total nitrogen and total phosphorus) variables and primary response variables (e.g., dissolved oxygen deficiency, water clarity, and algal biomass measured as chlorophyll *a* for phytoplankton and dry weight or ash-free dry weight for macroalgal species and selected biological resources of concern (e.g., seagrasses, finfish and oysters). This general approach was adopted because significant deviations from the reference condition-based criteria are reason for concern and various coastal States classify designated uses from the very general to highly specific but recreational and commercial species of living resources usually dominate their aquatic life-based designated use classifications.

Chapter 4 was rewritten with a major focus on estuaries with appropriate citations. The information on ammonia toxicity was greatly shortened to keep the focus on ecological effects of nutrient overenrichment. To provide examples of nutrient-related variables so managers might have a better idea of what the ranges were along their part of the coast, examples from the literature were selected with consideration of representation by coastal provinces. (Appendix G).

2. The introduction problem statement briefly introduces the notion that estuarine physics can confound unambiguous interpretation of nutrient effects on ecological responses. Does the manual appropriately integrate the influences of physical factors and ecosystem interactions with the various approaches to criteria development?

The review was mixed on this issue. All reviewers expressed the view that estuarine physics was addressed and one reviewer noted that the subject was technically addressed in Chapter 2

and Chapter 9, the modeling chapter. Two reviewers wished for more specific examples of how estuarine physics play out in the criteria process. One reviewer mentioned that more emphasis needed to be placed on the NOAA dissolved concentration potential (DCP) and estuarine export potential (EXP) and more emphasis be placed on the significance of estuarine physics to estuarine susceptibility in different estuaries. One reviewer felt that more examples from Gulf of Mexico estuaries should be provided.

EPA Response: The revised manual included an increased emphasis on estuarine physics as the up-dated references indicate the key role that physics (i.e., mixing of waters, vertical density stratification and depth of euphotic zone, and estuarine physical flushing) plays in estuarine susceptibility to nutrient enrichment. This topic was expanded upon in a conceptual model as well as in the core text and several appendices. In Appendix A, “Conditions for Bloom Development: Interplay Among Biogeochemical, Biological, and Physical Processes,” more emphasis was devoted to an understanding of the role of biogeochemical processes and the importance of understanding the significance of scaling ecosystem processes in space and time. In Appendix B, “Additional Information on the Role of Temperature and Light on Estuarine and Coastal Marine Phytoplankton” provided new discussion on the balance between phytoplankton primary production and respiration in a vertical section of the water column with information on corrections to the Secchi disc applicable to turbid estuarine waters. Appendix C, “Additional Information on Flushing in Estuaries” provided a new section on estuarine flushing with emphasis on understanding the importance of the several definitions of flushing. The revised manual devoted Appendix D to the NOAA scheme for determining the overall human potential for causing nutrient enrichment in estuaries. This scheme is one of the few simple indices for making initial estimates of estuarine susceptibility to nutrient enrichment. The revised manual provided additional examples from the Gulf of Mexico of estuarine responses to nutrient enrichment (e.g., Perdido Bay, AL/FL, Tampa and Sarasota Bays, and Charlotte Harbor).

3. Are the approaches to establishing reference conditions described in the manual scientifically valid and appropriate to initiate criteria development? Are the elements for developing nutrient criteria appropriate?

The reviewers held mixed opinions on this question. One reviewer found the recommended processes for establishing reference conditions to be clearly written with defensible logic behind each step in the process. This reviewer felt that it was hard to say if the processes would work but stated the program was relatively unprecedented and the approaches should be tested. Additionally, the reviewer would liked to have seen more examples enriched with hypothetical data and various modeling analyses to provide a clearer idea of how scientific knowledge and analyses can provide rigorous underpinnings for reference condition development. Another reviewer felt that the methodologies were clear and concise while a third did not understand how criteria were set in the examples given.

A fourth reviewer was not sure if the approaches described in the manual were scientifically

valid and appropriate for nutrient criteria development and provided examples of how problems can arise. A fifth reviewer argued that reference conditions are an essential component of proper management but the approaches provided in the manual seemed too subjective and each approach might lead to different reference conditions. Also, this reviewer argued that approaches described in section 6.4 and Table 6-2 were unclear as presented. This reviewer felt that few estuaries would qualify as pristine, the watershed segment approach would likely be a first-order stream and be unrepresentative of the main freshwater tributaries, and the term “fishable and swimmable” would be difficult to relate to a given nutrient enrichment status.

EPA Response: Estuaries and individual systems exhibit a high degree of individuality in their responses to human disturbance including nutrient enrichment. Because most large estuarine systems have no or, at best, a few meaningful analogs for comparison, the frequency distribution approach, a dominant approach described in the Rivers and Streams and Lakes and Reservoirs Manuals, was not given a dominant methodological status. However, for some estuaries with multiple embayments that share approximately similar flushing patterns (e.g., Buzzards Bay, Cape Cod, MA), the comparative regression modeling approach may be applicable as described in Appendix E. For this reason, EPA recognized that this diversity of estuarine types and their varied responses to nutrient enrichment required more than a single dominant approach to determining reference conditions. In addition, available ambient nutrient-related data applicable to reference condition determination is quite variable among the Nation’s estuaries. EPA would expect the RTAG to use their scientific judgement in assessing any divergence among various approaches to reference condition development and recommend which approaches are most applicable to a given situation. In most cases, the several approaches serve as checks against potential weaknesses in any single approach. Table 6-2 in the revised manual is intended as a summary, not a complete explanation. Although clarity can often be improved when one addresses complex issues, EPA believes that the lack of a consistent response to this concern by the reviewers indicates that clarity was not overly compromised. The concern expressed about the relevance of the term “fishable and swimmable” relative to nutrient status was addressed by providing additional discussion about this statement as an environmental goal-setting statement that inevitably is associated with variable nutrient conditions. Coastal marine waters perhaps present less ambiguity, and reference condition determination approach is presented in the Appendix H as a candidate for general application with regional adaptations.

4. Does the manual allow the user sufficient flexibility to establish their own criteria development approaches given variable budgets, staffs, and expertise while still adhering to the EPA mandate to reduce human-based eutrophication in these waters?

The responses ranged from reasonable to too much flexibility. Several reviewers expressed the need for additional relevant resource management science-based examples to guide local managers.

EPA Response: EPA modified the classification system to assist the smaller States and

Tribes who may wish to use information and strategies adopted for well-studied systems as a guide for their own estuaries. This aspect of flexibility was added to the revised manual. As one reviewer stated, no report can ever be a substitute for the need for local, state and regional governments to hire, and retain highly motivated and (*sic* capable) personnel and no document, no matter how detailed, can be completely on-target for every condition with which resource managers might be faced. This was a plea for more examples of how science could help managers make better nutrient-based decisions. EPA attempted to address this need by providing numerous tables, figures and appendices with examples of the science required to make decisions regarding nutrient management.

V. Specific Comments:

Some reviewers made specific editorial comments and some of these were made directly on the hard copy manual. A few spelling corrections were noted by the reviewers and were made on the revised manual. Some technical choices of terms were also considered and in most cases these were accepted. A number of questions concerning clarification were offered and in most cases these were addressed by incorporating the suggestion into the text. Several reviewers provided helpful references that supported a particular example for the section of the coast most familiar to them. Representative examples are listed below with the EPA response:

o Secchi disk measures water transparency, not turbidity. **EPA Response: Accepted. This correction is needed in several other places and will be made in the next version of the manual.**

o A suggestion was made to add a glossary. **EPA Response: Future editions should have a glossary as did the freshwater manuals.**

o Several specific comments were provided on the Executive Summary suggesting the need for clarification. **EPA Response: EPA addressed this issue by substantially re-writing the Executive Summary. Also, some material (e.g., stepwise approach for developing nutrient criteria) was removed and included in the Introductory Chapter 1.**

o Several specific comments on Chapter 1 suggested the need for clarification of goals and purpose of manual, scope of the nutrient over-enrichment problem, and who and how the manual should be used. **EPA Response: Chapter 1 was re-written in response to several specific comments by reviewers and EPA's view that some material was missing from Chapter 1 (e.g., definition of estuaries and coastal waters) and some material provided in Chapter 2 should be moved to Chapter 1 (e.g., the magnitude and scope of the nutrient enrichment problem in estuaries and coastal waters). The intent of the rewrite was to provide the reader with a sense of why the manual is needed, the goals of the nutrient program, and the role of the manual in this program, who is going to use the manual, how it should be used, and expected benefits of using the manual. Section 1.2- "Relationship Between Water Quality Standards and Criteria" was re-written and moved to Chapter 8 where this section was more appropriate to issues of using criteria to protect water quality.**

o One reviewer found the linkage between eutrophication and public health an odd way to begin an Introduction. **EPA Response: Disagree. There has been a long-standing separation in the U.S. in environmental quality management and human health. The introduction to Chapter 1 offers a rebuttal to this often explicit and implicit false dichotomy.**

o The issue was raised that application of only “bottom-up” nutrient controls will likely lead to disappointment toward solving the over-enrichment problem. **EPA Response: Agreed, the issue has merit. Page 2-33, last paragraph, was added and summarizes the importance of considering “top-down” food web influences on helping to reduce the negative effects of nutrient over-enrichment. However, as general guidance, other potential management approaches to minimizing nutrient enrichment-based water quality impairments such as dredging surficial sediments were not considered within the scope of the present manual because deposition of those sediments has potential environmental consequences and the goal of the Clean Water Act is to eliminate introduction of pollutants into the Nation’s waterbodies. Where a site-specific remedy is called for, other measures such as dredging may be appropriate when done according to applicable regulations. In summary, the principle thesis of the manual is that excess nutrients derived from human activities resulting in a failure to meet designated uses need to be reduced where feasible.**

o There was a question about the appropriateness of the coastal provinces as shown in Figure 1-3 (revised version of manual, Figure 1-1b). **EPA Response: The intent was to show general coastal, including open coastal marine waters climatic and associated faunal and floral regions. The manual presents both the coastal margins of the established ecoregions as regional delineations consistent with the other guidance manuals and continental drainage to the estuarine and coastal waters, as well as concomitant coastal marine provinces so both approaches are evident to the reader.**

o The question was raised about how to use this manual. **EPA Response: EPA believes that much of Chapter 1 addresses this issue, especially Figure 1-6 that provides a flow diagram of how the chapters are sequenced. EPA hopes that future editions of the manual will meet the practical level characterized as “a manual to be spread out on the hood of a field vehicle for local application.”**

o A question was raised about the clarity of Section 1.4- “Overview of the Nutrient Criteria Development Process.” **EPA Response: This section was re-written to improve clarity. Figure 1-4 was added to characterize the elements of the criteria development process.**

o Figure 1-1 (revised as Figure 1-5) was said not to be very illustrative. **EPA Response: EPA believes that the figure shows the intended relationship between ranges of nutrient enrichment expressed on a trophic enrichment scale indicated by nutrient-related variables (e.g., TN, TP, and chlorophyll a). No alternative figure was offered.**

o The applicability of the ecoregion classification approach was raised with reference to estuaries and open coastal waters. **EPA Response: EPA recognizes that the ecoregion**

concept has greatest direct applicability to inland freshwaters. However, from a watershed perspective including lakes/reservoirs and rivers/streams, the ecoregion concept provides an integrative approach to nutrient criteria development as upstream water quality can directly affect downstream quality including the coastal ocean (e.g., Mississippi River plume on TX/LA shelf). Rivers leading through multiple ecoregions to estuaries re-enforce the notion of the natural geochemical complexity of estuaries. Without an oceanographic perspective provided by coastal provinces EPA believes that the ecoregion classification would have more limited applicability.

o One reviewer suggested that dissolved oxygen is a primary variable in most estuaries. **EPA Response:** The NOAA National Eutrophication Assessment confirms that hypoxia is a wide-spread problem in many estuaries. However, one's perception of what is a major problem resulting from nutrient over-enrichment depends, in part, on which coastal region one has in mind. For example, many of the Gulf of Mexico estuaries are relatively shallow and dissolved oxygen (DO) deficiency can be an environmental problem initially in deeper areas, especially as these systems experience very high summer temperatures ; however, loss of seagrasses is often considered to be a major environmental issue in these systems as well as in many other estuaries , e.g., Chesapeake Bay. Also, there is some evidence that substantial acreage of seagrass losses can occur before large bottom areas experience hypoxic, and especially anoxic concentrations of DO (e.g., Tampa and Sarasota Bays). Consequently, EPA has included macroalgae and seagrasses as early warning response indicators associated with the four key variables. Because dissolved oxygen deficiency is such a widespread problem in estuaries, EPA added this variable to the response indicator list.

o The question was raised, are nutrients always the causal indicators (page 1-13, line 27)? **EPA Response:** The manual devoted much of Chapter 2 to the interplay between the physics of water motion (e.g., flushing, vertical density stratification, depth, and local dispersion) in estuaries and susceptibility to nutrient enrichment. However, removal of filter feeders and top predators has been suggested to significantly alter the nutrient “assimilative capacity “ of estuaries. The mitigation or exacerbation of overenrichment by these physical and biological considerations of the system is important, especially to resource management planning as an aspect of any nutrient reduction strategy.

o The claim was made that the chapter summaries at the end of Chapter 1 read more like a lecture than a concise introduction to the rest of the Guidance Document, the chapter summaries at the end of Chapter 1 are too long and lead to distraction more than a brief summary, redundancy is prevalent, and the chapters are not well integrated. **EPA Response:** This type of criticism was discussed among the EPA staff with due concern that such issues be appropriately addressed. The issue of style is difficult to resolve as few reviewers expressed concern about the so-called lecture aspect. The length of the summaries of individual chapters were designed for the reader who may wish to obtain an overview without spending considerable time reading the complete manual. The technical water quality staffs and natural resource managers in states and tribes are the primary audience

who would be expected to read most if not all of the manual. The issue of lack of integration among chapters may be more one of perception of what a guidance manual should look like. EPA believes the logic flow among chapters is strong as laid out in Chapter 1, especially Figures 1-4 through 1-6. There is frequent cross-referencing among chapters. At times, in an effort to remind the reader on matters of integration some redundancy inevitably occurred. There was an effort to minimize un-necessary redundancies but that issue will continue to be of concern and will be further examined in the next version of the manual.

o The question of the need to explain downstream effects—see page 1-15, last paragraph. **EPA Response: In the revised manual, the issue of downstream effects is addressed on page 1-8 and in Figure 1-4.**

o One reviewer expressed the view that the authors of the manual “ran out of gas” at the end of Chapter 1 at page 1-17. **EPA Response: The authors attempted to address this problem by providing a closing statement about where various States/Tribes might be along the nutrient criteria process and what the major elements of a nutrient management plan should include.**

o One reviewer felt that Chapter 2 presented a great deal of useful information including references; however, a concern was raised that this chapter needed a better organization and more direct statements explaining how this technical material can be used by managers. **EPA Response: EPA attempted to address the organizational issue in the revised version. Chapter 2 was largely re-written. The issue concerning direct statements about how the technical information can be used still remains as a continuing challenge.**

o A question was raised about whether diatoms contain harmful algal bloom (HAB) species. **EPA Response: Yes, the diatom *Pseudo-nitzschia* spp. (a species complex) produces domoic acid poisoning, a neurotoxin (see Symposium on Harmful Marine Algae in the U.S., Marine Biological Laboratory, Woods Hole, MA., December 4-9, 2000.)**

o It was pointed out that seagrasses (e.g., *Thalassia*) in Florida Bay is P limited but phytoplankton in overlying water may be N limited. **EPA Response: The manual makes the point for P and *Thalassia* but future editions should make the additional point about phytoplankton and N limitation.**

o Explain the Redfield Ratio. **EPA Response: Agreed. See page 2-3 in revised manual.**

o The limiting nutrient Section would be much stronger if it described exactly how to assess what if any nutrient is limiting in any particular estuary. **EPA Response: This section has been re-written (Section 2.2 Controlling the Right Nutrients) and the discussion differentiates between a limiting concentration and the potential limitation indicated by the Redfield Ratio. In addition, the point is made in the revised manual that N +P often yields a greater phytoplankton biomass production than a single addition of either nutrient. Also, there is**

evidence that both N+P may be required in some systems to elicit any phytoplankton biomass production response. The point should be made explicitly in the next edition of the manual that some estuaries have quite high nutrient concentrations where no nutrient limits production and production is limited by other factors.

o Add Steve Smith's (1984) argument for P limitation of phytoplankton production in marine systems with relatively long water residence times. **EPA Response: Good point. See Appendix A-2.**

o When mentioning nutrient ratios it is important to specify if they are weight or atomic-based.. **EPA Response: Agreed. This needs to be made clear on the Figures, although the original citations make this clear. The text consistently uses a molar basis to describe nutrient concentrations to facilitate stoichiometric relationships.**

o Figure 2-18 (now 2-7) should include other relevant processes, e.g., denitrification, burial, N:P ratios, and water exchange. **EPA Response: Agreed and processes were added.**

o Page 2-18, paragraph 2—explain temporal scales when discussing effects of stratification on hypoxia. **EPA Response: Accepted and addressed.**

o Several reviewers raised technical questions about Section 2.4 “Physical Processes, Salinity, and Algal Net Primary Production.” For example, there was a question about the correct use of terms “critical depth” and “mixing depth,” and Arrhenius temperature relationships. **EPA Response: This section was re-written to clarify these and other technical issues. Much of the technical material was placed in Appendices A (conditions for Bloom Development: Interplay Among Biogeochemical, Biological, and Physical Processes. The subsection on physical processes drew heavily from Smith 1984 (Limnol. Oceanogr. 29: 1149-1160; Appendix B (Additional Information on the Role of Temperature and Light on Estuarine and Coastal Marine Phytoplankton) included information on compensation depth, euphotic zone depth (figure adapted from Sverdrup 1953—see Literature Cited). Much of this information was taken from Mann and Lazier (1996)(see Literature Cited) to improve its accuracy and clarity. The section on estuarine flushing (Appendix C in revised manual) was re-written by an estuarine physical scientist located at the EPA Narragansett research facility and clarified concepts and provided important technical accuracy to this section. It was felt that much of the technical material could better be placed in appendices to improve readability of the core text.**

o The question was raised that the manual would solve the issue of when to use load vs concentration. **EPA Response: The quote from Hans Paerl noted that the issue has been contentious among scientists and managers suggests that resolution might not be a simple issue. An important issue was raised as to what does one need to know regarding predictability of chlorophyll a versus load or concentration. EPA attempted to clarify the issue from a general principle of hierarchy theory involving spatial and temporal scaling of underlying processes and by providing examples. Seagrass loss might occur across**

relatively large areas within an estuary over relatively a short time (e.g., several years) when the exposure to the limiting nutrient (e.g., nitrogen) reaches a critical threshold and is driven by rapid transport of the nutrient throughout the estuary (e.g., Chesapeake Bay's spring freshet that brings a huge TN load into the bay and distributes it over much of the Bay over a period of one to two months. In contrast, Tampa Bay does not have a dominant river delivering the load over a short period of time except during major tropical storms; therefore an integrative time effect in the relationship might be expected. Possibly future versions of the manual will be able to shed more insight regarding causal mechanisms associated with this issue. As a practical matter, when nutrient concentrations relate to a response variable, then they have utility in developing a criterion and a monitoring program, especially one designed to assess nutrient control performance. However, nutrient concentrations usually do not lead to integrative effects such as increasing hypoxic volumes in estuaries. In such cases, nutrient load may provide the best empirical predictive relationship. It should also be noted that many, if not most, published empirical nutrient and response variable (e.g., TN and chlorophyll a) relationships (e.g., regressions) involve loads and not concentrations.

o Concern was expressed that the single brief section of seagrasses and nutrient dynamics (page 2-29) needed to be expanded with more references to show the important role that seagrasses play in estuarine nutrient management. **EPA Response: Agreed and the revised manual benefitted from this issue being raised.**

o Concern was raised about the need for more discussion regarding photosynthesis and respiration and its influence on the DO budget. **EPA Response: This was partially addressed in the revised manual in Appendix B but future editions of the manual should give more attention to this issue.**

o The manual should mention the effects of hypoxia in reducing nitrification-denitrification in estuaries. **EPA Response: Agreed and was done in Appendix A.**

o Diurnal DO fluctuations should be given more importance because the typical 9-5 daylight hours may miss the early morning hypoxia events. **EPA Response: This issue is likely more fully appreciated by scientists and resource managers today than several decades ago; however, the point is worthy of mention in future editions of the manual with a few citations.**

o Page 3-1, it was recommended that a sentence was needed to explain that the reference state provides a benchmark against which to measure change, both degradation and restoration. **EPA Response: Agreed. This is an important aspect of the reference condition in nutrient criteria development, however, the context in this instance is not focused on reference state per se but on the importance of physical differences modulating nutrient enrichment effects. The concept of reference state is the primary topic of Chapter 6.**

o Why appear to favor mechanistic models when much useful predictions have been made with

empirical models? **EPA Response: Agreed.** An introduction to Chapter 9 (Modeling) now has added an introduction explaining the value of both empirical and computer-based mechanistic modeling approaches. However, the weakness of empirical models still stands because they have limitations in being able to predict situations where multi-colinearties, especially non-linear processes, are dominant. In such cases, empirical models are limited in addressing “what if questions.” The seagrass references suggested have been used in Chapter 2.

o One reviewer suggested an interesting analysis to test the predictive power of a geomorphic classification which the manual stated was generally a weak predictor of nutrient effects. For example, create a variable that measures relative response (e.g., oxygen deficit per N-loading, chlorophyll a per nitrogen loading, seagrass loss per nitrogen loading), then compare these response measures for a large pool of all classes. Then use a clustering technique to separate and compare groupings to classes. **EPA Response: Excellent idea and EPA plans to pursue this suggestion in the future.**

o Page 3-13, concern about clarity was raised about the section on Gravitational Circulation and Tidal Forcing –**EPA Response: This section was re-written(see page 3-6 in revised manual) to improve clarity. The structure of this section differs considerably from the earlier version.**

o The NOAA DCP/EXP should be further developed. **EPA Response: Agreed. It was done.**

o One reviewer felt that Ulanowicz’s scheme for analyzing ecosystem function is not very relevant to this discussion (see page 3-15). **EPA Response: Disagree. Granted the present theoretical approaches do not appear to be very predictive but the theory (an informational theoretic framed within a thermodynamic structure) was mentioned to show possibilities for future work.**

o Why “cop out” on classification? One reviewer thought that this section was going to review relevant classification systems, select aspects of each most relevant to nutrient criteria development, and then provide an integrated classification system for this analysis. The reviewer expressed the view that EPA should develop a workable classification system to help regional authorities do their jobs properly. **EPA Response: EPA has not given up but progress is slow. However, the chapter has been largely re-written to improve clarity and recommend a short list of environmental factors that should prove useful as a starting point to develop a useful estuarine classification system to help develop nutrient criteria. The Office of Research and Development has included research on estuarine classification as part of the Office’s Aquatic Stressors Research Plan.**

o Please define estuarine and coastal waters. They seem synonymous. **EPA Response: Agreed. See pages 1-2 to1-5 in the revised manual.**

o Page 4-1, Section 4-2, Causal and Response Indicator Variables: This section needs an

introductory paragraph that sets the stage for all that follows. **EPA Response: Agreed and paragraphs are provided.**

o The section on Nitrogen in 4-2 needed a through revision because of errors in units (e.g., $\mu\text{M}/\text{L}$), focus inappropriately primarily on north temperate marine waters, and over-generalization of seasonal cycles. **EPA Response: Units were corrected to μM . The emphasis in the discussion and examples was shifted to estuaries including sub-tropical systems where nutrient problems are more widely known to occur than open coastal and open ocean waters. Methods discussion was moved to the appropriate section in Chapter 4.**

o The section on phosphorus (Section 4-2) needs to be re-written because of an open ocean focus, implications that phytoplankton do not deplete total P but somehow do deplete total N is inaccurate, and the fact the P can limit coastal marine phytoplankton biomass production needs to be added to the discussion. **EPA Response: This section was largely re-written to address the noted problems.**

o Section on measuring primary productivity needs to include ways to relate chlorophyll a to primary production. **EPA Response: Agreed. This section should be expanded in the next edition to include more information on factors in addition to nutrients and light that influence primary production of phytoplankton, macroalgae, and rooted aquatic vegetation (e.g., seagrasses).**

o Page 4-6 contained several problems, e.g., line 27 stating that a spread sheet approach means nothing, 1 % of light level would be 10 cm to 3 m or so, not 10-20 m and a need to emphasize that attenuation coefficients are preferred over simple Secchi disc measurements. **EPA Response: EPA generally agrees with the comments and made adjustments to the text. Secchi disc measurements are included in the text because the technique is widely used and cost effective for state water quality monitoring.**

o After the section on Secchi Depth there should be another section on “Other Indicator Variables.” Also, the treatment of DO, also a long-standing indicator of water quality, and the balance between photosynthesis and respiration is too superficial. **EPA Response: Agreed. The re-write of this section reduced the problems identified but the future text could be further improved by adding more information about daily swings of DO in productive systems.**

o Page 4-7, organic carbon compounds could be considered either causal or response variables. **EPA Response: Agreed. The next version of the manual should make this point.**

o The methods beginning on page 4-11 seem quite sketchy. **EPA Response: EPA assumes that the user of the manual has a good working knowledge of various methods and has access to several methods manuals for details. The intent was to be indicative, not exhaustive in coverage.**

o Stick with $\mu\text{g/L}$ or mg/L in text and Table 4-1. Detection limits for N and P seem high. **EPA Response: Agreed. While the authors debated which units to use, the molar basis is followed because stoichiometric relationships are more easily followed.** Detection limits were taken from Standard Methods.

o Ammonia electrodes do not work in seawater. **EPA response: This is correct. However, the method was modified to account for this problem as applied by Flemer et al. 1998. Estuaries 21 (1): 145-159. The pH of the sample is raised to pH 11 which converts ammonium to ammonia.**

o Page 4-13–Why recommend DO and C-14 methods for measuring primary production? DO methods is preferable because it allows for measures of respiration, a measure related to hypoxia? **EPA Response: Many estuaries and especially open nearshore coastal marine waters do not have high enough primary productivity, at least for much of the year, to measure with DO methods without excessive long bottle incubations.**

o Page 4-13, you can not preserve a water sample before measuring primary productivity. **EPA Response: This is correct and this error will be corrected in the next published version after October 2001.**

o Page 4-14, lines 12-16, these sentences seem out of place. **EPA Response: Disagree. Doubling time of algal cells seems relevant to a discussion of phytoplankton species composition as slight differences in doubling time can account for changes in composition.**

o Page 4-14, this would be a good place to mention HPLC algal pigment methods. **EPA Response: Agreed. The HPLC method is mentioned in addition to fluorometry in numerous places and will be mentioned in this section in a future version of the manual.**

o Page 4-14, why have a short paragraph that list a few HAB species? **EPA Response: Agreed. The paragraph was made more general.**

o Page 4-15, this section should be labelled Sedimentation Analyses. The literature is weakly referenced. The section on pore water profiles is especially superficial. **EPA Response: Agreed. The term Bulk Sediment was added but the process of sedimentation will be added in future versions. Discussion of pore water profiles should also be expanded to include more information on the significance of sedimentation processes to water column nutrient availability as the reviewer pointed out.**

o Page 4-16, why is so much space devoted to ammonia toxicity? Surely the ammonia concentrations to protect SAV and minimize algal blooms will protect fish and shellfish. **EPA Response: Agreed. This topic was greatly reduced.**

o Page 5-1, this chapter is well-organized and it is an excellent source of information; however, it could be made a bit more readable and informative by adding more examples, figures, and

tables. **EPA Response: Agreed.** The suggested additions will be considered for the next version. However, a judgement will be required regarding such additions as they potentially can contribute to an unacceptable length in the manual.

o Page 5-12, paragraph 3, much of this material addressing sampling technique was presented earlier. It is recommended that methods should be separated into a chapter or section of their own and presented only once. **EPA Response: This issue is a judgement call. For context, some small repeating of concepts was felt to be useful. This chapter was intended to address the more generic aspects of sampling designs and techniques.**

o Page 5-15, paragraph 5, put up front the need to make appropriate statistical adjustments to water quality data before parametric tests are applied, e.g., ANOVA. **EPA Response: Agreed. As pointed out by the reviewer, this point was made on page 5-24 of the October 2001 version.**

o Page 5-24, a distinction should be made between Type I and II regression models. **EPA Response: Agreed. This will be done in the next version. The primary point of this section was to address general differences in Type I and II errors when testing hypotheses but since regression models are often used in water quality studies, they need to be highlighted with reference to these types of errors.**

o Page 6-3, the Tampa Bay approach should be included here. **EPA Response: The Tampa Bay approach is mentioned on Page 6-8 and a Case Study is provided beginning on p. CS-19.**

o Page 6-3, lines 5-9, it is not intuitive to relate “fishable and swimmable” goals to eutrophication whereas it is easier to do this for organic pollution. **EPA Response: The term “fishable and swimmable” is discussed as a goal and the difficulty of assessing early warning indicators of water quality changes are discussed. However, this manual cites numerous cases that eutrophication resulting from nutrient over-enrichment can be shown to result in loss of habitat required of many estuarine and coastal shelf marine species.**

o Page 6-3, paragraph 3, what about the interactions between fishing mortality (and related stress) and habitat (water) quality—see Lenihan and Peterson (1998)? **EPA Response: This paragraph was removed from this chapter. The Lenihan and Peterson reference and associated discussion including some of the points raised by paragraph 3 were added to Chapter 2.**

o Page 6-4, paragraph 5, the reviewer disagrees with the conclusion regarding classification systems and responses to nutrient enrichment are weakly predictive. In any case, the manual does not document that anyone has attempted to develop such a classification system. **EPA Response: Disagree. See Chapter 3. Much of Chapter 3 is drawn from the NRC 2000**

publication—Clean Coastal Waters, National Academy Press, Washington, D.C. This chapter discussed a variety of classification approaches but none were shown to be especially predictive.

o Page 6-9, point out that both Secchi disc and PAR meter measurements should be collected because Secchi disc records provide a tie back to historical data for trend analysis and PAR meters are more precise. **EPA Response: This is a good recommendation and the manual should make this point in future editions.**

o Page 6-10, line 16, do the N and P profiles reflect reference conditions for water quality? How does watershed and areal load-based approaches give reference conditions? Need worked out example. **EPA Response: The reference condition approach in this case is load-based and not concentration-based. A model would be required to estimate the estuarine receiving waters concentrations based on a varying estuarine hydrography. How does sediment core-based reconstruction give reference conditions? EPA Response: Sediment cores may provide information about loads and concentrations if environmental conditions are conducive. Sediment cores may be dated to reflect the time of sediment deposition (e.g., Pb-210) or presence of plastizers which were first produced in large quantities in the early 1930s. Sediment layers may reflect periods of anoxia based on chemical changes such as pyrite formation when H₂S is present, presence or absence of planktonic vs benthic (substrate-requiring) diatoms, loss of preserved seagrasses, etc.**

o Page 6-11, this section on determining area-specific N loads is actually a N yield, not a load and should be so noted. **EPA Response: Agreed. This distinction is technically correct and should be made.**

o Page 6-11, paragraph 1, model hind-casting should be tested on a system with a lot of historical water quality data, e.g., Chesapeake Bay. Conventional water quality models are likely to be insensitive to ecological feed-back relationships, e.g., changes in processes i.e., grazing, loss of SAV, and coupled nitrification and denitrification which will make the estimates relatively imprecise. **EPA Response: Agreed. The approach is likely crude but some useful information may still be extracted from the analysis. An actual test as suggested would be a useful comparison to make.**

o Page 6-13, lines 16-19, atmospheric inputs are not necessarily much less than river inputs. **EPA Response: EPA stated the relationship as generally and recognizes that estuaries under low freshwater flow and of a large surface area may receive a large share of N from the atmosphere.**

Page 6-13, line 21, the loading from coastal waters is usually not negligible, although it is seldom manageable. **EPA Response: Agreed. The load may not often be negligible but it may not dominate the N loading except where such processes as upwelling occurs. This point should be clarified in the next version of the manual.**

o Page 6-15, the EMAP approach works better for summer hypoxic conditions related to benthic systems but is often not appropriate for water column processes such as nutrient loading scenarios of interest in this document. **EPA Response: Agreed. This distinction should be made in a future version of the manual.**

o Page 7-1, Section 7.1, include a discussion of how states should use criteria and their adoption into standards to prepare 305 (b) reports and 303(d) lists and TMDLs. **EPA Response: This type of discussion has more of an implementation element and was beyond the purpose of the manual which focuses on the challenging activity of criteria development. However, the manual points out that criteria are useful in monitoring programs which are a basis for listing impaired waters and characterizing the water quality conditions of various waters within a state or tribal area.**

o Page 7-6, provide more information on the merits of empirical modeling approaches. **EPA Response: This section refers to statistical models, including regression models (e.g., Dettmann reference) with several examples provided. Also, regression models are emphasized in chapter 9 in the new version of the manual.**

o Page 7-9. Line 12, why was not the criteria set at 280 µg/L N (20 µM) or at least below 700 µg/L (50 µM)? **EPA Response: Agreed. The hypothetical illustration should have been set closer to 20 µM to protect living resources and recreation. This correction will be made in revised editions of the manual.**

o Page 7-10, line 18, the reference to sturgeon is confusing, they are rare from over-fishing and habitat loss, not eutrophication. **EPA Response: Restoration of sturgeon in systems where they used to be abundant such as the Potomac River Estuary suggests that hypoxia likely constrained restoration. The Chesapeake Bay Program makes note of the DO requirements for sturgeon.**

o Page 7-11, line 18, give examples of aquatic life uses and their relation to eutrophication. **EPA Response: Agreed. This will be expanded on in the next version of the manual.**

o Page 8-2, line 9, the statement, nutrients are a major contributor to use impairments has been made several times and should be referenced through use of examples. **EPA Response: Disagree. The manual makes numerous references with citations where nutrient over-enrichment caused water quality impairments with living resource impacts (See chapters 2 and 3).**

o Page 8-2, line 17, this document would be much stronger if EPA Section 304 (a) criteria were included in the Guidance Document rather than being released separately. **EPA Response: Disagree. This would make for an encyclopedic document and time for completion would be unacceptable. For example, the criteria recommendation documents for freshwaters were acknowledged as starting points for states/tribes to improve on the values, in part,**

because STORET did not contain adequate data to allow full application of the elements of criteria development. In the case for estuaries and coastal waters, very little relevant nutrient-related data are in STORET. Most of the data must be obtained from sources other than state/tribe and federal governments, respectively. This would greatly delay publication of the Estuarine and Coastal Marine Waters Nutrient Guidance Manual.

o Page 9-3, expand on merits of empirical models. **EPA Response: This was done.**

o Page 9-4 and 9-5, clarify scaling terms such as extent, dimension and resolution and note relationship must be retained between spatial and temporal resolution. **EPA Response: This will be done in the next version.**

o Appendix B, the appendix does not make it clear how information on light and nutrients that limit phytoplankton primary production can be used in criteria development. **EPA Response: This appendix was largely re-written to include information useful to criteria development. Practical information was included such as Secchi disc relationships to light limitation, light limitation of submerged aquatic vegetation, partitioning of extinction coefficient into several component extinction coefficients, and an example of where the relationship between nutrients and algal bioassays may suggest increased algal biomass but grazing and flushing place a cap on the actual biomass production.**

Appendix G needs more figures and illustrations to be useful. **EPA Response: The material in this appendix was modified and incorporated into Chapter 7.**

Appendix H, how was Fig. G-1 derived? **EPA Response: This appendix was removed and the text material was incorporated into Chapter 7 with explanation of how the reference condition was applied.**

Additional Considerations:

Table 6-1, page 6-5 in the October 2001 version of the manual list nutrient load as the criteria measure only for B. Watershed-Based Approaches for Estuarine Reference Conditions. The text emphasizes the importance of considering nutrient loads. Nutrient loads should be added to Section A. In Situ Observations as the Basis for Estuarine Reference Conditions and C. Coastal Reference Conditions.

o Page 5-19, spell Hass correctly. EPA response: It should be Haas.

Editorial Corrections for Appendix C:

Insert the following sentence between sentences two and three in paragraph 1 on p. C-1, i.e.

between “data.” and “This” at the end of line four. “For instance, the general term flushing time is often used synonymously with either of the (somewhat different) terms freshwater residence time and estuary residence time, defined below.”

Last sentence of first paragraph (P. C-1): Delete the last part of this sentence (“but also the lag phase between management and system improvements”), and then delete the words “not only” earlier in the same sentence.

Second line of paragraph 2 on p. C-1: add the word “required” between the words “transit” and “for”. I.e this should read “This is the mean transit time required for . . .”.

Changes to Appendix E:

o Spell Latimer not with 2 tt).

o Fixed problems with figure labels in Appendix E.

* Change Figure E-2 in October 2001 version of the manual to Figure E-1. Plot of annual TN loading rates versus phytoplankton primary production rates at a single station in the Chesapeake Bay from 1971-76 and 1985-90. From Boynton et al. 1995.

* In second paragraph, p. E-1, line 5, change in parentheses Figures E-1a,b) to Figure E-1.

* Change Figure E-1a to Fig. E-2a and legend to read---Scatter plots showing correlations between nitrogen loading, expressed using the volume Vollenweider-term flushing scale (V_r), and 92-98mean $\pm$ std. Errors of the Alternate Eutrophication Index scoring (without oxygen scores) (modified from Costa et al. 1999). Remove “w/o O_2 ” from ordinate. Remove Alt. And 4 yr mean from top of figure.

The axis label for the abscissa has no valid meaning as written, and should be rewritten $mg\ N\ m^{-3}\ V_r^{-1}$. Note that it appears here as written in the original source, but is nonsensical and should be rewritten.

* Change Figure E-1b to Figure E-2b. Keep legend as is except remove word “modified” from parentheses.

* The axis label in the new Fig. Label E-2b for the abscissa looks awkward with its mixing of conventions for representing units. It should be written $mg\ N\ m^{-3}\ V_r^{-1}$.

The term “ V_r ”, used in the axis labels for Figures 1a,b is not defined in this appendix. Given that it’s not a term that is widely known, it might be best to define it. The definition (Costa et al. 1999) is:

$V_r = r/(1+\sqrt{r})$, where r is the flushing time in years.

REFERENCES

The reference for Dettmann, EH. In press. should read: “Dettmann, EH. 2001 Effect of water residence time on annual export and denitrification of nitrogen in estuaries: A model analysis. Estuaries 24(4):481-490.” Note that both the publication status and the title have changed.

Following reference, i.e. Dettmann, EH, WA Brown . . . 1992: There should be a period between the words “estuary and “US Environmental” in line 2 of the reference.

Reference for Geyer, WR, P Dragos, T Donoghue. 1997: There should be a period after the report title, i.e, between the words “Pond” and “Report” in line 2. Also, the word “Buzzard” on line 2 should read “Buzzards”.

Reference for Signell, RP. 1992: the period after the word “International” in line 3 should be removed.

Appendix G:(Suggest following changes be considered for this appendix for next published version)

Is this information really helpful? What is given here for each system is a map and a very small smattering of the available data for each of the systems listed, with no interpretation. It’s not clear to me how the reader can make use of any of this. My sense is that this material needs to be significantly expanded with some interpretation (perhaps there is some specific point that can be made for each of these systems), or the section should be eliminated. Also, the references cited within the pages for individual systems are not given in the list of references. The following citations do not have corresponding entries in the reference list: Costa et al. (in press) on p. G-4; D’Avanzo on p. G-5; Fang et al (1977a,b), Maryland Department of Health and Mental Hygiene (1985), and National Park Service (1991), all on p. G-19.

Appendix D: (Suggest following changes for this appendix for next published version)

The material in this appendix is rather minimal. It would really be helpful to include more, even as little as an additional half page to a page would be really helpful. For instance, it would be helpful to give more context, describing the scope and general nature of this study. As written, one doesn’t know if the information presented here is based on a limited subset of U.S. estuaries (e.g. just the east coast), or is truly comprehensive. It would help to describe what the “National Assessment Workshop” is (mentioned in 2nd-last line on p. D-1). Also state how many estuaries (138) were included in the study described here. This number can be deduced from Tables D-1 and D-2, but without context, one is left wondering where the numbers in the last column of these tables came from.

An editorial comment:

Second-last line of first paragraph in section “Dilution and Flushing Potential” on p D-1: Add

“the” between “higher” and “rating”, i.e. it should read “higher the rating”.

Some comments on Table D-2 and Figure D-1:

Table D-2 and Figure D-1 are taken directly from the source document, but I think the following suggested changes, although they don’t follow the original word-by-word, would improve the description of the overall intent.

In Table D-2, column for tidal range, mesotidal estuaries are described as having a tidal range of “>2.5” ft. It would be more accurate to list the tidal range as “2.5-6”. This can be deduced, since macrotidal estuaries are listed as having tidal ranges of >6 ft, but why have the reader stop and have to figure it out?

Top matrix in Figure D-1: The legend below this can be improved as follows. Change the explanation for “MODERATE EXP.” to “MODERATE EXP. Estuary has moderate capacity to dilute and flush nutrients”. Change the explanation for “LOW EXP.” to “LOW EXP. Estuary low capacity to dilute and flush nutrients”.