2|4

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National Strategy for the Development of Regional Nutrient Criteria

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22550

CONTENTS

PREFACE

In February of this year, President Clinton and Vice President Gore released a comprehensive Clean Water Action Plan. The Action Plan provides a blueprint for Federal agencies to work with States and others stakeholders in restoring and protecting the Nation's water resources and addresses three major goals:

- enhanced protection from public health threats posed by water pollution;
- more effective control of polluted runoff; and
- promotion of water quality restoration and protection on a watershed basis.

A key part of the Action Plan provides for expanded efforts to reduce nutrient overenrichment of waters.

Nutrients, in appropriate amounts, are essential to the health of aquatic systems. Excessive nutrients, however, can result in excessive growth of macrophytes or phytoplankton and potentially harmful algal blooms leading to oxygen declines, imbalance of aquatic species, public health threats, and a general decline in the aquatic resource.

Recent reports on water quality conditions provided by States indicate that nutrients are the leading cause of impairment in lakes and coastal waters and the second leading cause of impairment to rivers and streams. Nutrient overenrichment has also been strongly linked to the large hypoxic zone in the Gulf of Mexico and to recent outbreaks of the toxic microorganism *Pfiesteria* along the Gulf and Mid-Atlantic coasts.

The Action Plan calls on EPA to accelerate the development of scientific information concerning the levels of nutrients that cause water quality problems and to organize this information by different types of waterbodies (e.g. streams, lakes, coastal waters, wetlands) and by geographic regions of the country. EPA is also to work with States and Tribes to adopt criteria (i.e. numeric concentration levels) for nutrients, including nitrogen and phosphorus, as part of enforceable State water quality standards under the Clean Water Act.

This **National Strategy for Development of Nutrient Criteria** describes the approach that EPA will follow in developing nutrient information and working with States and Tribes to adopt nutrient criteria as part of State water quality standards. Some key aspects of the Strategy are described below.

Region and Waterbody Approach

Section 304(a) of the Clean Water Act directs EPA to develop scientific information on pollutants and to publish "criteria guidance," often expressed as pollutant concentration levels, that will result in attainment of a designated use of the waterbody (e.g. fishing, swimming) that is determined by the State. These concentration levels generally are the same for all types of waterbodies and to all areas of the country. States consider these EPA "criteria guidance" when they adopt water quality standards for waterbodies. A water quality standard commonly includes a designed use for the waterbody and criteria (i.e. concentration levels) for a range of pollutants that will assure that the waterbody will support the designated use.

In the case of nutrients, however, there is a great deal of variability in inherent nutrient levels and nutrient responses throughout the country. This natural variability is due to differences in geology, climate and waterbody type. Because of this variation, EPA's custom of developing scientific information about a pollutant and recommending a single pollutant concentration number to support a designated use for nationwide application is not appropriate for nutrients. EPA believes that distinct geographic regions and types of waterbodies need to be evaluated differently and that recommended nutrient concentration levels need to reflect geographic variation and waterbody types.

Waterbody-Type Guidance Documents

An essential element of this Strategy is development of waterbody-type guidance documents describing the techniques for assessing the trophic state of a waterbody and methodologies for developing nutrient criteria appropriate to different geographic regions. Separate guidance documents will be developed for rivers, lakes, coastal waters, and wetlands.

Each waterbody guidance document will provide scientific information required by section 304(a) of the Clean Water Act, including recommended nutrient concentration levels that are appropriate for the waterbody type, the geographic region, and various designated uses. EPA will use State databases to develop these criteria guidance documents, supplemented with new regional case studies and demonstration projects to provide additional information. EPA expects that these levels will be expressed as numerical target ranges for variables such as phosphorus, nitrogen, and other nutrient indicators. Guidance documents for rivers, lakes, and coastal waters will be completed by the end of the year 2000 and the guidance document for wetlands will be developed by the end of 2001.

Adding Nutrients to Water Quality Standards

EPA expects States and Tribes to use the waterbody type guidance documents and nutrient target ranges as a guide in developing and adopting numeric levels for nutrients that support the designated uses of the waterbody as part of State water quality standards. EPA will work with States to support and assist in this process. States should have adopted nutrient criteria that support State designated uses by the end of 2003.

EPA will review and approve the new or revised nutrient elements of water quality standards under Section 303(c)(3) of the Clean Water Act. If EPA disapproves the new standard submitted by a State or Tribe (because EPA determines that it is not scientifically defensible), or if EPA determines that a new or revised nutrient standard is necessary for a State or Tribe (because EPA determines that the State or Tribe has not demonstrated reasonable progress toward developing numerical nutrient standards), EPA will initiate rulemaking to promulgate nutrient criteria values that will support the designated use of the waterbody and are appropriate to the region and waterbody types. Any resulting water quality standard would apply until the State or Tribe adopts, and EPA approves, a revised standard.

Once adopted as part of State or Tribal water quality standards, the nutrient criteria in State standards will become the basis for identifying waters where nutrients result in impairment of water quality and making many management decisions to reduce excessive nutrient levels in these waters.

National and Regional Nutrient Teams

The Office of Water will provide additional technical and financial assistance to the Regions and States to accelerate the development of nutrient criteria.

This effort will include the establishment of a National Nutrient Team, including coordinators from each EPA Region. The Regional Coordinator will foster the development and implementation of State projects, databases, nutrient criteria and standards, and the award of financial assistance to States and Tribes to support these endeavors. Each Regional coordinator will be responsible for nutrient management activities for that Region and its member States and Tribes consistent with decisions of the national nutrient program.

Each Regional Coordinator will form a Regional Nutrient Team that includes State and Tribal representatives and other federal and local representatives, as needed, to develop nutrient databases and nutrient target ranges.

I am confident that this effort to include nutrient concentration levels in State water quality standards will be a major step forward for efforts to restore and protect the Nation's waters. I look forward to working with water program managers and other interested parties in this important initiative.

Robert Perciasepe
Assistant Administrator
Office of Water

Date

NOTE TO THE READER

This document sets forth EPA's strategy to develop scientific information (i.e., criteria documents under section 304(a) of the Clean Water Act) which EPA will recommend that States use to adopt nutrient criteria to support State water quality standards. These nutrient criteria provide a critical foundation to address overenrichment problems in the Nation's surface waters. It also provides guidance to States, Tribes and the public regarding how EPA intends to exercise its discretion in implementing the provisions of the Clean Water Act concerning the adoption of water quality standards.

This document is designed to implement national policy on the issues it addresses. It does not, however, substitute for the Clean Water Act or EPA's regulations; nor is it a regulation itself. Thus, it cannot impose legally binding requirements on EPA, States, Tribes or the regulated community and may not apply to some particular situations. EPA, State and Tribal decisionmakers retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance where appropriate. EPA also retains discretion to change the guidance contained in this strategy in the future.

I. INTRODUCTION

A. Background

Nutrients, in the appropriate amounts, are essential to the health and continued functioning of natural ecosystems. Depending upon specific characteristics of the receiving waterbodies, they can be present in excessive, limiting, or optimal amounts. Insufficient nutrients will result in less than optimal growth of primary producers (i.e., plants, including phytoplankton and submerged aquatic vegetation). Adequate primary productivity is essential to support all the other trophic levels and a healthy, diverse, and productive ecosystem.

Excessive nutrient loadings will, however, result in excessive growth of macrophytes or phytoplankton and potentially harmful algal blooms (HAB), leading to oxygen declines, imbalance of prey and predator species, public health concerns, and a general decline of the aquatic resource. It is the excesses of these nutrients resulting from human activities, rather than natural spatial and temporal variations, that are the concern of this document and it is this cultural eutrophication that is most appropriately the subject of management efforts.

When nutrient inputs exceed the assimilative capacity of a waterbody system, the system progresses toward hypereutrophic conditions. Symptoms include an overabundance of primary producers, decreased biological diversity, algal blooms (some toxic), low dissolved oxygen, episodic anoxia, loss of vascular plant life, and fish kills. Investigations have shown that the key causative factors are excessive concentrations of the primary nutrients phosphorus and nitrogen.

The term *nutrient* is loosely used to describe a compound that is necessary for metabolism. Nitrogen (N) and phosphorus (P) are required in relatively large amounts by cells and are called macronutrients, as opposed to micronutrients such as iron or molybdenum.

Nutrient criteria is intended to be interpreted in its broadest sense, covering both legal and scientific interpretations. Legally, a nutrient criterion is the numeric value which supports a particular beneficial designated use in defining a water quality standard. Scientifically, a nutrient criterion is meant to encompass both causal and response variables (e.g., nitrogen or phosphorus levels), as well as aquatic community response parameters such as but not limited to algal biomass, chlorophyll a, and secchi depth.

Similarly, in this text the problem of *eutrophication* is used to describe an increase of nutrients in a waterbody which results in an overabundance of plant biomass (Flemer, 1972).

The terms *water quality measurement* and *water resource measurement* are both intended to mean a comprehensive array of measurements including chemical, physical, and biological parameters.

In all aquatic ecosystems some general processes determine whether N or P is the limiting macronutrient and can be expressed as the nitrogen-to-phosphorus ratio (N:P). The *Redfield ratio* of N:P for primary producers in marine systems is approximately 16:1 on a molar scale

22556

1997). This strategy envisions that all States/Tribes, with the active assistance and participation of all stakeholders, will implement dynamic and effective nonpoint source pollution programs to achieve and maintain beneficial uses of water by the end of calendar year 2013.

- **Strategy for Addressing Environmental Public Health Impacts from Animal Feeding Operations (AFOs)** (draft, March 1998). This strategy strives to minimize environmental and public health impacts from AFOs through an effective mix of voluntary and regulatory measures. EPA is working with the US Department of Agriculture to develop a joint USDA/EPA national strategy on Animal Feeding Operations. This joint strategy -- which will supersede the draft EPA AFO Strategy -- will be published in draft form in July and in final form in November.

- **The National Harmful Algal Bloom Research and Monitoring Strategy**. This strategy was developed as an effort to coordinate Federal research and monitoring activities on *Pfiesteria* and other HABs. Federal HAB programs are spread across several Federal agencies, including the National Oceanic and Atmospheric Administration (NOAA); EPA; the Department of Health and Human Services–Centers for Disease Control and Prevention, the Food and Drug Administration, and the National Institute of Environmental Health Sciences (DHHS– CDCP, FDA, and NIEHS); the National Biologic Service (NBS); the National Science Foundation (NSF); and the U.S. Fish and Wildlife Service (USFWS), and an interagency workgroup was formed to address a diverse list of current and planned HAB activities.

  After reporting relevant research and programmatic activities, questions were formulated that addressed the objectives of a comprehensive research strategy. The research questions and objectives were differentiated into near-term and long-term activities, and the workgroup classified each agency activity into groups that reflect the eight objectives cited in *Marine Biotoxins and Harmful Algae: A National Plan* (Anderson *et al.*, 1993). Agency activities have been categorized into these objectives allowing the workgroup to identify obvious coordination points, and data/research gaps.

- **Water Quality Standards Regulation: Advance Notice of Proposed Rule Making (ANPRM).** EPA is about to publish an Advance Notice of Proposed Rulemaking (ANPRM) on the Water Quality Standards Regulation in the Federal Register. The ANPRM solicits public comment on potential revisions to the basic water quality standards program regulation governing State adoption and EPA approval of water quality standards under Section 303(c) of the Clean Water Act. The ANPRM also requests comment on changes in policy and guidance that support the regulation.

  The ANPRM expresses current EPA thinking in a number of areas addressed by the current regulation, policy and guidance and requests comment on that thinking.

One of the main themes of the ANPRM is updating and modernizing water quality standards so that standards may be better implemented on a watershed basis using refined use designations and tailored criteria. New science and assessment methodologies, as well as better data, and new types of data and analysis would need to be used by States and Tribes to refine water quality standards in this manner. The ANPRM highlights the potential resource challenge for States and Tribes and requests comment regarding concerns over resource constraints and ideas for how to address them.

- **The USDA Nutrient Management Policy**. The USDA's Natural Resources Conservation Service (NRCS) proposed a revised nutrient management policy to its National Agronomy Manual. This revised policy will impact the NRCS national conservation practice standards for Nutrient Management (Code 590) and Waste Utilization (Code 633). The nutrient policy discusses certification of plans, describes what is in nutrient management plans, and discusses soil and plant tissue testing, nutrient application rates, record keeping and other special considerations. The revised policy will be adopted after the June 22, 1998 comment period closes.

The groups developing the strategies are all investigating related problems ... land use-nutrient loading relationships, ecological responses, and appropriate mitigation activities. As all of these strategies progress, it will be essential to coordinate the information and activities that result so that consistent policy is developed.

II. EPA NATIONAL STRATEGY FOR DEVELOPING REGIONAL NUTRIENT CRITERIA

This Strategy proposes to build on the work accomplished to date and to establish an objective, scientifically sound basis for assessing nutrient overenrichment problems. Improving the basis for assessing nutrient overenrichment problems will provide critical support for expanded efforts to control nutrient levels in waters and meet the Nation's clean water goals.

Specifically, this Strategy proposes a two-phase process for the development of water quality standards for nutrients:

1) EPA will develop "nutrient criteria guidance" for nitrogen, phosphorus, and other nutrient parameters such as chlorophyll a, secchi depth, and algal biomass. These criteria will be developed under section 304(a) of the Clean Water Act and will represent EPA's guidance regarding the amounts of those contaminants that may be present in waters without impairing their designated uses. Unlike other criteria guidance that EPA has developed, EPA intends to express nutrient criteria guidance as numerical ranges, reflecting a menu of different values based on the type of waterbody (i.e., streams and rivers, coastal waters and estuaries, lakes and reservoirs, and wetlands) and the region of the country in which the water is located.

2) EPA expects States and Tribes to adopt nutrient water quality criteria

(including N and P concentration levels) to support designated uses of waters. These "nutrient criteria" will be based on EPA's nutrient criteria guidance or other scientifically defensible methods and will be incorporated into the States' water quality standards. The goal is for the States/Tribes to establish these criteria as part of their water quality standards as soon as the appropriate criteria guidance is developed. The target date for adoption of nutrient criteria as part of water quality standards is within three years of completion of the guidance, (i.e., by the end of the calendar year 2003). EPA will step in and promulgate nutrient water quality criteria for a State or Tribe if EPA determines that federal action is necessary.

Adding nutrient criteria to State water quality standards is essential for Federal, State and local agencies, and the public, to better understand, identify, and manage nutrient overenrichment problems in surface waters.

The following sections will present the key elements of the Strategy and describe the tasks and activities that EPA will undertake to promote nutrient assessment and criteria development over the next several years.

A. The Five Key Elements of the Strategy

1) Geographic Region Approach.

EPA intends to develop nutrient criteria guidance on a regional, rather than a national, basis. The Agency expects States and Tribes to develop water quality criteria and standards for nutrients in their geographic regions based on the guidance provided by EPA. The criteria established would therefore be the product of a joint EPA-State/Tribal effort tailored to that part of the country. This approach permits the objective of overenrichment abatement to be met by recognizing the ambient "natural" background levels of nutrients in each region and then concentrating on the "cultural" eutrophication which exceeds this. As noted below, regional criteria information will be presented for four categories of waterbodies.

Although this Strategy is organized around the four major waterbody types specified below, it is recognized that approaches for assessing regional and waterbody-specific nutrient concerns must consider that waterbody types are not independent from each other, but are part of an interconnected and larger system. With that in mind, the need for integration of concepts associated with the assessment and control of nutrient overenrichment between waterbody types is clear. This understanding of an integrated approach is an important concept to keep in mind during the implementation of this Strategy.

One well-defined spatial framework which can be used to define a region for nutrient assessment is the "ecoregion" system developed by James Omernik of the EPA Corvalis, OR laboratory. While it is acknowledged that several other classification schemes have been developed, for the purposes of this strategy, EPA plans to use Ecoregions as defined by Omernik et al., to initiate development of regional nutrient indicator ranges and, ultimately, to include them in the State and Tribal nutrient water quality criteria. A draft map has been created as a starting point for this process (See figure 1). Still to be determined is what scale of ecoregion is appropriate for the development of regional nutrient criteria guidance within a short period of time (by the end of calendar year 2000). The degree of variability within each of these 14 nutrient ecoregions will determine whether the map needs further refinement. These issues will be resolved once data has been reviewed, analyzed, and discussed at meetings of the National Nutrient Team and its Regional components (see item 4 below). In addition, this does not preclude the use of other classification schemes by Regions and States and Tribes if they are judged to be more appropriate for that part of the country. For more details on the ecoregion concept and how it can be applied in a nutrient assessment see Omernik (1995) and Omernik et al (1988).

Upon determination of the best ecoregion scale, the next task which is integral to the development of nutrient ecoregional ranges is the identification of reference conditions within each of the nutrient ecoregions. Reference conditions refer to information from relatively undisturbed areas within each ecoregion. The concept of reference conditions and how they are selected will be described in more detail in the technical guidance documents.

2) Waterbody-Type Technical Guidance.

A major element of this Strategy will be the technical nutrient criteria guidance manuals, which will provide methodologies for developing region-specific nutrient criteria by waterbody type:

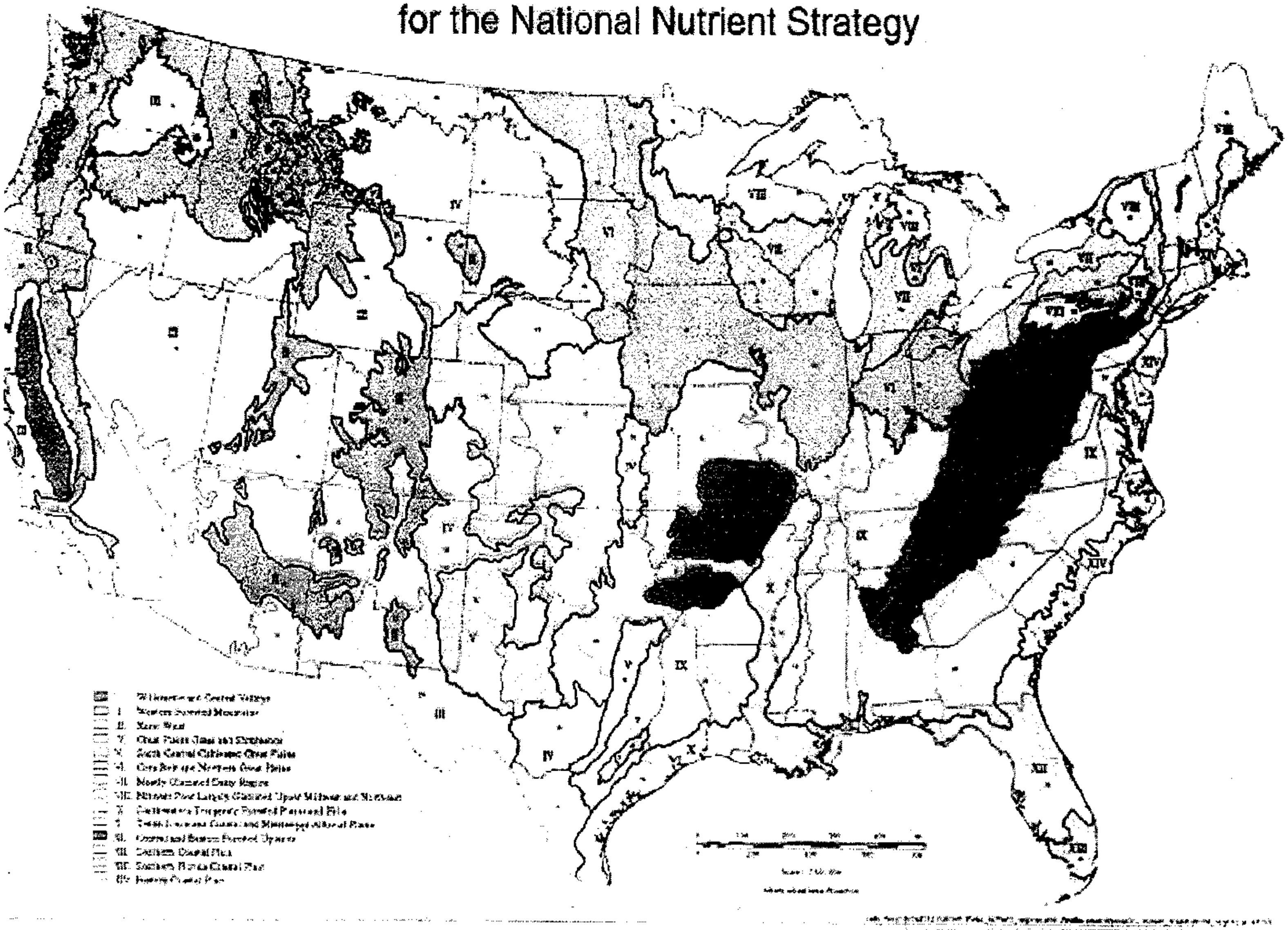
- streams and rivers,
- lakes and reservoirs,
- estuaries and coastal marine waters, and
- wetlands.

These manuals will also include discussions on overenrichment indicators, sampling and analytical techniques, and management methods. The manuals will be designed to be adapted in the various regions of the country.

The manuals will also provide technical assistance to implement nutrient abatement practices and will include data processing and manipulation techniques, best management practices, and case study demonstrations. An outline of the proposed content of the guidance document is in Appendix C, and elements of the technical material are presented in part III of this document. EPA plans to publish guidance documents for streams and rivers, and lakes and reservoirs in 1999; a guidance document on estuaries and coastal marine waters in 2000; and a guidance document on wetlands in 2001. **In each document, where data is available, EPA will also provide target regional nutrient ranges for phosphorus and nitrogen (and potentially other parameters)**, which States and Tribes may elect to use as the basis of their nutrient criteria and standards in lieu of applying the methodology. Where appropriate, they may also use these values as the basis for TMDLs and NPDES permit limits.

EPA and the Regional teams will collect and organize nutrient data on a geographic basis and develop target nutrient ranges based on historical nutrient data, reference conditions, and expert

Draft Aggregations of Level III Ecoregions for the National Nutrient Strategy



panel opinion. Where adequate data is available, EPA intends to append these ranges to its waterbody-type guidance manuals. This information can be used by individual States/Tribes which lack sufficient data of their own. Each appendix will be a "stand alone," peer reviewed document for a specific nutrient ecoregion.

As a preliminary measure for development of these nutrient criteria (i.e., the particular indicators used to assess the overenrichment or potential for overenrichment of a waterbody), EPA is seeking the cooperation of States and Tribes to pool available information in the determination of such ranges of target values for each region of the country. EPA will initially develop ranges for phosphorus, nitrogen, chlorophyll and secchi depth.

Collecting the data necessary to establish ranges for these parameters will be the first priority of the National Nutrient Team and Regional Coordinators. These ranges are intended to reflect the variability of conditions typically associated with particular waterbody types within an ecoregion. In addition, the ranges of target values serve as a starting point for making the proper measurements of waterbody enrichment and overenrichment so the appropriate management can be initiated. The guidance manuals are designed to provide the best methods for such measuring and evaluation.

An essential element of this process is the determination of the natural, background trophic state representative (Reference condition) of that area and waterbody so that abatement management can be directed at the cultural eutrophication of concern. It is not the intention of this strategy or the subsequent program to require States or Tribes to correct a natural enrichment process typical of their region; rather it is the purpose of the strategy to help States and Tribes develop mechanisms to remedy the enrichment effects of human development and commerce which impede the biota and beneficial uses of that waterbody.

3) Nutrient Criteria and Standards Development.

Upon completion of all the waterbody-type guidance documents, EPA expects all States and Tribes to adopt and implement numerical nutrient criteria into their water quality standards within three years of publication of waterbody type guidance documents and to complete adoption of nutrient criteria for all waterbodies in the State by no later than December 31, 2003. EPA expects States and Tribes to accomplish this by developing their own regional values in watersheds where applicable data are available, or by using the EPA target nutrient ranges. EPA expects States and Tribes to select a single value within the range as their water quality criterion where data is sufficient.

With regard to criteria and standards development, State and Tribes can choose to use the following approaches:

- The EPA target ranges, or values within those ranges, can be directly adopted by the States or Tribes as their criteria and standards and used to interpret narrative standards.

- The States or Tribes can use the EPA target ranges together with their own databases to develop their own criteria or to evaluate the protectiveness of any numerical nutrient criteria they may already have.

- States or Tribes may elect to use the EPA methodology described in waterbody-type guidance to develop criteria or employ their own approach, independent of the ranges, as long as it is scientifically defensible.

Once submitted to EPA, the Agency will review the new or revised standards under Section 303(c)(3) of the Clean Water Act. If EPA disapproves the new standard submitted by a State or Tribe (e.g., because EPA determines that it is not scientifically defensible), or if EPA determines that a new or revised nutrients standard is necessary for a State or Tribe (e.g., because EPA determines that the State or Tribe has not demonstrated reasonable progress toward developing numerical nutrient standards), EPA will initiate rulemaking to promulgate nutrient criteria values appropriate to the region and waterbody types. Any resulting water quality standard would apply until the State or Tribe adopts and EPA approves a revised standard. In the event EPA promulgates nutrient water quality standards for a State or Tribe, EPA would likely use the point in the range of greatest confidence (i.e., central tendency). When reviewing the adequacy of State/Tribe derived criteria and or ascertaining whether a State or Tribe is making reasonable progress toward developing an adequate nutrient criterion and standard, EPA is likely to use the target ranges.

When the initial target ranges have been established and the States or Tribes have begun the criteria and standard development process, EPA through the Regional Nutrient Coordinators will also provide technical and financial assistance for nutrient management planning and application. This will be through guidance manuals and the services of regional and national specialists associated with the Team, as well as financial assistance also administrated by these Regional Nutrient Coordinators.

4) Nutrient Teams.

EPA Headquarters and Regional staff will work closely with State officials and other interested parties in the development of the nutrient criteria. The overall national nutrient criteria project will be managed by a National Nutrient Team. The EPA National Nutrient Team will include Office of Water staff, a Coordinator from each EPA Region, State/Tribal representatives, and representatives of other Federal agencies (See Figures 2 and 3). EPA will provide guidance and support to States/Tribes in the form of technical and financial assistance to help establish their regional programs.

In addition, each Regional Office will select a Regional Nutrient Coordinator and will establish a Regional Nutrient Team. The Regional Coordinator will promote the development and implementation of State and Tribal projects, databases, and nutrient criteria and standards, as well as manage the award of financial assistance to support this endeavor. Specifically, Regional Coordinators will have a large role facilitating the collection of nutrient data from States and Tribes within their Regions. Ultimately, the Regional Coordinators and National Team will work together to develop nutrient ranges for each ecoregion wherever appropriate data is available.

FIG. 2

National Nutrient Team

EPA HQ Offices (OW, ORD)
10 Regional Coordinators
3-5 States
Other Federal Agencies (USGS, NOAA, USDA, et. al.)

Function:

Establish ecoregion maps for nutrients
Establish best process for collecting data from all sources
Establish best process for analyzing data and developing nutrient criteria (minimum data and statistics)

FIG. 3

Regional Nutrient Team

1 Regional Nutrient Coordinator
1 HQ Representative
1 State Representative from each State in the Region
Other Federal/State/Local Representatives as needed

Function:

Collect and analyze regional nutrient data
Establish nutrient ranges (criteria)
Award assistance grants to State/Academia where gaps exist in our knowledge

Ten Regional Nutrient Coordinators, one from each Region, have been selected and they have begun the process of forming their Regional Nutrient Teams. Regional Teams will likely include representatives from each State in the Region and other federal, State, local representatives, as needed (including water quality managers, NPDES permit writers, field biologists, monitoring and modeling experts). For example, a regional team could include other Regional EPA specialists such as those in Regional and ORD laboratories, as well as specialists from such agencies as the U.S. Geological Survey (USGS); NOAA– National Marine Fisheries Service (NOAA-NMFS); the U.S. Department of Agriculture-Natural Resources Conservation Service and Cooperative State Research, Education, and Extension Service (USDA– NRCS and CSREES); the U.S. Forest Service (USFS); and the USFWS. State/Tribal counterparts of these agencies and States and Tribes regulatory specialists should also be included. University specialists should be considered, as well as the local communities and environmental and special interest groups. While this list of participants might be the ideal, in reality local circumstances will probably dictate a smaller group whose composition is likely to change with time and needs. However, the agency and community resources described above should, at the very least, be consulted for information and historical perspectives on the waters in question.

As technical guidance and assistance is established in the various States and Tribes, periodic meetings of the Regional Nutrient Team Coordinators should be held to compare experiences, including successes and failures of approaches taken and techniques tried. Key participants, in addition to the Coordinators, should be the specialists and natural resource managers (as described above) who conducted the work so detailed question-and-answer sessions can be held. A proceedings document for each of these meetings should be prepared and circulated among the States and Tribes and agencies promptly so nutrient measurement and management information can be rapidly disseminated.

Following organizational meetings at which the objectives of the program are established, the business of obtaining State and Tribal cooperation in providing nutrient and other enrichment indicator data must be addressed. This is best accomplished by indicating the positive consequences of the information exchange. A trial watershed project, in which the information is actually applied to help solve an overenrichment problem significant to the State/Tribe, is an appropriate way to start. This demonstration project can be initiated in tandem with the overall data-gathering effort and will serve as an incentive to other States/Tribes to become involved.

5) Management and Evaluation.

While the primary focus of this Strategy is to develop regional nutrient criteria guidance, it is essential to understand the role criteria and standards play in overall nutrient management. The management of nutrient overenrichment is not just the development of nutrient criteria and the application of standards; it is a management process which must integrate a number of programs and methods including but not limited to: Nonpoint and Watershed programs; NPDES Permitting program; Biosolids Management program.

These various programs offer many options for the resource manager to consider and there are many new programs still being developed. However, there are some fundamental management concepts that should apply in most of these situations. Presented below are ten sequential elements to consider.

This comprehensive approach incorporates all of the key elements essential to good management planning, but the user might find that some steps can be consolidated or that circumstances necessitate a different sequence in the chronology.

1. Problem identification
   Make sure a problem exists and is clearly defined in terms that make it possible to seek a solution.

2. Background investigation
   Use literature searches, questionnaires, interviews, and other background investigations to better describe the problem and determine the information available about it.

3. Data gathering
   Conduct an assessment of water quality including physical, chemical, and biological parameters and related loading sources in the watersheds. This step should usually be of one or more years' duration to accommodate seasonal and annual variation.

4. Identification of key problem areas
   Conduct a thorough assessment of all of the above information.

5. Alternative management options
   Evaluate each possibility and its impact on present uses with respect to scientific validity, cost-effectiveness, and sociopolitical feasibility. Involve local and States and Tribal governments, property owners, citizen groups, and public and business interests in discussions about the optimal approach.

6. Detailed management plan
   Prepare a plan that discusses how to address each key element of the nutrient problem in the most effective sequence. Include a stepwise sequence of coordinated activities in detail. Usually such a management plan is of a maximum 5-year duration. Such a duration accommodates sufficient measurement and seasonal variation but is short enough in planning scope to be included in most budget systems. Longer projects might require sequential management plans.

7. Implementation and communication
   Initiate the management program, including adoption of nutrient water quality criteria and standards and, where appropriate, establishment of nutrients limitations in NPDES permits and development of TMDLs as elements of the program. Maintain community, interest group, and other agency involvement through regular updates on the process. This communication may begin earlier, e.g., at step 4 or sooner, but it

should be emphasized here.

8. Monitoring and periodic review

   Incorporate water quality monitoring before, during, and after the project to demonstrate relative response of the system to management efforts. Build in specific intervals for management review to allow response to changing circumstances; modifications of methods and schedules; and changes in emphasis as needed.

9. Completion and evaluation

   Has the water resource been protected or improved? Give credit to the community and other participants. Report on successes and failures for future applications and on lessons learned.

10. Continue monitoring and maintenance

   Water resource monitoring stations and parameters should continue on a reduced scale. Ensure regular maintenance of management efforts to preserve the effects achieved. Monitoring provides warning of any future degradation, so, if necessary, resource managers can intervene in a timely, cost-effective manner. Close the cycle by returning to step 1 for next generation response.

With a good database predicated on reliable indicators and the development of regional nutrient criteria guidance, States, Tribes, and other jurisdictions will be capable not only of assessing the trophic status of their waters, but also should be able to establish their criteria and plan, prioritize, and evaluate their management responses. In doing so, all five strategy objectives are interrelated at the regional level where problem recognition and remediation are most effective.

B. How the Elements are Integrated

This national Strategy consists of a **regional, waterbody-type approach** which permits the variability in natural nutrient loadings to waterbodies around the country to be recognized, and criteria to be established which account for this variability. The criteria so developed will also be waterbody-type specific because different waterbodies respond differently to nutrient loadings. Also, in recognition of this discrete, but interrelated enrichment process, the finally developed criteria must limit not only the unacceptable enrichment of a given waterbody or watercourse, but also must factor in the effects of that enrichment on downstream receiving waters.

The **waterbody-type technical guidance manuals** being developed will provide specific guidance to the States and Tribes for making the necessary measurements and for developing the criteria from those measurements, including the establishment of **regional target values** as guidelines. These manuals (including wetlands) are scheduled to be completed by the end of 2001. Each technical guidance manual will include ecoregional target ranges. If there is sufficient data within each of the 14 ecoregions available to develop a nutrient range within each of the ecoregions for the four waterbody types, 56 nutrient range appendices will be developed by the end of 2000. If sufficient nutrient data is not available or is insufficient to develop an acceptable peer reviewed nutrient range, EPA will continue to promote data development in these ecoregions after publication of guidance.

Once the nutrient guidance and ecoregional ranges are completed it is expected that States/Tribes will develop nutrient criteria (see Figure 4).

The implementation of the criteria will be supported by the **regional nutrient teams** by providing technical and logistical expertise as well as funding assistance. The criteria can then be used in **management planning and evaluation** on a watershed basis with community involvement so the ultimate objective of enhancing and protecting our nations water resources is achieved.

III. WATERBODY-TYPE TECHNICAL GUIDANCE.

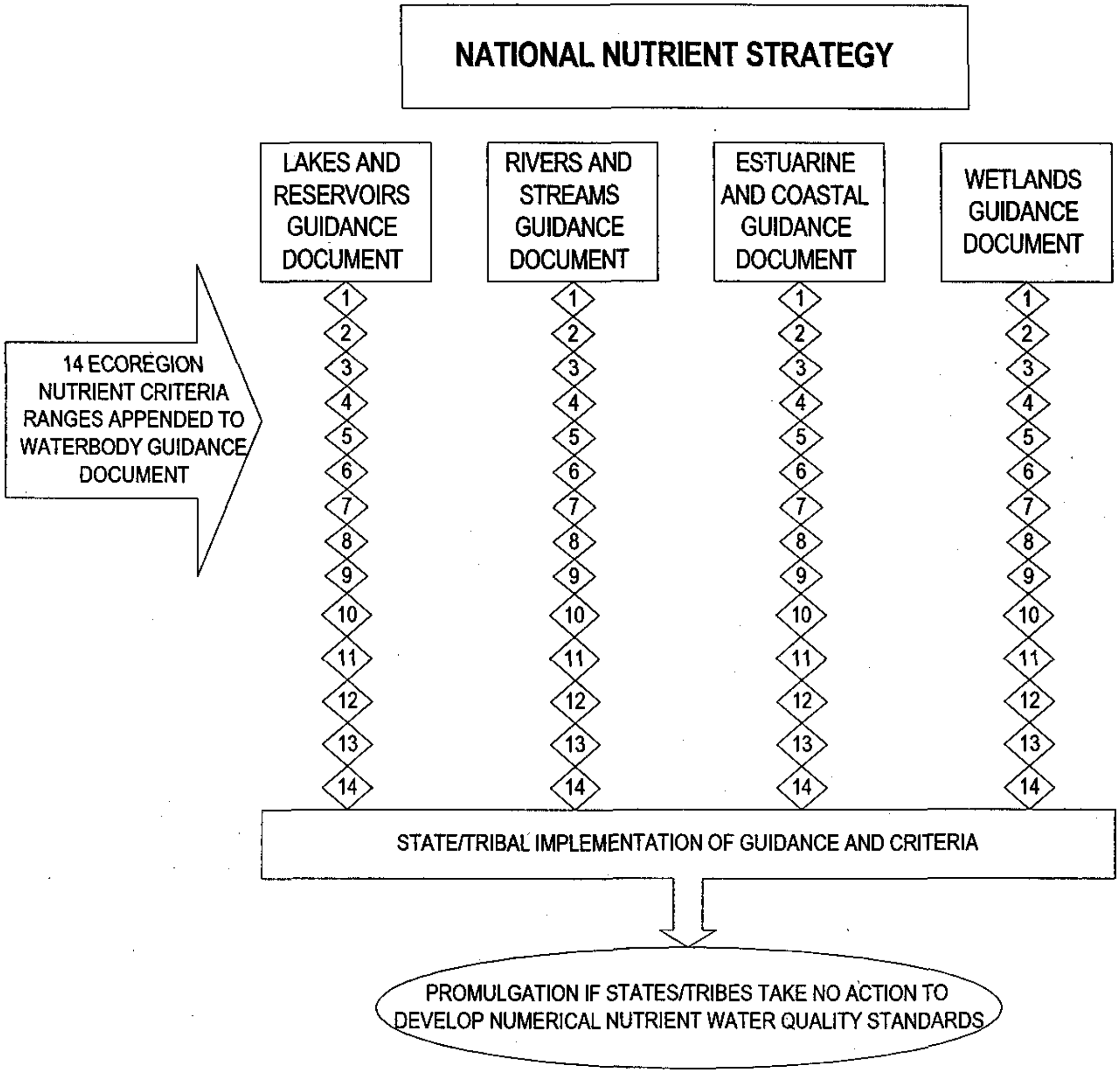
Waterbody-type guidance manuals will provide the standardized methods available to the States/Tribes and other jurisdictions to promote the development of consistent regional databases that reflect conditions in each part of the country. This is important because overenrichment and natural levels of enrichment differ from one geographic area to another, in part because of differing cultural, geologic, and climatologic influences. These factors change the ambient background from one region to another and necessitate a regional approach to these measurements and to the nutrient criteria to be developed.

A key element of each waterbody-type guidance manual is the recommended list of reliable indicators of overenrichment, how they might best be measured, and how and when to collect the necessary samples for this measurement. (These manuals may also include sections addressing the remaining objectives of this strategy, i.e., data storage and assessment, research needs, and best management practices for nutrient impact mitigation.) EPA intends that the publication of these technical guidance documents will help standardize assessments and promote regional interstate cooperation for nutrient control.

The following is a partial listing of overenrichment indicators, data requirements, management options, and research needs recommended by the component nutrient workgroups at the December 1995 meeting in Washington DC, and by subsequent reviewers. Some of these recommendations are qualitative in nature; such indicators are also valuable and definitive in their own right. All of the indicators are meant to serve as a starting point for enrichment assessments, which are expected to be expanded and refined into more quantitative evaluations as the guidance is further developed and as individual States/Tribes make regional adjustments to the methods.

Even as a partial listing, this material may seem remarkably detailed to the general reader for a strategy document. It must be recognized that this strategy is predicated upon the proper

Figure 4


NATIONAL NUTRIENT STRATEGY
LAKES AND RESERVOIRS GUIDANCE DOCUMENT
RIVERS AND STREAMS GUIDANCE DOCUMENT
ESTUARINE AND COASTAL GUIDANCE DOCUMENT
WETLANDS GUIDANCE DOCUMENT
14 ECOREGION NUTRIENT CRITERIA RANGES APPENDED TO WATERBODY GUIDANCE DOCUMENT
1 2 3 4 5 6 7 8 9 10 11 12 13 14
1 2 3 4 5 6 7 8 9 10 11 12 13 14
1 2 3 4 5 6 7 8 9 10 11 12 13 14
1 2 3 4 5 6 7 8 9 10 11 12 13 14
STATE/TRIBAL IMPLEMENTATION OF GUIDANCE AND CRITERIA
PROMULGATION IF STATES/TRIBES TAKE NO ACTION TO DEVELOP NUMERICAL NUTRIENT WATER QUALITY STANDARDS

measurement of valid environmental indicators for the establishment of scientifically defensible nutrient criteria. The identification of the premises upon which these criteria are based is essential to a fair and objective review of this strategy by the public.

A. INDICATORS

The indicators (parameters) listed below are the initial candidates for inclusion in the guidance documents. Each EPA technical guidance drafting committee will make final recommendations as they further explore the scientific veracity and practicality of the material. Additionally, each document will include recommendations for the most appropriate sampling and analytical techniques.

LAKES AND RESERVOIRS

A focus of this guidance will be to establish the connection between lake nutrient environmental impacts to public health concerns, e.g., septic and sewage effluent discharges. This twofold approach relating environmental degradation to potential public health risks (as well as recreational uses and biodiversity concerns) should further stimulate public support of these initiatives. An outline of this proposed guidance document is attached as Appendix C.

The guidance will include and emphasize watershed-scale assessments and management approaches, illustrated by case histories and demonstration projects.

Surveys should address both spatial and temporal variability, including seasonality and in some instances variation over the course of a day. Whenever possible, year-round sampling is advisable. For in-lake surveys, it is presumed that the investigator will design for optimal spatial and bathymetric placement of the stations for that waterbody and that these data will be compared to reference lakes in that classification. Some of the parameters or indicators to consider follow:

- *Early Warning Watershed Indicators*
  — Land use/loading assessments and changes in watersheds (geographic information systems (GIS) are effective tools for evaluating nutrient loadings as a function of land use at a variety of scales). In areas of the country where agriculture and/or animal feeding operations exist, it is imperative to identify and assess these locations of potential sources of nutrients by collecting data on size and location of farms/animal feeding operations within a given watershed.
  — Changes in hydrologic regimes

- *Chemical/Biomass Parameters*
  — Phosphorus (P) concentration (total P (TP) and total dissolved P in hypolimnion)
  — Nitrogen (N) Concentration (total KN, NO_2 as N, NO_3 as N, and NH_4 as N, e.g., total N (TN), also N:P ratios)
  — Chlorophyll (total or chlorophyll *a*)

— Secchi disk depth (m)
— DO (hypolimnetic)

- *Community Structure Parameters*
  — Algal community (composition and biomass)
  — Macroinvertebrate structure (composition and biomass)
  — Fish (composition and biomass)
  — Macrophytes (composition and biomass)

- *Secondary Parameters*
  — Total suspended solids (TSS)
  — Total organic carbon (TOC)

- *Indicators for Immediate Assessment*
  — Preliminary survey data in addition to early warning land use information: TP, total chlorophyll, Secchi depth and DO. These should have established validity, low cost, and they should be readily used in prediction and modeling.

A historical perspective might be helpful to the data assessment process by integrating paleolimnological surveys with an evaluation of land use practices and changes.

STREAMS AND RIVERS

It is useful, for assessment purposes, to separate streams and rivers into two categories with optimal reference systems: for plankton-dominated systems and periphyton-dominated systems. The major differentiating characteristic between these two systems is that nutrients saturate the biomass at a much lower level in the periphyton-dominated systems than they do in the plankton-dominated systems. Summarized below are potential nutrient indicators for the plankton- dominated and periphyton-dominated systems. Early warning indicators of potential excess nutrient loadings may be significant shifts in land use patterns or in climatological events or other activities contributing to extreme runoff.

The indicators that follow are not presented in any order of sensitivity or utility.

- Plankton-dominated Systems

— Algal biomass
— Transparency
— TN

- Periphyton-dominated Systems

— Algal biomass (mg/m^2 percent coverage)
— Transparency
— TN, dissolved inorganic nitrogen (DIN)

- Appropriate to Either Plankton or Periphyton-dominated Systems

22571

— pH (maximum and diel)

— DO (minimum and diel)

— Ash Free Dry Weight (AFDW)/ Chlorophyll *a*

— Aesthetics (foam, scum)

— Benthic community metabolism

— Secondary production (meiofauna, index macroinvertebrates, fish)

— Hydrologic characteristics

— TP, soluble reactive phosphorus (SRP)

— Sediment composition (physical/chemical)

— Ratios of summer/winter nutrient concentration

— Ratios of dissolved/total nutrient concentrations

— Temperature

— TSS, volatile to suspended solids ratio

— Biointegrity (macroinvertebrate community composition)

— Production/respiration

— Dissolved organic material

— Relative plankton composition of Cyanophyta and dinoflagellates

ESTUARIES AND COASTAL MARINE WATERS

Estuaries and coastal marine systems can be subclassified for assessment according to the dominant vegetation type, as was done by the Estuaries Workgroup during the 1995 workshop. However, other systems of classification, such as classification by physical characteristics, can also be used. The participants in the December 1995 workshop selected the following categories: seagrass-dominated, plankton-dominated, and macroalgae-dominated (as indicated below). The indicators associated with these categories can be applied to either short-term or long-term assessments. It should also be noted that there are physical, chemical, and biological indicators other than those listed below (such as fish kills, suspended material, nutrient concentrations, toxins, and benthic invertebrate communities). Early warning indicators of potential excess nutrient loadings might be significant shifts in land use patterns or in climatological events or other activities contributing to extreme runoff. All indicator measurements in these waters must be qualified by attention to tide cycles, density and salinity gradients, and currents when they were made.

- Seagrass-dominated Systems
  - — Areal surveys of distribution, abundance, and depth of grasses
  - — Waterbody-type light requirements (seagrass depth vs. light attenuation)
  - — C:N:P ratios in plant leaves
  - — Leaf chlorophyll *a*
  - — Quantum irradience levels
  - — Chlorophyll *a*-to-b ratios
  - — Transparency

- Plankton-dominated Systems
  - — Chlorophyll *a*
  - — Algae such as cyanophyta, dinoflagellate, and diatom assemblages including HABs; documentation of the incidence and location of blooms
  - — DO determinations that consider cyclic fluctuations and distinguish between natural

and anthropogenic causes
- — The role of silica relative to nitrogen and phosphorus in phytoplankton blooms
- — Macroinvertebrate and other consumer community changes

- *Macroalgae-dominated Systems*
  - — Macroalgae influence on DO concentrations, dissolved organic carbon concentrations, and lower trophic levels.

WETLANDS

Methods for assessing nutrient impacts to wetlands are perhaps less established and standardized than those for the other waterbody types. This is due to the variability within wetland types (e.g., bogs, swamps, etc.) and the lack of historic databases in these areas. Some methods developed for lakes and rivers are applicable to wetlands with standing water, but there are few methods appropriate for wetlands that have saturated soils or are infrequently flooded. Surveys of wetlands should address both the spatial and temporal variability in nutrient levels, including seasonal and diel variation. Surveys should also address the variation in nutrient levels both within a wetland and between different wetland types. Some wetlands are often naturally eutrophic and will respond to nutrient additions much differently than bogs and other oligotrophic wetlands. The variability in plant communities (i.e., succession) will also affect how a wetland assimilates nutrients.

The following are suggested methods for assessing the effects of nutrients in wetland habitats. However, for most of these parameters, few baseline data are available with which to compare collected data.

- *Early Warning Watershed Indicators*
  - — Land use/loading assessments and changes in watersheds
  - — Precipitation, in-flow, runoff, and any extreme climatological or anthropogenic events

- *Chemical/Biomass Parameters*
  - — Phosphorus concentration (total)
  - — Nitrogen concentration (total, also N:P ratios)
  - — Chlorophyll (total or chlorophyll *a*)
  - — Secchi disk depth (m) (for wetlands with standing water)
  - — DO and soil oxygen demand

- *Biological Assemblage Parameters (e.g., composition, richness, diversity, and indicator species)*
  - — Attached microbial community
  - — Algae such as dinoflagellates and diatoms
  - — Macrophytes including emergent vegetation
  - — Macroinvertebrates
  - — Fish (for wetlands with standing water)

- *Secondary Parameters*

— TSS
— TOC

Since wetlands differ in their capacity to assimilate nutrients, it might be difficult to evaluate whether a given nutrient load will have a significant ecological impact on a wetland. Biological monitoring is useful to assess the response of wetland plants and animal assemblages to overenrichment and to detect degraded habitats. Microbial, macrophyte communities and algae, such as dinoflagellate and diatom assemblages, are particularly useful for detecting nutrient impacts by measuring their diversity, richness, composition, and structure. These assemblages can be compared to the assemblages found in reference wetlands that range from "minimally disturbed" to severely impacted by nutrient enrichment. Thus, the biological integrity of a wetland can be determined relative to the biologic assemblages present in the reference wetlands. The macroinvertebrate, fish, and plant assemblages can also reflect direct impacts of overenrichment and indirect impacts such as reduced levels of dissolved oxygen.

Another method of monitoring wetlands is to identify the accumulation of organic material over time as an indication of a change in productivity. This can be done by placing pieces of feldspar within wetlands and monitoring them for accumulation. Feldspar does not react with other chemicals in the soil and, therefore, could be used as a benchmark for measuring the buildup of organic material.

There are two systems of wetland classification that might be useful for selecting and comparing wetlands. Cowardin et al. (1979) developed a hierarchical system of wetland classification based largely on the structure of the plant community (e.g., forested, scrub/shrub, emergent, etc.). In addition, Brinson (1993) developed a hydrogeomorphic (HGM) framework for classifying wetlands based on a wetland's landscape position, source of water, and hydrodynamics.

B. DATA STORAGE AND PROCESSING

Once a standardized methodology for data gathering is available, the States and Tribes will also need a consistent and mutually compatible data storage, retrieval, and assessment system to help them interpret data and convert them to meaningful management information. An element of each waterbody-type guidance document should be convenient desktop, PC-based data storage and modeling programs. Such programs will not only enhance data assessment, but will, if consistent throughout a region, promote coordinated interstate surveys and data sharing. Many States already have sufficient nutrient databases and such data storage systems should be established in consultation with all potential partners. In fact, as Regions develop this aspect of the strategy, it is imperative that they consult with the States/Tribes to establish what systems are most efficient, cost-effective, and appropriate for data sharing without violating resource management confidentiality. EPA is currently engaged in determining the future design of a nationwide database, and this strategy should be compatible with that effort. Ensuring compatibility would include standardization of both data storage systems and models. The success of multi-State cooperation and coordination of monitoring activities will depend on this.

In all cases it will be essential that the quality of the data entered into these databases be carefully documented. Documentation should include information on methods used, minimum detection limits, and comparison to standards. Modelers should use due caution if quality assurance aspects of the data are not available.

Once such a database system is in place, calibrated and verified models can be developed or applied to help predict the likely consequences of management actions or, just as important, the lack thereof. Listed below are suggested needs or available resources appropriate to each waterbody type.

LAKES AND RESERVOIRS

Modeling:

Modeling is ideal in many ways for lake assessments. The BATHTUB and Reckhow-Simpson technique are two of many examples of existing lake models used by managers to predict trophic responses to estimating nutrient loading adjustments. The BATHTUB applies a series of empirical eutrophication models to morphologically complex lakes and reservoirs. The program performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network that accounts for advective and diffusive transport, and nutrient sedimentation. (For details, see *National Nutrient Assessment Workshop Proceedings*, EPA 822-R-96-004, July 1996.)

The goal of this strategy is to provide simple, user-friendly, desktop-based software models for States and Tribes and local governments to aid them in waterbody management decision making. Impoundments/reservoirs often have unique hydrographic profiles and therefore will probably require models calibrated specifically for use with these waterbodies.

STREAMS AND RIVERS

Modeling:

It is necessary to identify ways to improve on the existing models to examine the interrelationships and links between nutrient sources and nutrient impacts and help to tailor these models to both plankton- and periphyton-dominated systems. Participants at the December 1995 workshop noted in particular that modeling tools are lacking for periphyton-dominated systems, including both simple mass balance or regression relationships and complex process-based models. Below are ways to improve on the existing models' capabilities. For more details on any of the models listed below, see the *National Nutrient Assessment Workshop Proceedings* (EPA 822-R-96-004, July 1996).

- Provide land use connections in watershed-scale models.
- Conduct sensitivity analyses.
- Conduct carbon-based simulations.

- Add temperature simulation to the WASP5 model. WASP5 is widely used in both water quality assessment and toxic modeling. The model considers comprehensive dissolved oxygen and algal processes, but does not include the carbon and silica cycles or full sediment diagenesis model. In addition, its use is limited because it does not account for temperature. Therefore, adding temperature simulation to WASP5 would allow for diurnal temperature variations.

- Add periphyton to the QUAL2E, WASP5, and HSPF models. QUAL2E and HSPF are models that capture the longitudinal transport that dominates in most rivers and streams. QUAL2E and HSPF both consider advection and dispersion. Adding periphyton to these models would allow for simulation of periphyton biomass in the riverine system.

- Introduce load/response relationship (plankton) and concentration/response relationship (periphyton) to pinpoint where nutrient loading reduction can be targeted.

- Develop desktop models that are easily transferred across waterbodies and use the following parameters: TP, TN, total chlorophyll, DO, temperature and transparency (Secchi disk and black disk).

ESTUARIES AND COASTAL MARINE WATERS

Modeling:

Estuarine and coastal marine models are in the process of development and testing around the country, including efforts on the Chesapeake Bay. Much of this work is promising, and the following are areas requiring further effort.

- <u>*Seagrass-dominated Systems*</u>

  — Develop water quality models, from simple to complex, that look at simulation of chlorophyll *a* concentrations over seagrass beds from nutrient loadings of the surrounding watershed.

  — Develop multiple regression analysis models that simultaneously consider such factors as TSS, color, and chlorophyll *a*.

- <u>*Plankton-dominated Systems*</u>

  — There is a need for an estuarine version of "Vollenweider" relationships to better understand the relation of nutrient loadings to chlorophyll *a*.

- <u>*Macroalgae-dominated Systems*</u>

  — Many databases exist that would allow identification of nutrient loading thresholds for macroalgae-dominated systems.

WETLANDS

Modeling:

Very few models exist that are capable of predicting wetland responses to nutrient loadings. Of the literature reviewed, Mitsch and Gosselink (1993) and Howard-Williams (1985) offer conceptual diagrams of potential relationships for nutrients in wetlands. Wetlands can function as a source, sink, or transformer for a particular nutrient. A wetland is considered a sink if it has a net accumulation of a nutrient. In contrast, a wetland is considered a source if it exports more of a nutrient than it accumulates. A wetland is a transformer if it transforms a chemical from one form to another, such as from dissolved to particulate form, but does not change the amount going into or out of the wetland (Mitsch and Gosselink, 1993). In some cases, a wetland can be a sink for one nutrient while it is simultaneously a source for another nutrient.

Nutrient models for wetlands, as for all waterbodies, should account for atmospheric, surface, and subsurface inflows and outflows. The models should account for gaseous, aqueous, solid, and sediment-attached forms of the nutrients. The models should also account for the uptake and release of nutrients by living biomass and by decomposition of biomass. In addition, the models should address the seasonal and daily patterns of nutrient uptake and release by plants and animals. Chemical transformations based on changes in pH and concentrations of other chemicals should also be considered. All models should be validated on reference wetlands.

Sediment loading models used to predict TMDL loading rates from storm events can be useful for estimating phosphorus inputs. Some traditional water quality models, such as CEQUAL-W2 and WASP5, have been used for evaluating wetlands. Hydrodynamic models, such as EFDC, are being applied to wetlands in Florida to assess hydrologic response. Analysis of wetlands may also include the assessment of inputs/loadings using a variety of loading models (e.g., SWMM, HSPF) that can be used to predict nutrient and sediment loads to local wetlands (USEPA 1992). Further model development is needed, particularly for wetlands that have saturated soils and are infrequently flooded.

C. MANAGEMENT AND EVALUATION

The material in this section is not intended to be an all-inclusive list of remediation, protection, and management approaches. However, it is an introductory presentation of some of the readily evident options States and Tribes and other responsible parties can use to make a positive response to the nutrient information they obtain and the water quality criteria States and Tribes develop.

Options also exist that might not be specific to waterbody-type, such as the watershed approach. This approach allows communities to focus resources on a watershed's most serious nutrient sources, which might include animal waste and excess fertilizer runoff. Additional basic management measures can be found in other EPA documents such as *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA 840-B-92-002). The following, as well as additional approaches (such as the development of TMDLs for nutrient-impacted waters, the control of animal waste discharges, and the control of outbreaks of *Pfiesteria* and similar harmful algal blooms), will be explored further in the guidance materials to be developed as part of this strategy.

MANAGEMENT

In considering the various management options, the resource manager should also keep in mind that the different waterbody types described here may often be interrelated, e.g., streams draining to and from lakes, and rivers entering estuaries and coastal waters. Under these circumstances, the manager should be careful to select for a management plan practices that do not have negative downstream effects. For example, it might not be appropriate to raise a lake level to the detriment of riparian wetlands and influent streams.

LAKES AND RESERVOIRS

Examples of management options to consider when dealing with lakes and reservoirs are provided below.

- Vegetative buffer zones— Preserve or reestablish natural, indigenous vegetation (ground cover, shrubs, trees) in the riparian zone to intercept sediment and nutrient runoff before the runoff reaches the waterbody.

- Watershed land use changes— Identify critical loading sources and promote changes of these land use practices. Examples of practices to promote are implementation of conservation farming; use of manure holding facilities; use of road, commercial, and municipal runoff diversions and detentions; restoration of woodlots in critical drainage areas; land use planning to avoid excessive tiers of lake residences; and on-site septic system use and improvement.

- Habitat restoration— Improve lake nursery and spawning areas to restore a diverse aquatic community and food chain.

- Fish stocking and removal— Perform adjustment of fish communities disrupted by overenrichment by the selective removal of undesired species, the addition of more preferred species.

- Water column precipitation and sediment sealing techniques— Apply alum to the water column to remove P and to seal nutrients into bottom sediments under precipitate.

- Macrophyte harvesting and flow regulation— Perform weed control by use of mechanical harvesters to enhance lake use of nutrients and to remove some nutrients present in biomass. Initiate winter or other episodic drawdowns of lake/reservoir waters to augment sediment removal or consolidation.

- Biomanipulations— Ensure balanced predator stocking or grazer support to control blue-green algae and other nuisance primary producers.

- Relocation of sewage outfalls— Move sewage outfalls to locations that will minimize deleterious impacts to the waterbody.

- Restoration and protection of strategic wetlands— Restore and protect wetlands located in areas critical to water quality concerns.

- Hypolimnetic aeration— Implement techniques designed to aerate the hypolimnion.

- Point source nutrient removal— Remove nutrients at point sources using techniques such as tertiary treatment and phosphorus precipitation.

- Storm water management— Implement storm water BMPs such as constructing ponds, wetlands, infiltration and detention basins, and diversions.

STREAMS AND RIVERS

Issues and actions to consider associated with the abatement of nutrients in streams and rivers include:

- Land use— Include land use as a separate early warning indicator (i.e., if development is proposed in a watershed, an environmental impact study should be done to assess the potential impact of such development on the surrounding waterbody).

- Designated use and biomass relationships— Employ public survey techniques to monitor relationships between designated uses and algal biomass.

- Seasonal relationships— Investigate seasonal relationships between nutrients and biomass across streams.

- Nitrogen-phosphorus cycling— Enhance nitrogen-phosphorus cycling on different land uses to reduce mobilization (septic, forest systems).

- Riparian zone management— Introduce riparian buffers, shade the streams, or perform canopy restoration to minimize direct sunlight on surface water. Shading can also reduce the amount of direct air deposition of nitrogen and other nutrient sources.

- Channel restoration— Minimize the nutrient loadings by constructing channels to help reduce the rapid nutrient flush from one segment of the waterbody to another.

- Biological controls— Introduce biomass eating organisms such as caddis fly larvae *(Dicomoecus gilvipes)*, which efficiently remove both periphytic diatoms and filamentous algae from rock substrata.

- Hydrology, hydraulics (flow regime, storm water management, stream regulation)— Identify natural hydrologic regimes and use such information in addressing dam operations to better replicate natural conditions in the area while generating power or preserving intended reservoir levels.

- Impoundment removal— Remove man-made impoundments that have lost their utility and are now causes of flow interruption and sources of excessive algae and water quality degradation.
- Restoration of riparian and floodplain wetlands— Implement programs designed to restore riparian and floodplain wetlands.
- Point source nutrient removal— Remove nutrients at point sources using techniques such as tertiary treatment and phosphorus precipitation.
- Storm water management— Implement storm water BMPs such as constructing ponds, wetlands, infiltration and detention basins, and diversions.

ESTUARIES AND COASTAL MARINE WATERS

The following are basic management options to consider for all vegetation system types:

- Land use and development controls— Promote natural vegetative cover in shore areas and zoning restrictions on dense residential or commercial/industrial development along shoreline areas.
- Discharge and dumping regulation and marine sanitation devices— Encourage enhanced Publicly Owned Treatment Works (POTW) design and operation, and the diversion of POTW effluent from sensitive or poorly circulated waters. Promote and enforce marine sanitation device (MSD) regulations including providing adequate pumpout services.
- Restricted estuarine/coastal areas— Protect sensitive waters such as endangered shellfish beds, spawning and nursery areas, and recovering weed beds.
- Shoreline erosion controls— Implement erosion controls on banks subject to wave or ice damage. Restrict access to sensitive shorelines, dune restoration areas, and shorelines susceptible to erosion.
- Seagrass replenishment— Restore weedbeds in estuaries, including wetland areas. Plant and protect emergents and terrestrial riparian vegetation as further protection of tidal zone wetlands from runoff.

WETLANDS

Best management options to consider for wetlands include:

- Wetland protection and restoration— Preserve and restore wetlands through the implementation of voluntary and regulatory programs.

- Vegetative buffer zones— Preserve or reestablish natural, indigenous vegetation (ground cover, shrubs, trees) as buffer zones adjacent to wetlands to intercept sediment and nutrient runoff before the runoff reaches the wetland.

- Watershed land use changes— Identify critical land loading sources and promote changes of these land practices. Examples of changes that could be made include the implementation of conservation farming techniques; the reduction of the use of fertilizers on farms and lawns; the construction of manure holding facilities, runoff diversions and detentions, filter strips, and vegetated drainage ways; the implementation of forestry BMPs; the implementation of controls on urbanization and industrial development; and the upgrading of on-site and municipal wastewater treatment systems.

- Land use planning— Protect wetlands by limiting amounts of impervious surfaces, limiting development near waterbodies or steep slopes, and minimizing discharges from storm water, sewer, and septic systems.

- Protect and restore streams entering wetland— Stabilize stream channels and establish riparian buffers to reduce the amount of sediment-attached nutrients entering a wetland.

EVALUATION

Once the appropriate parameters or indicators have been established, EPA and the States or Tribes will be able to evaluate the effectiveness of the management and regulatory approaches taken. The databases and monitoring systems developed, together with the derived criteria, should be used to assess actual management progress toward ameliorating overenrichment conditions. (This process will be described in detail in each waterbody type specific technical guidance manual.) Where methods and techniques have been successfully employed, the experience may be applied to similar circumstances elsewhere. Where success has not been achieved, the knowledge gained is valuable in developing alternative approaches and in avoiding making the same mistake again. This information should be shared among the Regional Nutrient Teams, through correspondence and national meetings, to enhance management effectiveness.

Periodic program progress reports and budget statements will be prepared for the Office of Water, based on the proceedings described immediately above, so continuity of the program can be maintained, funding and other administrative support provided, and new needs identified and addressed.

The sum total of these reports and proceedings of the periodic national team meetings will provide the necessary feedback to EPA Headquarters to help further development and shaping of national policy with respect to nutrient management of the Nation's waters.

D. RESEARCH NEEDS

For all four major waterbody types, there are a number of research needs that should be addressed. A number of these research needs are noted below. They are highlighted to indicate areas which each technical guidance drafting group should address to attempt to reduce uncertainty in the assessment process.

LAKES AND RESERVOIRS

- Phosphorus and nitrogen speciation investigations.
- Sedimentation and nutrient load impacts on trophic states.
- Internal loading and recycling of nutrients regarding biological responses.
- Biomanipulation techniques.
- Better understanding of cascading trophic interactions, i.e., the effects of nutrient changes on one level of the food chain and how the rest of the community is affected.

STREAMS AND RIVERS

- Chlorophyll measurements (periphyton).
  — Sampling methods
- Cladophora, diatom, and blue-green alga growth requirements.
  — Field research
- Literature search on stream models (periphyton system).
- Stream bank, riparian zone, and denitrification.
- Investigation of dissolved oxygen and pH amplitude.
- Investigation of community metrics to characterize rivers for nutrient effects.
  — Ecoregions
  — Which metrics are most sensitive?
  — Literature search on indicator taxa
  — Is biointegrity sensitive as an early warning tool?
- Role of fluvial geomorphology as a factor in controlling algae development.
- Whole stream overenrichment studies.
- Investigation of seasonal relationships between nutrients and biomass across streams.

In addition to identifying the above research needs, the December 1995 workshop participants discussed a number of other actions that should be taken to help managers and scientists assess nutrient impacts on river and stream systems. These actions include the following:

- Conduct literature searches on stream modeling techniques, community metrics, and designated use and biomass relationships (e.g., using survey techniques).
- Explore how biological indicators can be used to determine causes of systematic change.
- Explore, on an ecoregional basis, the level at which biomass and chlorophyll *a* concentrations begin to impair beneficial uses of rivers and streams.
- Explore causal linkages observed in stream community metrics.
- Explore how the use of various management options, in addition to nutrient controls, will help maintain designated uses of river and stream systems (e.g., sediment and erosion controls, channel restoration, riparian zone management, etc).
- Involve other organizations in efforts to understand nutrient impacts on river and stream

systems, including volunteer monitoring programs.

ESTUARIES AND COASTAL MARINE WATERS

- Resolution of N-P limiting question with salinity gradients.
- Role of dissolved oxygen in estuarine overenrichment.
- Role of sedimentation-turbidity in overenrichment.
- Biological community indicators.
- Tidal and discharge dynamics in estuarine nutrient flux resources including marine loadings vs. watershed resources.
- Impact of shore discharges on estuaries and coastal marine overenrichment including better loading estimation models.
- Models to predict HAB events in eutrophic systems and appropriate response strategy as described in *National Harmful Algal Bloom Research and Monitoring Strategy: an initial focus on Pfiesteria, fish lesions, fish kills and public health* (draft, November 1997).

WETLANDS

- Development of an accepted national wetland classification system similar to the hydrogeomorphic system developed by the Army Corps of Engineers.
- Development of a nationwide database for natural wetlands like that currently available for constructed wetlands should be developed. The database should include wetland types and statistical characteristics that apply to each type. A national database could be used to compare the measurement parameters of assessed (impacted) wetlands to an established set of reference conditions.
- Comprehensive literature search to determine what work has already been done on nutrient-related wetland issues.
- Development and testing of biological assessment and monitoring methods for detecting nutrient impacts.
  - — Which biological assemblages are most sensitive?
  - — Which metrics are most sensitive?
- Establishment of a regionalized network of wetlands of different types (e.g., bogs, swamp) across a gradient of nutrient disturbance from "minimally impacted" to degraded.
- Further research on the impacts of nutrients on different wetland types (e.g., bog, marsh, swamp).
- Further research on influence of land use within watersheds on the impacts of nutrients to wetlands.
- Field experimentation to determine nutrient limitation to wetland type and to isolate the effects of nutrients from other variables, such as hydrology, climate, and physical alteration of habitat.
- Models for nutrient inflow, export, and transformation within different wetland types.
- Further investigation of how the bioavailability of nutrients is affected by water chemistry (e.g., pH, dissolved metals) and substrate (e.g., percent clay, percent organic matter).

APPENDICES

Appendix A: Summary of Water Quality Criteria and Standards for Nutrient Overenrichment

In 1994, EPA commissioned a study that gathered information on State Water Quality Criteria and Standards for Nutrients. The following is an abstract of that study. Table 1 is a summary of water quality criteria and standards for nutrient enrichment listed by State.

Nitrogen

Seventeen States, the District of Columbia, and the Virgin Islands have no specified water quality criteria for nitrates and/or nitrites. Seven States have only narrative criteria for nitrogen. Four States have narrative and quantitative criteria. Nine States use only EPA-recommended nitrate-nitrogen criteria (10 mg/L) for the protection of domestic drinking water supplies. Twelve States and Puerto Rico use EPA-recommended criteria in conjunction with other criteria, either quantitative or narrative. Five States and four U.S. territories have quantitative water quality criteria for nitrogen but do not incorporate EPA-recommended criteria into them.

Phosphorus

In the case of phosphorus, 21 States, the District of Columbia, and the Virgin Islands have no specified water quality criteria. Twelve States have narrative criteria addressing phosphorus in general. Seven States have both narrative criteria and quantitative criteria addressing phosphorus. One state, Florida, uses the EPA-recommended phosphorus criterion of 0.10 ug/L for its estuarine and marine waters. Fifteen States and five U.S. territories have quantitative water quality criteria addressing phosphorus but do not use the EPA-recommended numerical criteria.

TABLE 1
SUMMARY OF STATES' EXISTING WATER QUALITY CRITERIA AND STANDARDS FOR NUTRIENT OVERENRICHMENT

Region/State	Nitrate	Ammonia	Total Nitrogen	Total Phosphorus
Region 1				
Connecticut				✓ (3)
Maine				✓ (7,3,8)
Massachusetts	✓ (2)	✓ (2)		✓ (2)
New Hampshire				✓ (2)
Rhode Island	✓ (3)	✓ (3)		✓ (3)
Vermont	✓ (2)	✓ (2)		✓ (2)
Region 2				
New Jersey	✓ (2)	✓ (2)		✓ (9,3)
New York				✓ (2)
Puerto Rico	✓ (9)	✓ (9)		✓ (8,2)
Virgin Islands				✓ (8,9)
Region 3				
Delaware	✓ (2)	✓ (2)		✓ (2)
District of Columbia				
Maryland				
Pennsylvania				
Virginia				✓ (4)
West Virginia				
Region 4				
Alabama				
Florida			✓ (2)	✓ (7,2)
Georgia				✓ (3)
Kentucky				✓ (2)
Mississippi				
North Carolina				✓ (3)
South Carolina	✓ (2)	✓ (2)		✓ (3)
Tennessee				

TABLE 1
SUMMARY OF STATES' EXISTING WATER QUALITY CRITERIA AND STANDARDS FOR NUTRIENT OVERENRICHMENT

Region/State	Nitrate	Ammonia	Total Nitrogen	Total Phosphorus
Region 5				
Illinois		✓ (1)		✓ (1,3,9)
Indiana				✓ (1,2)
Michigan	✓ (2)	✓ (2)		✓ (2)
Minnesota				
Ohio				✓ (2,4)
Wisconsin				
Region 6				
Arkansas	✓ (2)	✓ (2)	✓ (2)	✓ (2)
Louisiana	✓ (2)	✓ (2)		✓ (2)
New Mexico	✓ (2)	✓ (2)		✓ (7,2)
Oklahoma				
Texas	✓ (2)	✓ (2)		✓ (2)
Region 7				
Iowa				
Kansas				✓ (2)
Nebraska				
Missouri				
Region 8				
Colorado				
Montana				
North Dakota	✓ (2)			✓ (7,2,9)
South Dakota	✓ (2)			✓ (3)
Utah	✓ (2)	✓ (2)		✓ (7,3)
Wyoming				
Region 9				
American Samoa	✓(2)	✓(2)	✓ (1,9)	✓ (1,9)
Arizona	✓(5)	✓(5)	✓ (1,2)	✓ (1,2)
California	✓ (1,5)	✓(5)	✓(1,2)	✓ (1,6,7)

22588

TABLE 1
SUMMARY OF STATES' EXISTING WATER QUALITY CRITERIA AND STANDARDS FOR NUTRIENT OVERENRICHMENT

Region/State	Nitrate	Ammonia	Total Nitrogen	Total Phosphorus
Guam	✓ (2,7)	✓(5)	✓(2)	✓ (2,7)
Hawaii	✓ (1,9)	✓ (1,9)	✓ (1,9)	✓ (1,9)
Nevada	✓ (5)	✓ (2,5)	✓(1,7,9)	✓ (1,7,9)
Northern Mariana Islands	✓(7)	✓ (5)	✓ (7)	✓ (7)
Trust Territories of the Pacific Islands	✓(2)	✓(2)	✓ (7)	✓ (7,9)
Region 10				
Alaska				
Idaho				✓ (2)
Oregon				
Washington				

NOTES FOR TABLE 1

Blank entry indicates that neither a narrative nor numeric criterion for the nutrient have been specified by the State.

(1) Site-specific numeric values for ambient nutrient levels.

(2) Narrative criteria related to natural conditions, eutrophication and nutrient overenrichment for nitrate, ammonia, inorganic nitrogen, total nitrogen, or total phosphorus.

(3) Narrative criterion that is not related to natural conditions, eutrophication, or nutrient overenrichment issues.

(4) Numeric values for effluent nutrient levels.

(5) Numeric values related to public health (nitrate) or aquatic toxicity (ammonia).

(6) Habitat-based numeric values for ambient nutrient levels.

(7) Water use classification- or water use designation-based numeric values for ambient nutrient levels.

(8) State wide numeric values for ambient nutrient levels.

(9) Waterbody-based (streams, rivers, lakes, estuaries, coastal/oceanic waters) numeric values for ambient nutrient levels.

Appendix B: Nutrient Criteria Activities and Timeline

Year	Activities	Products	Date
1997	Publish Final National Nutrient Strategy	Strategy & FR Notice of Availability	6/98 FR notice
1998	**Publish Technical Guidance Document for:**		
	Lakes and Reservoirs	Final Guidance	12/98
	Demonstrations and Case Studies:		
	Initiate 3-5 case studies	Methodology validation and regional criteria for Lakes and Reservoirs	On-going
	Outreach Activities & Communication Strategy:		
	Regional/State Meetings on Strategy and Nutrient Criteria Development	Proceedings	10/98
	WQS Academy	Presentations	Summer,1998
	Document availability via Internet	Brochures & Fact Sheets	National Nutrient Strategy
	Link info to Regional Nutrient Teams	Training	On-going
1999	**Publish Technical Guidance Documents for:**		
	Rivers and Streams	Final Guidance	03/99

Year	Activities	Products	Date
1999	**Demonstrations and Case Studies:**		
	Initiate 5-10 case studies	Methodology validation and regional criteria for Rivers and Streams	On-going
		Methodology validation and regional criteria for Marine Coastal Waters and Estuaries	On-going
	Outreach Activities:		
	Regional/State Meetings on Rivers & Streams/Lakes Guidance	Proceedings	7/99
	WQS Academy,	Presentations	On-going
	Document availability via Internet	Brochures & Fact Sheets	Lakes and Reservoirs
2000-2	**Publish Technical Documents for:**		
	Coastal Marine Waters and Estuaries	Final guidance	03/00
	Wetlands	Draft guidance	03/00
	Data processing and assessment	Final Guidance & National Modeling Database	4/00
	Demonstrations and Case Studies:		
	Maintain ongoing case studies and publish regional criteria	Regional Criteria Guidance	01-02

Year	Activities	Products	Date
2000-02	**Outreach Activities:**		
	Regional/State Meetings on Coastal Waters and Estuaries Guidance	Proceedings	On-going
	WQS Academy	Presentations	On-going
	Document availability via Internet	Brochures & Fact Sheets	Rivers and Streams
			Coastal Waters and Estuaries
			Data processing and Assessment

Appendix C: Draft Outline for the Development of Nutrient Criteria for Streams and Rivers, Lakes and Reservoirs, and Estuaries and Coastal Marine Waters.

I. Introduction

Concept of Nutrient Criteria
- — Regional in nature
- — Methods and guidance to support development of nutrient criteria
- — Discussion of criteria vs. standards
- — Narrative criteria vs. numeric, but always quantitatively based

Uses of Nutrient Criteria
- — Basis for State/Tribal Water Quality Standards
- — Resource assessment
- — Setting of management priorities
- — Evaluation of management projects
- — Long-range planning
- — Coordination of nutrient management planning and implementation with other related programs

Rationale for Trophic Classification and Tiered Sampling Design
- — Discussion of deriving nutrient reference conditions
- — Discussion of cost-effectiveness of tiers, potential to evolve toward more detailed sampling as needed
- — Detailed discussion of importance of adequate data for decision making compared to budget and level of certainty needed

II. Conducting Nutrient Surveys

Classification of the surface waters

Indicators
- — How analyzed
- — When to sample
- — Where to sample

Survey Design

Data Storage and Processing

Interpretation

III. Trophic Classification

22593

How to establish regions

Size classifications

Watershed classifications

Cultural development classes

IV. Indicators

For each indicator:
- — Method of collection
- — Storage and time constraints
- — Method(s) of analysis
- — Expected range of results and trophic state indicated by geographic region and season

V. Sampling Design

Number of stations based on waterbody size

Placement of survey stations relative to characteristics of the waterbody and suspected loading sites

Time of year and frequency of sampling

VI. Data Processing and Storage

Discuss models and software packages

Regional databases and multi-State coordination of efforts

VII. Interpretation

Synopsis of indicator meanings

Discussion of interrelationships of trophic state and overenrichment indicators

Comprehensive interpretations

VIII. Detailed Nutrient Investigations for Cause and Effect Determination

Follow-up on initial surveys to generate definitive information

Seasonal adjustments

Relocation of some stations and addition of others
- — Importance of basic survey continuity

IX. Management Response

Should be broad-based and general to indicate potential as opposed to a directive to the community

Types of loadings the indicators reflect
- — BMPs and other protection or mitigation measures available

Approaches to achieve protection or change
- — Local government
- — Communities
- — Property owners
- — Businesses

Management Planning
- — Incorporate the 10-step approach described in Chapter IV of this nutrient strategy document

X. Evaluation Monitoring

A variation on the original survey plan is used to keep track of the response of the waterbody to the protection or remediation effort

This information is used to assess the relative success of the project and to plan future courses of action
- — Evaluation of "before, during, and after" project data

Close the loop in the management process by returning to step 1 of the 10-step process to plan the next phase of management or to apply these results to other similar, nearby waterbodies.

Appendices

Discussion of how States get from data gathering to using the information in management decision making to incorporation into State policies.

Illustration of these experiences with case studies and names of contacts for further information.

Appendix D: Drafting Committee for the National Nutrient Strategy

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APPENDIX E: Excerpt from the Clean Water Action Plan

Reduce Nutrient Over-enrichment

Nutrients, in the appropriate amounts, are essential to the health and continued functioning of aquatic ecosystems. Excessive nutrient loadings will, however, result in excessive growth of macrophytes or phytoplankton and potentially harmful algal blooms (HAB), leading to oxygen declines, imbalance of aquatic species, public health risks, and a general decline of the aquatic resource. Nutrient over-enrichment has also been strongly linked to the large hypoxic zone in the Gulf of Mexico and to recent outbreaks of *Pfiesteria* along the mid-Atlantic Coast.

State water quality reports indicate that over-enrichment of waters by nutrients (nitrogen and phosphorus) is the biggest overall source of impairment of the nation's rivers and streams, lakes and reservoirs, and estuaries. In the 1996 National Water Quality Inventory, states reported that 40 percent of surveyed rivers, 51 percent of surveyed lakes, and 57 percent of surveyed estuaries were impaired by nutrient enrichment. Agriculture is the most widespread source of these impairments, followed by municipal sewage treatment plants, urban runoff and storm sewers, and various other nonpoint pollution sources, including air deposition.

Define Nutrient Reduction Goals

Although nutrient over-enrichment is clearly a major challenge for the nation's waters, the assessment of the seriousness and extent of the problem is often based on subjective criteria that can result in widely varying assessments. Research to improve the basis for understanding and assessing nutrient over-enrichment problems is critical to better control of nutrient levels in waters and to meeting the nation's clean water goals.

EPA is developing a strategy to establish an objective, scientifically sound basis for assessing nutrient over- enrichment problems. Specifically, EPA will develop nutrient criteria - numerical ranges for acceptable levels of nutrients (i.e., nitrogen and phosphorus) in water. Unlike other criteria that EPA has developed, nutrient criteria will be established as a menu of different numeric values based on the type of water body (i.e., river, estuary, lake) and the region of the country in which the water is located. It is vital that this work be done to provide the technical basis for pollution reduction plans.

EPA will develop nutrient criteria for the various water body types and ecoregions of the country by the year 2000. Under the Clean Water Act, states use pollutant criteria established by EPA as the basis for adopting water quality standards. Within three years of EPA issuance of applicable criteria, all states and tribes with water quality standards should have adopted water quality standards for nutrients. Where a state or tribe fails to adopt a water quality standard for nutrients within the three-year period, EPA will begin to promulgate the nutrient criteria appropriate to the region and water body type. When promulgated, the EPA standard would apply until a state or tribe adopts, and EPA approves, a revised standard.

22598

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KEY ACTION: EPA will establish, by the year 2000, numeric criteria for nutrients (i.e., nitrogen and phosphorus) that are tailored to reflect the different types of water bodies (e.g., lakes, rivers, and estuaries) and the different ecoregions of the country, and will assist states in adopting numeric water quality standards based on these criteria over the following three years. If a state does not adopt appropriate nutrient standards, EPA will begin the process of promulgating nutrient standards.