Charge to the

Science Advisory Board (SAB)
ECOLOGICAL PROCESSES AND EFFECTS COMMITTEE

For Review of Guidance on:

EMPIRICAL APPROACHES FOR NUTRIENT CRITERIA DERIVATION

Prepared by the
EPA Office of Water,
Office of Science and Technology

September 9th – 11th, 2009

Background

The U.S. Environmental Protection Agency (EPA), Office of Water, is charged with protecting aquatic life, wildlife and human health from adverse anthropogenic, water-mediated effects under the purview of the Clean Water Act (CWA). Under the CWA, States, authorized Tribes, and Territories (hereafter referred to collectively as "States") are responsible for establishing water quality standards that include the designated uses, such as aquatic life protection and recreation, and water quality criteria that protect the designated uses. EPA's Office of Science and Technology (OST) is responsible for deriving national recommended water quality criteria that serve as guidance to States to assist them in establishing water quality standards.

The Nutrient Problem
Aquatic ecosystems require nutrients, such as nitrogen and phosphorus, to function naturally, but excess nutrients are harmful. Many of our nation's waters, including rivers, lakes, estuaries, and coastal marine waters, are affected by nitrogen and phosphorus pollution.

Excess nitrogen and phosphorus in waters can produce excess plant and algal growth. The excess primary production is then decomposed, a process that consumes oxygen and is, itself stimulated by nutrients as well. Low oxygen conditions (hypoxia and anoxia) result in insufficient oxygen to support aquatic life. The process is the basis for large "dead zones" found in many coastal areas.

The biannually published National Water Quality Inventory Report to Congress indicates that nutrients (nitrogen and phosphorus) are consistently a major source of water quality impairment in the Nation's waters. Since the first report published in 1992, nutrients have ranked in the top five causes of water quality impairment each time.

Sources of Nitrogen and Phosphorus Pollution

- Overusing fertilizer (both residential and agricultural usage)
- Storm runoff from cropland, Animal Feeding Operations and pastures
- Storm runoff from urban and suburban areas (e.g., parking lots, lawns, rooftops, roads)
- Discharge of nitrogen and phosphorus from wastewater treatment plants
- Overflow from septic systems
- Atmospheric deposition

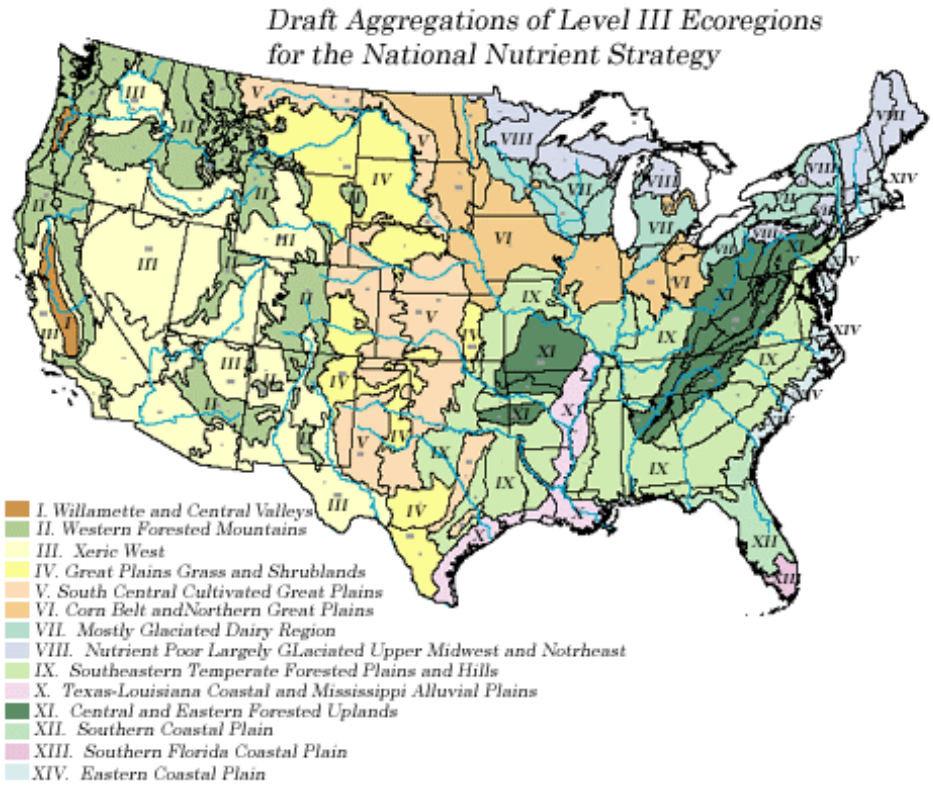
National Nutrient Strategy

EPA seeks to improve the progress of State adoption of numeric nutrient criteria into their WATER QUALITY STANDARDS by building on the scientific and technical foundation for deriving criteria to address nitrogen and phosphorus pollution.

In order to expand and update EPA nutrient related guidance, the Agency held a National Nutrient Assessment Workshop (see Proceedings of the National Nutrient Assessment Workshop: December 4-6, 1995, EPA 822-R-96-004). In response to this workgroup effort to address nutrient assessment and over-enrichment, EPA published a peer reviewed national

nutrient strategy (The National Strategy for the Development of Regional Nutrient Criteria) (http://www.epa.gov/waterscience/criteria/nutrient/strategy/index.html#strategy) in June 1998 that set the roadmap to develop and publish numeric nutrient water quality criteria recommendations.

The June 1998 strategy described the approach to develop nutrient information and work with States to adopt nutrient criteria as part of their water quality standards. It presented over-enrichment assessment tools and recognized current capabilities for conducting these assessments at regional watershed and waterbody levels. The major focus of the strategy was the development of waterbody-type technical guidance and ecoregion-specific nutrient criteria. Once the waterbody-type guidance and nutrient criteria were established, EPA expected States to adopt numeric nutrient criteria into water quality standards.



At the time the 1998 strategy was written, the only national nutrient related criteria that existed were from EPA's 1976 publication entitled Quality Criteria for Water (also known as the Red Book) in which EPA presented ambient water quality criteria for nitrates and elemental phosphorus. The criterion for nitrate was 10 mg/L for the protection of domestic water supplies. The nitrate criterion was intended to protect human and animal health. The phosphorus criterion was 0.10 µg/L elemental phosphorus for the protection of marine and estuarine waters. This criterion was based on a conservative estimate to protect against the toxic effects of the bioconcentration of elemental phosphorus to estuarine and marine organisms, and not on the potential to cause eutrophication.

As stated in the 1998 strategy, EPA believed the development of waterbody-type guidance and regional nutrient criteria could only be successfully accomplished with the cooperation and contributions of EPA regional offices and States, with the assistance of other expert parties. EPA regions were asked to form regional nutrient teams to draw on the talents and knowledge of States, universities and other interested/concerned parties within each EPA Region. States were specifically asked to provide information on nutrient levels in their surface waters to help provide information essential for identifying reference conditions (minimally impacted waters) and developing regional nutrient criteria.

Nutrient Criteria Development Guidance

EPA published peer reviewed technical guidance for developing nutrient criteria for lakes and reservoirs in April 2000, rivers and streams in July 2000, estuaries and coastal marine waters in October 2001, and wetlands in June 2008. These technical guidance documents describe the techniques used to develop numeric nutrient criteria for use in State water quality standards. They provide background information on classifying waterbodies, selecting criteria variables, designing monitoring programs, analyzing nutrient and algal data, deriving regional criteria, and implementing management practices. These guidance documents describe a reference condition approach for deriving nutrient criteria from distributions of nutrient concentrations and biological responses in minimally disturbed reference waterbodies. Each document can be accessed from OST's website:
http://www.epa.gov/waterscience/criteria/nutrient/guidance/index.html

Prior to the wetlands guidance manual, EPA published several methods modules (March 2002) to give States the "state-of-the-science" information that will help them develop biological assessment methods to evaluate both the overall ecological condition of wetlands and nutrient over- enrichment, see
http://www.epa.gov/waterscience/criteria/nutrient/guidance/wetlands/#modules

Ecoregional Nutrient Criteria

Using the reference condition approach described in the EPA's previously published nutrient criteria guidance for lakes and reservoirs, rivers and streams, estuaries and coastal marine waters, and wetlands, the Agency has developed numeric nutrient criteria values for both causal (total phosphorus (TP) and total nitrogen (TN)) and response (chlorophyll *a*, and measures of water clarity, e.g., Secchi depth, turbidity) variables. These criteria were to be used to help identify problem areas, serve as the basis of development for State numeric nutrient criteria, and evaluate relative success in reducing anthropogenic eutrophication.

EPA published 26 peer-reviewed ecoregional criteria documents in 2001 and 2002 that cover most waterbodies in the U.S. (12 lakes & reservoirs, 13 rivers & streams, and 1 wetland). These documents have numeric nutrient criteria values published as recommendations to States in setting water quality standards. These documents can be accessed at the following websites:
http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/lakes/index.html,

http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/index.html, and http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/wetlands/wetlands_13.pdf. Each document has tables that present the recommended criteria for each of the aggregate nutrient ecoregions for the following parameters: TP, TN, chlorophyll *a*, and turbidity or Secchi depth. These criteria values were intended as starting points for States to develop their own State-specific criteria.

Why Numeric Nutrient Criteria are Important

Numeric nutrient water quality standards drive water quality assessments and watershed protection management. They support improved development of nutrient related Total Maximum Daily Loads (TMDLs) (i.e, the calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards). Perhaps most importantly, they will create environmental baselines that allow EPA and States to manage more effectively, measure progress, and support broader partnerships based on nutrient trading, Best Management Practices (BMPs), land stewardship, wetlands protection, voluntary collaboration, and urban stormwater runoff control strategies. The progress of States in setting numeric nutrient water quality standards is extremely important to help address nutrient pollution. Adopting numeric standards has a number of key advantages:

- easier and faster development of TMDLs;
- quantitative targets to support trading programs;
- easier to write protective NPDES permits(i.e., permits to regulate the discharge of pollutants under the Clean Water Act);
- increased effectiveness in evaluating success of nutrient runoff minimization programs; and
- measurable objective water quality baselines against which to measure environmental progress.

Current Status

Over the last eleven years, EPA has taken a number of steps to provide leadership and articulate its commitment of working in partnership with States to establish quantitative endpoints to minimize excess nutrient loadings in our nation's waters. As stated previously, EPA issued a National Strategy for the development of regional nutrient criteria in June 1998, and followed it with a November 2001 Policy Memo for the development and establishment of numeric nutrient criteria. (http://www.epa.gov/waterscience/criteria/nutrient/files/nutrientswqsmemo.pdf).

Progress has been made, and a number of States have already moved ahead to establish numeric criteria for priority waterbodies. Others are in the process of collecting data. Still others are in the earlier stages of planning and deciding which criteria derivation approach will work best for them. In a more recent policy memo issued in 2007, which can be found at: http://www.epa.gov/waterscience/criteria/nutrient/files/policy20070525.pdf, EPA restated its commitment to support all efforts to adopt numeric nutrient criteria that are protective of designated uses.

How Will Information in the Empirical Approaches Document Be Used?

As stated in previously published guidance manuals, basic analytical approaches for nutrient criteria derivation include: (1) the reference condition approach, (2) stressor-response analysis, and (3) mechanistic modeling. EPA's draft guidance document, *Empirical Approaches for Nutrient Criteria Derivation* elaborates on the second of these three. The purpose of this guidance document is to provide information on the scientific foundation for using empirical approaches to describe stressor-response relationships for developing numeric nutrient criteria. This document supports and is consistent with existing nutrient criteria guidance (USEPA 2000a, 2000b, 2001, and 2008). The statistical and analytical approaches described in the document represent a scientifically defensible means of identifying patterns and relationships in field data. Examples illustrate how these approaches could be applied for purposes of deriving numeric nutrient criteria. Although the examples provided focus on streams and lakes, the information presented in the document should be applicable to any waterbody type. The document is intended for State, local and tribal government water resource managers and other interested stakeholders, with some scientific training.

EPA is seeking advice from the Science Advisory Board (SAB) Ecological Processes and Effects Committee regarding the technical soundness of these empirical approaches as the basis for future development of numeric nutrient water quality criteria.

Charge to SAB

Overall

1. What suggestions do you have that will improve the utility of the draft document, *Empirical Approaches for Nutrient Criteria Derivation,* for State water quality scientists and resource managers to derive numeric nutrient criteria based on stressor-response relationships?

Using an Empirical Stressor-Response Relationship to Set a Nutrient Criterion

2. Section 1 of the draft guidance document reviews how to select the variables that appropriately quantify the stressor (i.e., excess nutrients) and the response (e.g., chlorophyll *a*, dissolved oxygen, or a biological index). Please comment on whether the factors to consider described in section 1 of the draft document are appropriate for selecting response variables that are sensitive to nutrients and related to measures of designated uses.

3. In addition, Section 1 outlines methods to visualize available data. Please comment on the effectiveness of the following approaches described in the document (listed below) to demonstrate the distribution of and relationships among variables.
    a) Basic data visualization techniques
    b) Maps
    c) Conditional probability
    d) Classifications

4. Section 2 of the draft guidance document describes methods for assessing the strength of the cause-effect relationship represented in the stressor-response linkage. Please comment on whether the draft guidance document adequately describes how conceptual models, existing literature, and empirical models can be used to assess how changes in nutrient concentration are likely to cause changes in the chosen response variable.

Analyzing Data

5. Section 3 of the draft guidance document outlines statistical methods to analyze the data to estimate stressor-response relationships. Please comment on the appropriateness of the methods outlined in the document (listed below) for describing stressor-response relationships associated with nutrient pollution. What approaches would you recommend that could effectively address indirect pathways of adverse effects? What recommendations do you have to address the effects of confounding variables and uncertainty in the estimated relationships?

    a) Simple linear regression
    b) Quantile regression
    c) Logistic regression
    d) Multiple linear regression
    e) Non-parametric changepoint analysis
    f) Discontinuous regression models

Evaluating Estimated Stressor-Response Relationships

6. Section 4 of the draft guidance document describes how to evaluate the predictive accuracy of estimated stressor-response relationships. Please comment on the appropriateness of approaches in Section 4 of the guidance document and factors to consider in evaluating and comparing different estimates of the stressor-response relationships and selecting those most appropriate for criteria derivation.

Evaluating Candidate Stressor-Response Criteria

7. Section 5 of the draft guidance document describes how to evaluate the candidate stressor-response criteria. An approach is outlined for predicting conditions that might result after implementing different nutrient criteria. Please comment on uncertainties that would remain if water quality criteria for nutrients were based solely on estimated stressor-response relationships and in what ways would other information/analysis help address and possibly reduce this uncertainty?