Review of

Nutrient Criteria Technical Guidance Manual: Rivers and Streams

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The Technical Guidance Manual is a good resource for defining certain elements with which States/Tribes can develop nutrient and algal criteria for rivers and streams. The document defines many approaches for first classifying the physical environment and stream types, then choosing variables for a water quality assessment, then data analysis for criteria setting followed by implementation. Depending on resources, data gathering prior to criteria setting and monitoring and, likewise, re-evaluation afterward may occur. While the flexibility incorporated in this document is commendable, the incorporation of less-rigorous approaches may lead to criteria setting by some parties that is not scientifically defensible, a stated goal of the document. The comments below address suggested approaches within the guidance document which fall short of providing credible means of setting criteria.

The response of a water body to nutrient inputs is highly variable. Many factors — hydrology, geology, stream morphology, degree of canopy cover, land use, grazing organisms — influence a particular water body's assimilative capacity for dissolved nutrients. Thus, trophic status is not uniquely determined by nutrient load. As a result, the use of a single numeric nutrient criterion applied to a given region is likely to be under- or overprotective for a given water body. Scientifically defensible regulation of nutrients should focus on prevention or control of the undesirable effects of nutrient over-enrichment rather than on absolute nutrient limits.

In general, the establishment of criteria for so-called "primary" or "causal" variables such as nutrient element concentrations represents a departure from the modern process of developing standards based on definitive cause-and-effect relationships. For example, there is no criterion for biological oxygen demand (BOD); rather, there are waterbody-type-specific criteria for dissolved oxygen (DO). This is because the level of BOD itself does not determine the level of impairment within an individual waterbody, although indeed it may contribute to impairments. The proximate factor leading to the loss of biological integrity in an ecosystem is a depletion of DO, with chronic and acute effects on specific kinds of desirable or keystone organisms. Levels of BOD can be used to develop permit limits in a system-wide waste load allocation so as to protect the DO criterion, based on site-specific evaluations of the interaction of BOD with other processes which determine DO concentrations. It is this philosophical departure from effects-based criterion setting which is most disagreeable and which creates a fundamental problem of scientific credibility for the regional nutrient criteria setting process. It is strongly suggested that the process be revised to specifically address cause-and-effects factors.

The present guidance document contains many approaches for what may be called exploratory data analysis. These procedures are designed to uncover patterns in the primary variables from regionally aggregated data. However, the inability of such analyses to establish causal effects places constraints on their efficacy. The suggested procedures can be used to locate water bodies which may be susceptible to impairment. Statistical analyses based on regional or national data should be used only as screening tools to initiate further site-specific investigations, not for establishing criteria. The distinction between criteria versus screening-level warning flags is legally significant and needs to firmly established in the technical guidance documents.

In order to demonstrate the disconnect between primary variables (i.e., nutrients) and specific ecosystem (or use) impairments, several areas where we feel the Technical Guidance Document fails to establish scientifically credible interpretations will be discussed. Most of these issues could be resolved if it is recognized that the suggested solutions for gathering and evaluating data are extremely effective means for establishing screening values for flagging potential impacted systems rather than for establishing numeric nutrient criteria. These comments address the following components or approaches contained in the Technical Guidance Document:

(1) the frequency distribution approach to criteria setting,
(2) the ecoregional approach to classification,
(3) interpretations of relationships between dissolved nutrients or total nutrient element pools, e.g., total nitrogen (TN) or total phosphorus (TP), and algal biomass based on nationwide data, and
(4) a model for criteria development.

Frequency Distributions and Criteria Setting

In Section 7.5 "Methods for Establishing Nutrient and Algal Criteria," three approaches are outlined for defining a "reference reach" for establishing nutrient concentrations or algal biomass levels which would protect a stream's "natural biological integrity." While one relies on establishing reference conditions based on "best professional judgement (BPJ), the other two approaches use frequency distributions of available data for the primary variables (nutrients, algal biomass, water clarity as secchi depth, turbidity, or a measure of total suspended solids). One of these two methods suggests criteria-setting at the 75^{th} percentile of a data population from reference streams (presumably identified via BPJ), while the other sets a criterion level at the 5th or 25th percentile of data from all streams within an ecoregion. Lastly, it is suggested that a criterion value might be set at some level in between these reference and all-stream percentiles.

There is a strong caveat to the manager about using this approach at the end of this section. The document acknowledges the ambiguity and difficulty in picking a criterion level from this approach ("A single criterion forces the manager to make decisions about the number of streams that will be in unacceptable condition....", p. 97). In fact, such decision-making will have no basis in whether a given stream in fact has had its biological integrity compromised by a criterion level established from some lumped distribution of nutrient data from many streams and locations. Uncertainties about the relative distribution of data from reference versus impacted sites within the database may lead to criteria which are either too stringent or not stringent enough. More importantly, evaluation based on frequency distributions of primary variable data from a variety of streams even within some defined ecoregion simply does not contain information about the causal relationships between those variables and the potential for impairment of biological integrity in any given stream or reach. Even in light of the document's stated caveats, managers may view this is the simplest, least-costly approach to criterion setting, without a clear understanding of the processes leading to a given stream's susceptibility for impairment or ability to assimilate nutrients without impairment.

Ecoregional Classification of Waterbodies

The classification of water bodies in a hierarchical manner is presented so that managers have a means to compare data and make extrapolations among streams with common features and presumed similar functionality. Approximately half a dozen geologically, hydrologically, and/or biologically based schemes are presented. While Omernik's ecoregional classification scheme represents a starting point in this process, the final procedures for establishing meaningful sub-regions is left to the States and Tribes. Examples provided suggest several important interactions of factors which influence the primary nutrient, biomass, and light variables of concern, including underlying geology, land use, substrate type, and dominant primary producer (e.g., Table 1, p. 21). In the end, the determinants of a given stream's trophic state (Table 2, p. 27) may be either natural or human-induced, with little means of determining the causality. Because such classification schemes impact choice of monitoring sites, reference sites, and criterion-setting, this lack of a causal link between a stream's primary variables and the underlying processes which determine a stream's trophic state, incorrect inferences may be drawn about what nutrient concentration or algal biomass level is protective of a particular stream's designated and beneficial uses.

Interpretations of Relationships Between Nutrients and Algal Biomass

The document states that predictive relationships between nutrients and algal biomass are required to identify critical or threshold nutrient levels that produce nuisance algal blooms (p. 76). However, the simplest approach of regressing algal biomass versus nutrient element concentration (as either TN or TP), as stated, provides only moderate explanatory power, accounting for one-third or less of the observed variance in periphyton biomass. Suggested regression equations for suspended algae yielded somewhat better correlations, up to 73% of the variability, if the catchment area for the stations is known. As the document goes on to state, "critical and highly variable factors other than nutrient—shading, [substrate], scour, water level fluctuations..., grazing intensity—have major effects on algal biomass" (p. 76-77). In fact, as shown in Figure 7 of the document (p. 78), at 20 ug/L TP, mean algal biomass as chlorophyll a varied by two orders of magnitude while at 500 ug/L TN, mean biomass varied by a factor of 25. Those nutrient values are within suggested criteria ranges for nutrients presented in Table 4 (p. 101). In an investigation of 26 sites in seven streams, much of the control on periphyton biomass was influenced by macroinvertebrate grazers, riparian shading, and substrate (Welch et al., 1992). Without consideration of the multiple factors that influence algal biomass and species composition and ultimately influence dissolved oxygen and pH levels, nutrient-based criteria cannot be established with scientific credibility for a given stream environment.

The "Tennessee Ecoregional Nutrient Criteria" case study presented in Appendix A does serve as a good example of the use of approaches recommended in the guidance document to data analysis and the process of establishing numeric nutrient criteria. Unfortunately, it also shows the difficulty of actually ascertaining impairment or degrees of protection offered by even sub-ecoregionally applied numeric criteria. According to the Tennessee plan, "[s]treams with nutrient levels higher than the reference stream database range [at the 90th or 75th percentile, to be determined] will be considered in violation of the narrative [nutrient] criteria" (p. A-7). Such streams will be placed on the state 303(d) list. Yet, in an analysis of data relationships, nutrients were extremely poor predictors of response variables, such as total organic carbon (TOC) or turbidity. Thus, nutrients alone were not indicators of impaired uses.

Further analysis comparing data from the national database with recent monitoring data from identified reference streams demonstrated a potential for bias in the national database. EPA draft Nutrient Aggregate Ecoregion IX data, covering western Tennessee, had TP values ten-fold that found at the reference sites. The authors postulated that the national database stations may either have been biased by locations with high-phosphorus content soils or with sampling data targeted to quantity worst-case nutrient loading events. Without sufficient meta-data or local knowledge to stratify the data sets for such biases, procedures such as analysis of frequency distributions are likely to generate criterion values which may be under- or over-protective.

If, instead of using these empirical tools as means of establishing criteria, for which they have little power, they were used to establish screening values for particular ecoregional stream types, the guidance would be more acceptable.

Metals Criteria: A Model for Criteria Development.

Over the past two decades, national criteria for certain metal toxicants has progressively moved from a single numeric value to varying stages of site-specific values based on local environmental factors, such as water hardness, pH and dissolved organic carbon concentration, that influence a metal's bioavailability (e.g., Renner, 1997). Specific laboratory and statistical procedures have been developed to quantify effects in view of environmental factors. Lessons learned from metals criteria development should be applied to nutrient criteria development.

The importance of site-specific factors in determining appropriate pollutant limits is not unique to nutrients. The impacts of some toxics are also modified by receiving water characteristics. For example, the toxicity of metals, including Cd, Cu, Ni, Pb and Zn, to aquatic organisms typically range over several orders of magnitude for a single organism (Chapter 5; Meyer, 1999). In the natural environment, various processes that modify metal toxicity have been identified. In response to these problems the US EPA has allowed the use of site-specific adjustments to the ambient criteria for metals (e.g., the water-effect ratio procedure - WER; United States Environmental Protection Agency, 1994). The use of WER procedures to modifiy numeric criteria for metals, however, requires time-consuming and expensive bioassay testing. Recently, an alternative approach has been developed using a model of metal bioavailability and toxicity (Di Toro et al., 2000; Santore et al., 2000). The Biotic Ligand Model (BLM) uses a mechanistic understanding of the effects metals have on aquatic organisms and the way these effects are modified by the physical and chemical characteristics of a receiving water body. The use of a mechanistic model for determining criteria provides a scientifically defensible approach for considering the complex site-specific factors that determine the impact of metals in the environment.

The approach for establishing nutrient criteria in receiving water bodies should address many of these same concerns. A modeling approach for setting nutrient criteria can be designed to incorporate complex site-specific factors. Furthermore, a mechanistic framework will provide a direct linkage of nutrient loads with ecosystem response. This linkage will allow a proposed criteria to be based on the prevention or control of harmful effects such as low dissolved oxygen concentrations or trophic status rather than on nutrient concentrations per se. This type of mechanistic framework can explicitly consider the natural variability in the response of receiving water bodies to nutrient inputs and, therefore, is more scientifically sound than a regional numerical value determined from percentile values.

<u>References Cited</u>

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