1.0 DOCUMENT GOAL AND OBJECTIVES

This document provides guidance for deriving scientifically defensible nutrient criteria that are based on defined relationships among designated uses of water bodies, response variables, and nutrients. The guidance addresses the development of nutrient criteria for individual water bodies and classes of water bodies. The report is intended for use by (1) State and tribal regulatory agencies with the authority to derive criteria and standards; (2) regulated entities affected by the criteria, such as dischargers with National Pollutant Discharge Elimination System (NPDES) permits and those potentially affected by nonpoint source controls; and (3) other interested parties.

2.0 U.S. EPA'S NUTRIENT CRITERIA DEVELOPMENT PROCESS

On January 9, 2001, U.S. EPA announced the publication of recommended water quality criteria for nutrients under section 304(a) of the Clean Water Act (see 66 FR 1671). U.S.EPA developed these criteria with the intention that they serve as a starting point for states, authorized tribes, interstate commissions and others to develop more refined nutrient criteria, as appropriate, using U.S. EPA waterbody-specific technical guidance manuals (U.S. EPA 2000a, 2000b, 2001) and other scientifically defensible approaches. In that announcement, EPA emphasized that states and authorized tribes have several options available to them in developing and adopting water quality criteria for nutrients. U.S. EPA recommended the following approaches, in order of preference: 1) wherever possible, develop nutrient criteria that fully reflect localized conditions and protect specific designated uses, using the process outlined in the technical guidance manuals; 2) adopt U.S. EPA's recommended section 304(a) criteria for nutrients, either as numeric criteria or as a translator for a state or tribal narrative criterion; or 3) use other scientifically defensible methods and appropriate water quality data to develop criteria protective of designated uses (Grubbs, G., Director, U.S. EPA, Office of Science and Technology, Washington, D.C., memorandum, November 14, 2001).

By the end of 2004, States and Tribes were required either to adopt the U.S. EPA's ecoregional nutrient criteria and standards, or prepare a plan for developing nutrient criteria. To date, most States have prepared nutrient criteria development plans. However, if States and Tribes failed to meet the 2004 deadline, the U.S. EPA may promulgate criteria for these entities based on ecoregional analyses and recommendations. States, Tribes, or other entities may propose alternative criteria if the organizations believe the U.S. EPA criteria are not appropriate for a particular water body, or a class of water bodies. State- or Tribal-defined criteria must be scientifically defensible and approved by the U.S. EPA and State regulatory agencies.

U.S. EPA (2000b) discussed three approaches for developing nutrient criteria: (1) use of data from reference and non-reference water bodies, (2) use of predictive relationships between nutrients and response variables, and (3) use of literature threshold values. U.S. EPA, however, then proceeded to only use the reference and non-reference water body approach in its development of ecoregional nutrient criteria for lakes and reservoirs and rivers and streams, which does not evaluate attainment of designated uses (http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/). Reference water bodies, ideally, represent conditions where anthropogenic disturbances and pollution are absent (U.S. EPA 2000a, 2000b, 2001). Because most waters have been influenced by human activity, reference conditions in reality are those that are the least impacted (U.S. EPA 2000a). The U.S. EPA provides general guidance on selecting and classifying reference water bodies (2000a, 2000b, 2001).

For the reference and non-reference water body approach, two alternative approaches were presented. The first approach only uses data from reference water bodies located within an ecoregion to establish criteria, and the second uses data from both reference and non-reference water bodies located within an ecoregion. In the reference approach, waterbody data are used to establish a cumulative frequency distribution for each variable of interest, such as total phosphorus (TP), total nitrogen (TN), and chlorophyll a (Chl *a*). The upper 75th percentile of the distribution for each variable defines the ecoregional nutrient criterion. In the second

approach, nutrient data from both reference and non-reference water bodies in the ecoregion are used to establish a cumulative frequency distribution for each variable of interest. The lower 25th percentile of the distribution for each variable defines the ecoregional nutrient criterion.

3.0 Limitations to U.S. EPA's Guidance For Deriving Ecoregional Nutrient Criteria

The U.S. EPA's approach for deriving ecoregional nutrient criteria has the following important limitations:

1. Because 75% of all water bodies in U.S. EPA's nutrient database exceed the ecoregional criteria, if extrapolated to all water bodies, use of the U.S. EPA's percentile approach potentially could result in the non-attainment of about 75% of all water bodies, without any direct determination of nutrient impairment or non-attainment of designated uses. It is likely that most of these water bodies are unimpaired by nutrients and/or are attaining designated uses potentially affected by nutrients.
2. The U.S. EPA's approach for setting nutrient criteria does not require the determination of causal relationships between nutrients and attainment of designated uses. As a result, efforts to reduce nutrient concentrations can result in adverse effects to some designated uses, such as recreational or commercial fishing. Such efforts may result in decreases in fish populations caused by decreases in primary production (VA WRRC 2004).
3. Causal relationships between nutrients and response variables, such as Chl *a*, dissolved oxygen and pH, are not determined using U.S. EPA's approach (VA WRRC 2004, Warren-Hicks et al. 2005). Consequently, in waters where such relationships are weak or may not exist because of confounding factors, changes in nutrient concentrations may not produce the expected changes in Chl *a* concentrations or other response variables.

4.0 NUTRIENT CRITERIA AND DESIGNATED USES FOR WATER BODIES

Water quality standards incorporate criteria and use designations. The Clean Water (CWA) Act and its implementing regulations require that criteria should be developed considering use designations. Given this CWA directive and the fundamental difference between nutrients and other pollutants that are more directly toxic to aquatic life, the VA WRRC (2004) recommended that the VA DEQ base its nutrient criteria development process upon the concept of designated uses. We agree with this recommendation and recommend that it be applied to all States.

All water bodies have one or more designated uses. Designated uses potentially affected by nutrients include those related to aquatic life, recreation, and public water supply (i.e., drinking water). In some multiple-use water bodies, protection of multiple uses may result in management conflicts. For example, many water bodies have both recreational fishery and public water supply uses. While the public water supply use may best be served by more restrictive criteria placing tight limits on algal populations, recreational fisheries may be better served by more moderate algal levels. An effective criterion should seek to balance such tradeoffs. Jensen et al. (2004, see Appendix 3) have proposed a conceptual approach for determining Chl *a* levels that optimize the support of multiple, competing designated uses. Analyses of this type will be required to derive nutrient criteria based on suitability of the water body for multiple, competing designated uses.

4.1 Aquatic Life

Aquatic life includes fish, amphibians, reptiles, invertebrates, plants, and microbes. Most state water quality management agencies have programs that monitor at least some of these types of aquatic life in most water bodies as part of their biological assessment and/or biocriteria programs. In addition, most State agencies that regulate sport and commercial fisheries collect monitoring data on fish populations and/or sport and commercial fishery statistics. These types of data should be useful for determining the suitability of all classes of water bodies for aquatic

life use. We recommend that these types of information be used to rate the level of use suitability on a scale of 1 – 5, with 1 as the lowest rating and 5 as the highest rating. These types of qualitative use ratings are frequently applied in biological assessment/biocriteria programs. Most commonly, bioassessments are conducted on fish, benthic macroinvertebrates and algae. For more information on these types of monitoring programs, please refer to http://www.epa.gov/waterscience/biocriteria/.

The Virginia Water Resources Resource Commission (VA WRRC 2004) recommended that recreational fish population status be interpreted as an indicator of aquatic life status in impoundments, because most impoundments are used or managed for recreational fishing and recreational fish species are generally at the upper trophic level of the ecosystem. In the absence of fish population data, the VA WRRC (2004) proposed that recreational fishery status, as rated by Virginia Department of Game and Inland Fisheries (VDGIF) biologists on a 1 – 5 scale with 1 as the lowest rating and 5 as the highest rating, be used as an indicator of aquatic life use suitability. The VDGIF compared indices of fisheries status with nutrient levels. Based on the results of these analyses, the VA WRRC (2004) believes that the State's impoundments should be classified for nutrient criteria development based on the types of fisheries the impoundments support. We believe that this approach can be applied to impoundments in other States. We recommend that this type of approach be used to supplement the other types of bioassessment data used for evaluating the aquatic life use.

4.2 Recreation

The recreation category includes recreation, aesthetics, swimming, fishing, boating, and whole or partial body contact uses. User perception surveys can be used to define relationships between these types of recreational use and Chl *a*. (Warren-Hicks et al. 2005, VA WRRC 2004). User perception surveys use questionnaires to survey public perceptions of water quality. These surveys can be combined with water quality assessments of nutrients and response variables, such as Chl *a*, dissolved oxygen, fishing success, etc., so that the results of the user perception

surveys can be compared with nutrient-related water quality data. The Texas Water Conservation Association (2004) is conducting a user perception survey designed to evaluate the relationship between the recreational use of reservoirs and Chl *a* concentrations and water transparency in Texas impoundments. User perception surveys should be of value in nutrient criteria development for water bodies where existing or potential recreational usage would be significant (VA WRRC 2004, Warren-Hicks et al. 2005). It should be noted, however, that conducting these surveys can be difficult (VA WRRC 2004). If these surveys are implemented in a scientifically indefensible manner (i.e., proper question design, pretest, sampling protocol, and statistical procedures, etc.), the results may be inaccurate. Therefore, user perception surveys should be applied to the criteria development process only if adequate resources are available for conducting the surveys. For example, the survey protocols should be pre-tested, and the data used to define the relationship of survey respondents to the population that those respondents are intended to represent (VA WRRC 2004).

4.3 Public (Drinking) Water Supply

The public water supply designation includes all uses of water for human consumption. Impacts of high nutrient concentrations on the public water supply include increased treatment costs, bad taste, and odor. In general, as Chl *a* concentrations increase, water treatment costs and taste and odor problems tend to increase (Jensen et al. 2004). Jensen et al. (2004) investigated relationships among taste and odor problems, treatment costs, levels of nutrients, and Chl *a* in some Texas reservoirs. Similar studies will be needed to define these relationships for the public water supply use in other states.

5.0 DEVELOPMENT OF THIS GUIDANCE

The primary sources of information used to develop this guidance include the following:

- *Technical Approaches for Setting Site-specific Nutrient Criteria* (Warren-Hicks et al. 2005).
- *Nutrient Criteria Development Plan for the Commonwealth of Virginia* (VA DEQ 2004).
- *Report of the Academic Advisory Committee to the Virginia Department of Environmental Quality - Freshwater Nutrient Criteria* (VA WRRC 2004).
- *U.S. EPA Nutrient Criteria Guidance Manuals* (U.S. EPA 2000a, 2000b, 2001).
- *Nutrient Criteria and Designated Uses for Reservoirs in the Trinity River Basin* (Jensen et al. 2004).

All of these sources, except Warren-Hicks et al. (2005) and the US EPA manuals, are attached as appendices. Warren-Hicks et al. (2005) can be obtained from the Water Environment Research Foundation (www.werf.org). The US EPA manuals can be downloaded at:

http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/#docs.

The guidance presented in this report is a synthesis of materials from these sources. We recommend that all of these reports be reviewed before initiating any effort to develop nutrient criteria. We also reviewed some other State nutrient development plans for guidance on developing effects-based nutrient criteria. These States included California, Florida, West Virginia, Texas, Colorado, and others. Most State plans did not provide detailed guidance on methods for developing nutrient criteria based on the relationships among nutrients, response variables, and designated uses of water bodies. At best, only general guidance was provided. Based on our review, the VA DEQ (2004) provided the most useful and comprehensive State nutrient development plan. In addition, highly useful and informative information is found in *The Report of the Academic Advisory Committee to the Virginia Department of Environmental*

Quality - Freshwater Nutrient Criteria (VA WRRC 2004), which evaluated and provided recommendations on many of the important issues involved in developing nutrient criteria.

The effort required to develop nutrient criteria appropriate for all water bodies in a state will be a time-and resource-intensive process (VA WRRC 2004). Data useful for developing nutrient criteria, for the most part, have been collected for other purposes and may not be optimally suited for developing nutrient criteria. For example, data for nutrients and response variables are generally collected during the growing season, while fish and benthic macroinvertebrate data are usually collected during the spring or fall. Consequently, rarely are the required data collected during the same time period. For many water bodies or classes of water bodies, adequate data may not exist; therefore, collection of new data will be required. However "adaptive management" approaches, which include procedures for evaluating and refining criteria as new data are collected, may be useful in the criteria setting process.

6.0 RECOMMENDED STEPS FOR DEVELOPING NUTRIENT CRITERIA

Figure 1 shows 12 steps in the process for developing nutrient criteria protective of designated uses for water bodies. This process is applicable to individual water bodies, segments of individual water bodies, or classes of water bodies. The steps include the following:

- Step 1. Prioritize water bodies for criteria development.
- Step 2. Determine data requirements for developing nutrient criteria.
- Step 3. Compile data and create database.
- Step 4. Evaluate data adequacy. If the data are inadequate for developing nutrient criteria, then collect the required data.
- Step 5. If the data are adequate, then classify water bodies into appropriate groups for criteria development.
- Step 6. Evaluate relationships between Chl *a*, P, and N concentrations and levels of designated use support, including the aquatic life, recreation, and public water supply uses. If no significant relationships are identified, then either (1) collect additional data and re-evaluate the relationships, or (2) develop non-effects-based criteria.
- Step 7. If significant relationships are found between Chl a, P and N and level of use support, then evaluate relationships between P and N, and response variables.
- Step 8. Select trial Chl *a*, P, and/or N criteria based on relationships among these variables and levels of designated use support using a stakeholder decision-making process.
- Step 9. If significant relationships are not found between Chl a, P and N and levels of use support, then determine which physical, chemical, and/or biological factors may be confounding these relationships.
- Step 10. Select trial criteria based on non-effects data.
- Step 11. Evaluate whether the trial criteria may cause unacceptable effects to upstream or downstream nutrient criteria, water quality, or designated uses. If these types of unacceptable effects are predicted to occur, then the criteria should be re-

evaluated and new criteria selected that will not cause these types of effects. If these effects are not predicted to occur, then proceed to Step 12.

- Step 12. Begin criteria adoption process through the state water quality regulatory agency.

In the following subsections, the details of each step in the process are described.