NUTRIENT CRITERIA DEVELOPMENT PLAN

September 2006 Update

WATER QUALITY STANDARDS SECTION
OKLAHOMA WATER RESOURCES BOARD

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NUTRIENT CRITERIA DEVELOPMENT PLAN
EXECUTIVE SUMMARY

September 2006 update

WATER QUALITY STANDARDS SECTION
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This is the latest update to the Nutrient Criteria Development Plan for Oklahoma, developed by the Oklahoma Water Resources Board and submitted to EPA Region VI. This document integrates three different documents previously reviewed by EPA – the Nutrient Criteria Development Plan (of 2002), the June 2006 update, and the June 2, 2006 transmittal letter. In this plan, the OWRB outlines its long-term strategy for development of nutrient criteria in Oklahoma. The strategy is broken down into three phases, including: Phase One, development of Scenic Rivers criteria; Phase Two, development of nutrient criteria for lakes; and Phase Three, development of nutrient criteria for streams. At this point, OWRB has completed Phase One with the promulgation of the .037 mg/l total phosphorus criterion for Scenic Rivers, approved by EPA in 2004. OWRB expanded on this with promulgation of an assessment protocol for this criterion in 2005. OWRB has taken a significant first step in Phase Two with promulgation of a .010 mg/l chlorophyll-a criterion to protect the Public and Private Water Supply beneficial use on Sensitive Water Supplies, as well as Lake Wister and Tenkiller Ferry Reservoir. From here, OWRB will continue to focus on nutrient criteria development for other lakes and then streams in Oklahoma.

NUTRIENT CRITERIA DEVELOPMENT PLAN

September 2006 Update

Introduction

The Environmental Protection Agency (EPA) published notice recommending that a nutrient criteria development plan should be completed by each state by the end of 2001 and criteria should be promulgated by the end of 2004(FR 01-569 Filed 1-8-01). Oklahoma's nutrient criteria development plan, described here, is designed to meet EPA specifications. It delineates the steps required to develop numerical nutrient criteria that can be implemented in a rational, reasonable way. Nutrient criteria may take many forms because determination of beneficial use impairment by nutrients is expected to be a complicated process. Causal variables include phosphorus, nitrogen and various micronutrients. Response variables include algae, macrophytes, organic turbidity and dissolved oxygen. Excessive nutrient concentrations may cause excessive primary productivity. Excess algae or aquatic macrophytes may impair beneficial uses. Therefore, potential criteria may be nutrients themselves (phosphorus and/or nitrogen concentrations) and/or a measure of productivity, such as chlorophyll concentration or trophic state index (TSI). This plan recommends that all of the above possibilities should be investigated as potential criteria to be used where appropriate. The contents of this plan are not static and will be modified and updated as resources, research, data and technology become available to facilitate criteria development.

Oklahoma first submitted this plan for developing nutrient criteria to EPA in June 2004. The plan describes a general strategy for how to move the state from the current status of having narrative criteria and assessment rules and a newly adopted scenic rivers criterion to the desired goal of numeric criteria for phosphorus, nitrogen, and nutrient response variables. Over the past two years, progress has moved slowly toward this goal, with some major successes including establishment of an assessment protocol for the scenic river phosphorus criterion and promulgation of a chlorophyll-a criterion to protect Sensitive Water Supplies.

Water quality management will be immeasurably advanced in Oklahoma if we can continue to develop and promulgate balanced, reasonable and implementable nutrient criteria. These criteria may be used in TMDL's to allocate nutrient wasteloads for point sources and nutrient loads for nonpoint sources. Criteria may also be used in Use Support Assessment Protocols (USAP) for use support determinations and 303(d) listing/delisting.

Since the Plan was first drafted in 2004, EPA has established a set of components that articulates what comprises a mutually agreeable Nutrient Criteria Development Plan. Each of the thirteen components are addressed below.

1. SpecificTarget Parameters for Criteria.

There are several basic requirements for successful nutrient criteria development. One is a fundamental understanding of how nutrients impair beneficial uses. Nutrients can impair the Aesthetics, Fish and Wildlife Propagation or Public and Private Water Supply beneficial uses. It is necessary to have this understanding in order to decide what type of criteria are best for a particular situation. For example, it is not anticipated that the same types of criteria will be appropriate for both streams and lakes. It is also necessary to understand how criteria development and implementation work in Oklahoma. Ideally, criteria should be developed with implementation in mind.

Currently, there are limited established scientific protocols for showing a direct correlation between nutrient concentrations in water and beneficial use impairment. Therefore, many aspects of nutrient criteria development will rest on site-specific conditions and best professional judgment (BPJ). Monitoring and testing will be required to refine criteria. Since lake criteria will be different from stream criteria, there must be testing for each. A great deal of testing is proposed in order to eliminate false determinations of impairment or non-impairment. Consequences of a determination of nutrient impairment where no beneficial use is even likely to be impaired could cost millions of dollars to be spent needlessly. The opposite case where an impaired condition caused by nutrients exists but is not correctly identified can result in prolonged environmental degradation, irreversible impairment of critical public and private water supplies, and critical resources redirected to other causes of impairment.

Oklahoma has promulgated a total phosphorus criterion for Scenic Rivers and a chlorophyll-a criterion for sensitive drinking water supply lakes (SWS). Over the shorter term, OWRB will pursue chlorophyll-a in lakes and chlorophyll-a for both seston and periphyton in streams. As a longer-term priority, OWRB will pursue total phosphorus and nitrogen criteria for lakes and streams as time and the current technology allow.

2. Other Potential Parameters.

EPA has suggested other parameters suitable for guarding against impairments from nutrients. These include submerged aquatic vegetation (SAV), Total Suspended Solids (TSS), turbidity and secchi depth. Oklahoma already has turbidity criteria; however, because the inorganic turbidity frequently found in Oklahoma lakes overshadows the organic, OWRB will not pursue this parameter for controlling nutrients at this time. OWRB is not pursing TSS and secchi depth for the same reason. TSS and total volatile solids are also not being pursued because of the analytical costs. SAV criteria are not being pursued because, in general, SAV is being promoted in Oklahoma and substantial funds are being devoted to SAV restoration in the state. If needed, the existing narrative could address SAV.

3. Criteria Development Approaches.

Oklahoma has been performing limited nutrient management for some time. We have developed a use support assessment protocol (USAP) to determine, among other things, when beneficial uses are threatened by nutrients. Effects of turbidity, canopy, etc. are evaluated through the use of a dichotomous key. The possibility of using this protocol in criteria development will be explored.

Nutrients and Beneficial Use Impairments

Nutrient levels that may impair beneficial uses in lakes are likely to be lower than in streams. Nutrient criteria for streams will likely be of a different type than for lakes. For these reasons, we will address lakes and streams separately in our Nutrient Criteria Development Plan. Wetlands, while waters of the state, are not afforded specific use designations in the Oklahoma Water Quality Standards and are protected by the default fishable and swimable uses and their associated criteria. Wetland nutrient criteria will be deferred until a specific framework of wetland water quality standards can be adopted.

The long-term goal is for criteria to be developed that are protective of all designated beneficial uses. Beneficial uses assigned to water bodies in Oklahoma vary by water body size and type and attainable uses. For many parameters there are separate criteria to protect each of the uses assigned. In many cases the criteria to protect drinking water are much less stringent than that required for aquatic life. By rule, however, the most stringent criteria associated with the designated beneficial uses must drive permitting and water quality management decisions. Ideally, nutrient criteria should follow the same pattern with separate criteria to protect each of Oklahoma's eleven beneficial uses. Alternatively, criteria may be established such that they are generally protective of all beneficial uses. Criteria of this nature may be more stringent than necessary for many waterbodies and may result in many unnecessary TMDLS and undue regulation within their watersheds.

Lakes:
Excess nutrient loading is a primary cause of eutrophication. OWQS define eutrophication as "the process whereby the condition of a waterbody changes from one of low biologic productivity and clear water to one of high productivity and water made turbid by the accelerated growth of algae."(OAC 785:45-1-2) Cultural eutrophication results from human activities and is regulated. Carried to an extreme, eutrophication can convert a lake into a marsh, resulting in a loss of assigned beneficial uses.

Eutrophication leads to impairment of certain beneficial uses. The primary beneficial uses potentially affected by nutrients are Fish and Wildlife Propagation, Public and Private Water Supply, and Aesthetics. Algal respiration and/or decay and/or aquatic macrophyte decay may reduce D.O. concentrations in an impoundment such that aquatic organisms die. Algal blooms may cause taste and odor problems that greatly increase water treatment costs and impair use of the water as a Public and Private

Water Supply. Algal scum and/or nuisance macrophytes may reduce recreational use of a reservoir due to Aesthetics impairment.

Nearly all lakes in Oklahoma are man made reservoirs. Criteria and implementation in a southern reservoir may be different than in a natural northern lake. In general, turbid Oklahoma reservoirs are believed to be able to accept more nutrient loading without impairing beneficial uses than clear lakes. Primary productivity in turbid lakes tends to be light limited. Because of this and other abiotic factors, nutrient loading may not necessarily exhibit a direct cause and effect relationship with beneficial use impairment. Primary productivity in lakes is more closely tied to beneficial use impacts than nutrient loading. Trophic state index (TSI) based upon chlorophyll concentration is a measure of primary productivity. A specific TSI (e.g. 62, hypereutrophic) or a Chlorophyll concentration could be used as criteria. The nature of beneficial impacts and impairments caused by excessive primary productivity will need to be evaluated to determine if annual or seasonal mean measures of primary productivity should be adopted as criteria or if the frequency of individual samples exceeding a criterion is appropriate.

Streams:
A quantitative relationship between nutrient loading and beneficial use impairment is less well established for streams than for lakes. Nitrogen, phosphorus, micronutrients, substrate or light may limit productivity at a given location at a given time. However, the limitation may change rapidly with time and/or location. Stream morphology also affects the relationship between nutrient loading and primary productivity as does flow regime and slope. The correlation between nutrient concentration and chlorophyll is highly variable in streams because of floods, water velocity, turbidity, grazing, shading, etc. The potential adverse effects of nutrient enrichment may be obscured because these factors disrupt algal growth. Consequently, it is difficult to choose parameters upon which to base criteria. Nitrogen and phosphorus concentrations are obvious criteria candidates. Although it is difficult to establish a cause and effect relationship between nutrient loading and beneficial use impairment in streams, criteria based on nutrient concentrations would be easier to implement than criteria based on primary productivity, and would, therefore, be potentially more effective in managing nutrient loading problems, but less technically defensible.

Stream Nutrient Dynamics and Modeling
Among the options OWRB is considering for stream nutrient criteria development is the application of mathematic modeling principles. Nutrient criteria development should relate nutrient loading and beneficial use impairment. Several attempts have been made to relate nutrient loading and chlorophyll concentrations. Statistical models relating nutrient loading and chlorophyll have been used to estimate nutrient concentrations causing nuisance algal biomass. Streams with nutrient concentrations greater than that required to limit biomass may result in eutrophic conditions. Statistical models using total nutrient concentrations perform better than those using dissolved nutrients do. Dissolved nutrient concentrations are complicated by the balance between uptake and cycling.

A drawback of some statistical models is the difficulty in measuring benthic chlorophyll concentrations. Some statistical models attempt to relate nutrient concentrations to sestonic chlorophyll. Sestonic chlorophyll is easier to measure and may be used if relationship between sestonic and benthic chlorophyll concentrations can be better defined. It has been shown that there is a positive correlation between sestonic chlorophyll and total phosphorus concentrations.

Another approach to determining eutrophication uses the ratio of periphytic growth on artificial substrates with and without nutrient enrichment. This method is referred to as the Lotic Ecosystem Trophic State Index (LETSI). A LETSI of one suggests that a stream has exceeded its nutrient assimilative capacity.

An alternative basis for nutrient criteria that does not attempt to explain the relationship between nutrient loading and beneficial use impairment uses cumulative distributions of total nutrient and chlorophyll concentrations. This is the approach outlined in EPA guidance. The lower 25th percentile of all nutrient concentration data is suggested as representing the minimally impacted condition. Alternatively, the 75th percentile for reference streams in an ecoregion represents reference conditions. With criteria of this nature, a mechanism for relief must also be provided. Where a particular entity is seriously affected by a general or regional criterion, segment specific criteria protective of beneficial uses may be established to provide regulatory relief. Protocols for establishing site-specific stream nutrient criteria will need to be developed for this application.

EPA has enhanced their AQUATOX model to better simulate periphyton in response to changing nutrient, light, grazing, and flow conditions. Aquatox is now purported to predict commonly used endpoints in nutrient analysis, such as dissolved oxygen, chlorophyll, nitrogen and phosphorus. Its biological components can include periphyton, macrophytes and benthic invertebrates in streams. This model may help solve many of the nutrient criteria implementation problems for streams.

Keeping all these considerations in mind, OWRB is pursuing numeric criteria for response variables and for total nitrogen and phosphorus.

4. Nutrient Criteria Development Approach.

History of Nutrient Criteria in Oklahoma

OWQS contain many numerical criteria that are routinely implemented through the NPDES program. They include acute criteria, chronic criteria, criteria for protection of human health, and several others. These criteria protect beneficial uses from toxicity. There is a direct cause and effect relationship between a toxicant criterion and beneficial use impairment. For example, if an acute criterion is exceeded longer than the allowable exposure time, aquatic organisms will die, impairing the Fish and Wildlife

Propagation beneficial use. OWQS specify where toxicant criteria apply in receiving streams - after complete mix, at the point of maximum concentration on the chronic regulatory mixing zone boundary or on the acute regulatory mixing zone boundary. In each case, exact mathematical expressions for concentration at the points criteria apply are used to determine wasteload allocations. Wasteload allocations are point source effluent concentrations, which yield criteria at the point specified in OWQS. Often, no calibration measurements are required because cause and effect relationships are established for toxicants. There is also a direct cause and effect relationship between dissolved oxygen (D.O.) concentration and the Fish and Wildlife Propagation beneficial use. If D.O. concentration drops too low for a sufficient length of time, aquatic organisms die. Unlike toxicants, D.O. is not generally regulated in the effluent. Biochemical oxygen demand (BOD) of the effluent is regulated to ensure that D.O. in the receiving water is sufficiently high. Even though D.O. is generally not regulated directly in the effluent, empirical relationships have been developed and widely accepted to regulate BOD. However, an extra level of complexity has been added to D.O. criteria implementation. Calibration measurements are occasionally required because cause and effect relationships between BOD loading and beneficial use impairment are not as well known.

Additional complexity is involved in the development and implementation of nutrient criteria. Potentially, several beneficial uses may be impacted by excessive productivity. Algae or aquatic macrophytes may impact Oklahoma's Aesthetics, Fish and Wildlife Propagation, or Public and Private Water Supply beneficial uses. In general, there are no universally appropriate cause and effect relationships between the different beneficial use impacts and primary productivity. A given level of primary productivity may or may not cause an impairment of one or more beneficial uses. Therefore, nutrient criteria development, unlike toxicants or D.O., is more likely to be based on factors other than empirically derived equations driven by direct cause and effect relationships.

Nutrient criteria implementation will be like D.O. criteria implementation, in that, the cause of impairment (primary productivity or excessive algal growth) is not the permitted substance (phosphorus or nitrogen). High levels of nitrogen and/or phosphorus may produce excess primary productivity. However, unlike in D.O. implementation, the relationship between primary productivity and nutrients is not highly developed, particularly in streams. Either nitrogen or phosphorus may limit primary productivity at different times. Primary productivity may be limited by light in turbid streams or streams with heavy canopy. Other parameters, such as temperature or the presence of other substances in the water, may also impact primary productivity. Because of the complexity involved, implementation of primary productivity criteria may rest more on policy than on our inadequate understanding of reactions to various levels of nutrients. More data may be required for nutrient criteria implementation than for either conservative toxicants or D.O. because cause and effect relationships are so poorly defined.

Nutrient criteria and implementation should protect the beneficial uses that are designated for a given water body. Cumulative upstream nutrient loads may have

adverse effects on downstream beneficial uses. As criteria are developed, those downstream beneficial uses should also be considered and protected. Implementation rules should pay particular attention to protecting downstream beneficial uses and antidegradation policies. Downstream TMDL and implementation plans may dictate the nature of the criteria for many upstream and otherwise unimpacted waterbodies.

Oklahoma has been striving to address nutrient impairment of Oklahoma's waters since the earliest Oklahoma Water Quality Standards. The first OWQS published in 1959 contained narrative language prohibiting nutrients from impairing beneficial uses by excessive algae. In 1976, the OWRB proposed a criterion of 0.015 mg/l total phosphorus and no alteration of the naturally occurring N:P molar ratio. The criterion wasn't adopted, but the narrative not allowing change in the molar ratio was adopted. In 1988, the current language was adopted that prohibits discharge of nutrients that cause excessive growth of algae which impairs any beneficial use.

The 1988 narrative criterion as the sole nutrient criterion proved to be problematic. The 1994 Oklahoma 303(d) list had over 200 waterbody segments listed as impaired by nutrients. Many of those listings, however, were added to the 303(d) list through various means without ever violating a numerical criterion or otherwise specifically demonstrated to violate the narrative prescriptions. Oklahoma initiated various efforts in 1996 to establish protocols for determining waterbody beneficial use support in rule. After some effort, the OWRB established an assessment protocol for determining if a stream is threatened by nutrients. Through application of new rules and identification of unsubstantiated and unsupportable listings, the 1998 303(d) list was pared to ten waterbodies listed for phosphorus and one stream listed as impaired by nitrate. Many of the waterbodies previously identified as impaired are now considered threatened and require additonal study.

In 1996, the state began to realize the threats to critical water resources posed by the expanding animal agriculture industry. The state animal waste task force made recommendations to identify watersheds and ground waters that are impacted or threatened by nutrients, which were enacted in legislation. Subsequently, the OWRB (following the legislative mandates) initiated a process and a definition in the WQS to identify Nutrient Limited Watersheds (NLWs). Currently 20 lakes have been identified in the Water Quality Standards as NLWs. For the Oklahoma integrated report, NLW reservoirs are deemed threatened until an impairment study is completed.

Currently there are three nutrient criteria in Oklahoma Water Quality Standards (OWQS). The first two are located in OAC 785:45-5-19(2) to protect the Aesthetics beneficial use. The first reads as follows: "***(A)*** *Nutrients. Nutrients from point source discharges or other sources shall not cause excessive growth of periphyton, phytoplankton or aquatic macrophyte communities which impairs any existing or designated beneficial use.*" Oklahoma has been trying to implement this narrative criterion for decades with limited success. The second criterion was promulgated as OAC 785:45-5-19(2)(B) and OAC 785:45-5-25(d). This numerical criterion of 0.037 mg/l phosphorus is intended to protect Oklahoma's six scenic rivers. The most recently

promulgated criterion is located in 785:45-5-10(7) and protects Sensitive Water Supply reservoirs, as well as Lake Wister and Tenkiller Ferry Reservoir, for the Public and Private Water Supply beneficial use by establishing a criterion of .010 mg/l chlorophyll-a.

Development Process for Water Quality Management for Nutrients

Water quality management for nutrients will be a three-phase process in Oklahoma. The first phase was Oklahoma's scenic rivers. Scenic rivers are designated by Oklahoma's legislature and, as such, they require water quality better than that necessary to simply support beneficial uses. A phosphorus criterion to restore and protect the exceptional water quality of the Oklahoma scenic rivers was approved by EPA in May 2004.

The second phase will address Oklahoma lakes and their watersheds. Water quality management for nutrients in lakes, especially those reservoirs that serve as water supplies, will take precedence over all other nutrient management activities except on scenic rivers. Lakes provide a major source of drinking water. Taste and odor problems can greatly increase treatment costs. Because maintaining beneficial uses on lakes is so important, most of Oklahoma's scarce resources should be devoted to developing appropriate nutrient criteria for lakes. Nutrient loads on streams in watersheds of impaired lakes will be managed to eliminate lake impairments. Oklahoma has begun this phase by promulgating the chlorophyll-a criterion for Sensitive Water Supplies in 2006.

The final phase will be Oklahoma streams that are not designated as scenic rivers. They are of lower priority for water quality management. Nutrient criteria and implementation will likely be least stringent for these streams.

Oklahoma's development process for nutrient criteria needs to be based upon the following principles:

1) There needs to be a sound technical basis and rational policy for any criteria promulgated
2) Criteria promulgated must have a direct bearing on the support of beneficial uses or other designations set in the WQS (they must be directly related to causes of impairment).
3) Criteria must be such that they can be easily monitored and implemented through permit and NPS management plans.
4) Potential criteria must be tested to determine effectiveness and to determine if they are within a tolerable range for false negatives and false positives
5) There must be extensive stakeholder involvement in development of any criteria.

In general the criteria development process should involve the following steps:

- Establish stakeholder /state agency working group
- Establish theoretical basis
- Collect necessary data

- Develop potential criteria
- Test and refine criteria
- Public participation and administrative procedures to promulgate criteria.

Formation of nutrient working groups is critical to assure agency and stakeholder input. Very difficult decisions will have to be made based on limited data. A lake working group and a stream working group will both be required because stream and lake nutrient criteria development are completely different. Each group must be composed of experts, primarily from various state environmental agencies. Working groups should also extend the opportunity for participation to neighboring states. Technical advisory groups consisting of core members from the Oklahoma Department of Environmental Quality and the Oklahoma Conservation Commission have been employed as part of implementation and criteria development. The USGS, Cities, Councils of Government and Oklahoma Universities have also provided valuable contributions. Assessment protocol development for the Oklahoma Scenic Rivers included participation by representatives with the Arkansas Department of Environmental Quality. Criteria development should also include technical review by the Regional Technical Advisory Group (RTAG) sponsored by EPA Region Six.

Criteria Development for Scenic Rivers
Phase One of the Nutrient Strategy

Oklahoma's Water Quality Standards (OAC 785:45) provide for protection of all Oklahoma waters through the assignment of beneficial uses, criteria to protect those beneficial uses, and an Antidegradation Policy". Certain limitations for additional protection are found at OAC 785:45-5-25 and are designed (among other things) to protect the Scenic River status of Oklahoma's Scenic Rivers. Both empirical and anecdotal evidence over the last two decades indicates that, although the beneficial uses of the Illinois River may not be wholly impaired, its status as a Scenic River pursuant to Oklahoma Statute Title 82 Chapter 21 is seriously affected by excess nutrients. These nutrients - primarily phosphorus - are causing accelerated primary productivity in the Illinois River, resulting in significant growths of both attached algae (periphyton) and suspended algae (phytoplankton). As a consequence, historic river clarity and substrate quality are being adversely affected to such an extent that, without intervention, the Illinois River's exceptional ecological and recreational significance is in jeopardy.

Unfortunately, the problems with ecological and recreational integrity on the Illinois River are also reflected in the other five Scenic Rivers. Although less pronounced and obvious to the public, the Barren Fork River, Flint Creek, Lee Creek, Little Lee Creek and the Upper Mountain Fork River above Broken Bow reservoir are all showing signs of adverse impacts from excess nutrients. As a result, any nutrient control strategy put into place should be applied to all six Scenic Rivers.

To holistically address these problems and protect our Scenic Rivers, a numeric criterion has been incorporated into the WQS applicable to total phosphorus for all six

Scenic Rivers. This numeric value should assure that water quality better than that necessary to support beneficial uses is achieved. Consensus from the public at informal water quality standards meetings in late 2001 and from comments during the official comment period for the 2002 standards revision is that Oklahoma's six Scenic Rivers should have "better than average" water quality.

An analysis of nutrient values in relatively un-impacted streams is found in *Nutrient Concentrations and Yield in Undeveloped Stream Basins of the United States* (*Gregory M Clark, David K. Mueller and M. Alisa Mast; Journal of the American Water Resources Association Volume 36, No. 4 August 2000)* and may be used for Oklahoma's purposes because it evaluates total phosphorus data on least impacted/reference sites. This report determined that 75 % of the streams assessed in these least impacted areas had a flow weighted total phosphorus concentration of 0.037 mg/L or less. This value is similar to the median total phosphorus concentrations seen in the Barren Fork and the Mountain Fork rivers from Oklahoma's Beneficial Use Monitoring Program (0.045 mg/L and 0.028 mg/L respectively. It is also consistent with USGS monitoring of the Barren Fork, which results in a median concentration of 0.03 mg/L. The 0.037 mg/L criterion has been promulgated as a 30-day geometric mean by the OWRB and was approved by EPA Region VI in 2004.

Criteria Implementation for Scenic Rivers

Determining if the Scenic Rivers were compliant with the new criterion was problematic because of the extreme costs for collection and analysis of enough samples to routinely determine a 30-day geometric mean concentration. Staff of the OWRB, working with state environmental agencies, EPA Region VI and the Arkansas Department of Environmental Quality (ADEQ), proposed an assessment protocol for determining if the Scenic Rivers aesthetics beneficial use was supported with respect to concentrations of total phosphorus. This protocol established minimum data requirements and a decision rule for determining if routine monitoring data indicated that the 30-day geometric mean concentration of 0.037-mg/ l total phosphorus was exceeded. This protocol was adopted by the OWRB and promulgated as state rule in OAC 785 46-15 following the Oklahoma Administrative Procedures Act. The rule became effective July 1, 2004. In addition, a compliance schedule is built into the scenic river phosphorus criterion. Each state environmental agency must develop a water quality standards implementation plan to ensure that the 0.037 criterion is met by the year 2012.

Nutrient Criteria Development for Lakes
Phase Two of the Nutrient Strategy

Even before the Nutrient Criteria Development Plan was required by EPA, Oklahoma had already taken major steps toward promulgating nutrient criteria for lakes. As a result of Governor Keating's animal waste task force and statutory change requiring that the OWRB define nutrient limited watersheds, the following was promulgated in the 1998 revision of the water quality standards:

"NLW Impairment Study" means a scientific process of surveying the chemical, physical and biological characteristics of a nutrient threatened reservoir to determine whether the reservoir's beneficial uses are being impaired by human-induced eutrophication.

"Nutrient impaired reservoir" means a reservoir with a beneficial use or uses determined by an NLW Impairment Study to be impaired by human-induced eutrophication.

"Nutrient-limited watershed" means a watershed of a waterbody with a designated beneficial use which is adversely affected by excess nutrients as determined by Carlson's Trophic State Index (using chlorophyll) of 62 or greater, or is otherwise listed as "NLW" in Appendix A of this Chapter.

These definitions, of course, are not criteria. They do, however, set a course of action to protect and remediate reservoirs that are clearly hypereutrophic The immediate regulatory consequences of a NLW designation are more stringent controls on animal waste disposal from concentrated animal feeding operation, licensed animal feeding operations and poultry operations. The NLW designation does not trigger any regulatory action for point sources until an NLW impairment study determines an impaired condition and subsequent TMDL.

OWRB also promulgated the following in its implementation rules:

(d) ***Demonstration that nutrients may be adversely impacting a beneficial use in a lake.*** *If it is demonstrated that nutrient loading in a lake may be adversely impacting a beneficial use designated for that waterbody, then the Board may determine that the lake and its watershed is an NLW, and shall identify the lake and watershed as NLW in Appendix A of OAC 785:45.*

(e) ***Consequence of identification as NLW; results of study.*** *If a lake or its watershed is identified as NLW in Appendix A of OAC 785:45, then the Board or other appropriate state environmental agency may cause an NLW Impairment Study to be performed. The beneficial uses designated for lakes identified in OAC 785:45 Appendix A as NLW shall be presumed to be fully supported but threatened, unless an NLW Impairment Study demonstrates that the uses are partially supported or not supported; provided, if an NLW Impairment Study demonstrates that the uses are not threatened, then the Board shall consider deleting the NLW identification.*

(f) ***Consequence of assessment that use is threatened by nutrients.*** *If it is determined that one or more beneficial uses designated for a waterbody are threatened by nutrients, then that waterbody shall be presumed to be nutrient-threatened. If it is determined or presumed, in accordance with this Section, that a waterbody is nutrient-threatened, then before the waterbody is determined to be nutrient-impaired, an NLW Impairment Study if a lake or an impairment study if a stream must be completed by the appropriate state environmental agency.*

(g) ***Result of impairment study.***

(1) ***Impaired or threatened.*** *If, independent of or in addition to the process set forth in (b) of this Section, an impairment study of a waterbody*

demonstrates that a waterbody is impaired or threatened by nutrients, then the appropriate state environmental agency shall initiate the appropriate listing procedure developed by the Secretary of Environment pursuant to 27A O.S. 1-2-101.
(2) ***Not threatened nor impaired.*** *If, independent of or in addition to the process set forth in (b) of this Section, an impairment study of a waterbody demonstrates that a waterbody is neither threatened nor impaired by nutrients, then the appropriate state environmental agency shall initiate the appropriate de-listing procedure developed by the Secretary of Environment pursuant to 27A O.S. 1-2-101.*

Potential nutrient or related criteria for Oklahoma's lakes include the numerous nitrogen and phosphorus parameters, taste and odor compounds, water clarity, and measures of primary productivity. OWRB staff believe that chlorophyll concentration or a trophic state index (TSI) based on chlorophyll concentration are better choices for initial lake nutrient criteria in Oklahoma. At this time, TSI can not easily be tied to specific beneficial use impairments, but it is generally recognized that hypereutrophic lakes have a high potential to exhibit some sort of use impairment. TSI is a good choice because it is a measure of primary productivity, rather than nutrient loading. The external nutrient loading resulting in a given level of primary productivity is highly variable, depending on turbidity, lake morphology, internal loading, residence time, etc. Because of the highly variable response, nutrient concentrations may be less effective as criteria. A single TSI criterion can apply to many lakes with common features, rather than requiring separate nutrient criteria for each lake. Oklahoma has been analyzing lake chlorophyll concentrations for many years, so a good data set for criteria development exists. Criteria for parameters other than chlorophyll and combinations of nutrient concentrations and response variables will also be considered as the science associated with nutrients evolves.

It may not be practical to protect all lakes in Oklahoma with a single TSI or chlorophyll criterion. The state may wish to protect some lakes more than others. The criteria development process must delineate those lakes that require a higher level of protection. Criteria must be developed for the various levels of protection desired.
The lakes nutrient working group must determine different areas that may be homogenous enough to be represented by a single criterion. These areas could be delineated as low turbidity lakes of eastern Oklahoma versus high turbidity lakes generally found in the western half of the state. Reservoirs may also be segregated by ecoregion , age or by size. Another option is to segregate them by their anti-degradation tier. The group must determine appropriate criteria for each of the areas they choose. The group must refine criteria by checking for false negatives and false positives through NLW Impairment Studies. NLW Impairment studies, mandated by rule, determine if lakes with TSI greater than 62 are impaired. These studies can be modified to evaluate any given TSI.

Criteria may need to be targeted to protect specific lake beneficial uses. For example, criteria to protect fish and wildlife beneficial uses may not be suitable to prevent

impairment of the public and private water supply and aesthetics beneficial uses caused by taste and odor resulting from excess productivity. Substances which cause taste and odor problems are well documented. A direct cause and effect relationship between these substances and the Aesthetics beneficial use and Public and Private Water Supply beneficial use can be established. However, the taste and odor causing substances are very non-conservative. Furthermore, the relationship between nutrient loading and these substances is very complicated. Therefore, while these criteria could be developed, implementing them will be difficult. It makes little sense to promulgate criteria without any practical strategy to implement them.

Developing nutrient criteria for lakes will not be an easy task. There are few clear-cut relationships between beneficial use impairment and chlorophyll concentration. Literature studies and correlation of existing data with known impairments as identified by application of other nutrient related criteria such as dissolved oxygen or pH may prove helpful. Chlorophyll collection in future years may be used to refine TSI criteria for individual lakes.

Oklahoma has taken the first step in this phase by adopting a criterion for protection of the public and private water supply beneficial use of Sensitive Water Supplies and other critical sources of drinking water. The .010 mg/l criterion for chlorophyll-a will apply to Tenkiller Ferry Reservoir, Wister Lake and lakes designated as Sensitive Water Supplies in Appendix A of the Oklahoma Water Quality Standards. The criterion is intended to limit the occurrence of carcinogenic disinfection byproducts and offensive taste and odor problems in drinking water that are caused by excessive algae and blue green algae. This criterion will become effective as state law July 1, 2006 and is pending review and approval by EPA Region VI.

Implementing Nutrient Criteria for Lakes

Phosphorus is usually the limiting chemical nutrient in lakes. Even when phosphorus is not limiting, it should be restricted to drive the lakes towards phosphorus limitation. Nitrogen limitation can cause taste and odor problems which impair the beneficial uses. For implementation purposes, chlorophyll or a TSI must be related to phosphorus concentrations. Carlson's equations work well for this in clear northern lakes. Other equations have been developed for other types of impoundments. Once a phosphorus concentration has been determined for a lake, mass balance calculations can estimate an annual inflow to develop an allowable annual loading (TMDL) to insure the criterion is not exceeded. Phosphorus may be allocated as loads and wasteloads to non-point and point sources in the watershed.

Lake nutrient water quality management is a continuum. First, TSI or chlorophyll criteria are established. They are used with various models to develop an annual phosphorus load to a lake. This load is the TMDL end point. Wasteload allocations are assigned to point sources and load allocations to nonpoint sources in the lake’s watershed to ensure that annual loading does not exceed the TMDL. OWRB promulgates criteria and ODEQ assigns wasteload and load allocations.

Restoring impaired lakes is the foundation upon which Oklahoma's nutrient control rests. Models to obtain phosphorus loading are the crux of nutrient management in Oklahoma. If these models yield appropriate phosphorus concentrations, then nutrient management will protect lakes while balancing economic impact and resource utilization. The lakes nutrient working group should be able to develop guidance for phosphorus loading by 2008. Because lakes are generally more sensitive to nutrient loading than streams, loads and wasteloads may be more restrictive than those required to protect stream beneficial uses.

Criteria Development Process for Streams
Phase Three of the Nutrient Strategy

Criteria development for streams that are not scenic rivers is expected to be a more protracted effort. Scarce resources should primarily be devoted to lake nutrient management. Stream nutrient criteria are anticipated to be relatively less stringent than lake criteria. Nutrient management in streams within nutrient impaired lake watersheds will probably be controlled by more stringent lake TMDLs, not by implementing stream criteria. Therefore, such streams will be given lower priority for additional criteria development. Stream criteria for other than Scenic Rivers will only be implemented in the very limited circumstances where there is no downstream reservoir or monitoring shows that criteria for protecting the downstream lake is inadequate to protect the beneficial uses of the subject stream.

Oklahoma has adopted a protocol (USAP) for determining when a stream is threatened by nutrients. When monitoring and the USAP show that a stream is nutrient threatened or is shown to be impaired based upon parameters that would implicate nutrients as additional cause of impairment, a site-specific nutrient criterion may be considered. Nutrient criteria for non-scenic river streams should be strongly tied to identifying and preventing impairment of beneficial uses. Stream nutrient criteria development will take a longer process as new data are collected, models are created, and a sound basis for such criteria is established.

High levels of algal biomass may impair stream beneficial uses. Filamentous algae interfere with fishing and are aesthetically displeasing during other recreational activities such as canoeing, tubing or swimming. It may slough and impair water withdrawal for irrigation and/or municipal water supply. Algal biomass may contribute to oxygen demand and produce large diel variations in dissolved oxygen concentrations and pH. Excess productivity also results in changes in both the invertebrate and fish communities. A major challenge will be to determine what level of periphyton causes these problems and what will constitute and impaired condition.

The stream nutrient working group will have to develop protocols for criteria development over the next several years. The timeline for developing general stream nutrient criteria is highly dependent on resources devoted to relating nutrients to specific beneficial use impairments and the resources required to translate such research into

criteria and implementation. Measures of productivity (like TSI) may not be appropriate as stream nutrient criteria. There are too many factors that affect productivity aside from nutrient loading. Relating productivity with beneficial use impairment is difficult in streams, because productivity can manifest itself in so many different ways. Whether high productivity causes beneficial use impairment or not is dependent on different conditions. Unlike lakes, the task of developing definitive relationships between nutrient loading, primary productivity, and beneficial use impairment requires substantial research.

Because it is not currently possible to relate nutrient loading to primary productivity with confidence, much less beneficial use impairment, stream nutrient criteria may need to be developed on a case-by-case basis. The consequences of determining that a stream is impaired must be considered when developing protocols for stream nutrient criteria studies. The nutrient limiting primary productivity during critical conditions will have to be determined. It may be possible to develop a site-specific criterion for the limiting nutrient by spiking experimental streams with nutrients and observing the effect. This approach has already been used within the Illinois River watershed in Oklahoma.

Until acceptable stream nutrient criteria can be promulgated, the stream nutrient working group will have to develop interim protocols for site-specific criteria development over the next several years. Nutrient criteria will be immediately required if USAP suggests a nutrient threat to a specific stream. In this case, the stream must be further studied to determine impairment. Waterbodies determined to be impaired by nutrients must then be placed on the 303(d) list and a TMDL performed. A protocol for site-specific nutrient criteria would be needed to determine the impairment and to set the TMDL.

The stream nutrient working group must first determine those stream segments not in NLWs that are not nutrient sensitive. These stream segments may not need individual nutrient criteria or may be of lower priority for criteria development. A protocol, similar to the nutrient USAP, may be developed and used to determine those stream segments that are nutrient insensitive. Considerable data may be needed to make this determination, and its collection should be a top priority. Downstream sensitivity need not be considered in streams outside lakes' watersheds. A list of streams not requiring site-specific nutrient criteria should be developed. General nutrient criteria may be developed for those streams not requiring individual criteria at a later date.

Streams may be segregated by ecoregion and/or by morphological parameters such as stream order, substrate and slope as well as by designated beneficial uses to provide more refined criteria. Streams segregated in the fashion could be afforded less stringent criteria if identified features result in lower algae growth, less undesirable effects of greater algae levels, or differing public acceptance. Each of these aspects should be considered as stream criteria are developed. The USAP for stream nutrients currently in rule stratifies streams by stream order, substrate, slope, and other habitat features. This scheme will likely be the beginning point for future stream criteria development.

5. Waterbody Prioritization for Numeric Nutrient Criteria Development.

Nutrient Criteria Development Prioritization

As specified above, OWRB's nutrient criteria development plan proposes three phases for criteria development. First was the now completed criteria development for Oklahoma's Scenic Rivers. The second phase is development of criteria for lakes, and the third is criteria development for streams. The second phase is partially complete with the adoption of the chlorophyll-a criterion for SWS. Large, multiple-use lakes are next in priority within this phase. Phase 3 will focus on stream nutrient criteria. Criteria for large streams and wadable streams are of lower priority because of the presumption that criteria to protect downstream reservoirs beneficial uses will likely drive stream criteria rather than the beneficial uses of the streams themselves. Criteria to protect the beneficial uses of wetlands will be considered as the standards for wetlands evolve.

Lake/Reservoir Criteria Development.

Assuming federal approval of the chlorophyll-a criterion for SWS, the next steps will be to develop criteria for all lakes and nitrogen and phosphorus criteria for the SWS. Waterbodies deemed NLW will be given additional scrutiny with nutrient impairment studies following the requirements of OAC 785 46-15-10. Those waterbodies will be evaluated to determine if Water Quality Standards are exceeded to the extent that the water bodies are to be deemed impaired. TMDLs for waterbodies with nutrient related impairments will also be reviewed. OWRB will continue to review literature and criteria development strategies employed by other states. OWRB will review beneficial uses and long-term management goals of Oklahoma reservoirs to determine how nutrient criteria should best be tailored for those water bodies. OWRB will continue to monitor and compile lake nutrient, chlorophyll, dissolved oxygen and other parameters. Oklahoma will continue to review data following OAC 785:46-15 and list water bodies in the consolidated report following the requirements of section 303(d) for response variables with numeric or narrative criteria.

A potential strategy for criteria development will be forming separate criteria strategies for different classes of lakes. Non-public waters supply lakes managed for optimal fisheries and floodwater control, multiple use lakes with water supply, recreational, aesthetics, and fisheries concerns will be considered for separate criteria. Grand, Hudson, and Gibson lakes, a series of lakes impounding the Neosho River on the edge of the Ozark Plateau, may be considered as a separate class because of their unique nature and common watershed. As with conventional pollutants, both permits and assessments are driven by the most stringent applicable criteria and implementation strategy. With each lake or stream type, the state must evaluate the costs, feasibility and benefits of potential criteria on both the short and long term basis. As indicated in the initial criteria development plan, efforts will first focus on determining tolerable

chlorophyll levels for the respective beneficial uses. However, as other strategies for criteria development and implementation are identified or as desired nutrient concentrations are identified for specific lakes, phosphorus and nitrogen criteria will be proposed.

Large Rivers Criteria Development

Streams were relegated to a lowest priority in the January 2004 version of this plan for criteria development because criteria for downstream reservoirs was likely to be much more stringent. Oklahoma continues to believe this to be the general case. Some exceptions may require more immediate site-specific criteria development.

Wadable Stream Criteria Development.

Impairment of wadable streams is currently assessed through a translator protocol, which identifies threatened conditions. Threatened waterbodies must undergo additonal study to determine if the stream is impaired by nutrients. The nutrient impairment study minimum requirements have not been determined at this time. A study that links nutrients to fish kills, violation of the numerical dissolved oxygen, pH, turbidity, or biocriteria would likely satisfy the yet undefined study requirements. As numerical criteria are developed for wadable streams, OWRB may employ different strategies for the low gradient streams of the western Oklahoma ecoregions and the steeper cool water streams of eastern Oklahoma Ozark, Boston, and Ouachita Mountain ecoregions. Periphyton and sestonic chlorophyll will be considered for protecting wadable stream beneficial uses. Where downstream beneficial uses must be protected phosphorus and nitrogen criteria will established.

Wetland Nutrient Criteria Development

Criteria to protect the beneficial uses of wetlands will be considered as the standards for wetlands evolve. Oklahoma Water Quality Standards do not contain specifically designated beneficial uses for wetlands; rather, wetland beneficial uses for "*marshes…. or other bodies or accumulations of water…*" are defaulted to the Warm Water Aquatic Community subcategory of Fish and Wildlife Propagation and Primary Body Contact Recreation. Wetlands will be protected following criteria developed for the default beneficial uses until specific wetland beneficial uses and corresponding criteria are adopted

6. Criteria Prioritization Process.

The waterbody priorities were posed by the OWRB and presented for interagency and public review with development of the initial plan in 2003. The plan was presented and discussed with state environmental agencies in April 2003. The plan was subsequently distributed to stakeholder groups for review and comment in April 2003. The initial plan was presented to the Region Six Technical Advisory Group in 2003.

7. Waterbody Classification Schemes.

Oklahoma has employed a classification scheme based upon antidegradation requirements and given priority and special criteria to waters identified as special in the Water Quality Standards. Oklahoma has also established assessment protocols for wadable and non-wadable streams to determine a threatened condition. OWRB will investigate large rivers versus smaller rivers, and will likely employ different strategies for the low gradient western plains ecoregions and the steeper cool water eastern Oklahoma Ozark, Boston, and Ouachita Mountain ecoregions. Development of criteria will be tailored to the nature of identified impairments associated with nutrients in the various water body types.

8. Criteria Applicability.

Criteria applicability will generally follow the classification scheme. Criteria have been developed and are applicable now to protect the Aesthetics Beneficial Use of Oklahoma Scenic Rivers and the Public and Private Water Supply Beneficial Use of Sensitive Water Supplies. The structure and format of the Oklahoma Water Quality Standards generally has criteria applicable for specific beneficial uses. Where there are different criteria for separate beneficial uses for a given water body, the most stringent application of the criterion is implemented in permits. It is the intent for Oklahoma to maintain this format for new criteria development.

Implementation Rules and Reasonable Potential Determinations

Section 1-1-202 of Title 27A of the Oklahoma Statutes requires that Oklahoma state environmental agencies must establish rules to implement OWQS. Workable nutrient criteria must take into account how environmental programs are able to implement measures to eliminate impairments caused by nutrients. Rules that state agencies develop to implement nutrient criteria will also depend on experience and resources at each agency. Because nutrient criteria and implementation will have substantial basis in policy, rather than established science, they must receive widespread stakeholder support before they become law. Again, the threat of EPA promulgating very stringent criteria would likely be an important incentive for the regulated community to reach consensus on an alternative criterion.

Oklahoma Conservation Commission has administered management efforts for nonpoint source nutrient loading for several years. The OCC program has focused on several watersheds of reservoirs with identified nutrient problems. Targets for those projects have been based upon nutrient reductions recommended by Clean Lakes Projects or by draft TMDLs. OCC has used regional reference stream conditions as targets for nutrient load reductions where excess productivity has been related to

downstream dissolved oxygen problems and resulted in more stringent permit conditions for a municipal discharger.

A reasonable potential translator for permitting purposes will not be needed for SWS or for Scenic Rivers because of the existing restrictions and the limited number of point source discharges in those watersheds. However, policy or rule making will be needed to further prevent nonpoint sources from growing to the point where the remaining sensitive waters supplies are impaired. Where criteria are developed for lakes and streams with additional assimilative capacity for nutrients, then implementation rules will be needed to prevent impairment of beneficial uses.

Public participation is of vital importance for nutrient criteria development. It will not be possible to promulgate nutrient criteria without the public being fully behind this effort. Stakeholders must be educated as to the necessity of nutrient criteria during the criteria development and standards revision process. The threat of EPA promulgating the criteria recommended in its nutrient criteria guidance documents will likely be an important incentive for the public to reach consensus on alternative criteria. EPA must play an active role in this process for it to produce a workable water quality management tool. Public participation will be solicited through stakeholder working groups in developing criteria and ultimately through informal meetings and formal rule making of the Oklahoma Water Quality Standards revision processes.

Assessment rule for Scenic Rivers:
Determining if the Scenic Rivers were compliant with the new criterion was problematic because of the extreme costs for collection and analysis of enough samples to routinely determine a 30-day geometric mean concentration. Staff of the OWRB, working with state environmental agencies, EPA Region VI and the Arkansas Department of Environmental Quality (ADEQ), proposed an assessment protocol for determining if the Scenic Rivers aesthetics beneficial use was supported with respect to concentrations of total phosphorus. This protocol established minimum data requirements and a decision rule for determining if routine monitoring data indicated that the 30-day geometric mean concentration of 0.037-mg/ l total phosphorus was exceeded. This protocol was adopted by the OWRB and promulgated as state rule in OAC 785 46-15 following the Oklahoma Administrative Procedures Act. The rule became effective July 1, 2004

9. Criteria Development for Waters Shared Across Political Boundaries.

OWRB will work with EPA Region VI to implement the provisions of 40 CFR 25.5, 130.5(b)(6), and 131.7 131 10(b) with regard to both tribal and interstate waters. Tribal participation in development in Oklahoma Water Quality Standards is confounded by confusing and evolving EPA guidance regarding jurisdiction and tribal treatment as a state. All Oklahoma federally recognized tribes and adjacent states are included in the Oklahoma Water Quality Standards mailing list for distribution of formal notices regarding rulemaking for standards revisions. Oklahoma will meet with Region VI states

in conjunction with RTAG meetings or individually with regard to specific water bodies such as Lake Texoma. Oklahoma will consult with Kansas and Missouri as criteria are developed that may have upstream consequences in watersheds extending from those States.

10. Data Availability Adequacy and Elimination of Data Gaps.

The level of sampling required to manage a particular substance depends in large part on implementation. Often, conservative toxicants in Oklahoma are implemented using analytical solutions to fundamental physical laws, where no additional data collection is required. Since D.O. is implemented using an empirical equation, data collection for calibration is sometimes required. Because so little is known about nutrient criteria implementation, it may turn out that massive data collection efforts are required, and that chemical, physical and biological sampling occur simultaneously. It may also be that site-specific conditions are of such importance that site-specific water quality data will be required before promulgation of any criteria.

Water quality Monitoring to Support Criteria Development

The Oklahoma Water Quality Monitoring Strategy and Status Report submitted to EPA Region VI describes the Oklahoma program for monitoring principal nutrients and many nutrient related parameters. That document describes in general the monitoring conducted by the Oklahoma Conservation Commission (OCC), Oklahoma Water Resources Board (OWRB), Oklahoma Department of Environmental Quality (ODEQ), Oklahoma Corporation Commission (Corp Comm), United States Geological Survey (USGS), and Oklahoma Department of Wildlife Conservation (ODWC). Data from these sources as well as data from the Indian Nation Council of Governments (INCOG), and the Association of Central Oklahoma Governments (ACOG) are routinely evaluated to assess the beneficial use support status of Oklahoma's waters. Volunteer monitoring programs sponsored by the OWRB and OCC also contribute data.

Lakes:

The data available in Oklahoma to base lake nutrient criteria on are variable. There is a great wealth of lake data including chlorophyll data from the many clean lake studies conducted by the OWRB, universities, and the Oklahoma Conservation Commission. There is also USGS, COE, and municipal data available on selected lakes. The data in some cases is somewhat handicapped by age, format, and lack of quality documentation. Current data is somewhat limited to the routine monitoring by OWRB and COE and assorted studies by the universities, Conservation Commission and the DEQ. Lacking are data that could serve to relate algae concentrations to beneficial use support or impairment. Taste and odor and treatment costs by municipal waterworks are not available in a fashion that would establish acceptable thresholds. Similarly lacking are data for some the identified compounds attributed to algae that cause taste and odor problems. Nutrient effects on reservoir fisheries and aquatic communities are

likely well documented. However, such data have not been compiled for application toward nutrient criteria development.

The OWRB currently monitors each of its major reservoirs, quarterly, for a two-year period on a five-year rotation. This sampling includes the basic nutrient parameters and chlorophyll at each site. The ACOE, City of Tulsa, Bureau of Reclamation, USFW, and the Grand River Dam Authority conduct additonal lake monitoring. A probabilistic monitoring strategy is in planning for Oklahoma lakes.

Streams:
The OCC monitors over 300 sites on smaller watershed streams on a rotating basis across the state. They routinely collect the full nutrient suite of parameters plus biological and habitat assessments. The OWRB Beneficial Use Monitoring Program (BUMP) is currently monitoring approximately one hundred eighty (180) stations on a monthly basis. These sites are segregated into two discrete types of monitoring activities. The first monitoring activity is focusing on fixed station monitoring on rivers and streams and the second monitoring activity focuses on a number of sample stations whose locations rotate on an annual basis. The OWRB routinely collects nutrients and sestonic chlorophyll-a at each site. The OWRB is currently engaged in a cooperative effort with the USGS to conduct flow monitoring at BUMP sites that do not currently have an existing USGS flow gage. This effort focuses on collecting both water quality and quantity information in order to calculate nutrient loads. The OCC and OWRB are cooperatively implemented a probabilistic stream monitoring program.

Periphyton:
Periphyton monitoring was implemented statewide in the summer of 2002 and 2003. Collection of this data has proved problematic with substantial manpower requirements to collect samples. Periphyton collections were coordinated with photo documentation to help in public participation regarding stream aesthetics beneficial use. OWRB is currently monitoring 40 stations as part of a probabilistic assessment of waters across the state. The Illinois River basin will be part of a probabilistic monitoring program with approximately 50 sites. The probabilistic monitoring includes both sestonic and periphyton sampling. The OCC includes a visual assessment of the nature and density of periphyton for each of its water quality sampling events, habitat assessments, and macroinvertebrate collections.

Harmful Algae Boom (HAB) Monitoring
In addition to routine lake monitoring, additonal samples were taken from nutrient limited watershed (NLW) reservoirs for algae speciation and enumeration to identify potential harmful algae blooms. Limited monitoring for algal toxins is being conducted by the University of Oklahoma Health Sciences Center to assess the effects of HABs on drinking waters. The Oklahoma Department of Wildlife Conservation does follow-up monitoring on fish kills when golden algae are suspected.

11. Criteria Development Schedule and Milestones

Nutrient Criteria Development Progress (since original draft of plan)

Scenic River Criterion:
Even before the states were required to develop a nutrient criteria development plan and well before the deadlines to adopt criteria, Oklahoma initiated a bold step to establish a phosphorus criterion for its scenic rivers. Oklahoma adopted a criterion for the six state scenic rivers in March 2002, which was approved by EPA in May 2004. This criterion has spawned substantial controversy resulting in an interstate Joint Statement Of Principles agreed to by Oklahoma and the State of Arkansas. The criterion calls for the 30-day geometric mean concentration of phosphorus to be less than 0.037 mg/l in scenic rivers. The criterion is to be fully implemented by the year 2012. The Joint Statement Of Principles calls for review of the criterion in 2012.

Assessment rule for Scenic Rivers:
Determining if the Scenic Rivers were compliant with the new criterion was problematic because of the extreme costs for collection and analysis of enough samples to routinely determine a 30-day geometric mean concentration. Staff of the OWRB, working with state environmental agencies, EPA Region VI and the Arkansas Department of Environmental Quality (ADEQ), proposed an assessment protocol for determining if the Scenic Rivers aesthetics beneficial use was supported with respect to concentrations of total phosphorus. This protocol established minimum data requirements and a decision rule for determining if routine monitoring data indicated that the 30-day geometric mean concentration of 0.037-mg/ l total phosphorus was exceeded. This protocol was adopted by the OWRB and promulgated as state rule in OAC 785 46-15 following the Oklahoma Administrative Procedures Act. The rule became effective July 1, 2004

Chlorophyll-a Criterion to Protect Sensitive Water Supplies:
Oklahoma has adopted a criterion for protection of the public and private water supply beneficial use of Sensitive Water Supplies and other critical sources of drinking water. The 10 ug/l criterion for chlorophyll-a will apply to Tenkiller Ferry Reservoir, Wister Lake and lakes designated as Sensitive Water Supplies in Appendix A of the Oklahoma Water Quality Standards. The criterion is intended to limit the occurrence of carcinogenic disinfection byproducts and offensive taste and odor problems in drinking water that are caused by excessive algae and blue green algae. This criterion will become effective as state law July 1, 2006 and is pending review and approval by EPA Region VI.

Updated Nutrient Criteria Development Time Line.

Projected accomplishments	Milestone dates
Formation and meeting of stakeholder interest and technical working groups	Meetings as needed October 2002 to May 2008
Literature and methods review	Ongoing
Secondary data QAPP	Fall 2003
Develop Potential Criteria	2004 - 2009
Water Supply Lakes (SWS)	Summer 2004 - Fall 2006
Other Lakes and Reservoirs	2006 - 2008
Continued monitoring	
Continued research	2006 - 2008
Review and develop initial criteria to protect aquatic life	2006 - 2008
Review and develop initial criteria to protect aesthetics	2006 - 2008
Review and develop initial criteria to protect water supply uses	2006 - 2008
Test And Refine Criteria	2008
Public Participation and Administrative Procedures To Promulgate Criteria	Fall 2008 – Summer 2009
Streams	2007 - 2009
Revise assessment protocol	2007
Continued research	2007 - 2007
Develop and promulgate criteria for wadable streams	2007 - 2009
Develop criteria for larger streams	2007 - 2009
Develop criteria for large rivers	2007 - 2009
Test And Refine Criteria	2009
Public Participation and Administrative Procedures To Promulgate Criteria	Fall 2009 – Summer 2010
Wetlands	Pending wetland standards/ beneficial uses and guidance development

12. Criteria Promulgation Administrative Steps

Incorporating Nutrient Criteria into the Water Quality Standards and Rulemaking Requirements

Revision of the OWQS to adopt nutrient criteria must not only meet federal requirements outlined in the CFR but also the requirements of the Oklahoma Administrative Procedures Act. This means that adoption of nutrient criteria must include several major tasks including publication of rule making intent and informing potentially affected parties, and formulation of a rule impact statement. Proposed OWQS changes must weather a review of how they impact small businesses, a 45-day comment period, formal hearing and is approved by the 9 member Oklahoma Water Resources Board. In approving new rules the board considers all comments submitted during the comment period and the formal hearing. OWQS changes must then pass a legislative review period and receive gubernatorial approval and certification by the Oklahoma Attorney General before EPA approval. The OWRB normally begins any OWQS revision with an informal public meeting to introduce the topic prior to any formal proposal. In addition to these requirements is a statutory requirement that any rule more stringent than the federal requirements must have a separate economic impact analysis and justification prepared for gubernatorial review.

The rule impact statement requirement includes reporting about measures taken to minimize compliance costs or if non-regulatory or less intrusive measures may achieve the same result. This should be an important principle for nutrient criteria development. Nutrient criteria, if implemented in a draconian fashion, could cause widespread economic impact to municipalities and to agricultural non-point nutrient sources. On the other hand the consequences of not establishing protective nutrient criteria are also very great. Therefore, criteria for those waters not needing the additional protection of Tier II or III anti-degradation requirements should not be any more stringent than is needed to protect the designated beneficial uses to help minimize economic impacts.

Extended implementation time frames may be considered as means for reducing the impacts to municipalities and to allow implementation of nonpoint source controls. This strategy has already been exercised with the phosphorus criterion adopted for Oklahoma Scenic Rivers. Another strategy may be to allow for delayed implementation while use-attainability and site-specific criteria options are explored to insure that the criterion is appropriate.

13. Plan Revision Process and Schedule .

This update of the Oklahoma Nutrient Criteria Development plan was provided to the EPA as an indication of the OWRB staff efforts to develop and adopt nutrient criteria into the OWQS. The OWRB will provide drafts of criteria for EPA review throughout the process and invite EPA staff to participate in the workgroups. From time to time, due to

new information, research, technical input, public input, changing resources and schedule updates, revisions or updates to the plan may be necessary. OWRB will update the plan when significant changes in the milestones or in the developmental approach occur. Notification of revisions will be provided via letter to the EPA Region VI Water Quality Standards coordinator for Oklahoma and the nutrient criteria coordinator.

Nutrient Criteria Development Work Programs and Funding

Nutrient criteria development is proving to be a substantial burden to the state. Criteria development has been funded with a single $80,000 104(b)(3) grant and a $30,000 grant to initiate periphyton monitoring. Nutrient criteria development is currently being conducted with state funds. Lacking other funding, data collection and analysis is dependant upon the ODEQ TMDLs, OCC 319(h) monitoring and the OWRB BUMP program. The probabilistic monitoring projects promoted by EPA are expected to provide substantial data with much greater utility for criteria development. The rulemaking administrative tasks associated with Water Quality Standards revisions are partially funded with a $60,000 annual 604(b) annual grant. Funding sources need to be found for algae identification and enumeration and for monitoring algal toxins. Additonal funds are needed for individual lake assessments to determine impacts and impairments due to excess nutrients and algae.

Critical limiting factors for criteria development are data availability and basic research to lay as a foundation for criteria. The available guidance outside of that published for each ecoregion based upon percentiles is scarce. Literature available to help establish nutrient and chlorophyll criteria based upon protecting beneficial uses is limited and stops short of what is needed to easily promulgate criteria with confidence. The first task of criteria development is to review the available research published to build a technical basis .

Stream data in Oklahoma suitable to establish nutrient criteria are very limited. Periphyton collections are limited to only a few special studies. Most Oklahoma stream has been collected from periphytometers constructed from glass rods or glass slides. These apparatus assess short-term algae growth rather than the algae standing crop. Also available on a limited basis, are sestonic algae concentration and diurnal dissolved oxygen monitoring. The lack of sites with a full complement of long-term nutrient, diurnal dissolved oxygen, periphyton, fish and invertebrate data over a range of perceived impairments is of major consequence.

Additional funds will be required in order to complete criteria development where extensive modeling and data collection are required. To generate the data ideally needed for developing nutrient criteria, annual funding for each missing parameter may range from $50 thousand to over $500 thousand. These data would include even more extensive stream productivity data sets, and the biological and sociological response to increased productivity. Specific data is needed to relate increased productivity to impairment of specific beneficial uses such as diurnal DO and pH changes in the benthic invertebrate fish and algae communities. Public perception of lake water quality

and taste and odor need to be assessed for to determine aesthetics beneficial use impairment thresholds. Public water supply treatment costs and concurrent monitoring for geosmin, MIB and microrcystins are critical to determine impairment thresholds for public water supplies. These funds would supplement the data routinely collected by existing ambient monitoring programs.

Conclusions

So far, progress toward Oklahoma's goals for nutrient criteria outlined in this plan has been relatively smooth. It was relatively easy to establish a numerical phosphorus criterion for Oklahoma's Scenic Rivers. Scenic rivers are a political designation, so criteria was determined following EPA guidance and public policy decisions. It is hard to argue that Scenic Rivers should not have criteria at least as stringent as concentrations in unimpaired streams. The process to promulgate chlorophyll-a criterion to protect Public and Private Water Supplies was also fairly efficient, with only one formal comment received in opposition to the proposal.

More difficult will be development of viable TSI criteria or chlorophyll criteria for the remainder of Oklahoma's lakes. Are multiple criteria necessary, or will one criterion suffice for the entire state? Even more difficult will be the development of viable conversions from TSI criteria to allowable phosphorus loading. Loading must be obtained in order to implement TSI criteria through TMDL.

Viable statewide or even viable ecoregional nutrient criteria for streams will be difficult to develop and defend to nutrient sources who will face substantial economic hardship as criteria are implemented. Furthermore, nutrient criteria for streams that are not Scenic Rivers is of lower priority compared to lake criteria. Lakes are more sensitive than streams, and beneficial use impairment on lakes has more and greater long-term consequences. Therefore, state nutrient criteria development resources should be primarily expended on lakes criteria development over the next few years.