Introduction

In New England, there are hundreds of lakes and reservoirs identified as not meeting water quality standards because of excessive nutrient loading, and according to state 305(b) reports, hundreds more are considered threatened. Excessive nutrient concentrations in the water column can fuel undesirable growths of algae, and excessive accumulations in the sediment can promote nuisance growths of rooted aquatic plants. Such conditions may interfere with recreational and aquatic life uses and may also reduce the aesthetic quality of these waters. Section 303(d) of the Clean Water Act (CWA) and its implementing regulations (40 C.F.R. § 130.7) require states to identify waters that do not or will not meet applicable water quality standards after the application of technology-based or other required controls, and to establish Total Maximum Daily Loads (TMDLs) for pollutants that are causing non-attainment of water quality standards. In addition, the TMDL process offers an excellent opportunity to protect water quality in lakes and reservoirs. The potential effectiveness of pollutant load controls is greater and more cost-efficient in a protection mode rather than in a restoration mode.

Successful TMDL development and EPA approval requires a clear understanding of the regulatory requirements and the type/extent of information that EPA needs to conduct its review. The purpose of this document is to provide guidance on TMDL submission requirements with respect to nutrients and lakes. Most of the concepts in this document also apply to TMDL development for reservoirs. This document is presented in three sections. Part I of this document presents an overview of TMDLs and the TMDL process. Part II of this document presents the TMDL submission requirements as they relate to nutrients and lakes. Part III of this document presents a hypothetical example of a lake nutrient TMDL for the purpose of explaining the technical components of the TMDL submission requirements.

Part I

The TMDL Process

TMDL Requirements

Section 303(d) of the CWA and the implementing regulations (40 C.F.R. § 130.7) require states to develop TMDLs for waters where required point and nonpoint source pollution controls are not stringent enough to attain or maintain compliance with state water quality standards after the application of technology based and other required controls (see Appendix A for copies of CWA § 303(d) and 40 C.F.R. § 130.7). A TMDL establishes the maximum amount of a pollutant that may be introduced into a waterbody while still ensuring attainment and maintenance of water quality standards. A TMDL needs to account for seasonal variation and must include a margin of safety (MOS). The MOS is a safety factor that accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Also, a TMDL must specify pollutant load allocations among sources. The total of all allocations, including wasteload allocations (WLA) for point sources, load allocations (LA) for nonpoint sources (including natural background), and the MOS (if explicitly defined) cannot exceed the maximum allowable pollutant load:

TMDL = 3WLAs + 3LAs + MOS

The process for establishing TMDLs, as outlined in section 303(d) and the implementing regulations is an integral component of the Clean Water Act's surface water quality management requirements. The reader is encouraged to refer to EPA's 1991 guidance document: *"Guidance for Water Quality- based Decisions: The TMDL Process"* for a more complete description of the program. In EPA's view, the TMDL process is intended to protect all waters from excessive pollutant loading, regardless of sources, and to ensure attainment of all applicable water quality standards including narrative criteria. States have the primary responsibility for developing TMDLs and submitting them to EPA for review and approval. If EPA disapproves a TMDL, EPA is required to establish the TMDL.

Public participation is encouraged throughout the TMDL process. This is particularly important for many New England lakes, where excessive nutrient loading is primarily a result of nonpoint sources of pollution. In such cases, active involvement from the public and at the local government level will be essential in achieving the goals of the TMDL process. To facilitate stakeholder involvement, TMDL development should include public awareness and participation from the beginning. At a minimum, the public must be given an opportunity to review and comment on TMDLs before they are formally submitted to EPA for approval.

Technical Guidance

EPA believes that ample technical guidance exists that describes a variety of methods that are appropriate for estimating nutrient loading and lake response. *The Lake and Reservoir Restoration Guidance Manual (EPA-440/4-90-006, August 1990)* is a useful technical resource. A third edition of this document will be released in 2000. EPA's Office of Water is currently developing a protocol for developing nutrient TMDLs. The protocol will present a technical framework for developing nutrient TMDLs for streams, rivers, and lakes. EPA anticipates that the protocol will be particularly useful to the TMDL developer because it will describe a series of technical steps that will aid in the development of an approvable TMDL.

Scope of TMDL Studies

The level of effort necessary to address water quality problems through TMDL development will vary considerably. TMDLs can range from basic dilution calculations for water quality-based effluent limits to complex multi-source, time-varying water quality modeling analyses. EPA suggests that the level of effort should be determined on a case-by-case basis depending on factors such as waterbody type, watershed size and complexity, scientific understanding of the problem, the nature of the pollutant involved, the extent of available data, the number and types of sources, and the potential cost of controls needed to correct the water quality problem(s).

TMDLs should be based on available water quality data, supplementary information, and investigative studies. In many cases, simple analytical approaches provide an adequate basis for pollutant assessment and implementation planning. In some situations, however, complex analyses and modeling are necessary to better understand the relationship between pollutant loading and waterbody impairments. When information necessary to draw conclusions on the relationship between pollutant loading and water quality is limited, TMDLs may be developed through a phased or "adaptive management" approach. Such an approach allows for the establishment of the TMDL while additional data collection and analysis are conducted. Thus, the TMDL provides an estimate of necessary load reductions based upon available data and information. In this approach, post-implementation monitoring is critical to determine whether further load reductions are necessary.

TMDL generation should not be viewed as a one-time effort that results in an allowable loading estimate that is 100 percent accurate. This is particularly important when dealing with waters that are impaired by nonpoint sources, as variability is inevitable. Providing that a TMDL utilizes available data and information along with a sound and rational technical approach, the TMDL can successfully support the implementation of pollutant control activities even when based upon limited information and rough estimates. The TMDL process for such waters will serve as an overall plan or road map that will be the basis for mobilizing stakeholders and ultimately improving water quality. Actions that are likely to result from initial TMDL development include additional monitoring to fill data gaps, more complete and thorough identification of pollutant sources within the watershed, initiation or expansion of public education programs, and implementation of best management practices.

Benefits of the TMDL Process for New England Lakes and Reservoirs

Depending on the state's approach, there are numerous potential benefits associated with the TMDL process. First, the TMDL framework offers an excellent opportunity to involve and educate watershed residents and stakeholders on lake water quality issues. Well informed watershed advocates can be instrumental in defining water quality goals, collecting additional monitoring data, and identifying pollutant sources within the watershed. Second, the process can be used in a protection mode, by setting water quality targets designed to maintain high water quality and specifying cost-effective pollutant control measures that can be implemented as development occurs. Some other potential benefits of the TMDL process may include:

- encourages states to develop a consistent framework for conducting lake water quality studies and a state-wide lake management strategy;

- defines existing conditions, water quality impairments, and water quality goals for a given waterbody;

- provides a useful framework for assessing future impacts to lake water quality;

- focuses monitoring activities on filling data gaps;

- accelerates the schedule at which impaired lakes are addressed through more effective coordination of existing and future resources among local entities, state, and federal environmental agencies;

- engages the public more fully in all aspects of lake management

- provides a basis for revising local regulations (e.g., zoning and sub-division) and developing performance based standards for future development; and

- may incorporate pertinent water quality improvement activities into a Master Plan at the local government level;

Part II

TMDL Submission Requirements

Nutrients and Lakes

Section 303(d) of the CWA and the implementing regulations at 40 C.F.R. § 130.7 describe the statutory and regulatory requirements for approvable TMDLs. The following information is generally necessary for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations, and should be included in the submittal package. Use of the verb "must" below denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. The necessary information and items to be included in a TMDL submission are described under the following 12 headings:

1. Description of Waterbody, Priority Ranking, Pollutant of Concern, and Pollutant Sources
2. Description of Applicable Water Quality Standards and the Numeric Water Quality Target
3. Loading Capacity - Linking Water Quality and Pollutant Sources
4. Load Allocations (LAs)
5. Wasteload Allocations (WLAs)
6. Margin of Safety (MOS)
7. Seasonal Variation
8. Monitoring plan for TMDLs Developed Under the Phased Approach
9. Implementation Plans
10. Reasonable Assurances
11. Public Participation
12. Submittal Letter

1. Description of Waterbody, Priority Ranking, Pollutant of Concern, and Pollutant Sources

The TMDL analytical document must identify the waterbody as it appears on the State's 303(d) list, the pollutant of concern, and the priority ranking of the waterbody. The TMDL submittal must include a description of the point and nonpoint sources of the pollutant of concern, including the magnitude and location of the sources. EPA recommends that the TMDL identifies source categories, subcategories, and individual sources consistent with how WLAs and LAs are being established. States are encouraged to describe sources in as much detail as is practical given available information. Such information is necessary for EPA's review of the load and wasteload allocations, which are required by regulation.

For lake nutrient TMDLs, it is important to consider all sources important to the overall loading analysis. Source categories may include watershed load by sub-watershed and/or landuse category, atmospheric deposition on the lake surface, point sources, internal recycling from lake sediments, waterfowl and other potential sources. It is not necessary to identify and quantify sources that are determined to be insignificant.

Where it is possible to meaningfully separate natural background from nonpoint sources, a description of the natural background must be provided, including the magnitude and location of the source(s). Natural background could be estimated by using nutrient data from reference watersheds or by using literature-derived export coefficients/tributary concentrations for undisturbed forested watersheds. If separation is not feasible, the reasons for not separating natural background from nonpoint sources should be provided (see example in Part III, page 13).

The TMDL submittal should also contain a description of any important assumptions made in developing the TMDL, such as: (1) the assumed distribution of land use in the watershed; (2) population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources; (3) present and future growth trends, if taken into consideration in preparing the TMDL; (4) the extent to which values are extrapolated from sources other than watershed-specific data; and, (5) an explanation and analytical basis for expressing the TMDL through *surrogate measures*, if applicable. *Surrogate measures* are parameters such as chlorophyl *a* and phosphorus loading that may indicate excess algae.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Targets

The TMDL submittal must include a description of the applicable State water quality standards, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criteria, and the antidegradation policy, if relevant. Such information is necessary for EPA's review of the load and wasteload allocations, which are required by regulation. A numeric water quality target for the TMDL (a quantitative value used to measure whether or not the applicable water quality standard is attained) must be identified.

Where a numeric nutrient criterion for a pollutant does not exist in the state's water quality standards, it will be necessary to interpret a narrative standard by using a water quality indicator (e.g., in-lake total phosphorus concentration during springtime) and selecting an appropriate numeric target that will be sufficient for attaining water quality standards. It is important that the basis for selecting the numeric target in relation to attaining water quality standards is fully described in the TMDL.

3. Loading Capacity - Linking Water Quality and Pollutant Sources

As described in EPA guidance, a TMDL identifies the loading capacity of a waterbody for a particular pollutant. EPA regulations define loading capacity as the greatest amount of loading that a waterbody can receive without violating water quality standards (40 C.F.R. § 130.2(f)). For impaired waterbodies, the loading capacity will define the overall pollutant reductions that are necessary to attain water quality standards. For threatened waterbodies, the loading capacity should comply with state antidegradation policies and protect high water quality, and in some circumstances, could be set equal to existing loading. The loadings are required to be expressed as either mass-per-time, toxicity or some other appropriate measure (40 C.F.R. § 130.2(i)). As the term implies, TMDLs are typically expressed as total maximum daily loads. Where the TMDL is expressed in terms other than daily load, there should be an explanation as to why such an approach is appropriate.
For example, in the case of many lakes, it is appropriate and justifiable to express a nutrient TMDL in terms of allowable annual loadings because long-term average pollutant loadings are typically more critical to overall lake

water quality. The hydraulic residence time is a critical concept for lakes, as it influences so many aspects of lake condition and pollutant processing. The Hydraulic residence time is almost never on a scale of a day, but rather on a scale of weeks, months, or sometimes years. For many New England lakes, long hydraulic residence times justify expressing the TMDL in terms of annual loading. However, regardless of hydraulic residence time, an annual scale may be reasonable where the lack of information prevents any kind of meaningful monthly or seasonal analysis. Also, most of the available empirical lake models use annual loads rather than daily loads to estimate in-lake concentrations, and the overall accuracy of an analysis involving nonpoint source loading and lake water quality typically improves as the averaging period for estimating nonpoint source loading and lake water quality increases.

The TMDL submittal must identify the waterbody's loading capacity for the applicable pollutant and describe the rationale for the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources. In most instances, this method will be a water quality model. Supporting documentation for the TMDL analysis also must be contained in the submittal, including the basis for assumptions, strengths and weaknesses in the analytical process, results from water quality modeling, etc. (See the example in Part III (page 14).

In many circumstances, a *critical condition* must be described and related to physical conditions in the waterbody as part of the analysis of loading capacity (40 C.F.R. § 130.7(c)(1)). *Critical conditions* are important because they describe the factors that combine to make the greatest impact on water quality and will help in identifying the actions that may be necessary to meet water quality standards. In most New England lakes impacted by excessive nutrient loading, critical conditions typically occur during summer, when nuisance algal blooms and macrophyte growths are most common.

4. Load Allocations (LAs)

EPA regulations require that a TMDL include LAs, which identify the portion of the loading capacity allocated to existing and future nonpoint sources and to natural background (40 C.F.R. § 130.2(g)). Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. § 130.2(g)). Where it is possible to separate natural background from nonpoint sources, load allocations should be described separately for background and for nonpoint sources. LAs should be as source specific as is practical considering existing information. For example, LAs could be allocated to sub-watersheds, categories of sources (e.g., agricultural land), subcategories of sources (e.g., row crop agriculture), or individual sources (e.g., specific farm). If a single nonpoint source (e.g., storm water runoff from a specific land area) has been quantified and shown to be a significant contributor of the pollutant of concern, then it may be useful to establish an individual LA for this source.

5. Wasteload Allocations (WLAs)

EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to existing and future point sources (40 C.F.R. § 130.2(h)). If no point sources are present or if the TMDL recommends a zero WLA for point sources, the WLA must be expressed as zero. The TMDL should provide the rationale for a zero WLA since it implies that there are no point sources, that all existing point sources will be eliminated, or that none will be allowed.

In preparing wasteload allocations, industrial and municipal point source facilities with individual NPDES permits must receive individual WLAs. WLAs for point sources subject to a general permit (e.g., storm water) may be allocated to the category of sources subject to the general permit, a subcategory of those sources, or the individual sources. Pollutant loads that do not need to be reduced to attain or maintain water quality standards can be included within a category of sources, a subcategory of sources, or considered as part of the background loads.

The TMDL submittal also should discuss whether a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur. In such cases, the state will need to demonstrate reasonable assurance that the nonpoint source reductions will occur within a reasonable time. Reasonable assurance is discussed below in item 10.

6. Margin of Safety (MOS)

The statute and regulations require that a TMDL include a margin of safety to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA § 303(d)(1)(C), 40 C.F.R. § 130.7(c)(1)). EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis), or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set-aside for the MOS must be identified. The rationale for selecting the MOS and its adequacy must be included in the TMDL submittal.

As indicated, an explicit MOS would include setting a portion of the loading capacity aside as the MOS (i.e., not allocated to any source). Examples of an implicit margin of safety include the use of conservative assumptions in selecting a numeric water quality target and predicting the performance of best management practices. A related implicit MOS is the use of conservative design criteria for the sizing of best management practices.

7. Seasonal Variation

The statute and regulations require that a TMDL considers seasonal variation. The method chosen for including seasonal variation in the TMDL must be described (CWA § 303(d)(1)(C), 40 C.F.R. § 130.7(c)(1)). The

TMDL needs to provide an explanation of why the TMDL, when implemented, will be protective during all seasons. For example, a lake nutrient TMDL expressed as an annual load and developed to be protective of the most sensitive time of year will ensure attainment with water quality standards during all seasons. See Part III for an example (page 15) of an adequate discussion of seasonal variation for a lake nutrient TMDL. For lakes with very short detention times and pollutant sources that vary significantly among seasons it may be appropriate to set more than one TMDL to address seasonal variation. This practice is common in riverine systems with respect to maintaining dissolved oxygen levels where the loading capacity varies considerably between the winter and summer seasons.

For nonpoint source-impaired lakes, seasonal variation should also be accounted for in the design of best management practices. BMPs should be designed to accommodate peak loading rates that may occur during the season when loadings are typically highest. For example, phosphorus loading may be highest during early spring when vegetative cover is at a minimum and spring snow-melt results in high runoff rates and increased export of phosphorus-laden soils. Such conditions may set a waterbody up for a summer of nuisance algal blooms or may provide nutrient-rich sediments that fuel nuisance growths of rooted aquatic plants.

8. Monitoring Plan for TMDLs Developed Under the Phased Approach

EPA's 1991 document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA 440/4-91-001), recommends a monitoring plan when a TMDL is developed under the phased approach. The guidance recommends that a TMDL developed under the phased approach also should provide assurances that nonpoint source controls will achieve expected load reductions. The phased approach is appropriate when a TMDL is based on limited information and when there is considerable uncertainty associated with the analysis. EPA's guidance provides that a TMDL developed under the phased approach should include a monitoring plan that describes the additional data necessary to determine if the load reductions required by the TMDL will lead to attainment of water quality standards.

The phased approach is often appropriate for lake nutrient TMDLs considering the highly variable nature of nonpoint source pollutant loading assessments. This approach allows the TMDL to be refined, if necessary, as new information becomes available following implementation of needed controls. A monitoring plan associated with lake nutrient TMDLs offers an opportunity to focus existing monitoring activities in the watershed toward achieving the common goals of assessing and improving lake water quality. Some lakes have active watershed or lake associations that routinely collect water quality data and information. The monitoring plan could outline how collaborative monitoring efforts could be used to better define sources, target sources for control actions, evaluate the effectiveness of controls, and ultimately assess the adequacy of the TMDL.

9. Implementation Plans

On August 8, 1997, Bob Perciasepe (EPA Assistant Administrator for the Office of Water) issued a memorandum, "New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs)," (see Appendix B) that directs Regions to work in partnership with states/tribes to achieve nonpoint source load

allocations established for 303(d)-listed waters impaired solely or primarily by nonpoint sources. To this end, the memorandum asks that regions assist states in developing implementation plans that include reasonable assurances that the nonpoint source load allocations established in TMDLs for waters impaired solely or primarily by nonpoint sources will be achieved. The memorandum also includes a renewed focus on the public participation process and recognition of other relevant watershed management processes used in the TMDL process. Although implementation plans are not approved by EPA, they help establish the basis for EPA's approval of TMDLs. Review of implementation plans aids EPA's evaluation of the feasibility and reasonable assurance that WLAs and LAs will be attained.

Ideally, lake TMDL implementation plans will clearly identify mechanisms for implementing nutrient reduction activities and will outline a process that describes how the necessary nonpoint source reductions will be achieved. EPA recognizes that achieving nonpoint source reductions is often a resource intensive process that involves extensive planning, education and cooperative efforts among stakeholders, landowners and government agencies. States are encouraged, when necessary, to identify how they intend to solicit input and involvement from local groups. It is beneficial to identify key groups that are active in the watershed and may play an important role in the implementation of control actions.

The Congress of Lake Associations and the Maine Department of Environmental Protection have developed a useful *Citizens Guide to Lake Watershed Surveys* that instructs concerned citizens on how to conduct a nonpoint source phosphorus survey. This has been an effective approach for the State of Maine in directing citizen efforts to identify and ultimately control nonpoint sources of phosphorus. Maine's approach represents an excellent example of a key component to a meaningful lake TMDL implementation plan where nonpoint sources dominate.

10. Reasonable Assurances

EPA guidance calls for reasonable assurances when TMDLs are developed for waters impaired by both point and nonpoint sources. In a waterbody impaired by both point and nonpoint sources, where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur, reasonable assurance that the nonpoint source reductions will occur must be explained in order for the TMDL to be approvable. This information is necessary for EPA to determine that the load and wasteload allocations will achieve water quality standards.

In a waterbody impaired solely by nonpoint sources, reasonable assurances that load reductions will be achieved are not required in order for a TMDL to be approvable. However, for such nonpoint source-impaired waters, states are strongly encouraged to provide reasonable assurances regarding achievement of load allocations in the implementation plans described in section 9, above. As described in the August 8, 1997 Perciasepe memorandum, such reasonable assurances should be included in state implementation plans and "may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs."

11. Public Participation

EPA policy is that there must be full and meaningful public participation in the TMDL development process. Each state must, therefore, provide for public participation consistent with its own continuing planning process and public participation requirements (40 C.F.R. § 130.7(c)(1)(ii)). EPA guidance explains that final TMDLs submitted to EPA for review and approval must describe the State's public participation process, including a summary of significant comments and the state responses to those comments. When EPA establishes a TMDL, EPA regulations require EPA to publish a notice seeking public comment (40 C.F.R. § 130.7(d)(2)).

Inadequate public participation could be a basis for disapproving a TMDL; however, when EPA determines that a state has not provided adequate public participation, EPA may defer its approval action until adequate public participation has been provided, either by the state/tribe or by EPA.

12. Submittal Letter

A submittal letter should be included with the TMDL analytical document, and should specify whether the TMDL is being submitted for a *technical review* or is a *final submittal*. Each final TMDL submitted to EPA must be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's intent to submit and EPA's duty to review the TMDL under the statute. The submittal letter, whether for technical review or final submittal, should contain such information as the name and location of the waterbody, the pollutant(s) of concern, and the priority ranking of the waterbody as defined in the most recent 303(d) list.

Part III

Example Lake Nutrient TMDL (Hypothetical)

As previously discussed, TMDLs are based on available water quality data, information and studies. In some cases, simple analytical approaches provide an adequate basis for pollutant assessment and implementation planning. In other cases, complex analyses and modeling are necessary to better understand the relationship between pollutant loading and waterbody impairments. For the purpose of interpreting the technical components of the TMDL submission requirements (Items 1 through 7), the following is a simple hypothetical example of a lake nutrient TMDL. [Although not provided in this example, items 8-12 should or must be included in all TMDL submittals.]

1. Description of Waterbody, Priority Ranking, Pollutant of Concern, and Pollutant Sources

Description of Waterbody
Green Lake is approximately 300 acres in size and is located in southern New England. The lake has a mean depth of 3m and a hydraulic residence time of 0.5 years. An increase in the frequency and severity of nuisance algal blooms has prompted the state to include this water its 303(d) list. Designated uses for this water include primary/secondary contact recreation and fish/wildlife habitat. Existing uses at Green Lake include fishing, swimming, boating, and fish/wildlife habitat. Based upon the most recent land use data, land use in the 4000 acre watershed is 70% forest, 20% urban, and 10% agriculture. Point sources are absent. Recent in-lake water quality monitoring data was available for two consecutive years, but tributary data was minimal. [Although not included in this example, it is helpful to include information such as watershed maps, landuse maps, and any other pertinent background information.]

Priority Ranking
Green Lake is listed as targeted (highest priority) on the 303(d) list.

Pollutant of Concern
The Green Lake TMDL has been developed for total phosphorus, as phosphorus was determined to be the limiting nutrient to algal growth in this system.

Pollutant Sources
The present phosphorus load was estimated and allocated among watershed sub-basins and atmospheric deposition. The watershed load was estimated by using literature derived export coefficients for forest, urban, and agricultural landuse categories. The atmospheric load was estimated by using a literature derived export coefficient for watersheds dominated by forested land. It is our professional opinion, based upon experience with other lakes in the region, that the selected export coefficients are appropriate for the application lake. Results of this analysis indicated that the present phosphorus load was 380 kg/yr. [Although not included in this example, a table documenting loadings among the various source categories should also be provided.]

Although not explicitly specified in the mass balance, it is important to note that the relative contribution of other sources of phosphorus loading (e.g., internal recycling, waterfowl) were considered. This assessment was based upon two years of in-lake monitoring data, a watershed/atmospheric loading estimate as described above, and an empirical phosphorus retention model. This particular empirical model has been used quite extensively in our state and has proven to be effective in linking a total phosphorus load to an in-lake concentration. Additionally, hydraulic and morphometric features of Green Lake were within the bounds of the model development data set. Results of this assessment revealed that the empirically predicted in-lake phosphorus concentration (28 ug/L) was not significantly different from the average of in-lake monitoring data (25 ug/L). This indicates that sources other than watershed and atmospheric loading are insignificant to the overall phosphorus budget.

Natural Background

Natural background was not separated from the total nonpoint source load because of the limited and general nature of available information. Without more and detailed site specific information on nonpoint source loading, it is very difficult to meaningfully separate natural background from the total nonpoint source load.

2. Description of Applicable Water Quality Standards and Numeric Water Quality Target

State Water Quality Standard

The state water quality standard for nutrients, which is narrative, is as follows: None in such concentration that would impair any usages specifically assigned to said Class, or cause undesirable or nuisance aquatic species associated with cultural eutrophication.

Designated Uses

Green Lake is designated as a Class B water in the state water quality regulations. Designated uses for Class B waters include primary/secondary contact recreation and fish/wildlife habitat.

Numeric Water Quality Target

The numeric water quality target for Green lake is 20ug/L of total phosphorus during springtime. Since numeric criteria for phosphorus do not exist in the state water quality regulations, we used best professional judgment to select a target in-lake phosphorus concentration that would result in attainment of the narrative water quality standard. An empirical equation linking in-lake phosphorus to chlorophyll a indicated that a springtime phosphorus concentration of 20 ug/L would result in an average in-lake growing season chlorophyll a concentration of 6 ug/L. It is our professional opinion, based upon experience with other lakes in the region, that an average in-lake growing season chlorophyll a concentration of 6 ug/L will result in attainment of the state water quality standard for nutrients. It is important to note, the aforementioned empirical equation has proven to be appropriate for lakes in our state.

Antidegradation Policy

The state's antidegradation policy requires that existing uses and the level of water quality necessary to support existing uses will be maintained and protected. Existing uses at Green Lake include fishing, swimming, boating, and fish/wildlife habitat.

3. Loading Capacity - Linking Water Quality and Pollutant Sources

Loading Capacity

The loading capacity was set at 300 kg/yr of total phosphorus. As indicated, the Green Lake TMDL is expressed as an annual load as opposed to a daily load. As specified in 40 C.F.R. 130.2(i), TMDLs may be expressed in terms of either mass per unit time, toxicity or other appropriate measures. It is appropriate and justifiable to express the Green Lake TMDL as an annual load because Green Lake has a relatively long hydraulic residence time (0.5 years), and is more greatly influenced by average annual loading.

Linking pollutant loading to a numeric target

The loading capacity was set at 300 kg/yr of total phosphorus in order to meet the numeric water quality target of 20 ug/L of total phosphorus during springtime. A phosphorus retention model, calibrated to in-lake phosphorus data, was used to link phosphorus loading to the numeric target.

Supporting documentation for the TMDL analysis

Although not included in this example, supporting documentation for the TMDL analysis should be provided. Supporting documentation for Green Lake would include: water quality monitoring data, watershed/landuse maps, literature derived export coefficients, specification of phosphorus retention model (including both the empirical and observed retention coefficients), specification of empirical equation used to link in-lake phosphorus to chlorophyll a, and any other pertinent information that supports the development of the TMDL.

Strengths/Weakness in the overall analytical process

The Green Lake TMDL was developed by using existing data, literature derived export coefficients, a phosphorus retention model (incorporating both the empirical and observed retention coefficients), and an empirical equation linking in-lake phosphorus to chlorophyll a (algal biomass).

Strengths:

-Approach is commonly accepted practice in lake management
-Made best use of available data
-Export coefficients were derived from extensive data bases, and were determined to be appropriate for the application lake
-Based upon experience with other lakes in the region, both the empirical phosphorus retention model and the empirical equation linking in-lake P to chlorophyll a were determined to be appropriate for the application lake

Weaknesses:

-Greater uncertainty when compared to studies with extensive multi-year water quality monitoring data

Critical Conditions
Critical conditions in Green Lake occur during summertime, when the frequency and occurrence of nuisance algal blooms are greatest. The loading capacity was set to achieve water quality standards during this critical time period, and will also be protective throughout the year.

4. Load Allocations (LAs)

The load allocation for all existing and future nonpoint sources is 300 kg/yr of total phosphorus. [Although not included in this example, a table documenting load allocations by source category should also be provided.] As discussed earlier, it was not feasible to meaningfully separate natural background from nonpoint sources in this watershed because of the limited and general nature of available information.

5. Wasteload Allocations (WLAs)

There are no point sources in the Green Lake watershed. The Wasteload allocation for all existing and future point sources is 0 kg/yr of total phosphorus.

6. Margin of Safety (MOS)

An implicit MOS was incorporated into the Green Lake TMDL. First, implicit MOS is provided in the conservative selection of the numeric water quality target. The numeric water quality target was set to achieve a mean growing season chlorophyll a concentration of 6 ug/L. Based upon experience with other lakes in the region, we have documented that mean growing season chlorophyll a concentrations as high as 8 ug/L will fully support the state water quality standard for nutrients. Second, implicit MOS is provided in the conservative selection of design criteria for Best Management Practices. BMPs proposed for the Green Lake watershed have estimated phosphorus removal efficiencies of 40-60%. We have conservatively used the 40% figure in all of our calculations. [Although not included in this example, specific BMPs should be presented in the Implementation Plan or as part of the Load Allocation.]

The state is confident that the MOS provided in this TMDL is sufficient to ensure attainment of water quality standards. Although not considered MOS, it is important to note that post implementation monitoring will be conducted to evaluate the adequacy of the TMDL and the effectiveness of BMPs at improving water quality.

7. Seasonal Variation

The Green Lake TMDL is protective of all seasons, as the allowable annual load was developed to be protective of the most sensitive time of year (summer). With a hydraulic residence time of 0.5 years, average annual phosphorus loading is most critical to overall water quality in Green Lake. Finally, BMPs proposed for the Green Lake watershed have been designed to address loading during all seasons.