New York State Department of Environmental Conservation
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Commissioner

MEMORANDUM

TO: Regional Water Engineers, Bureau Directors and Section Chiefs

SUBJECT: Division of Water Technical and Operational Guidance Series (1.3.6)

PHOSPHORUS REMOVAL REQUIREMENTS FOR WASTEWATER DISCHARGES TO LAKES AND LAKE WATERSHEDS

(originator: Jay Bloomfield)

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PURPOSE

The purpose of this document is to provide guidance, which when followed, should result in the maintenance of the present blend of usage of lakes and other ponded waters in the State. The present uses include potable water supply, warm and cold water fishing opportunities, boating, swimming and aesthetic enjoyment of the lake and shoreline environment. This goal will be accomplished by limiting the amount of phosphorus that can be discharged either directly to a ponded water or anywhere in its watershed. This purpose is consistent with the **Department's Water Quality Antidegradation Policy** (ORGANIZATION AND DELEGATION MEMORANDUM NO. 85-40, 9 September 1985).

BACKGROUND

Lakes, ponds and reservoirs must be managed differently than flowing waters because of their retention of certain pollutants. With regard to the discharge of both certain conventional pollutants (BOD, fecal bacteria, etc.) and toxic substances (trace metals and synthetic organics), the analysis of the magnitude of the impact of a discharge can be conducted in a similar fashion for ponded and flowing waters. However, certain problems are more typical of ponded waters. These problems include:

1. Excess turbidity, caused by a combination of planktonic algae, dissolved organic matter, suspended calcium carbonate particles and inorganic silt.

2. Low dissolved oxygen and high levels of reduced substances (ammonia. hydrogen sulfide. methane. etc.), caused by an unacceptable oxygen demand from either bottom sediments or the constant sedimentation of dead algal cells from the overlying waters.

3. Excess growth of both exotic and native aquatic rooted plants which interfere with boating and swimming.

4. A green color, floating specks, undesirable taste and offensive odors caused by planktonic algae.

Phosphorus is almost always the factor that limits the growth of algae in the State's lakes. A more detailed discussion of the relationship between phosphorus and aquatic plant growth can be found in Appendix A. Phosphorus enters the upper waters of a lake from a variety of sources and if the loadings of phosphorus are large, the lake will almost always exhibit excessive aquatic plant growth.

In contrast to the relationship between phosphorus and algal growth, the growth of rooted aquatic plants can be limited by a number of additional factors, including light, currents, wave action, water depth and sediment type. A sandy, gravelly, rocky or clay bottom is not conducive to the growth of rooted plants. However, if human activity causes the deposition of a mucky sediment that is high in nitrogen and phosphorus, the growth of aquatic plants will be stimulated. As algal cells die and sink to the lake bottom, the sediments are more likely to become enriched in nutrients and suitable for rooted plants. This process is subtle, and is not predictable by any existing theoretical or empirical model of lake dynamics.

It is our intention to limit phosphorus loadings to the State's lakes by using the concept of "Best Treatment Technology" (BTI). The Division of Water, because of recent amendments to Article 43 of the ECL, is required to prepare a Technical Manual on this topic, but only for Lake George. This manual will be completed by early 1989. In the interim, this TOGS document will serve as guidance as to what constitutes BTI phosphorus removal. Regional staff should also refer to specific chapters in the latest edition of the Division of Water publication Standards for Waste Treatment Works. Intermediate-sized Sewerage Facilities (December 1987), for the details concerning each treatment process.

In the absence of a predictive model relating phosphorus and nitrogen loadings to rooted plant growth in lakes, we have opted for a conservative approach. We have assumed that phosphorus levels are an indicator of overall lake biological productivity. The discharge of phosphorus should be controlled not only because of its known impact on algae, but also because of the possible indirect stimulus to the growth of rooted plants. This guidance will result in better management of our lakes with regard to the above problem areas. As with other environmental issues, prevention of a problem is always less costly than remediation.

GUIDANCE

In order to preserve the lakes in New York State, with regard to their physical, chemical and biological integrity, and their current multiple use benefits; and to be consistent with the need to satisfy the water quality specifications for limiting deleterious substances as described in 6 NYCRR 701.19, keeping in mind the "treatability" limitations as provided for in 6 NYCRR 701.15(b), the following is to be used as a guide to both maintain the existing generic water quality standards and give consideration to treatability limits:

1. **In lake watersheds, new discharges which are required to obtain a SPDES permit, should be treated with the Best Treatment Technology (BTT) for phosphorus removal.** BTT will vary with plant size, but generally is understood to consist of secondary treatment and chemical removal of phosphorus (using aluminum salts, iron salts or pH adjustment with lime). In order to achieve the maximum benefit from BTT the applicant should employ water conservation technology, including compliance with ECL Section 15-3014. This will help assure that land disposal sys-

tems will be capable of treating to their design capacity in times of wet soil conditions. The information regarding the water conservation plan should be sent to the Bureau of Water Resources for review, as appropriate.

The scheme for reviewing SPDES applications in lake watersheds is summarized in Table 1 and shown in Figure 1. **For discharges of 10,000 gpd or less**, either soil or subsurface disposal should be required without chemical treatment, since the chemical addition process would be problematic due to limited operator involvement and capability. Surface water discharges should not be allowed in this flow range, regardless of the proposed treatment scheme. An exception can be considered, because of hardship, for expansion of discharges from existing one or two family residences, with a total flow of less than 1000 gpd.

For discharges over 10,000 but less than 50,000 gpd, BTT should be required for both surface water and soil discharges. The effluent that is discharged should not exceed 1.0 mg/l of total phosphorus. Regardless of design flow, a technical analysis should be conducted by the applicant as to the availability of appropriate soils for land disposal of the effluent. The discharge to the ground offers beneficial redundancy to the overall treatment system. This redundancy is useful, in the event of a plant upset affecting any of the main treatment processes. Also, the soil has some limited ability to remove phosphorus, providing an additional safeguard to the target ponded water. Also, for surface discharges, if there is a choice of discharge point between the ponded water and a tributary stream, the tributary stream should be chosen. Of course, other considerations may override this choice (for example, stream flow intermittency, etc.).

For discharges over 50,000 gpd, BTT should also be required for both surface water and soil discharges and the effluent that is discharged to either the sur- face water or the soils should not exceed 0.5 mg/1 of total phosphorus. Regardless of design flow, a technical analysis should be conducted by the applicant as to the availability of appropriate soils for land disposal of the effluent.

2. **Any proposed expansion of an existing discharge within a lake watershed, which would require a modification of an existing SPDES permit, should provide BTT for phosphorus removal to a degree that the annual quantity (mass loading, flow multiplied by concentration) of phosphorus discharged after the modification does not exceed the phosphorus discharged prior to the modification.** An expansion is defined, for purposes of this TOGS, to be an increase in the effluent flow of the system.

3. This guidance should be applied to discharges to ponded waters (those with a "P" in the index number, 6 NYCRR Parts 800-941) listed in the publication **Characteristics of New York State Lakes, Gazetteer of Lakes, Ponds and Reservoirs** (NYSDEC, 1987), and their topographic watersheds, with the exception of Lakes Erie and Ontario. This exception for the Great Lakes applies to discharges covered under the Great Lakes Water Quality Agreement only if there is no intermediate ponded water between the discharge and the Great Lakes. For example, the Regional staff should apply this guidance to a new 1.0 MGD discharge proposed to a tributary of Cayuga Lake. Ponded waters that are not listed in the Gazetteer could also be considered under this guidance at the discretion of Regional Water Engineer.

4. This guidance should be applied to all surface water and soil discharges in the watershed, no matter how far away the discharge point is upstream from the target ponded water.(The rationale here is that although the soil, groundwater and tributary sediments all exhibit some retention of phosphorus, in the long run, much

of the phosphorus that is discharged in the watershed is eventually delivered to the target ponded water.) If a choice is available, the discharge point that is farthest from the lake should be selected. See number 7. below, **Exceptions.**

5. **Monitoring.** Discharges over 10,000 gpd either to lakes or in lake watersheds should be required to monitor the effluent for at least flow and total phosphorus at an appropriate interval, for compliance purposes. For purposes of assessing the remaining soil phosphorus sorption capacity in subsurface systems, the following constituents may be monitored in the groundwater and/or the unsaturated (vadose) zone of the soil, at the discretion of the Regional Water staff:

a. total phosphorus
b. total soluble phosphorus
c. groundwater level
d. total kjeldahl nitrogen
e. soluble kjeldahl nitrogen
f. ammonia nitrogen
g. nitrate nitrogen
h. electrical conductance
i. chloride

The monitoring of these additional parameters may be useful in understanding the dynamics of phosphorus removal of the particular soil treatment system.

6. **Technical Assistance.** Assistance is available through the Lake Services Section on all matters referred to in this guidance. Regional staff are urged to seek their expertise. This guidance should be construed as a minimum requirement. For example, the Region should request from the Lake Services Section to conduct an analysis of the impact of a discharge of phosphorus to a ponded water, if they suspect that BTT for phosphorus removal will not be capable of maintaining the existing usage of the waterbody. If the results of such an analysis confirm these suspicions, then the discharge should not be allowed as planned. Requests for such assistance should be included in material sent to the Bureau of Monitoring and Assessment, with regard to permit application. BMA will subsequently forward the request to the LSS.

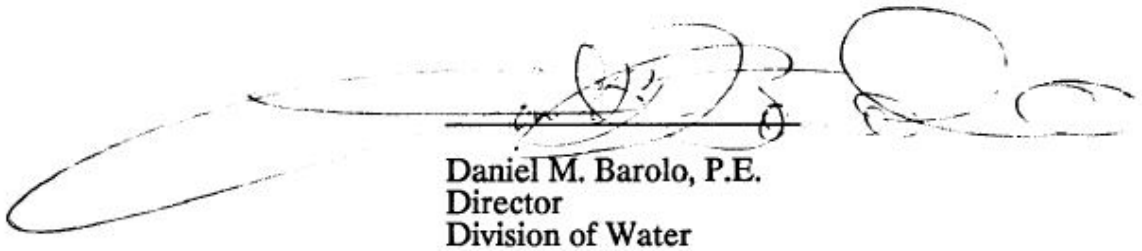
Additionally, SPDES permit applications for discharges to ponded waters or their watersheds, that have received a positive declaration under SEQR, should be transmitted to the Lake Services Section for review. This review will not only encompass the impacts of the wastewater discharge, but also any non-point source impacts that are indirectly related to the point source discharge. For example, the phosphorus, nitrogen, sediment and fecal bacteria loadings from a large subdivision, because of stormwater runoff from roads, rooftops, driveways and sidewalks may substantially overshadow the discharges from the point source.

If Regional staff are apprised of a development project which is not required to obtain a SPDES permit because it provides wastewater treatment through a number of small on-site systems, the Region should advise the lead agency on this project of the existence of this guidance document and its recommendations. It is the Division of Water's policy to discourage local governments from approving large subdivisions in lake watersheds, that rely on individual on-site systems for wastewater treatment.

7. **Exceptions.** There may be situations, that because of the overwhelming nature of nonpoint source or natural loadings of phosphorus, that certain small discharges that are distant from the lake may not require BTT P removal. A criterion that the

Regional staff can use in determining whether this guidance should apply or not is whether the requirement of BTT P removal for not only the discharge in question, but also all future discharges, would have no benefit in either restoring or protecting the target ponded water. The number and types of other future discharges should be determined based on a reasonable scenario of land development for the lake watershed. Requests by the permittee to not have this guidance apply to them must be forwarded, with supporting documents, to the Bureau of Monitoring and Assessment for review by the Lake Services Section. Requests are to include an analysis of the cumulative impact of all future discharges on the lake's algae, transparency, dissolved oxygen and rooted aquatic plants.

8. **Existing Discharges.** The Regional Water staff may apply this guidance to existing discharges which are not expanded, as appropriate. This TOGS was designed specifically for new and expanded discharges as a way of "holding the line" on existing phosphorus loadings to lakes and lake watersheds, under the assumption that the present loadings of phosphorus are unacceptable. The Regional staff should understand that it will be substantially easier, in most cases, to achieve BTI on a new facility or one that is being renovated during an expansion, than on an existing facility.



Daniel M. Barolo, P.E.
Director
Division of Water

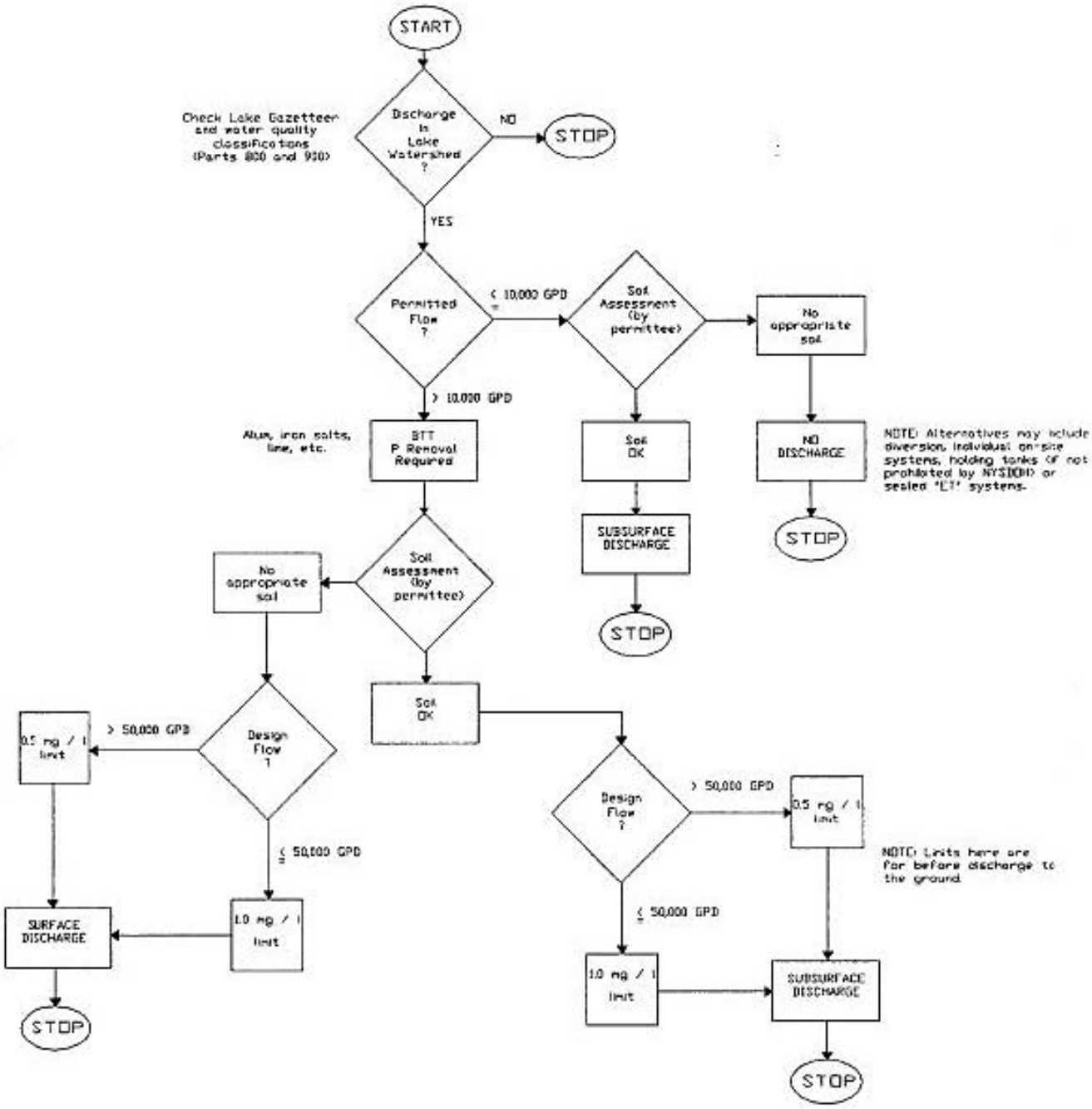
Table 1

Phosphorus Removal Requirements for Wastewater Discharges to Lakes or in Lake Watersheds

Flow (qpd)	**Required Treatment**	**Discharge types allowed**	**SPDES Total P limit (mg/l)**
A. New discharges.			
< 10,000	Primary	soil only	none
10,000 -50,000	BTT P removal	soil or surface water, but soil is preferred	1.0
> 50,000	BTT P removal	soil or surface water, but soil is preferred	0.5
B. Permit renewals with flow expansion.			
Phosphorus loading must be the same as prior to expansion.			
C. Permit renewals without flow expansion.			
Phosphorus removal should be required only if a detailed analysis conducted by the LSS at the request of the Regional staff shows removal to be necessary.			

Figure 1

Scheme for determining the type of Phosphorus Removal to be required for a new discharge in a lake watershed



APPENDIX A

Eutrophication, Nuisance Aquatic Plants and Phosphorus

Lakes, ponds and reservoirs must be managed differently than flowing waters be- cause of their retention of certain pollutants. With regard to the discharge of both certain conventional pollutants (BOD, fecal bacteria, etc.) and toxic substances (trace metals and synthetic organics), the analysis of the magnitude of the impact of a discharge can be con- ducted in a similar fashion for ponded and flowing waters. However, certain problems are more typical of ponded waters (Figure A-1). These problems include:

1. Excess turbidity, caused by a combination of planktonic algae, dissolved organic matter, suspended calcium carbonate particles and inorganic silt. The turbidity of a lake is commonly measured by using a secchi disk.

2. Low dissolved oxygen and high levels of reduced substances (ammonia. hydrogen sulfide. methane. etc.), caused by an unacceptable oxygen demand from either bot- tom sediments or the constant sedimentation of dead algal cells from the overlying waters. This problem is important primarily in waters exhibiting thermal stratification. Low oxygen levels may limit the bottom habitat available to certain types of game fish. Certain reduced substances are toxic to fish and other aquatic life. Low oxygen levels in bottom waters may also result in the release of additional phosphorus to the bottom waters. Phosphorus released from the sediments in this manner may eventually reach the upper waters of the lake.

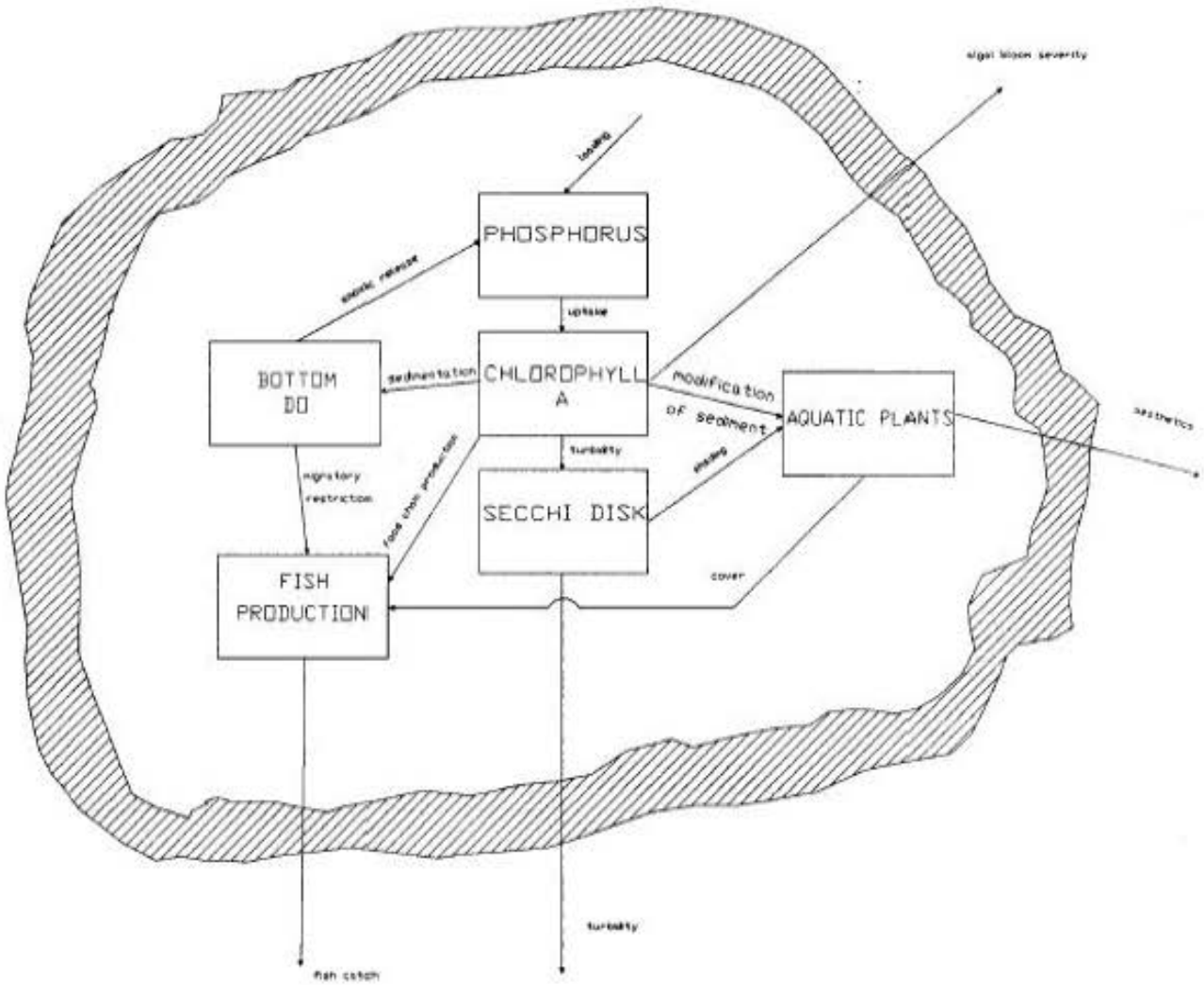
3. Excess growth of both exotic and native aquatic rooted plants which interfere with boating and swimming. It should be stressed that rooted plants are a necessary natural component of ponded waters. It is only when human activities encourage the spread of certain species that rooted plants can be considered a problem. For purposes of this document, we will define nuisance plants (often called "weeds" by the public) to be rooted aquatic plants which reach within 1 foot (approx 0.3 meters) of the surface of a ponded water, in areas where the presence of such plants substantially interferes with water-based recreation. It should be noted that nuisance plant growth in the State's lakes is only partially related to excess phosphorus levels in the water. The factors which influence nuisance plant growth are diverse. First, there must be adequate light and bottom conditions which are suitable for plant growth. Second, plants with weedy growth characteristics must be present. Exotic plants such as Eurasian watermilfoil (Myriophyllum spicatum), Curly-leaf pondweed (Potamogeton crispus), Water chestnut (Trapa natans) and Fanwort (Cabomba carolina), by definition, are not native to our waters. These species must be introduced from other waters, in order for them to cause nuisance conditions. Occasionally, native plants such as Broadleaf pondweed (P. amplifolius), Water celery (Vallisneria americana) and certain floating and emergent plants (rushs, reeds and water lilies) can be problematic, but the magnitude of this problem on a statewide basis is minimal. Often these native plants have formed large beds as a result of natural processes. When private citizens subsequently purchase shoreline property adjacent to such beds, the perception by these citizens is that the native plants constitute a nuisance. This type of situation is beyond the scope of this guidance.

4. A green color, floating specks, undesirable taste and offensive odors caused by planktonic algae. These factors are important both in terms of aesthetics and in determining the degree of treatment that raw water will need for potable use.

Phosphorus is almost always the factor that limits the growth of algae in the State's lakes. Phosphorus enters the upper waters of a lake from a variety of sources. There are low levels of phosphorus in atmospheric deposition (rain, snow and dust) and in runoff

Figure A-1

Relationship between the various components of the Lake Ecosystem



from undeveloped forested areas. These low levels would not be enough under normal conditions to sustain high levels of algae or rooted plants. Runoff from urban, suburban and agricultural areas contains more eroded soil, and hence more phosphorus.
Discharges from municipal and certain industrial wastewater treatment facilities and on-site wastewater systems ("septic systems") also contain high levels of soluble phosphorus, often at 100 to 150 times the concentrations needed to cause nuisance plant conditions in a lake. Without dilution or proper treatment, these discharges will usually lead to excess aquatic plant growth. Certain mechanisms within the lake also transport phosphorus to the upper waters. These mechanisms include disruption of the bottom sediments by wind-induced turbulence, release of phosphorus from deep bottom sediments during anoxic (no oxygen) conditions and the release of phosphorus from dying rooted aquatic plants in late summer and early fall. For these "internal" forces to be important, large amounts of phosphorus must have entered the lake initially, from the watershed.

In contrast to the relationship between phosphorus and algal growth, the growth of rooted aquatic plants can be limited by a number of additional factors, including light, currents, wave action, water depth and sediment type. A sandy, gravelly, rocky or clay bottom is not conducive to the growth of rooted plants. However, if human activity causes the deposition of a mucky sediment that is high in nitrogen and phosphorus, the growth of aquatic plants will be stimulated.

As algal cells die and sink to the lake bottom, the sediments are more likely to become enriched in nutrients and suitable for rooted plants. This process is subtle, and is not predictable by any existing theoretical or empirical model of lake dynamics. Although we know that nuisance levels of rooted plants are prevalent in lakes of moderate productivity, the exact cause and effect relationship between nitrogen and phosphorus loadings and plant growth is unknown (Figure A-2).

At this time, although we recognize that nitrogen may be a controlling factor in limiting the growth of rooted aquatic plants (and rarely the algae) in freshwaters, the connection between nitrogen levels and plant growth is poorly understood. Further study of this matter is needed. In addition to this problem, although biological nitrogen removal might be achieved for large (> 1.0 MGD) facilities, it is less likely that such technologies are applicable to smaller plants. If a ponded water can be demonstrated to be nitrogen limited during substantial portions of the year, nitrogen removal may be required, with the understanding that the technology for nitrogen removal is fairly limited. At present, the issue of nitrogen removal must be treated on a case by case basis. If the technology for nitrogen removal improves in the future, this guidance shall be revised accordingly.

In the absence of a predictive model relating phosphorus and nitrogen loadings to rooted plant growth in lakes, we have opted for a conservative approach. We have assumed that phosphorus levels are an indicator of overall lake biological productivity. The discharge of phosphorus should be controlled not only because of its known impact on algae, but also because of the possible indirect stimulus to the growth of rooted plants. We could have used an empirical phosphorus model (Vollenweider, etc.) to allocate discharges of phosphorus up to a known "permissive load", derived through empirical equations relating phosphorus levels to an oxygen, or secchi disk target value. However, although these empirical models can be used to relate phosphorus levels to both bottom dissolved oxygen and water clarity, the uncertainties concerning the relationship between phosphorus and nitrogen loadings and rooted aquatic plant growth necessitate a different approach.

Figure A-2
Use Impairment and Phosphorus Loadings