Impaired Waters Restoration Plan
For Greenwood Lake
Orange County, New York

Total Maximum Daily Load (TMDL) for Total Phosphorus

September 2005

New York State Department of Environmental Conservation
Bureau of Water Assessment and Management

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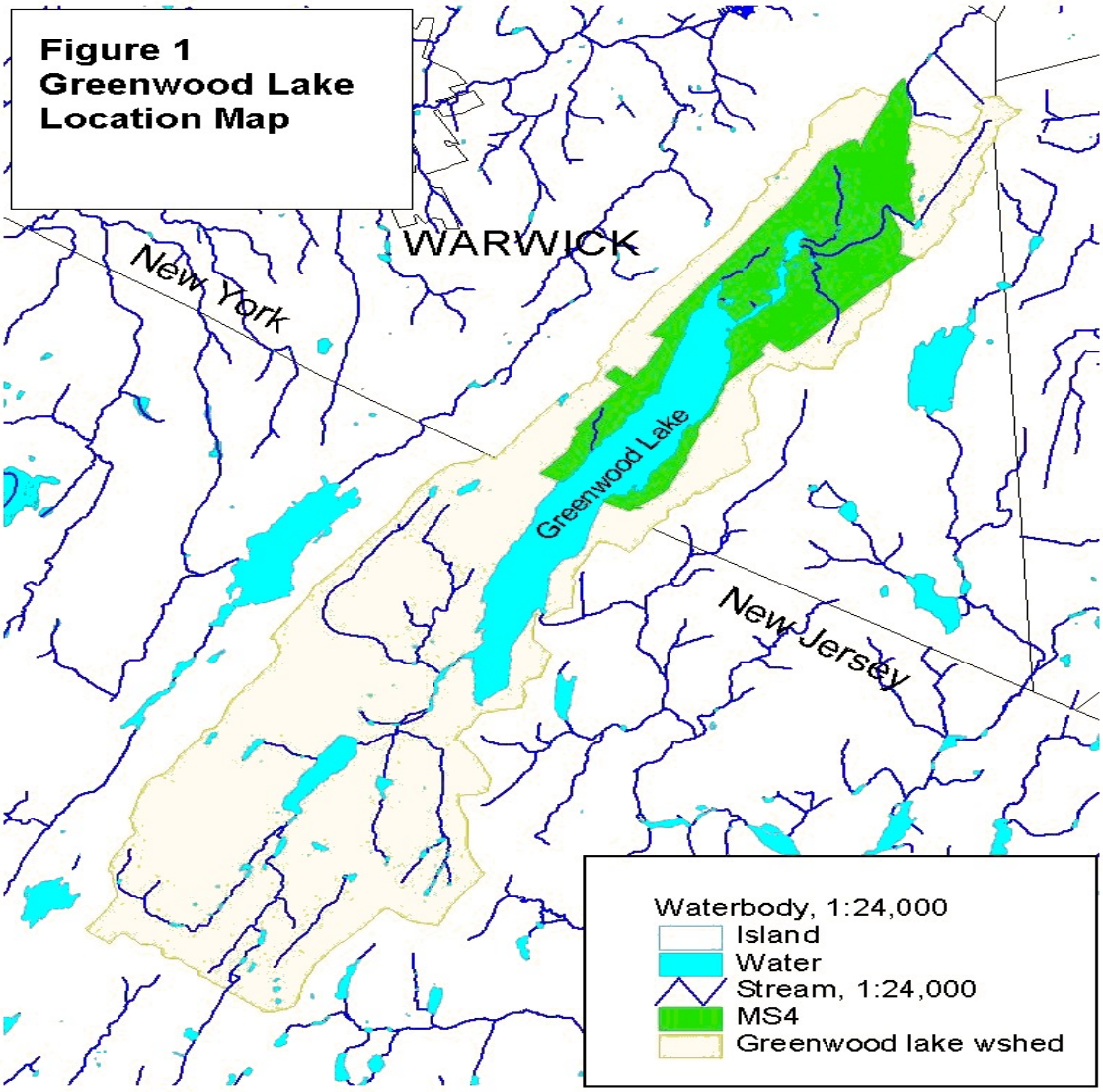
1.0 Introduction

The 2004 New York State Clean Water Act (CWA Section 303(d) List of Impaired Waters identifies Greenwood Lake (1501-0001) as having designated uses (public bathing/recreation) eutrophic/impaired due to phosphorus. The source of the phosphorus has been identified as urban/storm runoff and failing/inadequate on-site septic systems. This strategy establishes a Total maximum Daily Load (TMDL) for the phosphorus loading to the lake from the Greenwood Lake Watershed. A similar TMDL has been developed by the New Jersey Department of Environmental Protection for the southern portion of the lake and watershed that lies within New Jersey. The NJDEP document, Total Maximum Daily Load for Phosphorus to Address Greenwood lake in the Northeast Water Region, drafted June 7, 2004 and approved by USEPA in September 2004, is included as Appendix A of this report and the appropriate sections as directly referenced throughout.



2.0 Background

In accordance with Section 305(b) of the federal Clean Water Act (CWA) U.S.C. 1315(B), New York State is required biennially to prepare and submit to the United State's Environmental Protection Agency (USEPA) a report addressing the overall water quality of the State's waters. This report is commonly referred to as the 305(b) on a continuing, five-year rotating basin approach through its Waterbody Inventory/Priority Waterbodies List Assessment Program.

In accordance with Section 303(d) of the CWA, the State is also required biennially to prepare and submit to USEPA a report that identified waters that do not meet or are not expected to meet surface water quality standards (SWQS) after implementation of technology-based effluent limitations or other required controls. This report is commonly referred to as the Section 303(d) List. The listed waterbodies are considered to not support appropriate uses due to impairments that require the development of a total maximum daily load (TMDL) or other appropriate strategy to achieve water quality standards and restore uses.

2.1 Total Maximum Daily Loads

A TMDL represents the assimilative or carrying capacity of a waterbody, taking into consideration point and nonpoint source of pollutants of concern, natural background and surface water withdrawals. A TMDL quantifies the amount of a pollutant a waterbody can assimilate without violating a state's water quality standards and allocates that load capacity to known point sources in sources in the form of wasteload allocations (WLAs), nonpoint sources in the form of load allocations (LAs), and a margin of safety (MOS). A TMDL is developed to identify all the contributors to surface water quality impacts and set load reductions for pollutants of concern needed to meet SWQS.

1. Identification of waterbody, pollutant of concern, pollutant sources and priority ranking.
2. Description of applicable water quality standards and numeric water quality target(s).
3. Loading capacity - linking water quality and pollutant sources.
4. Load allocations.
5. Wasteload allocations.
6. Margin of safety.
7. Seasonal variation.
8. Reasonable assurances.

9. Monitoring plan to track TMDL effectiveness.
10. Implementation (although a specific Implementation Plan is not required).
11. Public Participation.

The New York State will be removing the Greenwood lake (1501-0001) segment from the Section 303(d) List for Phosphorus, once this TMDL is approved by USEPA.

3.0 Description of Waterbody and Watershed

As shown in Figure 1, Greenwood Lake is located on the border of New Jersey and New York. Greenwood Lake extends northward to the Town of Warwick, Orange County, New York and south to the Township of West Milford, Passaic County, New Jersey. The north and south basins are very different in terms of depth and bottom contours. The northern or New York section of the lake is characteristically deep, with a maximum depth of 18 meters and steeply sloped banks. In contrast, the southern or New Jersey section is shallow, with a maximum depth of three meters, gradually sloping banks. The lake's average depth is 5.2 meters, its surface area is 1,884 acres and its volume is 4.04×10^7 m^3 (Table 1).

Table 1 - Characteristics of Greenwood Lake

Lake Area (Acre)	Lakeshed Area (Acre)	Outflow[a] (m^3/yr)	Volume[3] (m^3)	Average Depth[a] (m)	Maximum Depth [a](m)
1,884	16,036	3.45E+07	4.04E+07	5.2	17.4

a: Taken from Phase 1 Study of Greenwood Lake (PAS, 1983)

Several streams flow into the lake, and of these, Belcher Creek, located in New Jersey is the major tributary. Discharge from the lake is to the Wanaque River, a tributary of the Passaic River. Annual tributary inflow to the lake totals 1.8×10^7 m^3 yr^1, while total outflow is 3.45×10^7 m^3 yr^1 (including evaporation). Greenwood Lake's watershed encompasses a total area of approximately 16,036 acres, exclusive of the lake's surface area (see Figure 1). The eastern and western boundaries of the watershed are defined by steep mountain ridges that parallel the lake's shoreline. Several small lakes are located within the watershed, including Pinecliff Lake, Reflection Lake, West Milford Lake, and Capri Lake.

Greenwood Lake was designated as eutrophic/impaired on the 2004 CWA Section 303(d) List of Impaired Waters as a result of data and evaluations conducted through the State's Lake Classification and Inventory Program. Indicators used to determine trophic status included elevated total phosphorus (TP), elevated chlorophyll-a and/or

macrophyte density. The pollutant of concern for this TMDL is total phosphorus. The mechanism by which phosphorus can cause use impairment is via excessive primary productivity. Phosphorus is an essential nutrient for plants and algae, but is considered a pollutant because it can stimulate excessive growth (primary production). Phosphorus is most often the major nutrient in shortest supply relative to the nutritional requirements of primary producers in freshwater lakes; consequently, phosphorus is frequently a prime determinant of the total biomass in a lake. Eutrophication has been described as the acceleration of the natural aging process of surface waters. It is characterized by excessive loading of silt, organic matter, and nutrients, causing high biological production and decreased basin volume (Cooke et al, 1993). Symptoms of eutrophication (primary impacts) include oxygen super-saturation during the day, oxygen depletion during night, and high sedimentation (filling in) rate. Algae and aquatic plants are the catalysts for these processes. Secondary biological impacts can include loss of biodiversity and structural changes to communities.

As reported in the *2004 CWA Section 303(d) List of Impaired Waters*, the Department, identified the Greenwood Lake as being eutrophic/impaired due to phosphorus. This TMDL, which will address the phosphorus loading and resulting in impairment, will cover 824 acres of the lake area located in New Jersey and 1,060 acres of the lake area located in New York, corresponding to a total of 16, 036 acres of land within the watershed. Eutrophic Lake impairment is not directly related to human health issues; however, eutrophication is an environmentally important issue.

3.1 Geographic Information System (GIS) Coverage

In order to describe the lake and lakeshed (watershed of the lake), NJDEP used Geographic Information System (GIS) coverages from USGS, New Jersey and New York State given the bi-state geographical location of Greenwood Lake as specified in Section 4.1 of the NJDEP report.

3.2 Greenwood Lake Commission and New York State

A bi-state Greenwood Lake Commission has been formed to address the environmental issues in Greenwood Lake. New Jersey adopted by the bill to create the Greenwood Lake Commission (S1788(1R);P.L. 1999 c.402) in January of 2000. The companion bill (A00294S416-A) was adopted by the New York State in January of 2001. The 11 voting members include representatives from: Passaic County, NJ: two representatives from the Township of West Milford, New Jersey; the Commissioner of the New Jersey Department of Environmenatl Protection (NJDEP) or designee; Orange County, New York; the Village of Greenwood Lake, New York; the Town of Warwick, New York; the Commissioner of the New York Department of Environmental Conservation (NYSDEC) or a designee thereof; the Greenwood Lake

Watershed Management District, a citizen advisory committee that has been active for more than 20 years; and from each state, an appointed representative from the public sector with related expertise. This TMDL has been developed in coordination with the Greenwood Lake Commission.

New Jersey has also listed Greenwood Lake as euthrophic/impaired, based on total phosphorus levels, elevated chlorophyll-a and/or macrophyte density. New Jersey established a TMDL for the portion of Greenwood Lake under its authority, in September 2004. At that time, New York determined this TMDL would be adequate to meet the New York narrative water quality requirements and offered its support of this TMDL. Furthermore, New York agreed to develop a companion TMDL for the northern (New York) end of the lake using the New Jersey TMDL as a basis.

4.0 Applicable Water Quality Standards

Portions of Greenwood Lake carry two different stream classifications. The portion of the lake from the New York-New Jersey border to a southwesterly line parallel to the peninsula of Village of Greenwood Lake drawn at the northern tip of Chapel Island is classified by New York State Class A(T), with the best usage of these waters serving as a source of water supply for drinking, culinary or food processing purposes (with disinfection), primary and secondary contact recreation and fishing. The portion of the lake lying north of that line is classified as Class B, with the best usage of these waters being primary and secondary contact recreation and fishing.

The only applicable water quality standard for phosphorus in waters designated Class A(T) and/or Class B is a narrative standard in part 703 of NYSCRR. Part 703.2 includes a narrative standard for phosphorus and nitrogen that reads: "None in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages."

In addition to the narrative water quality standards cited above, New York State also has a guidance value of 20 µg/l for Total Phosphorus. However this value was derived based on aesthetic impacts to recreational uses and is not necessarily reflective of impairment of recreational use.

Because Greenwood Lake is an interstate water, NYSDEC believes that its TMDL for Greenwood Lake should be consistent with the TMDL established by New Jersey DEP and approved by EPA in 2004.

For the southern portion of the lake that lies within New Jersey, the NJDEP applied a water quality standard of 50 µg/l total phosphorus in freshwater lakes. This water quality standard was used as the starting point for the development of a phosphorus TMDL that NJDEP proposed and was accepted in September 2004. In their TMDL,

NJ applied a peak to mean ratio derived from other lakes to arrive at an annual concentration target of 30 µg/l. Ultimately, NJDEP used a target concentration of 20 µg/l in the loading calculations in order to account for implicit and explicit margins of safety and achieve year-round compliance with its 50 µg/l total phosphorus water quality standard.

The TMDL for the northern (New York) portion of the lake is intended to be consistent with the NJ TMDL. NYSDEC reviewed the NJDEP TMDL and proposes that the annual concentration target of 30 µg/l and the 20 µg/l target concentration used in the NJ TMDL are appropriate TMDL endpoints and supportive of water quality in the NY portion of the lake as well. Therefore, NYSDEC will establish this TMDL using NJDEP's annual concentration target of 30 µg/l derived from their water quality standard for phosphorus as a site-specific interpretation of the NY's existing narrative standard, at Part 703.2, to protect the waters of its portion of Greenwood Lake.

Such an approach is justified given the limits of certainty inherent in the TMDL calculations, the current effort in NYS, and elsewhere, to revise nutrient standards, and the value of having a single consistent approach to addressing water quality concerns in this shared water. Both New York State and New Jersey agree that refinement of the TMDL based on the collection of additional water quality data and each state's efforts to establish nutrient criteria may be appropriate in the future.

5.0 Source Assessment

As part of the 1983 Phase I Diagnostic-Feasibility Study of Greenwood Lake, New Jersey and new York (PAS, 1983), the potential sources of phosphorus in the lake were evaluated and the annual influx of phosphorus from different sources was quantified. The annual TP load was estimated to be 5936.4 kilograms. The majority of the estimated phosphorus load originated from runoff from the land surface and the internal loading. However, septic tank and sewage treatment plant effluent are responsible for a sizable portion of the annual nutrient load as well. The Phase I Study was conducted over 20 years ago, so the contributions to the lake's annual phosphorus load were updated using the most recent data from these four major sources.

Phosphorus loads were characterized on an annual scale (kg TP/yr). Long-term pollutant loads are typically more critical to overall lake water quality than the load at any particular short-term period (e.g. day). Storage and recycling mechanisms in the lake, such as luxury uptake and sediments dynamics allow phosphorus to be used as needed regardless of the rate of delivery to the system. Also, empirical lake models use annual loads rather than daily or monthly loads to estimate in-lake concentrations.

5.1 Assessment of Point Sources other than Stormwater

There are no facilities with National Pollutant Discharge Elimination System (NPDES) permits located within the New York portion of the lakeshed. The NJDEP used its GIS on New Jersey Pollution Discharge Elimination System (NJPDES) Surface Water Discharge to identify five small point sources that could potentially contain phosphorous located within the NJ portion of the lakeshed. Appendix E of the NJDEP report contains a table and map of all NJPDES permitted facilities in the affected area. NJDEP estimates that the load from these facilities comprise the point-source load of TP entering Greenwood Lake, which is about 70 kg/yr.

5.2 Assessment of Load from Land Surfaces Runoff

Runoff from land surfaces comprises most of the non point and stormwater point sources of phosphorous into the lake. As described in the NJDEP report Section 5.3, NJDEP used the National Land Cover Data (Figure 2) and the Unit Areal Load (UAL) methodology by assigning an appropriate TP Export Coefficient for each type of NLCD land use (Table 2).

A UAL of 0.07 kg TP/ha/yr was used to estimate air deposition of phosphorus directly onto the lake surface. This value was developed from statewide mean concentrations of total phosphorus from the New Jersey Air Deposition Network (Eisenreich and Reinfelder, 2001).

Land uses and calculated loading rates for the Pinecliff and Greenwood Lakes are shown in Table 3. Since Pinecliff Lake is located within the Greenwood Lake watershed, the entire Greenwood Lake watershed was divided into two parts, Pinecliff Lake watershed and the remainder of the watershed. According to the Phase 1 study, Pinecliff Lake has a detention effect on the phosphorus entering into it and the detention factor is estimated to be 0.56. Therefore, to account fort TP retention in Pineclff Lake, it is assumed that only 44% of the load contributed by the lands within the Pinecliff Lake watershed reach Greenwood Lake. This load added to the load that originates from the lands outside of the Pinecliff Lake watershed constitutes the load from surface runoff.

Figure 2 **Land Use Type in Greenwood Lake Watershed**

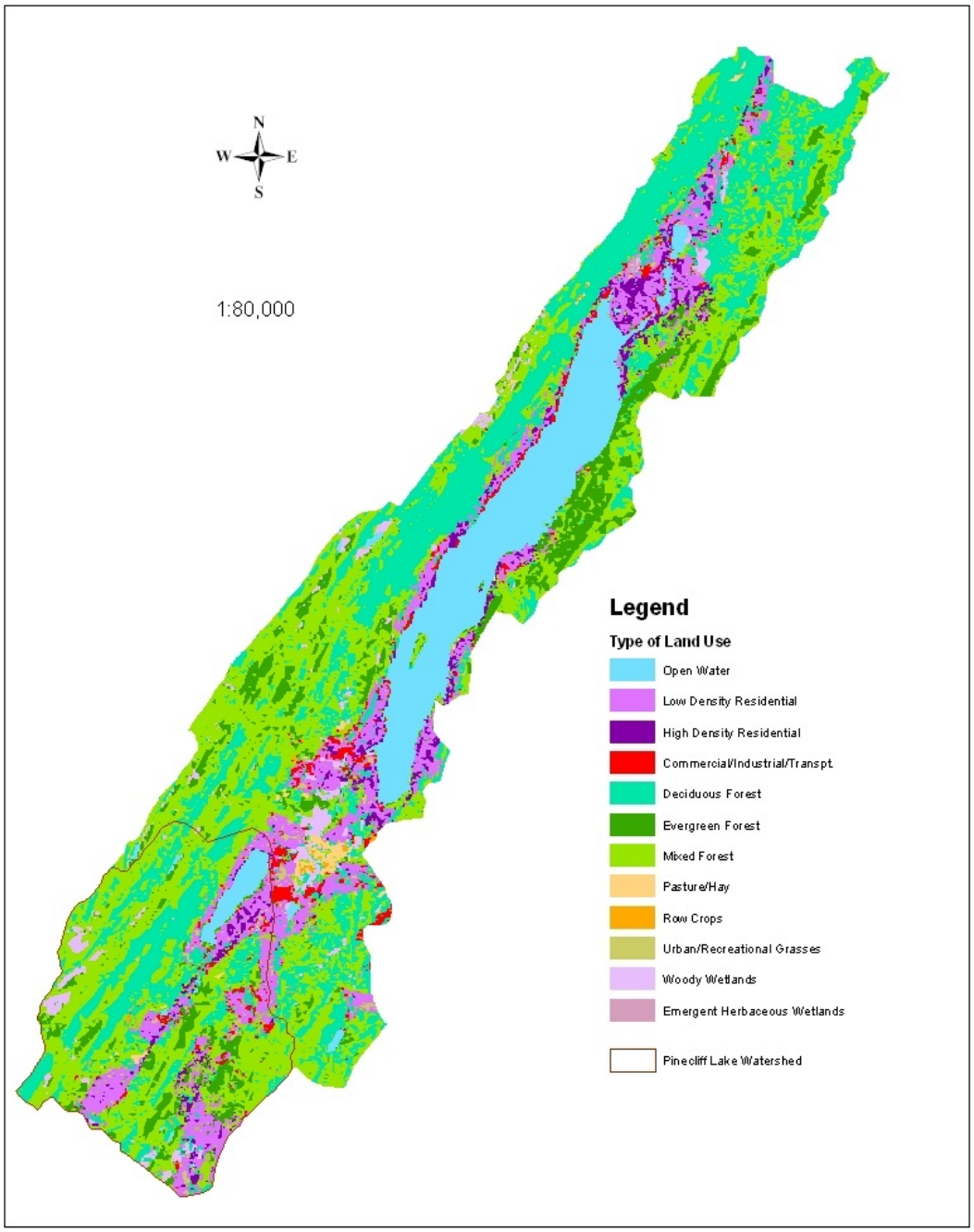


Table 2 - Phosphorus Export Coefficients *Unit Areal Loads)

Landuse Description	Gridcole	EC (Kg TP/ha/yr)
Open Water	11	0.07
Low Intensity Residential	21	0.7
High Intensity Residential	22	1.6
Commercial/Industrial/Transportation	23	2.4
Deciduous Forest	41	0.1
Evergreen Forest	42	0.1
Mixed Forest	43	0.1
Pasture/Hay	81	1.5
row Crops	82	1.5
Urban/Recreational Grasses	85	1
Woody Wetlands	91	0.1
Emergent Herbaceous Wetlands	92	0.1

Units: 1 hectare (ha) = 2.47 acres
1 kilogram (kg) = 2.2 pounds (lbs)
1 kg/ha/yr = 0.89 lbs/acre/yr

Table 3 - Surface Runoff Source of Phosphorus Load

Landuse Description	Pinecliff Watershed		Greenwood Lake Watershed beyond Pinecliff Watershed		Entire Greenwood Lake Watershed
	Area (acre)	TP Load (kg/yr)	Area (acre)	TP Load (kg/yr)	TP Load (kg/yr)
Low Intensity Residential	612	173.3	1,199	339.7	415.9
High Intensity Residential	110	71.4	405	262.2	293.6
Commercial/Indust/Transport	75	73.2	284	275.5	307.7
Pasture/Hay	13	7.7	86	52.3	55.7
Row Crops	12	7.4	39	23.9	27.2
Urban/Recreational Grasses	32	13.0	51	20.5	26.3
Deciduous Forest	1,127	45.6	3,960	160.3	180.3
Evergreen Forest	371	15.0	1,021	41.3	47.9
Mixed Forest	1,941	78.6	4,148	167.8	202.4
Woody Wetlands	116	4.7	271	11.0	13.0
Emergent Herbaceous Wetlands	2	0.1	26	1.0	1.1
Open Water	157	6.4	102	4.1	6.9
Air Deposition			1,884	53.4	53.4
Total		496		1,413	1,631.6

5.3 Assessment of Load from Septic Tank System

The TP load contributed to the lake as a result of onsite septic tank system use was quantified using the same methodology documented in the Phase 1 Study (PAS, 1983). The number of houses within 200 m of the lake's shoreline was determined from 2000 census data in conjunction with most recent aerial photos. A total of 2,075 units that rely on septic tank systems were found within 200 meters of the lake's perimeter. 2000 census data indicated that the average size of these dwellings is 3 persons/dwelling. The loading coefficient used in the Phase 1 study, 0.114 kg TP/capita/yr, was utilized to compute the annual load from septic tank systems. The resulting load is 710 kg TP/yr contributed to the lake via septic systems.

5.4 Internal Loading

In the Phase 1 study, internal loading was quantified to be 1,738.8 kg/yr, which accounted for 29.3% of the total annual load. At the time NJDEP established its TMDL in 2004, there was no new data to update the current internal loading. Therefore, in the NJDEP TMDL, it is assumed that the internal loading is still 1,738.8 kg/yr.

NYSDEC agrees that the 1,738.8 kg/yr remains the best existing estimate of internal loading and also used this value in its TMDL calculations.

6.0 Water Quality Analysis

In addition to the Phase I Study, in-lake monitoring was conducted for several growing seasons between 1992 and 2001 by Princeton Hydro. Samples were collected from three stations, one at the northern, New York end, one mid-lake station and one at the southern shallow New Jersey end. Overall, the concentrations at the southern station were lightly higher than the concentrations at the other two stations and the exceedance frequency at the southern station was 23% higher than the exceedance at the other two stations.

The NJDEP chose an empirical model as the most appropriate means, given the actual annual average total phosphorus concentration for the years when in-lake monitoring samples were collected. The annual average concentration varied year by year; the average of eight year's annual average concentrations is computed to be 0.031 mg/L. This value compares well to the concentration of 0.032 mg/l predicted by the Reckhow model, used by NJDEP.

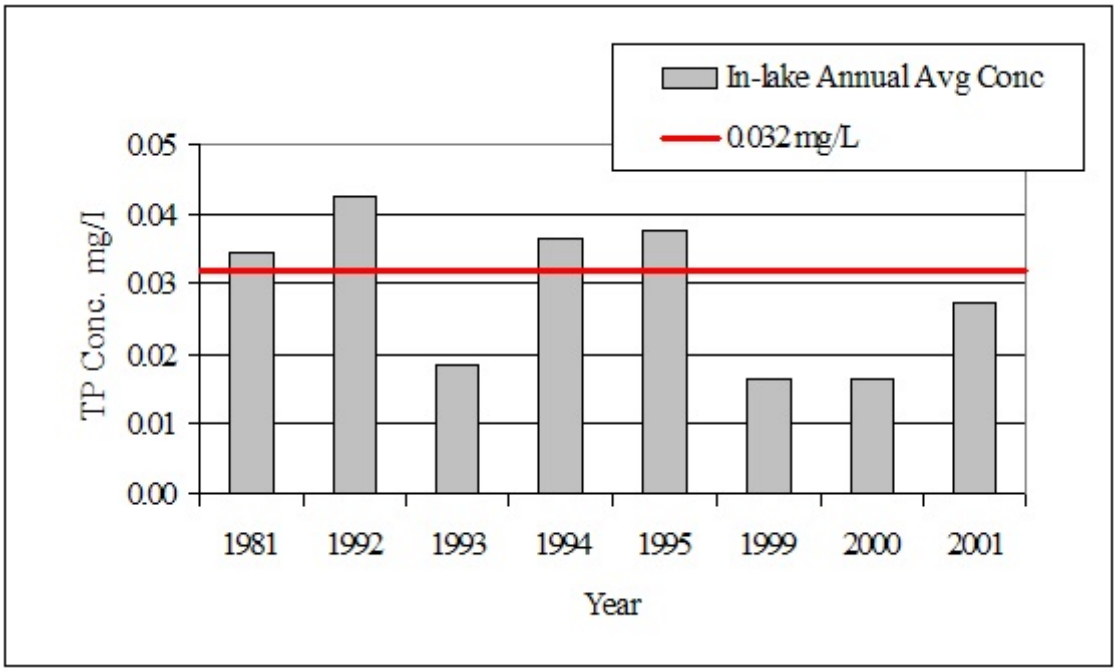


Figure 3 - Annual Average In-lake TP Concentration for Greenwood Lake

6.1 Current Conditions

Figure 3 presents the actual annual average total phosphorus concentration for the years when in-lake monitoring samples were collected. The annual average concentraton varied year by year; the averageof eight years' annual average concentrations is computed to be 0.031 mg/L. This value compaires will to the concentration of 0.032 mg/l predicted by the Reckhow model, used by NJDEP.

6.2 Reference Condition

For reasons stated in Section 7.2 of the NJDEP report, NYSDEC agrees that the reference condition will not be used for the TMDL calculations.

6.3 Seasonal variation/Critical Conditions

NJDEP assumed that a peak to mean ratio representative of lakes, in general in NJ, also applies to Greenwood Lake, which results in target phosphorus concentration of 0.03 mg TP/l. Since it is the annual pollutant load rather than the load at any particular time better determines overall lake water quality, the target phosphorus concentration of 0.03 mg TP/l accounts for critical conditions.

6.4 Margin of Safety

A margin of safety (MOS) is provided to account for "lack of knowledge concerning the relationship between effluent limitations and water quality." (40 CFR 130.7). A MOS is required in order to account for uncertainty in the loading estimates, physical parameters and the model itself. The margin of safety, as described in USEPA guidance (Sutfin, 2002), can be either explicit or implicit (i.e., addressed through conservative assumptions used in establishing the TMDL). For this TMDL calculation, an implicit as well as an explicit MOS are provided.

The NJDEP TMDL contains an implicit margin of safety by using conservative critical conditions and total phosphorus as the basis for reductions. Critical conditions are accounted for by peak concentrations to mean concentrations and adjusting the target concentration accordingly (0.03 mg TP/1 instead of 0.05 mg TP/1). In addition, the use of total phosphorus, as both the endpoint for the standard and in the loading estimates, is a conservative assumption. Use of total phosphorous does not distinguish readily between dissolved orthophosphorous, which is available for algal growth, and unavailable forms of phosphorus (e.g. particulate). While many forms of phosphorus are converted into orthophosphorous in the lake, many are captured in the sediment, for instance, and never made available for algal uptake.

In addition to conservative assumptions built in to the calculation, NJDEP include an additional explicit MOS to account for the uncertainty in the model itself. As described in the NJDEP report Section 7.4, setting the probability to 90% yields a MOS of 51% when expressed as a percentage of total loading capacity, the MOS is equal to 33.3%.

6.5 Target Condition

To assure compliance, the NJDEP applied the MOS to the upper bound target concentration of 0.03 mg/L to arrive at 0.02 mg/L as the target condition. Coincidently, 0.02 mg/l is the NYS guidance value for total phosphorus. In order to be consistent with the TMDL for NJ, NYS proposes that the 0.02 mg/l target concentration used in the NJ TMDL is appropriate target supportive of water quality in the NY portion of the lake as well. Such an approach is justified given the limits of

certainty inherent in the TMDL calculations, the current effort in NYS, and elsewhere, to revise nutrient standards, and the value of having a single consistent approach to addressing water quality concerning this shared water. Both NYS and NJ agree that refinement of the TMDL based on the collection of additional water quality data and each state's efforts to establish nutrient criteria may be appropriate in the future.

The overall reduction to attain the standard level in Greenwood Lake was calculated by comparing the current concentration (calculated using Reckhow Model) to 0.02 mg/L, the target concentration (table 4).

Table 4 - Current Condition, Reference Condition, Target Condition & Overall % Reduction for Greenwood Lake

Current Condition [TP] (mg/l)	Reference Condition [TP] (mg/L)	Upper Bound Target Condition [TP] (mg/L)	Target Condition [TP] (mg/l)	Overall TP Load Reduction (%)
0.032	0.005	0.03	0.02	37%

7.0 TMDL Calculation

7.1 Loading Capacity

The NJDEP used the Reckhow (1979a) model to solve for loading rate given the upper bound target concentration of 0.03 mg/l. This loading rate is used as the loading capacity for the lake and 33.3% of it accounts for the as determined by the uncertainty associated with the Rekhow Model. The NYSDEC concurs with this approach, so the acceptable loading capacity for Greenwood Lake is 3,895 Kg of TP per year (Table 6).

7.2 Reserve Capacity

Reserve capacity is an optional means of reserving a portion of the loading capacity to allow for future growth. The primary means by which future growth could increase phosphorus load is through the development of forest land within the lakeshed. The implementation plan includes the development of a Lake Restoration Plan that will require the collection of more detailed information about the lakeshed. If the development of forest within the watershed is planned, the issue of reserve capacity to account for the additional runoff load of phosphorus may be revisited. Currently the loading capacities and accompanying WLAs and LAs must be attained in consideration of any new sources that may accompany future development.

7.3 Allocations

USEPA regulations at 40 CFR § 130.2(I), state that "pollutant loadings may be expressed in terms of either mass per time, toxicity, or other appropriate measure." For lake nutrient TMDLs, it is appropirate to express the TMDL on a yearly basis. Long-term average pollutant loadings are typically more critical to verall lake water quality due to the storage and recycling mechanisms in the lake. Also, most available Empirical Lake models, such as the Reckhow model used in this analysis, use annual loads rather than daily loads to estimate in-lake concentrations.

The TMDLs for total phosphorus are therefore calculated as follows: TMDL = Loading capacity = sum of wasteload allocations (WLAs) + Load Allocations (LAs) + margin of safety.

NJDEP established the WLAs for all regulated point sources within each source category, LAs are established for stormwater sources that are not subject to regulation and include all other nonpoint sources. This distribution of loading capacity between WLAs and LAs is consistent with recent EPA guidance that clarified existing regulatory requirements for establishing WLAs for stormwater discharges (Wayland, November 2002). Stormwater discharges are captured within the runoff sources quantified according to land use, as depicted in Table 5. Distinguishing between regulated and unregulated stormwater is necessary in order to express WLAs and LAs numerically; however, "EPA recognizes that these allocations might be fairly rudimentary because of data limitations and variability within the system (Wayland, November 2002, p.1)." While there has been no effort to actually delineate the specific area which drains through the regulated stormwater system of the Village of Greenwood Lake and portions of the Town of Warwick, the land use runoff categories previously defined can be used to estimate between the WLA and LA. Therefore, allocations are established according to source categories as shown in Table 5. This demarcation between WLAs and LAs based on land use source categories is not perfect, but is represents an estimate based on available data. The Department acknowledges that there may be stormwater sources in the residential, commercial, industrial and mixed urban runoff source categories that are not regulated.

Table 5 - Distribution of WLAs and LAs Among Source Categories

Source Category	TMDL Allocation
Point sources other than stormwater	WLA
Internal Loading	LA
Septic Tank System	LA
Nonpoint & Stormwater Sources Medium/High Density Residential	WLA
Low Density/Rural Residential	WLA
Commercial	WLA
Industrial	WLA
Mixed Urban/Other Urban	WLA
Agricultural	LA
Forest, Wetland, Water	LA
Barren Land	LA
Air Deposition onto Lake Surface	LA

In order to attain the TMDL, the overall load reduction shown in Table 4 must be achieved. Since loading rates have been defined for multiple source categories, countless combinations of source reductions could be used to achieve the overall reduction target. The selected scenario by NJDEP calls for holding the load constant from wastewater treatment facilities (existing effluent quality) and achieving reductions from land use sources that can be affected by BMP implementation or stormwater regulation, requirng equal percent reductions from each in order to achieve the necessary overall load reduction. Note that no reduction is required for the discharges from the wastewater point sources. These wastewater point sources are already treated to remove phosphorus and represent less than 2% of the allocation. Therefore, the WLAs for the facilities is the existing loading. NYSDEC proposes the resulting TMDL calculations, rounded to two significant digits, and shown in Table 6. The Lake Restoration and Characterization Plan developed for Greenwood Lake as part of the TMDL implementation (Section 9) will revisit the distribution of reductions among the various sources in order to reflect the outcome of the plan, implementation projects and the option(s) selected by wastewater treatment plant sources.

Table 6 - TMDL Calculations for Greenwood Lake (annual loads & % Reductions)

Loading Capacity (LC)	Kg TP/yr 3,895	% of LC 100%	Reduction % n/a
Point Source other than stormwater	70	1.8%	0%
Loading from Septic Tank System	401	10%	43%
Internal Loading	983	25%	43
Land Use Surface Runoff			
-Low Intensity Residential	235	6.0%	43%
-High Intensity Residential	166	4.3%	43%
-Commercial/Industrial/Transportation	174	4.5%	43%
-Pasture/Hay	32	0.8%	43%
-Row Crops	15	0.4%	43%
-Urban/Recreational Grasses	15	0.4%	43%
-Deciduous Forest	180	5%	0%
-Evergreen Forest	48	1.2%	0%
-Mixed Forest	202	5%	0%
-Woody Wetlands	13	0.3%	0%
-Emergent Herbaceous Wetlands	1	0.03%	0%
-Open Water	7	0.2%	0%
-Air Deposition	53	1.4%	0%
Other Allocation			
-Margin of Safety	1,298	33%	n/a
-Reserve Capacity	0	0%	na/

A. Percent reductions shown for individual sources are necessary to achieve overall reductions in Table 6.

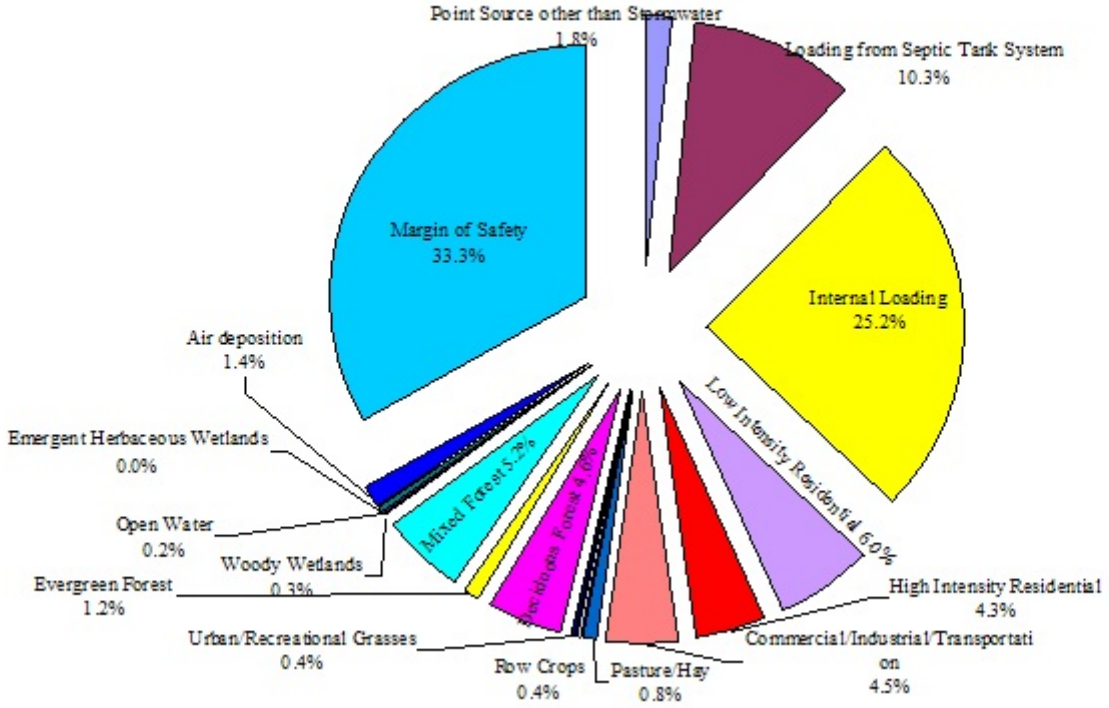


Figure 4 - Phosphorus Allocations for Greenwood Lake TMDL

8.0 Follow-Up Monitoring

A Lake Characterization and Restoration Project (LCRP) using funds from both NJ and NY under the Clean Water Act Section 319(h) began in 2005. This project will provide a-lake water quality monitoring data, monitoring data for eight tributary stations within the watershed and bathymetric survey for NJ portion of the lake to provide site-specific information and data for the LCRP, as described in Section 9.0 of the NJDEP TMDL.

In order to quantify the current phosphorus loads entering Greenwood Lake on a more site specific basis, eight tributary stations (6 in NJ & 2 in NY) will be monitored over ten sampling events from June 2005 to May 2006.

The two stations on unnamed creeks in NY are at locations (Old Tuxedo Road) where they will not be able to account for most of the stormwater flow from developed

areas. During each proposed sampling event, discrete water samples will be collected for total phosphorus (TP) and total suspended solids (TSS) analysis. The goal of the proposed tributary sampling program is to collect flow and select water quality data over the course of nearly a year to quantify loads.

9.0 Implementation

Greenwood Lake is a bi-state lake and will necessitate implementation measures undertaken by both NJ and NY. The Department, in coordination with the Greenwood Lake Commission will address the sources of impairment, using regulatory and nonregulatory tools, matching management strategies with sources, and aligning available resources to effect implementation.

The Department recognizes that TMDL designated load reductions alone may not be sufficient to restore eutrophic lakes. The TMDL establishes the required nutrient reduction targets and provides some regulatory framework to affect those reductions. However, the nutrient load only affects the eutrophication potential of a lake. The implementation plan therefore calls for the collection of additional monitoring data, as discussed in Section 8.0, and the development of a Lake Characterization and Restoration plan. The additional monitoring proposed will provide the information needed to update the Phase I diagnostic study of Greenwood Lake, which will provide the basis for the Lake restoration Plan. The Restoration Plan will consider in-lake measure that need to be taken to supplement the nutrient reduction measures required by the TMDL. For example, the shallow portion of the lake supports macrophytes that, at some density, are a natural part of a healthy clear-water lake ecology, but, because of density or location, interfere with boating. Phosphorus reductions alone may not address this issue and macrophyte harvesting or other measures may be a long-term maintenance measure needed in certain areas to facilitate the boating use. In addition, the plan will consider the ecology of the lake and adjust the eutrophication indicator target as necessary to protect the designated uses.

Generic Measures

Phosphorus is contributed to the environment from a number of sources. In the NY portion of the watershed, two of the more significant sources that can be reduced through management are, fertilizer application on lawns, and failing or improperly functioning septic systems. The NJDEP TMDL document summarizes generic management strategies for various source categories and responses, some of which are more applicable to the NJ portion of the watershed.

Regulatory Measures

In March 2002, the Department Issues SPDES general permit GP-02-02 for

stormwater discharges from municipal separate stormwater sewer system (MS4s) in response to the federal Phase II Stormwater rules. GP-02-02 requires municipalities, counties, highway systems, and large public complexes to develop stormwater management programs consistent with the permit requirements. Under GP-02-02 the Village of Greenwood Lake and portions of the Town of Warwick will be required to implement various control measures that should substantially reduce phosphorus loadings.

The Stormwater Management Program for both of these MS4 communities identified several components which, if implemented consistently throughout the watershed, could directly or indirectly reduce Phosphorus loads in stormwater discharges to the Lake.

- Public eduction regarding lawn and garden care.
- Prohibit illicit discharges to the stormdrain systems and perform illicit discharge trackdowns. This aspect of the program will focus on failing septic systems.
- Construction site stormwater runoff control ordinance and inspection and enforcement programs.
- Post construction stormwater management ordinance and inspection and maintenance programs.
- Pollution prevention practices which include street and catch basin cleaning programs and good housekeeping at maintenance yards.

Follow-up monitoring may determine that other additional measures are required, which would then be incorporated into Phase II permits. Additional measures that may be considered include, for example, more frequent street sweeping and inlet cleaning, or retrofit of stormwater management facilities to include nutrient removal.

Local communities within the Greenwood Lake drainage basin may also adopt regulatory measures. For example, the Village of Greenwood Lake adopted an ordinance on April 2, 2001 (Ordinance # 2-2001) prohibiting the use of fertilizer containing phosphorus.

On-site Wastewater Systems

Septic management measures will be an important component of the implementation plan. As a component of this TMDL the septic loading has been updated from the Phase I diagnostic study. As septic loads are a significant source of phosphorus, long-term management measures to address septic problems on both the NY and the NJ portion of the lake are necessary components. Failing or improperly functioning septic system can be a source of phosphorus, and the extent of the load is significantly determined by geologic and soil constraints. On Greenwood Lake's northern NY side

there are apparent severe restrictions to the proper operation of septic systems based on lack of depth to bedrock and steep slopes. An aggressive septic management plan, possibly including alternative treatment measures, will be necessary. Towards this end, the Village of Greenwood Lake adopted an ordinance on April 2, 2001, which requires proof of proper functioning systems and pump-out every three years as an on-going requirement. The Town of Warwick should adopt a similar program. Alternative treatment may still be needed due to the environmental constraints in the area. Both municipal governments should consider management districts for areas of concentrated development or severe site constraints. Perhaps, management can be organized on a watershed basis. Training of on-site professionals and education of homeowners should be promoted through the State's Onsite training Network and Orange County.

The NJ portion of Greenwood Lake also has septic management concerns, although the geology and slopes are less severe. There are documented instances of septic failure. The NJDEP is working with the Greenwood Lake Commission to address these issues.

An in-depth investigation of septic issues will be required to complete the Lake Characterization and Restoration Plan. Issues to be covered include detailed information on the number of septic systems which potentially impact the lake, the percentage of failing or improperly functioning systems, the ability of standard systems to function given specific geologic and soil restrictions, the area required for a properly functioning leach field given the environmental constraints, other options and a cost analysis.

Greenwood Lake Characterization and Restoration Plan

Under the funding provided in the 319(h) grant discussed in Section 8.0 the NJDEP has awarded $152,330 to the Township of West Milford and the Greenwood Lake Commission to complete a Lake Characterization and Restoration Plan. NYSDEC has contributed an additional $64,550. Stormwater related tasks that are funded under these grants include: identification of stormwater/surface runoff "hotspots" in need of restoration and/or protection; development of the stormwater component of the Lake Characterization and Restoration Plan; installation of a series of BMPs and retrofits in the Village of Greenwood Lake and West Milford; and Best Management Practices (BMP) monitoring in order to objectively assess the relative success of the BMP installation/retrofit projects that will be conducted as part of this project. The BMP monitoring will analyze total phosphorus (TP), total nitrogen (TN) and total suspended solids (TSS) prior to and after the BMP/retrofits are installed to quantify the NPS pollutant reductions associated with the various BMP/retrofit technologies that will be installed. While empirically derived percent reductions for NPS pollutants may be available within the existing literature, the collection of this BMP

data will provide site specific information on the relative efficiencies of these installed BMPs and retrofits. Site specific removal efficiencies can be used to quantify the degree of load reduction that can be obtained through BMPs and retrofits.

The Lake Characterization and Restoration Plan developed for the lake may revisit the distributions of reductions required among the various sources. It will be on the basis of refined source estimates and reduction efficiencies that more specific or revised strategies for reduction of nonpoint sources will be developed. Issues such as cost and feasibility will be considered when specifying the refined reduction targets for any source or source type.

9.1 Reasonable Assurance

NYSDEC will pursue follow-up monitoring, source identification and source reduction as described, to attempt the load reduction in this TMDL.

The phosphorus reductions proposed in this TMDL require that the existing NJPDEP permitted facilities containing phosphorus will receive effluent limits commensurate with holding the load from this source, subject to the options, such as water quality trading, as described in the NJDEP TMDL. Stormwater point sources will be controlled by requirements of the Phase II stormwater permitting program and additional measures. Nonpoint source controls are also planned, as described.

The Department's ambient monitoring network will be the means to determine if the strategies identified have been effective. Ambient monitoring will be evaluated to determine if additional strategies for source reduction are needed.

10.0 Public Participation

Notice of availability of the Draft TMDL was made to local government representatives and interested parties. This DRAFT TMDL was public noticed in the Environmental Notice Bulletin. A 30-day public review period was established for soliciting written comments from stakeholders prior to the finalization and submission to the TMDL for USEPA approval. No substantive comments were received.

NYSDEC and NJDEP met with members of the Greenwood Lake Commission, municipal officials, county agency staff, and other interested citizens on May 9, 2005 to discuss coordination of the two states' TMDLs and potential management measures.

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Amendment to the Northeast Water Quality Management Plan
Total Maximum Daily Load for Phosphorus To Address Greenwood Lake in the Northeast Water Region

http://www.state.nj.us/dep/watershedmgt/DOCS/TMDL/june2006/Greenwood%20Lake%20TMDL.pdf

Approved: September 29, 2004

New Jersey Department of Environmental Protection
Division of Watershed Management
P.O. Box 418
Trenton, New Jersey 08625-0418

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Greenwood Lake (1501-0001) Impacted Seg

Waterbody Location Information

Revised: 01/04/00

Water Index No: NJ-P1026
Drain Basin: Passaic-Newark
Hydro Unit Code: 02030103/060
Str Class: B

Waterbody Type: Lake
Reg/County: 3/Orange Co. (36)
Waterbody Size: 1068.7 Acres
Quad Map: GREENWOOD LAKE (Q-23-2)
Seg Description: entire lake, in New York

Water Quality Problem/Issue Information

(CAPS indicate PRIMARY Impair/Poll/Source)

Use Impairment(s)	Severity	Problem Documentation
PUBLIC BATHING	Impaired	Known
Recreation	Stressed	Known
Aesthetics	Stressed	Known

Type of Pollutant(s)

Known: Aesthetics (algal blooms, vegetation)
Suspected: NUTRIENTS, Silt/sediment
Possible: - - -

Source(s) of Pollutant(s)

Known: - - -
Suspected: URBAN RUNOFF, Failing On-Site Syst, Other Source (internal nutr recycling)
Possible: - - -

Resolution/Management Information

Lead Agency/Office: DOW/Reg3
Resolution Potential: High
Issue Resolvability: 2 (Strategy Exists, Needs Funding/Resources)
Verification Status: 5 (Management Strategy has been Developed)
TMDL/303d Status: 2c (TMDL Unlikely (Other Control Actions More Appropriate))

Further Details

Public bathing, other recreational uses (boating, fishing) and aesthetics in Greenwood Lake are restricted by algal blooms and excessive aquatic weed growth in the lake. Non-point source runoff from urban/suburban development in the watershed is the primary source of nutrients and other pollutants. An 1993 evaluation by NYSDEC of the phosphorus load in the lake indicated that internal nutrient recycling was a significant source. Failing and/or inadequate on-site septic systems serving lake shore camps and year-round residences contribute to nutrient loadings, as well. (Orange County WQCC, 1996)

A Clean Lakes demonstration project, involving various restoration activities (aquatic vegetation harvesting, lake drawdown, stormwater management, sensitive lands management plan, environmental monitoring and public education) was conducted with the State of New Jersey in early 1990s.