Amendment to the Northeast Water Quality Management Plan

Total Maximum Daily Load for Phosphorus To Address Pompton Lake and Ramapo River in the Northeast Water Region

Watershed Management Area 3

Proposed: July 5, 2005
Established:
Approved:
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1.0 Executive Summary

In accordance with Section 305(b) and 303(d) of the Federal Clean Water Act (CWA), the State of New Jersey, Department of Environmental Protection (Department) developed the *2004 Integrated List of Waterbodies* addressing the overall water quality of the State's waters and, in Sublist 5, identifying the list of impaired waterbodies. On October 4, 2004, the Department adopted the *2004 Integrated List of Waterbodies* as an amendment to the Statewide Water Quality Management Plan, pursuant to the Water Quality Planning Act at N.J.S.A.58:11A-7 and the Statewide Water Quality Management Planning rules at N.J.A.C. 7:15-6.4(a). In the Northeast Water Region the *2004 Integrated List of Waterbodies* Sublist 5 identifies the Ramapo River at Mahwah on Sublist 5 as being impaired for phosphorus, as indicated by elevated total phosphorus (TP) levels in the stream segment. Pompton Lake was not listed on the *2004 Integrated List of Waterbodies* as being impaired for phosphorus; however, data evaluated in the development of this TMDL report indicate the lake is impaired, as indicated by exceedances of the Surface Water Quality Standard (SWQS) of 0.05 mg/L of total phosphorus (TP) in lake water samples. A TMDL is required to be developed for each of the impairments listed on Sublist 5. A TMDL is developed to identify all the contributors of a pollutant of concern and the load reductions necessary to meet the Surface Water Quality Standards (SWQS) relative to that pollutant. TMDLs are proposed to address the phosphorus impairment in the waterbodies identified in Table 1.

Table 1 Phosphorus impaired stream segment and lake located in the Ramapo River watershed, for which phosphorus TMDLs are being established

TMDL Number	WMA	Station Name/Waterbody	Site ID	County	River Miles/Lake Area
1	3	Ramapo River near Mahwah[1]	01387500	Bergen	17.73 miles
2	3	Pompton Lake	01388000	Passaic	175.4 acres

This TMDL report is based on two supporting documents: "Pompton Lake and Ramapo River TMDL Support Study" (QEA, 2004), and "Development of a TMDL for the Wanaque Reservoir and Cumulative WLAs/LAs for the Passaic River Watershed" (Najarian, 2005). Because the Ramapo River at Pompton Lake station is one of the three diversion intake sites feeding the Wanaque Reservoir, phosphorus loading from the Pompton Lake watershed was addressed in the Wanaque Reservoir TMDL. The estimated phosphorus loadings, as well as the phosphorus percent reduction, within New Jersey, needed to comply with the lake criterion were comparable in both studies, a 68 percent and 69 percent reduction were determined by the QEA and Najarian studies, respectively. Both studies assumed a boundary condition in which the inflow from New York State, as calculated at the Mahwah station, attains the State SWQS for TP of 0.1 mg/L. This will require a 76 percent TP reduction from all sources upstream of Mahwah station. A mass-balance model developed in the previous modeling

[1] The Ramapo River near Mahwah station is located 8 miles upstream from Pompton Lake, near the New Jersey/New York boundary, and is considered to be the best representation of the NY inflow water quality.

studies of the Passaic River Basin (NJDEP, 1997) and further refined by Najarian in 2005 was used to calculate the loading capacity for the Pompton Lake Watershed.

The TMDLs in this report shall be proposed and adopted by the Department as amendments to the appropriate area-wide water quality management plan in accordance with N.J.A.C. 7:15-3.4(g). This TMDL report was developed consistent with the United States Environmental Protection Agency's (USEPA's) May 20, 2002 guidance document entitled: "Guidelines for Reviewing TMDLs under Existing Regulations issued in 1992," (Sutfin, 2002) which describes the statutory and regulatory requirements for approvable TMDLs.

2.0 Introduction

In accordance with Section 303(d) of the Federal Clean Water Act (CWA) (33 U.S.C. 1315(B)), the State of New Jersey is required biennially to prepare and submit to the USEPA a report that identifies waters that do not meet or are not expected to meet SWQS after implementation of technology-based effluent limitations or other required controls. This report is commonly referred to as the 303(d) List. In accordance with Section 305(b) of the CWA, the State of New Jersey is also required biennially to prepare and submit to the USEPA a report addressing the overall water quality of the State's waters. This report is commonly referred to as the 305(b) Report or the Water Quality Inventory Report. The *Integrated List of Waterbodies* combines these two assessments and assigns waterbodies to one of five sublists. Sublists 1 through 4 include waterbodies that are generally unimpaired (Sublist 1 and 2), have limited assessment or data availability (Sublist 3), are impaired due to pollution rather than pollutants or have had a TMDL or other enforceable management measure approved by EPA (Sublist 4). Sublist 5 constitutes the traditional 303(d) list for waters impaired or threatened by one or more pollutants, for which a TMDL may be required.

Sublist 5 of the State of New Jersey's *2004 Integrated List of Waterbodies* identified Ramapo River at Mahwah as being impaired for phosphorus, as evidenced by elevated total phosphorus (TP). Pompton Lake was not listed as phosphorus-impaired, but the TP concentration in over 70 percent of lake water samples collected near the dam exceeded the surface water quality standard (QEA, 2004). Therefore, the Department determined that the lake is phosphorus-impaired and requires the development of a phosphorus TMDL to address this impairment.

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 water body can assimilate without violating a state's water quality standards and allocates that load capacity to known point 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.

Recent EPA guidance (Sutfin, 2002) describes the statutory and regulatory requirements for approvable TMDLs as well as additional information generally needed for USEPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations. The Department believes that this TMDL report addresses the following items in the May 20, 2002 guideline document:

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 (USEPA is not required to and does not approve TMDL implementation plans).
11. Public Participation.

This report establishes TMDLs for the Ramapo River and Pompton Lake and proposes management measures in an implementation plan to attain applicable surface water quality and designated uses standards in the river and lake. Following approval of the TMDLs by EPA, the Department will place the Ramapo River at Mahwah impairment on Sublist 4 of the Integrated List.

3.0 Pollutant of Concern and Area of Interest

Pollutant of Concern

The pollutant of concern for this TMDL report is phosphorus. When present in excessive amounts, this nutrient can lead to excessive primary productivity in the form of algal and/or macrophyte overgrowth. The presence of excessive plant biomass can, in itself, interfere with designated uses, such as swimming or boating. In addition, the respiration cycle of excessive plant material can cause significant swings in pH and dissolved oxygen, which can result in violation of criteria for these parameters and can adversely affect the remainder of the aquatic community. Algal blooms can also affect taste and odor, an issue of importance with respect to drinking water standards.

As stated in N.J.A.C. 7:9B-1.14(c) of the SWQS for Fresh Water 2 (FW2) waters:

<u>Phosphorus, Total (mg/l):</u>

> i. Lakes: Phosphorus as total P shall not exceed 0.05 in any lake, pond or reservoir, or in a tributary at the point where it enters such bodies of water, except where watershed or site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g)3.
>
> ii. Streams: Except as necessary to satisfy the more stringent criteria in paragraph i. above or where watershed or site-specific criteria are developed pursuant to N.J.A.C. 7:9B1.5(g)3, phosphorus as total P shall not exceed 0.1 in any stream, unless it can be demonstrated that total P is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses.

Regarding site specific criteria, N.J.A.C. 7:9B-1.5(g)3 states:

> The Department may establish watershed or site-specific water quality criteria for nutrients in lakes, ponds, reservoirs or streams, in addition to or in place of the criteria in N.J.A.C. 7:9B-

> 1.14, when necessary to protect existing or designated uses. Such criteria shall become part of these Water Quality Standards.

Elaborating on "…render waters unsuitable…" N.J.A.C. 7:9B-1.5(g)2 states:

> Except as due to natural conditions, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation, abnormal diurnal fluctuations in dissolved oxygen or pH, changes to the composition of aquatic ecosystems, or otherwise render the waters unsuitable for the designated uses.

The waterbodies listed in Table 1 have a FW2 classification. The designated uses, both existing and potential, that have been established by the Department for waters of the State classified as such are as stated below:

In all FW2 waters, the designated uses are (N.J.A.C. 7:9B-1.12):

1. Maintenance, migration and propagation of the natural and established aquatic biota;
2. Primary and secondary contact recreation;
3. Industrial and agricultural water supply;
4. Public potable water supply after conventional filtration treatment (a series of processes including filtration, flocculation, coagulation and sedimentation, resulting in substantial particulate removal but no consistent removal of chemical constituents) and disinfection; and
5. Any other reasonable uses.

Area of Interest

The Mahwah station (USGS 01387500) is located on the Ramapo River at Mahwah, Bergen County, approximately 1.3 miles downstream of the NY/NJ borderline and 8 miles upstream of Pompton Lake. Pompton Lake is a 71-hectare artificial impoundment on the Ramapo River formed by the Pompton Lake Dam. The lake is located in Passaic County between Wayne Township and the Borough of Pompton Lakes. The dam is owned by the North Jersey District Water Supply Commission (NJDWSC), which uses the lake water as a supplemental drinking water source for the Wanaque Reservoir. The Ramapo Pump Station, one of the three intakes feeding the Wanaque Reservoir, has a capacity of delivering up to 150 million gallon per day (MGD), on an "as needed basis", to the Wanaque Reservoir. Pompton Lake is mainly fed by the Ramapo River; it also receives some ungaged inflow from Acid Brook and smaller tributaries. The Ramapo River continues downstream of Pompton Lake Dam, draining into the Pompton River, a tributary of the Passaic River. The Pompton Lake watershed covers about 160 mi^2 (41,440 ha) of which 29 percent (47 mi^2) falls within New Jersey's Watershed Management Area (WMA) 3 and 71 percent (113 mi^2) within New York State. Figure 1 shows the spatial extent of the Pompton Lake watershed. Some of the Pompton Lake's characteristics are summarized in Table 2.

Table 2 Characteristics of Pompton Lake[2]

Lake Area (acre)	Lakeshed Area (acre)	Inflow (m^3/yr)	Avg. Diversion	Ave. Outflow	Areal Water load (m/yr)

[2] Except lakeshed area, all the data are obtained from QEA's study on Pompton Lake (QEA, 2004).

			flow (m^3/yr)	(m^3/yr)	
175	102,400	2.6E+08	1.0E+07	2.5E+08	375

Figure 1 Location of the Pompton Lake Watershed

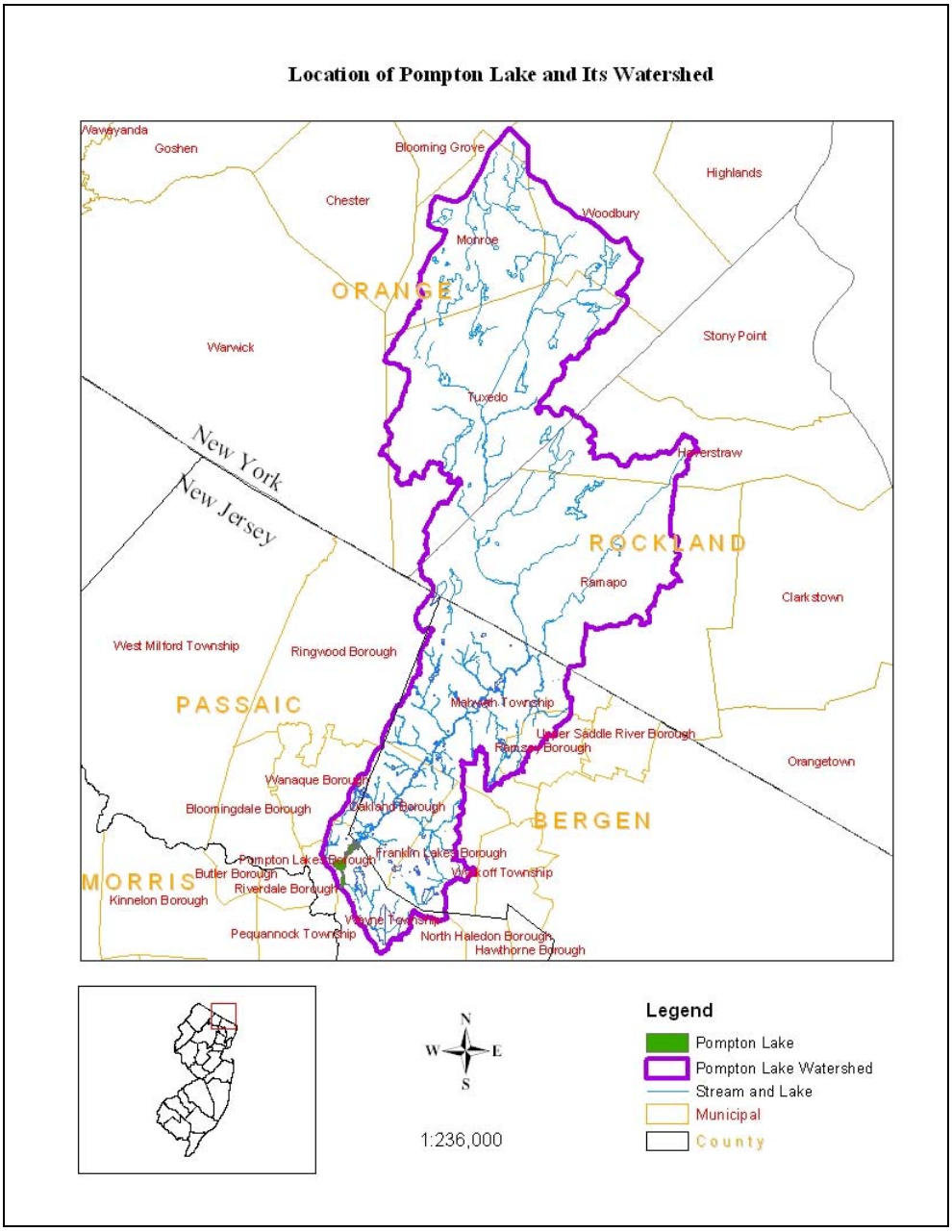
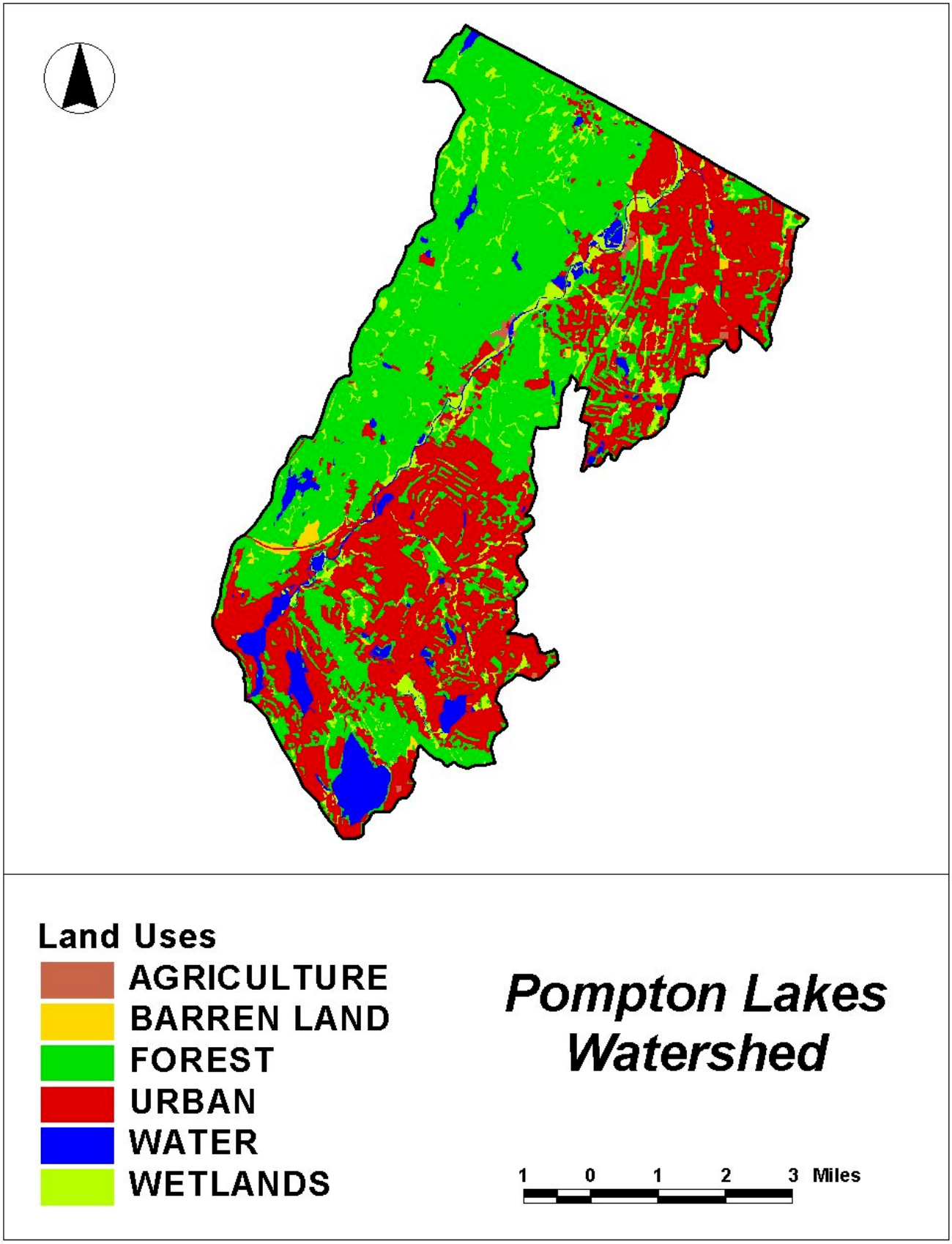


Figure 2 Pompton Lake Watershed land use GIS coverage



Geographic Information System (GIS) Coverage

Geographic Information System (GIS) data from the Department and for New York was used extensively to describe the lake and its watershed, specifically the following data:

- 1995/97 Land use/Land cover Update, published 12/01/2000 by NJDEP Bureau of Geographic Information and Analysis, delineated by watershed management area.
- NJDEP Countywide Lakes and Streams (Shapefile) with Name Attributes for Passaic and Bergen Counties to describe the lakes and streams located within the watershed. http://www.nj.gov/dep/gis/lakesshp.html and http://www.nj.gov/dep/gis/strmshp.html
- Lakeshed and subbasins were delineated using an automatic delineation of NJBASIN based on NJDEP 10-meter Digital Elevation Grid for WMA 3. (http://www.nj.gov/dep/gis/wmalattice.html) The manual QC check was conducted on the boundaries automatically generated by NJBASIN and necessary modifications were made to appropriately delineate the lakeshed and subbasins.
- NJDEP's 2000 Census Block Shapefile http://www.nj.gov/dep/gis/stateshp.html#CENBLK
- NJDEP's 2002 Orthophotography Image for Passaic and Bergen Counties. http://njgin.nj.gov/OIT_IW/index.jsp
- National Land Cover Data (NLCD) for New York, last updated in July 2000, and for New Jersey, last updated in March 2000. The data was produced under the direction of the USGS as part of the Multi-Resolution Land Characterization (MRLC) Regional Land Cover Characterization Project. The data used the NLCD Land Cover Classification Systems to categorize land use. http://edcsgs9.cr.usgs.gov/pub/data/landcover/states/
- Ramapo River and Pompton Lake Hydrology coverage (7.5 minute Quad Sheet) downloaded from Cornell University Geospatial Data Information Repository (CUGIR) was used to derive the entire lake boundary coverage. Hydrography (Census 2000) shapefiles were downloaded from CUGIR to describe the streams and lakes located in NY-side. http://cugir.mannlib.cornell.edu/browse_map/browse_map.html

4.0 Source Assessment

In order to evaluate and characterize phosphorus loadings in the waterbodies of interest in these TMDLs, and thus propose proper management responses, source assessments are critical. Source assessments include identifying the types of sources and their relative contributions to phosphorus loadings, in both time and space variables.

For the purpose of TMDL development, point sources include domestic and industrial wastewater treatment plants that discharge to surface water, as well as surface water discharges of stormwater subject to regulation under the National Pollutant Discharge Elimination System (NPDES). This includes facilities with individual or general industrial stormwater permits and Tier A municipalities and Federal, interstate agency, state and county facilities regulated under the New Jersey Pollutant Discharge Elimination System (NJPDES) municipal stormwater permitting program.

Stormwater point sources, like nonpoint sources, derive their pollutant load from runoff from land surfaces and load reduction is accomplished through BMPs. The distinction is that stormwater point sources are regulated under the Clean Water Act. Stormwater point sources are or will be addressed through the management practices required through the discharge permits and load reductions will be

expressed as a percent reduction for corresponding land use, as discussed under load allocation. The Tier A municipalities located in the affected streamsheds are identified in Appendix A.

For the purpose of TMDL development, potential nonpoint sources include stormwater discharges that are not subject to regulation under NPDES, including Tier B municipalities, which are regulated under the NJPDES municipal stormwater permitting program, and direct stormwater runoff from land surfaces, as well as malfunctioning sewage conveyance systems, failing or inappropriately located septic systems, and direct contributions from wildlife, livestock and pets. There are no Tier B municipalities within the affected streamsheds.

The phosphorus loads in the affected watershed contributed by stormwater point sources and nonpoint sources are effectively estimated using loading coefficients for land uses present in the watersheds. These loads for total phosphorus were, therefore, estimated using the Unit Areal Load (UAL) methodology, which applies pollutant export coefficients obtained from literature sources to the land use patterns within the watershed, as described in USEPA's Clean Lakes Program guidance manual (Reckhow, 1979b). National Land Cover Data (NLCD) for New York, last updated in July 2000, and for New Jersey, last updated in March 2000, were downloaded from USGS to examine the land use distribution in the watershed of Pompton Lake. The overall breakdown is provided in Table 4.

Based on the TMDL support documents: "Pompton Lake and Ramapo River TMDL Support Study" (QEA, 2004), and "Development of a TMDL for the Wanaque Reservoir and Cumulative WLAs/LAs for the Passaic River Watershed" (Najarian, 2005) potential sources of phosphorus to the river and lake were evaluated and the annual loading of phosphorus from different sources was quantified. According to both studies, the mean annual TP load entering the Pompton Lake was estimated in the same way. Phosphorus loadings from New York State were estimated based on the relationship between flow and phosphorus concentrations at the Ramapo River near Mahwah station (01387500, and therefore, TP loading at Mahwah represents both point and non-point sources combined together. Phosphorus loadings from New Jersey, on the other hand, were calculated based on assessment of point and nonpoint source loadings. Nonpoint source loadings were calculated based on the export coefficients approach and point sources loads were based on the Department's Discharge Monitoring Records (DMR). DMR data from 1997-2002 were used to quantify the point source loadings, and total TP loading were calibrated using the mass-balance approach.

As part of TMDL development, the Department reviewed phosphorus export coefficients from an extensive database (Appendix B). The selected values for the land use categories existing in Pompton Lake watershed are summarized in Table 3.

Phosphorus loads were characterized on an annual scale (kg TP/yr) or (lbs TP/yr). Long-term pollutant loads are typically more critical to overall lake water quality than the load at any particular short-term time 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.

Table 3 Phosphorus Export Coefficients (Unit Areal Loads)

Land use/Land Cover	LU/LC Codes	UAL (kg TP/ha/yr)
medium / high density residential	1120	1.6
low density / rural residential	1130, 1140	0.7
Commercial	1200	2.0
Mixed urban/other urban	1400, 1700, 1800	1.0
Agricultural	2000	1.5
Forest, wetland, water	1750, 2140, 2150, 4000, 6000, 5000, 7430	0.1
Barren land	7000	0.5

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

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).

Table 4 Land Use Types in the Pompton Lake Watershed[3]

Land Use	Area (ha)
Agriculture	440
Barren Land	110
Forest	31,755
Water	1,813
Wetlands	1,368
Recreational	290
Residential-High, Medium	2,058
Residential-Low, Rural	5,694
Other Urban	412
Commercial	1,280
Industrial	371

Loads from the point sources, other than stormwater point sources, that are a significant source of phosphorus within New Jersey were calculated based on the NJDEP's DMRs (Daily Monitoring Reports) as an average load for the period 1997- 2000 for each NJ facility. Table 5 lists the dischargers of interest within the Pompton Lake watershed (Najarian, 2005).

[3] Table 4-2 of Pompton Lake and Ramapo River TMDL Support Study, QEA 2004

Table 5 Point source discharges, other than stormwater point sources, that are a significant source of phosphorus into the Pompton Lake watershed- NJ

NJPDES #	Facility Name	Current Flow (mgd)[2]	Current Load (lbs/yr)[3]
NJ0029858	OAKLAND CARE CENTER	0.0239	9.5
NJ0053112	OAKLAND-CHAPEL HILL ESTATES STP	0.0069	0.5
NJ0080811	RAMAPO RIVER CLUB STP	0.0696	14.2
NJ0027774	OAKLAND-OAKWOOD KNOLLS WWTP	0.0177	2.4
NJ0021253	RAMAPO-INDIAN HILLS H.S. WTP	0.0068	7.1
NJ0021342	OAKLAND-SKYVIEW-HIGH BROOK STP	0.0130	2.3

5.0 Water Quality Analysis

The United States Geological Survey (USGS) in collaboration with the Department has collected monitoring data at two stations:

- Station 01387500, located on the Ramapo River near Mahwah, 8 miles upstream of Pompton Lake. During a period 1970-2003, 146 sets of TP and flow results were obtained. From this number, 96 TP results (66%) exceeded SWQS of 0.1 mg/L TP.
- Station 01388000, located in Pompton Lake, less than 10 meters upstream of the dam. Vertically-integrated composite samples were collected from 1987 through 1996 water year. During this time, 137 total phosphorus results were obtained, 96 TP results (70%) exceeded SWQS for lakes (0.05 mg/L).

In addition to these stations, water quality data were collected by:

- The Passaic Valley Water Commission (PVWC) sampled Ramapo River at Pleasure Land, Oakland. This station is located just upstream of the lake. Collection of water quality data was ceased in 2001.
- The North Jersey District Water Supply Commission (NJDWSC) collects surface water samples on the lakeside of the diversion channel for the Ramapo River 700 Pump Station, less than 10 meters upstream of the dam.
- The Department and QEA conducted a one-day sampling event to provide a snapshot assessment of in-lake water quality and to collect bathymetric data of the lake. Results from this sampling event are described in detail in the QEA study (QEA, 2004).

The observation of frequency exceedances above the standard is presented in Table 6.

Table 6 Frequency of violations of selected water quality standards from long-term monitoring stations[4]

Substance	SWQS[5]	Percent Violations (%)			
		USGS 0137500	PVWC Oakland	NJWSC Pompton Lake	USGS 01388000 Pompton Lake
Total phosphorus (stream)	<0.1 mg/L	66	17	Na	Na
Total phosphorus (lake)	< 0.05 mg/L	N/a		71	70
Chlorophyll-a	sasonal mean <24µg/L	17	-	22	-
	Summer	33	-	40	-
	Autumn	-	-	20	-
	Spring	0	-	33	-
	Winter	-	-	0	-
Dissolved oxygen	>5 mg/L (24-hour average)	1.6	6.4	1.3	2.2
Dissolved oxygen	>4 mg/L (instantaneous)	1.1	6.4	0.7	2.2

Na -not applicable

Analysis of the data available for the Ramapo River indicates that the river is a "losing" stream. The water quality in the downstream reach is substantially (approximately 30%) better than the quality at Mahwah station.

6.0 Technical Approach

Assumptions and methodology

To develop the total phosphorus TMDL for the Pompton Lake, some assumptions were made (QEA, 2004):

- Phosphorus loads from significant point sources, other than stormwater point sources, were derived from DMR data for the permitted wastewater treatment facilities in the watershed within New Jersey. Loading from point sources within New York were not distinguished from nonpoint sources; the state boundary was taken as a boundary condition. (see Section 4 Source Assessment);
- Nonpoint source loads were estimated using land use coverage distribution in eleven categories, as presented in Table 4, and the phosphorus export coefficients (Unit Areal Loads), are presented in Table 3. Land uses were estimated separately for the part of watershed north from the Mahwah station (01387500), the part of watershed entering the lake, and the part of the watershed draining directly to the lake, excluding Ramapo River watershed.
- The loads estimated directly from the water quality data and flow data at the Mahwah station were compared to the loads estimated using land use coverage and UAL. It was assumed that the loads estimated directly from monitoring data are likely to be more accurate because of the large amount of TP/flow data, and the quality of the regression of TP versus flow. The

[4] Table 3-2 of Pompton Lake and Ramapo River TMDL Support Study, QEA 2004

[5] Based on FW2-NT water body standards and the Department's Technical Manual for Phosphorus Evaluation (NJDEP, 2003a)

phosphorus load calculated using monitoring results was used for the further calculations of total TP load to Pompton Lake.

The TMDLs for total phosphorus are calculated as follows:

TMDL = loading capacity
= Sum of the wasteload allocations (WLAs) + load allocations (LAs) + margin of safety + reserve capacity.

Phosphorus Load to Pompton Lake

Due to the limitation of the available data, the Department chose an empirical model as the most appropriate means to relate annual phosphorus load and steady-state in-lake concentration of total phosphorus. The Department surveyed the commonly used models in Table 7. These empirical models consist of equations derived from simplified mass balances that have been fitted to large datasets of actual lake measurements. The resulting regressions can be applied to lakes that fit within the range of hydrology, morphology and loading of the lakes in the model database. The Reckhow (1979a) model was selected because the hydrologic, morphological and loading characteristics of Pompton Lake fit well within the assumptions of the model and because it appeared to give the best predictive results for phosphorus concentration. These characteristics are summarized in Table 8.

Table 7 Empirical models considered by the Department

Reference	Steady-state TP concentration in lake (mg/l)	Secondary term	Application
Rast, Jones and Lee, 1983	$1.81 \times NPL^{0.81}$	$NPL = \left(\frac{P_a \times DT/D_m}{1+\sqrt{DT}} \right)$	expanded database of mostly large lakes
Vollenweider and Kerekes, 1982	$1.22 \times NPL^{0.87}$	$NPL = \left(\frac{P_a \times DT/D_m}{1+\sqrt{DT}} \right)$	mostly large natural lakes
Reckhow, 1980	$\frac{P_a}{13.2}$	none	Upper bound for closed lake
Reckhow, 1979a	$\frac{P_a}{(11.6 + 1.2 \times Q_a)}$	$Q_a = \frac{Q_i}{A_l}$	General north temperate lakes, wide range of loading concentration, areal loading, and water load
Walker, 1977	$\frac{P_a \times DT/D_m}{(1 + 0.824 \times DT^{0.454})}$	none	oxic lakes with $D_m/DT < 50$ m/yr
Jones and Bachmann, 1976	$\frac{0.84 \times P_a}{(D_m \times (0.65 + DT^{-1}))}$	none	may overestimate P in shallow lakes with high D_m/DT

Reference	Steady-state TP concentration in lake (mg/l)	Secondary term	Application
Vollenweider, 1975	$\frac{P_a}{\left(D_m \times \left(DT^{-1} + S\right)\right)}$	$S = 10/D_m$	Overestimate P lakes with high D_m/DT
Dillon-Kirchner, 1975	$\frac{P_a}{\left(13.2 + D_m/DT\right)}$	none	low loading concentration range
Dillon-Rigler, 1974	$P_a \times DT/D_m \times (1 - R)$	R = phosphorus retention coefficient	general form
Ostrofksy, 1978	Dillon-Rigler, 1974	$R = 0.201 \times e^{(-0.0425 \times Q_a)} + 0.5743 \times e^{-0.00949 * Q_a}$	lakes that flush infrequently
Kirchner-Dillon, 1975	Dillon-Rigler, 1974	$R = 0.426 \times e^{\left(-0.271 \times D_m/DT\right)} + 0.5743 \times e^{-0.00949 * D_m/DT}$	general application
Larsen-Mercier, 1975	Dillon-Rigler, 1974	$R = \frac{1}{1 + \sqrt{1/DT}}$	Unparameterized form

where:
NPL = normalized phosphorus loading
P_a = areal phosphorus loading (g/m²/yr)
DT = detention time (yr)
D_m = mean depth (m)
Q_a = areal water load (m/yr)
Q_i = total inflow (m³/yr)
A_l = area of lake (m²)
S = settling rate (per year)

The Reckhow (1979a) model is described in USEPA Clean Lakes guidance documents: "Quantitative Techniques for the Assessment of Lake Quality" (Reckhow, 1979b) and "Modeling Phosphorus Loading and Lake Response Under Uncertainty" (Reckhow *et al*, 1980). The derivation of the model is summarized in Appendix C. The model relates TP load to steady state TP concentration, and is generally applicable to north temperate lakes.

Table 8 Hydrologic and loading characteristics of Pompton Lake

Parameters	**Ranges of Characteristics Reckhow Model can fit**		**Pompton Lake**	
	Min	**Max**	**Current condition**	**Target Condition[3]**
TP Conc. (mg/L)	0.004	0.135	0.063	0.02
Avg. Influent TP Conc. (mg/L)[2]	-	0.298	0.08	
Q_a, Areal Water Load (m/yr)	1.2	190	375	N/A
P_a, Areal TP Load (g/m²/yr)	0.07	31.4	28.8	

Note:
1. Predicted in-lake annual average concentration using Reckhow model (see section below).

2. Calculated using Pa*DT/Dm.
3. As explained below, the target concentration is 0.02 mg/L after considering the seasonal variability. The other parameters under target condition were all calculated based on the target concentration.

Current Condition

Using lake physical parameters and estimated TP external loads, the predicted steady-state in-lake phosphorus concentration calculated using the Reckhow (1979a) model predicts an in-lake TP concentration of 0.063 mg/L (QEA, 2004). The predicted in-lake concentration compares well with observed in-lake mean phosphorus concentrations—at the USGS station located about 35 ft. upstream of the lake outlet, the mean phosphorus concentration for the period of record 1987 through 1996 is 0.08 mg/L. In 2003, several locations within the lake were sampled, and results show that the mean phosphorus concentration was 0.06 mg/L, with data ranging between 0.05 and 0.07 mg/L. Data from NJDWSC/Pompton Lake Station from 1993 to 2001 were also investigated; this data revealed an average TP concentration of 0.11 mg/L, nearly twice the average concentration computed using the Reckhow model. However, it is important to point out that these data are not representative of the in-lake concentration, since they are lake surface water samples, taken one foot from the lake surface. In contrast, both the USGS and the one day sampling event were taken as depth integrated samples. The predicted TP concentration is representative of the depth-integrated concentration.

Reference Condition

A reference condition for Pompton Lake was estimated by calculating external loads as if the land use throughout the lakeshed were completely forest and wetlands and the loads from septic tank systems and internal recycling were assumed to be zero. Estimates of air deposition loads were included to calculate the reference condition. Using the same physical parameters and external loads from forest, wetlands and air deposition, a reference steady-state phosphorus concentration was calculated for Pompton Lake using the Reckhow (1979a) formulation as listed in Table 7. The reference condition was developed to estimate what the TP concentration would be under pristine conditions and assure that the target concentration based on the SWQS are achievable. For Pompton Lake, the target steady state concentration is 0.03 mg/l while the steady state concentration under the reference condition is only 0.014 mg/l. Therefore, the target concentration is achievable and is used for the TMDL calculations.

Seasonal Variation/Critical Conditions

The peak (based on the 90th percentile) to mean ratio was examined for the in-lake phosphorus concentration sampled by USGS at Pompton lake, station # 01388000 for period of record 1983 through 1996, the peak-to-mean ratio was estimated to be 1.62, this site-specific peak-to-mean ratio would result in target phosphorus concentrations of 0.031 mg/L. which compares well to previous target phosphorus concentrations set for other lakes in NJ, (*In previous lake TP TMDLs established by the Department, a critical condition of 0.03 mg/L was chosen based on the peak-to-mean ratios of 1.56 and 1.48 observed from Strawbridge Lake and Sylvan Lake, respectively ((Strawbridge Lake, NJDEP 2000a; Sylvan Lake, NJDEP 2000b).* Therefore, the Department determined that a target phosphorus concentration of 0.03 mg TP/l is appropriate for use in this TMDL. Since it is the annual pollutant load rather than the load at any particular time that determines overall lake water quality (section 6), the target phosphorus concentration of 0.03 mg TP/l accounts for critical conditions.

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(c)). 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, both an implicit and an explicit MOS are provided.

This 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 comparing peak concentrations to mean concentrations and adjusting the target concentration accordingly (0.03 mg TP/l instead of 0.05 mg TP/l). 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 orthophosphorus, which is available for algal growth, and unavailable forms of phosphorus (e.g. particulate). While many forms of phosphorus are converted into orthophosphorus in the lake, many are captured in the sediment, for instance, and never made available for algal uptake.

In addition to the conservative assumptions built in to the calculation, an additional explicit MOS was included to account for the uncertainty in the model itself. As described in Reckhow *et al* (1980), the Reckhow (1979a) model has an associated standard error of 0.128, calculated on log-transformed predictions of phosphorus concentrations. Transforming the terms in the model error analysis from Reckhow *et al* (1980) yields the following (Appendix C):

$$MoS_p = \sqrt{1 \big/ \left((1-\rho)*4.5\right)} \times \left(10^{0.128} - 1\right),$$

where: MoS_p = margin of safety as a percentage over the predicted phosphorus concentration;

ρ = the probability that the real phosphorus concentration is less than or equal to the predicted phosphorus concentration plus the margin of safety as a concentration.

Setting the probability to 90% yields a MOS of 51% when expressed as a percentage over predicted phosphorus concentration or estimated external load. The external load for each lake was therefore multiplied by 1.51 to calculate an "upper bound" estimate of steady-state phosphorus concentration. An additional explicit MOS was included in the analyses by setting the upper bound calculations equal to the target phosphorus concentration of 0.03 mg TP/l, as described in the next section and shown in Table 9. Note that the explicit MOS is equal to 51% when expressed as a percentage over the predicted phosphorus concentration; when expressed as a percentage of total loading capacity, the MOS is equal to 33.3%:

$$\left(MoS_{lc} = \frac{MoS_p \times P}{P + \left(MoS_p \times P\right)} = \frac{MoS_p}{1 + MoS_p} = \frac{0.51}{1.51} = 0.333 \right),$$

where: MoS_p = margin of safety expressed as a percentage over the predicted phosphorus concentration or external load;

MoS_{lc} = margin of safety as a percentage of total loading capacity;

P = predicted phosphorus concentration (or external load).

Target Condition

As discussed above, when considering the seasonal variation, the steady state concentration of phosphorus in the lake must be equal to or less than 0.03 mg/L to avoid exceeding the 0.05 mg/L phosphorus criterion. Using Reckhow (1979a), any predicted concentration has a MOS of 51% when expressed as a percentage over the predicted phosphorus concentration. To assure compliance with the 0.03 mg/L target, the predicted concentration can not be higher than 0.02 mg/L (0.02 + 0.02*51% = 0.03 mg/L) considering the effect of the MOS. Therefore, 0.02 mg/L is chosen as the target concentration to attain the standard while 0.03 mg/L is defined as the upper boundary target condition. The load corresponding to a 0.03 mg/L in-lake concentration is defined as the allowable loading capacity of the lake. The overall reduction to attain the standard level in Pompton Lake was calculated by comparing the current concentration (calculated using Reckhow Model) to 0.02 mg/L, the target concentration (Table 9).

Given the required boundary condition of water quality meeting the standard of 0.1 mg/L at the state border/Mahwah station and the fact that the Ramapo River is a "losing" stream, the in-stream standard of 0.1 mg/L will be met in the Ramapo River, without further demonstration.

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. Phosphorus contributions from future development are expected to be controlled through implementation of the Stormwater Management Rules, which establish quality standards for TSS and nutrients. The follow up monitoring and implementation plan will require the collection of more detailed information about the lakeshed, which may result in revisions to the loading capacity and/or allocations. The loading capacities and accompanying load allocations must be attained in consideration of any new sources that may accompany future development.

7.0 Allocations

WLAs are established for all point sources, while LAs are established for nonpoint sources, as these terms are defined in "Source Assessment." Both WLAs and LAs are expressed as percent reductions for particular stream segments, and are differentiated as discussed below.

Stormwater discharges can be a point source or a nonpoint source, depending on NPDES regulatory jurisdiction, yet the suite of measures to achieve reduction of loads from stormwater discharges is the same, regardless of this distinction. Stormwater point sources receiving a WLA are distinguished from stormwater generating areas receiving a LA on the basis of land use. This distribution of loading capacity between WLAs and LAs is consistent with recent EPA guidance that clarifies 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 described previously. 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). Therefore allocations are established according to source categories as shown in Table 9. This demarcation between WLAs and LAs based on land use source categories is not perfect, but it represents the best estimate defined as narrowly as data allow. The Department acknowledges

that there may be stormwater sources in the residential, commercial, industrial and mixed urban runoff source categories that are not NJPDES-regulated. Nothing in these TMDLs shall be construed to require the Department to regulate a stormwater source under NJPDES that would not already be regulated as such, nor shall anything in these TMDLs be construed to prevent the Department from regulating a stormwater source under NJPDES.

Table 9 Distribution of WLAs and LAs among source categories

Source Category	TMDL Allocation
Nonpoint and 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

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 appropriate to express the TMDL on a yearly basis. Long-term average pollutant loadings are typically more critical to overall 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.

Since this TMDL is based on two independent supporting TMDLs studies, the loading allocation will be based on the more stringent percent reduction. The allocation based on the Reckhow model requires an overall percent reduction of 68%. The allocation determined by the mass-balance model at the outlet of the lake requires an overall percent reduction of 69%. Therefore, the overall phosphorus reduction used in this TMDL will be 69%. Table 10 shows percent reductions required to achieve the overall reduction of 69%. Because some land use loads are not adjustable, the overall reduction, as a WLA or LA, depending on land use, must be achieved from land uses that can be affected by management measures. Therefore, 80 percent reduction will be allocated for adjustable nonpoint sources.

WLAs for point sources, other than stormwater point sources, is determined as follows:

WLA (lbs/yr) = LTA (ppm) * permitted flow rate (mgd) * 8.34 (conversion factor) * 365.

The WLAs are based on permitted flows and a uniform application of an LTA of 0.2 mg/L in the Wanaque Reservoir watershed (refer to Wanaque Reservoir TMDL, also proposed July 5, 2005), no percent reduction is required from the existing loading of the identified point sources. The loading in excess of that needed by the identified facilities would be available for water quality trading, which may be undertaken as part of the overall Passaic River Basin phosphorus TMDL studies. Effluent limits will be given in terms of load only, because the critical location is Pompton Lake and lakes are sensitive to annual loads. See allocation tables for both studies below:

Table 9 Current condition, reference condition, target condition and overall percent reduction for Pompton Lake- based on QEA TMDL study

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 (%)
.063	0.014	0.03	0.02	68%

Table 10 TMDL calculations for Pompton Lake (annual loads and percent reductions)[6]

	Existing Conditions[1]		TMDL Specification		Percent
	lbs TP/yr	% of CWL	lbs TP/yr	% of CWL	Reduction[2]
Cumulative Watershed Load (CWL)	43,925	100%	13,780	100%	69%
Point Sources other than Stormwater					
NJPDES Dischargers[3]	37	0.1%	149	1.1%	0%
Internal Loading					
Sediment/Base Flow	1,634	3.7%	1,634	11.9%	0%
Boundary Inputs					
New York[4]	28,320	64.5%	6,851	49.7%	76%
Land Use Surface Runoff[5]					
Low Intensity Residential	3,087	7.0%	617	4.5%	80%
High Intensity Residential	4,739	10.8%	948	6.9%	80%
Commercial/Industrial/Transportation	2,758	6.3%	552	4.0%	80%
Mixed Urban/Recreational	1,426	3.2%	285	2.1%	80%
Crops/Pasture/Hay	191	0.4%	38	0.3%	80%
Deciduous Forest	1,206	2.7%	1,206	8.8%	0%
Evergreen Forest	6	0.0%	6	0.0%	0%
Mixed Forest	44	0.1%	44	0.3%	0%
Shrubland	36	0.1%	36	0.3%	0%
Woody Wetlands	138	0.3%	138	1.0%	0%
Herbaceous Wetlands	10	0.0%	10	0.1%	0%
Open Water	142	0.3%	142	1.0%	0%
Disturbed Areas	150	0.3%	150	1.1%	0%
Other Allocations					
Margin of Safety	n/a	n/a	832	6.0%	n/a
Reserve Capacity	n/a	n/a	141	1.0%	n/a

1 average annual loads based on 1993-2002 model simulation
2 = 1 - (TMDL load /Existing load)*100
3 detailed listing of individual discharge facilities is provided with Table 5
4 includes PS and NPS discharges to Ramapo River within New York State

[6] Table 6-2 "Development of a TMDL for the Wanaque Reservoir and Cumulative WLAs/LAs for the Passaic River Watershed" (Najarian, 2005)

Table 11 WLAs for Treatment Facilities on the Pompton Lake watershed[7]

Sub-Shed[1]	NJPDES #	Facility Name	Current Flow (mgd)[2]	Current Load (lbs/yr)[3]	Permitted Flow (mgd)	WLA (lbs/yr)[4]	Load % Reduction*
1	NJ0029858	OAKLAND CARE CENTER	0.0239	9.5	0.0300	18.3	*
1	NJ0053112	OAKLAND-CHAPEL HILL ESTATES STP	0.0069	0.5	0.0100	6.1	*
1	NJ0080811	RAMAPO RIVER CLUB STP	0.0696	14.2	0.1137	69.2	*
1	NJ0027774	OAKLAND-OAKWOOD KNOLLS WWTP	0.0177	2.4	0.0350	21.3	*
1	NJ0021253	RAMAPO-INDIAN HILLS H.S. WTP	0.0068	7.1	0.0336	20.5	*
1	NJ0021342	OAKLAND-SKYVIEW-HIGH BROOK STP	0.0130	2.3	0.0230	14.0	*

[2] current flows are based on NJDEP's Municipal STP Flow Database for 2002
[3] current loads are based on facility's reported 1997-2000 discharge load
[4] based on a LTA effluent concentration of 0.20 mg/l
* denotes that projected TMDL is greater than the reported discharge load

8.0 Follow-up Monitoring and Lake Characterization Plan

The Water Resources Division of the U.S. Geological Survey and the Department have cooperatively operated the Ambient Stream Monitoring Network (ASMN) in New Jersey since the 1970s. The ASMN currently includes approximately 115 stations that are routinely monitored on a quarterly basis. A second ambient monitoring network, NJDEP's Supplemental Ambient Surface Water Network (100 stations), has improved spatial coverage for water quality monitoring in New Jersey. The data from these networks have been used to assess the quality of freshwater streams and percent load reductions. The ambient networks, as well as targeted studies, will be the means to determine the effectiveness of TMDL implementation and the need for additional management strategies.

In addition, a supplemental characterization and assessment study will be completed for Pompton Lake. This study should include sediment sampling, at a minimum. This will assist in refining implementation options and developing a restoration plan.

9.0 Implementation

Management measures are "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint and stormwater sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint and stormwater source pollution control practices, technologies, processes, sitting criteria, operating methods, or other alternatives" (USEPA, 1993).

The Department recognizes that TMDLs alone are not sufficient to restore impaired stream segments. The TMDL establishes the required pollutant reduction targets while the implementation plan identifies some of the regulatory and non-regulatory tools to achieve the reductions, matches management measures with sources, and suggests responsible entities for non-regulatory tools. This

[7] table 6-10 "Development of a TMDL for the Wanaque Reservoir and Cumulative WLAs/LAs for the Passaic River Watershed" (Najarian, 2005)

provides a basis for aligning available resources to assist with implementation activities. Projects proposed by the State, local government units and other stakeholders that would implement the measures identified within the impaired watershed are a priority for available State (for example, CBT) and federal (for example, 319(h)) funds. In addition, the Department's ongoing watershed management initiative will develop detailed watershed restoration plans for impaired stream segments in a priority order that will identify more specific measures to achieve the identified load reductions.

The stormwater facilities subject to regulation under NPDES in this watershed must be assigned WLAs. The WLAs for these point sources are expressed in terms of the required percent reduction for nonpoint sources and are applied to the land use categories that correspond to the areas regulated under industrial and municipal stormwater programs. The BMPs required through stormwater permits, including the additional measure discussed below, are generally expected to achieve the required load reductions. The success of these measures will be assessed through follow up monitoring. As needed through adaptive management, other additional measures may need to be identified and included in stormwater permits. Follow up monitoring or watershed restoration plans 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. A more detailed discussion of stormwater source control measures follows.

On February 2, 2004 the Department promulgated two sets of stormwater rules: The Phase II New Jersey Pollutant Discharge Elimination System (NJPDES) Stormwater Rules, N.J.A.C. 7:14A and the Stormwater Management Rules, N.J.A.C. 7:8

Municipal Stormwater Regulation Program

The Phase II NJPDES rules for the Municipal Stormwater Regulation Program require municipalities, highway agencies, and regulated "public complexes" to develop stormwater management programs consistent with the NJPDES permit requirements. The stormwater discharged through "municipal separate storm sewer systems" (MS4s) is regulated under the Department's Phase II NJPDES stormwater rules. Under these rules and associated general permits, Tier A municipalities are required to implement various control measures that should substantially reduce phosphorus loadings in the impaired watersheds. These control measures include adoption and enforcement of a pet waste disposal ordinance, prohibiting the feeding of unconfined wildlife on public property, cleaning catch basins, performing good housekeeping at maintenance yards, and providing related public education and employee training. These basic requirements will provide for a measure of load reduction from existing development. As the Phase II stormwater rules are a federal mandate, New York has also developed a municipal stormwater program.

In New Jersey, all municipalities with contributory drainage area into the impaired waterbodies will be required to adopt an ordinance as an additional measure that prohibits the outdoor application of fertilizer other than low phosphorus fertilizer, consistent with a model ordinance provided by the Department. Fertilizer does not include animal or vegetable manure or compost. This model ordinance has been posted on www.njstormwater.org. The additional measure is as follows:

Low Phosphorus Fertilizer Ordinance

Minimum Standard – Municipalities listed in Appendix A. shall adopt and enforce an ordinance, consistent with a model ordinance provided by the Department, to prohibit the outdoor application of fertilizer other than low phosphorus fertilizer, except:

Any application of fertilizer at a commercial farm that is exempted by the Right to Farm Act, N.J.S.A. 4:1C-1 et seq.

Any application of fertilizer needed for establishing new vegetation after land disturbance in accordance with the requirements established under the Soil Erosion and Sediment Control Act, N.J.S.A. 4:24-39 et seq. and implementing rules.

Measurable Goal - Municipalities listed in Appendix A. shall certify annually that they have met the Low Phosphorus Fertilizer Ordinance minimum standard.

Implementation - Within 6 months from adoption of the TMDL, municipalities listed in Appendix A. shall have fully implemented the Low Phosphorus Fertilizer Ordinance minimum standard.

Stormwater Management Rules

The Stormwater Management Rules have been updated for the first time since their original adoption in 1983. These rules establish statewide minimum standards for stormwater management in new development, and the ability to analyze and establish region-specific performance standards targeted to the impairments and other stormwater runoff related issues within a particular drainage basin through regional stormwater management plans. The Stormwater Management Rules are currently implemented through the Residential Site Improvement Standards (RSIS) and the Department's Land Use Regulation Program (LURP) in the review of permits such as freshwater wetlands, stream encroachment, CAFRA, and Waterfront Development.

The Stormwater Management Rules focus on the prevention and minimization of stormwater runoff and pollutants in the management of stormwater. The rules require every project to evaluate methods to prevent pollutants from becoming available to stormwater runoff and to design the project to minimize runoff impacts from new development through better site design, also known as low impact development. Some of the issues that are required to be assessed for the site are the maintenance of existing vegetation, minimizing and disconnecting impervious surfaces, and pollution prevention techniques. In addition, performance standards are established to address existing groundwater that contributes to baseflow and aquifers, to prevent increases to flooding and erosion, and to provide water quality treatment through stormwater management measures for TSS and nutrients.

As part of the requirements under the municipal stormwater permitting program, municipalities are required to adopt and implement municipal stormwater management plans and stormwater control ordinances consistent with the requirements of the stormwater management rules. As such, in addition to changes in the design of projects regulated through the RSIS and LURP, municipalities will also be updating their regulatory requirements to provide the additional protections in the Stormwater Management Rules within approximately two years of the issuance of the NJPDES General Permit Authorization.

Furthermore, the New Jersey Stormwater Management Rules establish a 300-foot special water resource protection area (SWRPA) around Category One (C1) waterbodies and their intermittent and perennial tributaries, within the HUC 14 subwatershed. In the SWRPA, new development is typically limited to existing disturbed areas to maintain the integrity of the C1 waterbody. C1 waters receive the highest form of water quality protection in the state, which prohibits any measurable deterioration in the existing water quality. Definitions for surface water classifications, detailed segment description, and designated uses may be found in various amendments to the Surface Water Quality Standards at www.state.nj.us/dep/wmm/sgwqt/sgwqt.html.

Agricultural and other measures

Generic management strategies for nonpoint source categories, beyond those that will be implemented under the Phase II stormwater management program, and responses are summarized below.

Table 12 Nonpoint source management measures

Source Category	Responses	Potential Responsible Entity	Possible Funding options
Human Sources	Septic system management programs	Municipalities, residents, watershed stewards, property owner	319(h), State sources
Non-Human Sources	Goose management programs, riparian buffer restoration	Municipalities, residents, watershed stewards, property owner	319(h), State sources
Agricultural practices	Develop and implement conservation plans or resource management plans	Property owner	EQIP, CRP, CREP

Human and Non-Human measures

Where septic system service areas are located in close proximity to impaired waterbodies, septic surveys should be undertaken to determine if there are improper effluent disposal practices that need to be corrected. Septic system management programs should be implemented in municipalities with septic system service areas to ensure proper design, installation and maintenance of septic systems. Where resident goose populations are excessive, community based goose management programs should be supported. Through stewardship programs, areas such as commercial/corporate lawns should be converted to alternative landscaping that minimizes goose habitat and areas requiring intensive landscape maintenance. Where existing developed areas have encroached on riparian buffers, riparian buffer restoration projects should be undertaken where feasible.

Agricultural measures

Several programs are available to assist farmers in the development and implementation of conservation management plans and resource management plans. The Natural Resource Conservation Service is the primary source of assistance for landowners in the development of resource management pertaining to soil conservation, water quality improvement, wildlife habitat enhancement, and irrigation water management. The USDA Farm Services Agency performs most of the funding assistance. All agricultural technical assistance is coordinated through the locally led Soil Conservation Districts. The funding programs include:

The Environmental Quality Incentive Program (EQIP*)* is designed to provide technical, financial, and educational assistance to farmers/producers for conservation practices that address natural resource concerns, such as water quality. Practices under this program include integrated crop management, grazing land management, well sealing, erosion control systems, agri-chemical handling facilities, vegetative filter strips/riparian buffers, animal waste management facilities and irrigation systems.

The Conservation Reserve Program (CRP) is designed to provide technical and financial assistance to farmers/producers to address the agricultural impacts on water quality and to maintain and improve wildlife habitat. CRP practices include the establishment of filter strips, riparian buffers and permanent wildlife habitats. This program provides the basis for the Conservation Reserve Enhancement Program (CREP).

Conservation Reserve Enhancement Program (CREP) The New Jersey Departments of Environmental Protection and Agriculture, in partnership with the Farm Service Agency and Natural Resources Conservation Service, signed a $100 million CREP agreement earlier this year. This program matches $23 million of State money with $77 million from the Commodity Credit Corp. within USDA. Through CREP, financial incentives are offered for agricultural landowners to voluntarily implement conservation practices on agricultural lands. NJ CREP will be part of the USDA's Conservation Reserve Program (CRP). There will be a ten-year enrollment period, with CREP leases ranging between 10-15 years. The State intends to augment this program to make these leases permanent easements. The enrollment of farmland into CREP in New Jersey is expected to improve stream health through the installation of water quality conservation practices on New Jersey farmland.

Current Implementation Projects

The following projects are either ongoing or are anticipated to be implemented in the TMDL study area. These projects were funded using 319(h) grants and are expected to have an immediate and positive effect on water quality.

- Visual Assessment of Streams in WMA 3 and ranking for stream restoration; Restoration of Sheffield Brook in Wayne nearing completion. (Work ongoing)
- Ramapo Reservation Lake: Installation of 1000 feet of riparian buffer restoration. (Completed)

- Acid Brook/Pompton Lake NPS Mitigation and Riparian Enhancement Project (Proposed) This project would stabilize approximately 1,000 linear feet of eroding shoreline along the northern end of Pompton Lake and 300 linear feet of streambank along Acid Brook at its mouth where it empties into Pompton Lake. The proposed restoration would re-establish a naturalized, native vegetated buffer, which would stabilize soils and mitigate the impacts of harmful waterfowl populations. The buffer would be of varying widths, totaling approximately 20,000 square feet. The project will reduce sediment and pollutant loading in the lake by retrofitting existing stormwater outfalls utilizing Best Management Practices, (BMPs) to treat nonpoint source (NPS) pollutants prior to entering the lake. Currently, the existing outfalls capture runoff from nearby roadways and residential areas and discharge directly into Pompton Lake. This is a priority project due to available public space, volumes of stormwater currently untreated prior to release, and volunteer and local support.

Priority Stream Segment Restoration Plans

In addition to the generic and specific, current and future implementation measures identified above, the Department, through its watershed management program, is undertaking the development of watershed restoration plans for priority stream segments. These restoration plans will identify specific measures and the means to accomplish them, beyond those identified in this TMDL report, that will assist in attainment of the required load reductions. Due to the number of TMDLs recently generated, the Department must prioritize which stream segments will be the focus of initial consideration. The Department's nutrient policy states that, "Except as due to natural conditions, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation, abnormal diurnal fluctuations in dissolved oxygen or pH, changes to the composition of aquatic ecosystems, or otherwise render the water unsuitable for the designated uses (N.J.A.C. 7:9B-1.5(g)3)." With respect to nutrient TMDLs, the initial priority will be given to those streams where use impairments exist in the impaired stream or downstream lakes, beyond simple exceedance of the water quality criterion. Other priority considerations include:

- Headwater area;
- Proximity to drinking water supply;
- Proximity to recreation area;
- Possibility of adverse human health conditions;
- Proximity to a lake intake;
- Existence of eutrophication;
- Phosphorus is identified as the limiting nutrient;
- Existence of use impairments;
- Ability to create a measurable change;
- Probability of human source;
- Stream Classifications;
- High success level.

10.0 Public Participation

The Water Quality Management Planning Rules NJAC 7:15-7.2 require the Department to initiate a public process prior to the development of each TMDL and to allow public input to the Department on policy issues affecting the development of the TMDL. On March 23, 2004; an informal presentation by QEA on the findings from the Ramapo and Pompton Lake Study was given to the WMA 3 PAC for their informal comment and feedback.

Additional public participation and input was received through the New Jersey EcoComplex. The role of NJEC is to provide comments on the Department's management strategies, including those related to the development of TMDL values. NJEC consists of a review panel of New Jersey University professors who provide a review of the technical approaches developed by the Department. The New Jersey Statewide Protocol for Developing Eutrophic Lakes TMDLs was presented to NJEC on September 27, 2002 and was subsequently reviewed. Feedback received from NJEC was incorporated into the TMDLs to address lake eutrophication. New Jersey's Statewide Protocol for Developing Lake and Fecal TMDLs was also presented at the SETAC Fall Workshop on September 13, 2002. Quantitative Environmental Analysis, LLC presented their draft final report on the Pompton Lake and Ramapo River TMDL Support Study to the Panel on March 12, 2004 for feedback and comment.

In accordance with N.J.A.C. 7:15–7.2(g), this TMDL is proposed by the Department as an amendment to the Northeast Water Quality Management Plan. Notice of this TMDL was published on July 5, 2005 in the New Jersey Register and the Star Ledger newspaper in order to provide the public an opportunity to review the TMDL and submit comments. Additional public participation will be provided at the Public Hearing for the Pompton Lake and Ramapo River TMDLs to be held on August 4, 2005 at 7 PM at the Cultural Center at Lewis Morris County Park. Following approval of this TMDL by the EPA, the TMDL will be adopted as an amendment to the Northeast WQMP.

Appendix A Municipalities Located in the Pompton Lake and Ramapo River and their MS4 Designation

Municipality	County	WMA(s)	Tier A or B
Franklin Lakes Boro	Bergen	3,4	A
Mahwah Twp	Bergen	3,4	A
Ramsey Boro	Bergen	3,4	A
Oakland Boro	Bergen	3	A
Pompton Lakes Boro	Passaic	3	A
Ringwood Boro	Passaic	3	A
Wanaque Boro	Passaic	3	A
Wayne Twp	Passaic	3, 4	A

Appendix B Database of Phosphorus Export Coefficients

In December 2001, the Department concluded a contract with the USEPA, Region 2, and a contracting entity, TetraTech, Inc., the purpose of which was to identify export coefficients applicable to New Jersey. As part of that contract, a database of literature values was assembled that includes approximately four-thousand values accompanied by site-specific characteristics such as location, soil type, mean annual rainfall, and site percent-impervious. In conjunction with the database, the contractor reported on recommendations for selecting values for use in New Jersey. Analysis of mean annual rainfall data revealed noticeable trends, and, of the categories analyzed, was shown to have the most influence on the reported export coefficients. Incorporating this and other contractor recommendations, the Department took steps to identify appropriate export values for these TMDLs by first filtering the database to include only those studies whose reported mean annual rainfall was between 40 and 51 inches per year. From the remaining studies, total phosphorus values were selected based on best professional judgment for eight land uses categories.

The sources incorporated in the database include a variety of governmental and non-governmental documents. All values used to develop the database and the total phosphorus values in this document are included in the below reference list.

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Appendix C: Summary of Reckhow (1979a) model derivation

The following general expression for phosphorus mass balance in lake assumes the removal of phosphorus from a lake occurs through two pathways, the outlet (M_o) and the sediments (ϕ):

$$V \cdot \frac{dP}{dt} = M_i - M_o - \phi \qquad \textbf{Equation 1}$$

where:

V = lake volume (10^3 m³)
P = lake phosphorus concentration (mg/l)
M_i = annual mass influx of phosphorus (kg/yr)
M_o = annual mass efflux of phosphorus (kg/yr)
ϕ = annual net flux of phosphorus to the sediments (kg/yr).

The sediment removal term is a multidimensional variable (dependent on a number of variables) that has been expressed as a phosphorus retention coefficient, a sedimentation coefficient, or an effective settling velocity. All three have been shown to yield similar results; Reckhow's formulation assumes a constant effective settling velocity, which treats sedimentation as an areal sink.

Assuming the lake is completely mixed such that the outflow concentration is the same as the lake concentration, the phosphorus mass balance can be expressed as:

$$V \cdot \frac{dP}{dt} = M_i - v_s \cdot P \cdot A - P \cdot Q \qquad \textbf{Equation 2}$$

where:

v_s = effective settling velocity (m/yr)
A = area of lake (10^3 m²)
Q = annual outflow (10^3 m³/yr).

The steady-state solution of Equation 2 can be expressed as:

$$P = \frac{P_a}{v_s + z/T} = \frac{P_a}{v_s + Q_a} \qquad \textbf{Equation 3}$$

where:

P_a = areal phosphorus loading rate (g/m²/yr)
z = mean depth (m)
T = hydraulic detention time (yr)
Q_a = Q/A = areal water load (m/yr).

Using least squares regression on a database of 47 north temperate lakes, Reckhow fit the effective settling velocity using a function of areal water load: $P = \frac{P_a}{11.6 + 1.2 \cdot Q_a}$. **Equation 4**

Derivation of Margin of Safety from Reckhow *et al* (1980)

As described in Reckhow *et al* (1980), the Reckhow (1979a) model has an associated standard error of 0.128, calculated on log-transformed predictions of phosphorus concentrations. The model error analysis from Reckhow *et al* (1980) defined the following confidence limits:

$$P_L = P - h \cdot \left(10^{(\log P - 0.128)} - P\right)$$
$$P_U = P + h \cdot \left(10^{(\log P + 0.128)} - P\right)$$
$$\rho \geq 1 - \frac{1}{2.25 \cdot h^2}$$

where:

P_L = lower bound phosphorus concentration (mg/l);
P_U = upper bound phosphorus concentration (mg/l);
P = predicted phosphorus concentration (mg/l);
h = prediction error multiple
ρ = the probability that the real phosphorus concentration lies within the lower and upper bound phosphorus concentrations, inclusively.

Assuming an even-tailed probability distribution, the probability (ρ_u) that the real phosphorus concentration is less than or equal to the upper bound phosphorus concentration is:

$$\rho_u = \rho + \frac{1-\rho}{2} = \rho + \frac{1}{2} - \frac{\rho}{2} = \rho \cdot \left(1 - \frac{1}{2}\right) + \frac{1}{2} = \frac{1}{2} \cdot \rho + \frac{1}{2}$$

Substituting for ρ as a function of h:

$$\rho_u = \frac{1}{2} \cdot \left(1 - \frac{1}{2.25 \cdot h^2}\right) + \frac{1}{2} = \frac{1}{2} - \frac{1}{4.5 \cdot h^2} + \frac{1}{2} = 1 - \frac{1}{4.5 \cdot h^2}$$

Solving for h as a function of the probability that the real phosphorus concentration is less than or equal to the upper bound phosphorus concentration:

$$\frac{1}{4.5 \cdot h^2} = 1 - \rho_u$$
$$h^2 = \frac{1}{4.5(1 - \rho_u)}$$
$$h = \sqrt{\frac{1}{4.5(1 - \rho_u)}}$$

Expressing Margin of Safety (MoS_p) as a percentage over the predicted phosphorus concentration yields:

$$MoS_p = \frac{P_U}{P} - 1 = \frac{P_U - P}{P}$$

Substituting the equation for $P_{U:}$

$$MoS_p = \frac{P + h \cdot \left(10^{(\log P + 0.128)} - P\right) - P}{P} = \frac{h \cdot \left(10^{(\log P + 0.128)} - P\right)}{P}$$

$$P \cdot MoS_p = h \cdot \left(10^{(\log P + 0.128)} - P\right)$$

$$\frac{P \cdot MoS_p}{h} = 10^{(\log P + 0.128)} - P$$

$$\frac{P \cdot MoS_p}{h} + P = 10^{(\log P + 0.128)}$$

Taking the log of both sides and solving for margin of safety:

$$\log\left(\frac{P \cdot MoS_p}{h} + P\right) = \log P + 0.128$$

$$\log\left(\frac{P \cdot MoS_p}{h} + P\right) - \log P = 0.128$$

$$\log\left(P\left(\frac{MoS_p}{h} + 1\right)\right) - \log P = 0.128$$

$$\log P + \log\left(\frac{MoS_p}{h} + 1\right) - \log P = 0.128$$

$$\log\left(\frac{MoS_p}{h} + 1\right) = 0.128$$

$$\frac{MoS_p}{h} + 1 = 10^{0.128}$$

$$\frac{MoS_p}{h} = 10^{0.128} - 1$$

$$MoS_p = h\left(10^{0.128} - 1\right)$$

Finally, substituting for *h* yields Margin of Safety (MoS_p) as a percentage over the predicted phosphorus concentration, expressed as a function of the probability (ρ_u) that the real phosphorus concentration is less than or equal to the upper bound phosphorus concentration:

$$MoS_p = \sqrt{1 \big/ \left((1 - \rho_u) * 4.5\right)} \times \left(10^{0.128} - 1\right)$$

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