LAKE HOPATCONG
WATER QUALITY MONITORING
ANNUAL REPORT 2005

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Table of Contents

1.0 INTRODUCTION

Princeton Hydro, LLC conducted general water quality monitoring of Lake Hopatcong during the 2005 growing season (May through September). This monitoring program represents a continuation of the long-term monitoring program of Lake Hopatcong. The current water quality monitoring program is a modified version of the program that was originally initiated in the Phase I Diagnostic / Feasibility Study of Lake Hopatcong (PAS, 1983) and continued through the Phase II Implementation Project. Both the Phase I and Phase II projects were funded by the US EPA Clean Lakes (314) Program.

The current water quality monitoring program is valuable in terms of continuing the inter-annual, baseline database of the lake, identifying long-term trends in water quality, and quantifying and objectively assessing the success and potential impacts of restoration efforts.

2.0 MATERIALS AND METHODS

In-lake water quality monitoring was conducted at the following eleven (11) locations in Lake Hopatcong (Figure 1 in Appendix A) during the study period:

Station Number	Location
1	Woodport Bay
2	Mid-Lake
3	Crescent Cove/River Styx
4	Point Pleasant/King Cove
5	Outlet
6	Henderson Cove
7	Inlet from Lake Shawnee
8*	Great Cove
9*	Byram Cove
10	Northern Woodport Bay
11	Jefferson Canals

* *In-situ* monitoring only

The 2005 sampling dates were 17 May, 16 June, 18 July, 18 August and 28 September. An Eureka Amphibian with Manta multi-probe unit was used to monitor the *in-situ* parameters dissolved oxygen (DO), temperature, pH, and conductivity during each sampling event. Data were recorded at 1.0 m increments starting at 0.5 m below the water's surface and continued to within 0.5 m of the lake sediments at each station during each sampling date. In addition, water clarity was measured at each sampling station with a Secchi disk.

Discrete water quality samples were collected with a Van Dorn sampling device at 0.5 m below the lake surface and 0.5 m above the sediments at the mid-lake sampling site (Station #2). Discrete samples were collected from a mid-depth position at the remaining six (6) original sampling stations (Stations #1, 3, 4, 5, 6 and 7) and additionally at the Northern Woodport Bay and Jefferson Canals site (Stations #10 and #11, respectively) on each date. Discrete water samples were appropriately preserved, stored on ice, and transported to a State-certified laboratory for the analysis of the following parameters:

total suspended solids
total phosphorous-P
nitrate-N
ammonia-N
chlorophyll *a*

All laboratory analyses were performed in accordance with *Standard Methods for the Examination of Water and Wastewater, 18th Edition* (American Public Health Association, 1992). Monitoring at the Great Cove (Station #8) and Byram Cove (Station #9) sampling stations consisted of collecting *in-situ* and Secchi disk data. It should be noted that prior to 2005, Station #10 had been monitored for *in-situ* observations only, however due to recent visual water observations of the Lake Hopatcong Commission operations staff, it was decided that this sampling station should be added to the discrete sampling list.

During each sampling event, vertical plankton tows were conducted at the deep sampling station (Station #2). A 50-µm mesh plankton net was used to sample the phytoplankton, while a 150-µm mesh plankton net was used to sample the zooplankton. The vertical tows were deployed starting immediately above the anoxic zone (DO concentrations < 1 mg/L) and conducted through the water column to the surface.

3.0 RESULTS AND DISCUSSION

Thermal Stratification

Thermal stratification is a condition where the warmer surface waters (called the epilimnion) are separated from the cooler bottom waters (called the hypolimnion) through differences in density, and hence, temperature. Thermal stratification separates the bottom waters from the surface waters with a layer of water that displays a sharp decline in temperature with depth (called the metalimnion or thermocline). In turn, this separation of the water layers can have a substantial impact on the ecological processes of a lake (for details see below). Thermal stratification tends to be most pronounced in the deeper portions of a lake. Thus, for convenience, the discussion on thermal stratification in Lake Hopatcong focuses primarily on the deep, mid-lake (Station #2) sampling station.

In-situ measurements during the 2005-growing season were generally consistent with values recorded in previous years' monitoring programs. However, through the 2005 sampling season the presence of an established thermocline or metalimnion was particularly distinct. This can be attributed to the below-average rainfall totals for the 2005-growing season, especially in the later summer months. The lack of individual storm events physically separates the warm epiliminion from the cooler hypolimnion.

On 17 May 2005, Lake Hopatcong was in the very early stages of seasonal thermal stratification, demonstrating a very narrow thermocline at a depth between and 6 and 7 meters. From surface to bottom (14 meters), the temperature decreased from 16.6°C at the surface to 10.1°C at the bottom (Appendix B).

By 16 June 2005, thermal stratification was apparent at the mid-Lake Station. The epilimnion was located from the surface to 4 meters (13.2 ft). The metalimnion was located between 5 and 7 meters (16.5 and 23.1 ft), while the hypolimnion began at a depth greater than 8 meters.

During the 21 July 2005 and 18 August 2005 sampling events, the epilimnion was located from the surface to 4 meters and 5 meters, respectively. The thermocline was located between 5 and 8 meters (16.5 and 26.2 ft), with the hypolimnion being below 8 meters.

Although water temperatures in the epiliminion were dramatically cooler, a thermally stratified condition remained during the 28 September 2005 sampling event while the thermocline remained narrow, between 8 and 9 meters.

The only sampling areas that were stratified from May through September were Stations #2 (mid-lake) and #9 (Byram Cove). The other moderately deep sampling station (> 5 meters), Station #8 (Great Cove), was stratified from June through July. The remaining eight (8) sampling stations were well mixed through the entire sampling season. These well-mixed conditions were the result of relatively shallow water depths (< 3 meters). In general, areas of Lake Hopatcong less than 2 to 3 meters (6.6 to 9.9 feet) in depth remain well mixed through the course of the summer (Appendix B).

Thermal stratification can effectively "seal off" the bottom waters from the surface and overlying atmosphere, which can result in a depletion of dissolved oxygen (DO) in the bottom waters. With the exception of a few groups of bacteria, all aquatic organisms require measurable amounts of DO (> 1 mg/L) to exist. Thus, once the bottom waters of a lake are depleted of DO, a condition termed anoxic, that portion of the lake is no longer available as viable habitat.

Dissolved Oxygen

Atmospheric oxygen enters water by diffusion from the atmosphere, facilitated by wind and wave action and as a by-product of photosynthesis. Adequate dissolved oxygen (DO) is necessary for acceptable water quality. Oxygen is a necessary element for almost all forms of life. As dissolved oxygen concentrations fall below 5.0 mg/L, aquatic life is put under stress. DO levels that remain below 1.0 – 2.0 mg/L for a few hours can result in large fish kills and loss of other aquatic life. Although many aquatic organisms require a minimum of 1.0 mg/L of DO to survive, the NJDEP State criteria for DO concentrations in surface waters is 5.0 mg/L or greater, for a healthy and diverse aquatic ecosystem.

In addition to a temporary loss of bottom habitat, anoxic conditions can produce chemical reactions that result in a release of phosphorus from the sediments and into the overlying water. In turn, once the lake is mixed, this phosphorus can be transported to surface waters and stimulate additional algal growth. This process is called internal phosphorus loading. Given the temporary loss of bottom water habitat and the increase in the internal phosphorus load, anoxic conditions are generally considered undesirable in a lake.

During the 17 May 2005 sampling event, DO concentrations were above the 5.0 mg/L threshold throughout most of Lake Hopatcong. Only the deepest waters (> 12 meters) of Station #2 (mid-Lake) had depressed levels of DO (< 4.0 mg/L).

The surface waters of Lake Hopatcong were generally well oxygenated (> 5.0 mg/L) during the 16 June 2005 sampling event. Anoxic conditions (DO concentrations < 1 mg/L) were identified at depths greater than 12 meters.

During the 21 July 2005 sampling event, Lake Hopatcong was well oxygenated from the surface to a depth of about 5 meters. Anoxic conditions were identified from 6 meters to the bottom of the lake during the late July sampling event.

During the 18 August 2005 sampling event, from the surface to 5 meters the lake was well oxygenated, while anoxic conditions were measured at depths greater than 9 meters. Typically, anoxic conditions in the bottom waters persist through the summer season in Lake Hopatcong. This condition was intensified in 2005 by the lack of storm events during the late summer season. The general lack of sizable storm events resulted in a minimum amount of mixing through the water column. Such conditions maintain the anoxic conditions in the bottom waters through the growing season by preventing the transfer of oxygenated water to the deeper sections of the lake.

On 28 September 2005, anoxic conditions persisted in sections of Lake Hopatcong greater than 10 meters in depth (Appendix B). In contrast, from the surface to 8 meters, Lake Hopatcong was well oxygenated, with DO concentrations typically being greater than 6.0 mg/L (Appendix B).

pH

The optimal range of pH for most freshwater organisms is between 6.0 and 9.0. For the most part, the pH throughout the water column of Lake Hopatcong was within this optimal range. The exception to this was the pH at the Northern Woodport Bay (Station #10) during the 21 July monitoring event, when the pH was in the mid 9.0 ranges. Such temporarily elevated pH values in the surface waters can be attributed to high rates of algal and/or aquatic plant photosynthesis. As algae and plants photosynthesize, they produce DO as a by-product, as well as increase the pH of their immediate environment. While aquatic plants are distributed throughout the Northern Woodport Bay section of the lake, the most common macrophyte in this part of the lake is the benthic dwelling alga *Lyngbya*. In any event, for the most part the pH of Lake Hopatcong through the 2005 growing season was within the optimal range for most aquatic organisms.

Water Clarity (as measured with a Secchi disk)

Water clarity or transparency, as measured with a Secchi disk, was generally acceptable at all of the sampling stations during the 2005 sampling season. Based on Princeton Hydro's in-house long-term database of lakes in northern New Jersey, water clarity is considered acceptable for recreational activities when the Secchi depth is equal to or greater than 1.0 m (3.3 ft). Thus, Secchi depth measurements throughout almost all of Lake Hopatcong were greater than 1.0 meter. For example, at the mid-lake sampling station (Station #2), the Secchi depth varied from 1.2 to 2.5 meters (4.0 to 8.25 ft) through the course of the 2005 sampling season. The exception to these acceptable water clarity measurements was the Crescent Cove / River Styx (Station #3) sampling station, where Secchi depth fell below the 1.0 meter threshold during the July and August sampling events (Figure 2) and the Northern Woodport Bay (Station #10) during the June sampling event.

Of the eleven sampling stations, the Crescent Cove / River Styx (Station #3) sampling station historically tends to have the lowest water clarity, particularly in July and August. During these months, Secchi depths are typically below the 1.0 m threshold. Such conditions were certainly observed during the 2005 sampling season. Secchi depths at Station #3 averaged 0.7 meters from July through September in 2005. Over this same time period, TSS (total suspended solids) concentrations were moderate (between 8 and 17 mg/L) relative to high chlorophyll-*a* concentrations (between 24 and 135 mg/m^3). These observed conditions indicate that the sub-optimal July and August Secchi depths at Station #3 were primarily due to algal blooms. Annually, Station #3 has the lowest Secchi depths relative to the other sampling stations of the lake; both algal blooms and excessive densities of aquatic plants typically plague this section of the lake during the summer season. Such unacceptable water quality conditions have directed the watershed-based restoration measures to focus on the portion of the Borough of Hopatcong that directly drains into the Crescent Cove / River Styx section of the lake.

Ammonia-Nitrogen (NH_4-N)

Surface water NH_4-N concentrations above 0.05 mg/L tend to stimulate elevated rates of algal growth. Over the 2005 season, surface water NH_4-N concentrations throughout Lake Hopatcong varied between <0.02 mg/L and 0.20 mg/L. All (8) of the stations had NH_4-N concentrations equal to or greater than the 0.05 mg/L threshold in May. This remained consistent in June, dropped to four (4) stations in July, was eight (8) stations in August an dropped to five (5) stations in September. NH_4-N concentrations measured during the last several monitoring years have been slightly to moderately higher than those of past monitoring years (1992 through 1999).

Bottom water NH_4-N concentrations are monitored seasonally at the mid-lake sampling site (Station #2). As in 2004, bottom water NH_4-N concentrations remained above the 0.05 mg/L threshold from May through September. However, bottom water NH_4-N concentrations are typically elevated during summer months, as a result of a depletion of dissolved oxygen. Under such conditions, bacterial decomposition of organic matter results in an accumulation of NH_4-N. The severe limitation of light in the bottom waters exacerbates these conditions through the negligible uptake of NH_4-N by algae. Thus, this seasonal accumulation of NH_4-N is common occurrence in Lake Hopatcong.

Nitrate-Nitrogen (NO_3-N)

NO_3-N concentrations throughout the 2005 sampling season of Lake Hopatcong varied between <0.02 mg/L and 0.20 mg/L. During the May sampling event, NO_3-N concentrations varied between 0.03 mg/L and 0.14 mg/L.

While there was a considerable amount of variation both among the sampling stations and between sampling events, the NO_3-N concentrations measured in June were considerably lower relative to the May concentrations. All NO_3-N concentrations measured in June were below analytical detection limit of 0.02 mg/L. In contrast, during the July sampling event, the surface water NO_3-N concentrations varied between < 0.02 and 0.08 mg/L.

On 18 August 2005, the NO_3-N concentrations at all of the sampling stations were less than or equal to 0.06 mg/L. Similar to other water quality parameters, the Crescent Cove / River Styx sampling station had the highest NO_3-N concentrations during the July and August sampling events. In contrast, NO_3-N concentrations during the 28 September 2005 sampling event at all Stations varied between <0.02 mg/L and 0.03 mg/L.

Total Phosphorous (TP)

Phosphorus has been identified as the primary limiting nutrient for algae and aquatic plants in Lake Hopatcong. Essentially, a small increase in the phosphorus load will result in a substantial increase in algal and aquatic plant growth. For example, one pound of phosphorus can generate as much as 1,100 lbs of wet algae biomass. This fact emphasizes the continued need to reduce the annual phosphorus load entering Lake Hopatcong.

Studies have shown that TP concentrations as low as 0.03 mg/L can stimulate high rates of algal growth resulting in eutrophic or highly productive conditions. Based on Princeton Hydro's in-house database on northern New Jersey lakes, TP concentrations equal to or greater than 0.06 mg/L will typically result in the development of algal blooms / mats that are perceived as a recreational nuisance by the layperson. Based on the completed refined phosphorus TMDL, the long-term management goal is to maintain a mean growing season TP concentration of 0.03 mg/L within the surface waters of Lake Hopatcong.

During the 17 May sampling event, TP concentrations throughout the lake generally varied between 0.02 mg/L and 0.05 mg/L. The lake at this time had a slight brown to greenish hue, which was more than likely the result of a moderate spring algal bloom (see Section on phytoplankton for details). Spring storm events transport phosphorus from the watershed to the lake, resulting in spring algal blooms.

During the 16 June 2005 sampling event, TP concentrations throughout Lake Hopatcong varied between < 0.01 mg/L and 0.03 mg/L. Surface water TP concentrations during the 18 July 2005 sampling event were within a similar range with one notable exception. During the July 2005 sampling event, the TP concentration at Station #3 (River Styx / Crescent Cove) was 0.05 mg/L, nearing the threshold where algal blooms are typically experienced in a Mid-Atlantic waterbody.

During the 18 August 2005 sampling event, TP concentrations in the surface waters were similar to earlier sampling events, generally varying between < 0.02 mg/L and 0.02 mg/L, while the TP concentration at Station #3 was 0.03 mg/L (Appendix C). Finally, during the 28 September 2005 sampling event, surface water TP concentrations again varied between 0.01 mg/L and 0.03 mg/L, with the Station #3 concentration being 0.05 mg/L.

In general, TP concentrations in Lake Hopatcong were moderate in the spring but were generally lower through the summer. The exception to the general pattern was the Crescent Cove / River Styx (Station #3) sampling station, where July and August TP concentrations were near the 0.06 mg/L bloom threshold. As previously identified such elevated TP concentrations in this section of the lake is a re-occurring condition. The elevated summer TP concentrations at Station #3 are the result of the land use and activities within the surrounding sub-watersheds (Borough of Hopatcong), as well as the minimal amount of hydrologic flushing. Combined, these factors provide the opportunity for algae and aquatic plants to assimilate available phosphorus, producing the blooms and large stands of rooted aquatic plants that are typically observed in the Crescent Cove / River Styx portion of the lake.

Similar to previous monitoring years (pre 2003), the TP concentrations at the mid-lake, deep sampling station (Station #2) were elevated in mid-summer, varying from 0.13 mg/L to 0.22 mg/L between July and September 2005 (Appendix C). During previous monitoring events, TP concentrations as high as 0.33 mg/L were measured in the deep waters of Station #2. Such elevated TP concentrations in the deep waters are attributed to the establishment of anoxic conditions (DO < 1 mg/L) during the summer months. The elevated bottom water TP concentrations were attributed to the lack of storm events experienced in the late summer of 2005.

Dry growing seasons tend to strengthen the density difference between the epilimnion and hypolimnion and impede the transport of deep water TP to the surface. This allows for an accumulation of phosphorus in the bottom waters. In contrast, growing seasons that experience large and frequent storm events, such as 2003 and 2004, tend to have weakened thermal stratification, allowing for the transfer of deeper waters to the surface. In turn, bottom water TP concentrations tend to be lower relative to the bottom water in dry growing seasons. However, this transfer of bottom water TP during “wet” years can fuel the development of algal blooms and surface scums.

Chlorophyll a

Chlorophyll *a* is a pigment possessed by all algal groups, used in the process of photosynthesis. Its measurement is an excellent means of quantifying algal biomass. In general, an algal bloom is typically perceived as a problem by the layperson when chlorophyll *a* concentrations are equal to or greater than 30.0 mg/m^3. Based on the findings of the refined TMDL, the mean seasonal chlorophyll *a* concentration under existing conditions is 15 mg/m^3, while the maximum seasonal value is 26 mg/m^3. In contrast, the targeted mean and maximum chlorophyll *a* concentrations, once Lake Hopatcong is in complete compliance with the TMDL, are 8 and 14 mg/m^3, respectively.

The mean chlorophyll *a* concentrations for May, June, July and September 2005 were below the existing mean concentration of 15 mg/m^3. In contrast, the August 2005 mean chlorophyll *a* concentrations was 26.2 mg/m^3, greater than the existing mean of 15 mg/m^3 and approximately equal to the existing maximum seasonal value. In addition, the July and August 2005 chlorophyll *a* concentrations at Station #3 exceeded the maximum seasonal value of 26 mg/m^3. These elevated chlorophyll *a* concentrations in July and August indicate that algal blooms were experienced in Lake Hopatcong during the mid-summer season. While the majority of the 2005 concentrations did not attain the 30 mg/m^3 threshold, the measured concentrations in conjunction with some select shoreline observations made during the summer season (for details see below), were indicative of nuisance conditions. These results indicate that efforts must continue in complying with the targeted TP and chlorophyll *a* concentrations for Lake Hopatcong, as established in its TMDL.

Phytoplankton

Phytoplankton are algae that are freely floating in the open waters of a lake or pond. These algae are vital to supporting a healthy ecosystem, since they are the base of the aquatic food web. However, high densities of phytoplankton can result in nuisance conditions. The majority of nuisance algal blooms in freshwater ecosystems is the result of cyanobacteria, also known as blue-green algae. Some of the more common water quality problems created by blue-green algae include bright green surface scums, taste and odor problems and cyanotoxins.

Table 1 lists the dominant phytoplankton identified in Lake Hopatcong during each 2005 water quality monitoring program. In contrast to many previous spring sampling events, a bloom of the diatoms *Melosira* and *Tabellaria* was observed on 17 May 2005. While diatoms were very common in Lake Hopatcong during pervious spring sampling events, chrysophytes such as *Dinobryon* tend to be the dominant algae in spring. While both algal groups can give the water a brown, turbid appearance, this “shift” from chrysophytes to diatoms may be due to slightly higher TP concentrations in May 2005. Chrysophytes tend to out-compete other algae in low TP waters. TP concentrations in May 2005 were 0.04 mg/L, while in May 2004 TP concentrations were generally between < 0.02 and 0.03 mg/L.

In addition to *Melosira* and *Tabellaria*, the chrysophyte *Dinobryon*, several other diatoms, cryptomonads and green algae were identified in the May 2005 sample (Table 1). Two blue-green algae were also identified in the May 2005 sample and included *Oscillatoria* and *Coelosphaerium*. Neither of these identified blue-greens attained nuisance densities during the May 2005 sampling event.

By mid-June 2005 the dominant algae in the mid-lake sampling station of Lake Hopatcong were the diatom *Fragilaria* and the blue-green alga *Coelosphaerium*. A variety of other algae were identified including the diatom *Tabellaria*, an euglenoid, a dinoflagellate and a variety of green and blue-green algae (Table 1). While four genera of blue-green algae were identified in the June 2005 sample, *Coelosphaerium, Oscillatoria*, *Microcystis* and *Anabaena*, nuisance surface scums or blooms were not observed in the open waters (Station #2) of the lake. Secchi depth was well above the 1 meter threshold and the surface water chlorophyll *a* concentration at Station #2 was 6 mg/m^3.

The dominant algae in Lake Hopatcong on 21 July 2005 were the filamentous blue-green algae *Oscillatoria* and *Anabaena*. These two genera are well known to produce nuisance conditions and although from June to July water clarity declined by approximately 50%, the mid-lake, open waters of the lake remained acceptable for recreational use with a Secchi depth of 1.2 meters. Two other blue-green algae were identified in the July 2005 sample, in addition to a variety of green algae, a few diatoms, a cryptomonad and the dinoflagellate *Ceratium* (Table 1).

The dominant alga in Lake Hopatcong during the August 2005 sampling event was the blue-green alga *Oscillatoria*. Other blue-greens were identified in the sample as well as diatoms, green algae and the dinoflagellate *Ceratium*. In spite of the dominance of the blue-green algae, mid-lake, open water conditions were still acceptable with a Secchi depth of 1.8 m and a chlorophyll *a* concentration of 13 mg/m^3. However, it should be noted that at the River Styx / Crescent Cove (Station #3) sampling station, the Secchi depth was less than the 1 meter threshold (0.4 m) and the chlorophyll *a* concentration was well above the 30 mg/m^3 threshold at 135 mg/m^3. Thus, while the open waters of Lake Hopatcong were generally acceptable for recreational use, the River Styx / Crescent Cove section of the lake experienced intense blue-green algal blooms.

From August to September, algal dominance shifted from entirely blue-green algae to a mix of diatoms (*Melosira*) and blue-green algae (*Anabaena*) (Table 1). Such shifts in the composition of the phytoplankton community in temperate lakes are common with the seasonal decline in water temperatures. In Lake Hopatcong surface water temperatures declined by over 6^{o}C from August to September (Appendix B). A variety of other algae were identified in the September sample.

Total biomass, as measured by chlorophyll *a*, slightly declined from August to September at the mid-lake sampling station. There was a substantial decline in chlorophyll *a* during this same period of time at the River Styx / Crescent Cove sampling station, from 135 to 24 mg/m^3. However, the River Styx / Crescent Cove sampling station still had the highest density of phytoplankton of all nine sampling stations. The nuisance algal blooms experienced in the River Styx / Crescent Cove area of the lake is an annual occurrence during the mid-summer to early fall season. As various studies have revealed, the "developed" phosphorus loads entering the lake from the River Styx / Crescent Cove section of the watershed (the Borough of Hopatcong, Sussex County) are the highest. Such high phosphorus loads have consistently resulted in elevated in-lake phosphorus concentrations and, in turn, elevated chlorophyll *a* concentrations within this section of the lake. These annually occurring conditions are why many of the current stormwater-based restoration projects are focusing on the Borough of Hopatcong section of the watershed.

Table 1

Phytoplankton in Lake Hopatcong during the 2005 Growing Season

Sampling Date	Phytoplankton
17 May 2005	A bloom of the diatom *Melosira* and to a less degree *Tabellaria*. Other diatoms were identified (*Synedra*, *Stephanodiscus*, *Fragilaria*). The chrysophyte *Dinobryon* and identified as well as green algae (*Chlorella*, *Scenedesmus*, *Gloeocystis*), cryptomonds (*Cryptomonas*, *Rhodomonas*) and two genera of blue-green algae (*Oscillatoria*, *Coelosphaerium*).
16 June 2005	The dominant algae were the diatom *Fragilaria* and the blue-green alga *Coelosphaerium*. Other diatoms (*Tabellaria*) and blue-green algae (*Oscillatoria*, *Microcystis*, *Anabaena*) were identified in the June sample. A euglenoid (*Trachelomonas*), a dinoflagellate (*Peridinium*) and variety of green algae (*Pediastrum*, *Gloeocystis*, *Sphaeriocystis*, *Chlorella*) were also identified in the sample.
21 July 2005	The dominant algae were the blue-green algae *Oscillatoria* and *Anabaena*. Other blue-green were identified and included *Microcystis* and *Aphanizomenon*. The samples also included a variety of green algae (*Pediastrum*, *Gloeocystis*, *Sphaeriocystis*, *Chlorella, Staurastrum*), a few diatoms, a cryptomonad and the dinoflagellate *Ceratium*.
18 August 2005	The dominant alga was the blue-green *Oscillatoria*. Other blue-green algae were identified and included *Aphanizomenon*, *Microcystis* and *Anabaena*. Diatoms (*Melosira*, *Fragilaria*, *Asterionella*), green algae (*Pediastrum*, *Gloeocystis*, *Staurastrum*, *Chlorella*) and the dinoflagellate *Ceratium* were identified in the sample.
29 September 2005	The dominant alga was the diatom *Melosira*, while the sub-dominant alga was the blue-green *Anabaena*. Other diatoms (*Tabellaria*, *Fragilaria*), a chrysophyte (*Synura*), dinoflagellates (*Ceratium, Peridinium*) a blue-green alga (*Oscillatoria*), and several green algae (*Pediastrum*, *Pandorina, Oedogonium*, *Sphaeriocystis*) were also identified in the sample.

Zooplankton

Zooplankton are the micro-animals that live in the open waters of a lake or pond. Some large-bodied zooplankton are a source of food for forage and/or young gamefish. In addition, many of these large-bodied zooplankton are also herbivorous (i.e. algae eating) and can function as a natural means of controlling excessive algal biomass. Given the important role zooplankton serve in the aquatic food web of lakes and ponds, samples for these organisms were collected at Station #2 during each monitoring event. The results of these samples are provided in Table 2.

The zooplankton community of Lake Hopatcong was dominated by small-bodied cladocerans such as *Bosmina* and *Chydorus* and/or several genera of rotifers and the predaceous copepod *Cyclops* through the course of the 2005 monitoring season. These types of zooplankton tend to feed on bacteria, detritus and in some cases other zooplankton. None of the dominant zooplankton are highly herbivorous; that is, algae is not their primary source of food.

While herbivorous zooplankton were not common in Lake Hopatcong, two herbivorous genera were identified through the 2005 sampling season. These two genera included the cladoceran *Ceriodaphnia* and the copepod *Diaptomus* (Table 2). In contrast, three herbivorous zooplankton were identified in Lake Hopatcong during the 2005 sampling program. Two of the three herbivores identified in 2005 were *Ceriodaphnia Diaptomus*, while the third was *Daphnia*. Of these zooplankton, *Daphnia* is the most efficient herbivore; this is primarily due to its potential to attain large lengths (up to 2 mm) and its particular mode of filter feeding. While *Daphnia* may have been present in other sections of Lake Hopatcong, its absence in the open waters of the lake may indicate that resident zooplankton-eating fishes (i.e. minnows, alewives, young yellow perch, white perch) were heavily grazing on large-bodied zooplankton in 2005.

Finally, it should be recognized that although herbivorous zooplankton were not common in Lake Hopatcong, the water quality impacts of the herbivores that were present could be detected in the 2005 database. For example, during the May 2005 sampling event, no herbivorous zooplankton were identified and the Secchi depth was 1.3 meter, which was slightly higher than the 1.0 meter threshold of concern. In general, when the Secchi depth falls below 1.0 meter, water clarity is perceived as being unacceptable for recreational activities by the layperson. In contrast, during the June 2005 sampling event, the two herbivorous zooplankton *Ceriodaphnia* and *Diaptomus* were identified in the plankton and the Secchi depth was approximately twice the depth measured in May 2005 at 2.5 meters. This increase in water clarity in the early summer is the “clear water phase”, which is the result of herbivorous zooplankton grazing on the phytoplankton that bloomed in the spring. By mid-July, Secchi depth was back to being slightly above the 1.0 meter threshold (1.2 meters) due to smaller fish grazing on the zooplankton and a shift within the resident phytoplankton community.

Table 2

Zooplankton in Lake Hopatcong during the 2005 Growing Season

Sampling Date	Zooplankton
17 May 2005	Similar to 2004, small-bodied cladocerans (*Bosmina* and *Chydrous*) were the dominant zooplankton. Some predatory copepods (*Cyclops*) and juvenile (known as nauplii) were also found in the sample. In addition, a few rotifers (*Tetramastrix*, *Trichocera*) were also identified.
16 June 2005	Similar to 2004, the small-bodied cladoceran *Bosmina* was the dominant zooplankter. Several rotifers (*Asplanchna*, *Keratella*, *Kellicottia*) and two herbivorous zooplankton (the cladoceran *Ceriodaphnia* and the copepod *Diaptomus*) were also identified in the sample.
21 July 2005	Overall zooplankton abundance declined from June to July and the dominant zooplankton included *Bosmina* and the rotifers *Conochilus* and *Asplanchna*. *Ceriodaphnia*, *Diaptomus*, *Cyclops* and nauplii were also identified in the sample.
18 August 2005	*Cyclops* and nauplii were the dominant zooplankton in this sample. The cladocerans *Bosmina*, *Chydorus* and *Ceriodaphnia*, the copepod *Diaptomus* and the rotifers *Conochilus*, *Asplanchna* and *Keratella* were the dominant zooplankton in this sample.
29 September 2005	The small-bodied cladoceran *Bosmina* and the predaceous copepod *Cyclops* were the dominant zooplankton. Several rotifers (Keratella, *Conochilus*, *Kellicottia*), nauplii the herbivores *Diaptomus* and *Ceriodaphnia* were also identified in the sample.

Recreational Fishery and Potential Brown Trout Habitat

Of the recreational game fish that reside or are stocked in Lake Hopatcong, trout are the most sensitive in terms of water quality. For their sustained management, all species of trout require DO concentrations of at least 4 mg/L or greater. However, the State's designated water quality criterion to sustain a healthy, aquatic ecosystem is a DO concentration of at least 5mg/L.

While all trout are designated as coldwater fish, trout species display varying levels of thermal tolerance. Brown trout (*Salmo trutta*) have an optimal summer water temperature range of 18 to 24^{o}C (65 to 75^{o}F) (USEPA, 1994). However, these fish can survive in waters as warm as 26^{o}C (79^{o}F) (Scott and Crossman, 1973), defined here as acceptable habitat. The 2005 temperature and DO data for Lake Hopatcong were examined to identify the present of optimal or acceptable brown trout habitat. As with previously monitoring reports, this analysis focused solely on *in-situ* data collected at the mid-lake sampling station (Station #2).

For the sake of this analysis, sections of the lake that had DO concentrations equal to or greater than 5 mg/L and water temperatures less than 24^{o}C were considered optimal habitat for brown trout. In contrast, sections of the lake that had DO concentrations equal to or greater than 5 mg/L and water temperatures between 24 and 26^{o}C were considered carry over habitat for brown trout.

In May 2005 optimal brown trout habitat was identified from the surface water down to a depth of 14 meters (46 feet) at Lake Hopatcong (Appendix B). By 16 June 2005, the optimal brown trout habitat was compressed to depths between 4 and 6 meters (between 13 and 20 feet), while carry over brown trout habitat was distributed from the surface to a depth of 3 meters (10 feet).

By 21 July 2005, carry over brown trout habitat was limited to depths between 4 and 5 meters (between 13 and 16.5 feet). However, by 18 August 2005, the carry over brown trout habitat zone was distributed from the surface to a depth of 5 meters (16.5 feet). By late September optimal brown trout habitat returned and was distributed from the surface to a depth of 8 meters (26 feet). Based on these data varying levels of acceptable brown trout habitat persisted through the entire growing season in Lake Hopatcong.

Mechanical Weed Harvesting Program

Many of the more shallow sections of Lake Hopatcong are susceptible to the proliferation of nuisance densities of rooted aquatic plants. Given the size of Lake Hopatcong, the composition of its aquatic plant community, and its heavy and diverse recreational use, mechanical weed harvesting is the most cost effective and ecologically sound method of controlling nuisance weed densities. Thus, the weed harvesting program has been in operation at Lake Hopatcong since the mid-1980's with varying levels of success. However, one consistent advantage mechanical weed harvesting has over other management techniques, such as the application of herbicides, is that phosphorus is removed from the lake along with the weed biomass. In fact, it has been estimated that between 8 and 12% of the total annual phosphorus load of Lake Hopatcong can be removed through mechanical weed harvesting.

During the last four growing seasons, since the State-designated Lake Hopatcong Commission has been operating the mechanical weed harvesting program, an average of 1,394 tons of aquatic vegetation is removed from the lake per year. This roughly equates to 2.79 million pounds of plant biomass removed from Lake Hopatcong per year. Specifically in 2005, a total of 2.0 million pounds of plant biomass was removed, an approximately 150% increase than what was removed in 2004. This substantial increase was attributed to inter-annual variations in local climate, impacting the Lake Hopatcong ecosystem.

The 2004 growing season was relatively "wet" and cool, experiencing a high frequency of storm events. Such frequency storm events and relatively cooler water temperatures reduced the amount of light penetrating to the sediments. Such conditions result in lower aquatic plant growth rates, which in turn, resulted in a lower amount of aquatic plant biomass requiring removal through harvesting. While the first half of the 2005 growing season was relatively wet and cool, the later half (July through September) has extremely dry and sunny, stimulating the growth of aquatic plants. These high rates of growth produced nuisance densities of submerged plants that were removed from the lake through the mechanical weed harvesting program. Thus, the substantial increase the amount of plant biomass removed from Lake Hopatcong in 2005, relative to 2004, was largely attributed to prevailing weather conditions.

Inter-annual Analysis of Water Quality Data

Annual mean values of Secchi depth, chlorophyll *a* and total phosphorus concentrations were calculated for the years 1991 through 2005. The annual mean values for Station #2 were graphed, along with the long-term, "running mean" for the lake.

The mean 2005 Secchi depth at Station #2 was 1.8 meters, which was the lowest mean Secchi depth recorded at Lake Hopatcong since 1997 (Figure 3). While the mean Secchi depth was above the 1.0-meter threshold for recreational waterbodies, it was the second lowest mean measured at Lake Hopatcong. The lowest mean Secchi depth at Lake Hopatcong was 1.6 meters, measured in both 1994 and 1997. The first half of the 2005 growing season experienced a high frequency of storm events, followed by extremely dry and hot conditions experienced in the later half of the season. Thus, the lack of storms in the second half of the 2005 growing season allowed nutrients that entered the lake via the spring and early summer storms to remain "in place" and not be flushed from the system. In turn, the elevated phosphorus load and lowered flushing rate stimulate algal growth.

Based on Princeton Hydro's in-house database, Secchi depths greater than 1 m (3.3 ft) are considered acceptable for recreational waterbodies; Secchi depths less than 1 m are perceived as "dirty" or "cloudy" to the layperson. Thus, while the 2005 mean Secchi depth was lower than what has been measured in previous years, Lake Hopatcong's water clarity again remained acceptable in terms of recreational use.

One of the major factors responsible for the observed water clarity of a lake is the amount of algal biomass in the water. In other words, the less algae in the water, the higher the water clarity. An effective way of quantifying algae biomass is to measure the amount of chlorophyll *a* in the water. Chlorophyll *a* is a photosynthetic pigment all algae possess, so measuring chlorophyll *a* provides a measurement of the amount of algae biomass in the open waters of a lake.

The relatively low mean Secchi depth in 2005 correlated well with the relatively high mean chlorophyll *a* concentration. The 2005 annual mean chlorophyll *a* concentration for Station #2 was 10.9 mg/m^3 (Figure 4). While the 2005 chlorophyll *a* mean was lower than the 2004 mean, it is the fourth highest concentration since the long-term monitoring program was initiated in the early 1990's (Figures 4). Elevated amounts of algal biomass in Lake Hopatcong can be attributed to in increase in phosphorus loading, coupled with a reduced flushing rate late in the growing season. Such conditions emphasize the need for watershed-based control measured to reduce the existing phosphorus loads entering Lake Hopatcong.

While the 2005 mean chlorophyll *a* concentration was elevated, it was still below the 30 mg/m^3

threshold, when laypeople perceive water quality problems (i.e. algal blooms) in terms of recreational use. Neither the 2005 chlorophyll *a* mean, nor any of the actual concentrations measured at the mid-lake, deep water station (Station #2) were equal to or greater than 30 mg/m^3. However, some single chlorophyll *a* measurements, specifically at Station #3 during the mid-summer months, did exceed the 30 mg/m^3 threshold.

For most waterbodies in the northeastern portion of the United States, phosphorus is the primary nutrient limiting algal growth. This means that higher amounts of phosphorus entering a lake or pond, typically translates into more algae being produced. Past studies have demonstrated that phosphorus is the primary limiting nutrient for algae in Lake Hopatcong.

The 2005 annual mean TP concentration was again 0.02 mg/L, consistent with the 2004 mean of 0.02 mg/L (Figure 5). While the 2005 TP mean was again the second highest measured in Lake Hopatcong over the last six years (Figure 5), it is relatively low. The low mean TP concentration in 2005, relative to the elevated chlorophyll *a* concentration and low Secchi depth mean values, indicates that the algae at Station #2 probably originated from another section of the lake and were transported to the mid-lake area through wind and wave action. Similar observations were made in 2004 and it is more than likely that the River Styx / Crescent Cove section of the lake is the origin of a least a portion of the algae found in the mid-lake section.

4.0 SUMMARY

This report documents the findings of the 2005 Lake Hopatcong water quality monitoring program. This section provides a summary of the 2005 water quality conditions, as well as recommendations on how to preserve the highly valued aquatic resources of Lake Hopatcong.

1. Based on the 2005 water quality database, and similar to past monitoring years, the water quality conditions of Lake Hopatcong were generally consistent with those of a meso- to slightly eutrophic ecosystem.

2. Lake Hopatcong was thermally stratified from mid-May through late-September 2005. The strength of this thermal stratification was strongest during July and August.

3. Overall, the surface waters (to approximately 5 meters) of Lake Hopatcong remained well oxygenated (dissolved oxygen concentrations > 4 mg/L) throughout the monitoring season. An anoxic zone (waters with DO concentrations less than 1 mg/L) developed along the lake's bottom by late June. This is in contrast to previous monitoring years, when anoxic is typically first detected in May. By late July, this layer of anoxic water had reached a depth of 7 meters from the surface.

4. It has been well documented that phosphorus is the primary limiting nutrient in Lake Hopatcong. That is, a slight increase in phosphorus will result in a substantial increase amount of algal and/or aquatic plant biomass. TP concentrations in the surface waters of Lake Hopatcong typically varied between <0.01 mg/L and 0.05 mg/L, relatively below the 0.06 mg/L bloom threshold.

5. While the chlorophyll *a* concentrations were not excessive at the mid-lake sampling station, other sections of the lake experienced nuisance algal blooms. As is typical each year, Station #3 (Crescent Cove / River Styx) experienced nuisance algal blooms through the summer months.

6. Based on the *in-situ* conditions, hold over brown trout habitat was available throughout the entire 2005 growing season. Such results are consistent with those measured in previous monitoring years at Lake Hopatcong.

7. The annual mean Secchi depth at the mid-lake sampling station was 1.8 meters. While this Secchi depth is acceptable for a recreational waterbody, it is the lowest mean in Lake Hopatcong since 1997.

8. Similar to Secchi depth, the mean chlorophyll *a* concentration for 2005 was acceptable for a recreational waterbody, however, relative to past monitoring years, it was one of the higher values measured in Lake Hopatcong. This elevated chlorophyll *a* mean was attributed to an elevated phosphorus load as a result of the high frequency of storm events early in 2005, followed by a lack of storm events and subsequent flushing late in the 2005 season.

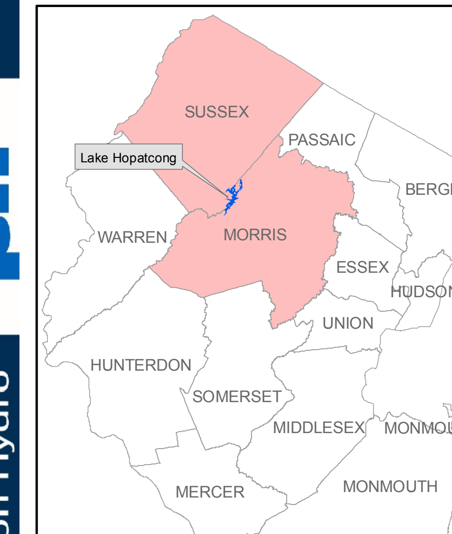
9. Over the last four growing seasons, an average of approximately 1,394 tons of aquatic plant biomass was harvested from Lake Hopatcong per year. Approximately 1,000 tons of aquatic plant biomass was removed in 2005, an approximately 150% increase from 2004 removals. The mechanical weed-harvesting program increases the recreational and ecological value of Lake Hopatcong, as well as removes a phosphorus source from the lake. Thus, this in-lake management technique should continue to be used at Lake Hopatcong.

APPENDIX A

FIGURES

Princeton Hydro

NEW JERSEY COUNTY MAP



PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

0 650 1,300 2,600 Feet

1 inch equals 2,500 feet

SOURCES:

1. Data accuracies are limited to the accuracy and scales of the original data sources.
2. USGS Quadrangle of Stanhope and Dover, NJ.

FIGURE 1: WATER SAMPLING LOCATIONS

LAKE HOPATCONG
WATER QUALITY SAMPLING
MORRIS & SUSSEX CO., NJ

LEGEND

● Sampling Locations

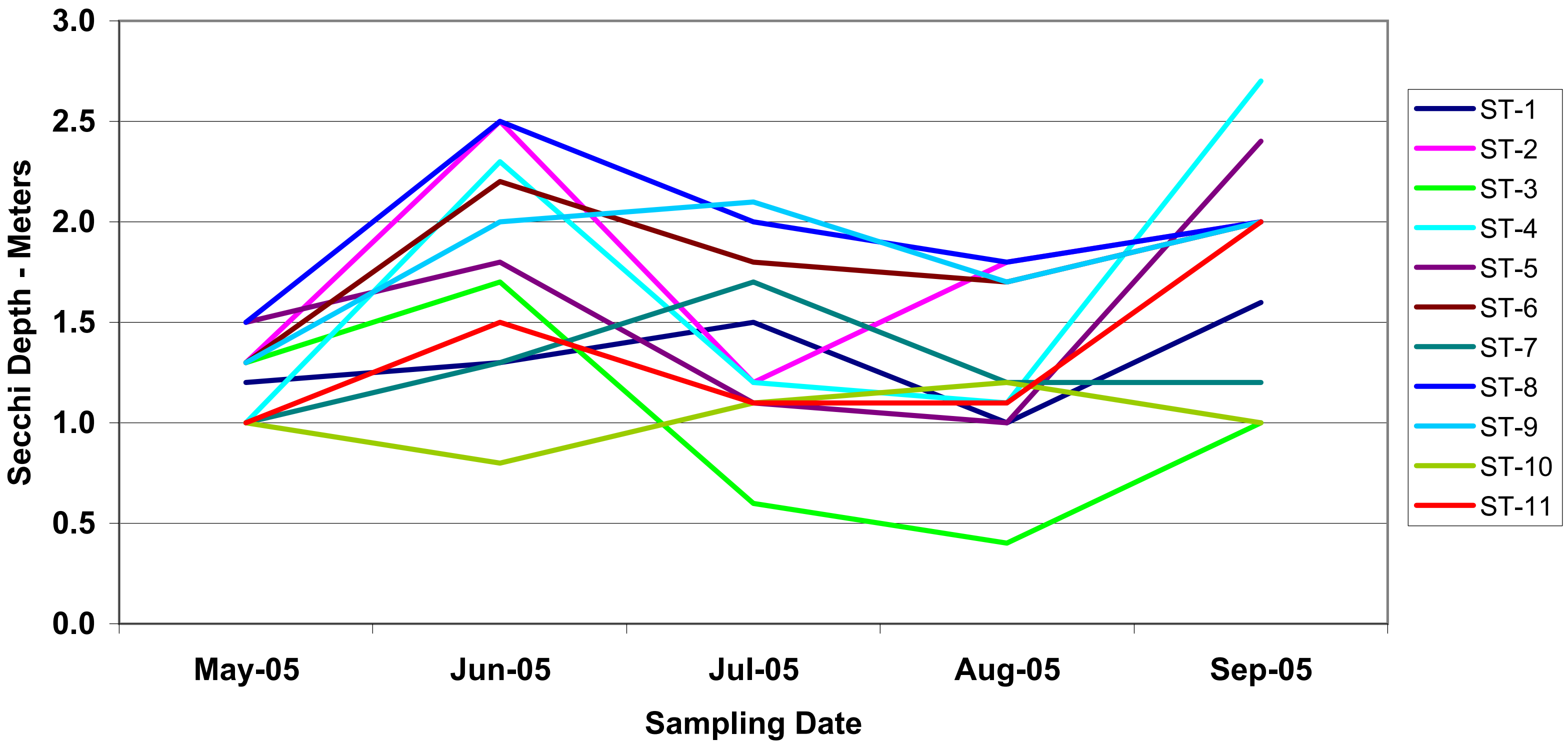


Figure 2 - Lake Hopatcong 2005 Secchi depth values

Princeton Hydro, L.L.C.
1108 Old York Road
Ringoes, N. J. 08551

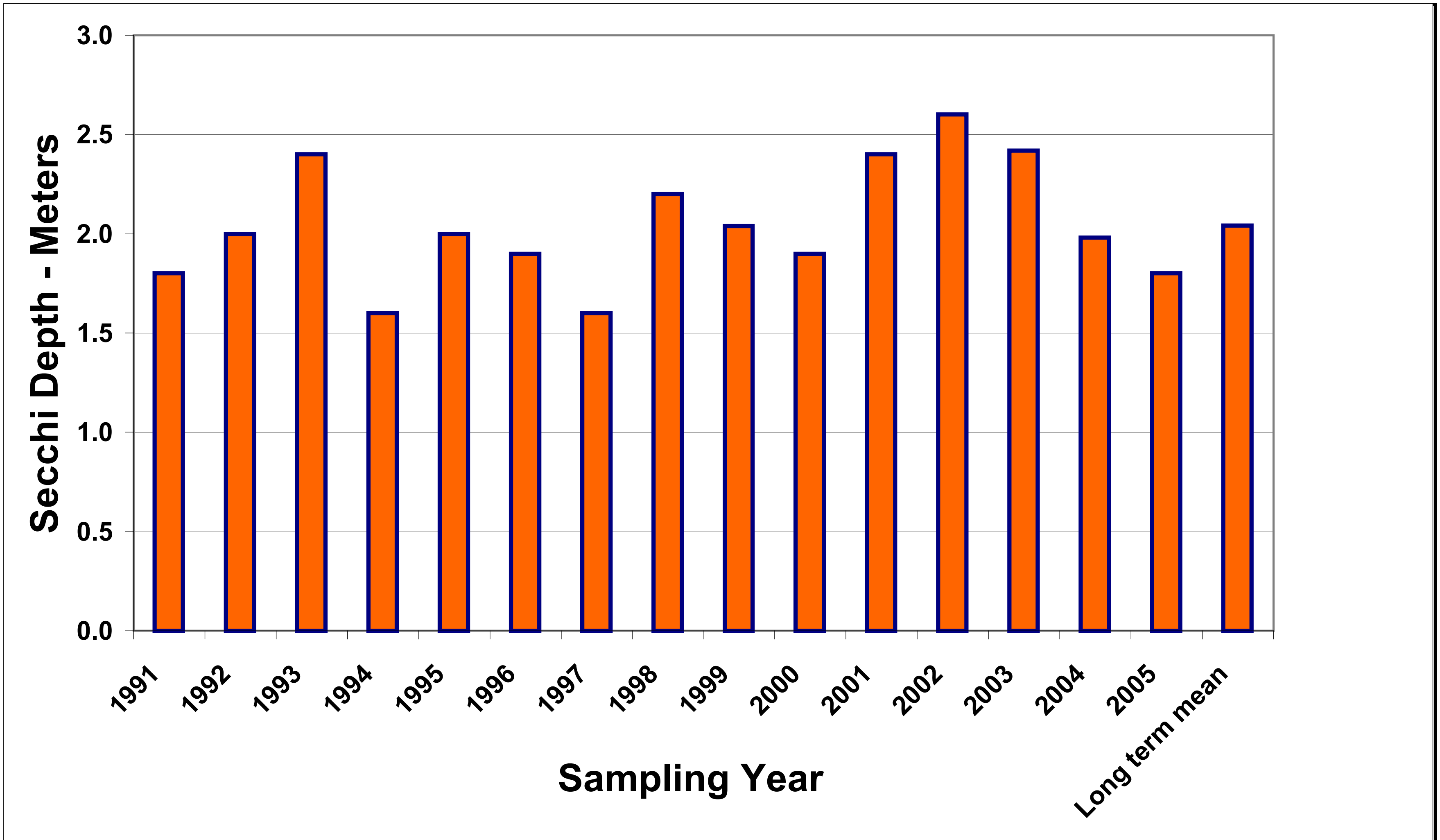


Figure 3 - Lake Hopatcong Long Term
Secchi Depth Values at Station #2

Princeton Hydro, L.L.C.
1108 Old York Road
Ringoes, N. J. 08551

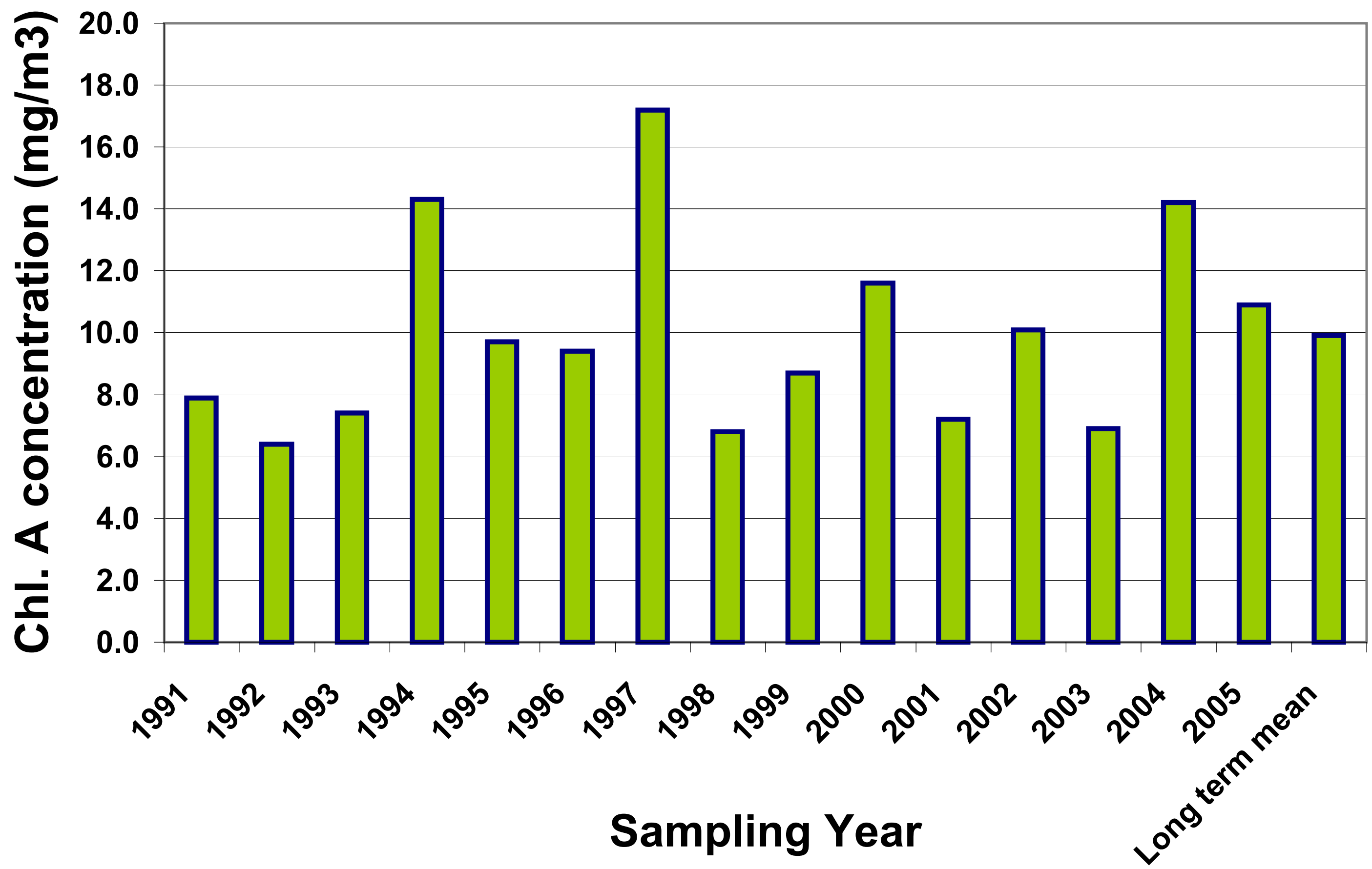


Figure 4 - Lake Hopatcong Long Term Chl A concentrations at Station #2

Princeton Hydro, L.L.C.
1108 Old York Road
Ringoes, N. J. 08551

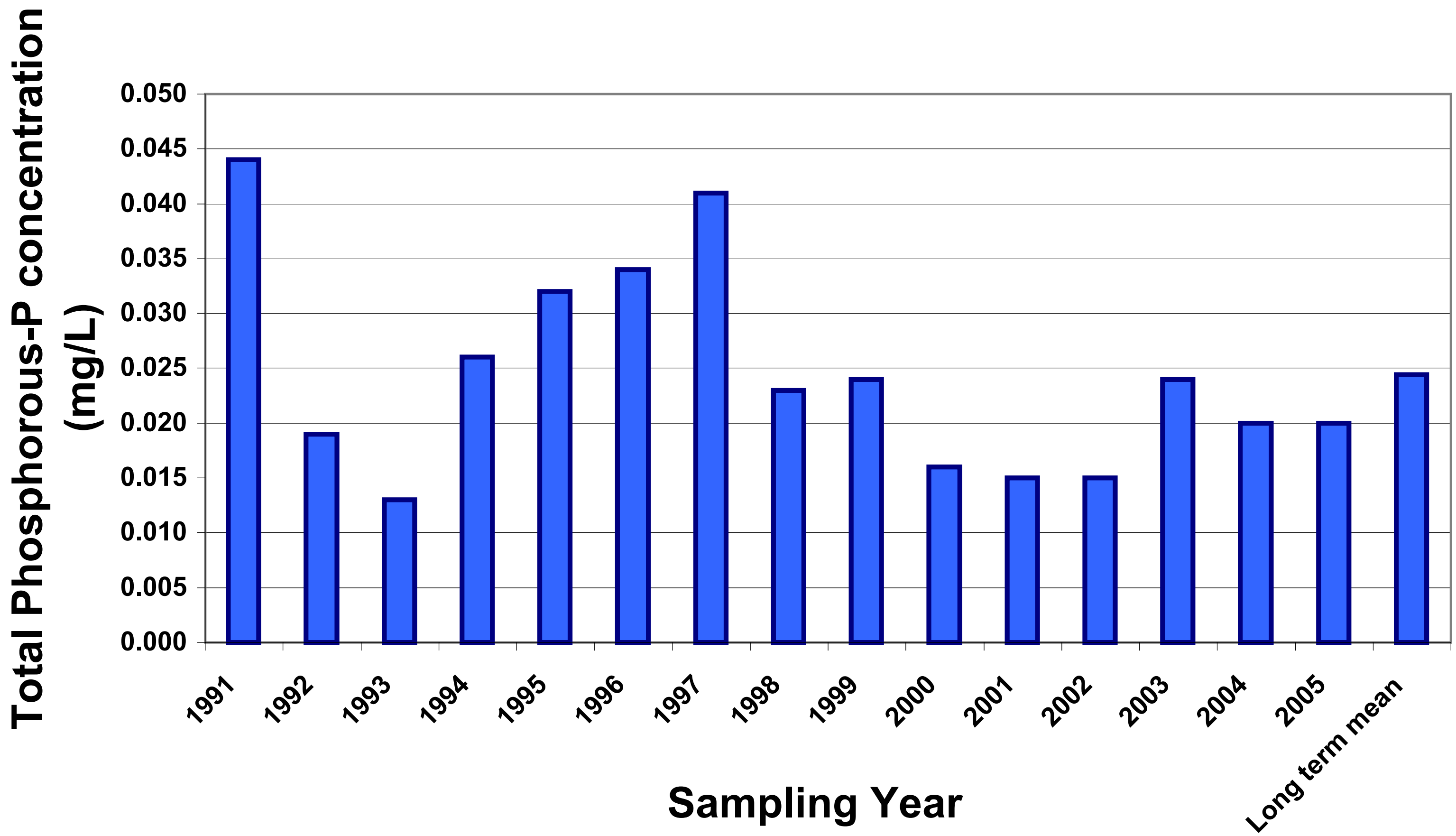


Figure 5 - Lake Hopatcong Long Term TP concentrations at Station #2

pH

Princeton Hydro, L.L.C.
1108 Old York Road
Ringoes, N. J. 08551

APPENDIX B

IN-SITU DATA

In-Situ Monitoring for Lake Hopatcong 5/17/05							
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**Dissolved Oxygen**	**pH**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(mmhos/cm)**	**(mg/L)**	**(units)**
ST-1	**1.8**	**1.2**	**Surface**	19.27	0.397	8.82	7.81
			1.0	19.22	0.397	8.63	7.75
			2.0	18.89	0.394	8.43	7.7
ST-2	**15**	**1.3**	**Surface**	16.64	0.374	10.35	8.77
			1.0	16.58	0.374	10.4	8.77
			2.0	16.52	0.374	10.53	8.78
			3.0	16.5	0.374	10.65	8.77
			4.0	16.42	0.374	10.54	8.7
			5.0	16.29	0.374	10.5	8.63
			6.0	15.93	0.374	10.46	8.49
			7.0	13.48	0.371	10.21	8.23
			8.0	12.59	0.37	9.45	8.01
			9.0	11.78	0.37	8.69	7.89
			10.0	11.39	0.369	8.1	7.8
			11.0	11.03	0.369	7.61	7.72
			12.0	10.73	0.371	6.68	7.64
			13.0	10.61	0.371	6.24	7.56
			14.0	10.22	0.373	5.17	7.47
			15.0	10.14	0.396	2.33	7.35
ST-3	**2**	**1.3**	**Surface**	19.03	0.41	9.7	8.51
			1.0	17.11	0.395	10.78	8.75
			2.0	16.31	0.391	10.28	8.42
ST-4	**2.6**	**1**	**Surface**	16.79	0.378	9.66	8.39
			1.0	16.76	0.378	9.88	8.45
			2.0	16.71	0.378	10.16	8.49
			3.0	16.7	0.378	10.19	8.48
ST-5	**1.7**	**1.5**	**Surface**	16.86	0.384	8.43	8.01
			1.0	16.59	0.382	8.76	7.98
ST-6	**2.5**	**1.3**	**Surface**	18.77	0.372	10.35	8.49
			1.0	15.66	0.373	11.12	8.47
			2.0	14.82	0.371	11.3	8.63
ST-7	**1.6**	**1**	**Surface**	20.44	0.334	7.61	7.47
			1.0	19.52	0.332	7.26	7.37
ST-8	**7.2**	**1.5**	**Surface**	17.24	0.375	10.28	8.76
			1.0	17.17	0.375	10.23	8.73
			2.0	16.94	0.374	10.41	8.74
			3.0	16.1	0.374	10.57	8.6
			4.0	15.95	0.374	10.49	8.52
			5.0	15.6	0.374	10.35	8.41
			6.0	14.71	0.373	10.4	8.31
			7.0	14.33	0.373	9.72	8.11
ST-9	**8**	**1.3**	**Surface**	17.28	0.374	11.2	8.71
			1.0	16.48	0.374	11.17	8.81
			2.0	16.05	0.375	11.04	8.8
			3.0	14.74	0.372	11.13	8.62
			4.0	14.36	0.372	10.77	8.46
			5.0	13.92	0.371	10.26	8.27
			6.0	13.49	0.371	9.76	8.12
			7.0	12.76	0.371	8.98	8.01
ST-10	**1.5**	**1**	**Surface**	18.75	0.412	9.69	7.92
			1.0	18.4	0.41	9.49	7.98
ST-11	**1**	**1**	**Surface**	19.52	0.261	7.14	7.83
			1.0	18.81	0.255	7.13	7.62

In-Situ Monitoring for Lake Hopatcong 6/16/04							
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)
ST-1	2	1.3	Surface	27.29	0.424	7.14	7.58
			1.0	27.24	0.424	6.73	7.53
			2.0	26.72	0.425	6.69	7.48
ST-2	14.2	2.5	Surface	25.48	0.395	8.4	8
			1.0	25.47	0.394	8.44	8.1
			2.0	25.44	0.394	8.46	8.14
			3.0	25.39	0.394	8.48	8.13
			4.0	22.19	0.389	8.81	7.98
			5.0	18.71	0.386	7.89	7.76
			6.0	15.16	0.383	6.5	7.67
			7.0	14.35	0.383	4.45	7.52
			8.0	13.66	0.382	4.39	7.46
			9.0	13.17	0.382	3.1	7.36
			10.0	12.79	0.381	2.84	7.3
			11.0	12.28	0.381	2.03	7.25
			12.0	11.82	0.381	1.15	7.19
			13.0	11.27	0.384	0.48	7.13
			14.0	10.72	0.448	0.37	7.1
ST-3	2.2	1.7	Surface	26.53	0.425	8.19	7.86
			1.0	26.51	0.424	8.39	7.98
			2.0	26.12	0.456	7.52	7.78
ST-4	3	2.3	Surface	25.53	0.395	8.62	8.07
			1.0	25.53	0.395	8.56	8.15
			2.0	25.47	0.395	8.51	8.16
			3.0	23.4	0.393	6.11	7.67
ST-5	3	1.8	Surface	25.46	0.395	7.92	7.34
			1.0	25.43	0.395	8.05	7.5
			2.0	25.34	0.395	7.75	7.61
			3.0	23.38	0.397	2.49	7.25
ST-6	2.4	2.2	Surface	27.12	0.396	7.73	7.72
			1.0	27.11	0.396	7.84	7.76
			2.0	26.8	0.396	8	7.82
ST-7	1.5	1.3	Surface	27.3	0.384	6.61	7.28
			1.0	26.99	0.379	6.38	7.25
ST-8	7.5	2.5	Surface	25.94	0.395	8.59	7.95
			1.0	25.91	0.395	8.46	8.03
			2.0	25.8	0.394	8.4	8.06
			3.0	25.74	0.394	8.26	8.02
			4.0	22.97	0.39	8.34	7.87
			5.0	19.14	0.386	8.95	7.83
			6.0	15.35	0.385	6.74	7.76
			7.0	14.14	0.385	3.37	7.52
ST-9	8	2	Surface	26.38	0.394	8.66	7.93
			1.0	26.39	0.394	8.74	8.08
			2.0	26.02	0.394	8.89	8.1
			3.0	25.89	0.393	9.03	8.11
			4.0	25.74	0.393	8.79	8
			5.0	21.91	0.388	9.57	7.88
			6.0	16.19	0.383	8.09	7.8
			7.0	14.53	0.384	6.23	7.72
			8.0	13.86	0.403	3.73	7.37
ST-10	1.3	0.8	Surface	26.78	0.43	8.91	8.23
			1.0	26.79	0.43	8.95	8.39
ST-11	1.5	1.5	Surface	26.35	0.318	5.25	7.23
			1.0	26.05	0.319	4.86	7.14

In-Situ Monitoring for Lake Hopatcong 7/21/05							
Station	DEPTH (meters)			Temperature	Conductivity	pH	Dissolved Oxygen
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(units)	(mg/L)
ST-1	4	1.5	Surface	29.79	0.414	8.01	8.27
			1.0	29.54	0.414	7.94	8.29
			2.0	28.64	0.413	7.51	7.87
			3.0	27.59	0.414	7.01	5.6
			3.5	25.21	0.412	6.97	2.26
ST-2	14.5	1.2	Surface	28.52	0.391	8.46	8.32
			1.0	28.37	0.391	8.45	8.37
			2.0	28	0.391	8.45	8.41
			3.0	27.17	0.39	8.14	8.31
			4.0	25.14	0.39	7.26	6.86
			5.0	23.58	0.389	6.85	4.47
			6.0	20.42	0.387	6.45	1.48
			7.0	17.75	0.387	6.35	1.08
			8.0	14.82	0.387	6.4	1.21
			9.0	13.23	0.387	6.46	1.28
			10.0	12.55	0.388	6.53	1.33
			11.0	11.83	0.395	6.53	1.38
			12.0	11.49	0.399	6.58	1.46
			13.0	11.07	0.405	6.65	1.58
			13.5	10.74	0.416	6.64	1.76
ST-3	2.1	0.6	Surface	29.31	0.415	8.76	9.13
			1.0	28.44	0.413	8.63	9.08
			2.0	26.97	0.411	6.84	2.79
ST-4	3	1.2	Surface	28.41	0.388	8.54	8.67
			1.0	28.4	0.387	8.52	8.74
			2.0	27.86	0.387	8.53	8.83
			2.5	27.27	0.387	7.97	8.08
ST-5	1.8	1.1	Surface	28	0.387	8.45	8.46
			1.0	27.82	0.386	8.47	8.51
			1.5	27.46	0.386	8.39	8.42
ST-6	2.6	1.8	Surface	28.94	0.389	8.43	8.48
			1.0	28.87	0.399	8.5	8.73
			2.0	28.2	0.388	8.59	9.3
			2.5	27.99	0.388	8.5	9.34
ST-7	1.8	1.7	Surface	29.99	0.283	7.86	8.43
			1.0	29.91	0.285	7.91	8.47
ST-8	7.2	2	Surface	28.59	0.389	8.42	8.36
			1.0	28.61	0.389	8.39	8.35
			2.0	28.54	0.389	8.38	8.33
			3.0	28.47	0.389	8.36	8.33
			4.0	27.75	0.399	8.42	8.52
			5.0	23.37	0.388	6.62	3.43
			6.0	20.7	0.386	6.58	1.69
			7.0	17.54	0.395	6.67	1.41
ST-9	8.2	2.1	Surface	28.03	0.388	8.23	8.16
			1.0	27.95	0.388	8.23	8.16
			2.0	27.06	0.388	8.27	8.37
			3.0	26.77	0.389	8.13	8.2
			4.0	26.25	0.39	7.38	7.22
			5.0	24.04	0.388	6.72	5.18
			6.0	20.84	0.386	6.49	1.25
			7.0	15.76	0.393	6.5	1.22
			8.0	14.27	0.451	6.51	1.53
ST-10	1.1	1.1	Surface	29.99	0.418	9.24	11.02
			1.0	29.36	0.425	9.57	13.23
ST-11	1.1	1.1	Surface	29.43	0.263	7.9	8.08
			1.0	28.43	0.252	8.51	10.31

In-Situ Monitoring for Lake Hopatcong 8/18/05							
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)
ST-1	1.5	1	Surface	25.81	0.376	7.05	7.08
			1.0	25.81	0.376	7.02	6.99
			2.0	25.63	0.377	7.13	6.97
ST-2	14.5	1.8	Surface	25.92	0.358	7.16	8.02
			1.0	25.95	0.358	7.21	8.02
			2.0	25.95	0.358	7.28	8
			3.0	25.92	0.358	7.31	7.99
			4.0	25.89	0.358	7.3	7.95
			5.0	25.87	0.358	7.25	7.9
			6.0	22.37	0.346	1.98	6.97
			7.0	18.8	0.349	1.32	6.87
			8.0	15.75	0.346	1.08	6.83
			9.0	13.85	0.344	0.89	6.83
			10.0	12.94	0.349	0.7	6.93
			11.0	12.22	0.351	0.61	7.03
			12.0	11.51	0.359	0.54	7.17
			13.0	10.95	0.373	0.48	7.23
			13.5	10.93	0.381	0.44	7.28
ST-3	2	0.4	Surface	26.31	0.377	8.5	8.44
			1.0	25.21	0.382	7.56	8.1
			2.0	25.01	0.383	6.6	7.47
ST-4	3	1.1	Surface	25.49	0.363	7.07	7.76
			1.0	25.45	0.363	7.1	7.78
			2.0	25.35	0.363	7.1	7.74
			3.0	25.38	0.377	5.27	7.22
ST-5	2.5	1	Surface	25.15	0.364	6.7	7.84
			1.0	25.17	0.364	6.82	7.91
			2.0	25.11	0.364	6.78	7.91
ST-6	2.2	1.7	Surface	26.14	0.359	8.35	8.07
			1.0	26.11	0.359	8.36	8.13
			2.0	25.74	0.358	9.12	8.45
ST-7	1.2	1.2	Surface	25.79	0.318	6.04	6.97
			1.0	25.58	0.318	6.41	6.96
ST-8	7.5	1.8	Surface	26.04	0.358	7.17	7.81
			1.0	26.03	0.358	7.24	7.81
			2.0	25.94	0.357	7.26	7.77
			3.0	25.84	0.357	7.28	7.69
			4.0	25.78	0.357	7.18	7.59
			5.0	25.13	0.354	5.24	7.13
			6.0	22.78	0.341	2.2	6.73
			7.0	19.61	0.35	1.25	6.65
ST-9	8	1.7	Surface	26.14	0.357	7.65	7.58
			1.0	26.18	0.357	7.66	7.59
			2.0	26.12	0.357	7.73	7.58
			3.0	25.93	0.357	7.86	7.64
			4.0	25.81	0.357	7.74	7.53
			5.0	25.76	0.357	7.68	7.47
			6.0	25.7	0.357	7.59	7.4
			7.0	21.37	0.349	2.03	6.57
			8.0	16.76	0.356	1.65	6.6
ST-10	1.2	1.2	Surface	25.76	0.387	7.89	7.66
			1.0	25.6	0.388	8.77	8.28
ST-11	1.1	1.1	Surface	24.54	0.38	6.8	7.18
			1.0	24.33	0.376	7.15	7.18

In-Situ Monitoring for Lake Hopatcong 9/28/05							
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)
ST-1	1.6	1.6	Surface	19.68	0.243	8.75	7.94
			1.0	19.25	0.39	8.78	7.83
			1.6	19.19	0.39	8.71	7.94
ST-2	14	2	Surface	20.67	0.359	7.59	7.82
			1.0	20.71	0.359	7.36	7.74
			2.0	20.71	0.358	7.34	7.71
			3.0	20.69	0.358	7.34	7.67
			4.0	20.65	0.358	7.27	7.62
			5.0	20.59	0.358	7.13	7.55
			6.0	20.55	0.358	7.07	7.52
			7.0	20.49	0.358	6.94	7.5
			8.0	20.31	0.358	6.53	7.49
			9.0	16.69	0.355	1.66	7.49
			10.0	15.96	0.356	0.93	7.52
			11.0	14.57	0.357	0.85	7.73
			12.0	12.7	0.36	0.83	8.67
			13.0	12.04	0.367	0.82	9.09
			14.0	11.35	0.405	0.8	9.22
ST-3	1.8	1	Surface	18.93	0.223	9.29	8.06
			1.0	19.94	0.372	8.6	7.99
			1.8	19.48	0.373	7.24	7.97
ST-4	2.7	2.7	Surface	18.82	0.312	8.45	8.17
			1.0	19.42	0.368	8.54	8.16
			2.0	19.39	0.367	8.61	8.13
			2.7	19.39	0.367	8.68	8.11
ST-5	2.5	2.4	Surface	18.45	0.473	8.09	7.74
			1.0	19.33	0.371	7.97	8.02
			2.0	19.2	0.371	8.03	7.96
			2.5	19.06	0.37	8.06	7.92
ST-6	2	2	Surface	20.73	0.273	8.44	8.22
			1.0	20.61	0.36	8.54	8.13
			2.0	19.87	0.361	9.7	8.25
ST-7	1.2	1.2	Surface	19.4	0.436	7.61	7.77
			1.0	19.15	0.446	7.53	7.85
ST-8	7.1	2	Surface	20.3	0.352	7.68	7.72
			1.0	20.61	0.358	7.56	7.75
			2.0	20.51	0.358	7.41	7.72
			3.0	20.4	0.358	7.2	7.69
			4.0	20.36	0.358	7.07	7.62
			5.0	20.34	0.358	7.21	7.55
			6.0	20.3	0.359	7.38	7.53
			7.0	20.2	0.359	7.41	7.54
ST-9	7.8	2	Surface	21.12	0.321	7.85	8.03
			1.0	21.33	0.359	7.46	7.79
			2.0	21.12	0.359	7.55	7.82
			3.0	20.88	0.359	7.54	7.95
			4.0	20.72	0.359	7.39	8.01
			5.0	20.55	0.359	6.93	7.99
			6.0	20.43	0.359	6.56	7.89
			7.0	20.37	0.359	6.46	7.83
			7.5	20.14	0.359	6.21	7.81
ST-10	1	1	Surface	20.03	0.327	9.91	8.19
			1.0	19.35	0.397	8.26	8.03
ST-11	2	2	Surface	18.16	0.577	7.3	7.63
			1.0	17.9	0.582	7.07	7.7
			2.0	17.5	0.587	6.81	7.8

APPENDIX C

LABORATORY DATA SHEETS

HOPATCONG
5/17/2005

STATION	CHL A	NH3-N	NO3-N	TP	TSS
ST-1	10.8	0.09	0.03	0.05	5
ST-2	18	0.09	0.14	0.04	<3
ST-3	7.1	0.08	0.14	0.04	7
ST-4	13.9	0.08	0.04	0.04	4
ST-5	12.4	0.08	0.04	0.05	5
ST-6	10.4	0.08	0.03	0.04	7
ST-7	18.1	0.07	0.04	0.02	9
ST-11	17.9	0.06	0.05	0.05	<3
ST-2 DEEP					
MEAN	13.58	0.08	0.06	0.04	6.17

HOPATCONG
6/16/2005

STATION	CHL A	NH3-N	NO3-N	TP	TSS
ST-1	13.4	0.12	<0.02	0.03	8
ST-2	6.1	0.12	<0.02	0.01	<3
ST-3	12.7	0.2	<0.02	0.03	4
ST-4	7.7	0.11	<0.02	<0.01	3
ST-5	7.9	0.1	<0.02	<0.01	5
ST-6	3.8	0.2	<0.02	0.02	7
ST-7	11.5	0.06	<0.02	0.02	8
ST-10	14.2	0.06	<0.2	0.03	5
ST-11	12	0.1	<0.02	<0.01	<3
ST-2 DEEP		0.3	<0.02	<0.01	7
MEAN	9.92	0.12	#DIV/0!	0.02	5.71

HOPATCONG
7/18/2005

STATION	CHL A	NH3-N	NO3-N	TP	TSS
ST-1	9.9	0.09	0.05	0.03	7
ST-2	7.7	0.07	ND <0.02	0.01	5
ST-3	33.5	0.07	0.08	0.05	11
ST-4	10.2	0.06	0.03	0.01	6
ST-5	15.2	0.03	0.05	0.02	5
ST-6	7.1	ND <0.02	0.05	0.01	4
ST-7	4.4	0.04	0.05	0.02	4
ST-10	8.1	0.04	0.03	0.02	3
ST-11	5.4	0.04	0.07	0.02	4
ST-2 DEEP		0.59	0.18	0.15	11
MEAN	11.28	0.06	0.05	0.02	5.44

HOPATCONG
8/18/2005

STATION	CHL A	NH3-N	NO3-N	TP	TSS
ST-1	11.8	0.15	0.03	ND <0.01	5
ST-2	13.1	0.11	ND <0.02	0.02	ND <3
ST-3	135	0.08	0.06	0.03	17
ST-4	23	0.08	ND <0.02	ND <0.01	8
ST-5	25	0.11	0.02	0.01	9
ST-6	8.3	0.11	0.02	ND <0.01	ND <3
ST-7	4.9	0.08	0.03	ND <0.01	ND <3
ST-10	11.1	0.08	0.02	ND <0.01	ND <3
ST-11	4.4	0.16	0.03	ND <0.01	6
ST-2 DEEP		0.52	0.13	0.22	7
MEAN	26.29	0.15	0.04	0.07	8.67

HOPATCONG
9/28/2005

STATION	CHL A	NH3-N	NO3-N	TP	TSS
ST-1	9.8	0.14	0.03	0.01	6
ST-2	9.8	0.02	ND <0.02	0.01	ND <3
ST-3	24	0.03	0.03	0.05	8
ST-4	4.8	0.04	ND <0.02	0.01	ND <3
ST-5	7.2	0.06	0.02	0.02	3
ST-6	4.9	0.05	ND <0.02	0.02	ND <3
ST-7	1.5	0.05	0.03	0.01	ND <3
ST-10	4.9	0.05	0.03	0.03	3
ST-11	3.4	0.04	0.03	0.03	3
ST-2 DEEP		0.65	0.2	0.13	10
MEAN	7.81	0.11	0.05	0.03	5.50