LAKE HOPATCONG
WATER QUALITY MONITORING
ANNUAL REPORT 2014

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May 2015
Princeton Hydro, LLC Project No. 3.47, task 2

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1.0 INTRODUCTION

Princeton Hydro, LLC conducted general water quality monitoring of Lake Hopatcong during the 2014 growing season (May through October). This monitoring program represents a continuation of the long-term monitoring program of Lake Hopatcong. While the 2010 through 2012 water quality monitoring programs have been funded with funds awarded to the Lake Hopatcong Commission by NJDEP through the Non-Point Source (319(h) of the Clean Water Act) grant program (Project Grant RP10-087), the water quality monitoring program of 2013 was funded through the Lake Hopatcong Foundation as a monetary match toward the grant. However, remaining funds in the 319(h) grant were made available for the 2014 water quality monitoring program.

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 modified monitoring program also continued through the development, revision and approval of the TMDL-based Restoration Plan, as well as through the installation of a series of watershed projects funded through a NJDEP 319 grants and a US EPA Targeted Watershed grant.

The current water quality monitoring program is valuable in terms of continuing to assess the overall "health" of the lake on a year to year basis, identifying long-term trends or changes in water quality, and quantifying and objectively assessing the success and potential impacts of restoration efforts. In addition, the in-lake water quality monitoring program will be an important component of evaluating the long-term success of the implementation of the phosphorus TMDL-based Restoration Plan, which was approved by NJDEP in April of 2006.

2.0 MATERIALS AND METHODS

In-lake water quality monitoring was conducted at the following eleven (11) locations in Lake Hopatcong (represented as red circles in Figure 1, 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 2014 sampling dates were 21 May, 24 June, 17 July, 15 August and 1 October. A Eureka Amphibian PDA with Manta multi-probe unit was used to monitor the *in-situ* parameters: dissolved oxygen (DO), temperature, pH, and specific conductance during each sampling event. Data were recorded at 1.0 m increments starting at 0.25 m below the water's surface and continued to within 0.5-1.0 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 sites (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 phosphorus-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; no discrete water samples were collected from these two stations for laboratory analyses. It should be noted that prior to 2005, Station #10 had been monitored for *in-situ* observations only. However, due to observations made at Station #10 by 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 also 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.

Additional Water Quality Data Collected in 2014

In addition to the standard, long-term, in-lake monitoring program, supplemental in-lake data were collected as part of the 2014 monitoring program. From 2006 to 2014 some select, near shore, in-lake sampling sites were established and monitored. These additional in-lake sampling sites were located immediately adjacent to drainage areas where a stormwater structure was installed as part of an existing 319(h) grant (SFY05; Grant RP05-080). The three near-shore, in-lake sampling stations included:

1. The southern end of Crescent Cove in the Borough of Hopatcong (NPS-1).
2. Ingram Cove, located in the Borough of Hopatcong (removed from monitoring program).
3. Along the eastern shoreline of the lake, in the Township of Jefferson, just south of Brady's Bridge (NPS-2).

Through the course of implementing the SFY05 319(h) grant, it was determined that no BMP would be installed in the Ingram Cove drainage basin; the Ingram Cove project was dropped from the grant project due to site specific limitations associated with existing utilities. Subsequently, the proposed Ingram Cove project was moved to the Crescent Cove drainage area. However, monitoring of the Ingram Cove sampling station continued through 2008 and was discontinued from 2009 through the 2014 monitoring programs.

For the remaining two supplemental in-lake sampling stations, monitoring occurred during the May through September 2014 in-lake monitoring events. Monitoring included collecting *in-situ* data at 0.5 – 1.0 meters from surface to bottom for temperature, dissolved oxygen, pH and specific conductance. Water clarity was also measured at each station with a Secchi disk. Discrete mid-depth water samples were collected and analyzed for TP and TSS. The Crescent Cove station is NPS-1, while the Township of Jefferson station is NPS-2; both are shown in Figure 1 as yellow circles with an "X" inside (Appendix A).

As part of the SFY10 319 grant, some additional watershed-based restoration projects are being implemented to reduce the NPS pollutant load entering Lake Hopatcong, with an emphasis on TP and TSS. Similar to the SFY05 grant, three near-shore sampling sites were located immediately adjacent to drainage areas that were receiving a structural BMP or MTD as part of the SFY10 319(h) grant (Grant RP10-087). These three nearshore, in-lake sampling stations include:

1. In Ashley Cove in the Township of Jefferson (NPS-3).
2. In King Cove in the Township of Roxbury (NPS-4).
3. Southern end of the public beach at the Hopatcong State Park (NPS-5).

Similar to the SFY05 near-shore sampling program (NPS-1 and NPS-2), *in-situ* monitoring and discrete samples were collected for TP and TSS at the three SFY10 near-shore sampling stations during each of the five 2014 monitoring events. However, discrete samples were also collected for the analysis of chlorophyll *a*, a photosynthetic pigment all algae possess, at the SFY10 sampling stations.

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 2014 growing season were generally consistent with values recorded in previous monitoring programs. By the late May event Station #2 exhibited thermal stratification with the epilimnion extending to 5.0 m and the thermocline between 5.0 m and 7.0 m. A weaker degree of thermal stratification was also present at the other stations with sufficient depth (i.e. stations 8 and 9). Stratification persisted throughout the rest of the sampling season with seasonally maximum values observed on 17 July 2014.

All five 319 sampling sites were generally well mixed from May through early October 2014 with the exception being in May when NPS-1 exhibited some degree of thermal stratification.

Strong and extensive amounts of thermal stratification can effectively "seal off" the bottom waters from the surface waters 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 anoxia, 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 most forms of life. As dissolved oxygen concentrations fall below 5.0 mg/L, aquatic life is put under stress. DO concentrations 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 some 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 (DO < 1 mg/L) can produce chemical reactions that result in a release of dissolved phosphorus from the sediments and into the overlying waters. In turn, a storm event can transport this phosphorus to the upper waters and stimulate additional algal growth. This process is called internal 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.

Station #2 was well oxygenated during the May event from surface to bottom with DO concentrations varying between 5.06 and 10.56 mg/L. However, by 24 June anoxic conditions

(DO concentration < 1 mg/L) were established at Station #2 from 10 meters to the bottom. Also, Station #2 was the only monitoring station that exhibited anoxia over the sediments.

While anoxic conditions in deeper waters (equal to or greater than 8.0 meters) persisted into mid-July at Station #2, all of the other sampling stations remained oxygenated from surface to bottom on 17 July 2014. On 15 August 2014 anoxic conditions were still present at 8.0 meters and deeper at Station #2, while the other sampling stations remained oxygenated from surface to bottom. By 1 October 2014 anoxic conditions were still measured at Station #2 but were limited to depths of 11.0 meters or deeper, while all the other stations remained oxygenated from surface to bottom.

All five of the NPS sampling stations were well oxygenated (DO > 5 mg/L) from surface to bottom during all five 2014 monitoring events. In addition, DO concentrations were frequently greater than 100% saturation, particularly during the months of July and August. Such conditions of super-saturation indicate the presence of elevated rates of algal and aquatic plant photosynthesis, which generates DO. Such super-saturation was particularly high (as high as 137%) in Station #3 (River Styx / Crescent Cove), which had high densities of aquatic plants (particularly Eurasian watermilfoil) fairly early in the growing season.

Overall, a depression of DO was limited to the hypolimnion of Station #2. Thus, the majority of the lake had a sufficient amount of DO to support a diverse and healthy aquatic ecosystem (Appendix B).

pH

The pH is defined as the negative logarithm of the hydrogen ion concentration in water. pH values greater then 7 are termed alkaline while those less then 7 are acidic; a pH value of 7 is neutral. The optimal range of pH for most freshwater organisms is between 6.0 and 9.0. However, the State water quality standard for pH is for an optimal range between 6.5 and 8.5.

Similar to 2013, the pH values during the May 2014 sampling event were generally acceptable throughout the lake with the exception being Station #3 where pH values were as high as 9.48. By 24 June the pH values at Station #3 were within the optimal range, which was largely a result of removing a large portion of the existing aquatic plant / mat algae biomass through the mechanical weed harvesting program between the May and June sampling events. In general, the northern end of the lake had slight higher pH values in June relative to the southern end in June. In addition, it should be noted that based on the elevated pH values (> 8.7) and supersaturated DO (up to 130%) conditions, Byram Cove was experiencing an algal bloom at this time.

By 17 July 2014 the pH throughout Lake Hopatcong ranged from the low to mid-7's with the exception being Station #3 where the pH was in the low 8's. These pH values were elevated but still within the optimal range for acceptable water quality conditions as per NJDEP. While overall pH values were slightly higher in August relative to July, a similar pattern was observed in August, where Station #3 pH values were in the low 8's.

By 1 October 2014 most of the pH values throughout Lake Hopatcong varied between the upper 6's and the upper 7's. However, some of the northern sampling stations, such as Henderson Cove (ST-#6) and Byram Cove (ST-#9), had pH values in the 8's. In fact, some of the pH values in Henderson Cove exceeded the State criteria.

The near-shore sampling stations (NPS 1 through 5) generally had higher pH values relative to the open water stations. This is primarily due to elevated rates of photosynthesis from rooted aquatic vegetation and mat algae, in addition to the free-floating planktonic algae. Of the five sampling events, the July event was the only time when none of the five NPS stations exceeded the upper limit for pH (8.5).

Water Clarity (as measured with a Secchi disk)

Water clarity or transparency was measured at each in-lake monitoring station, during each monitoring event, with a Secchi disk. 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). In May 2014 Secchi depths were greater than 1 m throughout the lake. In June 2014 the Secchi depth fell below the 1 meter threshold at ST-1 (Woodport Bay) and ST-10 (Northern Woodport Bay), with all remaining stations having Secchi depths greater than 1 m.

By mid-July 2014 all sampling stations had Secchi depths equal to or greater than 1 m with the exception being ST-3 (River Styx / Crescent Cove), which had a Secchi depth of 0. 9 m. In late August 2014 both ST-3 and ST-10 had Secchi depths less than 1 m while all other stations had values equal to or greater than 1 meter. Finally, all Secchi depths in early October were equal to or greater than 1 meter or reached the bottom except for Station 10 where the Secchi value was 0.8 m (2.6 ft). Thus, as has been documented in past monitoring years, the sections of the lake that exhibit problems relative to water clarity (and hence water quality) is River Styx / Crescent Cove and Woodport / Northern Woodport.

Ammonia-Nitrogen (NH_4-N)

Surface water NH_4-N concentrations above 0.05 mg/L tend to stimulate elevated rates of algal growth. Ammonia concentrations measured during the May 2014 event varied from low (0.02 mg/L) at ST-1 and ST-2 to extremely high (0.81 and 0.24 mg/L) at ST-3 and ST-11, respectively. Bottom water NH_4-N concentrations were also excessive, at 0.28 mg/L, at the ST-2 deep water station but elevated concentrations of NH_4-N are a natural occurrence in the bottom water of lakes due to the bacterial decomposition of organic material. By late June 2014 most NH_4-N concentrations were low throughout the lake (<0.01 to 0.02 mg/L) except for ST-3 (0.13 mg/L) and the deep waters of ST-2 (0.50 mg/L).

By mid-July 2014 all surface water NH_4-N concentrations were low (<0.01 to 0.01 mg/L) throughout the lake. The bottom water NH_4-N concentration remained high at 0.62 mg/L. NH_4-N concentrations in mid-August 2014 essentially exhibited the same pattern of distribution observed in July 2014; all surface water concentrations were low but the deep waters at ST-2 were excessive (1.30 mg/L). In early October 2014 NH_4-N concentrations were low to moderate throughout the surface waters (0.02 to 0.03 mg/L), while the deep waters at ST-2 continued to have a high concentration of NH_4-N (1.8 mg/L).

In summary, the excessively high concentration of NH_4-N in the deep (hypolimnetic) waters at ST-2 was attributed to the depletion of DO and the bacterial decomposition of the organic matter raining to the bottom from the surface waters. While surface water NH_4-N concentrations were consistently low to slightly moderate from July through early October, concentrations were moderate to extremely high in May 2014. The elevated NH_4-N concentrations throughout the entire lake in the late spring of 2014 were at least partially attributed to the unusually heavy and long winter of 2013-2014. However, leachate from near-shore septic systems also attributed to the extremely high NH_4-N concentrations in the surface waters of ST-3 (0.81 mg/L) and ST-11 (0.24 mg/L). The watershed lands immediately adjacent to these two sampling stations are known to have high densities of old (some > 50 years old), near-shore septic systems, which frequently contribute elevated pollutant loads (e.g. nitrogen, phosphorus, fecal coliform, and *E. coli*) to the lake.

Nitrate-Nitrogen (NO_3-N)

Nitrate-N concentrations greater than 0.1 mg/L are considered excessive relative to algal and aquatic plant growth. Thus, in May 2014 nitrate-N concentrations varied from moderate to slightly above the 0.1 mg/L threshold (0.05 to 0.16 mg/L). The exception to this was at ST-3 where the measured nitrate-N concentration was 0.48 mg/L. By June 2014 almost all of the nitrate-N concentrations throughout Lake Hopatcong were below the 0.1 mg/L threshold, varying between <0.02 and 0.07 mg/L. The exception to this was ST-11 where the measured the concentration was 0.12 mg/L, slightly above the threshold.

By mid-July all measured nitrate-N concentrations were below the 0.1 mg/L threshold, however, ST-11 had the highest measured concentration at 0.08 mg/L, while ST-3 had the second highest at 0.06 mg/L. In mid-August all sampling stations had nitrate-N concentrations below the 0.1 mg/L except for ST-4 (Point Pleasant/King Cove), where the measured concentration was 0.25 mg/L. In early October 2014 nitrate-N concentrations were low throughout most of Lake Hopatcong, varying between <0.02 and 0.03 mg/L. However, the northern end of the lake (Jefferson Township, Morris County part of the watershed) had nitrate-N concentrations that varied from 0.04 to 0.09 mg/L.

In summary, all in-lake concentrations were consistently below the State and Federal drinking water standard of 10.0 mg/L. However, nitrate-N concentrations periodically exceeded the 0.1 mg/L threshold that stimulates elevated amounts of algal and aquatic plant growth. Such exceedances typically occurred in those sections of the lake immediately adjacent to lands that have homes using septic systems (Borough of Hopatcong around Crescent Cove / River Styx; Township of Jefferson around Woodport and in the Canals). These data indicate that aged, near-shore septic systems contribute to the pollutant load of Lake Hopatcong and thus have a direct impact on its water quality.

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, as detailed in the lake's revised TMDL and associated Restoration Plan.

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 nuisance by the layperson.

The State's Surface Water Quality Standard (SWQS, N.J.A.C. 7:9B – 1.14(c) 5) for TP in the surface waters of a freshwater lake or impoundment is 0.05 mg/L. This established TP concentration is for any freshwater lake or impoundment in New Jersey that does not have an established TMDL. Lake Hopatcong has established a phosphorus TMDL, which was revised and approved by NJDEP in June 2006. Based on its refined phosphorus TMDL, the long-term management goal is to maintain an <u>average</u>, growing season TP concentration of 0.03 mg/L within the surface waters of Lake Hopatcong.

TP concentrations measured in the surface waters during the May 2014 sampling event ranged from 0.02 mg/L to 0.03 mg/L with a surface water mean concentration of 0.03 mg/L. The deep water TP concentration at Station #2 was 0.03 mg/L. Thus, May 2014 TP concentrations were consistently below the State and TMDL thresholds.

TP concentrations in the surface waters during the June 2014 event and ranged from 0.02 mg/L to 0.06 mg/L with a mean concentration of 0.03 mg/L. ST-1, ST-3 and ST-10 had elevated TP concentrations of 0.04, 0.06 and 0.05 mg/L, respectively, with the ST-3 concentration exceeding the State's Surface Water Quality Standard.

The majority of the surface water TP concentrations measured during the July 2014 event ranged from 0.02 mg/L to 0.03 mg/L in the surface waters. The exception to this was the TP concentration at ST-3 (0.06 mg/L), which again exceeded the State's Surface Water Quality Standard. The deep water TP concentration at ST-2 was high (0.11 mg/L) but was a result of the depletion of DO immediately over the sediments. In the absence of DO, phosphorus normally adsorbed onto sediment particles leaches into the overlaying waters.

In August 2014 all TP concentrations were equal to or below the State's Surface Water Quality Standard of 0.05 mg/L. The highest TP concentration of 0.05 mg/L was measured at ST-2. In contrast to the rest of the growing season, early October 2014 TP concentrations were consistently low throughout the lake, varying between < 0.01 and 0.03 mg/L with an overall surface water mean of 0.01 mg/L.

Deep water TP concentrations at Station #2 varied between < 0.02 and 0.28 mg/L. Again, the deep water TP concentrations increased over the growing season once the bottom waters were depleted of DO.

The mean TP concentration was calculated for each surface water sampling station to determine if they comply with or exceed the concentration of 0.03 mg/L established under the lake's TMDL. Of the nine standard, long-term water quality monitoring stations, seven complied with the TMDL; that is, they had a mean 2014 growing season concentration at or less than 0.03 mg/L. The two stations that were out of compliance with the TMDL included ST-3 (Crescent Cove/River Styx) and ST-10 (Northern Woodport Bay). Both had a mean 2014 growing season TP concentration of 0.04 mg/L. Additionally, ST-3 was out of compliance with the State's Surface Water Quality Standard for TP two of the five 2014 monitoring events. As past monitoring data have revealed, these two sections of the lake are in the highest need of restoration efforts in order to move the lake into compliance with its TMDL. These sections of the lake have some of the highest density of residential housing and/or include lots with aged, near-shore septic system, which contributes to the elevated TP loads and concentrations.

As part of the existing SFY05 319 grant, two large Aqua-Filter Manufactured Treatment Devices (MTDs) were installed in the southern end of the Crescent Cove drainage basin to reduce a large portion of the TP and TSS loads that enter the lake from this section of the watershed. The first MTD was installed in November of 2008, while the second was installed in June of 2011. The NPS-1 monitoring station was established in 2006 in order to assess how the implementation of these MTDs, as well as other restoration measures (i.e. sewering part of the drainage area; more wide-spread use of non-phosphorus fertilizers) have impacted this section of the lake.

The data collected from 2006 to 2008 were prior to the installation of the two large Aqua-Filters, while the data collected in 2009 and 2010 were after the first Aqua-Filter was installed and the data collected in 2011 through 2014 were after the second Aqua-Filter was installed.

As shown in Table 1, before the first Aqua-Filters installed the mean growing season (May – September) TP concentration in Crescent Cove was 0.06 mg/L; these mean values are obviously greater than both the State's Surface Water Quality Standard of 0.05 mg/L for standing waterbodies as well as the targeted TMDL concentration of 0.03 mg/L. However, after the first Aqua-Filter was installed in late 2008, the mean TP concentration declined to 0.045 mg/L (Table 1; 2009 monitoring year). While this value was still greater than the targeted TMDL concentration of 0.03 mg/L, it was below the State's Surface Water Quality Standard of 0.05 mg/L. In addition, only one of four TP measurements in 2009 was above the State standard.

Table 1
The Mean and Range of TP and TSS Concentrations for Crescent Cove Over the Growing Season of Each Monitored Year

Monitoring Year	TP mean and range	TSS mean and range
2006 (pre-installation)	0.06 mg/L (0.05 – 0.075 mg/L)	10 mg/L (6 – 15 mg/L)
2007 (pre-installation)	0.06 mg/L (0.04 – 0.08 mg/L)	7 mg/L (3 – 11 mg/L)
2008 (pre-installation)	0.06 mg/L (0.04 – 0.08 mg/L)	14 mg/L (1.5 – 48 mg/L)
2009 (post-installation)	0.045 mg/L (0.03 – 0.06 mg/L)	7 mg/L (1.5 – 8 mg/L)
2010 (post-installation)	0.07 mg/L (0.02 – 0.09 mg/L)	8 mg/L (1 -15 mg/L)
2011 (post-installation)	0.04 mg/L (0.01 – 0.08 mg/L)	5 mg/L (1 – 11 mg/L)
2012 (post-installation)	0.06 mg/L (0.03 – 0.08 mg/L)	6 mg/L (3 – 10 mg/L)
2013 (post-installation)	0.05 mg/L (0.04 – 0.07 mg/L)	7 mg/L (2 – 15 mg/L)
2014 (post-installation)	0.05 mg/L (0.03 – 0.09 mg/L)	8 mg/L (4 – 13 mg/L)

In sharp contrast to the 2009 results, during the 2010 growing season, only one of the five sampling events was below the Sate Standard at NPS-1. The mean TP concentration at NPS-1 in 2010 was 0.07 mg/L greater than the mean values measured prior to the installation of the Aqua-Filter (2006-08). These conditions were in spite of the fact that 2010 had a relatively dry growing season. More than likely, these elevated TP concentrations indicated that the first Aqua-Filter needed to be maintained. Specifically, the filter pillows needed to be replaced and the Aqua-Swirl portion of the structure needed to be cleaned out. At a minimum, the Aqua-Filter should be inspected quarterly and accumulated material in the Aqua-Swirl should be vacuumed out several times a year. This would allow the structure to at least continue to remove accumulated sediments and the phosphorus adsorbed onto such particles. However, to maximize its phosphorus removal capacity, the filter pillows should be replaced as well.

The second Aqua-Filter was operating by the end of June 2011 and the resulting mean 2011 growing season TP concentration for NPS-1 was 0.04 mg/L, the lowest mean value of the entire 2006 - 2014 dataset (Table 1). Of the five 2011 sampling events, only one was above the State standard. In addition, three of the five had TP concentration at or below the TP concentration targeted under the TMDL (0.03 mg/L). However, by 2012 TP concentrations were again on the rise with a mean of 0.06 mg/L, again above the State threshold (Table 1 and Figure 1). Of the five measurements collected over the 2012 growing season, only two were below the State threshold. In 2013, the mean TP concentration was 0.05 mg/L (Table 1), with three of the five values at or below the State standard.

The 2014 monitoring data were similar to that documented in 2013. That is, the mean TP concentration was 0.05 mg/L. Additionally, three of the five TP concentrations were below the State's standard (Figure 1). A comparison of the overall pre-installation mean TP concentration (0.06 mg/L; 2006 to 2008) to the overall post-installation mean TP concentration (0.05 mg/L; 2009 to 2014) indicates that the Aqua-Filter stormwater systems have contributed toward an approximately 17% reduction in the in-cove phosphorus concentrations.

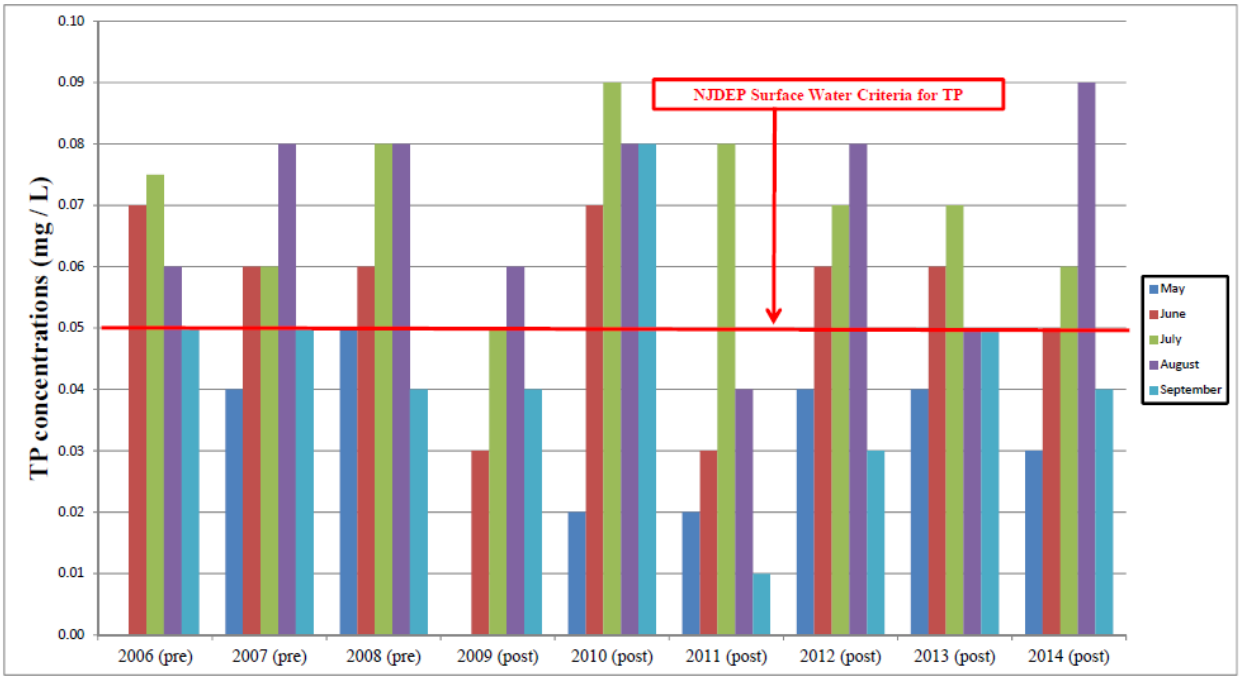
While not discussed in a high level of detail as TP, it should be noted that there has been a measurable decline in total suspended solids (TSS) concentrations once the Aqua-Filters were installed. Prior to their installation (2006 – 2008) TSS concentrations ranged from 1.5 to 48 mg/L, with growing season means ranging from 7 to 14 mg/L. In contrast, after the Aqua-Filters were installed, TSS concentrations ranged from 1 to 15 mg/L, with growing season means ranging from 5 to 8 mg/L (Table 1). A comparison of the overall pre-installation mean TSS concentration (10 mg/L; 2006 to 2008) to the overall post-installation mean TSS concentration (7 mg/L; 2009 to 2014) indicates that the Aqua-Filter stormwater systems have contributed toward a 30% reduction in the in-cove TSS concentrations. Thus, in-lake TP and TSS concentrations were lower in the southern end of Crescent Cove, once the Aqua-Filters were installed. However, it is worth repeating that in order to maximize pollutant removal efficiencies, both structures, at a minimum, should be cleaned out at least once a year.

Based on some conversations over the last year, it is understood that the Borough of Hopatcong has been at least pumping out the Aqua-Swirl portion of the two stormwater structure in the Hopatcong Beach Club's parking lot. Routine clean-outs of these stormwater structures have directly contributed to these reduced TP and TSS concentrations in the southern end of Crescent Cove. However, in order to continue to reduce the concentrations and loads of these pollutants, the following must be conducted:

1. At a minimum, inspect the Aqua-Swirl portion of the Aqua-Filter 2-4 times a year and pump out the Aqua-Swirl portion of each structure at least once a year.
2. Inspect and clean out the Aqua-Filter chambers; in addition, if possible replace the existing filter pillows with new ones (the filter pillows are designed to remove dissolved phosphorus from the stormwater).

Finally, while some reductions in TP and TSS concentrations have been made, there is still more pollutant loading that needs to be addressed in this part of the Lake Hopatcong watershed. Other sources of untreated stormwater and leachate from aged, near-shore septic systems are contributing to still elevated concentrations of TP in the River Styx / Crescent Cove part of the lake. Thus, additional restoration measures need to be implemented.

Figure 1
TP Concentrations in Crescent Cove (NPS-1) Over the Growing Season of Each Monitored Year from 2006 to 2014



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 µg/L. Based on the findings of the refined TMDL, the existing average seasonal chlorophyll *a* concentration under current conditions is 15 µg/L, while the maximum seasonal value is 26 µg/L. In contrast, the targeted average and maximum chlorophyll *a* concentrations, once Lake Hopatcong is in complete compliance with the TMDL, are predicted to be 8 and 14 µg/L, respectively.

Chlorophyll *a* concentrations during the May 2014 event ranged from 8.4 µg/L at Station #3 to 26.2 µg/L at Station #6 with a mean concentration of 15.5 µg/L. The mean value for May 2014 was almost twice as large as the targeted mean value and almost three times as large as the mean chlorophyll *a* concentration measured in May of 2013. In addition, seven of the nine measured May 2014 concentrations were above the TMDL targeted maximum concentration previously described.

Chlorophyll *a* concentrations increased at most of the sampling stations by the June 2014 event, with concentrations ranging from 7.0 µg/L at Station #11 to 34.0 µg/L at Station #1 with a mean concentration of 15.4 µg/L. It should be noted that Station #10 also had a high chlorophyll *a* concentration of 29.0 µg/L. Of the nine June 2014 concentrations, all except three (Stations #7 and #11) exceeded the targeted maximum concentration under the TMDL.

Chlorophyll *a* continued to increase by the late July event with concentrations ranging from 5.3 µg/L at Station #11 to 34.0 µg/L at Station #3 with a mean concentration of 17.8 µg/L. The mean July concentration exceeded the targeted mean of 8 µg/L, while the maximum threshold concentration was exceeded in seven of the nine sampling stations. The only concentrations below the threshold were in the Jefferson Canal sampling stations (Stations #7 and #11).

In late August chlorophyll *a* concentrations varied between 4.2 µg/L at Station #11 to 40.0 µg/L at Station #10 with a mean concentration of 24.4 µg/L. A same pattern observed in July was also observed in August. That is, all concentrations exceeded the maximum threshold except for Stations #7 and #11.

In mid-September 2014 chlorophyll *a* concentrations varied from 4.2 µg/L at Station #11 to 20.0 µg/L at Station #6 with a mean concentration of 10.8 µg/L. In September four of the nine sampling stations had concentrations that exceeded the maximum threshold concentration (Stations #1, #2, #3 and #10).

Chlorophyll *a* concentrations at the NPS-3 station were high May, moderate in June through August but still above the maximum threshold and low (below the maximum threshold) by September 2014. In contrast, chlorophyll *a* concentrations at NPS-4 and NPS-5 were below the maximum threshold in May, June and September. In July both were above the maximum threshold, while in August the concentration for NPS-4 was below the maximum threshold but for NPS-5 above the threshold.

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 produce nuisance conditions. The majority of nuisance algal blooms in freshwater ecosystems are 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 the generation of cyanotoxins.

Table 1 lists the dominant phytoplankton identified in Lake Hopatcong during each water quality monitoring event in 2014. Algal abundance was moderate during the 21 May 2014 event with the dominant algae being several genera of small, green coccoid algae. Several diatoms and the blue-green algal *Aphanizomenon* were relatively common as well.

Total algal abundance was high during 24 June 2014 sampling event with the dominant algae being two genera of blue-greens (*Aphanizomenon* and *Aphanothece*) and the diatom Fragilaria.

By the 17 July 2014 event algal abundance was high the dominant genera were exclusively blue-green algae (*Aphanizomenon* and *Anabaena*), although green algae, chrysophytes and diatoms were quite common.

By 15 August 2014 algal abundance was moderately high with the dominant group again being the blue-green algae, with three genera identified (*Lyngbya*, *Microcystis* and *Anabaena*). Four genera of diatoms were also identified with the most common being *Tabellaria*.

Algal abundance was moderate by the 1 October 2014 event. While the blue-green *Anabaena* was the dominant genera several green algae, chrysophytes and diatoms were also identified.

Finally, it should be noted that nuisance blooms of blue-green algae, primarily *Anabaena*, were identified within the River Styx / Crescent Cove section of the lake in early August 2014. This blooms resulted in NJDEP conducting some water quality and cyanotoxin sampling. While open water measurements of microcystin, one of the most common cyanotoxin, were low and not of concern, some of the near shore concentrations were high. Although no beaches were found along the section of shoreline that was sampled, this indicates that elevated cyanotoxins along beaches or bathing areas may be an issue of concern for the future.

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 identified during the 21 May 2014 sampling event showed co-dominance of the copepod *Cyclops* and the small-bodied cladoceran *Bosmina*. The herbivorous cladoceran *Daphnia* was also identified but in lower densities.

During the 24 June 2014 sampling event zooplankton abundance was moderate but diversity was low. The most abundant zooplankton were the copepod *Cyclops* and the herbivorous cladoceran *Daphnia*.

During the 17 July 2014 sampling event zooplankton abundance was high and included two rotifers (*Asplanchna* and *Conochilus*), two cladocerans (*Daphnia* and *Bosmina*) and the copepod *Cyclops*.

Moderate zooplankton densities were noted during the 15 August 2014 sampling event where co-dominance was shared among *Bosmina* and *Cyclops*. The herbivorous cladoceran *Daphnia* was again present.

Zooplankton densities remained moderate during the 1 October 2014 sampling event with the identified genera including *Daphnia*, *Bosmina*, *Diaptomus* and the rotifer *Asplanchna*. However, the most abundant zooplankter was the copepod *Cyclops*.

Similar to past monitoring years, herbivorous zooplankton were present in Lake Hopatcong but not in high densities and none attained large sizes (total length). Such conditions are indicative of a fishery community dominated by a large number of small, zooplankton-feeding fishes (e.g. golden shiners, alewife, young perch), where large-bodied zooplankton cannot exert a high degree of algal control through grazing.

Table 1
Phytoplankton in Lake Hopatcong during the 2014 Growing Season

Sampling Date	Phytoplankton
21 May 2014	Algal abundance was moderate. The dominant algae included a variety of small, coccoid green algae (*Chlamydomonas* among others). Other common algae included the diatoms, *Tabellaria, Fragilaria* and *Melosira* and the blue-green alga *Aphanizomenon*.
24 June 2014	Total algal abundance was high with co-dominance exerted between the blue-green algae *Aphanizomenon* and *Aphanothece* and the diatom *Fragilaria*. In addition, a variety of other diatoms, green algae and chrysophytes were present.
17 July 2014	Algal abundance was moderately high with dominance exerted by the blue-green algae *Aphanizomenon* and *Anabaena*. Several green algae, chrysophytes, diatoms and other blue-green algae were present in varying densities, including the dinoflagellate *Ceratium*.
15 August 2014	Algal abundance was moderately high with dominance exerted by the blue-green algae including *Lyngbya, Microcystis* and *Anabaena*. Four genera of diatoms were also identified with the most abundant being *Tabellaria*. The green alga *Pediastrum* was also present.
1 October 2014	Abundance was moderate with the dominant alga being the blue-green *Anabaena*. In addition, several genera of green algae, chrysophytes and diatoms were identified as well as the cryptomonad *Cryptomonas* and two more genera of blue-green algae.

Table 2
Zooplankton in Lake Hopatcong during the 2014 Growing Season

Sampling Date	Zooplankton
21 May 2013	Zooplankton numbers were moderate and co-dominance was exerted between the copepod *Cyclops* and the small-bodied cladoceran *Bosmina*. *Daphnia* was also present but was not as prolific as the other zooplankters.
24 June 2014	Zooplankton abundance was moderate with low diversity (5 genera were identified). The most abundant were the copepod *Cyclops* and the herbivorous cladoceran *Daphnia*.
17 July 2014	Zooplankton abundance was high and included two rotifers (*Asplanchna* and *Conochilus*), two cladocerans (*Daphnia* and *Bosmina*) and the copepod *Cyclops*.
15 August 2014	Moderate zooplankton abundance was noted during this event with co-dominance between the copepod *Cyclops* and the cladoceran *Bosmina.* Only one herbivorous zooplankter was identified, which was the cladoceran *Daphnia*. Two genera of rotifers were also identified.
1 October 2014	The zooplankton community exhibited moderate abundance with *Daphnia*, *Bosmina*, *Diaptomus* and the rotifer *Asplanchna* all listed as ‘common.” However, the most abundant zooplankter was the copepod *Cyclops*.

Recreational Fishery and Potential Brown Trout Habitat

Of the recreational gamefish 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 5 mg/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 2014 temperature and DO data for Lake Hopatcong were examined to identify the presence of optimal and acceptable brown trout habitat. As with previous monitoring reports, this analysis focused primarily 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.

Optimal brown trout habitat was present throughout the entire water column of Lake Hopatcong at Station #2 during the May 2014 sampling event. By June 2014 optimal brown trout habitat was present from the surface waters down to a depth of 5.0 meters (16.5 ft). By mid-July optimal brown trout habitat was limited to depths between 5.0 and 6.0 meters (16.5 to 19.8 ft) but carryover habitat was found between the surface and 5.0 meters (16.5 ft). By mid-August 2014 optimal habitat was re-established between depths of 0 to 6.0 meters (19.8ft). By early October 2014 this optimal brown trout habitat expanded from 0 to 9.0 meters (29.7 ft).

Similar to past monitoring years, the *in-situ* data revealed that varying levels of optimal and acceptable brown trout habitat persisted through the entire 2013 growing season in Lake Hopatcong. However, optimal brown trout habitat was found throughout the entire 2014 growing season, although it was limited in July to depths of 5 to 6 meters. The persistence of optimal brown trout habitat through the entire 2014 growing season was attributed to the relatively cool conditions of 2014.

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 aquatic herbicides, is that phosphorus is removed from the lake along with the weed biomass. In fact, based on a plant biomass study conducted at Lake Hopatcong in 2006 and the plant harvesting records from 2006 to 2008, approximately 6-8% of the total phosphorus load targeted for reduction under the established TMDL was removed through the mechanical weed harvesting program.

In sharp contrast to the 2006 – 2008 harvesting years, only 1.2% of the phosphorus load targeted for reduction under the TMDL was removed through mechanical weed harvesting during the 2009 growing season. This substantial reduction in the amount of plant biomass and phosphorus removed in 2009 was due to severe budgetary cuts that resulted in laying off the Commission’s full time Operation Staff and late start up date. In turn, this resulted in only 1.2% of the plant biomass harvested in 2009. However, the 2010 harvesting season resulted in the estimated removal of approximately 6% of the phosphorus load targeted for reduction under the TMDL, similar to the percentages removed in 2006 – 2008.

In contrast to the 2012 growing season, the mechanical weed harvesting program ran longer in both 2013 and 2014; this was primarily due to the fact that the program was initiated earlier in the years of 2013 and 2014 relative to 2012. NJDEP has directly overseen the operation of the weed harvesting program for the last three years and each year displays a higher rate of removal, which was attributed to becoming more familiar with the operations and lake-specific conditions. In addition, the operations staff has been excellent at maximizing high rates of efficiency during harvesting operations.

The mechanical weed harvesting program at Lake Hopatcong over the 2014 growing season resulted in the removal of approximately 2,644 cubic yards of wet plant biomass (slightly more than removed in 2013), which resulted in the removal of 56 lbs (25 kg) of phosphorus. In turn, this accounted for 0.8% of the TP load targeted for removal under the TMDL. During the 2011 and 2012 harvesting events these removal rates were 0.3% and 0.6%, respectively, of the TP load targeted for removal under the TMDL. The 56 lbs of TP removed through the 2014 weed harvesting program had the potential to generate up to 61,675 lbs of additional wet algal biomass.

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 2014. The annual mean values for Station #2 were graphed, along with the long-term, "running mean" for the lake.

The 2014 mean Secchi depth was 1.8 meters, which is the first time since 2009 that Secchi depth fell below 2.0 meters. Additionally, the last time mean Secchi depth was 1.8 meters was 2005 (Figure 2 in Appendix A).

In contrast to Secchi depth, chlorophyll *a* concentrations exhibited a wide range of variability at Lake Hopatcong (Figure 3 in Appendix A). Of particular note and concern was that the mean 2014 chlorophyll a concentration was the highest measured out of the entire 1991 – 2014 dataset. Several factors may have contributed to this. First, while 2014 was a relatively cool year, it was a dry year, particularly from July through September. Such dry conditions favor the growth of nuisance blue-green algae such *Anabaena*, which was responsible for the early August bloom in River Styx / Crescent Cove. Second, some filamentous, benthic blue-green algae, such as *Lyngbya*, were identified in the open waters of Lake Hopatcong (Station #2) during the mid-August 2014 sampling event, and it was quite common. Thus, the presence of benthic dwelling algae in the open waters of the lake resulted in contributing higher amounts of chlorophyll *a* in the measured concentrations. Finally, it should be noted that the 2014 mean chlorophyll *a* concentration exceeded the targeted mean under the TMDL.

The 2014 mean TP concentration (0.017 mg/L) was higher than those mean values of 2010, 2011 and 2013 but lower than the value for 2012 (Figure 4 in Appendix A). The unusual discrepancy between the high chlorophyll a concentrations and low TP concentrations at Station #2 is largely attributed to the presence of benthic blue-green algae in the open waters of the lake. The benthic algae obtain most of this phosphorus from the sediments instead of the open waters.

Water Quality Impairments and Established TMDL Criteria

As identified in N.J.A.C. 7:9B-1.5(g)2 "Except as due to natural condition, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation or otherwise render the waters unsuitable for the designated uses." For Lake Hopatcong, these objectionable conditions specifically include both algal blooms and nuisance densities of aquatic vegetation.

As described in detail in the Lake Hopatcong TMDL Restoration Plan, a targeted mean TP concentration, as well as mean and maximum chlorophyll *a* ecological endpoints, was established to identify compliance with the TMDL. For the sake of this 2014 analysis, the mid-lake (Station #2), Crescent Cover / River Styx (Station #3) and Northern Woodport Bay (Station #10) monitoring stations were reviewed. To provide guidance for this review, the criteria developed under Lake Hopatcong's TMDL are provided below:

TMDL Criteria for Lake Hopatcong

Targeted mean TP concentration	0.03 mg/L
Targeted mean chlorophyll *a* concentration endpoint	8 mg/m^3
Targeted maximum chlorophyll *a* concentration endpoint	14 mg/m^3

The seasonal mean and single TP concentrations at Station #2 were all consistently below or equal to the targeted mean TP concentration, recognized under the TMDL (0.03 mg/L). However, both the mean and maximum chlorophyll *a* concentrations for Station #2 were greater than the targeted endpoints listed above.

For Station #3, the mean TP concentration in 2014 (0.04 mg/L) was greater than the targeted mean of 0.03 mg/L. In addition the mean chlorophyll *a* concentration was more than twice as large as the targeted mean value; however, the maximum chlorophyll *a* concentration threshold was exceed during three of the five monitoring events (July – early October).

Similar to Station #3, the mean TP concentration in 2014 (0.04 mg/L) for Station #10 was greater than the targeted mean of 0.03 mg/L. In addition, all measured chlorophyll *a* concentrations for Station #10 were greater than the targeted maximum endpoint, while the mean concentration was more than twice as high as the mean chlorophyll *a* targeted endpoint.

4.0 SUMMARY

This section provides a summary of the 2014 water quality conditions, as well as recommendations on how to preserve the highly valued aquatic resources of Lake Hopatcong.

1. By late May 2014 the lake was already thermally stratified but the lake was well oxygenated from surface to bottom with DO concentrations greater than 5.0 mg/L. From late June through early October 2014 the lake remained thermally stratified to varying degrees with an anoxic zone varying between 8 and 11 meters.

2. 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 0.02 mg/L and 0.04 mg/L, with a few instances of TP concentrations reaching 0.06 mg/L at Station #3 (River Styx/Crescent Cove).

3. Two of the nine sampling stations had a mean TP concentration greater than the targeted mean concentration of 0.03 mg/L as recognized under the TMDL. These two stations were Station #3 (River Styx/Crescent Cove) and Station #10 (northern Woodport).

4. Based on the *in-situ* conditions, carry-over brown trout habitat was available throughout the entire 2014 growing season. Optimal brown trout habitat was also present throughout a substantial portion of the water column over the entire growing season, except for July when it was limited to depths of 5 to 6 meters. The presence of optimal brown trout habitat over the entire 2014 growing season was attributed to the slightly cooler water temperatures.

5. NJDEP continued to increase its efficiency in mechanical weed harvesting at Lake Hopatcong. During the 2014 harvesting program approximately 2,644 cubic yards of wet plant biomass was removed. This resulted in removing 56 lbs of TP, accounting for 0.8% of the TP targeted for removal under the TMDL. This was a slight increase in the amount of weeds harvested in 2014 relative to 2013 (approximately 628 more cubic yards).

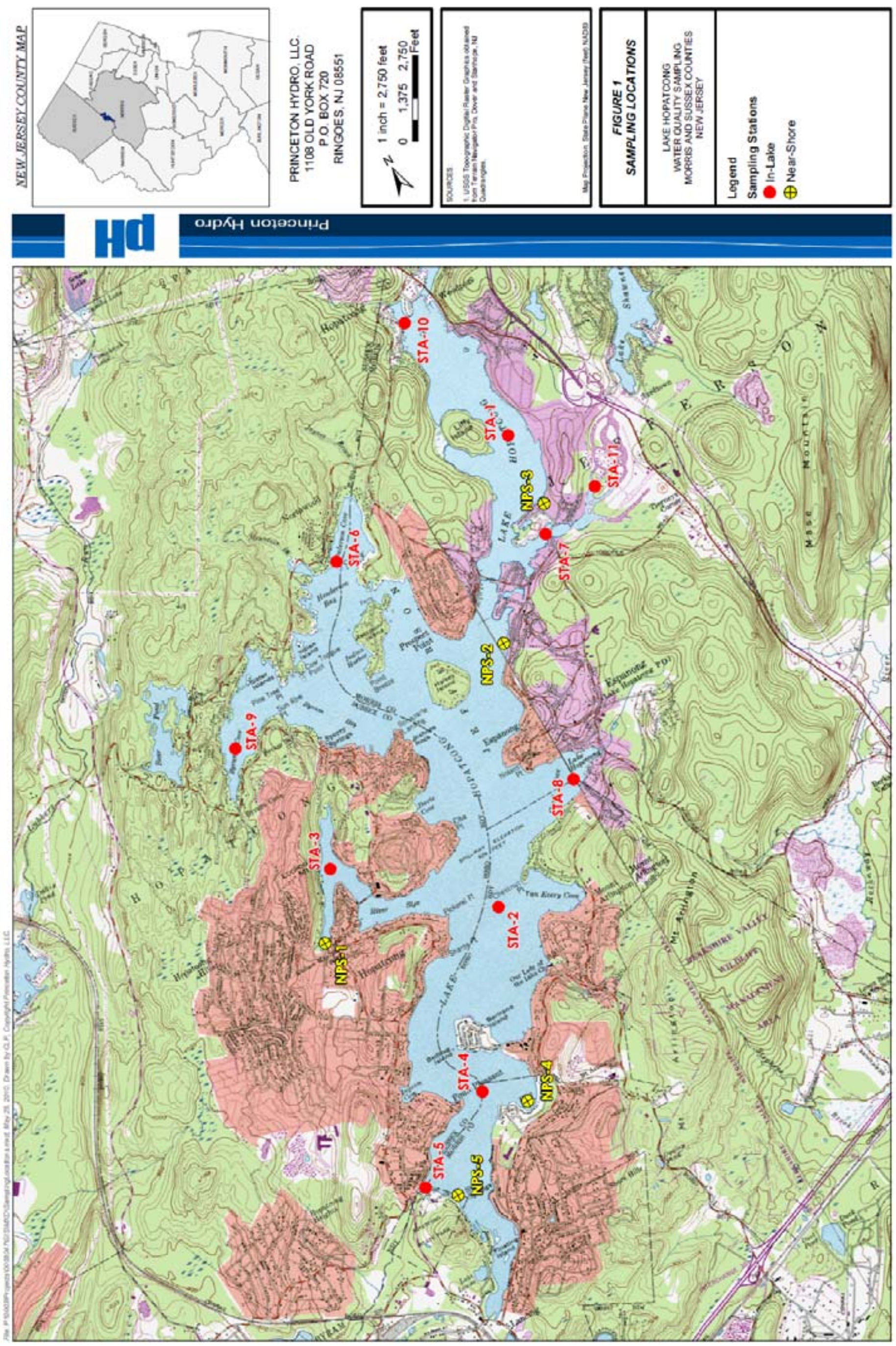
6. While the 2014 mean TP concentration at Station #2 was slightly higher relative to previous years, there was a substantial increase in the amount of chlorophyll *a* (algal biomass) in 2014. This was attributed to the presence of benthic dwelling algae (particularly the blue-green alga *Lyngbya*) in the open waters of the lake over the summer season.

7. Seven of the nine long-term, water quality monitoring stations were in compliance with the TMDL; that is, the mean TP concentration was at or less than 0.03 mg/L. In contrast, two stations were out of compliance and included Station #3 (River Styx / Crescent Cove) and Station #10 (northern Woodport Bay). Both of these stations had a mean TP concentration of 0.04 mg/L, with single measurements at high as 0.06 mg/L. Thus, restoration measures need to prioritize these sections of the watershed to get these sections of the lake in compliance with the TMDL.

8. Finally, it should be noted that a nuisance algal bloom of the blue-green alga *Anabaena* occurred in early August in the River Styx / Crescent Cove section of the lake and was sampled by NJDEP. This monitoring included an analysis for microcystin, which is a cyanotoxin that has recently been recognized as a pollutant of concern by US EPA. Specifically, Health Advisories can be issued on this pollutant for drinking water supplies; similar Health Advisories are supposed to be announced for recreational waterbodies by the end of this year. Open water concentrations of microcystin were low but wind-blow, near shore areas had concentrations that exceeded the tentative / proposed threshold for recreational waterbodies. While the presence of cyanotoxins in open waters used for recreational is not a major concern, near shore beach and bathing areas can be potential sites where cyanotoxins can be of concern. This is an issue that will need to be addressed at Lake Hopatcong in the near future.

APPENDIX A

FIGURES


NEW JERSEY COUNTY MAP
PRINCETON HYDRO, LLC
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551
1 inch = 2,750 feet
0 1,375 2,750 Feet
FIGURE 1
SAMPLING LOCATIONS
LAKE HOPATCONG
WATER QUALITY SAMPLING
MORRIS AND SUSSEX COUNTIES
NEW JERSEY
Legend
Sampling Stations
In-Lake
Near-Shore
Princeton Hydro
STA-1
STA-2
STA-3
STA-4
STA-5
STA-6
STA-7
STA-8
STA-9
STA-10
STA-11
NPS-1
NPS-2
NPS-3
NPS-4
NPS-5

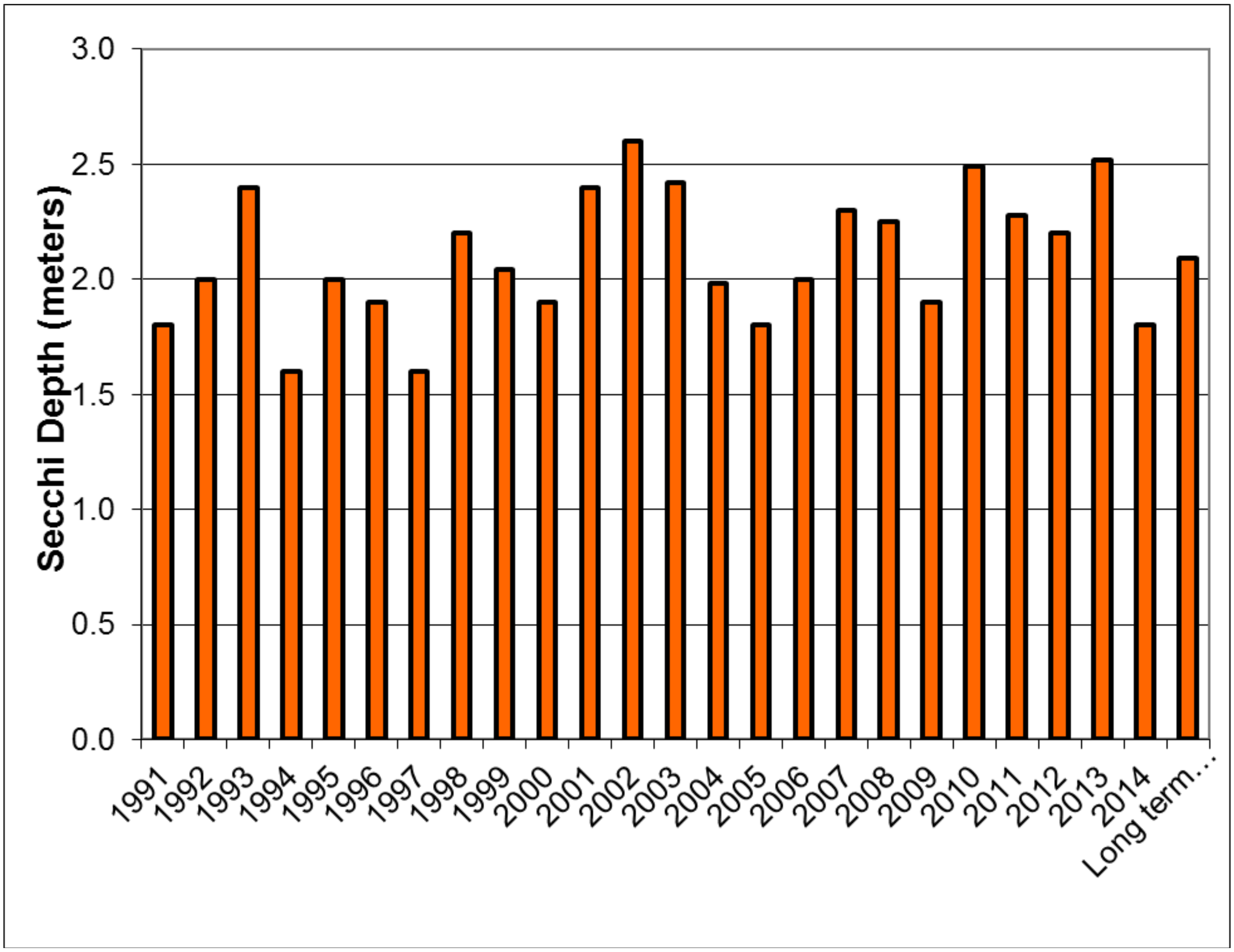


Figure 2 - Lake Hopatcong Long-Term Secchi Depth (meters)

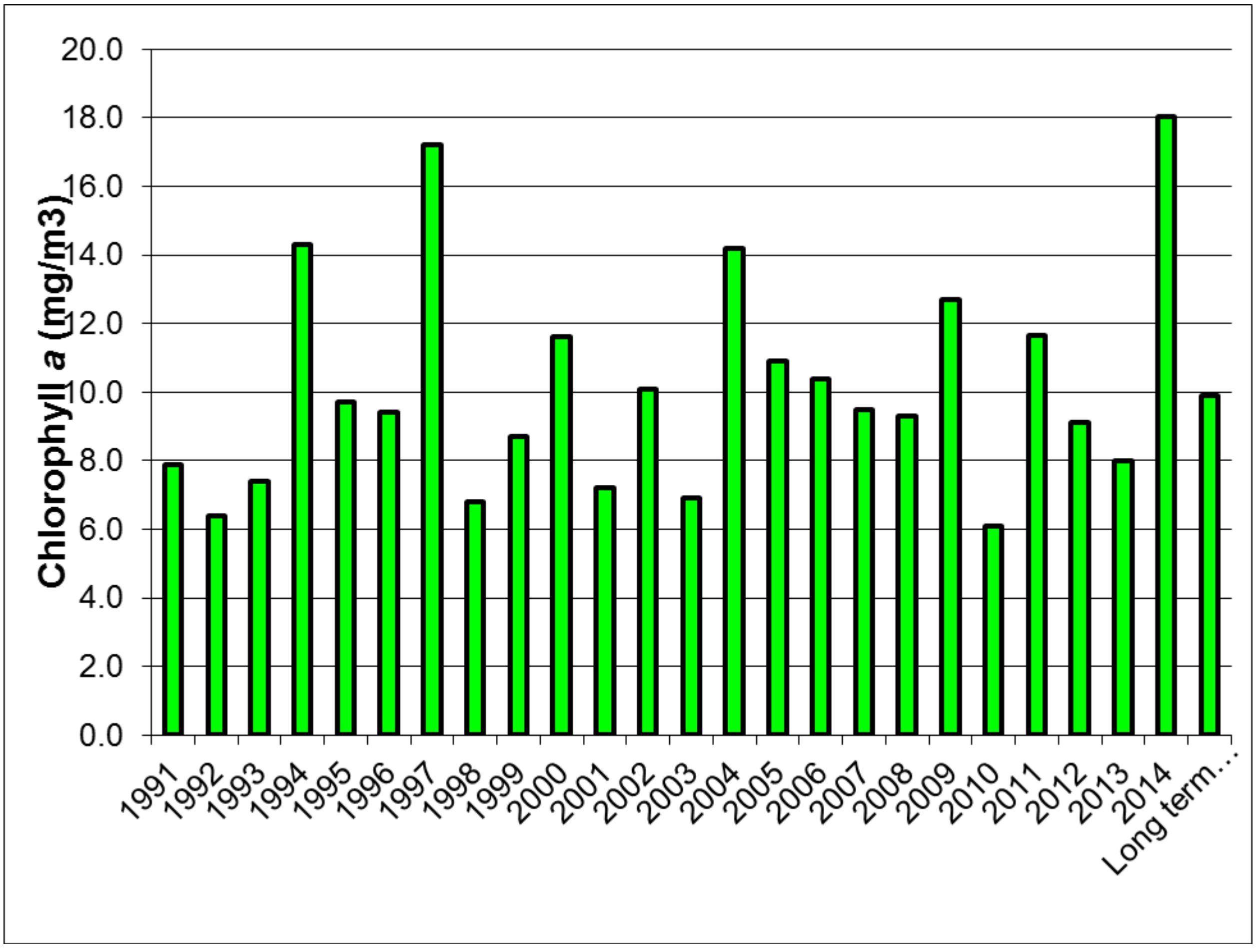


Figure 3 - Lake Hopatcong Long-Term Chlorophyll a Concentrations (mg/m^3)

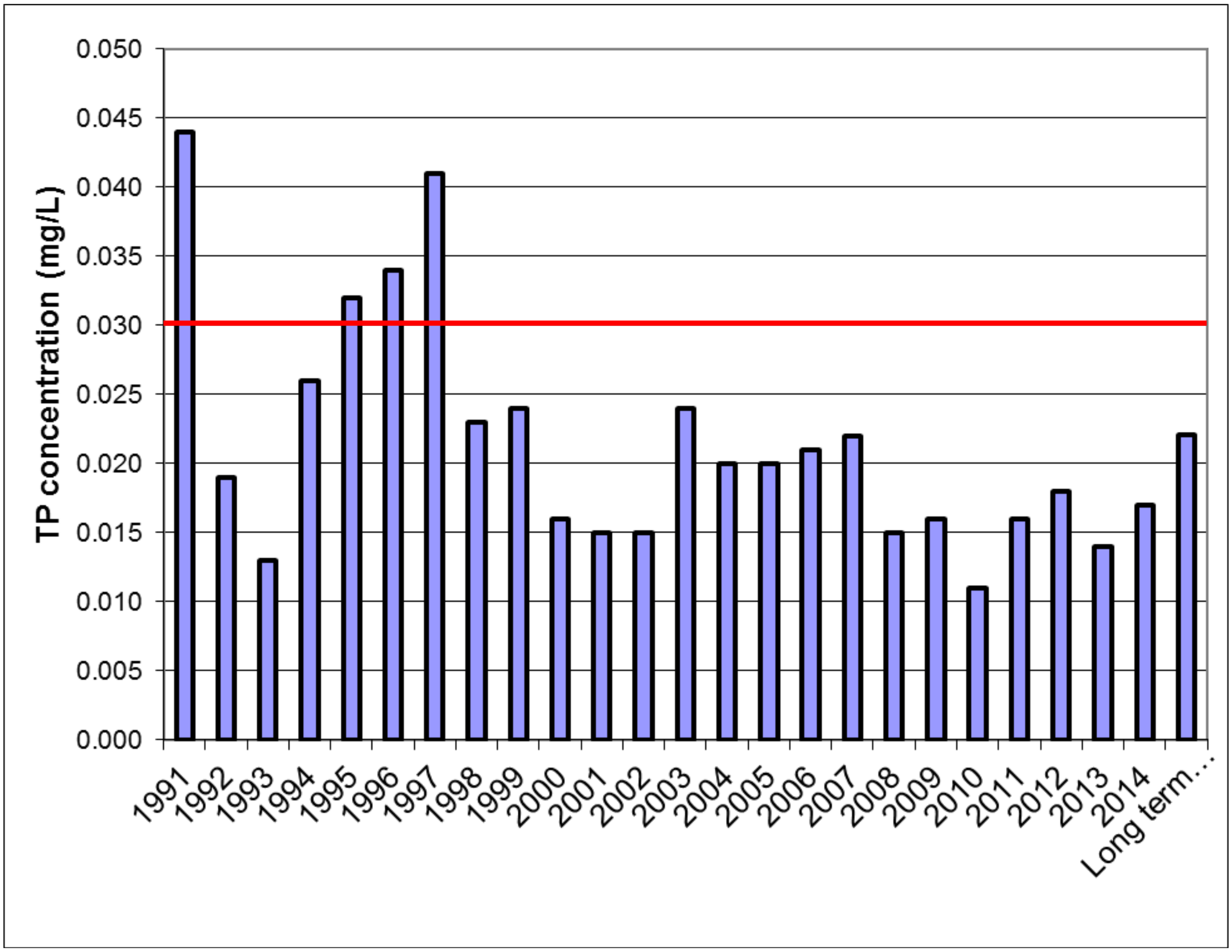


Figure 4 - Lake Hopatcong Long-Term Total Phosphorus Concentrations (mg/L)

APPENDIX B

IN-SITU DATA

***In-Situ* Monitoring for Lake Hopatcong 5/21/14**								
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**pH**	**Dissolved Oxygen**	**Dissolved Oxygen**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(µmhos/cm)**	**(units)**	**(mg/L)**	**(%)**
ST-1	**2.1**	**1**	**Surface**	18.73	373.4	7.41	9.47	101.6
			1.0	18.63	373.9	7.47	9.56	102.4
			2.0	18.44	372.5	7.46	9.6	102.4
ST-2	**13.8**	**1.9**	**Surface**	17.54	380.4	7.5	10.26	107.4
			1.0	17.51	380.4	7.66	10.34	108.3
			2.0	17.44	380.5	7.71	10.4	108.7
			3.0	17.3	380.7	7.76	10.5	109.4
			4.0	16.74	379.2	7.79	10.56	108.8
			5.0	16.42	380.8	7.79	10.51	107.6
			6.0	14.04	379.8	7.74	9.98	97
			7.0	12.35	380.2	7.62	8.59	80.4
			8.0	11.95	380.1	7.55	7.99	74.1
			9.0	11.66	380.5	7.5	7.65	70.5
			10.0	11.52	380.6	7.46	7.2	66.2
			11.0	11.35	381.2	7.42	7	64.1
			12.0	11.1	382	7.36	6.42	58.4
			13.0	10.95	383.8	7.31	5.99	54.3
			13.5	10.89	385.5	7.22	5.06	45.8
ST-3	**2**	**2**	**Surface**	18.57	555.1	9.48	11.98	128.3
			1.0	17.77	493.2	9.47	13.04	137.3
			2.0	15.09	731.4	7.82	2.61	26
ST-4	**3.2**	**1.8**	**Surface**	17.78	390.1	7.06	9.77	102.8
			1.0	17.75	389.8	7.11	9.78	102.9
			2.0	17.43	388.2	7.19	9.46	98.9
			3.0	16.25	389.4	7.17	8.69	88.6
ST-5	**2.8**	**1.5**	**Surface**	17.43	390.5	6.96	9.85	102.9
			1.0	17.3	390.3	7.02	9.94	103.6
			2.0	16.35	389.5	7.12	10.15	103.7
			2.5	15.71	392.9	7.11	8.8	88.7
ST-6	**2.5**	**1.5**	**Surface**	18.03	369.8	7.77	10.49	111
			1.0	17.83	370.7	8.01	10.84	114.2
			2.0	16.22	379.1	7.97	11.13	113.4
			2.5	16.09	381.7	7.74	8.53	86.7
ST-7	**2**	**1.3**	**Surface**	18.88	213.5	7.35	9.27	99.8
			1.0	18.7	216.1	7.32	9.09	97.5
			2.0	18.53	228.5	7.28	8.88	94.9
ST-8	**7.5**	**1.9**	**Surface**	17.5	379.6	7.6	10.32	108
			1.0	17.43	379.4	7.68	10.36	108.2
			2.0	17.22	378.5	7.71	10.4	108.2
			3.0	17.17	378.8	7.73	10.4	108.1
			4.0	17.14	379	7.75	10.4	108.1
			5.0	17.07	379	7.76	10.41	108
			6.0	13.68	380	7.73	9.8	94.6
			7.0	12	380.3	7.57	7.93	73.7
			7.5	11.78	380.6	7.48	7.25	67
ST-9	**8**	**1.7**	**Surface**	16.74	380.1	7.67	9.91	102.1
			1.0	16.71	380.1	7.82	10.28	105.8
			2.0	16.4	380.4	7.89	10.47	107.1
			3.0	16.32	380.3	7.93	10.58	108.1
			4.0	16.09	382.2	7.96	10.69	108.6
			5.0	15.9	382.3	7.94	10.73	108.6
			6.0	15.76	385.9	7.91	10.69	107.8
			7.0	15.6	381.5	7.87	10.41	104.7
			8.0	13.21	383.6	7.41	5.35	51.1
ST-10	**1.6**	**1**	**Surface**	18.35	386.8	7.39	9.13	97.3
			1.0	17.96	388.2	7.38	9.03	95.4
			1.5	17.41	414.5	7.32	8.49	88.7
ST-11	**1.3**	**1.3+**	**Surface**	18.75	165.2	7.46	9.65	103.6
			1.0	18.36	170.8	7.42	9.67	103

***In-Situ* Monitoring for Lake Hopatcong 6/24/14**

Station	DEPTH (meters)			Temperature	Conductivity	pH	Dissolved Oxygen	Dissolved Oxygen
	Total	Secchi	Sample	(^{0}C)	(µmhos/cm)	(units)	(mg/L)	(%)
ST-1	2	0.9	Surface	24.19	379.1	7.75	8.36	99.8
			1.0	24.17	378.6	7.65	8.33	99.4
			2.0	23.84	383.4	7.55	6.92	82.1
ST-2	14.5	1.8	Surface	23.02	388	8	9.34	109.1
			1.0	23.03	388	8.05	9.42	109.9
			2.0	23	388.1	8.09	9.52	111.1
			3.0	22.99	387.8	8.1	9.56	111.5
			4.0	22.89	387.7	8.09	9.57	111.4
			5.0	19.62	382.3	7.82	6.83	74.6
			6.0	18.41	382.2	7.56	4.08	43.5
			7.0	15.58	382.3	7.44	2.57	25.8
			8.0	12.93	381.6	7.38	1.58	15
			9.0	12.16	381.4	7.32	1.06	9.8
			10.0	11.66	381.7	7.29	<1	8.2
			11.0	11.45	383.9	7.24	<1	5.6
			12.0	11.25	385.2	7.21	<1	3.5
			13.0	11.01	389.5	7.17	<1	2.3
			14.0	10.83	425.3	7.04	<1	1.7
ST-3	2.1	2.1+	Surface	24.63	701.8	7.73	8.12	97.8
			1.0	24.48	689.1	7.71	8.03	96.4
			2.0	23.62	690.5	7.51	6.23	73.6
ST-4	3	1.8	Surface	23.54	393.4	7.41	8.9	104.9
			1.0	23.53	393.3	7.49	8.93	105.2
			2.0	23.35	393	7.52	8.97	105.3
			3.0	21.97	385.5	7.47	7.97	91.2
ST-5	3.3	1.7	Surface	24.05	395.1	7.57	8.32	99.1
			1.0	23.9	394.8	7.54	8.41	99.8
			2.0	23.69	394.6	7.52	8.47	100.2
			3.0	21.65	421.1	7.06	4.57	52
ST-6	2.5	1.8	Surface	24.51	384.3	8.28	9.59	115.2
			1.0	24.24	385.2	8.34	9.9	118.3
			2.0	23.91	384.2	8.2	9.9	117.5
			2.5	23.88	384.3	8.09	9.26	109.9
ST-7	1.8	1.6	Surface	24.84	240.6	7.82	8.52	102.9
			1.0	24.84	240.6	7.71	8.5	102.7
			1.5	24	238.5	7.68	8.59	102.1
ST-8	7	1.8	Surface	23.95	389.5	8.31	9.9	117.6
			1.0	23.96	389.5	8.45	10.16	120.7
			2.0	23.93	389.4	8.5	10.24	121.6
			3.0	23.59	388.3	8.49	10.35	122.2
			4.0	23.42	387.7	8.45	10.36	121.9
			5.0	22.37	387.9	8.1	8.89	102.5
			6.0	18.65	382.2	7.77	5.08	54.4
			7.0	16.4	386	7.6	3.53	36.1
ST-9	8	1.5	Surface	24.06	391.2	8.71	10.59	126
			1.0	24.04	391.5	8.72	10.77	128.2
			2.0	23.92	390.5	8.73	10.9	129.4
			3.0	23.82	389.8	8.7	10.98	130.2
			4.0	23.68	389.8	8.6	10.94	129.4
			5.0	23.14	390	8.32	9.98	116.7
			6.0	21.67	387.6	8.03	8.47	96.4
			7.0	17.47	385.3	7.61	3.04	31.8
			8.0	13.16	400.3	7.49	2.38	22.7
ST-10	1.7	0.8	Surface	24.71	384.2	7.94	9.4	113.3
			1.0	24.71	384.1	7.91	9.51	114.6
			1.5	24.63	385.4	7.87	9.52	114.5
ST-11	1.2	1.2+	Surface	23.66	212.2	8.17	8.49	100.2
			1.0	23	210.8	7.98	8.64	100.8

***In-Situ* Monitoring for Lake Hopatcong 7/17/14**

Station	DEPTH (meters)			Temperature	Conductivity	pH	Dissolved Oxygen	Dissolved Oxygen
	Total	Secchi	Sample	(^{0}C)	(µmhos/cm)	(units)	(mg/L)	(%)
ST-1	2	1.2	Surface	26.57	376.7	7.61	8.3	103.4
			1.0	26.32	375.8	7.53	8.18	101.5
			2.0	26.03	374.8	7.51	8.1	100
ST-2	14	1.8	Surface	25.65	391	7.55	8.63	105.8
			1.0	25.48	390.6	7.65	8.77	107.1
			2.0	25.29	390.4	7.71	8.83	107.5
			3.0	25.21	390.1	7.76	8.87	107.9
			4.0	25.17	389.7	7.79	8.81	107
			5.0	25.12	389.7	7.82	8.79	106.7
			6.0	23.5	390.2	7.64	5.4	63.7
			7.0	19.02	386.4	7.43	1.43	15.4
			8.0	14.94	386.7	7.42	<1	9.2
			9.0	13.39	385.8	7.41	<1	5.8
			10.0	12.59	385.5	7.37	<1	3.5
			11.0	11.98	386.7	7.35	<1	2.4
			12.0	11.5	389	7.32	<1	1.5
			13.0	11.08	399.9	7.21	<1	1
			14.0	10.79	411.9	7.12	<1	0.8
ST-3	2	0.9	Surface	26.88	618.7	8.08	7.28	91.3
			1.0	26.01	615.6	8.06	8.4	103.7
			2.0	25.35	619.4	7.89	8.27	101
ST-4	3	1.2	Surface	25.4	392.6	7.2	8.33	101.7
			1.0	25.23	392.5	7.22	8.34	101.4
			2.0	25.15	392.4	7.27	8.29	100.7
			3.0	25.12	392.4	7.28	8.21	99.7
ST-5	3.5	1.2	Surface	24.99	392.2	7.02	8.03	97.2
			1.0	24.82	392.6	7.04	7.84	94.7
			2.0	24.82	392	7.15	7.64	92.3
			3.0	24.42	395.2	7.12	6.56	78.6
			3.5	22.86	442.9	6.76	5.02	58.4
ST-6	2.5	1.6	Surface	26.73	381.5	7.54	8.01	100.2
			1.0	26.13	380.3	7.58	8.54	105.6
			2.0	25.68	379.4	7.59	8.62	105.8
			2.5	25.66	383.5	7.47	7.77	95.3
ST-7	1.5	1.5+	Surface	25.84	303.1	7.33	8.16	100.4
			1.0	24.92	311	7.28	8.36	101.2
			1.5	24.78	313.7	7.23	8.41	101.4
ST-8	8	1.9	Surface	25.94	390.1	7.38	8.86	109.2
			1.0	25.79	390.2	7.48	8.79	108
			2.0	25.42	389.9	7.54	8.76	107
			3.0	25.36	389.8	7.58	8.65	105.5
			4.0	25.32	390.1	7.58	8.56	104.3
			5.0	25.04	391.5	7.56	8.41	102
			6.0	22.69	389.7	7.52	6.75	78.3
			7.0	19.74	387	7.44	5.55	60.8
			8.0	17.87	407.3	7.19	3.61	38
ST-9	8	1.9	Surface	26.29	389.9	7.86	8.87	110
			1.0	26	389.9	7.91	8.99	110.9
			2.0	25.32	390.5	7.96	9.09	110.8
			3.0	25.17	390.4	7.93	8.95	108.8
			4.0	25.08	390.2	7.87	8.79	106.7
			5.0	24.8	390.8	7.76	8.32	100.5
			6.0	22.1	388	7.69	7.63	87.6
			7.0	19.76	388.4	7.6	5.45	59.8
			8.0	16.23	402.4	7.26	3.34	34
ST-10	1.8	1	Surface	26.55	381.2	7.63	7.24	90.3
			1.0	25.96	380.3	7.59	7.96	98.2
			1.5	25.4	382	7.57	8.13	99.2
ST-11	1.3	1.3+	Surface	24.6	226.5	7.36	8.06	96.9
			1.0	24.26	226.9	7.21	7.8	93.2

In-Situ **Monitoring for Lake Hopatcong 8/15/14**

Station	DEPTH (meters)			Temperature	Conductivity	pH	Dissolved Oxygen	Dissolved Oxygen
	Total	Secchi	Sample	(^{0}C)	(µmhos/cm)	(units)	(mg/L)	(%)
ST-1	2	0.8	Surface	23.17	391.2	7.89	8.96	104.9
			1.0	23.15	391.2	7.85	8.95	104.7
			2.0	22.92	389	7.83	8.84	103
ST-2	14.5	1.2	Surface	23.27	397.1	7.79	8.75	102.6
			1.0	23.29	397.1	7.73	8.1	95
			2.0	23.3	397.1	7.69	8.04	94.3
			3.0	23.31	396.9	7.67	7.98	93.7
			4.0	23.31	397	7.64	7.94	93.2
			5.0	23.3	396.8	7.62	7.9	92.8
			6.0	23.27	396.8	7.6	7.87	92.3
			7.0	20.12	396.5	7.34	2.91	32.2
			8.0	15.93	393.7	7.19	0.93	9.4
			9.0	13.25	392.3	7.13	0.47	4.5
			10.0	12.45	394.3	7.1	0.19	1.8
			11.0	11.8	396.6	7.14	0.07	0.7
			12.0	11.21	405	7.12	0.06	0.5
			13.0	10.97	413.3	7.1	0.05	0.5
			14.0	10.9	415.5	7.11	0.05	0.4
			14.5	10.83	577.1	7.09	0.05	0.4
ST-3	2	0.6	Surface	23.73	560.3	8.24	9.51	112.6
			1.0	23.09	525.2	8.2	9.53	111.4
			2.0	22.79	532	7.6	5.42	63
ST-4	3	1.1	Surface	23.09	404.9	7.39	8.41	98.3
			1.0	23.09	405.1	7.49	8.44	98.6
			2.0	23.07	405.3	7.52	8.46	98.9
			3.0	23.08	404.9	7.42	8.07	94.3
ST-5	3	1	Surface	23.11	406.3	7.21	8.4	98.2
			1.0	22.88	406.3	7.18	7.9	92
			2.0	22.72	406.3	7.2	7.53	87.4
			3.0	22.7	406.2	7.21	7	81.3
ST-6	2	1	Surface	23.72	400	7.9	8.97	106.2
			1.0	23.49	399.8	7.87	8.97	105.6
			2.0	23.23	399.5	7.81	8.76	102.7
ST-7	1.4	1.4+	Surface	22.55	408.2	7.82	8.84	102.2
			1.0	22.41	410.2	7.79	8.82	101.8
			1.4	22.42	413.8	7.91	9.18	106
ST-8	7	1.2	Surface	23.34	397.2	7.54	8.25	96.9
			1.0	23.35	397.2	7.54	8.18	96.2
			2.0	23.34	397.1	7.55	8.16	95.8
			3.0	23.34	397.1	7.55	8.14	95.6
			4.0	23.33	397.1	7.55	8.13	95.4
			5.0	23.33	397	7.57	8.11	95.2
			6.0	23.27	397	7.56	8.11	95.1
			7.0	22.99	411.1	7.35	7.71	89.9
ST-9	8	1.3	Surface	23.63	396.4	7.83	8.71	102.9
			1.0	23.61	396.4	7.78	8.29	97.9
			2.0	23.48	396.2	7.74	8.19	96.5
			3.0	23.25	396	7.7	8.08	94.8
			4.0	23.2	396	7.66	7.93	92.9
			5.0	23.06	395.7	7.63	7.78	90.9
			6.0	22.68	394.9	7.58	7.53	87.3
			7.0	21.08	388.7	7.41	4.21	47.4
			8.0	17.94	469.5	7.09	1.86	19.6
ST-10	1.4	0.8	Surface	23.35	393.9	8.05	8.76	102.9
			1.0	22.94	393.5	7.93	8.51	99.2
			1.4	23.06	393.2	7.85	8.1	94.6
ST-11	1.1	1.1+	Surface	21.7	443.6	7.69	7.44	84.7
			1.0	21.26	439.3	7.58	7.26	82

***In-Situ* Monitoring for Lake Hopatcong 10/1/14**

Station	DEPTH (meters)			Temperature	Conductivity	pH	Dissolved Oxygen	Dissolved Oxygen
	Total	Secchi	Sample	(°C)	(µmhos/cm)	(units)	(mg/L)	(%)
ST-1	1.5	1	Surface	19.66	412	7.67	9.28	101.5
			1.0	19.67	412.1	7.62	9.08	99.4
			1.5	19.66	412.1	7.6	9.08	99.3
ST-2	13.5	2.3	Surface	19.47	400.2	7.69	9.17	99.9
			1.0	19.48	400.1	7.68	9.11	99.3
			2.0	19.49	400.1	7.65	9.1	99.1
			3.0	19.49	400.1	7.64	9.06	98.8
			4.0	19.48	400.1	7.61	9.05	98.6
			5.0	19.48	399.9	7.59	9.06	98.7
			6.0	19.47	400	7.57	8.99	98
			7.0	18.88	399.1	7.49	8.26	88.9
			8.0	18.66	399.1	7.43	7.6	81.4
			9.0	18.16	398.6	7.31	5.8	61.6
			10.0	15.75	418.8	7.02	2.8	28.2
			11.0	12.08	410.4	6.83	<1	8
			12.0	11.4	419.9	6.92	<1	3.7
			13.0	11.17	430.7	6.96	<1	2.8
			13.5	11.13	448.9	6.98	<1	2.1
ST-3	1.7	1	Surface	19.9	501.4	7.76	9.74	107.1
			1.0	19.9	500.5	7.84	9.55	105
			1.5	19.85	513.2	7.79	9.02	99.1
ST-4	2.8	2.1	Surface	19.92	403.4	7.73	9.18	100.9
			1.0	19.94	403.5	7.72	9.02	99.2
			2.0	19.93	403.4	7.71	8.99	98.8
			2.5	19.87	403.2	7.66	8.89	97.6
ST-5	2.5	2.1	Surface	20.18	410.2	7.19	9.36	103.4
			1.0	20.19	410.5	7.39	9.26	102.4
			2.0	20.17	410.3	7.39	9.11	100.6
ST-6	2	1.8	Surface	19.87	402.9	8.46	10.27	112.8
			1.0	19.9	402.6	8.78	10.65	117
			2.0	19.91	402.7	8.76	10.7	117.6
ST-7	1.2	1.2+	Surface	20	568.8	7.56	7.95	87.6
			1.0	20.04	573.6	7.54	7.72	85.1
ST-8	7	2	Surface	19.44	400.4	7.44	9.24	100.6
			1.0	19.46	400.3	7.5	9.14	99.5
			2.0	19.36	399.9	7.49	8.82	95.9
			3.0	19.22	399.7	7.48	8.7	94.3
			4.0	19.09	399.4	7.43	8.38	90.6
			5.0	19.04	399.3	7.39	8.05	86.9
			6.0	18.99	399.2	7.36	7.78	84
			7.0	18.76	414	7.07	5.79	62.2
ST-9	7.8	1.5	Surface	20.14	400.4	8.38	9.92	109.5
			1.0	20.14	400.3	8.34	9.92	109.6
			2.0	20.14	400.2	8.28	9.92	109.6
			3.0	20.12	400.2	8.22	9.92	109.5
			4.0	20.08	400.2	8.17	9.83	108.4
			5.0	18.92	399.5	8.03	8.26	89
			6.0	18.53	399.9	7.9	7.61	81.4
			7.0	18.32	402.4	7.68	5.17	55
			7.5	18.34	420.7	7.41	3.53	37.6
ST-10	1.2	0.8	Surface	19.86	418.7	7.75	9.1	99.9
			1.0	19.87	418	7.77	8.89	97.7
ST-11	0.8	0.8+	Surface	18.78	622.5	7.62	8.35	89.7
			0.5	18.76	622.6	7.52	7.85	84.4

***In-Situ* Monitoring for Hopatcong 319 Stations 5/21/14**								
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**pH**	**Dissolved Oxygen**	**Dissolved Oxygen**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(μmhos/cm)**	**(units)**	**(mg/L)**	**(%)**
NPS 1	**1.7**	**1.5**	**Surface**	18.42	1045	9	12.66	135.2
			1.00	17.25	1106	8.86	13.22	137.9
			1.50	15.53	1304	8.54	14.05	141.5
NPS 2	**1.1**	**1.1**	**Surface**	18.3	363.8	7.39	9.75	103.7
			1.00	18.21	363.3	7.42	9.66	102.6
NPS 3	**0.8**	**0.8+**	**Surface**	19.03	388.9	7.45	10.01	108.1
			0.50	18.83	389.1	7.47	9.98	107.4
NPS 4	**1.9**	**1.6**	**Surface**	17.72	390.5	7.34	9.79	102.9
			1.00	17.65	398.3	7.38	9.82	103.1
			1.50	17.21	525.2	7.35	9.88	102.8
NPS 5	**1.8**	**1.6**	**Surface**	17.81	399.8	7.19	9.72	102.4
			1.00	17.38	393.1	7.26	9.81	102.5
			1.50	16.49	397.9	7.21	8.57	87.8

In-Situ Monitoring for Hopatcong 319 Stations 6/24/14									
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**pH**	**Dissolved Oxygen**	**Dissolved Oxygen**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(µmhos/cm)**	**(units)**	**(mg/L)**	**(%)**
NPS 1	**1.5**	**1.5+**	**Surface**	23.8	897.5	8.07	9.82	116.5
			1.00	23.71	900.2	8.12	10.05	119.1
			1.50	23.12	944	8.45	10.43	122.2
NPS 2	**1.1**	**1.1+**	**Surface**	24.34	348.7	8.73	10.05	120.3
			1.00	24.34	354.5	8.85	10.26	122.8
NPS 3	**1**	**1.0+**	**Surface**	25.05	381	7.81	8.9	108
			1.00	24.34	375.9	7.76	9.05	108.3
NPS 4	**1.8**	**1.8**	**Surface**	24.16	418.7	7.54	8.83	105.4
			1.00	23.82	407	7.55	8.7	103.2
			1.50	23.78	429.1	7.51	8.71	103.1
NPS 5	**2.6**	**1.7**	**Surface**	24.12	85.1	7.34	8.52	101.4
			1.00	24.01	394.3	7.36	8.5	101
			2.00	23.74	394.8	7.35	8.03	95.1
			2.50	23.21	401.5	7.13	5.28	61.9

***In-Situ* Monitoring for Hopatcong 319 Stations 7/17/14**									
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**pH**	**Dissolved Oxygen**	**Dissolved Oxygen**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(µmhos/cm)**	**(units)**	**(mg/L)**	**(%)**
NPS 1	**1.7**	**0.9**	**Surface**	26.61	658.9	8.05	9.5	118.6
			1.00	25.46	668.8	8.34	10.31	126.1
			1.50	24.05	714.7	8.08	9.31	110.9
NPS 2	**1.2**	**1.2+**	**Surface**	26.03	374.4	7.49	8.54	105.4
			1.00	25.12	382.7	7.55	8.67	105.2
NPS 3	**0.95**	**0.95+**	**Surface**	26.12	367.3	7.69	8.84	109.4
			0.90	25.81	366	7.91	9.21	113.2
NPS 4	**1.6**	**1.3**	**Surface**	25.35	410.2	7.28	8.61	105
			1.00	25.04	406.3	7.27	8.57	103.9
			1.50	25.09	404.7	7.27	8.27	100.4
NPS 5	**2.8**	**1.3**	**Surface**	25.2	392.3	7.22	7.91	96.2
			1.00	25.03	392.3	7.2	8.03	97.4
			2.00	24.92	392.1	7.22	8.03	97.2
			2.50	24.86	393.5	7.14	6.93	83.7

In-Situ Monitoring for Hopatcong 319 Stations 8/15/14									
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**pH**	**Dissolved Oxygen**	**Dissolved Oxygen**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(µmhos/cm)**	**(units)**	**(mg/L)**	**(%)**
NPS 1	**1.3**	**0.4**	**Surface**	22.71	656.3	8.65	9.53	110.7
			1.00	22.2	652	8.54	9.6	110.4
NPS 2	**1**	**1.0+**	**Surface**	21.63	395.8	8.11	9.07	103.1
			1.00	21.51	396	8.13	9.07	102.9
NPS 3	**0.8**	**0.8+**	**Surface**	22.11	384.6	8.26	9.36	107.4
			0.75	22.13	384.1	8.52	9.7	111.3
NPS 4	**1.1**	**1.1+**	**Surface**	22.52	432.5	7.96	9.06	104.8
			1.00	22.12	433.8	7.88	8.53	97.9
NPS 5	**2.5**	**0.8**	**Surface**	23.04	406.1	7.31	8.25	96.4
			1.00	22.99	406.1	7.36	8.29	96.7
			2.00	22.81	407.1	7.36	8.18	95.1
			2.50	22.81	407.1	7.23	6.64	77.2

In-Situ **Monitoring for Hopatcong 319 Stations 10/1/14**									
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**pH**	**Dissolved Oxygen**	**Dissolved Oxygen**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(µmhos/cm)**	**(units)**	**(mg/L)**	**(%)**
NPS 1	**1.2**	**0.8**	**Surface**	20.03	553.5	7.8	8.26	91
			1.00	20.02	553	7.71	7.95	87.6
NPS 2	**0.8**	**0.8+**	**Surface**	20	411.4	7.83	9.63	106.1
			0.50	20	410.8	8.01	9.68	106.5
NPS 3	**0.5**	**0.5+**	**Surface**	19.27	415.8	7.75	9.05	98.2
			0.50	19.34	415.2	7.74	8.85	96.2
NPS 4	**1.2**	**1.2+**	**Surface**	19.64	423.7	7.7	9.16	100.1
			1.00	19.62	426.2	7.68	8.98	98.1
NPS 5	**2.2**	**2.2+**	**Surface**	20.02	408.6	7.67	9.43	103.9
			1.00	20.02	408.5	7.73	9.55	105.2
			2.00	19.98	411	7.69	9.47	104.3

APPENDIX C

WATER QUALITY DATA

HOPATCONG **21-May-2014** **STATION**	**Chlorophyll *a*** **(mg/m^3)**	**NH3-N (mg/L)**	**NO3-N (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**
ST-1	20.6	0.02	0.11	0.03	9
ST-2	16.1	0.02	0.05	0.02	7
ST-3	8.4	0.81	0.48	0.02	6
ST-4	8.9	0.07	0.06	0.02	7
ST-5	15.0	0.08	0.07	0.03	7
ST-6	26.2	0.07	0.05	0.03	5
ST-7	16.0	0.04	0.13	0.03	4
ST-10	14.6	0.11	0.16	0.03	6
ST-11	14.0	0.24	0.14	0.02	3
ST-2 DEEP		0.28	0.13	0.02	3
MEAN	**15.5**	**0.17**	**0.14**	**0.03**	**5.70**

24-Jun-2014 **STATION**	**Chlorophyll *a*** **(mg/m^3)**	**NH3-N (mg/L)**	**NO3-N (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**
ST-1	34.0	ND <0.01	0.06	**0.04**	11
ST-2	16.0	ND <0.01	ND <0.02	0.02	4
ST-3	13.0	0.13	0.07	**0.06**	ND <3
ST-4	13.0	0.01	ND <0.02	0.02	5
ST-5	10.0	0.02	0.03	0.02	3
ST-6	9.0	0.02	0.02	0.02	ND <3
ST-7	8.0	0.02	0.07	0.03	ND <3
ST-10	29.0	0.02	0.05	**0.05**	11
ST-11	7.0	0.02	0.12	0.03	ND <3
ST-2 DEEP		0.50	0.06	0.02	ND <3
MEAN	**15.4**	**0.09**	**0.06**	**0.03**	**6.80**

17-Jul-2014	**Chlorophyll *a***	**NH3-N**	**NO3-N**	**TP**	**TSS**
STATION	**(mg/m^3)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**
ST-1	20.0	ND <0.01	0.05	0.03	6
ST-2	14.0	ND <0.01	ND <0.02	0.01	3
ST-3	34.0	ND <0.01	0.06	**0.06**	4
ST-4	21.0	ND <0.01	ND <0.02	0.02	4
ST-5	25.0	ND <0.01	0.03	0.02	ND <3
ST-6	15.0	ND <0.01	0.02	0.02	3
ST-7	5.8	0.01	0.05	0.02	ND <3
ST-10	20.0	ND <0.01	0.04	0.03	5
ST-11	5.3	0.02	0.08	0.02	ND <3
ST-2 DEEP		0.62	0.05	0.11	11
MEAN	**17.8**	**0.22**	**0.05**	**0.03**	**5.14**

15-Aug-2014	**Chlorophyll *a***	**NH3-N**	**NO3-N**	**TP**	**TSS**
STATION	**(mg/m^3)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**
ST-1	38.0	0.01	0.05	**0.04**	7
ST-2	30.0	ND <0.01	ND <0.02	0.03	ND <3
ST-3	35.0	0.01	0.03	**0.05**	5
ST-4	22.0	ND <0.01	0.25	0.03	3
ST-5	29.0	0.01	0.02	**0.04**	5
ST-6	17.0	ND <0.01	0.04	0.03	3
ST-7	4.2	0.01	0.03	0.02	ND <3
ST-10	40.0	0.01	0.04	**0.04**	9
ST-11	4.2	0.01	0.03	0.02	ND <3
ST-2 DEEP		1.30	0.07	0.28	7
MEAN	**24.4**	**0.19**	**0.06**	**0.03**	**5.57**

1-Oct-2014

STATION	Chlorophyll (mg/m3)	NH3-N (mg/L)	NO3-N (mg/L)	TP (mg/L)	TSS (mg/L)
ST-1	15.0	0.02	0.02	0.02	5
ST-2	14.0	0.02	ND <0.02	ND <0.01	4
ST-3	20.0	0.02	0.02	0.02	5
ST-4	9.0	0.03	ND <0.02	0.01	5
ST-5	6.1	0.03	0.03	0.02	6
ST-6	5.3	0.03	ND <0.02	ND <0.01	5
ST-7	8.0	0.03	0.09	ND <0.01	5
ST-10	16.0	0.03	0.04	0.03	10
ST-11	4.2	0.03	0.06	ND <0.01	3
ST-2 DEEP		1.80	0.14	0.28	9
MEAN	**10.8**	**0.20**	**0.06**	**0.01**	**5.70**

Lake Hopatcong 319(h) Water Quality Sampling for 2014

Station	TP (mg/L)	TSS (mg/L)	CHL *a* (mg/m^3)
5/21/2014			
NPS 1	0.03	4	x
NPS 2	0.03	6	x
NPS 3	**0.05**	9	22.3
NPS 4	0.02	6	9
NPS 5	0.02	7	9
6/24/2014			
NPS 1	**0.05**	13	x
NPS 2	0.02	3	x
NPS 3	0.03	8	18
NPS 4	0.02	3	11
NPS 5	0.02	3	13
7/17/2014			
NPS 1	**0.06**	8	x
NPS 2	0.02	ND <3	x
NPS 3	0.03	8	14
NPS 4	0.02	5	18
NPS 5	0.03	ND <3	25
8/15/2014			
NPS 1	**0.09**	6	x
NPS 2	0.03	ND <3	x
NPS 3	0.03	3	15
NPS 4	0.02	ND <3	10
NPS 5	0.03	ND <3	32
10/1/2014			
NPS 1	**0.04**	11	x
NPS 2	ND <0.01	5	x
NPS 3	0.01	4	6.2
NPS 4	ND <0.01	ND <3	5
NPS 5	ND <0.01	5	5.4