

Lake Hopatcong Water Quality Report 2017

Morris and Sussex Counties, New Jersey

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1.0 Introduction

Princeton Hydro, LLC conducted general water quality monitoring of Lake Hopatcong during the 2017 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 were conducted 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. Remaining funds in the 319(h) grant were made available for the 2014, 2015 and 2016 water quality monitoring programs. The 2017 water quality monitoring program was funded by the Lake Hopatcong Foundation and the Lake Hopatcong Commission.

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 Projects. 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 two 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 continues to be an important component in the evaluation of the long-term success of the implementation of the phosphorus TMDL-based Restoration Plan, which was approved by NJDEP in April of 2006. Finally, the monitoring program provides the data necessary to support the Foundation’s and Commission’s requests for grant funding to implement both watershed-based and in-lake projects to improve the water quality of Lake Hopatcong.

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:

<u>Station Number</u>	<u>Location</u>
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 2017 sampling dates were 2 May, 6 June, 19 July, 21 August and 2 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 sub-surface (0.5 m) 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.

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 2017 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 located between 5.0 m and 7.0 m. Stratification persisted throughout the rest of the sampling season at this station with seasonally maximum values observed on 19 July 2017. Varying degrees of thermal stratification were noted at seven of the stations during the May event. Three stations were stratified during the June sampling, six stations during the July event and two during the August sampling. Only Station 2 was thermally stratified during the final sampling event in October 2017.

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 DO 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.

DO at Station #2 decreased sharply with depth during all sampling events during the 2017 season. The bottom of the lake exhibited conditions above the recommended State threshold during the May sampling event. These conditions did not persist into the June sampling event, becoming anoxic (DO concentration < 1 mg/L) immediately over the sediments. By 19 July 2017, anoxic conditions were established starting at 6 m. Anoxic conditions were noted in the bottom waters of this station through the August and October sampling events, beginning at 9 and 10 m, respectively.

DO concentrations remained above the recommended threshold at the remaining stations during the May sampling event. Bottom waters at ST-3 and ST-9 exhibited conditions below the recommended threshold, with concentrations of 1.39 mg/L and 2.74 mg/L, respectively. Three stations were below this threshold by July, two of which exhibited anoxic conditions in the

bottom waters. Finally, ST-9 was anoxic over the sediments during August. Well-oxygenated conditions were re-established at these stations by the October 2017 sampling event.

In addition, surface DO concentrations were frequently highly saturated or super saturated. Especially high values were noted during July. Such conditions of super-saturation indicate the presence of high densities of algal and aquatic plant biomass and hence elevated rates of photosynthesis, which generates DO.

Overall, a depression of DO was mainly limited to the hypolimnion of Station #2, with instances of anoxic conditions in the bottom meters of Stations #9 and #11. 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. When pH values are greater than 7 they are termed alkaline while those less than 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 NJDEP State water quality standard for pH is for an optimal range between 6.5 and 8.5.

Throughout the majority of the lake in May 2017, pH values were generally acceptable, with the exception at Station #3, maxing out at 9.43. The aquatic weed harvesting program was delayed in 2017 and was not initiated until June. Thus, Station #3 contained extremely high amounts of weeds and mat algae in May, resulting in extremely high amounts of photosynthesis, which in turn elevates the pH.

The pH was also above the NJDEP State standard at Station #3 during the June, July and October events but was less than the May 2017 value. The pH of the remaining stations during May and June were within the optimal range. The pH was similar during the July sampling event, with only the bottom meter of Station #11 and the surface meter of Station #3 out of the optimal range. By the August sampling event, pH fell back into the NJDEP range at all stations. The final event yielded elevated pH values at Stations #3 and #10, with high values of 9.12 and 8.76, respectively. Again, high pH value at Station 3 can be attributed to the high plant growth often noted at this station. An algal bloom was also noted during the October event, where higher pH values were detected.

Overall, the open water stations remained well within the NJDEP State optimal range of 6.5 and 8.5. The main deviation was seen at Stations #3 during all events, except in August. The only other deviations were at Station #10 during October and the bottom waters of Station #11.

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 2017, Secchi depths were all greater than 1 meter or down to the sediment. This persisted at all stations through both the June and July sampling events. By the August sampling event, transparency declined below recommended thresholds at four stations, Stations #1, #7, #10 and #11. Transparency was restored to 1 m or greater at all stations by the October 2017 sampling event. Clarity issues typically seen in past years at various stations were not present for the majority of the growing season, with only slightly impaired Secchi depths at the above stations.

Ammonia-Nitrogen (NH₄-N)

Surface water NH₄-N concentrations above 0.05 mg/L tend to stimulate elevated rates of algal growth. Surface ammonia concentrations measured during the May 2016 event were generally low throughout the lake and varied from non-detectable (ND<0.01mg/L) to 0.18 mg/L. Stations #4 and #7 had concentrations that exceeded the threshold of 0.05 mg/L. Bottom water NH₄-N concentrations at Station #2 were elevated, reaching 0.56 mg/L. Elevated concentrations of NH₄-N are a natural occurrence in the bottom waters of lakes due to the bacterial decomposition of organic material. By the June sampling event, ammonia-N concentrations decreased at the surface, ranging from non-detectable to 0.04 mg/L. None of the stations exceeded the recommended threshold. Once again, deep waters at Station #2 were elevated, however, they were greatly reduced from the previous sampling, with a concentration of 0.15 mg/L.

Similar results were seen in the surface waters during the 19 July 2017 sampling. NH₄-N concentrations ranged from 0.01 and 0.04 mg/L, all but two of the stations yielded concentrations of 0.01 mg/L. Deep water concentrations were again highly elevated to 0.68 mg/L. Surface concentration remained low by the August sampling, ranging between non-detectable to 0.04 mg/L. Each of these stations were non-detectable, with the exception of Station #11. Bottom waters had elevated concentrations of 0.52 mg/L during this event. The October sampling also consisted of non-detectable concentrations at all surface stations, except Station #11, which was 0.01 mg/L.

In summary, the excessively high concentration of $\text{NH}_4\text{-N}$ in the deep (hypolimnetic) waters at Station #2 was attributed to the depletion of DO and the bacterial decomposition of the organic matter raining to the bottom from the surface waters. Surface water $\text{NH}_4\text{-N}$ concentrations were consistently low throughout the season, with only a few spikes, one at Station #5 and #7 in May. Ammonia-N concentrations seemed lower than previous years, indicating septic systems may be becoming less problematic during drier conditions.

Nitrate-Nitrogen ($\text{NO}_3\text{-N}$)

Nitrate-N concentrations greater than 0.10 mg/L are considered excessive relative to algal and aquatic plant growth. During the May 2017 sampling, Nitrate-N concentrations at the surface stations ranged between 0.03 and 0.37 mg/L. Four of these stations contained concentrations greater than the recommended threshold of 0.10 mg/L. These stations include #1 (0.15 mg/L), #3 (0.37 mg/L), #10 (0.19 mg/L) and #11 (0.12 mg/L). It should be noted that all of these sampling stations are located close to near-shore septic systems, which may explain the elevated concentrations. The deep-water nitrate concentrations were below the threshold, only yielding 0.07 mg/L. Similar results were seen during the June sampling event, with nitrate-N concentrations ranging between 0.03 and 0.30 mg/L. Both Station #7 and #10 had nitrate-N concentrations of 0.12 and 0.30 mg/L, respectively, which exceeded the recommended threshold. Deep water concentrations decreased further to 0.03 mg/L.

By July, the range of concentrations diminished to between 0.02 and 0.14 mg/L. Only two stations (#10 and #11) slightly exceeded the recommended threshold with concentrations of 0.14 mg/L. Deep water concentrations increased above the 0.10 mg/L threshold reaching 0.18 mg/L. Nitrate-N concentrations in August were similar to those measured in July, varying between non-detectable ($\text{ND} < 0.02$ mg/L) and 0.13 mg/L. Both Stations #6 and #11 were slightly above the recommended threshold. By this sampling event, concentrations within the deep waters decreased back below the threshold to 0.06 mg/L. By the final sampling on 2 October 2017, each station was below the threshold, with a range of 0.02 to 0.08 mg/L. Deep water concentrations also remained below the threshold.

In summary, all in-lake nitrate-N concentrations were consistently below the State and Federal drinking water standard of 10.0 mg/L. Nitrate-N concentrations exceeded the 0.10 mg/L threshold (stimulates elevated amounts of algal and aquatic plant growth) during each event at least one station, with exception being the October sampling event. In 2014, 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). This indicates that aged, near-shore septic systems contribute to the pollutant load of Lake Hopatcong and thus have a direct impact on its

water quality. While not very obvious during the past few, drier growing seasons, these stations still displayed elevated concentrations during a few of the sampling events.

Total Phosphorus (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 average, 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 2017 sampling event ranged from 0.02 mg/L to 0.04 mg/L with a surface water mean concentration of 0.03 mg/L. The deep-water TP concentration at Station #2 was 0.02 mg/L, below the recommended threshold. All of the surface stations were below the State threshold, while three of these stations were slightly above the TMDL threshold; however, the overall mean for May 2017 was at the threshold.

TP concentrations in the surface waters during the June 2017 event were similar with a range of 0.03 mg/L to 0.05 mg/L with a mean concentration of 0.04 mg/L. Station #2 Deep remained below the standard at 0.02 mg/L. Three surface stations TP concentrations exceeded the State's Surface Water Quality Standard during this sampling, while four exceeded the TMDL threshold.

The surface water TP concentrations measured during the July event returned to the May range of 0.02 and 0.04 mg/L. Five of these surface stations contained concentrations of 0.04 mg/L, above the TMDL target of 0.03 mg/L. The TP concentration at ST-2 Deep increased above both State and TMDL threshold, yielding 0.11 mg/L.

TP concentrations continued to remain low during the August sampling, ranging between 0.01 and 0.04 mg/L. Three of the surface concentrations were above the targeted TMDL concentration. Once again, deep water phosphorus concentrations were above the recommended thresholds, reaching 0.09 mg/L.

As was observed during previous events, the TP concentrations ranged during the October sampling was between 0.02 and 0.04 mg/L. Only two of the stations were above the recommended TMDL threshold. Deep water TP tripled from the last event at this time, yielding 0.31 mg/L. This was likely due to the lengthy period of anoxia this station experienced over the season. In the absence of DO, phosphorus normally adsorbed onto sediment particles, leaches into the overlaying waters.

In summary, surface concentrations were very consistent across the whole lake, ranging between 0.01 and 0.05 mg/L. Certain stations, such as #10 and #11, consistently exceeded the TMDL threshold and even State Standards during one sampling event. While concentrations at certain stations were slightly above the set threshold, large spikes in surface TP were not recorded during the 2017 growing season. Deep water concentrations were elevated during the last three sampling events, spiking to a high of 0.31 mg/L in October. This spike in TP can be explained by the continuing anoxic conditions and internal loading of phosphorus.

The mean TP concentration was calculated for each surface water sampling station to determine if they complied with or exceeded the concentration of 0.03 mg/L established under the lake's TMDL. Of the nine, long-term water quality monitoring stations, five complied with the TMDL. That is, they each had a mean 2017 growing season concentration at or less than 0.03 mg/L. Stations #3, #7, #10 and #11 all had averages of 0.04 mg/L, which is out of compliance with the TMDL average of 0.03 mg/L. However, all of the averages remained below the State's Surface Water Quality Standard. These stations only slightly exceeded thresholds, and with no severe spikes noted, surface water TP did not appear to be a cause for concern during the 2017 season. However, it should be noted that the four stations that did exceed the mean value under the TMDL are either in the northern end of the lake or in the River Styx / Crescent Cove area (#3). Additionally, these stations are also notable for being in sections of the watershed that still have a substantial number of near-shore septic systems.

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 25 to 30.0 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 2017 event ranged from 8.6 µg/L at Station #5 to 24.0 µg/L at Station #11 with a mean concentration of 12.5 µg/L. The mean concentration was above the targeted average of 8.0 µg/L. The targeted maximum of 14.0 µg/L was only exceeded at Station #11, reaching 24.0 µg/L, however, two of the stations yielded concentrations of 14.0 µg/L.

Chlorophyll *a* concentrations during the June sampling ranged from 3.8 µg/L at Station #5 to 22.0 µg/L at Station #10 with a mean concentration of 10.5 µg/L. Once again, the sampling mean exceeded the targeted average. Two stations exceeded the targeted maximum, with 16.0 µg/L at Station #3 and 22.0 µg/L at Station #10.

Overall, chlorophyll *a* increased by the July event with concentrations ranging from 7.1 µg/L at Station #7 to 23.0 µg/L at Station #10 with a mean concentration of 14.0 µg/L. Four of the sampling stations (Stations #1, #3, #10, #11) exceeded the targeted maximum, with concentrations between 15.0 and 23.0 µg/L. The targeted average was also exceeded during this sampling event.

In August, chlorophyll *a* concentrations reached seasonal high values, varying between 9.9 µg/L at Station #11 to 27.0 µg/L at Stations #1 and #10 with a mean concentration of 15.8 µg/L. Similar to previous sampling events, the targeted mean was exceeded. The targeted maximum was also exceeded by three stations, including Stations #1 (27.0 µg/L), #7 (15.0 µg/L) and #10 (27.0 µg/L).

During the October sampling, chlorophyll *a* concentration decreased overall, varying from 3.3 µg/L at Station #5 to 11.0 µg/L at both Stations #2 with a mean concentration of 7.4 µg/L. At this time, all of the sampled stations had concentrations that were below the targeted maximum concentration and an average below the targeted mean.

All of the sampling events, with exception to October, had averages that exceeded the TMDL targeted average of 8 µg/L. Similarly, each sampling event yielded at least one station that

exceeded the targeted maximum of 14 $\mu\text{g/L}$, except the October sampling. Again, the stations in the norther end and in the River Styx / Crescent Cove typically had the highest chlorophyll *a* concentrations.

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 2017. Algal composition during the 2 May 2017 event consisted of strictly diatoms. *Tabellaria* was noted as common during this event, while *Asterionella* and *Fragilaria* were present. *Rhizosolenia* was also observed in small quantities. Diversity was low, yielding only 4 genera of diatoms during this sampling event.

Total algal richness greatly increased during the 6 June 2017 sampling event to 10 genera. The sample was diatom-dominated, with both *Fragilaria* and *Tabellaria* being abundant and *Asterionella* listed as common. A more diverse community was present during this sampling, with genera of diatoms, blue-greens, dinoflagellates, and green and golden algae. Blue-green algae *Coelosphaerium* and golden algae *Dinobryon* were also common. Various green algae (*Sphaerocystis*, *Pediastrum*, *Staurastrum*), dinoflagellates (*Ceratium*) and golden algae (*Mallomonas*) were also noted as present or rare during this event.

Richness increased slightly by the 19 July 2017 event, with 12 genera observed. The dominant algae during this sampling was the cyanobacteria *Anabaena*, which was heavily abundant. The community had a similar makeup as the previous sampling, with blue-greens, dinoflagellates, green and golden algae, and diatoms represented. Three genera were noted as common, including *Fragilaria*, *Tabellaria* and the blue-green *Lyngbya*. Five other genera were listed as present and included *Melosira*, *Pediastrum*, *Ceratium*, *Coelosphaerium* and *Microcystis*. Three genera were also observed as rare.

Algal richness persisted through the 21 August sampling event with 12 genera identified. Densities were also high, with an abundant amount of *Tabellaria*. Also common within this sample were various colonial greens, and the blue-greens, *Anabaena*, *Microcystis* and *Lyngbya*. The remaining genera were listed as present or rare and were represented by blue-greens, dinoflagellates, diatoms and green algae.

Total algal richness was highest during the 2 October 2017 sampling event with 14 different genera identified. *Tabellaria* was dominant at this time. Two genera of plankton were considered common, both cyanobacteria (*Anabaena* and *Microcystis*). Six genera were identified as present, represented by diatoms, chrysophytes, green algae and dinoflagellates. Five genera were also identified as rare during this sampling.

Cyanobacteria were not present during the entirety of the 2017 season. No genera of blue-greens were noted during the first sampling event in May. One genera, *Coelosphaerium*, was common during the second sampling. Higher densities were seen during the last three sampling events. During these events, a blue-green was only listed as abundant during one sampling (*Anabaena* during the July sampling), while the remaining identified genera range from rare to common.

Table 1
Phytoplankton in Lake Hopatcong
during the 2017 Growing Season

Sampling Date	Phytoplankton
2 May 2017	Algal diversity was low with only 4 genera of diatoms. <i>Tabellaria</i> was common during this event. <i>Asterionella</i> and <i>Fragilaria</i> were listed as present. <i>Rhizosolenia</i> were listed as rare.
6 June 2017	Total algal diversity and abundance increased. Abundant phytoplankton were the diatoms <i>Fragilaria</i> and <i>Tabellaria</i> . In addition, <i>Asterionella</i> , <i>Dinobryon</i> and <i>Coelosphaerium</i> were common at this time. Various other genera were noted as present or rare.
19 July 2017	Algal abundance remained high, with the dominant genera being the blue-green algae <i>Anabaena</i> . Diversity remained high, with 12 genera and representations from green algae, chrysophytes, diatoms, dinoflagellates and blue-green algae. <i>Lyngbya</i> , <i>Fragilaria</i> and <i>Tabellaria</i> were all common at this time.
21 August 2017	Algal abundance remained high with 12 identified genera, with the diatom <i>Tabellaria</i> noted as dominant. Also common were the blue-green algae <i>Anabaena</i> , <i>Lyngbya</i> and <i>Microcystis</i> , and various colonial greens. The remaining seven genera were identified as present or rare.
2 October 2017	Diversity was high with 14 genera identified. <i>Tabellaria</i> was the dominant algae. Two genera were listed as common, including <i>Anabaena</i> and <i>Microcystis</i> . In addition, six genera of green algae, chrysophytes, and diatoms were identified as present. Five genera were also listed as rare.

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 2 May 2017 sampling event was low in richness. The copepod *Cyclops* was abundant during this sampling. Copepod nauplii were noted as present. Three genera, *Asplanchna*, *Ostracoda* and *Bosmina* were identified as rare.

During the 6 June 2017 sampling event, zooplankton abundance and richness increased, yielding six different genera. The cladoceran *Bosmina* was the dominant zooplankton at this time. Three genera were identified as common, including the copepod *Cyclops* and rotifers *Asplanchna* and *Polyarthra*. Copepod nauplii and *Keratella* were also noted as present.

Richness once again increased to nine genera during the 19 July 2017 sampling event. No single genus was dominant at this time. Both Cladocerans identified, *Bosmina* and *Ceriodaphnia*, were common during this sampling event. Seven of the nine genera were listed as present. These included the rotifers *Keratella*, *Kellicottia*, *Polyarthra* and *Asplanchna*, the copepods *Cyclops*, *Diaptomus* and nauplii.

Zooplankton richness reached a seasonal high during the August sampling event, yielding 10 identified genera. *Cyclops* was dominant during this event. Also common were *Bosmina*, copepod nauplii and the rotifer *Trichocerca*. Six of the identified genera were rotifers, ranging between rare and common abundances.

By the 2 October 2017 sampling event, zooplankton richness was 9 recorded genera. Of these, three were listed as common, including cladoceran *Bosmina*, copepod *Cyclops* and rotifer *Keratella*. The remaining six genera were listed as present or rare, and mainly consisted of rotifers, with the exception of copepod nauplii.

Similar to past monitoring years, herbivorous zooplankton were present but not in high densities in Lake Hopatcong. 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 a large population of large-bodied zooplankton cannot exert a high degree of algal control through grazing.

**Table 2
Zooplankton in Lake Hopatcong
during the 2017 Growing Season**

Sampling Date	Zooplankton
2 May 2017	Zooplankton richness were low to moderate, with 5 genera represented. <i>Cyclops</i> was dominant, while copepod nauplii were present. The remaining three genera were rare.
6 June 2017	Zooplankton abundance and richness increased 6 genera were identified. The cladoceran <i>Bosmina</i> was abundant. <i>Cyclops</i> , <i>Asplanchna</i> and <i>Polyarthra</i> were common during this sampling. Copepod nauplii and <i>Keratella</i> were also noted as present.
19 July 2017	Zooplankton abundance was high with high richness, yielding 9 genera. The cladocerans <i>Bosmina</i> and <i>Ceriodaphnia</i> were common. Four genera of rotifers and three genera of copepods were present during this event.
21 August 2017	High zooplankton abundance was noted during this event with only 10 genera recorded. <i>Cyclops</i> was dominant at this time. Also common were nauplii, <i>Bosmina</i> and <i>Trichocerca</i> . The remaining genera were listed as rare or present.
2 October 2017	The zooplankton community exhibited moderate to high abundance and once again 9 genera were identified. <i>Bosmina</i> , <i>Cyclops</i> and <i>Keratella</i> were all listed as common during this sampling. The remaining six genera were all rotifers, with the exception of nauplii, and were either present or rare.

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 criteria to sustain a healthy, aquatic ecosystem is a DO concentration of at least 5 mg/L.

While all trout are designated as cold-water fish, trout species display varying levels of thermal tolerance. Brown trout (*Salmo trutta*) have an optimal summer water temperature range of 18 to 24°C (65 to 75°F) (USEPA, 1994). However, these fish can survive in waters as warm as 26°C (79°F) (Scott and Crossman, 1973), defined here as acceptable habitat. The 2017 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°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°C were considered acceptable or carry over habitat for brown trout.

Optimal brown trout habitat was present throughout the water column of Station #2 during the May event. Optimal brown trout habitat was present during the June sampling from the surface waters to a depth of 7 meters. Optimal habitat was not noted during the July sampling due to elevated temperatures at the surface and anoxic conditions in the bottom waters. However, carry over habitat was noted between 4 and 5 meters, with temperatures between 24.47 and 25.66 °C. Similar to the previous sampling, the August sampling event only contained carry over habitat. This habitat extended from the surface to 5 meters. Optimal brown trout habitat was reestablished by the final sampling event in October, ranging from the surface to 7 meters.

Optimal brown trout habitat was found at the remaining stations during the May sampling. Similarly, optimal habitat was noted at these stations during the June sampling, with the exceptions of the bottom waters at Stations #3 and #9. Optimal habitat was no longer present during July, leaving five stations with portions of the water column suitable for use as carry over habitat. This included the bottom waters of Stations #4, #8 and #10, and the mid-depth waters of Stations #9 and #11. This trend continued through the August sampling event. Carry over habitat was present at all stations in various magnitudes. Optimal brown trout habitat was again found at the remaining ten stations by the October sampling event.

Mechanical Weed Harvesting Program

Many of the shallower 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, as well as initiating the harvesting program later in the growing season. In turn, this resulted in only 1.2% of the phosphorus associated with plant biomass being 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 2013 through 2016. This was primarily due to the fact that the program was initiated earlier in these years relative to 2012. NJDEP has directly overseen the operation of the weed harvesting program for the last five years and each year displays a higher rate of removal, which was attributed to hired staff 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 during the 2017 growing season ran from 24 June through 16 October. The harvesting during this year began a month later than the years previous due to logistical issues and receiving parts for the harvesters. During the 2017 harvesting program, 3,872 cubic yards of wet plant biomass were removed from various areas of the lake. This was a slight reduction from the previous year, which yielded a removal of 4,024 cubic yards of material. This reduction of 152 cubic yards of material can be attributed to the

shorter harvesting period during 2017. Even with the late initiation of operation, 2017 removals were still larger than 2015 values by approximately 1,000 cubic yards.

During the 2017 mechanical weed harvesting program, the removal of 3,872 cubic yards of plant material resulted in removing approximately 80 lbs of TP or 1.1% of the TP load targeted for removal under the TMDL. This is the second time since 2010 that the annual TP removed through mechanical harvesting exceeded a value of 1%. The 80 lbs of TP removed through the 2017 weed harvesting program had the potential to generate up to 88,546 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 2017. The annual mean values for Station #2 were graphed, along with the long-term, “running mean” for the lake.

The 2017 mean Secchi depth was 2.2 meters, which is one of the higher Secchi depths recorded in Lake Hopatcong’s long-term data. Secchi depth was also above the long-term mean of 2.1. Additionally, the Secchi depth remained high over the past few years since a drop to 1.8 m in 2014 (Figure 2 in Appendix A).

The mean chlorophyll *a* concentration (11.8 µg/L) for the 2017 season was just above the long-term mean of 10.2 µg/L. Chlorophyll *a* concentrations increased for the second year in a row. The 2017 mean concentration also exceeded the targeted average of 8 µg/L. The mean 2014 chlorophyll *a* concentration was the highest measured out of the entire 1991 – 2017 dataset. The 2014 growing season was cool but unusually wet, transporting watershed-based nutrients and solids into the lake, which more than likely stimulated additional algal growth.

Due to high water clarity (as measured with the Secchi disk) and low to moderate algal biomass (as measure through chlorophyll *a*), the abundance of submerged, rooted aquatic vegetation has increased within the past few years.

The 2017 mean TP concentration was 0.020 mg/L (Figure 4 in Appendix A). The mean TP value slightly increased from the previous three years (0.017 mg/L). The 2017 mean was the highest recorded mean TP concentration since 2007 (which was 0.022 mg/L). While slightly higher than previous years, TP concentrations were still below State Standards and TMDL thresholds.

While some sections of Lake Hopatcong, such as River Styx / Crescent Cove and the northern parts such as Woodport, still occasionally exhibit nuisance algae and weed growth, the main body of the lake has shown improved water quality conditions relative to phosphorus reductions and acceptable amount of algal growth. However, the nuisance conditions still experienced in the northern and River Styx / Crescent Cove parts of the lake indicate that efforts need to continue to implement projects to move the lake toward compliance with its TMDL.

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 2017 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 <i>a</i> concentration endpoint	8 µg/L
Targeted maximum chlorophyll <i>a</i> concentration endpoint	14 µg/L

The 2017 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). The seasonal mean chlorophyll *a* concentration exceeded the targeted mean chlorophyll *a* concentration of 8 µg/L. Two of the five sampling events yielded chlorophyll *a* concentrations in Station #2 that exceeded the targeted maximum chlorophyll *a* concentration endpoint.

For Station #3, the mean TP concentration in 2017 was 0.04 mg/L, slightly above the targeted mean of 0.03 mg/L. This decreased from the previous year, which yielded an average of 0.07 mg/L. Two of the five concentrations exceeded the targeted mean, reaching a high of 0.05 mg/L. Similar to Station #2 the seasonal 2017 mean chlorophyll *a* concentration exceeded targeted mean by 4.3 µg/L. Once again, two of these samplings were above the targeted maximum chlorophyll *a* concentration. While elevated, the maximum chlorophyll *a* concentration still only reached 16 µg/L.

At Station #10, the mean TP concentration in 2017 was also 0.04 mg/L, slightly above the targeted mean of 0.03 mg/L. All of the samples were above this target, yielding either 0.04 or 0.05 mg/L. The mean concentration of chlorophyll *a* (18.6 µg/L) greatly exceeded the targeted mean concentration of 8 µg/L. Three of the sampling events had a value greater than the targeted maximum chlorophyll *a* concentration endpoint of 14 µg/L, ranging between 22.0 and 27.0 µg/L

4.0 Summary

This section provides a summary of the 2017 water quality conditions, as well as recommendations on how to preserve the highly valued aquatic resources of Lake Hopatcong.

1. Thermally stratified waters were noted during the early May sampling event, which then persisted throughout the remainder of the growing season. The waters were well oxygenated from surface to bottom during the first sampling event. By the June event, the bottom meter of the lake reached anoxic conditions. From July to October 2017 the lake contained greater degrees of anoxia beginning between 6 and 10 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 varied between 0.02 mg/L and 0.04 mg/L. Deep water concentrations reached a seasonal average of 0.11 mg/L.
3. The majority of the nine sampling stations had mean TP concentrations at or below the targeted mean concentration of 0.03 mg/L, as recognized under the TMDL. Four of these stations only exceeded the TMDL target by 0.01 or 0.02 mg/L. None of the large spikes seen in previous years were seen during the 2017 growing season.
4. Based on the *in-situ* conditions, optimal brown trout habitat was available in varying degrees in May, June, and October 2017. Carry-over brown trout habitat was present during the July and August sampling events. Carry over habitat was identified at six stations during the July sampling, increasing to all stations by August. Brown trout habitat was seen during all months in 2017 in one form or another.
5. Due to the shorter harvesting period, a slight reduction in biomass was noted in 2017 at Lake Hopatcong. During the 2017 harvesting program, approximately 3,872 cubic yards of wet plant biomass was removed, which was only 152 cubic yards less than 2016 yield. This resulted in removing 80 lbs of TP, accounting for 1.1% of the TP targeted for removal under the TMDL. This was one of the highest percentages of TP removed through mechanical weed harvesting since 2010 when approximately 6% of the TP targeted under the TMDL was removed through harvesting.

APPENDIX A

FIGURES

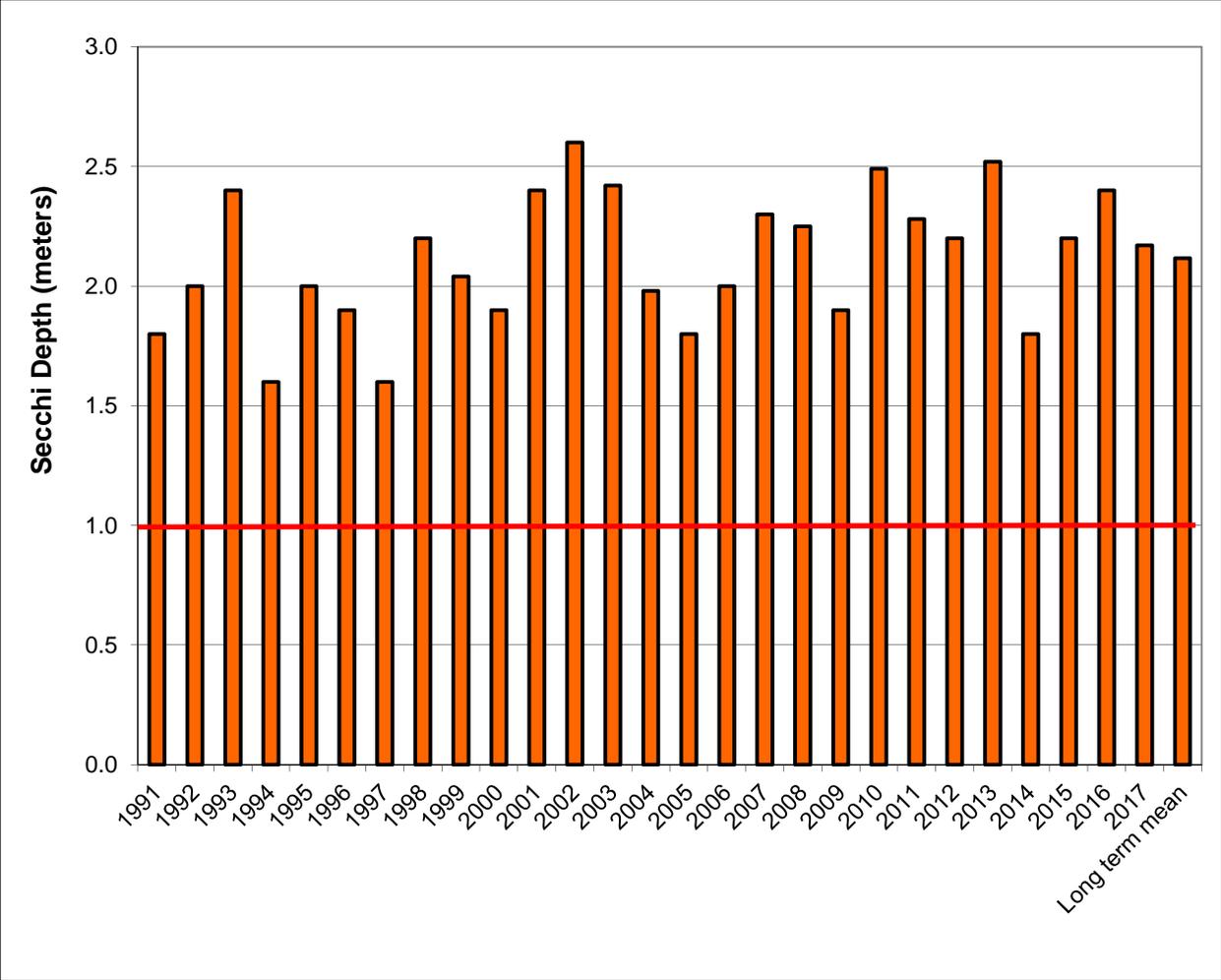


Figure 2 - Lake Hopatcong Long-Term Secchi Depth (meters)

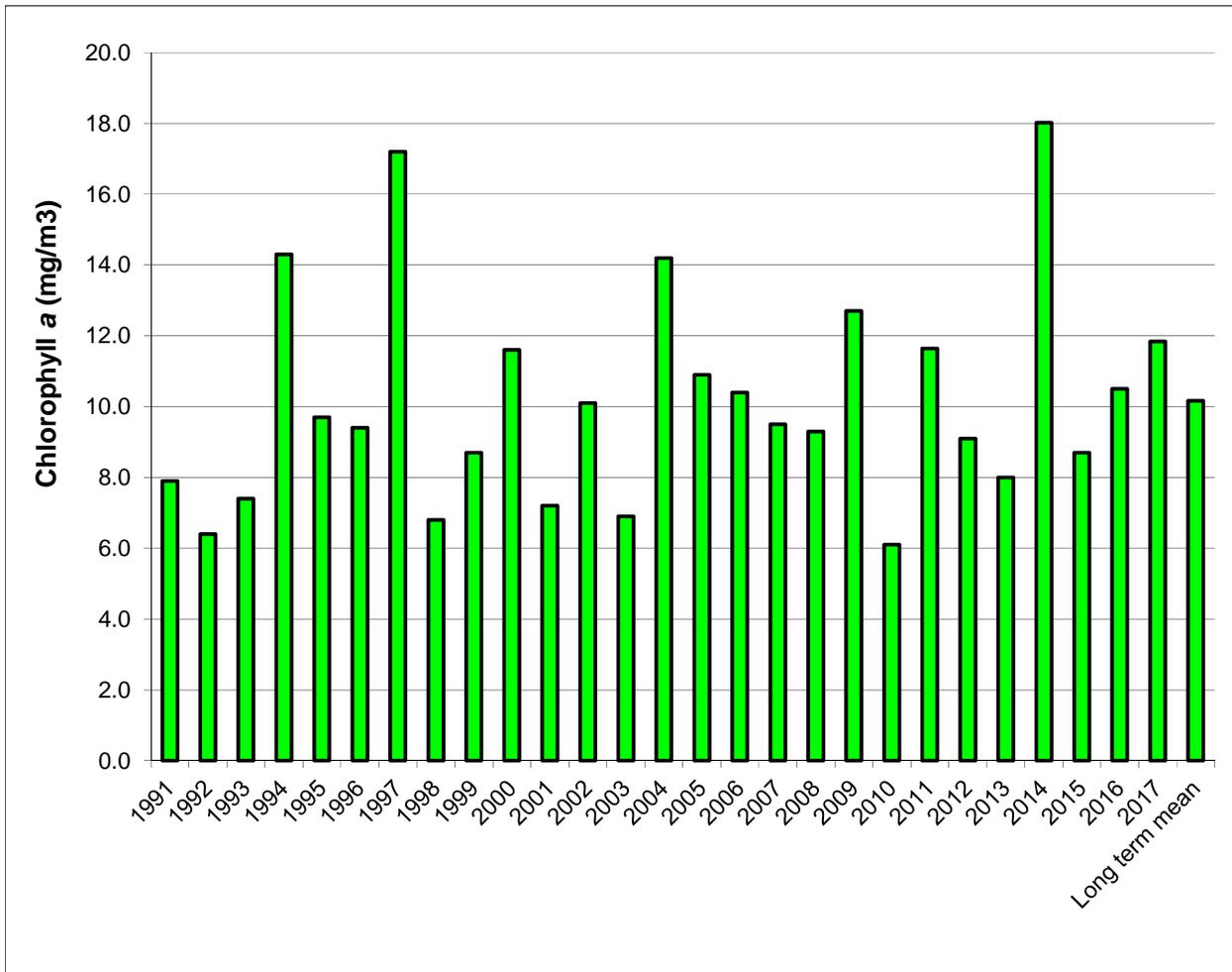


Figure 3 - Lake Hopatcong Long-Term Chlorophyll a Concentrations (mg/m³)

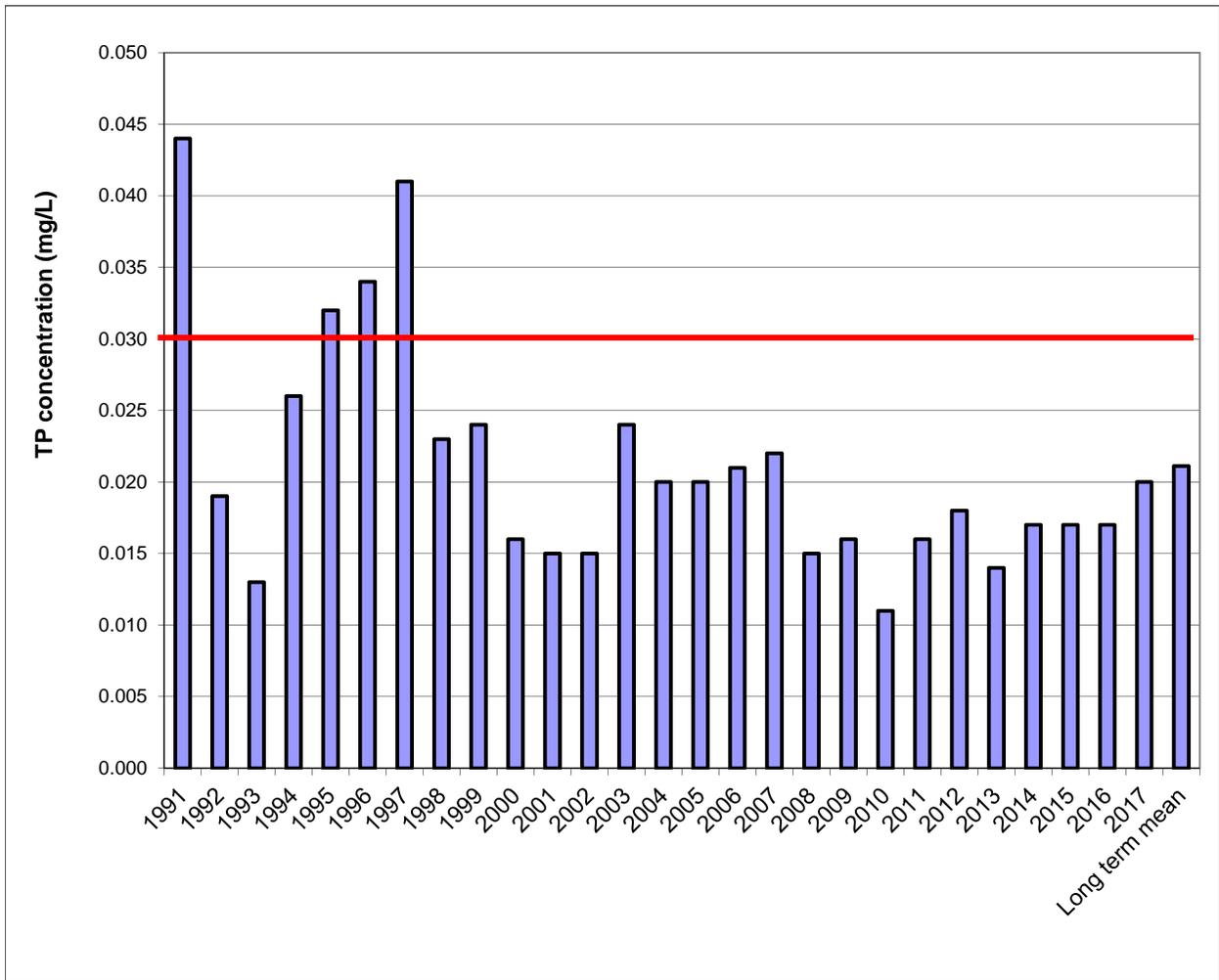


Figure 4 - Lake Hopatcong Long-Term Total Phosphorus Concentrations (mg/L)

APPENDIX B

IN-SITU DATA

<i>In-Situ Monitoring for Lake Hopatcong 5/02/2017</i>								
Station	DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
STA-1	2.00	1.90	0.1	17.44	0.444	9.35	100.8	7.55
			1.0	17.41	0.445	9.36	100.7	7.49
			2.0	17.05	0.452	8.72	93.2	7.35
STA-2	14.50	2.00	0.1	14.61	0.503	10.47	106.2	7.86
			1.0	14.59	0.503	11.03	111.8	7.89
			2.0	14.48	0.503	11.09	112.2	7.87
			3.0	14.00	0.504	11.00	110.2	7.72
			4.0	13.53	0.504	11.06	109.6	7.63
			5.0	13.25	0.504	10.94	107.7	7.57
			6.0	12.10	0.505	10.88	104.4	7.49
			7.0	11.20	0.503	10.64	100.0	7.38
			9.0	9.75	0.503	10.13	92.0	7.21
			10.0	9.40	0.503	9.27	83.5	7.12
			11.0	8.74	0.504	9.28	82.3	7.10
			12.0	8.43	0.505	8.95	78.8	7.06
13.0	8.23	0.505	8.67	75.9	7.04			
14.0	7.84	0.532	7.92	68.7	7.24			
STA-3	2.10	1.50+	0.1	17.51	0.790	11.92	128.8	9.43
			1.0	16.56	0.643	13.15	139.2	9.06
			1.7	15.20	0.728	6.52	67.1	9.08
STA-4	2.90	1.80	0.1	15.85	0.511	9.85	102.7	7.57
			1.0	15.73	0.511	9.83	102.2	7.51
			2.0	14.39	0.504	9.83	99.3	7.51
			2.9	12.68	0.563	7.68	74.7	7.23
STA-5	1.80	1.50	0.1	17.23	0.520	10.44	112.0	8.07
			1.0	16.51	0.519	10.60	112.0	8.21
			1.8	15.00	0.518	10.94	112.0	7.96
STA-6	3.20	1.80	0.1	15.92	0.497	9.96	104.0	7.57
			1.0	15.91	0.497	10.13	105.7	7.55
			2.0	15.47	0.498	10.23	105.8	7.56
			3.0	13.85	0.517	7.58	75.7	7.53
STA-7	0.80	0.80+	0.1	18.17	0.259	7.99	87.3	6.74
STA-8	3.80	2.30	0.1	15.11	0.504	9.96	102.1	7.98
			1.0	15.13	0.504	10.86	111.4	7.94
			2.0	15.13	0.504	10.98	112.7	7.95
			3.0	13.92	0.513	10.36	103.6	7.42
STA-9	8.10	1.90	0.1	15.27	0.502	9.79	100.8	7.93
			1.0	15.11	0.502	10.53	108.1	7.88
			2.0	14.97	0.502	10.97	112.1	7.83
			3.0	14.71	0.502	11.08	112.7	7.81
			4.0	14.64	0.502	11.08	112.5	7.77
			5.0	14.61	0.502	11.07	112.3	7.80
			6.0	14.50	0.502	11.09	112.3	7.77
			7.0	14.31	0.502	11.05	111.4	7.71
8.0	11.39	0.465	6.48	61.2	7.28			
STA-10	1.6	1.4	0.1	17.84	0.506	9.40	102.1	7.63
			1.0	17.17	0.508	8.78	94.0	7.59
STA-11	1.00	1.00+	0.1	18.08	0.203	8.59	93.7	6.74
			0.9	17.40	0.212	8.22	88.5	6.58

<i>In-Situ Monitoring for Lake Hopatcong 6/6/2017</i>								
Station	DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
ST-1	2.00	2.00	0.1	18.75	0.462	7.65	84.7	7.42
			1.0	18.78	0.462	7.40	82.0	7.44
			2.0	18.78	0.462	7.35	81.4	7.42
ST-2	13.60	2.60	0.1	18.21	0.512	8.68	95.1	7.75
			1.0	18.23	0.512	8.67	94.9	7.73
			2.0	18.23	0.512	8.68	95.0	7.70
			3.0	18.22	0.512	8.67	95.0	7.68
			4.0	18.22	0.512	8.66	94.8	7.67
			5.0	18.17	0.512	8.64	94.6	7.64
			6.0	16.98	0.512	6.59	70.3	7.23
			7.0	15.58	0.513	5.42	56.1	7.07
			8.0	13.88	0.513	4.12	41.1	6.96
			9.0	12.79	0.512	3.72	36.2	6.93
			10.0	12.38	0.513	3.26	31.5	6.91
			11.0	11.92	0.514	2.57	24.6	6.90
12.0	11.19	0.517	1.85	17.3	6.88			
13.0	10.88	0.519	0.88	8.2	6.87			
ST-3	2.20	1.00	0.1	18.41	0.827	10.00	110.0	9.76
			1.0	18.43	0.938	9.82	108.2	9.69
			2.0	16.38	0.898	1.39	14.6	6.94
ST-4	3.10	2.40	0.1	18.73	0.524	9.00	99.6	7.86
			1.0	18.77	0.524	8.84	97.9	7.90
			2.0	18.76	0.524	8.84	97.9	7.88
ST-5	1.40	1.40	0.1	19.24	0.525	8.42	94.1	7.76
			1.0	19.26	0.525	8.28	92.6	7.79
ST-6	3.80	2.00	0.1	18.60	0.500	9.07	100.0	7.96
			1.0	18.71	0.503	9.09	100.6	7.92
			2.0	18.59	0.506	8.99	99.2	7.76
			3.0	18.44	0.504	8.41	92.5	7.52
ST-7	1.70	1.30	0.1	18.61	0.264	7.58	83.6	7.15
			1.0	18.59	0.264	6.98	77.0	7.04
ST-8	4.50	2.30	0.1	17.91	0.512	8.44	91.8	7.61
			1.0	17.90	0.512	8.29	90.2	7.60
			2.0	17.90	0.512	8.26	89.8	7.57
			3.0	17.90	0.511	8.23	89.5	7.54
			4.0	17.34	0.513	6.93	74.5	7.25
ST-9	7.80	2.50	0.1	18.66	0.511	9.01	99.6	7.77
			1.0	18.72	0.511	8.86	98.0	7.80
			2.0	18.72	0.511	8.85	97.9	7.75
			3.0	18.71	0.511	8.82	97.6	7.72
			4.0	18.71	0.511	8.80	97.3	7.71
			5.0	18.69	0.511	8.79	97.2	7.70
			6.0	14.48	0.515	4.21	42.6	6.98
			7.0	13.18	0.518	2.74	26.9	6.92
ST-10	1.2	1.2	0.1	18.86	0.503	8.77	97.2	7.95
			1.0	18.83	0.542	8.71	96.6	7.91
ST-11	1.90	1.4	0.1	18.08	0.221	6.62	72.2	6.89
			1.0	18.10	0.224	6.09	66.5	6.85

In-Situ Monitoring for Lake Hopatcong 7/19/2017								
Station	DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
STA-1	2.1	1.3	0.1	27.56	0.449	8.83	115.9	7.83
			1.0	27.37	0.448	9.01	117.8	7.79
			2.0	26.91	0.446	6.96	90.3	7.24
STA-2	14.9	2.2	0.1	26.26	0.517	8.67	111.2	8.03
			1.0	26.22	0.518	8.89	113.9	8.05
			2.0	26.16	0.518	9.00	115.2	8.04
			3.0	26.08	0.518	8.91	113.8	8.01
			4.0	25.66	0.517	8.56	108.5	7.70
			5.0	24.47	0.518	5.74	71.3	7.22
			6.0	22.54	0.517	0.86	10.3	6.83
			7.0	18.51	0.519	0.41	4.5	6.82
			8.0	14.30	0.518	0.15	1.5	6.85
			9.0	13.27	0.518	0.11	1.0	6.85
			10.0	12.52	0.521	0.09	0.8	6.84
			11.0	12.05	0.526	0.08	0.7	6.95
			12.0	11.58	0.528	0.07	0.7	6.98
13.0	11.23	0.531	0.07	0.7	7.02			
14.0	10.75	0.542	0.07	0.7	7.09			
STA-3	2.3	1.5	0.1	28.90	0.746	9.70	130.4	8.65
			1.0	27.79	0.752	11.09	146.3	8.78
			2.0	26.28	0.909	6.47	83.1	7.25
STA-4	3.1	1.9	0.1	27.03	0.527	8.10	105.3	7.53
			1.0	26.98	0.527	8.20	106.6	7.57
			2.0	25.89	0.516	8.40	107.0	7.68
			3.0	25.23	0.521	8.43	106.0	7.38
STA-5	2.3	1.6	0.1	27.17	0.524	7.86	102.4	7.59
			1.0	27.00	0.522	7.78	101.1	7.58
			2.0	26.81	0.525	5.34	69.2	7.08
STA-6	3.2	1.9	0.1	27.67	0.505	8.77	115.4	8.16
			1.0	27.51	0.505	9.13	119.7	8.08
			2.0	27.26	0.502	8.72	113.8	7.72
			3.0	26.38	0.491	2.63	33.8	6.94
STA-7	1.7	1.5	0.1	26.90	0.234	6.53	84.6	6.90
			1.0	26.50	0.233	6.27	80.7	6.72
STA-8	5.2	2.1	0.0	26.96	0.515	8.71	113.2	8.12
			1.0	26.96	0.516	9.11	118.2	8.35
			2.0	26.95	0.516	9.22	119.7	8.28
			3.0	26.95	0.516	9.22	119.7	8.22
			4.0	26.79	0.520	9.05	117.2	8.00
			5.0	25.82	0.520	7.05	89.6	7.33
STA-9	7.7	2	0.1	27.69	0.518	9.69	127.4	8.44
			1.0	27.39	0.518	9.96	130.3	8.51
			2.0	26.79	0.519	9.85	127.5	8.37
			3.0	26.37	0.523	9.31	119.7	7.84
			4.0	25.11	0.522	8.00	100.4	7.40
			5.0	23.08	0.519	2.02	24.4	6.86
			6.0	21.41	0.519	0.63	7.4	6.77
			7.0	18.90	0.524	0.30	3.3	6.79
STA-10	1.3	1.3+	0.1	27.74	0.475	10.39	136.8	8.67
			1.0	25.35	0.535	11.03	139.1	8.44
STA-11	2.6	1.6	0.1	26.77	0.195	6.70	86.6	6.76
			1.0	25.60	0.200	5.16	65.3	6.59
			2.0	23.48	0.224	0.93	11.4	6.25

<i>In-Situ</i> Monitoring for Lake Hopatcong 8/21/2017								
Station	DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
STA-1	1.8	0.7	0.1	25.87	0.419	8.18	100.7	7.41
			1.0	25.56	0.422	8.23	100.9	7.44
STA-2	13.8	1.75	0.1	25.02	0.495	8.71	105.7	7.74
			1.0	25.00	0.494	8.76	106.2	7.75
			2.0	24.94	0.493	8.71	105.6	7.75
			3.0	24.88	0.493	8.49	102.7	7.69
			4.0	24.86	0.493	8.47	102.4	7.68
			5.0	24.76	0.495	8.28	99.9	7.67
			6.0	22.98	0.496	3.21	37.5	6.99
			7.0	20.35	0.496	1.89	21.0	6.77
			8.0	16.85	0.508	1.61	16.0	6.82
			9.0	15.04	0.505	0.00	0.0	7.78
			10.0	13.51	0.505	0.00	0.0	6.76
			11.0	12.49	0.508	0.00	0.0	6.82
12.0	11.70	0.514	0.00	0.0	6.87			
13.0	11.29	0.521	0.00	0.0	6.87			
STA-3	2.1	1.2	0.1	26.62	6.610	9.77	122.0	8.28
			1.0	25.81	0.648	9.33	115.2	8.07
			2.0	25.55	0.648	9.23	113.0	8.11
STA-4	2.9	1.25	0.1	25.23	0.502	7.43	90.5	7.32
			1.0	25.17	0.502	7.49	91.0	7.29
			2.0	24.90	0.502	7.48	90.4	7.27
STA-5	2	1.5	0.1	25.24	0.501	7.64	93.0	7.48
			1.0	25.11	0.501	7.41	90.0	7.43
STA-6	3.2	1.6	0.1	25.64	0.494	8.67	106.3	7.65
			1.0	25.59	0.494	8.65	106.0	7.62
			2.0	25.47	0.493	8.64	105.7	7.61
			3.0	25.15	0.492	8.17	99.0	7.44
STA-7	1.1	0.9	0.1	25.22	0.285	6.75	82.1	7.14
			1.0	24.51	0.278	5.70	68.4	6.94
STA-8	6.8	1.75	0.1	25.20	0.497	8.95	108.7	7.97
			1.0	25.17	0.497	8.97	109.2	7.98
			2.0	24.93	0.497	8.84	107.0	7.92
			3.0	24.85	0.497	8.68	104.9	7.85
			4.0	24.81	0.497	8.51	102.7	7.78
			5.0	24.79	0.498	8.63	104.3	7.84
STA-9	7.3	1.9	0.1	25.42	0.496	9.00	109.9	7.84
			1.0	25.31	0.499	9.05	110.3	7.83
			2.0	25.24	0.499	9.05	110.1	7.86
			3.0	24.86	0.499	8.49	102.6	7.64
			4.0	24.76	0.501	8.06	97.0	7.55
			5.0	24.29	0.498	6.56	78.8	7.27
			6.0	23.14	0.497	2.20	25.4	7.83
STA-10	1.4	0.8	0.1	26.26	0.437	9.11	112.9	7.78
			1.0	25.43	0.448	9.14	111.4	7.86
STA-11	0.98	0.75	0.1	24.27	0.242	5.39	64.4	6.86
			0.5	24.33	0.242	5.39	64.4	6.78

<i>In-Situ Monitoring for Lake Hopatcong 10/2/2017</i>								
Station	DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
STA-1	1.8	1.3	0.1	18.95	0.430	8.31	90.9	7.75
			1.0	19.02	0.428	8.22	89.8	7.78
STA-2	13.5	2.3	0.1	20.33	0.499	7.81	87.8	7.66
			1.0	20.32	0.499	7.82	87.8	7.66
			2.0	20.32	0.499	7.79	87.5	7.66
			3.0	20.31	0.499	7.72	86.7	7.65
			4.0	20.31	0.499	7.71	86.6	7.63
			5.0	20.26	0.498	7.25	81.4	7.55
			6.0	20.09	0.497	6.47	72.4	7.38
			7.0	19.92	0.497	7.02	78.3	7.45
			8.0	19.45	0.495	4.74	52.4	7.15
			9.0	18.07	0.499	1.67	17.9	6.91
			10.0	16.39	0.514	0.00	0.0	6.98
	11.0	13.63	0.530	0.00	0.0	7.08		
	12.0	12.10	0.530	0.00	0.0	7.08		
	13.0	11.46	0.544	0.00	0.0	7.09		
STA-3	1.9	1.9	0.1	19.28	0.623	9.29	102.1	9.11
			1.0	18.99	0.625	9.29	101.7	9.12
STA-4	2.7	2.0	0.1	19.20	0.505	7.72	84.8	7.66
			1.0	19.29	0.506	7.80	85.8	7.70
			2.0	19.24	0.507	7.67	84.3	7.63
STA-5	1.8	1.8	0.1	18.91	0.506	7.93	86.6	7.84
			1.0	18.89	0.506	7.84	85.6	7.84
STA-6	3.3	2.2	0.1	19.73	0.497	7.62	84.6	7.62
			1.0	19.72	0.497	7.59	84.3	7.58
			2.0	19.53	0.497	7.52	83.1	7.56
			3.0	18.93	0.498	8.00	87.4	7.67
STA-7	1.5	1.5	0.1	17.80	0.362	6.26	66.8	7.25
			1.0	17.55	0.365	6.29	66.7	7.20
STA-8	4.0	2.3	0.1	20.12	0.499	7.32	82.0	7.50
			1.0	20.10	0.499	7.32	81.9	7.53
			2.0	20.10	0.499	7.32	81.9	7.52
			3.0	20.05	0.498	7.29	81.4	7.53
STA-9	7.6	2.0	0.1	19.98	0.496	7.70	85.8	7.58
			1.0	19.91	0.497	7.75	86.4	7.57
			2.0	19.70	0.497	7.86	87.2	7.60
			3.0	19.63	0.497	7.80	86.4	7.69
			4.0	19.58	0.497	7.64	84.6	7.55
			5.0	19.54	0.497	7.59	83.9	7.54
			6.0	19.46	0.497	7.55	83.4	7.53
7.0	19.41	0.497	7.43	82.0	7.49			
STA-10	1.0	1.0	0.1	17.47	0.441	9.45	100.3	8.74
			0.7	17.37	0.438	9.49	100.7	8.76
STA-11	2.3	2.0	0.1	16.42	0.328	5.30	55.1	7.01
			1.0	16.00	0.334	5.35	55.0	6.94
			2.0	15.76	0.336	5.36	54.8	6.89

APPENDIX C

DISCRETE DATA

HOPATCONG					
2-May-2017					
STATION	Chlorophyll (mg/m³)	NH3-N (mg/L)	NO3-N (mg/L)	TP (mg/L)	TSS (mg/L)
ST-1	9.8	0.03	0.15	0.03	8
ST-2	14.0	0.01	0.05	0.02	9
ST-3	10.0	0.01	0.37	0.03	8
ST-4	9.2	0.18	0.06	0.03	11
ST-5	8.6	ND<0.01	0.03	0.03	9
ST-6	12.0	0.02	0.09	0.03	10
ST-7	14.0	0.08	0.10	0.04	8
ST-10	11.0	0.02	0.19	0.04	7
ST-11	24.0	0.03	0.12	0.04	13
ST-2 DEEP		0.56	0.07	0.02	8
MEAN	12.5	0.09	0.12	0.031	9.1

6-Jun-2017					
STATION	Chlorophyll (mg/m³)	NH3-N (mg/L)	NO3-N (mg/L)	TP (mg/L)	TSS (mg/L)
ST-1	8.6	0.03	0.08	0.03	ND<3
ST-2	9.2	0.02	0.03	0.03	ND<3
ST-3	16.0	0.01	0.06	0.05	ND<3
ST-4	7.2	0.01	0.05	0.03	3
ST-5	3.8	ND<0.01	0.10	0.03	ND<3
ST-6	6.5	0.01	0.04	0.03	ND<3
ST-7	7.9	0.04	0.12	0.04	ND<3
ST-10	22.0	0.01	0.30	0.05	ND<3
ST-11	11.0	0.03	0.08	0.05	ND<3
ST-2 DEEP		0.15	0.03	0.02	ND<3
MEAN	10.2	0.03	0.09	0.036	1.7

19-Jul-2017					
STATION	Chlorophyll (mg/m³)	NH3-N (mg/L)	NO3-N (mg/L)	TP (mg/L)	TSS (mg/L)
ST-1	21.0	0.01	0.08	0.04	8
ST-2	11.0	0.01	0.02	0.02	3
ST-3	15.0	0.01	0.04	0.04	5
ST-4	11.0	0.01	0.04	0.02	4
ST-5	11.0	0.01	0.03	0.02	4
ST-6	12.0	0.01	0.02	0.02	3
ST-7	7.1	0.02	0.10	0.04	3
ST-10	23.0	0.01	0.14	0.04	7
ST-11	16.0	0.04	0.14	0.04	ND<3
ST-2 DEEP		0.68	0.18	0.11	6
MEAN	14.1	0.08	0.08	0.039	4.5

21-Aug-2017					
STATION	Chlorophyll (mg/m ³)	NH3-N (mg/L)	NO3-N (mg/L)	TP (mg/L)	TSS (mg/L)
ST-1	27.0	ND<0.01	0.06	0.04	9
ST-2	14.0	ND<0.01	ND<0.02	0.02	ND<3
ST-3	13.0	ND<0.01	0.03	0.03	ND<3
ST-4	14.0	ND<0.01	0.03	0.03	ND<3
ST-5	11.0	ND<0.01	0.06	0.03	ND<3
ST-6	11.0	ND<0.01	0.12	0.01	ND<3
ST-7	15.0	ND<0.01	0.09	0.03	ND<3
ST-10	27.0	ND<0.01	0.05	0.04	6
ST-11	9.9	0.04	0.13	0.04	3
ST-2 DEEP		0.52	0.06	0.09	3
MEAN	15.8	0.06	0.06	0.036	3.0

10/2/17 (Sept)					
STATION	Chlorophyll (mg/m ³)	NH3-N (mg/L)	NO3-N (mg/L)	TP (mg/L)	TSS (mg/L)
ST-1	-	ND<0.01	0.05	0.03	5
ST-2	11.0	ND<0.01	0.02	0.02	ND<3
ST-3	7.6	ND<0.01	0.04	0.03	4
ST-4	5.3	ND<0.01	0.04	0.02	ND<3
ST-5	3.3	ND<0.01	0.03	0.02	ND<3
ST-6	-	ND<0.01	0.03	0.03	ND<3
ST-7	-	ND<0.01	0.08	0.03	ND<3
ST-10	10.0	ND<0.01	0.04	0.04	ND<3
ST-11	-	0.01	0.07	0.04	ND<3
ST-2 DEEP		1.80	0.09	0.31	12
MEAN	7.4	0.19	0.05	0.057	3.2

APPENDIX D

Plankton Data

Phytoplankton and Zooplankton Community Composition Analysis											
Sampling Location: Lake Hopatcong				Sampling Date: 5/2/2017				Examination Date: 5/5/2017			
Site 1: Mid-Lake											
Phytoplankton											
Bacillariophyta (Diatoms) 1											
<i>Asterionella</i> P											
<i>Fragilaria</i> P											
<i>Rhizosolenia</i> R											
<i>Tabellaria</i> C											
Zooplankton											
Cladocera (Water Fleas) 1				Copecoda (Copepods) 1				Rotifera (Rotifers) 1			
<i>Bosmina sp.</i> R				<i>Cyclops sp.</i> A				<i>Asplanchnopus sp.</i> R			
Arthropoda (Arthropods)				<i>D Nauplius</i> P							
<i>Ostracoda</i> R											
Sites: 1				Comments:							
Total Phytoplankton Genera 4											
Total Zooplankton Genera 5											
Sample Volume (mL)				Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)							
				Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare (R);							

Phytoplankton and Zooplankton Community Composition Analysis										
Sampling Location: Hopatcong			Sampling Date: 6/6/2017			Examination Date: 6/7/2017				
Site 1: ST2										
Phytoplankton										
Bacillariophyta (Diatoms)	1				Chlorophyta (Green Algae)	1			Cyanophyta (Blue-Green Algae)	1
<i>Asterionella</i>	C				<i>Sphaerocystis</i>	P			<i>Coelosphaerium</i>	C
<i>Fragilaria</i>	A				<i>Pediastrum</i>	P			Pyrrhophyta (Dinoflagellates)	
<i>Tabellaria</i>	A				Desmids (Green Algae)				<i>Ceratium</i>	P
Chrysophyta (Golden Algae)					<i>Staurastrum</i>	R				
<i>Dinobryon</i>	C									
<i>Mallomonas</i>	R									
Zooplankton										
Cladocera (Water Fleas)	1				Copecoda (Copepods)	1			Rotifera (Rotifers)	1
<i>Bosmina sp.</i>	A				<i>Cyclops sp.</i>	C			<i>Keratella</i> (H)	P
					<i>D Nauplius</i>	P			<i>Asplanchna</i>	C
									<i>Polyarthra</i>	C
Sites:	1	2			Comments: High density sample for both zooplankton and phytoplankton					
Total Phytoplankton Genera		10								
Total Zooplankton Genera		6								
Sample Volume (mL)					Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)					
					Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare (R);					

Phytoplankton and Zooplankton Community Composition Analysis																	
Sampling Location: Lake Hopatcong				Sampling Date: 7/19/2017				Examination Date: 7/19/2017									
Site 1: Mid-Lake																	
Phytoplankton																	
Bacillariophyta (Diatoms)			1				Chlorophyta (Green Algae)			1							
<i>Asterionella</i>			R				<i>Pediastrum</i>			P							
<i>Fragilaria</i>			C				Desmids (Green Algae)										
<i>Melosira</i>			P				<i>Staurastrum</i>			R							
<i>Tabellaria</i>			C														
							<i>Coelosphaerium</i>			P							
							<i>Lyngbya</i>			C							
							<i>Microcystis</i>			P							
Chrysophyta (Golden Algae)												Pyrrhophyta (Dinoflagellates)					
<i>Dinobryon</i>			R										<i>Ceratium</i>			P	
Zooplankton																	
Cladocera (Water Fleas)			1				Copepoda (Copepods)			1				Rotifera (Rotifers)			1
<i>Bosmina sp.</i>			C				<i>Cyclops sp.</i>			P				<i>Keratella spp.</i>			P
<i>Ceriodaphnia</i>			C				<i>Diaptomus (H)</i>			P				<i>Kellicottia longispina</i>			P
							<i>D Nauplius</i>			P				<i>Asplanchnopus sp.</i>			P
													<i>Polyarthra</i>			P	
Sites:			1				Comments: High density sample										
Total Phytoplankton Genera			12														
Total Zooplankton Genera			9														
Sample Volume (mL)							Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)										
							Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare (R);										

