LAKE HOPATCONG HABS GRANT INTERIM REPORT

MORRIS AND SUSSEX COUNTIES, NEW JERSEY

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1.0 INTRODUCTION

Lake Hopatcong (Appendix I) experienced unprecedented harmful algal blooms (HABs) of cyanobacteria over the majority of the 2019 summer season from mid-June well into October. These HABs resulted in the posting of advisories over large sections of the lake and the closing of all beaches by local/County Departments of Health. These conditions resulted in substantial impacts on the ecological, recreational, and economic resources of the lake and region. These conclusions are based on routine, baseline monitoring of Lake Hopatcong, conducted by the Lake Hopatcong Commission's (LHC) environmental consultant, Princeton Hydro (PH). These blooms were triggered by some of the highest June total phosphorus (TP) concentrations measured over the last 25 years. While prevailing weather conditions contributed toward these elevated TP concentrations, the contributing sources of TP stem from external sources, primarily stormwater and septic systems.

The LHC recently updated its TMDL-based Restoration Plan, approved in 2006, with funds provided by the NJ Highlands Council. The Restoration Plan was updated to include potential streambank and shoreline projects, as well as stormwater / surface runoff projects. Additionally, wherever possible, Green Infrastructure (GI) stormwater measures were integrated into this updated Watershed Implementation Plan (WIP). There were also a very cursory assessment of the water quality benefits, specifically reductions in phosphorous, that would result from sewering the remaining portions of the watershed that are still on septic systems. Finally, the WIP followed the nine elements of a WIP, as outlined by US EPA, in order to maximize opportunities for Federal and State funding.

While the update WIP focuses on stormwater and septic management, it will take years to implement all of the recommended measures. It has taken approximately 12 years to implement watershed-control measures throughout the watershed, as identified in the original Restoration Plan, to attain 33% compliance with the lake's TMDL for TP. Thus, while these long-term, watershed measures are absolutely necessary, some more short-term, in-lake/nearshore measures needed to be implemented to minimize the local impacts of HABs to protect the lake and the local economy.

There are a variety of in-lake/near-shore management measures that can prevent, mitigate, and/or control HABs on a more short-term basis and in localized areas. As the stewards of Lake Hopatcong, the LHC has been closely working with the Lake Hopatcong Foundation (LHF), Sussex and Morris Counties, and the four municipalities that surround the lake (Jefferson, Hopatcong, Mt. Arlington, and Roxbury) to develop both short and long-term strategies to address, minimize, or even prevent a recurrence of the HAB problems of 2019. Thus, the LHC applied for and were awarded funds from the New Jersey Department of Environmental Protection (NJDEP) to implement and evaluate a set of innovative management measures to prevent, mitigate and/or control HABs, particularly in local, near-shore areas where people have the highest degree of direct contact with the water.

This study evaluates a variety of innovative, in-lake management measures designed to prevent, mitigate, and control the development of HABs in Lake Hopatcong. These measures include floating wetland islands (FWIs), new types of phosphorus removal filter media installed in existing stormwater basins, installation of three types of aeration systems, application of a nutrient inactivating product (PhosLock), a treatment of a non-copper-based algaecide (GreenClean), the use of a filter media (Biochar) that removes phosphorus and can subsequently be used for mulch and the implementation of the Rutgers rain garden program. These innovative management techniques have been objectively evaluated through a variety of water quality monitoring activities that were conducted before and after each management measure was implemented and compared treated sites with untreated (control) sites. Thus, the overall Project Goals were two-fold. First, implement innovative, in-lake management measures that can be utilized in the control and management of HABs. Second, objectively document the cost effectiveness of these in-lake measures to determine if they are applicable to other lakes in New Jersey to combat HABs. The following report documents and objectively assesses the effectiveness of the management techniques implemented in 2020 to prevent, mitigate, and control the development of HABS in Lake Hopatcong.

2.0 METHODOLOGY

BASELINE MONITORING

As is routinely conducted, Lake Hopatcong was monitored five (5) times over the 2020 growing season. There are a total of eleven (11) standard in-lake sampling stations (Appendix I). During each monitoring event, *in-situ* data was collected at all stations, from surface to bottom at 0.5 to 1.0-meter intervals for temperature, dissolved oxygen, pH and conductivity. Water clarity was measured with a Secchi disk.

Discrete water quality samples were collected with a Van Dorn sampling device at 0.5 m below the lake surface, mid-depths 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 total phosphorus (TP), soluble reactive phosphorus (SRP), ammonia-N (NH_3-N), nitrate-N (NO_3-N), chlorophyll-*a* (Chl *a)*, total suspended solids (TSS).

During each sampling event, phytoplankton and zooplankton samples were collected at the surface and mid-depths at the deep sampling station (Station 2). Phytoplankton samples were collected at the surface and mid-depths utilizing a Van Dorn sampling device and quantitatively assessed, while zooplankton samples were collected utilizing a Schindler sampling device at each of those depths and qualitatively assessed.

An updated Quality Assurance Protection Plan (QAPP) was developed for Lake Hopatcong that outlines all of the sampling locations associated with the project sites (Appendix II).

OBJECTIVE 1: PHOSLOCK, BIOCHAR, AND FLOATING WETLAND ISLANDS IN ASHLEY COVE

The goal of Objective 1 was to determine if several in-lake management measures could be implemented collectively to prevent or control the development of HABs in a more isolated section of Lake Hopatcong, where flushing with the main body of the lake was minimal. Ashely Cove is a 2-acre cove separated from the main body of the lake by a narrow canal and is located in Jefferson Township. The cove is frequently used to temporarily store the mechanical weed harvesters over the growing season. In 2020 Biochar (proceeded wood material that has a high affinity for removing pollutants) was installed in the cove and a series of PhosLock treatments were conducted to strip the water column of available phosphorus. While not part of the original Scope of Work a GreenClean treatment (an algicide which is a strong oxidizer) was conducted in Ashely Cove to know down the mat and plankton algae biomass. In the spring of 2022, an existing Floating Wetland Island (FWI) will be refurbished and a new one will be installed in the cove.

Pre- and post-treatment monitoring were conducted one (1) time before the PhosLock applications and two (2) times after the applications. One (1) central sampling station was established in Ashley Cove and monitored during each sampling event. During each sampling event, *in-situ* measurements with a calibrated meter were taken for dissolved oxygen (DO), pH, temperature, and conductivity. Water clarity was measured with a Secchi disk and sub-surface discrete samples for the analysis of ammonia-N, nitrate-N, total suspended solids, chlorophyll-*a* and phytoplankton (cyanobacteria cell counts) were collected during each monitoring event. Samples were also collected for various species of phosphorus (total phosphorus, total dissolved phosphorus and soluble reactive phosphorus) from mid-cove (both sub-surface and bottom).

OBJECTIVE 3: INSTALLATION AND EVALUATION OF VARIOUS TYPES OF AERATION ALONG NEARSHORE BEACH AREAS FOR HAB CONTROL

Once the three nearshore aeration systems are installed, Princeton Hydro will conduct three on-lake assessments of the systems to evaluate their relative effectiveness at controlling HABs. Tentatively, these sampling events will be conducted in June, July, and August, and samples will be collected within the aerated zones and analyzed for cyanobacteria cell counts, microcystins, chlorophyll a, and phycocyanin. *In-situ* data will also be collected for temperature, dissolved oxygen, pH, and conductivity.

OBJECTIVE 4: TREATMENT AND EVALUATION OF PHOSLOCK TO PREVENT OR MINIMIZE THE DEVELOPMENT OF CYANOHABS

While a dosage rate for PhosLock was provided for the grant, a formal assessment of the organic / inorganic fractions of phosphorus in the sediments, as well as their relative availability, needed to be conducted in order to determine the specific dosage rate and treatment strategy. Princeton Hydro collected a total of five (5) sediment samples from the northern end of the lake and formed a composite sample for each that was appropriately preserved and transported to SePRO's analytical laboratory and analyzed for various forms of phosphorus in the sediment (labile, organic, apatite, residual, etc.).

Pre- and post-treatment monitoring were conducted one (1) time before the PhosLock application and three (3) times after the application. One central sampling station was established in Landing Channel and monitored during each sampling event. During each sampling event, in-situ measurements with a calibrated meter were taken for dissolved oxygen (DO), pH, temperature, and conductivity. Water clarity was measured with a Secchi disk and sub-surface discrete samples for the analysis of phytoplankton cell counts, chlorophyll a, phycocyanin, microcystins, and various species of phosphorus (total phosphorus, soluble reactive phosphorus, and total dissolved phosphorus). In addition, nearby long-term monitoring sampling sites, specifically Station 5 (ST-5) was used as pre-treatment and "control" sites to evaluate the effectiveness of the PhosLock.

OBJECTIVE 5: TREATMENT AND EVALUATION OF STRONG OXIDIZER FOR HAB CONTROL

Pre- and post-treatment monitoring were conducted just before and after the GreenClean application at one station just off Capp Beach. During each sampling event, in-situ measurements with a calibrated meter were taken for dissolved oxygen (DO), pH, temperature, and conductivity. Water clarity was measured with a Secchi disk and sub-surface discrete samples for the analysis of microcystins, cyanobacteria cell counts, chlorophyll a, and phycocyanin.

OBJECTIVE 6: USE OF BIOCHAR TO PREVENT HABS IN NEARSHORE INLET OR BEACH AREAS

After the Biochar was installed, monitoring was conducted immediately upgradient and down gradient of the structures. Two sampling events were conducted at each sampling site and all collected samples will be analyzed for TP, TDP and SRP. The Biochar was installed at the following sites:

- Lorettacong Drive
- Yacht Club
- Edith M Decker Elementary School
- Lakeside
- Memorial Pond
- Duck Pond

3.0 OBJECTIVE 1: PHOSLOCK, BIOCHAR, AND FLOATING WETLAND ISLANDS IN ASHLEY COVE

PROJECT SUMMARY

A series of three projects were approved for Ashley Cove to be implemented and evaluated over a two-year period. These projects include a series of low-dose, PhosLock applications that are intended to see if phosphorus stripping in an enclosed waterway can achieve the desired levels of HAB control. Thus, Ashley Cove was treated with PhosLock twice over the growing season to strip the water column of phosphorus and to inactivate the mobilization of phosphorus from the sediments. However, prior to the first PhosLock treatment, a treatment with the oxidizing algicide GreenClean was conducted to knock down the existing algae biomass that was in Ashley Cove. Note, Princeton Hydro's licensed applicators secured the State permit to conduct the algicide treatment in Ashley Cove prior to treatment.

To further reduce available phosphorus in Ashely Cove, some sleeves of Biochar were also installed over the 2020 growing season. The Biochar sleeves were placed directly in front of a large stormwater pipe that enters the cove just off of Espanong Road.

Finally, two-existing floating wetland islands (FWIs) are to be re-planted and provided with upgraded anchoring and tethering material and then relocated to an area where they will receive full sunlight. Additionally, another FWI structure (approximately 160 sq. ft in surface area) will be purchased, built, planted, and installed in a nearshore area that will receive full sunlight. However, an inspection of the existing FWIs over the 2021 growing season revealed that one of them is being used as a nesting site for a family of swans. Thus, it was decided to refurbish the Island that is not being used by the swans, purchase a new, larger Island, and possibly purchase more Biochar for use at Ashley Cove. The Island project will be conducted in spring of 2022 but the materials will be purchased in 2021.

SCHEDULE OF EVENTS

After a review of the baseline monitoring data in Lake Hopatcong, the first PhosLock application was scheduled for late July. Pre-treatment monitoring was conducted on 5 June 2020. Two PhosLock applications were conducted on 31 July 2020 and 28 August 2020. Two (2) post-treatment monitoring events were conducted on 4 September 2020 and 9 October 2020. As previously mentioned, a GreenClean treatment was conducted on 15 July 2020 to knock down the accumulated mat and planktonic algae before the PhosLock was added. A full breakdown of the pre- and post-treatment monitoring schedule, including the date of the treatments, is provided in Table 3.1 below.

Table 3.1: Ashley Cove: Treatment and monitoring schedule.

Ashley Cove: Treatment Schedule	
Date	**Activity**
6/5/2020	Pre-treatment monitoring event
7/15/2020	GreenClean application
7/31/2020	1st PhosLock application
8/28/2020	2nd PhosLock application
9/4/2020	1st post-treatment monitoring event
10/9/2020	2nd post-treatment monitoring event

MONITORING RESULTS AND DATA ANALYSIS

The following section will discuss and objectively assess the results of the water quality data collected in Ashley Cove in 2020 relative to the success of the management measures in controlling the development of HABs. This section will focus primarily on the parameters that are most closely associated with the development of HABs, such as phosphorus and chlorophyll-*a* concentrations, cyanobacteria cell counts, phycocyanin concentrations, and water clarity. All *in-situ* and discrete data collected as part of the Ashley Cove monitoring can be found in full in Appendix III.

NITROGEN (NITRATE-N AND AMMONIA-N)

Surface samples for the analysis of nitrate-N and ammonia-N were collected pre- and post-treatment in Ashley Cove (Figure 3.1). Nitrate-N and ammonia-N both decreased during the first post-treatment event following the PhosLock and GreenClean treatments. However, neither of these products have a direct effect on nitrogen in the water column.

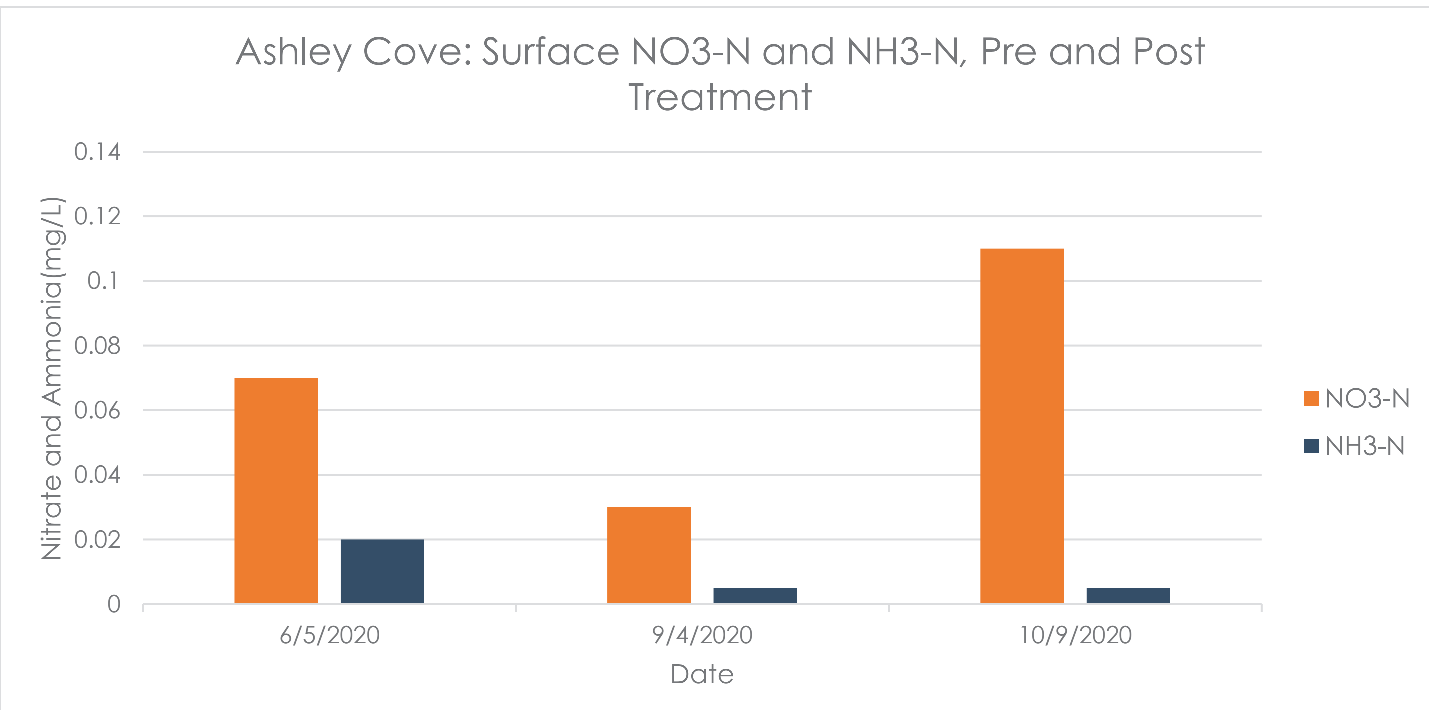


Figure 3.1: Pre- and post-treatment nitrate-N and ammonia-N concentrations in Ashley Cove.

TOTAL SUSPENDED SOLIDS

Surface samples for the analysis of total suspended solids were collected pre- and post-treatment in Ashley Cove (Figure 3.2). TSS concentrations were low during all three monitoring events and did not exceed 5 mg/L. The pre-treatment and initial post-treatment monitoring events yielded TSS concentrations of 5 mg/L before decreasing to a concentration of 3 mg/L during the second post-monitoring event in October.

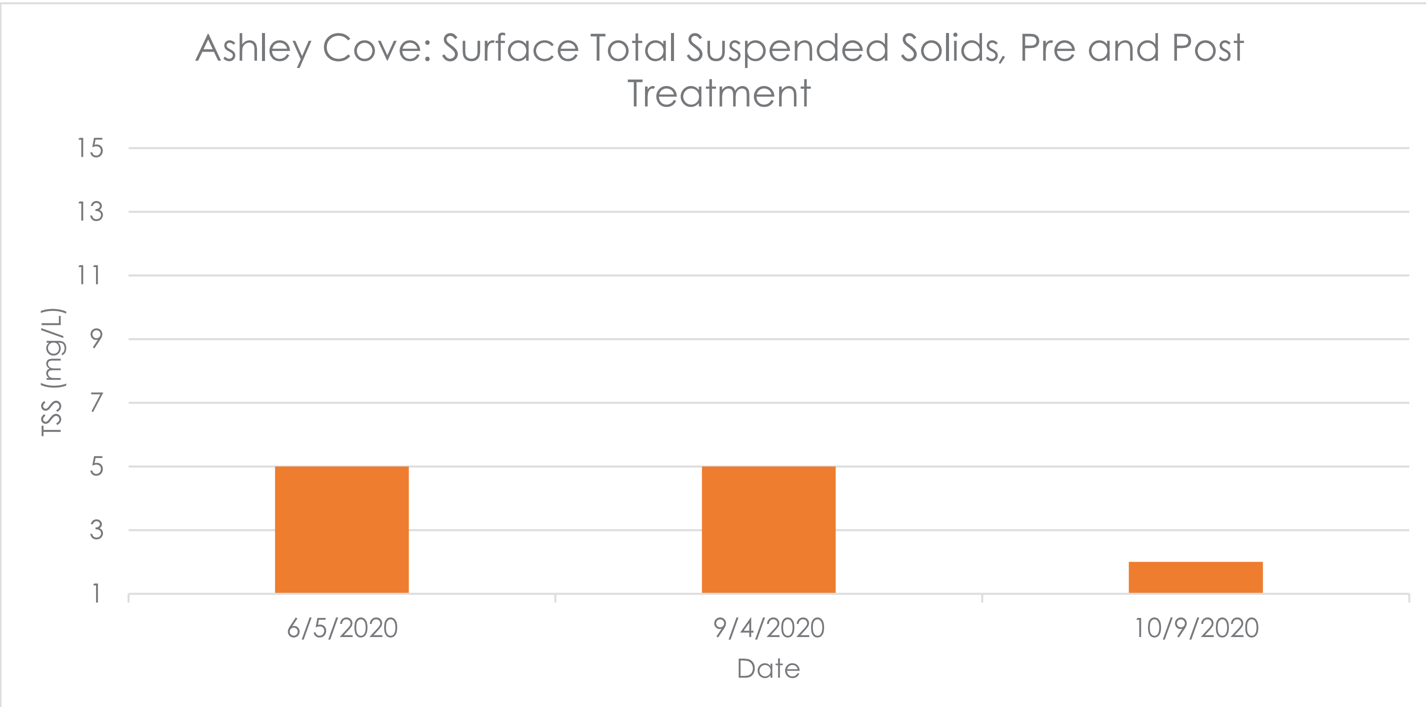


Figure 3.2: Pre- and post-treatment total suspended solid concentrations in Ashley Cove.

PHOSPHORUS (TOTAL PHOSPHORUS, SOLUBLE REACTIVE PHOSPHORUS, DISSOLVED REACTIVE PHOSPHORUS)

Surface samples for the analysis of phosphorus, soluble reactive phosphorus, and total dissolved phosphorus were collected pre- and post-treatment in Ashley Cove (Figure 3.3). Surface TP concentrations increased to 0.04 mg/L during the 4 September and 9 October monitoring events from a pre-treatment monitoring event concentration of 0.02 mg/L. Surface TDP concentrations increased to 0.02 mg/L during the 4 September and 9 October monitoring events from a pre-treatment monitoring event concentration of 0.01 mg/L However, the first post-treatment monitoring event occurred over two months after the early season pre-treatment monitoring event in June and TP concentrations had increased lake wide by late August. Similar to what we observed following the PhosLock application in Landing Channel, post-treatment SRP concentrations remained extremely low, even as TP and TDP concentrations increased later in the season.

However, what was particularly promising is that surface water TP concentrations remained at or below 0.04 mg/L over the 2020 growing season. This is substantially lower than the TP concentrations of 0.07 mg/L, which were measured in Ashely Cove in July 2012. Thus, the implementation of these in-lake management technique did appear to reduce phosphorus concentrations in Ashely Cove relative to past measurements.

Deep phosphorus metrics followed similar trends as those observed in the surface water (Figure 3.4). Deep TP concentrations increased from a pre-treatment monitoring concentration of 0.03 mg/L to an initial post-treatment monitoring concentration of 0.05 mg/L. However, deep TP concentrations during the second post-treatment monitoring event decreased to 0.02 mg/L, which was lower than the surface concentration of 0.04 mg/L. Deep TDP concentrations also decreased to non-detectable levels during the October post-treatment monitoring event while surface concentrations were 0.02 mg/L. Deep SRP concentrations remained low following the treatments, never exceeding 0.003 mg/L.

Overall, the PhosLock application appeared to have a positive effect on phosphorus concentrations in Ashley Cove. TP and TDP concentrations did increase slightly during the first post-treatment monitoring event, although never exceeded 0.05 mg/L for TP or 0.02 mg/L for TDP. Additionally, phosphorus concentrations lake wide had increased during the peak growing season months from July through September. Most importantly, and as expected with the PhosLock application, SRP concentrations remained extremely low throughout the season, even as TP concentrations increased. This is a positive sign, as SRP is the dissolved inorganic portion of total phosphorus that is readily available for assimilation by all algal forms. Even as SRP concentrations increased slightly during the October monitoring event, concentrations never exceeded 0.003 mg/L; SRP concentrations exceeding 0.005 mg/L are often associated with increases in nuisance algal growth. Finally, 2020 TP concentrations in Ashely Cove were substantially lower relative to past (20212) concentrations.

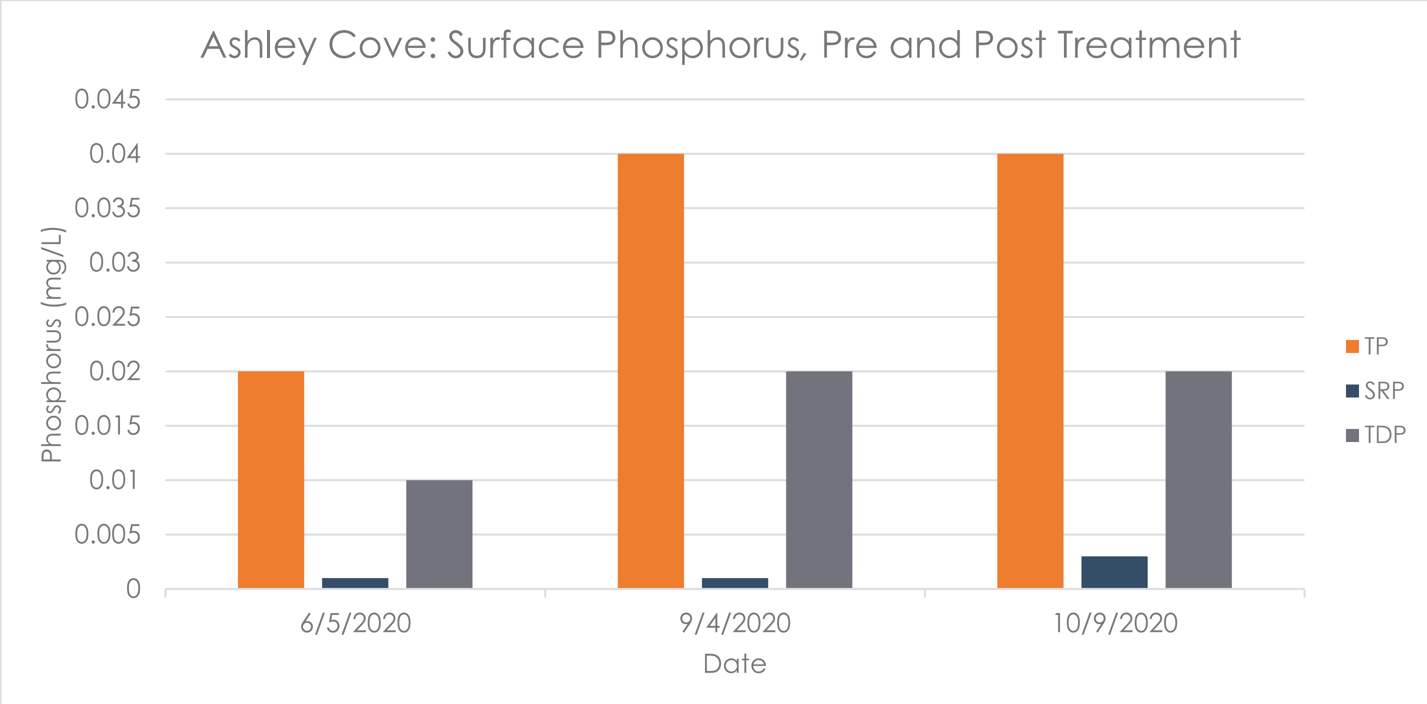


Figure 3.3: Pre- and post-treatment surface TP, TDP, and SRP concentrations in Ashley Cove.

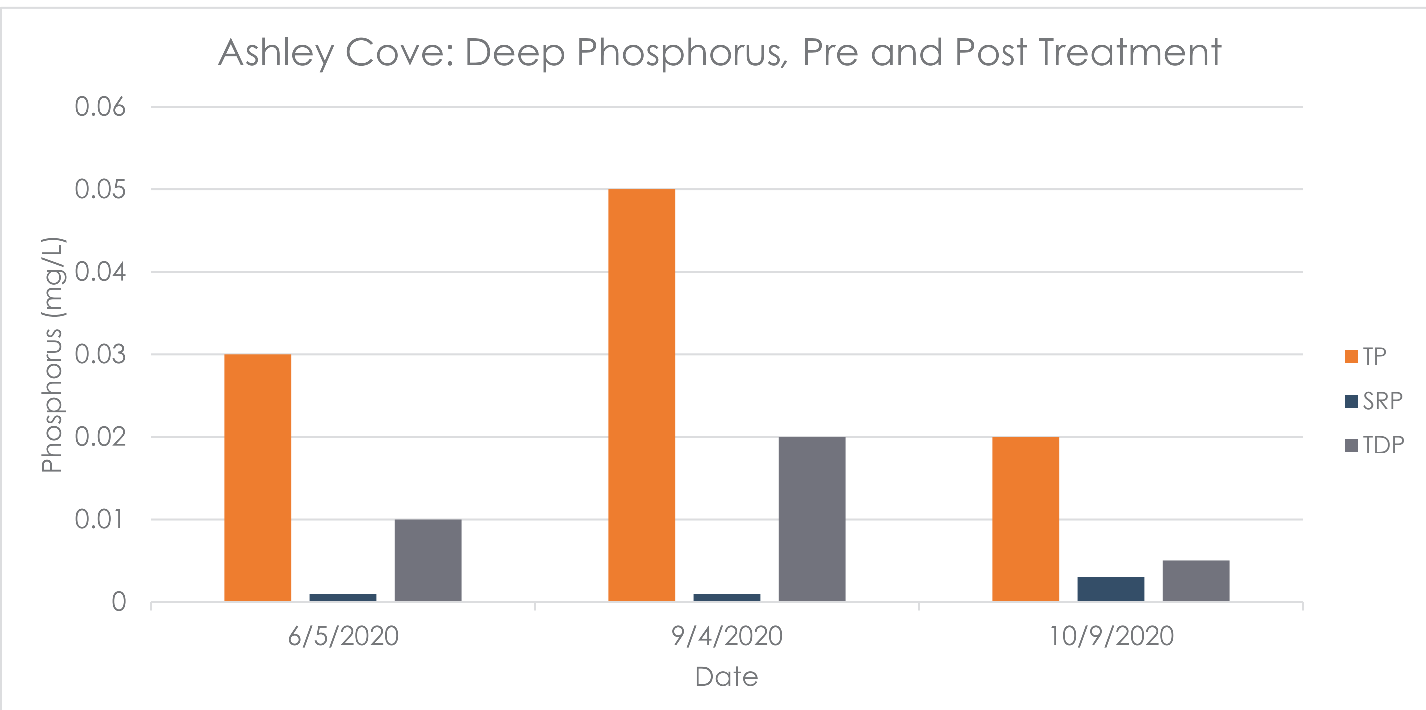


Figure 3.4: Pre-and post-treatment deep TP, TDP, and SRP concentrations in Ashley Cove.

CHLOROPHYLL *A*

Surface samples for the analysis of chlorophyll-a were collected pre- and post-treatment in Ashley Cove (Figure 3.5). Pre-treatment chlorophyll-a concentrations were low at 3.2 µg/L. Chlorophyll-*a* concentrations increased to a modest concentration of 13.0 µg/L during both post-treatment monitoring events. This is not unexpected, as surface TP concentrations were 0.04 mg/L during this time.

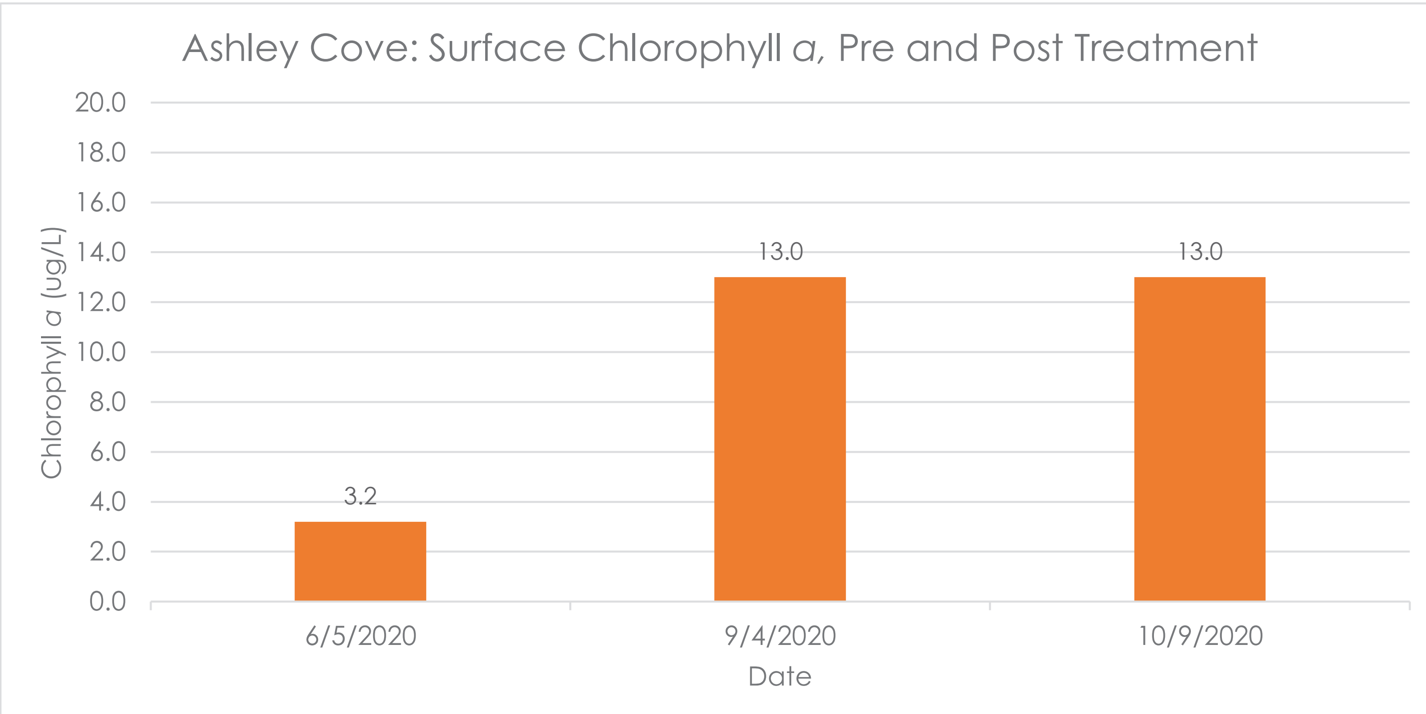


Figure 3.5: Pre-and post-treatment chlorophyll-*a* concentrations in Ashley Cove.

CYANOBACTERIA (PHYCOCYANIN AND CELL COUNT)

Surface samples for the analysis of cyanobacteria cell count and phycocyanin concentrations were collected during the pre- and post-treatment events in Ashley Cove (Figure 3.6). Cyanobacteria cell counts remained relatively low and well under any NJDEP HAB alerts during the three monitoring events, with a maximum of 12,970 cells/mL during the September monitoring event. Cyanobacteria cell counts remained below 3,000 cells/mL during the remaining monitoring events. Phycocyanin concentrations also remained relatively low, following a similar trend as cyanobacteria cell counts and a maximum concentration of 10 µg/L in September. Overall, it appears as though the PhosLock treatment has had a positive effect relative to cyanobacteria concentrations in Ashley Cove during the 2020 season, as both metrics remained low throughout.

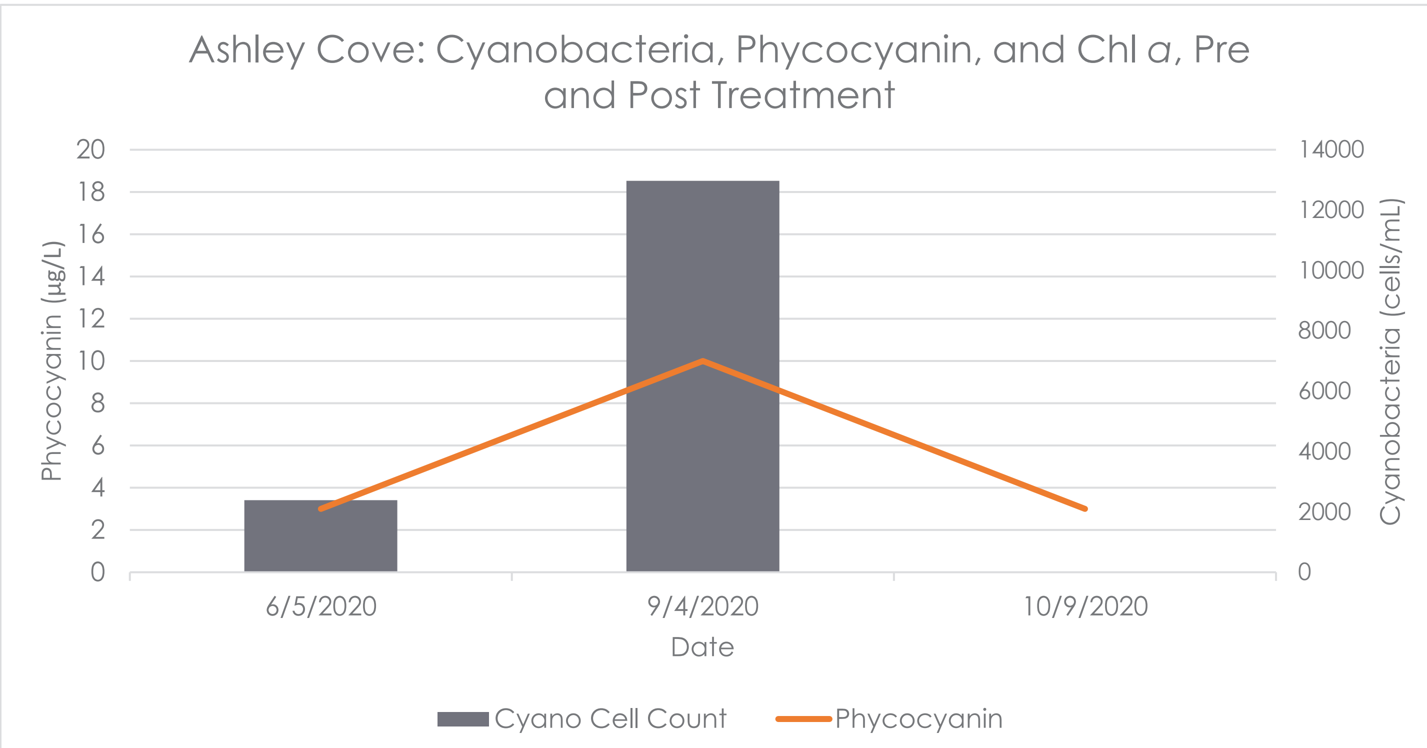


Figure 3.6: Pre- and post-treatment cyanobacteria cell counts and phycocyanin concentrations in Ashley Cove.

A few other points should be made. First, no microcystins were measured during the post-treatment monitoring events in Ashley Cove. In contrast, microcystins were measured during the pre-treatment June 2020 sampling event; however, the measured concentration, 1 ug/L, was below the State's threshold for recreational waters of 2 ug/L.

Second, while no cyanobacteria were identified in the October 2020 sample, there was still a reading of phycocyanin of 3 ug/L. The measurable concentrations of phycocyanin at that time was due to the presence of *Cryptomonas*, a small unicellular cryptomonad group of algae also known to produce phycocyanin. Indeed, in October 2020 the *Cryptomonas* cell density was 881 cells / mLs.

WATER CLARITY

Water clarity was measured with a Secchi disk pre- and post-treatment in Ashley Cove (Figure 3.7). Water clarity decreased slightly as the season progressed as chlorophyll-*a* concentrations increased. Clarity slightly decreased from a pre-treatment depth of 1.5 meters in early June to post-treatment depths of 1.3 meters and 1.2 meters in September and October, respectively. Water clarity never fell below 1.2 meters during the three monitoring events.

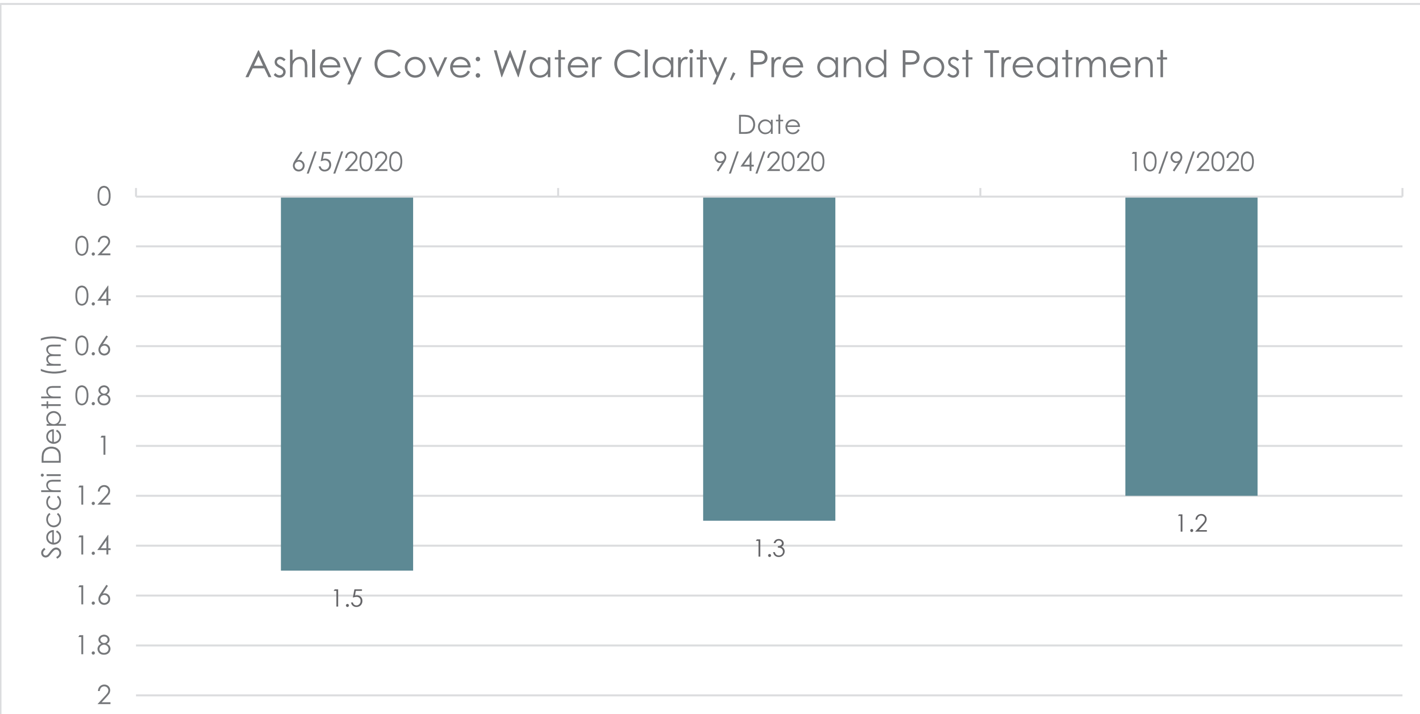


Figure 3.7: Pre- and post-treatment cyanobacteria cell counts and phycocyanin concentrations in Ashley Cove.

It should be noted that during the pre-treatment June sampling event, there was a dense canopy of Eurasian watermilfoil (*Myriophyllum spicatum*) and largeleaf pondweed (Potamogeton amplifolius). In addition, there were sporadic mats of filamentous algae. By September and October, the algal mats were gone but the sub-canopy of plants, including tapegrass (*Vallisneria americana*) were identified in Ashely Cove. Such conditions were expected, as water column phosphorus concentrations decline, there should be less algal growth (both planktonic and mat algae) and less competition for space and light. Thus, higher amounts of submerged aquatic vegetation are typically associated with a decline in algal growth, both planktonic and filamentous mat algae.

4.0 OBJECTIVE 3: INSTALLATION AND EVALUATION OF VARIOUS TYPES OF AERATION ALONG NEARSHORE BEACH AREAS FOR HAB CONTROL

PROJECT SUMMARY

Three varying forms of near-shore aeration for HAB prevention, mitigation, and/or control were installed along three specific beach areas in Lake Hopatcong. The first is the installation of an Air Curtain system along Shore Hills Beach (195 Mt. Arlington Blvd, Landing; Township of Roxbury). Air Curtain systems can be very effective at preventing the accumulation of cyanobacteria along near-shore areas. The second is the installation of a Nanobubble oxygen system along the Mount Arlington Municipal Beach (511 Windemere Ave, Borough of Mt. Arlington). The third is the installation of a Nanobubble ozone system along the Lake Forest Yacht Club (35 Yacht Club Drive, Lake Hopatcong: Township of Jefferson). Nanobubble technology is a fairly new form of aeration that has started to yield very positive results relative to HAB control and prevention. Thus, this new aeration technology was evaluated at Lake Hopatcong.

SCHEDULE OF EVENTS

The Air Curtain was installed at the Shore Hills Country Club (Roxbury) on 4-6 November 2020 (Photo 4.1). An evaluation of the Air Curtain and how it can prevent, mitigate and/or control HABs will be conducted over the 2021 growing season. In contrast, the Nanobubble system at the Memorial Municipal Beach (Mt. Arlington) and the Nanobubble / Ozone system at the Lake Forest Yacht Club (Jefferson)will be installed in 2021. Note, even though the HAB grant will end December 2021, due to logistical and infrastructure issues the nanobubble systems will be evaluated over the 2022 growing season.

MONITORING RESULTS AND DATA ANALYSIS

Again, the Air Curtain system will be evaluated over the 2021 growing season, while the two Nanobubble systems will be evaluated over the 2022 growing season. Note, while the HABs grant will end December 2021, the nanobubble systems will be evaluated over the 2022 growing season. Monitoring of the nanobubble systems sites will be conducted during the five standard, long-term, water quality monitoring events from May through September. Each nanobubble system site will include stations within the treatment zone and a control, outside of the treatment zone.

5.0 OBJECTIVE 4: TREATMENT AND EVALUATION OF PHOSLOCK TO PREVENT OR MINIMIZE THE DEVELOPMENT OF CYANOHABS

PROJECT SUMMARY

To better address the phosphorus that is fueling HABs from the shallow, organically enriched sediments, the LHC was interested in using an alternative to both copper-based algaecides and alum. Specifically, a treatment of PhosLock was conducted in Landing Channel in the early summer of 2020. PhosLock is a clay-based, non-aluminum-based nutrient inactivator that has been used in a variety of ways to inactivate phosphorus, making it unavailable for algal growth. While the product is frequently used to strip the water column of dissolved phosphorus, as well as to inactivate phosphorus generated from deep, anoxic sediments, it has recently been effectively used to inactivate the mobilization of phosphorus from shallow sediments where there is a mobilization of phosphorus from both chemical and biological processes.

Objective 4 involved a PhosLock treatment in Landing Channel to determine if this can be used to minimize or avoid HABs without the use of copper-based algaecides. The treatment was designed to inactivate some of the phosphorus originating from organically enriched sediments. Pre- and post-treatment monitoring, before and after the treatment, were conducted as part of the existing baseline monitoring for Lake Hopatcong. The monitoring program was also used to assess the effectiveness of the treatment relative to water quality parameters that quantify the impacts associated with HABs.

SCHEDULE OF EVENTS

Sediment sampling in Landing Channel was conducted early in the season so the dosage rate could be calculated, and the samples were collected on 23 April 2020. After a review of the baseline monitoring data in Lake Hopatcong, the PhosLock application was scheduled for mid-June. As such, pre-treatment monitoring was conducted on 12 June 2020. The PhosLock application was conducted from 15 June 2020 – 17 June 2020. Finally, three (3) post-treatment monitoring events were conducted on 24 June 2020, 22 July 2020, and 23 September 2020. A full breakdown of the pre- and post-treatment monitoring schedule, including the date of the treatments, is provided in Table 5.1 below.

Table 5.1: Landing Channel: Treatment and monitoring schedule.

Ashley Cove: Treatment Schedule	
Date	**Activity**
4/22/2020	Sediment sampling in Landing Channel
6/12/2020	Pre-treatment monitoring
6/15/2020 – 6/17/2020	PhosLock application in Landing Channel
6/24/2020	1st post-treatment monitoring event
7/22/2020	2nd post-treatment monitoring event
9/23/2020	3rd post-treatment monitoring event

The PhosLock application was conducted by Princeton Hydro. Approximately 22,000 lbs. of PhosLock were applied over an area of approximately 50 acres over the course of three (3) days. Thus, the dosage rate, as determined through the sediment sampling, was 440 lbs of PhosLock per acre.

MONITORING RESULTS AND DATA ANALYSIS

The following section will discuss and objectively assess the results of the water quality data collected in Lake Hopatcong relative to the success of the PhosLock treatment in controlling the development of HABs. This section will focus primarily on the parameters that are most closely associated with the development of HABs, such as phosphorus and chlorophyll-*a* concentrations, cyanobacteria cell counts, phycocyanin concentrations, and water clarity. Additional water quality data collected during the baseline monitoring of Lake Hopatcong will also be included in the analysis; Station 5 (ST-5) from the baseline monitoring program was used as a control site. All *in-situ* and discrete data collected as part of the PhosLock monitoring can be found in full in Appendix IV.

TOTAL PHOSPHORUS

Surface and deep-water samples for the analysis of total phosphorus (TP) were collected pre- and post-treatment in Landing Channel; surface samples were collected at Station 5 (ST-5) during the baseline monitoring as a control site (Figure 5.1). The initial post-treatment results were positive, as both surface and deep TP concentrations in the treatment zone decreased to 0.02 mg/L during the 24 June monitoring event; surface and deep TP concentrations were 0.03 mg/L and 0.04 mg/L two weeks prior, respectively. There was no control sample taken during the initial post-treatment monitoring event since it did not occur during a baseline monitoring event. Surface and deep TP concentrations in Landing Channel increased during the 22 July monitoring event, with respective concentrations of 0.05 mg/L and 0.08 mg/L. Control site TP concentrations remained constant at 0.03 mg/L during this monitoring event. Finally, surface and deep TP in Landing Channel as well as the surface TP in the control zone were uniform at 0.03 mg/L during the final monitoring event in September.

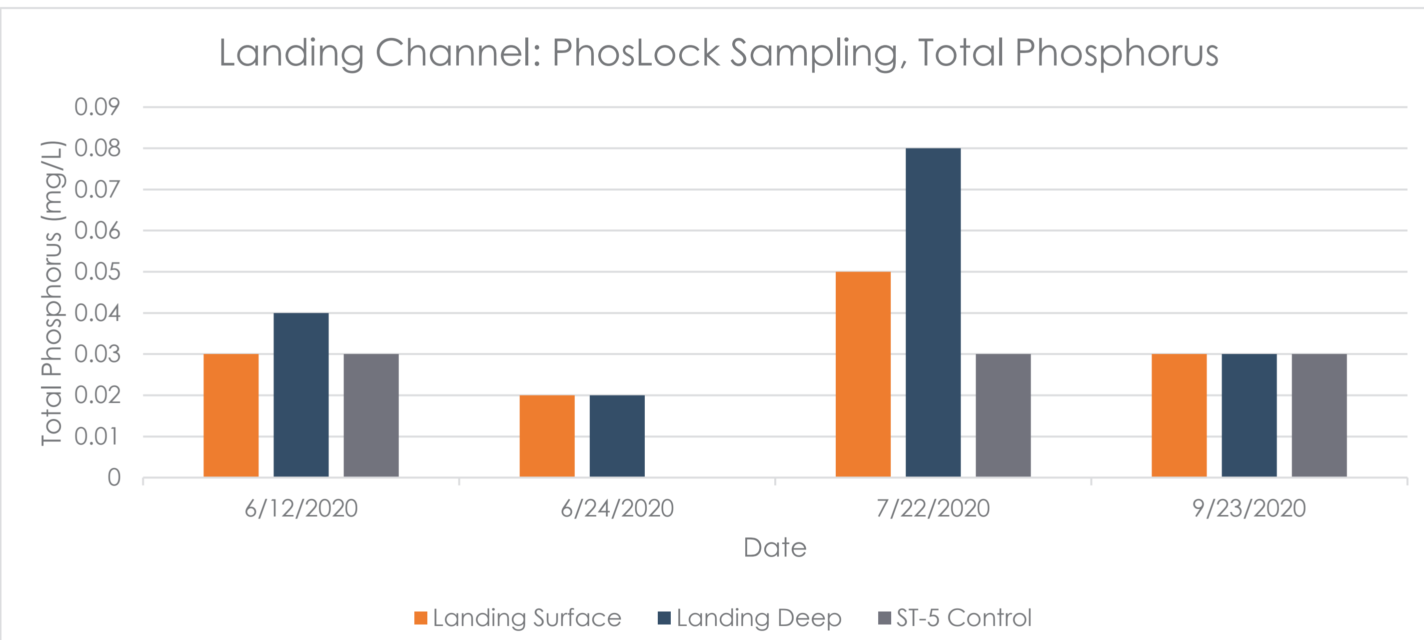


Figure 5.1: Pre- and post-treatment total phosphorus concentrations in Landing Channel. Please note that no sample was taken from the control site on 24 June 2020.

The initial TP results during the first post-treatment monitoring event were positive, as surface and deep TP concentrations in Landing Channel decreased from pre-monitoring concentrations of 0.03 mg/L and 0.04 mg/L to post treatment concentrations of 0.02 mg/L and .02 mg/L, respectively. However, TP concentrations in Landing channel increased during the following monitoring event in July while control zone TP concentrations remained at 0.03 mg/L. It should be noted that water temperatures throughout the lake were elevated during this time and remained above 28.00 °C throughout the water column in Landing Channel, which may have led to an increase in the oxic release of phosphorus from the bottom sediment. Additionally, TP concentrations exceeded 0.04 mg/L at three (3) additional baseline monitoring stations during this sampling event. The slight increase in TP throughout the lake was the result of a storm event that transported NPS pollution to the lake immediately prior to the July sampling event. The seasonal mean of surface TP concentrations in Landing Channel was 0.033 mg/L based on these four sampling events, which is slightly above the established 0.03 mg/L goal, as per the TMDL.

SOLUBLE REACTIVE PHOSPHORUS

Surface and deep-water samples for the analysis of soluble reactive phosphorus (SRP) were collected pre- and post-treatment in Landing Channel; surface samples were collected at Station 5 (ST-5) during the baseline monitoring as a control site (Figure 5.2). SRP concentrations remained below the detection limit (< 0.002 mg/L) at both surface stations during the pre-treatment monitoring event while the Landing Channel deep sample had a concentration of 0.002 mg/L. Following the treatment, both surface and deep SRP concentrations in Landing Channel remained below the detection limit during the following two post-treatment events in June and July. It is a positive sign that deep-water SRP remained below the detection limit during the July monitoring event while TP concentrations were slightly elevated at 0.08 mg/L. Surface SRP concentrations did increase to 0.004 mg/L during the final monitoring event in September, although deep-water and control zone SRP concentrations remained below the detection limit. However, it is not likely that the SRP in the surface water of Landing Channel originated from the sediments, since deep-water SRP concentrations at that station were below the detection limit.

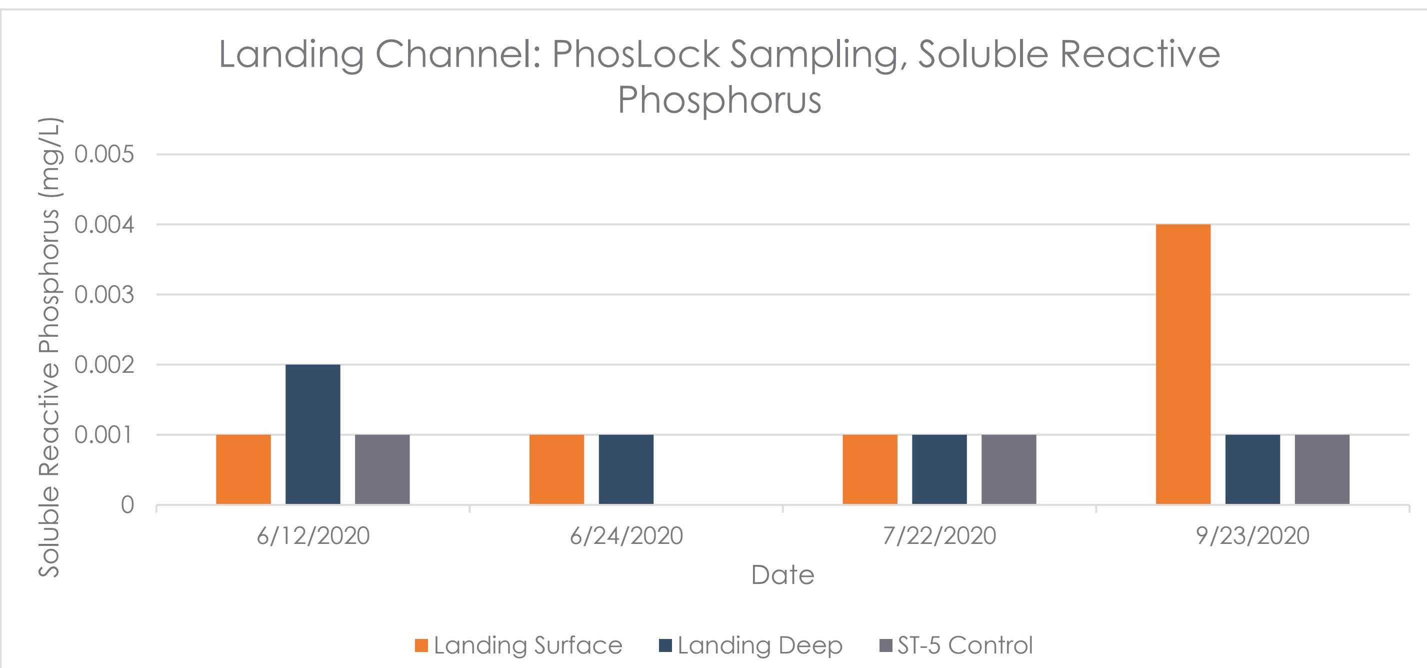


Figure 5.2: Pre- and post-treatment soluble reactive phosphorus concentrations in Landing Channel. Please note that no sample was taken from the control site on 24 June 2020.

Overall, it appears as though the PhosLock application had a positive effect on SRP concentrations in Landing Channel, as surface water concentrations remained non-detectable through July while deep-water concentrations remained non-detectable through the end of the season. Additionally, as TP concentrations increased in both the surface and deep-water of Landing Channel during the July monitoring event, SRP concentrations remained non-detectable. This is a positive sign, as SRP is the dissolved inorganic portion of total phosphorus that is readily available for assimilation by all algal forms. Even as SRP concentrations increased in Landing Channel later in the season, concentrations remained below 0.005 mg/L; SRP concentrations exceeding 0.005 mg/L are often associated with increases in nuisance algal growth.

TOTAL DISSOLVED PHOSPHORUS

Surface and deep-water samples for the analysis of total dissolved phosphorus (TDP) were collected pre- and post-treatment in Landing Channel; no samples were collected at Station 5 (ST-5) during the baseline monitoring as a control site since this parameter is not routinely monitored (Figure 5.3). TDP concentrations were uniform at 0.02 mg/L in the surface and deep-water of Landing Channel during the pre-treatment monitoring event in June. TDP concentrations decreased at both depths following the treatment, with respective concentrations of 0.005 mg/L and 0.01 mg/L on 24 June 2020. As TP concentrations increased in Landing Channel during the July monitoring event, TDP concentrations also increased. Surface and deep-water TDP concentrations during this sampling event were 0.04 and 0.05, respectively; TP concentrations were 0.05 and 0.08, respectively, during this time. TDP concentrations were low again during the final monitoring event in September, at 0.02 mg/L.

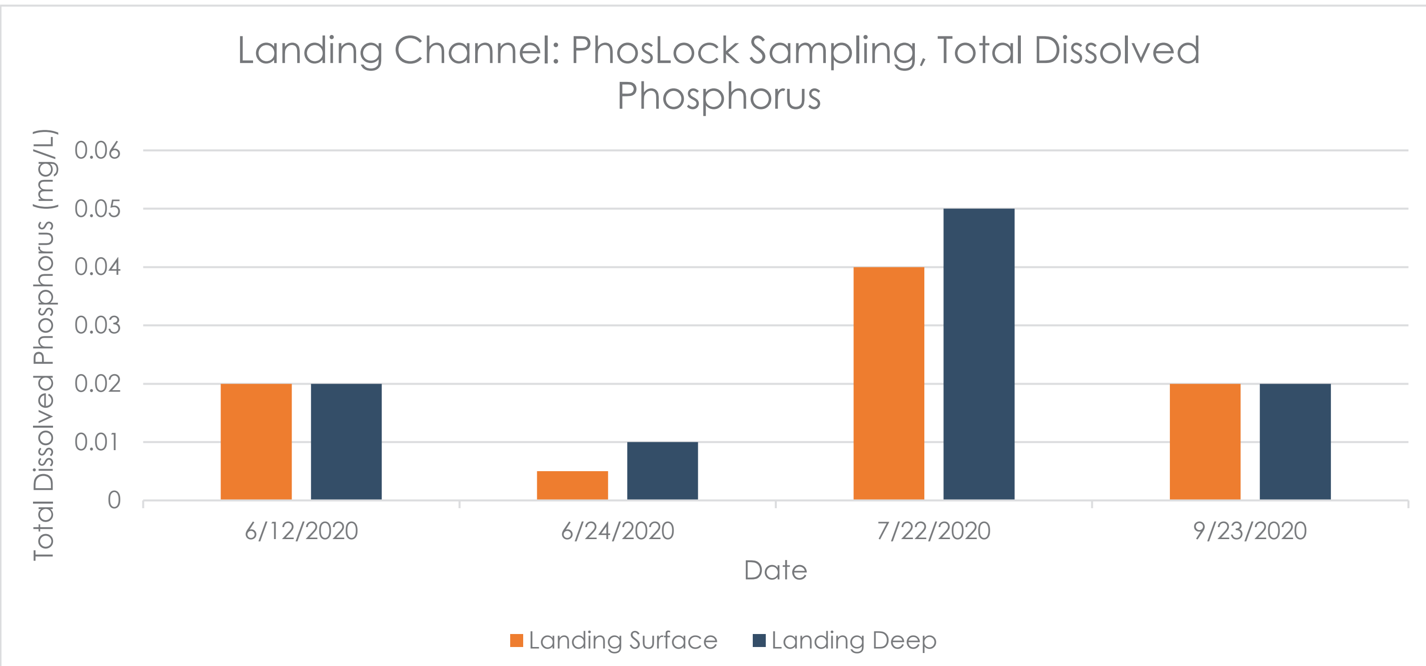


Figure 5.3: Pre- and post-treatment soluble reactive phosphorus concentrations in Landing Channel. Please note that no sample was taken from the control site on 24 June 2020.

The initial TDP results during the first post-treatment monitoring event were positive, as surface and deep TDP concentrations in Landing Channel decreased from a pre-monitoring concentration of 0.02 mg/L to post treatment concentrations of 0.005 mg/L and .01 mg/L, respectively. However, similar to TP concentrations, TDP concentrations in Landing channel increased during the following monitoring event in July. As previously mentioned, water temperatures were elevated and above 28.00 °C during this time, and TP concentrations throughout the lake were elevated as a result of a recent storm.

CHLOROPHYLL *A*

Surface samples for the analysis of chlorophyll-*a* were collected pre- and post-treatment in Landing Channel; surface samples were collected at Station 5 (ST-5) during the baseline monitoring as a control site (Figure 5.4). Chlorophyll-*a* concentrations were relatively low during the pre-treatment monitoring event, with a concentration of 5.2 µg/L in Landing Channel. Following the PhosLock application, chlorophyll *a* in Landing Channel decreased slightly to 4 µg/L. As temperatures rose and phosphorus concentrations increased lake wide during the July monitoring event, chlorophyll-*a* concentrations increased in Landing Channel and the control zone, with respective concentrations of 26 µg/L and 22 µg/L. Chlorophyll-*a* concentrations exceeded 25 µg/L in three other baseline monitoring stations during this monitoring event.

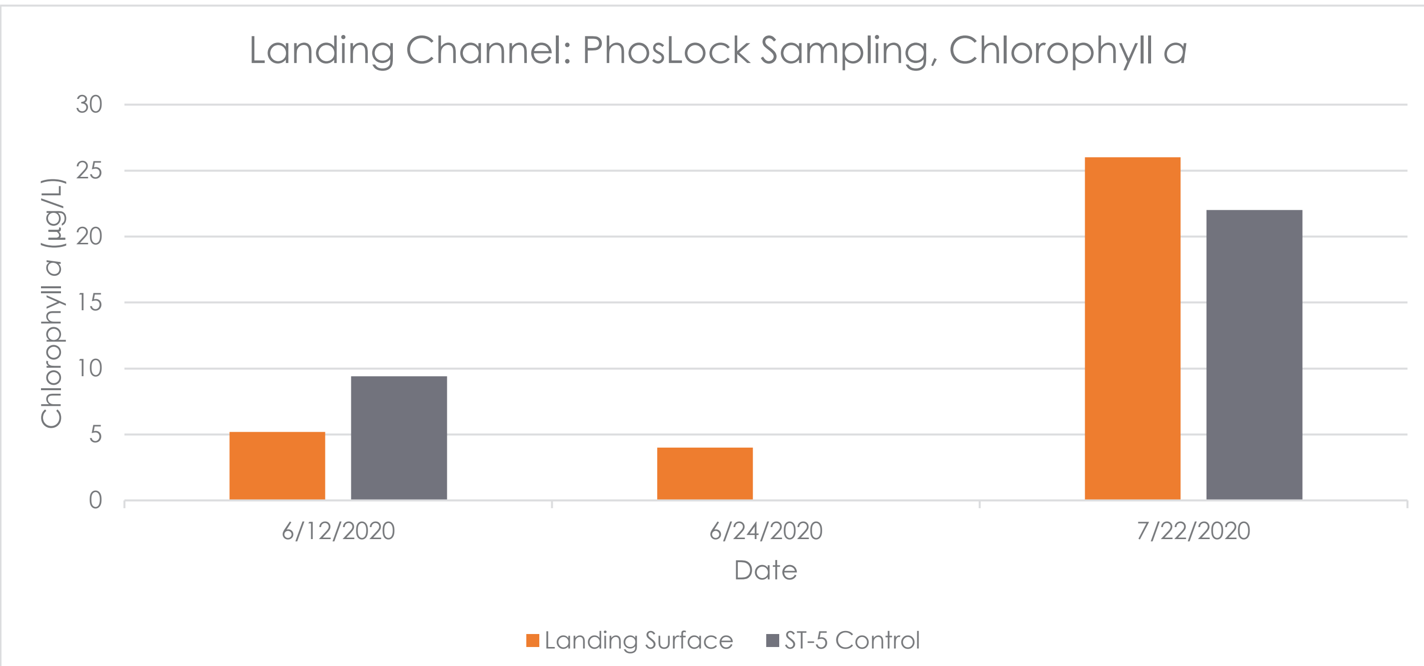


Figure 5.4: Pre- and post-treatment chlorophyll-*a* concentrations in Landing Channel. Please note that no sample was taken from the control site on 24 June 2020.

The initial chlorophyll-*a* results during the first post-treatment monitoring event were positive, as chlorophyll-*a* concentrations remained relatively consistent; chlorophyll-*a* concentrations were already low during the pre-treatment monitoring event. However, chlorophyll-*a* concentrations increased in July as they did at most stations throughout the lake, including the control station. Increased water temperatures and a recent storm more than likely had an effect on chlorophyll-*a* concentrations during this time.

PHYCOCYANIN

Phycocyanin is a supplemental pigment cyanobacteria almost exclusively produce. Thus, while chlorophyll-a can be a surrogate measure of total algae biomass, phycocyanin can be surrogate measure of cyanobacteria biomass. Surface samples for the analysis of phycocyanin were collected pre- and post-treatment in Landing Channel; surface samples were collected at Station 2 (ST-2) during the baseline monitoring as a control site (Figure 5.5). Phycocyanin concentrations were low during the pre-treatment monitoring event in Landing Channel and remained at a concentration of 3 µg/L during the initial post-treatment monitoring event on 24 June. Similar to the other primary productivity metrics, phycocyanin concentrations increased to a concentration of 22 µg/L in Landing Channel during the July monitoring event, while phycocyanin concentrations at the control station were 11 µg/L. Finally, phycocyanin concentrations in Landing Channel were lower, at 10 µg/L, during the final monitoring event in September. It should be noted that based on some detailed monitoring of both phycocyanin and cyanobacteria cell counts throughout 2020, a phycocyanin reading of 12 ug/L typically represents a cyanobacteria cell count of 20,00 cells / mLs, which is the threshold when NJDEP's first HAB Alert Level of WATCH is reached.

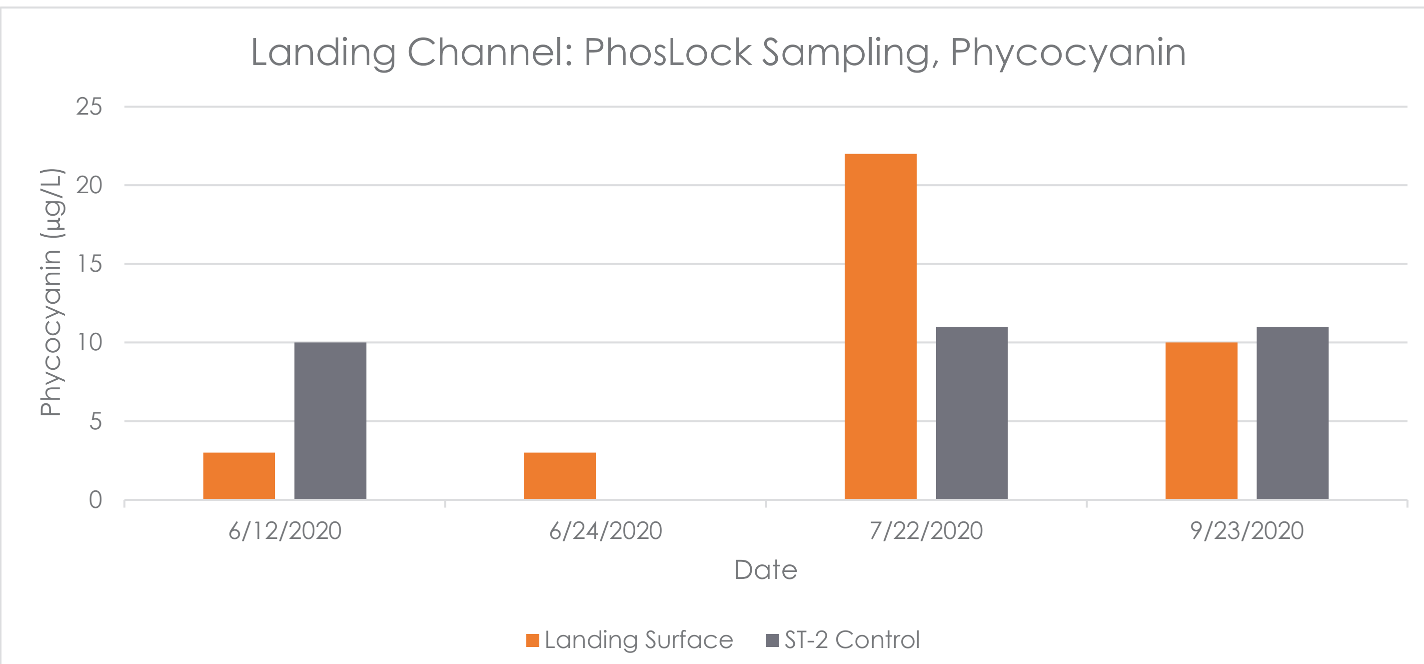


Figure 5.5: Pre- and post-treatment phycocyanin concentrations in Landing Channel. Please note that no sample was taken from the control site on 24 June 2020.

The initial phycocyanin results during the first post-treatment monitoring event were positive, as phycocyanin concentrations remained relatively consistent; phycocyanin concentrations were already low during the pre-treatment monitoring event. However, phycocyanin concentrations increased in July as they did at most stations throughout the lake, including the control station. Similar to the results observed with chlorophyll-a, increased water temperatures and a recent storm resulted in the elevated phycocyanin concentrations in July. However, by September the phycocyanin concentration was below the 12 ug/L threshold.

CYANOBACTERIA

Since cyanobacteria have the potential to produce dozens of various cyanotoxins, it would be extremely difficult to monitor for all of these compounds. Thus, various regulatory agencies including NJDEP as well as US EPA and the World Health Organization, use cyanobacteria cell counts as a means of assessing the potential risk of cyanotoxins being present. For example, based on NJDEP's developed Recommended HAB Alert Levels, the first level of a WATCH is reached when the cyanobacteria cell count is 20,000 cells / mLs or greater. The raw data of the plankton cell counts, including cyanobacteria, are included in Appendix IV.

Prior to the conducting the PhosLock treatment, 12 June 2020, total algal cell count and cyanobacteria cell count values were 7,889 and 5,969 cells / mLs, respectively and cyanobacteria accounted for 76% of the total count. In contrast after the treatment, 24 June 2020, total algal cell count and cyanobacteria cell count values were 5,266 and 1,624 cells / mLs, respectively and cyanobacteria accounted for 31% of the total count. On 22 July 2020, total algal cell count and cyanobacteria cell count values increased to 75,085 cells/mL and 63,230 cells/mL, respectively and cyanobacteria accounted for 84% of the total count. By September, total algal cell count and cyanobacteria cell count values were 32,216 and 26,214 cells / mLs, respectively and cyanobacteria accounted for 81% of the total count. While the cyanobacteria cell counts were high in July and September, both samples had cyanobacteria cell counts at the WATCH level which is the lowest Alert Level.

WATER CLARITY

Water clarity was measured with a Secchi disk pre- and post-treatment in Landing Channel and the control zone (Figure 5.6). Water clarity in Landing Channel increased following the PhosLock application, from a pre-treatment Secchi depth of 1.5 meters to a post-treatment depth of 1.9 meters; water clarity at the control station was 1.5 meters during this post-treatment monitoring event. Water clarity decreased at both stations during the July sampling event, with respective depths of 1.0 meters and 1.1 meters in Landing Channel and the control zone. These decreases in water clarity followed lake-wide increases in productivity. Water clarity was similar between both stations during the final monitoring event in September, with respective depths of 1.1 meters and 1.0 meters in Landing Channel and the control zone.

The initial post-treatment monitoring results indicate that the PhosLock application led to an increase in water clarity, as Secchi depth in the treatment zone increased from 1.5 meters to 1.9 meters, while the control zone increased from 1.4 meters to 1.5 meters. Water clarity at both stations decreased during the July monitoring event as water temperatures, nutrient concentrations, and primary productivity increased throughout the lake. However, the targeted Secchi depth for Lake Hopatcong is 1.0 meters to greater. Secchi depths less than 1.0 meter are generally perceived by the layperson to represent "dirty" or "scummy" water. Thus, the Secchi depth remained accepted in Landing Channel throughout the 2020 sampling season.

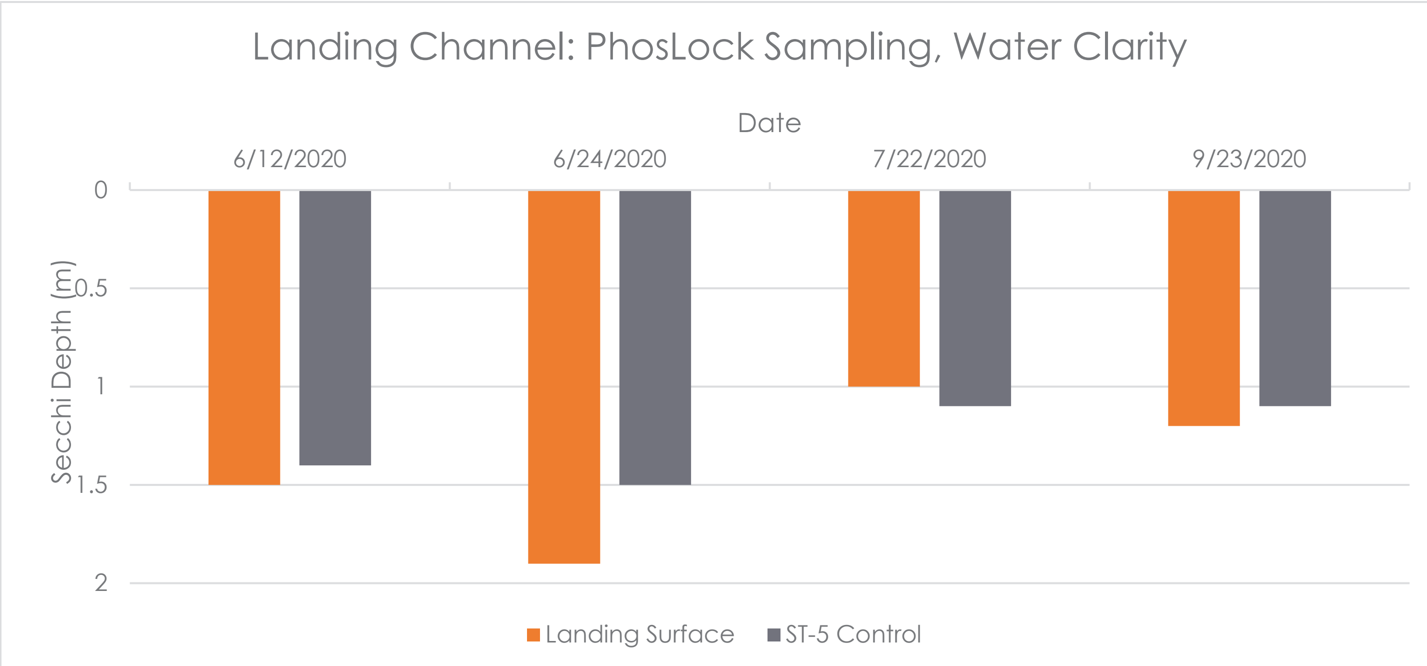


Figure 5.6: Pre- and post-treatment Secchi depths in Landing Channel.

SUMMARY

The initial results one week after the PhosLock treatment were positive in Landing Channel, as all metrics responded in a positive manner – phosphorus concentrations decreased, phycocyanin and chlorophyll-*a* concentrations decreased, and water clarity increased by almost half a meter. As the season progressed and water temperatures and nutrient and primary productivity metrics increased lake wide, most phosphorus species as well as primary productivity metrics also increased in Landing Channel. However, it is a very positive sign that SRP concentrations in both the surface and deep-water of Landing Channel remained non-detectable while total phosphorus concentrations increased in July. This indicates that SRP was likely not being released by a significant amount in the treated sediment of Landing Channel. The overall results from this study indicate the following:

- The initial TP results during the first post-treatment monitoring event were positive, as surface and deep TP concentrations in Landing Channel decreased from pre-monitoring concentrations of 0.03 mg/L and 0.04 mg/L to post treatment concentrations of 0.02 mg/L and 0.02 mg/L, respectively. However, TP concentrations in Landing channel increased during the following monitoring event in July while control zone TP concentrations remained at 0.03 mg/L; TP concentrations increased lake wide during this time. TP then declined by September.

- Overall, it appears as though the PhosLock application had a positive effect on SRP concentrations in Landing Channel, as surface water concentrations remained non-detectable through July while deep-water concentrations remained non-detectable through the end of the season. Additionally, as TP concentrations increased in both the surface and deep-water of Landing Channel during the July monitoring event, SRP concentrations remained non-detectable.

- The initial TDP results during the first post-treatment monitoring event were positive, as surface and deep TDP concentrations in Landing Channel decreased from a pre-monitoring concentration of 0.02 mg/L to post treatment concentrations of 0.005 mg/L and 0.01 mg/L, respectively. However, similar to TP concentrations, TDP concentrations in Landing channel increased during the following monitoring event in July.

- The initial chlorophyll-*a* and phycocyanin results during the first post-treatment monitoring event were positive, as concentrations remained relatively consistent; chlorophyll-*a* and phycocyanin concentrations were already low during the pre-treatment monitoring event. However, these concentrations increased in July as they did at most stations throughout the lake, including the control station.

- Cyanobacteria cell counts declined after the PhosLock treatment. While the cell count increased in Landing Channel by September, the cyanobacteria cell count was still relatively low, being slightly above 20,000 cells / mLs.

- The initial post-treatment monitoring results indicate that the PhosLock application led to an increase in water clarity, as Secchi depth in the treatment zone increased from 1.5 meters to 1.9 meters, while the control zone increased from 1.4 meters to 1.5 meters. Water clarity at both stations increased during the July monitoring event as water temperatures, nutrient concentrations, and primary productivity increased throughout the lake.

6.0 OBJECTIVE 5: TREATMNENT AND EVALUATION OF STRONG OXIDIZER FOR HAB CONTROL

PROJECT SUMMARY

One of the most frequently used group of algicides to control cyanobacteria and HABs are copper-based products. While the copper does kill algae there are a number of undesirable ecological issues such as the accumulation of copper in sediments, lysing of algal cells and releasing dissolved cyanotoxins and taste & odor compounds into the water, impacts on nontarget organisms such as zooplankton and young-of-the-year fish, and the increased tolerance to such products by algae. Thus, the LHC was interested in conducting one treatment of GreenClean (a strong oxidizer that uses a form of hydrogen peroxide) at a beach site at Lake Hopatcong and critically evaluate its effectiveness as a more ecologically friendly replacement to copper-based algaecides.

Objective 5 involved a GreenClean treatment at the nearshore, beach site of Capp Beach to determine if this product can be used as an effective alternative to copper-based algaecides. Pre- and post-treatment monitoring, before and after the treatment, were conducted as part of the existing baseline monitoring for Lake Hopatcong.

SCHEDULE OF EVENTS

After a review of the baseline monitoring data in Lake Hopatcong, the first GreenClean treatment was scheduled for mid-August. Princeton Hydro's certified applicators filed for and obtained the permit for the treatment. Pre-treatment monitoring was conducted on 12 August 2020. The GreenClean treatment was conducted on 13 August 2020. Finally, the post-treatment monitoring event was conducted on 17 August 2020. A full breakdown of the pre- and post-treatment monitoring schedule, including the date of the treatment, is provided in Table 6.1 below.

Table 6.1: CAPP Beach: Treatment and monitoring schedule.

Capp Beach GreenClean: Treatment Schedule	
Date	**Activity**
8/12/2020	Pre-treatment monitoring event
8/13/2020	GreenClean application
8/17/2020	Post-treatment monitoring event

The treatment was conducted by Princeton Hydro. The treatment was conducted at the prescribed labelled rate of 12.8 gallons/acre-ft, focusing on the upper 3 feet of the water column.

MONITORING RESULTS AND DATA ANALYSIS

The following section will discuss and objectively assess the results of the water quality data collected in Lake Hopatcong relative to the success of the GreenClean treatment in controlling the development of HABs. This section will focus primarily on the parameters that are most closely associated with the development of HABs, such as chlorophyll-*a* concentrations, cyanobacteria cell counts, phycocyanin concentrations, and water clarity. All *in-situ* and discrete data collected as part of the GreenClean monitoring can be found in full in Appendix V.

PHYCOCYANIN

Surface phycocyanin concentrations were monitored via multi-probe pre- and post-treatment in the Capp Beach treatment zone. Phycocyanin concentrations increased from a pre-treatment concentration of 23 µg/L to a post-treatment concentration of 31 µg/L (Figure 6.1). However, the post-treatment sampling event occurred four (4) days post-treatment and may have been influenced by the site location. Capp Beach is located along a relatively open part of Lake Hopatcong, and, as a result, is subject to significant mixing and water movement. Because of the significant mixing that likely occurs around Capp Beach, results are likely to be heavily influenced by non-treated lake water that mixes with the water in the treatment zone, especially four (4) days after the treatment. It does not appear as though the GreenClean treatment had a significant effect on phycocyanin concentrations in the treatment zone.

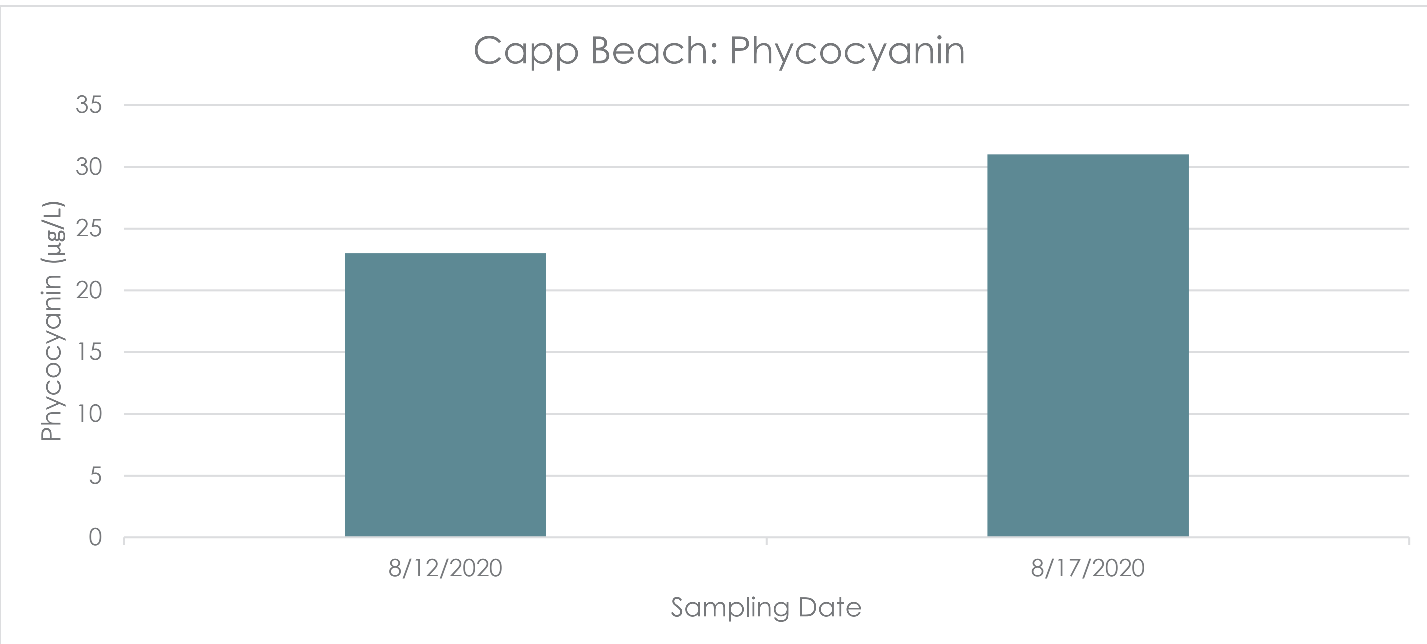


Figure 6.1: Pre- and post-treatment phycocyanin concentrations at Capp Beach.

CHLOROPHYLL A

Surface chlorophyll-*a* concentrations were monitored via multi-probe pre- and post-treatment in the Capp Beach treatment zone. Chlorophyll-*a* concentrations increased from a pre-treatment concentration of 20 µg/L to a post-treatment concentration of 26 µg/L (Figure 6.2). As mentioned above, the post-treatment results were likely influenced by the site location and the significant mixing that would have occurred post-treatment.

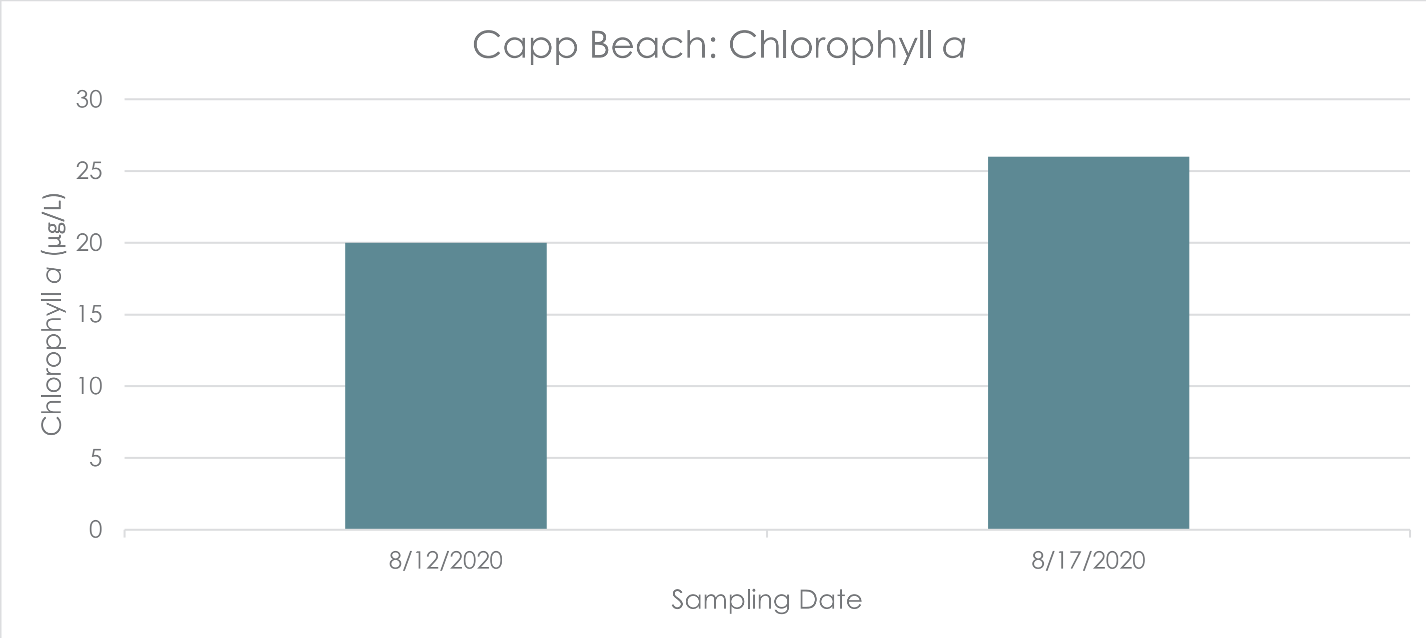


Figure 6.2: Pre- and post-treatment chlorophyll-*a* concentrations at Capp Beach.

WATER CLARITY

Water clarity was measured with a Secchi disk during the pre- and post-treatment events in the Capp Beach treatment zone. Water clarity increased slightly from a pre-treatment Secchi depth of 0.8 meters to a post-treatment depth of 1.1 meters (Figure 6.3).

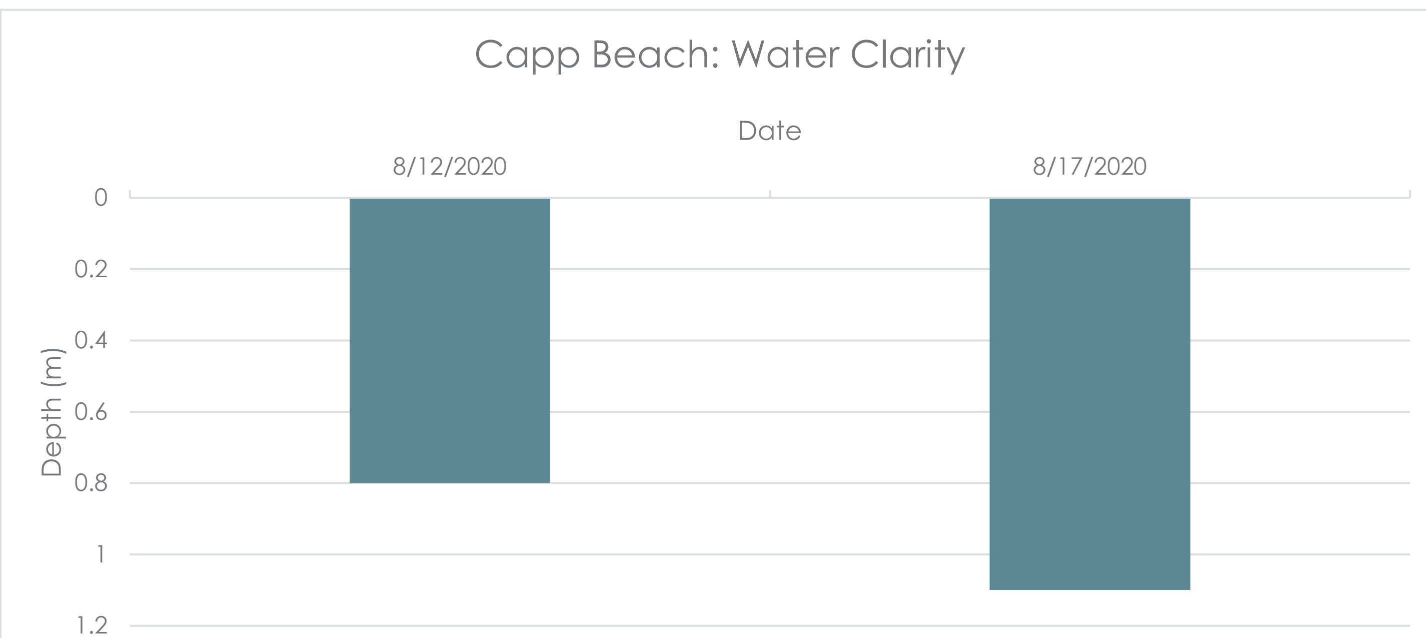


Figure 6.3: Pre- and post-treatment Secchi depths at Capp Beach.

SUMMARY

The results of the GreenClean treatments were variable by parameter but remained inconclusive overall due to mixed results. The small sample size of only one (1) pre-treatment and one (1) post-treatment monitoring event limits the capability to perform meaningful statistical analyses. Additionally, due to the small size of the treatment zone and the significant mixing that occurs due to its position on the main body of the lake, the GreenClean treatment did not appear to be successful in lowering phycocyanin or chlorophyll-*a* concentrations.

While the results of the GreenClean treatment at Capp Beach was somewhat inconclusive, the treatment appeared to be far more effective at Ashley Cove. Based on these observations it appears that GreenClean may be more appropriate and more cost effective for areas that are not prone to high amounts of flushing or water movement.

7.0 OBJECTIVE 6: USE OF BIOCHAR TO PREVENT HABS IN NEARSHORE INLET OR BEACH AREAS

PROJECT SUMMARY

One of the filter media that will be assessed for dissolved phosphorus removal for the Aqua-Filters (Objective 2) will be Biochar. As previously stated, Biochar is woody material that has a high affinity for a variety of pollutants including phosphorus. Thus, another possible way this material can be used is to place it into floatation balls, sausages, or cages and tether them along a beach area or where an inlet enters the lake. Such Biochar floatation balls or cage have been shown to remove dissolved phosphorus directly out of the nearshore waters, contributing toward limiting algal growth. Additionally, the relatively low cost of the Biochar and its re-use as a form of mulch make it a particularly attractive means of contributing toward the removal of in-lake phosphorus.

Objective 6 involved the installation of a series of "Biochar socks" in drainage streams and nearshore locations of Lake Hopatcong where stormwater pipes discharge to determine if they are a cost-effective means of reducing available phosphorus and contribute towards preventing HABs. Post-installation monitoring was conducted immediately upgradient and down gradient of the structures to determine if there is a significant difference in the phosphorus species immediately up and down gradient of the material.

SCHEDULE OF EVENTS

Biochar socks were installed at different sites throughout the watershed during the month of July. Biochar socks were installed at the following locations and dates:

- Lorettacong Drive – 2 July 2020
- Yacht Club – 2 July 2020
- Edith M. Decker Elementary School – 2 July 2020
- Lakeside Blvd – 2 July 2020
- Memorial Pond – 31 July 2020
- Duck Pond – 31 July 2020

The two post-treatment monitoring events occurred on 10 July 2020 and 29 October 2020.

MONITORING RESULTS AND DATA ANALYSIS

The following section will discuss and objectively assess the results of the stormwater sampling data collected immediately upgradient and down gradient of the structures to determine if there is a significant difference in the phosphorus species immediately up and down gradient of the material. All discrete data collected as part of the Biochar monitoring can be found in full in Appendix VI.

TOTAL PHOSPHORUS

Stormwater samples for the analysis of total phosphorus (TP) were collected immediately upgradient and down gradient of all Biochar structures (Figure 7.1). TP reductions downgradient of all Biochar structures was substantial at all sites besides Edith Decker during the first stormwater sampling event on 10 July 2020, 8 days after the Biochar was installed; please note that the Biochar in Memorial Pond and Duck Pond was not installed until 31 July 2020. TP concentrations during this first monitoring event were reduced by 44% at Lorettacong Drive, 55% at the Yacht club, and 21% at the Lakeside Blvd. site. However, TP concentrations increased by over 200% at the Edith M Decker site. Please note that there was an additional pipe discharging into the sampling area at Edith Decker that was likely not being filtered by the Biochar and likely had an influence on the extremely elevated downstream TP samples; the Biochar in this site was later adjusted.

The second stormwater sampling event occurred on 29 October 2020, approximately three (3) months after the initial Biochar was installed in the streams and two (2) months after the Biochar was installed in the two ponds. TP reductions downgradient of the four (4) stream sites was minimal during this event, with concentrations decreasing at only the Edith M Decker site by 8 %; TP concentrations were uniform upstream and downstream of the three (3) other stream sites. However, the TP reductions downgradient of the Biochar that was placed near the outlet of two ponds was substantial. TP concentrations at Memorial Pond and Duck Pond were reduced by 67% and 81%, respectively.

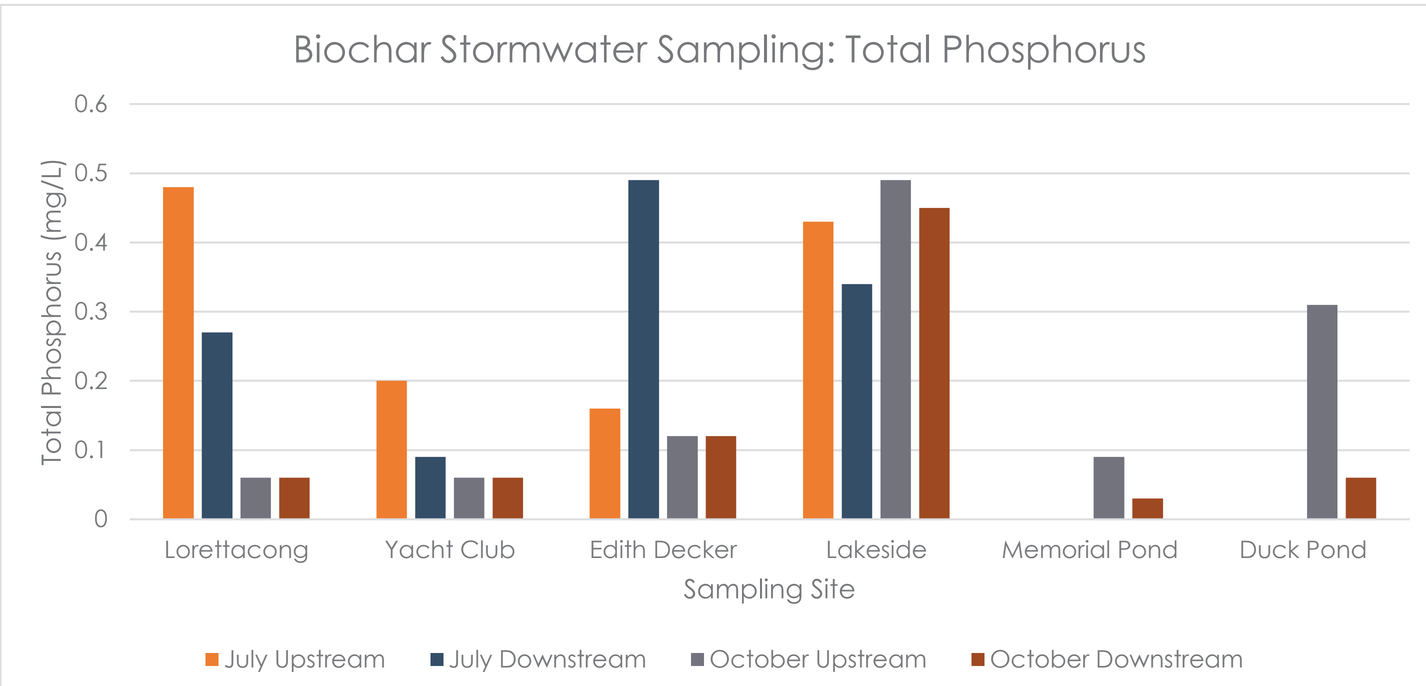


Figure 7.1: Upgradient and down gradient total phosphorus concentrations from two separate sampling events; 10 July 2020 and 29 October 2020.

Total phosphorus results indicate that Biochar placed in streams can provide total phosphorus removal rates between 20% – 55% while Biochar placed in ponds can provide total phosphorus removal rates between 67% - 81%. While these removal rates are substantial, it appears as though Biochar provides higher removal rates when placed in ponds due to the extended contact time relative to flowing water in streams. Additionally, it appears as though the total phosphorus removal efficiencies dropped well below 10% in the stream sites three months post-installation, indicating that they should be replaced every 2 – 3 months.

SOLUBLE REACTIVE PHOSPHORUS

Stormwater samples for the analysis of soluble reactive phosphorus (SRP) were collected immediately upgradient and down gradient of all Biochar structures (Figure 7.2). SRP concentrations were reduced at all sites, by varying degrees, during the first stormwater sampling event on 10 July 2020, 8 days after the Biochar was installed; please note that the Biochar in Memorial Pond and Duck Pond was not installed until 31 July 2020. SRP concentrations during the first event were reduced by 24% at Lorettacong Drive, 96% at the Yacht Club, 16% at Edith M Decker, and 2% at Lakeside Blvd.

The second stormwater sampling event occurred on 29 October 2020, approximately three (3) months after the initial Biochar was installed in the streams and two (2) months after the Biochar was installed in the two ponds. SRP reductions downgradient of the four (4) stream sites were minimal during this event, with concentrations decreasing at Lorettacong Drive by 31%. However, the SRP reductions downgradient of the Biochar that was placed near the outlet of two ponds was substantial. SRP concentrations at Memorial Pond and Duck Pond were reduced by 76% and 97%, respectively.

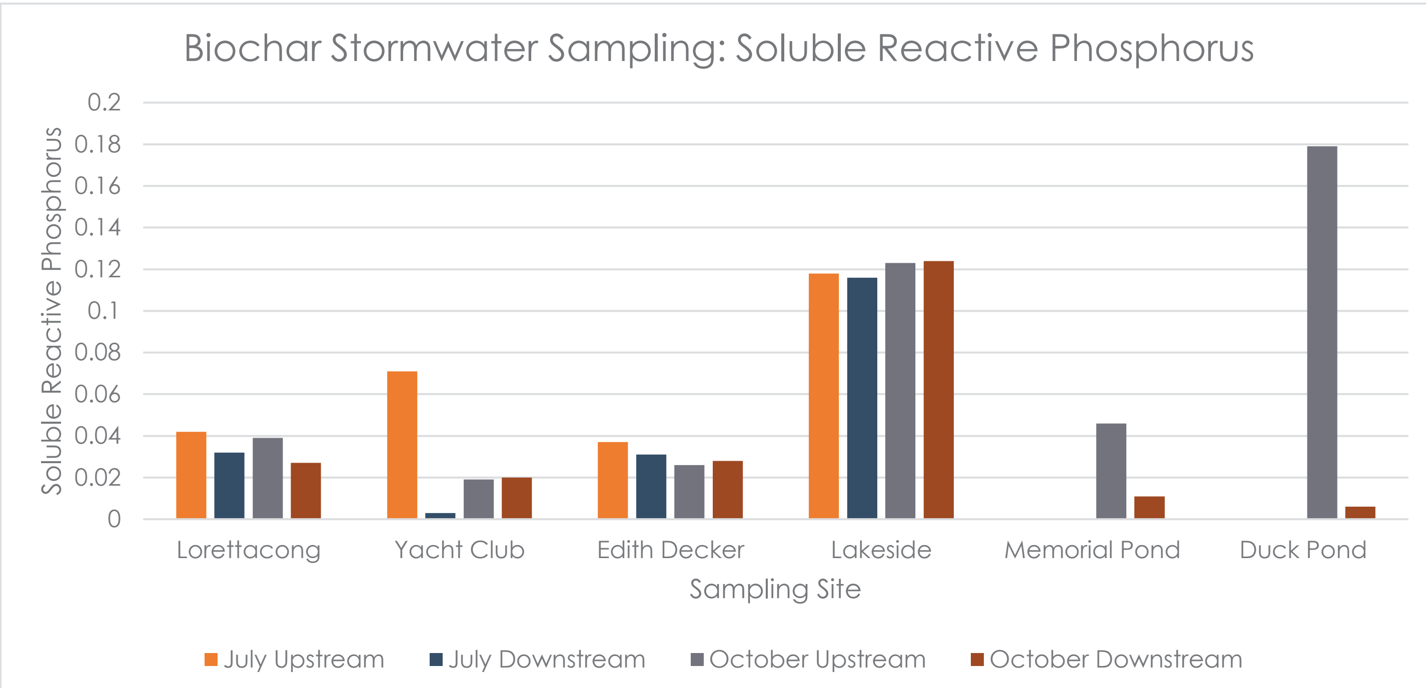


Figure 7.2: Upgradient and down gradient soluble reactive phosphorus concentrations from two separate sampling events; 10 July 2020 and 29 October 2020.

Soluble reactive phosphorus results indicate that Biochar placed in streams can provide SRP removal rates between 2% – 97% while Biochar placed in ponds can provide SRP removal rates between 76% - 97%. Similar to the TP removal rates, it appears as though Biochar provides higher removal rates when placed in ponds due to the extended contact time relative to flowing water in streams. Additionally, it appears as though the SRP removal efficiencies dropped substantially in the stream sites three months post-installation, indicating that they should be replaced every 2 – 3 months.

TOTAL DISSOLVED PHOSPHORUS

Stormwater samples for the analysis of total dissolved phosphorus (TDP) were collected immediately upgradient and down gradient of all Biochar structures (Figure 7.3). TDP were variable by site during the first stormwater sampling event on 10 July 2020, 8 days after the Biochar was installed; please note that the Biochar in Memorial Pond and Duck Pond was not installed until 31 July 2020. TDP concentrations during the first event were reduced by 73% at the Yacht Club and 75% at Edith M Decker; removal rates were 0% at the other two sites during this time.

The second stormwater sampling event occurred on 29 October 2020, approximately three (3) months after the initial Biochar was installed in the streams and two (2) months after the Biochar was installed in the two ponds. TDP reductions downgradient of the four (4) stream sites were minimal during this event, with concentrations decreasing at only Lorettacong Drive and Lakeside Blvd. by 25% and 7%, respectively. However, the TDP reductions downgradient of the Biochar that was placed near the outlet of two ponds was substantial. TDP concentrations at Memorial Pond and Duck Pond were reduced by 60% and 94%, respectively.

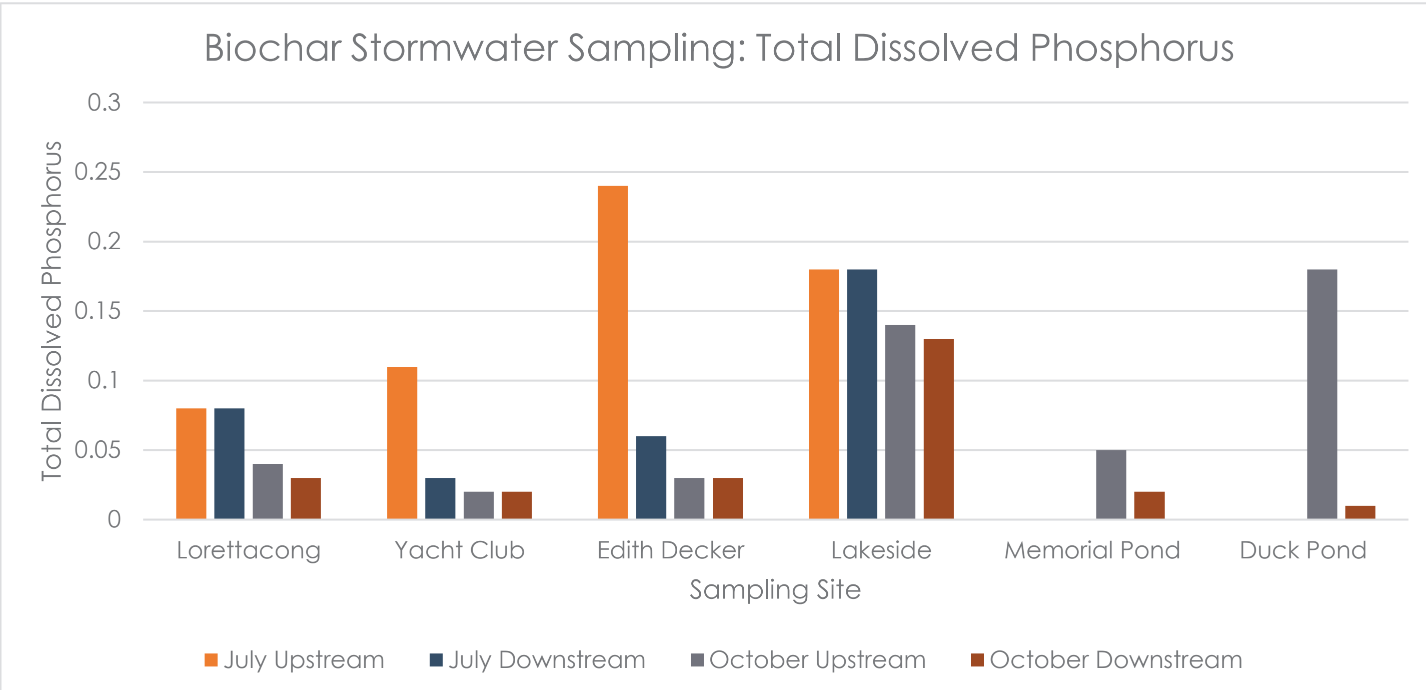


Figure 7.3: Upgradient and down gradient total dissolved phosphorus concentrations from two separate sampling events; 10 July 2020 and 29 October 2020.

Total dissolved phosphorus results indicate that Biochar placed in streams can provide TDP removal rates between 0% – 75% while Biochar placed in ponds can provide TDP removal rates between 60% - 94%. Similar to other phosphorus removal rates, it appears as though Biochar provides higher removal rates when placed in ponds due to the extended contact time relative to flowing water in streams. Additionally, it appears as though the TDP removal efficiencies dropped substantially in the stream sites three months post-installation, indicating that they should be replaced every 2 – 3 months.

SUMMARY

The phosphorus removal rates provided by the Biochar socks varied greatly by parameter and by site but were positive overall. It appears as though contact time between the Biochar and the stormwater is key, with extended contact time resulting in higher removal rates, as shown by the superior removal rates provided by the Biochar socks in the two ponds. The Biochar socks in the stream sites removed a substantial amount of phosphorus during the first monitoring event, 8 days after they were installed, but provided much less phosphorus removal three months later, indicating they should be replaced or flipped over every 2 – 3 months. Under normal flow conditions in the streams, the socks are likely not inundated. Thus, the water is flowing through the same area of the sock constantly and the Biochar at the "bottom" of the sock (lying on the ground) is getting filled with sediment and nutrients while the top of the sock is likely much cleaner. The stormwater results indicate the following about phosphorus removal efficiencies:

- Total phosphorus results indicate that Biochar placed in streams can provide total phosphorus removal rates between 20% – 55% while Biochar placed in ponds can provide total phosphorus removal rates between 67% - 81%.

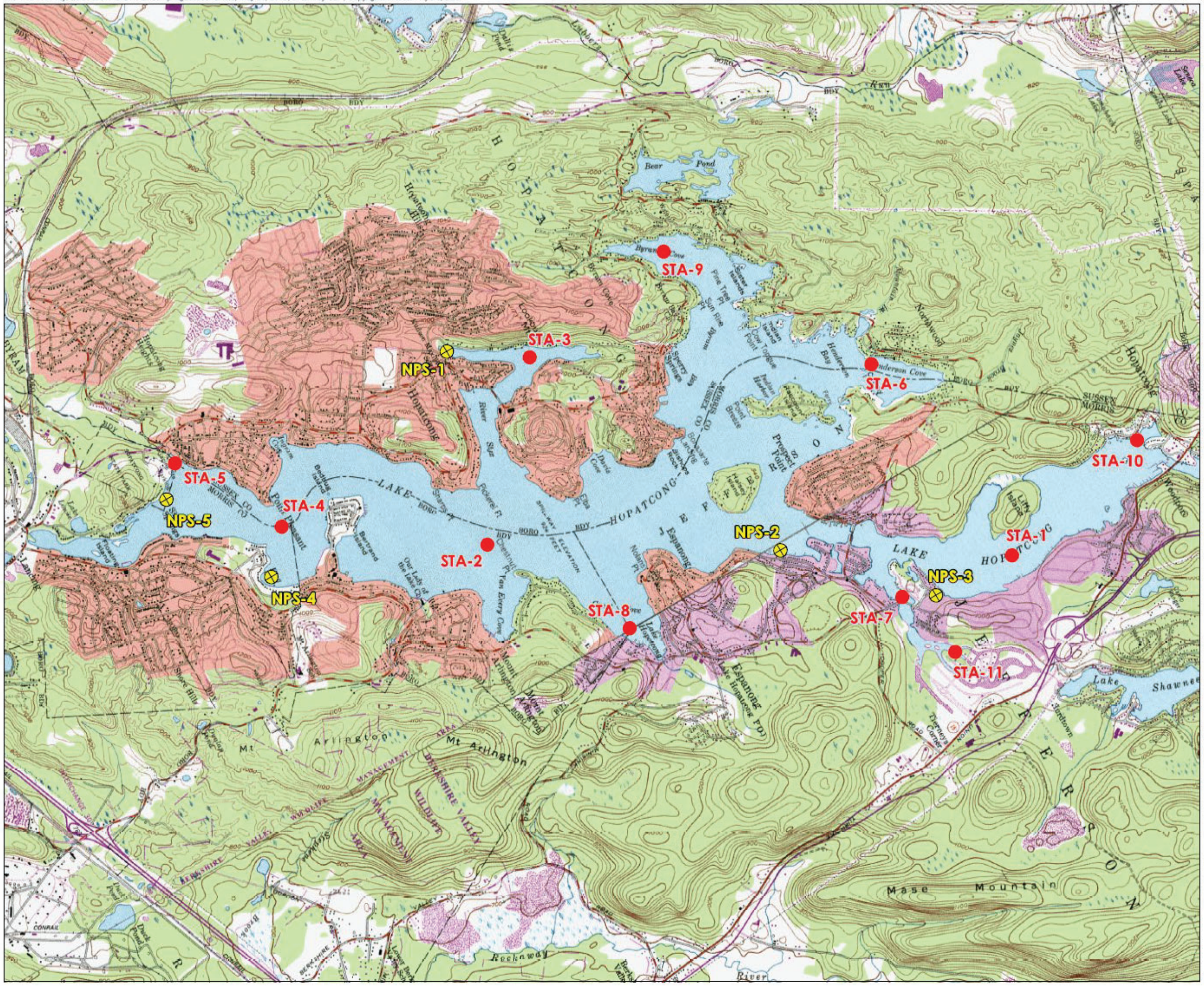
- Soluble reactive phosphorus results indicate that Biochar placed in streams can provide SRP removal rates between 2% – 97% while Biochar placed in ponds can provide SRP removal rates between 76% - 97%.

- Total dissolved phosphorus results indicate that Biochar placed in streams can provide TDP removal rates between 0% – 75% while Biochar placed in ponds can provide TDP removal rates between 60% - 94%.

Overall, Biochar shows great potential in removing various forms of phosphorus from stormwater. While the initial results indicate superior removal rates from Biochar placed near the inlet or outlet of a lake or pond, the removal rates in the stormwater streams were still positive, although with greater variability. The key takeaway from this study appears to be that extended contact time results in higher nutrient removal. Thus, if Biochar is to be placed in streams, the Biochar will need to be replaced or potentially flipped or rotated more often, likely every 2 months.

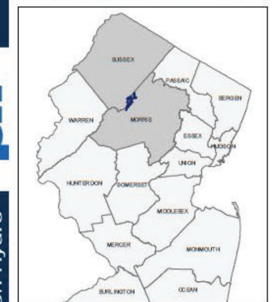
APPENDIX I:

SAMPLING LOCATIONS



Princeton Hydro

NEW JERSEY COUNTY MAP



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

1 inch = 2,750 feet
0 1,375 2,750 Feet

SOURCES:
1. USGS Topographic Digital Raster Graphics obtained from Terrain Navigator Pro, Dover and Stanhope, NJ Quadrangles.

Map Projection: State Plane New Jersey (feet) NAD83

FIGURE 1
SAMPLING LOCATIONS

LAKE HOPATCONG
WATER QUALITY SAMPLING
MORRIS AND SUSSEX COUNTIES
NEW JERSEY

Legend
Sampling Stations
- In-Lake
- Near-Shore

APPENDIX II:

QUALITY ASSURANCE PROJECT PLAN

QAPP ADDENDUM FOR LAKE HOPATCONG

SUSSEX AND MORRIS COUNTIES, NEW JERSEY

HUC 14: Lake Hopatcong Sub-watershed - 02040105150020
Grant Identifier: WM20-034; Revision # 4
Submitted for the Evaluation of HAB prevention, mitigation and control in Lake Hopatcong

AUGUST 2021

PREPARED FOR:

THE LAKE HOPATCONG COMMISSION
PO BOX 8515
LANDING, NEW JERSEY 07850

PREPARED BY:

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SUBMITTED TO:

NEW JERSEY DEPARTMENT OF ENVIROMENTAL PROTECTION
DIVISION OF WATERSHED MANAGEMENT
PO BOX 418
TRENTON, NEW JERSEY 08625-0418

TABLE OF CONTENTS

1.0 PROJECT MANAGEMENT

1.1 TITLE AND APPROVAL SHEET

Project Title: Quality Assurance Project Plan
Evaluation of HAB prevention, mitigation and control in Lake Hopatcong
Sussex and Morris Counties, New Jersey

Grant Identifier: WM20-034

Approvals:

____ Date: __________
Princeton Hydro, LLC, Fred Lubnow, Ph.D., Principal Investigator

____ Date: August 31, 2021
Princeton Hydro, LLC, Jack Szczepanski, PhD, QA/QC Officer

____ Date: __________
Lake Hopatcong Commission, Colleen Lyons, Administrator

____ Date: __________
NJDEP Bureau of Environmental Analysis & Standards, Deborah Kratzer, QAPP reviewer

____ Date: __________
NJDEP Bureau of Environmental Analysis & Standards, Jay Springer, Section Chief

____ Date: __________
NJDEP, Bureau of Quality Assurance and Evaluation Monitoring, Melissa Hornsby, Quality Assurance Officer

1.2 CONTACT INFORMATION

All contact information for associated parties, including Princeton Hydro, Lake Hopatcong Commission, Environmental Compliance Monitoring and NJDEP, can be found in the original In-Lake Monitoring QAPP (May 2021) for Lake Hopatcong dated May 2021. In addition to these parties mentioned in the original QAPP (May 2021), SePRO Research & Technology Campus will be utilized for sediment sample analyses and EMSL Analytical Inc. will be used for T&O compound analysis. All of the personnel listed in the original QAPP (May 2021) and Table 1 below will receive copies of this QAPP addendum (May 2021), and any approved revisions of this plan (August 2021), should they occur.

Table 1: Contact Information

Title	Name (Affiliation)	Phone Number/E-mail
SePRO Laboratory Manager	Sam Mason SePRO Research & Technology Campus	(252) 391-8383 samm@sepro.com
SePRO Laboratory QA/QC Officer	Jason Scott SePRO Research & Technology Campus	(252) 391-8383 jasons@sepro.com
EMSL Analytical, Inc Lab Manager	Bin Wang, Ph.D., P.E EMSL Analytical, Inc.	800-220-3675 bwang@emsl.com

LINES OF COMMUNICATION

The lines of communication remain the same to the original QAPP (May 2021), with exception to SePRO and EMSL being added to the Laboratory section alongside Environmental Compliance Monitoring, Inc (ECM).

LABORATORY INFORMATION

In addition to ECM, information for SePRO Research & Technology Campus and EMSL Analytical, Inc. has been provided below.

Name: SePRO Research & Technology Campus	
Address: 16013 Watson Seed Farm Road	
Phone: (252) 437-3282	Contact Name: Sam Mason

Name: EMSL Analytical, Inc; NJ Certified Lab # 03036	
Address: 200 Route 130 North Cinnaminson, NJ 08077	
Phone:	Contact Name:

800-220-3675	Bin Wang, Ph.D., P.E.

1.3 PROJECT OBJECTIVES AND APPROACH

Lake Hopatcong experienced unprecedented harmful algal blooms (HABs) of cyanobacteria over most of the summer season from mid-June well into October in 2019. These HABs resulted in the posting of advisories over large sections of the lake and the closing of all beaches by local/County Departments of Health. These conditions resulted in substantial impacts on the ecological, recreational, and economic resources of the lake and region. These blooms were triggered by some of the highest June total phosphorus (TP) concentrations measured over the last 25 years. These conclusions are based on routine, baseline monitoring of Lake Hopatcong, conducted by the Lake Hopatcong Commission's (LHC) environmental consultant, Princeton Hydro. While prevailing weather conditions contributed toward these elevated TP concentrations, the contributing sources of TP stem from stormwater and septic systems. Long-term, watershed-based measures are currently being explored for Lake Hopatcong, but some more short-term, in-lake/nearshore measures are needed to minimize the local impacts of HABs to protect the lake and the local economy.

Funds were obtained through the NJDEP's HAB Management program to implement a variety of innovative, nearshore management measures to prevent, mitigate, and/or control HABs through habitat modifications, nutrient reduction, and/or by directly killing HABs. Projects have been identified within the two Counties and four municipalities throughout the Lake Hopatcong Watershed (Appendix B). The overall project Goal is to implement these projects and objectively evaluate the relative effectiveness through water quality monitoring. These projects include evaluating various filtering media in two Aqua-Filter stormwater basins, three types of aeration, the nutrient inactivator PhosLock, Floating Wetland Islands, the non-copper algaecide GreenClean, and the use of Biochar to remove phosphorus from nearshore waters.

1.4 DATA QUALITY OBJECTIVES

The data quality objectives (DQOs) of this project follow the same guidelines as presented in the original QAPP (May 2021).

1.5 TRAINING OF FIELD SAMPLING PERSONNEL

Training of field personnel will follow the same guidelines as presented in the original QAPP (May 2021).

1.6 DOCUMENTATION AND RECORDS

Information on the documentation and records for this project can be found in the original QAPP (May 2021).

2.0 SAMPLE COLLECTION PROCEDURES

2.1 FIELD SAMPLING INFORMATION

Where applicable, all sampling procedures shall be in conformance with standard limnological practices and procedures listed in *Standard Methods for the Analysis of Water and Wastewater, 18th Edition* (American Public Health Association, 1992), State protocol (NJDEP, 2005) and/or any comparable US EPA guidance document.

Details on the sampling procedures can be found in sections of the NJDEP Field Sampling Procedures Manual (2005). Specifically, these include Section 5.2.3 - *Surface Water and Liquid Sampling Equipment, Section 5.3.2 – Sediment and Sludge Sampling Equipment* and Sections 6.8.1 and 6.8.2 - *Sample Collection*. For the collection of discrete water samples, Princeton Hydro will utilize either a Kemmerer or a Van Dorn sampler; both devices are listed in the NJDEP Manual More lake-specific details are provided in Section 6.8.2.2.5 – *Lake / Standing Water Sampling*.

Instrumentation used for the collection of field data (dissolved oxygen, temperature, pH and conductivity) shall be properly calibrated in conformance with manufacturer instructions. All sampling sites were chosen to be representative sites and are subject to the approval of the New Jersey Department of Environmental Protection.

STORMWATER SAMPLING

1. As part of a past 319(h) grant application (SFY2005), two large stormwater basins and Aqua-Filters were installed in the parking lot of the Crescent Cove Beach Club. These basins will be cleaned out and the media replaced.

2. All project sites will be located with the use of GPS technology. GPS data will be collected with a hand held GPS unit (+/- 3 meters). The resulting coordinates and digital data will be supplied to the Commission as part of the summary report.

3. Once the media is installed, the basins will be sampled during three stormwater events over the course of the 2020 growing season. Sampling will occur immediately upgradient and downgradient of each basin, totaling four sampling locations.

4. Discrete water quality samples will be collected at these four sampling locations at Crescent Cove Beach Club. All discrete water samples will be collected with a laboratory cleaned sample bottle as per Section 5.2.3 - *Surface Water and Liquid Sampling Equipment* of the NJDEP Field Sampling Procedures Manual (2005). All sample containers will be identified with their respective station IDs and also labeled with the date and time of collection.

5. These discrete samples will be analyzed for total phosphorus, soluble reactive phosphorus and total dissolved phosphorus.

AERATION EVALUATION

1. Three different nearshore aeration systems will be installed along three specific beach areas. These Locations and associated aeration types can be found in Table 2 below.

2. Once the three systems are installed, Princeton Hydro will conduct three sampling events within the aerated zones to be conducted in June, July and August 2020.

3. All sampling stations will be located with the use of GPS technology. GPS data will be collected with a hand held GPS unit (+/- 3 meters). The resulting coordinates and digital data will be supplied to the Commission as part of the summary report.

4. At each of the three sampling stations a calibrated Surveyor IV Hydrolab or similar device will be used to monitor the *in-situ* parameters dissolved oxygen (DO), temperature, pH and conductivity. Princeton Hydro is State certified for the collection of these four *in-situ* parameters (State ID # 10006). Data will be recorded at 0.5 - 1.0 meter increments beginning at 0.5 meters below the water's surface to within 0.5 meters of each lake's sediment bottom. In addition, water clarity will be measured at each station with a Secchi disk.

5. Prior to any in-lake sampling event the Surveyor IV Hydrolab or similar device will be calibrated as per the manufacturer's specifications. The boat's on-board fathometer will provide guidance as to the total

depth. The meter will be lowered into the water to 0.5 m below the water's surface. Once the readings on the device have equilibrated the *in-situ* measurements (dissolved oxygen, temperature, pH and conductivity) will be recorded. The calibrated line will be lowered at 1.0 meter intervals, and equilibrated measurements will continue to be recorded. At each sampling station the device will be lowered to within 0.5 meters of the bottom.

6. Discrete water quality samples will be collected at the three sampling stations, approximately 0.5 meters below the water's surface. All sub-surface discrete water samples will be collected with a Kemmerer or Van Dorn sampling device or laboratory cleaned sample bottle as per Section 5.2.3 - *Surface Water and Liquid Sampling Equipment* of the NJDEP Field Sampling Procedures Manual (2005). All sample containers will be identified with their respective station IDs and also labeled with the date and time of collection. The sub-surface discrete samples will be analyzed for chlorophyll *a*, microcystins, and phycocyanins by staff scientists.

7. Whole water, sub-surface (0.5 m below surface) samples will be collected for phytoplankton as per the NJDEP Field Sampling Procedures Manual (2005). Analysis via quantification utilizing cell counts (cells/mL) will be performed on these samples and plankton will be identified down to genus or species. The focus will be on cyanobacteria cell count.

Table 2: Station ID

Site ID	Location ID	Location	Coordinates (approximate)	Aeration Type
A1	Shore Hills Beach	195 Mt. Arlington Blvd, Landing NJ	40.9098, -74.6573	Air Curtain System
A2	Mount Arlington Municipal Beach	511 Windemere Ave., Mt. Arlington NJ	40.9291, -74.6391	Nanobubble Oxygen System
A3	Lake Forest Yacht Club	35 Yacht Club Drive, Lake Hopatcong NJ	40.9705, -74.6093	Nanobubble Ozone System

PHOSLOCK SAMPLING AT LANDING

1. Princeton Hydro will conduct a pre- and two post-treatment monitoring events of the area that will be treated with PhosLock. A sampling station will be established in the area where this treatment will take place (Appendix B).

2. All sampling stations will be located with the use of GPS technology. GPS data will be collected with a handheld GPS unit (+/- 3 meters). The resulting coordinates and digital data will be supplied to the Commission as part of the summary report.

3. At the established sampling station, a calibrated Surveyor IV Hydrolab or similar device will be used to monitor the *in-situ* parameters dissolved oxygen (DO), temperature, pH and conductivity. Princeton Hydro is State certified for the collection of these four *in-situ* parameters (State ID # 10006). Data will be recorded at 0.5 - 1.0-meter increments beginning at 0.5 meters below the water's surface to within 0.5 meters of each lake's sediment bottom. In addition, water clarity will be measured at each station with a Secchi disk.

4. Prior to any in-lake sampling event the Surveyor IV Hydrolab or similar device will be calibrated as per the manufacturer's specifications. The boat's on-board fathometer will provide guidance as to the total depth. The meter will be lowered into the water to 0.5 m below the water's surface. Once the readings on the device have equilibrated the *in-situ* measurements (dissolved oxygen, temperature, pH and conductivity) will be recorded. The calibrated line will be lowered at 1.0-meter intervals, and equilibrated

measurements will continue to be recorded. At each sampling station the device will be lowered to within 0.5 meters of the bottom.

5. Discrete water quality samples will be collected at the three sampling stations, approximately 0.5 meters below the water's surface. All sub-surface discrete water samples will be collected with a Kemmerer or Van Dorn sampling device or laboratory cleaned sample bottle as per Section 5.2.3 - *Surface Water and Liquid Sampling Equipment* of the NJDEP Field Sampling Procedures Manual (2005). All sample containers will be identified with their respective station IDs and also labeled with the date and time of collection.

6. The sub-surface discrete samples will be analyzed for total phosphorus, soluble reactive phosphorus, total dissolved phosphorus, chlorophyll *a,* microcystins, and phycocyanins

7. Whole water, sub-surface (0.5 m below surface) samples will be collected for phytoplankton as per the NJDEP Field Sampling Procedures Manual (2005). Analysis via quantification utilizing cell counts (cells/mL) will be performed on these samples and plankton will be identified down to genus or species. The focus will be on cyanobacteria cell counts.

8. Sediment samples will be collected at five sampling sites in the Landing PhosLock treatment area. All sediment samples will be collected utilizing an acetate tube or Ponar dredge as per the NJDEP Field Sampling Procedures Manual (2005). These samples will be analyzed by SePRO Research & Technology Campus for P fractionation. These analyses will report total phosphorus (labile, metal oxide, reductant-soluble, organic, apatite and residual) and soluble reactive phosphorus (organic portion).

PHOSLOCK SAMPLING AT ASHLEY COVE

1. Princeton Hydro will conduct water quality monitoring of Ashley Cove four times during both the 2020 and 2021 growing seasons to monitor continued PhosLock treatments. All stations that receive Phoslock applications will receive pre and post treatment sampling A sampling station will be established in the area where this treatment will take place (Appendix B).

2. All sampling stations will be located with the use of GPS technology. GPS data will be collected with a hand-held GPS unit (+/- 3 meters). The resulting coordinates and digital data will be supplied to the Commission as part of the summary report.

3. At the established sampling station a calibrated Surveyor IV Hydrolab or similar device will be used to monitor the *in-situ* parameters dissolved oxygen (DO), temperature, pH and conductivity. Princeton Hydro is State certified for the collection of these four *in-situ* parameters (State ID # 10006). Data will be recorded at 0.5 - 1.0 meter increments beginning at 0.5 meters below the water's surface to within 0.5 meters of each lake's sediment bottom. In addition, water clarity will be measured at each station with a Secchi disk.

4. Prior to any in-lake sampling event the Surveyor IV Hydrolab or similar device will be calibrated as per the manufacturer's specifications. The boat's on-board fathometer will provide guidance as to the total depth. The meter will be lowered into the water to 0.5 m below the water's surface. Once the readings on the device have equilibrated the *in-situ* measurements (dissolved oxygen, temperature, pH and conductivity) will be recorded. The calibrated line will be lowered at 1.0-meter intervals, and equilibrated measurements will continue to be recorded. At each sampling station the device will be lowered to within 0.5 meters of the bottom.

5. Discrete water quality samples will be collected at one mid-cove sampling station, approximately 0.5 meters below the water's surface and 0.5 m above the sediment. All sub-surface and bottom water discrete water samples will be collected with a Kemmerer or Van Dorn sampling device or laboratory cleaned sample bottle as per Section 5.2.3 - *Surface Water and Liquid Sampling Equipment* of the NJDEP

Field Sampling Procedures Manual (2005). All sample containers will be identified with their respective station IDs and also labeled with the date and time of collection.

6. The sub-surface (0.5 m below surface) discrete samples will be analyzed for total phosphorus, soluble reactive phosphorus, total dissolved phosphorus, ammonia-N, nitrate-N, total suspended solids and chlorophyll *a*. Bottom water (0.5 m above the sediment) discrete samples will be analyzed for total phosphorus, soluble reactive phosphorus, total dissolved phosphorus, microcystins, and phycocyanins.

7. Whole water, sub-surface (0.5 m below surface) samples will be collected for phytoplankton as per the NJDEP Field Sampling Procedures Manual (2005). Analysis via quantification utilizing cell counts (cells/mL) will be performed on these samples and plankton will be identified down to genus or species. The focus will be on cyanobacteria cell counts.

Table 3: Station ID

Site ID	Location ID	Location	Coordinates (approximate)	Treatment Type
P1	Ashley Cove	Jefferson, NJ	40.9639, -74.6114	PhosLock
P2	Landing	Landing, NJ	40.9060, -74.6633	PhosLock

GREENCLEAN ASSESSMENT

1. Princeton Hydro will conduct pre- and post-treatment monitoring of the area that will be treated with GreenClean. Sampling will be conducted at Capp Beach where this treatment will take place.

2. All sampling sites will be located with the use of GPS technology. GPS data will be collected with a hand held GPS unit (+/- 3 meters). The resulting coordinates and digital data will be supplied to the Commission as part of the summary report.

3. At the established sampling area, a calibrated Surveyor IV Hydrolab or similar device will be used to monitor the *in-situ* parameters dissolved oxygen (DO), temperature, pH and conductivity. Princeton Hydro is State certified for the collection of these four *in-situ* parameters (State ID # 10006). Data will be recorded at 0.5 - 1.0-meter increments beginning at 0.5 meters below the water's surface to within 0.5 meters of each lake's sediment bottom. In addition, water clarity will be measured at each station with a Secchi disk.

4. Prior to any in-lake sampling event the Surveyor IV Hydrolab or similar device will be calibrated as per the manufacturer's specifications. The boat's on-board fathometer will provide guidance as to the total depth. The meter will be lowered into the water to 0.5 m below the water's surface. Once the readings on the device have equilibrated the *in-situ* measurements (dissolved oxygen, temperature, pH and conductivity) will be recorded. The calibrated line will be lowered at 1.0-meter intervals, and equilibrated measurements will continue to be recorded. At each sampling station the device will be lowered to within 0.5 meters of the bottom.

5. Discrete water quality samples will be collected at the three sampling stations, approximately 0.5 meters below the water's surface. All sub-surface discrete water samples will be collected with a Kemmerer or Van Dorn sampling device or laboratory cleaned sample bottle as per Section 5.2.3 - *Surface Water and Liquid Sampling Equipment* of the NJDEP Field Sampling Procedures Manual (2005). All sample containers will be identified with their respective station IDs and also labeled with the date and time of collection. The sub-surface discrete samples will be analyzed for chlorophyll *a,* microcystins, phycocyanins, geosmin and MIB.

6. Whole water, sub-surface (0.5 m below surface) samples will be collected for phytoplankton as per the NJDEP Field Sampling Procedures Manual (2005). Analysis via quantification utilizing cell counts (cells/mL) will be performed on these samples and plankton will be identified down to genus or species.

Table 4: Station ID				
Site ID	**Location ID**	**Location**	**Coordinates (approximate)**	**Treatment Type**
G1	Capp Beach	Jefferson, NJ	40.9639, -74.6114	GreenClean 5.0

BIOCHAR ASSESSMENT

1. A series of balls, cages or similar structures will be filled with Biochar (processed wood material that removes nutrients from water) will be installed at Mt. Arlington Beach, Ashley Cove, Landing Channel, Byram Bay Community Club Beach and Hopatcong State Park. However, it should be noted that up to 14 near-shore areas, which includes the beach locations sited above, are being assessed for potential use of Biochar (see project map).

2. Once installed, monitoring will be conducted immediately upgradient and downgradient of Biochar media at each installment site. This sampling will be conducted two times during the 2020 season.

3. All sampling sites will be located with the use of GPS technology. GPS data will be collected with a hand held GPS unit (+/- 3 meters). The resulting coordinates and digital data will be supplied to the Commission as part of the summary report.

Table 5: Station ID for confirmed Biochar installation sites				
Site ID	**Location ID**	**Location**	**Coordinates (approximate)**	**Treatment Type**
B1	Mt Arlington Beach	Mt Arlington NJ	40.9290, -74.6392	Biochar
B2	Landing Channel	Landing NJ	40.9101, -74.6576	Biochar
B3	Ashley Cove	Jefferson NJ	40.9639, -74.6114	Biochar
B4	Byram Bay Community Club Beach	Byram NJ	40.9632, -74.6552	Biochar
B5	Lake Hopatcong State Park	Hopatcong NJ	40.9167, -74.6620	Biochar

4. Discrete water quality samples will be collected at each installment locations in Lake Hopatcong. All discrete water samples will be collected with a laboratory cleaned sample bottle as per Section 5.2.3 - *Surface Water and Liquid Sampling Equipment* of the NJDEP Field Sampling Procedures Manual (2005). All sample containers will be identified with their respective station IDs and also labeled with the date and time of collection.

5. The specific taste and odor parameters that will be lab measured within the lake are Geosmin and MIB. This testing will be conducted by the NJDEP certified analytical laboratory EMSL Analytical Inc (#03036).

6. These discrete samples will be analyzed for total phosphorus, soluble reactive phosphorus and total dissolved phosphorus.

Table 6 – Proposed Sampling Parameters				
Parameter	**Analytical Method**	**Sample Container & Preservation**	**Holding Time**	**Laboratory**
Soluble Reactive Phosphorus	4500-P E and EPA 200.7	1 Quart HDPE bag/bottle, cool to 4°C	48 Hours	ECM
Total Phosphorus	4500-P B-5 and 4500-P E and EPA 200.7	1 Quart HDPE bag/bottle, cool to 4°C	28 Days	ECM
Total Dissolved Phosphorus	4500-P B-5 and 4500-P E	1 Pint plastic, H_2SO_4 added to pH <2, cool to 4°C	28 Days	ECM
Redox (Oxidation-Reduction Potential)	SM 2580 B	Analyzed In-situ	Analyze Immediately	Princeton Hydro
Sediment Phosphorus Fractioning Analysis**	Modified Psenner Sequential Extraction	Plastic Bag	48 hours	SePro
Geosmin**	SM 6040-D	40 mL glass bottle, cool to 4°C sodium omadine (optional)	72 hrs w/o preservation; 7days with preservation	EMSL
MIB**	SM 6040-D	40 mL glass bottle, cool to 4°C sodium omadine (optional)	72 hrs w/o preservation; 7days with preservation	EMSL
Phytoplankton Cell Counts and IDs**	10200 F 1 & 2	100 mL plastic bottle, Lugols solution added, cool to 4°C	ASAP	Princeton Hydro
Microcystins**	Abraxis Test Strip Kit, P/N 520020	Glass sample vials	5 days	Princeton Hydro
Phycocyanin**	Portable Fluorometer	Analyzed in-situ	Analyze Immediately	Princeton Hydro

***** = For Informational Purposes Only and to Inform Advisories, not for regulatory purposes.***

SAMPLE LABELS

A sample label will be affixed to each sample container at the time the samples are collected in the field. The following will be recorded on each label with waterproof ink:

- Sample station location and identification number
- Client/project name
- Date of sample collection
- Time of sample collection
- Name of sample collector
- Type of preservative (if used)

2.2 SAMPLE STORAGE, PRESERVATION AND HOLDING TIMES

Sample containers will be supplied by the laboratory (ECM, EMSL, or SePRO) pre-cleaned and certified to be free of contamination according to the United States Environmental Protection Agency (U.S. EPA) specification for the appropriate methods.

Sampling devices (that are not pre-sterilized and do not contain preservatives/fixing agents) will be rinsed three times with sample water prior to collecting each sample. All samples will be refrigerated or stored on ice (approximately 40°F, do not freeze) and sent to the laboratory immediately at the end of field sampling day for proper storage and preservation.

The sample holding containers, sample preservation methods and maximum holding time for each parameter have been supplied by ECM, EMSL and SePro and are listed in the original QAPP (May 2021).

2.3 CHAIN OF CUSTODY PROCEDURE

For discrete, water and sediment samples (chemical and biological), the sampling containers, preservation, and holding times will follow the specifications in Table 3. Procedures for direct measurements (in-situ water quality) can be found in the original QAPP (May 2021).

Chain of custody procedures will follow those detailed in the original QAPP (May 2021). Copies of both the ECM and SePRO chain of custodies can be found in Appendix A.

3.0 ANALYTICAL REQUIREMENTS

3.1 CHEMISTRY ANALYSES

Chemistry analyses will follow the same guidelines as presented in the original QAPP (May 2021).

3.2 LABORATORY STANDARDS AND REAGENTS

All stock standards and reagents will follow the same guidelines as presented in the original QAPP (May 2021).

4.0 QUALITY OBJECTIVES AND CRITERIA

Summaries of all water quality parameters to be measured and analytical methods to be used are shown in the original QAPP (May 2021). Additional parameters included in this addendum can be found in Table 3. This table was developed in coordination with the independent analytical laboratories; Both Environmental Compliance Monitoring, Inc. (ECM) and SePRO Research & Technology Campus will follow the methods and protocols listed in Table 3. ECM will be responsible for all laboratory analyses except for phytoplankton and zooplankton, which will be identified and enumerated by Princeton Hydro, LLC, and the fractionation analyses performed by SePRO.

Additional information on project detection limits, levels of interest, precision and accuracy for parameters of interest is listed in Table 4. This table was developed in conjunction with Mr. Thomas Grenci of ECM, Inc and Sam Mason of SePRO, and indicates the data quality that is expected for this study.

Table 7 - Information on Detection Limits, Precision and Accuracy for Discrete and Select *In-Situ* Water Quality Parameters

Parameter	Sample Matrix	Project Required Detection Limit	Reporting Level	Level of Interest	Relative Percent Difference*	Percent Recovery*
Total Dissolved Phosphorus*	Water	0.02 mg/L	0.01 mg/L	0.03 mg/L	-9 to 9	88 to 124
Soluble Reactive Phosphorus**	Water	N/A	5.0 µg/L	0.005 mg/L	-20 to 20	99.8 to 100.9
Total Phosphorus**	Water	N/A	10.0 µg/L	5.0 mg/L	-20 to 20	88.6 to 110.7
Microcystin***	Water	1.0 µg/L	0.5 µg/L	3.0 µg/L	N/A	N/A
Phycocyanin†	Water	1.0 µg/L	1.0 µg/L	12.0 µg/L	N/A	N/A

* As supplied by ECM

** As supplied by SePRO

*** Princeton Hydro will use the Abraxis field test strips, which are read with the Abrascan Dipstick Reader. The generated data are not being used for regulatory use but for educational and management purposes. Additionally, while concentrations of the cyanotoxin can be provided with the Reader, the data is essentially being used to identify the presence/absence of the cyanotoxin. If measurable concentrations of a cyanotoxin are identified, subsequent sampling and laboratory-based analyses (i.e. ELISA) may be required

† Level of interest is based on regression analysis done by both Princeton Hydro and NJDEP, and using the more conservative value that corresponds to 20,000 cells/mL threshold for HAB "Watch" Alert Status.

5.0 CALIBRATION PROCEDURES AND PREVENTATIVE MAINTENANCE

All calibration procedures will follow those detailed in the original QAPP (May 2021).

6.0 DOCUMENTATION, DATA REDUCTION AND REPORTING

All documentation, data reduction and reporting will follow the same guidelines as presented in the original QAPP (May 2021).

REFERENCES

References are presented in the original QAPP (May 2021).

APPENDIX A

SePRO Chain of Custody

SRTC

SePRO Research
& Technology Campus

SePRO

Algae & Water Quality Analytical Services

SeSCRIPT® Chain of Custody

Company Name:* ______________________ Contact Person:* ______________________

Billing Address:* ______________________

Telephone:* ______________________ Email Address:* ______________________

Annual? Circle One (YES / NO)

Site Location/State:* ______________________

*Required fields

Project/Reference Name: ______________________

SePRO Aquatic Specialist Name: ______________________

Sampler: ______________________

Number of samples to be analyzed: ______________________

Check Payment Method: ☐ PO Number__________ ☐ VISA ☐ MasterCard Card No.__________________ CCV Code:______ Expiration Date: ______

☐ Check here if you would like us to keep this credit card information on file for future lab analysis orders. Quote No.: ______________

(To establish a secure credit card file for future billing, please contact the SePRO Accounting Department at 317-580-8291).

Sample Location and Identification

Draw a map of water body, to include sample locations by sample identification number as listed on the other side of this form or enclose a copy of a prepared map with this information.

Direct all inquiries about your sampling and SeSCRIPT results to your SePRO Technical Sales Specialist.

Ship samples to:
SePRO SRTC
16013 Watson Seed Farm Road
Whitakers, NC 27891-9114
Email: srtclab@sepro.com
Tel: (252) 437-3282

Field Notes:

Page 1 of 2

COC#: ____________ Report #: ____________

SRTC SePRO Research & Technology Campus

Algae & Water Quality Analytical Services

SeSCRIPT® Chain of Custody

Water Body Name: ____________ City ____________ State ____________

Water Body Size: (acres) ____________ Average Depth: (feet) ____________ Date/Time Sample Collected: ____________ One form for each water body

Bundle Analysis:

- ☐ **Water Quality Baseline Bundle** (pH, alkalinity, conductivity, hardness, dissolved oxygen, turbidity, total phosphorus, free reactive phosphorus)
- ☐ **Water Quality Baseline Plus Bundle** (Baseline Bundle plus chlorophyll a, nitrates, nitrites and total nitrogen)
- ☐ **Algae and WQ Baseline Plus Bundle** (WQ Baseline Plus Bundle and algae I.D./enumeration)
- ☐ **Comprehensive Algae Bioassay** (A multi-phase bioassay screening process to evaluate site specific algaecide performance. Also includes the Algae & WQ Baseline Plus analyses. Contact SePRO prior to collection and shipment.)

Individual Analysis:

- ☐ Algae ID††
- ☐ Alkalinity
- ☐ Chloride††
- ☐ Chlorophyll a
- ☐ Conductivity
- ☐ Dissolved Oxygen†
- ☐ Hardness
- ☐ Microbial Bacteria†† (total coliform & E. coli)
- ☐ Nitrates & Nitrites
- ☐ Nitrogen, Total (Kjeldahl)
- ☐ pH
- ☐ Phosphorus, Total (water)
- ☐ Phosphorus, Free Reactive (water)
- ☐ Phosphorus, Total & Free Reactive (water)
- ☐ Phosphorus, Total (sediments)
- ☐ Salinity††
- ☐ Total Dissolved Solids
- ☐ Total Suspended Solids
- ☐ Turbidity

Phosphorus, Fractioning†† (sediments)

- ☐ Level 1 Total & Available P
- ☐ Level 2 SRTC Comprehensive

Algae Infestation:

☐ Low ☐ Moderate ☐ High

Additional description: ____________

Water Uses:

☐ Swimming ☐ Fishing ☐ Potable ☐ Irrigation ☐ All listed

Describe algae management history (*if any*): ____________

† In order for the lab to generate more accurate D.O. data, it is recommended to preserve the sample immediately after collecting using appropriate reagents. †† This laboratory is not accredited for these tests: Salinity, Chloride, Phosphorus fractioning, Algae ID and Microbial Bacteria.

Client Sample Site I.D. (Required field)	Date Sample Collected (Required field)	Depth Sample Collected (feet)	Sample Location – Identify sites on map (GPS coordinates preferred)	Lab Use Only - Notes
1.				
2.				
3.				
4.				
5.				
6.				

Shipped by: ____________ **Date/Time:** ____________

To be filled out by laboratory

Received by: ____________ **Date/Time:** ____________

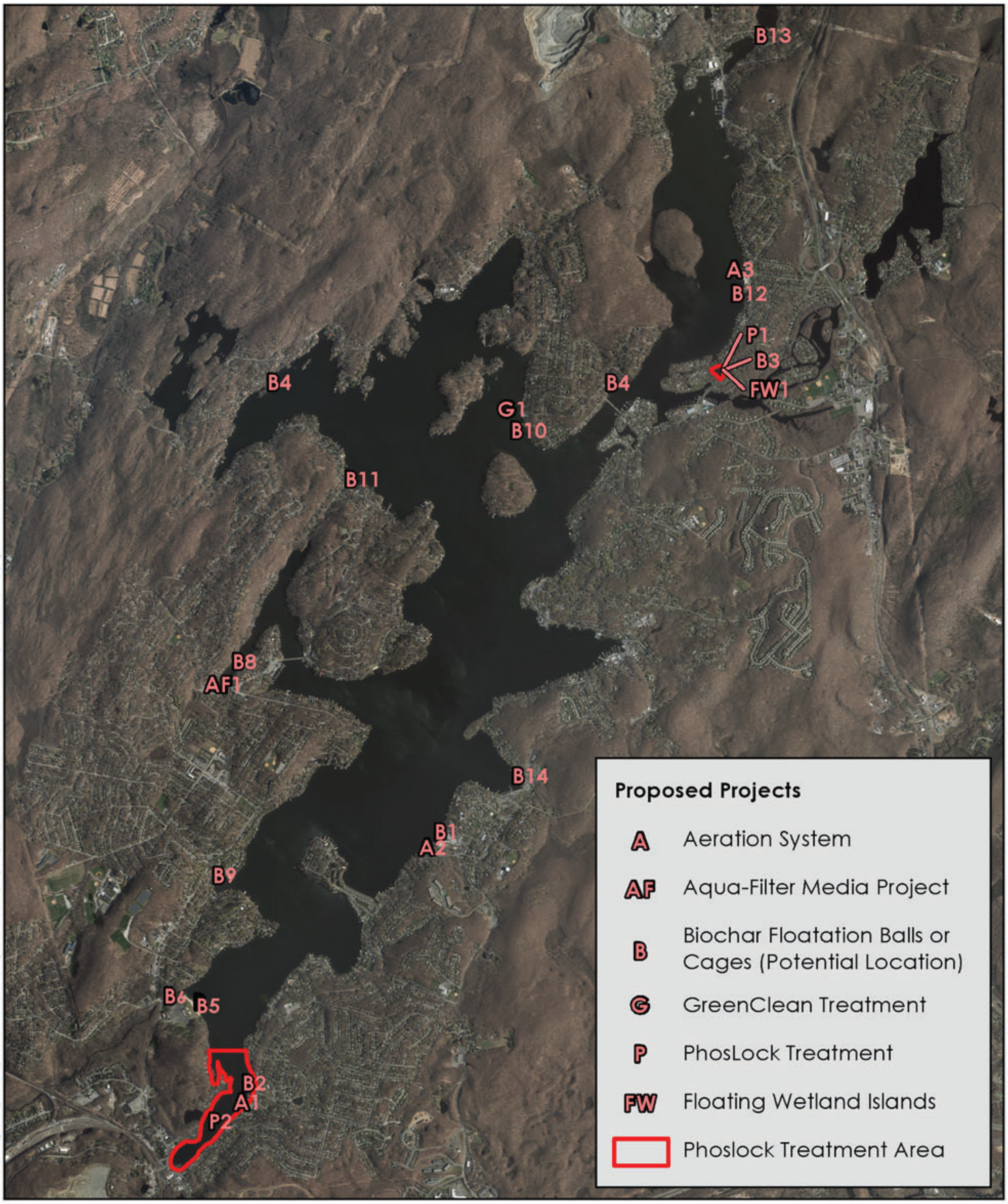
Sample condition upon receipt: ☐ Good condition ☐ No (explain) ____________

Sample temperature upon receipt: ____________ **Thermometer ID:** ____________

Page 2 of 2

APPENDIX B

Maps



NOTES:
1. Project site locations are approximate.
2. 2015 orthoimagery obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS).

0 1,750 3,500 Feet

Map Projection: NAD 1983 StatePlane New Jersey FIPS 2900 Feet

FIGURE 2
PROJECT SITE LOCATION MAP

LAKE HOPATCONG
HOPATCONG AND MT. ARLINGTON BOROUGHS
AND JEFFERSON AND ROXBURY TOWNSHIPS
MORRIS AND SUSSEX COUNTIES, NEW JERSEY

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APPENDIX C

Sampling Plan Table

Summary Table: Sampling Plan Details							
Site ID	Location ID	Location	Coordinates (approximate)	Treatment Type	Parameters	Media	Schedule
AF1	Crescent Cove Beach Club	Hopatcong NJ	40.9405, -74.6615	SW Basins & Aquafilters	TP, SRP, TDP	water	3 stormwater samples after BMP implementation in 2020 growing season
A1	Shore Hills Beach	195 Mt. Arlington Blvd, Landing NJ	40.9098, -74.6573	Air Curtain System	Water clarity, DO, temperature, pH and conductivity; Chl a, microcystin, Phycocyanin, plankton counts	water	3 WQ sampling after BMP implementation June, July August of 2020
A2	Mount Arlington Municipal Beach	511 Windemere Ave., Mt. Arlington NJ	40.9291, -74.6391	Nanobubble Oxygen System	Water clarity, DO, temperature, pH and conductivity; Chl a, microcystin, Phycocyanin, plankton counts	water	3 WQ sampling after BMP implementation June, July August of 2020
A3	Lake Forest Yacht Club	35 Yacht Club Drive, Lake Hopatcong NJ	40.9705, -74.6093	Nanobubble Ozone System	Water clarity, DO, temperature, pH and conductivity; Chl a, microcystin, Phycocyanin, phytoplankton cell counts	water	3 WQ sampling events after BMP implementation June, July August of 2020
B1	Mt Arlington Beach	Mt Arlington NJ	40.9290, -74.6392	Biochar	TP, SRP and TDP	water	2 WQ sampling events during the 2020 growing season, each at 1 up- and 1 downgradient site
B2	Landing Channel	Landing NJ	40.9101, -74.6576	Biochar	TP, SRP and TDP	water	2 WQ sampling events during the 2020 growing season, each at 1 up- and 1 downgradient site
B3	Ashley Cove	Jefferson NJ	40.9639, -74.6114	Biochar	TP, SRP and TDP	water	2 WQ sampling events during the 2020 growing season, each at 1 up- and 1 downgradient site
B4	Byram Bay Community Club Beach	Byram NJ	40.9632, -74.6552	Biochar	TP, SRP and TDP	water	2 WQ sampling events during the 2020 growing season, each at 1 up- and 1 downgradient site
B5	Lake Hopatcong State Park	Hopatcong NJ	40.9167, -74.6620	Biochar	TP, SRP and TDP	water	2 WQ sampling events during the 2020 growing season, each at 1 up- and 1 downgradient site
P1	Ashley Cove	Jefferson, NJ	40.9639, -74.6114	PhosLock	Water clarity, DO, temperature, pH and conductivity; TP, SRP, TDP, ammonia-N, nitrate-N, and TSS; phytoplankton cell counts, phycocyanin, Chl a, microcystins	water	4 times during the 2020 and 2021 growing seasons, each (8 total) All stations that receive Phoslock will receive pre and post treatment sampling
P2	Landing	Landing, NJ	40.9060, -74.6633	PhosLock	Water clarity, DO, temperature, pH and conductivity; TP, SRP and TDP; phytoplankton cell counts, phycocyanin, Chl a, microcystins	water	1 pre- and 2 post-treatment each in the 2020 growing season
					P fractionation - TP (labile, metal oxide, reductant-soluble, organic, apatite and residual) and SRP (organic portion)	sediment	1 pre- and 2 post-treatment each in the 2020 growing season at 5 sampling sites (TBD)
G1	Capp Beach	Jefferson, NJ	40.9639, -74.6114, TBD TBD	GreenClean 5.0	Water clarity, DO, temperature, pH and conductivity; phytoplankton cell counts, phycocyanin, Chl a, microcystins, geosmin and MIB	water	1 pre- and 1 post-treatment each in the 2020 growing season at 3 sites (TBD)

APPENDIX III:

ASHLEY COVE – WATER QUALITY DATA

Ashley Cove: Pre-Treatment Monitoring - 6/5/20							
DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
1.5	1.5	0.1	22.4	0.307	8.64	99.6	8.97
		1	20.11	0.332	6.94	76.6	8.28

Ashley Cove: Pre-Treatment Monitoring - 9/4/20							
DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
1.3	1.3	0.1	22.93	0.329	5.05	58.9	7.47
		1	22.66	0.331	2.55	29.6	7.18

Ashley Cove: Pre-Treatment Monitoring - 10/9/20							
DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
1.2	1.2	0.1	13.95	0.319	5.74	55.7	6.41
		1	13.85	0.319	5.73	55.5	6.46

Ashley Cove: Discrete Data (Surface)								
Date	Station	Chl a	NH3-N	NO3-N	SRP	TDP	TP	TSS
		ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
6/5/2020	AC-S	3.2	0.02	0.07	0.001	0.01	0.02	5
9/4/2020	AC-S	13.0	0.005	0.03	0.001	0.02	0.04	5
10/9/2020	AC-S	13.0	0.005	0.11	0.003	0.02	0.04	2

Ashley Cove: Discrete Data (Deep)				
Date	Station	SRP	TDP	TP
		mg/L	mg/L	mg/L
6/5/2020	AC-D	0.002	0.01	0.03
9/4/2020	AC-D	0.001	0.02	0.05
10/9/2020	AC-D	0.002	0.005	0.02

Ashley Cove: Cyanobacteria and Clarity Metrics						
Date	Station	Phycocyanin	Chl a	Cyano Cell Count	Microcystin	Secchi Depth
		ug/L	ug/L	cells/mL	ppb	meters
6/5/2020	Ashley Cove	3	6	2384	1 ppb	1.5
9/4/2020	Ashley Cove	10	12	12970	Negative	1.3
10/9/2020	Ashley Cove	3	6	0	Negative	1.2

Phytoplankton and Zooplankton Community Composition Analysis					
Sampling Location: Ashley Cove		Sampling Date: 6/5/20		Examination Date: 6/9/20	
Site 1: Surface grab					
Phytoplankton					
Bacillariphyta	**1**	**Chlorophyta**	**1**	**Cyanophyta**	**1**
Cymbella	51	*Chlamydomonas*	609	*Dolichospermum*	2384
		Crucigenia	51		
Chrysophyta		*Eudorina*	203	**Cryptomonads**	
Uroglena	1572	*Coelastrum*	254	*Cryptomonas*	1065
Sites:	**1**	**Comments: Microcystins: 1 ppb**			
Total Phytoplankton genera/ Cells per mL	6189				
Total Cyanobacteria Cells per mL	2384				
		Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)			
		Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare			

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Phytoplankton and Zooplankton Community Composition Analysis					
Sampling Location: Ashley Cove		**Sampling Date: 9/4/20**		**Examination Date: 9/9/20**	
Site 1: Surface grab					
Phytoplankton					
Bacillariphyta	**1**	**Chlorophyta**	**1**	**Cyanophyta**	**1**
Synedra	440	*Chlamydomonas*	440	*Dolichospermum*	5935
		Chlorella	989	*Pseudanabaena*	1209
Chrysophyta		*Scenedesmus*	1539	*Merismopedia*	1759
Dinobryon	989	*Crucigenia*	440	*Aphanizomenon*	4067
		Haematococcus	110	**Cryptomonads**	
Pyrrhophyta		*Coelastrum*	879	*Cryptomonas*	1759
Gymnodinium	110	*Staurastrum*	110		
Sites:	**1**	**Comments: Microcystin: Negative**			
Total Phytoplankton genera/ Cells per mL	20775				
Total Cyanobacteria Cells per mL	12970				
		Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)			
		Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare			
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Phytoplankton and Zooplankton Community Composition Analysis					
Sampling Location: Ashley Cove		Sampling Date: 10/9/20		Examination Date: 10/12/20	
Site 1: Surface grab					
Phytoplankton					
Bacillariphyta	**1**	**Chlorophyta**	**1**	**Cyanophyta**	**1**
Synedra	80	*Crucigenia*	640		
Navicula	80				
Chrysophyta					
Dinobryon	961				
				Cryptomonads	
Euglenophyta				*Cryptomonas*	881
Trachelomonas	80				
Sites:	**1**	**Comments: Microcystin: Negative**			
Total Phytoplankton genera/ Cells per mL	2722				
Total Cyanobacteria Cells per mL	0				
		Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)			
		Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare			
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APPENDIX IV:

LANDING CHANNEL – WATER QUALITY DATA

Landing Channel: Pre-Treatment Monitoring - 6/12/20								
Station	DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
Landing	2.0	1.5	0.1	23.59	0.455	5.93	70.1	7.40
			1.0	23.47	0.457	5.89	69.5	7.24
			1.5	23.21	0.459	5.93	69.6	7.21
ST-5	1.4	1.4	0.1	22.97	0.437	7.66	89.5	7.52
			1.0	22.38	0.436	6.58	76.0	7.44

Landing Channel: Post-Treatment Monitoring - 6/24/20								
Station	DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
Landing	2.1	1.9	0.1	26.93	0.467	7.62	95.1	7.50
			1.0	26.59	0.469	7.62	94.5	7.47
			1.8	26.14	0.464	7.73	95.1	7.54
ST-5	2.7	1.5	0.1	25.88	0.452	6.64	81.3	7.67
			1.0	25.24	0.445	6.24	75.5	7.56
			2.0	24.62	0.444	6.22	74.4	7.50
			2.5	24.34	0.445	5.78	68.8	7.42

Landing Channel: Post-Treatment Monitoring - 7/22/20								
Station	DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
Landing	1.9	1.0	0.1	28.75	0.452	9.33	120.2	8.37
			1.0	28.67	0.452	9.61	123.7	8.35
			1.5	28.24	0.45	7.41	94.8	7.79
ST-5	1.2	1.1	0.1	28.12	0.446	8.82	112.5	8.17
			1.0	28.06	0.446	8.88	113.0	8.10

Landing Channel: Post-Treatment Monitoring - 9/23/20								
Station	DEPTH (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
Landing	2.0	1.2	0.1	15.76	0.442	10.15	102.4	7.91
			1.0	15.73	0.442	10.09	101.8	7.97
			1.5	15.69	0.442	10.07	101.5	7.99
ST-5	3.1	1.1	0.1	16.72	0.439	10.16	104.6	8.00
			1.0	16.71	0.439	10.12	104.2	8.01
			2.0	16.60	0.439	10.14	104.2	8.01
			2.5	16.54	0.439	10.04	103.0	8.05

Landing Channel: Discrete Data (Surface)					
Date	Station	Chl a	SRP	TDP	TP
		µg/L	mg/L	mg/L	mg/L
6/12/2020	Landing Channel	5.2	0.001	0.020	0.03
	ST-5 Control	9.4	0.001	n.s	0.03
6/24/2020	Landing Channel	4.0	0.001	0.005	0.02
	ST-5 Control	n.s.	n.s.	n.s	n.s.
7/22/2020	Landing Channel	26.0	0.001	0.040	0.05
	ST-5 Control	22.0	0.001	n.s	0.03
9/23/2020	Landing Channel	n.s.	0.004	0.020	0.03
	ST-5 Control	17.0	0.001	n.s.	0.03

Landing Channel: Discrete Data (Deep)				
Date	Station	SRP	TDP	TP
		mg/L	mg/L	mg/L
6/12/2020	Landing Channel	0.0	0.02	0.04
6/24/2020	Landing Channel	0.0	0.01	0.02
7/22/2020	Landing Channel	0.0	0.05	0.08
9/23/2020	Landing Channel	0.0	0.02	0.03

Landing Channel: Cyanobacteria and Clarity Metrics						
Date	Station	Phycocyanin	Chl *a*	Cyano Cell Counts	Microcystin	Secchi Depth
		µg/L	µg/L	mg/L	ppb	meters
6/12/2020	Landing Channel	3	4	5969	Negative	1.5
6/24/2020	Landing Channel	3	9	1624	Negative	1.9
7/22/2020	Landing Channel	22	16	63230	n.s.	1
9/23/2020	Landing Channel	10	9	26214	Negative	1.2

Phytoplankton and Zooplankton Community Composition Analysis

Sampling Location: Hopatcong		Sampling Date: 6/12/20		Examination Date: 6/17/20	
Site 1: Landing Surface					
Phytoplankton					
Bacillariphyta	**1**	**Chlorophyta**	**1**	**Cyanophyta**	**1**
Navicula	43	*Chlorella*	171	*Dolichospermum*	298
Tabellaria	554	*Chlamydomonas*	43	*Aphanizomenon*	5287
Asterionella	640	*Crucigenia*	298	*Pseudanabaena*	384
Chrysophyta		*Gloeotila*	171	**Cryptomonads**	
Sites:	**1**	**Comments:**			
Total Phytoplankton genera/ Cells per mL	7889				
Total Cyanobacteria Cells per mL	5969				
		Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)			
		Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare			

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Phytoplankton and Zooplankton Community Composition Analysis

Sampling Location: Hopatcong			Sampling Date: 6/24/20			Examination Date: 6/26/20		
Site 1: Landing Surface			Site 2: ST-5 Surface					
Phytoplankton								
Bacillariphyta	**1**	**2**	**Chlorophyta**	**1**	**2**	**Cyanophyta**	**1**	**2**
Navicula	*49*		*Chlorella*	*148*	337	*Dolichospermum*	*1624*	562
Cymbella	*49*		*Chlamydomonas*	*98*	225	*Aphanizomenon*		2756
Fragilaria		450	*Pediastrum*	*788*	900			
Synedra		169	*Gloeotila*	*98*	1237	**Cryptomonads**		
Stephanodiscus		56	*Scenedesmus*	*591*	225	*Cryptomonas*	*394*	619
Chrysophyta			*Pandorina*	*197*				
Dinobryon	*689*	225	*Eudorina*	*394*	450			
			Haematococcus	*98*	112			
			Ankistrodesmus	*49*				
			Treubaria		46			
Sites:	**1**	**2**	**Comments: Microcystin tests were Negative at both stations**					
Total Phytoplankton genera/ Cells per mL	5266	8369						
Total Cyanobacteria Cells per mL	1624	3318						
			Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)					
			Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare (R); Herbivorous (H) or Carnivorous (C)					

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Phytoplankton and Zooplankton Community Composition Analysis								
Sampling Location: Hopatcong			**Sampling Date: 7/22/20**			**Examination Date: 7/23/20**		
Site 1: Landing Surface								
Phytoplankton								
Bacillariphyta	1	2	**Chlorophyta**	1	2	**Cyanophyta**	1	2
Fragilaria	675		*Akinstrodesmus*	771		*Aphanizomenon*	34892	
Melosira	771		*Chlamydomonas*	289		*Aphanocapsa*	6843	
Synedra	96		*Chlorella*	1446		*Dolichospermum*	12338	
Tabellaria	1157		*Cosmarium*	193		Lyngbya	4338	
			Scenedesmus	771		*Woronchinia*	4819	
Chrysophyta			*Sphaerocystis*	5301				
			Staurastrum	96		**Cryptomonads**		
						Chroomonas	289	
Sites:	1	2	**Comments:**					
Total Phytoplankton genera/ Cells per mL	75085	0						
Total Cyanobacteria Cells per mL	63230	0						
			Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)					
			Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare (R); Herbivorous (H) or Carnivorous (C)					
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Phytoplankton and Zooplankton Community Composition Analysis								
Sampling Location: Hopatcong			**Sampling Date: 9/23/20**			**Examination Date: 9/24/20**		
Site 1: Landing Surface								
Phytoplankton								
Bacillariphyta	1		**Chlorophyta**	1		**Cyanophyta**	1	
Navicula			*Chlorella*	200		*Dolichospermum*	9505	
Melosira	200		*Haematococcus*	200		*Aphanizomenon*	12807	
Fragilaria	400		*Ankistrodesmus*	100		*Pseudanabaena*	3902	
Synedra	2802		*Staurastrum*	200		**Cryptomonads**		
Stephanodiscus			*Scenedesmus*	600		*Cryptomonas*	300	
Chrysophyta			*Eudorina*	800				
Dinobryon	100					**Euglenophyta**		
						Euglena	100	
Sites:	1		**Comments: Microcystin tests were Negative**					
Total Phytoplankton genera/ Cells per mL	32216							
Total Cyanobacteria Cells per mL	26214							
			Phytoplankton Key: Bloom (B), Common (C), Present (P), and Rare (R)					
			Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare (R); Herbivorous (H) or Carnivorous (C)					
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APPENDIX V:

CAPP BEACH – WATER QUALITY DATA

Capp Beach: *In-Situ*						
Date	Secchi	Temperature	Specific Conductance	Dissolved Oxygen		pH
	(m)	°C	mS/cm	mg/L	% Sat.	S.U.
8/12/2020	0.8	28.28	0.367	8.40	107.6	7.88
8/17/2020	1.1	26.25	0.419	9.09	112.0	7.77

CAPP Beach: Cyanobacteria and Clarity Metrics						
Date	Station	Phycocyanin	Chl a	Cyano Cell Count	Microcystin	Secchi Depth
		ug/L	ug/L	cells/mL	ppb	meters
8/12/2020	B2	23	20	60297	Negative	0.8
8/17/2020	B2	31	26	n.s.	Negative	1.1

APPENDIX VI:

BIOCHAR – STORMWATER SAMPLING DATA

Biochar: Stormwater Sampling					
Date	Site	Stream Side	SRP	TDP	TP
			mg/L	mg/L	mg/L
7/10/2020	Lorettacong Drive	Upstream	0.042	0.08	0.48
		Downstream	0.032	0.08	0.27
	Yacht Club	Upstream	0.071	0.11	0.2
		Downstream	0.003	0.03	0.09
	Edith M Decker	Upstream	0.037	0.24	0.16
		Downstream	0.031	0.06	0.49
	Lakeside	Upstream	0.118	0.18	0.43
		Downstream	0.116	0.18	0.34
10/29/2020	Lorettacong Drive	Upstream	0.039	0.04	0.06
		Downstream	0.027	0.03	0.06
	Yacht Club	Upstream	0.019	0.02	0.06
		Downstream	0.02	0.02	0.06
	Edith M Decker	Upstream	0.026	0.03	0.12
		Downstream	0.028	0.03	0.12
	Lakeside	Upstream	0.123	0.14	0.49
		Downstream	0.124	0.13	0.45
	Memorial Pond	Upstream	0.046	0.05	0.09
		Downstream	0.011	0.02	0.03
	Duck Pond	Upstream	0.179	0.18	0.31
		Downstream	0.006	0.01	0.06

APPENDIX VII:

CYANOBACTERIA AND PHYCOCYANIN REGRESSION RAW DATA

Cyanobacteria, Phycocyanin, and Chlorophyll *a* Summary						
Date	**Lake**	**Station**	**Depth**	**Phycocyanin**	**Chl *a***	**Cyano Cell Count**
				µg/L	µg/L	cells/mL
6/12/2020	Hopatcong	ST-2	Surface	10	12	53,600
7/22/2020	Hopatcong	ST-2	Surface	11	7	18,643
8/24/2020	Hopatcong	ST-2	Surface	20	8	162,260
9/23/2020	Hopatcong	ST-2	Surface	11	10	26,954
7/15/2020	Hopatcong	B1	Surface	24	34	65,681
7/15/2020	Hopatcong	B2	Surface	9	12	33,019
7/15/2020	Hopatcong	B3	Surface	22	27	22,384
7/15/2020	Hopatcong	B4	Surface	19	30	19,718
7/15/2020	Hopatcong	B5	Surface	11	8	34,249
7/15/2020	Hopatcong	B6	Surface	17	18	82,777
7/15/2020	Hopatcong	B7	Surface	16	15	83,617
7/15/2020	Hopatcong	B8	Surface	11	9	52,533
8/12/2020	Hopatcong	B1	Surface	27	26	37,377
8/12/2020	Hopatcong	B2	Surface	23	20	60,297
8/12/2020	Hopatcong	B3	Surface	90	18	530,992
8/12/2020	Hopatcong	B4	Surface	105	29	323,022
8/12/2020	Hopatcong	B5	Surface	15	5	58,311
8/12/2020	Hopatcong	B7	Surface	18	9	73,585
8/12/2020	Hopatcong	B8	Surface	23	6	50,832
8/12/2020	Hopatcong	Outlet	Surface	18	12	65,380
8/12/2020	Hopatcong	ST-3	Surface	78	25	261,156
6/5/2020	Hopatcong	Ashley Cove	Surface	3	6	2,384
9/4/2020	Hopatcong	Ashley Cove	Surface	10	12	12,970
10/9/2020	Hopatcong	Ashley Cove	Surface	3	6	0
6/12/2020	Hopatcong	Landing Channel	Surface	3	4	5,969
6/24/2020	Hopatcong	Landing Channel	Surface	3	9	1,624
6/25/2020	Hopatcong	ST-5	Surface	4	8	3,318
7/22/2020	Hopatcong	Landing Channel	Surface	22	16	63,230
9/23/2020	Hopatcong	Landing Channel	Surface	10	9	26,214