Lake Sagamore – 2017 Water Quality and Macrophyte Survey
Town of Kent, Putnam County, New York

Prepared for:

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October 2017

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Executive Summary

Princeton Hydro conducted a single water quality monitoring event and aquatic plant survey on Lake Sagamore on 8 September 2017. Data collected from this event showed low nutrient concentrations, acceptable, but lower than normal clarity, moderate algal densities and low macrophyte growth. As such, water quality conditions were acceptable in 2017 in terms of swimming, boating and general aesthetics.

Continued monitoring, on an annual basis, should be continued in order to track any changes in water quality or plant growth. This serves to not only inform the Lake's residents but has proven vital in procuring State permits for management activities.

1.0 Lake Sagamore – Historic Water Quality

Lake Sagamore is an approximately 110 acre waterbody located in the town of Kent, Putnam County, New York. Created in 1947, the lake is an impoundment of numerous small streams and serves not only as the focal point of the community but as a critical source of drinking water for New York City via Boyds Corner Reservoir. Princeton Hydro has served as the lake manager for the lake for numerous years. In this capacity Princeton Hydro routinely collects pertinent water quality data and uses this data to make informed decisions regarding management measures.

As a lake manager it is necessary to take into account all of the various uses of the lake in designing a sampling program and in using this data to properly manage the waterbody. The question arises, what are the primary uses of the lake and what type of data should we collect in order to provide for informed management decisions that have a tangible impact on improving the lake?

For Lake Sagamore we look at upholding appropriate conditions for swimming, boating and general aesthetics while maintaining water quality for consumptive end use. As such, it is necessary to ensure that the lake does not suffer from high levels of nutrients, such as phosphorus, nitrogen and sediment, which will lead to high levels of plant and algae growth. It should be noted that every lake has nutrients, they are necessary for a healthy lake, but, excessive nutrients are commonly related to things we can control and will create lake poor lake conditions.

We have historically tracked total phosphorus in Lake Sagamore as increases in phosphorus lead to increases in plant and algae growth. Increases in this nutrient are commonly associated with watershed sources such as improper stormwater management, improperly designed and maintained septic systems, excessive densities of waterfowl and lack of shoreline buffers. Historic phosphorus concentrations at Lake Sagamore are as follows:

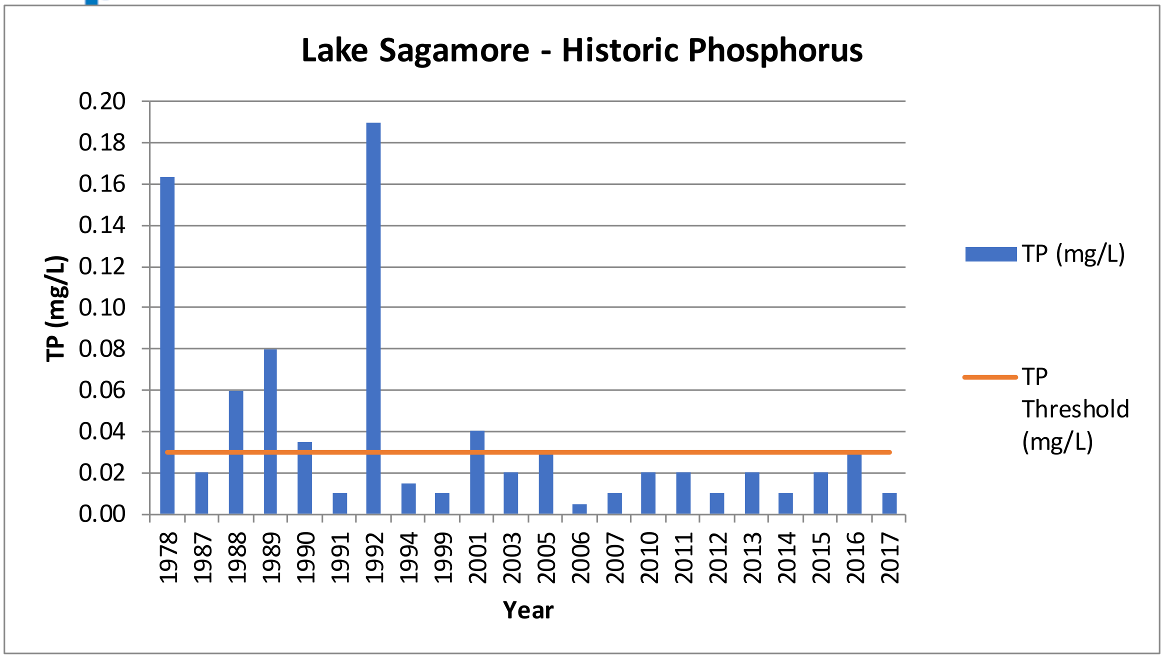


Figure 1.1: Lake Sagamore – Historic Phosphorus Concentrations

The above figure shows that, for the most part, total phosphorus concentrations in Lake Sagamore are well below the threshold established by Princeton Hydro of 0.03 mg/L. The exceptions to this were spikes in TP which occurred in 1978 and 1992. New York State water quality guidelines are narrative in nature for phosphorus, that is, phosphorus should not be present in concentrations that lead to growths of algae and plants that will impair waters for their best usages. We have found that concentrations above 0.03 mg/L tend to lead to these aforementioned conditions. Phosphorus concentrations are low in Lake Sagamore primarily because of the relatively undisturbed nature of the watershed. TP concentrations have showed a reduction in 2017 to 0.01 mg/L thereby reversing a trend of slight increases in this nutrient from 2014 through 2016. The concentration measured in 2017 is well below the threshold of 0.03 mg/L.

Another parameter we look at is Secchi disk transparency. This is simply a measure of the clarity of the water and is determined through the lowering of a Secchi disk throughout the water column until it is just barely visible. Secchi depth is important in Lake Sagamore because increases in planktonic algae, due to excessive nutrients, will cause a reduction in clarity and indicates declining water quality conditions related to swimming and aesthetics. Conversely, high transparency will indicate good water quality but also means that ample light is reaching the lake bottom thereby promoting plant growth. Generally, Secchi depths greater than 1.0 m are indicative of acceptable water clarity while depths of 2.0 m and greater are ideal for swimming. Historical Secchi depth from Lake Sagamore is presented below.

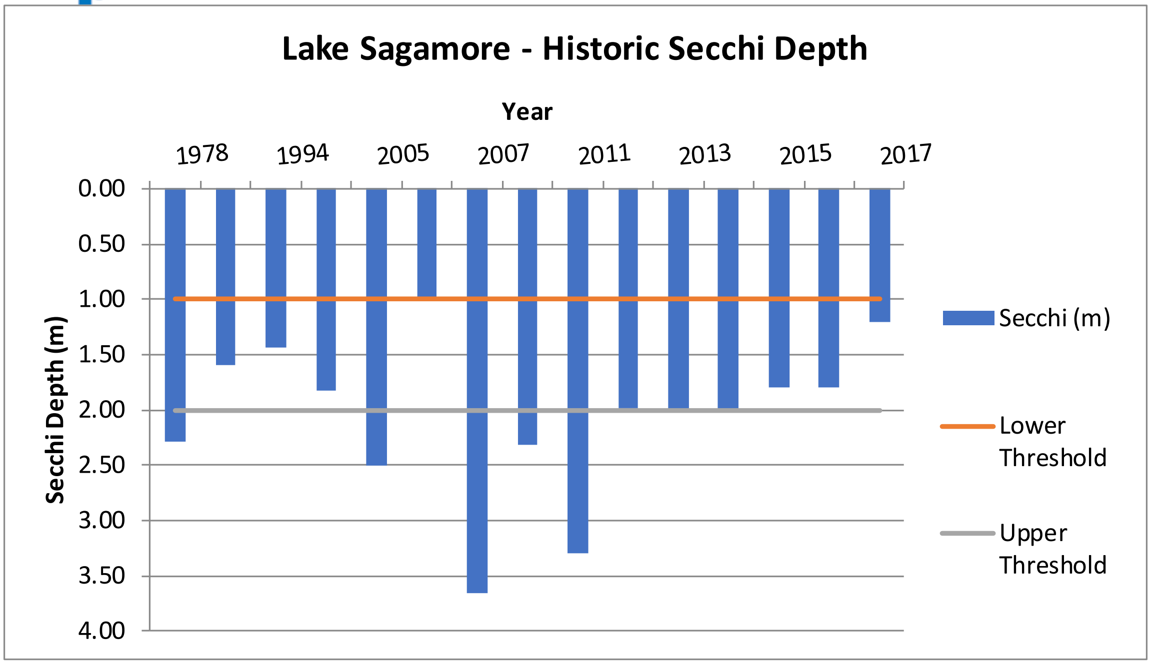


Figure 1.2: Lake Sagamore – Historic Secchi Depth

Secchi depth at Lake Sagamore has been equal to or greater than the lower threshold of 1.0 m throughout the entire historical dataset and depths have been greater than the higher threshold of 2.0 m in 1978, 2005 and 2007-2011. More recently, transparency has hovered around 2.0 m thereby indicating excellent conditions for swimming. Secchi depth for 2017 was just above the lower threshold value with a measure of 1.2 m. This value is markedly lower than measures taken during the past eight years. The reduction in clarity in 2017 was associated with increased algal densities. Nevertheless, this measure was still acceptable for swimming and recreation. The following data provides a glimpse at the amount of plant growth observed throughout Lake Sagamore during the historical monitoring period.

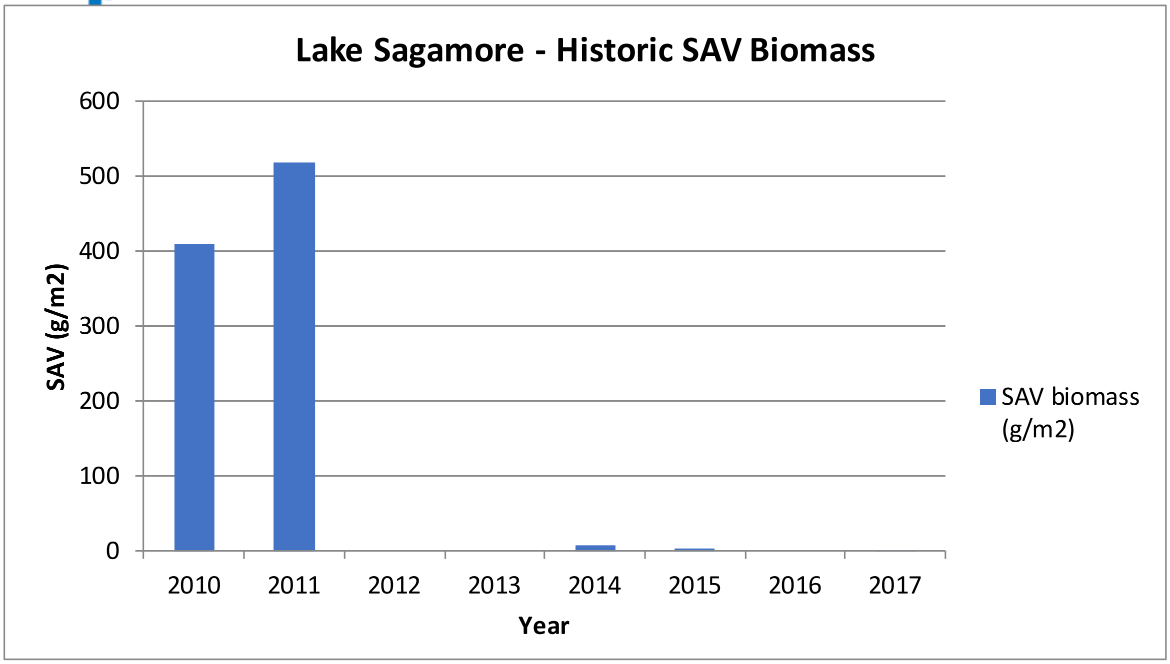


Figure 1.3: Lake Sagamore – Historic Plant Biomass

A review of Princeton Hydro's quantitative SAV dataset in conjunction with information provided by the Lake Sagamore Community Association has shown that the lake suffered from elevated densities of pondweeds from 2001-2003. This plant growth was subsequently cleared due to the addition of sterile grass carp with low plant growth noted from 2005-2006. Subsequently, bladderwort became the dominant plant with increasing growth in 2010-2011. Additional grass carp stocking has brought weed densities to zero during the 2013 season. A very slight increase, to 8 g/m^2, was measured during the 2014 season. Very sporadic growth of low-lying plants was periodically observed in 2017. Plant biomass along the 2017 transects was 1 g/m^2.

The continued monitoring of SAV has documented changes not only in the densities of plants in the lake but also in the species. This data has proved invaluable in terms of providing the scientific data necessary to secure state permits for the addition of sterile grass carp which have served as the primary management measure in maintaining Lake Sagamore as a community resource.

2.0 Recommendations on Maintaining the Quality of Lake Sagamore

The review of the historic data in section 1 has shown that Lake Sagamore is in excellent condition for its designated uses. Phosphorus concentrations are low while transparency is acceptable and nuisance plant growth is minimal. The following section will touch briefly on what the community can do to ensure the lake is in as good or better condition for future generations.

The focus for maintaining acceptable lake water quality will be on making sure excessive nutrients do not enter the lake from the watershed. There are many things a homeowner can do to facilitate this goal. The following provides a very brief synopsis of basic steps a homeowner can make to ensure excellent lake quality.

Septic System Management

Septic systems at lakefront homes may contribute excessive phosphorus to lakes due to site constraints, proximity to the seasonal water table and improper maintenance. Simple measures such as water conservation practices and routine system pump outs (approximately every 3 years) can go a long way to maintaining properly functioning septic systems that will not contribute phosphorus or fecal coliforms to the lake.

Shoreline Buffers

Establishment or maintenance of an area of native plants and grasses in an approximately 100 foot buffer along the lake shore can enhance nutrient filtering all while increasing vital habitat for the lakes inhabitants. Creating such a buffer can help to intercept sediment and phosphorus before it flows into the lake thereby helping to reduce nutrient pollution. Furthermore, this shoreline habitat is crucial in a properly functioning aquatic ecosystem.

Fertilizer Management

Applications of lawn fertilizers and other lawn chemicals may directly run into the lake when it rains. Before conducting any fertilizer applications take a soil sample and determine what nutrients are necessary for a healthy growing lawn. These services are often offered at low or no cost through the local soil and conservation service or agricultural extension. Many companies are now offering phosphorus free fertilizers that are becoming ever popular in lake communities. To tell if the fertilizer you are using is phosphorus free, look at the N-P-K ratio, this tells you how much nitrogen – phosphorus – potassium is in the fertilizer. A ‘zero’ in the middle will indicate you have found a lake-friendly (phosphorus free) fertilizer.

Salt Management

The basic principal behind salt management is the same as fertilizer management. Any salt applied to asphalt for ice control will be transported to the lake once the snow melts. Increasing lake salinity will then result along with changes to the ecosystem. Reduce the amount of salt that is used or utilize alternative agents such as cindering.

Impervious Area and Stormwater Management

Increases in impervious areas, such as driveways and roofs, serves to alter the way water flows in a watershed. Increased impervious areas in a watershed reduce percolation while increasing the speed of the water entering the lake thereby increasing its potential for erosion. This basically translates to increased nutrient transport to the lake and such conditions have caused the decline of numerous waterbodies throughout the region and the country.

Some basic things the community can do to combat these conditions is to limit future development of impervious areas and capture the rainwater that is running off current parcels of impervious areas. This can be done through the implementation of rain barrels which are simply barrels placed at the end of downspouts that collect stormwater before it enters the lake. The collected water can be utilized on-site for watering plants and flowers. Also, the community can install rain gardens. Rain gardens are basically gardens that are strategically placed to intercept stormwater. The vegetation in a rain garden serves to slow the flow of water and in doing so phosphorus and sediments settle out of the stormwater before it enters the lake.

All of the aforementioned measures may seem like relatively minor steps but can, if taken in conjunction, serve to uphold the water quality of the lake and may actually serve to cause noticeable improvements.

3.0 Summary of 2017 Water Quality and Plant Data

Princeton Hydro collected water quality and macrophyte data at Lake Sagamore on 8 September 2017. Stations were consistent with those in the past. Specifically, water quality data was collected at two in-lake stations; L2 (near the dam) and L3 (south end of lake). Macrophyte data was collected at five 20’ intervals along five transects throughout the lake (Appendix II).

In-situ data was collected through the use of a calibrated Hach MS5 meter which was utilized to measure temperature, dissolved oxygen, specific conductance and pH at 1.0 m increments throughout the water column. Discrete water samples were collected at L2 and L3 and analyzed for nutrients which are pertinent to lake management. Specifically, those parameters were total phosphorus, soluble reactive phosphorus, chlorophyll *a*, ammonia, nitrate and total suspended solids. Environmental Compliance Monitoring of Hillsborough, NJ conducted the analysis. In addition, phytoplankton and zooplankton samples were collected and analyzed by Princeton Hydro. An addition to this year’s sampling was the collection of a single sample for microcystin analysis. This sample was collected at the surface of the dam station and analyzed utilizing an *Abraxis* test kit.

In-situ Data

Lake Sagamore was mixed at the time of sampling with temperatures ranging from 19.79°C at 3.5 m to 20.27°C at the surface. Dissolved oxygen concentrations were acceptable in the upper 3 m of the water column but were low at 3.5 m with a measure of 2.36 mg/L. Typically, measures greater than 4 mg/L are preferred for a warm-water fishery. pH values were acceptable with measures ranging from mid- to high-7s. Clarity, as measured with a Secchi disk, was 1.2 m. This value is above the lower threshold of 1.0 m established for Lake Sagamore but was lower than historical measures made during the past eight years.

Discrete Data

Ammonia and nitrate, both of which are nitrogen parameters, were low in the lake and not reflective of an issue in terms of water quality. Phosphorus metrics were also low. Soluble reactive phosphorus was non-detectable (ND < 0.002 mg/L) at all stations. TP concentrations were 0.01 mg/L in the surface at the Dam and South stations and non-detectable (ND < 0.01 mg/L) at the deep waters of the dam station. Chlorophyll *a* concentrations were higher than normal with a measure of 20 µg/L at the surface of the Dam station and 13 µg/L at the surface of the South station. Measures taken in 2016 were markedly lower than those measured this year with concentrations of 5.7 µg/L and 4.2 µg/L measured at the dam and south stations, respectively. Princeton Hydro recommends chlorophyll *a* concentrations remain below 20 µg/L for recreational water bodies while the classical eutrophication threshold for chlorophyll *a* is 6 µg/L. Total suspended solids, which are a measure of suspended particulates in the water column, were 4mg/L at the Dam and non-detectable (ND <3 mg/L) at the South station.

Plankton Data

Princeton Hydro collected a plankton tow at both stations for community composition and relative abundance of phytoplankton and zooplankton. Relative abundance was scored with a measure of 'A' for abundant, 'C' for common and 'P' for present. The phytoplankton community at the Dam station was diverse with a mixture of diatoms, chrysophytes and cyanobacteria. Such a community composition is typical of the transition from late-summer to early-fall in the northeast United States. Co-dominance was exerted between the diatoms *Melosira* and *Tabellaria*, the chrysophyte *Dinobryon* and various small-celled chlorophytes. Cyanobacteria were present in relatively small numbers and included *Microcystis* and *Anabaena*. Princeton Hydro also collected a sample for cyanotoxin (Microcystin) analysis and this measure was 0.3 µg/L. Currently, measures of less than 4 µg/L are recommended for recreational waterbodies.

The plankton assemblage at the South station was similar to that identified at the Dam station.

Zooplankton composition was diverse at the Dam station with a mixture of rotifers and copepods. The rotifera were the most abundant and diverse grouping consisting of four genera. Rotifers were again the dominant group at the South station. In addition, the cladoceran *Bosmina* was noted at this location.

Macrophyte Data

The macrophyte community of Lake Sagamore was surveyed at the five historically established transects. Plant growth was low at the time of sampling. Plant growth consisted of sporadic patches of chara (*Chara* sp.) listed as 'trace' at T-1. Quillwort (*Isoetes* sp.) was identified at trace densities at T-2. In addition, an un-identified, low growing (height < 1") plant was observed at T-5. The aforementioned un-identified species has been observed before at various locations in Lake Sagamore and is found at extremely low densities with a biomass of 1 – 3 g/m^2. As such, this plant is of zero concern in terms of management and will never reach high densities. None of the historically identified plants, such as bladderwort (*Utricularia* sp.) or various pondweeds (*Potamogeton* sp.) or various macroalgae were identified in 2017.

4.0 Summary

Princeton Hydro conducted routine monitoring for key water quality parameters related to lake trophic state in addition to a lake-wide macrophyte monitoring on September 8, 2017. The data collected from this event showed the lake to exhibit low nitrogen and phosphorus concentrations. Despite low phosphorus concentrations, the lake did exhibit higher than normal chlorophyll *a* concentrations which led to lower than normal clarity. The algal community was comprised largely of normal groups that do not produce nuisance conditions such as the diatoms and chlorophytes. The cyanobacteria were identified in low densities but were present. Cyanotoxin testing was conducted for the first time at this waterbody and produced a low result of 0.3 µg/L of microcystin. The plant community remains virtually unchanged from years past and densities were close to zero.

The continuation of excellent water quality in the lake is due to the largely undisturbed watershed which consists primarily of forest and secondarily of low-density residential. The lack of abundant macrophytes is associated with the management of the lake through the use of sterile grass carp. Annual monitoring of the lake, following the same general protocol as above, should be continued.

Appendix I

Lake Sagamore - *In-situ* Data - September 8, 2017								
Station	Depth Max (m)	Secchi (m)	Sample (m)	Temp (°C)	SpC (mS/cm)	DO (mg/L)	DO% (%)	pH (units)
Dam	3.7	1.2	0.2	20.27	0.225	8.19	90.6	7.89
			1	20.09	0.226	7.14	78.8	7.73
			2	20.02	0.225	7.03	77.4	7.66
			3	19.96	0.224	5.38	59.4	7.57
			3.5	19.79	0.227	2.36	25.9	7.47
South	0.9	0.9	0.2	17.34	0.191	7.40	77.1	7.54
			0.7	16.46	0.141	8.20	83.9	7.47

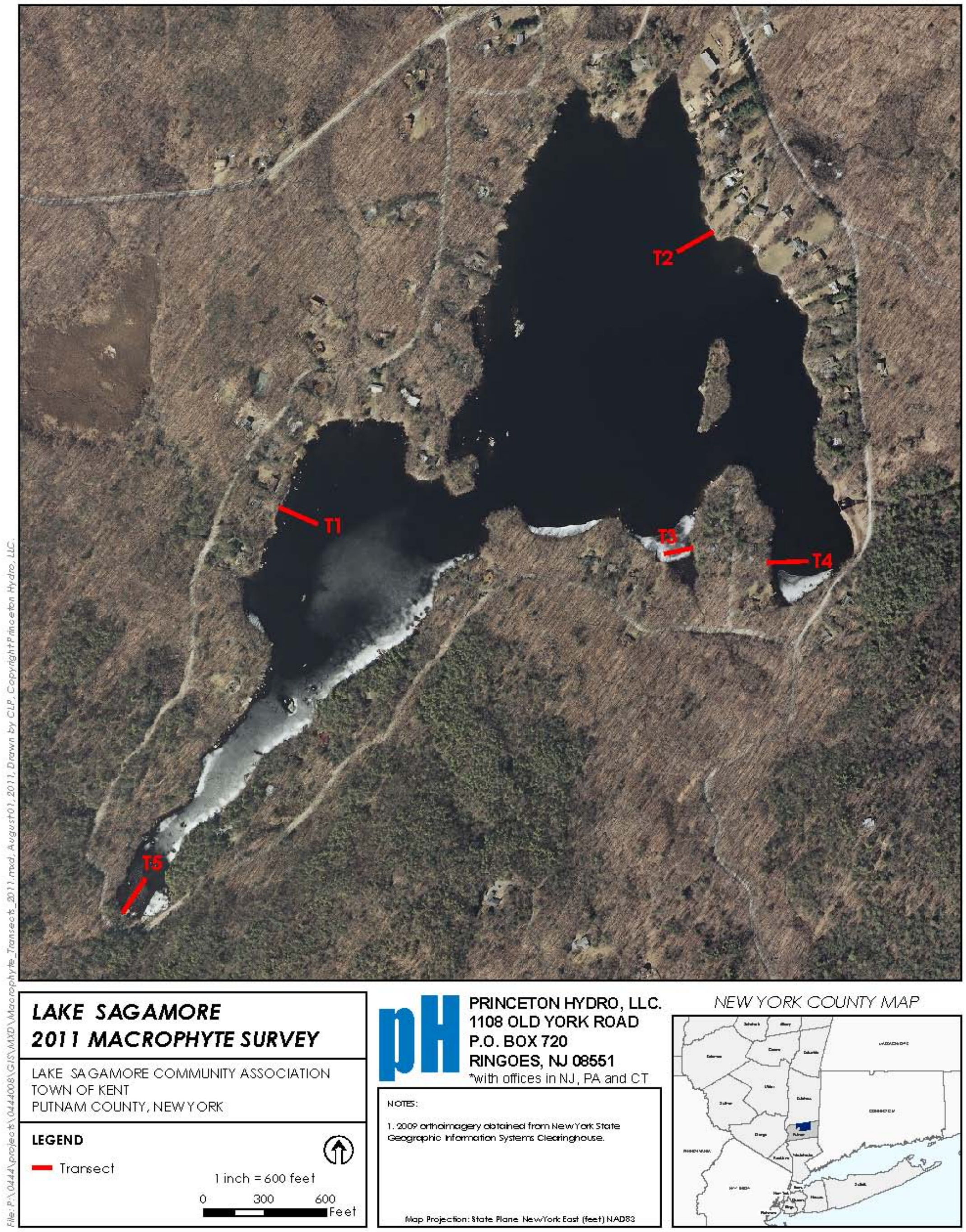
Lake Sagamore - Discrete Data - September 8, 2017						
Station	Chl a (µg/L)	NH3-N (mg/L)	NO3-N (mg/L)	SRP (mg/L)	TP (mg/L)	TSS (mg/L)
Dam Surface	20	ND < 0.01	0.06	ND < 0.002	0.01	4
Dam Deep				ND < 0.002	ND < 0.01	
South Surface	13	ND < 0.01	0.13	ND < 0.002	0.01	ND < 3

Lake Sagamore - Dam - September 8, 2017			
Phytoplankton		Zooplankton	
Taxon	Abundance	Taxon	Abundance
Diatoms		**Cladocerans**	
Melosira	C		
Synedra	R		
Fragilaria	R		
Navicula	R	**Copepods**	
Tabellaria	C	*Diaptomus*	R
		Cyclops	P
Chrysophytes		*nauplii*	C
Dinobryon	C		
Mallomonas	R		
		Rotifers	
Cyanobacteria		*Polyarthra*	P
Microcystis	R	*Keratella*	P
Anabaena	P	*Conochilus*	R
		Asplanchna	R
Chlorophytes			
Golenkinia	P	P.A.R.E Anlaysis -	
Pediastrum	R	Microcystin 0.3 ppb	
*Small celled greens	C		

Lake Sagamore -South - September 8, 2017			
Phytoplankton		Zooplankton	
Taxon	Abundance	Taxon	Abundance
Chlorophytes		**Cladocerans**	
Chlamydomonas	R	*Bosmina*	P
Micrasterias	R		
Diatoms		**Copepods**	
Melosira	C	*Cyclops*	P
		nauplii	C
Chrysophytes			
Dinobryon	C	**Rotifers**	
		Asplanchna	R
Dinoflagellates		*Polyarthra*	C
Ceratium	P	*Keratella*	C
Cyanobacteria			
Anabaena	P		
Microcystis	R		

Lake Sagamore - September 8, 2017 - SAV								
Transect	Species	Scientific	20	40	60	80	100	Biomass (g/m2)
T1	Chara	*Chara* sp.	Tr	X	X	X	Tr*	1
T2	Quillwort	*Isoetes* sp.	Tr	X	X	X	Tr*	1
T3	None	N/A	N/A	N/A	N/A	N/A	N/A	0
T4	None	N/A	N/A	N/A	N/A	N/A	N/A	0
T5	Water moss	*Fontinalis* sp.	X	X	X	Tr	X	N/A
	Un-Identified		P*	X	X	X	X	3

Appendix II


T1
T2
T3
T4
T5
LAKE SAGAMORE
2011 MACROPHYTE SURVEY
LAKE SAGAMORE COMMUNITY ASSOCIATION
TOWN OF KENT
PUTNAM COUNTY, NEW YORK
LEGEND
Transect
1 inch = 600 feet
0 300 600 Feet
PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551
*with offices in NJ, PA and CT
NOTES:
1. 2009 orthoimagery obtained from New York State Geographic Information Systems Clearinghouse.
Map Projection: State Plane New York East (feet) NAD83
NEW YORK COUNTY MAP
File: P:\0444\projects\0444008\GIS\MXD\Macrophyte_Transects_2011.mxd, August 01, 2011, Drawn by CLP, Copyright Princeton Hydro, LLC.