PRINCETON HYDRO

SCIENCE ENGINEERING DESIGN

Lake Sagamore – 2022 Water Quality and Macrophyte Survey
Town of Kent, Putnam County, New York

Prepared for:

Lake Sagamore Community Association
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1.0 Introduction

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.

Princeton Hydro conducted a single water quality monitoring event and aquatic plant survey on Lake Sagamore on 8 September 2022. This sampling event followed the same general methodology as years past and examined the water quality and submerged aquatic vegetation (SAV) community of the lake. The following sections detail the results of this survey.

2.0 Summary of 2022 Water Quality and Plant Data

Princeton Hydro collected water quality and macrophyte data at Lake Sagamore on 8 September 2022. 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. A single sample was collected at the dam station to be analyzed for the cyanotoxin total microcystins. This sample was analyzed utilizing an Abraxis test kit.

In-situ Data

Temperatures at the dam station ranged from a minimum of 18.20°C (64.76°F) at the bottom (4.5 m) to 23.23°C (73.81°F) at the surface. Water temperatures were slightly warmer in the deep waters but cooler in the surface waters compared to 2021. The water column was weakly thermally stratified at this time with generally consistent temperatures throughout the upper 3 m and cooler waters at 4 m. Such conditions are routinely identified in Sagamore during this time period.

Dissolved oxygen (DO) concentrations were also weakly stratified throughout the water column ranging from anoxic conditions (Less than 1 mg/L) at 4 m to 6.71 mg/L (78.6%) at the surface. Typically, DO concentrations 4.0 mg/L and greater are necessary for the maintenance of warm-water fisheries while concentrations less than 1 mg/L may lead to accelerated internal loading of phosphorus from the sediments. As such, the bottom .7 m of the water column was in a condition to promote internal release of phosphorus but there was no strong indication of this occurring in 2022.

pH values were within a normal range (pH 6-8) ranging from 6.62 at 4.5 m to 7.10 at 2 m. pH values measured in 2022 were lower than those measured in 2021.

2022 transparency was 1.2 m. In contrast, transparency in 2021 was 1.6 m while that in 2020 was 1.35 m. Diminished transparency in 2022 is associated with higher algal biomass as indicated by the chlorophyll a concentrations discussed below.

Princeton Hydro has established a lower and upper Secchi disc threshold for Lake Sagamore of 1.0 and 2.0 m, respectively. As such, measures were above the lower threshold.

In-situ values at the South sampling were generally similar as the dam station but water temperatures were slightly cooler at 21.42°C (70.56°F) while DO was higher at 7.41 mg/L (83.9%).

Discrete Data

Ammonia and nitrate (both nitrogen species) measures were low and not a cause for concern in terms of acute nitrogen pollution. Total Phosphorus ranged from 0.01 to 0.02 mg/L which was lower than that measured in 2021. In 2020, deep water TP was 0.08 mg/L which was elevated. Such conditions were not evident in 2022.

SRP measures were moderate (0.004 mg/L) in the surface of the south station and dam station while deep water measures were non-detectable (ND < 0.002 mg/L). Princeton Hydro recommends concentrations of this parameter to stay below 0.005 mg/L as this nutrient is quickly utilized by algae for growth.

Chlorophyll a concentrations were on the low to moderate side with a measure of 12 µg/L at the dam station and 4.9 µg/L at the south station. Princeton Hydro recommends chlorophyll a concentrations remain below 20 µg/L for recreational water bodies.

Total suspended solids, which are a measure of suspended particulates in the water column, were moderately elevated with a measure of 13 mg/L at the dam and 15 mg/L at the south station.

Plankton Data

The plankton community was highly diverse at both sampling stations with a mixture of diatoms, chlorophytes, cyanobacteria, dinoflagellates, chrysophytes, and euglenoids. At the dam station, the dominant algae was the diatom Melosira which was listed as 'Abundant.' No one genus was dominant at the south station where many were listed as 'common.' The nuisance cyanobacteria *Aphanizomenon* was identified at both stations and listed as 'common.' This genus has the capacity to form nuisance blooms but typically does not in Sagamore.

Princeton Hydro also conducted a total microcystin (cyanotoxin) test at the launch site which was negative.

The zooplankton community was relatively diverse. An increase in copepods was noted while the rotifers were diverse and well represented as is often the case at Sagamore. Cladocerans remain relatively sparse with only Bosmina identified in low to moderate densities at both stations.

Macrophyte Data

The macrophyte community of Lake Sagamore was surveyed at the five historically established transects. The SAV community was sparse with limited plant biomass identified at all transects and biomass was low (max of 5 g/m2) The macroalgae Chara was again identified. In addition, waterwort (Elatine sp.) was identified at T5. Waterwort is considered an introduced native in this region. Spatterdock (Nuphar advena) was also identified in small stands adjacent to the transects. Aquatic moss (Fontinalis sp.) was also identified in low densities.

3.0 Lake Sagamore – Historic Water Quality

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:

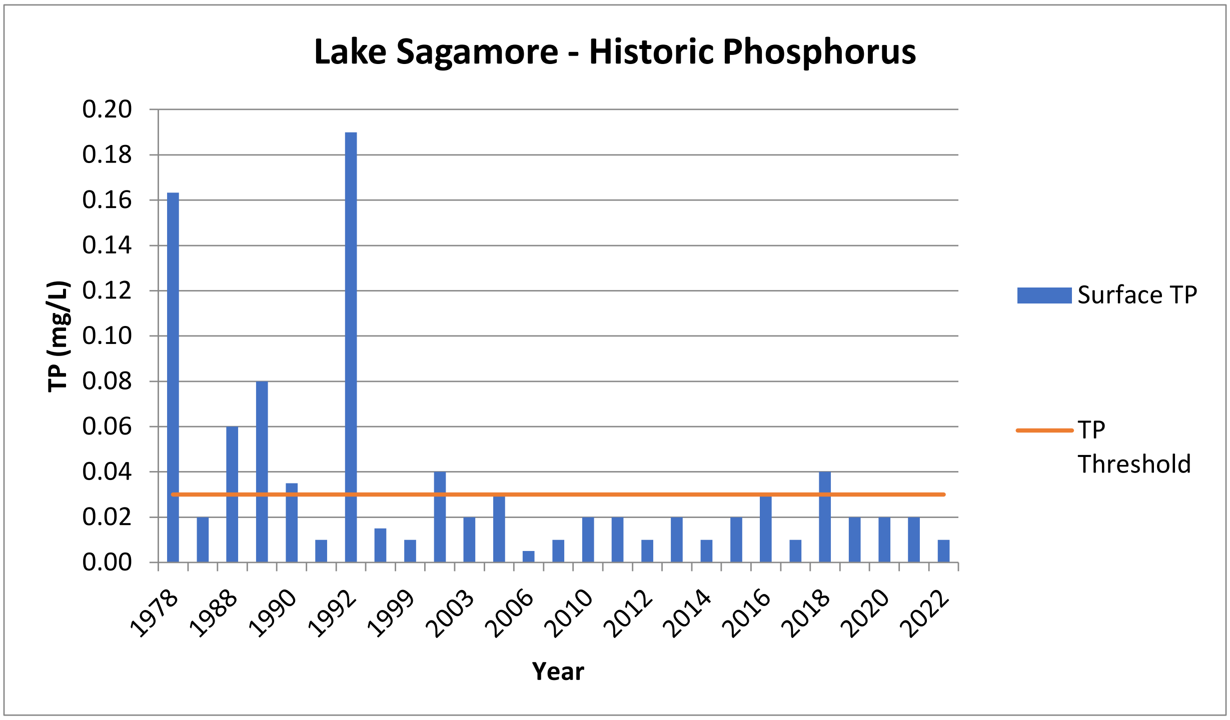


Figure 3.1: Lake Sagamore – Historic Phosphorus Concentrations

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 greatest 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 increased in 2018 to 0.04 mg/L, exceeding the recommended threshold. This is the highest concentration observed in the lake since 2001. In 2019, concentrations in the surface waters were again below the threshold with a measure of 0.02 mg/L and these concentrations remained consistent in 2020. In 2020, deep water concentrations were elevated at 0.08 mg/L (Not shown in this graph). Concentrations in 2021 in the surface waters were similar to 2020 while those in 2022 were lower.

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.

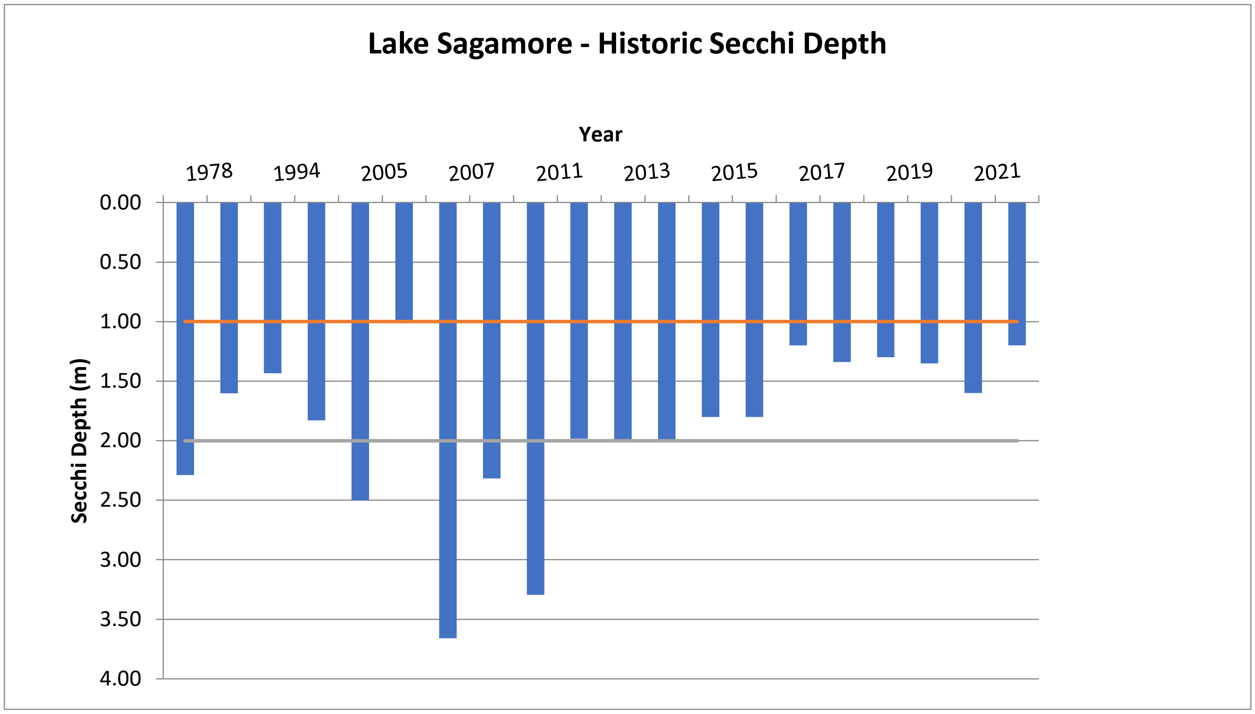


Figure 3.2: Lake Sagamore – Historic Secchi Depth

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 between the 1.0 m and 2.0 m thresholds indicating acceptable water quality conditions. Secchi depth for 2017 was just above the lower threshold value with a measure of 1.2 m. This value increased to 1.34 m by the 2018 event and measures in 2019 were 1.3 m. In 2020, measures increased very slightly to 1.35 m. 2021 measures increased to 1.6 m while those in 2022 decreased slightly to 1.2 m as a result of higher algal biomass.

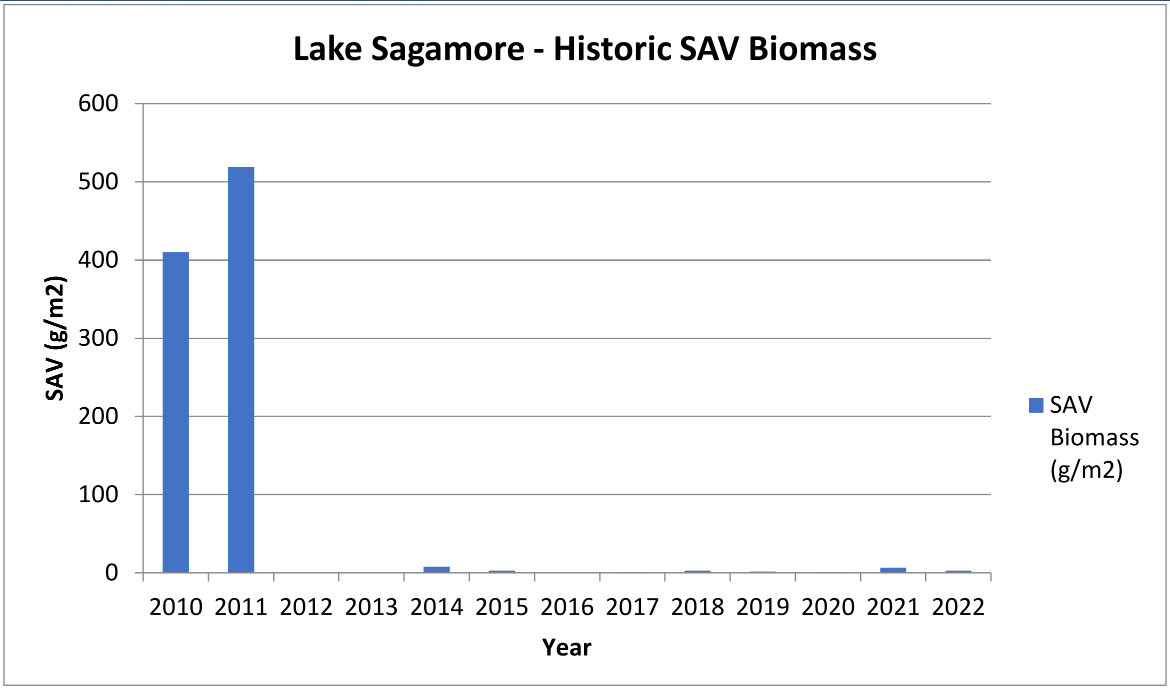


Figure 3.3: Lake Sagamore – Historic Plant Biomass

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/m2, was measured during the 2014 season. Very sporadic growth of low-lying plants was periodically observed in both 2017 and 2018. Plant biomass along the 2018 transects was <5 g/m2. Mean plant biomass in 2019 continued to be exceptionally low with an average biomass of 1.5 g/m2. Such conditions continued in 2020, 2021, and 2022.

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.

4.0 Recommendations on Maintaining the Quality of Lake Sagamore

The review of the historic data in Section 3 has shown that Lake Sagamore is in excellent condition for its designated uses. Phosphorus concentrations were below the recommended threshold at all stations, transparency is acceptable, but long-term, is decreasing, 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 or via internal sources. 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.

Internal Loading

The historic database shows that the deeper portions of Lake Sagamore, at times, go anoxic. During these instances, we are measuring increased phosphorus in the deeper waters which is likely the result of sediment release of this nutrient. Such conditions were again documented in 2020 with deep water TP concentrations twice as high as those in 2019. In lake systems, phosphorus is often tightly bound to iron in the sediments under oxic (oxygenated) conditions. As waters go anoxic, this bond breaks thereby allow phosphorus to migrate from the sediments in hypolimnetic waters where it can be utilized for algal growth. As such, Lake Sagamore may want to consider possibly aerating these deeper portions of the lake.

5.0 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, 2022. The data collected from this event showed the lake to exhibit low phosphorus concentrations and low nitrogen species. Clarity was 0.4m less than that in 2021. On a long-term basis, Secchi depth has been steadily declining. The algal community dominated primarily by the beneficial algae (diatoms and chrysophytes). Cyanobacteria were observed with one genera listed as 'common.' While these types have the capability to produce cyanotoxins, our testing showed that total microcystins were not present during this event at the sampling location. The plant community continues to show extremely low biomass and diversity.

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. Low oxygen in deeper waters, combined with higher deep-water TP concentrations (such as those seen in 2020), may contribute to increased eutrophication over time. Annual monitoring of the lake, following the same general protocol as above, should be continued.

Appendix I

Lake Sagamore - *In-situ* Data - September 8, 2022								
Station	Max Depth	Secchi Depth	Sample	Temp	SpC	DO	DO%	pH
	(m)	(m)	(m)	(°C)	(mS/cm)	(mg/L)	(%)	(units)
Dam	4.7	1.2	0.1	23.23	0.233	6.71	78.6	7.07
			1	23.06	0.233	6.57	76.7	7.09
			2	22.90	0.233	6.18	72.0	7.10
			3	22.81	0.233	5.60	65.0	7.09
			4	20.31	0.288	0.57	6.3	6.70
			4.5	18.20	0.334	0.25	2.6	6.62
South	0.7	0.7	0.1	21.42	0.221	7.41	83.9	6.86
			0.5	21.35	0.219	7.15	80.7	6.87

Lake Sagamore - September 8, 2022 - Discrete Data							
Station	Depth	Chl a	NH3	NO3	SRP	TP	TSS
		(µg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Dam	Surface	12	0.06	0.06	0.004	0.01	13
	Deep				ND < 0.002	0.02	
South	Surface	4.9	0.04	0.09	0.004	0.02	15

Lake Sagamore - September 8, 2022 - SAV										
Transect	Species	Scientific	0	20	40	60	80	100	Biomass (g/m2)	Notes:
T1	Waterwort	*Elatine sp.*	P	-	-	-	-	-	<5	
	Chara	*Chara sp.*	-	-	P	P*	-	-		
T2	Waterwort	*Elatine sp.*	-	-	-	P*	P	-		
	Chara	*Chara sp.*	-	-	P	C	-	-	< 5	
T3	Aquatic moss	Fontinalis sp	-	P	-	-	-	-	<5	
T4	Chara	*Chara* sp.	-	P*	-	-	-	-		
	Waterwort	*Elatine sp.*	P	-	-	-	-	-	<5	
T5	Waterwort	*Elatine* sp.	A	A*	A	A	A	C		Few stands of spatterdock adjacent to station
	Spatterdock	*Nuphar advena*	-	P	P	-	P	Adjacent	5	

Phytoplankton and Zooplankton Community Composition Analysis

Sampling Location: Sagamore Lake	Sampling Date: 9/8/22	Examination Date: 9/14/22
Site 1: Dam tow	Site 2: South tow	

Phytoplankton

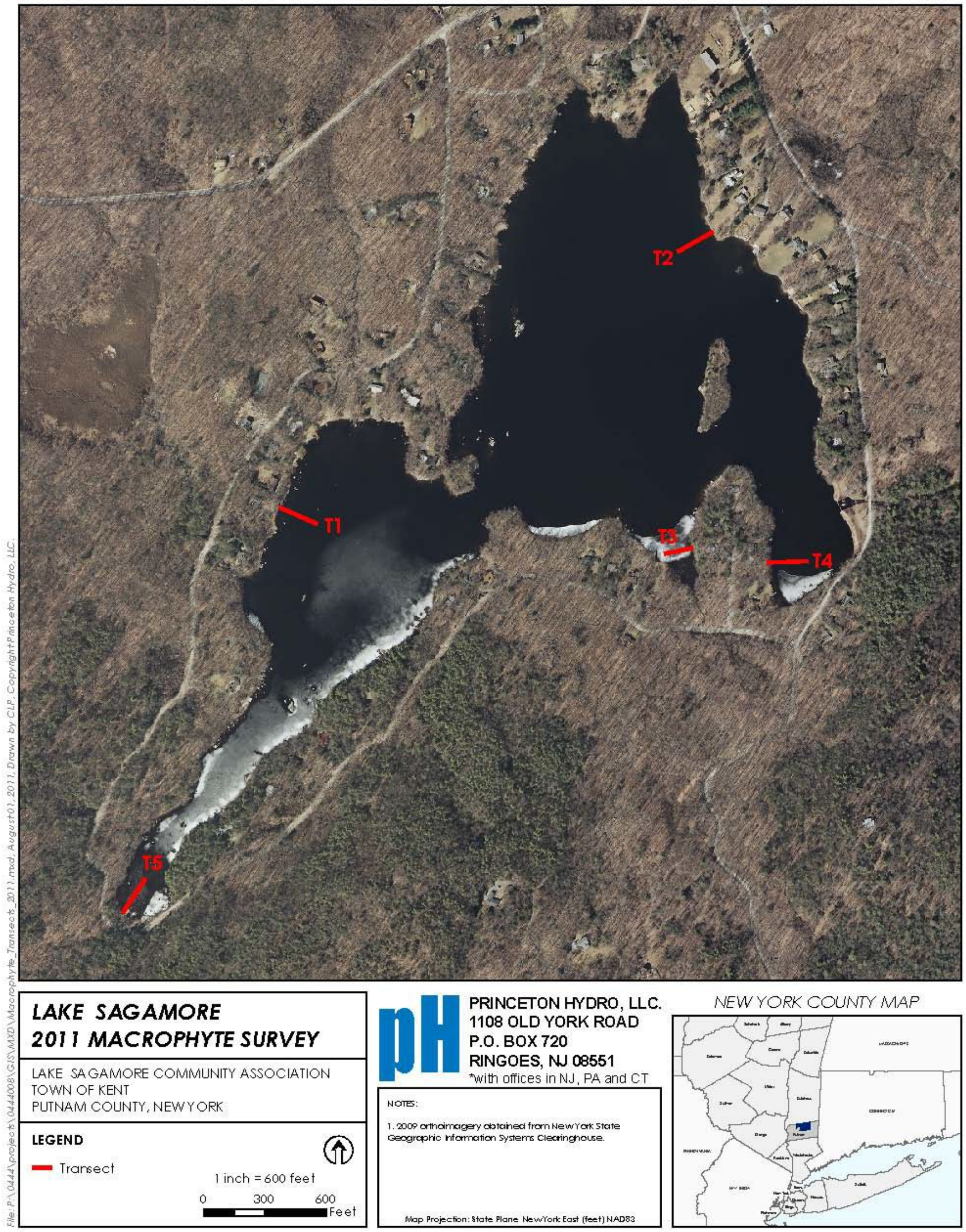
Bacillariophyta (Diatoms)	1	2	Chlorophyta (Green Algae)	1	2	Cyanophyta (Blue-Green Algae)	1	2
Surirella		P	*Desmidium*	R		*Aphanizomenon*	C	C
Melosira	A	C	*Coelastrum*	R		*Cylindrospermum*	P	R
			Micrasterias	R	P	*Coelosphaerium*	R	
			Haematococus	P		*Dolichospermum*	P	P
			Staurastrum	R	P	*Microcystis*	R	R
			Eudorina		R	*Pseudanabaena*	P	
			Spirogyra		R	*Merismopedia*		R
Chrysophyta (Chrysophytes)			*Pediastrum*		R	**Pyrrhophyta (Dinoflagellates)**		
Dinobryon	P	C	*Crucigenia*		P	*Ceratium*	P	P
Mallomonas	R							
Cryptomonads						**Euglenophyta (Euglenoids)**		
Cryptomonas		P				*Euglena sp.*	P	
						Trachelomonas	R	

Zooplankton

Cladocera (Water Fleas)	1	2	Copecoda (Copepods)	1	2	Rotifera (Rotifers)	1	2
Bosmina	P	C	*Nauplii*	C	A	*Asplanchna*	P	P
			Cyclops	A	C	*Conochilus*	C	C
			Diaptomus	R	R	*Brachionus*	R	R
						Kellicottia		R
						Keratella	P	P
						Tricocerca		R
						Polyartha		P

Sites:	1	2	Comments: Microcystis at launch site: zero
Total Phytoplankton Genera	17	16	
Total Zooplankton Genera	8	11	
Sample Volume (mL)			Phytoplankton Key: Bloom (B), Abundant (A), Common (C), Present
			Zooplankton Key: Dominant (D), Abundant (A), Present (P), and

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.