Song Lake
Watershed Implementation Plan
Town of Preble, Cortland County, New York

Prepared for:

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1.0 Introduction

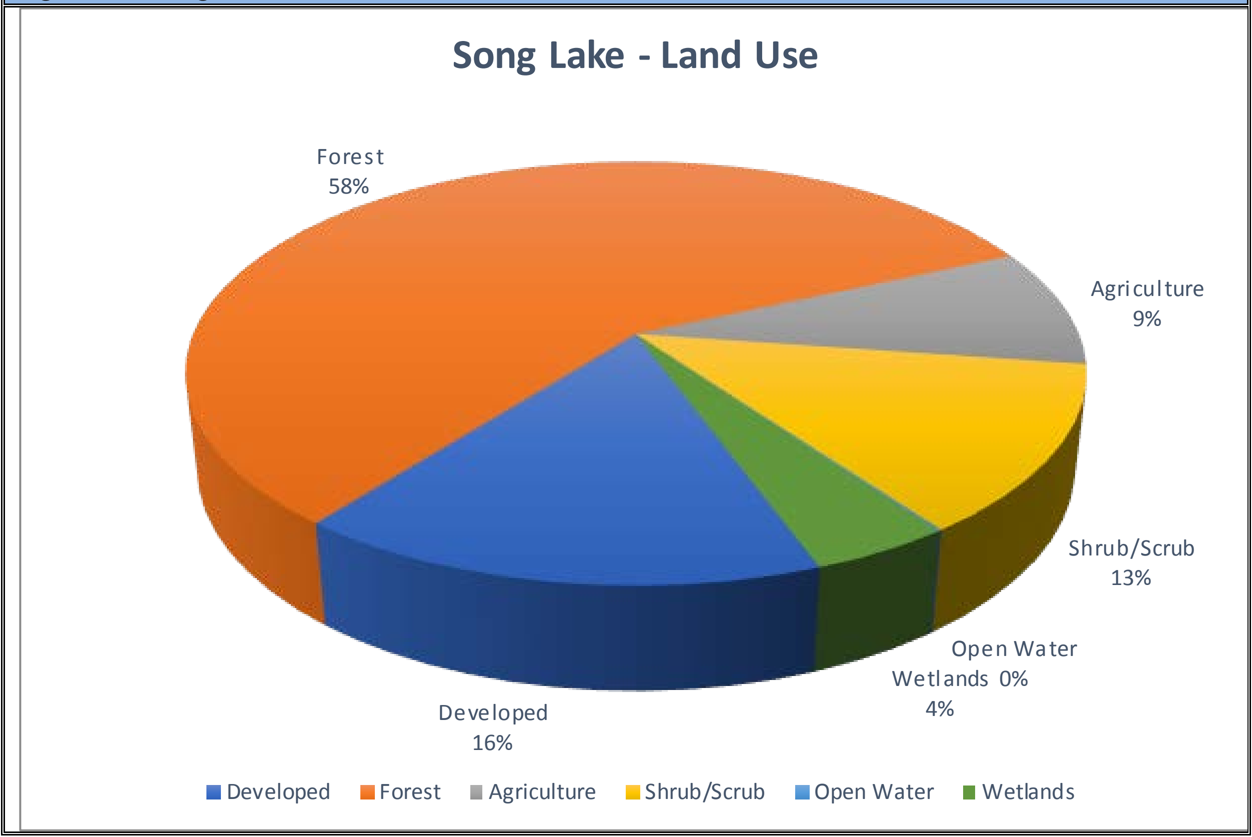
Song Lake, located in the town of Preble, Cortland County, New York, is part of a kettle lake system. Historically, this lake has suffered from symptoms of eutrophication such as elevated phosphorus concentrations, lack of oxygen (anoxia), and harmful algal blooms. In addition, Song Lake has suffered from inundation of invasive macrophyte species and a newly discovered population of zebra mussel (*Dreissena polymorpha*). While the water quality and hydrology of Song Lake has been studied in the past there has not been a concerted effort to conduct a watershed plan for this waterbody. As part of this project, Princeton Hydro, in concert with the Cortland-Onondaga Federation of Kettle Lake Associations (C-OFKLA), Cortland County Soil and Water Conservation District and the Syracuse University Environmental Finance Center, has prepared small-scale Watershed Implementation Plans for Song Lake, Tully Lake, Crooked Lake and Little York Lake. Each plan is comprised of several inter-related components aimed to characterize the water quality of the lake, assess the external and internal phosphorus load, characterize the land use of the watershed and areas where best management practices (BMPs) may be implemented, and to correlate reductions in nutrient loading from each BMP into the nutrient budget for each lake. This plan is considered 'small-scale' given that only a single water quality sampling event was conducted and only ½ day was available to survey the watershed for areas which may benefit from BMPs. As such, this plan does not constitute an extensive lake and watershed management plan. Ultimately, this document may be utilized to seek funding sources to implement the projects contained herein and may be utilized in a larger context for lake management.

2.0 Lake and Watershed Characteristics

Song Lake is a 42 ha (105 ac) kettle lake located in Cortland county, New York. The watershed of Song Lake (Appendix I, Figure 1) encompasses 319 ha (788 ac) resulting in a watershed to lake ratio of 8:1. Typically, watershed to lake ratio values greater than 6 are indicative of a lake which is susceptible to higher levels of nutrient and sediment loading from the watershed. The shoreline development index (SDI), which relates the length of the shoreline to the circumference of a circle of equal area, is 1.46. The SDI is typically utilized to assess the amount of littoral area in a lake and increasing numbers relate to the increased possibility of higher shoreline development and nutrient loading. For comparison, the SDI for Little York Lake is similar at 1.44 while values at Tully and Crooked Lakes are higher with values of 2.66 and 2.06, respectively.

Watershed land use categories are displayed graphically in Appendix I, Figure 2 and broken down by category in figure 2.1.

Figure 2.1: Song Lake – Land Use



Forest represents the dominant land use in the watershed with a coverage of 184 ha (454 ac) located predominantly along the western ridge, and secondarily along the east shore, of the watershed. Developed lands, including low and medium density residential and developed open space, represent 51 ha (127 ac). Medium density residential land is located along the west shoreline of the lake while small patches of low intensity residential are located along the northwestern shore. Developed open space, associated with the Girl Scout camp, is located along the east shore. Scrub / shrub land use is the third most dominant land use comprising 13% of total area and is located along the top of the west ridge.

The hydrology of Song Lake, located in the Susquehanna River basin, is unique in that there are no tributary inflow or outflows (USGS, 2011). Water comes into the lake through groundwater, precipitation and diffuse, stormwater sheetflow and leaves the lake through evaporation and groundwater seepage. Ultimately the catchment of Song Lake, in conjunction with Tully Lake, flow into Little York Lake.

3.0 Water Quality Monitoring

3.1 Introduction and Methodology

Princeton Hydro conducted limited water quality monitoring of Song Lake to characterize the extent of thermal stratification, dissolved oxygen depletion and internal loading of phosphorus. This monitoring was conducted during a single event on July 11, 2017. During this event, Princeton Hydro established a monitoring station at a deep portion of the lake. Maximum depth was recorded and water transparency was measured with a Secchi disc. *In-situ* data collection consisted of measuring temperature, specific conductance, dissolved oxygen, dissolved oxygen percent saturation and pH, at 1 m intervals, throughout the water column. All *in-situ* measures were made utilizing a calibrated Hach MS5 water quality meter tethered to a Hydrolab surveyor. Discrete samples were also collected approximately 0.5 m below the surface and 1 m above the sediments for the analysis of total phosphorus (TP) and soluble reactive phosphorus (SRP). Upon collection, samples were placed on ice to 4°C and forwarded under chain-of-custody procedures to Environmental Compliance Monitoring of Hillsborough, NJ for analysis. Finally, assessment of the plankton (phytoplankton and zooplankton) was conducted through the deployment of a plankton tow net throughout the water column. Upon collection, this sample was preserved with Lugol's solution and analyzed for relative abundance and community composition by Princeton Hydro. The results of this single sampling event are presented below.

3.2 Results

Song Lake was thermally stratified at the time of sampling with temperatures ranging from 14.17°C at 8 m to 24.53°C at the surface (Z_{max} = 8.7 m). Dissolved oxygen concentrations were variable throughout the water column. Anoxic (no oxygen) conditions were measured from 7 m to the lake bottom while concentrations in the upper 2 m were supersaturated. pH values were also variable, ranging from 7.07 at 7 m to 8.46 at the surface. Variation in pH and DO throughout the water column was due to varying rates of primary productivity versus respiration. Secchi disc transparency was excellent with a measure of 3.7 m (Table 3.1 and Figure 3.1).

Discrete measures for phosphorus in the surface waters showed surface TP as 0.01 mg/L while SRP concentrations were 0.003 mg/L. Deep measures for TP were considerably higher than those in the surface with a measure of 0.05 mg/L while deep SRP measures were non-detectable (ND < 0.002 mg/L). Typically, threshold values for TP are 0.03 mg/L while those for SRP are 0.005 mg/L. Concentrations greater than these thresholds may relate to elevated levels of algal and macrophyte growth. The disparity between surface and deep-water TP concentrations, in conjunction with internal anoxia, points to internal loading of P from the sediments.

Phytoplankton samples (Table 3.2) collected at the deep station showed the community to be comprised primarily of cyanobacteria with *Anabaena* exerting dominance over the community. Other cyanobacteria identified during this event included *Coelosphaerium, Microcystis,* and *Lyngbya.* Low densities of a single genus of chlorophyte, diatom, chrysophyte and dinoflagellate were also identified. The zooplankton community was dominated by the herbivorous cladoceran *Daphnia* followed by the copepods then rotifers.

The plankton community at the beach stations showed lower densities of cyanobacteria and greater densities of chlorophytes. *Anabaena* was still present at this station but in much lower densities than the deep station. The zooplankton at the beach were comprised of a single rotifer (*Asplanchna*).

Table 3.1: Song Lake – *In-situ* Data

Kettle Lakes *in-situ* 7/11/17								
Station	Max	Secchi	Depth	Temp	SpC	DO	DO %	pH
	(m)	(m)	(m)	(C)	(mS/cm)	mg/L	(%)	(units)
Song	8.7	3.7	0.1	24.53	0.228	8.92	107.1	8.46
			1.0	24.33	0.228	8.87	106.1	8.45
			2.0	24.05	0.228	8.51	101.3	8.36
			3.0	23.65	0.227	7.89	93.2	8.17
			4.0	22.89	0.230	5.43	63.3	7.64
			5.0	21.14	0.232	1.24	13.9	7.22
			6.0	18.16	0.239	1.49	15.8	7.15
			7.0	15.54	0.241	0.00	0.0	7.07
			8.0	14.17	0.275	0.00	0.0	7.25

Figure 3.1: Song Lake – Temperature and Dissolved Oxygen Profile

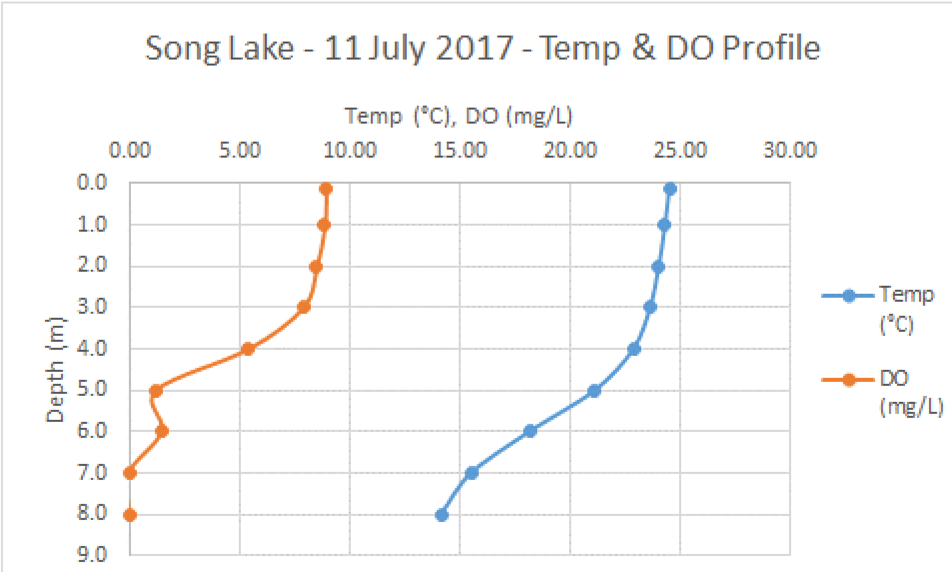


Table 3.2: Song Lake – Plankton Data

Phytoplankton and Zooplankton Community Composition Analysis								
Sampling Location: Kettle Lakes			**Sampling Date: 7/11/2017**			**Examination Date: 7/17/2017**		
Site 1: Song Deep			**Site 2: Song Beach**					
Phytoplankton								
Bacillariphyta (Diatoms)	**1**	**2**	**Chlorophya (Green Algae)**	**1**	**2**	**Cyanophyta (Blue-Green Algae)**	**1**	**2**
Synedra	C	P	*Pediastrum*	P		*Anabaena*	A	P
			Sphaerocystis		R	*Coelosphaerium*	P	
			Pediastrum		R	*Microcystis*	P	R
			Mougeotia		C	*Lygnbya*	C	P
			Spirogyra		C			
Chrysophyta (Golden Algae)						**Pyrrhophyta (Dinoflagellates)**		
Dinobryon	P					*Ceratium*	A	
Zooplankton								
Cladocera (Water Fleas)	**1**	**2**	**Copecoda (Copepods)**	**1**	**2**	**Rotifera (Rotifers)**	**1**	**2**
Daphnia	A		*Cyclops sp.*	C		*Keratella*	P	
			D Nauplius	C		*Kellicottia*	P	
			Diaptomus	R		*Polyarthra*	R	
						Asplanchna		P
Sites:	**1**	**2**	**Comments:**					
Total Phytoplankton Genera	8	8						
Total Zooplankton Genera	7	1						
Sample Volume (mL)			**Phytoplankton Key: Bloom (B), Abundant (A) Common (C), Present (P), and Rare (R)**					
			Zooplankton Key: Dominant (D), Abundant (A), Present (P), and Rare (R);					

4.0 Pollutant Loading Budget

In order to properly analyze the trophic state of Song Lake and decide on appropriate watershed and in-lake management techniques a comprehensive nutrient budget must first be developed. In this sense all pollutant inputs must be identified and quantified in order to assess those areas which contribute a disproportional amount of that load and their relative influence on lake productivity. The pollutants of concern are total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS). Phosphorus and nitrogen are those two nutrients most critical to plant and algal growth and as such, increases in these nutrients generally lead to increased lake productivity. While both nutrients are modeled the nutrient of primary concern is phosphorus. In most temperate freshwater ecosystems this is the limiting nutrient, that is, the nutrient that is least available in relation to biological demand, and as such, small increases in phosphorus loading may result in exponential increases in algal and weed growth. There are several sources, both external and internal, of phosphorus loading to freshwater systems and each of these potential sources must be evaluated to develop a proper loading estimate. Total suspended solids represent the total amount of inorganic and organic particles within the water column and are the prime determinant of water clarity. High TSS concentrations may be associated with "muddy" water clarity and are generally the result of excessive sediment loading and suspensions of algal particles. Primary sources of sediment loading to the lake are generally derived through erosion of watershed soils and stream banks. Sediment loading generally results in the formation of sediment deltas and infilling of near shore areas thereby increasing aquatic weed habitat and providing the fertile substrate for benthic, filamentous algae. In addition, as phosphorus is often tightly bound to soil particles, increases in sediment loading are commonly correlated with increases in total phosphorus loading.

To address the issues of nutrient loading to trophic response Princeton Hydro conducted a comprehensive pollutant model which served to quantify both external and internal sources of nutrient loading. Those sources of nutrients which were quantified in this study include the following:

External

- Watershed as based on land use and land cover
- Atmospheric deposition
- Septic systems

Internal

- Sediment phosphorus release under oxic and anoxic conditions

Watershed Loading

Watershed based nutrient loading is often times the largest contributor of nutrients and sediments to the receiving waterbody. The watershed area and land uses in conjunction with the soils and slopes which comprise the watershed are all prime determinants of the magnitude of nutrient loading to a lake system. For the purpose of calculating the watershed based nutrient load Princeton Hydro utilized the Unit Areal Loading (UAL) approach. The UAL approach is the recommended pollutant modeling technique as per 40 CFR Part 35, Appendix A, the USEPA's "Guidance for Diagnostic-Feasibility Studies." This modeling approach is widely used by both USEPA and NYSDEC, and Princeton Hydro has applied it to compute the nutrient and sediment loads for well over 200 lakes and reservoirs located throughout the mid-Atlantic and New England states. The unit areal loading modeling approach is based on the premise that land use activities throughout a watershed have a direct impact on nutrient release and transport to a receiving waterbody. Essentially, those land uses which are disturbed (i.e. urban, commercial, and agricultural lands) serve to transport more pollutants to a receiving waterbody than those which are undisturbed (i.e. forest and wetlands). For the application of this model Princeton Hydro first utilized topography data provided by the New York State GIS Clearinghouse to delineate the watershed boundary of Song Lake. Following this delineation land use / land cover data was clipped to this boundary. This data was subsequently reviewed for accuracy utilizing recent aerial photography and reclassified. This information was then utilized as the basis for the selection of pollutant export coefficients, in the units of (Kilogram of pollutant / Hectare / Year), which were most suitable for the watershed given prevailing soils, slopes, geology, and climatic conditions. Sources of export coefficients chosen for the Song Lake watershed were derived primarily from the scientific literature which included but was not limited to those published by Reckhow, 1980 and Uttomark et al, 1974.

Septic

Septic systems serve as the primary method for treating wastes in the Song Lake watershed. Even when the systems are fully operational in their primary function they may contribute phosphorus to the nearby lake. Loading may be attributable to many factors including poor siting as a result of low depth to bedrock, poor soil infiltration or high seasonal water table. In addition, many lakeside houses and septic systems that were originally designed for seasonal use transition into full-time residences and are not properly sized and maintained for this increase in use. For the determination of septic system loads to the lake Princeton Hydro first calculated the number of residences within the zone of influence of the lake or other waterways. For this study, the zone of influence represents those systems within 100 m (330 ft.) of the lake or other waterways per recommendations from the USEPA. Following this determination, Princeton Hydro utilized census data to determine the population served by these systems. Upon this determination, Princeton Hydro applied the phosphorus export coefficient of 0.165 kg/capita/yr to these systems. This export coefficient was developed by Princeton Hydro utilizing empirical septic leachate data on Greenwood Lake (NY/NJ). Nitrogen loading from septic systems was not modeled for this study.

Atmospheric Deposition

The final modeled external input of nutrients and sediments to the lake was that of the atmosphere. Sediments and their bound nutrients may be precipitated as dryfall (dust) or through stripping during rainfall or snow events. While generally recognized as a small source of loading to many waterbodies atmospheric loading may play a critical role in large lakes or in those waterbodies with small watersheds.

This load was calculated using empirically derived loading coefficients (Schueler, 1992, Uttormark, et al. 1974, USEPA 1980 and Owe, et al. 1982) of phosphorus, nitrogen and sediment sources during dryfall and wetfall (rain / snow).

Internal Loading Assessment

A critical component in the development of this WIP was the assessment of the internal phosphorus load for Song Lake. Kettle lakes in this region, formed by glacial retreat, are categorized by relatively deep depths and small watershed areas. These morphometric characteristics, combined with eutrophication resultant from developed watersheds, may lead to deep water anoxia (no oxygen). When this occurs, phosphorus, which is typically chemically bound to iron in the lake sediments, becomes released to the overlying water whereby it becomes accessible to algae for growth.

Internal loading assessment for Song Lake was determined through an evaluation of historical data collected through the CSLAP program including temperature and dissolved oxygen stratification patterns and surface and deep-water total phosphorus concentrations. This data was supplemented through sampling conducted by Princeton Hydro in July 2017. During a single event, Princeton Hydro collected *in-situ* temperature, specific conductance, pH and dissolved oxygen data in profile throughout the water column at the deepest portion of the lake. In addition, samples were collected for total phosphorus and soluble reactive phosphorus in the surface and deep waters of the lake (Section 3). This data was utilized in concert with bathymetric data provided by the NYSDEC to determine the temporal and spatial extent of internal loading in Song Lake. Finally, this information was utilized to help determine export coefficients from the scientific literature for internal phosphorus loading rates under oxic (with oxygen) and anoxic (no oxygen) conditions. The internal loading period was estimated at a total of 120 days per year, 45 of these days were under anoxic conditions while the remainder were under oxic loading. These rates were then applied to Song Lake to determine the annual internal phosphorus load.

Results

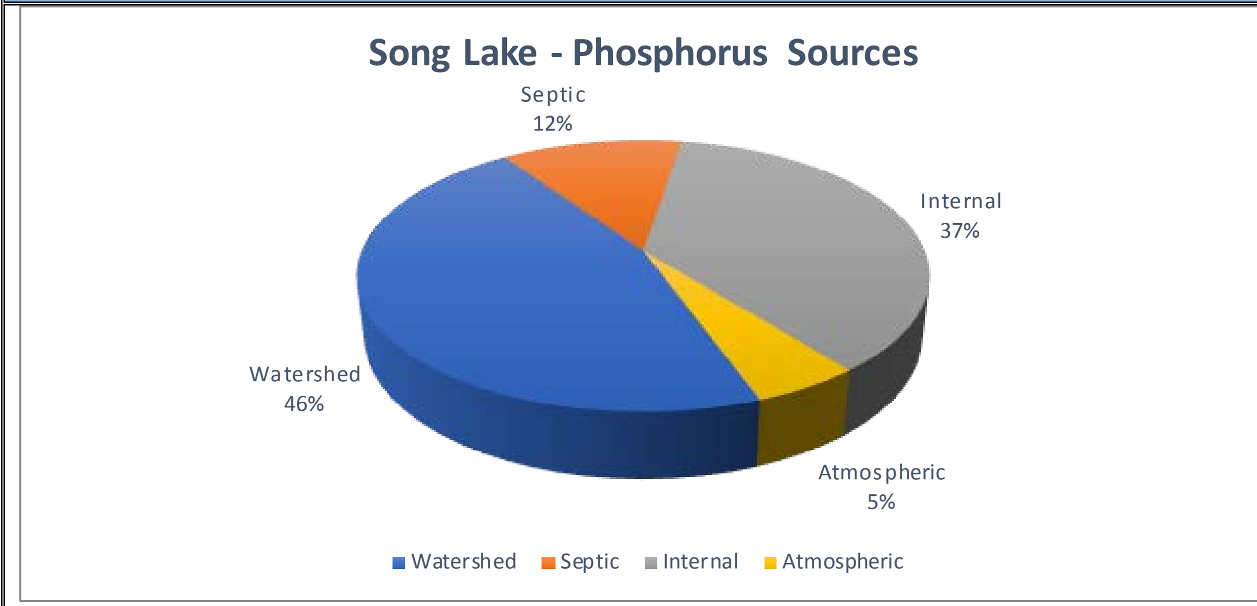
Summary results for nutrient loading to the lake are presented in table 4.1.

Table 4.1: Song Lake Pollutant Loading Summary

Song Lake - Nutrient Loading Summary					
	Watershed	Septic	Internal	Atmospheric	Sum
TN (kg/yr)	1,647	n/a	n/a	425	2,072
TP (kg/yr)	94	25	75	11	205
TSS (kg/yr)	136,548	n/a	n/a	297	136,845

On an annual basis, 2,072 kg (4,568 lbs) of nitrogen, 205 kg (452 lbs) of phosphorus and 136,845 kg (301,692 lbs) of sediments are transported to Song lake. A breakdown of the sources of phosphorus to Song Lake are hereby presented in figures 4.1 and 4.2.

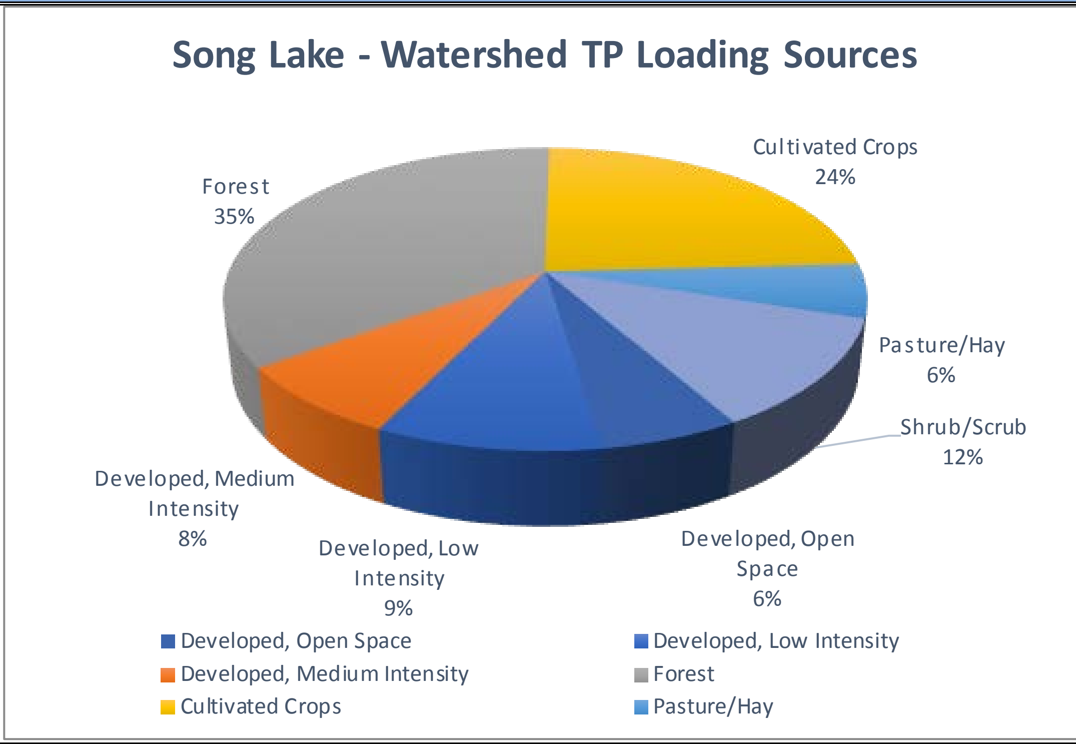
Figure 4.1: Song Lake TP Loading Summary



The primary source of phosphorus loading to Song Lake is derived by external, watershed based sources which contribute 46% to the annual phosphorus budget. Internal loading comprises the second greatest nutrient source at 37% of the annual budget while septic systems comprise 12% of the annual load. It is important to note, that while internal loading is the second greatest contributor of phosphorus to the lake, this contribution only occurs over the short growing period of approximately 120 days. As such, the impact of this load is likely more pronounced relative to its effect on algal growth. Also, the Internal phosphorus load is the largest relative load compared to the internal portions at the other three lakes included in this study. Finally, septic sources, the third greatest contributor overall, are in close spatial proximity to the lake and as such should be actively managed.

Watershed sources of total phosphorus are broken down according to land use area in figure 4.2. Forest represents the largest contributor on an absolute basis, contributing 35% of the annual phosphorus load. Since this is a natural phosphorus load, and proportionally related to the predominance of forest in the watershed, this load is not targeted for management. Instead, agriculture and developed lands, which both account for 30% and 23% of the load, respectively, should be targeted for management.

Figure 4.2: Song Lake – Watershed TP Loading



Watershed based BMPs will need to focus on phosphorus derived from both agriculture and residential land use. Residential (and associated septic systems) based phosphorus loading is the closest in proximity to the lake proper and may have pronounced, acute impacts on lake water quality. The following section will detail the results of a watershed walk conducted by Princeton Hydro in May 2017. Please note, this section is not an exhaustive survey of the watershed. Specifically, many areas, such as agricultural lands, that are on private land or are otherwise inaccessible are excluded from this report but will very likely need managed to reach nutrient reduction goals. This section will provide examples of watershed issues which could benefit from better management and provide information on approximate costs, nutrient reduction and maintenance opportunities for each section.

5.0 Watershed Disturbance and Best Management Practices

In anthropogenically altered watersheds, land use practices have been changed in ways that consequently alter the hydrologic cycle and increase pollutant loading to a lake. For this document, the term 'pollutant,' refers primarily to phosphorus, nitrogen and sediment but may also include salts, heavy metals or pesticides. Some of these pollutants are contributed directly to a lake, but, more commonly, these pollutants are derived from diffuse 'non-point sources.' Non-point source pollution is a term which relates to the contribution of sediments, phosphorus and nitrogen to waterways through land and stream bank erosion, stormwater and septic.

The watersheds of the Kettle Lakes were historically dominated by forest and wetland. With development came the clearing of forests and modification of wetlands, either through infilling, draining or flow alteration. The current land use of the Song Lake watershed is comprised of a mixture of these forests and wetlands but also the human dominated land uses of residential housing, agriculture and transportation infrastructure. The anthropogenic land use changes reduced vegetative cover, exposed soils, increased impervious areas and introduced pollutants through fertilizers, road salts and byproducts of human materials. These changes ultimately lead to a marked change in the hydrology of the watershed in such a way that infiltration and groundwater recharge was likely reduced while the volume and rate of stormwater based surface discharge increased. Ultimately, this change in stormwater leads to increased sediment and nutrient loading to lakes.

To mitigate non-point source pollution, we look to implement watershed best management practices. Watershed best management practices focus on structures, retrofits and even behaviors that may help reduce pollution to a waterway. Princeton Hydro focuses primarily on the selection and utilization of best management practices which fit in with Green Infrastructure. Green Infrastructure is a water management approach that seeks to mimic the natural environment and associated natural processes. These processes include sedimentation, filtration / flow resistance, bio-uptake, recharge, decomposition and bioretainment. Many of the structures or techniques listed below aim to utilize soils and vegetation to mimic these processes found in nature. In doing so, these techniques may serve to not only reduce nutrients to a lake but also serve as habitat for aquatic and terrestrial organisms in an ever increasing fragmented landscape.

The following section details the results of a watershed walk conducted over a half-day in May 2017 by Princeton Hydro and various stakeholders including members of Syracuse University, C-OFOKLA, local residents and members of Cortland County Soil and Water Conservation District. This walk aimed to photo-document areas of non-point source pollution which may benefit from the inclusion of best management practices. This summary is not an exhaustive survey of watershed conditions or BMP recommendations but provides specific examples of areas that can be improved. Furthermore, prior to the implementation of any BMP there will likely be additional, site specific, information needed such as: Utility, topographic and/or transportation surveys, stormwater engineering calculations, property ownership assessment, geologic or soil assessments, local, state and/or federal permits, etc.

Recommendation of BMP types are included along with rough estimates for costs and pollutant removal. Costs are based on similar projects conducted by Princeton Hydro but are very site specific based upon a myriad of factors and do not include associated permitting or engineering. Pollutant removal was computed based on removal estimates provided by various BMP manuals including those issued by the States of New York and Pennsylvania. A summary of the types of maintenance associated with each BMP is also listed. Finally, recommendations on the priority of each BMP are listed as ‘low’, ‘medium’, and ‘high.’ These priorities are based on several factors including overall cost, ease of installation, permitting requirements, the need for cooperation from various government entities and pollutant removal. In general, those projects which may be easily implemented with minimal permitting and cost while providing ecological and pollutant removal benefits are rated as ‘High.’ This is particularly the case for those sites which occur on public property. Sites of high cost, extensive permitting or those on private property may be more difficult to implement and are therefore given a lower rating.

A summary of recommended BMPs is presented first (table 5.1) followed by a breakdown of each site.

Table 5.1: Song Lake - Watershed BMP Summary

Site	BMP	Estimated Cost ($)	Pollutants Removed (kg/yr)			Priority
			TSS	TP	TN	
1	Shoreline Buffer	$5,000 - $10,000 / lot	400	0.3	1.0	High
2	Reforestation	$10,000	400	0.3	1.0	High

Site 1: Shoreline Buffer

Site Location and Description: *N42.77417° W76.15160° and various* – Lake Shoreline

Issues: Turf grass to edge of lake does not filter nutrients from watershed, is prone to erosion from wind and wave action and lacks ecological benefits of a healthy, vegetated littoral zone.

BMP Recommendation: Vegetate shoreline with native, water loving plants.

Cost: Approximately $5,000 - $10,000 per lot

Pollutant Removal: TSS 400 kg/yr, TP 0.3 kg/yr, TN 1.0 kg/yr

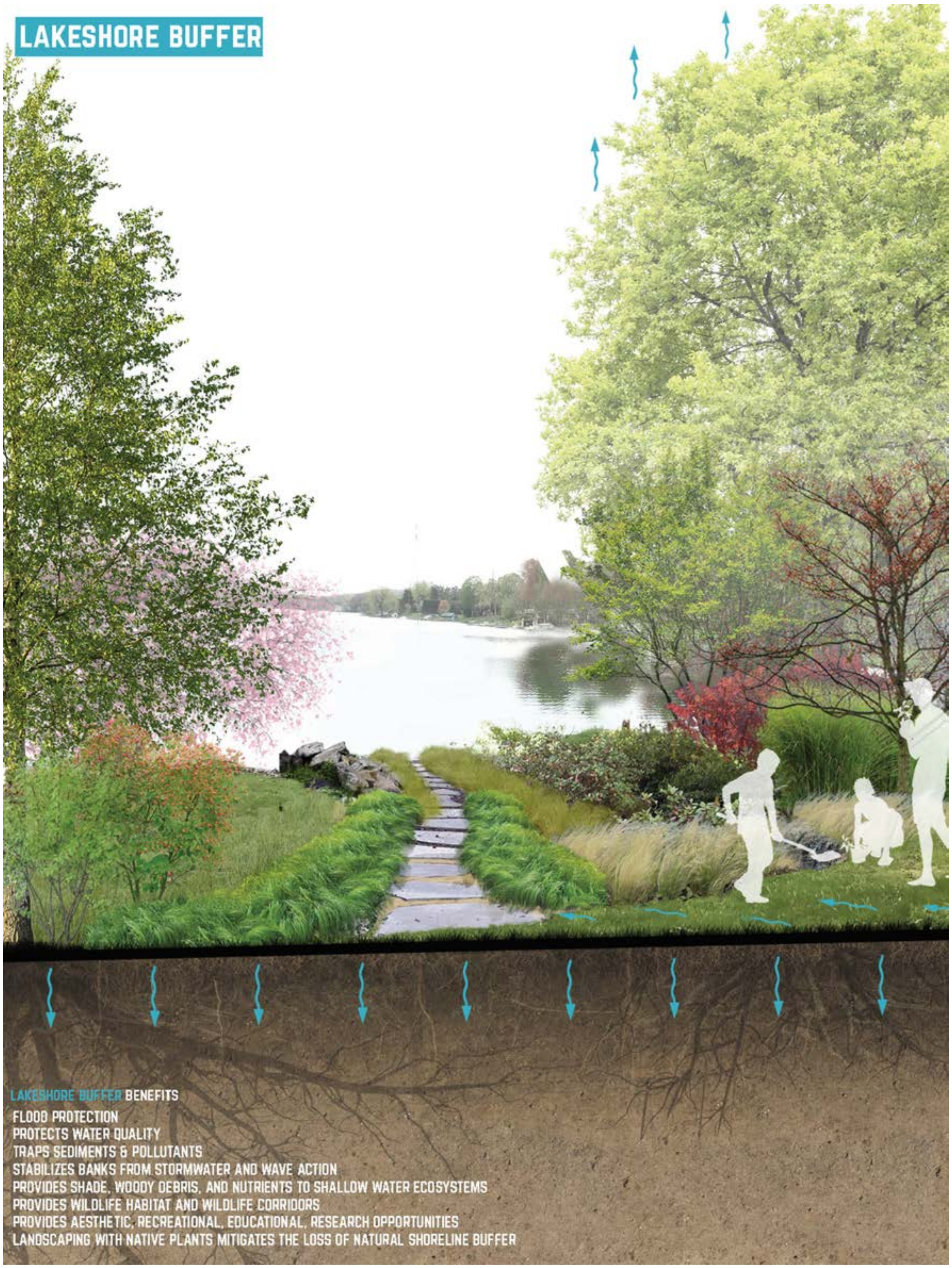
Maintenance: Check site several times throughout the year to manually remove invasives.

Priority: High

Examples of the recommended BMPs are provided below.

Figure 5.1: Song Lake – Typical Shoreline

Figure 5.2: Schematic of Naturalized Shoreline



Source: Mr. Josue Cruz

Site 2: South Shore - Reforestation

Site Location and Description: *N42.76149° W76.14262°* – South shoreline bordering agriculture

Issues: Agricultural land use and road abutting south shore which lacks buffer

BMP Recommendation: Increase vegetated buffer around to road side. If possible, vegetate portion of agricultural land adjacent to road to provide buffer / setback. Cover cropping is in place and should be continued along with conservation minded agricultural practices.

Cost: Approximately $10,000

Pollutant Removal: TSS 400 kg/yr, TP 0.3 kg/yr, TN 1.0 kg/yr

Maintenance: Check site several times throughout the year to manually remove invasives.

Priority: High

Figure 5.3: Song Lake – South Shoreline

Song Mountain Ski Area

A portion of Song Mountain Ski Area drains to Song Lake while the bulk of this area drains to Crooked Lake. BMPs for this area were described in the Crooked Lake WIP and may benefit nutrient reduction to Song Lake. Recommendations for this area included containment and silt fencing for a gravel storage area, riparian buffers, streambank stabilization, creation of a forebay at the mountain's retention basin and utilization of bioswales. Numerous improvements to the maintenance area(s) of this mountain will directly benefit the water quality of both Crooked and Song Lakes.

Septic Management

Much of the residential land surrounding Song Lake utilizes septic systems for treatment of human wastes. The soils, slopes and water table surrounding the lake make on-site wastewater treatment a critical issue for the health of the lake relative to phosphorus loading. Review of the Septic Tank Absorption Field ratings derived from the National Resources Conservation Service show the soils surrounding the lake to range from 'somewhat limited' to 'very limited' in their ability to adequately treat wastes. The estimated total phosphorus load derived from septic systems is 12% of the total load. While a small percentage, the proximity of the systems to the lake impart a higher importance on septic maintenance.

At a minimum, septic tanks should be pumped out every three years. Maintaining this pump-out schedule may reduce phosphorus loading from this source by 20 - 30% (Day, 2001). The Song Lake Property Owners Association has, in the past, incentivized maintenance, inspection and pumping of residential septic systems through a $25 credit. Princeton Hydro commends this incentive and recommends the continuation of this program. In addition, water conservation measures should be implemented at each residence. Lowering the burden on the septic system will allow for reduced nutrient transport to shallow groundwater, and ultimately, Song Lake. Finally, the type and age of septic systems may play a significant role in their functionality and contribution of nutrients to the watershed. This study merely looked at the presence of such systems without conducting a detailed assessment of whether systems need upgraded or replaced. Princeton Hydro recommends implementing such a study with backing by the local municipality and C-OFOKLA.

Lawn Fertilizers

Lawn fertilizers are often an acute source of nutrient pollution to lakes. Often, these products are applied in spring or fall and are quickly washed away during precipitation events directly into the lake where they fuel algal blooms. Currently, New York bans phosphorus fertilizers under ECL § 17-2101 et seq. This law, applicable to all persons, states the use of phosphorus fertilizers on lawns or non-agricultural turf is restricted. Only fertilizers with less than 0.67 %/w phosphate may be applied legally. Furthermore, applications between December 1 and April 1 are prohibited. An application buffer of 20 feet from a waterway or paved surface was also implemented as part of this rule.

Prior to application of any fertilizers, homeowners should have their soil tested by the local agricultural district or similar entity. This testing will provide empirical data on the amount of nutrients in the soil and need for any additional nutrients. Often times, phosphorus is present in abundance in soils and does not need additional application. Many times, the pH of the soil needs adjusted with lime thereby raising pH to a level where the phosphorus that is present in the soil becomes biologically available for turf grass. If fertilizers are needed, homeowners should look for and use phosphorus free fertilizers. Fertilizers are typically labeled with three vales (N-P-K) representing the proportion of nitrogen – phosphorus – potassium in the product. As such, look for fertilizers with a middle number of zero (e.g. 24-0-12) or a bag with 'lake friendly' on the front.

Educational campaigns about the 2012 State rule banning phosphorus fertilizer should be conducted routinely for watershed residents.

Deicers

There is considerable concern in the kettle lakes region of the impact of salts on the water quality of the lakes. Road salts (chloride) are commonly applied not only to driveways but also on state roads and interstate 81. The major issue with the application of road salts is that chloride is a conservative ion that is not readily sorbed onto mineral sources or involved in many significant biochemical reactions. As such, this ion persists in soils and ground and surface water. Ultimately, increases in chloride levels follow increases in watershed development and impervious area. These increases may alter the composition of the lake food web through changes in the invertebrate, plankton and fishery structures.

Management of road salts is a complex subject due to the human safety aspect. When possible, those who apply road salts should look into alternative deicers such as calcium magnesium acetate. Additives, such as natural beet sugars, lower the temperature of brine used to pretreat roads and has been documented in reducing overall salt use. such as Furthermore, where possible, setbacks should be established so that deicing compounds are not applied near surface water sources.

6.0 In-lake Phosphorus Management

In Song Lake, 37% of the annual phosphorus load is estimated to be derived from internal sediment release. As previously mentioned, this load is pronounced related to the other loading sources (watershed, atmospheric and septic) and also in regard to the duration and the timing of the load. Specifically, the internal load represents a pulse of phosphorus during the growing season where it may be readily assimilated by algae for explosive growth. As such, in Song Lake, in-lake management of phosphorus is recommended.

There are several ways to manage internal loading of phosphorus in lake systems. These techniques focus on the maintenance of oxygen in the hypolimnion of the lake or the 'sealing' of lake sediments through the application of chemical flocculant or inactivation products. In addition, floating wetland islands may be utilized to assimilate phosphorus from the epilimnion. While floating wetlands islands will not control internal loading, they serve as a chemical free in-lake measure to reduce the overall phosphorus load in the lake.

Aeration

Aeration for internal phosphorus control focuses on the maintenance of dissolved oxygen in the hypolimnion thereby serving to keep the redox potential at such a level as to mitigate large scale internal release of phosphorus and metals. Aeration systems for lake management typically fall under the categories of systems which disrupt thermal stratification, such as submerged diffuser systems, or systems which keep stratification in place, such as hypolimnetic aeration systems. Typically, the latter is utilized when there is the desire to maintain cold-water fishery habitat while destratification systems are commonly utilized in relatively shallow lakes.

For Song Lake, a hypolimnetic aeration unit, or similar, would likely be the desired type of unit. An additional, full year of monitoring would be necessary to accurately characterize the stratification patterns, carbon demand and phosphorus loading rates to size and spec a system. Estimated costs for monitoring, sizing, material and installation are significant and would be upwards of $150,000 not including annual operating costs.

Nutrient Inactivation

Nutrient inactivation in lakes occurs through the application of a chemical, typically an aluminum or lanthanum/clay based product. Typically, phosphorus is bound to iron in the sediments through a relatively weak molecular bond which is broken under anoxic conditions. In contrast, the bond between phosphorus and nutrient inactivation products is stronger and therefore is not broken, or is broken more slowly, under anoxic conditions.

The products commonly utilized in lake management for nutrient inactivation includes aluminum sulfate (alum) or alum surrogates such as polyaluminum chloride. More recently, the utilization of lanthanum modified bentonite clay based products, such as the proprietary Phoslock©, have been utilized when there are concerns about alum toxicity or regulatory restraints on the use of such products. The latter is currently the case in New York State which has placed an indefinite moratorium on the utilization of alum for lake management purposes. While Phoslock is utilized with efficacy for phosphorus 'stripping' in lakes, where P is removed from the water column, the efficacy of control of sediment released P under anoxic conditions is relatively low while costs are much higher than aluminum based products. As such, this management measure is not currently possible for Song Lake. Alum, if permitted in the future by NYSDEC, could be a feasible and relatively inexpensive product for sealing the profundal sediments thereby preventing phosphorus release. The cost for such an application, including monitoring, bench testing, permitting, application and follow up monitoring would likely range between $75,000 to $125,000. Alum applications which seal the sediments typically provide 5 to 7 years of internal load control.

Floating Wetland Islands

Floating wetland islands (FWIs) are a relatively new technique in lake management that uses biomimicry to assimilate and process nutrients that would otherwise stimulate algal growth. FWIs are structures composed of woven, recycled plastic material. Vegetation is planted directly in the plastic matrix of the islands with peat and then these structures are deployed in the lake. Once positioned, these units are anchored, typically with rope and cinder blocks. The vegetation grows on the FWIs with their roots growing down through the plastic matrix into the lake. The combination of the root structure and plastic matrix relates to a very high surface area which subsequently serves as habitat for bacteria and biofilm. It is estimated that one 250 ft^2 island has a surface area equal to approximately one acre of natural wetland. Once installed, the FWI serves as a nutrient sink whereby the plants and microbial community associated with the root mass and plastic matrix assimilate phosphorus. In turn, a portion of this phosphorus may be incorporated up the food chain and transported out of the lake system. Diverting this phosphorus reduces the amount of phosphorus which may be assimilated by harmful algae. Studies by Princeton Hydro have shown that one (1) 250 ft^2 island has the potential to sequester up to 10 lbs of phosphorus per year. Given that each pound of phosphorus has the potential to produce up to 1,100 lbs of algae per year, each island has the potential to mitigate 11,000 lbs of wet algae biomass annually.

Floating wetland islands are less costly than the measures mentioned above but do not directly address internal loading. Instead, they remove phosphorus from the epilimnion during the growing season. The cost for a single 250 ft^2 island, including plants and installation, is roughly $10,000. Each island has a lifespan of approximately 15 years. Approximately five (5) islands would be recommended for Song Lake to be placed in shallow areas that are known to receive storm inflow. These units would be installed in conjunction with a holistic watershed / in-lake management plan and as such are viewed as a piece of an overall management approach.

Harvesting

Macrophyte harvesting is currently conducted on Tully Lake and Little York Lake. In addition to removing nuisance densities of aquatic plants, harvesting has the added benefit of removing the nutrients contained within the plant biomass. For example, Princeton Hydro quantified the phosphorus concentration in SAV at Lake Hopatcong in New Jersey. The mean P concentration in this wet SAV biomass was 2,216 mg/kg. Plant removal from Tully and Little York Lake was estimated at approximately 100 tons wet weight thereby resulting in a removal of approximately 200 kg of P per year. If plant densities warrant, harvesting may play an effective role in a larger nutrient reduction plan for Song Lake.

Boating Impacts

Significant study has been conducted on the impacts boat motors have on sediment suspension and the effects of this on reductions in water transparency and phosphorus mobilization. The degree of impact is generally related to motor size, water depth and sediment type (Buetow, 2000). There is some evidence that, depending on the lake, boat motors may increase phosphorus loading which may lead to increases in algal growth. This is particularly the case in shallow areas comprised of fine, nutrient rich sediments. Impacts are less pronounced or absent in deep areas or areas of coarse sediments. Care should be taken to operate a motorized boat in a mindful manner in shallow areas and no-wake zones. Motor sizes and correlated mixing depths are as follows (Nedohin, 1996 & Yousef, 1978):

- 10 hp – 6 feet
- 28 hp – 10 feet
- 50 hp – 15 feet
- 100 hp – 18 feet

Princeton Hydro recommends abiding by the above guidelines. If necessary, local municipalities may consider adopting ordinances or similar to enforce safe, mindful boating practices.

7.0 Summary

Princeton Hydro, along with project partners, conducted a miniature watershed implementation plan for Song Lake. This plan aimed to characterize the water quality and pollutant load to the lake and to identify areas in the watershed that may be contributing nutrients to the waterbody that could benefit from best management practices. Ultimately, this plan may be integrated into a full-scale watershed implementation plan or lake management plan to contribute towards the restoration of the lake. In addition, this plan may serve as a jump-off point for securing funding for the projects identified herein.

Phosphorus loading to Song Lake was estimated to occur primarily from the watershed which contributes 46% of the P load followed by internal loading (37%) and septic systems (12%). Of the watershed sources, agriculture contributes approximately 30% of the load while residential contributes 23% of the load. Watershed BMPs will need to focus on controlling nutrient loading from both agriculture and developed land to reduce phosphorus loading to the lake. The internal phosphorus load to the lake is sizeable compared to the external load and would warrant management. Currently, alum and surrogates are banned in the State. If the moratorium is lifted in the future, this may serve as an effective means to neutralize internal P loading for 5 to 7 years. Another solution for internal P control may include the design and installation of a hypolimnetic (or similar) aeration system. This system could provide longer term control but with more capital and operational costs.

Princeton Hydro recommends the adoption of this plan by the town of Preble. The successful implementation of this, and any, watershed plan is contingent on the cooperation of multiple stakeholders of varied interests. Finally, Princeton Hydro would like to thank the local residents, C-OFOKLA, Syracuse University and the Cortland County Soil and Water Conservation District for all of their input, help and support during this project.

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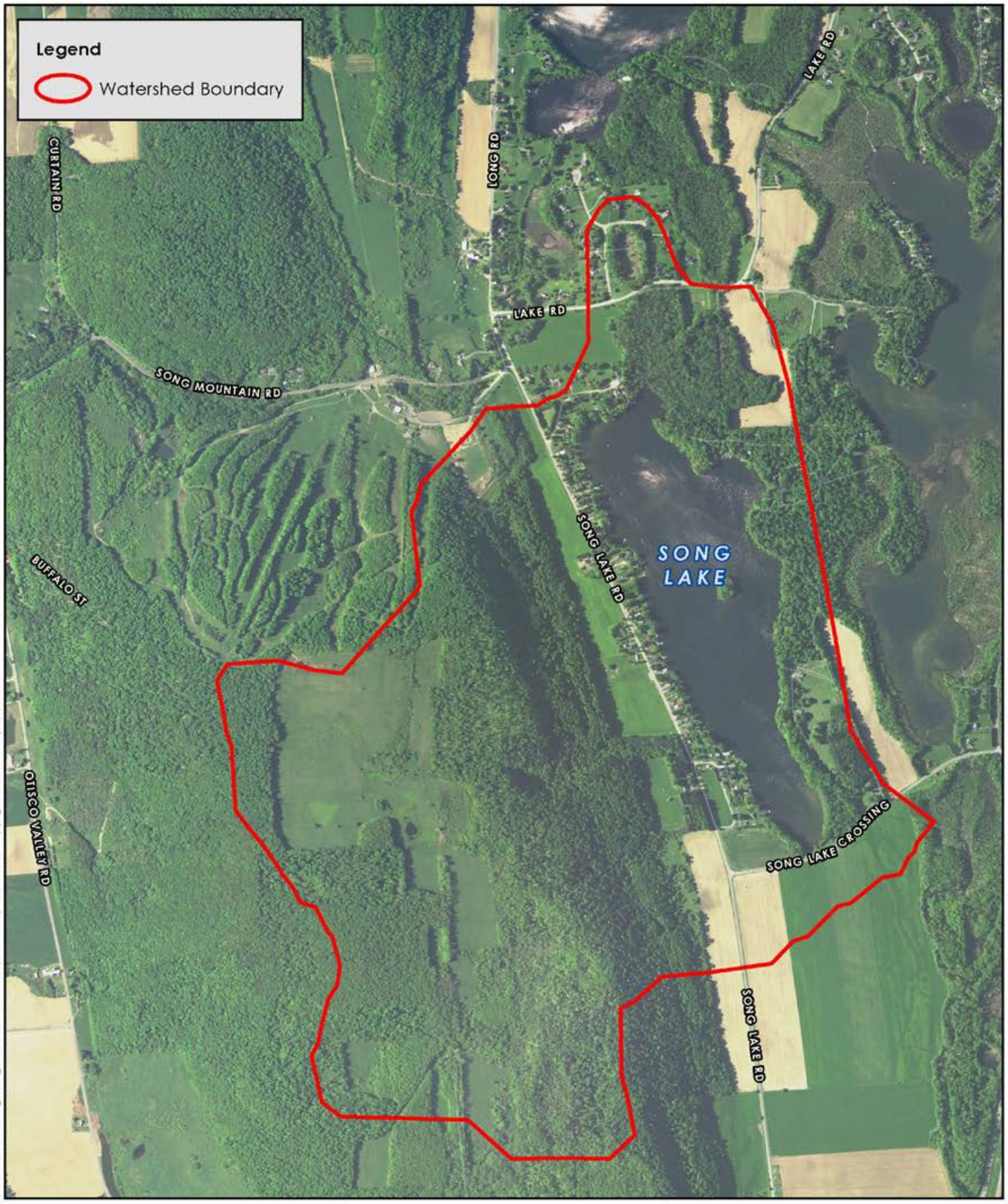
Appendix I



SONG LAKE WATERSHED

SONG LAKE
WATERSHED IMPLEMENTATION PLAN
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CORTLAND COUNTY, NEW YORK

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*with offices in NJ, PA and CT

NOTES:
1. 2015 Cortland county orthophotography obtained from the National Agriculture Imagery Program (NAIP).

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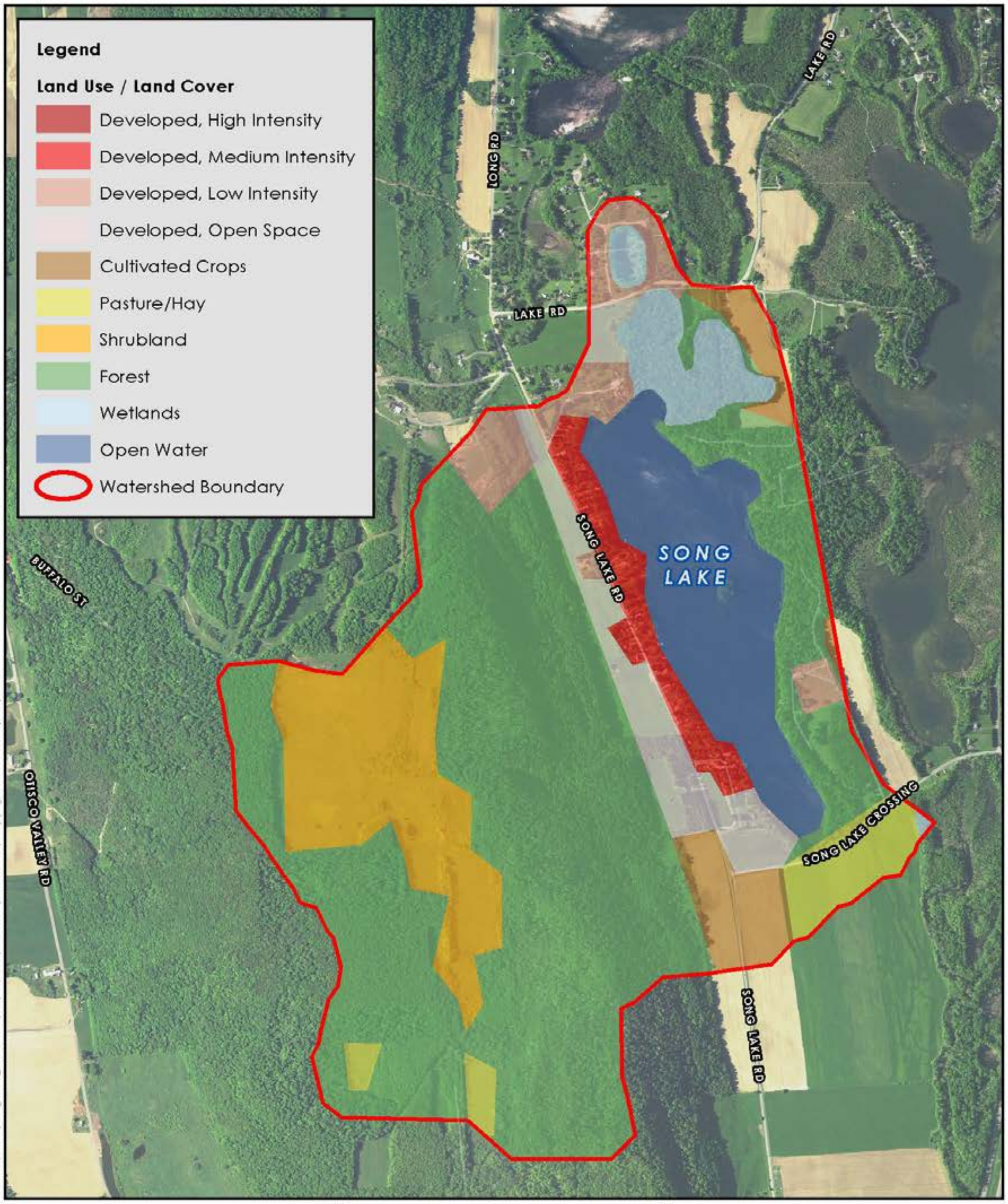
Map Projection: NAD 1983 StatePlane New York Central FIPS 3102 Feet



SONG LAKE LAND USE

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NOTES:
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2. Hand-digitized land use/land cover is approximate.

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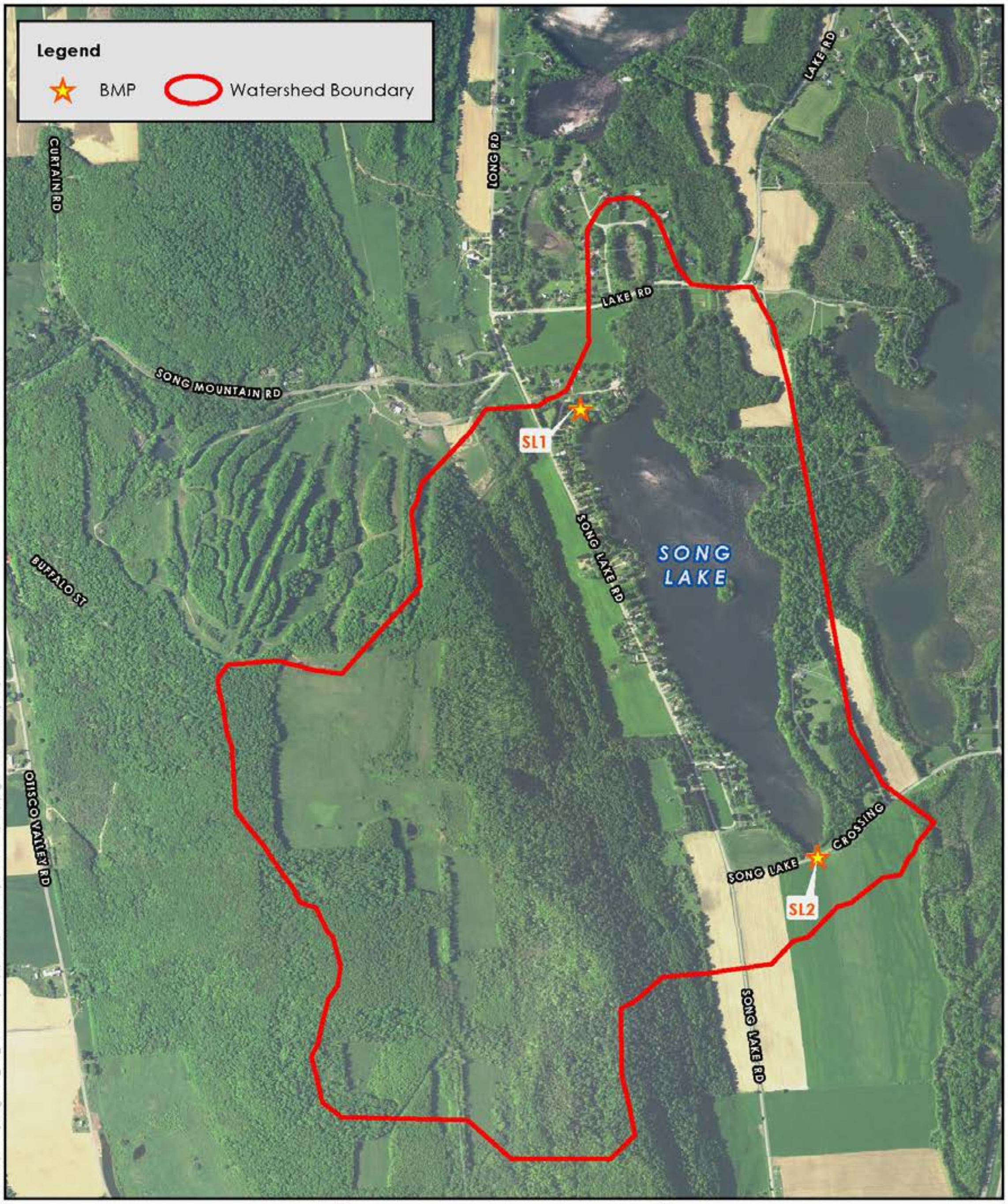
Map Projection: NAD 1983 StatePlane New York Central FIPS 3102 Feet



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