Report For:
Lake Shirley Improvement Corporation
Shirley, MA 01464

Lake Shirley Lake Management Annual Report 2019-2020

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INTRODUCTION

The Lake Shirley Improvement Corporation (LSIC) contracted Aquatic Restoration Consulting, LLC (ARC) to perform the fall aquatic plant survey and summarize the lake management activities that occurred during the prior year (October 15, 2019 through October 14, 2020) in accordance with the Order of Conditions (MassDEP File No. 208-1168 for the Town of Lunenburg and 284-0474 for the Town of Shirley). The report summarizes the LSIC management activities, data evaluation and recommendations. The report is organized in a semi-chronological order of activities for the 2019-2020 year:

- winter water level drawdown,
- water quality monitoring,
- herbicide/algaecide treatment,
- fall aquatic plant survey and prior year data comparison,
- education and outreach activities; and
- recommended changes (if appropriate) from the management program.

WINTER WATER LEVEL DRAWDOWN

Winter water level drawdowns in combination with targeted herbicide treatments have shown combined success as a nuisance weed management strategy in Lake Shirley. The principle mechanism through which water level drawdown controls aquatic plants is exposure to dry and freezing conditions for an extended period. Not every year is a “good” drawdown year as frequent rainfall, fluctuating water levels, early insulating snowfall, groundwater seepage and other factors can limit freezing and drying. Bottom substrates can also affect how well the drawdown works, as mucky and peaty soils (as are often seen in cove areas) are more resistant to drying.

Winter water level drawdown of Lake Shirley has been used for many years mainly to manage the growth of nuisance aquatic plant growth. A Metcalf & Eddy Diagnostic Feasibility study prescribed an optimal drawdown of up to nine feet, but due to impacts on shallow private wells, the drawdown is limited to four to six feet. The drawdown has worked well to control nuisance growth of milfoil (*Myriophyllum heterophyllum* and *M. spicatum*) and fanwort (*Cabomba caroliniana*) in the shallow margins of the lake, but the effectiveness is variable year-to-year as the technique requires sustained lowered water level and freezing temperatures absent of insulating snowfall. Some plant species, particularly those that produce seed or winter turions are often less impacted (e.g., tapegrass/wild celery and naiads) and can show increased growth following a drawdown. Plants in areas deeper than the drawdown zone (>6 feet) are generally not impacted by this technique. The current drawdown practice in Lake Shirley reduces nuisance plant growth within the drawdown zone lessening the need for additional herbicide use.

The LSIC goal is to achieve a seasonal six-foot drawdown on an annual basis. The drawdown is accomplished by opening the two gates at the Lake Shirley dam in the fall (on or after October 15). The drawdown rate is monitored and maintained at approximately two to three inches per day. The desired depth is typically achieved by December 1, but weather conditions (precipitation) can prohibit achievement of the target level. The gates are adjusted to balance desired water level and downstream river flow once the target depth is achieved. LSIC provides notification to the Conservation Commissions and lake residents prior to initiating lowering.

The lake is generally refilled by April 1 of the following year. The lake refills quickly during ice melt and spring flows given its large watershed (over 9,000 acres). This is not a precise process and

is highly dependent on precipitation. Additionally, ice and debris can clog the gates limiting the depth of the drawdown and/or delay refill. Both the drawdown and refill are monitored closely by LSIC in coordination with the Lunenburg dam caretaker. The caretaker records lake level and stream flow readings no less than weekly between October and April and adjusts the outlet gates as needed.

The target drawdown depth of six feet was not achieved during the 2019-2020 drawdown season. This was due to a late start associated with delayed permitting and weather conditions. While the Notice of Intent for a five-year Lake Shirley Aquatic Vegetation Management Program was filed in August 2019, coordinating efforts between the two towns and addressing comments from both Conservation Commissions took longer than expected. As a result, the drawdown did not proceed until the end of November 2019. An Emergency Certification was issued by the Town of Lunenburg to allow an extension in the drawdown period until December 31, 2019. A three-foot drawdown was achieved, and that level was held until January 30, 2020 when a precipitation event raised the water level three inches. Refill was complete by March 27, 2020. Table 1 provides the water level and flow monitoring data. There were no fish kills reported in Lake Shirley during the drawdown period.

WATER QUALITY MONITORING

The LSIC volunteers performed routine water quality monitoring during the 2020 summer season. Monitoring included measurements of water clarity, in-situ measurements and collection of nutrient and phytoplankton samples for analytical analysis. Results of the monitoring program are discussed below.

Secchi Disk Transparency

Secchi disk transparencies (SDT) were recorded on a weekly basis at three locations (Figure 1) starting in April 2020 and lasting through September. SDT is a measure of water clarity and is used as an indicator of possible presence of suspended sediments and algae. Water with clarities greater than four feet is often deemed water suitable for swimming. The Order of Conditions establishes a SDT minimum of five feet before additional testing is required by the LSIC. If readings fall below five feet, the LSIC is required to collect grab samples for phytoplankton analysis. These data are used to ascertain if an algal bloom is forming and whether an algaecide treatment is warranted. SDT remained above five feet with a minimum clarity report of 5.2 feet on September 21, 2020 in the North Basin (Figure 2). Overall water clarity in 2020 ranged from 5.2 to 12.8 feet. In 2019, the range of clarity was 5.5 to 10 feet. Clarity is typically better in the South Basin and worse in the Upper North Basin.

In-situ Measurements

LSIC volunteers collected in-situ measurements of temperature, dissolved oxygen, specific conductivity, pH and turbidity at each of the three stations (Figure 1) on June 26, July 31 and August 31, 2020. Data are presented on Table 2.

Lake Shirley is considered a Class B warm waterbody by Massachusetts Surface Water Quality Standards. As such, epilimnetic (surface) water temperatures are not expected to exceed 28.3°C. Temperatures in July exceeded this threshold at all stations. Dissolved oxygen data were desirable and remained above the 5.0 milligrams per liter (mg/L) minimum. The lake stations sampled did not exhibit thermal stratification (Figure 3), but the deep hole in the South Basin was not evaluated and is expected to show stratification and low dissolved oxygen in the hypolimnion (bottom waters).

Table 1. 2019-2020 Water Level and Outflow Monitoring Data

Date	Mid Valve	Low Valve	Level (in)	Notes	Rate (in/day)
10/16/2019	Closed	Closed	0		
10/17/2019	Closed	Closed	4		4
10/18/2019	Closed	Closed	5		1
10/19/2019	Closed	Open	6		1
10/20/2019	Closed	Open	4		-2
10/21/2019	Closed	Open	2		-2
10/23/2019	Closed	Open	-1		-1.5
10/26/2019	Closed	Open	2		1
10/29/2019	Closed	Open	4		0.7
11/11/2019	Closed	Open	3		-0.1
11/13/2019	Closed	Open	3		0
11/20/2019	Closed	Open	3		0
11/24/2019	Open	Open	6		0.8
11/26/2019	Open	Open	2		-2
11/27/2019	Open	Open	-1		-3
11/29/2019	Open	Open	-4		-1.5
11/30/2019	Open	Open	-7		-3
12/2/2019	Open	Open	-13		-3
12/10/2019	Open	Open	-30		-2.1
12/11/2019	Open	Open	-26		4
12/13/2019	Open	Open	-25		0.5
12/15/2019	Open	Open	-24	Heavy Rain 12/14	0.5
12/17/2019	Open	Open	-14		5
12/19/2019	Open	Open	-14		0
12/21/2019	Open	Open	-15		-0.5
12/23/2019	Open	Open	-20		-2.5
12/26/2019	Open	Open	-28		-2.7
12/29/2019	Open	Open	-32		-1.3
12/31/2019	Open	Open	-36	Rain	-2.0
01/03/20	Open	Closed	-36		0.0
01/05/20	Open	Closed	-36		0.0
01/12/20	Open	Closed	-36		0.0
01/19/20	Open	Closed	-36		0.0
01/22/20	Closed	Closed	-36		0.0
01/30/20	Closed	Closed	-33	Rain	0.4
02/06/20	Open	Closed	-34	Rain forecasted	-0.1
02/12/20	Open	Closed	-34		0.0
02/19/20	Closed	Closed	-35		-0.1
02/22/20	Closed	Closed	-35		0.0
02/28/20	Closed	Closed	-29		1.0
03/05/20	Closed	Closed	-24		0.8
03/10/20	Closed	Closed	-20		0.8
03/15/20	Closed	Closed	-16		0.8
03/20/20	Closed	Closed	-12		0.8
03/25/20	Closed	Closed	-4		1.6
03/27/20	Closed	Closed	2	**LAKE FULL**	2.0
04/01/20	Closed	Closed	6		1.2
04/06/20	Closed	Closed	9		0.6
04/10/20	Closed	Closed	7		-0.5
04/15/20	Closed	Closed	11		0.8

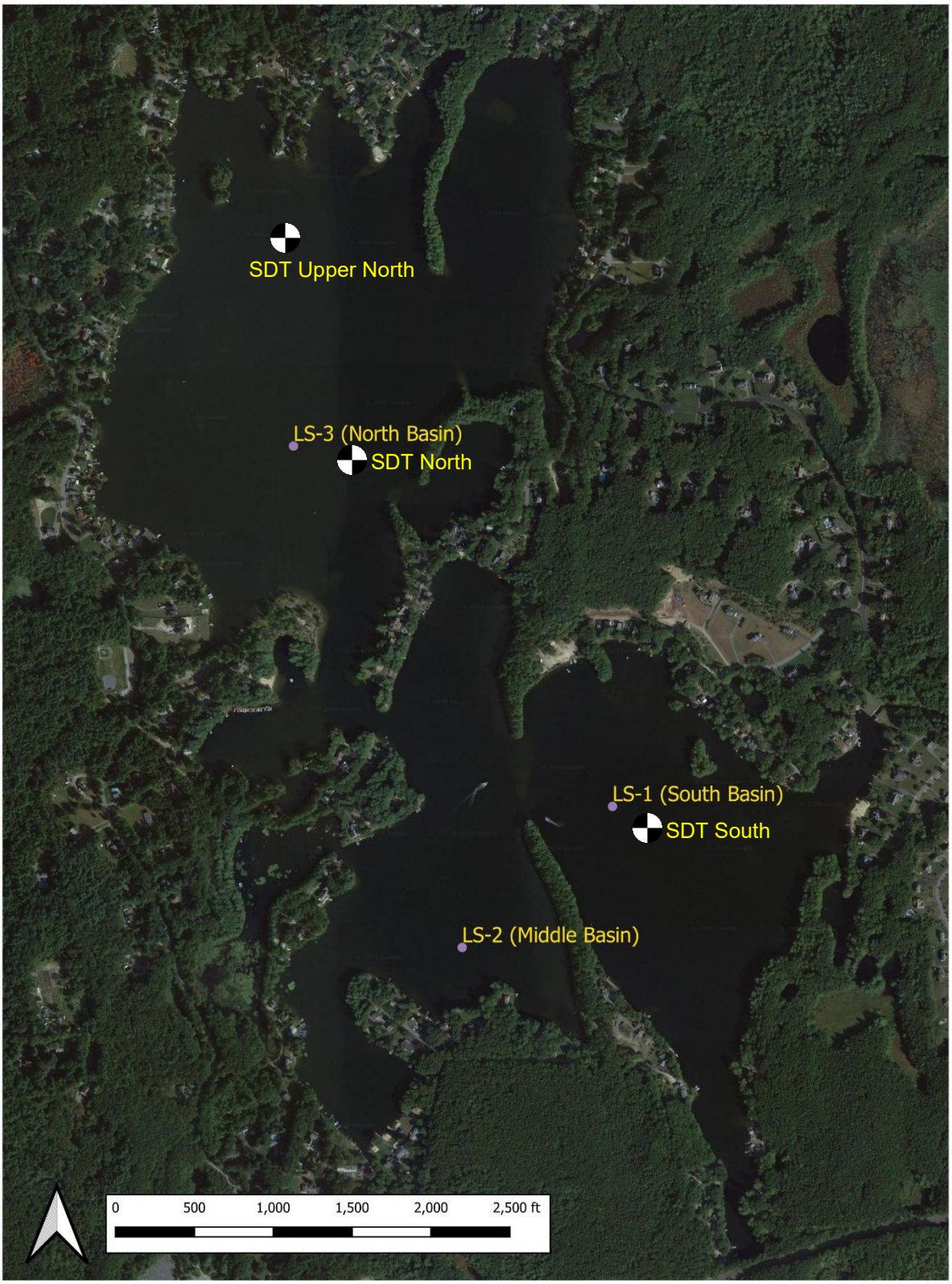


Figure 1. Water Quality and Secchi Disk Transparency Locations

Figure 2. Lake Shirley 2020 Secchi Disk Transparency

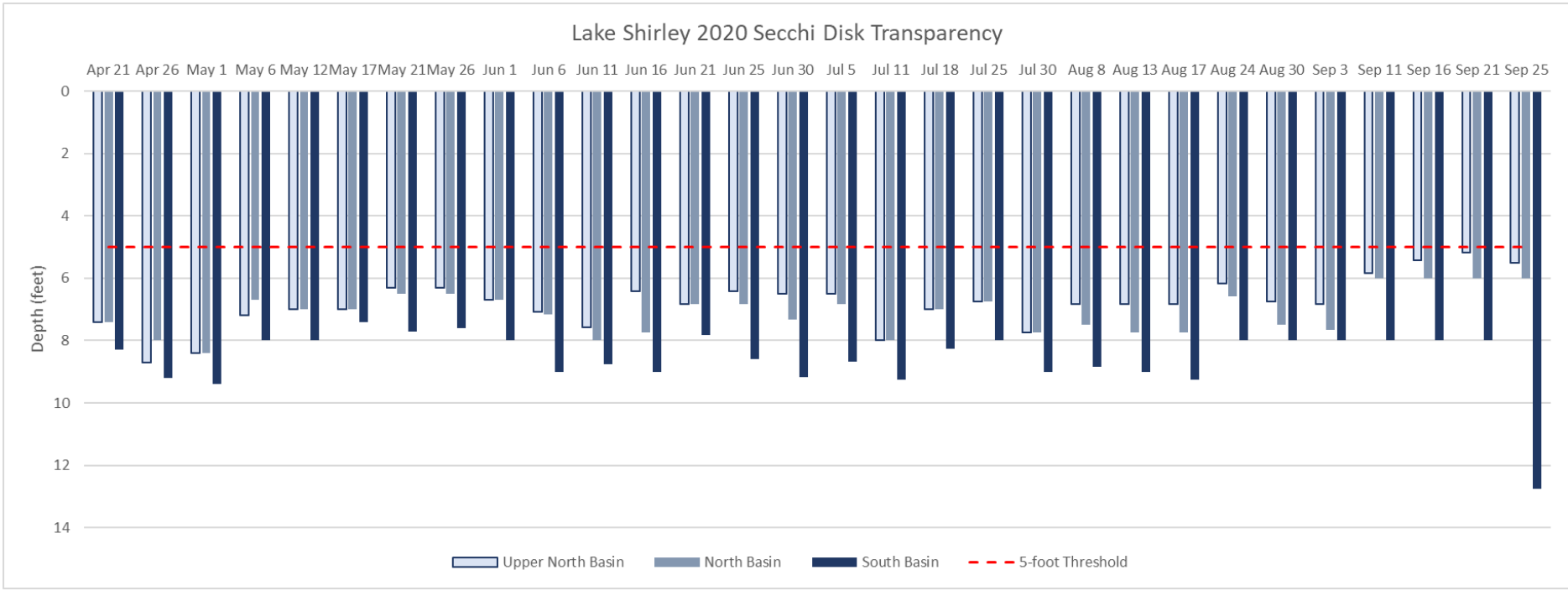


Table 2. Lake Shirley 2020 In-Situ Data

26-Jun-20							31-Jul-20							31-Aug-20						
Station	Depth (ft)	Temp (DegC)	DO (mg/L)	Spec. Cond. (uS)	pH (su)	Turb (NTU)	Station	Depth (ft)	Temp (DegC)	DO (mg/L)	Spec. Cond. (uS)	pH (su)	Turb (NTU)	Station	Depth (ft)	Temp (DegC)	DO (mg/L)	Spec. Cond. (uS)	pH (su)	Turb (NTU)
1	0	27.9	8.46	252	8.1	0.2	1	0	30.4	8.44	267	8.2	0	1	0	23.7	9.7	274	8.5	0.3
1	1	27.9	8.8	251	8.2	0.2	1	1	30.4	8.46	263	8.6	0.1	1	1	23.7	9.38	273	8.7	0
1	2	27.9	8.81	251	8.2	0.1	1	2	30.4	8.36	266	8.6	0.1	1	2	23.7	9.37	273	8.7	0
1	3	27.8	8.83	249	8.2	0.3	1	3	30.4	8.3	264	8.6	0.2	1	3	23.7	9.36	273	8.8	0
1	4	27.7	8.59	253	8.2	0.1	1	4	29.6	8.33	267	8.7	0.3	1	4	23.7	9.4	273	8.9	0
1	5	27.7	8.59	249	8.2	0.2	1	5	28.9	8.59	262	8.8	0.3	1	5	23.6	9.3	273	8.9	0
1	6	27.3	8.58	248	8.2	0.1	1	6	28.8	8.69	265	8.8	0.2	1	6	23.5	9.41	272	9.0	0
1	7	27.1	8.56	249	8.1	0.3	1	7	28.7	8.5	264	8.8	0.1	1	7	23.3	9.5	272	9.0	0.2
1	8	26.9	8.25	249	8.0	0.3	1	8	28.7	8.39	267	8.9	0.1	1	8	23.2	9.2	273	8.7	19 (hit bottom)
1	9	26.9	7.22	249	7.8	644 (hit bottom)	1	8.6	28.7	6.94	270	8.2	30 (hit bottom)	2	0	24.0	8.95	264	8.1	0
2	0	27.8	8.85	250	8.1	0.4	2	0	29.7	8.72	258	8.6	0	2	1	24.1	8.52	261	8.1	0
2	1	27.7	8.8	251	8.1	0.2	2	1	29.9	8.71	257	8.6	0.2	2	2	24.1	8.38	264	8.9	0
2	2	27.7	8.77	250	8.1	0.2	2	2	29.9	8.72	255	8.6	0.2	2	3	24.1	8.39	263	8.2	0
2	3	27.7	8.71	250	8.1	0.3	2	3	29.8	8.71	255	8.6	0.1	2	4	24.1	8.36	262	8.2	0
2	4	27.7	8.43	251	8.1	0.2	2	4	29.7	8.73	257	8.5	0.1	2	5	24.1	8.33	263	8.2	0
2	5	27.6	8.37	250	8.1	0.4	2	5	29.5	8.69	258	8.5	0.1	2	6	24.0	8.39	262	8.2	0
2	6	27.5	8.44	251	8.1	0.2	2	6	29.2	8.72	255	8.6	0	2	7	23.4	8.55	260	8.3	0
2	7	27.1	8.42	250	8.1	0.3	2	7	28.9	8.75	258	8.6	0.1	2	8	23.4	8.6	260	8.3	0.1
2	8	26.9	8.4	250	8.1	0.2	2	8	28.8	8.54	257	8.4	0.2	2	8.8	23.4	8.46	262	8.2	124 (hit bottom)
2	8.7	26.7	8.25	250	8.2	0.5	2	8.8	28.7	8.17	256	8.1	0.2	3	0	24.2	9.4	262	8.4	0
3	0	28.1	8.24	250	7.9	0.2	3	0	30.2	8.62	256	8.5	0.1	3	1	24.3	8.6	262	8.3	0
3	1	28.1	8.69	248	8.0	0.2	3	1	30.1	8.57	256	8.4	0.2	3	2	24.3	8.5	262	8.3	0.1
3	2	28.1	8.7	248	8.0	0	3	2	29.9	8.56	255	8.4	0.1	3	3	24.3	8.5	262	8.2	0
3	3	28.1	8.68	249	8.0	0	3	3	29.9	8.56	253	8.4	0.2	3	4	24.2	8.3	262	8.2	0
3	4	27.9	8.7	249	8.0	0	3	4	29.4	8.54	256	8.5	0.1	3	5	24.1	8.47	262	8.2	0
3	5	27.7	8.68	249	8.0	0	3	5	29.3	8.56	255	8.5	0.2	3	6	24.1	8.41	262	8.2	0
3	6	27.4	8.64	247	8.0	0	3	6	29.2	8.49	253	8.5	0.2	3	7	24.0	8.37	259	8.2	0
3	7	26.9	8.37	248	7.9	0	3	7	28.8	7.84	254	8.1	0.1	3	8	23.9	8.3	261	8.2	0
3	8	26.7	7.23	248	7.7	0	3	8	28.8	7.78	255	8.0	0.1	3	9	23.7	8.2	260	8.1	260 (hit bottom)
3	9	26.4	6.18	249	7.6	6.5 (hit bottom)	3	8.7	28.8	7.78	252	8.0	0.1							

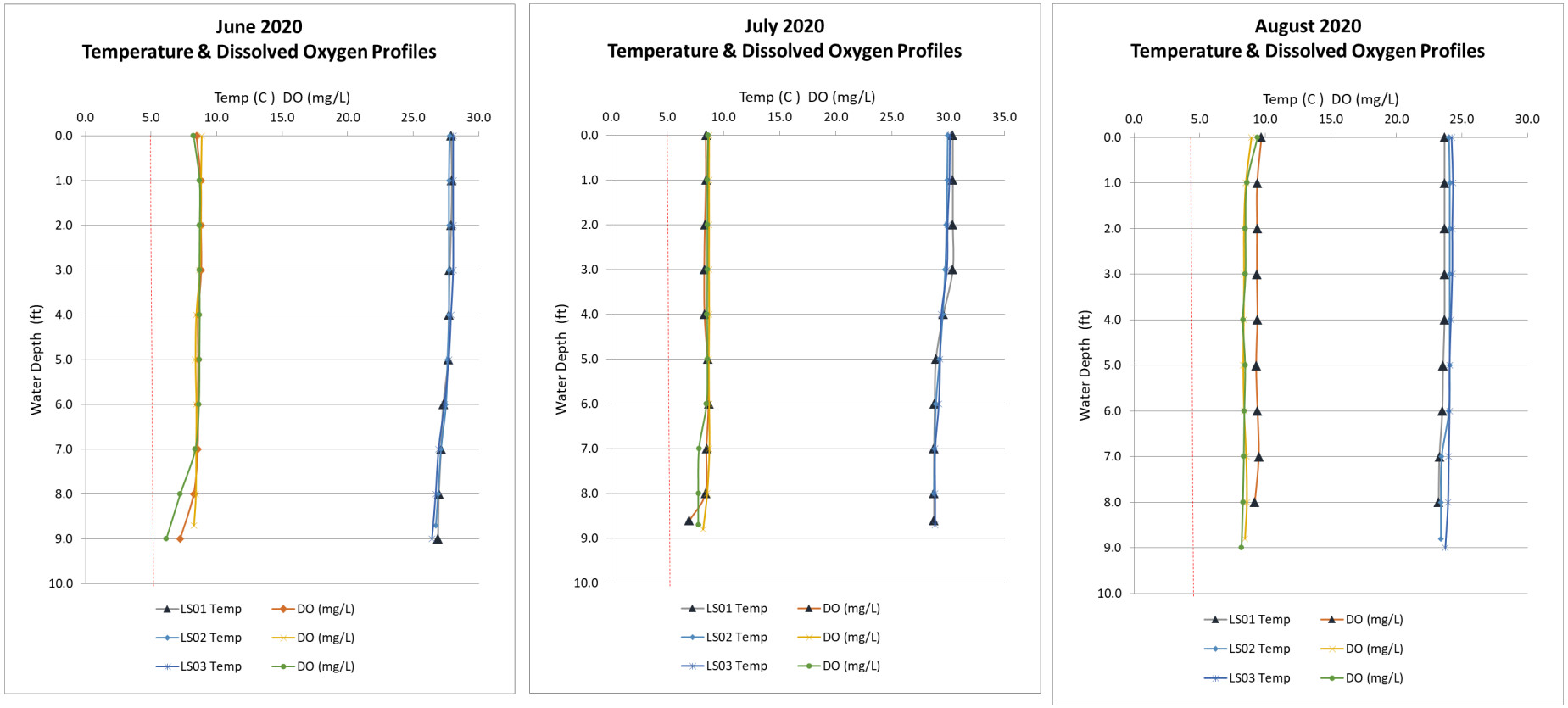


Figure 3. Lake Shirley 2020 Temperature and Dissolved Oxygen Profiles

The state standard for pH (log scale of the hydrogen and hydroxide ion concentrations) is between 6.5 and 8.3 standard units (su). Lake Shirly pH was higher than 8.3 su during July and August in 2020. Photosynthesis, respiration and decomposition influence pH and these changes occur throughout the day. It is likely that photosynthesis occurring from the excessive plant density contribute to the rise in pH as plants will remove carbon dioxide from the water.

There are no state numerical standards for specific conductivity or turbidity. Specific conductivity is a measure of the electrical conductance (ability to pass electrical current) of water. The higher the conductivity, the higher number of ions are in the water. Conductivity is a relatively stable parameter and changes over time can indicate changes in the system (e.g., pollutant inputs). Conductivity values below 100 microsiemens (µS) are low and values above 500 µS are high. Lake Shirley values averaged 258 µS. Turbidity in lakes below three nephelometric turbidity units (NTU) is considered desirable. All values recorded in Lake Shirley in 2020 were less than 1.0 NTU.

Nutrient Concentrations

LSIC volunteers and ARC collected grab samples at three locations in the lake at two depths (surface and bottom) on five dates during 2020. Samples were laboratory analyzed for nitrogen and phosphorus, the two nutrients that influence algal growth. Phosphorus is the nutrient in shortest supply in freshwater systems and is commonly referred to as the limiting nutrient, meaning that primary production (algae and plant growth) is controlled or limited by the amount of phosphorus in the system. Total nitrogen (TN) and total phosphorus (TP) data are shown in Table 3. TN concentrations ranged from 0.22 to 0.75 mg/L and are considered moderate (around 0.5 mg/L). TP in 2020 was generally low, ranging from <0.01 to 0.105 mg/L; averaging 0.019 mg/L. These concentrations are below the 0.020 mg/L threshold where algal blooms typically begin to be more frequent and problematic. The one high value (0.105) was recorded at the bottom and the sample likely contained suspended sediment raising the phosphorus concentration. Excluding that value, the highest concentration was 0.040 mg/L and recorded at the surface of LS-3 (North Basin). Surface TP concentrations in the Upper North Basin are historically higher that the other locations. This location was only slightly higher on average than the others (0.017, 0.016 and 0.020 mg/L for LS-1, LS-2 and LS-3, respectively). Bottom phosphorus concentrations did not show a pattern between basins or over time.

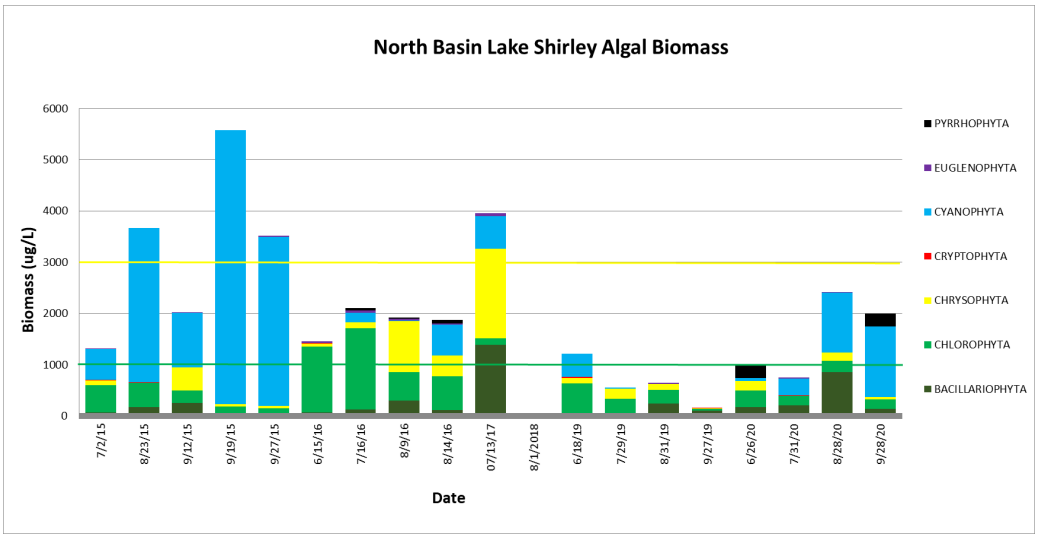
Phytoplankton

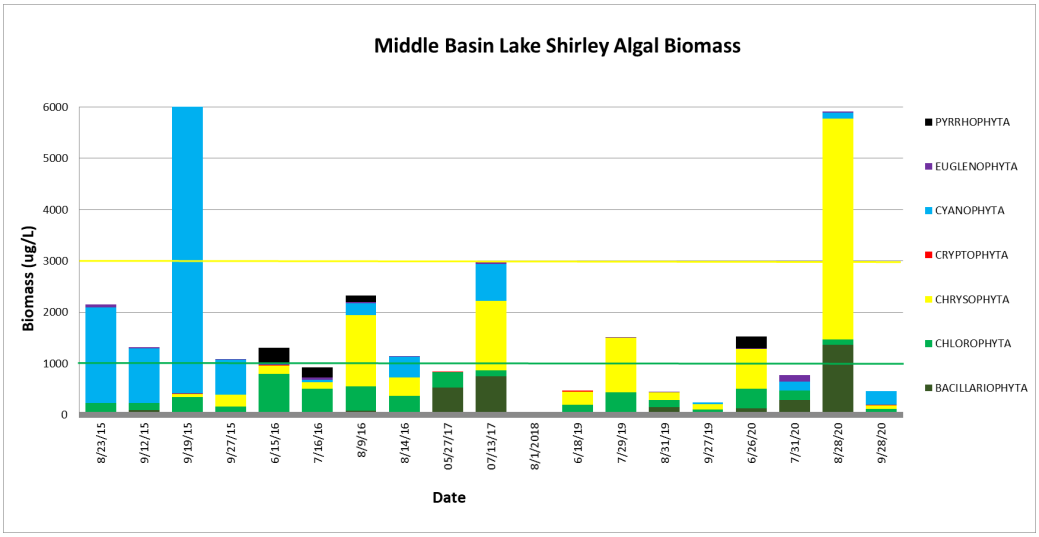
LSIC collected grab samples for phytoplankton monthly from June through September. Concentration (cells/milliliter[mL]) were low and ranged from 864 cells/mL in May 2020 to 14,442 cells/mL in September 2020 (Appendix A). Cyanobacteria cells were well below the 70,000 cells/mL used as the threshold for Department of Health to issue a contact recreation advisory or beach closure. The maximum cell count for cyanobacteria (blue green algae) was 13,775 cells/mL on September 28, 2020 in the South Basin. Cell density data in 2020 suggest that cyanobacteria issues have been much less of a problem since the bloom observed in 2015 (Figure 4).

Table 3. Lake Shirley 2020 Nutrient Concentrations

	SURFACE TN mg/L				BOTTOM TN mg/L		
	LS-1	**LS-2**	**LS-3**		**LS-1**	**LS-2**	**LS-3**
Minimum	0.24	0.22	0.25		0.43	0.28	0.28
Maximum	0.59	0.54	0.64		0.75	0.65	0.40
Average	0.41	0.41	0.45		0.54	0.45	0.35
	LS-1	**LS-2**	**LS-3**		**LS-1**	**LS-2**	**LS-3**
6/10/2020	0.24	0.22	0.25		0.75	0.28	0.28
6/26/2020	<0.30	0.48	0.64		0.56	0.65	0.33
7/31/2020	0.43	0.54	0.50		0.43	0.47	0.40
8/28/2020	0.50	0.40	0.45		0.45	0.49	0.38
9/28/2020	0.59	0.42	0.41		0.49	0.37	0.38

	SURFACE TP mg/L				BOTTOM TP mg/L		
	LS-1	**LS-2**	**LS-3**		**LS-1**	**LS-2**	**LS-3**
Minimum	0.010	0.010	0.010		0.010	0.013	0.010
Maximum	0.021	0.026	0.040		0.105	0.018	0.019
Average	0.017	0.016	0.020		0.034	0.016	0.015
	LS-1	**LS-2**	**LS-3**		**LS-1**	**LS-2**	**LS-3**
6/10/2020	0.021	0.026	0.021		0.105	0.018	0.019
6/26/2020	0.017	0.012	0.040		0.016	0.014	0.014
7/31/2020	0.019	0.017	0.014		0.018	0.017	0.019
8/28/2020	0.016	0.014	0.015		0.021	0.016	0.014
9/28/2020	<0.010	<0.010	<0.010		0.010	0.013	<0.010





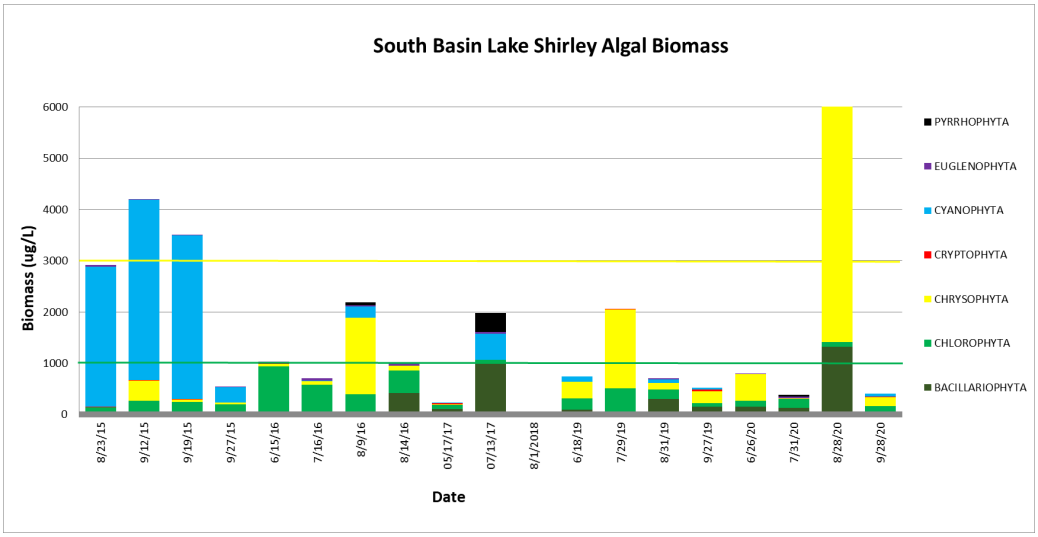


Figure 4. Lake Shirley Algal Biomass (2015-2020).

2020 HERBICIDE AND ALGAECIDE TREATMENTS

SOLitude Lake Management biologists surveyed Lake Shirley aquatic plants on June 5th and June 22nd to evaluate if herbicide treatment was warranted. Both the pre- and post-treatment reports are provided in Appendix B. Results of the survey were vastly different than prior years in terms of abundance of native seed producing pondweeds. For this reason, SOLitude added additional observation locations along the shoreline to assess the nuisance level of pondweed growth: variable (or grassy) pondweed (*Potamogeton gramineus*), leafy pondweed (*Potamogeton foliosus*), clasping leaf pondweed (*Potamogeton perfoliatus*) and snailseed pondweed (*Potamogeton bicupulatus*). Density and biomass of these plants were high along many of the shallow areas of the lake. Other management target species were observed: non-native fanwort (*Cabomba caroliniana*) and curly-leaf pondweed (*Potamogeton crispus*), and native tapegrass/wild celery (*Vallisneria americana*). Neither species of non-native milfoils [variable milfoil (*Myriophyllum heterophyllum*) nor Eurasian milfoil (*Myriophyllum spicatum*)] were observed.

The reason for the change in species composition and density is unknown but two things were different this year: 1) the desired winter water level drawdown of six feet was not achieved and was limited to three feet, and 2) the summer weather conditions were highly favorable for plant growth: sunny skies, clear water, and limited precipitation (i.e., reduced stormwater inputs)[1]. These native pondweeds are primarily seed producers and there was likely a seed bank in the sediment that favored their growth under the unusual 2020 climatic conditions.

As prescribed in the Lake Management Plan, areas where plant biomass was greater than 50% or contained non-native species were proposed for treatment. Some areas containing dense plants were not designated for treatment because they were proximal to undeveloped shorelines where contact recreation is minimal. Additionally, treatment was avoided near survey points 4, 5, 22 and 44 (Figure 5) due to the presence of desirable native species [coontail (*Ceratophyllum demersum*) and Robins pondweed (*Potamogeton robbinsii*)] that have been less frequent in the lake over the years. Approximately 68 acres were designated for treatment.

SOLitude conducted treatment on July 16, 2020 using Reward (diquat), Nautique (copper) and Clipper (flumioxazin). The herbicide treatment details are listed in Table 2 of the 2020 Year-End Treatment Report provided in Appendix B. Overall 65 acres were treated using 93 gallons of Reward, 22.5 gallons of Nautique and five pounds of Clipper. There were no fish kills reported in Lake Shirley prior to, during or following the herbicide treatments.

SOLitude conducted a post treatment survey to evaluate herbicide efficacy on August 19, 2020. Treatment was deemed successful as it reduced densities of nuisance vegetation (pondweeds, wildcelery) in the shallow areas around the lake. The test application of 2.5 acres using Clipper for control of fanwort in the Pearl Street Cove area was also successful. Fanwort was not observed in this are post-treatment.

[1] Most of Massachusetts fell into Level 2 Significant Drought for the months of May through September 2020.

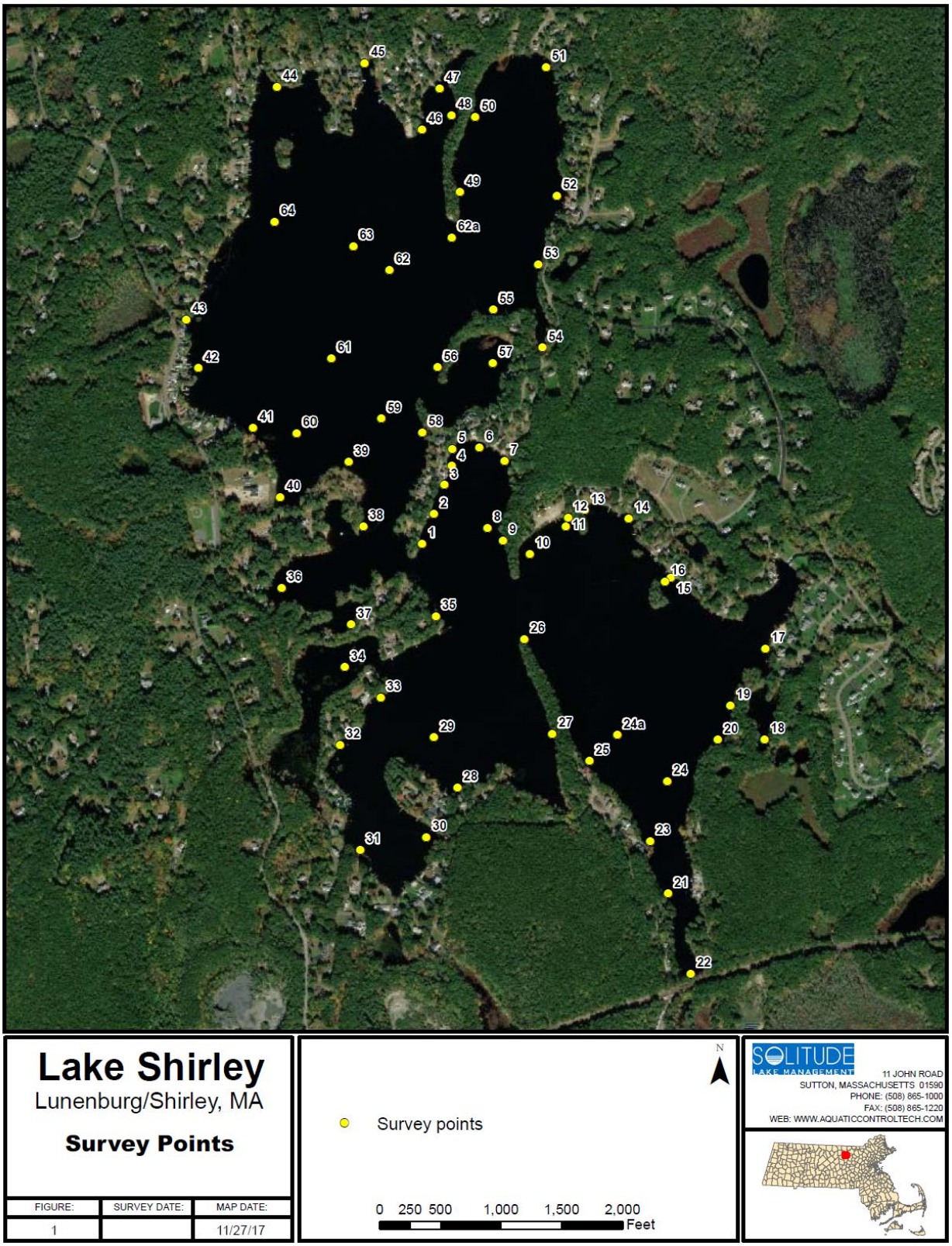


Figure 5. Lake Shirley Plant Survey Points

END OF SEASON PLANT SURVEY

Aquatic Restoration Consulting, LLC performed a late summer plant survey. The purpose of the survey was to document conditions at the end of the growing season and compare these results to prior annual surveys. ARC used the same 66 survey locations as prior surveys and observed plants at these locations using both a rake-toss and underwater video. Both plant cover (estimated percent area containing plants in two dimensions) and biovolume (estimated percent volume containing plants in three dimensions)[2] are estimated using a semi-quantitative (0-4) ranking system as follows:

0 = 0% 1 = 1–25% 2 = 26–50% 3 = 51–75% 4 = 76–100%

The presence of species and their relative densities were recorded. Relative densities were categorized as trace (only one or two plants present), sparse (multiple plants but not abundant, about a handful), moderate (multiple plants but not dominant, about a rake full) and dense (dominant component of assemblage, more than one rake full). Results of the survey are provided in Table 4.

Of the 66 observation locations, 63 contained plants (95%). Overall plant cover and biovolume were less in 2020 than 2019 (Figure 6). Plant cover was greater than 50 percent (> category 2) at 65% of the sites containing plants. Biovolume exceeded 50% at only 11% of the sites. Most of the observation locations (52%) contained plants with a biovolume of 26-50%. Wild celery was the most frequently encountered plant (observed at 67% of the sites) with the two other management target species also very frequent (European naiad and fanwort at 56% and 52%, respectively). When present, fanwort and wild celery were dense and dominated the community. Bladderwort was present at 43% of the sites and the remaining plant species were much less frequent (<20%). Neither species of invasive milfoils (variable nor Eurasian) were encountered during the ARC survey.

The two native species SOLitude avoided during treatments (coontail and Robbin's pondweed) were present in September 2020 but were infrequent (2% and 3% of the sites respectively). Interestingly, they were not observed at the survey points where treatment was avoided (4, 5, 22 and 44) but were found at other locations (17, 18 and 54), where they were not observed in the pretreatment survey. At the four sites excluded from treatment, fanwort and European naiad dominated. These species could have shaded out the desirable natives over the summer having been left untreated, or this difference could illustrate natural variability over time.

[2] Note that "cover" is interchangeable with "density" in prior consultant reports and "biovolume" is interchangeable with "biomass". ARC believes cover and biovolume are more precise descriptions of what is actually observed. For coverage, the scientist is estimated the areal coverage of the survey point with plants and biovolume is estimating the percent of the water volume occupied by plants.

Table 4. Lake Shirley Plant Survey Data (Sep 2020).

Point	Water Depth (ft)	Cover	Bio-volume	Cc	Nm	Va	Cd	FG	Nf	Ngrac	Nit	No	Nv	Pf	Pp	Ppus	Pr	Pz	Spar.	Usp	Species Richness	Richness w/o Target Sp[2]
1	9.0	4	2	D	M															M	3	1
2	9.0	4	2	D	M															S	3	1
3	7.5	4	2	D	M															T	3	1
4	8.0	4	2	D	D																2	0
5	6.1	4	2	D		M															2	0
6	7.5	2	1	S		D									S						3	1
7	3.3	2	1		T	D									D				T		4	2
8	9.6	4	2	M	M															D	3	1
9	6.7	3	1	M	S	D				S										M	5	2
10	9.7	4	2	D																T	2	1
11	6.2	2	2	S		D														M	3	1
12	3.0	2	1			D									M						2	1
13	5.6	3	1	M	S	M									T					D	5	2
14	5.0	2	1	T		D														T	3	1
15	4.9	2	2			D									D					S	3	2
16	5.3	2	1		S	D														M	3	1
17	4.0	3	2	S		D				S					D		T			M	6	4
18	6.4	3	2					M									D	M			3	3
19	5.5	1	1	T		T															2	0
20	3.1	1	1		T				T											T	3	2
21	6.6	4	2	M	M	D			M												4	1
22	4.6	4	3	D																M	2	1
23	6.8	3	2	T	S	D			T											M	5	2
24	8.6	3	1	T	M			S	M											D	5	3
24a	9.8	2	2	M	T					M										T	4	2
25	5.9	4	2		M	D									M	T				S	5	3
26	2.7	0	0																		0	0
27	6.3	0	0																		0	0
28	2.6	2	2	T		D								S							3	1
29	8.1	3	2	S	D	D															3	0
30	4.7	2	2	T		D			S	S										S	5	3
31	4.5	2	2	S		D									M				T		4	2
32	6.5	2	2			D			S	T					M						4	3
33	6.0	2	2			D								S							2	1
34	4.1	4	4			D				T	T	T								S	5	4
35	5.3	3	2	M		D			S											T	4	2
36	7.9	4	3	D																S	2	1
37	5.5	4	4	D		M								T						M	4	2
38	8.0	3	2	D		D			S					T						T	5	3
39	4.4	4	2			D									D						2	1
40	2.5	4	2			D								T	D						3	2
41	6.6	1	1		T	D															2	0
42	6.0	3	2	T	M	D		S													4	1
43	3.3	4	2		D	S						M	T	S							5	3
44	5.6	4	3	D	T	S															3	0
45	4.2	4	4	D		S		S													3	1
46	5.0	2	2			D														S	2	1
47	5.5	1	1			T															1	0
48	5.7	3	1			D															1	0
49	7.6	4	3		D	T															2	0
50	6.9	1	1		D			S												M	3	2

Table 4 continued. Lake Shirley Plant Survey Data (Sep 2020).

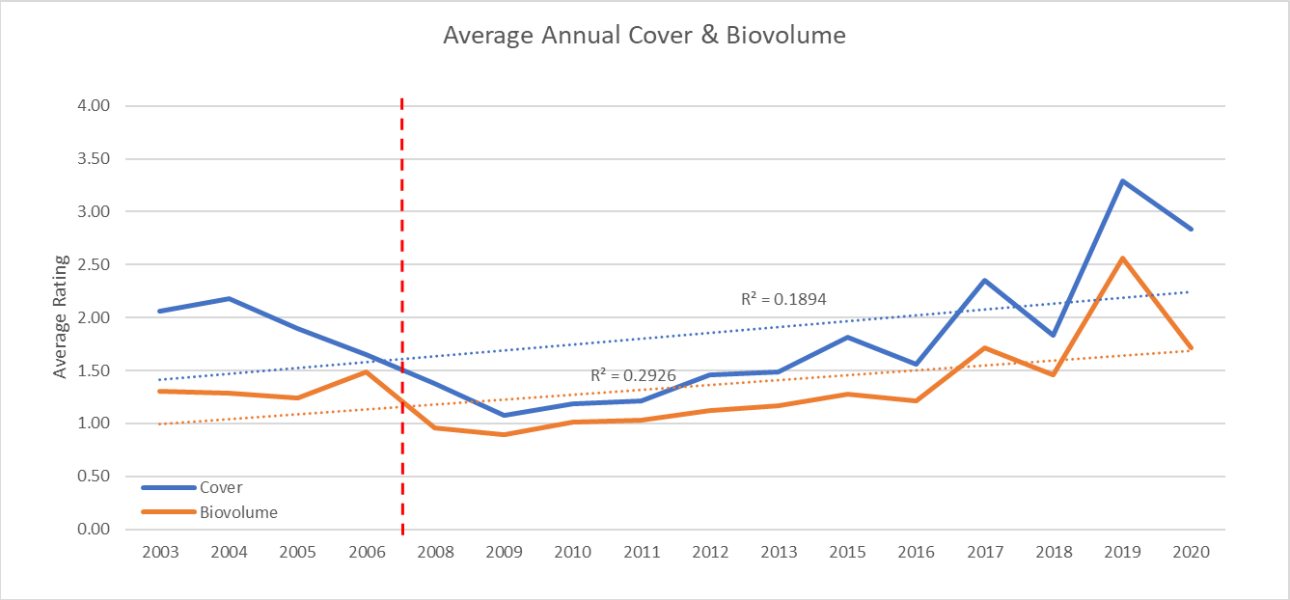
Point	Water Depth (ft)	Cover	Bio-volume	Cc	Nm	Va	Cd	FG	Nf	Ngrac	Nit	No	Nv	Pf	Pp	Ppus	Pr	Pz	Spar.	Usp	Species Richness	Richness w/o Target Sp[2]
51	4.9	3	2			D									D						2	1
52	5.9	4	2		D	D															2	0
53	4.8	0	0																		0	0
54	2.0	4	2	D	S		S						T							D	5	3
55	7.8	3	2	D	M																2	0
56	5.5	2	1		S	D															2	0
57	6.8	4	1		D	S			S	S											4	2
58	5.0	1	1		S	D															2	0
59	10.6	1	1	M	D																2	0
60	6.4	4	2		M	M															2	0
61	9.2	4	1		D																1	0
62	10.0	4	1		D			D													2	1
62a	9.3	3	1		D																1	0
63	9.8	4	1		D			M													2	1
64	7.9	4	1		S			D													2	1
Frequency of Occurrence				33	35	42	1	8	9	7	1	2	2	6	12	1	2	1	2	27	17	14
Frequency of Occurrence (%)[1]				52%	56%	67%	2%	13%	14%	11%	2%	3%	3%	10%	19%	2%	3%	2%	3%	43%		
Density When Present (%)																						
			Dense	42%	34%	74%	0%	25%	0%	0%	0%	0%	0%	0%	50%	0%	50%	0%	0%	15%		
			Moderate	21%	29%	10%	0%	25%	22%	14%	0%	50%	0%	0%	33%	0%	0%	100%	0%	33%		
			Sparse	15%	23%	10%	100%	50%	56%	57%	0%	0%	0%	50%	8%	0%	0%	0%	0%	26%		
			Trace	21%	14%	7%	0%	0%	22%	29%	100%	50%	100%	50%	8%	100%	50%	0%	100%	26%		

[1] - Frequency of occurrence (%) is the number of observations where plants are present (# observed/63 total observations with plants)

[2] - Richness w/o Target Species is the richness at the sample location not including fanwort (Cc), European naiad (Nm) or wild celery (Va).

Key to species

Cc - *Cabomba caroliniana* (fanwort)	Pf - *Potamogeton foliosus* (leafy pondweed)
Cd - *Ceratophyllum demersum* (coontail)	Pp - *Potamogeton perfoliatus* (Clasping pondweed)
FG - Filamentous green algae	Ppus - *Potamogeton pusillus* (Thin-leaf [Small] pondweed)
Nf - *Najas flexilis* (bushy pondweed)	Pr - *Potamogeton robbinsii* (Robbins' pondweed)
Ngrac - *Najas gracillima* (Northern [Thread-like] naiad)	Pz - *Potamogeton zosterformis* (flatstem pondweed)
Nm - *Najas minor* (European Naiad)	Spar - *Sparganium sp.* (bur-reed)
Nit - *Nitella sp.* (Stonewort)	Usp - *Utricularia sp.* (bladderwort)
No - *Nymphaea odorata* (white waterlily)	Va - *Vallisneria americana* (wild celery)
Nv - *Nuphar variegatum* (yellow waterlily)	



red dash indicates when herbicide treatments began

Figure 6. Lake Shirley End of Growing Season Plant Cover & Biovolume over Time

Species richness (number of different species observed) at the sites in 2020 ranged from one to six (Table 4), with an average of 3.0. After removing richness data for the managed target species (fanwort, European naiad and wild celery) average species richness declines to 1.3. While there were changes in species during the end of growing season surveys in 2019 vs 2020, the overall richness, with and without managed species, was the same: 17 total species and 14 without target species in both years (Figure 7).

Two other common metrics used to summarize and assess biotic communities are diversity and evenness. The diversity index, Shannon Index (H), considers both species richness and abundance (i.e., dominance). The higher the H' value the greater the diversity and evenness, or lack of dominance by a few species. Values closer to zero indicates that richness is low and the community is dominated by only a few species. The Shannon Index is often discussed along with an equitability (or evenness) index. Evenness is expressed on a scale of 0 to 1, where values closer to 1 indicated that species are evenly represented in the community. Evenness value (E) near 0 indicates dominance by only a few species. These two indices are described in detail, including formulas, in the Lake Shirley Long Term Macrophyte Monitoring Assessment Report – 2002-2019 prepared by ARC in April 2020 (available at https://www.lakeshirley.com/resources.html).

Plant diversity and evenness in 2020 were comparable to 2019 with only a slight improvement in the metrics when the management target species are removed (Figure 8). Diversity in 2019 and 2020 were 2.22 and 2.20, respectively. Removing the target management species from the population, diversity (H*) yields only a slightly greater value in 2020 than 2019 (2.10 vs 1.99, respectively). Evenness was the same in 2020 and 2019 at 0.78 considering the entire population. With the target species removed, evenness (E*) was higher in 2020 (0.75 in 2019 and 0.80 in 2020), suggesting that species were more evenly represented with less dominance by a few species.

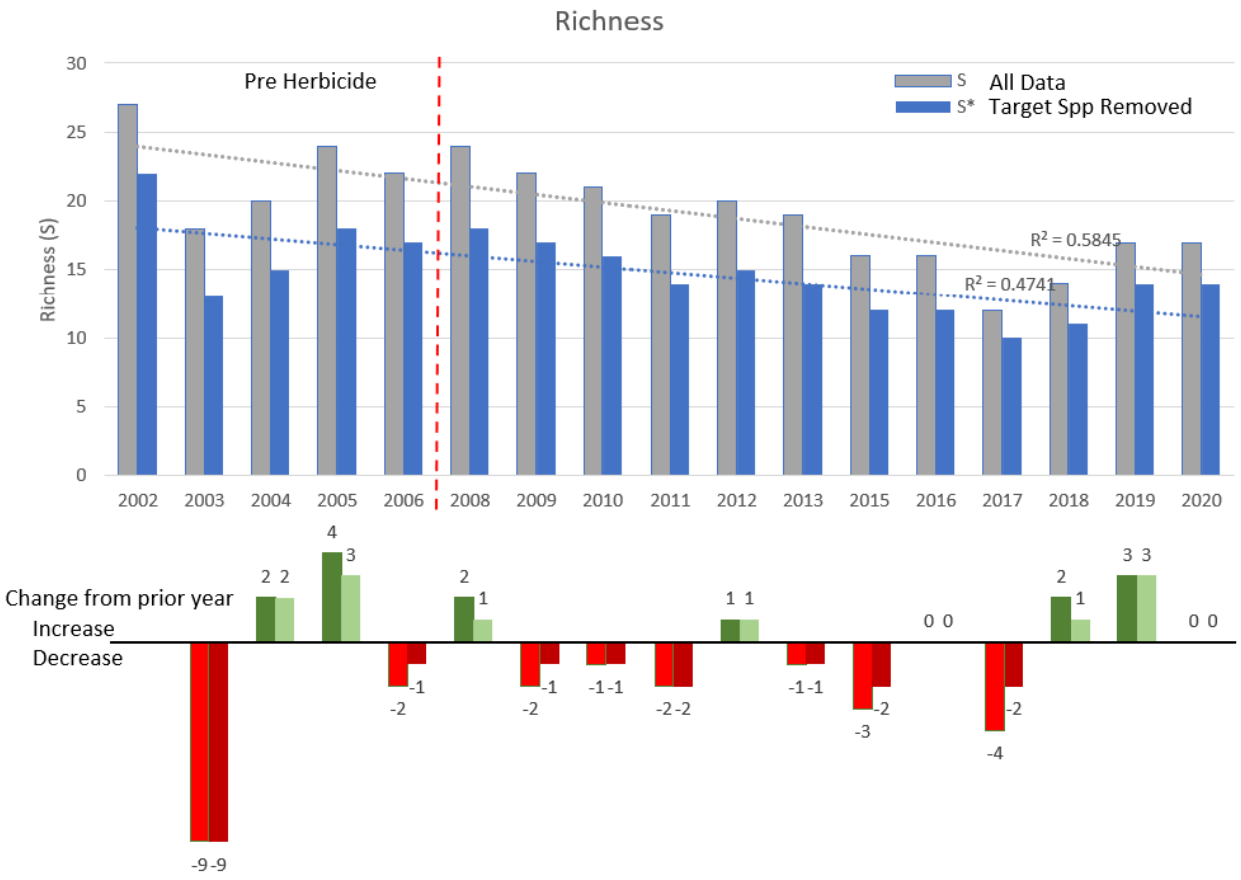


Figure 7. Lake Shirley End of Growing Season Plant Species Richness

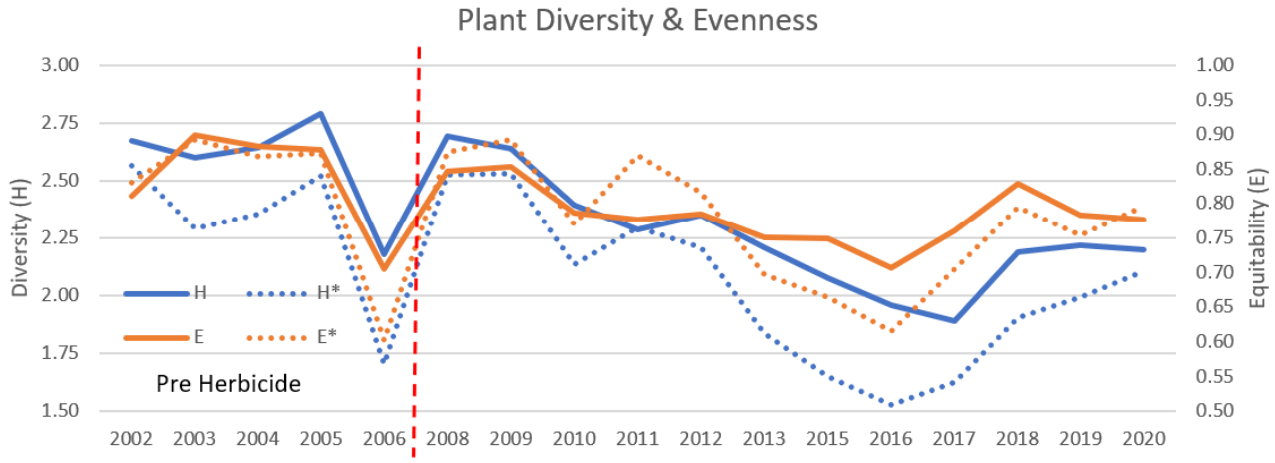


Figure 8. Lake Shirley Plant Diversity and Evenness over Time

Two of the non-native invasive plant species, fanwort and European naiad were less abundant in 2020 vs 2019 and likely the result of an effective herbicide treatment. Fanwort was 42% less abundant and European naiad was 34% less abundant than in 2019. The herbicide Clipper (a more effective herbicide in controlling fanwort) was applied in Pearl Street Cove area in 2020 for the first time. Fanwort was not observed in the cove at survey points 46, 47 and 48. These areas were still dominated by wild celery however, a native species that can reach nuisance levels. Wild celery was only slightly less frequent (observed at 8 fewer locations) in 2020. There was also less bladderwort, bushy pondweed and thin-leaf pondweed. There were small changes in other species that are typically found at relatively low frequencies from year to year (Table 5).

EDUCATION AND OUTREACH

While the LSIC does not own the lake or dam, this volunteer-based lake association is dedicated to the protection and management of this system. LSIC works continually to further the education and outreach to lake association members, general public and town representatives. They hold monthly association meetings available to the public, where issues such as nutrient loading, responsible lakefront ownership, best management practices. LSIC openly discussions goals and objectives and prioritization of volunteer funding to manage Lake Shirley. The largest limitation to their ability to educate and manage the lake continues to be the lack of funding and ability to control inputs and watershed land use, as these areas are privately owned or controlled by the Town of Lunenburg and/or Town of Shirley.

In the past, the LSIC has partnered with the Town of Lunenburg on a Low Impact Development (LID) Project as part of a three-year grant to reduce sedimentation and nutrient loading to the lake and control in-lake nuisance vegetation. As a result, the Town adopted Massachusetts Department of Environmental Protection (MassDEP) requirements for an 80% removal of total suspended solids for new developments and implemented five LID demonstration projects around Lake Shirley. These LID projects included constructed wetlands, raingardens, vegetated buffer strips and sediment capture forebays. Details of these projects are described in the Section 319 Non Point Source Pollution Project Report available at https://www.lakeshirley.com/assets/2009-low-impact-development-project.pdf. LSIC continues to search out grant opportunities and partner with the two municipalities.

This past year was particularly difficult for everyone. With the Covid-19 pandemic, in-person gatherings were limited. Unfortunately, LSIC had to cancel all planned in-person fundraising and educational events. However, LSIC was able to accomplish the following:

- Updated the Lake Shirley website (https://www.lakeshirley.com/).
- Posted public educational best practices on lake friendly lawn maintenance “Green Grass and Clear Water”(https://www.lakeshirley.com/assets/2020-green-rrass-clear-water.pdf).
- Held monthly virtual association meetings via Zoom. The public is encouraged to attend. Lake management, watershed Best Management Practices, water quality, volunteer opportunities, etc. are recurring topics on the agenda.
- LSIC continues to utilize Facebook as well as the website to communicate with the public regarding best practices and notices of management activities, etc.
- Signage and posters notices were distributed around the lake notifying residents of the upcoming lake herbicide treatments. Individual notices were sent to residents in the Pearl Street Cove area for the new use of Clipper.
- Treatment notices were published in the Sentinel on 7/9/2020 and in the Lunenburg Ledger on 7/10/2020

Table 5. Lake Shirley Species Frequency over the Last Ten Years.

	Common Name	Genus species	Oct-15	May-16	Oct-16	Jul-17	Oct-17	Jul-18	Sep-18	Jun-19	Sep-19	Sep-20
Target Non-native Invasives	Eurasian milfoil	Myriophyllum spicatum										
	Variable milfoil	Myriophyllum heterophyllum	1									
	European Naiad	Najas minor	13		40	6		10	39		60	35
	Fanwort	Cabomba caroliniana	19	7	18	17	7	23	19	27	50	33
	Curlyleaf pondweed	Potamogeton crispus		11	2			3		7		
Target Native	Wild celery	Valisneria americana	38	20	52	21	32	22	30	30	50	42
Emergent Wetland	Arrow arum	Peltandra virginica										
	Arrowhead	Sagittaria latifolia										
	Bur-reed	Sparganium sp.										2
	Pickerel weed	Pontederia cordata										
	Spike rush	Eleocharis sp.	2		2							
	Wool grass	Scirpus cyperinus										
Macro Algae	Stonewort	Nitella sp.						13		4	3	1
	Musk grass	Chara sp.	12	3	1	7	11	14		2		
	Stonewort/Musk grass	Nitella/Chara sp							29			
	Filamentous green algae			23	5	3	6	6		7	16	8
Similar Bladderworts	Bladderwort	Utricularia sp.	10	1	6	10	22	18	16	34	50	27
	Eastern purple bladderwort	Utricularia purpurea										
	Little floating bladderwort	Utricularia radiata										
Free floating	Watermeal	Wolffia sp.										
	Giant duckweed	Spirodela polyrhiza										
	Duckweed	Lemna minor										
Similar floating leaves	Watershield	Bresenia schreberi							2			
	White waterlily	Nymphaea odorata	2	1	3	1		1		2	4	2
	Yellow waterlily	Nuphar variegatum	2			1		1		6	6	2
Similar naiad	Bushy pondweed	Najas flexilis	48	46	50	58	40	10	10	12	30	9
	Northern (Thread-like) naiad	Najas gracillima						3	20	10		7
Similar pondweeds	Clapsing pondweed	Potamogeton perfoliatus	4		8	2	3	2	7	8	12	12
	Richardson's pondweed	Potamogeton richardsonii										
Other Pondweeds	Grassy pondweed	Potamogeton gramineus										
	Flatstem pondweed	Potamogeton zosterformis						2	1		2	1
	Big leaf (Large leaf) pondweed	Potamogeton amplifolius										
	Floating (broad-leaf) pondweed	Potamogeton natans										
	Leafy pondweed	Potamogeton foliosus								26	1	6
	Thin-leaf (Small) pondweed	Potamogeton pusillus	9	1	2	4	1	11			17	1
	Ribbonleaf pondweed	Potamogeton epihydrus	1	3	1		1	3	2	2	1	
	Robbins' pondweed	Potamogeton robbinsii	1	1	2		1	1	1	1		2
	Sago pondweed	Potamogeton pectinatus		3	2	1						
	Coontail	Ceratophyllum demersum	1		1	3	1	2	3	4	5	1
	Waterweed	Elodea sp.								1	1	
	Hedge hyssop	Gratiola sp.										
	Quilwort	Isoetes sp.									1	
	Small waterwort	Elantine minima										
	Water marigold	Megalodonta beckii										
	Water purslane	Ludwigia palustris										
	Water starwort	Callitriche sp.						1				
	Bog moss	Musci sp.	1	2			6		3			

- LSIC and ARC reached out to the Town of Lunenburg to gauge whether the Town would again partner on a Section 319 nonpoint source competitive grant available through the MassDEP. The proposed project would be a pilot tributary alum treatment to reduce incoming phosphorus to the lake as recommended in the 2017 Lake Shirley Diagnostic Feasibility Study (available at https://www.lakeshirley.com/assets/2017-lake-diagnostic-study.pdf). The Town agreed to participate but upon further examination of the grant restrictions, it appeared that this project may not meet the grant requirements as it is within a Phase II Stormwater Municipal Separate Storm Sewer System (MS4) area. These areas are typically exempt from receiving this specific grant. We intend to discuss this project with MassDEP this winter to evaluate if this project would meets the criteria for Section 319 funding and potentially submit a proposal if applicable.

LAKE MANAGEMENT PROGRAM 2020-2021

LSIC continues to utilize a comprehensive approach focusing on management measures that they have physical control over and are within the limited funding level. For management year 2020-2021, LSIC will continue with the winter water level drawdown, herbicide treatments (including Clipper), algaecide treatment if warranted, volunteer-based water quality & water clarity monitoring, and contract for an independent evaluation of aquatic plants at the end of the growing season. LSIC will continue to provide educational and outreach materials, continue to stress the importance of boat inspections and plant removal prior to launch and following boat removal (at the campground, home owners and their guests) and continue discussions with the Town of Lunenburg and MassDEP regarding a possible Section 319 grant for a pilot alum tributary dosing project.

LSIC intends to implement the winter water level drawdown to a target depth of six feet during the winter of 2020-2021. The initiation of the drawdown in October was off to a good start as the starting water level was below the normal elevation due to the ongoing drought. Recent rains have raised the water level and the water level was about four feet below the normal level at the end of November.

SOLitude is expecting that herbicides will be required to control both nuisance native and non-native plant species. The lake is shallow with clear water and is expected to support lush growth with nutrient rich sediment. SOLitude has provided their recommendations in their annual report (Appendix B) which includes:

- an early season plant survey and herbicide treatment if curly-leaf pondweed density is extensive,
- mid-season survey and treatment targeted at extensive growth of wild celery, naiad and milfoil using Reward with the possible addition of a copper-based herbicide/algaecide (Nautique or Captain) for improved control of wild celery.
- Identify another location dominated by fanwort to use Clipper since it was successful at controlling fanwort in the test area,

SOLitude will provide ARC draft copies of the survey data and proposed treatment plans prior to submittal to the two Conservation Commissions. The intent of the ARC review is to discuss the preservation and encouragement of growth of two native species (coontail and Robbins pondweed) that have been less frequent in the lake over the years. SOLitude will adjust the treatment plan if needed based on those discussions. SOLitude will present all proposed treatments to the Conservation Commissions prior to implementation and proceed with treatments as prescribed in the Order of Conditions. No new herbicides or algaecides are proposed for the 2020-2021 management season.

Appendix A
Lake Shirley Phytoplankton
(Analyzed by Water Resource Services)

PHYTOPLANKTON DENSITY (CELLS/ML)

TAXON	Shirley 1 06/26/20	Shirley 2 06/26/20	Shirley 3 06/26/20	Shirley 1 07/31/20	Shirley 2 07/31/20	Shirley 3 07/31/20	Shirley 1 08/28/20	Shirley 2 08/28/20	Shirley 3 08/28/20	Shirley 1 09/28/20	Shirley 2 09/28/20	Shirley 3 09/28/20
BACILLARIOPHYTA												
Centric Diatoms												
Aulacoseira	0	0	0	0	0	0	52	27	121	0	0	0
Urosolenia	0	0	0	0	42	15	65	27	0	0	0	0
Araphid Pennate Diatoms												
Asterionella	0	0	0	0	0	0	26	0	0	0	0	0
Fragilaria/related taxa	202	0	0	270	0	0	52	0	0	73	0	0
Synedra	72	0	14	54	56	31	297	27	91	116	44	14
Tabellaria	58	162	173	108	250	108	593	1581	1510	0	0	28
Monoraphid Pennate Diatoms												
Biraphid Pennate Diatoms												
Eunotia	14	0	0	0	0	0	26	0	0	0	0	0
Gyrosigma	0	0	0	0	0	0	0	13	0	0	0	0
Navicula/related taxa	0	0	0	0	0	0	13	0	0	15	22	14
Nitzschia	0	0	0	0	0	0	0	0	0	15	0	0
CHLOROPHYTA												
Flagellated Chlorophytes												
Pandorina	0	0	0	0	0	0	0	161	0	0	0	0
Other Flagellated Greens	0	0	0	0	0	92	0	0	0	0	0	0
Coccoid/Colonial Chlorophytes												
Coelastrum	0	0	173	0	0	185	0	107	121	0	0	0
Crucigenia	0	0	0	0	56	0	103	107	121	116	262	0
Elakatothrix	29	41	58	108	83	62	26	54	45	0	0	0
Kirchneriella	0	0	0	0	0	62	103	0	0	0	0	0
Oocystis	691	864	115	108	56	62	0	0	60	0	87	28
Paulschulzia	0	0	0	54	0	0	0	0	0	0	0	0
Pediastrum	0	0	58	108	334	185	155	0	0	116	0	0
Quadrigula	29	0	0	54	0	0	52	27	30	0	0	0
Scenedesmus	230	54	58	378	56	62	52	107	60	116	44	56
Filamentous Chlorophytes												
Ulothrix	0	0	0	122	0	0	0	0	0	0	0	0
Desmids												
Closterium	0	0	0	0	0	0	26	0	0	29	0	28
Cosmarium	0	0	0	0	0	15	26	0	0	0	0	0
Staurastrum	14	27	14	14	83	46	26	40	30	29	0	0
Staurodesmus	0	14	0	0	0	0	0	0	0	0	0	0

CHRYSOPHYTA												
Flagellated Classic Chrysophytes												
Dinobryon	58	257	173	0	0	0	52	1434	1661	15	22	56
Kephyrion/Pseudokephyrion	0	0	0	0	0	0	0	0	0	0	0	0
Mallomonas	14	0	0	0	0	15	13	13	15	15	22	14
Non-Motile Classic Chrysophytes												
Haptophytes												
Tribophytes/Eustigmatophytes												
Raphidophytes												
CRYPTOPHYTA												
Cryptomonas	0	0	14	41	14	15	0	0	0	0	65	28
CYANOPHYTA												
Unicellular and Colonial Forms												
Aphanocapsa	0	0	0	0	0	0	1290	0	0	0	0	0
Microcystis	0	0	0	0	0	0	0	0	1208	7250	8720	5560
Filamentous Nitrogen Fixers												
Aphanizomenon	432	0	0	2565	1390	0	1806	0	0	0	0	0
Dolichospermum	0	0	0	0	0	0	4644	536	2416	6525	872	0
Filamentous Non-Nitrogen Fixers												
EUGLENOPHYTA												
Euglena	14	0	14	14	70	15	0	0	0	0	0	0
Phacus	0	0	0	0	14	0	0	13	0	0	0	0
Trachelomonas	0	14	0	14	28	31	13	27	15	0	0	0
PYRRHOPHYTA												
Ceratium	14	14	0	0	0	0	0	0	0	15	0	0
Peridinium	0	0	0	0	0	15	0	0	0	0	0	0
DENSITY (CELLS/ML) SUMMARY												
BACILLARIOPHYTA	**345.6**	**162**	**187.2**	**432**	**347.5**	**154**	**1122.3**	**1675**	**1721.4**	**217.5**	**65.4**	**55.6**
Centric Diatoms	0	0	0	0	41.7	15.4	116.1	53.6	120.8	0	0	0
Araphid Pennate Diatoms	331.2	162	187.2	432	305.8	138.6	967.5	1608	1600.6	188.5	43.6	41.7
Monoraphid Pennate Diatoms	0	0	0	0	0	0	0	0	0	0	0	0
Biraphid Pennate Diatoms	14.4	0	0	0	0	0	38.7	13.4	0	29	21.8	13.9
CHLOROPHYTA	**993.6**	**999**	**475.2**	**945**	**667.2**	**770**	**567.6**	**603**	**468.1**	**406**	**392.4**	**111.2**
Flagellated Chlorophytes	0	0	0	0	0	92.4	0	160.8	0	0	0	0
Coccoid/Colonial Chlorophytes	979.2	958.5	460.8	810	583.8	616	490.2	402	437.9	348	392.4	83.4
Filamentous Chlorophytes	0	0	0	121.5	0	0	0	0	0	0	0	0
Desmids	14.4	40.5	14.4	13.5	83.4	61.6	77.4	40.2	30.2	58	0	27.8
CHRYSOPHYTA	**72**	**256.5**	**172.8**	**0**	**0**	**15.4**	**64.5**	**1447.2**	**1676.1**	**29**	**43.6**	**69.5**

Flagellated Classic Chrysophytes	72	256.5	172.8	0	0	15.4	64.5	1447.2	1676.1	29	43.6	69.5
Non-Motile Classic Chrysophytes	0	0	0	0	0	0	0	0	0	0	0	0
Haptophytes	0	0	0	0	0	0	0	0	0	0	0	0
Tribophytes/Eustigmatophytes	0	0	0	0	0	0	0	0	0	0	0	0
Raphidophytes	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOPHYTA	**0**	**0**	**14.4**	**40.5**	**13.9**	**15.4**	**0**	**0**	**0**	**0**	**65.4**	**27.8**
CYANOPHYTA	**432**	**0**	**0**	**2565**	**1390**	**0**	**7740**	**536**	**3624**	**13775**	**9592**	**5560**
Unicellular and Colonial Forms	0	0	0	0	0	0	1290	0	1208	7250	8720	5560
Filamentous Nitrogen Fixers	432	0	0	2565	1390	0	6450	536	2416	6525	872	0
Filamentous Non-Nitrogen Fixers	0	0	0	0	0	0	0	0	0	0	0	0
EUGLENOPHYTA	**14.4**	**13.5**	**14.4**	**27**	**111.2**	**46.2**	**12.9**	**40.2**	**15.1**	**0**	**0**	**0**
PYRRHOPHYTA	**14.4**	**13.5**	**0**	**0**	**0**	**15.4**	**0**	**0**	**0**	**14.5**	**0**	**0**
TOTAL	**1872**	**1444.5**	**864**	**4009.5**	**2529.8**	**1016.4**	**9507.3**	**4301.4**	**7504.7**	**14442**	**10158.8**	**5824.1**
CELL DIVERSITY	**0.81**	**0.56**	**0.89**	**0.64**	**0.72**	**1.08**	**0.73**	**0.74**	**0.76**	**0.41**	**0.26**	**0.12**
CELL EVENNESS	**0.70**	**0.59**	**0.85**	**0.54**	**0.63**	**0.88**	**0.54**	**0.60**	**0.64**	**0.36**	**0.26**	**0.12**
NUMBER OF TAXA												
BACILLARIOPHYTA	**4**	**1**	**2**	**3**	**3**	**3**	**8**	**5**	**3**	**4**	**2**	**3**
Centric Diatoms	0	0	0	0	1	1	2	2	1	0	0	0
Araphid Pennate Diatoms	3	1	2	3	2	2	4	2	2	2	1	2
Monoraphid Pennate Diatoms	0	0	0	0	0	0	0	0	0	0	0	0
Biraphid Pennate Diatoms	1	0	0	0	0	0	2	1	0	2	1	1
CHLOROPHYTA	**5**	**5**	**6**	**8**	**6**	**9**	**9**	**7**	**7**	**5**	**3**	**3**
Flagellated Chlorophytes	0	0	0	0	0	1	0	1	0	0	0	0
Coccoid/Colonial Chlorophytes	4	3	5	6	5	6	6	5	6	3	3	2
Filamentous Chlorophytes	0	0	0	1	0	0	0	0	0	0	0	0
Desmids	1	2	1	1	1	2	3	1	1	2	0	1
CHRYSOPHYTA	**2**	**1**	**1**	**0**	**0**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Flagellated Classic Chrysophytes	2	1	1	0	0	1	2	2	2	2	2	2
Non-Motile Classic Chrysophytes	0	0	0	0	0	0	0	0	0	0	0	0
Haptophytes	0	0	0	0	0	0	0	0	0	0	0	0
Tribophytes/Eustigmatophytes	0	0	0	0	0	0	0	0	0	0	0	0
Raphidophytes	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOPHYTA	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**
CYANOPHYTA	**1**	**0**	**0**	**1**	**1**	**0**	**3**	**1**	**2**	**2**	**2**	**1**
Unicellular and Colonial Forms	0	0	0	0	0	0	1	0	1	1	1	1
Filamentous Nitrogen Fixers	1	0	0	1	1	0	2	1	1	1	1	0
Filamentous Non-Nitrogen Fixers	0	0	0	0	0	0	0	0	0	0	0	0
EUGLENOPHYTA	**1**	**1**	**1**	**2**	**3**	**2**	**1**	**2**	**1**	**0**	**0**	**0**
PYRRHOPHYTA	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**
TOTAL	**14**	**9**	**11**	**15**	**14**	**17**	**23**	**17**	**15**	**14**	**10**	**10**

PHYTOPLANKTON BIOMASS (UG/L)

TAXON	Shirley 1 06/26/20	Shirley 2 06/26/20	Shirley 3 06/26/20	Shirley 1 07/31/20	Shirley 2 07/31/20	Shirley 3 07/31/20	Shirley 1 08/28/20	Shirley 2 08/28/20	Shirley 3 08/28/20	Shirley 1 09/28/20	Shirley 2 09/28/20	Shirley 3 09/28/20
BACILLARIOPHYTA												
Centric Diatoms												
Aulacoseira	0.0	0.0	0.0	0.0	0.0	0.0	15.5	8.0	36.2	0.0	0.0	0.0
Urosolenia	0.0	0.0	0.0	0.0	50.0	18.5	77.4	32.2	0.0	0.0	0.0	0.0
Araphid Pennate Diatoms												
Asterionella	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0
Fragilaria/related taxa	60.5	0.0	0.0	81.0	0.0	0.0	15.5	0.0	0.0	21.8	0.0	0.0
Synedra	57.6	0.0	11.5	43.2	44.5	24.6	237.4	21.4	72.5	92.8	34.9	11.1
Tabellaria	46.1	129.6	138.2	86.4	200.2	86.2	474.7	1265.0	1208.0	0.0	0.0	22.2
Monoraphid Pennate Diatoms												
Biraphid Pennate Diatoms												
Eunotia	14.4	0.0	0.0	0.0	0.0	0.0	25.8	0.0	0.0	0.0	0.0	0.0
Gyrosigma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.9	0.0	0.0	0.0	0.0
Navicula/related taxa	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	7.3	10.9	7.0
Nitzschia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	0.0	0.0
CHLOROPHYTA												
Flagellated Chlorophytes												
Pandorina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.1	0.0	0.0	0.0	0.0
Other Flagellated Greens	0.0	0.0	0.0	0.0	0.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes												
Coelastrum	0.0	0.0	34.6	0.0	0.0	37.0	0.0	21.4	24.2	0.0	0.0	0.0
Crucigenia	0.0	0.0	0.0	0.0	5.6	0.0	10.3	10.7	12.1	11.6	26.2	0.0
Elakatothrix	2.9	4.1	5.8	10.8	8.3	6.2	2.6	5.4	4.5	0.0	0.0	0.0
Kirchneriella	0.0	0.0	0.0	0.0	0.0	6.2	10.3	0.0	0.0	0.0	0.0	0.0
Oocystis	276.5	345.6	46.1	43.2	22.2	24.6	0.0	0.0	24.2	0.0	34.9	11.1
Paulschulzia	0.0	0.0	0.0	21.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pediastrum	0.0	0.0	11.5	21.6	66.7	37.0	31.0	0.0	0.0	23.2	0.0	0.0
Quadrigula	5.8	0.0	0.0	10.8	0.0	0.0	10.3	5.4	6.0	0.0	0.0	0.0
Scenedesmus	23.0	5.4	5.8	37.8	5.6	6.2	5.2	10.7	6.0	11.6	4.4	5.6
Filamentous Chlorophytes												
Ulothrix	0.0	0.0	0.0	24.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Desmids												
Closterium	0.0	0.0	0.0	0.0	0.0	0.0	103.2	0.0	0.0	116.0	0.0	111.2
Cosmarium	0.0	0.0	0.0	0.0	0.0	12.3	20.6	0.0	0.0	0.0	0.0	0.0
Staurastrum	11.5	21.6	11.5	10.8	66.7	37.0	20.6	32.2	24.2	23.2	0.0	0.0
Staurodesmus	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CHRYSOPHYTA												
Flagellated Classic Chrysophytes												
Dinobryon	172.8	769.5	518.4	0.0	0.0	0.0	154.8	4301.4	4983.0	43.5	65.4	166.8
Kephyrion/Pseudokephyrion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mallomonas	7.2	0.0	0.0	0.0	0.0	7.7	6.5	6.7	7.6	7.3	10.9	7.0
Non-Motile Classic Chrysophytes												
Haptophytes												
Tribophytes/Eustigmatophytes												
Raphidophytes												
CRYPTOPHYTA												
Cryptomonas	0.0	0.0	2.9	8.1	2.8	3.1	0.0	0.0	0.0	0.0	13.1	5.6
CYANOPHYTA												
Unicellular and Colonial Forms												
Aphanocapsa	0.0	0.0	0.0	0.0	0.0	0.0	12.9	0.0	0.0	0.0	0.0	0.0
Microcystis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.1	72.5	87.2	55.6
Filamentous Nitrogen Fixers												
Aphanizomenon	56.2	0.0	0.0	333.5	180.7	0.0	234.8	0.0	0.0	0.0	0.0	0.0
Dolichospermum	0.0	0.0	0.0	0.0	0.0	0.0	928.8	107.2	483.2	1305.0	174.4	0.0
Filamentous Non-Nitrogen Fixers												
EUGLENOPHYTA												
Euglena	7.2	0.0	7.2	6.8	34.8	7.7	0.0	0.0	0.0	0.0	0.0	0.0
Phacus	0.0	0.0	0.0	0.0	4.2	0.0	0.0	4.0	0.0	0.0	0.0	0.0
Trachelomonas	0.0	13.5	0.0	13.5	87.6	30.8	12.9	26.8	15.1	0.0	0.0	0.0
PYRRHOPHYTA												
Ceratium	250.6	234.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	252.3	0.0	0.0
Peridinium	0.0	0.0	0.0	0.0	0.0	32.3	0.0	0.0	0.0	0.0	0.0	0.0
DENSITY (UG/ML) SUMMARY												
BACILLARIOPHYTA	**178.6**	**129.6**	**149.8**	**210.6**	**294.7**	**129.4**	**857.9**	**1369.5**	**1316.7**	**133.4**	**45.8**	**40.3**
Centric Diatoms	0.0	0.0	0.0	0.0	50.0	18.5	92.9	40.2	36.2	0.0	0.0	0.0
Araphid Pennate Diatoms	164.2	129.6	149.8	210.6	244.6	110.9	732.7	1286.4	1280.5	114.6	34.9	33.4
Monoraphid Pennate Diatoms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biraphid Pennate Diatoms	14.4	0.0	0.0	0.0	0.0	0.0	32.3	42.9	0.0	18.9	10.9	7.0
CHLOROPHYTA	**319.7**	**384.8**	**115.2**	**180.9**	**175.1**	**175.6**	**214.1**	**101.8**	**101.2**	**185.6**	**65.4**	**127.9**
Flagellated Chlorophytes	0.0	0.0	0.0	0.0	0.0	9.2	0.0	16.1	0.0	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	308.2	355.1	103.7	145.8	108.4	117.0	69.7	53.6	77.0	46.4	65.4	16.7
Filamentous Chlorophytes	0.0	0.0	0.0	24.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Desmids	11.5	29.7	11.5	10.8	66.7	49.3	144.5	32.2	24.2	139.2	0.0	111.2
CHRYSOPHYTA	**180.0**	**769.5**	**518.4**	**0.0**	**0.0**	**7.7**	**161.3**	**4308.1**	**4990.6**	**50.8**	**76.3**	**173.8**

Flagellated Classic Chrysophytes	180.0	769.5	518.4	0.0	0.0	7.7	161.3	4308.1	4990.6	50.8	76.3	173.8
Non-Motile Classic Chrysophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raphidophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	**0.0**	**0.0**	**2.9**	**8.1**	**2.8**	**3.1**	**0.0**	**0.0**	**0.0**	**0.0**	**13.1**	**5.6**
CYANOPHYTA	**56.2**	**0.0**	**0.0**	**333.5**	**180.7**	**0.0**	**1176.5**	**107.2**	**495.3**	**1377.5**	**261.6**	**55.6**
Unicellular and Colonial Forms	0.0	0.0	0.0	0.0	0.0	0.0	12.9	0.0	12.1	72.5	87.2	55.6
Filamentous Nitrogen Fixers	56.2	0.0	0.0	333.5	180.7	0.0	1163.6	107.2	483.2	1305.0	174.4	0.0
Filamentous Non-Nitrogen Fixers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA	**7.2**	**13.5**	**7.2**	**20.3**	**126.5**	**38.5**	**12.9**	**30.8**	**15.1**	**0.0**	**0.0**	**0.0**
PYRRHOPHYTA	**250.6**	**234.9**	**0.0**	**0.0**	**0.0**	**32.3**	**0.0**	**0.0**	**0.0**	**252.3**	**0.0**	**0.0**
TOTAL	**992.2**	**1532.3**	**793.4**	**753.3**	**779.8**	**386.5**	**2422.6**	**5917.4**	**6918.8**	**1999.6**	**462.2**	**403.1**
BIOMASS DIVERSITY	**0.85**	**0.58**	**0.52**	**0.86**	**0.91**	**1.09**	**0.87**	**0.38**	**0.40**	**0.58**	**0.80**	**0.70**
BIOMASS EVENNESS	**0.75**	**0.61**	**0.50**	**0.73**	**0.80**	**0.88**	**0.64**	**0.31**	**0.34**	**0.51**	**0.80**	**0.70**

	1	2	3	1	2	3	1	2	3	1	2	3
DENSITY (UG/ML) SUMMARY	6/26/20	6/26/20	6/26/20	7/31/20	7/31/20	7/31/20	8/28/20	8/28/20	8/28/20	9/28/20	9/28/20	9/28/20
BACILLARIOPHYTA	179	130	150	211	295	129	858	1369	1317	133	46	40
CHLOROPHYTA	320	385	115	181	175	176	214	102	101	186	65	128
CHRYSOPHYTA	180	770	518	0	0	8	161	4308	4991	51	76	174
CRYPTOPHYTA	0	0	3	8	3	3	0	0	0	0	13	6
CYANOPHYTA	56	0	0	333	181	0	1176	107	495	1378	262	56
EUGLENOPHYTA	7	14	7	20	126	39	13	31	15	0	0	0
PYRRHOPHYTA	251	235	0	0	0	32	0	0	0	252	0	0

Appendix B
Lake Shirley Herbicide/Algaecide
Pre-Treatment Plan and Post Treatment Report
(Prepared by SOLitude Lake Management)

590 Lake Street
Shrewsbury, MA 010545

Phone: (508) 865-1000
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Date: December 13, 2020

To: Lunenburg Conservation Commission
Shirley Conservation Commission

From: Dominic Meringolo, Senior Environmental Engineer/Project Manager

Re: Lake Shirley – Survey and Treatment Plan

Dear Commissioners,

Based on surveys conducted by our Biologists on June 5th & June 22nd, we are recommending treatment to approximately 65-acres of Lake Shirley to manage nuisance weed growth. Several seed producing pondweed species, that had either not been seen or seen to this level of abundance in many years, have appeared this summer, mostly along the shallower margins of the lake. These species are variable (or grassy) pondweed (*Potamogeton gramineus*), leafy pondweed (*Potamogeton foliosus*), clasping leaf pondweed (*Potamogeton perfoliatus*) and snailseed pondweed (*Potamogeton bicupulatus*). Other target species include non-native curlyleaf pondweed (*Potamogeton crispus*) and tapegrass (*Vallisneria americana*).

Per the Lake Management Plan, areas of the lake that exhibit either density or biomass factors of 3 or greater (>50%) are candidates for management. Additionally, any growth of non-native species, in this case curlyleaf pondweed (*Potamogeton crispus*) can also be treated. Because many areas of abundant pondweed were not captured with the data points, additional GPS points were collected in those areas of nuisance growth. Some candidate areas were not designated for treatment due to their proximity to undeveloped shorelines and/or the presence of non-nuisance species (ex. Stonewort/Chara) or unmanaged species such as fanwort (*Cabomba caroliniana*). Additionally, treatment areas were scaled back or eliminated in the areas of Points 4, 5, 22 and 44 due to the presence of coontail (*Ceratophyllum demersum*) and Robbins Pondweed (*Potamogeton robbinsii*), both of which are plants that we would like to see expand in the lake based on recent management discussions.

The LSIC wishes to conduct a pilot treatment with Clipper (flumioxazin) herbicide in the Pearl Street cove (marked in yellow on the map) to investigate managing non-native fanwort in the lake. The designated cove is approximately 2-acres and will be treated with 100 ppb of flumioxazin and a low dose of diquat. In the other areas, Reward (diquat) herbicide will be used for treatment at a rate of 1.0-1.5 gallons per acre and a copper-based product, either Nautique or copper sulfate will also be applied in areas dominated by tapegrass.

Treatment is tentatively scheduled for July 16th.

A map of the recommended treatment areas is attached as well as the June survey data table. On the map of the proposed treatment areas, the data points that meet management criteria are included as well as the additional GPS point collected in areas of nuisance growth. The LSIC will be attending upcoming meetings of the Conservation Commissions to discuss this plan and answer any questions.

Regards,
SOLitude Lake Management

Dominic Meringolo
Senior Environmental Engineer/Regional Leader

Lake Shirley
Lunenburg/Shirley, Massachusetts
2020 Year-End Treatment Report

November 16, 2020

Report Prepared by: SOLitude Lake Management
590 Lake Street
Shrewsbury, MA 01524

Report Prepared for: Ms. Joanna Bilotta, President
Lake Shirley Improvement Corporation (LSIC)
PO Box 567
Shirley, MA 01464
jobilotta@comcast.net

Dear Joanna:

In accordance with the aquatic plant management contract between SŌLitude Lake Management (SOLitude) and the Lake Shirley Improvement Corporation (LSIC) for Lake Shirley, the following document serves to provide this year's treatment and survey results, as well as management recommendations for next season. The continued objective of the program is to manage non-native and nuisance aquatic vegetation as well as potentially harmful cyanobacteria (blue-green algae) blooms. Multiple monitoring events, herbicide/algaecide treatments and reporting are key tasks of the project.

All management activities were consistent with the Order of Conditions [DEP File #284-0474 (Shirley), DEP File #208-1168 (Lunenburg)] and the License to Apply Chemicals issued by MA DEP (#WM04-0000198).

A chronology of the 2020 program's primary milestone activities is as follows:

- Issuance of License to Apply Chemicals permit from MA DEP ..... May 18th
- Pre-treatment inspection ..... June 5th & June 22nd
- Reward (diquat)/Nautique (copper) herbicide treatment ..... July 16th
- Post-Treatment Inspection ..... August 19th

Pre-Treatment Survey

This year's initial pre-treatment survey was conducted on June 5th. The survey was conducted according to the expanded methodology used in recent years, which is a combination of SLM's historical qualitative assessment and Geosyntec's more quantitative procedures. In addition to recording data on the general plant assemblage, point data was collected at 66 data points throughout the lake. At each point, data was collected on the species

composition (species present), plant growth density and plant biomass. These are the same locations and point #'s used by Geosyntec in past reports. The pre-treatment survey serves to assess the growth of all invasive species [fanwort (*Cabomba caroliniana*), curly-leaf pondweed (Potamogeton crispus), Eurasian milfoil (*Myriophyllum spicatum*) and variable milfoil (*Myriophyllum heterophyllum*)] as well as identify any nuisance growth of native plant species.

Several seed producing pondweed species, that had either not been seen or seen to this level of abundance in many years, were observed during the survey in high abundance, mostly along the shallower margins of the lake. These species are variable (or grassy) pondweed (*Potamogeton gramineus*), leafy pondweed (*Potamogeton foliosus*), clasping leaf pondweed (*Potamogeton perfoliatus*) and snailseed pondweed (*Potamogeton bicupulatus*). Other target species include non-native curlyleaf pondweed (*Potamogeton crispus*) and tapegrass (*Vallisneria americana*). No milfoils were observed but fanwort was present in many areas of the lake.

Per the Lake Management Plan, areas of the lake that exhibit either density or biomass factors of 3 or greater (>50%) are candidates for management. Additionally, any growth of non-native species, in this case curlyleaf pondweed and fanwort can also be treated. Because many areas of abundant pondweed were not captured with the data point survey, additional GPS points were collected in those areas of nuisance growth on June 22nd. Some candidate areas were not designated for treatment due to their proximity to undeveloped shorelines and/or the presence of non-nuisance species (ex. Stonewort/Chara) or unmanaged species such as fanwort (*Cabomba caroliniana*).

Due to the presence of non-native curlyleaf pondweed and nuisance growth of native plants, approximately 68 acres were designated for treatment. The pre-treatment report, which includes plant survey data and the proposed treatment map (**Figure 1**), is **attached**. The Commission approved this treatment at their June 23rd meeting with some slight revisions to exclude areas of native plant growth which reduced the treatment area to 65-acres. Additionally, based on discussion at the meeting, the 2.5-acre Pearl Street Cove was selected for a pilot treatment of fanwort with Clipper (flumioxazin) herbicide.

Herbicide Treatment

The herbicide treatment was conducted on July 16th, for target species as specified in the pre-treatment report. Treatment was conducted with Reward (diquat), Nautique (copper) and Clipper (flumioxazin) herbicides. All proposed areas, as adjusted during the meeting were treated.

As with all treatments, the lake community and the two towns were notified prior to treatment by LSIC. Several means of notification were utilized: placement of a written notice in the newspaper(s); placement of large, printed signs at major road intersections/locations around the lake and posting of numerous 8.5 inch by 11-inch orange colored, printed signs around the lake shoreline and other means of communication/notification.

The treatment was performed with a 20-foot airboat equipped with tank, pump, and sub-surface injection system. By injecting the diluted herbicide sub-surface, it eliminates the potential for aerial drift. GPS guidance was used to monitor the position of the boat and its relation to the treatment areas. The treatment proceeded smoothly and without difficulty, **Figure 2** shows the GPS recorded treatment tracks. A summary of the treatment specifications is as follows.

Table 1 – Herbicide Treatment Specifications

Treatment Date	July 16th
Product	Reward (diquat) & Nautique (copper) & Clipper (flumioxazin)
Treatment Area	65 acres

Quantity	93 gallons – Reward 22.5 gallons – Nautique 5 pounds – Clipper
GPS Tracks	See Figure 2
Applicator name	Dominic Meringolo, MA Certification #24004
Site Conditions	Weather: Partly to Mostly Cloudy, light winds 8-10 MPH SE, 72^{o}F Water Temp: 25.4^{o}C at surface, 23.9^{o}C near bottom Dissolved Oxygen: 8.1 mg/l at surface; 4.5 mg/l near bottom (9-feet) Water clarity: 6'9"

Post Treatment Inspection

A post-treatment inspection was conducted on August 19th to evaluate the efficacy of the herbicide treatment. Overall, the treatment worked well on the targeted species, especially the pondweeds and the fanwort in the Pearl Street Cove. Tapegrass biomass was also reduced in the treatment areas. As required in the new Order of Conditions, the final data point survey was completed by Aquatic Restoration Consulting LLC under separate contract with the LSIC.

Anticipated Management in 2021

Based on the results of the 2020 management program, we anticipate seeing continued, minimal growth of watermilfoil this coming summer, however there is a chance that curly-leaf pondweed will be present in significant proportions early in the season as well as fanwort a short time after. Native growth, primarily tapegrass and naiad will also likely require management later in the season. We will continue to proceed and determine treatment needs based on the established criteria. While we continue to recommend planning for a two-treatment approach, herbicide applications can be combined, as has been the case in recent years, depending on observed growth and availability of funding. The proposed plan for 2021 is as follows

Table 2 – Proposed Plan for 2021

Task	Schedule	Notes/Criteria
Early Season Survey	Mid/late April	Survey for early emerging plants, primarily curlyleaf pondweed but also milfoil. Survey will be conducted at established survey points but will not include full collection of data.
1st Treatment	Early/Mid May	Treat all areas of the lake with curlyleaf pondweed and milfoil
Mid-Season Survey	Late June/Early July	Full data point survey
2nd Treatment	Mid-Late July	Treat any additional areas of non-native growth, plus selected areas of problematic native plant growth based on density/biomass criteria.
Late Season Survey	Late September/early October	Full data point survey

Reward (diquat) herbicide alone will provide good control of milfoil, curly-leaf pondweed and naiad. Tapegrass is sometimes more difficult to control and, if needed, a combination of Reward and a copper-based herbicide (Nautique) or algaecide (Captain/copper sulfate) should be used to increase effectiveness and produce more desirable results.

Given the success of the pilot fanwort treatment in the Pearl Street Cove, we recommend identifying other areas of the lake that could benefit from this type of treatment. The on-going issue with the use of Clipper is that under current regulations, the same areas of the lake can only be treated once every 4 years unless it's in the immediate vicinity of a high-use area such as a beach or boat launch. While it is possible this condition may be lifted in the future, for it will be necessary to either rotate the areas treated with Clipper or treat subsections of larger areas of fanwort over the course of multiple years.

Monitoring of water clarity and algal populations (as necessary) provides timely information to guide algaecide treatments should such treatments be warranted. It continues to be of paramount importance to ensure that the water clarity monitoring is conducted on a regular basis (weekly or bi-weekly depending on general observation) from May-October and that results are provided to SOlitude and other project partners so that algaecide treatments are scheduled in a timely manner. Should treatment of the algae be required in 2021, copper sulfate is again proposed for use.

We recommend LSIC continue to pursue an integrated approach to manage nuisance plants and algae utilizing drawdown and herbicide/algaecide as required. To address overall lake management and long-term goals, the LSIC should continue the investigation and implementation of alternative in-lake methods, watershed management, public education and diagnostic assessments.

We hope this report will be of help to LSIC in planning for 2021 and beyond. If you have any questions regarding this report, please feel free to contact me. We look forward to working you again in the year ahead.

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Shrewsbury, MA 010545

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Date: November 16, 2020

To: Lunenburg Conservation Commission

Shirley Conservation Commission

From: Dominic Meringolo, Senior Environmental Engineer/Project Manager

Re: Lake Shirley – Survey and Treatment Plan

Dear Commissioners,

Based on surveys conducted by our Biologists on June 5th & June 22nd, we are recommending treatment to approximately 68-acres of Lake Shirley to manage nuisance weed growth. Several seed producing pondweed species, that had either not been seen or seen to this level of abundance in many years, have appeared this summer, mostly along the shallower margins of the lake. These species are variable (or grassy) pondweed (*Potamogeton gramineus*), leafy pondweed (*Potamogeton foliosus*), clasping leaf pondweed (*Potamogeton perfoliatus*) and snailseed pondweed (*Potamogeton bicupulatus*). Other target species include non-native curlyleaf pondweed (*Potamogeton crispus*) and tapegrass (*Vallisneria americana*).

Per the Lake Management Plan, areas of the lake that exhibit either density or biomass factors of 3 or greater (>50%) are candidates for management. Additionally, any growth of non-native species, in this case curlyleaf pondweed (*Potamogeton crispus*) can also be treated. Because many areas of abundant pondweed were not captured with the data point, additional GPS points were collected in those areas of nuisance growth. Some candidate areas were not designated for treatment due to their proximity to undeveloped shorelines and/or the presence of non-nuisance species (ex. Stonewort/Chara) or unmanaged species such as fanwort (*Cabomba caroliniana*).

Treatment is tentatively scheduled for July 16th. The Reward (diquat) herbicide will be used for this treatment at a rate of 1.0-1.5 gallons per acre and a copper-based product, either Nautique or copper sulfate will also be applied in areas dominated by tapegrass.

A map of the recommended treatment areas is attached as well as the June survey data table. On the map of the proposed treatment areas, the data point that meet management criteria are included as well as the additional GPS point collected in areas of nuisance growth. The LSIC will be attending upcoming meetings of the Conservation Commissions to discuss this plan and answer any questions.

Regards,
SOLitude Lake Management

Dominic Meringolo
Senior Environmental Engineer/Regional Leader

Table 1: Aquatic Vegetation Survey Results

Date: June 22, 2020 X= Present D = Dominant

Plant Species: Common Name	Scientific Name	# stations present	# stations dominant	% stations present	% stations dominant
Fanwort	*Cabomba caroliniana*	34	17	52%	26%
Waterweed	*Elodea canadensis*	0	0	0%	0%
Wild Celery	*Valisneria americana*	52	19	79%	29%
Bladderwort	*Utricularia Sp.*	39	6	59%	9%
Musk Grass	*Chara sp.*	0	0	0%	0%
Stonewort	*Nitella sp.*	8	3	12%	5%
Snailseed Pondweed	*Potamogeton bicupulatus*	13	5	20%	8%
Slender Naiad	*Najas flexillis*	10	0	15%	0%
Variable Leaf Pondweed	*Potamogeton gramineus*	3	1	5%	2%
Filamentous Algae	*Various*	6	2	9%	3%
Northern Naiad	*Najas gracilima*	0	0	0%	0%
Curlyleaf Pondweed	*Potamogeton crispus*	8	0	12%	0%
Ribbon-leaf Pondweed	*Potamogeton epihydrus*	1	0	2%	0%
Clasping-leaf Pondweed	*Potamogeton perfoliatus*	19	7	29%	11%
Leafy Pondweed	*Potamogeton foliosus*	14	4	21%	6%
Coontail	*Ceratophyllum demersum*	3	0	5%	0%
Flatstem Pondweed	*Potamogeton zosteriformis*	1	1	2%	2%
Yellow Waterlily	*Nuphar variegata*	1	0	2%	0%
White Waterlily	*Nymphaea odorata*	2	0	3%	0%
Aquatic Moss	*Fontinalus sp.*	3	0	5%	0%
Robbin's Pondweed	*Potamogeton robbinsii*	1	0	2%	0%

Monitoring Locations

Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Fanwort	D	D	X	X	D	D		X	X	D	D	D	D	X		X					X	D
Waterweed																						
Wild Celery	X	X	D	X	X	X	D		D	X	X	X	X		X	X	X			D	X	X
Bladderwort	X	X	X	D	X	X	X	X	X	X	X			X			X				D	X
Musk Grass																						
Stonewort																						
Snailseed Pondweed										X					X							
Slender Naiad				X											X						X	
Variable Leaf Pondweed																						
Filamentous Algae																						
Northern Naiad																						
Curlyleaf Pondweed																						
Ribbon-leaf Pondweed																						
Clasping-leaf Pondweed							X					X		D	D	D	D					X
Leafy Pondweed		X						D						X			X					X
Coontail				X	X																	
Flatstem Pondweed																		D				
Yellow Waterlily																						
White Waterlily																						
Aquatic Moss																						
Robbin's Pondweed																						X
Species Richness	3	4	3	5	4	3	3	3	3	4	3	3	2	4	4	3	4	1	0	1	4	6
Plant density Index	3	3	3	2	4	4	3	3	2	3	3	3	3	3	3	2	3	4	0	1	2	3
Plant biomass index	3	3	3	2	2	2	2	2	2	3	2	4	3	4	4	3	4	3	0	2	2	3

Common Name	23	24	24a	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Fanwort	X	X	X		D		X		X	X					D	D						X	D
Waterweed																							
Wild Celery	X			X	X	D	X	X	D	D	D	X	D	D	X	X	D		X		X	X	X
Bladderwort	D	D	D	X	X	X	X	X	X	X	X			X	X							X	
Musk Grass																							
Stonewort																							
Snailseed Pondweed								D		X		D			X	X						D	
Slender Naiad	X		X																				
Variable Leaf Pondweed				X			D					X											
Filamentous Algae															X	X			X				
Northern Naiad																							
Curlyleaf Pondweed								X			X				X	X	X						X
Ribbon-leaf Pondweed																							X
Clasping-leaf Pondweed				D			X					X						D	D		X	X	
Leafy Pondweed								X			X			X						D	D		
Coontail																							X
Flatstem Pondweed																							
Yellow Waterlily										X													
White Waterlily																						X	
Aquatic Moss																							
Robbin's Pondweed																							
Species Richness	4	2	3	4	3	2	5	5	3	5	4	4	1	3	6	5	2	1	3	1	3	6	5
Plant density Index	3	1	2	3	2	1	3	3	3	4	3	3	3	2	3	4	3	2	4	3	4	4	4
Plant biomass index	2	2	2	4	2	2	4	3	3	3	3	4	3	2	3	3	4	3	3	3	3	4	4

Common Name	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	62a	63	64
Fanwort	D		X	D					D	D	X						X				
Waterweed																					
Wild Celery	X	D	D		D	X	X	D	X	X	X	D	X	D		D					D
Bladderwort	X				X	X		X	X	X	X		D	X							X
Musk Grass																					
Stonewort					X		X								D	X	D		D	X	X
Snailseed Pondweed		X	X			D	D			X											
Slender Naiad				X	X			X					X							X	
Variable Leaf Pondweed																					
Filamentous Algae																		D	X	D	
Northern Naiad																					
Curlyleaf Pondweed				X						X											
Ribbon-leaf Pondweed																					
Clasping-leaf Pondweed		X	X							X			X	X							
Leafy Pondweed		X	X				X				D										
Coontail																					
Flatstem Pondweed																					
Yellow Waterlily																					
White Waterlily										X											
Aquatic Moss			X		X	X															
Robbin's Pondweed																					
Species Richness	3	4	6	3	5	4	4	3	3	7	4	1	4	3	1	2	2	1	2	3	3
Plant density Index	4	4	4	2	3	3	4	2	3	4	3	1	3	2	1	2	2	3	2	2	2
Plant biomass index	3	4	4	2	2	3	3	2	2	4	2	2	4	3	1	2	2	1	1	1	2

***Non-native, invasive species**

Proposed Treatment Areas (July 2020)

SOLITUDE
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888.480.5253
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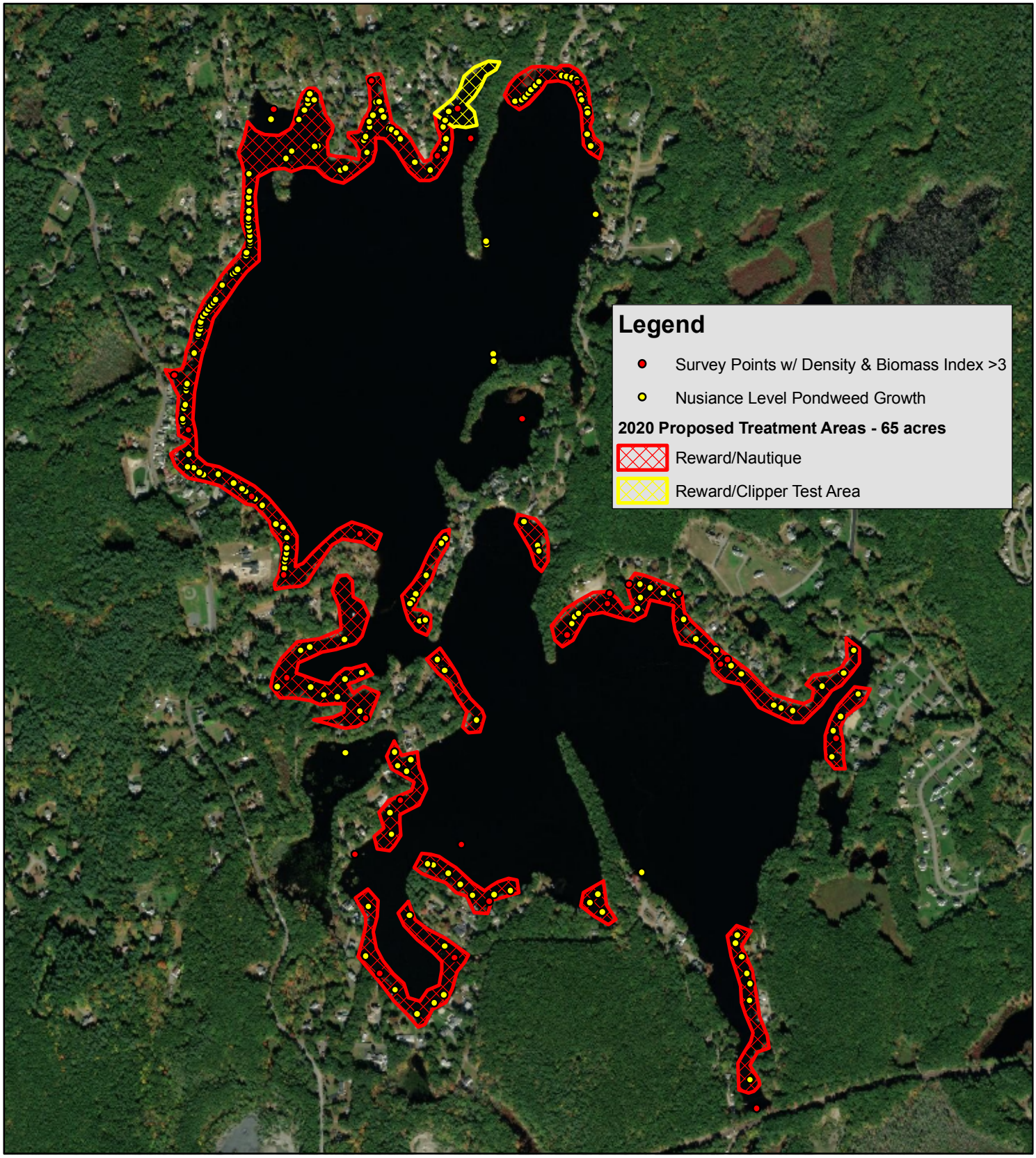
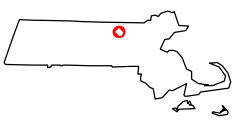


Lake Shirley
Lunenburg, MA



Lake Shirley

0 920 1,840 Feet

N

1:11,661

Map Date: 6/23/2020
Prepared by: DMM
Office: SHREWSBURY, MA

Figure 2 - July 2020 Herbicide Treatment Tracks

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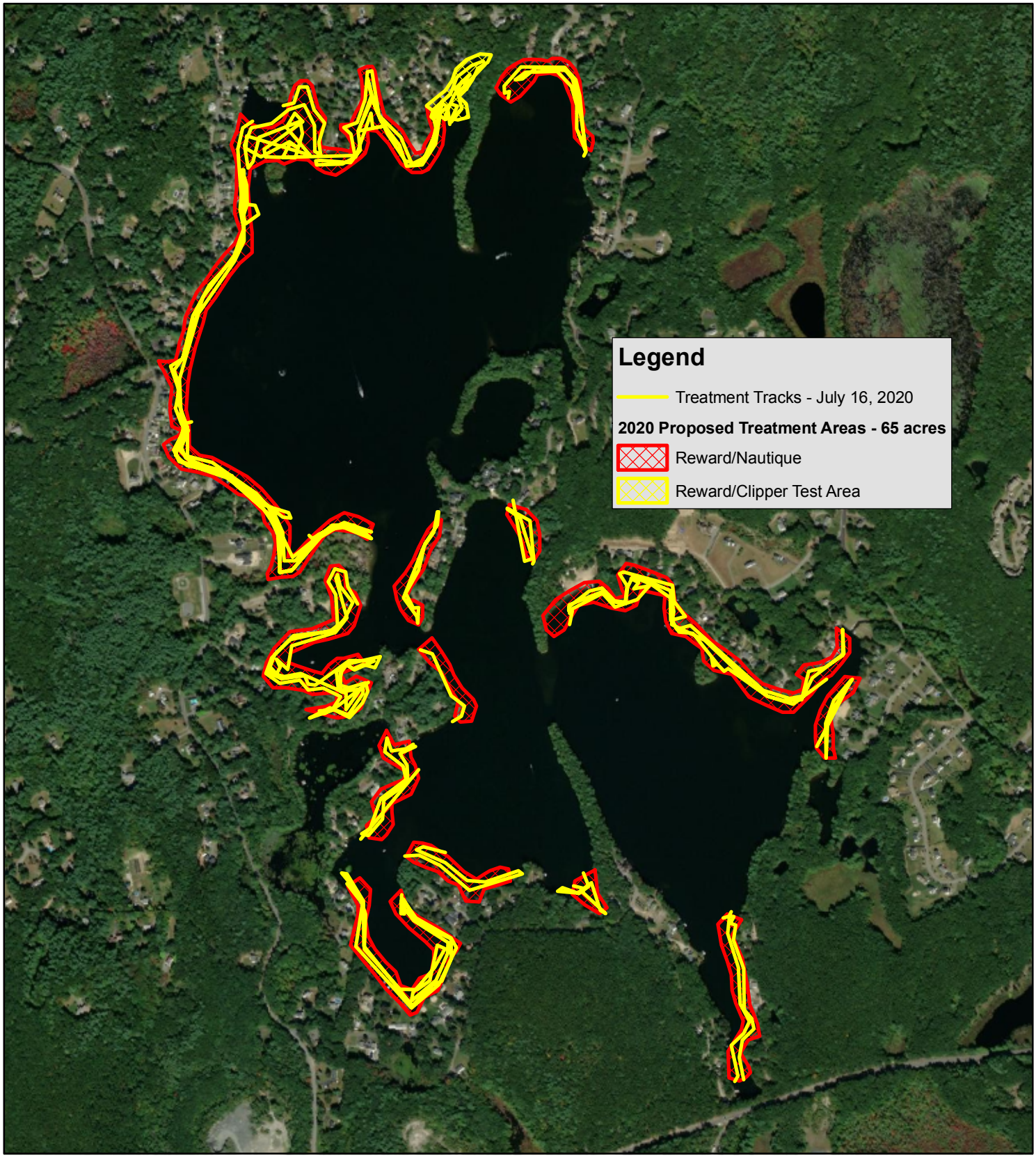
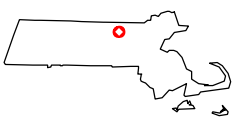


Lake Shirley
Lunenburg, MA



Lake Shirley

0 1,000 2,000 Feet

N

1:11,671

Map Date: 11/2/2020
Prepared by: DMM
Office: SHREWSBURY, MA