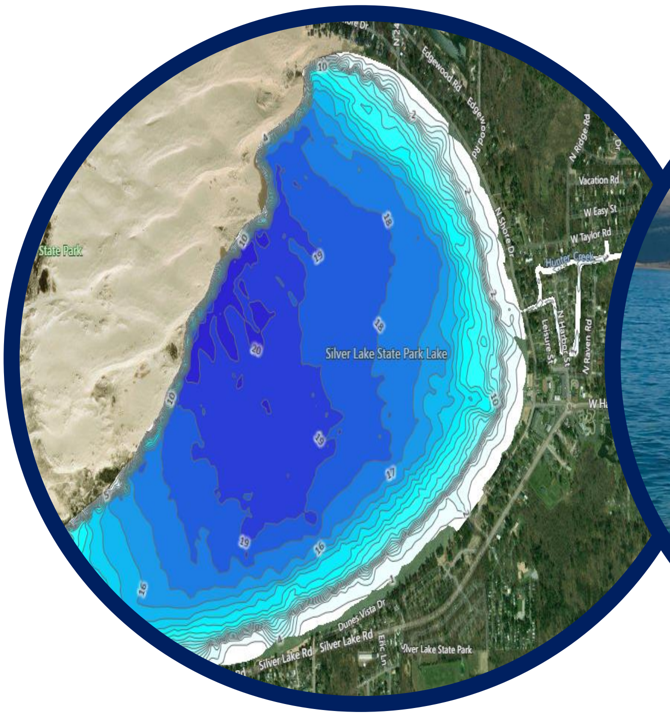
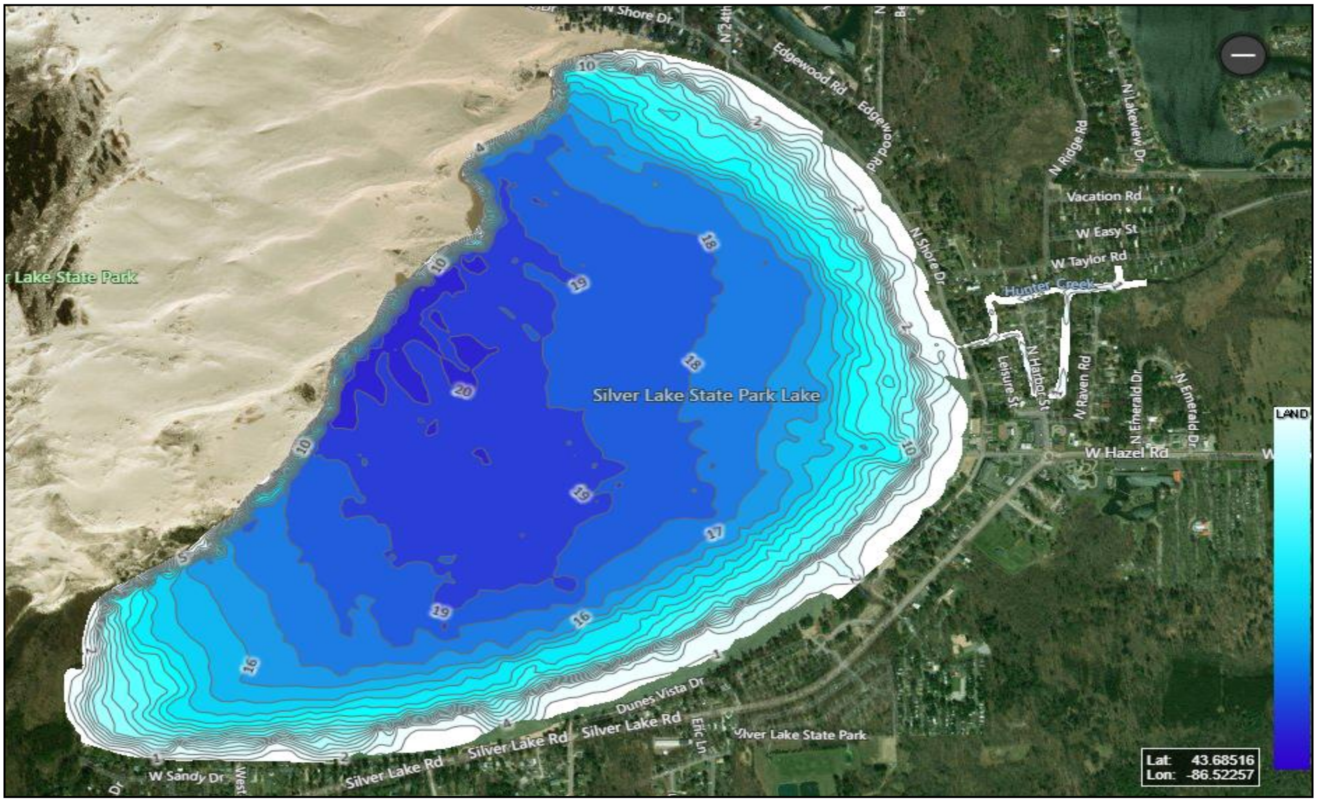
Silver Lake 2020 Aquatic Vegetation, Water Quality, and 2021 Management Recommendations Report



October, 2020

Silver Lake 2020 Aquatic Vegetation, Water Quality, and 2021 Management Recommendations Report

(2020)



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Section

1

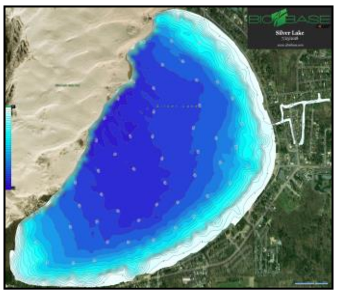
Silver Lake 2020 Aquatic Vegetation, Water Quality, and 2021 Management Recommendations Report

The following information is a summary of key lake findings collected in 2020.

The overall condition of Silver Lake in 2020 was challenged due to increased nutrient concentrations and chlorophyll-a concentrations, and low relative abundance of native aquatic vegetation. The nutrient concentrations in the water column of Silver Lake in October of 2020 were above the eutrophic threshold and encouraged further water column algae growth. The nutrients entering Silver Lake from Hunter Creek are relatively low and the Creek was not found to be a significant source of nutrients or solids for Silver Lake. The major challenge facing Silver Lake is that due to previous over-management of the lake vegetation coupled with the lake being a very high-energy environment with waves, boat activity, and winds, the aquatic vegetation has had a tough time with re-establishment. There are favorable native aquatic plant species present in the lake, but they are very low in relative abundance which lowers the productivity of the lake. This vegetation is crucial for the lake fishery which together compromises major aspects of lake health. The planktonic algae in the water column thrive on the nutrients present and since no vegetation are there to compete with them, the algae dominate the primary producers present in Silver Lake. Algae are known to create water clarity declines whereas a balanced submersed aquatic plant community leads to a clearer-water state. Management recommendations for 2021 and beyond are provided in Section 4.0 of this report and are based on a review of data to date.

Section 2

Silver Lake and Hunter Creek Water Quality Data (2020)



Water Quality Parameters Measured

There are numerous water quality parameters that can be measured on an inland lake, but several are the most critical indicators of lake health. In 2019, the following parameters were measured in the deep basins and in the critical source areas of Hunter Creek: water temperature (measured in °C), dissolved oxygen (measured in mg/L), pH (measured in standard units-SU), conductivity (measured in micro-Siemens per centimeter-µS/cm), total dissolved solids (mg/L), secchi transparency (feet), total phosphorus and total nitrate nitrogen (both in mg/L), chlorophyll-*a* (in µg/L), and algal community composition. All chemical water samples were collected at the surface, mid-depth, and bottom using a 4-liter VanDorn horizontal water sampler with weighted messenger (Wildco® brand). Water quality physical parameters (such as water temperature, dissolved oxygen, conductivity, total dissolved solids and pH) were measured with a calibrated Eureka Manta II® multi-probe meter at middle depths of the sampling sites. Total phosphorus was titrated and analyzed in the laboratory according to method SM 4500-P E. Total suspended solids were analyzed for each sample using SM 2540 D-97. Total nitrate and nitrite and ammonia nitrogen was titrated and analyzed in the laboratory according to methods EPA 300.0 Rev. 2.1 and EPA 350.1 Rev 2.0. Total Kjeldahl nitrogen was Figure 1 shows the three water quality sampling locations. Figure 2 shows the specific critical source area sampled within Hunter Creek (near inlet).

Table 1 below demonstrates how lakes are classified based on key parameters. Silver Lake would be considered meso-eutrophic (somewhat productive) since it does contain ample phosphorus, nitrogen, and algal growth and has fair to good water clarity yet currently low vegetation growth. 2020 water quality data for Silver Lake are shown below in Tables 2-8. 2020 water quality data for Hunter Creek are shown below in Table 9.

Figure 1. Water quality sampling sites in Silver Lake, Oceana County, MI (2020).

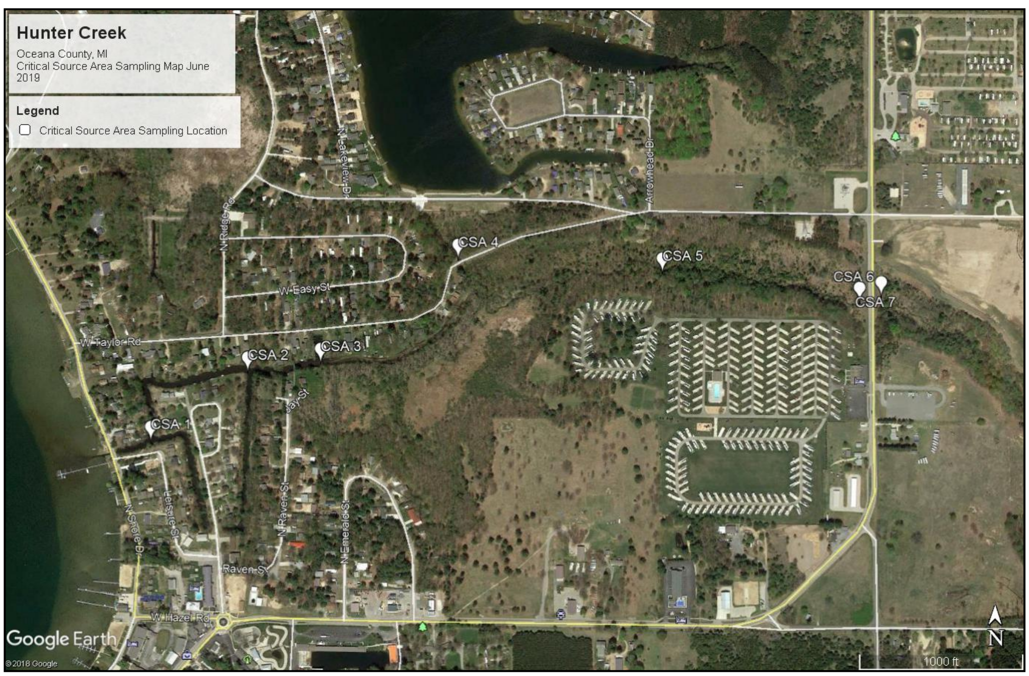


Figure 2. Water quality sampling sites in Hunter Creek, Oceana County, MI. CSA #1 was sampled in 2020.

Table 1. Lake trophic classification (MDNR).

Lake Trophic Status	*Total Phosphorus ($\mu g\ L^{-1}$)*	*Chlorophyll-a ($\mu g\ L^{-1}$)*	*Secchi Transparency (feet)*
Oligotrophic	< 10.0	< 2.2	> 15.0
Mesotrophic	10.0 – 20.0	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 20.0	> 6.0	< 7.5

Table 2. Physical water quality data collected at DB#1 on 9 Oct 2020.

Depth	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	TDS (mg/l)	Chl-a (µg/l)
0	14.0	11.0	8.4	320.1	204.9	11.0
10	14.0	9.9	8.4	320.1	204.9	
20	13.9	9.8	8.4	320.3	205.0	

Table 3. Chemical water quality data collected at DB#1 on 9 Oct 2020.

Depth	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)
0	0.039	0.050	<0.10	<0.10	0.050	0.6
10	0.040	0.060	<0.10	<0.10	0.060	0.7
20	0.041	0.060	<0.10	<0.10	0.060	0.8

Table 4. Physical water quality data collected at DB#2 on 9 Oct 2020.

Depth	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	TDS (mg/l)	Chl-a (µg/l)
0	14.1	10.3	8.4	320.2	204.8	6.0
10	14.0	10.0	8.4	320.2	204.9	
19	13.9	9.6	8.4	320.4	205.1	

Table 5. Chemical water quality data collected at DB#2 on 9 Oct 2020.

Depth	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)
0	0.032	0.020	<0.10	<0.10	0.020	<0.5
10	0.036	0.030	<0.10	<0.10	0.030	0.7
19	0.570*	0.030	<0.10	<0.10	0.030	8.6*

Table 6. Physical water quality data collected at DB#3 on 9 Oct 2020.

Depth	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	TDS (mg/l)	Chl-a (µg/l)
0	14.0	10.0	8.4	320.2	204.9	4.0
9	14.0	9.9	8.4	320.1	204.9	
18	13.9	9.7	8.3	320.1	205.0	

Table 7. Chemical water quality data collected at DB#3 on 9 Oct 2020.

Depth	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)
0	0.034	0.030	<0.10	<0.10	0.030	0.6
9	0.037	0.020	<0.10	<0.10	0.020	<0.5
18	0.050	0.040	<0.10	<0.10	0.040	0.7

Table 8. Physical water quality data collected at Hunter Creek Site CSA#1.

Date	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	TDS (mg/l)
9 Oct 20	13.8	10.5	8.3	330.1	215.6

Table 9. Chemical water quality data collected at Hunter Creek Site #1.

Date	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Ortho P (mg/l)
9 Oct 20	0.010	0.010	<0.10	<0.10	0.010	<0.5	<0.010

Water Clarity (Transparency)

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency throughout Silver Lake was adequate in 2020 (6.0-7.5 feet) to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake. Secchi transparency is variable and depends on the number of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement. Late season algae were prominent and thus late summer readings were lower than in late spring.

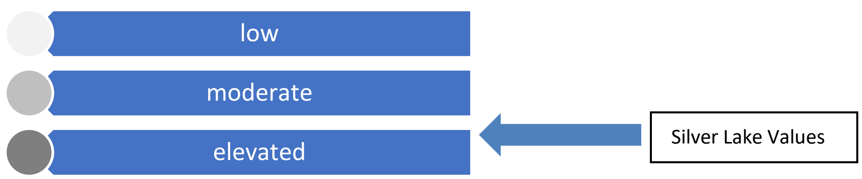
Water Temperature

A lake's water temperature varies within and among seasons and is nearly uniform with depth under the winter ice cover because lake mixing is reduced when waters are not exposed to the wind. When the upper layers of water begin to warm in the spring after ice-off, the colder, dense layers remain at the bottom. This process results in a “thermocline” that acts as a transition layer between warmer and colder water layers. During the fall season, the upper layers begin to cool and become denser than the warmer layers, causing an inversion known as “fall turnover”. In general, shallow lakes will not stratify and deeper lakes may experience single or multiple turnover cycles. Silver Lake experiences multiple turnover events throughout the season.

Water temperature was measured in degrees Celsius (ºC) with the use of a calibrated Eureka Manta II® submersible thermometer. The water temperature measurements on the day of sampling ranged from 13.9-14.1°C which is low in variation and cool but normal for early fall.

Dissolved Oxygen

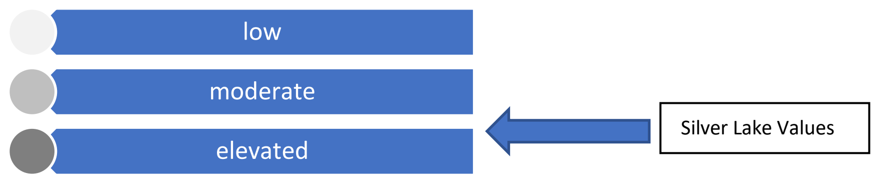
Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg/L to sustain a healthy warm-water fishery. Dissolved oxygen concentrations may decline if there is a high biochemical oxygen demand (BOD) where organismal consumption of oxygen is high due to respiration. Dissolved oxygen is generally higher in colder waters. Dissolved oxygen was measured in milligrams per liter (mg/L) with the use of a calibrated Eureka Manta II® dissolved oxygen meter. The dissolved oxygen concentrations in the deep basins ranged from 9.6-11.0 mg/L which was high and favorable. The dissolved oxygen concentrations in Hunter Creek were around 10.5 mg/L. It is not uncommon for flowing waters to have higher dissolved oxygen concentrations.



Total Phosphorus and Ortho-Phosphorus

Total Phosphorus

Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. Lakes which contain greater than 0.020 mg/L of TP are defined as eutrophic or nutrient-enriched. TP concentrations are usually higher at increased depths due to the higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. Total phosphorus was measured in milligrams per liter (mg/L) with the use of Method EPA 200.7 (Rev. 4.4). The TP concentrations in the deep basins ranged from 0.032-0.570 mg/L. The latter value is an outlier and may have been attributed to waterfowl droppings or some other biological entity that was found in the sample. TP concentrations were elevated in 2020 and may be attributed to increased runoff due to heavy rainfall earlier in the season and in late summer. The TP concentration in Hunter Creek was around 0.010 mg/L which is low.

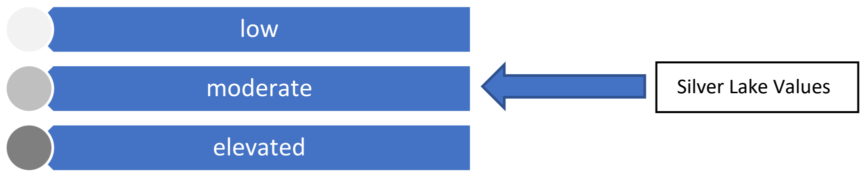


Total Kjeldahl Nitrogen and Total Inorganic Nitrogen

Total Kjeldahl Nitrogen (TKN) is the sum of nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_4^+), and organic nitrogen forms in freshwater systems. TKN was measured with Method EPA 351.2 (Rev. 2.0) and Total Inorganic Nitrogen (TIN) was calculated based on the aforementioned three different forms of nitrogen at Trace Analytical Laboratories, Inc. (a NELAC-certified laboratory). Much nitrogen (amino acids and proteins) also comprises the bulk of living organisms in an aquatic ecosystem. Nitrogen originates from atmospheric inputs (i.e. burning of fossil fuels), wastewater sources from developed areas (i.e. runoff from fertilized lawns), agricultural lands, septic systems, and from waterfowl droppings. It also enters lakes through groundwater or surface drainage, drainage from marshes and wetlands, or from precipitation (Wetzel, 2001). In lakes with an abundance of nitrogen (N: P > 15), phosphorus may be the limiting nutrient for phytoplankton and aquatic macrophyte growth. Alternatively, in lakes with low nitrogen concentrations (and relatively high phosphorus), the blue-green algae populations may increase due to the ability to fix nitrogen gas from atmospheric inputs. Lakes with a mean TKN value of 0.66 mg/L may be classified as oligotrophic, those with a mean TKN value of 0.75 mg /L may be classified as mesotrophic, and those with a mean TKN value greater than 1.88 mg/L may be classified as eutrophic.
The TKN concentrations in Silver Lake ranged from <0.5-1.4 mg/L which is variable but higher than the phosphorus. The TKN concentrations in Hunter Creek ranged from <0.5-8.6 mg/L which is lower than the lake basins. The latter value was an outlier and may have

been due to localized nutrient inputs present at the time of sampling. This location has not traditionally been elevated in nutrients.

The total inorganic nitrogen (TIN) consists of nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3) forms of nitrogen without the organic forms of nitrogen. The TIN concentrations in Silver Lake ranged from 0.020-0.060 mg/L which is also variable but higher than phosphorus. The TIN in Hunter Creek was around 0.010 mg/L which is quite low.

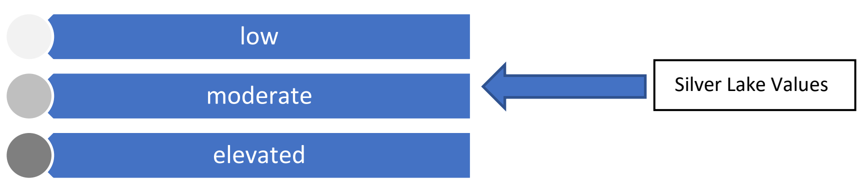


Total Dissolved Solids and Total Suspended Solids

Total Dissolved Solids

Total dissolved solids (TDS) are the measure of the amount of dissolved organic and inorganic particles in the water column. Particles dissolved in the water column absorb heat from the sun and raise the water temperature and increase conductivity.

Total dissolved solids were measured with the use of a calibrated Eureka Manta II® meter in mg/L. Spring values are usually higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. The total dissolved solids in the lake ranged from 204-205 mg/L which are moderate values. The TDS in Hunter Creek was around 215 mg/L which is slightly higher than the lake basins but still falls within the median range.



Total Suspended Solids (TSS)

Total suspended solids are the measure of the number of suspended particles in the water column. Particles suspended in the water column absorb heat from the sun and raise the water temperature. Total suspended solids were measured in mg/L in Hunter Creek and analyzed in the laboratory with Method SM 2540 D-11. The creek bottom contains many fine sediment particles that are easily perturbed from winds and rain. Spring values would likely be higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. The TSS concentrations were low and around <10 mg/L in both the lake and Hunter Creek; however, these may be much higher immediately after a rain event (Figure 7).

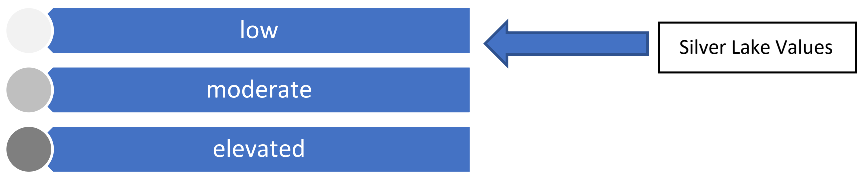


Figure 7. Suspended solids in Hunter Creek after a rainstorm (2019). Photo courtesy of SLDAPO.

pH

Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (pH < 7) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). pH was measured with a calibrated Eureka Manta II® multi-parameter sonde. Silver Lake is considered "slightly basic" on the pH scale. The pH of Silver Lake ranged from 8.3-8.4 S.U. during the 2020 sampling event, which is ideal for an inland lake. The pH in Hunter Creek was around 8.3 S.U. It is common for tributaries to have a lower pH due to the presence of tannins.

Conductivity

Conductivity is a measure of the number of mineral ions present in the water, especially those of salts and other dissolved inorganic substances and was measured with a calibrated Eureka Manta II® multi-parameter sonde. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. The conductivity values for Silver Lake during the 2020 sampling event were moderate and around 320 µS/cm. The conductivity in Hunter Creek was slightly higher and around 330 µS/cm. Severe water quality impairments do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm.

Chlorophyll-*a* and Algal Community Composition

Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than 6 µg L^{-1} are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 µg/L are found in nutrient-poor or oligotrophic lakes. The chlorophyll-*a* concentrations in Silver Lake ranged from 4.0-11.0 µg/L which is moderately high for an inland Michigan lake and explains the observed lower water clarity later in the season. This indicates that there are still adequate nutrients for abundant algal growth. Encouragement of submersed aquatic vegetation may help to reduce these chl-a values over time.

The algal genera were determined from composite water samples collected over the deep basin of Silver Lake in 2020 were analyzed with a Zeiss® compound bright field microscope. The genera present included the Chlorophyta: *Spirogyra* sp., *Scenedesmus* sp., *Rhizoclonium* sp., *Mougeotia* sp., *Cladophora* sp., and *Chloromonas* sp. The Cyanophyta: G*leocapsa* sp., and *Gleotrichia* sp.; The Bascillariophyta: *Navicula sp., Fragilaria* sp., *Cymbella* sp., *Synedra* sp., and *Navicula* sp. The aforementioned species indicate a diverse algal flora, but the blue-green algae were more abundant than the diatoms. RLS will continue to monitor these algal communities and will make recommendations for algal management if needed.

Section 3

Aquatic Vegetation Data (2020)

Status of Native Aquatic Vegetation in Silver Lake

The native aquatic vegetation present in Silver Lake is essential for the overall health of the lake and the support of the lake fishery. The July 22, 2020 survey of Silver Lake determined that there were a total of 9 native aquatic plant species in Silver Lake. These included 6 submersed species, 0 floating-leaved species, and 3 emergent species. This indicates a low biodiversity of aquatic vegetation in Silver Lake (Table 18). The most common native aquatic plant species included the macro alga Chara (Figure 8) and Elodea (Figure 9). Both of these species are low-lying and ideal for fish spawning habitat but much more is needed to help the fishery relative to forage habitat. RLS has recommended native aquatic plant species plantings for Silver Lake but a permit is being discussed and has not yet been issued.

Figure 8. Chara

Figure 9. Elodea

Table 18. Silver Lake Native Aquatic Plant Species (July 22, 2020).

Native Aquatic Plant Species	*Common Name*	*% Abundance*	*Growth Habit*
Chara vulgaris	Muskgrass	6.1	Submersed; Rooted
Stuckenia pectinatus	Sago Pondweed	3.0	Submersed; Rooted
Potamogeton praelongus	White-stemmed Pondweed	4.0	Submersed; Rooted
Najas guadalupensis	Southern Naiad	3.2	Submersed; Rooted
Elodea canadensis	Common Elodea	5.0	Submersed; Rooted
Utricularia vulgaris	Common Bladderwort	0.8	Submersed; Non-Rooted
Typha latifolia	Cattails	0.1	Emergent
Scirpus acutus	Bulrushes	0.1	Emergent
Eleocharis acicularis	Spike rush	0.1	Emergent

Status of Invasive (Exotic) Aquatic Plant Species in Silver Lake

The amount of Eurasian Watermilfoil (Figure 10) present in Silver Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. In 2020, many lakes experienced EWM outbreaks from intense rainfall events carrying nutrients into the water. The July 22, 2020 survey revealed that approximately 0.5 acres of milfoil was found throughout the entire lake. Figure 11 shows the current cover of submersed aquatic vegetation in the lake (green color) which is critically low and must increase or RLS will request permission for transplants of native vegetation for adequate fish cover. No treatments were needed in 2020 due to lack of milfoil growth and the need for some vegetative cover. The MDNR report (2020-001) by Mark A. Tonello recommended no further treatments at this time. RLS agrees with this recommendation; however, if milfoil is determined to be an imminent threat to the ecology of Silver Lake through development of dense beds that form canopies that may fragment, then RLS will recommend management of those localized beds to reduce the threats of spreading. RLS will carefully monitor the lake again next year for any possible invasions.

Figure 10. Eurasian Watermilfoil

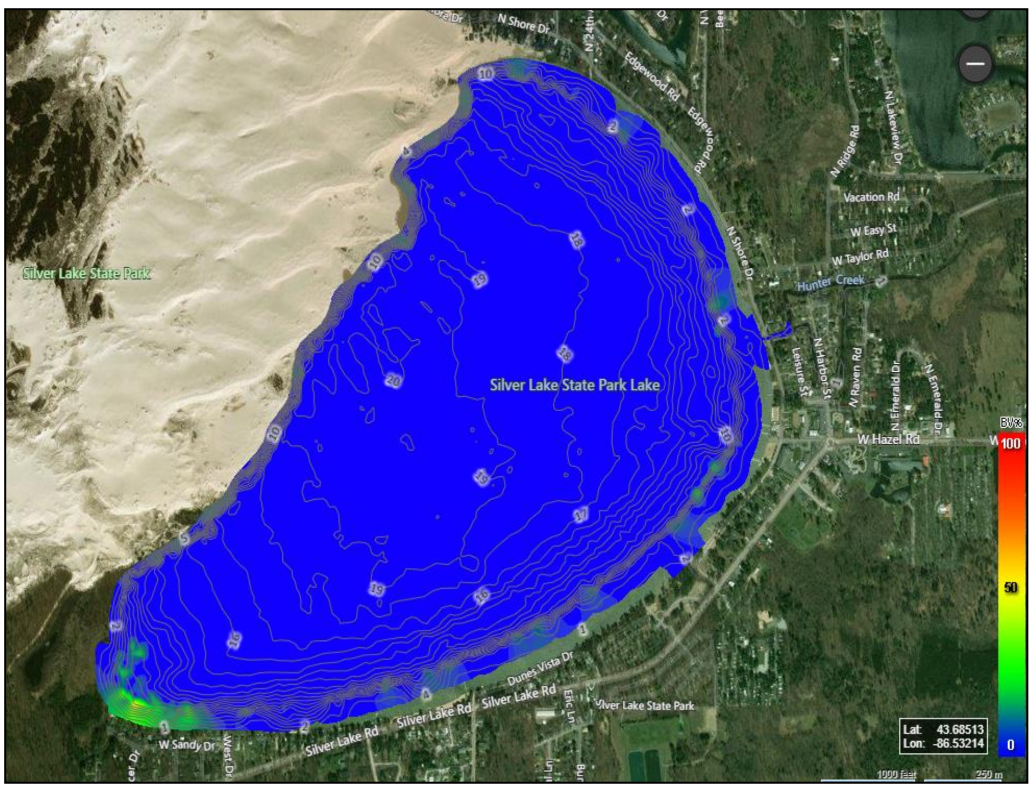


Figure 11. Aquatic Vegetation Biovolume in Silver Lake (October 9, 2020).

Section

4

Overall 2020 Conclusions and Management Recommendations for 2021

Aquatic Vegetation Management:

Continuous aquatic vegetation surveys are needed to determine the precise locations of EWM other problematic invasives in and around Silver Lake. These surveys should occur in late-May to early-July and again post-treatment (if needed) in 2021. As in 2020, RLS scientists will be present to oversee all aquatic herbicide treatments if they occur. It must again be stated that treatments of milfoil will only be recommended if the milfoil beds are an imminent threat to Silver Lake. RLS has requested permission from the MDNR and EGLE to plant native aquatic plant species in Silver Lake and that is being discussed. If this is permitted, RLS will assist in the plantings of these species since Silver Lake urgently needs more native aquatic vegetation. Additional fish cover may be added to the lake if permitted by the MDNR and RLS recommends evergreen trees or other woody debris be added as fish structure since the lake has such little structure and forage habitat.

Water Quality Improvements:

Another reason for the lower water clarity in Silver Lake is due to the high number of planktonic algae in the water column. The nutrients were elevated in October of 2020 and may be attributed to increased runoff events and retention of associated nutrients in the lake. These elevated levels led to increased chlorophyll-a concentrations in 2020. Lower nutrients and algae would allow for more light penetration for low-growing aquatic plant species which are the most prevalent (though scarce) in Silver Lake. RLS continues to support a local septic compliance ordinance that would reduce these loads to the lake and hold all riparians accountable for the lake health. Riparians can visit the site: https://www.epa.gov/septic to learn more about how to care for their septic systems and drain fields.

Fishery Habitat Improvements:

Lake riparians can also help the lake by encouraging the growth of native emergent aquatic plants around the lakeshore. Although many may view these plants as unsightly, they serve a very important ecological function in the lake with creating fish spawning habitat and also providing protection from shoreline erosion. For more information on how to get involved with these plantings, riparians can visit the site: http://www.mishorelinepartnership.org/.

Lake Education and Outreach:

Due to COVID-19 issues in 2020 an educational workshop was not conducted but is proposed to be held in 2021 if conditions improve. Proposed locations would include either Golden Township Park or the State Park and should include many stakeholders such as the MDNR, EGLE, local conservation groups, SLDAPO, PLM, and MSU Extension. The workshop will have educational handouts and materials that will help local residents and those who visit Silver Lake to better understand its ecology and needs for optimum lake health.