Silver Lake 2022 Aquatic Vegetation, Water Quality, and 2023 Management Recommendations Report

October, 2022

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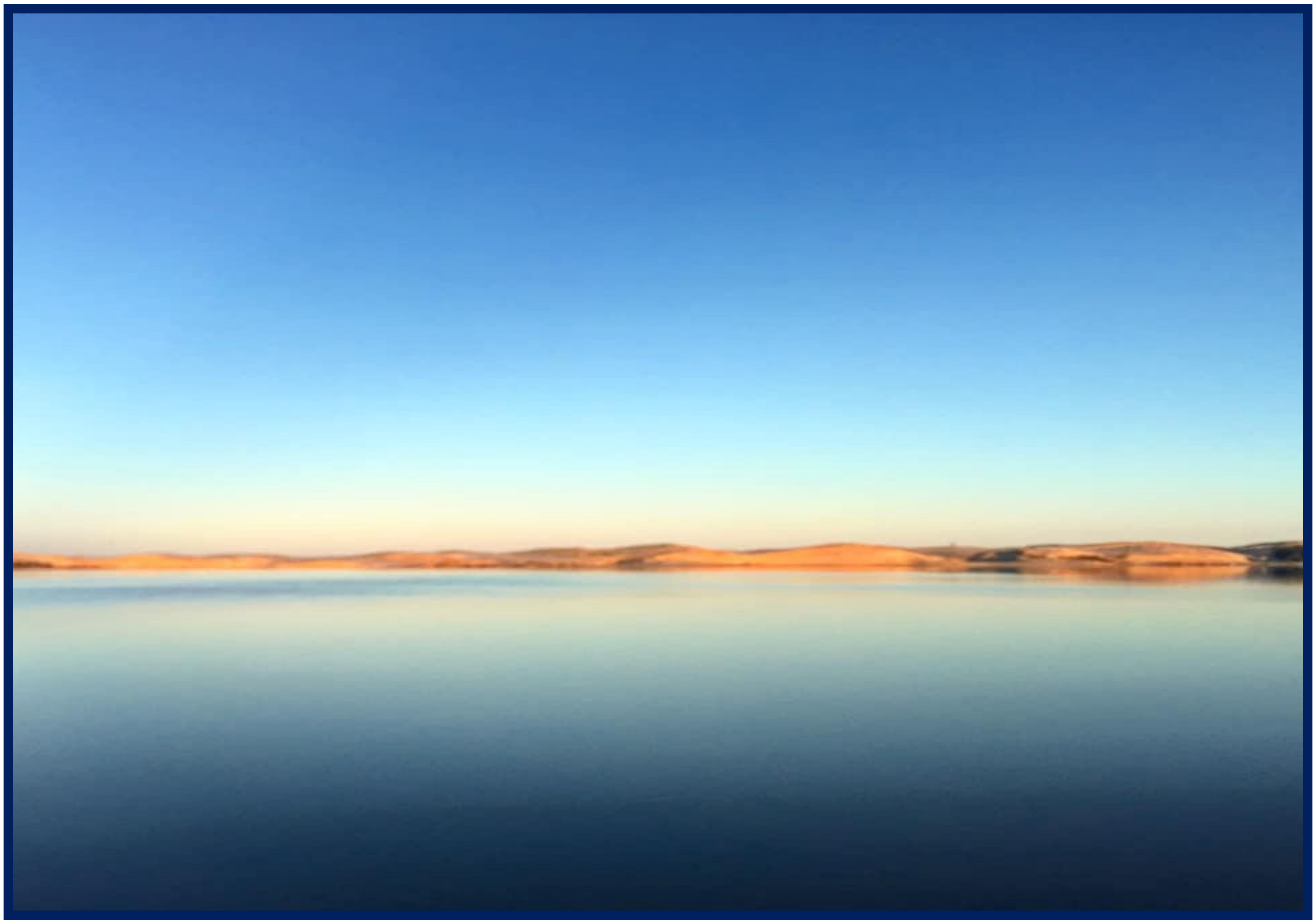

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1

Silver Lake 2022 Aquatic Vegetation, Water Quality, and 2023 Management Recommendations Report

The overall condition of Silver Lake in 2022 was challenged due to increased nutrient concentrations (especially from runoff) and chlorophyll-*a* concentrations, and low relative abundance of native aquatic vegetation. The nutrient concentrations in the water column of Silver Lake in July of 2022 were above the eutrophic threshold and especially high at the bottom of the deep basin #3. Previous evaluations have demonstrated that 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. In 2022, a sperate runoff evaluation concluded that runoff is a large contributor of nutrients to the lake. Septic systems are also another probable source. Reduction of runoff nutrients is critical, and some areas will be simpler to address than others. RLS has submitted recommendations for improvements all of the runoff areas.

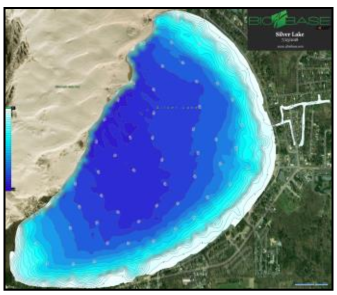
The relative abundance of each aquatic plant species is still critically low, and any future plantings will require more water clarity for successful germination. This vegetation is crucial for the lake fishery. The planktonic blue-green algae in the water column thrive on the nutrients present and since 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. Reduction of all nutrient sources to Silver Lake should reduce the presence of blue-green algae over time. Management recommendations for 2023 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 Water Quality Data (2022)

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 2021, 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 nitrogen was titrated and analyzed in the laboratory according to methods EPA 300.0 Rev. 2.1 and EPA 350.1 Rev 2.0. Figure 1 shows the three water quality sampling locations.

Table 1 below demonstrates how lakes are classified based on key parameters. In 2022, Silver Lake would be considered eutrophic (very productive) since it contained ample phosphorus, nitrogen, and algal growth and had fair water clarity yet currently low vegetation growth. 2022 water quality data for Silver Lake are shown below in Tables 2-7.

Figure 1. Water quality sampling sites in Silver Lake, Oceana County, MI (2022).

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 in DB#1 on July 20, 2022.

Depth (m)	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	TDS (mg/l)	Chl-a (µg/l)
0	24.6	8.6	8.5	504	322	5.0
1.0	24.4	8.6	8.5	503	322	
2.0	24.4	8.6	8.5	503	323	
3.0	24.4	8.6	8.5	503	322	
4.0	24.4	8.6	8.5	502	321	
5.0	24.4	8.6	8.5	501	321	
6.0	24.4	8.6	8.5	501	321	

Table 3. Chemical water quality data collected in DB#1 on July 20, 2022.

Depth (m)	TP (mg/l)	TKN (mg/l)
0	0.027	0.8
3.0	0.044	2.8
6.0	0.038	1.7

Table 4. Physical water quality data collected in DB#2 on July 20, 2022.

Depth (m)	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	TDS (mg/l)	Chl-a (µg/l)
0	24.4	8.4	8.4	507	324	5.0
1.0	24.4	8.4	8.4	504	325	
2.0	24.4	8.4	8.4	505	324	
3.0	24.3	8.4	8.4	505	324	
4.0	24.3	8.4	8.4	504	322	
5.0	24.3	8.4	8.4	502	321	
6.0	24.2	8.2	8.4	502	321	

Table 5. Chemical water quality data collected in DB#2 on July 20, 2022.

Depth (m)	TP (mg/l)	TKN (mg/l)
0	0.026	0.9
3.0	0.037	1.1
6.0	0.037	1.4

Table 6. Physical water quality data collected in DB#3 on July 20, 2022.

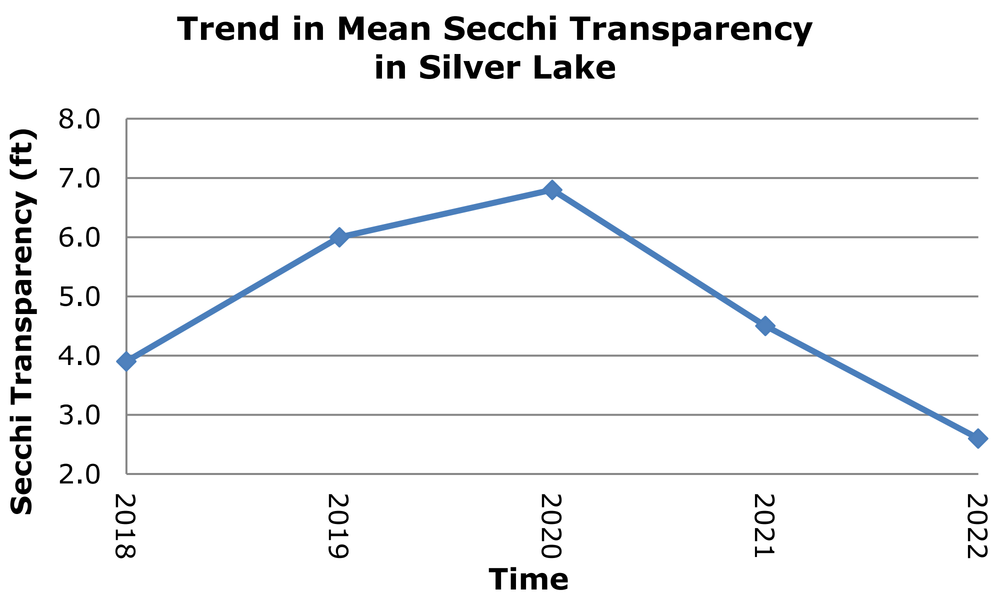
Depth (m)	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	TDS (mg/l)	Chl-a (µg/l)
0	24.6	8.8	8.5	505	323	4.0
1.0	24.6	8.8	8.5	505	323	
2.0	24.6	8.8	8.5	507	325	
3.0	24.6	8.8	8.5	508	325	
4.0	24.5	8.7	8.5	507	324	
5.0	24.4	8.4	8.4	503	322	

Table 7. Chemical water quality data collected In DB#3 on July 20, 2022.

Depth (m)	TP (mg/l)	TKN (mg/l)
0	0.041	1.0
3.0	0.036	1.3
6.0	0.160	3.4

Water Clarity (Transparency)

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. Secchi transparency is measured with an 8-inch Secchi disk on the calm side of the boat. The transparency throughout Silver Lake was very low in 2022 (range of 2.3-2.8 feet) and not conducive to allow growth of aquatic plants in 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. Mid and late season algae were prominent and thus late summer readings were lower than in late spring. The water clarity of Silver Lake needs to be above a mean of 7.0 feet to allow for successful germination of low-lying submersed aquatic plants. The graph below demonstrates the change in mean Secchi transparency with time in Silver Lake. The clarity has declined over the past few years due to more intense blue-green algal blooms.



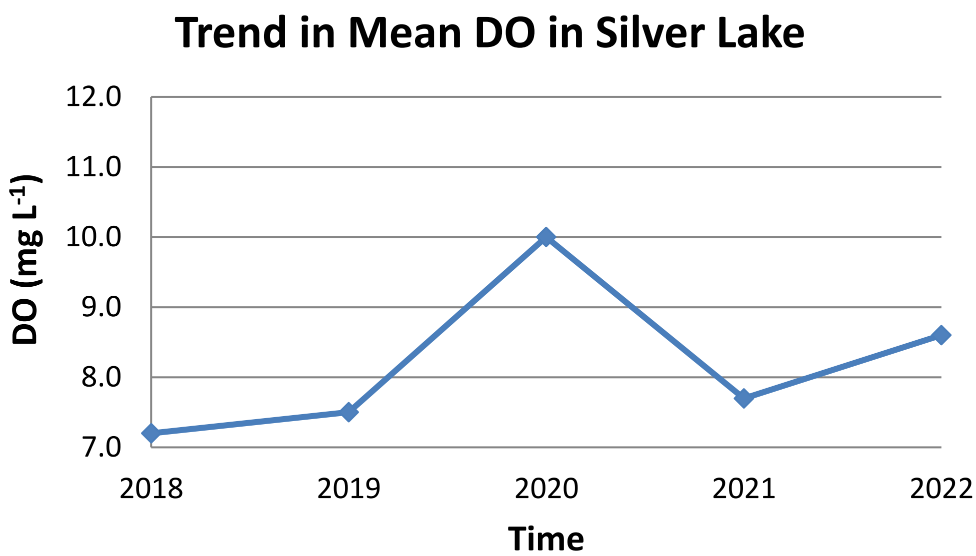
Water Temperature

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 24.2-24.6°C which is low in variation and represents warm waters.

Dissolved Oxygen

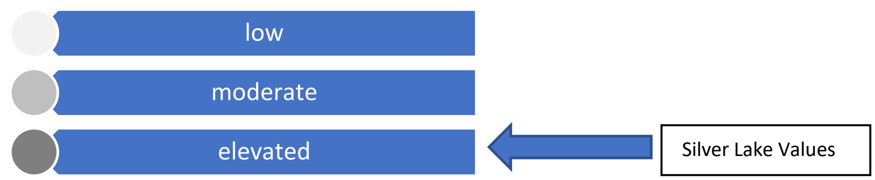
Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg/L to sustain a healthy warm-water fishery. Dissolved oxygen concentrations may decline if there is a high biochemical oxygen demand (BOD) where organismal 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 were favorable and ranged from 8.2-8.8 mg/L which was high and favorable at the surface and mid-depth and also at the lake bottom. These concentrations are much higher than the same time last year and would reduce the probability of the release of phosphorus from lake sediments. Dissolved oxygen can vary within a single day.

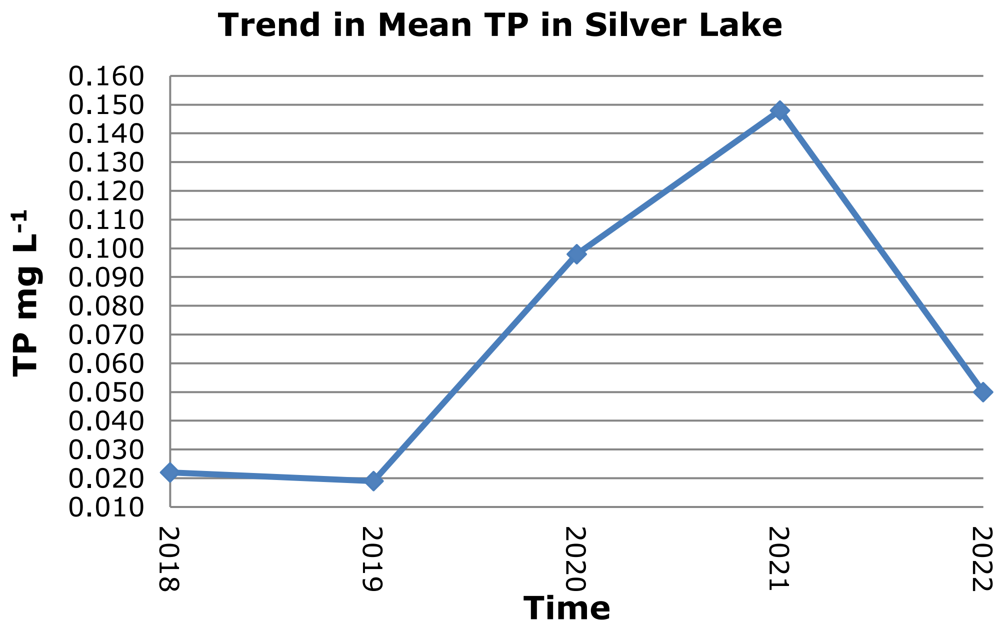


Total Phosphorus

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 generally 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 0.026-0.160 mg/L and have increased significantly over the past few years. TP concentrations were elevated in 2022 at the bottom of the deep basin #3 and this indicates internal loading which may be attributed to increased runoff from areas around the lake and septic systems.



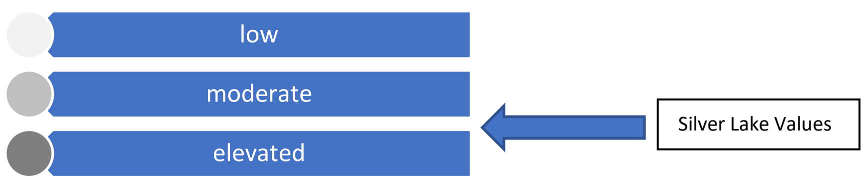


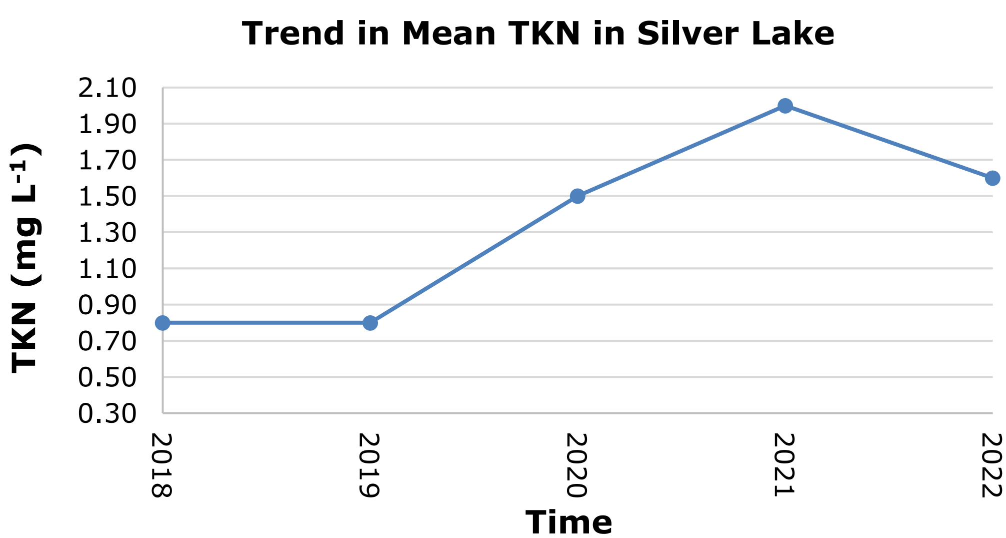
Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen plus ammonia (NH_3) 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 0.8-3.4 mg/L which is variable but higher than the phosphorus. The bottom concentrations were higher than the upper water column strata. This TKN may be contributed from runoff and septic systems. The graph below shows the steady increase in TKN over the past few years.





Total Dissolved 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 generally higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. The total dissolved solids in the lake ranged from 217-325 mg/L which are moderate values. Figure 2 displays the concern for both suspended and dissolved solids that enter the lake from runoff during heavy rainfall events.

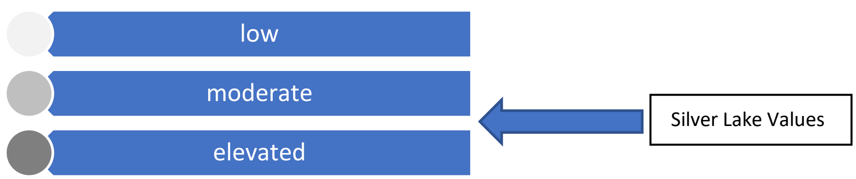
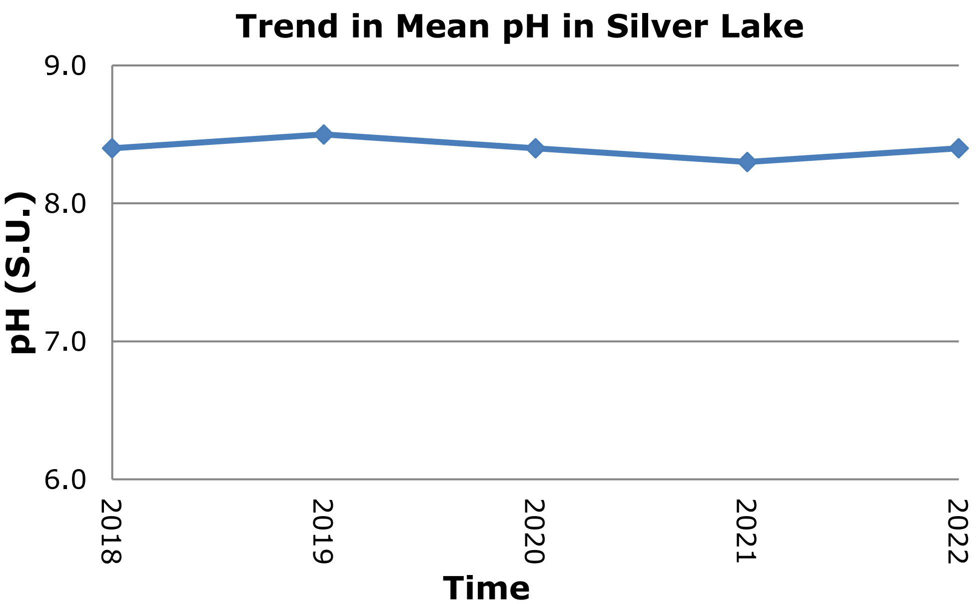


Figure 2. Suspended solids exiting Hunter Creek after a rainstorm (July, 2022).

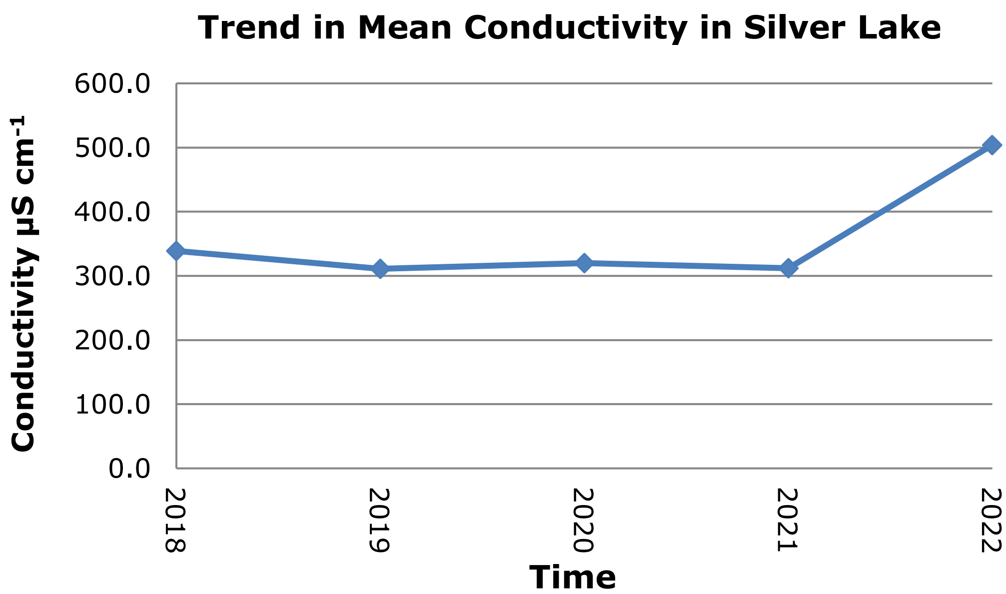
pH

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 8.4-8.5 S.U. during the 2022 sampling event, which is ideal for an inland lake.



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 2022 sampling event were moderate and ranged from 501-508 µS/cm which is moderate and favorable. 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 during the July sampling event were all around 4.0-5.0 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 chlorophyll-a values over time.

The algal genera were determined from composite water samples collected over the deep basin of Silver Lake in 2022 were analyzed with a Zeiss® compound bright field microscope. The genera present included the Chlorophyta: *Spirogyra* sp., *Rhizoclonium* sp., *Mougeotia* sp., *Cladophora* sp., and *Chloromonas* sp. The Cyanophyta: *Microcystis* sp., and *Gleotrichia* sp.; The Bascillariophyta: *Navicula sp., Fragilaria* 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 and green algae. RLS will continue to monitor these algal communities and will make recommendations for algal management if needed. Figure 3 displays the dense filamentous algae, *Cladophora glomerata* found along the shoreline of Silver Lake in July, 2022.

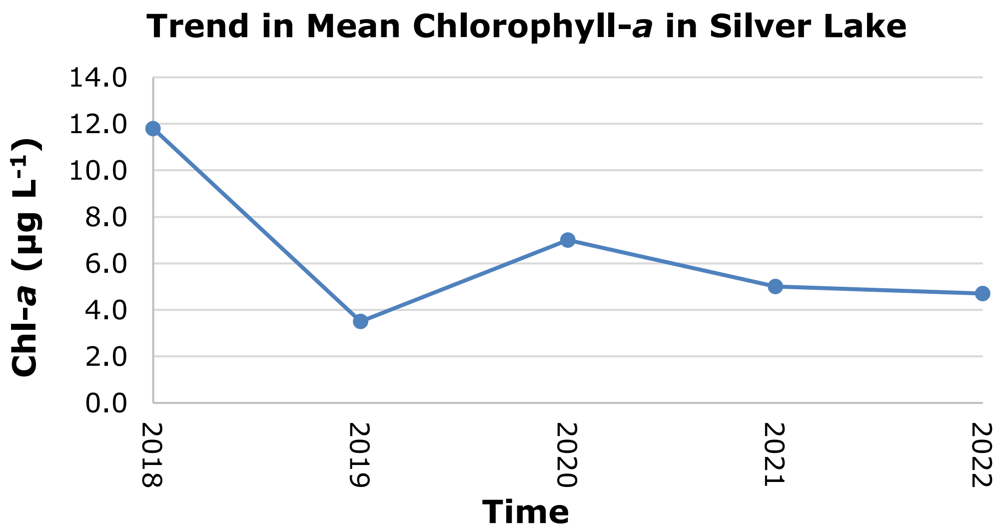


Figure 3. ***Cladophora glomerata*** **growing along the shore in Silver Lake (July, 2021).**

Section

3

Aquatic Vegetation Data (2022)

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 20, 2022 survey of Silver Lake determined that there were a total of 7 native aquatic plant species in Silver Lake (Table 8). These included 2 submersed species, 0 floating-leaved species, and 5 emergent species. This indicates a low biodiversity of aquatic vegetation in Silver Lake with a high scarcity of submersed vegetation. The present native submersed aquatic plant species included the macro alga Chara (Figure 4) and Bladderwort (Figure 5). 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. RLS recommends increasing the water clarity to allow the aquatic plants to successfully germinate.

Figure 4. Chara

Figure 5. Bladderwort

Table 8. Silver Lake Native Aquatic Plant Species (July 22, 2022). Note: *Iris pseudacorus* is considered invasive but is not a current threat to the Silver Lake shoreline. Also note the disappearance of 5 species previously noted.

Native Aquatic Plant Species	*Aquatic Plant Common Name*	*% Abundance*	*Aquatic Plant Growth Habit*
Chara vulgaris	Muskgrass	0.2	Submersed; Rooted
Stuckenia pectinatus	Sago Pondweed	0	Submersed; Rooted
Potamogeton praelongus	White-stemmed Pondweed	0	Submersed; Rooted
Potamogeton robbinsii	Fern-leaf Pondweed	0	Submersed; Rooted
Najas guadalupensis	Southern Naiad	0	Submersed; Rooted
Elodea canadensis	Common Elodea	0	Submersed; Rooted
Utricularia vulgaris	Common Bladderwort	0.2	Submersed; Non-Rooted
Typha latifolia	Cattails	0.9	Emergent
Scirpus acutus	Bulrushes	2.0	Emergent
Decodon verticillatus	Swamp Loosestrife	0.1	Emergent
Eleocharis acicularis	Spike rush	0.1	Emergent
*Iris pseudacorus**	Yellow Iris	0.6	Emergent

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

The amount of Eurasian Watermilfoil (Figure 6) present in Silver Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. The July 20, 2022 survey revealed that approximately 0 acres of milfoil were found throughout the entire lake. Figure 7 shows the current biovolume of submersed aquatic vegetation in the lake which is critically low and must increase to assist in the reduction of blue-green algae in the lake, as this algae competes with submersed aquatic vegetation for nutrients. The clarity of the lake is being reduced by runoff, blue-green algae, and bottom-feeding carp. Once these factors are reduced and the clarity improves, then RLS will request permission in the future for transplants of native vegetation for adequate fish cover. No treatments were needed in 2020-2022 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 6. Eurasian Watermilfoil leaflets and seed head.

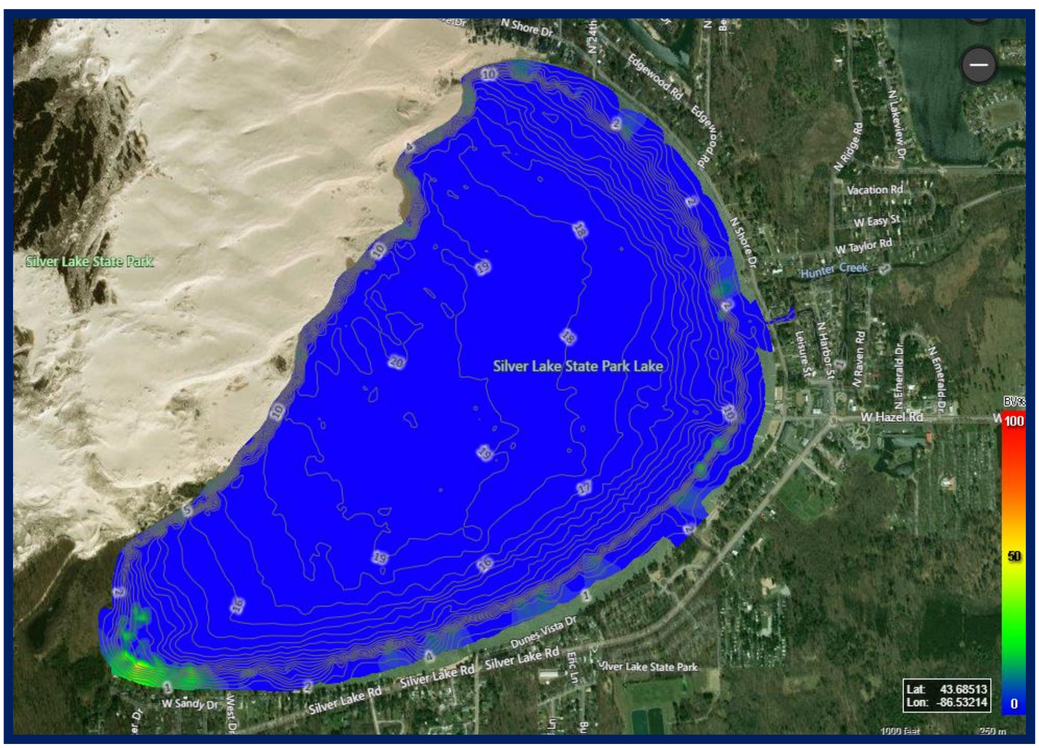


Figure 7. Aquatic Vegetation biovolume in Silver Lake (July 20, 2022).

Section

4

2022 Conclusions and Management Recommendations for 2023

Aquatic Vegetation & Blue-Green Algae 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 2022. If treatments are needed, RLS scientists will be present to oversee all aquatic herbicide treatments. 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 discussed planting of native aquatic plant species in Silver Lake which may be permitted in the near future if water clarity improves to allow for successful germination. There was only two species of submersed aquatic plants present in 2022 which is critically low. **RLS recommends testing for blue-green algal toxins in 2023.**

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 2022 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 2022. 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. **Additionally, RLS recommends in situ digesters such as IMET® and SludgeHammer® for all septic systems.**

RLS also recommends discussion of possible nutrient inactivation methods such as benthic aluminum or PhosLock® or whole-lake aeration. Such improvement methods are used solely in the lake basin to reduce nutrients and blue-green algae; however, strategic reductions of nutrients from the runoff and septic systems is still necessary.

Fishery Habitat Improvements:

Lake riparians can also help the lake by encouraging the growth of native emergent aquatic plants around the lakeshore. The lake currently has some emergent aquatic plants, mostly along the south shoreline. Although many may view these plants as unsightly, they serve an especially important ecological function in the lake with creating fish spawning habitat and also providing protection from shoreline erosion. Additionally, thick buffers of these plants may help to reduce runoff nutrients into the lake. For more information on how to get involved with these plantings, riparians can visit the site: http://www.mishorelinepartnership.org/.

Lake Education and Outreach:

A 2021 educational workshop was conducted held on August 28, 2021 at the Golden Township Park. Many different local vendors were present, along with RLS, PLM (the applicator), and other members of the public. The workshop lasted a few hours and even included interviews by a local film maker. During the workshop, all groups shared information on the lake as well as photos and videos of the current lake conditions. RLS recommends that another workshop be held in 2023 and should include a presentation of all possible improvement alternatives for Silver Lake along with benefits and disadvantages.