Silver Lake 2023 Aquatic Vegetation, Water Quality, and 2023 Management Recommendations Report with Biochar Efficacy Results

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Silver Lake 2023 Aquatic Vegetation, Water Quality, and 2024 Management Recommendations Report with Biochar Efficacy Evaluation

EXECUTIVE SUMMARY:

The submersed aquatic vegetation in Silver Lake is increasing due to higher water clarity from Biochar nutrient reductions from Biochar filters in the lake basin mounted on docks and boats, and the drains. The nutrients in the water column of Silver Lake during the summer of 2023 were significantly lower than in recent years, due to these efforts and also reduced runoff overall. The Biochar in the drains resulted in a decline in TP and TSS in Hunter Creek, the State Park, Taylor Road, Dunes Vista, and Lollygagging. Forms of nitrogen such as ammonia were also reduced at all of these drains. Once more flow rate data is collected in 2024, RLS will calculate loading rates and compare that to the quantity of nutrients removed with the Biochar. A recent analysis of the harvested Biochar filters has revealed that approximately 1.4 tons of phosphorus were removed during the 2023 season. Over time, this should result in a decline of phosphorus in the lake, which will reduce algae and increase water clarity. This should assist with restoring the lake back to an aquatic plant dominant ecosystem, which will consequently improve the lake fishery and possibly eliminate the need for supplemental native aquatic plantings in the lake. Continued annual carp culls at in 2023 are needed to effectively reduce the current population and reduce sediment re-suspension and spawning habitat burial. A summer Silver Lake 2024 workshop is proposed with the theme on non-point source pollution and protection of the Silver Lake immediate watershed.

Section 2

Silver Lake Basin Water Quality Data (2023)

Water Quality Parameters Measured

In 2023, multiple water quality parameters were measured including 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), secchi transparency (feet), total phosphorus, soluble reactive phosphorus (in mg/L), and total Kjeldahl and inorganic 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 3 deep basin sampling sites (Figures 1-2). Total phosphorus was titrated and analyzed in the laboratory according to method SM 4500-P E. Total inorganic 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 2 shows the three water quality sampling locations. Silver Lake would be considered eutrophic (productive; Table 1) since it contained ample phosphorus, nitrogen, and algal growth and had fair water clarity yet currently low vegetation growth. 2023 water quality data for Silver Lake are shown below in Tables 2-7. Trend graphs for critical parameters are also shown in the section below.

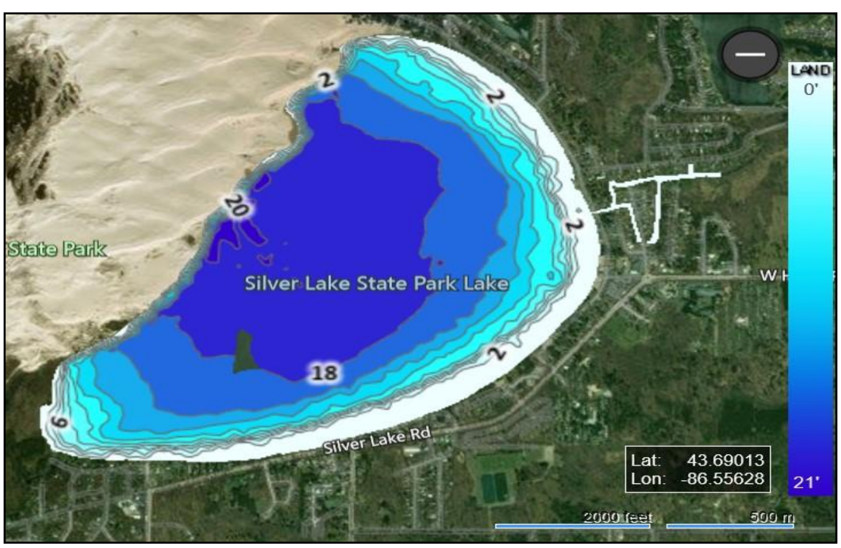


Figure 1. Silver Lake Depth Contours (2023)

Figure 2. Water quality sampling sites in Silver Lake, Oceana County, MI (2018-2023).

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 28, 2023.

Depth (m)	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	Chl-a (µg/l)	Secchi (feet)
0	24.9	8.0	8.6	308	5.0	3.9
1.0	24.9	8.0	8.5	308		
2.0	24.9	7.9	8.5	308		
3.0	24.9	7.9	8.5	308		
4.0	24.9	7.8	8.5	308		
5.0	24.4	3.6	8.4	313		
6.0	23.8	2.3	8.1	315		

Table 3. Chemical water quality data collected in DB#1 on July 28, 2023.

Depth (m)	TP (mg/l)	SRP (mg/l)	TKN (mg/l)	TIN (mg/l)
0	0.018	<0.010	0.7	<0.100
3.0	0.020	<0.010	0.8	<0.100
6.0	0.031	<0.010	0.9	<0.100

Table 4. Physical water quality data collected in DB#2 on July 28, 2023.

Depth (m)	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	Chl-a (µg/l)	Secchi (feet)
0	24.8	8.1	8.5	308	4.0	3.5
1.0	24.8	7.7	8.5	308		
2.0	24.8	7.8	8.5	308		
3.0	24.8	7.8	8.4	308		
4.0	24.8	7.7	8.4	309		
5.0	24.0	4.7	8.2	312		
6.0	23.6	1.6	8.2	516		

Table 5. Chemical water quality data collected in DB#2 on July 28, 2023.

Depth (m)	TP (mg/l)	SRP (mg/l)	TKN (mg/l)	TIN (mg/l)
0	0.016	<0.010	0.7	<0.100
3.0	0.023	<0.010	0.6	<0.100
6.0	0.023	<0.010	0.9	<0.100

Table 6. Physical water quality data collected in DB#3 on July 28, 2023.

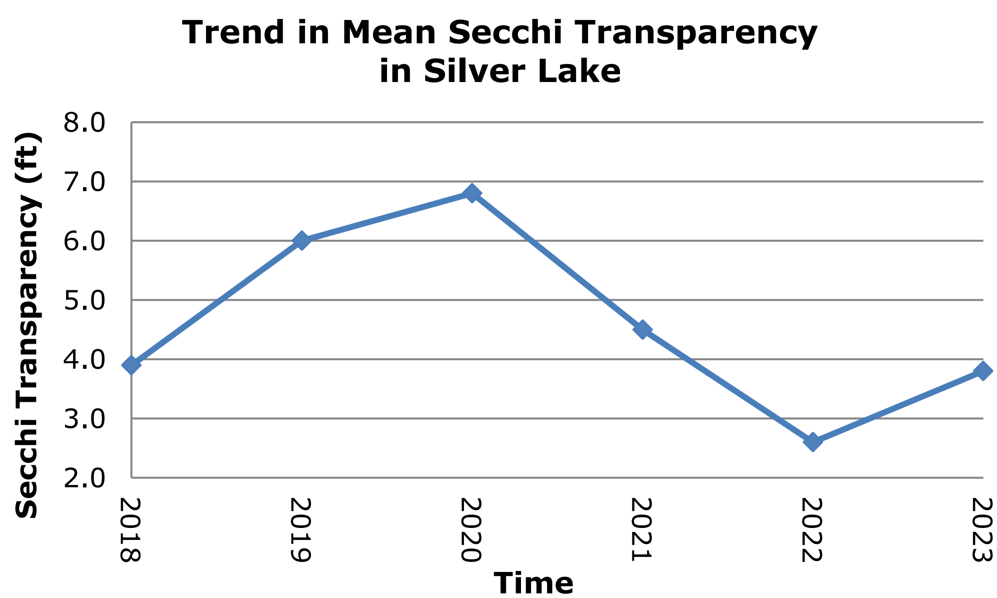
Depth (m)	Temp (ºC)	DO (mg/l)	pH (SU)	Cond (uS/cm)	Chl-a (µg/l)	Secchi (feet)
0	24.9	7.9	8.6	308	5.0	3.9
1.0	24.9	7.8	8.6	308		
2.0	24.8	7.8	8.5	309		
3.0	24.8	7.6	8.5	309		
4.0	24.7	7.4	8.5	309		
5.0	24.7	7.1	8.4	309		
6.0	24.3	6.7	8.4	310		

Table 7. Chemical water quality data collected In DB#3 on July 28, 2023.

Depth (m)	TP (mg/l)	SRP (mg/l)	TKN (mg/l)	TIN (mg/l)
0	0.019	<0.010	0.7	<0.100
3.0	0.021	<0.010	0.7	<0.100
6.0	0.021	<0.010	0.8	<0.100

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 2023 (range of 3.5-3.9 feet) with a mean of 3.8 feet and not conducive to allow growth of aquatic plants in the littoral zone of the lake.** It was, however, an improvement compared to 2022. 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 many 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.



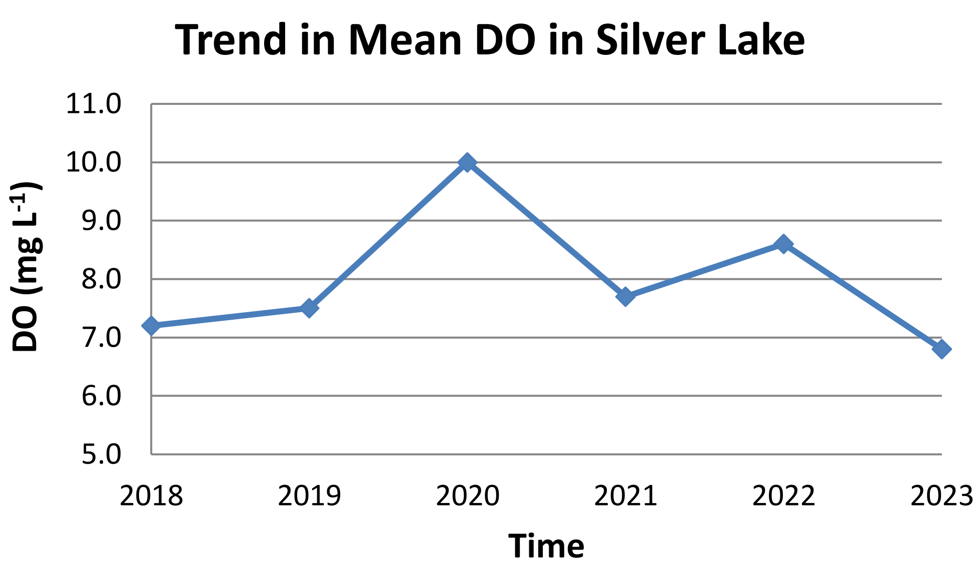
Water Temperature

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 2023 water temperature measurements on the day of sampling ranged from 24.9-23.6°C which is low in variation and represents warm waters.**

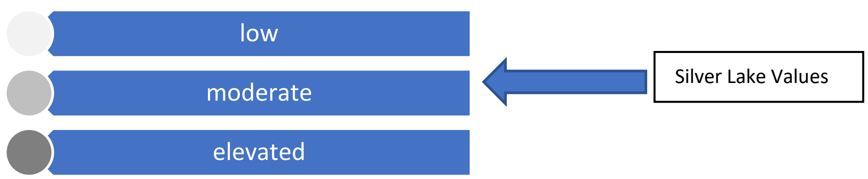
Dissolved Oxygen

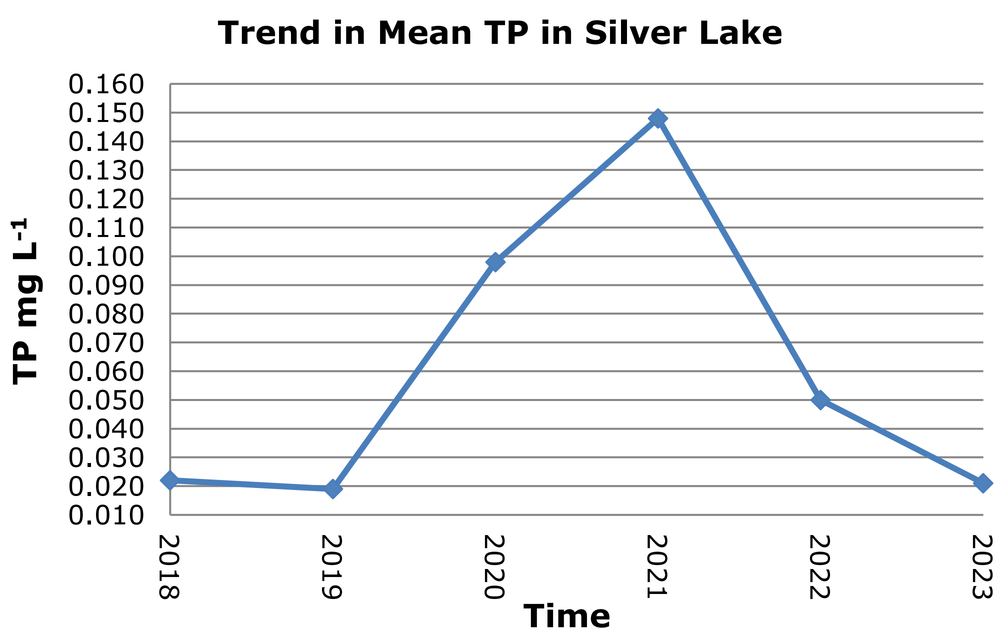
Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg/L to sustain a healthy warm-water fishery. Dissolved oxygen concentrations may decline if there is a high biochemical oxygen demand (BOD) where organismal 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 8.1-2.3 mg/L which was high and favorable at the surface and mid-depth but lower at the lake bottom. The mean dissolved oxygen concentration was 6.9 mg/L.** Dissolved oxygen can vary within a single day and may decline when algae or other biota are decaying which can use oxygen in the water.



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 0.016-0.031 mg/L which is much lower than recent years. The mean TP concentration in 2023 was 0.021 mg/L which is favorable and below the eutrophic threshold.** Soluble reactive phosphorus was also measured, and all samples were <0.010 mg/L which is ideal.

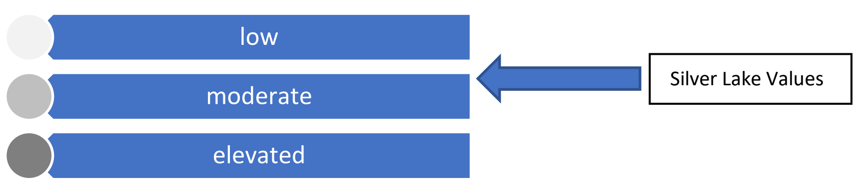


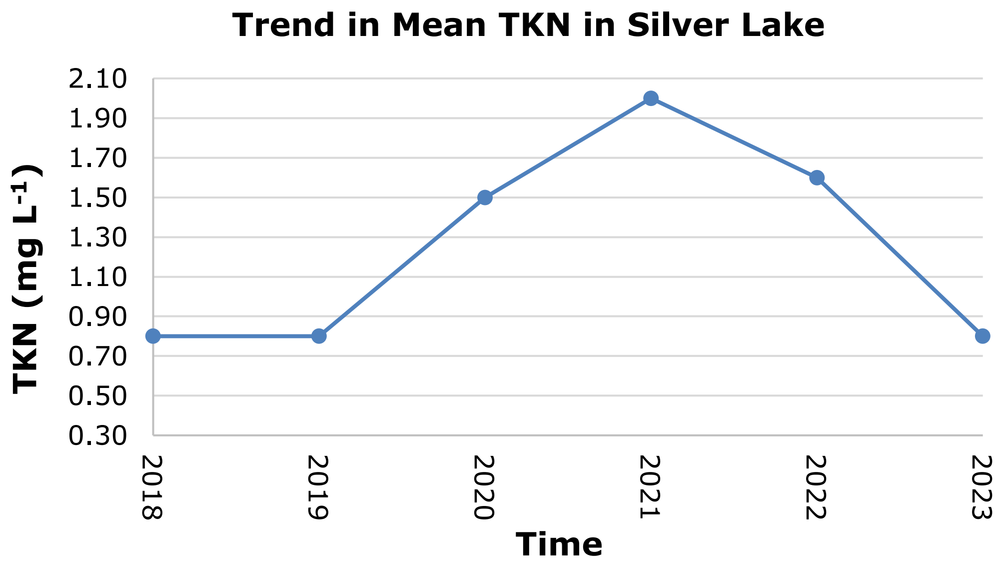


Total Kjeldahl Nitrogen

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.

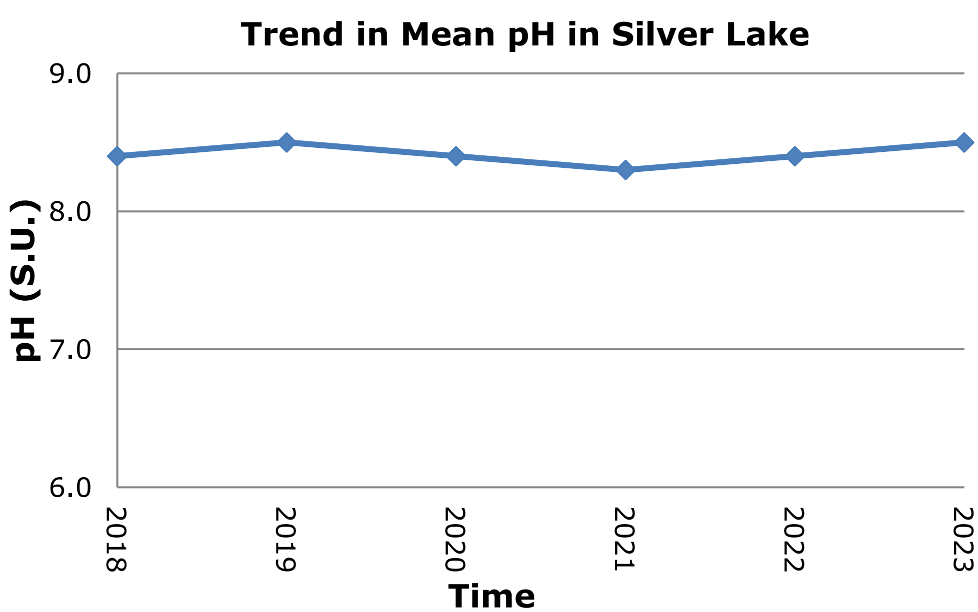
The TKN concentrations in Silver Lake ranged from 0.6-0.9 mg/L with a mean of 0.8 mg/L which is much lower than in 2022. The bottom concentrations were higher than the upper water column strata. This TKN may be contributed from runoff and septic systems.





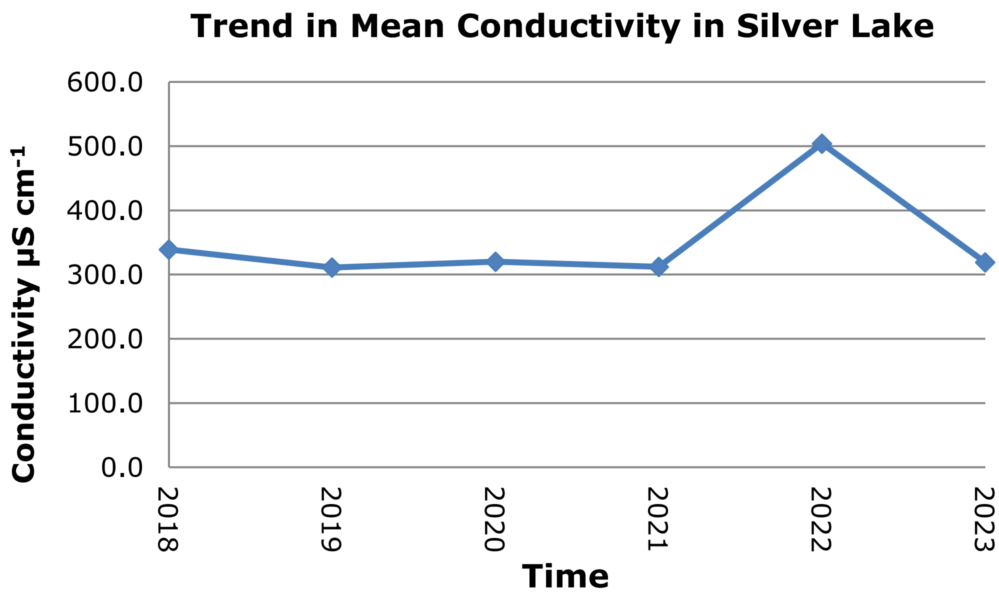
pH

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 8.2-8.6 S.U. with a mean of 8.5 S.U. during the 2023 sampling event, which is ideal for an inland lake.**



Conductivity

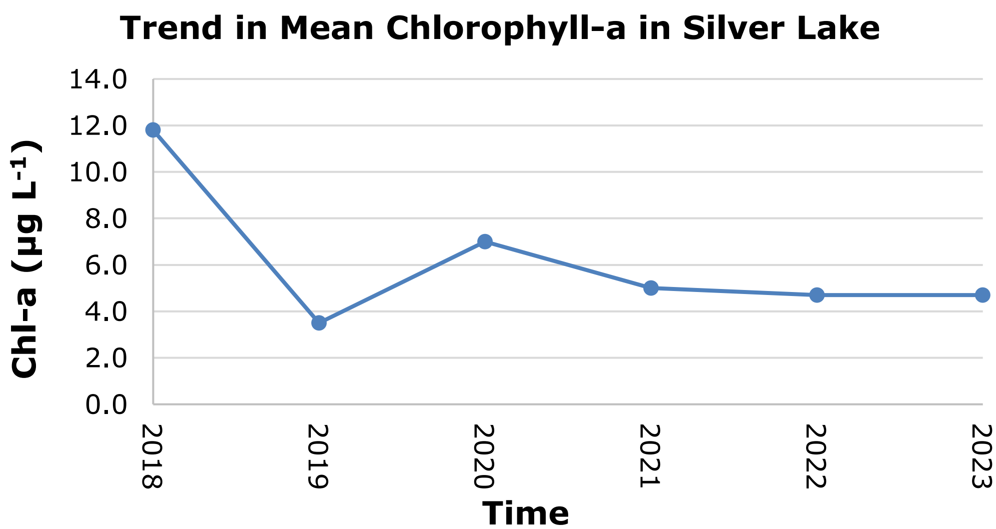
Conductivity is a measure of the number of mineral ions present in the water, especially those of salts and other dissolved inorganic substances and was measured with a calibrated Eureka Manta II® multi-parameter sonde. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. **The conductivity values for Silver Lake during the 2023 sampling event were moderate and ranged from 308-516 µS/cm with a mean of 319 mS/cm which is moderate and favorable and lower than in 2022 due to less runoff.** 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 with a mean of 4.7 µg/L which is moderately high for an inland Michigan lake but stable in recent years.** 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 2023 and 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.



Section

3

Silver Lake Drain Water Quality Data & Post -Biochar Efficacy Evaluation (2023)

A total of N=8 water quality sampling sites were originally selected based on pre-sampling evaluation of sediment plumes entering the lake during an intense rainfall event in the fall of 2021 (Figure 3). Based on this event, the sites selected were determined to contribute significant quantities of water to the lake. Due to the ongoing increases in nutrients and solids within the lake over time, there was a great need to understand the origins of these non-point source pollutants. **Both septic systems and drain runoff contribute to the nutrient loads in Silver Lake. In 2022, the magnitude of pollutant contributions to the lake was determined and it was recommended that all critical drains have EarthFood Biochar filters installed. These filters were permitted by EGLE and were installed in June 2023. Post-biochar monitoring required all filters to be in place and have ample water flow. Qualified flow was determined on two dates prior to the seasonal removal of the filters and included August 6, 2023 and September 6, 2023.** The data below display all water quality parameters measured along with means and standard deviations for those parameters. The water quality parameters measured with a calibrated Eureka Manta II® multi-meter probe with parameter electrodes included the following:

1. Water temperature (°c)
2. Dissolved oxygen (mg L^{-1})
3. pH (S.U.)
4. Specific conductivity (mS cm^{-1})
5. Total dissolved solids (mg L^{-1})

In addition to the *in situ* measurements, chemical water quality parameters such as total phosphorus, total inorganic nitrogen (nitrate, nitrite, and ammonia), total suspended solids, were also measured and collected at the surface, mid-depth, and bottom. All samples were taken to TRACE Analytical Laboratory in Muskegon, Michigan (a NELAC-certified laboratory).

TSS was analyzed in the laboratory with Method SM2549-D15. Total phosphorus was analyzed in the laboratory with Method EPA 200.7, Rev. 4.4. TIN was analyzed in the laboratory with Method EPA 300. Rev 2.1 and Method EPA 350.1, Rev 2.0. Water quality data is displayed below in Tables 8-11.

In addition to water quality samples, water flow velocity was measured at each site when flow was present (in cubic feet per second or cfs). Flow rate data are displayed in Table 12. Mean physical and chemical water quality data are shown in Tables 13-17 with favorable declines highlighted in yellow color.

Water flow rates (velocity) are a measure of the volume of water moved over a specific period of time. Silver Lake runoff flow rates were measured with a calibrated Swoffer® digital velocity meter (in cfs) for each runoff event. Flow rates are usually measured in cubic feet per second (cfs) and vary significantly with rainfall quantity and frequency. Flow rates are useful for determining load contributions over time. The flow rates from the runoff locations ranged from 0.3-2.5 cfs with the highest flow rates measured in Hunter Creek and the State Park. Although many of the other flow rates seemed low, they still contributed a high amount of nutrients and solids to the lake during the rain events.

Figure 3. Silver Lake drain sampling location map (2022-2023). Note: During both years only flowing drains could be sampled.

Table 8. Silver Lake runoff water quality parameter data post Biochar (August 6, 2023). Note: Only drains that had flow were measured and are listed below.

Silver Lake Runoff Sampling Site	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*TDS mg L^{-1}*	*TSS mg L^{-1}*	*TP mg L^{-1}*	*TIN mg L^{-1}*	*NO_3 mg L^{-1}*	*NH_3 mg L^{-1}*	*TKN mg L^{-1}*
Hunter Creek	17.6	9.1	8.1	347	222	<10	0.011	0.570	0.540	0.030	0.5
Lollygagging	18.0	8.9	8.1	334	214	<10	0.011	<0.100	<0.100	<0.010	0.5
State Park	12.9	9.8	8.3	362	232	18	0.024	0.620	0.620	<0.010	<0.5
Dunes Vista	14.1	10.0	8.5	395	253	16	0.031	0.690	0.670	0.014	0.7

Table 9. Silver Lake runoff water quality parameter data post Biochar (September 6, 2023). Note: Only drains that had flow were measured and are listed below.

Silver Lake Runoff Sampling Site	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*TDS mg L^{-1}*	*TSS mg L^{-1}*	*TP mg L^{-1}*	*TIN mg L^{-1}*	*NO_3 mg L^{-1}*	*NH_3 mg L^{-1}*	*TKN mg L^{-1}*
Hunter Creek	18.9	8.8	8.1	350	220	<10	0.017	0.740	0.710	0.030	<0.5
Taylor	18.7	8.1	8.3	355	226	<10	0.012	0.710	0.670	0.039	<0.5
State Park	13.6	9.3	8.4	390	250	13	0.043	0.620	0.610	0.014	<0.5
Dunes Vista	15.9	9.7	8.5	390	250	16	0.070	0.610	0.590	0.014	<0.5

Table 10. Silver Lake mean physical water quality data (August-September, 2023).

Silver Lake Runoff Sampling Site	*Water Temp °C*	*DO mg L^{-1}*	*pH S.U*	*TDS mg L^{-1}*	*Conduct. mS cm^{-1}*
Hunter Creek	18.3±0.9	9.0±0.2	8.1±0	221±1.4	349±2.1
State Park	15.8±3.1	9.1±0.3	8.3±0.2	232±25.5	362±39.6
Dunes Vista	14.4±2.1	9.8±0.1	8.4±0.1	241±12.7	376±19.8
Lollygagging	14.1	10.0	8.5	253	395
Taylor	18.7	8.1	8.3	226	355

Table 11. Silver Lake mean chemical water quality data (August-September, 2023).

Silver Lake Runoff Sampling Site	*TSS mg L^{-1}*	*TP mg L^{-1}*	*TIN mg L^{-1}*	*TKN mg L^{-1}*	*NO_3 mg L^{-1}*	*NH_3- mg L^{-1}*
Hunter Creek	10.0±0	0.014±0	0.655±0.1	0.5±0	0.625±0.1	0.030±0
State Park	11.5±2.1	0.027±0	0.360±0.4	0.5±0	0.355±0.4	0.012±0
Dunes Vista	17±1.4	0.047±0	0.317±0.4	0.5±0	0.605±0	0.012±0
Lollygagging	16	0.031	0.031	0.7	0.670	0.014
Taylor	10	0.012	0.710	0.5	0.670	0.039

Table 12. Silver Lake drain flow rate data (August-September, 2023).

Silver Lake Runoff Sampling Site	*August 6 Flow Rate (cfs)*	*September 6 Flow Rate (cfs)*
Hunter Creek	2.0	1.8
State Park	2.5	2.3
Dunes Vista	0.9	0.6
Lollygagging	0.3	0
Taylor	0	0.5

Table 13. Change in Hunter Creek Silver Lake Drain Mean Water Quality Parameters after Bio-char Implementation.

Parameter	Pre-Biochar	Post-Biochar
Water Temp (°C)	17.6±5.2	18.3±0.9
DO (mg/L)	9.2±1.6	9.0±0.2
pH (S.U.)	7.8±0.4	8.1±0.0
Conductivity (mS/cm)	341±120.0	349±2.1
TDS (mg/L)	218±77.0	221±1.4
TSS (mg/L)	23±11	10±0.0
TP (mg/L)	0.042±0.0	0.014±0.0
TIN (mg/L)	0.622±0.4	0.655±0.1
NO_3 (mg/L)	0.564±0.4	0.625±0.1
NH_3 (mg/L)	0.060±0.045	0.030±0.0

Table 14. Change in State Park Silver Lake Drain Mean Water Quality Parameters after Bio-char Implementation.

Parameter	Pre-Biochar	Post-Biochar
Water Temp (°C)	14.1±3.1	15.8±3.1
DO (mg/L)	9.9±1.0	9.1±0.3
pH (S.U.)	7.9±0.1	8.3±0.2
Conductivity (mS/cm)	352±125	362±39.6
TDS (mg/L)	225±80.0	232±25.5
TSS (mg/L)	69±32	11.5±2.1
TP (mg/L)	0.085±0.1	0.027±0.0
TIN (mg/L)	0.764±0.3	0.360±0.4
NO_3 (mg/L)	0.726±0.3	0.355±0.4
NH_3 (mg/L)	0.040±0.0	0.012±0.0

Table 15. Changes in Dunes Vista Silver Lake Drain Mean Water Quality Parameters after Bio-char Implementation.

Parameter	Pre-Biochar	Post-Biochar
Water Temp (°C)	15.0±3.7	14.4±2.1
DO (mg/L)	9.9±1.0	9.8±0.1
pH (S.U.)	7.9±0.1	8.4±0.1
Conductivity (mS/cm)	308±99.0	376±19.8
TDS (mg/L)	198±65.0	241±12.7
TSS (mg/L)	83±68	17±1.4
TP (mg/L)	0.239±0.2	0.047±0.0
TIN (mg/L)	0.654±0.2	0.317±0.4
NO_3 (mg/L)	0.596±0.2	0.605±0.0
NH_3 (mg/L)	0.061±0.0	0.012±0.0

Table 16. Change in Lollygagging Silver Lake Drain Water Quality Parameters after Bio-char Implementation.

Parameter	Pre-Biochar	Post-Biochar
Water Temp (°C)	17.8±5.2	14.1
DO (mg/L)	9.3±1.4	10.0
pH (S.U.)	7.6±0.1	8.5
Conductivity (mS/cm)	299±106	395
TDS (mg/L)	190±68.0	253
TSS (mg/L)	21±15	16
TP (mg/L)	0.077±0.1	0.031
TIN (mg/L)	0.184±0.1	0.684
NO_3 (mg/L)	0.154±0.1	0.670
NH_3 (mg/L)	0.036±0.0	0.014

Table 17. Change in Taylor Road Tube Silver Lake Drain Water Quality Parameters after Bio-char Implementation.

Parameter	Pre-Biochar	Post-Biochar
Water Temp (°C)	18.0±14.0	18.7
DO (mg/L)	9.1±1.1	8.1
pH (S.U.)	7.9±0.2	8.3
Conductivity (mS/cm)	207±115	355
TDS (mg/L)	132±73.0	226
TSS (mg/L)	18±14	10
TP (mg/L)	0.036±0.0	0.012
TIN (mg/L)	0.646±0.6	0.710
NO_3 (mg/L)	0.432±0.5	0.670
NH_3 (mg/L)	0.199±0.2	0.039

Section

4

Silver Lake Aquatic Vegetation Data (2023)

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 June 20, 2023 survey of Silver Lake determined that there were a total of 8 native aquatic plant species in Silver Lake (Table 18). These included 5 submersed species, 0 floating-leaved species, and 3 emergent species. This indicates a low biodiversity of aquatic vegetation in Silver Lake with a high scarcity of submersed vegetation but an improvement in the relative abundance over recent years.** The most abundant included the native submersed macro alga Chara (Figure 4) and emergent Bulrushes (Figure 5). The Chara is low-lying and ideal for fish spawning habitat but much more is needed to help the fishery relative to forage habitat. The Bulrushes also serve as fishery habitat and help with reducing sediment resuspension. Increasing the water clarity may allow the aquatic plants to successfully germinate over time.

Figure 4. Chara

Figure 5. Bulrushes

Table 18. Silver Lake Native Aquatic Plant Species (June 20, 2023). Note: *Iris pseudacorus* is considered invasive but is not a current threat to the Silver Lake shoreline and is beneficial.

Native Aquatic Plant Species	*Aquatic Plant Common Name*	*% Abundance*	*Aquatic Plant Growth Habit*
Chara vulgaris	Muskgrass	22.7	Submersed; Rooted
Stuckenia pectinatus	Sago Pondweed	3.0	Submersed; Rooted
Drepanocladus revolvens	Scorpion Moss	1.5	Submersed; Rooted
Elodea canadensis	Common Elodea	3.0	Submersed; Rooted
Utricularia vulgaris	Common Bladderwort	1.5	Submersed; Non-Rooted
Typha latifolia	Cattails	4.5	Emergent
Scirpus acutus	Bulrushes	7.6	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 June 20, 2023 survey revealed that approximately 5 locations of milfoil were found throughout the entire lake at the "a" or low abundance level. In addition, there was the presence of another invasive species, Curly-leaf Pondweed (Figure 7) which was found in 13 locations within the lake at the "a" and "b" low abundance levels. Currently, both invasives are welcomed habitat for the fishery but are being monitored for any aggressive invasion or growth. Figure 8 shows the current biovolume of submersed aquatic vegetation in the lake which is still low but higher than in previous years. It must continue to 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 has been reduced by runoff, blue-green algae, and bottom-feeding carp but these issues are being addressed and the water clarity is improving and should continue to improve.** No treatments were needed in 2020-2023 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 (*Myriophyllum spicatum*)

Figure 7. Curly-leaf Pondweed (*Potamogeton crispus*)

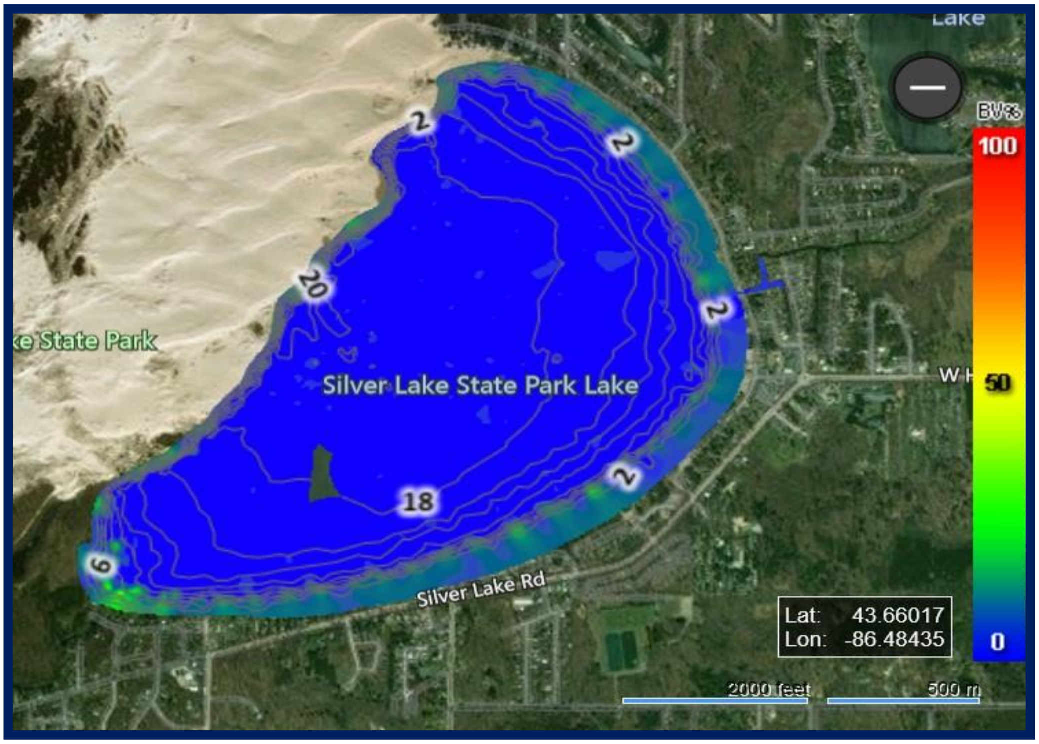


Figure 8. Aquatic Vegetation biovolume in Silver Lake (June 20, 2023).

Section

5

2023 Conclusions and Management Recommendations for 2024

I. Conclusions:

The submersed aquatic vegetation in Silver Lake is increasing due to higher water clarity from Biochar nutrient reductions. The nutrients in the water column of Silver Lake during the summer of 2023 were significantly lower than in recent years, due to these efforts and also reduced runoff overall. The Biochar in the drains resulted in a decline in TP and TSS in Hunter Creek, the State Park, Taylor Road, Dunes Vista, and Lollygagging. Forms of nitrogen such as ammonia were also reduced at all of these drains. Once more flow rate data is collected in 2024, RLS will calculate loading rates and compare that to the quantity of nutrients removed with the Biochar. A recent analysis of the harvested Biochar filters has revealed that approximately 1.4 tons of phosphorus were removed during the 2023 season. Over time, this should result in a decline of phosphorus in the lake, which will reduce algae and increase water clarity. This should assist with restoring the lake back to an aquatic plant dominant ecosystem, which will consequently improve the lake fishery.

II. Recommendations:

Ongoing Aquatic Vegetation & Blue-Green Algae Management:

Continuous whole-lake aquatic vegetation surveys are needed to determine the precise locations of EWM and 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 2024. 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 and acceptable biomass does not naturally grow. In 2023, the relative abundance of many favorable native aquatic plants was higher, and this is an encouraging outcome from recent improvements.

<u>Ongoing Water Quality Improvements:</u>

Although the water clarity in Silver Lake is lower than ideal due to an overabundance of planktonic algae in the water column, the Biochar applications are resulting in reduced nutrients and improved clarity with lower algal concentrations. This will take years for significant improvements to occur and result in more rooted aquatic plant growth and less algal growth. 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 <u>all</u> septic systems. The drains are being improved and thus it depends on riparians at the site-scale to implement septic tank best management practices (BMP's) to reduce the other source of nutrients to the lake. RLS will continue to monitor the water quality of the lake basin and also the drains to further determine efficacy of Biochar.**

<u>Ongoing Fishery Habitat Improvements:</u>

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 by 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 assist with this effort, visit: http://www.mishorelinepartnership.org/.
Indirectly, the placement of Biochar bags on docks and boats as in 2023, will continue to filter the water in Silver Lake and improve water clarity, which will continue to allow for increased germination of rooted, submersed aquatic plants. Additionally, annual carp culls will continue to reduce the abundance of the carp in the lake. This process may take years to effectively reduce the population with minimal to no impact on the native fishery.

<u>Ongoing Lake Education and Outreach:</u>

A septic system-themed lake riparian workshop/seminar was held at the Golden Township Park in July, 2023. Informative booths were there including lake restoration information from RLS as well as information from SludgeHammer, Biochar US, and other volunteer groups such as the Silver Lake United Voice and other partners. RLS plans to host another workshop in 2024 with the theme including non-point source pollution and the protection of the Silver Lake immediate watershed.