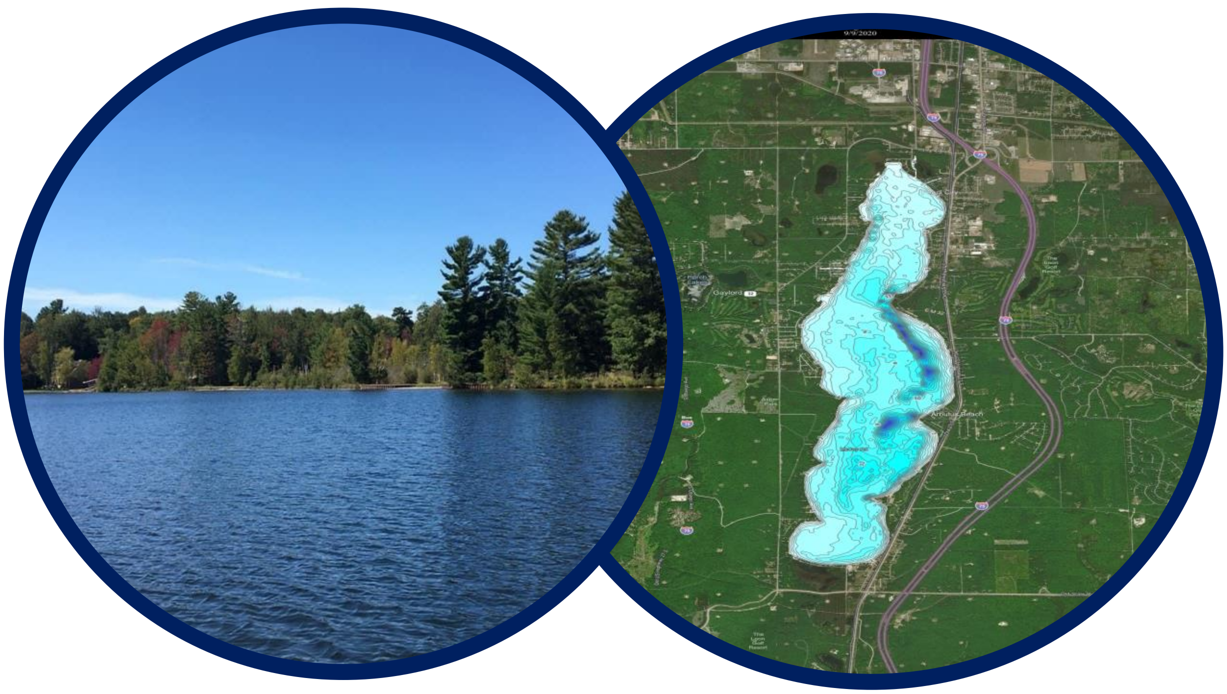
Otsego Lake 2021 Annual Lake Evaluation & 2022 Management Recommendations



Provided for: Otsego Lake Association (OLA) Board

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Otsego Lake 2021 Lake Evaluation & 2022 Management Recommendations

February, 2022

1.0 2021 EXECUTIVE SUMMARY

In 2021, the water quality of Otsego was excellent relative to dissolved oxygen, conductivity, total dissolved solids and low nutrient concentrations. The turbidity of the lake and consequential clarity continues to be compromised by increased erosion inputs of soils to the lake which then become sediments. In 2022, RLS will continue to measure these parameters and will begin trend analysis for each parameter to determine the changes in these parameter with time.

During the 2021 lake evaluation, Otsego Lake contained three invasive submersed aquatic plant species including approximately 1.1 acres of Eurasian Watermilfoil (*Myriophyllum spicatum*) and approximately 0.1 acres of invasive Curly-leaf Pondweed (*Potamogeton crispus*), and 2.8 acres of Starry Stonewort with the latter present only in the canals. All of these species may increase in some years with certain environmental conditions. Recommendations for prevention and treatment of invasives are offered later in this management plan report.

Otsego Lake contained 17 native submersed, 2 floating-leaved, and 5 emergent aquatic plant species, for a total of 24 native aquatic macrophyte species during the lake survey on July 22-23, 2021. Although this biodiversity is favorable, the relative abundance of each plant genus was sparse to moderate overall and thus protection of native biodiversity is critical.

A detailed, Early Detection- Rapid Response Protocol for future invasives that may enter the lake was initiated in 2021 by RLS for the lake community and will be revised in 2022 when new information becomes available.

A professional limnologist/lake manager from RLS will continue to perform regular GPS-guided whole-lake surveys each summer/early fall to monitor the growth and distribution of all invasives prior to and after treatments to determine treatment efficacy. Continuous monitoring of the lake for potential influxes of other exotic aquatic plant genera (i.e., *Hydrilla*) that could also significantly disrupt the ecological stability of Otsego Lake is critical.

In 2022, the lake manager will oversee all management activities and would be responsible for the creation of aquatic plant management survey maps, direction of the herbicide applicator to target-specific areas of aquatic vegetation for removal, and other relevant management activities.

In 2022, lake weed treatments should consist only of early spring contact herbicides for any nuisance-level Curly-leaf Pondweed (CLP) and systemic herbicides for Eurasian Watermilfoil (EWM) when needed.

In 2022, RLS will continue to work with the OLA on formation of a Special Assessment District (SAD) to fund critical future improvements. These include aquatic vegetation surveys and necessary invasive weed treatments, improvements in water quality, reduction of erosion, and reduction of transfer of invasive species to the lake. Additionally, RLS will work with the OLA to consider evaluation of muck reduction in the north region of the lake.

A bottom sediment hardness scan with 20,392 GPS soundings was conducted of the entire lake bottom on July 22-23, 2021. The bottom hardness map shows (Figure 1) that most of the lake bottom consists of fairly sandy sediments throughout the shallow areas of the lake with larger areas of soft organic deposits in the deeper waters. Table 1 below shows the categories of relative bottom hardness with 0.0-0.1 referring to the softest and least consolidated bottom and >0.4 referring to the hardest, most consolidated bottom. This scale does not mean that any of the lake contains a truly “hard” bottom but rather a bottom that is more cohesive and not flocculent. The lake was used for logging in the late 1800s and early 1900s with 4 sawmills once operating on the lake. It has been estimated that up to 23 feet of organic sediments were deposited in the south basin from these activities (MDNR, 2009).

Table 1. Otsego Lake relative hardness of the lake bottom on July 22-23, 2021 by category or hardness and percent over of each category (relative cover).

Lake Bottom Relative Hardness Category	% Relative Cover of Bottom by Category 2021
0.0-0.1	0.1
0.1-0.2	4.9
0.2-0.3	47.0
0.3-0.4	47.9
>0.4	0.1

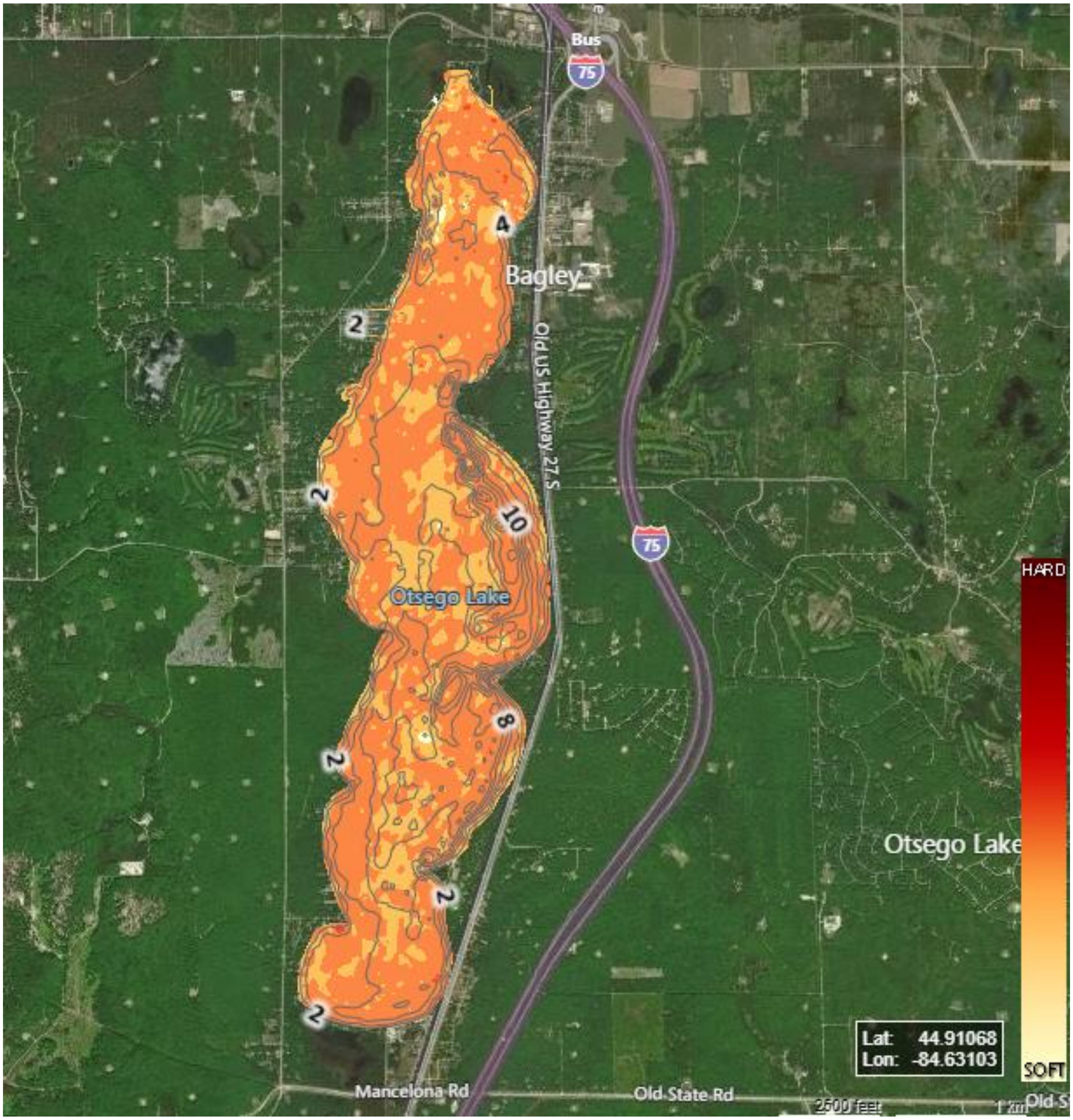


Figure 1. Otsego Lake 2021 sediment relative bottom hardness Map. Note: The north end of the lake still contains abundant muck; however, the new mapping algorithm shows more consolidation.

2.0 2021 OTSEGO LAKE WATER QUALITY

Water quality is highly variable among Michigan's inland lakes, although some characteristics are common among particular lake classification types. The water quality of Otsego Lake is affected by both land use practices and climatic events. Climatic factors (i.e. spring runoff, heavy rainfall) may alter water quality in the short term; whereas, anthropogenic (man-induced) factors (i.e. shoreline development, lawn fertilizer use) alter water quality over longer time periods. Since many lakes have a fairly long hydraulic residence time, the water may remain in the lake for years and is therefore sensitive to nutrient loading and pollutants. Furthermore, lake water quality helps to determine the classification of particular lakes (Table 2). Lakes that are high in nutrients (such as phosphorus and nitrogen) and chlorophyll-*a*, and low in transparency are classified as eutrophic; whereas those that are low in nutrients and chlorophyll-*a*, and high in transparency are classified as oligotrophic. Lakes that fall in between these two categories are classified as mesotrophic. Otsego Lake is classified as a meso-eutrophic (moderately nutrient-rich) lake due to the low to moderate nutrients, low to moderate Secchi transparency, and low to moderate chlorophyll-a concentrations.

Table 2. General Lake Trophic Status Classification.

Lake Trophic Status	*Total Phosphorus ($mg\ L^{-1}$)*	*Chlorophyll-a ($\mu g\ L^{-1}$)*	*Secchi Transparency (feet)*
Oligotrophic	< 0.010	< 2.2	> 15.0
Mesotrophic	0.010-0.025	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 0.025	> 6.0	< 7.5

2.1 Water Quality Parameters

Water quality parameters were measured on September 10, 2021 and included dissolved oxygen (in mg/L), water temperature (in °C), specific conductivity (mS/cm), turbidity (NTU's), total suspended solids (mg/L), total dissolved solids (mg/L), pH (S.U.), total alkalinity (mg $CaCO_3$/L), total phosphorus (in mg/L), total Kjeldahl nitrogen (in mg/L), chlorophyll-a (in µg/L), and Secchi transparency (in feet). All of these parameters respond to changes in water quality and consequently serve as indicators of change. The deep basin results are discussed below and are presented in Tables 3-8. A map showing the sampling locations for all water quality samples is shown below in Figure 2.

All water samples and readings were collected at the three deepest basins on September 10, 2021 with the use of a Van Dorn horizontal water sampler and calibrated Eureka Manta II® multi-meter probe with parameter electrodes, respectively. All samples were collected with new bottles, placed on ice, and taken to a NELAC (EPA)-certified laboratory for analysis. Turbidity was measured with a calibrated Lutron® turbidity meter and chlorophyll-a was measured in situ with a calibrated Turner Designs® fluorimeter. Whenever possible, historical data comparisons were made for certain parameters that utilized similar periods and methods as those used in this study. Water quality data in the same deep basins and using the same EPA methods was scarce but comparisons were made when possible.

For information on Otsego Lake water levels, daily water level data can be found online at the following USGS website:
https://waterdata.usgs.gov/mi/nwis/uv/?site_no=445512084415301&PARAmeter_cd=00065,62615

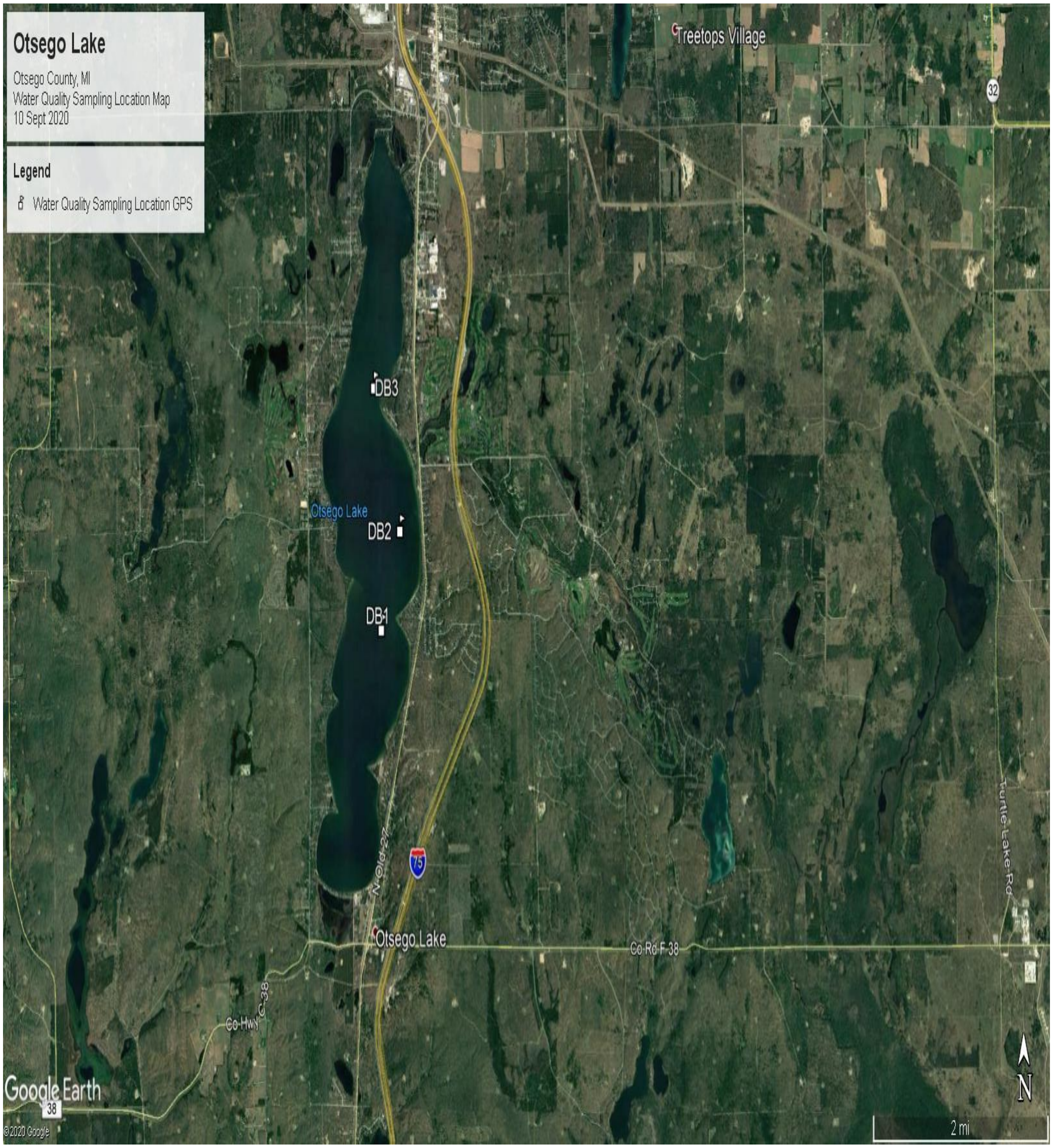
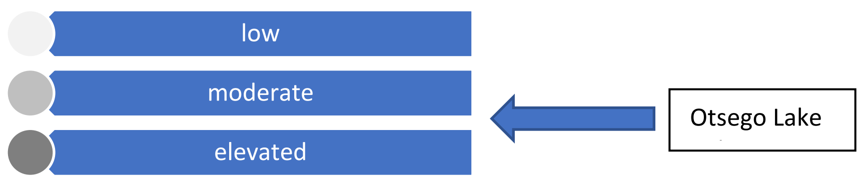


Figure 2. Locations for deep basin water quality sampling in Otsego Lake (September 10, 2021).

2.1.1 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 and even higher around 6 mg/L for trout. 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. Dissolved oxygen (DO) concentrations in the deep basins ranged from 6.2-8.8 mg/L on September 10, 2021, with the highest values measured at the surface and lowest values near the lake bottom. The bottom of the lake produces a biochemical oxygen demand (BOD) due to microbial activity attempting to break down high quantities of organic plant matter, which reduces dissolved oxygen in the water column at depth. Furthermore, the lake bottom is distant from the atmosphere where the exchange of oxygen occurs. A decline in the dissolved oxygen concentrations to near zero may result in an increase in the release rates of phosphorus (P) from lake bottom sediments. All of the deep basins experienced some loss of DO with depth, but Deep Basin #3 experienced the least depletion. A previous study by the MDNR (2008) determined the surface to bottom DO concentrations to range from 9.8-6.2 mg/L, which are similar to the concentrations measured during this evaluation.



2.1.2 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" (Figure 3). In general, shallow lakes will not stratify and deeper lakes may experience single or multiple turnover cycles. Water temperature was measured in degrees Celsius (ºC) with the use of a calibrated Eureka Manta II® submersible thermometer. The September 10, 2021 water temperatures of Otsego Lake demonstrated a lack of thermoclines and are indicative of a continually mixed (polymictic) lake that mixes multiple times per year due to the overall shallow depths.

On the day of sampling, water temperatures ranged from 17.0°C at the surface to 15.9°C at the bottom of the three deep basins. The MDNR (2008) study also reported the lack of a thermocline. Deep basin #1 exhibited the most difference with a water temperature difference of 1.1°C.

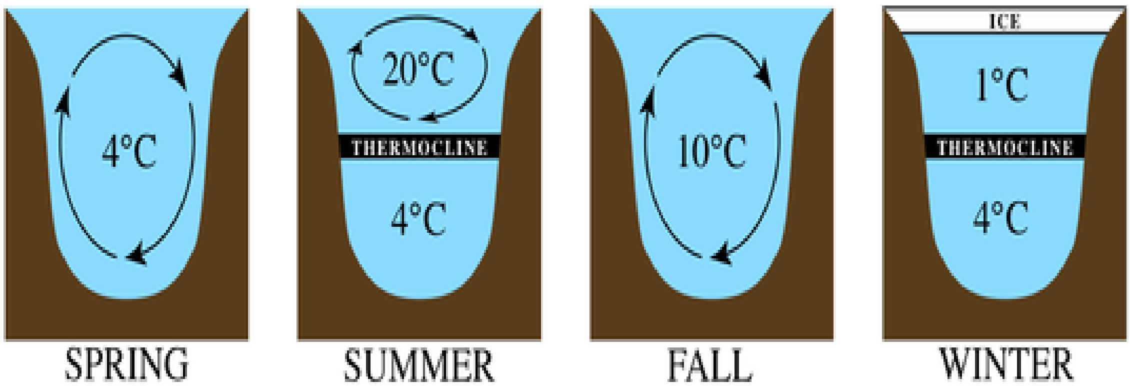
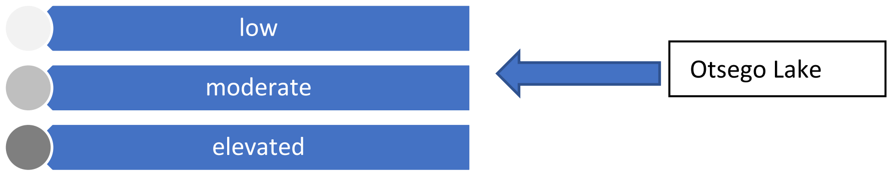


Figure 3. The lake thermal stratification process.

2.1.3 Specific Conductivity

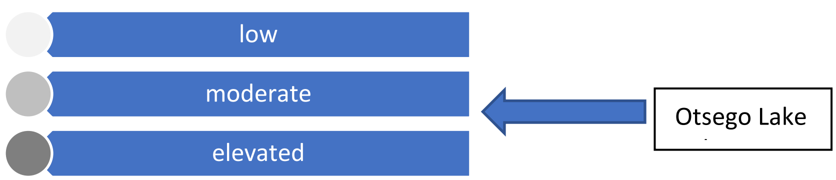
Specific conductivity is a measure of the number of mineral ions present in the water, especially those of salts and other dissolved inorganic substances that can conduct an electrical current. Specific conductivity generally increases with water temperature and the amount of dissolved minerals and salts in a lake. Specific conductivity was measured in micro Siemens per centimeter (µS/cm) with the use of a calibrated Eureka Manta II® specific conductivity probe and meter. Specific conductivity values for Otsego Lake were variable among depths at the deep basins on September 10, 2021 and ranged from 220-250 mS/cm which are low values. The highest specific conductivity values were recorded in deep basin #3 which had the highest specific conductivity at the lake bottom of 250 mS/cm. Since these values are moderate for an inland lake, the lake water contains ample dissolved metals and ions such as calcium, potassium, sodium, chlorides, sulfates, and carbonates. Baseline parameter data such as specific conductivity are important to measure the possible influences of land use activities (i.e. road salt influences) on Otsego Lake over a long period of time, or to trace the origin of a substance to the lake in an effort to reduce pollutant loading. Elevated conductivity values over 800 mS/cm can negatively impact aquatic life.



2.1.4 Turbidity, Total Dissolved Solids, and Total Suspended Solids

Turbidity

Turbidity is a measure of the loss of water transparency due to the presence of suspended particles. The turbidity of water increases as the number of total suspended particles increases. Turbidity may be caused by erosion inputs, phytoplankton blooms, storm water discharge, urban runoff, re-suspension of bottom sediments, and by large bottom-feeding fish such as carp. Particles suspended in the water column absorb heat from the sun and raise water temperatures. Since higher water temperatures generally hold less oxygen, shallow turbid waters are usually lower in dissolved oxygen. Turbidity was measured in Nephelometric Turbidity Units (NTU's) with the use of a calibrated Lutron® turbidity meter. The World Health Organization (WHO) requires that drinking water be less than 5 NTU's; however, recreational waters may be significantly higher than that. The turbidity of Otsego Lake was moderate and ranged from 3.0-7.0 NTU's during the September 10, 2021 sampling event. On the day of sampling, the winds were calm in the morning, and turbidity was not likely influenced by much re-suspension of sediments although bottom samples are usually higher in turbidity due to fine particle re-suspension.



Total Dissolved Solids

Total dissolved solids (TDS) is a 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 TDS in Otsego Lake on September 10, 2021 ranged from 140-156 mg/L for the deep basins which is moderate for an inland lake and correlates with the measured moderate conductivity.

2.1.5 pH

pH is a measure of acidity or basicity of water. pH was measured with a calibrated Eureka Manta II® pH electrode and pH-meter in Standard Units (S.U). The standard pH scale ranges from 0 (acidic) to 14 (alkaline), with neutral values around 7. Most Michigan lakes have pH values that range from 7.0 to 9.5 S.U. 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). The pH of Otsego Lake water ranged from 8.0-8.3 S.U. during the September 10, 2021 sampling event. This range of pH is neutral to slightly alkaline on the pH scale and is ideal for an inland lake and is similar to the value of 8.4 S.U. recorded by the MDNR in 2007. pH tends to rise when abundant aquatic plants are actively growing through photosynthesis or when abundant marl deposits are present.

2.1.6 Total Alkalinity

Total alkalinity is a measure of the pH-buffering capacity of lake water. Lakes with high alkalinity (> 150 mg/L of $CaCO_3$) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of $CaCO_3$ and are categorized as having "hard" water. Total alkalinity was measured in milligrams per liter of $CaCO_3$ through the acid titration Method SM 2320 B-11.

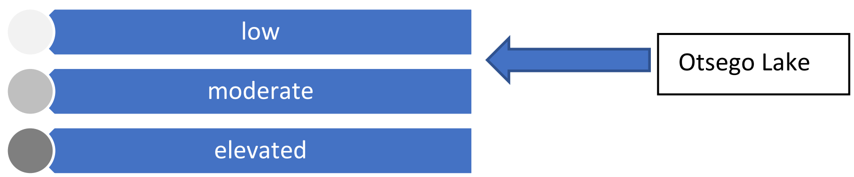
Total alkalinity in the deep basins ranged from 66-71 mg/L of $CaCO_3$ during the September 10, 2021 sampling event, which represents a moderately low alkalinity (slightly soft water) and may be a characteristic of the lake sediments and geology. Total alkalinity may change on a daily basis due to the re-suspension of sedimentary deposits in the water and respond to seasonal changes due to the cyclic turnover of the lake water. This range of total alkalinity was similar to those previously measured by the MDNR (2009) and U of M (1980).

2.1.7 Total Phosphorus

Total Phosphorus

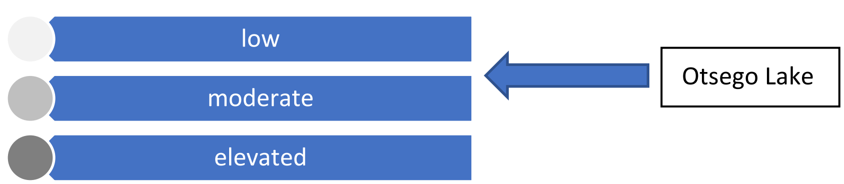
Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. Lakes which contain greater than 0.020 mg/L (or 20 µg/L) of TP are defined as eutrophic or nutrient-enriched.

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 total phosphorus (TP) concentrations in the lake deep basins ranged from 0.010-0.020 mg/L during the September 10, 2021 sampling event. The highest concentration was measured near the bottom of all deep basins, but these values are still considered below the eutrophic threshold. Surface water TP concentrations are almost always lower than middle and bottom depth concentrations.



2.1.8 Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen is the sum of organic nitrogen and ammonia (NH_3^+), nitrogen forms in freshwater systems. TKN was measured with Method EPA 351.2 (Rev. 2.0). 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, which is correct for Otsego Lake. 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. Otsego Lake contained low concentrations of TKN at all depths (≤0.5-1.0 mg/L), which is normal for an inland lake of similar size and favorable. In the absence of dissolved oxygen, nitrogen is usually in the ammonia form and will contribute to rigorous submersed aquatic plant growth if adequate water transparency is present.

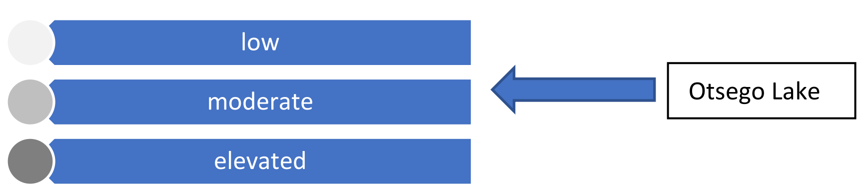


2.1.9 Chlorophyll-a and Algal Communities

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 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.

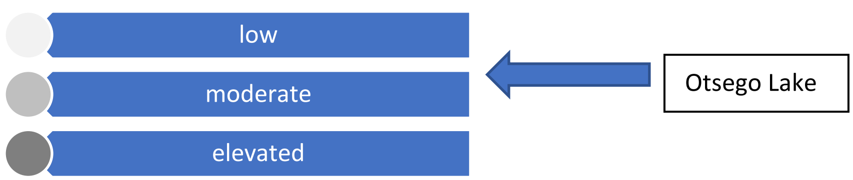
Chlorophyll-*a* was measured in micrograms per liter (µg/L) with Method SM 10200H. The chlorophyll-*a* concentrations in Otsego Lake were determined by collecting a composite sample of the algae throughout the water column at the deep basin sites from just above the lake bottom to the lake surface. The chlorophyll-*a* concentrations in the deep basins ranged from 2.0-4.0 µg/L during the September 10, 2021 sampling event. These concentrations were favorable and are within the previously reported ranges from MDNR (2009) and U of M (1980). Chlorophyll-a concentrations may significantly fluctuate with changes in air and water temperatures and with storm-driven runoff.

Algal genera from a composite water sample collected from the deep basins of Otsego Lake were analyzed under a Zeiss® compound brightfield microscope. The genera present included the Chlorophyta (green algae): *Chlorella* sp., *Scenedesmus* sp., *Cosmarium* sp., *Rhizoclonium* sp., *Spirogyra* sp., *Mougeotia* sp., *Staurastrum* sp., *Botryococcus* sp., and *Pediastrum* sp.; the Cyanophyta (blue-green algae): *Microcystis* sp., *Dichlicospermum* sp., *Chroococcus* sp., and *Oscillatoria* sp; the Bascillariophyta (diatoms): *Navicula* sp., *Synedra* sp., *Fragilaria* sp., *Tabellaria* sp., and *Cymbella* sp., and; the Chrysophyta (golden algae) *Dinobryon* sp. The aforementioned species indicate a moderately diverse algal flora and represent a relatively balanced freshwater ecosystem, capable of supporting a strong zooplankton community in favorable water quality conditions. The green algae and diatoms were the most abundant, followed by the blue-green algae. Algal blooms, including blue-green algae have been historically reported on Otsego Lake with time (U of M study, 1980; MDNR, 2009).



2.1.10 Secchi Transparency

Secchi transparency is a measure of the clarity or transparency of lake water, and is measured with the use of an 8-inch diameter standardized Secchi disk. Secchi disk transparency is measured in feet (ft.) or meters (m) by lowering the disk over the shaded side of a boat around noon and taking the mean of the measurements of disappearance and reappearance of the disk (Figure 4). Elevated Secchi transparency readings allow for more aquatic plant and algae growth. Eutrophic systems generally have Secchi disk transparency measurements less than 7.5 feet due to turbidity caused by excessive planktonic algae growth. The Secchi transparency of Otsego Lake was measured on September 10, 2021 and ranged from 7.5-8.0 feet over the deep basins which are fair measurements. Measurements were collected during calm conditions. This transparency indicates a moderate quantity of suspended particles and algae throughout the water column which would result in reduced water clarity. Secchi transparency is variable and depends on the amount 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. Secchi transparency has fluctuated throughout time and ranged from 9.0-14.8 feet (U of M study 1980; MDNR, 2008) and is likely correlated with lake use and wind and storm events as well as the concentrations of algae and solids.



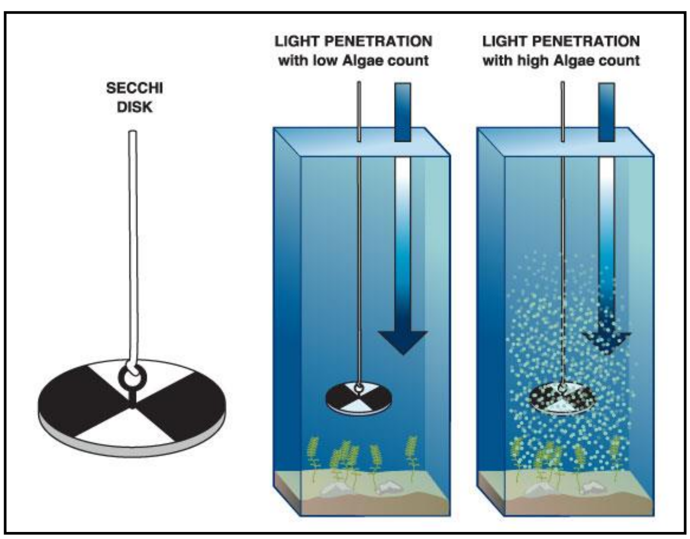


Figure 4. Measurement of water transparency with a Secchi disk.

Table 3. Otsego Lake physical water quality parameter data collected in deep basin #1 (September 10, 2021).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Turb. (NTU)	Secchi Depth (ft)
0	17.0	8.8	8.3	229	144	4.0	8.0
0.5	17.0	8.8	8.3	229	144	4.0	
1.0	16.9	8.8	8.3	229	144	5.0	
1.5	16.9	8.8	8.3	227	142	5.0	
2.0	16.9	8.8	8.2	227	142	5.0	
2.5	16.9	8.4	8.2	227	142	5.0	
3.0	16.9	8.0	8.2	227	142	6.0	
3.5	16.6	8.0	8.2	227	142	6.0	
4.0	16.6	7.8	8.2	227	142	6.0	
4.5	16.3	7.5	8.2	230	145	6.0	
5.0	16.2	7.5	8.1	230	145	6.0	
5.5	16.1	6.9	8.0	230	145	6.0	
6.0	15.9	6.9	8.0	240	151	7.0	

Table 4. Otsego Lake chemical water quality parameter data collected in deep basin #1 (September 10, 2021).

Depth (m)	TKN (mg/L)	TP (mg/L)	Chl-a (µg/L)	Talk (mg/L)
0	0.5	0.010	2.0	71
3.0	0.5	0.017	--	71
6.0	1.0	0.020	--	69

Table 5. Otsego Lake physical water quality parameter data collected in deep basin #2 (September 10, 2021).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Turb. (NTU)	Secchi Depth (ft)
0	16.9	8.7	8.2	220	140	4.0	7.8
0.5	16.9	8.7	8.2	220	140	4.0	
1.0	16.9	8.7	8.2	220	140	5.0	
1.5	16.9	8.6	8.2	222	142	5.0	
2.0	16.9	8.4	8.2	222	142	5.0	
2.5	16.9	7.9	8.1	239	151	5.0	
3.0	16.8	6.9	8.0	240	151	5.0	
3.5	16.8	6.2	8.0	240	151	5.0	

Table 6. Otsego Lake chemical water quality parameter data collected in deep basin #2 (September 10, 2021).

Depth (m)	TKN (mg/L)	TP (mg/L)	Chl-a (µg/L)	Talk (mg/L)
0	<0.5	0.010	3.0	67
1.5	<0.5	0.010	--	67
3.0	1.0	0.020	--	67

Table 7. Otsego Lake physical water quality parameter data collected in deep basin #3 (September 10, 2021).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Turb. (NTU)	Secchi Depth (ft)
0	16.8	8.7	8.3	221	141	3.0	7.5
0.5	16.8	8.7	8.3	221	141	3.0	
1.0	16.8	8.7	8.3	221	141	4.0	
1.5	16.8	8.5	8.3	221	141	4.0	
2.0	16.8	8.5	8.3	221	141	4.0	
2.5	16.6	8.5	8.2	230	145	5.0	
3.0	16.4	8.3	8.1	230	144	6.0	
3.5	16.4	8.3	8.0	230	144	6.0	
4.0	16.1	8.3	8.0	250	156	7.0	

Table 8. Otsego Lake chemical water quality parameter data collected in deep basin #3 (September 10, 2021).

Depth (m)	TKN (mg/L)	TP (mg/L)	Chl-a (µg/L)	Talk (mg/L)
0	<0.5	0.010	4.0	67
2.0	0.5	0.010	--	67
4.0	0.5	0.020	--	66

3.0 2021 OTSEGO LAKE AQUATIC VEGETATION

3.1 Otsego Lake Aquatic Vegetation Communities

Aquatic plants (macrophytes) are an essential component in the littoral zones of most lakes in that they serve as suitable habitat and food for macroinvertebrates, contribute oxygen to the surrounding waters through photosynthesis, stabilize bottom sediments (if in the rooted growth form), and contribute to the cycling of nutrients such as phosphorus and nitrogen upon decay. In addition, decaying aquatic plants contribute organic matter to lake sediments which further supports healthy growth of successive aquatic plant communities that are necessary for a balanced aquatic ecosystem. An overabundance of aquatic vegetation may cause organic matter to accumulate on the lake bottom faster than it can break down. Aquatic plants generally consist of rooted submersed, free-floating submersed, floating-leaved, and emergent growth forms. The emergent growth form (i.e., Cattails, Native Loosestrife) is critical for the diversity of insects onshore and for the health of nearby wetlands. Submersed aquatic plants can be rooted in the lake sediment (i.e., Milfoils, Pondweeds), or free-floating in the water column (i.e., Coontail). Nonetheless, there is evidence that the diversity of submersed aquatic macrophytes can greatly influence the diversity of macroinvertebrates associated with aquatic plants of different structural morphologies (Parsons and Matthews, 1995). Therefore, it is possible that declines in the biodiversity and abundance of submersed aquatic plant species and associated macroinvertebrates, could negatively impact the fisheries of inland lakes. Alternatively, the overabundance of aquatic vegetation can compromise recreational activities, aesthetics, and property values. Otsego Lake currently has a favorable quantity of submersed aquatic vegetation but there are still many areas of the lake that lack aquatic vegetation and thus preservation of native aquatic plants is important.

A whole-lake scan of the aquatic vegetation biovolume in Otsego Lake was conducted on July 22-23, 2021 with a WAAS-enabled Lowrance HDS 9® GPS with variable frequency transducer. This data included 20,392 GPS data sounding points which were uploaded to a cloud software program to reveal maps that displayed depth contours, sediment hardness, and aquatic vegetation biovolume (Figure 5). On the biovolume scan map, the color blue refers to areas that lack vegetation. The color green refers to low-lying vegetation. The colors red/orange refer to tall-growing vegetation. There are many areas around the littoral (shallow) zone of the lake that contain low-growing plants like Chara or Naiad. For this reason, the scans are conducted in conjunction with a whole lake GPS Point Intercept survey to account for individual species identification of all aquatic plants in the lake. Table 9 shows the biovolume categories by plant cover on July 22-23, 2021.

The GPS Point Intercept survey is sometimes used with an Aquatic Vegetation Assessment Site (AVAS) Survey method to assess the relative abundance of submersed, floating-leaved, and emergent aquatic vegetation within and around the littoral zones of inland lakes.

With this survey method, the littoral zone areas of the lakes are divided into lakeshore sections approximately 100 - 300 feet in length. Each AVAS segment is sampled using visual observation, dependent on water clarity, and weighted rake tows to verify species identification. The species of aquatic macrophytes present and density of each macrophyte are recorded onto an AVAS data sheet. Each separate plant species found in each AVAS segment is recorded along with an estimate of each plant density. Each macrophyte species corresponds to an assigned number. There are designated density codes for the aquatic vegetation surveys, where a = found (occupying < 2% of the surface area of the lake), b = sparse (occupying 2-20% of the surface area of the lake), c = common, (occupying 21-60% of the surface area of the lake), and d = dense (occupying > 60% of the surface area of the lake). In addition to the particular species observed (via assigned numbers), density information above was used to estimate the percent cumulative coverage of each species within the AVAS site. Where shallow areas were present in the open waters of the lake, individual AVAS segments were sampled at those locations to assess the macrophyte communities in offshore locations. This is particularly important since exotics often expand in shallow island areas located offshore in many lakes.

The GPS Point-Intercept/AVAS survey of Otsego Lake was conducted on July 22-23, 2021 and consisted of 1,304 sampling locations around the littoral zone (Figure 6). Data were placed in a table showing the relative abundance of each aquatic plant species found and a resultant calculation showing the frequency of each plant. The majority of the lake contained low-growing aquatic plants that were within the 0-20% cover category (a total of 91.9% of the lake area).

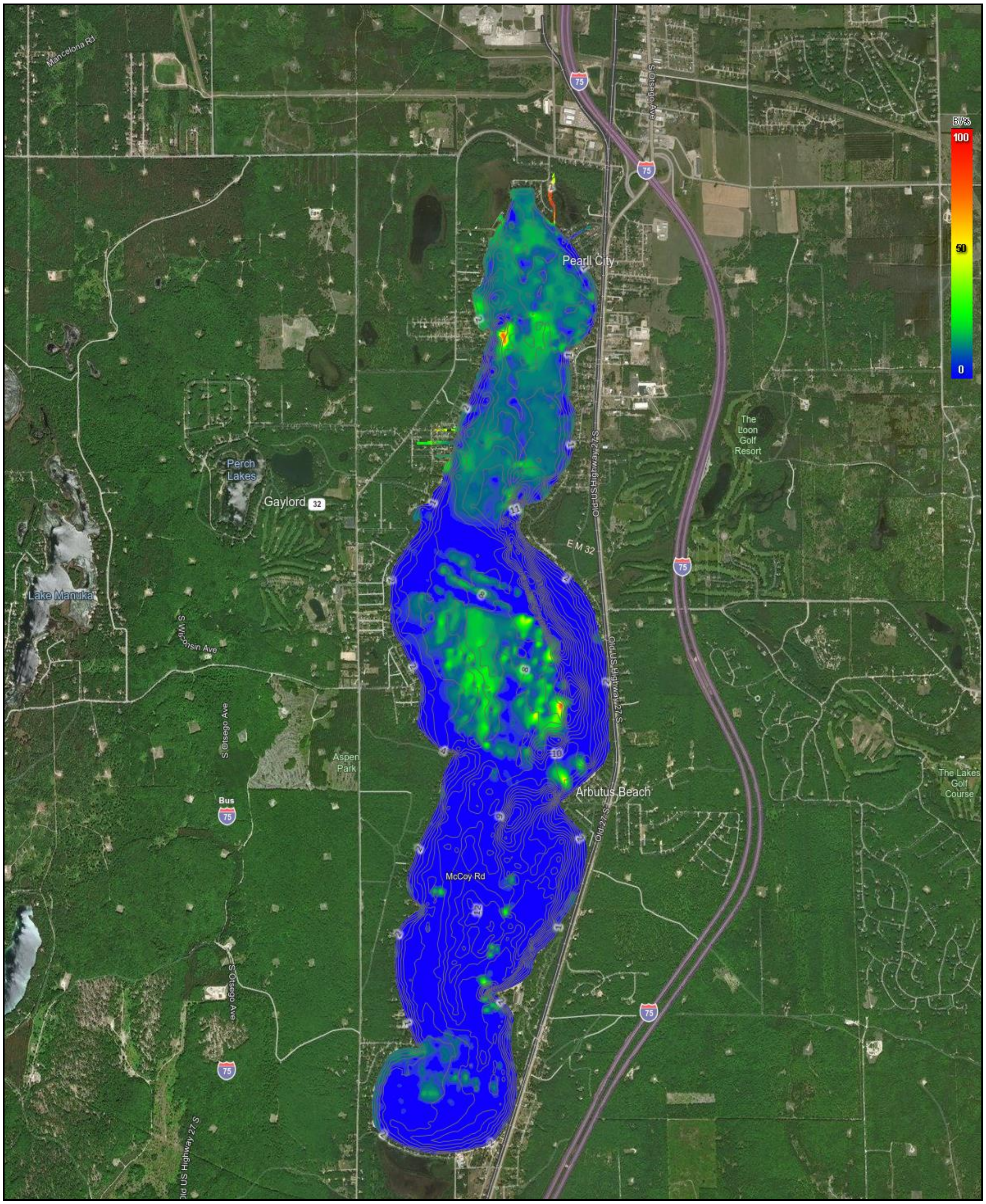


Figure 5. Aquatic plant biovolume of all aquatic plants in Otsego Lake, Otsego County, Michigan (July 22-23, 2021). Note: Red color denotes high-growing aquatic plants, green color denoted low-growing aquatic plants, and blue color represents a lack of aquatic vegetation.

Table 9. Otsego Lake aquatic vegetation biovolume by bottom cover category (relative cover on July 22-23, 2021).

Aquatic Vegetation Biovolume Cover Category	% Relative Cover of Bottom by Category 2021
0-20%	91.9
20-40%	5.5
40-60%	0.7
60-80%	0.0
>80%	2.0

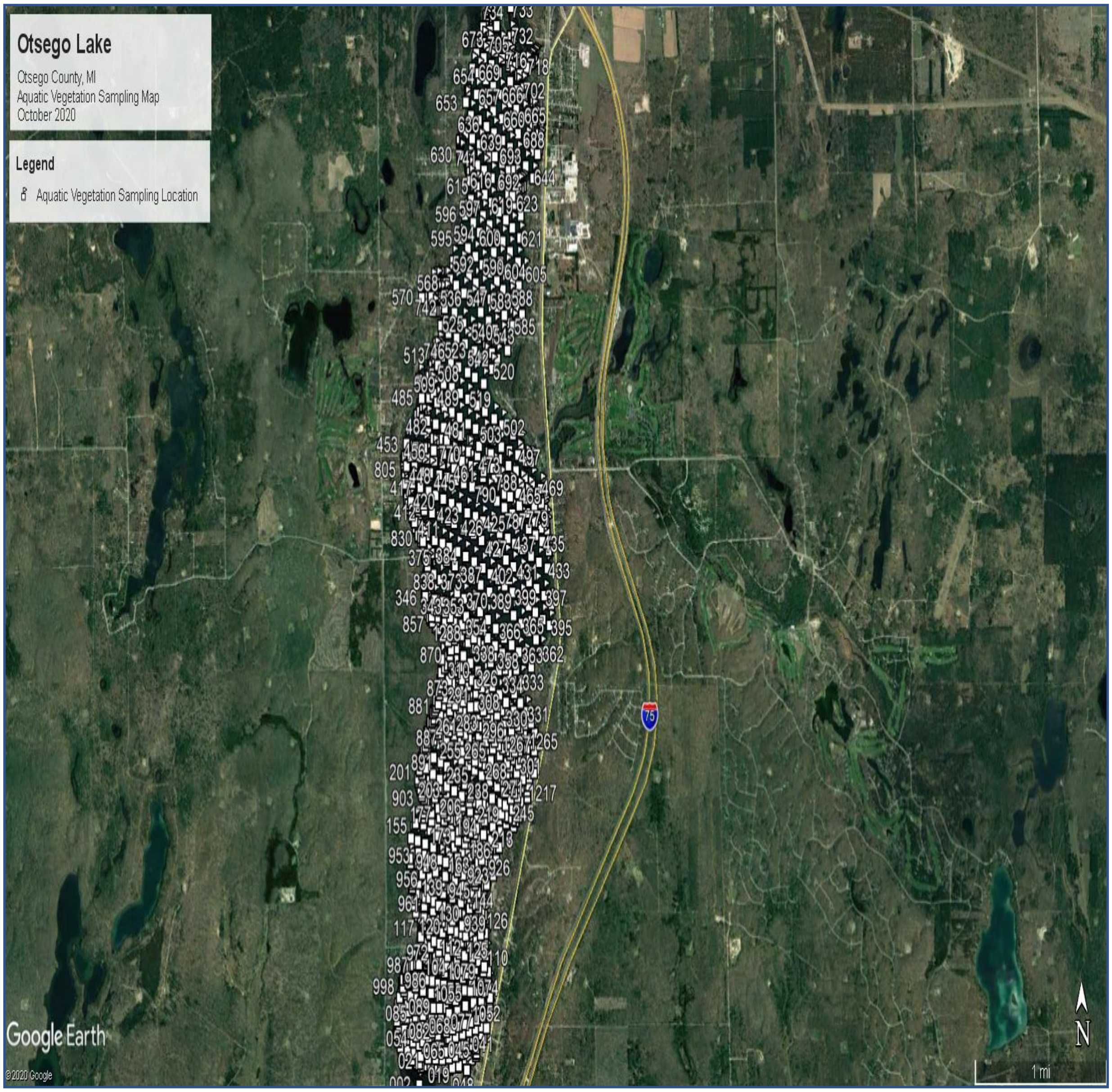


Figure 6. Aquatic vegetation sampling locations in Otsego Lake (July 22-23, 2021).

3.1.1 Otsego Lake Native Aquatic Macrophytes

There are hundreds of native aquatic plant species in the waters of the United States. The most diverse native genera include the Potamogetonaceae (Pondweeds) and the Haloragaceae (Milfoils). Native aquatic plants may grow to nuisance levels in lakes with abundant nutrients (both water column and sediment) such as phosphorus, and in sites with high water transparency. The diversity of native aquatic plants is essential for the balance of aquatic ecosystems because each plant harbors different macroinvertebrate communities and varies in fish habitat structure.

Otsego Lake contained 17 native submersed, 2 floating-leaved, and 5 emergent aquatic plant species, for a total of 24 native aquatic macrophyte species (Table 10). Relative abundance for each aquatic plant species is shown in Table 11. Photos of all native aquatic plants are shown below in Figures 12-35. The emergent macrophytes were found along the shoreline areas of the lake. The rare emergent Wild Rice (*Zizania aquatica*) was found in a few areas of the lake and should be protected. Additionally, the lower-growing species were found throughout the littoral zone and the higher-growing pondweeds were present in the deeper waters of the littoral zone where they were protected from wave action.

The dominant aquatic plants in the main part of the lake included the Clasping-leaf Pondweed (13.7% of the sampling locations), the macro alga Chara (5.9 % of the sampling locations), and the floating-leaved White Waterlily (4.1% of the sampling locations). The pondweeds grow tall in the water column and serve as excellent fish cover. Protection of all native aquatic plant species is critical for the lake ecosystem especially since the relative abundance is overall low for most native aquatic plant species.

The relative abundance of rooted aquatic plants (relative to non-rooted plants) in the lake suggests that the sediments are the primary source of nutrients (relative to the water column) since these plants obtain most of their nutrition from the sediments.

Table 10. Otsego Lake native aquatic vascular plants and frequency (July 22-23, 2021).

Native Aquatic Plant Species Name	*Native Aquatic Plant Common Name*	*Growth Form*	*% Frequency*
Chara vulgaris	Muskgrass	Submersed	5.9
Stuckenia pectinatus	Sago Pondweed	Submersed	1.8
Potamogeton zosteriformis	Flat-stem Pondweed	Submersed	0.2
Potamogeton robbinsii	Fern-leaf Pondweed	Submersed	0.8
Potamogeton illinoensis	Illinois Pondweed	Submersed	1.5
Potamogeton richardsonii	Clasping-leaf Pondweed	Submersed	13.7
Potamogeton natans	Floating-leaf Pondweed	Submersed	0.6
Potamogeton praelongus	White-stem Pondweed	Submersed	0.4
Potamogeton amplifolius	Large-leaf Pondweed	Submersed	2.2
Myriophyllum sibiricum	Northern Watermilfoil	Submersed	3.4
Zosterella dubia	Water Stargrass	Submersed	0.2
Elodea canadensis	Common Waterweed	Submersed	1.2
Utricularia vulgaris	Bladderwort	Submersed	1.1
Utricularia minor	Mini Bladderwort	Submersed	0.2
Vallisneria americana	Wild Celery	Submersed	2.7
Najas guadalupensis	Southern Naiad	Submersed	1.2
Najas flexilis	Slender Naiad	Submersed	1.6
Nymphaea odorata	White Waterlily	Floating-Leaved	4.1
Nuphar advena	Yellow Waterlily	Floating-Leaved	0.2
Schoenoplectus acutus	Bulrushes	Emergent	1.7
Pontedaria cordata	Pickerelweed	Emergent	0.2
Typha latifolia	Cattails	Emergent	0.4
Eleocharis sp.	Spikerush	Emergent	0.5
Zizania aquatica	Wild Rice	Emergent	0.7

Table 11. Otsego Lake native aquatic vascular plants and relative abundance (July 22-23, 2021).

Native Aquatic Plant Species Name	***"a" Level***	***"b" Level***	***"c" Level***	***"d" Level***
Chara vulgaris	65	8	2	2
Stuckenia pectinatus	19	2	1	1
Potamogeton zosteriformis	1	1	1	0
Potamogeton robbinsii	3	6	1	0
Potamogeton illinoensis	9	9	1	0
Potamogeton richardsonii	105	33	18	23
Potamogeton natans	1	3	3	1
Potamogeton praelongus	2	2	1	0
Potamogeton amplifolius	19	6	4	0
Myriophyllum sibiricum	29	11	3	1
Zosterella dubia	1	0	1	0
Elodea canadensis	8	3	1	3
Utricularia vulgaris	5	7	2	0
Utricularia minor	2	0	0	0
Vallisneria americana	31	3	1	0
Najas guadalupensis	8	5	1	1
Najas flexilis	17	4	0	0
Nymphaea odorata	32	19	2	1
Nuphar advena	2	1	0	0
Schoenoplectus acutus	9	13	0	0
Pontedaria cordata	2	1	0	0
Typha latifolia	3	1	1	0
Eleocharis sp.	5	2	0	0
Zizania aquatica	5	3	1	0

Figure 7. Chara (Muskgrass)

Figure 8. Sago Pondweed

Figure 9. Flat-stem Pondweed

Figure 10. Fern-leaf Pondweed

Figure 11. Illinois Pondweed

Figure 12. Clasping-Leaf Pondweed

Figure 13. Floating-leaf Pondweed

Figure 14. White-stem Pondweed

Figure 15. Large-leaf Pondweed

Figure 16. Northern Watermilfoil

Figure 17. Water Stargrass

Figure 18. Common Waterweed (Elodea)

Figure 19. Common Bladderwort

Figure 20. Mini Bladderwort

Figure 21. Wild Celery

Figure 22. Slender Naiad

Figure 23. Southern Naiad

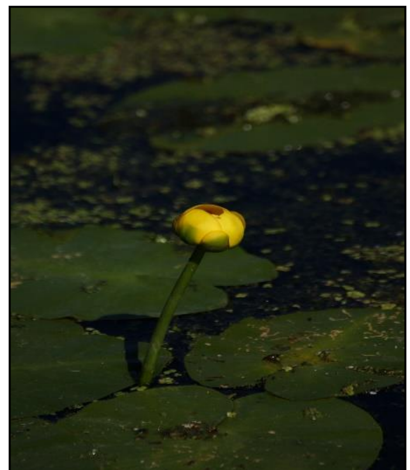


Figure 24. Yellow Waterlily

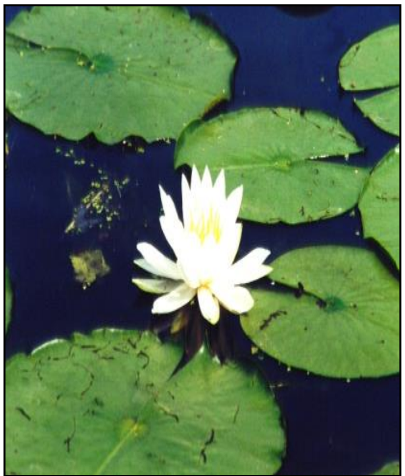


Figure 25. White Waterlily

Figure 26. Cattails

Figure 27. Spikerush

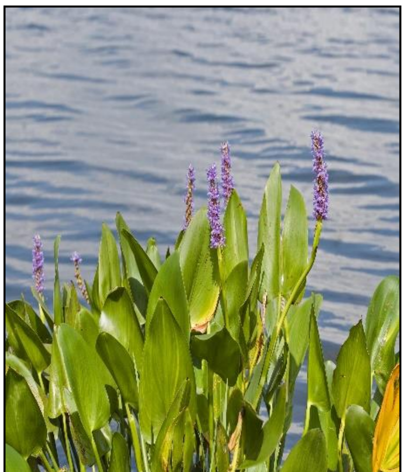


Figure 28. Pickerelweed

Figure 29. Bulrushes

Figure 30. Wild Rice

3.1.2 Otsego Lake Exotic Aquatic Macrophytes

Exotic aquatic plants (macrophytes) are not native to a particular site and are introduced by some biotic (living) or abiotic (non-living) vector. Such vectors include the transfer of aquatic plant seeds and fragments by boats and trailers (especially if the lake has public access sites), waterfowl, or by wind dispersal. In addition, exotic species may be introduced into aquatic systems through the release of aquarium or water garden plants into a water body. An aquatic exotic species may have profound impacts on the aquatic ecosystem. Eurasian Watermilfoil (*Myriophyllum spicatum*; Figure 31) is an exotic aquatic macrophyte first documented in the United States in the 1880's (Reed 1997), although other reports (Couch and Nelson 1985) suggest it was first found in the 1940's.

In recent years, this species has hybridized with native milfoil species to form hybrid species. Eurasian Watermilfoil has since spread to thousands of inland lakes in various states through the use of boats and trailers, waterfowl, seed dispersal, and intentional introduction for fish habitat. Eurasian Watermilfoil is a major threat to the ecological balance of an aquatic ecosystem through causation of significant declines in favorable native vegetation within lakes (Madsen et *al*. 1991), in that it forms dense canopies and may limit light from reaching native aquatic plant species (Newroth 1985; Aiken et *al*. 1979). Additionally, Eurasian Watermilfoil can alter the macroinvertebrate populations associated with particular native plants of certain structural architecture (Newroth 1985).

Approximately 1.1 acres of Eurasian Watermilfoil were found in Otsego Lake during the July 22-23, 2021 survey (Figure 32). An intensive management program is proposed below. This cover was reduced in 2021 likely due to climatic conditions which favored growth of native milfoil over Eurasian Watermilfoil. Eurasian Watermilfoil growth in Otsego Lake is capable of producing dense surface canopies in shallow areas as well as in deeper waters due to the sometimes high light penetration. In addition, it could hybridize with the native northern watermilfoil and create a highly herbicide-resistant strain.

There were approximately 0.1 acres of invasive Curly-leaf Pondweed found in a few areas at the southern region of the lake. Curly-leaf Pondweed (*Potamogeton crispus*) is an exotic, submersed, rooted aquatic plant that was introduced into the United States in 1807 but was abundant by the early 1900's. It is easily distinguished from other native pondweeds by its wavy leaf margins. It grows early in the spring and as a result may prevent other favorable native aquatic species from germinating. The plant reproduces by the formation of fruiting structures called turions. It does not reproduce by fragmentation as invasive watermilfoil does; however, the turions may be deposited in the lake sediment and germinate in following seasons. Curly-leaf Pondweed is a pioneering aquatic plant species and specializes in colonizing disturbed habitats. It is highly invasive in aquatic ecosystems with low biodiversity and unique sediment characteristics.

Lastly, approximately 2.8 acres of invasive Starry Stonewort were found only in the canals and may be treated in 2022. Starry Stonewort (*Nitellopsis obtusa*) is an invasive macro alga that has invaded many inland lakes and was originally discovered in the St. Lawrence River. The "leaves" appear as long, smooth, angular branches of differing lengths. The alga has been observed in dense beds at depths beyond several meters in clear inland lakes and can grow to heights in excess of a few meters. It prefers clear alkaline waters and has been shown to cause significant declines in water quality and fishery spawning habitat Individual fragments can be transported to the lake via waterfowl or boats. Although it prefers alkaline waters, it can thrive in most clear waters and especially in shallow canals.

The species of invasive aquatic plants present, and relative abundance of each plant were recorded and then the amount of cover in the littoral zone was calculated. Exotic aquatic plant species that were found in Otsego Lake on July 22-23, 2021 are shown in Table 12 below and discussions of key invasives also follow below. Figures 33-37 display the locations where each invasive aquatic plant was located during the survey.

Figure 31. Hybrid Eurasian Watermilfoil plant with seed head and fragments.

Figure 32. EWM found in Otsego Lake (July 23, 2021).

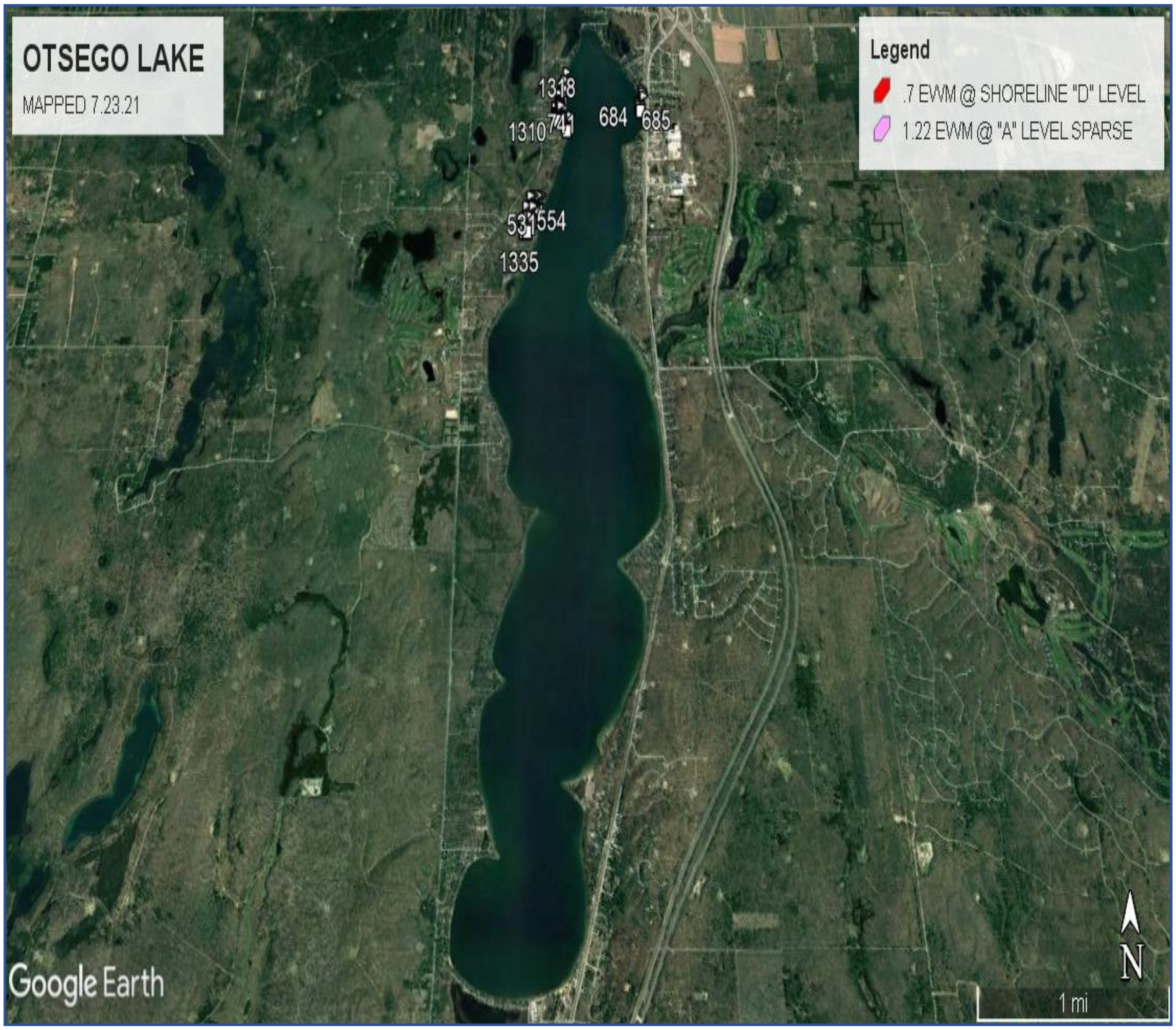


Figure 33. EWM distribution in Otsego Lake (July 23, 2021).

Figure 34. EWM distribution in Otsego Lake (July 23, 2021).

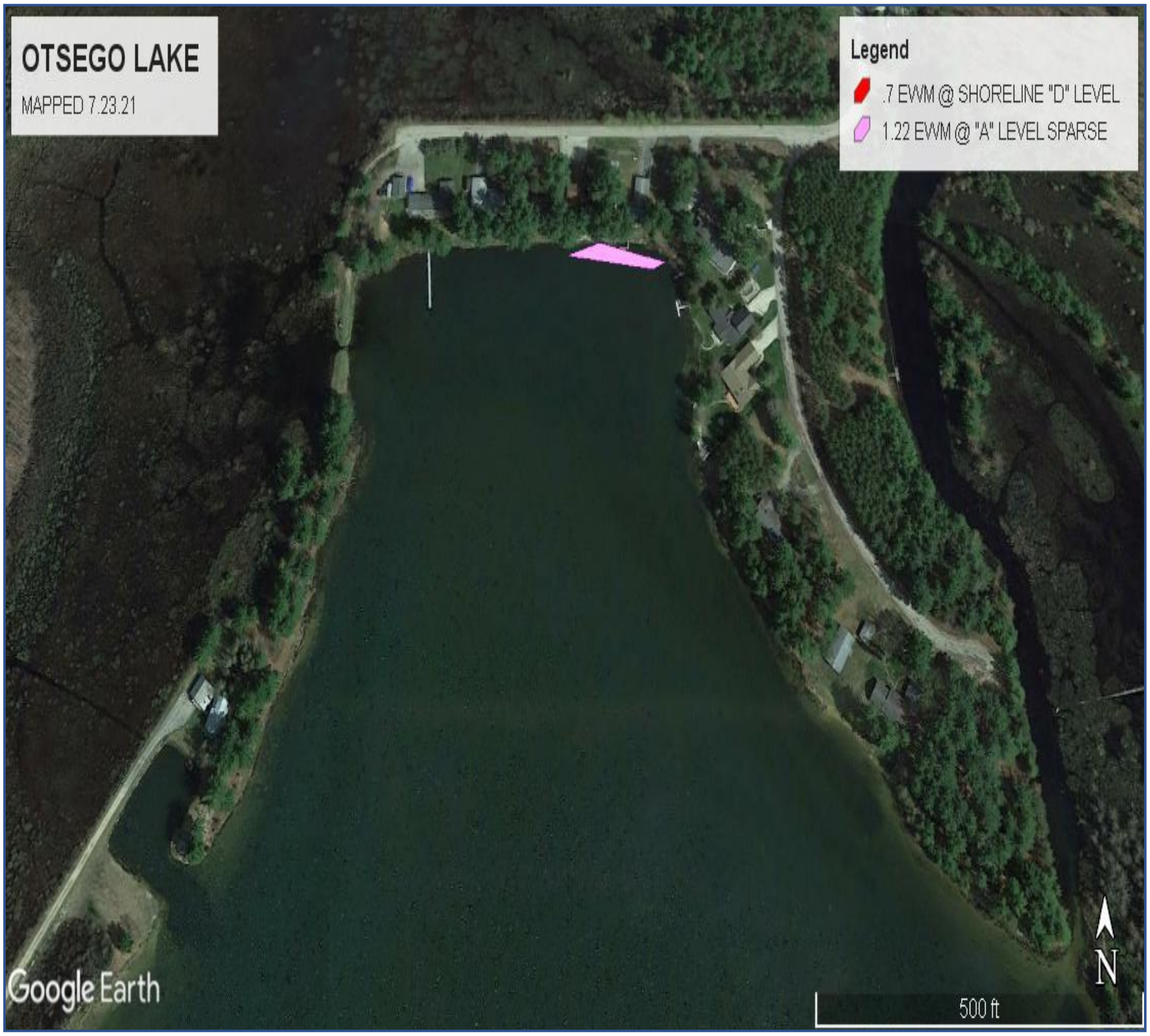


Figure 35. EWM distribution in Otsego Lake (July 23, 2021).

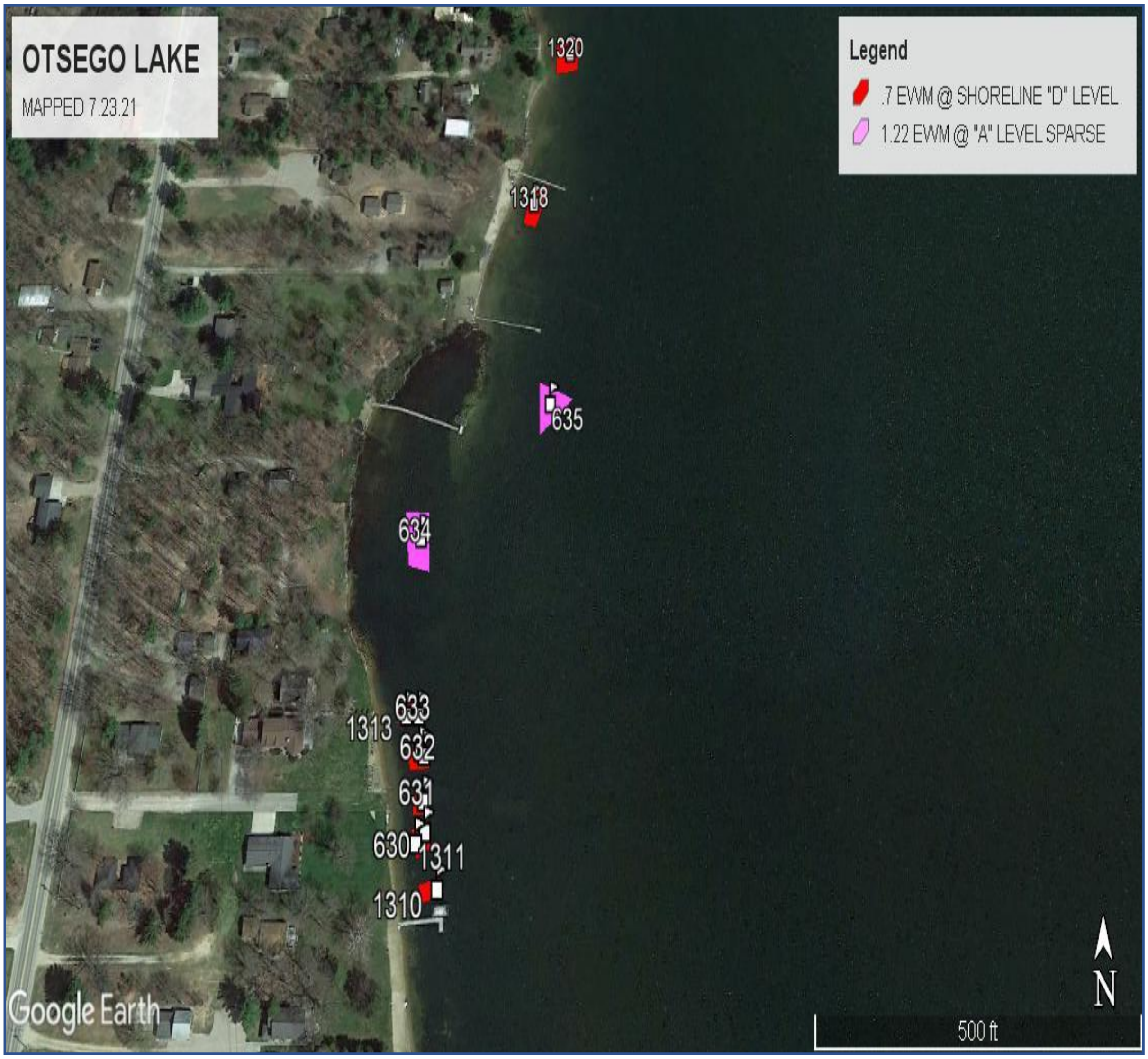


Figure 36. EWM distribution in Otsego Lake (July 23, 2021).

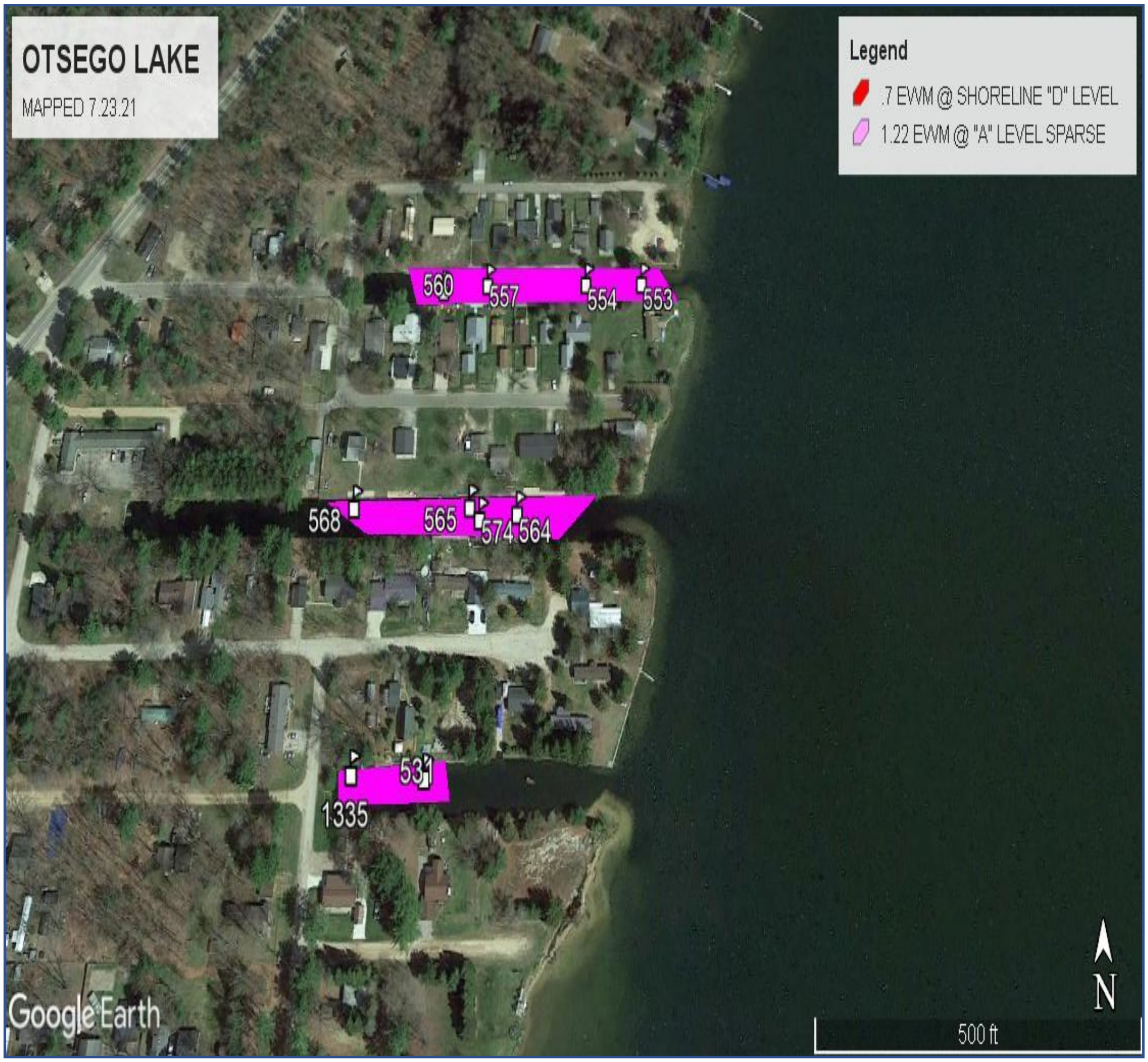


Figure 37. EWM distribution in Otsego Lake Canals (July 23, 2021).

Table 12. Otsego Lake exotic aquatic plant species (July 22-23, 2021).

Exotic Aquatic Plant Species	***Exotic Aquatic Plant Common Name***	***Exotic Aquatic Plant Growth Habit***	***Abundance in Otsego Lake***
Myriophyllum spicatum	Eurasian Watermilfoil	Rooted, Submersed	~1.1 acres
Potamogeton crispus	Curly-leaf Pondweed	Rooted, Submersed	~0.1 acres
Nitellopsis obtusa	Starry Stonewort	Rooted, Submersed	~2.8 acres

4.0 2021 OTSEGO LAKE ZOOPLANKTON

A zooplankton tow using a Wildco® pelagic plankton net (63 micrometer) with collection jar (Figure 38) was conducted by RLS scientists September 10, 2021 in the 3 deep basins of Otsego Lake. The plankton net was left at depth for 30 seconds and then raised slowly to the surface at an approximate rate of 4 feet/second. The net was then raised above the lake surface and water was splashed on the outside of the net to dislodge any zooplankton from the net into the jar. The jar was then drained into a 125-mL bottle with a CO_2 tablet to anesthetize the zooplankton. The sample was then preserved with a 70% ethyl alcohol solution. Plankton sub-samples (in 1 ml aliquots) were analyzed under a Zeiss® dissection scope with the use of a Bogorov counting chamber. Taxa were keyed to genus and are shown in Tables 13-15 below.

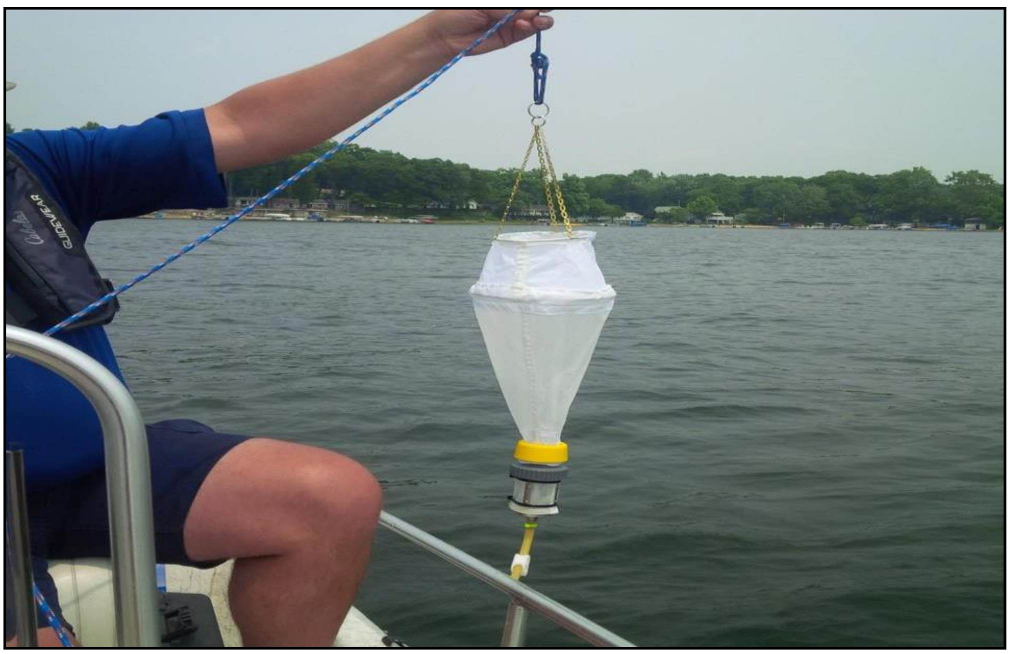


Figure 38. A zooplankton collection tow net.

Table 13. Zooplankton taxa and count data from Otsego Lake Deep Basin #1 (September 10, 2021).

Cladocerans	Count	Copepods	Count	Rotifers	Count
***Daphnia* sp.**	12	***Cyclops* sp.**	6	***Keratella* sp.**	9
***Chydorus* sp.**	3	***Nauplius* sp.**	4	***Tricocerca* sp.**	1
***Bosmina* sp.**	6	***Diaptomus* sp.**	1	***Asplanchna* sp.**	7

Table 14. Zooplankton taxa and count data from Otsego Lake Deep Basin #2 (September 10, 2021).

Cladocerans	Count	Copepods	Count	Rotifers	Count
***Daphnia* sp.**	19	***Cyclops* sp.**	6	***Keratella* sp.**	11
***Chydorus* sp.**	2	***Diaptomus* sp.**	3	***Asplanchna* sp.**	6
***Bosmina* sp.**	1	***Nauplius* sp.**	8	***Tricocerca* sp.**	1

Table 15. Zooplankton taxa and count data from Otsego Lake Area #3 (September 10, 2021).

Cladocerans	Count	Copepods	Count	Rotifers	Count
***Daphnia* sp.**	23	***Cyclops* sp.**	6	***Keratella* sp.**	9
***Bosmina* sp.**	5	***Nauplius* sp.**	7	***Asplanchna* sp.**	6
***Diaphanasoma* sp.**	1	***Diaptomus* sp.**	1	***Kellicottia* sp.**	4
***Chydorus* sp.**	5				

5.0 2021 OTSEGO LAKE AIS DETECTION & RAPID RESPONSE PROTOCOL

An exotic species is a non-native species that does not originate from a particular location. When international commerce and travel became prevalent, many of these species were transported to areas of the world where they did not originate. Due to their small size, insects, plants, animals, and aquatic organisms may escape detection and be unknowingly transferred to unintended habitats.

The first ingredient to successful prevention of unwanted transfers of exotic species to Otsego Lake is awareness and education. In the 2020 Otsego Lake Management Plan, RLS recommended boat washing stations and other prevention techniques. In 2021, RLS created the first draft of an aquatic invasive species (AIS) prevention and rapid response protocol. This is explained below in Section 5.2.

I. **OVERVIEW**: **Otsego Lake** is located in northwest Michigan at 44°57’20”N 84°41’32”W,[1] south of the city of Gaylord in Otsego County. The lake spans the boundary between Otsego Lake Township to the south and Bagley Township to the north. Otsego Lake State Park is located on the southeast shore of the lake and Otsego County Park is on the northwest shore. The lake has many private cottages and homes with direct access to the lake and parks.

Otsego Lake is 1,972 acres (7.98 km^2), and 5 miles (8.0 km) long and 1 mile (1.6 km) at its widest. In general, it is a shallow lake averaging about 6–8 feet in most places, with a maximum depth of approximately 23 feet (7.0 m) in a few spots. The bottom shoal composed of sand and light gravel forms many "drop-offs" and holes. The lake is full of vegetation which is submerged at the bottom of the lake with very little floating vegetation.

Otsego Lake is within the Au Sable Watershed which drains 1,932 square miles and covers parts of eight counties (Otsego, Crawford, Montmorency, Roscommon, Ogemaw, Oscoda, Iosco and Alcona). The Au Sable River begins at the confluence of Kolke and Bradford creeks, about 2 miles north of Frederic in northwest Crawford County, and eventually empties into Lake Huron near the town of Oscoda. Major Tributaries of the Au Sable Watershed are East Branch Au Sable River, North Branch Au Sable River, South Branch Au Sable River, East Branch Big Creek, Middle Branch Big Creek, West Branch Big Creek, Pine River, East Branch Pine River, West Branch Pine River, South Branch Pine River, South Branch River

II. SPECIES AT RISK

Native Aquatic Plants

Otsego Lake hosts at least 24 valuable native aquatic plant species including all of the aquatic plants listed in the 2020 lake management plan. Rare species such as Wild Rice are also present and should be preserved.

Lake Fishery

Otsego Lake is home to a diverse population of cool and warm water fish including Muskellunge, Lake Sturgeon, Northern Pike, Largemouth, Smallmouth Bass, Walleye, Pumpkin Seed (Sunfish), Bluegill, Rock Bass, Smallmouth Bass. Continued shoreline development and loss of natural habitat have challenged the fishery and natural populations of some native fish are sustained, however larger game fish populations like Walleye, Northern Pike, Lake Sturgeon, and Muskellunge have been periodically stocked by the MDNR to sustain their populations which do vary naturally at times with the lake water level and access to suitable breeding areas.

Birds

Otsego Lake shows large stands of wooded areas that include tree species such as Oak, Pine, and Maples which make it a highly desired habitat for native bird species such as Northern Bald Eagles, Common Loon, Belted Kingfisher, SandHill Crane, and numerous other migratory birds. Rare bird species recently spotted on Otsego Lake are the Golden Eagle and the Rose Breasted Grosbeak.

III. GOALS: The goal of this management plan is to achieve sustainable results in the control of invasive species and help facilitate the maintenance of valuable native plant and animal species within Otsego Lake. Elimination and control of invasive species in Otsego Lake will help to conserve the balance of this unique ecosystem and allow long term sustainability of the Au Sable Watershed as a whole.

IV. OUTLINE OF KEY AIS PROTOCOL COMPONENTS:

1. PREVENTION

a. **Signage at launches and access sites**

b. **Education sessions Q & A of riparians/stakeholders about AIS**

c. **Visual education cards for distribution about AIS**

d. **Boat wash at launch**

2. EARLY DETECTION AND RAPID RESPONSE (EDRR) PLAN

a. **Regular surveys to map aquatic plants present**

RLS recommended that a AVAS survey take place in early Spring and mid to late summer with periodic review as needed if treatment is required.

b. **Invasive aquatic plants will be sampled and mapped**

RLS does visual AVAS surveys as well as physical sampling of aquatic biomass. Other mapping techniques include GPS mapping and BioBase scanning for bottom hardness and sediment monitoring.

c. **Lake Management will coordinate efforts with a licensed state** contractor/ applicator to obtain permit.

d. **Recommended chemical product and/or mechanical treatments**

3. CONTROL AND MANAGEMENT

a. Conduct surveys beginning spring and into late fall

b. Invasive species identified and assessed:

1. Eurasian Water Milfoil
2. Curly-leaf Pondweed
3. Starry Stonewort

c. Restoration Plan (see Otsego Lake Management Plan 2020)

4. COLLABORATION AND ENGAGEMENT

a. Board/riparian education

1. Educational presentation at board meetings
2. Board correspondence to stakeholders
3. Newsletters
4. Press release
5. Visual media, social media
6. Educational workshops

b. Continue with Lake Management Best Practices (see Otsego Lake Management Plan 2020)

6.0 OTSEGO LAKE 2021 CONCLUSIONS AND 2022 MANAGEMENT RECOMMENDATIONS

Otsego Lake is facing significant issues that degrade water quality, including inputs of nutrients from septic systems and significant shoreline erosion which leads to a decline in lake health over time. Additionally, invasive species such as Eurasian Watermilfoil (EWM), Curly-leaf Pondweed (CLP), and Starry Stonewort are located in the lake with the latter two present in the south region and canal region of the lake. These invasives pose a serious risk to the native aquatic plant biodiversity and recreational activities in the lake. Protection of the high biodiversity of native aquatic plants is essential for lake health, especially given the low relative abundance of most native aquatic plant species. Here are the key conclusions and recommendations for successful management of Otsego Lake in 2022:

1. Management of invasive species would be best achieved with aquatic herbicides but could be removed on a smaller scale with DASH technology. EGLE permits treatment of invasive EWM, CLP, and Starry Stonewort with aquatic herbicides. In 2021, there were approximately 1.1 acres of EWM, 0.1 acres of CLP, and 2.8 acres of Starry Stonewort. RLS recommends spot-treating the EWM with granular 2,4-D (offshore) or triclopyr products (nearshore) or the new systemic herbicide ProcellaCOR®. The product types and doses should rotate each year to lessen the occurrence of herbicide tolerance by EWM in Otsego Lake.

2. Beginning in late spring 2022, an independent professional limnologist/aquatic botanist at RLS will perform regular GPS-guided whole-lake surveys to monitor the growth and distribution of all invasives prior to and after all treatments to determine treatment efficacy. Continuous monitoring of the lake for potential influxes of other exotic aquatic plant genera (i.e., *Hydrilla*) that could also significantly disrupt the ecological stability of Otsego Lake is critical.

3. In 2022, the lake manager should oversee all management activities and would be responsible for the creation of aquatic plant management survey maps, direction of the applicators to target-specific areas of aquatic vegetation for removal and reviewing all contractor invoices for accuracy.

4. In 2022, water quality monitoring of the three deep basins will be conducted to evaluate long-term trends with trend analyses. The water quality parameters measured include physical parameters such as water temperature, dissolved oxygen, pH, conductivity, Secchi transparency, and total dissolved solids. In addition, chemical water quality parameters such as total phosphorus (TP), total Kjeldahl nitrogen (TKN), and chlorophyll-a.

5. In 2022, RLS will work with the OLA to form a Special Assessment District (SAD) for future improvements to improve water quality and reduce the presence and threats of invasive species.

6. RLS will continue to be involved with the education of riparians around Otsego Lake. This includes education on proper lakeside best management practices, septic system maintenance, erosion control, and more. During the lawn mowing phase, make sure to bag your clippings and return them to your local yard waste disposal site.

6.1 Proposed Cost Estimates for Otsego Lake Improvements

A breakdown of estimated costs associated with the various proposed management items proposed for 2022 in Otsego Lake is presented in Table 16. It should be noted that proposed costs are estimates and may change in response to changes in environmental conditions (i.e., increases in aquatic plant growth or distribution, or changes in herbicide costs). Note that this table is adaptive and is likely to change. Any of these could be conducted during different years of a new or existing SAD program. However, it is highly recommended to perform all of these management methods as soon as possible. The annual cost will decline over time with the boat wash station, early detection rapid response protocol, and reductions in invasive aquatic plant species as well as shoreline erosion.

Table 16. Otsego Lake 2022 proposed lake management program costs. Note: These items could be implemented over a period of years with professional services and treatment of invasives recommended on an annual basis.

Proposed Otsego Lake Improvement Item	Estimated Itemized Costs
Invasive aquatic plant treatments/EGLE permit	$5,000
Professional Services/SAD assistance	$18,000
Contingency	$2,300
Total Estimated Cost of all Items	$25,300

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