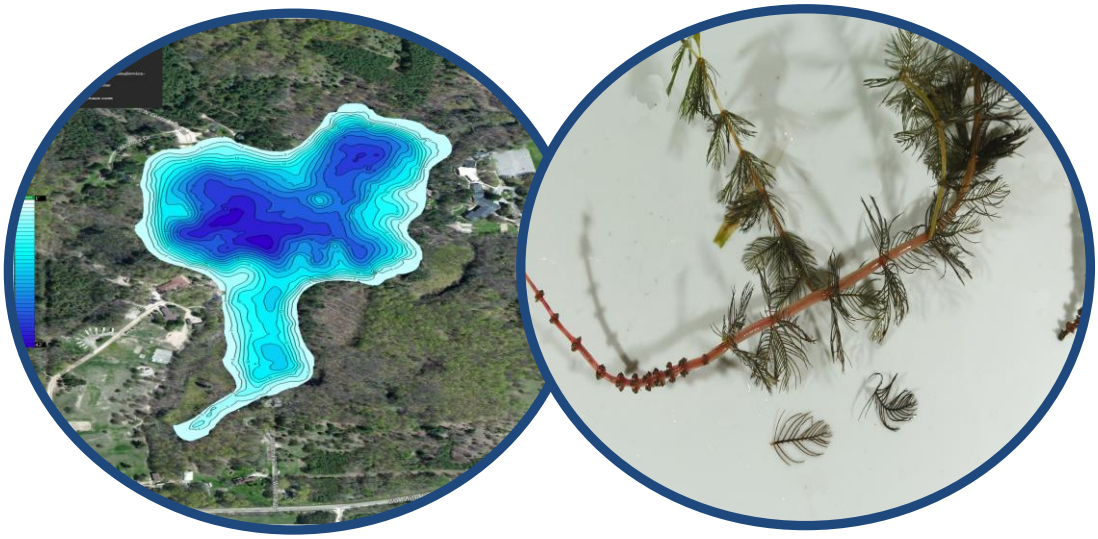
Restorative Lake Sciences™

Center Lake 2016 Aquatic Vegetation & Water Quality Report & 2017 Management Recommendations



October, 2016

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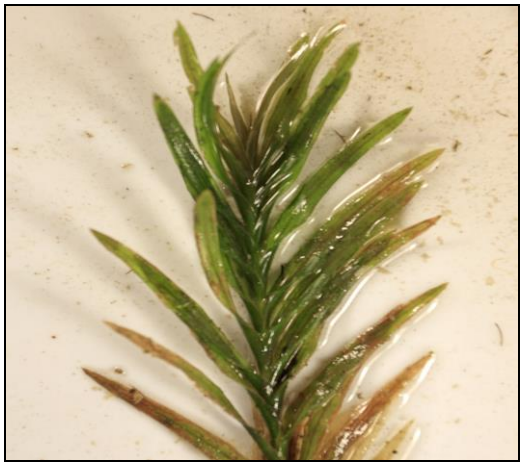

Provided for: The Residents of Center Lake,
the Sherman Township Board & the Kettunen Center

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Section 1

Center Lake 2016 Aquatic Vegetation & Water Quality Report & 2017 Management Recommendations

The following Center Lake report is a summary of key lake findings collected in 2016.

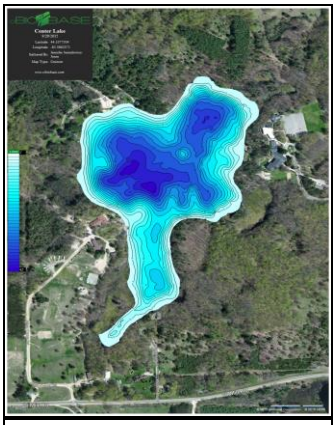
The overall condition of Center Lake is ranked in the top 10% of developed lakes of similar size in the state of Michigan. The water clarity was between 12 feet at the lowest and 24 feet at the highest during the summer of 2016. Center Lake, comprising 40 acres, is of glacial origin with approximately 1.56 miles of shoreline. A small outlet is located at the northeast corner of the lake and the lake receives most of its water from springs at the bottom of the lake. The lake has been historically stocked with Brown Trout and has excellent water quality due to these springs. Based on the current study, Center Lake contains a high amount of submersed native aquatic plant biodiversity but contains 3 invasive aquatic plant species, including the exotic submersed Eurasian Watermilfoil (3.75 acres) and the macro alga Starry Stonewort (0.70 acres), and the exotic emergent Purple Loosestrife (0.25 acres) which threaten the biodiversity of the submersed and emergent native aquatic plant communities, may impede navigation and recreational activities, and may reduce lakefront property values if not properly managed. **There are a total of 22 native aquatic plant species in and around Center Lake that are threatened by the 3 invasive, exotic aquatic plants. Fortunately, the EWM was treated in 2016 with the use of liquid and then granular systemic triclopyr and 2,4-D. A survey will be conducted in the spring of 2017 to determine the treatment efficacy. Other invasives such as Starry Stonewort and Purple Loosestrife can also be addressed in 2017.**

Section

2

Center Lake Water Quality Data (2016)

Water Quality Parameters Measured



Did You Know? Center Lake has a maximum depth of 42 feet

There are hundreds of water quality parameters one can measure on an inland lake but several are the most critical indicators of lake health. These parameters include water temperature (measured in °F), dissolved oxygen (measured in mg/L), pH (measured in standard units-SU), conductivity (measured in micro-Siemens per centimeter-µS/cm), total alkalinity or hardness (measured in mg of calcium carbonate per liter-mg $CaCO_3$/L), total dissolved solids (mg/L), secchi transparency (feet), total phosphorus and total nitrate nitrogen (both in µg/L), chlorophyll-*a* (in µg/L), and algal species composition. Water quality was measured in the deep basin of Center Lake in late spring to early summer. Table 1 below demonstrates how lakes are classified based on key parameters. Center Lake would be considered mesotrophic (relatively productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth but has excellent water clarity and moderate algal growth. 2016 water quality data for Center Lake is shown below in Table 2.

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. Center Lake water quality parameter data collected over the deep basin on May 26, 2016.

Depth ft.	*Water Temp °F*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. Mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	71.5	9.9	8.3	121	0.5	133.6	46	98	<0.010
21	64.2	9.2	8.1	126	0.5	129.4	49	101	<0.010
42	55.3	7.9	7.9	129	1.2	115.4	50	104	0.030

Water Clarity (Transparency) Data

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency throughout Center Lake is adequate (12-20 feet) to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake. Secchi transparency is variable and depends on the 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. Other parameters such as turbidity (measured in NTU's) and Total Dissolved Solids (measured in mg/L) are correlated with water clarity and show an increase as clarity decreases. **The turbidity and total dissolved solids in Center Lake have been quite low at less than 1.2 NTU's and 50 mg/L, respectively during the 2016 sampling period.**

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. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. Fortunately, even though the TP levels in Center Lake are moderate, the dissolved oxygen levels are good enough at the bottom to not cause release of phosphorus from the bottom. **TP concentrations during the sampling period was ≤0.030 mg L^{-1} with the highest concentration at the lake bottom.**

Total Alkalinity

Lakes with high alkalinity (> 150 mg L^{-1} 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 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. **During the sampling period, the alkalinity of Center Lake is moderate from ≤104 mg L^{-1} $CaCO_3$.**

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). Center Lake is considered "slightly basic" on the pH scale. **The pH of Center Lake ranged from 98-104 mg L^{-1} during the 2016 sampling period.**

Conductivity

Conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. 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 Center Lake were low and ranged from 121-129 µS/cm during the 2016 sampling period.** 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 Species 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 concentration during the 2016 sampling event was <1.0 µg/L which is very low.**

The algal genera were determined from composite water samples collected over the deep basin of Center Lake in 2016 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae; Figure 1): *Haematococcus* sp., *Chlorella* sp., *Scenedesmus* sp., *Pediastrum* sp., *Radiococcus* sp., *Gleocystis* sp., *Pandorina* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae; Figure 2): *Oscillatoria* sp., the Bascillariophyta (diatoms; Figure 3)*: Fragilaria* sp., *Navicula* sp., *Cymbella* sp., *Synedra* sp., and *Tabellaria* sp. The aforementioned species indicate a diverse algal flora and represent a good diversity of alga with an abundance of diatoms that are indicative of great water quality.

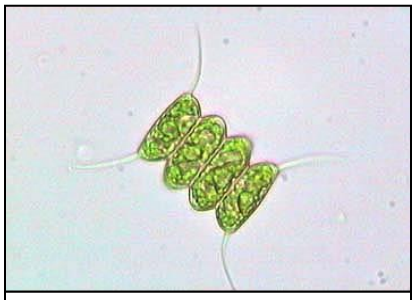


Figure 1. A Green Alga

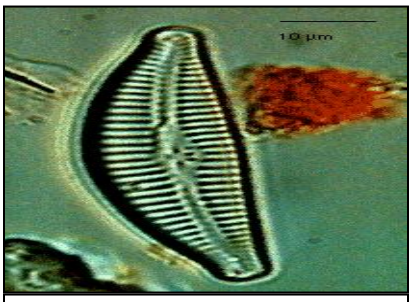


Figure 3. A Diatom

Figure 2. A Blue-Green Alga

Section

3

Aquatic Vegetation Data (2016)

Status of Native Aquatic Vegetation in Center Lake

The native aquatic vegetation present in Center Lake is essential for the overall health of the lake and the support of the lake fishery. **The September, 2016 determined that there were a total of 22 native aquatic plant species in Center Lake. These include 13 submersed species, 2 floating-leaved species, and 7 emergent species.** This indicates a very high biodiversity of aquatic vegetation in Center Lake. The overall % cover of the lake by native aquatic plants is low relative to the lake size due to the great mean depth and thus these plants should be protected unless growing near swim areas at nuisance levels.

The most dominant aquatic plant species included Floating-leaf Pondweed (Figure 4), the macro alga Chara (Figure 5), and Leafless Watermilfoil (Figure 6). A list of all current native aquatic plant species is shown below in Table 3.

Figure 4. Floating-leaf Pondweed

Figure 5. Chara

Figure 6. Leafless Watermilfoil

Table 3. Center Lake native aquatic plants (September 27, 2016).

Native Aquatic Plant Species Name	***Aquatic Plant Common Name***	***Abundance in/around Center Lake***	***Aquatic Plant Growth Habit***
Chara vulgaris	Muskgrass	10.5	Submersed, Rooted
Potamogeton pectinatus	Thin-leaf Pondweed	0.9	Submersed, Rooted
Potamogeton zosteriformis	Flat-stem Pondweed	1.1	Submersed, Rooted
Potamogeton amplifolius	Large-leaf Pondweed	1.0	Submersed, Rooted
Potamogeton gramineus	Variable-leaf Pondweed	0.9	Submersed, Rooted
Potamogeton robbinsii	Fern-leaf Pondweed	1.9	Submersed, Rooted
Potamogeton natans	Floating-leaf Pondweed	18.8	Submersed, Rooted
Potamogeton nodosus	American Pondweed	1.2	Submersed, Rooted
Elodea canadensis	Common Waterweed	0.2	Submersed, Rooted
Potamogeton pusillus	Small-leaf Pondweed	0.1	Submersed, Rooted
Utricularia vulgaris	Bladderwort	0.8	Submersed, Non-Rooted
Najas flexilis	Slender Naiad	0.6	Submersed, Rooted
Myriophyllum tenellum	Leafless Watermilfoil	7.2	Submersed, Rooted
Nymphaea odorata	White Waterlily	3.5	Floating-Leaved, Rooted
Brasenia schreberi	Watershield	2.7	Floating-Leaved, Rooted
Typha latifolia	Cattails	0.2	Emergent
Scirpus acutus	Bulrushes	0.4	Emergent
Arrow Arum	Arrowhead	0.2	Emergent
Sparganium americanum	Burr Reed	6.5	Emergent
Pontedaria cordata	Pickerelweed	4.9	Emergent
Chamaedaphne calyculata	Leatherleaf	5.5	Emergent
Decodon verticillatus	Swamp Loosestrife	0.8	Emergent

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

Figure 7. Eurasian Watermilfoil

The amount of Eurasian Watermilfoil (EWM; Figure 7) present in Center Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. 2016 was among the hottest years on record and many lakes experienced nuisance milfoil and algal outbreaks of significant scope. The June 2016 survey revealed that approximately 3.8 acres of milfoil was found throughout the entire lake. On May 25, 2016 the the milfoil was treated with high dose liquid triclopyr (Renovate 3 ®) at a dose of 3 gal/acre. The treatment was successful for an acre but the remaining 2 acres required a re-treatment which was conducted on August 30, 2016 with Renovate OTF® granular and Sculpin G®.

The locations of each of these invasive species are shown in Figure 8 below.

Table 4. Center Lake exotic aquatic plant species (September 27, 2016).

Exotic Aquatic Plant Species	*Common Name*	*Growth Habit*	*# Acres in Center Lake*
Myriophyllum spicatum	Eurasian Watermilfoil	Submersed; Rooted	2.0
Lythrum salicaria	Purple Loosestrife	Emergent	0.3
Nitellopsis obtusa	Starry Stonewort	Submersed; Rooted	0.7

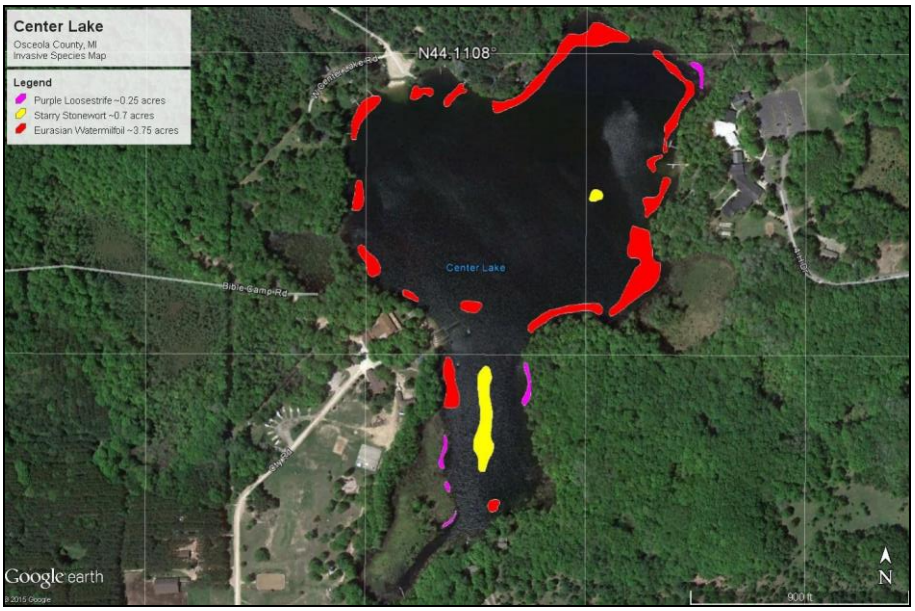


Figure 8. Center Lake invasive aquatic plants (red=EWM; yellow = Starry Stonewort; purple=Purple Loosestrife).

Section

4

Management Recommendations for 2017

Continuous aquatic vegetation surveys are needed to determine the precise locations of EWM, Starry Stonewort, or other problematic invasives in Center Lake. These surveys should occur in late-May to early-June and again post-treatment in 2017.

Due to the relative scarcity of native aquatic vegetation in Center Lake, the treatment of these species with aquatic herbicides is not recommended. The plan for 2017 includes the use of higher doses of systemic aquatic herbicides (such as triclopyr nearshore and 2, 4-D offshore) for the milfoil that may be present and the use of Komeen copper crystals or flumioxazin on the Starry Stonewort.

Water quality parameters in the lake will also be monitored as in 2016.

In conclusion, Center Lake is a healthy lake with good aquatic plant biodiversity, excellent water clarity, moderate nutrients, and a healthy lake fishery. Management of the EWM and Starry Stonewort and protection of the water quality are paramount for the long-term health of the lake.

Glossary of Scientific Terms used in this Report

1) Biodiversity- The relative abundance or amount of unique and different biological life forms found in a given aquatic ecosystem. A more diverse ecosystem will have many different life forms such as species.

2) CaCO3- The molecular acronym for calcium carbonate; also referred to as "marl" or mineral sediment content.

3) Eutrophic- Meaning "nutrient-rich" refers to a lake condition that consists of high nutrients in the water column, low water clarity, and an over-abundance of algae and aquatic plants.

4) Mesotrophic- Meaning "moderate nutrients" refers to a lake with a moderate quantity of nutrients that allows the lake to have some eutrophic qualities while still having some nutrient-poor characteristics

5) Oligotrophic- Meaning "low in nutrients or nutrient-poor" refers to a lake with minimal nutrients to allow for only scarce growth of aquatic plant and algae life. Also associated with very clear waters.

6) Sedimentary Deposits- refers to the type of lake bottom sediments that are present. In some lakes, gravel and sand are prevalent. In others, organic muck, peat, and silt are more common.