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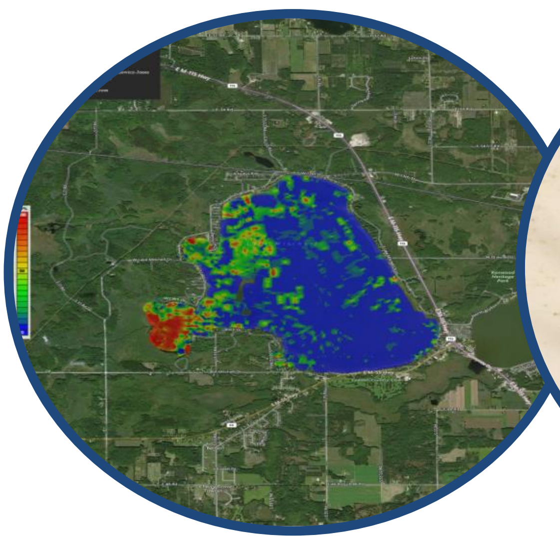
Lake Mitchell 2017 Aquatic Vegetation, Water Quality, and 2018 Management Recommendations Report



October, 2017

Lake Mitchell 2017 Aquatic Vegetation, Water Quality, and 2018 Management Recommendations Report

(2009-2017)

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1

Lake Mitchell 2017 Aquatic Vegetation, Water Quality, and 2018 Management Recommendations

The following information is a summary of key lake findings collected in 2017.

The overall condition of Lake Mitchell is ranked in the top 15% of developed lakes of similar size in the state of Michigan. The water clarity in 2016 averaged around 8.5 feet which is favorable. Additionally, the lake has enough nutrients (phosphorus and nitrogen) to support some algae and submersed aquatic plant growth in the shallow littoral zone, but the nutrient levels are considered moderate.

Protection of the 26 native aquatic plant species is paramount for the health of the lake fishery and these plants should not be managed unless they are a nuisance to lakefront property owners and possess navigational and recreational hazards (i.e. lily pads or nuisance pondweeds in the coves).

Invasive species such as Eurasian Watermilfoil (EWM) are able to grow in moderate nutrient waters and thus are a challenge to the Lake Mitchell ecosystem. In 2017, approximately 77.8 acres of EWM was treated throughout the entire lake. EWM decreased in 2017 due to rigorous treatments in 2016 and a mild season relative to weather. A total of $54,378.24 was spent on aquatic herbicide treatments in 2017.

The Purple Loosestrife stocking occurred in 2017 and is still showing results and more stocking is recommended in 2018. A thorough section on management recommendations for 2018 is offered at the end of this report.

Section

2

Lake Mitchell Water Quality Data (2009-2017)

Water Quality Parameters Measured

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 chlorophyll-*a* (in µg/L), and algal species composition. In 2016, water quality was measured in the deepest basins of Lake Mitchell in late summer (Figure 1). Trend data was calculated using mean values for each parameter for each season. Lake Mitchell would be considered eutrophic (relatively productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth but also has good water clarity and moderate algal growth. General water quality classification criteria are defined in Table 1. 2017 water quality data for Lake Mitchell and its tributaries are shown below in Tables 2-4.

Figure 1. Water quality sampling locations for Lake Mitchell and its tributaries

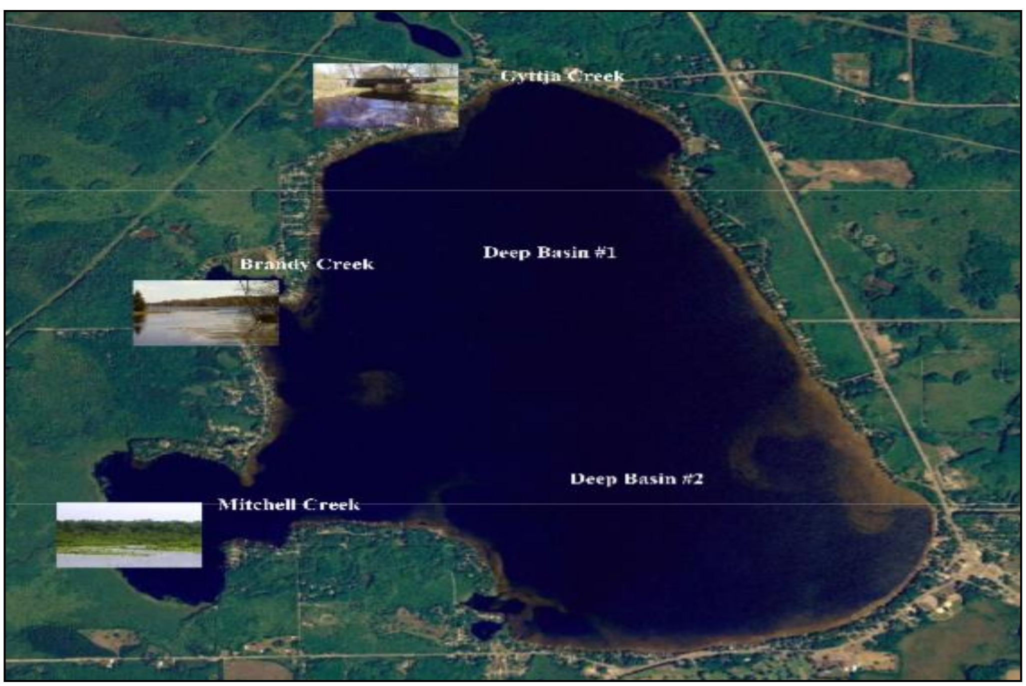


Table 1. Lake trophic classification (MDNR).

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. Lake Mitchell water quality parameter data collected over the north deep basin on September 29, 2017.

Depth ft.	*Water Temp °F*	*DO mg L^{-1}*	*pH S.U.*	*Cond. $\mu S\ cm^{-1}$*	*Turb. NTU*	*ORP mV*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*	*TKN Mg L^{-1}*
0	67.0	8.6	9.0	151	0.9	122.5	55	47	0.013	0.7
10	67.0	8.5	8.9	151	0.9	118.3	55	49	0.014	0.6
21	66.8	8.1	8.9	151	1.1	99.6	48	50	0.036	1.0

Table 3. Lake Mitchell water quality parameter data collected over the south deep basin on September 29, 2017.

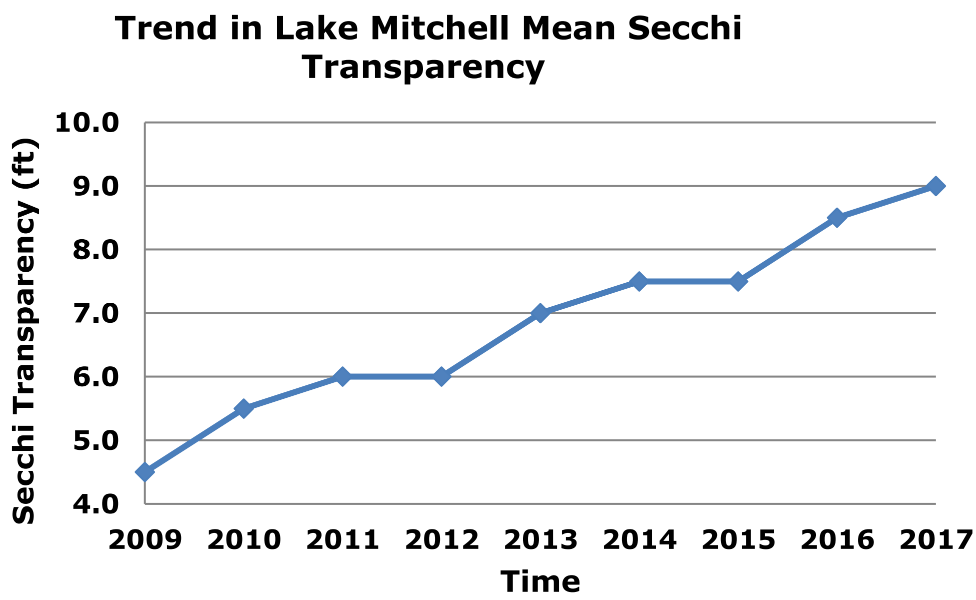
Depth ft.	*Water Temp °F*	*DO mg L^{-1}*	*pH S.U.*	*Cond. $\mu S\ cm^{-1}$*	*Turb. NTU*	*ORP mV*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*	*TKN Mg L^{-1}*
0	66.6	8.6	8.9	151	0.6	111.5	52	47	0.013	0.5
10	67.5	8.3	8.8	151	0.9	105.8	50	49	0.010	1.0
20	67.5	8.2	8.8	151	0.9	97.4	52	51	0.015	0.7

Table 4. Lake Mitchell Tributary water quality parameter data collected on September 29, 2017.

Tributary	*Water Temp °F*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*TDS mg L^{-1}*	*ORP mV*	*Total Phos. mg L^{-1}*
Mitchell	57.5	8.5	8.1	288	101	133.6	0.019
Brandy	56.7	6.9	8.6	288	87	124.7	0.036
Gyttja	55.5	7.3	8.6	322	72	125.9	0.019

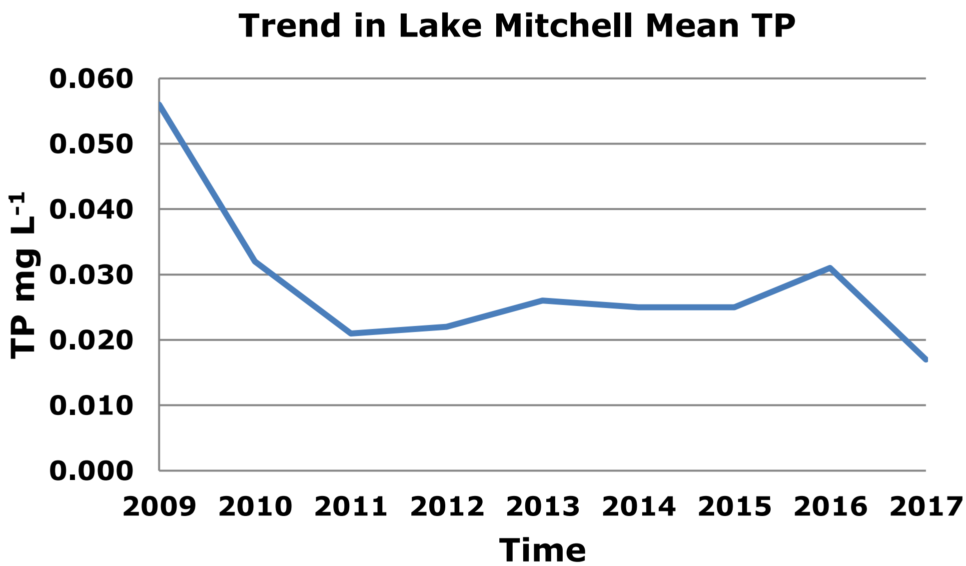
Water Clarity (Transparency) Data

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency in Lake Mitchell during the 2017 sampling event averaged around 9.0 feet which is adequate 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 Lake Mitchell were quite low in 2017 at ≤1.1 NTU's and ≤55 mg/L, respectively. The figure below shows an increase in Secchi transparency in recent years. This cannot be attributed to solely Zebra Mussel filtration since their population is not very strong in the lake due to the low alkalinity. RLS is keeping a close eye on the Zebra Mussel population since it is strong in Lake Cadillac.



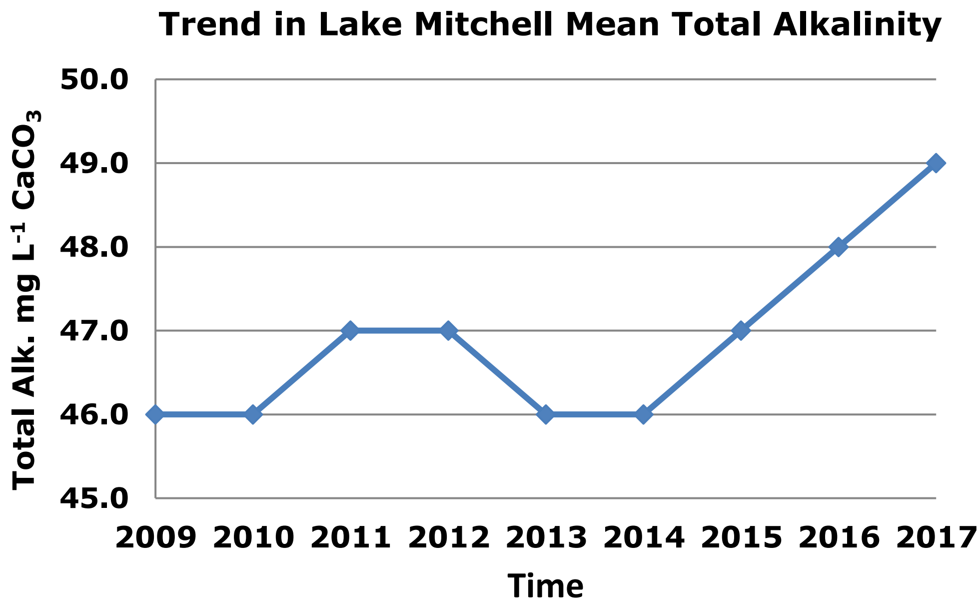
Total Phosphorus

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 Lake Mitchell 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 2017 sampling events ranged from 0.010-0.036 mg L^{-1}, which is amongst some of the lowest concentrations as observed also in 2016 (below figure). Again, this may be attributed to decreased runoff during long dry spells which would also reduce the TP concentrations in the tributaries (this was observed in 2017).



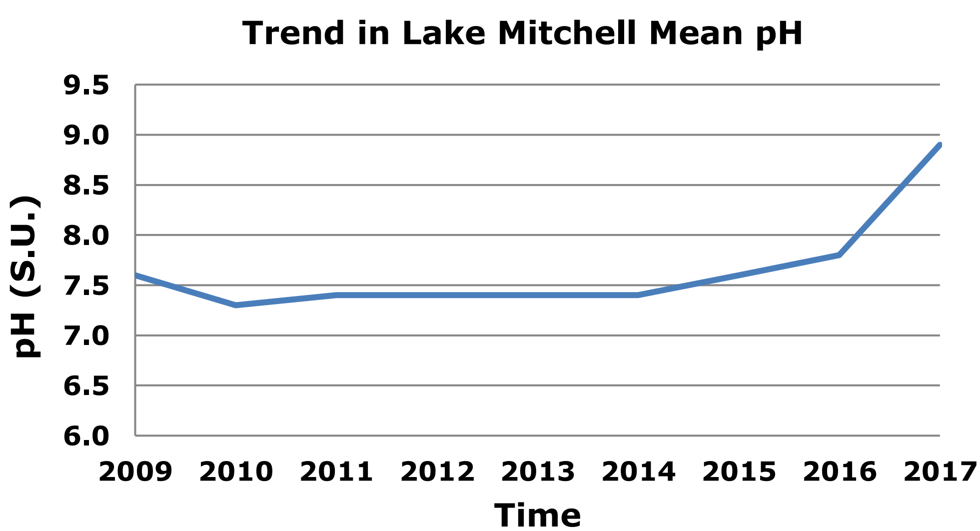
Total Alkalinity

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. The alkalinity of Lake Mitchell is quite low and is indicative of a "soft water" aquatic ecosystem. The total alkalinity during the sampling event in 2017 ranged from 47-51 mg L^{-1} of $CaCO_3$ which is similar to recent years (below figure).



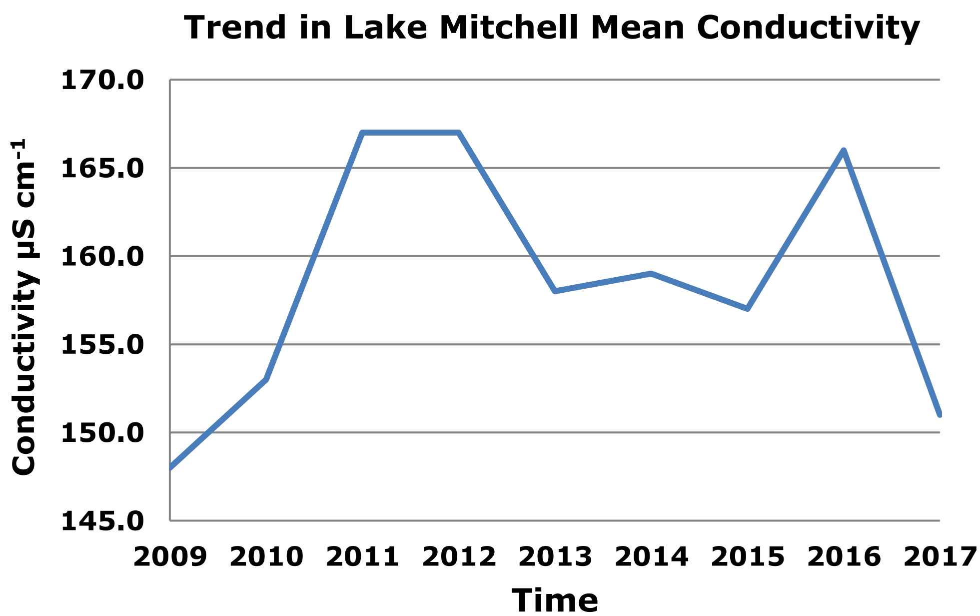
pH

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). Lake Mitchell is considered "neutral" on the pH scale. The pH of Lake Mitchell in 2016 was similar to previous years and ranged from 8.8-9.0 S.U. which is higher than in previous years and may be due to less tannins from the inlets reaching the lake. This may also support the observed increase in transparency (below figure).



Conductivity

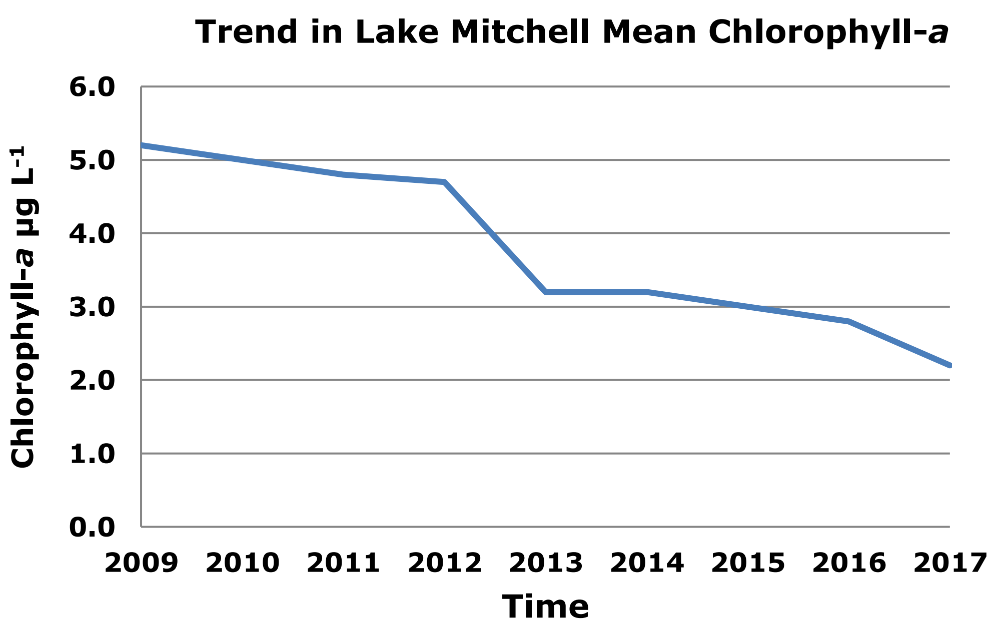
Conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. The conductivity values for Lake Mitchell are moderately low for a large, shallow inland lake and were all recorded at 151 µS/cm during the 2017 sampling event (below figure). Severe water quality impairments do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm. Conductivity may be increasing due to more road salt applications during recent harsh winters.



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 mean chlorophyll-*a* concentrations in late September in Lake Mitchell did not exceed 2.2 μg/L which is quite low for an inland Michigan lake and appears to be on the decline which may be resulting in increased transparency (below figure).

The algal genera were determined from composite water samples collected over the deep basins of Lake Mitchell in 2017 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta: *Scenedesmus* sp., *Haematococcus* sp., *Scenedesmus* sp., *Chlorella* sp., *Cladophora* sp., *Pediastrum* sp., *Mougeotia* sp., *Radiococcus* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae): *Gleocapsa* sp., and *Microcystis* sp.; The Bascillariophyta (diatoms): *Navicula* sp., *Fragilaria* sp., *Synedra* sp., and *Nitzschia* 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.



Toxic Blue-Green Algae: Microcystis sp.

The blue-green alga, *Microcystis* sp. can be found in many algal samples across lakes in Michigan (including even the Great Lakes!). However, when it is growing in high abundance, it can result in surface scums that may produce a toxin that humans and animals should avoid contact with when swimming. The photo below (Figure 2) shows this algal scum in the Channel leading from Lake Mitchell to Lake Cadillac. There are many potential causes of these blooms that include nutrient enrichment, the proliferation of Zebra Mussels which filter the good algae out of the water column for food and then expel blue-greens, and possibly enrichment of CO2 since this phenomenon is occurring globally. The preferred treatment of this algae is not to apply copper-based algaecides since it can actually result in further blooms. If watershed inputs of nutrients cannot be adequately reduced, then aeration with bioaugmentation is a useful tool. RLS will continue to monitor this algae on both Lake Mitchell and Lake Cadillac and provide solutions as more data is obtained.

Figure 2. A surface bloom of Microcystis in the Channel from Lake Mitchell (summer, 2017).

Section

3

Aquatic Vegetation Data (2017)

Status of Native Aquatic Vegetation in Lake Mitchell

The native aquatic vegetation present in Lake Mitchell is essential for the overall health of the lake and the support of the lake fishery. The most recent survey in September of 2017 determined that there were a total of 26 native aquatic plant species in Lake Mitchell. These include 17 submersed species, 4 floating-leaved species, and 5 emergent species which is similar to recent years and means that the lake is maintaining its biodiversity. This indicates a very high biodiversity of aquatic vegetation in Lake Mitchell and is likely a significant reason for the great fishery in the lake. The overall % cover of the lake by native aquatic plants is low relative to the lake size and thus these plants should be protected and not treated unless they become a nuisance in shallow coves or the Torenta Canal. A list of all native aquatic plants and their relative abundance can be found in Table 5 below.

The most common aquatic plants found during the 2016 surveys included: 1) Fern-leaf Pondweed (Figure 3) which lies close to the bottom and resembles an underwater fern yet is creates a dense carpet on the lake bottom; Leafless Watermilfoil (Figure 4) which also lies close to the bottom and resembles green turf with individual plants having linear shoots that do not branch, and ; 3) Large-leaf Pondweed which grows tall into the water column and has brownish large leaves with the plant often remaining close to the lake bottom (Figure 5).

During the whole-lake scan, an aquatic vegetation biovolume map (Figure 6) was developed which shows the areas where aquatic vegetation is absent (blue color), sparse (green color), or high-growing (red color). The red colors usually represent milfoil growth in Lake Mitchell which has declined over the past few years.

Figure 3. Fern-leaf Pondweed

Figure 4. Leafless Watermilfoil

Figure 5. Large-leaf Pondweed

Table 5. Native aquatic plants found in Lake Mitchell in 2017.

Aquatic Plant Species Name	*Aquatic Plant Common Name*	*Aquatic Plant Growth Form*	*% Coverage of Lake (2017)*
Chara vulgaris (macroalga)	Muskgrass	Submersed; Rooted	12
Potamogeton pectinatus	Sago Pondweed	Submersed; Rooted	19
Potamogeton robbinsii	Fern-leaf Pondweed	Submersed; Rooted	68
Potamogeton gramineus	Variable-leaf Pondweed	Submersed; Rooted	11
Potamogeton praelongus	White-stem Pondweed	Submersed; Rooted	42
Potamogeton richardsonii	Clasping-leaf Pondweed	Submersed; Rooted	9
Potamogeton illinoensis	Illinois Pondweed	Submersed; Rooted	33
Potamogeton amplifolius	Large-leaf Pondweed	Submersed; Rooted	39
Myriophyllum sibiricum	Northern Watermilfoil	Submersed; Rooted	10
Ceratophyllum demersum	Coontail	Submersed; Non-rooted	4
Elodea canadensis	Common Waterweed	Submersed: Rooted	9
Utricularia vulgaris	Common Bladderwort	Submersed; Non-rooted	25
Utricularia minor	Mini Bladderwort	Submersed; Non-rooted	4
Najas guadalupensis	Southern Naiad	Submersed; Rooted	15
Najas flexilis	Slender Naiad	Submersed; Rooted	11
Myriophyllum tenellum	Leafless Watermilfoil	Submersed; Rooted	66
Potamogeton pusillus	Small-leaf Pondweed	Submersed; Rooted	14
Megalodonta beckii	Water Marigold	Submersed; Rooted	7
Nymphaea odorata	White Waterlily	Floating-leaved	10
Nuphar variegata	Yellow Waterlily	Floating-leaved	9
Brasenia schreberi	Watershield	Floating-leaved	8
Lemna trisulca	Star Duckweed	Floating-Leaved; Non-rooted	2
Pontedaria cordata	Pickerelweed	Emergent	11
Typha latifolia	Cattails	Emergent	11
Scirpus acutus	Bulrushes	Emergent	35
Decodon verticillatus	Swamp Loosestrife	Emergent	9
Eleocharis acicularis	Spikerush	Emergent	13

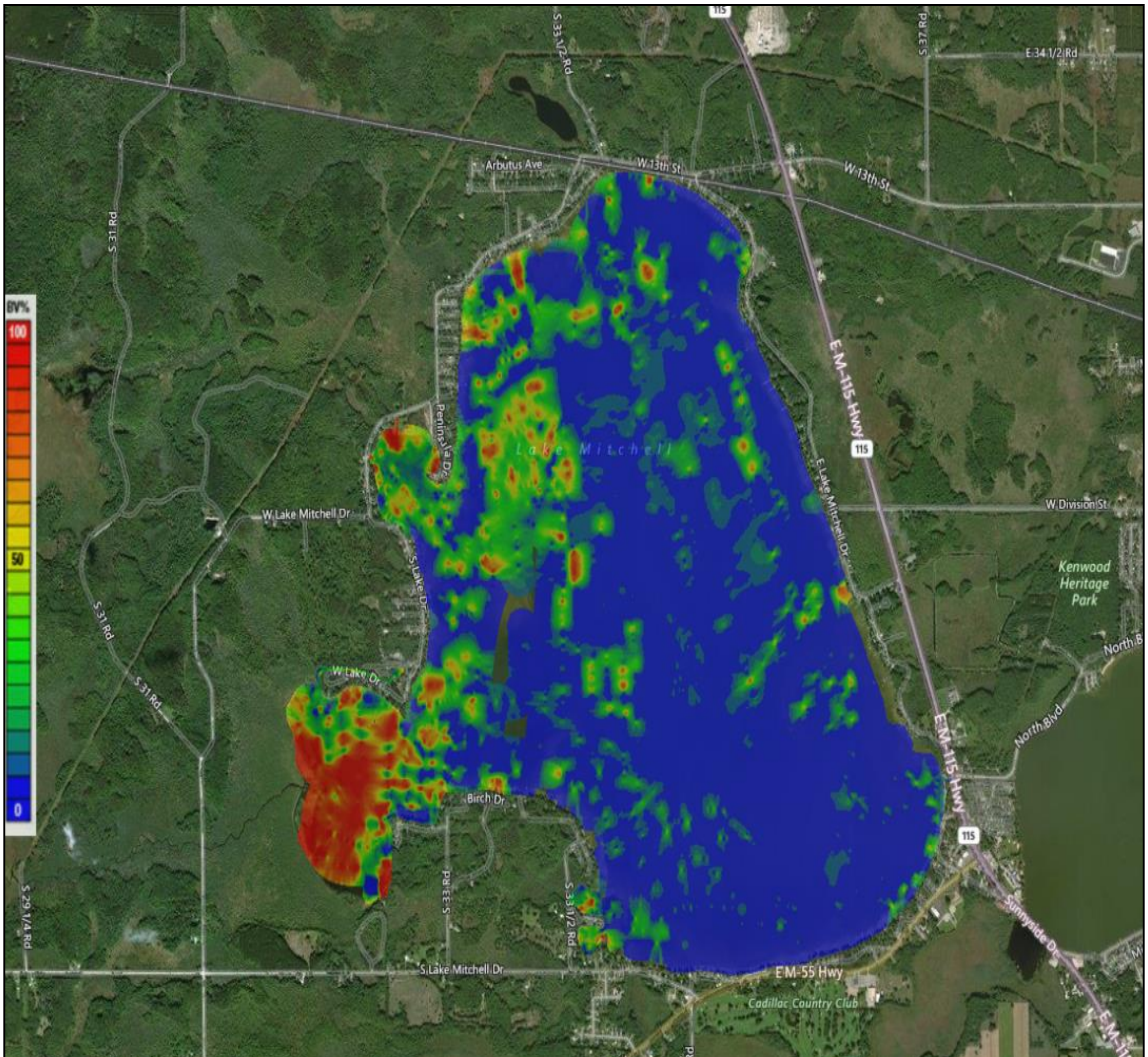


Figure 6. Aquatic Vegetation Biovolume in Lake Mitchell (May, 2017).

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

The amount of Eurasian Watermilfoil (Figure 7) present in Lake Mitchell varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. A whole-lake survey of the main lake was conducted on May 30-31, 2017 and revealed that approximately 56.3 acres of milfoil were found throughout the entire lake and Little Cove (Note: some additional new growth of milfoil was noted after the survey and this was added to the total for treatment to equal total acres). Earlier on May 19, 2017, the Franke Coves and Torenta Canal were surveyed. The Torenta Canal contained only a few stems of milfoil along with some filamentous algae. Table 6 below shows the total acres of milfoil and Curly-leaf Pondweed (Figure 8) found in each region of the lake that was treated on various dates. Also noted are the effective products and doses used.

The treatments were very successful with little viable milfoil remaining at the end of 2017 with the exception of a small area near the northwest shore (this area has been quite resistant to treatments). A spring 2018 survey is needed, however, to determine the 2017 treatment efficacy. Treatment maps for each of these invasive species are shown in the maps below (Figures 9-13). Also noted are the effective products and doses used. As in previous years, Loosestrife Beetles were also placed in Little Cove and Big Cove in late June of 2017.

Figure 7. Eurasian Watermilfoil

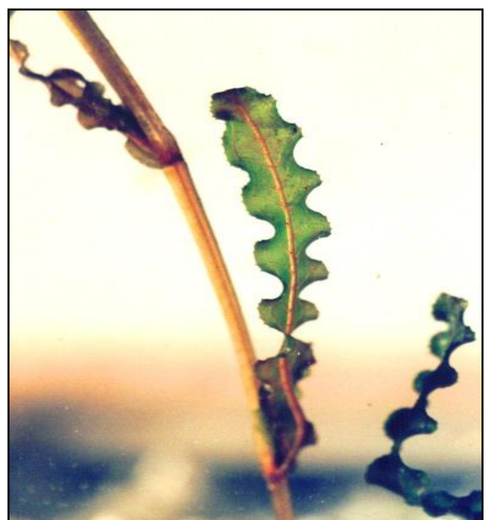


Figure 8. Curly-leaf Pondweed

Table 6. Number of acres of milfoil present in various regions of Lake Mitchell (May, 2017).

Area of Lake Treated	Date Treated	# Acres of EWM	# Acres of CLP or Nuisance Pondweeds	Products Used and Associated Doses
Main Lake	6-8	15.83	NONE	Renovate OTF @240#/acre
		16.5	NONE	Sculpin G @240#/acre
	8-3	7.5	NONE	Renovate OTF @240#/acre
		5.5	NONE	Sculpin G@240#/acre
Big Cove	6-8	18	NONE	Sculpin G@200#/acre
	8-3	3	NONE	Sculpin G@200#/acre
Little Cove	5-25	6	NONE	Renovate OTF @200#/acre
	6-27		3.5	1 gal/acre AK + Clipper 200 ppb and 100 ppb +AK
Franke South Cove	6-8	2.6	NONE	2 gal/diquat + 100 ppb Clipper
	8-3		4.0	2 gal/acre diquat
	8-30		1.5	AK/Clipper @200ppb
Franke North Cove	6-8	2.6	NONE	2 gal/diquat + 100 ppb Clipper
	8-3		2.5	2 gal/acre diquat
Torenta Canal	6-8	0	NONE	1.5 gal/SeClear for algae

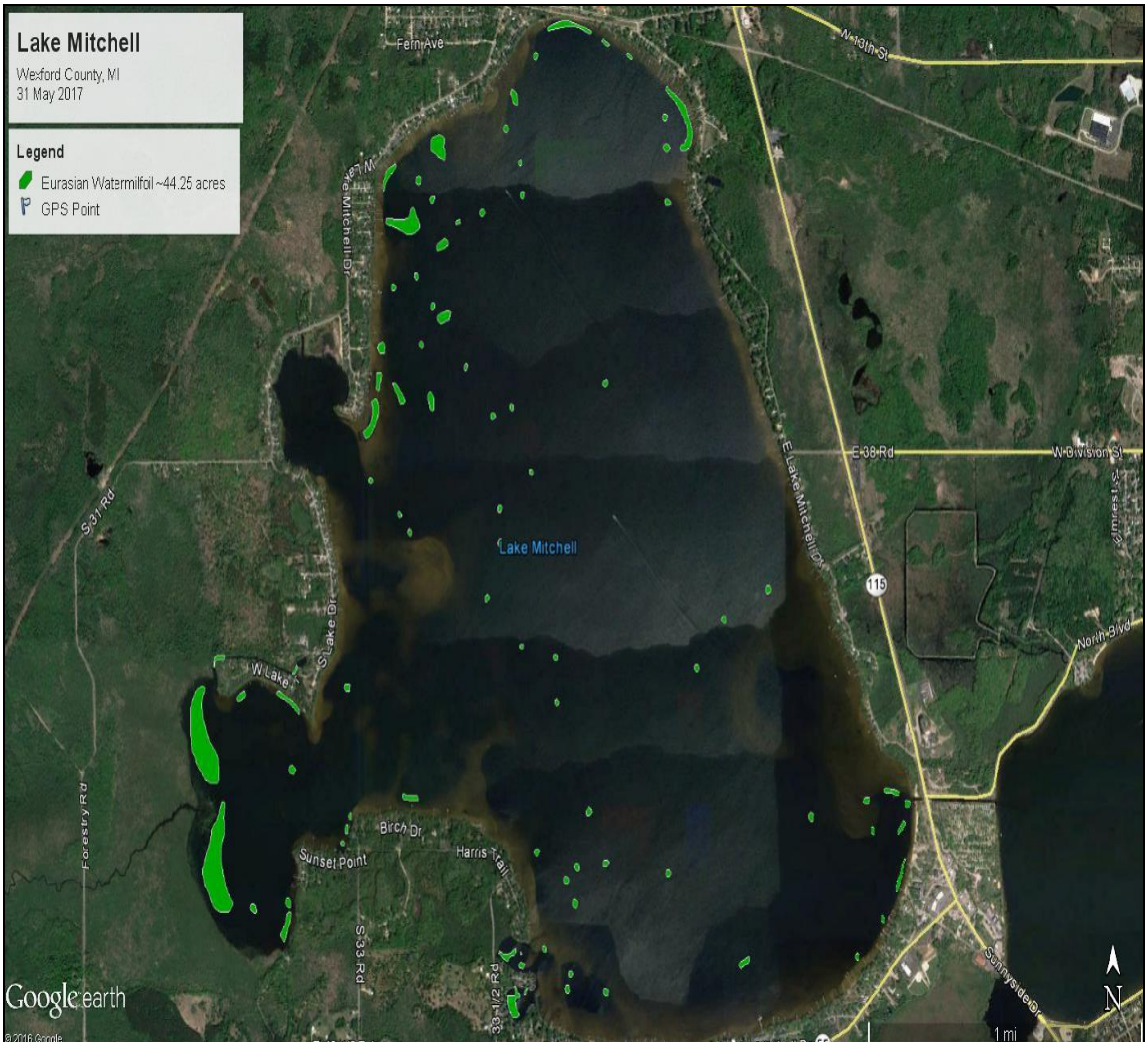


Figure 9. Distribution of EWM in Lake Mitchell (May 31, 2017). Note: Milfoil was mapped separately in the coves. A marked reduction in EWM in the main lake occurred relative to previous years due to intense treatment efforts and surveys.

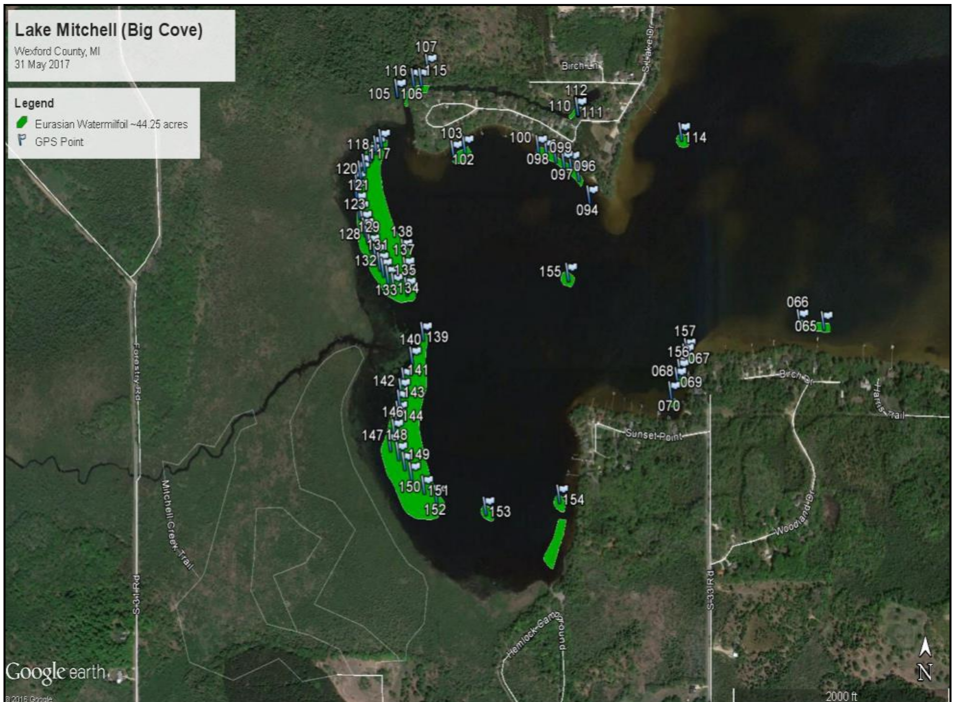


Figure 10. Distribution of EWM in Big Cove (May 31, 2017).

Figure 11. Distribution of EWM in Franke North and Franke South Coves (May 31, 2017).

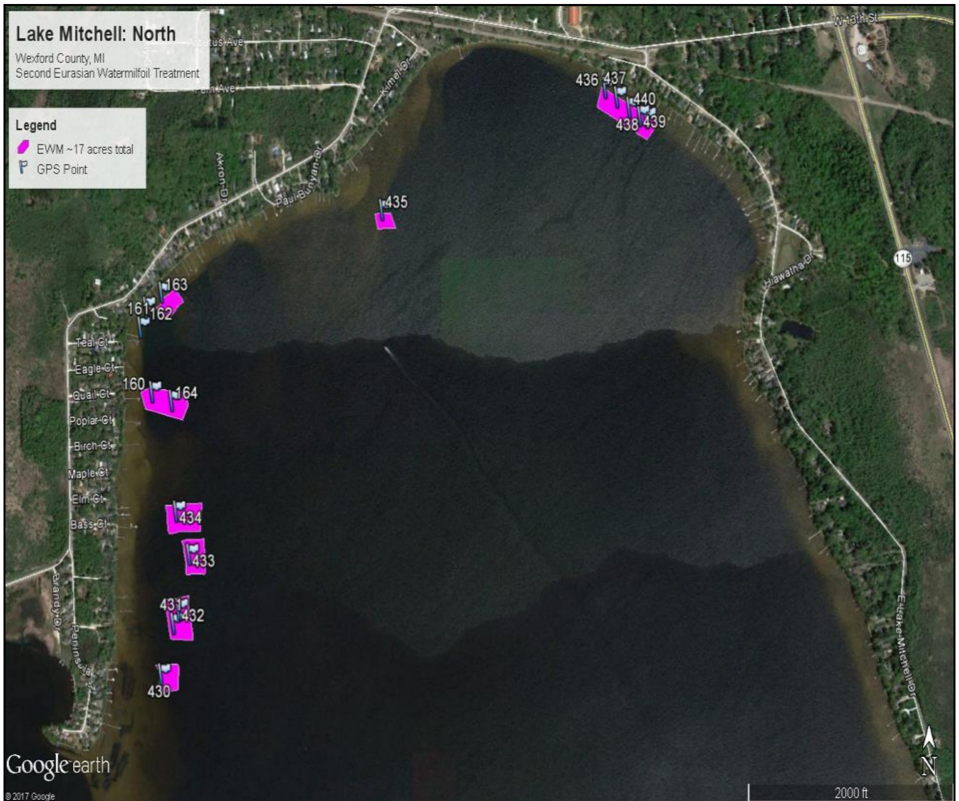


Figure 12. Distribution of EWM in north region of lake (July 27, 2017)

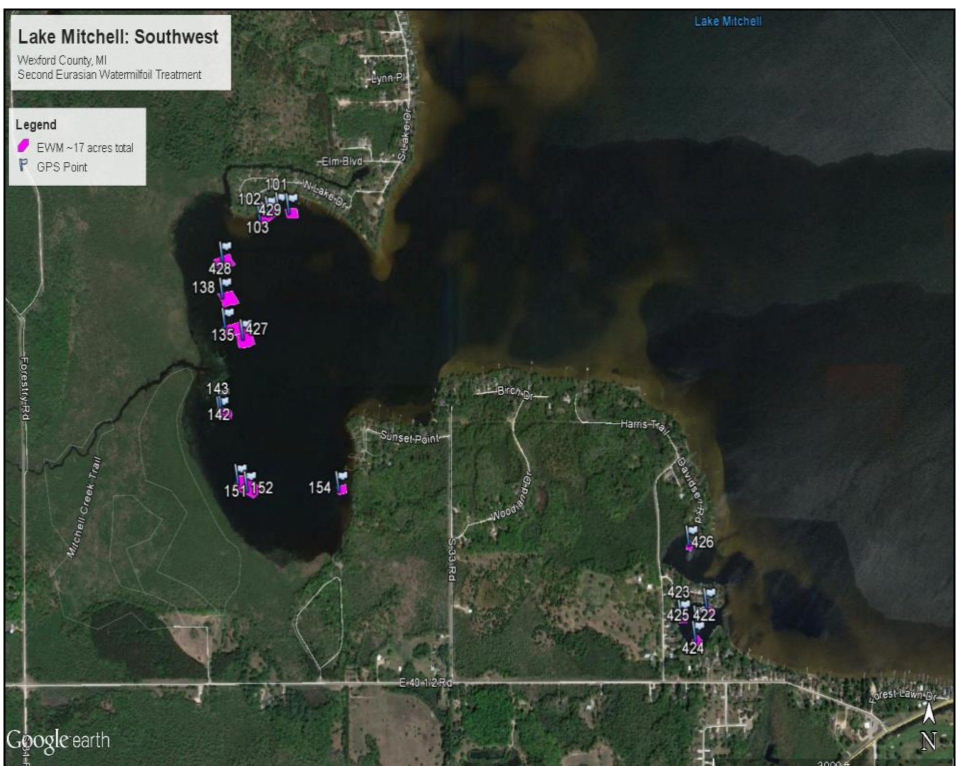
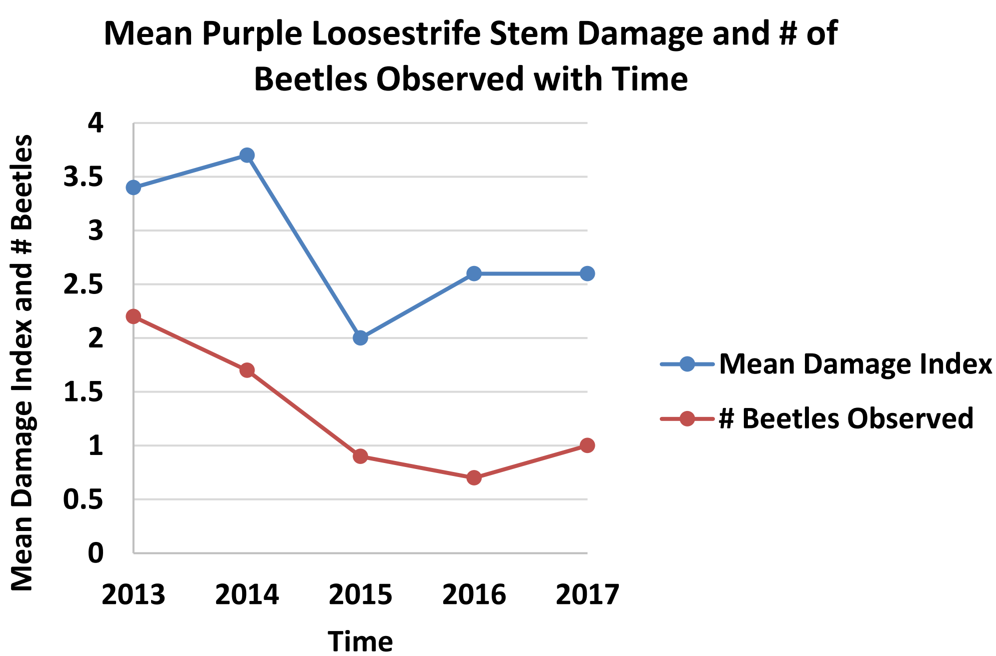


Figure 13. Distribution of EWM in south region of lake (July 27, 2017)

Evaluation of Purple Loosestrife Beetles on Lake Mitchell
Purple Loosestrife Reduction:

The beetle, *Galerucella* sp. is stocked each season around areas of Lake Mitchell infested with Purple Loosestrife. The goal has been to introduce enough beetles each season to create a sustainable population around the lake to naturally take over management of the invasive Purple Loosestrife. Beetle counts are performed on the plants each year to evaluate the number of beetles found along with damage of the inflorescences (flower portions of the plants). Based on the graph below, the beetle population is holding steady and should result in continued control of the Purple Loosestrife with time. More stocking is recommended for 2018 and beyond as budget allows.



Section

4

Management Recommendations for 2018

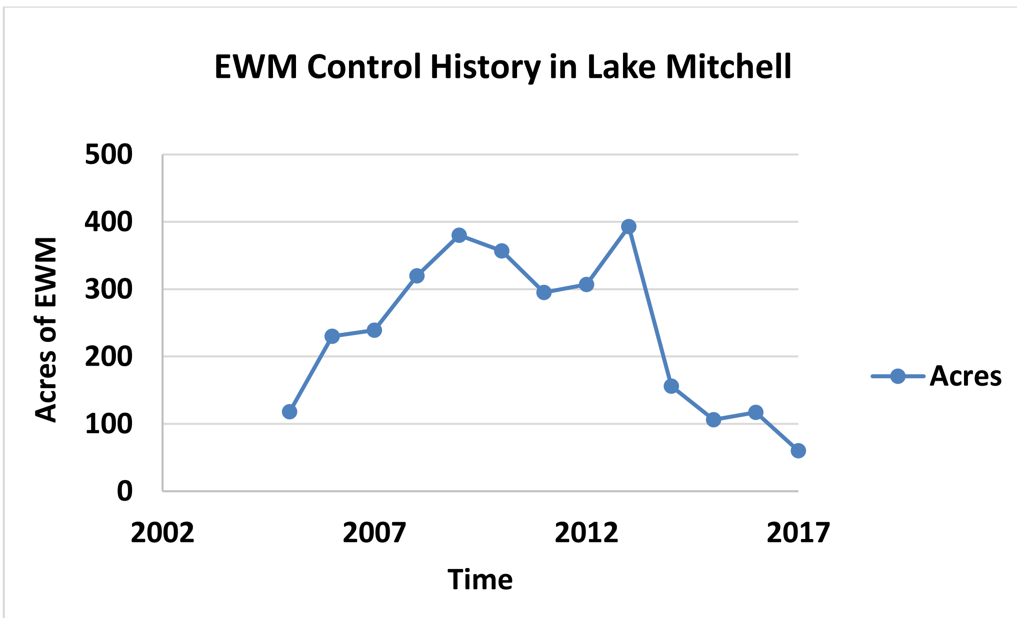
Detailed aquatic vegetation surveys will be done in 2018 to determine locations of EWM, CLP, and any other nuisance invasive species or natives. Along with the surveys, bottom scans will be conducted to determine changes in composition and biovolume of aquatic vegetation. These surveys will occur in late May or early June depending on weather patterns which correspond with growth patterns. A post treatment survey will also be scheduled, along with intermittent post-treatment surveys if small-scale treatments are conducted. RLS scientists will oversee all treatments. As in 2017 and previous years, RLS will notify the LMIB of the survey and treatment dates and update the LMIB on all management activities.

This year RLS is recommending that we treat large off shore area with Navigate® (2,4-D) at 200 pounds/acre and small isolated areas with 240 pounds/acre. Navigate® is recommended for a change from Sculpin® (2,4-D) so that plant tolerance does not become established. Near shore areas will continue to be treated with Renovate OTF® (triclopyr) at 200 or 240 pounds/acre depending on the size of the treatment polygon. Diquat and/or Clipper will continue to be used in the cove areas for nuisance natives. Maintaining EWM at existing low levels will be the top priority to keeping a healthy aquatic plant balance and continuing to maintain a low assessment for the lakefront owners in the special assessment district. The canal will be assessed for the need for a possible harvest and scheduled if necessary.

Water quality will continue to be monitored in the lake and tributaries. New water quality data from 2018 will be compared to historic data to establish any long-term trends.

Lake Mitchell is a healthy lake with excellent aquatic plant diversity. It has acceptable water clarity that is reduced somewhat by tannins and lignins coming from extensive wetland drainage. This water clarity has been favorable over the past few years. Nutrients are at acceptable levels and there is a robust fisheries indicated by the many fishing tournaments held on the lake. Temporary algal blooms occur during hot windless periods but do not tend to become established. RLS will continue to monitor the lake for any problematic algal blooms.

Lake Mitchell Improvement Board meetings will be attended by an RLS scientist as in previous years and RLS will develop a comprehensive annual report during the year that will be presented to the LMIB in the fall of 2018. The graph below shows the results of the successful EWM reduction plan for Lake Mitchell which has resulted in substantial savings to the LMIB over the years.



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.