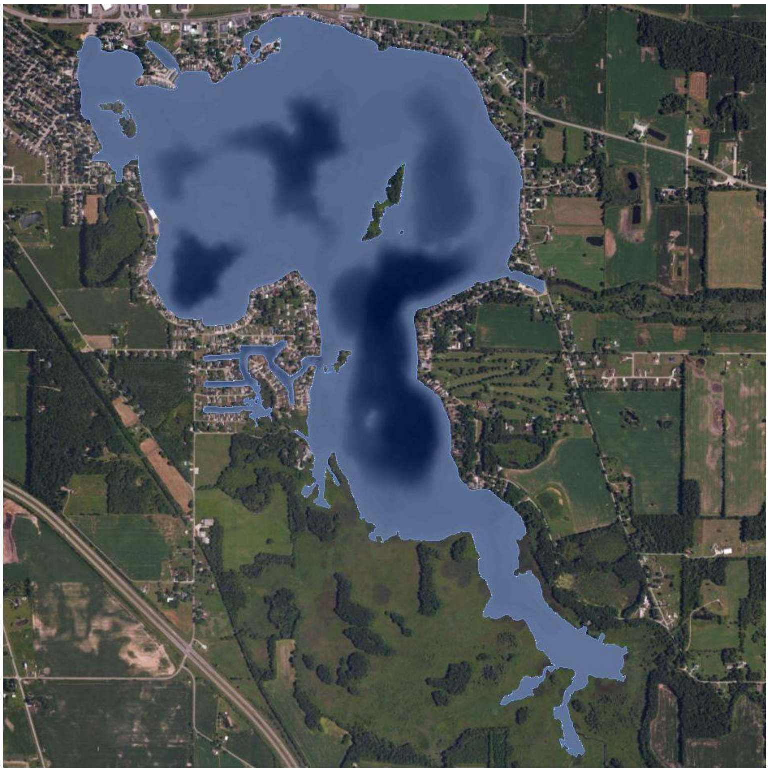

2016 Lake Manitou Aquatic Vegetation Management Plan Update
Fulton County, IN
December 19, 2016

Prepared for:
Indiana Department of Natural Resources
402 W. Washington St. Rm. W273
Indianapolis, IN 46204

Prepared by:
SePRO Corporation, Aquatic Control, Aquatic Weed Control, and ReMetrix

Executive Summary

SePRO Corporation has been contracted since 2007 by the Indiana Department of Natural Resources (IDNR) to support an extended effort to fully eradicate the submersed invasive plant hydrilla (*Hydrilla verticillata*) from Lake Manitou. In 2006, hydrilla was discovered in Manitou by IDNR. This was the first confirmed case of hydrilla in the Midwest, and hydrilla eradication was selected as the primary management goal. Following the 2006 hydrilla discovery, IDNR took quick action by closing the lake's public ramps, using contact herbicides to reduce the potential of spread, and requesting a proposal for an eradication plan. SePRO was awarded a multi-year contract to support initial eradication efforts beginning in 2007 and teamed with ReMetrix LLC (Carmel, IN), Aquatic Control, Inc. (Seymour, IN) and Aquatic Weed Control, Inc. (Syracuse, IN) to complete the project. A lake-wide fluridone (Sonar®) treatment maintaining > 6 ppb for 180 days and tuber sampling were conducted that year. An 86% total reduction in pretreatment tuber densities was recorded. Between 2008 and 2014, technical modifications were made to Sonar treatments on Manitou as consecutive annual cycles of hydrilla eradication effort were refined to improve efficiency based on monitoring and assessment results and potential enhance selectivity to non-target, desirable aquatic vegetation. By 2011, hydrilla tuber densities had been reduced by 99.5%, and assessment efforts shifted to intensive diver surveys to enhance ability to detect remnant, isolated hydrilla. In a June 2012 intensive dive survey, 58 acres of lake bottom were surveyed and hydrilla was discovered in 7 locations. In 2013, further dive survey efforts discovered four plants in three locations. In 2014 and 2015, direct management efforts were focused on just 423 of the lake's 809 total acres. Both traditional Tier II vegetation surveys and the intensive dive survey were unable to locate any hydrilla in the lake. Further details on 2007 – 2015 management can be found in previous management plan updates.

Control strategies were adjusted in 2016 to only include treatment of areas of known past hydrilla presence. A 160 acre area was treated with Sonar PR on 3 occasions; May 9th, June 30th, and August 15th. FasTEST® water samples for monitoring of Sonar concentrations were collected May 9th, June 20th, July 18th, August 8th and September 6th. Analytical results showed effective, efficient season-long concentrations were maintained in a 2 – 3 ppb range. The main dive survey was completed on June 15th and 16th, and a secondary single diver survey was completed August 3rd. Both of these surveys once again failed to detect any vegetative hydrilla. Tier 2 surveys completed on June 30th and August 29th also failed to detect hydrilla.

Based on best-available information on hydrilla tuber depletion rates in the scientific literature and technical reports of other eradication efforts, it is projected that the sustained management efforts of Indiana DNR have achieved the ultimate goal of hydrilla eradication from Lake Manitou. 2016 marked the third year since the start of the eradication program where hydrilla was not detected in the lake through any survey effort. At this point following a decade of sustained control efforts, outcomes of successful eradication programs in Washington, Maine, and other US states using Sonar herbicide support that the current lack of detection projects to full depletion of monoecious hydrilla tubers from previously infested areas. While SePRO's conclusion here based on current project findings supports the end of proactive annual cycles of Sonar application to Manitou, continued intensive vegetation assessment including dive surveys should continue for at least two more seasons to further verify full hydrilla eradication from the lake. This continued monitoring effort will also provide useful data on the ongoing recovery of the lake's aquatic plant community building off of adaptive reductions in treatment intensity in recent years.

Based on overall project status and ongoing dialogue with DNR regarding adaptive next steps, the following is a list of recommended actions specifically designed for 2017 to confirm apparent full hydrilla eradication in Lake Manitou:

1) **Continued utilization of intensive late spring dive survey for hydrilla detection.** The focus of hydrilla detection in the last several years of the eradication program has been intensive dive surveys in areas of past hydrilla infestation. It is recommended that the mid-June intensive dive surveys continue in a similar timeframe in 2017.

2) **Addition of multiple diver 'spot checks' at monthly intervals during the summer**. In addition, to further insure that any unanticipated hydrilla growth is detected early in the absence of proactive, season-long control with Sonar, SePRO would propose monthly 'spot check' assessments via diver beginning approximately 1 month following the mid-June full dive survey and continuing into mid-September or early October (maximum of three smaller dive surveys). These assessments will involve several hours of diver effort in 'high intensity' zones delineated for the more intensive June surveys.

3) **Implementation of a rapid response plan for additional hydrilla detection.** If any of the surveys detect hydrilla, a rapid-response plan should be implemented. This plan should involve immediate treatment of the infestation and an appropriate 'buffer zone' (0.5 – 5 acres) around the find(s) with a contact herbicide such as Komeen® or Komeen Crystal chelated copper herbicide. Depending on the time of year of the find and its initial treatment, a spot application of Sonar pellets to limit risk of potential regrowth of any surviving hydrilla following the contact application may be warranted.

4) **Review of prevention strategies for potential re-introduction of hydrilla or introduction of other AIS.** The current conclusion of full hydrilla eradication from Manitou represents an opportunity for revisiting broader AIS prevention and response strategies for the lake such as enhanced ramp signage and volunteer ramp 'stewards' or inspections. The investment in hydrilla eradication effort on Manitou has been significant and its value should be protected through enhanced prevention and response strategies where feasible.

Acknowledgements

Funding for vegetation sampling, herbicide treatment, and preparation of the aquatic vegetation management plan was provided by the IDNR. Aquatic Control, Inc., Aquatic Weed Control, Inc., ReMetrix LLC, and SePRO Corporation completed the fieldwork, data processing, and map generation. Special thanks to Mr. Eric Fischer and Mr. Doug Keller from the IDNR for their assistance on design and implementation of this plan. In addition, special thanks are given to the Lake Manitou Association for their efforts. Authors of this report are Dr. Mark Heilman of SePRO, Mr. Leif Willey of SePRO, Mr. Nathan Long of Aquatic Control, Inc., and Mr. J.T. Gravelie of ReMetrix LLC. The authors would like to acknowledge the valuable input from the staff of SePRO Corp., Aquatic Control, Inc., and Aquatic Weed Control, Inc.

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1.0 INTRODUCTION

This report was created in order to update the Lake Manitou Aquatic Vegetation Management Plan. In 2004, the Lake Manitou Association was awarded a grant through the Lake and River Enhancement (LARE) program to complete the original Lake Manitou Aquatic Vegetation Management Plan. Aquatic Weed Control completed the original plan in March 2005 (Donahoe & Keister 2005). The Association was awarded grants again in 2005 and 2006 to update the plan and these updates were also completed by Aquatic Weed Control (Donahoe & Keister 2006 & 2007). The Indiana Department of Natural Resources (IDNR) took over funding vegetation management on Lake Manitou in 2007 following the discovery of hydrilla.

The following management goals were established by the original plan:

1. Develop or maintain a stable diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species.

2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.

3. Provide reasonable public access while minimizing the negative impacts on plant and wildlife species (Donahoe & Keister 2005).

The primary purpose of the 2016 vegetation sampling and plan update is to document recent hydrilla eradication activities and to adjust the management plan as needed following the discovery of hydrilla in Lake Manitou in 2006. SePRO completed updates to the plan each year from 2008 through 2015 (SePRO 2008-2015). Items covered in this 2016 update include the 2016 sampling results, a review of the 2016 vegetation management activities, and updates to the action plan. Recent Lake Manitou invasive species treatment history is summarized below in Table 1.0.1.

Table 1.0.1. Lake Manitou Invasive Species Control History 2005-2016.

Year	Invasive Species Treated	Acres Treated	Product(s) Applied
2005	Eurasian watermilfoil	45	2,4-D
2006	Eurasian watermilfoil & Hydrilla	95 milfoil & 20 hydrilla	2,4-D & Copper (Komeen)
2007	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar Q)
2008	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar PR)
2009	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar PR)
2010	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar PR)
2011	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar PR)
2012	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar PR)
2013	Hydrilla	592 (partial lake)	Fluridone (Sonar AS & Sonar PR)
2014	Hydrilla	423 (partial lake)	Fluridone (Sonar AS & Sonar PR)
2015	Hydrilla	423 (partial lake)	Fluridone (Sonar AS & Sonar PR)
2016	Hydrilla	160 (spot treatment)	Fluridone (Sonar PR)

Lake Manitou is an 809-acre lake located in Fulton County, Indiana. The control of Eurasian watermilfoil was the primary objective of the original plan. This changed in August of 2006 when IDNR discovered hydrilla during a routine Tier 2 survey. This discovery precipitated a rapid response by IDNR Aquatic Invasive Species Coordinator, Doug Keller.

Upon confirmation of species, access to the lake was immediately closed to the public to prevent the potential for spread through boats and boat trailers (Figure 1.0.1). Due to a lack of viable hydrilla fragments following treatment, the public ramp was re-opened in June of 2008. In 2009 and 2010 the public ramp was closed prior to treatment and then reopened by July 1st of each year. The ramps were left open during the 2011 - 2016 seasons.

Figure 1.0.1. Public notices posted at Lake Manitou public launches.

Hydrilla is an invasive species that can form dense populations that disrupt ecosystems, displace native species, and impair fish and wildlife habitat. It has unique physiological and biological characteristics that can create a competitive advantage over many native submersed plant species, and has been termed "The Perfect Aquatic Weed" (Langeland 1996). Hydrilla has a low light and CO_2 compensation point compared to some native submersed plant species (Van et al. 1976); can switch between C_3 and C_4 carbon utilization under limiting conditions (Rao et al. 2002); forms dense canopies at the water surface which limits light penetration (Haller and Sutton 1975); and can have up to 85% of its biomass in the top 2 feet of water. Hydrilla can create an environment that is difficult for other plant species to effectively grow and compete (Figure 1.0.2). If hydrilla was not eradicated or its spread contained, it could rapidly spread to other waters, form monocultures of vegetation, impede recreation, reduce biodiversity, and result in biological pollution in many shallow lakes of Indiana. A recent literature review of monoecious hydrilla biology and management is now available as a result of efforts supported by the NE Aquatic Nuisance Species Panel through the Great Lakes Restoration Initiative:

Location of Resources: http://www.northeastans.org/resources.html

Summary ppt: http://www.northeastans.org/docs/hydrillalitsearch12.14.12.pdf

Actual review: http://www.northeastans.org/docs/hydrillalitsearch12.31.12.pdf

Figure 1.0.2. Photograph examples of dense, surface-matted hydrilla.

Eradication of hydrilla remains the primary goal of vegetation management in Lake Manitou. Lake Manitou was the first confirmed location of hydrilla in the Midwest. Hydrilla is the number one aquatic plant problem in the U.S. with more money expended on management than for any other aquatic plant species. Other states have taken aggressive approaches against hydrilla recognizing the potential impact this species can have on recreation, water conveyance, biodiversity, and water use. California legislatively mandated an eradication program after the plant was identified in the State in 1976; Washington and Maine enacted eradication programs shortly after identifying hydrilla; hydrilla was discovered in Wisconsin in 2007 with eradication completed through physical means (filling small pond); recently hydrilla was identified in a number of additional states including (but not limited to) New York, Idaho, Kansas, and Missouri with aggressive control programs initiated. Many of these programs have, at a minimum, minimized the potential for further spread of hydrilla within each state and regionally by keeping infestations at the lowest possible level and decreasing vegetative production. In 2015 and 2016, new infestations in Ohio, Kentucky, and Pennsylvania were identified. The Ohio River is known to have numerous populations of hydrilla at public accesses along the river. These regional infestations reinforce the need for continued vigilance, improvement of education and prevention strategies, and effective early detection/rapid response throughout the Ohio Valley.

Hydrilla can be easily spread through fragmentation, so control of this species took precedence over all other aquatic vegetation control efforts on Lake Manitou. Shortly after discovery, IDNR personnel mapped the hydrilla population in Lake Manitou and contracted Aquatic Weed Control, Inc., to treat approximately 20 acres of hydrilla in the lake with Komeen® (chelated copper herbicide) in the Poet's Point area in the northern section of the lake and near the City ramp. The treatment was effective in controlling extant hydrilla biomass in the treatment areas to reduce potential for vegetation spread in Lake Manitou and downstream. Further surveys conducted independently by IDNR personnel and SePRO personnel (Figure 1.0.3) confirmed additional sites in the lake with hydrilla. This led to a Request for Proposal (RFP) for a comprehensive hydrilla eradication program for Lake Manitou.

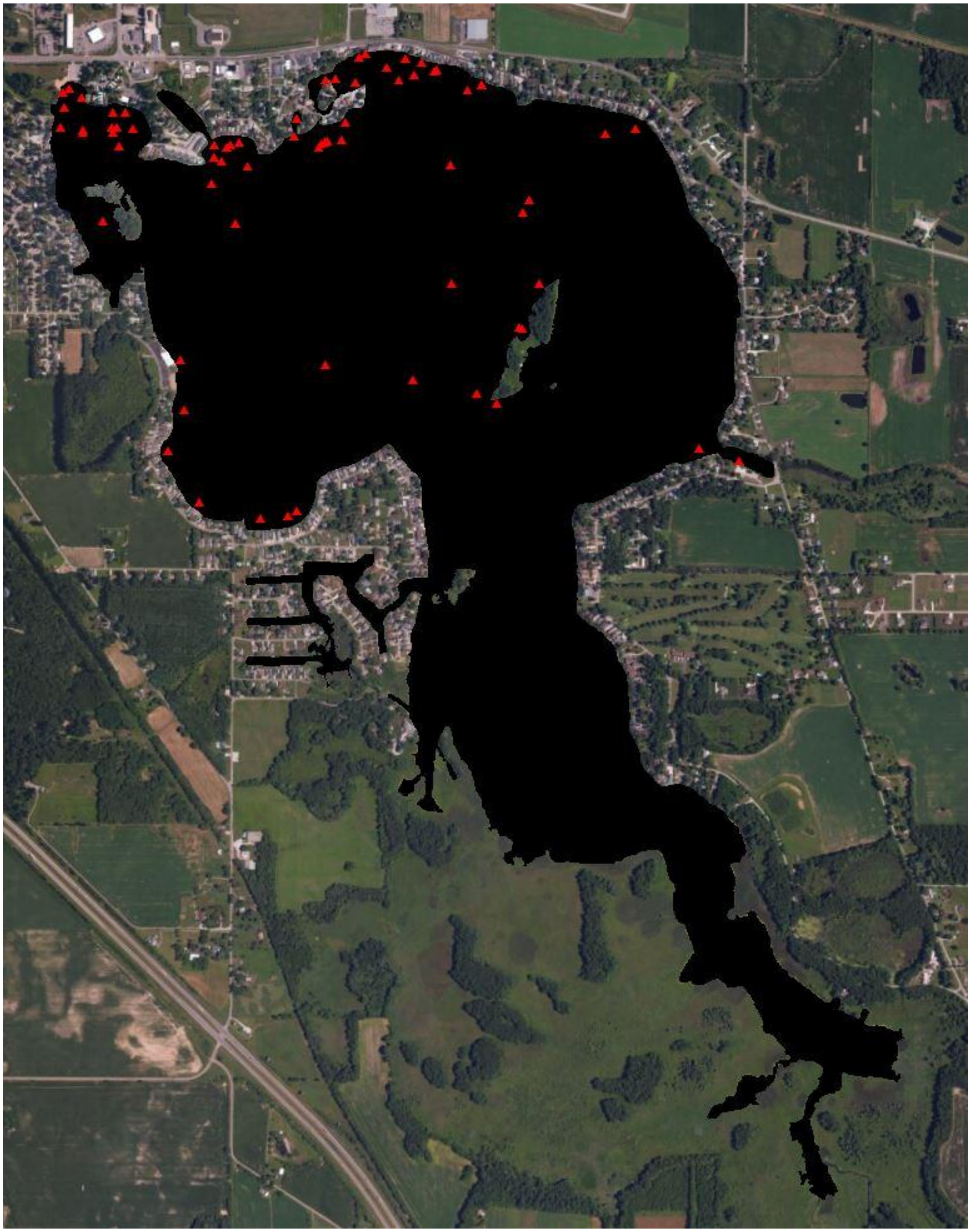

Figure 1.0.3. Lake Manitou hydrilla sightings 2006-2016. (Includes all sightings recorded by the project team and IDNR.)

SePRO Corporation was awarded the contract and assembled a team focused on the management of vegetation in Lake Manitou, with the objective of hydrilla eradication. The team consisted of personnel from Aquatic Control, Inc., Aquatic Weed Control, Inc., ReMetrix LLC, and SePRO. Sonar® Aquatic Herbicide (a.i. fluridone) treatments were initiated in 2007 with the objective of maintaining greater than 6 ppb for 180 days. Applications were completed with a combination of Sonar AS and Sonar Q. By the end of the season tuber sampling revealed hydrilla tuber numbers were reduced by 86%. Modifications were made to the 2008 treatment prescription in an attempt to increase selectivity and protect that native plants. Sonar pellet formulations were switched from Sonar Q to Sonar PR, and the whole lake concentration was to be maintained at 3ppb in of the 6 ppb. In 2009 a similar program was initiated, and this was the first year that hydrilla was not found during the Tier II surveys. This lead to changes in the 2010 treatments and surveys. The 2010 treatment prescription called for an initial dose of 6 ppb target followed by maintenance of 2.5 to 5 ppb throughout the growing season. In addition to the Tier II surveys a diver survey was added and they were able to readily detect herbicide stressed hydrilla. The tuber sampling from 2010 indicated tubers banks had been reduced by 96% since the beginning of the project in 2007. Following the success of these treatments both 2011 and 2012 continued with the same treatment and survey plans. By the end of 2012 tuber depletion had reached a point where tuber sampling was highly inefficient and therefor dropped from the project moving forward. In 2013, in an effort to allow for increased native growth in the southern portion of the lake, only the northern 75% of the lake was actively treated. The 2013 dive survey only found 4 plants growing within 3 locations. Control efforts in 2014 were further modified to focus management to the northern end of the lake, and the use of Sonar AS was reduced in order to minimize the overall lake wide concentration. The 2014 dive survey was unable to find any hydrilla, and the Tier II surveys found increases in native diversity and abundance.

A similar control strategy was maintained in 2015. On May 22, 2015, the first application was made with Sonar AS was applied at a concentration of 7.0 ppb to the lower (northern) 423 acres of the lake along with pelletized Sonar PR to 18 zones at concentrations ranging from 20-70 ppb. A pre-planned Sonar PR bump application and an extra Sonar AS bump was completed on July 7th. The Sonar AS bump was required due to low fluridone concentrations caused by extreme June and July rains. Sonar PR was applied to the same locations as the initial Sonar PR treatment but at half the initial rate. A second pre-planned Sonar PR application was completed on August 21st at the same locations and concentrations as the July 7th application (Figure 4.1.4). Fluridone concentrations remained steady throughout the summer months. Concentrations began to drop in early fall (<2.5 ppb lakewide average per September 21st FasTEST) and a final Sonar AS bump was required. This treatment was completed on October 8th. Dive surveys and Tier 2 surveys completed in 2015 did not detected any hydrilla.

The following sections will detail the progress of the 2016 hydrilla eradication program along with future Lake Manitou vegetation management plans.

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2.0 VEGETATION SAMPLING

Several vegetation sampling events were completed in 2016 (Table 2.0.1). Sampling was similar to past efforts. A dive survey has been a component of the project assessment activities since 2011 to more accurately pinpoint and monitor for the presence of vegetative hydrilla. The 2016 dive survey was completed on June 15th and 16th. In addition to this standard multi-diver survey, and single diver spot check was performed on August 3rd. Standard Tier 2 surveys (IDNR 2014) were completed on June 29th and August 29th to monitor the hydrilla population (if detectable) and quantify native species abundance. In addition, visual observations of the plant community were recorded throughout the season during FasTEST sampling.

Table 2.0.1. Summary of 2016 Plant Surveys on Lake Manitou. 2016 herbicide treatment dates: May 9, June 29, and August 15

Date (2016)	Type of Survey
May 31	FasTEST Collection
June 15 & 16	Dive Survey
June 21	FasTEST Collection
June 29	Tier 2 Survey
July 13	FasTEST Collection
August 3rd	Single Diver Survey
August 9	FasTEST Collection
August 29	Tier 2 Survey
September 6	FasTEST Collection

2.1 Reconnaissance Surveys

For reference: The initial Sonar PR treatment was conducted on May 9, June 29, and August 15. Details of the treatments can be found in Section 4.0.

In the past reconnaissance surveys were completed during FasTEST collections, however with the hydrilla eradication project coming to a close the number of FasTEST samples were cut back to 5 and the reconnaissance survey removed to reduce cost. The visual surveys were still performed when collecting FasTEST samples. Surveyors followed an updated route designed to maneuver over formerly known areas of hydrilla. (Figure 2.1.1) Along with collecting FasTEST samples, personnel recorded Secchi depth, and surface temperature readings.

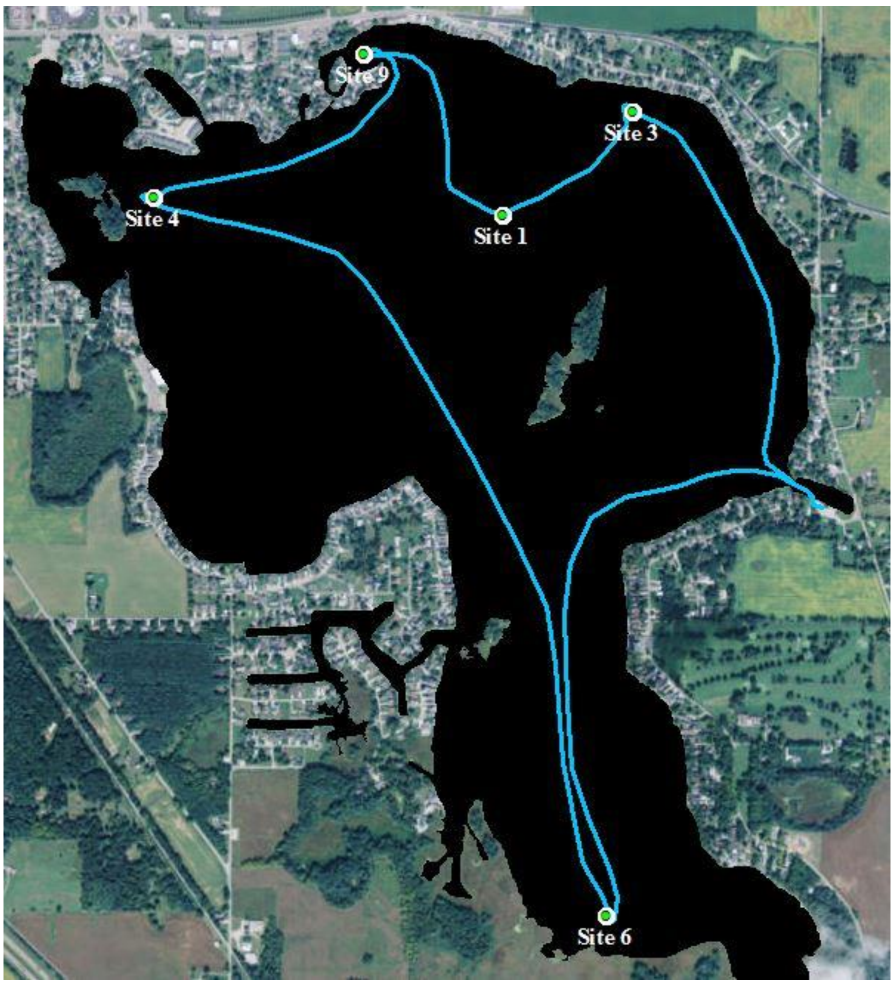

Figure 2.1.1. FasTEST monitoring route. Route shown is representative track from May 31, 2016 collection. Tracks of all collections are available upon request.

Collection of water temperature and clarity measures in conjunction with water sampling provided a rapid and cost effective means of assessing treatment results. A summary of the water clarity results for 2016 can be seen in section 3: Water Quality Monitoring of this report

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2.2 Tuber Sampling

Sampling for hydrilla tubers in the fall of the treatment cycle was discontinued in 2012 after results of fall 2011 survey indicated 99.5% reduction in tuber bank densities at permanent stations established in earlier years. For review of 2007 – 2011 tuber assessment results, please reference 2011 Lake Manitou Aquatic Vegetation Management Plan Update: http://www.in.gov/dnr/fishwild/files/fw-Lake_Manitou_AVMP_2011_Update_Fulton_County_Jan_2012.pdf.

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2.3 Tier 2 Surveys

For reference: The initial Sonar PR treatment was conducted on May 9 followed by smaller re-applications of Sonar PR on June 29 and August 15. Details of the treatments can be found in Section 4.0.

Tier 2 surveys were completed on June 29th and August 29th. Tier 2 surveys were included in the vegetation monitoring program to quantify species diversity and abundance, allow for pre- and post-treatment comparisons of the plant community, and potentially locate additional areas of hydrilla. The design of the Lake Manitou point-intercept survey was based on the LARE protocol (IDNR 2014). A total of 122 sites were sampled (Figure 2.3.1).

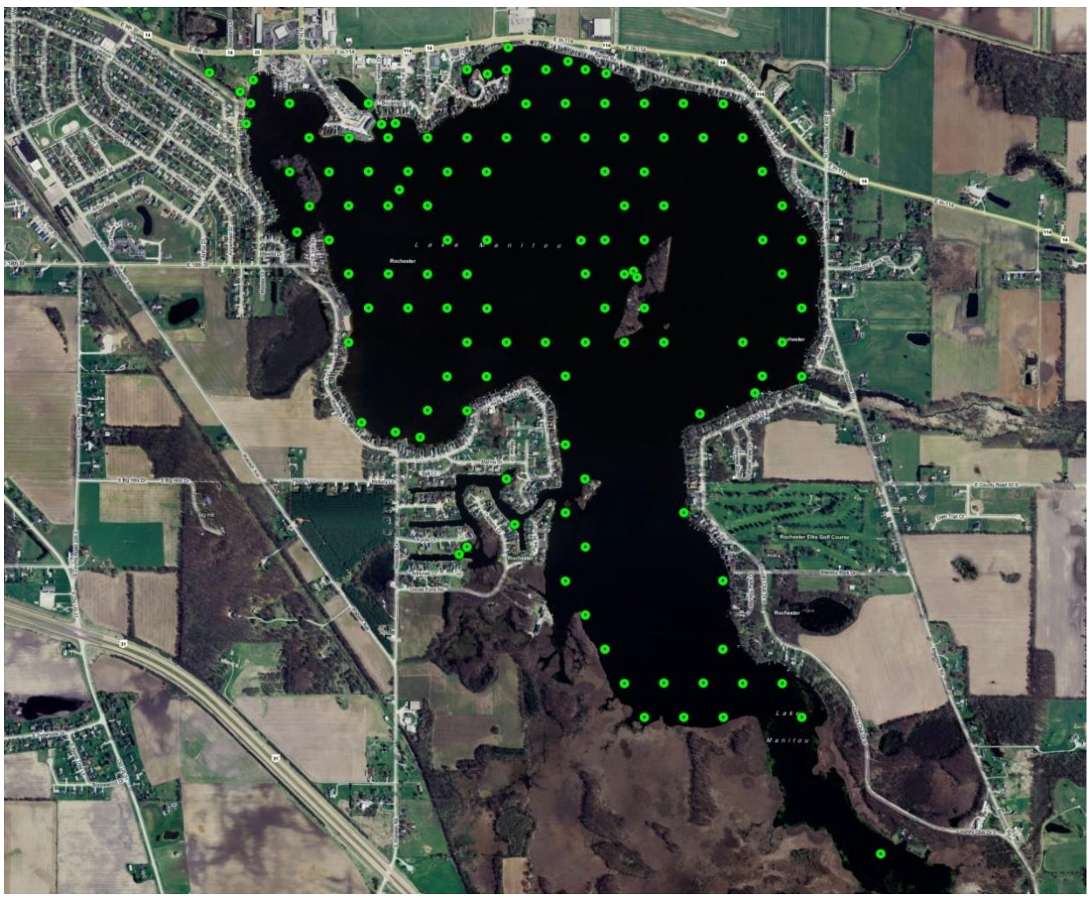

Figure 2.3.1. Tier 2 vegetation sample sites visited in 2016.

2.3.1 Spring Tier 2 Survey Results

The spring survey was conducted on June 29th. One rake drag was completed at each survey location. Plant density and injury ratings were recorded for individual species (Table 2.3.1). Vegetation was collected to a maximum depth of 10 feet and aquatic vegetation was present at 43.5% of sites. Ten native submersed species were collected. The maximum number of species per site was 4; the mean species collected per site was 0.56, and the species diversity index was 0.78 (Table 2.3.2).

Table 2.3.1. Plant rating scales used during the Tier 2 surveys.

Density Ratings	Injury Ratings
0: No plants retrieved	1: Healthy
1: 1-20% of rake teeth filled	2: Slight Injury
3: 20-99% of rake teeth filled	3: Moderate Injury
5: 100%+ of rake teeth filled	4: Severe Injury
8: Plant present but unranked	5: Dead Plant

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Table 2.3.2. Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou. All depths: June 29, 2016.

Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (all depths).								
County:	Fulton	Total Sites:	122				Mean species/site:	0.57
Date:	6.29.16	Sites with plants:	54				SE Mean species/site:	0.07
Secchi (ft):	3.5	Sites with native plants:	53				Mean native species/site:	0.54
Max Plant Depth (ft):	10.0	Number of species:	11				SE Mean natives/site:	0.07
Trophic Status:	Meso	# of native species:	10				Species diversity:	0.78
Littoral Sites:	100	Maximum species/site:	4				Native species diversity:	0.76
All Depths		Frequency of Occurrence	Rake score freq per sp.				Plant Dominance	
Species			**0**	**1**	**3**	**5**		
Chara		19.7	80.6	13.7	4.8	0.8	6.5	
Coontail		15.6	84.7	9.7	0.8	4.8	7.3	
Leafy pondweed		7.4	92.7	6.5	0.8	0.0	1.8	
Sago pondweed		4.1	96.0	1.6	1.6	0.8	2.1	
Curly-leaf pondweed		2.5	97.6	2.4	0.0	0.0	0.5	
Water stargrass		2.5	97.6	1.6	0.8	0.0	0.8	
Common bladderwort		1.6	98.4	1.6	0.0	0.0	0.3	
Common waterweed		0.8	99.2	0.8	0.0	0.0	0.2	
Flat-stemmed pondweed		0.8	99.2	0.8	0.0	0.0	0.2	
Horned pondweed		0.8	99.2	0.8	0.0	0.0	0.2	
Large-leaved pondweed		0.8	99.2	0.0	0.0	0.8	0.8	
Filamentous Algae		60.7						
Other species observed: Pickerelw eed, w ater w illow , w atermeal, duckw eed, spatterdock, w hitw w ater lily, and cattail								
Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (0-5 ft).								
County:	Fulton	Total Sites:	88				Mean species/site:	0.60
Date:	6.29.16	Sites with plants:	40				SE Mean species/site:	0.09
Secchi (ft):	3.5	Sites with native plants:	39				Mean native species/site:	0.57
Max Plant Depth (ft):	10.0	Number of species:	10				SE Mean natives/site:	0.08
Trophic Status:	Meso	# of native species:	9				Species diversity:	0.79
Littoral Sites:	88	Maximum species/site:	4				Native diversity:	0.76
Depth: 0 to 5 ft		Frequency of Occurrence	Rake score frequency per s				Plant Dominance	
Species			**0**	**1**	**3**	**5**		
Chara		20.5	79.5	14.8	5.7	0.0	6.4	
Coontail		15.9	84.1	8.0	1.1	6.8	9.1	
Leafy pondweed		6.8	93.2	6.8	0.0	0.0	1.4	
Sago pondweed		5.7	94.3	2.3	2.3	1.1	3.0	
Curly-leaf pondweed		3.4	96.6	3.4	0.0	0.0	0.7	
Water stargrass		3.4	96.6	2.3	1.1	0.0	1.1	
Common waterweed		1.1	98.9	1.1	0.0	0.0	0.2	
Flat-stemmed pondweed		1.1	98.9	1.1	0.0	0.0	0.2	
Horned pondweed		1.1	98.9	1.1	0.0	0.0	0.2	
Large-leaved pondweed		1.1	98.9	0.0	0.0	1.1	1.1	
Filamentous Algae		61.4						
Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (5-10 ft).								
County:	Fulton	Total Sites:	12				Mean species/site:	0.33
Date:	6.29.16	Sites with plants:	3				SE Mean species/site:	0.19
Secchi (ft):	3.5	Sites with native plants:	3				Mean native species/site:	0.33
Max Plant Depth (ft):	10.0	Number of species:	3				SE Mean natives/site:	0.19
Trophic Status:	Meso	# of native species:	3				Species diversity:	0.63
Littoral Sites:	12	Maximum species/site:	2				Native diversity:	0.63
Depth: 5 to 10 ft		Frequency of Occurrence	Rake score frequency per s				Plant Dominance	
Species			**0**	**1**	**3**	**5**		
Coontail		16.7	83.3	16.7	0.0	0.0	3.3	
Chara		8.3	91.7	8.3	0.0	0.0	1.7	
Common bladderwort		8.3	91.7	8.3	0.0	0.0	1.7	
Filamentous Algae		33.3						

Chara was present at the highest percentage of sample sites (19.7%) followed by common coontail (*Ceratophyllum demersum)* (15.6%) (Figure 2.3.2 & 2.3.3). Leafy pondweed (*Potamogeton foliosus*) ranked third in frequency (7.4%), followed by sago pondweed (*Potamogeton pectinatus*) (4.1%). Curly-leaf pondweed was the only invasive collected and it was found at 3 sites (Figure 2.3.4). Filamentous algae was present at 60.7% of sites.

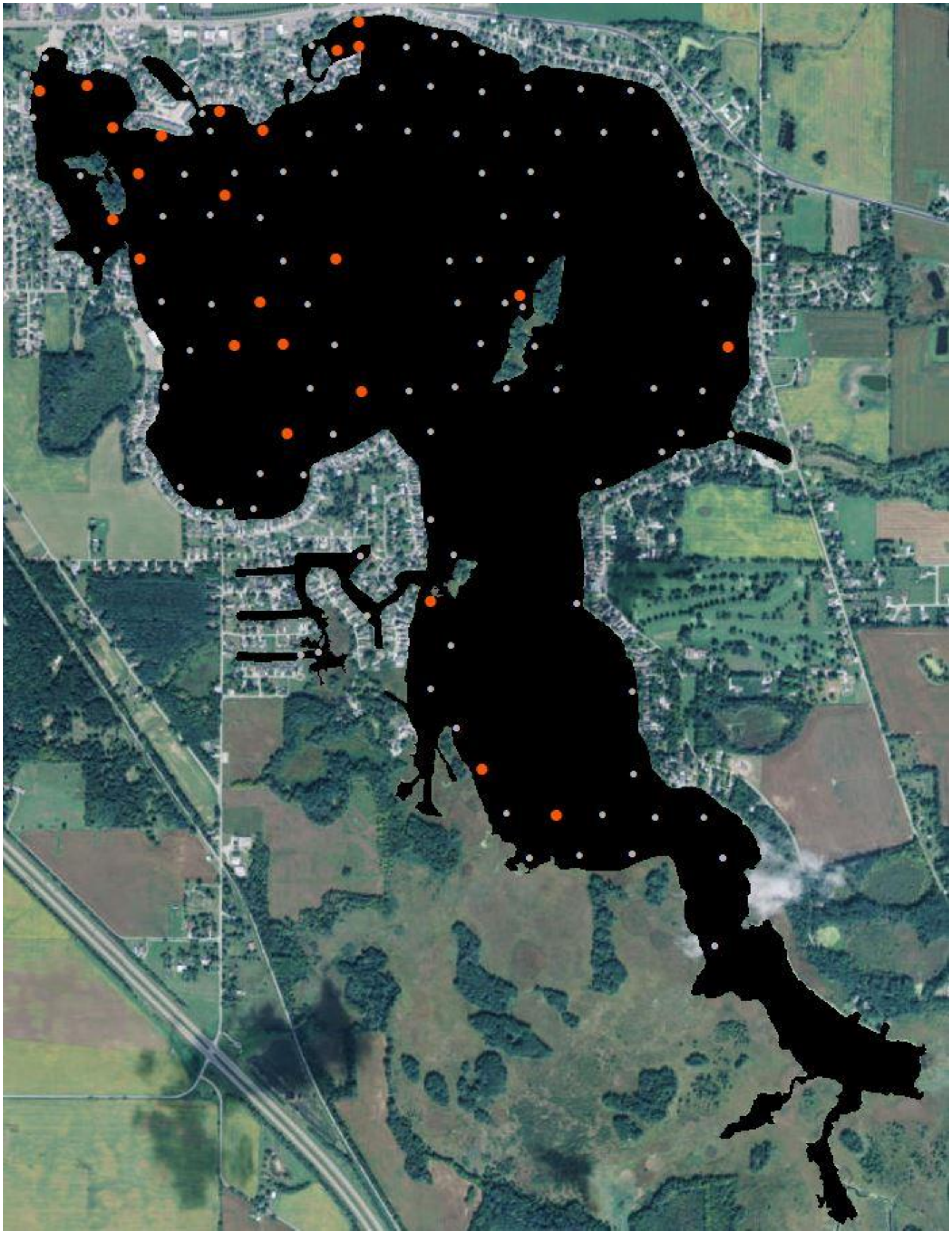

Figure 2.3.2. Lake Manitou, chara distribution, June 29, 2016.

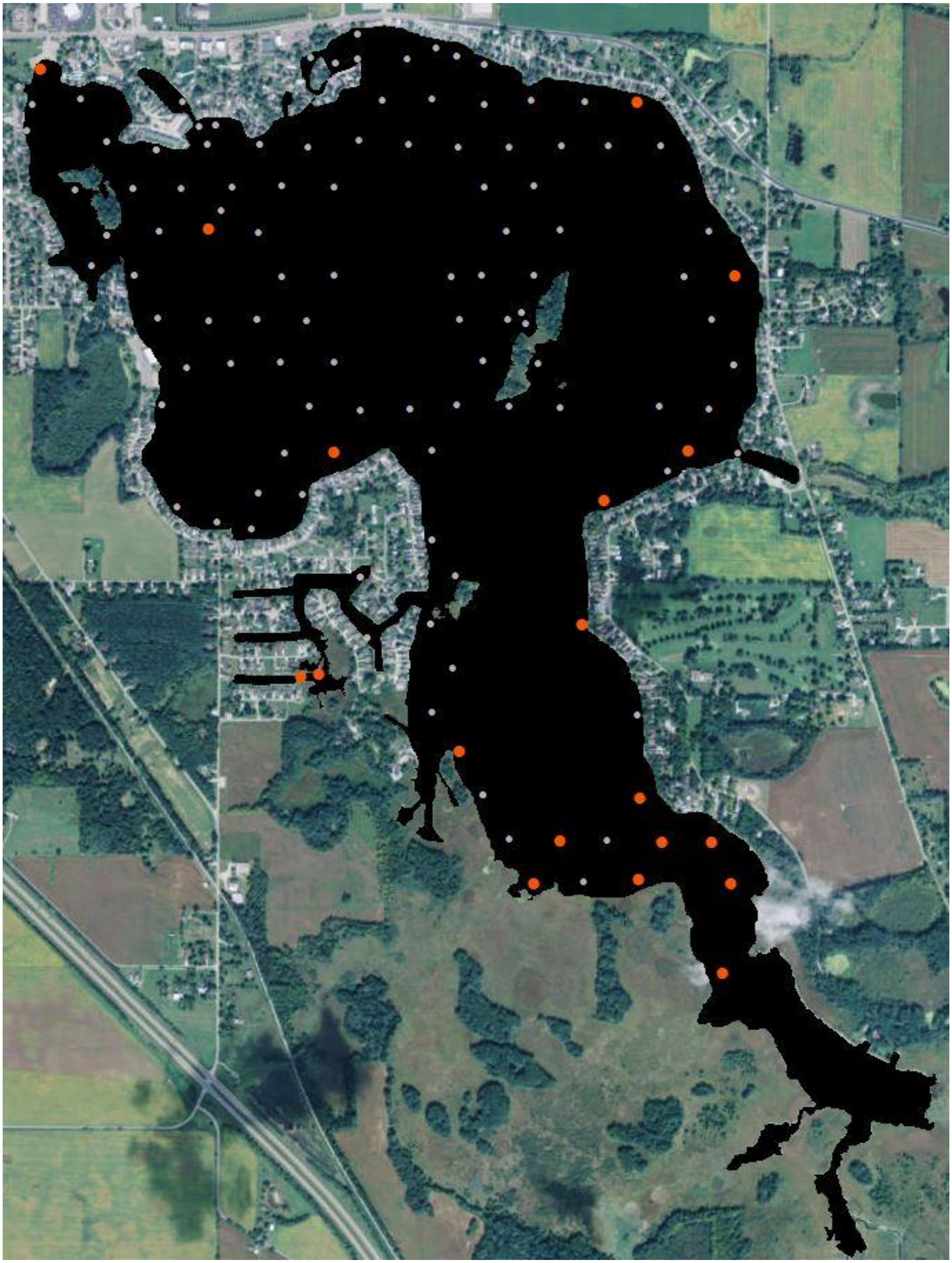

Figure 2.3.3. Lake Manitou, common coontail distribution, June 29, 2016.

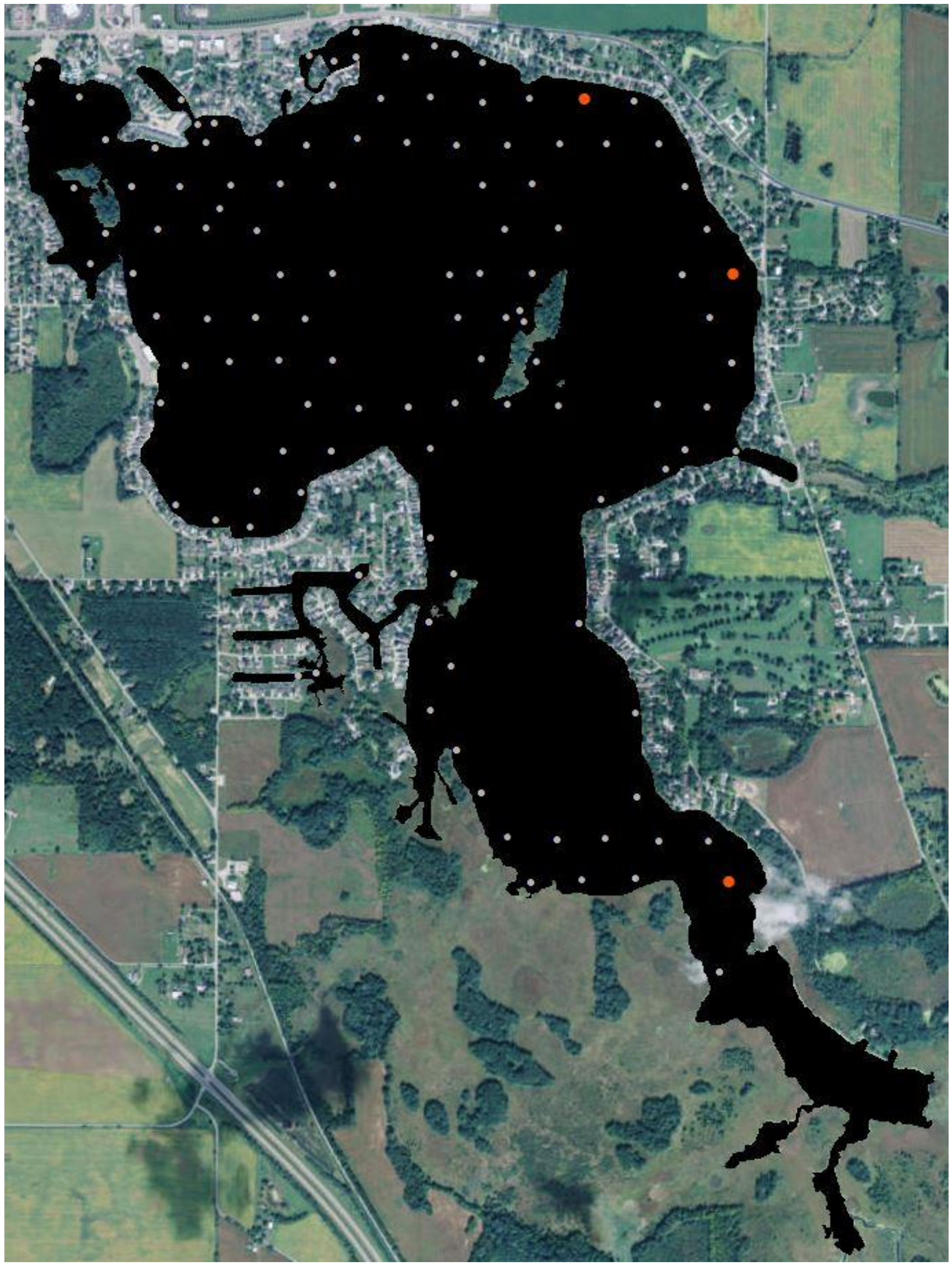

Figure 2.3.4. Lake Manitou, curly-leaf pondweed distribution, June 29, 2016.

2.3.2 Summer Tier 2 Survey Results

The methods used in the spring survey were applied again on August 29, 2016 (summer survey). Results of the sampling are listed in Table 2.3.3. Plants were growing to a maximum depth of 7.5 feet. Aquatic vegetation was present at 24.6% of the sites. A total of six species were collected. The maximum number of species per site was 3, the mean species collected per site was 0.43, and the species diversity index was 0.77.

Table 2.3.3. Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou. All depths: August 29, 2016.

Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (all depths).								
County:	Fulton	Total Sites:	122				Mean species/site:	0.43
Date:	8.29.16	Sites with plants:	30				SE Mean species/site:	0.08
Secchi (ft):	3.0	Sites with native plants:	30				Mean native species/site:	0.43
Max Plant Depth (ft):	7.5	Number of species:	6				SE Mean natives/site:	0.08
Trophic Status:	Meso	# of native species:	6				Species diversity:	0.77
Littoral Sites:	94	Maximum species/site:	3				Native species diversity:	0.77
All Depths		Frequency of Occurrence	Rake score freq per sp.				Plant Dominance	
Species			**0**	**1**	**3**	**5**		
Leafy pondweed		13.1	86.9	11.5	1.6	0.0	3.3	
Coontail		10.7	89.3	4.9	1.6	4.1	6.1	
Chara		8.2	91.8	3.3	3.3	1.6	4.3	
Small pondweed		4.9	95.1	4.1	0.0	0.8	1.6	
Water stargrass		2.5	97.5	2.5	0.0	0.0	0.5	
Large-leaved pondweed		1.6	98.4	0.8	0.8	0.0	0.7	
Filamentous Algae		30.3						
Other species observed: Cattails, duckweed, watermeal, fragrant water lily, purple loosestrife, hibiscus, bladderwort, arrowhead and spatterdock.								
Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (0-5 ft).								
County:	Fulton	Total Sites:	80				Mean species/site:	0.46
Date:	8.29.16	Sites with plants:	26				SE Mean species/site:	0.09
Secchi (ft):	3.0	Sites with native plants:	26				Mean native species/site:	0.46
Max Plant Depth (ft):	7.5	Number of species:	6				SE Mean natives/site:	0.09
Trophic Status:	Meso	# of native species:	6				Species diversity:	0.76
Littoral Sites:	80	Maximum species/site:	3				Native diversity:	0.76
Depth: 0 to 5 ft		Frequency of Occurrence	Rake score frequency per s				Plant Dominance	
Species			**0**	**1**	**3**	**5**		
Coontail		13.8	86.3	5.0	2.5	6.3	8.8	
Leafy pondweed		13.8	86.3	12.5	1.3	0.0	3.3	
Chara		10.0	90.0	5.0	5.0	0.0	4.0	
Small pondweed		3.8	96.3	3.8	0.0	0.0	0.8	
Large-leaved pondweed		2.5	97.5	1.3	1.3	0.0	1.0	
Water stargrass		2.5	97.5	2.5	0.0	0.0	0.5	
Filamentous Algae		32.5						
Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (5-10 ft).								
County:	Fulton	Total Sites:	16				Mean species/site:	0.25
Date:	8.29.16	Sites with plants:	3				SE Mean species/site:	0.14
Secchi (ft):	3.0	Sites with native plants:	3				Mean native species/site:	0.25
Max Plant Depth (ft):	7.5	Number of species:	3				SE Mean natives/site:	0.14
Trophic Status:	Meso	# of native species:	3				Species diversity:	0.63
Littoral Sites:	14	Maximum species/site:	2				Native diversity:	0.63
Depth: 5 to 10 ft		Frequency of Occurrence	Rake score frequency per s				Plant Dominance	
Species			**0**	**1**	**3**	**5**		
Coontail		12.5	87.5	12.5	0.0	0.0	2.5	
Leafy pondweed		6.3	93.8	6.3	0.0	0.0	1.3	
Water stargrass		6.3	93.8	6.3	0.0	0.0	1.3	
Filamentous Algae		12.5						

Leafy pondweed now occurred at the highest percentage of sample sites (13.1%) (Figure 2.3.5) followed by common coontail (10.7%) (Figure 2.3.6). Chara was found at 10% of sites. Small pondweed (*Potamogeton pusillus*), large-leaved pondweed (*Potamogeton amplifolius*), and water stargrass were also collected. Filamentous algae was present at 30.3% of sites.

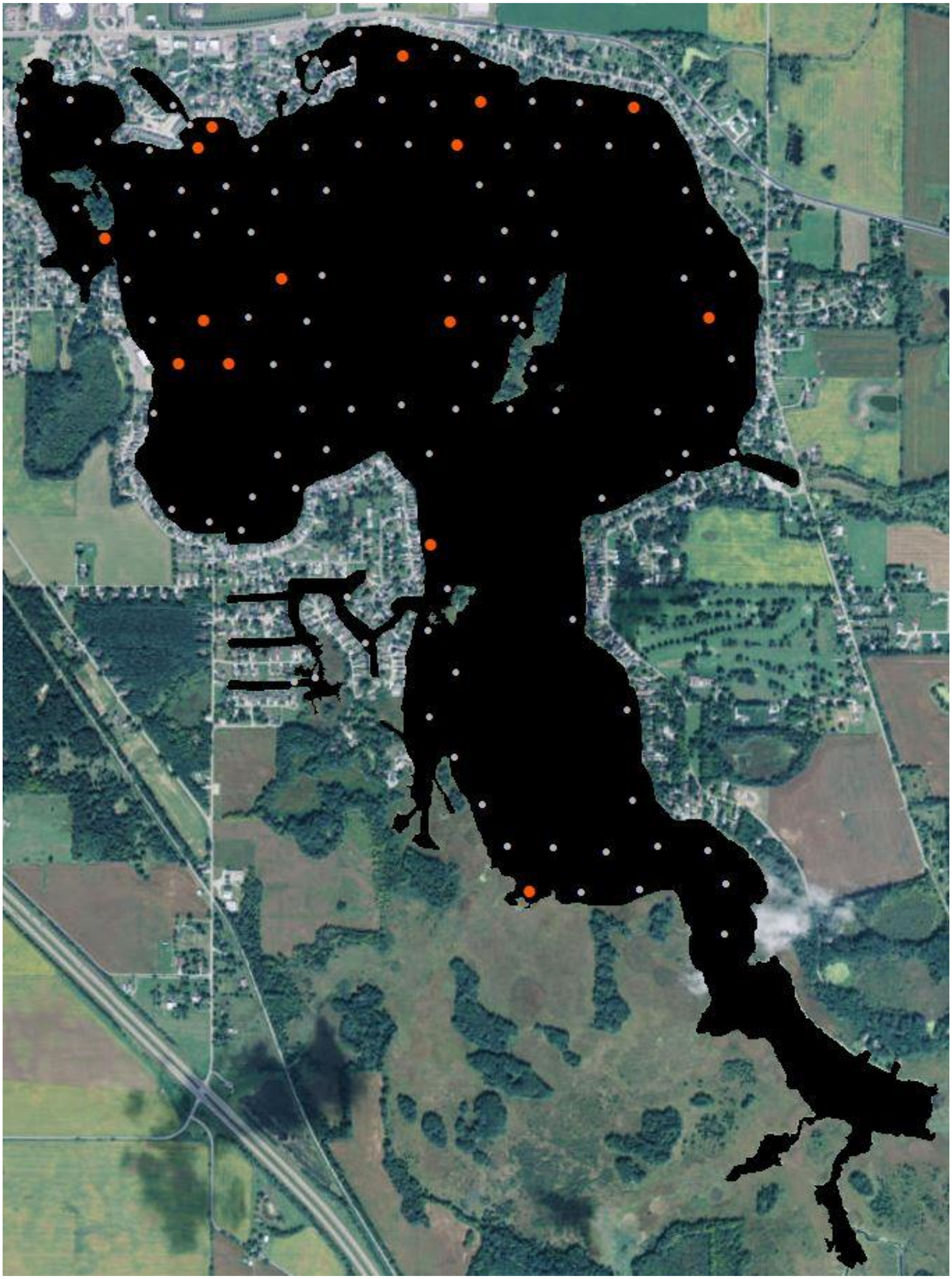

Figure 2.3.5. Lake Manitou, leafy pondweed distribution, August 29, 2016.

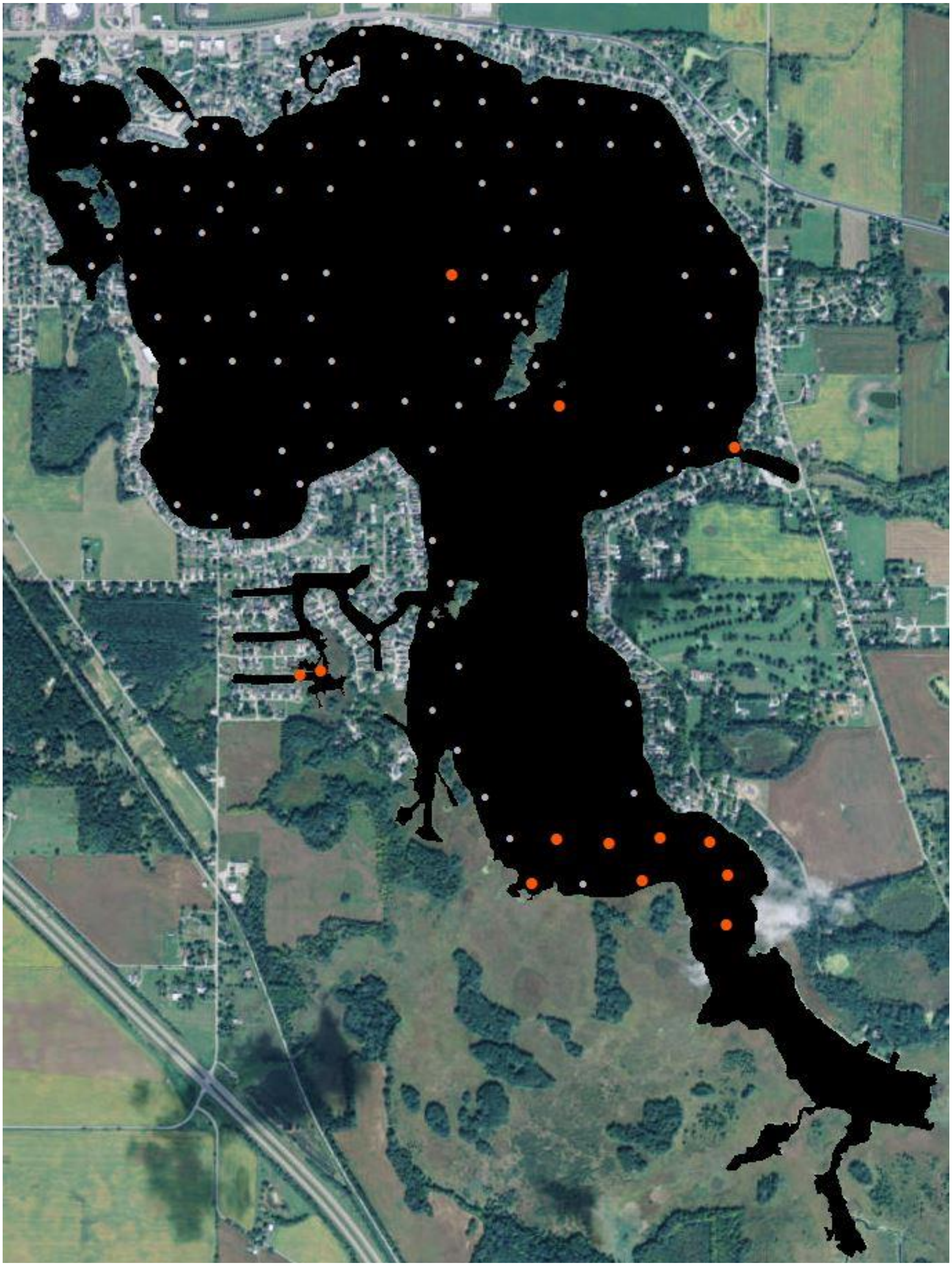

Figure 2.3.6. Lake Manitou, common coontail distribution, August 29, 2016.

2.3.3 Tier 2 Survey Discussion

For reference: The initial Sonar PR treatment was conducted on May 9, June 29, and August 15. Details of the treatments can be found in Section 4.0.

Annual Tier 2 surveys have been completed on Lake Manitou since 2004. Aquatic Weed Control, Inc. completed surveys in 2004, 2005 and 2006 and Aquatic Control and ReMetrix completed Tier 2 surveys in 2007-2016. The primary objective of the Manitou vegetation management plan has been the eradication of hydrilla. Hydrilla was detected during the 2007 spring Tier 2 survey but was not observed or collected during the 2008-2016 surveys. Before the introduction of hydrilla, Eurasian watermilfoil control was the primary objective of vegetation management. Milfoil is highly susceptible to low doses of Sonar, and has not been observed since the May 2007 survey.

The hydrilla eradication treatment with Sonar was expected to temporarily alter the makeup of the submersed native plant community. Prior to the whole lake treatments, eel grass occurred at the highest percentage of sample sites, but was either not collected or collected at low levels since treatment began. Chara, common coontail, leafy pondweed, and sago pondweed are now the most frequently occurring species since initiation of the eradication program. After posting declines in 2012 and 2013, occurrence of these species appears increased the past three years. In addition, horned pondweed (*Zannichellia palustris*) and common waterweed (*Elodea canadensis*) were collected for the first time in 2016. The changes in percent occurrence in the last 23 Tier 2 surveys are illustrated in Table 2.3.4 and Chart 2.3.1.

Table 2.3.4. Percent occurrence of species in Lake Manitou since 2004.

Species	% of survey sites identified																						
	Aug-04	Aug-05	Aug-06	May-07	Aug-07	Jun-08	Aug-08	Jun-09	Aug-09	Jun-10	Aug-10	Jun-11	Aug-11	Jun-12	Aug-12	Jun-13	Aug-13	Jun-14	Aug-14	Jun-15	Aug-15	Jun-16	Aug-16
hydrilla (*Hydrilla verticillata*)				3.3%																			
Eurasian watermilfoil (*Myriophyllum spicatum*)	27.5%	30.0%	2.9%	5.0%																			
curlyleaf pondweed (*Potamogeton crispus*)				3.3%				1.6%		1.6%	80.0%					1.7%						2.5%	
common coontail (*Ceratophyllum demersum*)	26.4%	11.0%	24.3%	36.4%	7.4%		0.8%	0.8%	0.8%	4.9%	4.1%	5.7%	11.5%	13.1%	2.5%	3.3%	2.5%	14.8%	4.1%	12.5%	0.8%	15.6%	10.7%
Chara (*Chara spp.*)	12.1%	10.0%	10.0%	24.0%	38.8%	50.0%	33.9%	18.9%	2.5%	31.1%	19.7%	29.5%	0.8%	13.9%	4.1%	3.3%		52.5%	15.6%	11.7%	4.1%	19.7%	8.2%
Common waterweed (*Elodea canadensis*)																						0.8%	
Water stargrass (*Heteranthera dubia*)									0.8%									0.8%	1.6%	1.7%		2.5%	2.5%
naiad species (Najas spp.)	11.0%	23.0%																					
slender naiad (*Najas flexillis*)			8.6%				0.8%																
Nitella (Nitella sp.)														0.3%									
largeleaf pondweed (*Potamogeton amplifolius*)				2.5%				0.8%								0.8%		1.6%	1.6%		0.8%	0.8%	1.6%
Leafy pondweed (Potamogeton foliosus)																0.8%		0.8%	1.6%	2.5%	1.6%	7.4%	13.1%
variable pondweed (*Potamogeton gramineus*)				0.8%																1.7%			
Illinois pondweed (Potamogeton illinoensis)	1.1%	2.0%	5.7%												0.8%								
sago pondweed (*Potamogeton pectinatus*)	14.3%	16.0%	10.0%	20.7%	0.8%	6.5%	3.2%	9.8%	4.2%	5.7%	7.4%	5.7%	4.1%	3.3%		2.5%	3.3%	0.8%	0.8%	1.7%	12.3%	4.1%	
Small pondweed (Potamogeton pusillus)																				4.2%			4.9%
flatstem pondweed (*Potamogeton zosteriformis*)				4.1%						0.8%									0.8%	0.8%	4.1%	0.8%	
Aquatic Moss (Riccia sp.)																	0.8%						
common bladderwort (*Utricularia vulgaris*)					0.8%		0.8%	0.8%	0.8%		0.8%		1.6%					0.8%	1.6%	2.5%	1.6%	0.8%	
eelgrass (Vallisneria americana)	50.5%	61.0%	42.9%	60.3%	6.6%			0.8%						0.8%	0.8%								
Horned pondweed (*Zannichellia palustris*)																						0.8%	

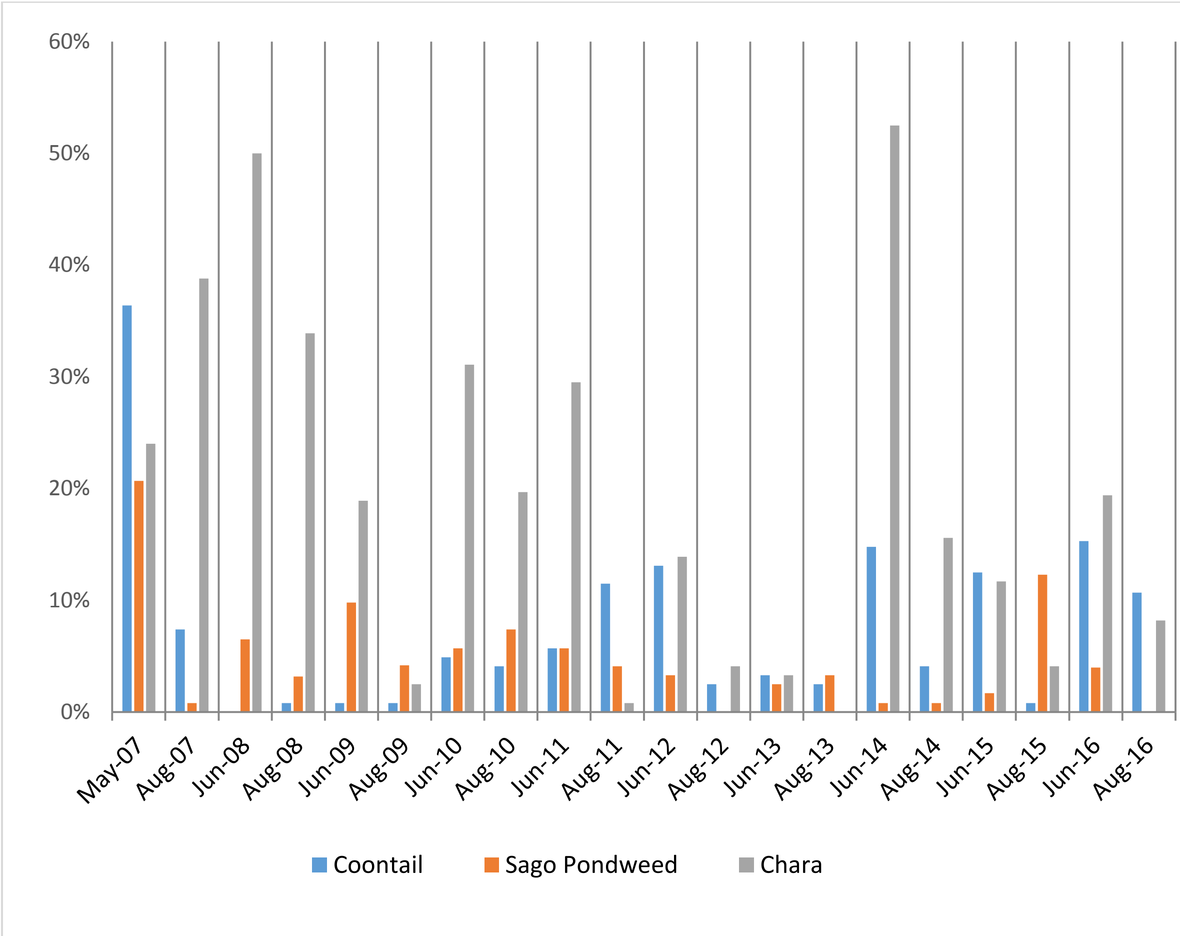

Chart 2.3.1. Percent occurrence of common coontail, sago pondweed, and Chara in Lake Manitou since 2007 (data from Table 2.3.4).

Tier 2 surveys also provide insight into changes of submersed aquatic plant diversity and overall abundance. Table 2.3.5 and Chart 2.3.2 compare the percentage of sample sites with vegetation, native species per site, and the number of native species collected in the last decade. Figure 2.3.7 shows the change in total species abundance between the spring and summer surveys. The 2016 spring survey posted the highest number of native species collected since Tier 2 surveys began in 2004. The percentage of vegetated sites also increased, but is not yet to pre-treatment levels. A trend of increased water clarity, the decrease in the size of the active treatment area, and the greater use of Sonar pellets versus liquid formulation may have contributed to the uptick in observed native plants. Submersed vegetation metrics are expected to further increase once the hydrilla eradication project is completed. There are well-established populations of coontail and pondweeds in the upper end of the lake that will likely repopulate Lake Manitou once the eradication of hydrilla is complete.

Table 2.3.5. Comparison of number of sample sites, % of sites with vegetation, native diversity index, and number of native species collected in since 2004.

Survey Date	Number of Sample Sites	% of sites with vegetation	Mean Native Species/Site	Number of Native Species Collected
Aug 2004[1]	95	83.5%	1.15	6
Aug 2005[2]	100	79.0%	1.07	6
Aug 2006[3]	70	56.0%	1.03	7
May 2007	119	92.0%	1.49	7
Aug 2007	111	47.0%	0.55	5
June 2008	121	56.2%	0.56	2
Aug 2008	121	39.7%	0.40	5
June 2009	122	28.7%	0.32	6
Aug 2009	119	8.4%	0.09	5
June 2010	122	40.9%	0.43	5
Aug 2010	122	28.6%	0.32	4
June 2011	122	38.5%	0.41	3
Aug 2011	122	16.4%	0.18	4
June 2012	122	30.3%	0.33	6
Aug 2012	122	7.4%	0.08	4
June 2013	122	8.3%	0.11	5
Aug 2013	122	4.9%	0.07	3
June 2014	122	63.1%	0.73	8
Aug 2014	122	23.0%	0.26	7
June 2015	120	26.7%	0.45	8
Aug 2015	122	15.6%	0.28	7
June 2016	122	44.3%	0.54	10
Aug 2016	122	24.6%	0.43	6

[1]Donahoe & Keister 2005. [2]Donahoe & Keister 2006. [3]Donahoe & Keister 2007.

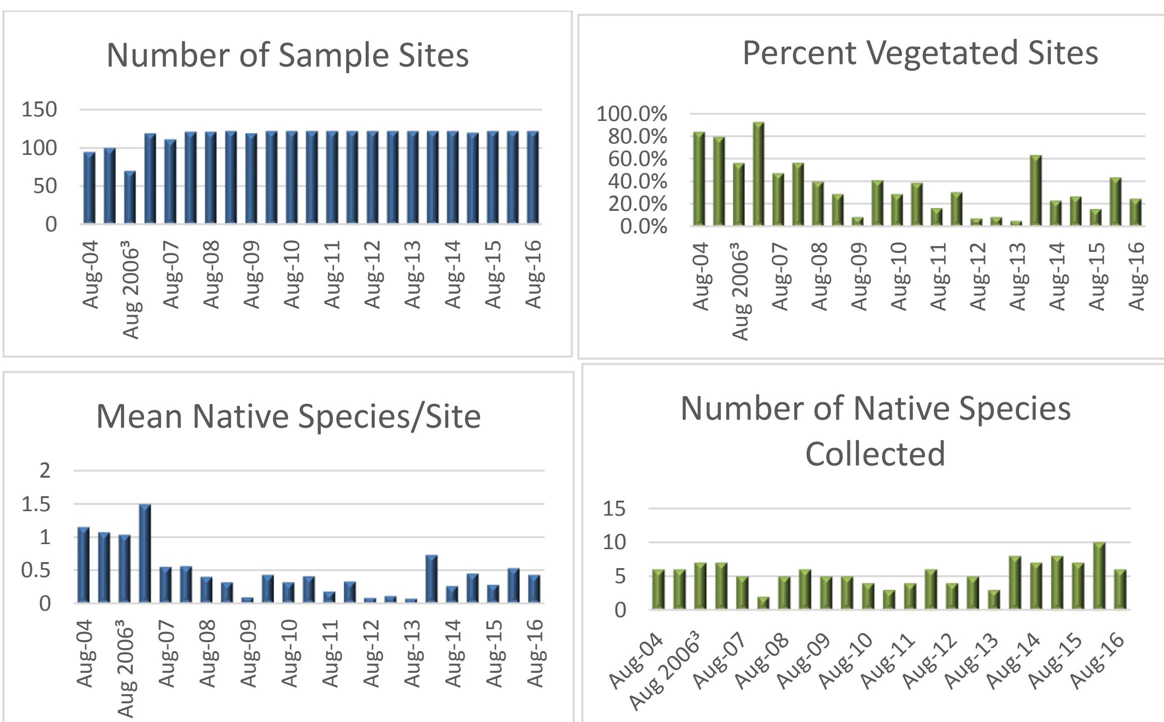

Chart 2.3.2. Comparison of number of sample sites, percentage of sites with vegetation, mean native species per site, and number of native species collected since 2004. (Data are from Table 2.3.5)

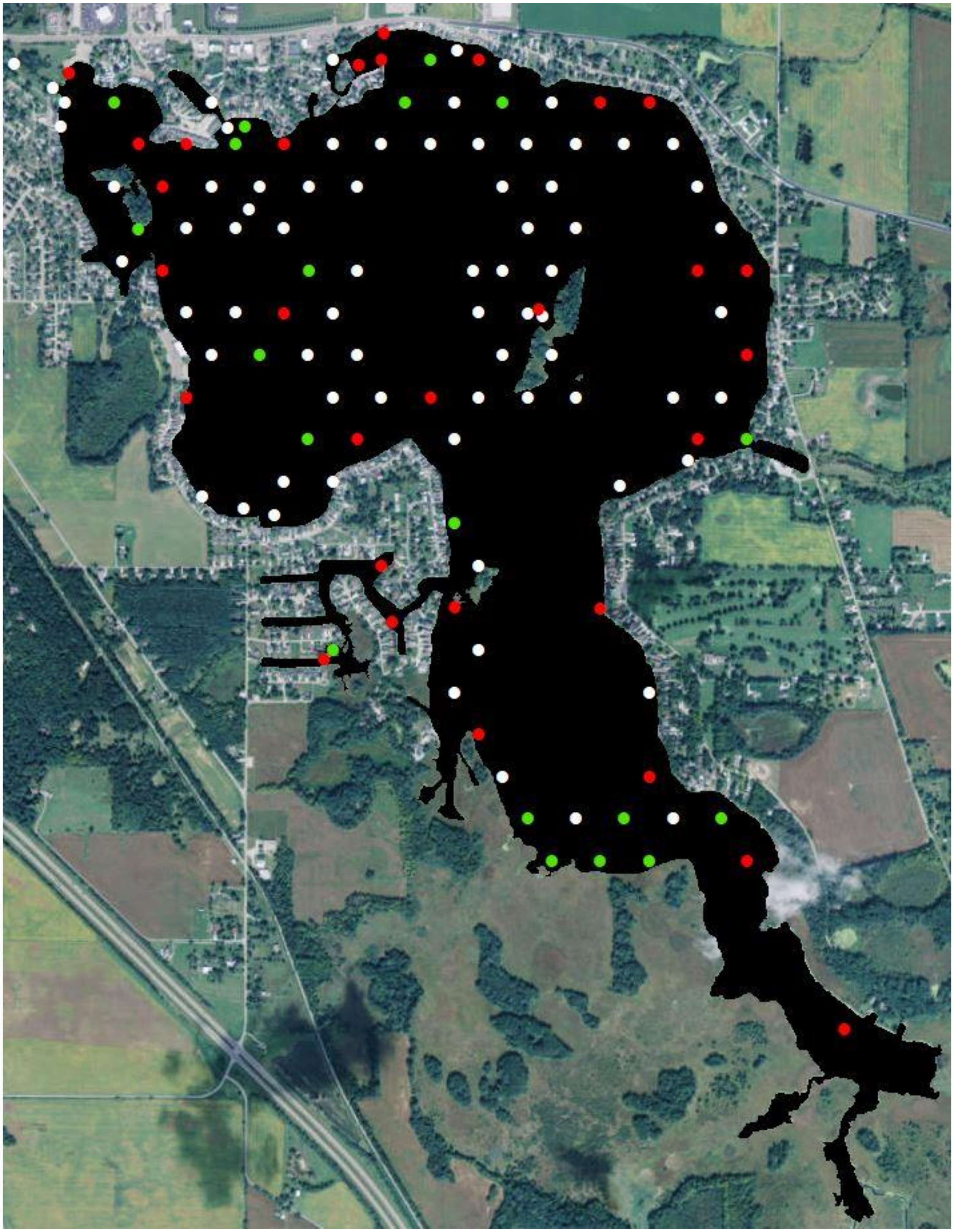

Figure 2.3.7 Lake-wide change in total species abundance, June 29, 2016 to August 29, 2016. Green markers indicate an increase in species present, white markers indicate no change, and red markers indicate a decrease in species present from June to August.

2.4 Dive Survey for Vegetative Hydrilla Detection

2.4.1. Dive Survey Background and Methods Summary

In a day-long survey in 2011, SCUBA divers surveyed ~1,000 square-foot areas centered around 140 total sites of past hydrilla finds by IDNR and relevant lake wide LARE Tier II points between 2 and 8 feet in depth. The objective was detection of vegetative hydrilla growth as an indicator of status relative to the management objective of eradicating hydrilla from the lake. Prior to 2011, hydrilla tuber sampling was the method utilized to track the progress towards eradication, but 99.5% reduction in tuber density during five years of management with Sonar® had greatly reduced the efficiency of tuber sampling as a tracking method. The 2011 survey detected vegetative hydrilla growth in two areas: the north shoreline of the lake and immediately west of the mid-lake island, also known as Big Island.

To enhance detection of hydrilla in these two regions of the lake, the 2012 dive survey was expanded to a day and a half effort (all-day June 14 and the morning of June 15) and conducted in 35 zones in littoral areas of the north shore and west of Big Island. During the survey, the zones were marked by temporary buoys at the corners of each zone based on pre-determined GPS coordinates. The 35 zones totaled 58 acres, and divers completed between 3 and 8 transects through each zone depending on its morphology. In general, although conditions were quite favorable for the survey (sunny and light winds), water visibility was notably reduced versus 2011. Where 2011 visibility was generally 4+ feet, 2015 visibility was approximately 2 – 3 feet. Despite the reduced visibility, divers visually inspected 184 transects with an average 'swath' of 5 feet and typical length of 120 meters (394 feet). This translates to 363,000 square feet, or approximately 2.5 times more bottom area covered than the 2011 survey. When a diver found hydrilla, they deployed a small additional temporary buoy, which when the zone survey was complete, was collected and located with a new GPS point.

In 2013, the 1.5-day dive survey design was further refined with goal to have a long-term approach for diver assessment to support the remainder of the hydrilla eradication efforts on Manitou. Seven new 'high-intensity' survey areas were established in blocks surrounding discrete locations of diver hydrilla finds in 2011 and 2012. Each high-intensity zone was 6600 square feet in size (60 by 100 feet). Divers traversed these zones with objective of visual coverage of the entire bottom for maximum ability to detect vegetative hydrilla growth. 21 additional 'low intensity' blocks were surveyed that were a select number of the 35 zones surveyed in 2012 that immediately surrounded the new high-intensity blocks of past hydrilla finds. This design (shown in Figures 2.4.1, 2.4.2, and 2.4.3) balanced the objectives of 1) developing data on discrete number of vegetative hydrilla plants within the high intensity areas to track hydrilla decline through time as a metric for late-stage eradication success while also 2) surveying the broader area of past infestation to provide a wider look in case 'hot spots' of remaining hydrilla might still be detected for closer assessment in the future. Four single hydrilla plants were detected in the 2013 dive survey. This same design was used again in 2014, and no hydrilla was detected. The same design was used again in 2015. The 2015 dive survey was conducted on June 29 and 30. To focus efforts on hydrilla detection, other submersed plant species were not individually tracked but were qualitatively noted for the diver survey overall.

As in 2014, no hydrilla was detected in the 2015 dive survey. Full reviews of past dive survey results can be found in earlier annual reports on the project.

Figure 2.4.1 Dive survey design.

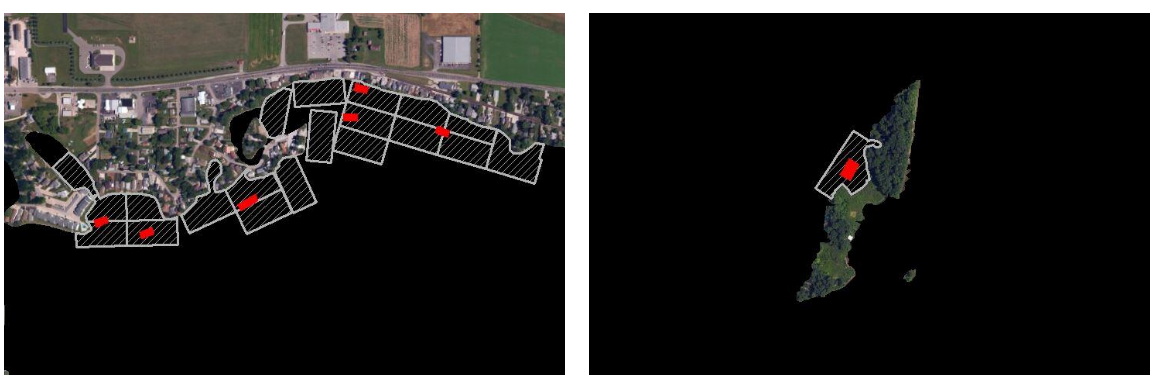

Figure 2.4.2 and 2.4.3 Dive survey design close ups.

2.4.2 2016 Dive Survey Results and Discussion

No hydrilla was detected during the 2016 dive surveys. Native species observed during the survey included chara, coontail, elodea, sago pondweed, Illinois pondweed and spatterdock (small 'seedling' plants). Based on water visibility at the time of the main 2016 survey (~2.5 ft), total bottom areal coverage by diver in the 2016 survey is estimated at 128,000 square feet. In addition to the standard survey, a secondary survey was performed by a single diver on August 23rd. This survey consisted of passes through the high intensity zones to look at the 'hot spots'. During this survey chara, coontail, sago pondweed, and filamentous algae were observed. With water visibility around 1.5 ft, it is estimated that 1,200 square feet were covered.

The lack of hydrilla in the 2016 survey is a milestone development relative to the multi-year objective of hydrilla eradication in Lake Manitou. Qualitatively, there were ~ 20 plants detected across seven locations (3 in close proximity) during the 2012 dive survey versus four single plants detected in 2013. With a lack of hydrilla detected in the last three years (2014, 2015, 2016), the Manitou eradication effort has reached a point where full hydrilla tuber bank depletion and full eradication of the plant can be a preliminary conclusion. This conclusion supports ending proactive larger-scale, season-long management without additional new finds of hydrilla in the lake.

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3.0 WATER QUALITY MONITORING

In the past, an Aquatic Weed Control biologist recorded dissolved oxygen and temperature profiles at FasTEST sample sites 2 and 7. These data were used in determining the position of the lake's thermocline, which is important in calculating rates for Sonar treatments with liquid formulations. However, with the 2016 low-rate treatment protocol using only Sonar pellets in key targeted areas, collection of water quality data was reduced to Secchi measurements and surface temperatures.

Secchi transparency readings were taken throughout the 2016 season at FasTEST sample site 7 (Table 3.0.1). Secchi measurements ranged from a maximum of 6.2 feet on May 31st to a low of 3.5 feet on September 6th. Overall, 2016 maximum Secchi depth and July-August 2016 average Secchi depth were within typical ranges when compared with historical data, while minimum Secchi depths were was the highest historical depth values (Table 3.0.2).

Table 3.0.1. 2016 Temperature and Secchi Measurements for Site 7

Collection Date	Surface-Temp. Range (˚F)	Secchi Depth (ft)
May 31	75.1	6.2
June 21	78.2	4.5
July 13	78.6	3.8
August 9	--	--
September 6	76.5	3.5

-- indicates no reading taken

Site locations can be seen in Figures 2.1.1 or 4.2.1.

Table 3.0.2. Summary of Secchi depths recorded on Lake Manitou 1999-2016.

(1999 to 2004 data from Fascher & Jones 2006.)

Year	Minimum	Maximum	Jul-Aug Mean	Observations
1999	2.8	5.4	3.1	10
2000	2.6	6.3	3.2	11
2001	2.5	5.5	3.7	13
2002	2.5	7.2	3.8	15
2003	2.5	10.4	3.3	14
2004	2.7	4.1	3.3	12
2007*	2.6	9.0	3.9	80
2008*	2.1	8.6	3.3	95
2009*	2.3	6.2	3.8	96
2010*	2.1	10.1	3.5	96
2011*	1.7	6.5	2.8	80
2012*	1.2	7.5	3.3	107
2013*	1.8	6.5	2.7	40
2014*	2.3	10.1	3.5	90
2015*	1.8	6.9	3.5	79
2016*	3.5	6.2	3.8**	4

*2007 - 2016 data are by authors of this report and are added for comparison with historical data.

** reading is just the single July 13, 2016 value

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4.0 2016 VEGETATION CONTROL

The eradication of hydrilla has been the primary objective of recent Lake Manitou Aquatic Vegetation Management Plans. Due to the extensive reproductive capability of monoecious hydrilla through fragmentation, turions, and tubers, an aggressive prescription using the systemic herbicide Sonar was selected for the eradication project. Similar approaches have been taken in the States of Washington, Massachusetts, Maine, California, Kansas, Missouri, and North Carolina.

The initial lack of flow data for Lake Manitou resulted in the preparation of a treatment protocol based on static water conditions, with inclusion of additional "bump" treatments to sustain a Sonar residual in the lake for a period of 180 days at a lethal dose for hydrilla. Subsequent water flow data provided by the Indiana Department of Water indicated relatively long retention times, with a long-term (18-year) average of ~50% volume turnover from the period of April to September. This period would coincide with chemical control operations. However, large rain events cause the retention time to be much shorter (<30 days). Therefore, maintenance of an effective dose of Sonar for hydrilla required regularly scheduled monitoring of Sonar concentrations and periodic "bump" treatments as necessary.

SePRO collected hydrilla samples from Lake Manitou in 2006 and conducted a PlanTEST at the SePRO Research and Technology Campus (SRTC) in Whitakers N.C. The PlanTEST is a proprietary test developed by SePRO Corporation that uses key biochemical parameters (Sprecher et al. 1998) to determine the plants inherent susceptibility to Sonar. The test was used to direct Sonar treatment recommendations by providing an indication of concentrations necessary for control. The hydrilla in Lake Manitou responded favorably to Sonar under laboratory conditions (Chart 4.0.1 and Figure 4.0.1). SePRO's recommended treatment protocol was based on results of the PlanTEST, extensive experience in hydrilla control throughout the U.S., and proprietary modeling of Sonar dissipation from various formulations.

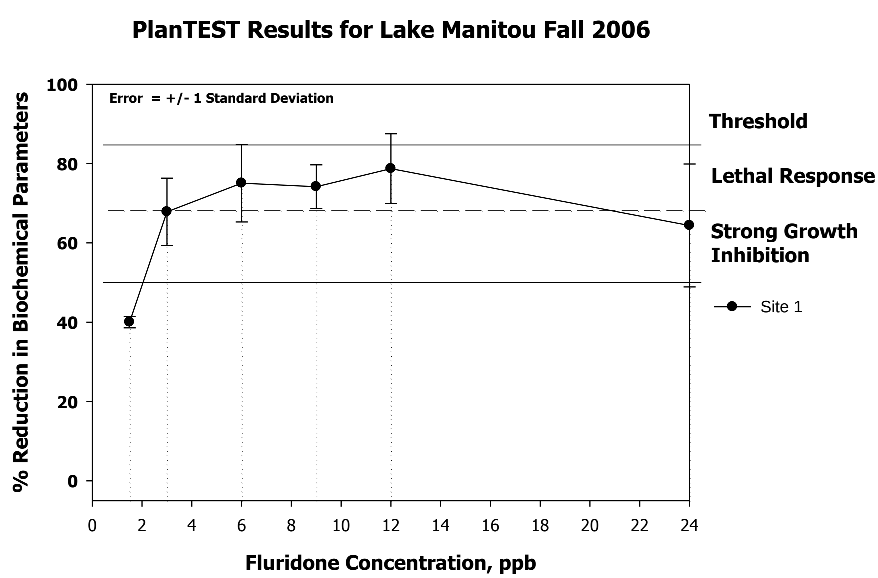

Chart 4.0.1 PlanTEST Results for Lake Manitou.

Figure 4.0.1. Lake Manitou hydrilla susceptibility to Sonar (PlanTEST).

Initially, the treatment prescription recommended for Lake Manitou was a minimum three-year program, followed by comprehensive analysis of collected data and recommendations for either extension of this program or alternative management procedures to achieve eradication of hydrilla. Each year, relatively long exposure time to Sonar was targeted to control the standing crop of hydrilla, prevent production of new tubers, and to control biomass sprouting from existing tubers.

The 2007 application maintained targeted levels of fluridone throughout the growing season and no hydrilla was observed that year. Modifications were made to the 2008 treatment prescription in an attempt to increase selectivity. Sonar pellet formulations were switched from Sonar Q, which was applied throughout the littoral zone in 2007, to Sonar PR, which was only applied to areas where hydrilla was previously documented and in a small inflow area. In addition, the whole lake concentration was to be maintained above 3 ppb instead of 6 ppb, with more frequent bump applications to minimize exposure of native species to relatively high concentrations. This same treatment strategy was used in 2008 and 2009. In 2010, target Sonar rates were further refined based on successful target rate attainment and control outcomes in past seasons. In 2011 and 2012, an initial 6 ppb target rate was utilized with repeat 'bump' applications seeking to maintain herbicide rate in a range of 2.5 – 5 ppb. This treatment strategy was continued in 2013, 2014, and 2015 however, beginning in 2014 only the lower 423 acres was included the treatment. This change was made in an effort to promote increased native plant growth in the southern end of the lake. In addition, hydrilla had never been detected in the upper (southern) reaches of Lake Manitou, so hydrilla control was not deemed to be impacted by this more targeted strategy. The control strategy was adjusted in 2016 to reduce overall Sonar use and management pressure on the lake's native plant community by utilizing Sonar PR pellets only in areas of known past hydrilla presence.

4.1 Sonar Application

On May 9, 2016, the first application was made by Aquatic Control, Inc., with SePRO Corporation and ReMetrix personnel on site for technical assistance. Pelletized Sonar PR was applied to 18 zones (Figure 4.1.1) at concentrations ranging from 20-70 ppb (total of 4.1 ppb based on lake volume). A custom built herbicide blower on a 19-foot Carolina Skiff was used for application of the granular Sonar PR product. Pre-planned Sonar PR bump applications were completed on June 29th and August 15th (Figure 4.1.2). For these two re-applications, Sonar PR was applied to the same locations as the initial Sonar PR treatment but at half the initial rate.

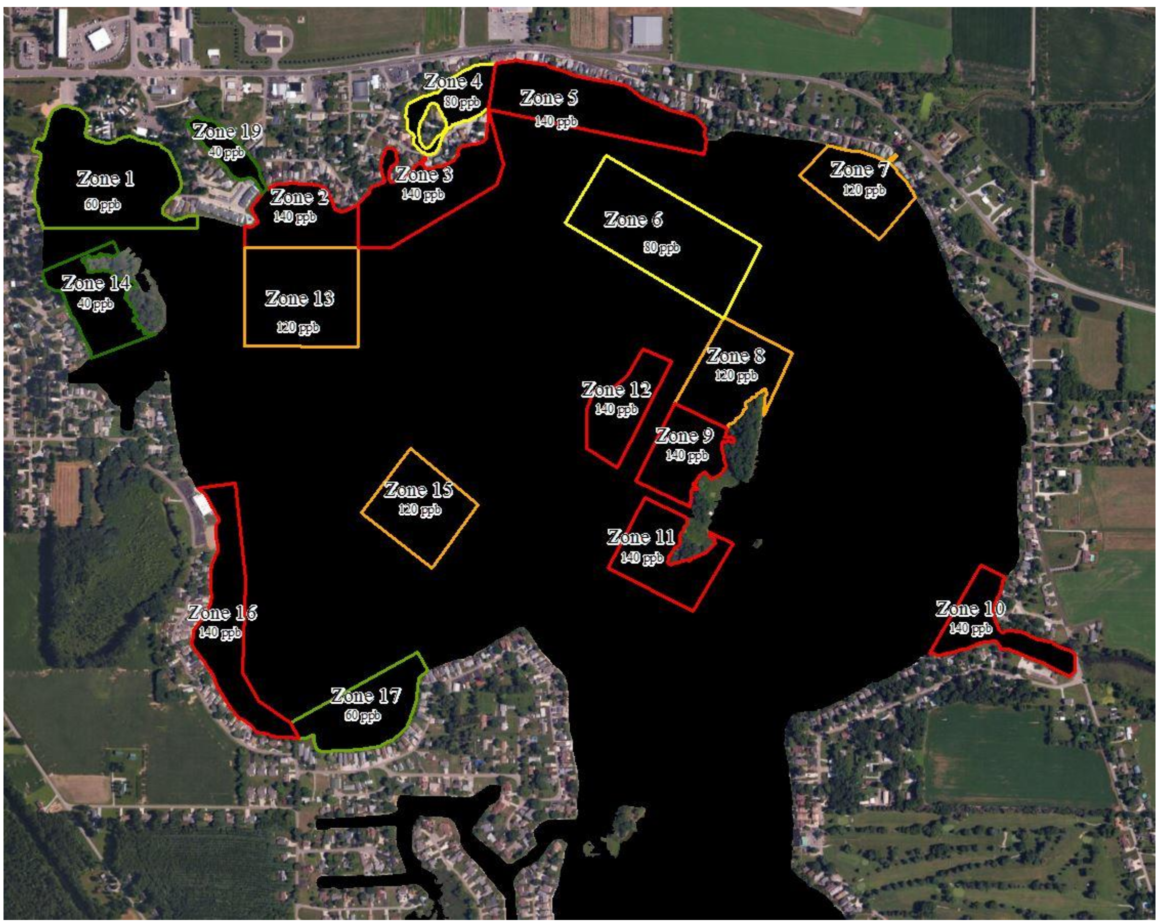

Figure 4.1.1. Treatment areas for Sonar PR application on May 9, June 29, and August 15, 2016. Total ppb of Sonar PR applied for the season is noted for each zone. The total Sonar utilized in 2016 was spread across three different split applications.

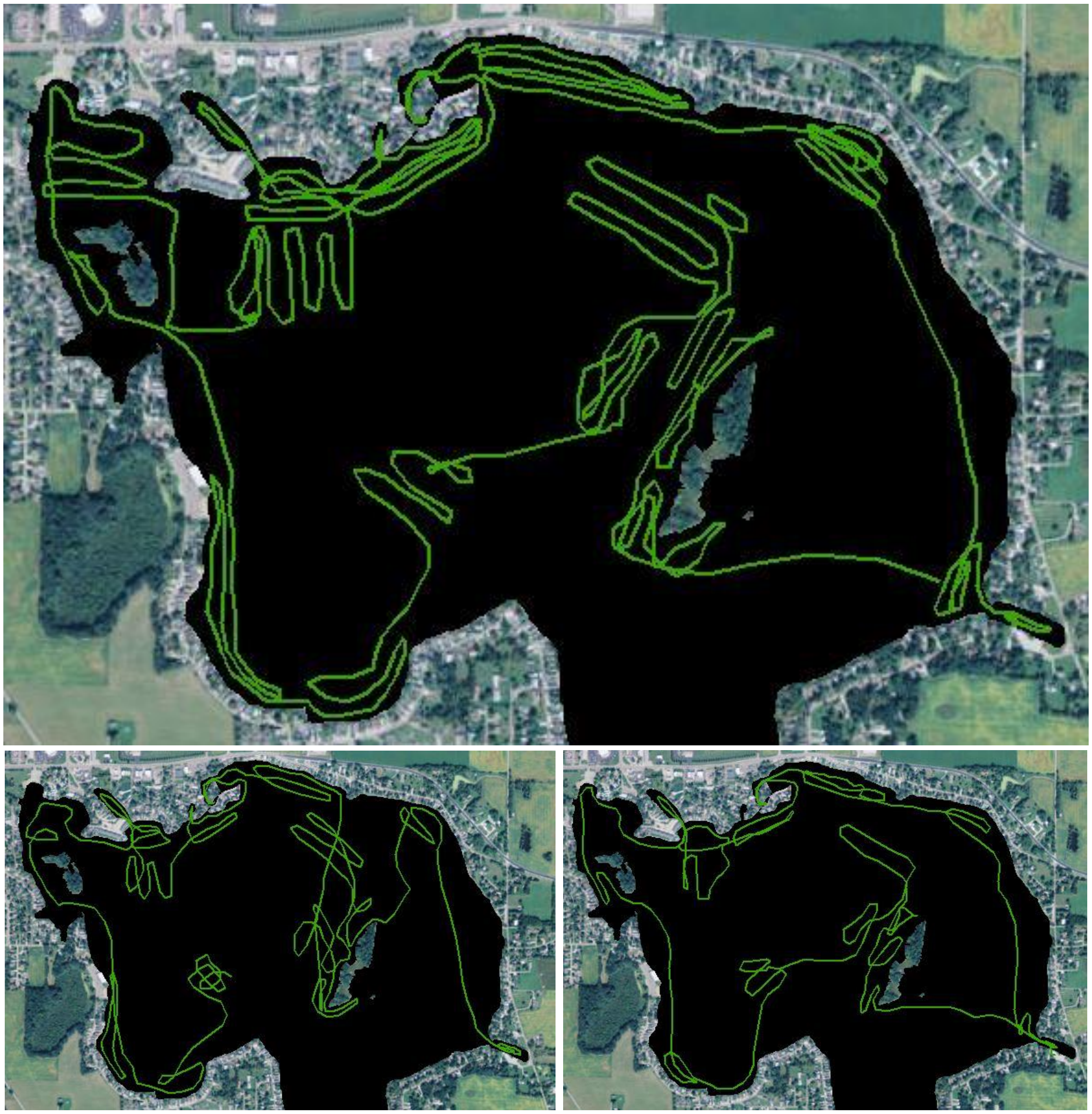

Figure 4.1.2. Maps of Sonar PR 'as-applied' boat tracks for May 9 (*top*), June 29 (*lower left*), and August 15 (*lower right*) applications in 2016.

4.2 FasTEST Herbicide Concentration Monitoring

Due to the reduced treatment regime in 2016, FasTEST monitoring was also reduced from 8 permanent stations to 5 (Figure 4.2.1 & Table 4.2.1). The FasTEST was used to monitor fluridone concentration on 5 dates between May 31st and September 6th, 2016—a span of 121 days following initial treatment. The FasTEST measurements confirmed that effective Sonar concentrations for monoecious hydrilla control were achieved and maintained through the summer with projected effective levels into the early fall. Results indicate the concentration was maintained above 2.0 ppb for the vast majority of the 2016 growing season (Table 4.2.2, and Chart 4.2.1).

The objective of modifications to the Sonar treatment program for Lake Manitou over the last four seasons has been to decrease herbicide pressure on the lake's native aquatic plant community in the upper (south) end of the lake. In 2013, lakewide seasonal average Sonar concentrations were 3.3 ppb versus 3.9 ppb in 2012, and samples from untreated site 6 in the south end averaged 2.8 ppb in 2013 versus 3.3 ppb in 2012. In 2014, the lakewide seasonal average concentration was effectively the same at 3.2 ppb and the site 6 average tracked in similar fashion at 2.7 ppb. However, spikes of concentration associated with Sonar AS bumps were minimized with the highest lakewide average of 3.0 ppb observed at the start of the program versus 7.2 ppb in 2013. The highest reading observed at site 6 in 2015 was just 3.9 ppb versus 5.8 ppb in 2013 (a 4.6 ppb reading was also measured in 2013). The 2015 treatment program did require two "reactive" Sonar AS bumps while no "reactive" bumps were required in 2014. Due to heavy rains in the early growing season and unseasonable warm temperatures late in the growing season, the decision was made to maintain >2.5 through October 2015. A final late-season bump application of Sonar AS was applied on October 8th and the final FasTEST sample was collected October 23rd to ensure lethal concentration was sustained. In 2016, the highest Sonar reading measured on the lake was 4.0 ppb, and site 6 in the southern end had a measured peak concentration of 2.8 ppb. A continued analysis of historic precipitation records during the May-Sept period over the last 20 years (Table 4.2.3) indicates that precipitation in most of the nine years of treatment has been below seasonal averages, particularly in the drought year of 2012. 2016 was another season of overall near-normal rainfall versus historical averages but did have slightly higher than normal precipitation in July and September. The reduced 2016 Sonar program with pellets and no liquid bump treatments was minimally influenced by seasonal rainfall in terms of localized impact to any isolated hydrilla that might have existed in the managed zones. In conclusion, the FasTEST monitoring results documented the efficiency of the 2016 protocol and its continue refinement to reduce native aquatic plant exposure to Sonar herbicide while producing Sonar levels sufficient to control any isolated remaining hydrilla.

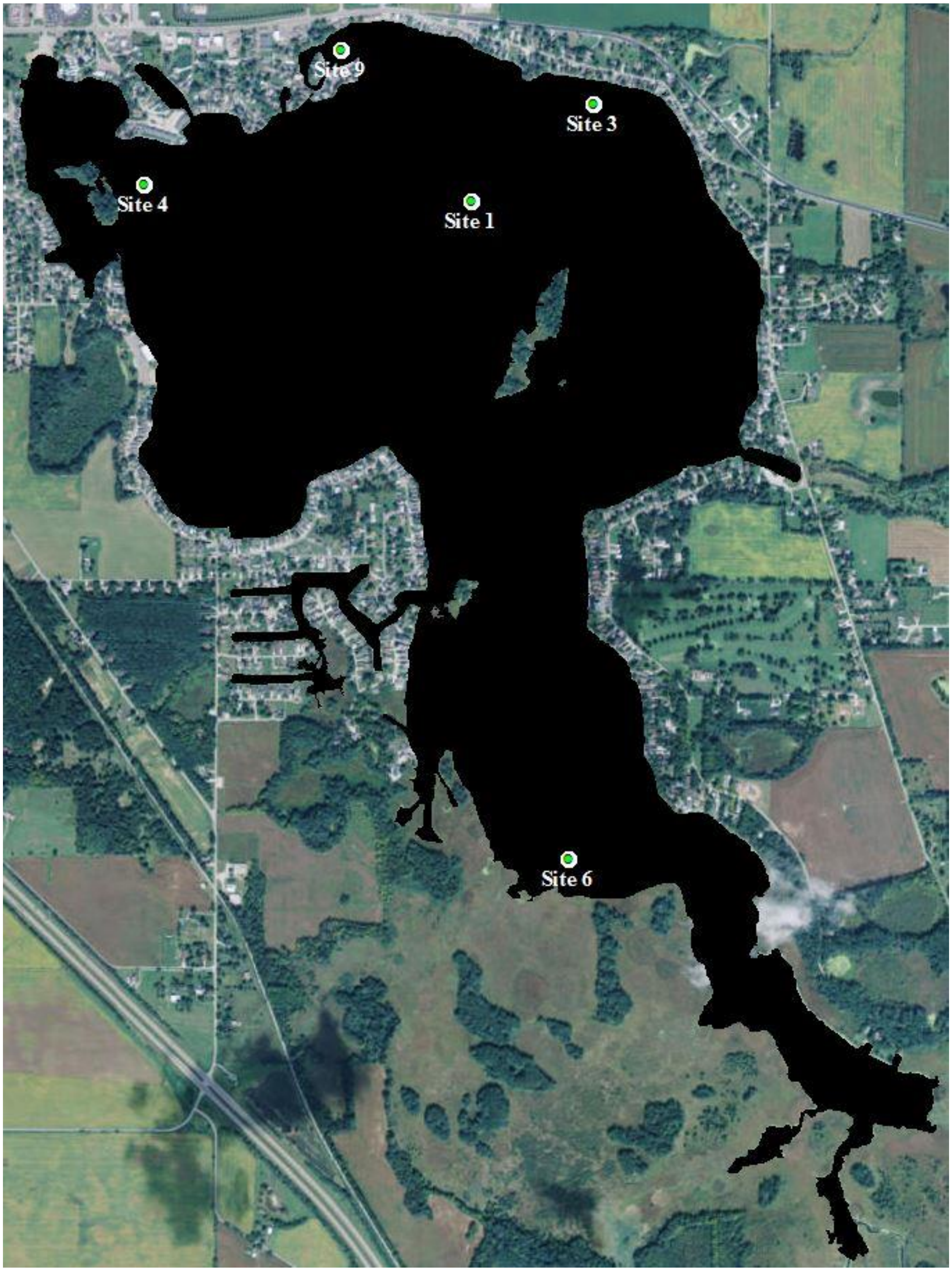

Figure 4.2.1. Permanent FasTEST sample locations during 2016.

Table 4.2.1. Latitude and longitude coordinates for the five 2016 FasTEST monitoring stations

Site	Latitude	Longitude
1	N 41˚ 03' 26.0"	W 86˚ 10' 44.9"
3	N 41˚ 03' 35.3"	W 86˚ 10' 29.6"
4	N 41˚ 03' 27.4"	W 86˚ 11' 26.1"
6	N 41˚ 02' 23.3"	W 86˚ 10' 32.1"
9*	N 41˚ 03' 40.4"	W 86˚ 11' 01.4"

Station 9 was added in 2008.

Table 4.2.2. Concentration of 2016 FasTEST results from surface water samples. Vertical black lines indicate when "bump" treatments were made

5/9/2016	5/31	6/21	7/13	8/9	9/6	Season
DAT[a] -->	**22**	**43**	**65**	**92**	**120**	**120**
Sites						
1	0.5	2.2	2.7	3.1	2.4	**2.2**
3	0.5	1.5	3.1	2.7	3.2	**2.2**
4	0.5	1.6	2.7	3.1	2.8	**2.1**
6	0.5	2.0	2.3	2.8	2.8	**2.1**
9	0.5	2.5	3.6	4.0	2.0	**2.5**
Lake Avg	**0.5**	**2.0**	**2.9**	**3.1**	**2.6**	**2.2**
Treatment Area Avg*	**0.5**	**2.0**	**3.0**	**3.2**	**2.6**	**2.3**

[a] Days after initial treatment on May 9, 2016.

* Sites 6 lies outside of the active treatment area and was not used in determining treatment-area averages.

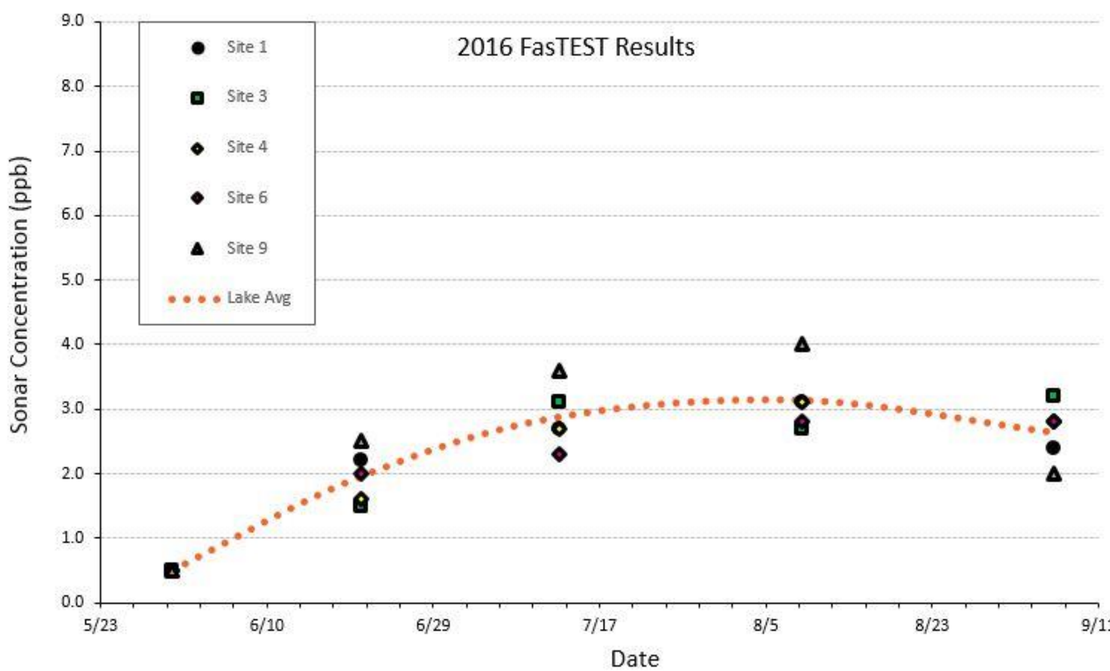

Chart 4.2.1. Sonar concentration (ppb fluridone on vertical axis) by FasTEST site (five locations) and lakewide average during 2016.

Table 5.1.1. May through September monthly precipitation records from 1995-2016 for the Fulton County Airport just north of Lake Manitou in Rochester, Indiana. 2007 – 2016 records are compared to 20-year mean and median seasonal precipitation.

	Monthly Precipitation (inches)					
	May	Jun	Jul	Aug	Sept	TOTAL
1995	5.1	5.9	1.8	4.5	0.5	17.8
1996	7.0	3.9	9.3	1.5	3.4	25.1
1997	5.7	3.6	6.4	4.2	5.9	25.7
1998	4.7	7.3	9.5	3.3	1.2	26.1
1999	3.2	4.2	1.4	3.2	2.5	14.4
2000	5.0	6.3	3.5	5.0	4.4	24.1
2001	4.2	4.1	8.5	5.6	3.2	25.6
2002	6.4	2.1	3.3	3.3	1.9	16.9
2003	6.3	2.0	9.3	2.0	5.3	24.8
2004	6.3	4.6	4.0	9.6	1.0	25.5
2005	2.3	3.5	4.0	2.7	4.4	16.9
2006	6.0	2.6	6.1	5.4	2.7	22.7
2007	2.3	2.5	5.1	6.6	1.1	17.6
2008	4.1	5.6	1.6	2.6	3.6	17.5
2009	5.2	2.9	2.7	5.3	1.5	17.6
2010	6.0	5.7	4.2	1.5	3.0	20.4
2011	6.9	2.7	4.3	2.0	6.4	22.3
2012	0.8	0.8	3.1	2.6	1.1	8.4
2013	2.8	9.0	1.1	3.9	2.6	19.3
2014	3.5	4.1	1.9	6.6	4.1	20.2
2015	3.3	11.0	3.7	2.4	2.1	22.5
2016	2.7	4.1	6.1	4.5	4.1	21.4
MEAN	4.5	4.5	4.6	4.0	3.0	20.6
MEDIAN	5.0	4.0	4.0	3.6	2.8	20.3

Difference from 20-Year Mean Precipitation

	May	Jun	Jul	Aug	Sept	TOTAL	% Diff
2007	-2.20	-2.00	0.46	2.58	-1.87	-3.0	-14.7
2008	-0.41	1.17	-3.01	-1.40	0.60	-3.1	-14.9
2009	0.70	-1.56	-1.87	1.25	-1.47	-3.0	-14.4
2010	1.47	1.23	-0.38	-2.50	0.01	-0.2	-0.9
2011	2.37	-1.77	-0.28	-2.00	3.41	1.7	8.3
2012	-3.73	-3.67	-1.48	-1.40	-1.89	-12.2	-59.2
2013	-1.73	4.49	-3.51	-0.07	-0.41	-1.2	-6.0
2014	-1.1	-0.4	-2.7	2.6	1.1	-0.4	-2.1
2015	-1.23	6.53	-0.88	-1.65	-0.89	1.9	9.1
2016	-1.8	-0.4	1.5	0.4	1.1	0.9	4.2

Difference from 20-Year Median Precipitation

	May	Jun	Jul	Aug	Sept	TOTAL	% Diff
2007	-2.71	-1.51	1.07	2.95	-1.73	-2.7	-13.4
2008	-0.92	1.67	-2.43	-1.04	0.75	-2.8	-13.6
2009	0.20	-1.07	-1.29	1.62	-1.33	-2.7	-13.1
2010	0.97	1.73	0.21	-2.14	0.16	0.1	0.6
2011	1.87	-1.28	0.31	-1.64	3.56	2.0	10.0
2012	-4.24	-3.18	-0.90	-1.04	-1.75	-11.9	-58.6
2013	-2.24	4.99	-2.93	0.30	-0.27	-0.9	-4.6
2014	-1.6	0.1	-2.1	3.0	1.3	-0.1	-0.6
2015	-1.74	7.03	-0.30	-1.29	-0.75	2.2	10.7
2016	-2.30	0.15	2.06	0.82	1.24	1.2	5.7

5.0 ACTION PLAN UPDATE

Ten consecutive years of Sonar (fluridone) have fully controlled monoecious hydrilla in Lake Manitou each year and depleted the lake of hydrilla tubers capable of germinating and re-infesting the lake. The sustained eradication program has reached the milestone of three consecutive years of active management without hydrilla detection—even with intensive dive survey efforts each year. Based on other hydrilla eradication efforts in the US, this milestone projects to a pending conclusion of full eradication of hydrilla from the lake. The successful multi-year program has helped prevent the spread of hydrilla to other lakes and had minimal impacts on the overall water quality of Lake Manitou. In 2016, while the lake's plant community remains suppressed versus pre-eradication conditions, there were continued indications of increased native vegetation abundance and diversity per the objective of recent management plan adjustments.

At this stage, SePRO presents the formal recommendation to end annual, season-long cycles of hydrilla management with Sonar Aquatic Herbicide. Past technical outcomes of eradication efforts in other states supports a current conclusion that hydrilla has been fully removed from the lake, but continued active monitoring of the lake's aquatic plant community must be maintained to confirm the full hydrilla eradication. In addition to continued vegetation assessment, an action plan must be in place for rapid response actions in the unlikely event that hydrilla should be found again in the lake.

5.1 Technical Recommendations for Future Vegetation Assessment and Potential Rapid Response to New AIS Finds (2017- 2019)

The following are recommendations regarding future assessment and potential rapid response efforts on Manitou:

1) **Continued utilization of intensive late spring dive survey for hydrilla detection.** The focus of hydrilla detection in the last several years of the eradication program has been intensive dive surveys in areas of past hydrilla infestation. It is recommended that the mid-June intensive dive surveys continue in a similar timeframe in 2017. Such surveys should be considered also for 2018 and potentially 2019. Past hydrilla eradication programs have utilized three years of intensive monitoring beyond the last active management cycle to make a final determination of full eradication if no additional hydrilla is detected. Some eradication programs have also implemented late-season (late summer / early fall) dive surveys as well. DNR may wish to consider such a second intensive dive survey as an alternative or complement to more-focused, less intensive dive observations (see below).

2) **Addition of multiple diver 'spot checks' at monthly intervals during the summer**. In addition, to further insure that any unanticipated hydrilla growth is detected early in the absence of proactive, season-long control with Sonar, SePRO would propose monthly 'spot check' assessments via diver beginning approximately 1 month following the mid-June full dive survey and continuing into mid-September

or early October (maximum of three smaller dive surveys). These assessments will involve several hours of diver effort in 'high intensity' zones delineated for the more intensive June surveys. The exact timing of these focused surveys will be adjusted to work around weather and water quality conditions. One such survey was conducted this past summer and noted poor water visibility for dive observations. This assessment component should also be considered for 2018 and 2019.

3) **Implementation of a rapid response plan for additional hydrilla detection.** If any of the additional surveys detect hydrilla, a rapid-response plan should be implemented. This plan should involve immediate treatment of the infestation and an appropriate 'buffer zone' (0.5 – 5 acres) around the find(s) with a contact herbicide such as Komeen® or Komeen Crystal chelated copper herbicide. As a goal for rapid response, this initial treatment should be implemented within one week after the hydrilla discovery. Depending on time of year of the find and its initial treatment, spot application of Sonar PR (or other alternate pellet formulations as can be made available for use per SePRO recommendations) should be implemented to limit risk of potential regrowth of any surviving hydrilla following the contact application. It is recommended that Sonar pellets be applied to this same localized area of infestation for at least the season following the discovery to help insure full removal of hydrilla from the area of the new find.

4) **Review of prevention strategies for potential re-introduction of hydrilla or introduction of other AIS.** The sustained management pressure applied to Lake Manitou for hydrilla eradication since 2007 has made moot the potential for additional hydrilla introduction to the lake from other regional infestations. However, starting in 2017, the risk of re-introduction of hydrilla or other invasive aquatic plants will become a factor in a revised long-term vegetation management plan for Manitou. It is possible that intensive searches for hydrilla detection in the coming years to confirm its eradication may result in finds of other AIS, even beyond invasive plants. The pending status of hydrilla eradication from Manitou represents an opportunity for revisiting broader AIS prevention and response strategies for the lake such as enhanced ramp signage and volunteer ramp 'stewards' or inspections. The investment in hydrilla eradication effort on Manitou has been significant and its value should be protected through enhanced prevention and response strategies where feasible.

The original Manitou AMVP established three management goals:

1) Develop or maintain a stable diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species.

2) Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.

3) Provide reasonable public access while minimizing the negative impacts on plant and wildlife species

Even after the introduction of hydrilla to Lake Manitou, the overall aquatic plant management objectives remain relatively the same: establish a diverse aquatic plant community, control aquatic invasive species, and provide reasonable public access. Since 2007, controlling hydrilla and eradicating this invasive species has been paramount to the other objectives outlined in this plan. With full hydrilla eradication now potentially achieved, the other objectives of the lake's long-term management can gain higher priority for implementation. Based on experiences in other US sites of hydrilla eradication, a solid recovery of a vigorous aquatic plant community in the Manitou can be projected over the next few years. Some minor introduction of additional native species may be justified long-term, as the plant community was historically dominated by a single species (i.e. eelgrass) but near-term activities should focus on monitoring changes in the lake's aquatic vegetation relative to documenting progress towards objective #1 above and preventing/responding to entry of new invasive threats.

5.2 Budget Update

Budget review and updated cost projections are based on contract parameters. The 2016 project cost was down compared to 2015 and earlier years of the eradication program (Table 5.2.1). Anticipated cost savings were the result of the smaller active management zone, reduced application rate and an increased reliance on Sonar pellets instead of a strategy that also included liquid Sonar applications. Future management budgets should adjust for enhanced monitoring and transition to contingencies for smaller rapid response treatment should it become necessary.

Table 5.2.1. Budget update for 2016.

Year	Actual expenditures	Year	Actual expenditures
2007	$349,920	**2012**	$268,094
2008	$317,549	**2013**	$299,219
2009	$351,949	**2014**	$238,370
2010	$268,076	**2015**	$291,357
2011	$248,315	**2016**	$170,579

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6.0 PUBLIC AND REGIONAL REGULATORY INTERACTION

The hydrilla eradication effort on Lake Manitou appears to have reached the major milestone of potential full removal of the invasive plant from the lake. The project is a resounding success for preventing spread to other lakes in Indiana and the Midwest. With many aquatic invasive issues, including the recent activity regarding the threat of Asian carp spread into the Great Lakes, it is important for IDNR to promote successful management in Manitou. This success needs to be put in context with local stakeholders who have enjoyed recreational benefits of weed-free conditions over the last 10 years but may experience different lake conditions as the hydrilla eradication effort transitions now to a lower intensity management approach favoring greater native plant growth.

In terms of 2016 public access, successful multi-year eradication efforts have eliminated the risk of hydrilla contamination of boats and movement from Manitou to another water body. Therefore, ramp closure and inspections are unnecessary relative to any possible movement of hydrilla from Manitou pending an unexpected new find in the lake. However, potential full eradication outcome on Manitou represents an opportunity to further assess broader AIS prevention strategies for the lake that would reduce future risk of movement of new AIS into Manitou including possible re-introduction of hydrilla.

Additionally, routine dialogue with Midwest and other northern public agency partners and other resource managers on the threat of hydrilla should be maintained to help prevent or limit hydrilla expansion into more Indiana lakes. Rapid response plans should be revisited and adjusted as needed to fit current regulations and technical considerations (e.g., NPDES, possible improved assessment tools and techniques). The success of Manitou should be appropriately reviewed with various Midwest and northern DNR groups to reinforce the value of past and current management expenditures to help support decisions and funding for aggressive response to possible future regional hydrilla infestations. In particular, recently discovered dense hydrilla infestations in public access areas of the Ohio River, reservoirs in Kentucky, multiple water bodies in northeast and southeast Ohio, and several western Pennsylvania sites all pose elevated risk of regional spread.

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APPENDIX

LARE Tier 2 Survey Raw Data 6/29/16

WPT	Lat	Long	Depth	Curly-leaf pondweed	Fil. Algae	Common bladderwort	Coontail	Sago pondweed	Water stargrass	Chara	Flat-stemmed pondweed	Large-leaved pondweed	Leafy pondweed	Common waterweed	Horned pondweed
1	41.06090	-86.17843	3		P										
2	41.06142	-86.18021	3		P										
3	41.05924	-86.18810	3		P					3					
4	41.05921	-86.18875	3		P										
5	41.05530	-86.17996	5												
6	41.05695	-86.18784	4							3					
7	41.05406	-86.17718	3		P										
8	41.04456	-86.18524	3				5		1			5			
9	41.06030	-86.19520	3												
10	41.06090	-86.19662	3												
11	41.03551	-86.16812	2				5								
12	41.03916	-86.17678	2		P		5		1						
13	41.03912	-86.17497	2		P										
14	41.03920	-86.17338	2		P		5	5							
15	41.03875	-86.17026	2				5	3					1	1	
16	41.04039	-86.17759	3		P										
17	41.04025	-86.17583	6		P		1			1					
18	41.04029	-86.17409	3		P										
19	41.04030	-86.17235	3		P		1								
20	41.04031	-86.17057	2		P		5								
22	41.04149	-86.17858	3	1	P					1					
23	41.04152	-86.17311	2		P		1								
24	41.04280	-86.17948	2		P		1								
26	41.04377	-86.18035	4		P										
27	41.04377	-86.17334	4	1											
28	41.04453	-86.18439	1		P		3								
29	41.04501	-86.17950	3		P										
30	41.04610	-86.18044	2		P					1					
31	41.04595	-86.17508	5		P		1								
32	41.04719	-86.18302	7			1									
33	41.04733	-86.17958	3		P										
34	41.04847	-86.18036	3		P			1							
35	41.04945	-86.18648	5		P										
36	41.04946	-86.18499	3		P										
37	41.05072	-86.18577	4							1					
38	41.05066	-86.18387	4		P		1								
39	41.05078	-86.18034	6		P										
40	41.05064	-86.17142	10		P		1								
41	41.05074	-86.16973	3		P										
42	41.05179	-86.18995	3		P						1				
43	41.05177	-86.18490	6												
44	41.05178	-86.18318	3							3					
45	41.05181	-86.18140	5		P			1							
46	41.05181	-86.17945	5		P										
47	41.05184	-86.17769	4		P										
48	41.05192	-86.17586	6												
49	41.05190	-86.17243	6												
50	41.05202	-86.17079	5												
51	41.05301	-86.18918	5												
52	41.05298	-86.18740	3							3					
53	41.05300	-86.18563	3							1					
54	41.05302	-86.18388	5												
55	41.05293	-86.17865	4		P										
56	41.05296	-86.17679	2		P										
57	41.05291	-86.16979	5		P					1			1		
58	41.05430	-86.19016	4										1		
59	41.05415	-86.18856	5												
60	41.05407	-86.18675	4							1					1
61	41.05424	-86.18489	4												
62	41.05413	-86.17949	5		P										
63	41.05412	-86.17764	3		P										

LARE Tier 2 Survey Raw Data 6/29/16 Continued

WPT	Lat	Long	Depth	Curly-leaf pondweed	Fil. Algae	Common bladderwort	Coontail	Sago pondweed	Water stargrass	Chara	Flat-stemmed pondweed	Large-leaved pondweed	Leafy pondweed	Common waterweed	Horned pondweed
64	41.05425	-86.17063	5		P										
65	41.05540	-86.19107	3		P					1					
66	41.05523	-86.18561	4										1		
67	41.05542	-86.18407	4							1					
68	41.05529	-86.17871	5		P										
69	41.05532	-86.17694	4		P										
70	41.05537	-86.17161	5		P								1		
71	41.05542	-86.16978	5	1	P		1	3							
72	41.05641	-86.19216	2		P					1					
73	41.05646	-86.19026	4												
74	41.05643	-86.18845	5				1								
75	41.05644	-86.18676	7												
76	41.05652	-86.17782	6												
77	41.05655	-86.17593	5		P										
78	41.05659	-86.17067	4		P										
79	41.05756	-86.19298	2		P										
80	41.05757	-86.19115	4		P					1					
81	41.05761	-86.18916	4		P										
82	41.05770	-86.18755	4												
83	41.05762	-86.18570	4												
84	41.05771	-86.18401	4										1		
85	41.05782	-86.17862	5												
86	41.05776	-86.17679	6												
87	41.05813	-86.17139	4												
88	41.05883	-86.19191	3		P					3					
89	41.05858	-86.19007	3		P				3	1					
90	41.05882	-86.18841	3		P										
91	41.05880	-86.18665	4		P					1					
92	41.05877	-86.18495	4												
93	41.05881	-86.18324	4		P										
94	41.05876	-86.18144	5												
95	41.05882	-86.17971	6												
96	41.05880	-86.17796	4												
97	41.05890	-86.17607	5		P										
98	41.05893	-86.17439	8		P										
99	41.05894	-86.17246	5												
100	41.05986	-86.19466	2							1					
101	41.05994	-86.19282	2							5					
102	41.05995	-86.18944	5												
103	41.06005	-86.18215	4		P										
104	41.05995	-86.18052	4												
105	41.05998	-86.17874	4		P										
106	41.06002	-86.17694	4		P										
107	41.05997	-86.17505	4		P										
108	41.05986	-86.17323	3		P		1								
109	41.06092	-86.18498	2		P										
110	41.06113	-86.18318	2		P					1					
111	41.06108	-86.18132	3		P										
112	41.06111	-86.17951	4		P								1		
113	41.05424	-86.1773	3		P					1					
DK 1	41.06071	-86.19449	4				1						1		
DK 2	41.05927	-86.19456	5										3		
DK 3	41.06106	-86.18397	2		P					1					
DK 4	41.06179	-86.18296	2		P					3					
DK 5	41.05555	-86.19245	2		P										
DK 6	41.04855	-86.18697	3		P										
DK 7	41.04933	-86.18957	4		P										
DK 8	41.04548	-86.18241	7			1									
DK 9	41.04945	-86.17431	12				1								
DK 10	41.0502	-86.17181	3		P										
DNR 1	41.04877	-86.18804	5		P										

LARE Tier 2 Survey Raw Data 8/29/16

WPT	Lat	Long	Depth	Fil. Algae	Coontail	Leafy pondweed	Water stargrass	Chara	Small pondweed	Large-leaved pondweed
1	41.06090	-86.17843	3.5	P						
2	41.06142	-86.18021	3.5	P						
3	41.05924	-86.18810	2.5	P		1		1		
4	41.05921	-86.18875	3	P						
5	41.05530	-86.17996	5		1					
6	41.05695	-86.18784	3							
7	41.05406	-86.17718	3							
8	41.04456	-86.18524	2.5		3		1			3
9	41.06030	-86.19520	1.5							
10	41.06090	-86.19662	1.5							
11	41.03551	-86.16812	2		5					
12	41.03916	-86.17678	2		5	1				
13	41.03912	-86.17497	2	P						
14	41.03920	-86.17338	2	P	1					
15	41.03875	-86.17026	1		5					
16	41.04039	-86.17759	3	P						
17	41.04025	-86.17583	6	P	1		1			
18	41.04029	-86.17409	4	P	3					
19	41.04030	-86.17235	2.5	P	1					
20	41.04031	-86.17057	2		5					
22	41.04149	-86.17858	3	P						
23	41.04152	-86.17311	3							
24	41.04280	-86.17948	2.5							
26	41.04377	-86.18035	2.5	P						
27	41.04377	-86.17334	10							
28	41.04453	-86.18439	1.2		1					1
29	41.04501	-86.17950	2							
30	41.04610	-86.18044	1.5	P						
31	41.04595	-86.17508	14							
32	41.04719	-86.18302	12							
33	41.04733	-86.17958	2							
34	41.04847	-86.18036	3.5	P		1			1	
35	41.04945	-86.18648	4							
36	41.04946	-86.18499	3	P				1		
37	41.05072	-86.18577	5	P				1		
38	41.05066	-86.18387	4							
39	41.05078	-86.18034	6							
40	41.05064	-86.17142	7.5							
41	41.05074	-86.16973	3.5	P	5		1		1	
42	41.05179	-86.18995	3	P						
43	41.05177	-86.18490	6							
44	41.05178	-86.18318	3							
45	41.05181	-86.18140	4							
46	41.05181	-86.17945	5	P						
47	41.05184	-86.17769	4							
48	41.05192	-86.17586	7.5		1					
49	41.05190	-86.17243	8							
50	41.05202	-86.17079	5							
51	41.05301	-86.18918	5			1				
52	41.05298	-86.18740	3.5			1		3		
53	41.05300	-86.18563	3					3		
54	41.05302	-86.18388	4.5							
55	41.05293	-86.17865	4	P						
56	41.05296	-86.17679	2.5	P						
57	41.05291	-86.16979	5.5							
58	41.05430	-86.19016	6							
59	41.05415	-86.18856	4			1				
60	41.05407	-86.18675	3.5					3		
61	41.05424	-86.18489	3.5							
62	41.05413	-86.17949	4.5			1				
63	41.05412	-86.17764	3.5	P						
64	41.05425	-86.17063	5			1				

LARE Tier 2 Survey Raw Data 8/29/16 Continued

WPT	Lat	Long	Depth	Fil. Algae	Coontail	Leafy pondweed	Water stargrass	Chara	Small pondweed	Large-leaved pondweed
65	41.05540	-86.19107	3.5							
66	41.05523	-86.18561	3.5			3		3	1	
67	41.05542	-86.18407	4							
68	41.05529	-86.17871	5							
69	41.05532	-86.17694	4							
70	41.05537	-86.17161	5							
71	41.05542	-86.16978	5							
72	41.05641	-86.19216	2.5	P		1				
73	41.05646	-86.19026	4							
74	41.05643	-86.18845	6							
75	41.05644	-86.18676	6							
76	41.05652	-86.17782	5.5							
77	41.05655	-86.17593	5	P						
78	41.05659	-86.17067	3.5							
79	41.05756	-86.19298	2							
80	41.05757	-86.19115	4							
81	41.05761	-86.18916	4							
82	41.05770	-86.18755	4							
83	41.05762	-86.18570	4							
84	41.05771	-86.18401	4							
85	41.05782	-86.17862	5.5							
86	41.05776	-86.17679	5.5							
87	41.05813	-86.17139	4.5							
88	41.05883	-86.19191	3					1		
89	41.05858	-86.19007	3							
90	41.05882	-86.18841	3	P		1				
91	41.05880	-86.18665	3.5	P						
92	41.05877	-86.18495	4							
93	41.05881	-86.18324	4							
94	41.05876	-86.18144	5							
95	41.05882	-86.17971	6			1				
96	41.05880	-86.17796	4	P						
97	41.05890	-86.17607	5							
98	41.05893	-86.17439	7	P						
99	41.05894	-86.17246	5							
100	41.05986	-86.19466	2							
101	41.05994	-86.19282	2.5					5	1	
102	41.05995	-86.18944	6							
103	41.06005	-86.18215	4	P						
104	41.05995	-86.18052	4	P						
105	41.05998	-86.17874	4	P		3				
106	41.06002	-86.17694	4							
107	41.05997	-86.17505	4							
108	41.05986	-86.17323	4			1				
109	41.06092	-86.18498	3			1				
110	41.06113	-86.18318	3						5	
111	41.06108	-86.18132	3	P		1				
112	41.06111	-86.17951	4	P						
113	41.05424	-86.1773	3							
DK 1	41.06071	-86.19449	3.5							
DK 2	41.05927	-86.19456	3							
DK 3	41.06106	-86.18397	1.5	P						
DK 4	41.06179	-86.18296	2.5					5		
DK 5	41.05555	-86.19245	2						1	
DK 6	41.04855	-86.18697	3	P						
DK 7	41.04933	-86.18957	5	P						
DK 8	41.04548	-86.18241	12							
DK 9	41.04945	-86.17431	20							
DK 10	41.0502	-86.17181	3							
DNR 1	41.04877	-86.18804	5	P						