Watershed Assessment and Management Plan Update for Black Otter Lake, Outagamie County, Wisconsin

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Introduction

Black Otter Lake is a shallow 75-acre impoundment located in the village of Hortonville (**Figures 1 and 2**). Two tributary streams and numerous storm water culverts feed the lake. Black Otter Creek drains from the lake directly into the Wolf River. With two public boat launches, a county park and a village park on its shores, Black Otter Lake receives substantial recreational use throughout the year. As the only lake in Outagamie County having public access, area residents consider Black Otter Lake an important natural resource. The Black Otter Lake District was formed in 1976 to help restore and protect the lake.

Lake Management History

Due to its shallowness and nutrient inputs from the watershed, Black Otter Lake has a history of nuisance aquatic plants, water quality issues, and sedimentation problems. In January, 2003 a comprehensive lake management study was completed. This study found that high levels of nutrients continued to enter the lake. It was also documented that much of the lake turned anoxic during the summer months. A small-scale aeration system was initially installed in Black Otter Lake in order to maintain a viable fishery by preventing winter and summer fish kills.

To date, members of the Black Otter Lake District use a variety of lake management practices to encourage water quality and a healthy biotic community. These practices include the use and maintenance of the aeration system, exotic species control, and encouragement of Best Management Practices within the watershed. There has been much support from the Black Otter Lake District, the Village of Hortonville, and many other local groups and individuals.

In 1989 two locations within Black Otter Lake and one location upstream of the lake to the south were dredged in an effort to trap inflowing sediments. The location to the south soon filled with sediments. The two in-lake locations have not filled as quickly. To date no significant effort has been made to specifically assess the effectiveness of these efforts and determine if further sediment retention measures should be considered.

In 1982, 55 acres within Black Otter Lake were dredged. In 1982, 1992, 2002 and again in 2008, lake studies that resulted in management plans were completed. Both the Village of Hortonville and Black Otter Lake District have followed up on recommendations proposed from past management plans.

Since 2003 annual herbicide treatments have been used to treat Eurasian watermilfoil (*Myriophyllum spicatum*) and/or curly-leaf pondweed (*Potamogeton crispus*). Target species, treatment sizes and efficacy have varied from year to year. Annual reports have been prepared since 2007. These reports contain a summary of lake management activities during that year, maps of invasive species and management recommendations for following years. These reports should be referenced to better understand the year-to-year activities on Black Otter Lake.

Figure 1. Black Otter Lake and the surrounding area, Outagamie County, WI

Figure 2. Public access locations surrounding Black Otter Lake, Outagamie County, WI

Over the past ten years, the members of the Black Otter Lake District have actively managed Eurasian watermilfoil and curly-leaf pondweed. Both species have dominated the lake at various times over this period. Treatments for exotic species date back to 2003. Annual treatment for curly-leaf pondweed have utilized endothall while 2,4-D has been the herbicide of choice for management of Eurasian watermilfoil.

In 2004 a small-scale aquatic plant restoration project funded in part by a Lake Management Protection Grant took place. Similar plantings have taken place in the summers of 2009 and 2010. Pre- and post-treatment monitoring was conducted in accordance with the current Aquatic Invasive Species grant awarded to the Black Otter Lake District in 2008.

During the winter of 2008-2009 a drawdown of Black Otter Lake was conducted. The goal of this drawdown was to alleviate nuisance plant growth, both native and exotic, and to encourage the desiccation and compaction of lake sediments. Results of the drawdown indicate that the diversity of the native plant community increased and the distribution of Eurasian watermilfoil declined. However, the distribution of curly-leaf pondweed in Black Otter Lake increased to essentially lake-wide coverage. Sediment depth did decrease as did the organic content of the sediments throughout the lake, albeit by small percentages.

Prior to the 2008-2009 drawdown of Black Otter Lake, fish were captured and moved to a private pond to be held until after the lake was refilled. After the drawdown, the fish were returned and additional fish were stocked in the lake.

Since the drawdown, the Black Otter Lake District has taken steps to improve habitat for fish and wildlife. The District has stocked thousands of game fish and minnows. They have also, in cooperation with the Wisconsin DNR, conducted a tree-fall of over 60 trees along the shore of the lake. In 2009 and 2010, seven emergent and floating-leafed plant species were planted in the lake. In total 1000 plants were planted in nine locations. Although some of the species appeared to thrive after the planting, in subsequent years, survival rates dropped and the only species that appear to have survived are the water lilies.

In 2010, the District installed an osprey/eagle nesting platform at the southeast end of the lake. The District also kicked off a Clean Boats Clean Waters program on Black Otter Lake in the spring 2010.

Following the 2008-2009 drawdown, annual herbicide treatments for Eurasian watermilfoil and curly-leaf pondweed began again in the spring of 2010. In April 2010, post-drawdown treatments of curly-leaf pondweed and Eurasian watermilfoil took place. Approximately 57 acres of curly-leaf pondweed in the main body of the lake were treated with Aquathol K® (liquid endothall) at a rate of 1.5 ppm. An additional 5 acres of curly-leaf pondweed located above the train trestle was treated with Aquathol Super K® (granular endothall) at a rate of 1.5 ppm. In addition, 14 acres of Eurasian watermilfoil were treated with DMA4 IVM® (liquid 2,4-D) at a rate of 1.5 ppm. In 2011 and 2012, curly-leaf pondweed and Eurasian watermilfoil were treated in the same manner as in 2010. In 2013, the most recent curly-leaf pondweed treatment targeted the entire lake volume at

1.0 ppm with a combination of Aquathol K® and Aquathol Super K®. Following the 2013 treatment, water samples were collected by volunteers to monitor the concentrations and movement of endothall within Black Otter Lake. Monitoring lasted at regular intervals for approximately 35 days at nine locations. This work was coordinated by John Skogerboe, formerly with the U.S. Army Corps of Engineers. A copy of his report can be found in **Appendix A**. Results showed the concentrations in the main body of the lake remained at or above the target concentration for approximately five days. Concentrations measured south of the train trestle and near the east inlet dropped off relatively quickly.

By fall 2011, Eurasian watermilfoil was greatly reduced and was found in only a small number of locations in the northeast portion of the lake. No treatments for Eurasian watermilfoil took place in 2012 or 2013.

For a number of years, lake volunteers have monitored water quality in Black Otter Lake through the Wisconsin DNR's Citizen Lake Monitoring Network. During the summer months, oxygen and temperature profiles are developed and water samples are collected and sent to the State Lab of Hygiene for analysis of phosphorus and chlorophyll.

The previous management plan for Black Otter Lake District included action items for a number of ongoing lake management activities. These include exotic species management, shoreline habitat restoration/aquatic plantings, fishery enhancements, and water quality monitoring. The District would like to maintain this momentum and take the next step to focus efforts on assessing the watershed of Black Otter Lake and determine a course of action to decrease nutrient loading and improve water quality conditions in the lake. This study has been designed as the next step in the lake management process and a means to update the lake's management plan.

Goals and Objectives

The objectives of this study have been to 1) assess the water quality of Black Otter Lake during the growing season, 2) identify sources of nutrient inputs from the tributaries and near-shore areas of the watershed, 3) analyze nutrient data and predict lake responses to changes in the watershed, 4) assess condition of current aquatic plant communities, and 5) use the knowledge gained by this study to identify lake management needs and implement a program toward 'restoring' Black Otter Lake by reducing nutrient inputs and improving water quality.

Methods

Many processes affect water quality, algae, and aquatic plant conditions in Black Otter Lake. As a result, a number of elements were evaluated as part of this study. This included assessing surface water quality, stormwater and tributary contributions and near-shore conditions. A number of previous watershed studies conducted by the Wisconsin Department of Natural Resources

(WDNR) and researchers at UW-Stevens Point were used to develop the methodology for this study, particularly, the Watershed Assessment of Shawano Lake, Shawano County, Wisconsin.

Surface water sampling

In order to track the quality of the water in Black Otter Lake, water analyses were conducted throughout the growing season in 2012. Samples for analysis of chlorophyll *a* and total phosphorus, as well as Secchi depth data, were collected 17 times (approximately every two weeks) from April through October at the lake's deepest point. Volunteers have collected data for a number of years through the Citizen Lake Monitoring Network program. As a result, District volunteers agreed to conduct the water sampling for this portion of the study. In addition, volunteers collected dissolved oxygen and temperature data at three-foot intervals from surface to bottom at the lake's deepest point. This occurred 13 times from April through October. Results were obtained from the WDNR's Surface Water Integrated Monitoring System (SWIMS).

The results of this season-long volunteer monitoring program were used to quantify the productivity of Black Otter Lake (Trophic State Index). Software available from the Wisconsin DNR entitled Wisconsin Lake Modeling Suite (WiLMS) was used to predict the trophic state of Black Otter Lake given its size, watershed area, mean depth and eco-region. Black Otter Lake lies within the Northern Central Hardwood Forests region of Wisconsin. In addition, this software was used to predict the spring turnover, growing season mean, and annual average total phosphorus concentration in Black Otter Lake. Comparisons have been made between the predicted phosphorus and TSI values, and those calculated from the phosphorus, chlorophyll and Secchi data.

Watershed Assessment

Because much of what happens in the watershed surrounding a lake can influence the overall water quality and health of a lake, it was important to investigate and document aspects of the watershed which can have such an impact.

Tributary Sampling

To understand how the watershed influences water quality in Black Otter Lake an evaluation of the movement of contaminants, including nutrients, through the watershed and into Black Otter Lake was made. Volunteers also conducted this sampling. Water was collected from the mouth of the two tributaries feeding Black Otter Lake (**Figure 3, Table 1**). These tributaries are Black Otter Creek to the south and an unnamed creek to the northeast. Black Otter Creek was sampled at the three culverts which pass under the Wiowash Trail. The unnamed creek was sampled at the culvert under South Lake Street. Water samples and water flow readings were also measured approximately every two weeks following the same schedule previously described for surface water sampling. Samples were analyzed for total phosphorus, pH, alkalinity and conductivity. This limited list of analyses was chosen to keep the cost of analyses lower and because these parameters have shown to be useful in determining if pollutants such as road salts, wastewater or runoff from agricultural fields are occurring. Samples were sent to the State Lab of Hygiene for analysis. When rates were high enough, stream flow was measured with a propeller-style flow meter. During low-flow conditions, either a float or dye was used to record the time needed for water to pass through the culverts.

Stormwater sampling

There are nine culverts along the shore of Black Otter Lake that direct stormwater into the lake. As part of this study, a map of culvert locations was developed (**Figure 3, Table 1**). It was unclear the extent to which nutrients and contaminants enter Black Otter Lake through these stromwater drains. As a result, water samples and flow data were collected from five of these culverts during five rain events in 2012. As a cost-saving measure, four culverts were not sampled. Data from the five sampled culverts were used to extrapolate contributions from the remaining culverts. Samples were analyzed for the same parameters as the tributary sampling.

Watershed Nutrient Loading

Computer models were used to understand how and where water and nutrients are moving into and out of Black Otter Lake and how the processes within the lake affect the availability of nutrients to algae and aquatic plants. Nutrient models that predict nutrient movement from the watershed to the lake require data specific to the watershed. Water quality data from the tributary streams and stormwater culverts were used to assess nutrient and water budgets. Three mathematical models available from the U.S. Army Corps of Engineers and the Wisconsin Department of Natural Resources were used.

FLUX

The FLUX model allows for estimations of tributary discharges (phosphorus loading) from sample concentration data and flow data. FLUX requires grab sample concentration data and regular flow records. FLUX calculates the annual yield or load of phosphorus into the lake. This model takes a more sophisticated approach to nutrient loading than by simply multiplying nutrient concentrations by the rates of stream flow.

BATHTUB

The BATHTUB program applies a series of eutrophication models to complex lakes and reservoirs. The program performs water and nutrient balance calculations in a network of sub-watersheds. Eutrophication-related water quality conditions are predicted using the relationship of available data. It is a linear model based on phosphorus to estimate algae response represented by changes in chlorophyll a concentrations. BATHTUB requires information describing watershed characteristics, observed water and nutrient loads, and lake or reservoir morphology. In addition to measured parameters from the lake and watershed, it takes in account precipitation, evaporation, and atmospheric nutrient loads.

WiLMS

In addition to predicting trophic conditions in a lake, the WiLMS program estimates the internal nutrient loading occurring in a lake by incorporating nutrient and dissolved oxygen data. The WiLMS model uses watershed characteristics and lake response to predict total phosphorus concentrations in lakes. It includes four main parts: front-end, phosphorus prediction, internal loading, and trophic response. The front-end portion or model setup includes the lake characteristics, watershed loading inputs, and the observed in-lake phosphorus concentrations.

Figure 3. Locations of culverts and tributaries contributing surface water to Black Otter Lake, Outagamie, WI.

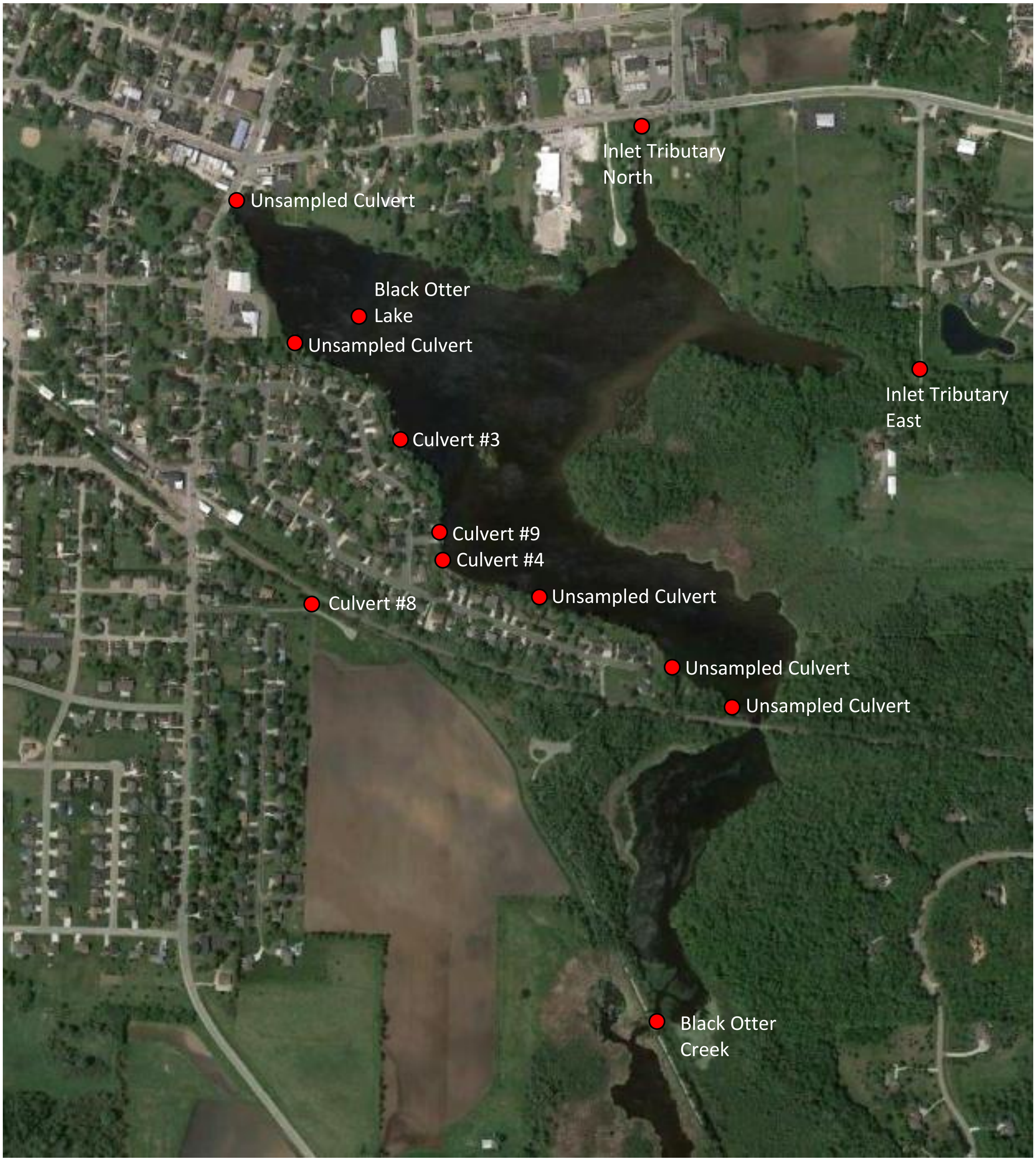


Table 1. Black Otter Lake monitoring locations and sampling schedule.

Site	SWIMS* ID #	Description	Location Lat/Long	Sampling Frequency
Culvert # 3 (**D**)	10035059	Lakeshore Drive - East	44° 19’ 53.3” N 88° 38’ 8.6” W	Storm event
Culvert # 4 (**E**)	10035060	Lakeview Ave just south of public access	44° 19’ 45.2” N 88° 38’ 4.2” W	Storm event
Culvert # 8 (**F**)	10035067	Ditch by Railroad tracks to Black Otter Lake	44° 19’ 43.1” N 88° 38’ 12.8” W	Storm event
Culvert # 9 (**G**)	10019222	At public access site	44° 19' 46.2" N 88° 38' 5.1" W	Storm event
Inlet Tributary North (**H**)	453275	Unnamed Tributary on the north side of Black Otter Lake	44° 20' 1.3" N, 88° 37' 51.8" W	Storm event
Black Otter Lake deep spot (**A**)	453121	Deep spot	44° 19’ 54.9” N 88° 38’ 0.9” W	Every 2 weeks
Inlet Tributary East (**B**)	10034827	Unnamed Tributary to Black Otter Lake east tributary at S. Lake Street	44° 19' 54.0" N, 88° 37' 32.8" W	Every 2 weeks
Black Otter Creek at mouth before entering Black Otter Lake (**C**)	10034826	Black Otter Creek before it enters Black Otter Lake on south side	44° 19' 23.1" N, 88° 37' 49.8" W	Every 2 weeks

* Surface Water Integrated Monitoring System

WiLMS and BATHTUB can be used as both descriptive and predictive tools. These models use export coefficients for various land-use and cover types, as well as precipitation, point sources and septic systems to represent phosphorus loading into the lake from external sources. These programs also take in account lake morphology, and watershed drainage area.

Land-use Assessment
The boundary of the watershed and the sub-watersheds of the three tributaries surrounding Black Otter Lake were delineated using topographic maps, aerial photos, and city stormwater plans. Researchers contacted Village of Hortonville personnel to determine the flow of stormwater in and around Black Otter Lake. It was important to know which areas of the town contribute stormwater to the lake and which areas do not. A map showing areas of contribution (sub-watersheds) was developed with this information.

Data obtained from the Wisconsin DNR's Bureau of Technology Services were used to determine the land-use and vegetative cover types within the watershed. The percent cover for each of these categories was determined. The Wisconsin DNR's Surface Water Data Viewer was used to further assess elements of Black Otter Lake's watershed, particularly if environmentally sensitive areas exist within the watershed.

Data available from the Natural Resources Conservation Service (NRCS) was used to determine the soil types within the Black Otter Lake watershed. These data include the percent watershed area for and the characteristics of each soil type including slope, drainage and suitability for farmland. This information has been used to assess whether certain areas, which may or may not be in agriculture, have soils conducive to such practices.

Land-use patterns, vegetative cover, potential nutrient loading sources, and environmentally sensitive areas were further assessed visually. Land-use within the watershed was assessed on site. Certain areas were identified as possibly problematic nutrient sources. These areas were documented by recording location data, and collecting photos from the ground.

Near-shore Assessment
Since a significant amount of nutrients and sediments can enter a lake from areas closest to the lake, it was important to also focus on the conditions nearest the lake and identify potential areas of concern. The shoreline was assessed to determine if environmentally sensitive areas, such as areas of disturbance, high erosion, or generally poor riparian health existed.

Land-use was further evaluated in the near-shore region to determine the amount of impervious surfaces that may increase the amount of runoff and pollutants delivered to the lake during storms. Aerial photos were used to determine the area covered by roads and parking lots that drain into the lake.

Aquatic Plant Assessment

On August 21 and 22, 2013, a submergent aquatic plant survey was conducted utilizing methods developed by the WDNR. The Department's Bureau of Research developed plant survey maps for Black Otter Lake. A series of 284 grid points were mapped across the lake (**Figure 4**). At each of the navigable locations, aquatic plant samples were collected from a boat with a single rake tow. Following WDNR guidelines, the rake used consisted of two short-toothed garden rake heads welded together. At each sample point, the rake was briefly dragged along the bottom to collect plants. All plant samples collected were identified to *genus* and *species* whenever possible, and recorded. An abundance rating was given for species collected using the criteria described in **Figure 5**. This rating was also used as a tool to map plant abundance within Black Otter Lake. Data collected was used to determine species composition and diversity, percent frequency and floristic quality.

Exotic Plant Distribution Mapping

In order to best manage aquatic invasive species in Black Otter Lake, detailed mapping surveys were conducted in 2013. Spring and fall surveys of Black Otter Lake were conducted for curly-leaf pondweed and Eurasian watermilfoil, respectively. Cason & Associates staff monitored the results of previous treatments and identified the locations where these species were in need of further treatment. Care was taken to accurately document the distribution and density of these species during each survey in order to track the progress made by management efforts. The spring survey was conducted on May 8, 2013 and served to best identify the distribution and treatment needs of curly-leaf pondweed while the fall survey, conducted on October 24, 2013, focused primarily on Eurasian watermilfoil. The spring survey utilized the point-intercept map provided by the Wisconsin DNR (**Figure 4**). At each location the presence or absence of invasive species were determined using surface observations and rake tows. The abundance of these species was also recorded following the same guidelines used during the summer plant survey and detailed in **Figure 5**. During the fall survey, a meandering survey of the littoral area of the lake was conducted to identify Eurasian watermilfoil. Particular attention was paid to the northeast section of the lake where milfoil had been identified during the August survey.

Figure 4. Aquatic plant survey map for Black Otter Lake, Outagamie County, WI.

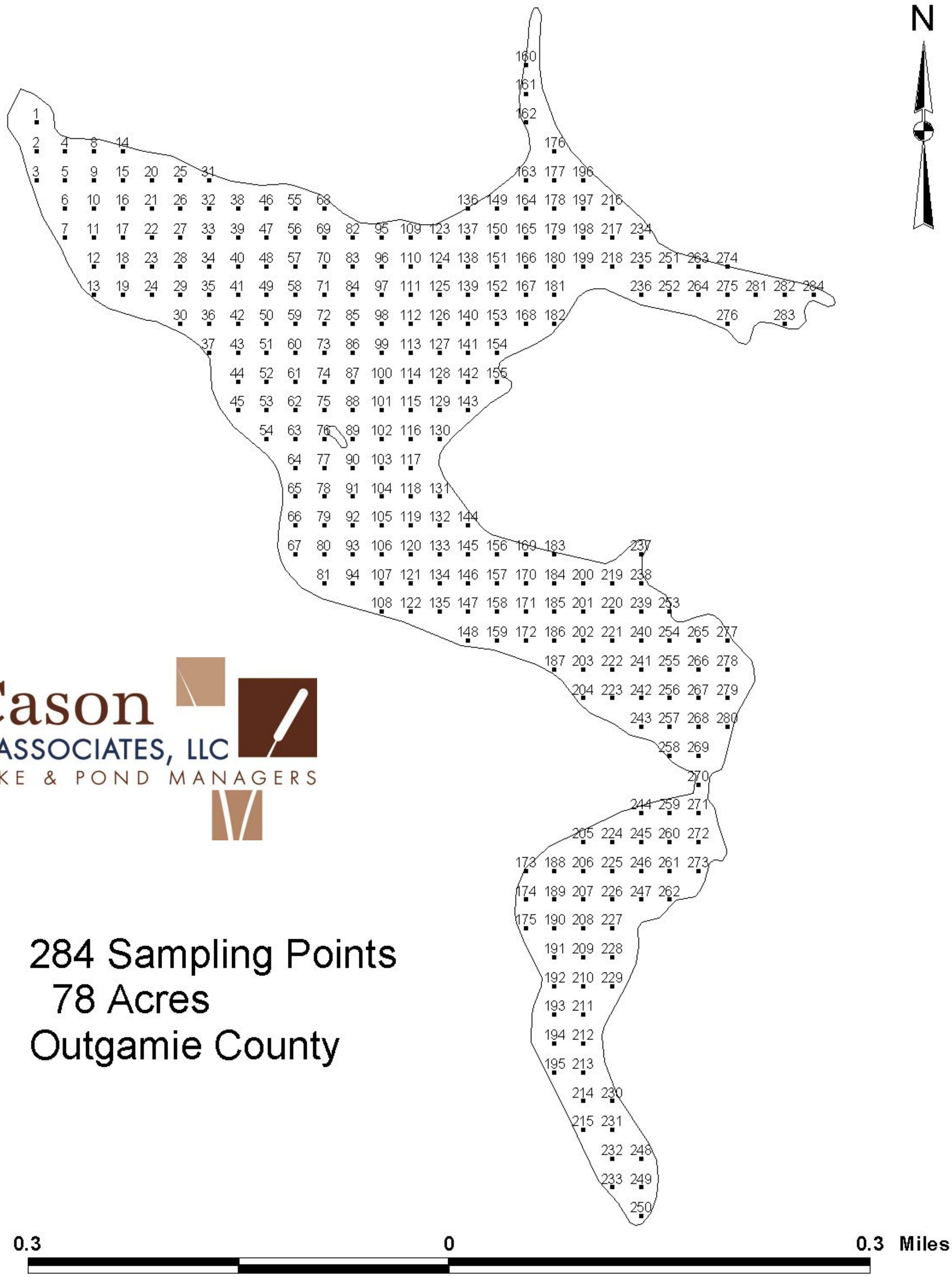


Figure 5. Plant abundance rating criteria used in submergent aquatic plant surveys.

Fullness Rating	Coverage	Description
1		Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer.
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines.
3		The rake is completely covered and tines are not visible.

Results

Watershed delineation

Figure 6 shows the border of Black Otter Lake's wetland. In total, this wetland encompasses approximately 9,896 acres or 15.5 square miles. This wetland was further delineated into five sub-watersheds (**Figure 7** and **Table 2**). These sub-watersheds include the areas drained by Black Otter Creek (south and west), the unnamed creek to the east, the northern areas draining into the lake near Alonzo Park, the residential area drained by the west shore culverts, and other nearshore areas (**Figure 8**).

Figure 6. Watershed surrounding Black Otter Lake, Outagamie County, WI.

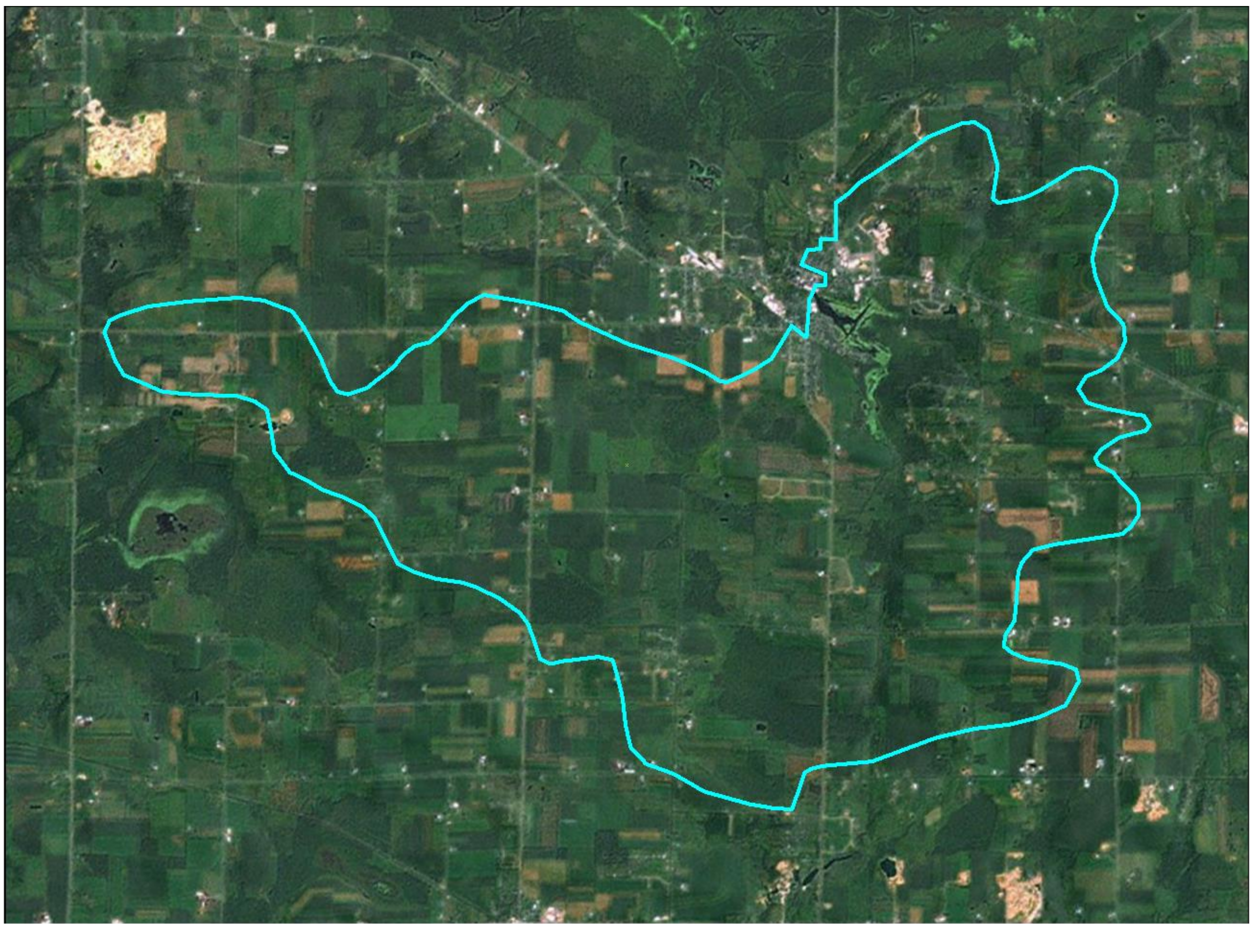


Figure 7. Sub-watersheds surrounding Black Otter Lake, Outagamie County, WI.

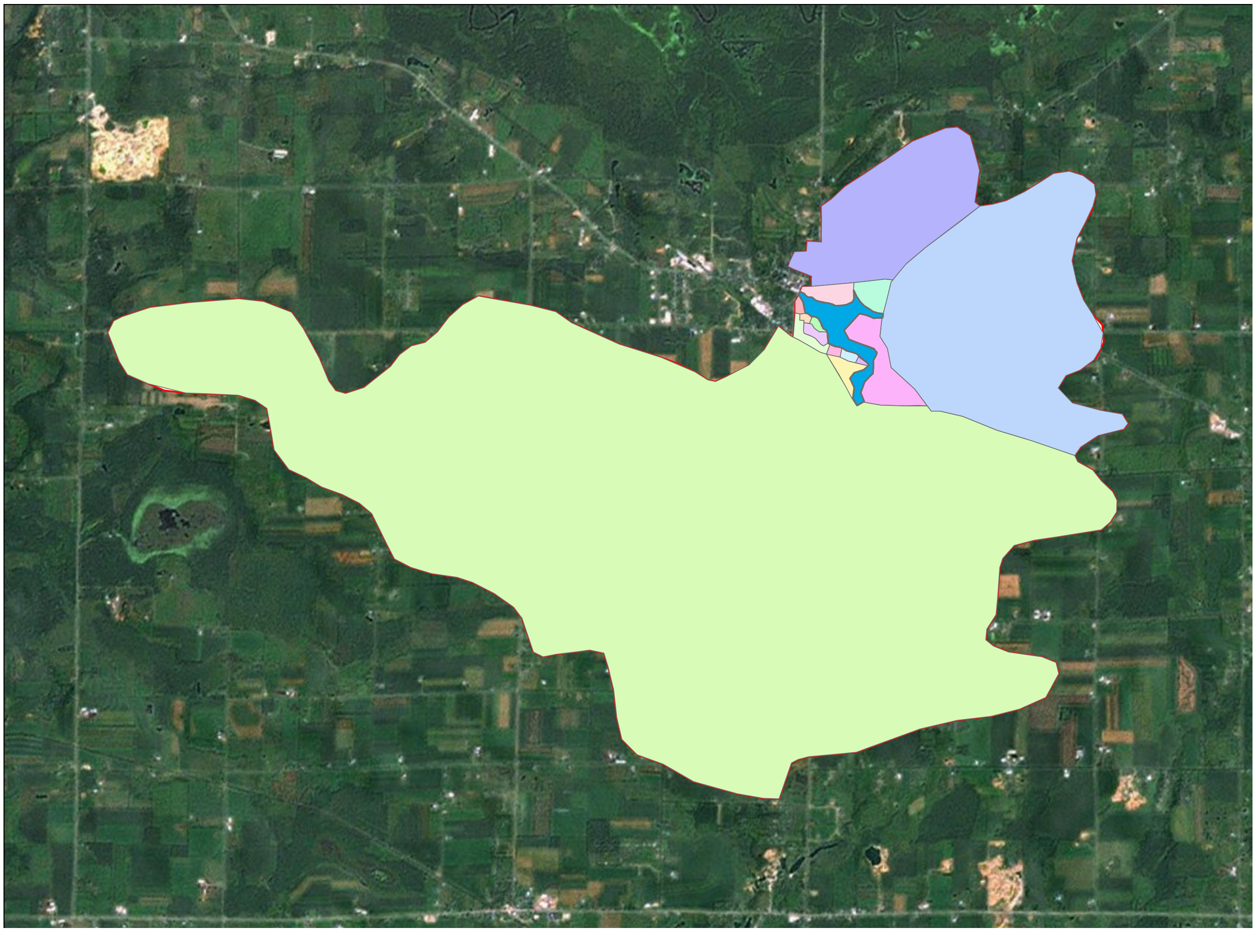
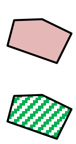


Table 2. Areas of sub-watershed surrounding Black Otter Lake, Outagamie County, WI.

Sub-watersheds	Acreage	
B.O. Creek	7,853	
East watershed	1,303	
North watershed	531	
Nearshore areas	165	
West shore culverts	44	
	9,896	acres
	15.5	mi^2

Figure 8. Near-shore areas that drain directly into Black Otter Lake, Outagamie County, WI.



Surface water sampling

Table 3 presents the results of water quality sampling from the main body of Black Otter Lake in 2012. Note: Historic water quality data is available for Black Otter Lake. Previous data have been presented in annual reports since 2007; available from Cason & Associates, LLC. Additional historic data is available from the SWIMS database.

Table 3. Water quality data from Black Otter Lake in 2012 (Site A).

Date	Total Phosphorus	Chlorophyll	Secchi
	mg/L	ug/L	ft
4/01/2012	--	--	4.4
4/09/2012	--	--	5.6
4/20/2012	0.076	4.49	--
5/3/2012	0.161	2.85	2.3
5/23/2012	0.103	10.2	7.2
6/4/2012	0.099	96.1	--
6/24/2012	0.074	22.8	5.2
7/9/2012	0.135	41.5	4.7
7/20/2012	--	--	4.2
7/24/2012	0.080	9.14	4.8
8/8/2012	0.030	10.1	4.9
8/22/2012	0.054	1.58	6.2
9/5/2012	0.061	28.0	5.9
9/17/2012	0.045	7.61	5.8
10/2/2012	0.031	9.46	5.7
10/9/2012	0.032	4.76	5.1
10/29/2012	0.053	16.9	--

Phosphorus

Phosphorus is one of the most important water quality indicators. Levels of phosphorus can determine the amount of algae growth in a lake. It can come from external sources within the watershed (fertilizers, livestock, septic systems) or to a lesser extent, from groundwater. Phosphorus can also come from within the lake through a process called internal loading. Internal loading occurs when plants and chemical reactions release phosphorus from the lake sediments into the water column. The average phosphorus concentration for natural lakes in Wisconsin is 0.025 mg/L (Shaw, et al, 2004). Values above 0.05 mg/L are indicative of poor water quality. Data in 2012 from Black Otter Lake ranged from 0.030 to 0.161 mg/L. Ten of the 14 sampling events results in total phosphorus levels above 0.05 mg/L.

Chlorophyll

Chlorophyll is the green pigment found in all green plants and algae, and is the site in plants where photosynthesis occurs. Chlorophyll absorbs sunlight to convert carbon dioxide and water to oxygen and sugars. Chlorophyll data is collected to estimate how much phytoplankton (algae) there is in a lake. Generally, the more nutrients there are in the water and the warmer the water, the higher the production of algae and consequently chlorophyll. Chlorophyll concentrations below 10 µg/L are most desirable for lakes. Measurements in 2012 ranged between 2.85 and 96.1 µg/L. Seven of the 14 measurements were above 10 µg/L.

Secchi Transparency

Water clarity is often used as a quick and easy test for a lake's overall water quality, especially in relation to the amount of algae present. There is an inverse relationship between Secchi depth and the amount of suspended matter, including algae, in the water column. The less suspended matter, the deeper the Secchi disc is visible. Secchi depths greater than six feet are generally indicative of good water quality. Secchi depths in 2012 ranged from 2.3 to 7.2 feet. Only two of the 14 measurements were greater than six feet.

Trophic State

There is a strong relationship between levels of phosphorus, chlorophyll and water clarity in lakes. As a response to rising levels of phosphorus, chlorophyll levels increase and transparency values often decrease. The effect of this is viewed as an increase in the productivity of a lake.

Lakes can be categorized by their productivity or trophic state. When productivity is discussed, it is normally a reflection of the amount of plant and animal biomass a lake produces or has the potential to produce. The most significant and often detrimental result is elevated levels of algae and nuisance aquatic plants. Lakes can be categorized into three trophic levels:

- oligotrophic - low productivity, high water quality
- mesotrophic - medium productivity and water quality
- eutrophic - high productivity, low water quality

These trophic levels form a spectrum of water quality conditions. Oligotrophic lakes are typically deep and clear with exposed rock bottoms and limited plant growth. Eutrophic lakes are often shallow, typically having heavy layers of organic silt and abundant plant growth. Mesotrophic lakes are typically deeper than eutrophic lakes with significant plant growth, and areas of exposed sand, gravel or cobble-bottom substrates.

Lakes can naturally become more eutrophic with time, however the trophic state of a lake is more influenced by nutrient inputs than by time. When humans negatively influence the trophic state of a lake the process is called *cultural eutrophication*. A sudden influx of available nutrients may cause a rapid change in a lake's ecology. Opportunistic plants such as algae and nuisance plant species are able to out-compete other more desirable species of macrophytes. The resulting appearance is typical of poor water quality.

Total phosphorus, chlorophyll and Secchi depth are often used as indicators of the water quality and productivity (trophic state) in lakes. Values measured for these parameters can be used to calculate Trophic State Index (TSI) values (Carlson 1977). The formulas for calculating the TSI values for Secchi disk, chlorophyll, and total phosphorus are as follows:

$$TSI = 60 - 14.41 \ln \text{Secchi disk (meters)}$$
$$TSI = 9.81 \ln \text{Chlorophyll } (\mu g/L) + 30.6$$
$$TSI = 14.42 \ln \text{Total phosphorus } (\mu g/L) + 4.15$$

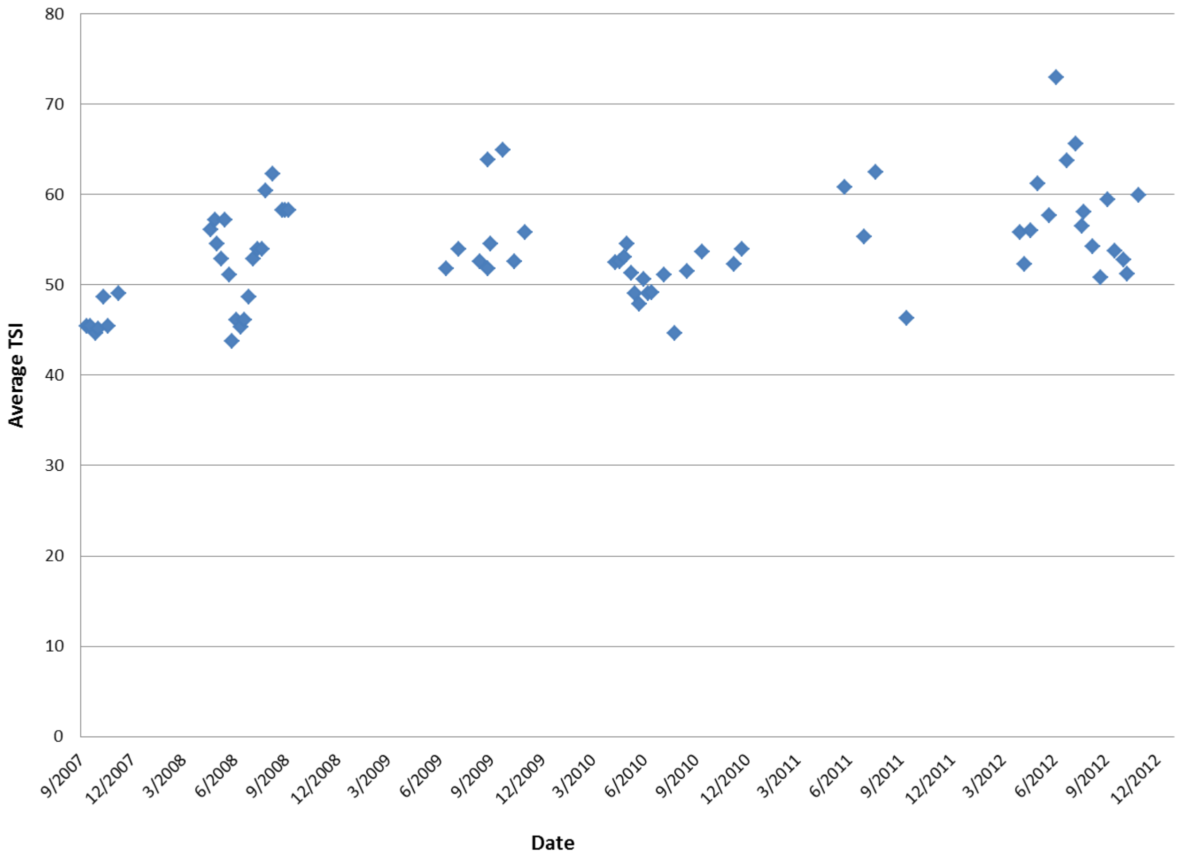
The higher the TSI calculated for a lake, the more eutrophic it is. Classic eutrophic lakes have TSI values starting around 50 (**Table 4**). Many of the TSI values calculated from Black Otter Lake's 2012 water quality data were above 50. These values indicate Black Otter Lake falls within the boundary of a eutrophic lake.

Table 4. Trophic State Index data from 2012 for Black Otter Lake, Outagamie County, WI.

Date	Chlorophyll TSI	Phosphorus TSI	Secchi TSI	Average TSI
4/01/2012	--	--	55.77	55.77
4/09/2012	--	--	52.30	52.30
4/20/2012	45.33	66.60	--	55.97
5/3/2012	40.87	77.42	65.12	61.14
5/23/2012	53.38	70.98	48.67	57.68
6/4/2012	75.39	70.41	--	72.90
6/24/2012	61.27	66.21	--	63.74
7/9/2012	67.15	74.88	54.82	65.62
7/20/2012	--	--	56.44	56.44
7/24/2012	52.31	67.34	54.52	58.05
8/8/2012	--	--	54.22	54.22
8/22/2012	--	--	50.83	50.83
9/5/2012	63.29	63.43	51.54	59.42
9/17/2012	50.51	59.04	51.79	53.78
10/2/2012	52.64	53.67	52.04	52.78
10/9/2012	45.91	54.13	53.64	51.23
10/29/2012	58.34	61.40	--	59.87

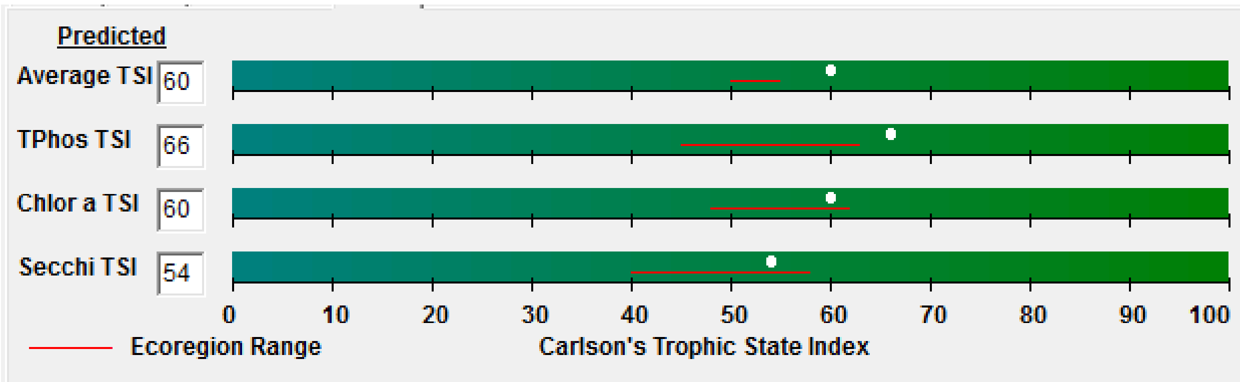
Average Trophic State Index values available from 2007 through 2012 were collected and are presented in **Figure 9**. This chart shows the slow increase in productivity and decline in water quality in the past six years. Note, the drawdown on Black Otter Lake took place in the winter of 2008 and 2009.

Figure 9. Average Trophic State Index (TSI) values from 2007 through 2012 for Black Otter Lake, Outagamie County, WI.



Results of the WiLMS modeling (**Figure 10**) found that the Trophic State Index values for Black Otter Lake in 2012 fell above the predicted range of TSI values for phosphorus, chlorophyll and average TSI. The predicted range is based on data from other lakes within the Northern Central Hardwood Forests region. However, the Secchi data fell within the expected range. In other words, the water quality of Black Otter Lake, based on these parameters, was lower than expected for a lake of this type.

Figure 10. Results of Wisconsin Lake Modeling Suite (WiLMS) analysis in 2012 for Black Otter Lake, Outagamie County, Wisconsin.



Watershed Assessment

Tributary and Stormwater Sampling

Tables 5 and 6 contain the water quality data collected from the two main inlets and five selected culverts contributing surface water to Black Otter Lake.

Table 5. Water quality data collected from the East Inlet Tributary (Site B) and Black Otter Creek (Site C) in 2012.

Site B: Inlet Tributary East - Lake Street

Date	pH	Conductivity	Alkalinity	Total Phosphorus
	SU	mmhos/cm	mg/L	mg/L
4/20/2012	8.15	653	275	0.061
5/3/2012	7.93	440	188	0.169
5/23/2012	8.08	899	333	0.043
6/4/2012	8.31	847	332	0.093
6/25/2012	8.3	965	347	0.128
7/9/2012	8.07	1080	346	0.156
7/24/2012	8.17	1040	323	0.137
8/8/2012	8.26	1080	338	0.116
8/21/2012	8.16	1080	345	0.077
9/5/2012	8.24	1060	343	0.114
9/17/2012	8.44	814	316	0.067
10/2/2012	8.10	1070	358	0.067
10/9/2012	7.70	1030	347	0.073
10/29/2012	7.83	1090	355	0.052

Site C: Black Otter Creek Before Black Otter Lake

Date	pH	Conductivity	Alkalinity	Total Phosphorus
	SU	mmhos/cm	mg/L	mg/L
4/20/2012	8.24	575	255	0.09
5/3/2012	7.88	470	209	0.168
5/23/2012	8.38	815	348	0.043
6/4/2012	8.60	787	333	0.085
6/25/2012	8.20	878	374	0.187
7/9/2012	8.44	853	360	0.156
7/24/2012	8.37	848	343	0.137
8/8/2012	8.38	820	325	0.086
8/22/2012	8.12	831	332	0.071
9/5/2012	8.16	831	329	0.104
9/17/2012	8.25	1070	349	0.152
10/2/2012	8.56	798	301	0.114
10/9/2012	8.08	858	332	0.162
10/29/2012	7.87	865	276	0.082

Table 6. Water quality data collected from the five selected culverts on Black Otter Lake in 2012.

Site D: Lakeshore Drive East, Culvert #3

Date	pH	Conductivity	Alkalinity	Total Phosphorus
	SU	mmhos/cm	mg/L	mg/L
5/3/2012	8.17	507	227	0.071
5/26/2012	7.08	73	29.2	0.070
8/9/2012	7.58	44	21.2	0.031
10/9/2012	6.38	100	34	0.671
10/14/2012	7.06	29	14.2	0.044

Site E: Lakeview Ave., Culvert #4

Date	pH	Conductivity	Alkalinity	Total Phosphorus
	SU	mmhos/cm	mg/L	mg/L
5/3/2012	8.29	556	239	0.078
5/26/2012	7.29	121	39.7	0.066
8/9/2012	7.61	72	28	0.034
10/9/2012	6.26	128	31.7	0.593
10/14/2012	7.02	32	14.1	0.069

Site F: Ditch by Railroad Tracks, Culvert #8

Date	pH	Conductivity	Alkalinity	Total Phosphorus
	SU	mmhos/cm	mg/L	mg/L
5/3/2012	--	--	--	0.064
5/26/2012	7	74	26.9	0.052
8/9/2012	7.71	72	27.8	--
10/9/2012	6.45	248	34.9	--
10/14/2012	7.04	22	10.9	--

Site G: At Public Access Site, Culvert #9

Date	pH	Conductivity	Alkalinity	Total Phosphorus
	SU	mmhos/cm	mg/L	mg/L
5/3/2012	8.12	550	232	0.076
5/26/2012	7.48	370	118	0.214
8/9/2012	7.22	50	21.4	0.069
10/9/2012	6.32	50	19.8	0.298
10/14/2012	6.79	17	9.3	0.048

Site H: Inlet Tributary North

Date	pH	Conductivity	Alkalinity	Total Phosphorus
	SU	mmhos/cm	mg/L	mg/L
5/3/2012	7.73	595	169	0.143
5/26/2012	7.5	390	74.8	0.068
8/9/2012	7.56	161	49.3	0.075
10/9/2012	7.07	625	108	0.215
10/14/2012	7.35	68	22.6	0.088

pH

pH is the measure of a lake's acidity or alkalinity. Many factors influence pH including geology, productivity, pollution, etc. pH levels between seven and nine are not uncommon for lakes in Wisconsin. The data from the two inlets fall within this range (7.70 to 8.56). The data from the culverts varied more; ranging from 6.26 to 8.29. These lower pH levels are likely due to the effects of chemicals and residues on the pavements where the stormwater originates. Within the tributaries, the water is exposed for a longer period of time to biological activities than can neutralize or buffer the effects of these chemicals.

Conductivity
Conductivity is the measure of the inorganic compounds in a body of water as determined by how well an electrical current is carried through a water sample. Conductivity is dependent upon the concentration of inorganic compounds suspended in the water column. High conductivity values may indicate contamination from septic systems, fertilizers, animal wastes or road salts. As a result, conductivity can be used to determine if human activities are influencing water quality. The recommended value for conductivity in lake samples is below 300 µmhos/cm. The data from the tributaries to Black Otter Lake were consistently greater than 300 µmhos/cm. Land-use and human activities are the likely reasons for these levels. The data from the shoreline culverts varied greatly from one rain event to another; ranging from 17 to 625 µmhos/cm. Again, this is likely due to specific conditions on the impermeable surfaces around the lake at any given time. Also, the timing of the water sampling may affect the results. Early in a rain event, it is likely chemicals are being transported in the stormwater at higher concentrations than later in a rain event.

Alkalinity
Alkalinity is a measure of the amount of carbonates, bicarbonates and hydroxide present in water. Alkalinity is predominantly determined by soil and bedrock characteristics. Lakes and ponds fed by groundwater from limestone aquifers tend to have high alkalinity. High alkalinity can also be a result of high algae and aquatic plant production. Low alkalinity (< 25 mg/L) waters are susceptible to acid rain. Alkalinity levels within the Black Otter Lake tributaries in 2012 were within the range of 188 to 374 mg/L. The culvert samples were in the range of 9.3 to 239 mg/L with many values below 25 mg/L. These levels fluctuated alongside the conductivity readings. Again the effects of pavement, sample timing and general lack of biological activities are likely the reasoning behind these results.

Dissolved Oxygen and Temperature
Dissolved oxygen and temperature data collected from Black Otter Lake in 2012 are presented in **Table 7**. The ideal level of oxygen needed for fish, such as bass, perch, and sunfish to survive and grow, is 5 mg/L or greater. Spring and fall oxygen levels in the upper portion of the lake were above this threshold. Levels during the months of June and July show lower than desired levels. The aeration system in operation during this time period was unable to maintain oxygen levels.

Table 7. Dissolved oxygen and temperature data collected in 2012 on Black Otter Lake, Outagamie County, WI.

Date	April 1, 2012		May 3, 2012		May 23, 2012		June 24, 2012	
Depth (ft)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
0	--	--	--	--	--	--	--	--
3	9.2	11.72	18.0	12.11	20.2	11.60	23.9	4.77
6	8.6	10.04	13.3	11.03	18.2	2.07	21.5	0.21
9	7.8	9.17	12.7	6.54	--	--	--	--

Date	July 9, 2012		July 20, 2012		July 24, 2012		August 8, 2012	
Depth (ft)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
0	--	--	25.7	0.19	27.5	4.49	25.4	7.94
3	28.2	4.05	25.8	0.17	27.3	2.58	25.4	7.82
6	23.9	0.19	25.8	0.12	23.5	0.09	24.0	0.16
9	--	--	--	--	--	--	--	--

Date	August 22, 2012		September 5, 2012		September 17, 2012		October 2, 2012	
Depth (ft)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
0	24.4	11.53	24.0	7.70	19.6	9.34	17.6	11.99
3	23.0	11.15	24.2	7.47	19.4	9.35	15.9	12.93
6	22.2	2.39	23.8	0.45	19.2	8.55	15.5	13.43
9	--	--	--	--	--	--	--	--

Date	October 9, 2012	
Depth (ft)	Temp (°C)	D.O. (mg/l)
0	10.1	9.45
3	10.0	9.43
6	10.0	9.43
9	--	--

Nutrient Loading

FLUX

Results of the FLUX model calculations based on the two main tributaries of Black Otter Lake are shown in **Table 8**. These results indicate a large majority of the nutrients entering through these tributaries arrive through Black Otter Creek to the south. These results are to be expected given the size difference between the two sub-watersheds from which these tributaries flow and the land-use within these areas. The FLUX model requires grab sample concentration data and regular flow records. As a result, the data from the intermittently flowing tributaries/culverts would not have been appropriate for use in this model.

Table 8. Estimated phosphorus loading from the main tributaries into Black Otter Lake based on FLUX model calculations.

Source	TP load (kg/yr)
B.O. Creek	5158.2
East Trib.	68.4
Total	5226.6

BATHTUB

Results of the BATHTUB model calculations (**Table 9**) show a similar trend as the FLUX model results. The BATHTUB model was able to take in account not only contributions from the two main tributaries, but also those from the remaining tributary and near-shore culverts. Again, the results indicate a large portion of the inflowing phosphorus comes from the Black Otter Creek sub-watershed. The results also show that over the span of a year, the contributions from the intermittently flowing sources are far less significant than the two main sources. It estimates these intermittent sources, when combined, account for only 2.4% of the phosphorus inputs into the lake.

Table 9. Estimated phosphorus loading external sources into Black Otter Lake based on BATHTUB model calculations.

Subwatershed	TP load (kg/yr)	% contribution
B.O. Creek	1525	74.0
East Trib.	486	23.6
North Trib.	40	1.9
Culverts	10	0.5
Total	2061	100.0

WiLMS

When dissolved oxygen data is included in the WiLMS modeling for Black Otter Lake, results show a small amount of internal nutrient cycling took place in 2012 (**Table 10**). It is under oxygen-depleted conditions (anoxia) that phosphorus is readily released from the sediments of a lake. The WiLMS modeling results suggest that internal nutrient release is minor in comparison to external nutrient sources. This is due primarily from the large watershed and relatively shallow lake.

Table 10. Estimated phosphorus loading from internal and external sources for Black Otter Lake based on WiLMS model calculations.

Source	TP load (kg/yr)
Internal Loading	5.9
External Loading	3,139
Total	3,144.9

Results of the FLUX, BATHTUB and WiLMS models support the assumptions made during the course of this study based on the observable characteristics of the lake and its watershed. That is:

1. A majority of the nutrient input into the lake comes from external sources, more specifically from the largest sub-watershed, Black Otter Creek, which accounts for the largest portion of agricultural land in the whole watershed.
2. The east tributary drains a significantly smaller sub-watershed area with a lower percentage of agricultural land and subsequently contributes less phosphorus.
3. The remaining intermittent sources make up a small area of the watershed including only a small portion of the Town of Hortonville. As a result, even less phosphorus comes from these sources.
4. Predicted models show lower than predicted loading from land-uses versus water sampling.
5. Internal nutrient cycling also accounts for a small portion of the total nutrient inputs.
6. Water quality data show levels of concern for nutrients, chlorophyll and conductivity.

Nutrient Reduction Scenarios

The BATHTUB and WiLMS models were also used to predict changes to the water quality of Black Otter Lake. By comparing current phosphorus loads from the watershed to hypothetical reductions in loading by 20% and 40% as well as an increase of 20%, changes in water quality (phosphorus and chlorophyll concentrations) were calculated. Results of these analyses are found in **Table 11**. Results for both models show that the total phosphorus levels change relatively proportionally to the increase or decrease in loading. This is to be expected since phosphorus is directly measured from lake water samples. In terms of chlorophyll and Secchi depths, the change is more gradual. This is likely due to other factors that can affect these parameters; such as weather and turbidity.

Table 11. Predicted changes to total phosphorus and chlorophyll concentrations and Secchi depth based on three hypothetical scenarios; 20% decrease, 40% decrease and 20% increase in external nutrient loading (based on 2012 averages) into Black Otter Lake, Outagamie County, WI.

	BATHTUB			
	Total Phosphorus	% Change	Chlorophyll	% Change
	mg/L	%	ug/L	%
2012 avg.	73.86	--	18.96	--
20% dec.	61.87	16%	16.56	13%
40% dec.	49.88	32%	14.16	25%
20% inc.	85.85	-16%	21.36	-13%

	WiLMS					
	Total Phosphorus	% Change	Chlorophyll	% Change	Secchi	% Change
	mg/L	%	ug/L	%	ft	%
2012 avg.	73.86	--	18.96	--	5.14	--
20% dec.	59.66	19%	16.37	14%	5.93	-15%
40% dec.	48.29	35%	14.58	23%	6.72	-31%
20% inc.	88.06	-19%	21.55	-14%	4.39	15%

Watershed Land Use

Figure 11 shows the delineation of the watershed and the land-use types present. The data for this map was provided by the Wisconsin DNR's Bureau of Technology Services. **Table 12** contains a breakdown of land-use and cover types within the watershed. Not surprisingly, the watershed as a whole is dominated by row crops/agriculture (75%).

Figure 11. Land cover types and watershed delineation for the Black Otter Lake, Outagamie County, WI.

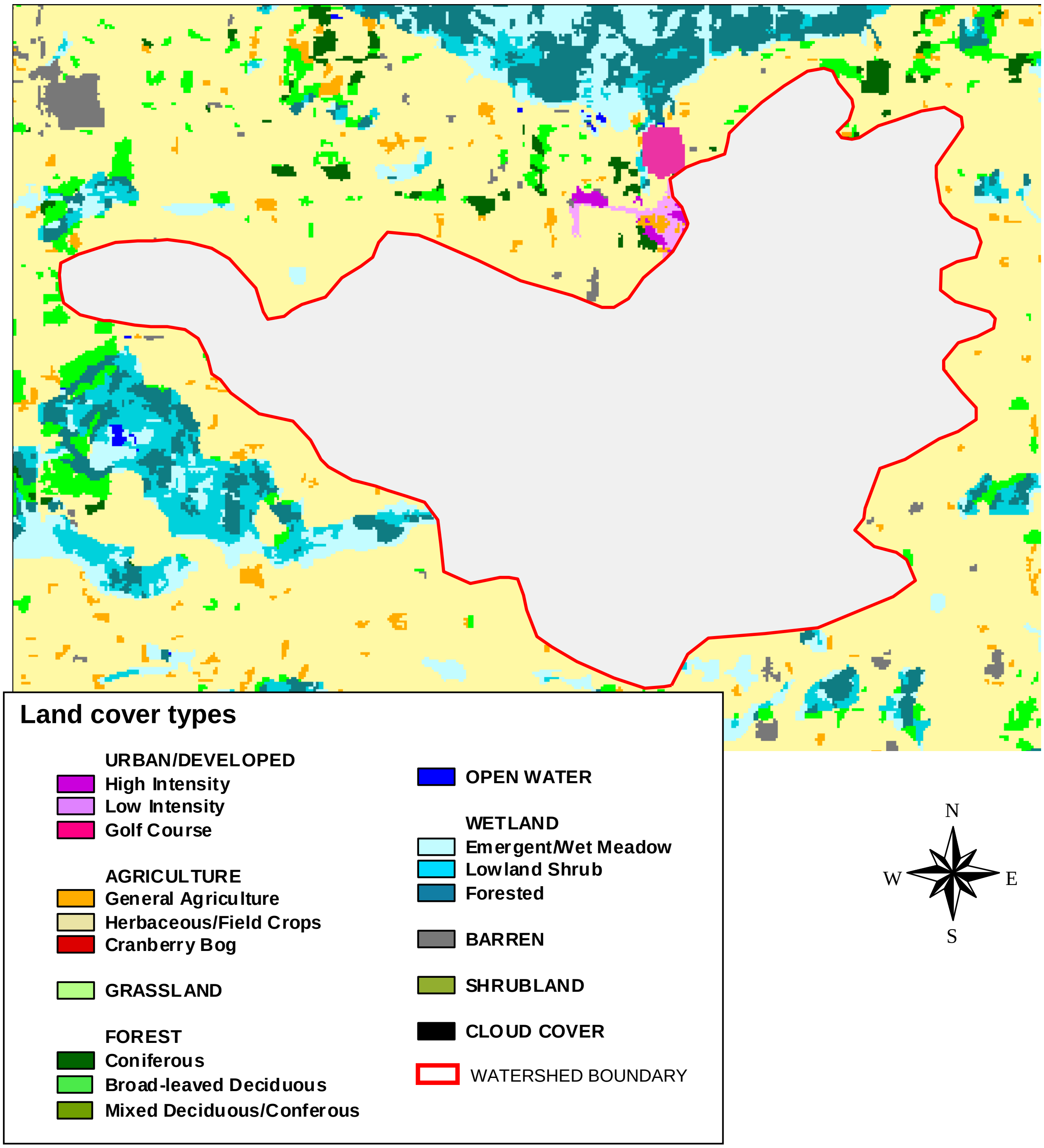


Table 12. Land-use and cover types found within the watershed of Black Otter Lake, Outagamie County, Wisconsin.

Land Type	% cover
Agriculture (row crops)	71.5
Wetland (forested/wet meadow)	16.6
Forest (coniferous/deciduous)	6.9
Agriculture (general)	3.5
Urban	1.0
Barren	0.5

During the on-site survey of the District's watershed much of the digital land-use data was confirmed. In addition, a number of observations were made:

- Some areas of Hortonville, primarily to the north, drain into Black Otter Lake. Much of Hortonville drains to the river below Black Otter Lake dam.
- The portion of Hortonville within Black Otter Lake's watershed located south of the train tracks drains through a culvert (sample site #8) and into a ditch that runs along the Wiowash Trail until it reaches Black Otter Creek south of the trail. Much of this ditch is dry throughout the year. Only during high rain events would water reach the lake. Otherwise, most of the water from this area seeps into the ground.
- Although much of the watershed is agriculture (row crops, hay fields, pasture land), a significant portion of the waterways leading to Black Otter Lake have natural vegetative buffer strips; some wooded, some more marshy.
- Four locations were highlighted to illustrate both the positive and negative activities taking place within the watershed.

Surface Water Data Viewer

The following information was gathered from the Wisconsin DNR's online Surface Water Data Viewer, regarding the classification of Black Otter Lake and its tributaries:

- Black Otter Lake and its two main tributaries are listed as waterbodies receiving non-point source (NPS) pollution. According to the Data Viewer, these waterbodies have not yet been "ranked" under this category.
- Not listed as "Impaired Waters". Under section 303(d) of the Clean Water Act, "impaired waters" are those that are too polluted or otherwise degraded to meet the water quality standards set by the State.
- Not listed as an Outstanding or Exceptional Resource Water (ORW, ERW), Priority Navigable Waterway (PNW), Areas of Special Natural Resource Interest (ASNRI).
- No listing for Wild Rice or Critical Habitat Areas within the Black Otter Lake watershed.

Watershed Soils

Data available from the Natural Resources Conservation Service (NRCS) was used to determine the soil types within the Black Otter Lake watershed (**Table 13**). These data include the percent watershed area for, and the characteristics of each soil type including slope, drainage and suitability for farmland. This information has been used to assess whether certain areas, which may or may not be in agriculture, have soils conducive to such practices. Much of the watershed soils have been classified as 'well drained' and considered prime farmland or "farmland of State-wide importance". Some areas, due to the slope of the land or lack of sufficient drainage are not deemed appropriate farmland.

Table 13. Soil types within the watershed of Black Otter Lake, Outagamie County, WI.

Soil type	Percent of Watershed	Description
Hortonville silt loam, 2 to 6 percent slopes	29.34%	Ground moraines, well drained. Prime farmland.
Hortonville silt loam, 6 to 12 percent slopes, eroded	14.79%	Moraines, well drained. Farmland of statewide importance.
Symco silt loam, 1 to 3 percent slopes	9.15%	Drainageways on ground moraines, depressions on ground moraines, somewhat poorly drained. Prime farmland if drained.
Carbondale muck	6.80%	Depressions on ground moraines, depressions on lake plains, very poorly drained. Not prime farmland
Hortonville fine sandy loam, 2 to 6 percent slopes	4.95%	Ground moraines, well drained. Prime farmland.
Pella silt loam	4.50%	Depressions on ground moraines, drainageways on ground moraines, Poorly drained. Prime farmland if drained.
Menominee loamy fine sand, loamy substratum, 2 to 6 percent slopes	3.61%	Ground moraines, lake plains, well drained. Farmland of statewide importance.
Cathro muck	3.19%	Depressions on lake plains, very poorly drained. Farmland of statewide importance.
Shawano fine sand, rolling	2.34%	Dunes on outwash plains, Excessively drained. Not prime farmland.
Kolberg silt loam, 1 to 6 percent slopes	2.17%	Ground moraines, well drained. Prime farmland.
Markey muck	1.76%	Depressions on outwash plains, very poorly drained. Not prime farmland.
Wainola loamy fine sand, 0 to 3 percent slopes	1.51%	Outwash plains, lake plains, somewhat poorly drained. Farmland of statewide importance.
Manistee loamy fine sand, 2 to 6 percent slopes	1.38%	Lake plains, ground moraines, well drained. Farmland of statewide importance.
Poy silty clay loam	1.28%	Depressions on outwash plains, depressions on lake plains, drainageways on lake plains, drainageways on outwash plains, Poorly drained. Prime farmland if drained.

Table 13. Soil types within the watershed of Black Otter Lake, Outagamie County, WI.

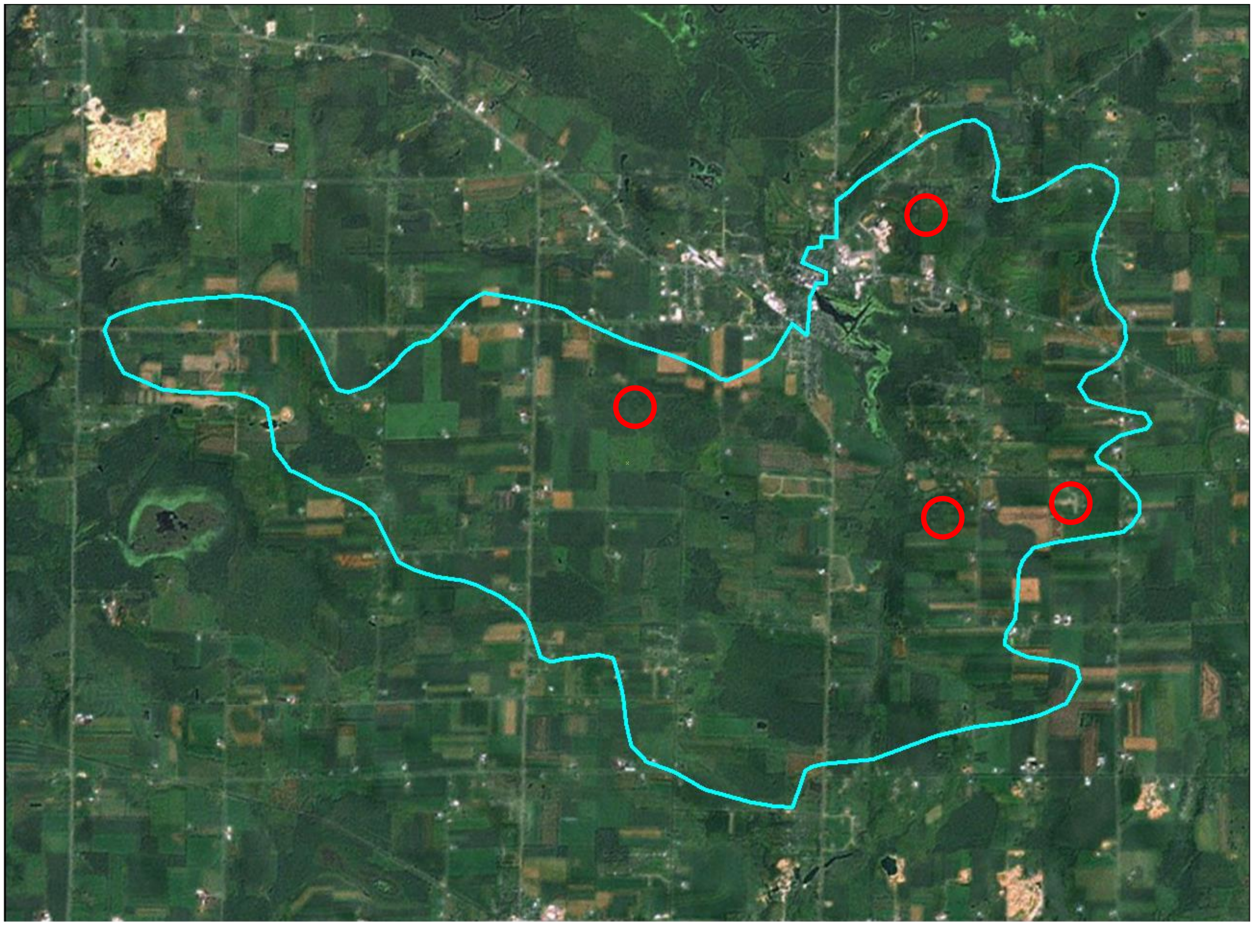
Soil type	Percent of Watershed	Description
Hortonville silt loam, 12 to 20 percent slopes, eroded	1.27%	Moraines, well drained. Not prime farmland.
Rousseau loamy fine sand, 2 to 6 percent slopes	1.06%	Lake plains, outwash plains, well drained. Not prime farmland.
Water	1.02%	--
Fluvaquents	0.93%	Flood plains, drainageways, poorly drained. Not prime farmland.
Deford loamy fine sand	0.86%	Depressions on lake plains, depressions on outwash plains, drainageways on lake plains, drainageways on outwash plains, poorly drained. Not prime farmland.
Allendale loamy fine sand, 0 to 3 percent slopes	0.77%	Flats on ground moraines, flats on lake plains, drainageways on ground moraines, drainageways on lake plains, somewhat poorly drained. Farmland of statewide importance.
Keowns silt loam	0.64%	Depressions on lake plains, poorly drained. Prime farmland if drained.
Manistee loamy fine sand, 6 to 12 percent slopes, eroded	0.60%	Ground moraines, lake plains , well drained. Farmland of statewide importance.
Manawa silty clay loam, 1 to 3 percent slopes	0.60%	Drainageways on lake plains, drainageways on ground moraines, depressions on lake plains, depressions on ground moraines, Somewhat poorly drained. Prime farmland if drained.
Kolberg silt loam, 6 to 12 percent slopes, eroded	0.57%	Ground moraines, well drained. Farmland of statewide importance.
Casco loam, 2 to 6 percent slopes	0.49%	Outwash plains, well drained. Farmland of statewide importance.
Menominee loamy fine sand, loamy substratum, 6 to 12 percent slopes, eroded	0.44%	Ground moraines, lake plains, well drained. Not prime farmland.
Shawano fine sand, hilly	0.39%	Dunes on outwash plains, Excessively drained. Not prime farmland.
Casco loam, 6 to 12 percent slopes, eroded	0.36%	Eskers on outwash plains, kames on outwash plains, well drained. Not prime farmland.
Hortonville silt loam, limestone substratum, 2 to 6 percent slopes	0.35%	Ground moraines, well drained. Prime farmland.
Casco loam, 12 to 20 percent slopes, eroded	0.34%	Eskers on outwash plains, kames on outwash plains, well drained. Not prime farmland.
Shiocton silt loam, 0 to 3 percent slopes	0.33%	Lake plains, somewhat well drained. Prime farmland if drained.
Poygan silty clay loam	0.33%	Depressions on outwash plains, depressions on lake plains, drainageways on lake plains, drainageways on outwash plains, Poorly drained. Prime farmland if drained.

Table 13. Soil types within the watershed of Black Otter Lake, Outagamie County, WI.

Soil type	Percent of Watershed	Description
Udorthents	0.27%	Somewhat excessively drained. Not prime farmland.
Suamico muck	0.18%	Lake plains, depressions on ground moraines, very poorly drained. Farmland of statewide importance.
Manistee fine sandy loam, 2 to 6 percent slopes	0.16%	Ground moraines, lake plains, well drained. Farmland of statewide importance.
Nichols very fine sandy loam, clayey substratum, 2 to 6 percent slopes	0.15%	Lake plains, moderately well drained. Prime farmland.
Hortonville silt loam, 20 to 30 percent slopes	0.13%	Moraines, well drained. Not prime farmland.
Symco variant, 0 to 3 percent slopes	0.13%	Depressions on outwash plains, somewhat poorly drained. Prime farmland if drained.
Bonduel silt loam, 0 to 3 percent slopes	0.13%	Ground moraines, somewhat poorly drained. Prime farmland if drained.
Sand pit	0.11%	Sandy and gravelly outwash. Not prime farmland.
Landfill	0.06%	Not prime farmland.
Grays silt loam, 2 to 6 percent slopes	0.06%	Lake plains, moderately well drained. All areas are prime farmland
Winneconne silty clay loam, 0 to 2 percent slopes	0.05%	Lake plains, well drained. Prime farmland.
Gravel pits	0.03%	Not prime farmland.
Udifluvents	0.03%	Flood plains, moderately well drained. Not prime farmland
Shiocton silt loam, clayey substratum, 0 to 3 percent slopes	0.03%	Lake plains, somewhat well drained. Prime farmland if drained.
Winneconne silty clay loam, 2 to 6 percent slopes	0.02%	Lake plains, well drained. Prime farmland.

Nearshore assessment on Black Otter Lake did not identify any areas of significant concern. Much of the eastern and northern shores are undeveloped or nearly so. The more residential areas of the shoreline do not appear to be eroding significantly. Although some areas have mowed lawns up to the water's edge, others have more natural vegetative strips and/or riprap. Although a number of culverts drain into the lake, their contributions have previously been addressed.

Figure 12. Noteworthy locations within the Black Otter Lake watershed, Outagamie County, WI.



N2024 Greendale Road

Many farms in the State have livestock fenced within areas where the animals have direct access to surface water such as the intermittent stream located at N2024 Greendale Road. There is a clear advantage for the livestock to have a constant source of water available. Unfortunately, in areas such as this, sediments and manure are able to freely move into tributaries and ultimately into Black Otter Lake. These sediments and manure contain high levels of nutrients which then contribute to declines in the water quality of Black Otter Lake.

Figure 13. Location of direct runoff from livestock located at N2024 Greendale Road, Hortonville, WI.

W9104 Spring Road

Similar to the Greendale Road farm, the farm at W9104 Spring Road has the potential of contributing significant nutrient loads to Black Otter Lake. On this property, the livestock area noticeably slopes to the south and west where a tributary stream of Black Otter Lake flows to the north then northwest. Unlike the Greendale Road farm, the livestock do not have direct access to the water. However, the fenced area is approximately 65 feet from the water's edge. It is likely during rain events and the spring snow melt, more sediments, manure and nutrients flow overland into this stream.

Figure 14. Location of direct runoff from livestock located at W9104 Spring Road, Hortonville, WI.

Figure 14 (continued). Location of direct runoff from livestock located at W9104 Spring Road, Hortonville, WI.

Schmidt's Auto Salvage, East Main Street, Hortonville

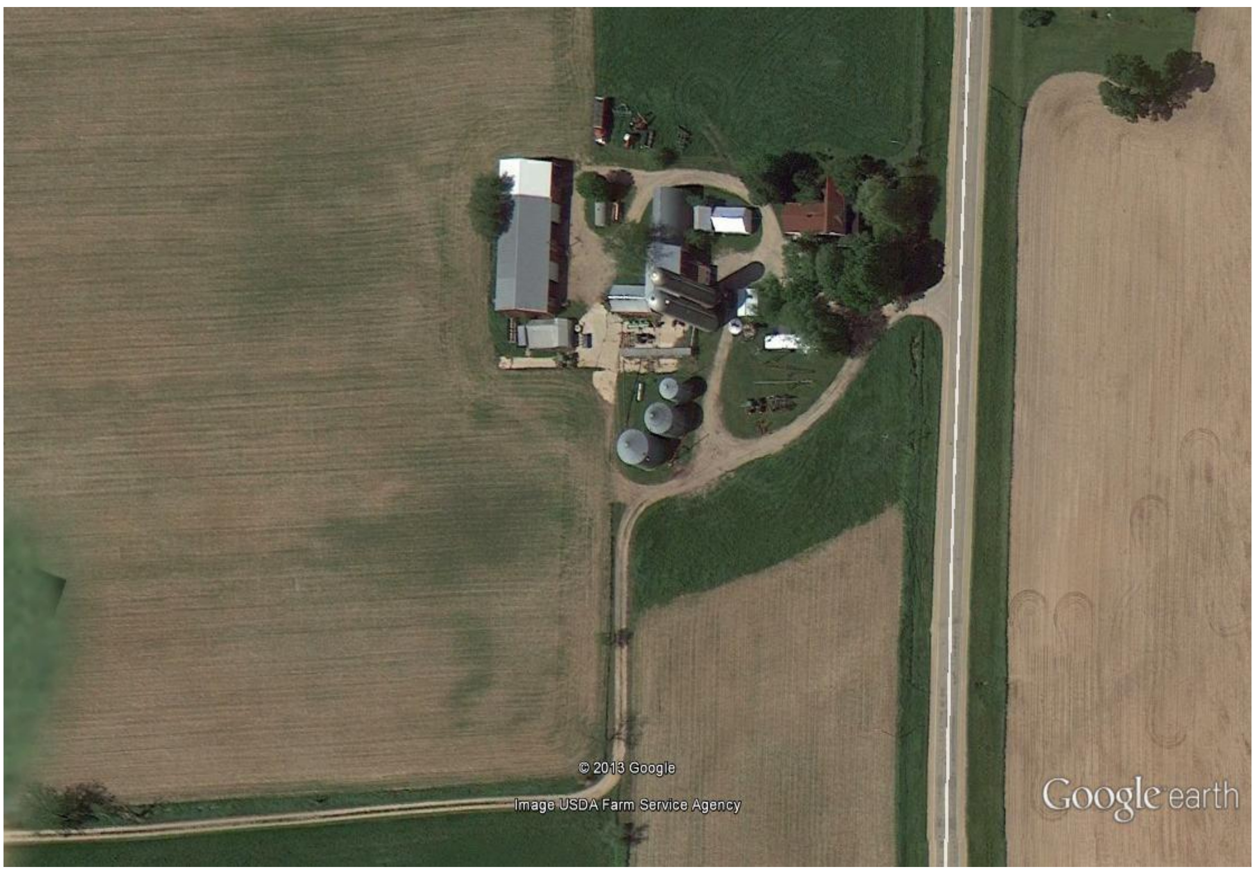
Members of the Lake District are concerned over the potential of runoff from Schmidt's Auto Salvage flowing into Black Otter Lake. If and when runoff from this location occurs it has the potential to carry more than nutrients and sediments, like in other runoff scenarios. It may also contribute measureable levels of automotive pollutants such as petroleum-based fuels, oils and other fluids. After conferring with the offices of Outagamie County, it was determined this does not fall within the jurisdiction of either the Zoning or Land Conservation Departments. Runoff concerns fall within the jurisdiction of the Wisconsin Department of Natural Resources (WDNR). If District members witness runoff actively leaving this site, it should be addressed to the WDNR.

Figure 15. Location of Schmidt's Auto Salvage on East Main Street, Hortonville, WI.

Preisler Farm, County Road T, Hortonville

In 2013, the Preisler Farm received a Targeted Runoff Management Grant from the Wisconsin DNR to address manure issues and mitigate farm runoff. It is a cost-sharing grant for the "installation of manure management systems in response to existing overflows of agricultural runoff containing nutrients, bacteria and other pathogenic organisms affecting Black Otter Creek and the Wolf River Watershed and to address violations of the NR 151 Agricultural Performance Standards and Prohibitions relating to: manure storage facilities-new/significant alterations, manure storage facilities-existing failing/leaking, process wastewater handling, clean water diversions, nutrient management, prevention of overflow from manure storage facilities, and prevention of direct runoff from a feedlot or stored manure into waters of the state. This grant was obtained with the assistance of the Outagamie County Land Conservation Department. It includes a State share of $149,900.

Figure 16. Preisler Farm County Road T, Hortonville, WI.



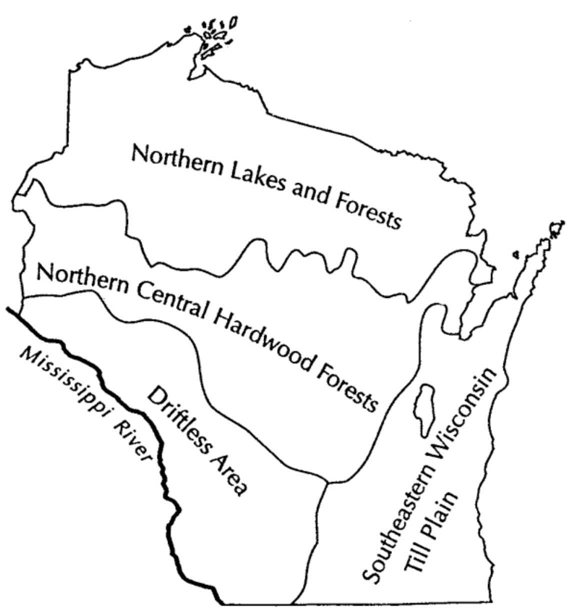
Aquatic Plant Communities

Although 284 points were originally mapped across Black Otter Lake, it was only possible to reach 223 locations at the time of the August 2013 survey. The remaining locations were not navigable due to shallow water and extremely dense growth of common waterweed (**Figure 18**). This was the same case during the August 2012 survey when 173 sites were navigable and the August 2011 survey when only 158 sites were navigable. Very little plant growth was found in areas deeper than 7.5 feet.

A total of 16 submergent, floating-leafed and emergent aquatic plant species were found during the 2012 survey (**Table 14**). This is above the state-wide average of 13 species. Black Otter Lake lies within the Northern Central Hardwood Forests region of Wisconsin[1] (**Figure 17**). The average number of species found in lakes in this region is 14 species. The percent frequency values listed in **Table 14** reflect the relationship between the number of locations where a particular species was found versus the total number of locations sampled. Relative frequency values reflect the abundance of a particular species in relation to all other species found.

The most abundant plant species encountered in Black Otter Lake in 2013 were coontail (*Ceratophyllum demersum*), common waterweed (*Elodea canadensis*), filamentous algae, watermeal (*Wolffia columbiana*), sago pondweed (*Stuckenia pectinata*) and small duckweed (*Lemna minor*). **Figures 18 to 23** show the distribution of these species during the August 2013 survey. These species all contributed to the nuisance conditions on Black Otter Lake in 2012. These species were also commonly found in 2011 and 2012 when conditions in terms of navigation and aesthetics were similar. In particular, the level of common waterweed in the lake in 2011 and 2012 has been very concerning to the District and lake users. In 2013, it appears the levels of coontail were more of an issue. Data show that these species have been on the increase annually since 2009. The lake was dominated by coontail prior to the 2008-2009 drawdown. In terms of native plant growth, it appears the lake has returned to pre-drawdown conditions.

Figure 17. Ecoregions of Wisconsin (after Omernick and Gallant, 1988)



Appendix B contains the plant survey data collected for Black Otter Lake in 2013.

Table 14. Results of the submergent aquatic plant survey conducted on Black Otter Lake on August 1, 2011, July 5, 2012 and August 21, 2013.

Species		2013		2012		2011	
Species common name	**scientific name**	**Percent Frequency**	**Relative Frequency**	**Percent Frequency**	**Relative Frequency**	**Percent Frequency**	**Relative Frequency**
Coontail	*Ceratophyllum demersum*	83.80	31.3	56.80	22.0	32.43	19.8
Common waterweed	*Elodea canadensis*	54.17	20.2	89.94	34.9	88.51	54.1
Filamentous algae	--	39.35	14.7	55.03	21.3	4.05	2.5
Watermeal	*Wolffia columbiana*	30.56	11.4	23.67	9.2	4.73	2.9
Sago pondweed	*Stuckenia pectinata*	25.93	9.7	2.37	0.9	21.62	13.2
Small duckweed	*Lemna minor*	23.61	8.8	24.85	9.6	3.38	2.1
Common bladderwort	*Utricularia vulgaris*	5.56	2.1	1.78	0.7	0.68	0.4
Water stargrass	*Heteranthera dubia*	2.31	0.9	visual	--	2.03	1.2
Muskgrass	*Chara* sp.	1.85	0.7	--	--	--	--
Curly-leaf pondweed	*Potamogeton crispus*	0.46	0.2	0.59	0.2	2.03	1.2
Bushy pondweed	*Najas flexilis*	0.46	0.2	--	--	1.35	0.8
Eurasian watermilfoil	*Myriophyllum spicatum*	visual	--	--	--	--	--
Cattails	*Typha* sp.	visual	--	visual	--	visual	--
White water lily	*Nymphaea odorata*	visual	--	visual	--	visual	--
Softstem bulrush	*Schoenoplectus tabernaemontani*	visual	--	visual	--	visual	--
Spatterdock	*Nuphar variegata*	visual	--	visual	--	visual	--
Stiff water crowfoot	*Ranunculus aquatilis*	--	--	visual	--		
Stonewort	*Nitella* sp.	--	--	1.78	0.7	0.68	0.4
Small pondweed	*Potamogeton pusillus*	--	--	0.59	0.2	2.03	1.2
Northern watermilfoil	*Myriophyllum sibiricum*	--	--	0.59	0.2	--	--
Floating-leaf pondweed	*Potamogeton natans*	--	--	--	--	--	--
Water smartweed	*Polygonum amphibium*	--	--	--	--	--	--
Common arrowhead	*Sagittaria latifolia*	--	--	--	--	--	--
Forked duckweed	*Lemna trisulca*	--	--	--	--	--	--
Grass-leaved arrowhead	*Sagittaria graminea*	--	--	--	--	--	--

Simpson Diversity Index	0.81	0.77	0.65
Coefficient of Conservatism	5.2	5.1	4.9
Floristic Quality Index	17.2	19.9	18.4
(WI ave. 22.2, Region ave. 20.9)			

Table 14 (continued). Results of the submergent aquatic plant survey conducted on Black Otter Lake on July 18, 2008, July 31, 2009 and August 17, 2010.

		2010		2009		2008	
Species common name	**scientific name**	**Percent Frequency**	**Relative Frequency**	**Percent Frequency**	**Relative Frequency**	**Percent Frequency**	**Relative Frequency**
Coontail	*Ceratophyllum demersum*	58.17	28.9	47.64	15.3	95.20	36.6
Common waterweed	*Elodea canadensis*	44.22	21.9	19.74	6.3	0.90	0.3
Filamentous algae	--	17.93	8.9	14.59	4.7	49.60	19.1
Watermeal	*Wolffia columbiana*	--	--	--	--	38.30	14.7
Sago pondweed	*Stuckenia pectinata*	3.59	1.8	39.91	12.8	10.00	3.8
Small duckweed	*Lemna minor*	27.89	13.8	3.43	1.1	32.20	12.4
Common bladderwort	*Utricularia vulgaris*	--	--	--	--	--	--
Water stargrass	*Heteranthera dubia*	23.11	11.5	9.01	2.9	2.60	1.0
Muskgrass	*Chara* sp.	16.73	8.3	11.59	3.7	0.90	0.3
Curly-leaf pondweed	*Potamogeton crispus*	1.59	0.8	69.53	22.3	6.50	2.5
Bushy pondweed	*Najas flexilis*	1.20	0.6	25.32	8.1	1.30	0.5
Eurasian watermilfoil	*Myriophyllum spicatum*	visual	--	5.15	1.7	16.50	6.4
Cattails	*Typha* sp.	1.59	0.8	7.73	2.5	--	--
White water lily	*Nymphaea odorata*	visual	--	5.15	1.7	visual	--
Softstem bulrush	*Schoenoplectus tabernaemontani*	0.80	0.4	0.43	0.1	--	--
Spatterdock	*Nuphar variegata*	0.40	0.2	visual	--	visual	--
Stiff water crowfoot	*Ranunculus aquatilis*						
Stonewort	*Nitella* sp.	0.40	0.2	--	--	--	--
Small pondweed	*Potamogeton pusillus*	0.40	0.2	36.48	11.7	--	--
Northern watermilfoil	*Myriophyllum sibiricum*	--	--	8.58	2.8	0.90	0.3
Floating-leaf pondweed	*Potamogeton natans*	2.79	1.4	4.29	1.4	5.20	2.0
Water smartweed	*Polygonum amphibium*	--	--	1.72	0.6	--	--
Common arrowhead	*Sagittaria latifolia*	visual	--	0.86	0.3	--	--
Forked duckweed	*Lemna trisulca*	--	--	0.43	0.1	--	--
Grass-leaved arrowhead	*Sagittaria graminea*	visual	--	--	--	--	--
	Simpson Diversity Index	0.82		0.88		0.79	
	Coefficient of Conservatism	5.0		4.9		5.2	
	Floristic Quality Index	19.4		20.1		17.9	
	(WI ave. 22.2, Region ave. 20.9)						

Figure 18. Locations of coontail (*Ceratophyllum demersum*) identified on August 21 and 22, 2013 on Black Otter Lake, Outagamie County, WI.

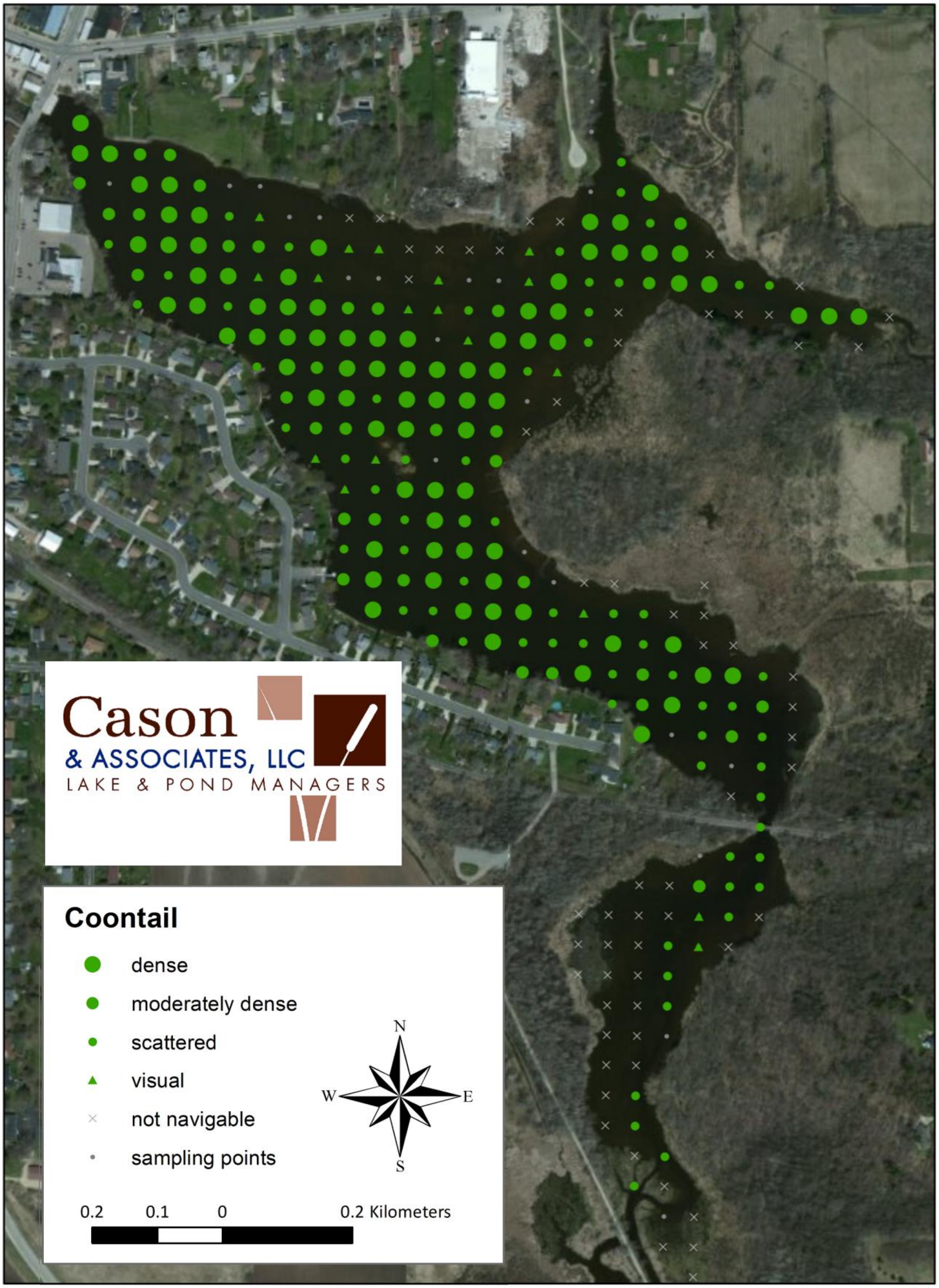


Figure 19. Locations of common waterweed (*Elodea canadensis*) identified on August 21 and 22, 2013 on Black Otter Lake, Outagamie County, WI.

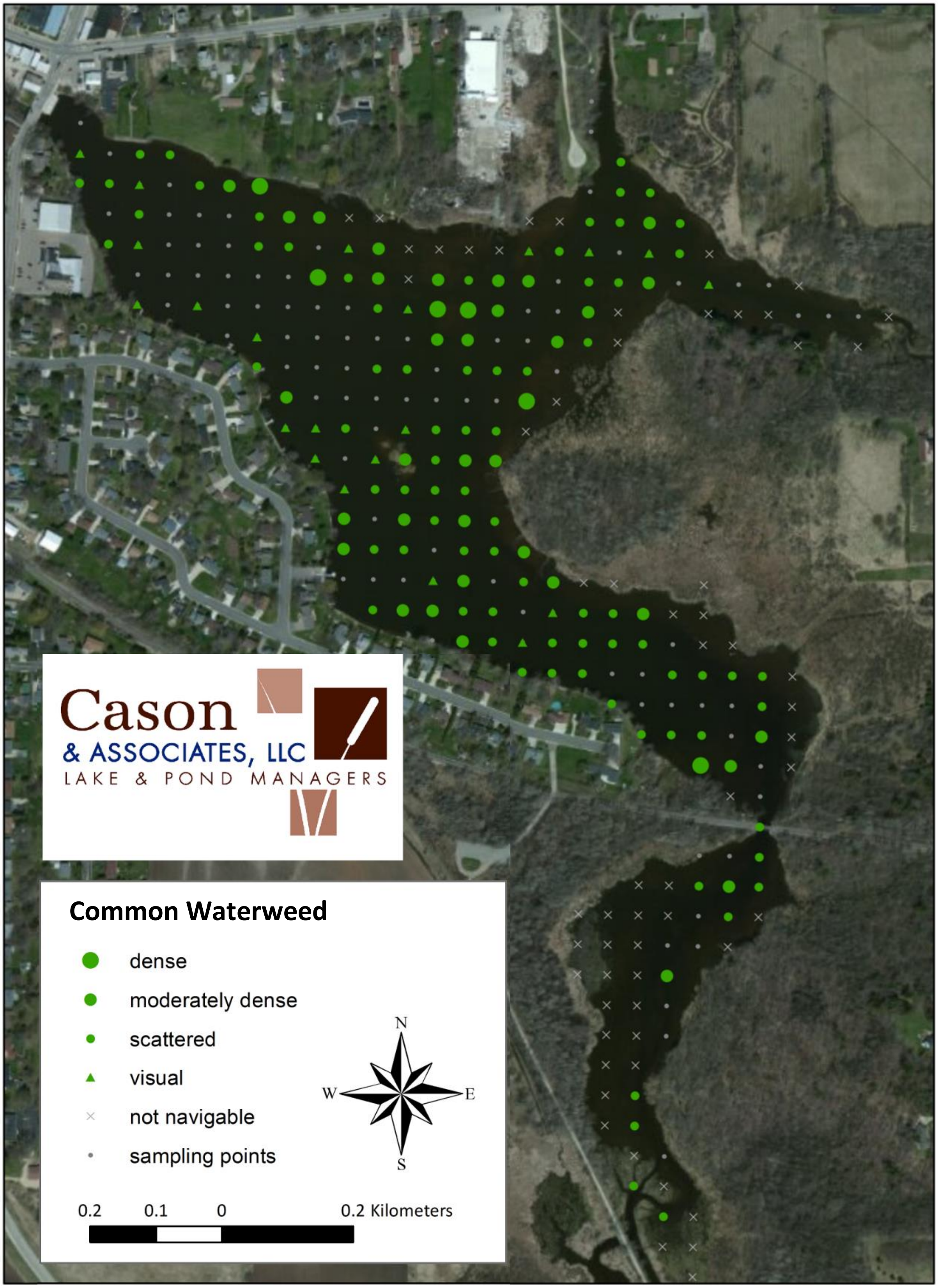


Figure 20. Locations of filamentous algae identified on August 21 and 22, 2013 on Black Otter Lake, Outagamie County, WI.

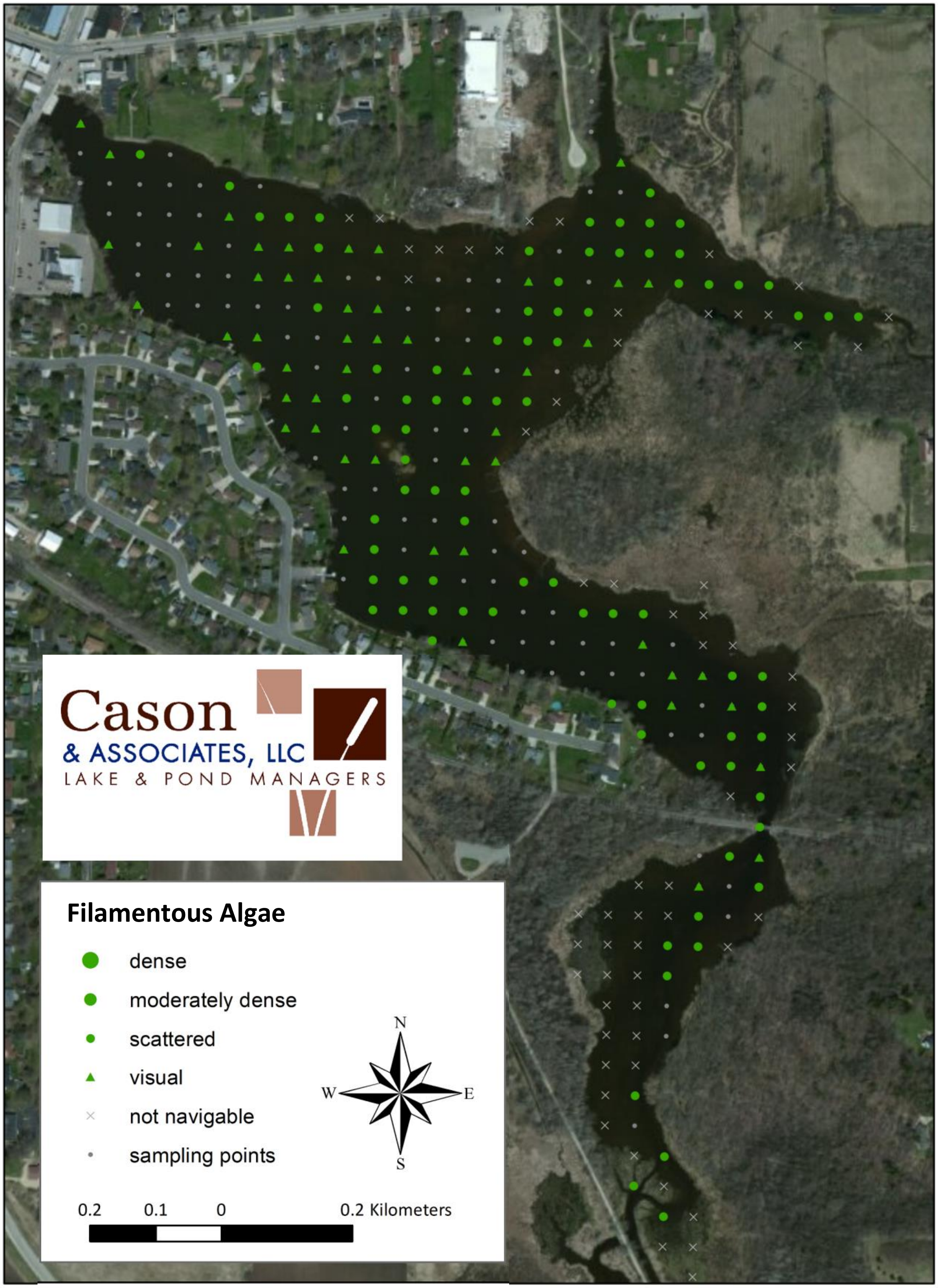


Figure 21. Locations of watermeal (*Wolffia columbiana*) identified on August 21 and 22, 2013 on Black Otter Lake, Outagamie County, WI.

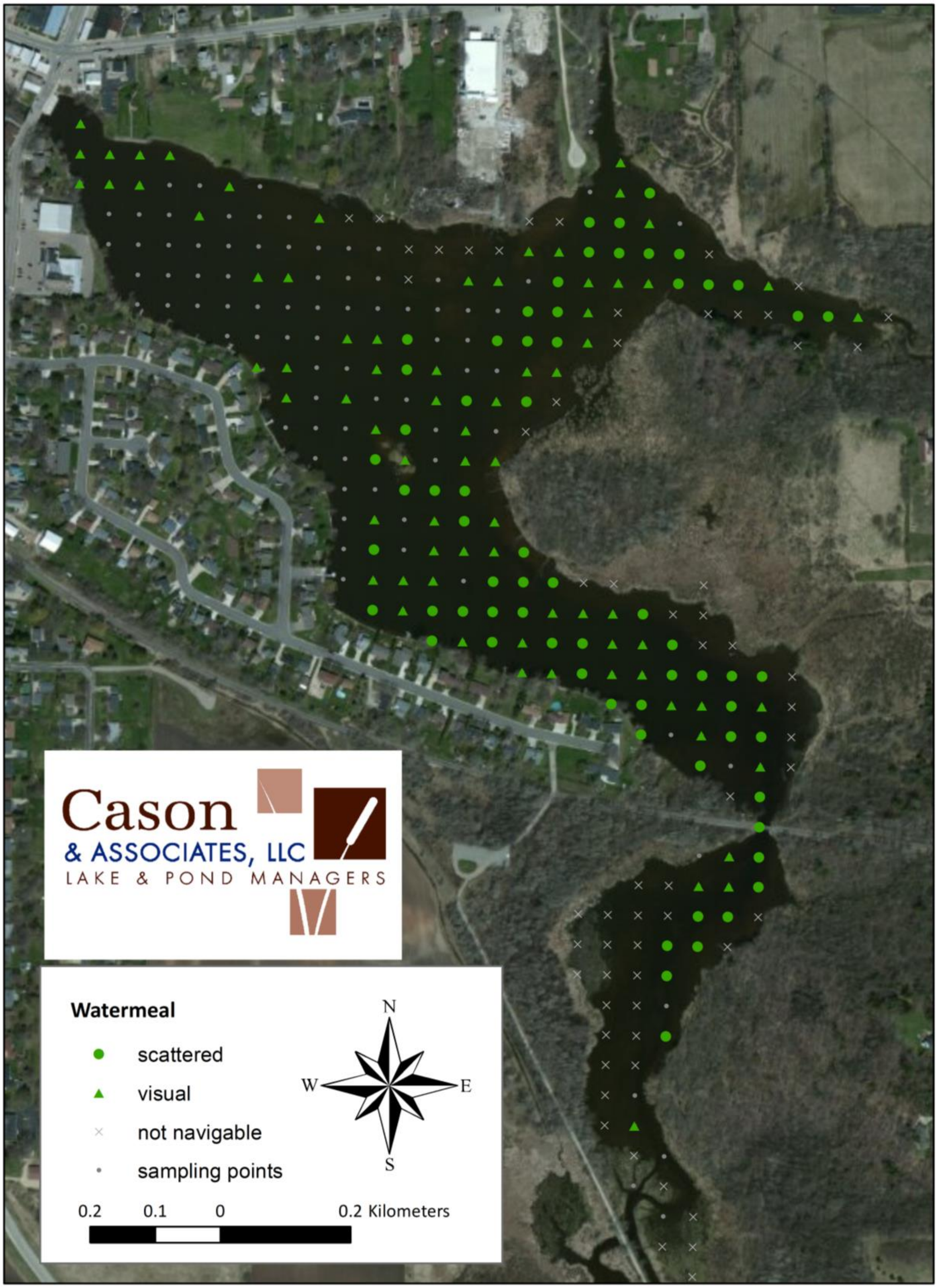


Figure 22. Locations of sago pondweed (*Stuckenia pectinata*) identified on August 21 and 22, 2013 on Black Otter Lake, Outagamie County, WI.

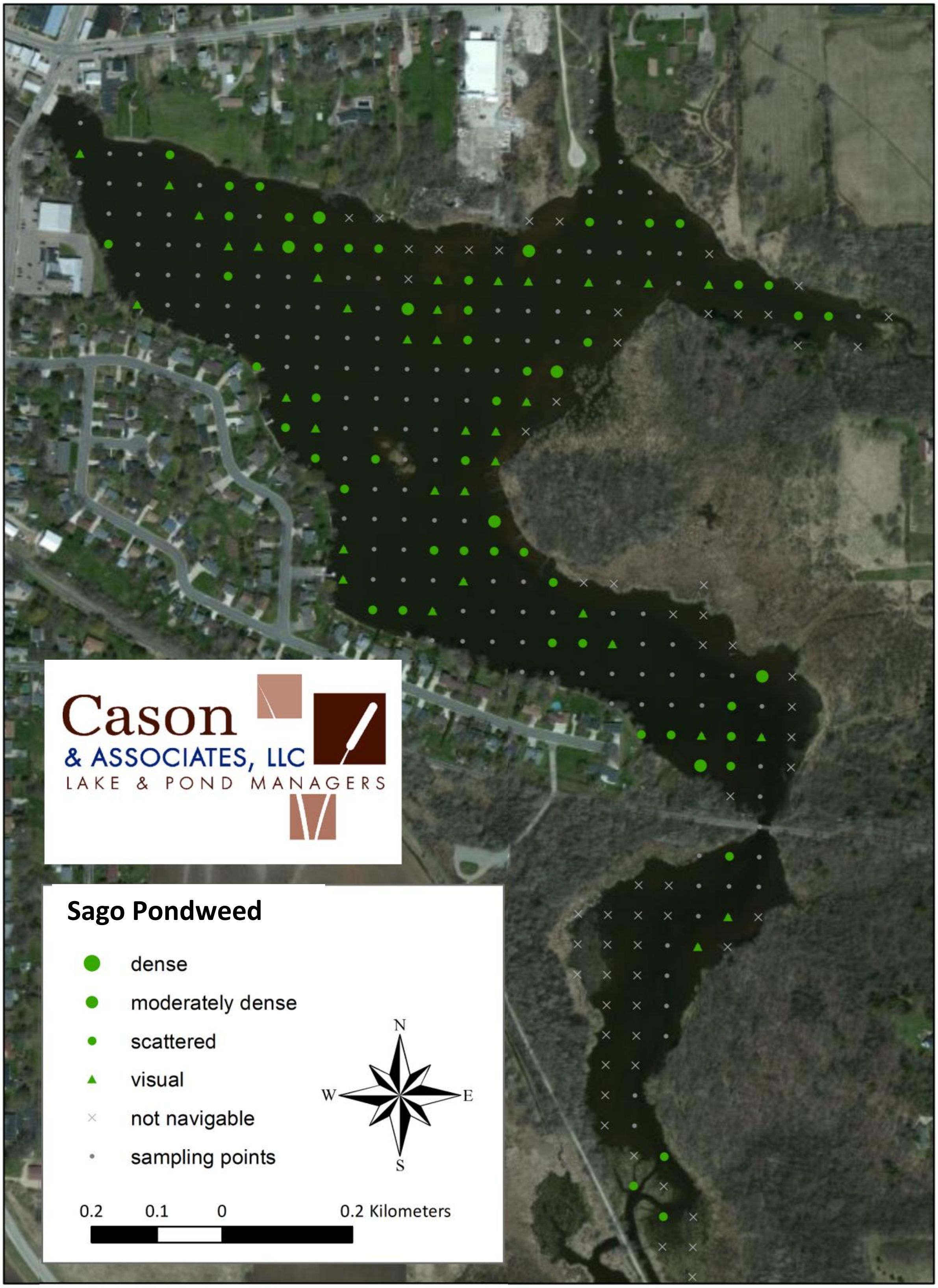
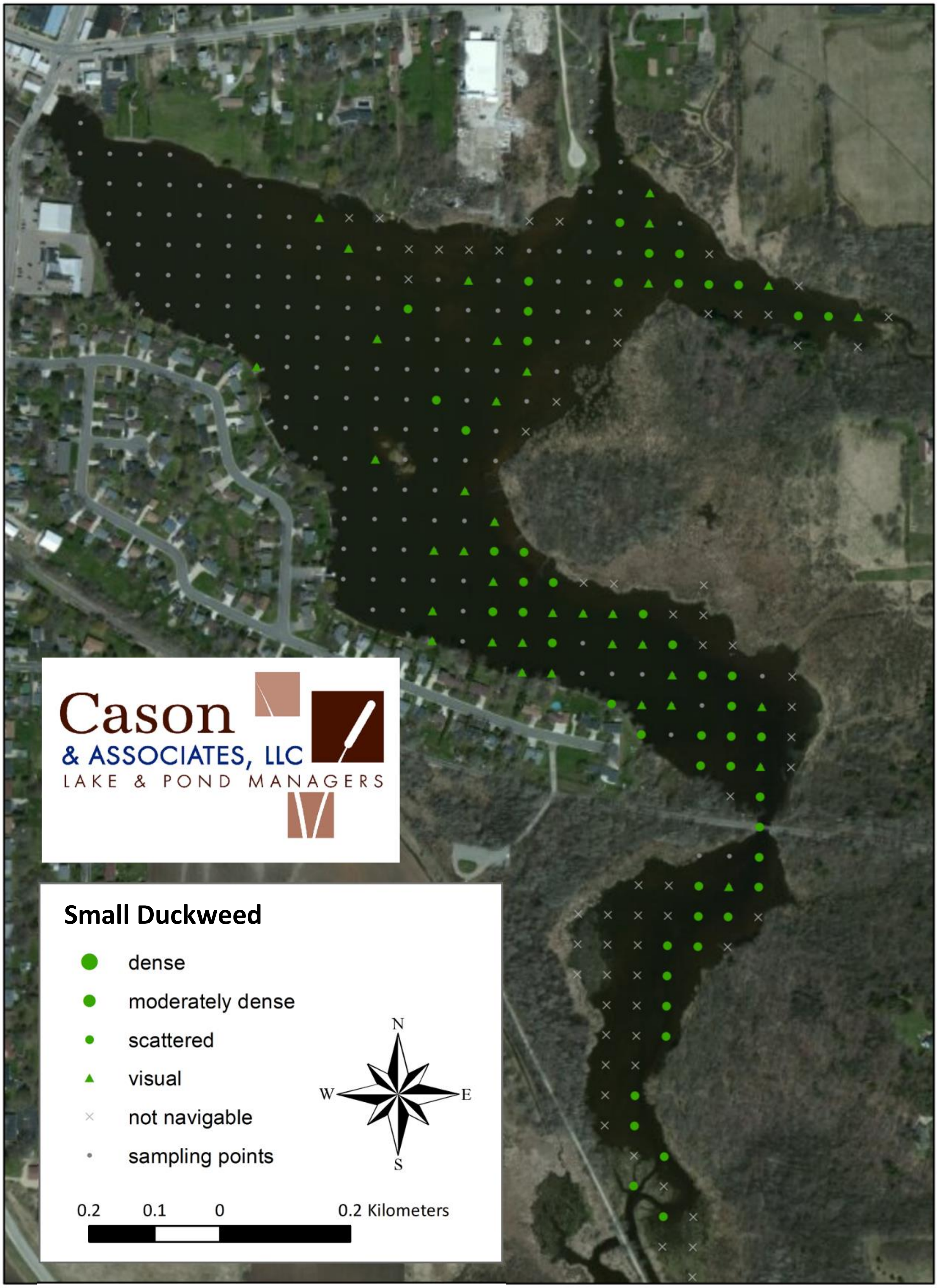


Figure 23. Locations of small duckweed (*Lemna minor*) identified on August 21 and 22, 2013 on Black Otter Lake, Outagamie County, WI.



Simpson Diversity Index
The plant data collected from Black Otter Lake were used to calculate the Simpson Diversity Index. In order to estimate the diversity of the aquatic plant community, this index takes in account both the number of species identified (richness) and the distribution or relative abundance of each species. As these parameters increase, so does the overall diversity. With the Simpson Diversity Index (D), 1 represents infinite diversity and 0, no diversity. That is, the bigger the value of D, the higher the diversity. The value of D calculated for Black Otter Lake based on the 2013 data was 0.81. Data from 2012 resulted in a D value of 0.77. In 2011 the value was 0.65, in 2010 it was 0.82 and in 2009 it was 0.88. Although State-wide or regional averages for D are not available, data from lakes surveyed in neighboring counties have yielded values of 0.75 or greater. Many lakes have values above 0.85.

Assessment of Floristic Quality
The plant data collected for Black Otter Lake were used to assess the *floristic quality* of the lake. This method assigns a value to each native plant species called a *Coefficient of Conservatism*. Coefficient values range from 0-10 and reflect a particular species' likelihood of occurring in a relatively undisturbed landscape. Species with low coefficient values, such as sago pondweed, are likely to be found in a variety of habitat types and can tolerate high levels of human disturbance. On the other hand, species with higher coefficient values, such as water stargrass, are much more likely to be restricted to high quality natural areas. By averaging the coefficient values available for the submergent and emergent species found in Black Otter Lake, a lake-wide value of 5.2 was calculated from the 2013 data. In 2012 this value was 5.1. In 2011 this value was 4.9, in 2010, it was 5.0 and in 2009 it was 4.9. Prior to the drawdown, this value was 5.2. The average value for lakes in Wisconsin is 6.0 while the average in the Northern Central Hardwood Forests region of Wisconsin, which includes Outagamie County, is 5.6 (1).

By utilizing the *Coefficients of Conservatism* for the plant species of Black Otter Lake, further assessment of floristic quality can be made. Combining coefficient values with the number of plant species found, a *Floristic Quality Index* (FQI) can be calculated. This value based on the 2013 data is 17.2. In 2012, the value was calculated to be 19.9. In 2011 this value was 18.4, in 2010 it was 19.4 and in 2009 it was 20.1. Prior to the drawdown, in 2008 this value was 17.2. In general, higher FQI values reflect higher lake quality. The average for Wisconsin lakes is 22.2. The average for lakes in the Northern Central Hardwood Forests region is 20.9 (1).

The *Simpson Diversity Index*, the *Coefficient of Conservatism* and the *Floristic Quality Index* values suggest the quality of Black Otter Lake, specifically in terms of the plant community, is below average. This is not surprising for an artificial waterbody such as Black Otter Lake. However, the values for these calculations are now at or below the pre-drawdown levels. The data suggest conditions in the lake improved initially following the drawdown, but have declined since. Progress toward reaching lake management goals of improving the quality of the native plant community is no longer being achieved.

Exotic Species Surveys

Eurasian watermilfoil and curly-leaf pondweed have been the main exotic species of concern in Black Otter Lake over the past ten years or so. On May 8, 2013 a focused-point intercept survey was conducted on Black Otter Lake by Cason Associates staff. Results of this survey (**Figure 24**) show continued wide-spread curly-leaf pondweed in the lake. This is not surprising. Following the 2008-2009 drawdown, curly-leaf pondweed was found throughout the lake. By the time the lake had refilled, and this discovery had been made, it was too late in the season to treat. Curly-leaf pondweed produces vegetative reproductive structures called turions. These turions develop on the plants mid-summer and fall to the lake sediments when the plants die back before the fall. Turions then resprout in the spring resulting in a new crop of plants each year. Turions can remain viable for five or more years and are resistant to chemical treatments. As a result, repeated spring treatments are needed until the supply if viable turions is depleted.

Data from the October 24, 2013 mapping survey were used to develop a distribution map of Eurasian watermilfoil. A few locations of Eurasian watermilfoil were noted in the northeast section of the lake during the summer full point-intercept survey. Due to abundant plant and algae growth, it was difficult to effectively navigate and quantify the abundance of milfoil at that time. Since a fall survey had been planned, it was decided that waiting to properly map milfoil was warranted. In total, approximately 6.5 acres of scattered Eurasian watermilfoil were found at the time of the survey (**Figure 25**).

Figure 24. Locations of curly-leaf pondweed found on May 8, 2013 on Black Otter Lake, Outagamie County, WI.

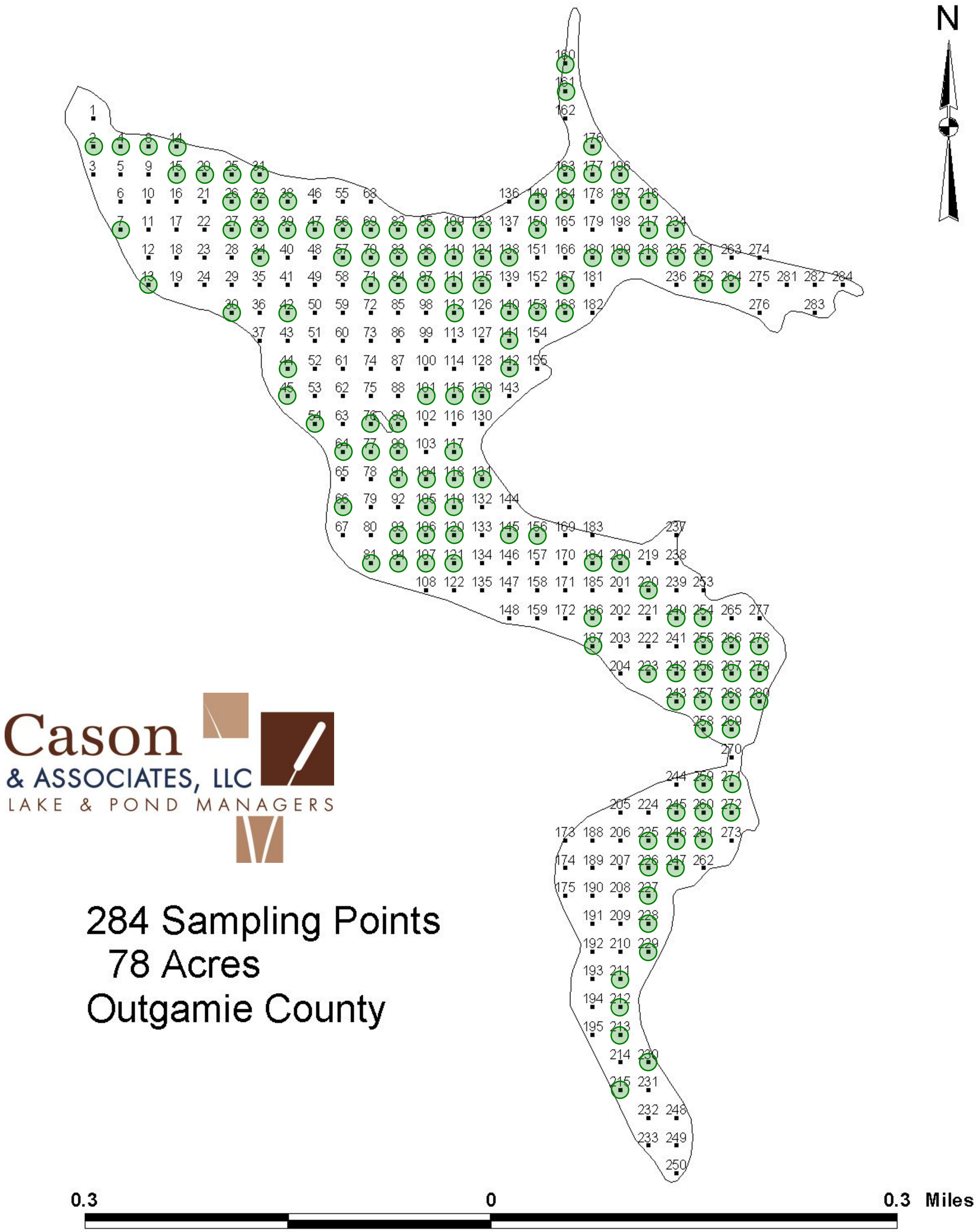
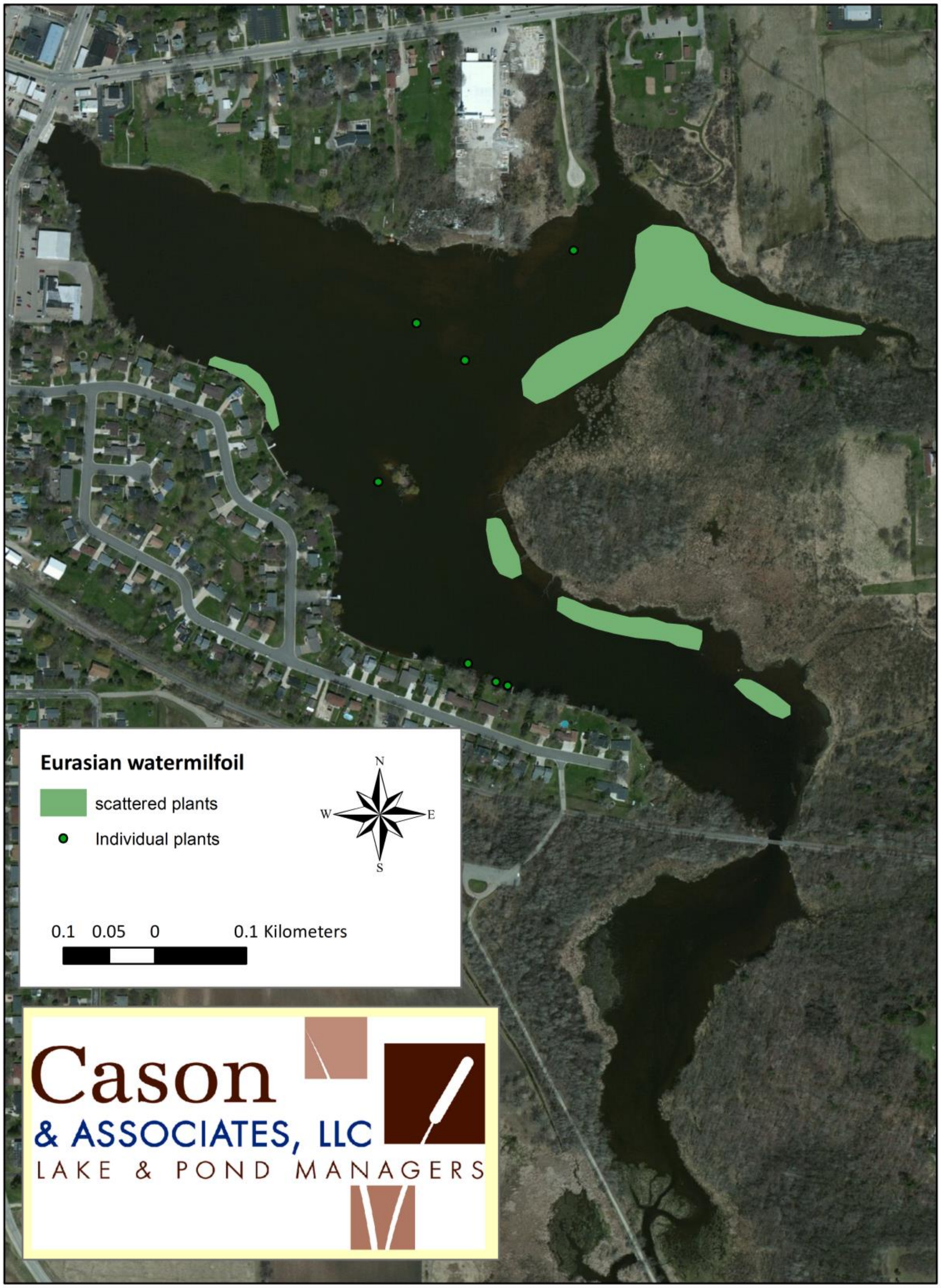


Figure 25. **Locations of Eurasian watermilfoil found on October 24, 2013 on Black Otter Lake, Outagamie County, WI.**



Conclusions and Recommendations

Black Otter Lake is a valuable resource in Outagamie County. As a shallow impounded lake in an area with significant agricultural and urban influences, abundant aquatic plant growth and impaired water quality are not surprising. The introduction of the aquatic invasive species, Eurasian watermilfoil and curly-leaf pondweed, complicate effective whole-lake management even further. The results of the current watershed study and the ongoing water quality and aquatic plant monitoring help to better understand the complex nature of this lake.

Water quality in recent years in Black Otter Lake has been lower than desired. Phosphorus, chlorophyll and Secchi depth data have indicated Black Otter Lake is a eutrophic lake. Data from additional water chemistry parameters also indicate non-point source pollution from within the watershed is affecting the conditions of the lake. Low summer dissolved oxygen levels are putting undue stress on the lake's biological communities, namely the fishery. Sedimentation into the lake causes nutrient pollution, turbid water conditions, eliminates fish spawning habitat, and increases eutrophication.

Nutrient loading in Black Otter Lake is largely from external sources, more specifically, from the agriculturally-dominated sections feeding the main tributary, Black Otter Creek. Contributions from the culverts draining portions of Hortonville are significantly smaller in comparison. The same is true for internal nutrient cycling. Early spring treatments of curly-leaf pondweed ensure minimal biomass die off and the associated nutrient release from decomposing plant matter. Nutrient release from the lakebed is also likely minimized due to the shallow nature of Black Otter Lake's sediments.

Following the 2008-2009 drawdown, plant diversity within the lake increased markedly. Since that time, as water levels have remained more static, the diversity of plants has declined. In many ways, the plant community has returned to pre-drawdown conditions. Although the aquatic invasive species are better under control, they are still at significant levels and the native plants are again dominated by a handful of nuisance species.

Nutrient Management

Elevated nutrient inputs from human activities around a lake can adversely affect both water clarity and water quality. A number of practices can be carried out to improve water quality.

The largest source of nutrients to Black Otter Lake is the large southern sub-watershed draining into Black Otter Creek. Wisconsin State Statute NR 115 provides that all navigable streams have a 35-foot buffer zone. It was noted that although many stream segments within the watershed have sufficient buffer zones, a number of areas are lacking. Some of these areas may be grandfathered in, but this is still a good standard to use. It is recommended the District start with the areas identified previously in this report. The District Board should consider assembling a committee of District members to work with landowners and the County to install or improve buffer strips. In many cases, leaving an area undisturbed will allow for vegetation to naturally fill in an area along a stream. When possible, livestock should also be kept out of these areas to avoid bank erosion and nutrient inputs from manure. Farmers should avoid planting crops too close to a stream. A more deliberate approach could be taken where native plant species are intentionally planted in a cleared area to encourage buffer strips free of invasive species. However, this would likely be a more expensive and labor-intensive approach.

Erosion is a natural process, but it's for the benefit of the landowner and health of the lake that erosion control practices be carried out to slow the process as much as possible. Known areas of erosion should be addressed immediately. There are a number of stabilization practices that can be used. Before any project is initiated, it is advised that property owners contact the local Wisconsin DNR office for project approval and to obtain any necessary permits.

Farmland should be managed in a way that specifically addresses a reduction in nutrient and sediment runoff. Reducing the phosphorus content in fertilizers should be a focus within the watershed. Manure management should also be a top priority. As was seen with the Priesler Farm, there is State grant money available to implement a large-scale manure management program. Regardless, manure should be stored in the winter and only applied to fields and incorporated into the soils when the ground is not frozen or waterlogged. Planting winter cover crops or allowing crop residuals to remain on the fields over the winter will help to reduce soil erosion in the spring.

Natural areas including wetlands within the watershed should be protected. These areas act as natural filters along the streams. When possible, drained wetlands should be restored or mitigated. Enrollment of unused or underused farmland into the Wetland Reserve Program (WRP) and/or Conservation Reserve Program (CRP) is another option. These are programs run by the Natural Resource Conservation Service (NRCS) as a means toward soil conservation, erosion control and habitat improvement. Farmers who are eligible can contact their local NRCS office to enroll.

Wherever feasible, changes to roads and bridges over tributaries should be made to redirect stormwater runoff to vegetated or retention areas where water can infiltrate into the ground rather than flow into the streams carrying along with it sediments and nutrients. A similar approach can be used in the Village of Hortonville along parking lots, driveways and streets. These types of projects can be rather significant in scope and require space or funding that is unavailable. However, if the capability exists, improvements of this type show be pursued for the benefit of the lake.

It is possible that excess nitrogen from farm fields can or has reached the groundwater. As a precautionary measure, private drinking water wells can be tested for nitrate levels. A list of certified testing labs in the State is available through the Wisconsin DNR.

This study has shown that in relative terms, fewer nutrients reach the lake through near-shore sources than from the larger watershed. However, there are activities individual property owners can undertake in an effort to improve water quality including proper lawn care, vegetative buffers and reducing run-off.

Mowed grass up to the water's edge is a poor choice for the well-being of a lake. Studies show that a mowed lawn can lead to high levels of phosphorus and sediment entering a waterbody (Korth and Dudiak, 2003). Lawn grasses also tend to have shallow root systems that cannot protect the shoreline as well as deeper-rooted native vegetation (Henderson et al., 1998). Property owners within the District should take care to keep leaves and grass clippings out of the lake whenever possible, as they contain nitrogen and phosphorus. The best disposal for organic matter, like leaves and grass clippings, is to compost them. Landowners should also refrain from the use of lawn fertilizers whenever possible. In most cases, soil phosphorus concentrations are adequate for maintaining a healthy lawn without the use of fertilizers. In in doubt, homeowners can have their soil tested to determine if phosphorus fertilizers are needed.

Like with the use of buffer strips along the tributary streams, buffer strips along individual property frontages is also recommended. If the natural shoreline has been disturbed or removed it would be ideal to restore it. A recommended buffer zone consists of native vegetation that may extend 25 feet or more from the water's edge. A buffer should cover between 50% and 75% of the shoreline frontage (Henderson et al., 1998). In most cases this still allows plenty of room for a dock, swimming area, and lawn. Buffer zones can be made up of a mixture of native trees, shrubs, and other upland and aquatic plants. Studies have also shown that providing complex habitats through shoreline features, such as plants and erosion control devices, can result in significant increases in fish diversity and numbers (Jennings et al., 1999). A number of resources are available to assist property owners in creating beneficial buffer zones. These include the Wisconsin DNR, local UW-Extension office, and the County Land and Water Conservation Department. These organizations can provide descriptions of beneficial native plant species and listings of aquatic nurseries in the State.

The placement of logs, brush mats, and rock riprap are also options against erosion. When riprap is used it is recommended that desirable shrubs and aquatic plants be planted within the riprap. The plantings serve as nutrient filters and habitat.

Property owners should also be encouraged to install rain gardens in their yards. A rain garden allows rainwater runoff from impervious areas, like roofs and driveways to soak into the ground rather than flow into storm drains and surface waters which can contribute to erosion and water pollution. Rain gardens should be planted with native plants that do not require fertilizer and are accustomed to local soil and water conditions.

Aquatic Plant Management Alternatives

Manual removal of vegetation

Manual removal options include raking or hand-pulling aquatic plants. In most instances, control of native aquatic plants is restricted to an area that is 30 feet or less in width along the shore. Aquatic invasive species may be removed beyond 30 feet without a permit, as long as native plants are not harmed. Manual removal of native plants beyond the 30 foot area would require a Chapter 109 (Wisconsin Administrative Code - NR 109) permit. Benefits of manual removal include low cost compared to other control methods. However, raking or hand-pulling aquatic plants can be labor intensive.

Herbicide treatment of navigation lanes

In areas where native plant growth interferes with navigation, a broad spectrum herbicide or mixture of herbicides can be used to target multiple plant species. Herbicide treatment of native plants may be a less desirable option when exotic species are a threat. Because the herbicides kill plants instead of merely cutting them, more opportunistic exotic plants may be better able to colonize the treated areas. With any herbicide treatment, the risk of dilution exists. If this approach is used, it is likely that annual treatments would be needed to maintain effective control. Any treatment of this type would require a Chapter 107 permit.

Aquatic plant harvesting

Mechanical harvesting involves the removal of aquatic plants from a lake using a machine that cuts and collects the plants for transport to an off-shore disposal site. Harvesting is often used for areas where dense, sometimes monotypic, aquatic plant growth significantly interferes with navigation. Harvesting produces fast results on a small scale, and the removal of plant biomass from a lake. However, this method is limited to water deep enough for navigation. In addition, harvesting is not generally used to restore aquatic plant communities. It is a maintenance approach used primarily for navigational issues. Harvesting can complicate the management of exotic species, particularly Eurasian watermilfoil which spreads efficiently through fragmentation. Harvesting also comes with high initial equipment costs, as well as relatively high maintenance, labor, and insurance costs, disposal site requirements, and a need for trained staff. A WDNR permit is required by NR 109 for aquatic plant harvesting.

The Black Otter Lake District recently purchased a mechanical harvester to manage nuisance levels of native aquatic plants during the summer months. In the spring of 2014, the District finalized a harvesting plan with assistance from the WDNR. This plan is found in **Appendix C**.

Herbicide treatment of invasive species

Herbicides have been the most widely used and often most successful tools for controlling Eurasian watermilfoil and curly-leaf pondweed. The most commonly employed herbicide used to treat Eurasian watermilfoil in Wisconsin is 2,4-D (e.g. Navigate®, DMA4®, Sculpin®). Herbicides containing 2,4-D have been effective at managing Eurasian watermilfoil in hundreds of Wisconsin lakes. When applied at labeled rates, 2,4-D has been shown to be an effective tool at selectively controlling Eurasian watermilfoil.

The herbicide most often used to control curly-leaf pondweed is endothall (e.g. Aquathol®). While endothall herbicides are effective on a broad range of aquatic monocots, early season applications made at low rates are able to select for curly-leaf pondweed. Endothall herbicides effectively kill the parent plant, but the turions are resistant to herbicides, allowing curly-leaf pondweed to regenerate annually.

Both endothall and 2,4-D are herbicides which break down microbially and do not persist in the environment. When applied at the labeled rates, herbicides are an effective management tool for control of many aquatic plant species. While no control method could be considered cheap, herbicide treatments are among the least costly of methods. This is in part due to the relatively low labor costs in comparison to measures such as hand-pulling, mechanical harvesting, etc. Several follow-up treatments, whether in-season or in subsequent years, may be needed to reduce exotic species to target levels.

More recently, whole-lake treatments have gained favor within the State. By targeting a whole-lake low-dose concentration of herbicide, the exposure time can be extended since dilution is generally mitigated. In addition, not only are the known locations of invasive species targeted with whole-lake treatments, the unknown locations are as well.

As with any herbicide treatment, collateral damage is always a concern. Often native species sensitive to herbicide treatments are present or large amounts of plant biomass may remain after treatment. To offset this risk, early-season treatments with selective herbicides and concentrations can target exotic species when the plants are small and cooler temperatures slow the microbial decomposition of herbicides.

Biological control - milfoil weevils

There has been considerable research on biological vectors, such as insects, and their ability to affect a decline in Eurasian watermilfoil populations. Of these, the milfoil weevil (*Euhrychiopsis lecontei*) has received the most attention. While numerous lakes have attempted stocking milfoil weevils in hopes of controlling milfoil in a more natural manner, this method has not proven successful in Wisconsin. In order for weevils to be successful in reducing the extent of Eurasian watermilfoil, a number of environmental criteria are needed, including the availability of proper year-round habitat. Most developed lakes in Wisconsin do not have sufficient habitat.

Lake Drawdowns

Lake drawdowns have been used as a means to manage both exotic and native aquatic plants in flowages. Drawdowns for control of exotic species have been more heavily promoted by the WDNR in recent years. The benefits of an effective drawdown can include reductions in both exotic and native plant densities, increases in plant diversity, and compaction and decomposition of organic sediments. The costs of a drawdown include loss of recreational use, impacts to local economies and loss of wildlife including fish, mollusks and other invertebrates. The most effective drawdowns have taken place during the growing season. The financial cost of conducting a drawdown is often minimal. There are, however, costs associated with the permitting process and outreach efforts.

Aquatic Invasive Species

Eurasian watermilfoil and curly-leaf pondweed have been a long-time presence in Black Otter Lake. Currently 6.5 acres of Eurasian watermilfoil are in need of treatment in 2014. It is recommended the District again target this species with Navigate®. New changes to the Navigate® label include updated application rates of 2.0 to 4.0 ppm (28.4 to 56.8 lbs/acre-foot). Because of the expected dissipation of herbicides out of the treatment area, the higher application rate is recommended at this time. If Eurasian watermilfoil is found to be more lake-wide in the future, a whole-lake liquid 2,4-D treatment approach may be warranted. When weed harvesting takes place on Black Otter Lake, the cutters should avoid known areas of Eurasian watermilfoil growth. Milfoil spreads primarily through fragmentation and cutting produces many fragments. In areas where only single plants or small groups of plants are found, particularly after a treatment has taken effect, it is recommended hand-pulling be used to further reduce the distribution of this species.

Since the drawdown, there have been four whole-lake treatments of Aquathol® to manage curly-leaf pondweed. Because turions can remain viable in the sediment for five years or more, it is anticipated that the District will need to continue large-scale treatments of curly-leaf pondweed for at least one more year. The most recent treatment targeted the entire lake volume at 1.0 ppm with a combination of Aquathol K® applied within the main body of the lake and Aquathol Super K® applied above the train trestle. If a whole-lake treatment is needed moving forward, this approach should be repeated. It is possible, that a significant reduction in the distribution of curly-leaf pondweed will take place over the next couple of years. In this case, spot treatments will likely need to be used to maintain this species at low levels.

In many ways Black Otter Lake has ideal conditions for the growth and spread of aquatic plants including the exotic species which will continue to be a threat to the lake's ecosystem. The nature of Black Otter Lake will also continue to complicate control efforts which are more easily employed on other lakes. Black Otter Lake is a shallow, fertile waterbody which encourages both plant and algae growth. As a flow-through system, chemicals applied during a treatment can be diluted by inflowing water. The full extent of dilution and its impact is difficult to determine.

Currently, Black Otter Lake has a low diversity of submergent aquatic plants. The District can begin weed-cutting activities in the lake while Eurasian watermilfoil and curly-leaf pondweed management is ongoing. Operators should be made aware of the locations treated, how to properly identify Eurasian watermilfoil, and to avoid cutting in areas of active Eurasian watermilfoil growth. Cutting areas of curly-leaf pondweed in the spring and early summer is recommended. This should reduce the number of turions produced. By mid-summer, curly-leaf pondweed will begin to die-back. At that point, cutting to manage this species will be unnecessary. The need for cutting native plants will depend upon the level of nuisance plant growth. If the past few years are any indication, it is likely that cutting of either coontail or common waterweed will be needed to maintain navigable lanes through the lake.

While active management of Eurasian watermilfoil and curly-leaf pondweed continues, it is recommended that annual surveys be performed to monitor these species. Spring surveys prior to treatment should be used to monitor the growth of curly-leaf pondweed. Summer full point-intercept surveys will allow for further assessment of the native plant communities in the years following the drawdown. Fall surveys will provide the best opportunity to assess the distribution of Eurasian watermilfoil. Spring and fall surveys should result in maps showing the locations of invasive species. These maps will be necessary for determining treatment needs and for the purposes of obtaining DNR permits.

Water Level Control

The District has again discussed manipulating the water level of Black Otter Lake. The best results in terms of improvements to the plant community and sediment compaction/desiccation come from a growing season drawdown rather than a winter drawdown. The District has the option of also drawing the water down by a small margin in the winter in order to minimize damage from ice shoves. Due to the decline in the native plant community, the District should strongly consider a more extensive but still partial drawdown during the growing season. The beginning of this drawdown would take place in May after the spring curly-leaf pondweed treatment has taken effect. The lake can then be refilled in the fall. There are benefits to a partial drawdown that a full drawdown would not include. The fishery has a better chance of remaining intact and recreational use of the lake can continue. A partial drawdown would also be able to improve conditions of the emergent and submergent plant communities in the area drawn down. As previously discussed, it is recommended a two to four foot drawdown be conducted every two to three years. This will encourage emergent plant growth, while deterring the growth of exotics and other nuisance submergent plant growth in the shallow locations of the lake.

Water Quality Assessment

Phosphorus, chlorophyll and Secchi depth data for Black Otter Lake in the past few years indicate fair to poor water quality. Because water quality can be affected by management activities on the lake, continued water quality monitoring is recommended. The frequency to which volunteer monitoring has taken place in the recent past should continue in 2014 and beyond. This data will be valuable in determining what impact the management of exotics, in particular, has on the water quality of the lake.

Dissolved oxygen data from 2011 suggest the current aeration system may not be providing sufficient oxygen to the lake during the warmest times of the year. It is recommended an assessment of the current system be made to assure it is working at full capacity. An expansion of the system may be warranted following this assessment.

Implementation Plan

Since 2011, annual fall meetings have taken place to discuss management of Black Otter Lake. Meeting attendees have included members of the Lake District and representatives from the WDNR, the Village of Hortonville and Cason & Associates, LLC. Recent management efforts are discussed at these meeting and additional efforts are planned. The following management goals have been drafted as a result of these conversations. Some of the goals listed fall outside of the scope f this study/report, but are included due to their importance to the District and their efforts toward comprehensive lake management.

Management Goal 1: Reduce exotic aquatic plant growth within Black Otter Lake.

Management Action: Annual monitoring and chemical treatment(s).
Timeframe: Annual surveys in spring, summer and fall. Spring treatments to control curly-leaf pondweed and possibly Eurasian watermilfoil.
Facilitators: District Board, Cason & Associates, LLC.

Description: Surveys for exotic species, namely curly-leaf pondweed and Eurasian watermilfoil will be conducted in the spring and fall, respectively. These surveys will be conducted by Cason & Associates staff and will follow the focused point-intercept approach previously employed on Black Otter Lake.

Spring surveys will be used to monitor the distribution of curly-leaf pondweed in Black Otter Lake. The District plans to use the information obtained to annually refine the spring treatment plan. Fall surveys will be used to monitor the distribution of Eurasian watermilfoil and determine the need for treatment. Annual spring treatments are anticipated to further reduce the distribution of curly-leaf pondweed and Eurasian watermilfoil. Whole-lake endothall treatments have been the most recent and successful approach used. It is anticipated that this approach will continue in the coming years until the bank of curly-leaf pondweed turions is depleted.

As treatments take place, hand-pulling will be encouraged by the District. As small scattered locations of invasive species are identified, the District will solicit volunteers to hand-pull these plants. In addition, property owners will be encouraged to hand-pull exotic species around their docks and shorelines.

In addition, the District Board will continue to use water-level manipulation as a tool for invasive species management. It is expected temporary, partial drawdowns of two to four feet will take place annually to discourage the growth of invasive species and promote the growth of beneficial native species, particularly emergent plants. The timing and duration of these partial drawdowns will be determined through discussions with the WDNR and Village representatives.

The District has an on-going relationship with the Biology Department at Hortonville High School. Students in this program have assisted with a number of lake projects over the past decade or more. The District plans to continue to include students in projects such as plant surveys, hand-pulling efforts and participation in Clean Boats/Clean Waters, etc.

Management Goal 2: Manage the health of the native plant community within Black Otter Lake.

Management Action: Selective harvesting of native plants within Black Otter Lake according to DNR permit conditions.
Timeframe: Annual summer harvesting.
Facilitator: District Board
Description: In order to manage nuisance levels of native aquatic plants, the District has establish an annual harvesting program on Black Otter Lake as detailed in **Appendix C**. Harvesting for native aquatic plants is expected to focus on providing navigational relief to boaters. Operators will be instructed to cut in areas specifically allowed by the permit. They will be made aware of all permit conditions. They will also be educated on the difference between Eurasian watermilfoil and curly-leaf pondweed and aware (via onboard maps) of the current distribution of the species in the lake. For the time being, they will be instructed to avoid cutting in areas of Eurasian watermilfoil growth. It is anticipated the harvesting permit will be renewed as a multi-year permit starting in 2014.

Management Goal 3: Encourage improvements within the watershed of Black Otter Lake to improve water quality.

Management Action: Restore or improve impaired areas within the watershed.
Timeframe: Ongoing
Facilitator: District Board
Description: The District board plans to work cooperatively with land owners, the County and State and Federal Agencies to improve land-use practices in the greater watershed of Black Otter Lake. This is expected to include addressing buffer strips along waterways, the use of fertilizers and alternative farming practices as well as manure management. Riparian property owners will also be provided information regarding shoreline improvement options and lawn care practices to reduce eroosionand nutrient inputs into the lake. Resources included in this plan as well as those available from the Wisconsin DNR, Outagamie County and UW-Extension will be utilized. The District will also solicit appropriate speakers to address these issues at membership meetings. Shoreline improvement demonstrations may be planned upon District's discretion.

Management Goal 4: Continued participation in the Clean Boats, Clean Waters Citizen Lake Monitoring Network programs.

Management Action: Continue with established Clean Boats Clean Waters and Citizen Lake Monitoring Network programs on Black Otter Lake.
Timeframe: Annual, continuous
Facilitator: District Board

District volunteers are currently trained and participate in the monitoring of boat landings through the Clean Boats, Clean Waters program. Member of the Board are dedicated to this program and will continue to encourage lake residents to become trained and volunteer through this program. The District will work with the Wisconsin DNR to expand this program and increase the number of volunteers and hours.

For a number of years, the District has participated in the Wisconsin DNR's Citizen Lake Monitoring Network program. The District Board has acknowledged the benefit of participating in this program and plans to continue participating at the same level of involvement for the foreseeable future. New volunteers will be encouraged to take part in the training to identify invasive species.

Management Goal 5: Continued promotion of healthy fish and wildlife in and around Black Otter Lake.

Management Action: Continue to pursue habitat improvements such as emergent plantings, tree drops root wads, etc. in and around Black Otter Lake.
Timeframe: Annual, continuous
Facilitator: District Board

District volunteers have, for a number of years, made efforts to promote a healthy fishery and wildlife habitat of Black Otter Lake. Efforts have included emergent plantings, deliberate tree drops, placement of sunken root wads, placement of a nesting platforms for eagles, fish stocking, maintaining an aeration system, water level manipulation, etc. These and other effort will continue to be pursued. More specifically, the District Board plans to pursue additional tree drops, root wads and emergent plantings as needed and practical. In addition, the Board plans to fund annual stocking or minnow and/or game fish into Black Otter Lake as needed. Members of the Board will rely on advice from the Wisconsin DNR as to the sizes and numbers of fish species to be planted.

In addition, the District Board plans to assess the current aeration system in Black Otter Lake. Little maintenance has been done on the system in the past five years. The Board will work with a contactor to determine if the existing system is meeting the needs of the lake, if the system should be expanded and if components of the system are in need of replacement.

Management Goal 6: Restoration of the island

Management Action: Investigate options for restoring the island on Black Otter Lake which has experience increased erosion and tree damage in recent years.
Timeframe: Annual, continuous
Facilitator: District Board

Over the past two or three years, options for restoring the island on Black Otter Lake have been discussed. These have included planting emergent species, placement of stones/rip-rap or boil-logs around the shore, etc. The District Board will continue to plan for this project and pursue the necessary permits needed to complete the work.

Appendix A

Black Otter Lake, Outagamie County Endothall Concentration Monitoring Summary, 2013.

Draft: Black Otter Lake, Outagamie County
Endothall Concentration Monitoring Summary, 2013

5 November 2013

John Skogerboe

Black Otter Lake has an area of 78 acres, and a maximum depth of 9 ft. The lake is listed on the WI DNR Lake Finder web page as a flowage and has a water control structure on the north side of the lake. On 16 May 2013, the main part of the lake was treated with a liquid formulation of endothall (Aquathol K) to control curly-leaf pondweed (*Potamogeton crispus*). The endothall was applied at a lake wide target concentration of 1000 ug/L (1 mg/L) active ingredient (ai). An additional 5 acre site in an isolated bay south of the railroad bridge was treated using a granular formulation of endothall (Aquathol Super K) at a target concentration of 1000 ug/L ai. Endothall application rates are specified as active ingredient (ai) in the product label, while endothall chemical analysis concentrations are specified as acid equivalent (ae). A concentration of 1000 ug/L ai is equal to 710 ug/L ae.

Two water sample sites (BO1 and BO2) were located in the isolated bay treated with granular endothall (Figure 2). Site BO1 was believed to be upstream of the actual treatment area. Three water sample sites (BO3, BO4, and BO5) were located in bays on the eastern (upstream) side of the lake. Three water sample sites (BO6, BO7, and BO8) were located in western part of the lake, and one sample site (BO9) was located downstream from the dam.

Water samples were collected from each sample site using an integrated water sampler which collects water from most of the water column. Water samples were collected at intervals of approximately 0.25, 1, 2, 3, 5, 7, 10, 14, 21, 28, and 35 days after treatment (DAT). Samples were taken to shore after completion of each sample interval, and 3 drops of muriatic acid were added to each sample bottle to fix the endothall and prevent degradation. Samples were then stored in a refrigerator, until shipped to the US Army Engineer Research and Development Center (ERDC) laboratory in Gainesville, FL for analysis of endothall.

Peak endothall concentrations in the isolated bay ranged from 491 ug/L ae at 0.25 DAT in samples from site BO1 to 589 ug/L ae at 1 DAT in samples from site BO2 (Figure 3). The mean endothall concentration in samples collected from 0.25 to 7 DAT was 204 ug/L ae. Concentrations of endothall in samples were less 100 ug/L ae by 5 DAT.

Peak endothall concentrations in samples from the main lake ranged from 750 to 1439 ug/L ae compared to the lake wide target concentration of 710 ug/L ae (Figure 4, Figure 5). Endothall concentrations in samples from site BO5 were initially 1439 ug/L ae at 0.25 DAT but dropped to only 119 ug/L ae by 1 DAT. The mean lake wide concentration in samples collected from 0.25 to 7 DAT was 649 ug/L ae compared to the target concentration of 710 ug/L ae. Endothall concentrations were near or less than 100 ug/L ae by 10 DAT.

Endothall concentrations ranged from 347 to 720 ug/L ae from 1 to 7 DAT in samples collected from the site (BO9) downstream from the dam (Figure 6). Endothall concentrations from the sample site (BO8) immediately upstream from the dam ranged from 460 to 1341 ug/L ae during the same period of time.

Figure 1. Black Otter Lake Curly-Leaf Pondweed Areas 2013 (Cason & Associates)

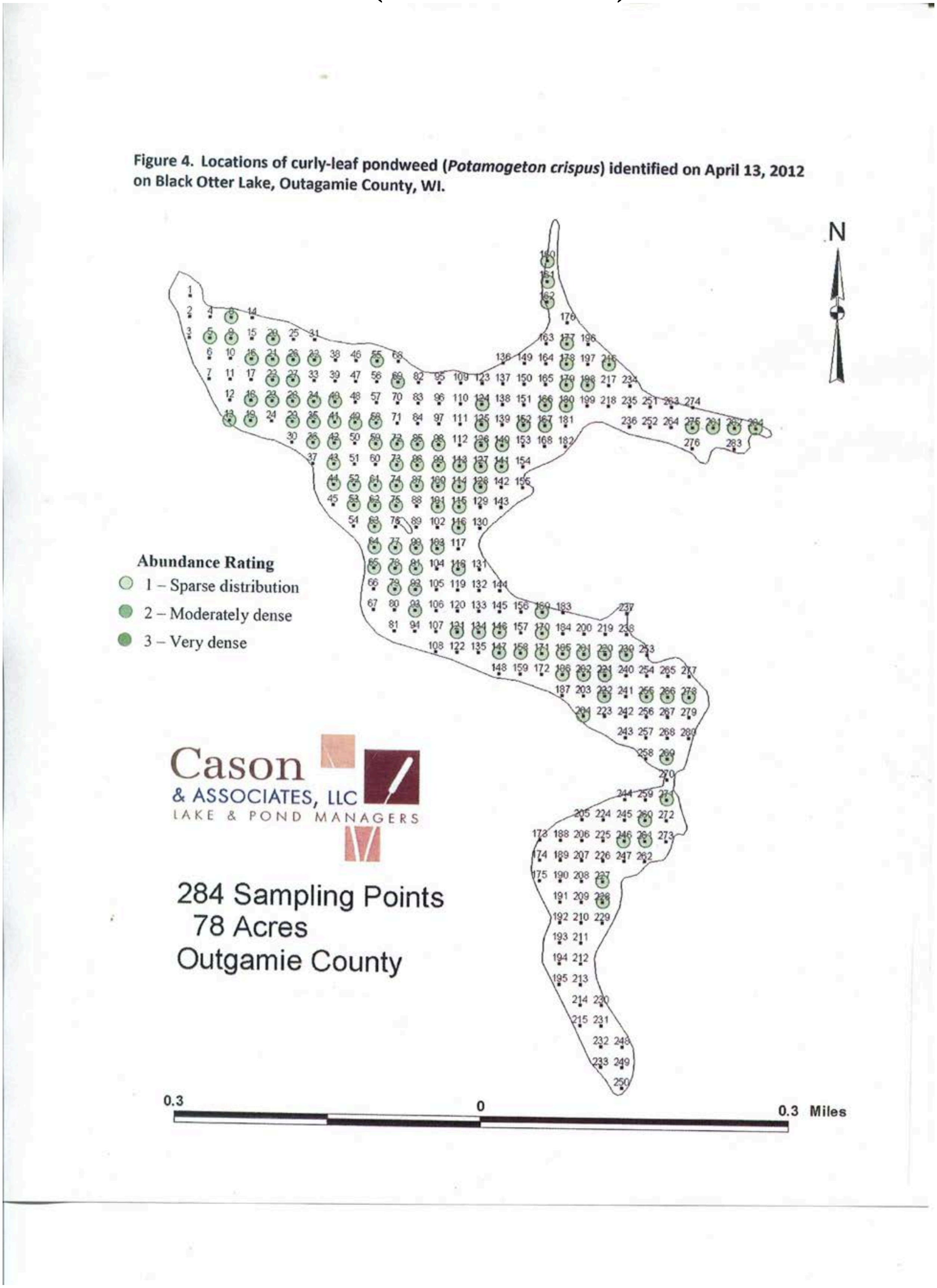


Figure 2. Black Otter Lake Endothall Sample Locations 2013

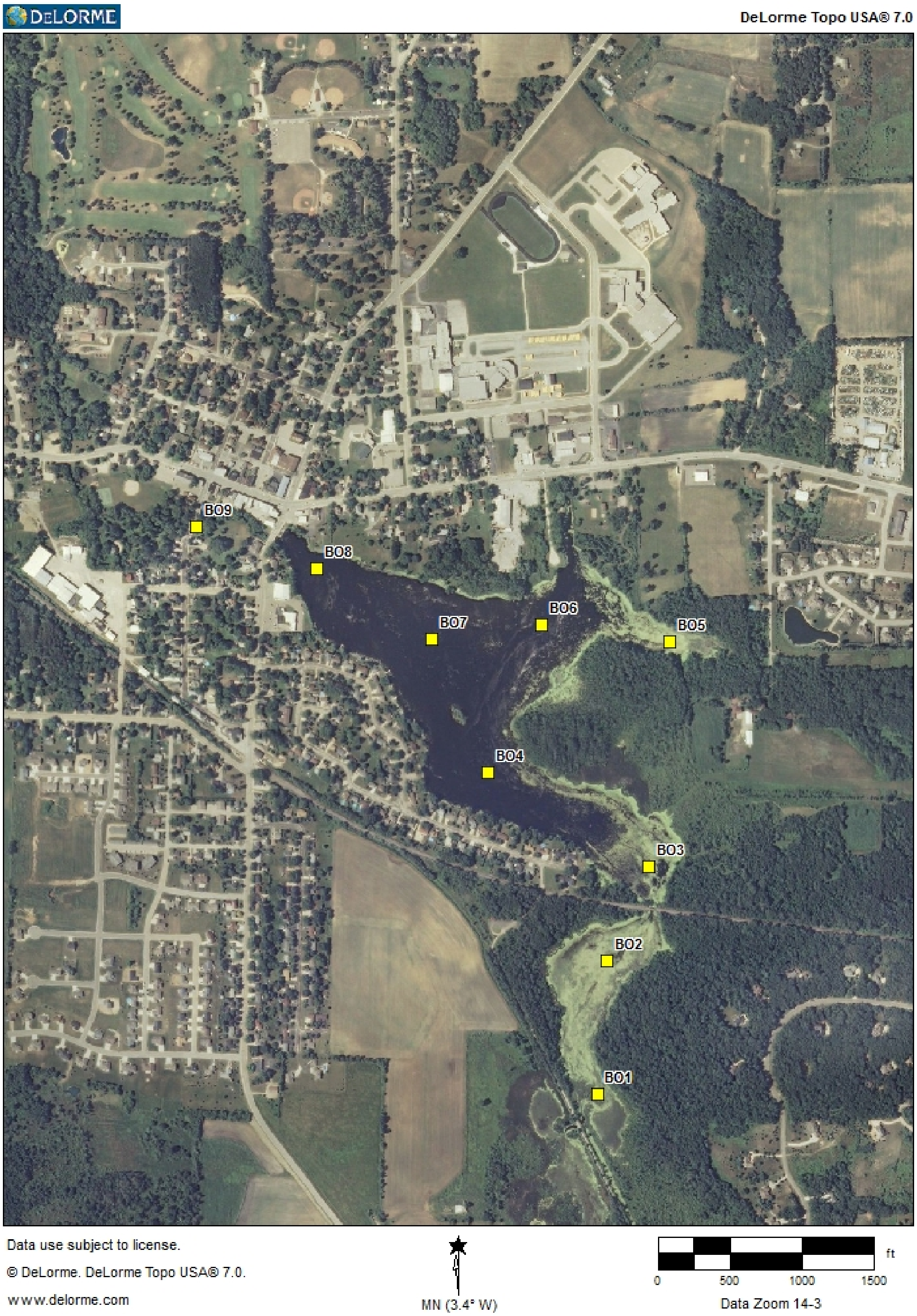


Figure 3

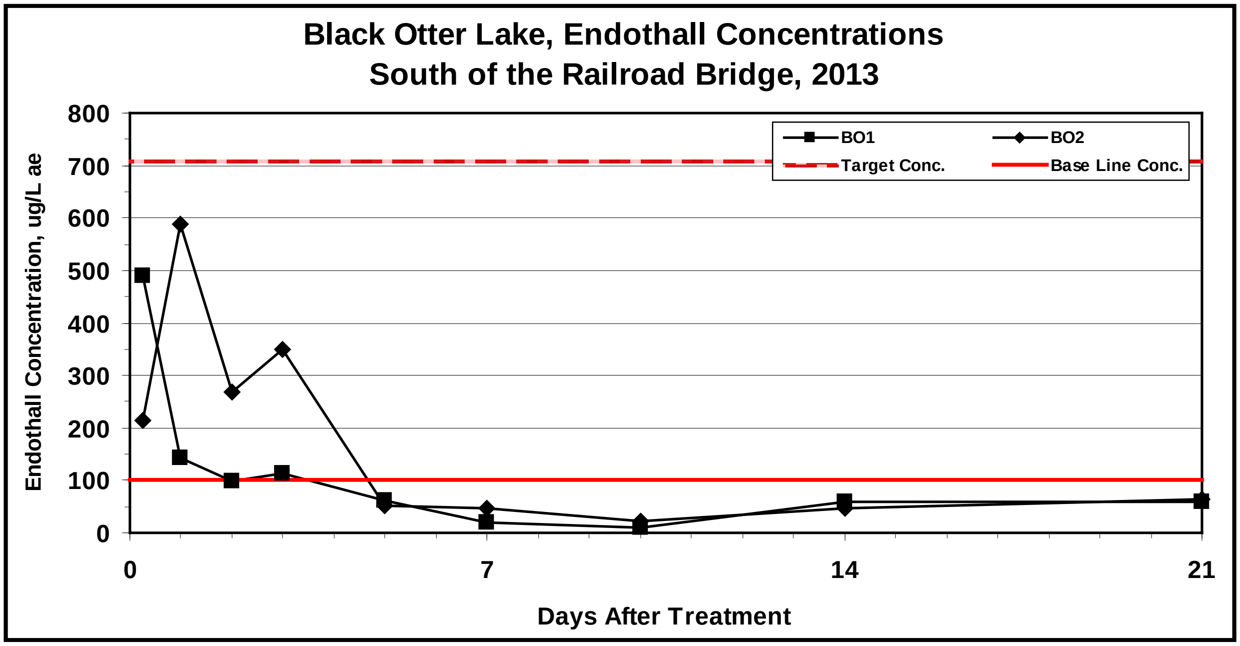


Figure 4

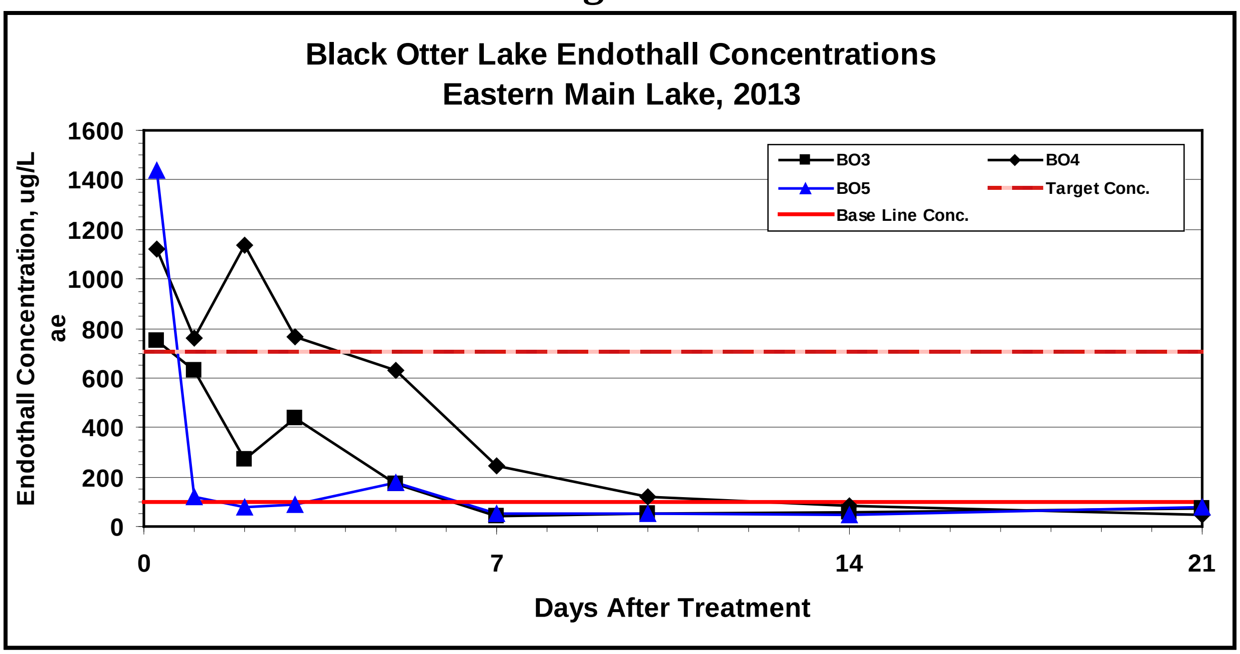


Figure 5

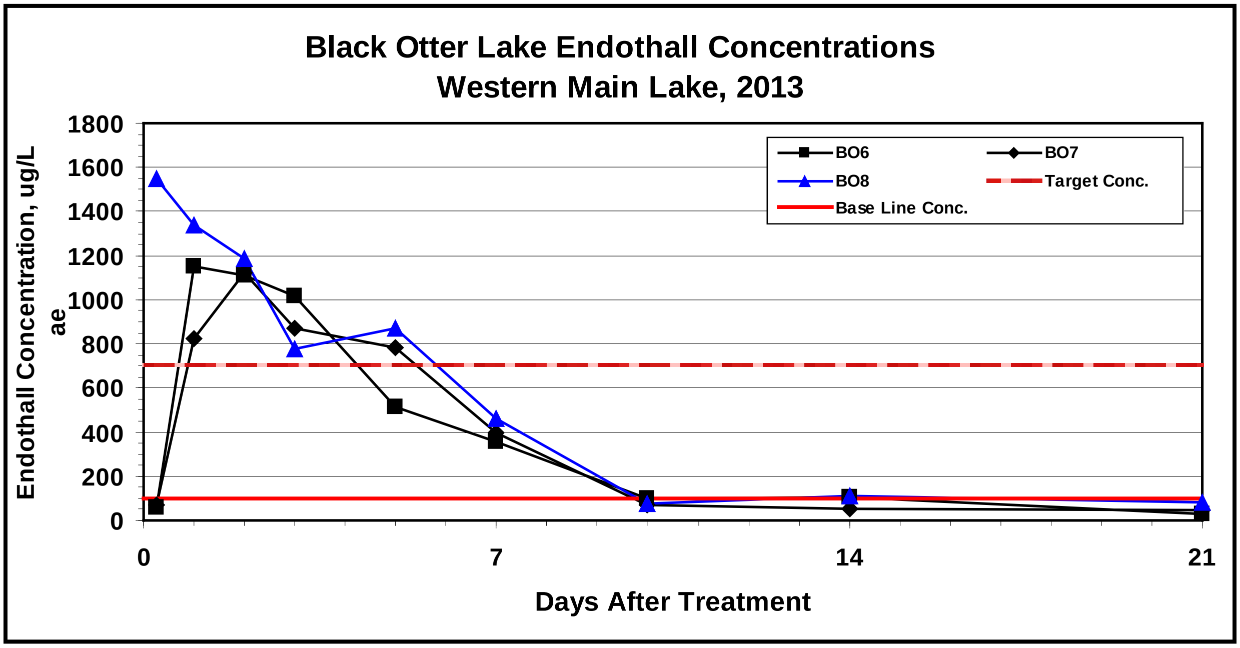
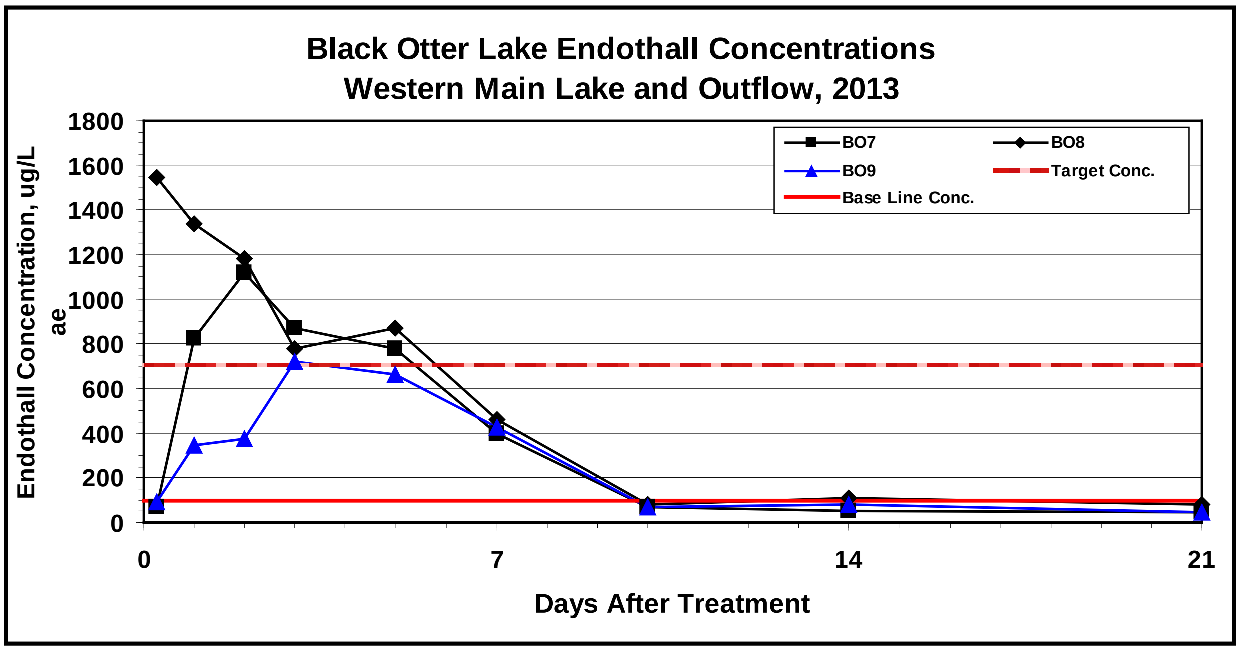


Figure 6



Appendix B

Aquatic plant survey data from August 21, 2013 for Black Otter Lake, Outagamie County, Wisconsin.

sampling point	Depth (ft)	comments	*Myriophyllum spicatum* ,Eurasian water-milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum* ,Coontail	*Chara* ,Muskgrasses	*Elodea canadensis* ,Common waterweed	*Heteranthera dubia* ,Water star-grass	*Lemna minor* ,Small duckweed	*Najas flexilis* ,Bushy pondweed	*Nuphar variegata* ,Spatterdock	*Nymphaea odorata* ,White water lily	*Stuckenia pectinata* ,Sago pondweed	*Utricularia vulgaris* ,Common bladderwort	*Wolffia columbiana*,*Common watermeal*
1	9.4				v	3										v
2	9.6					3		v						v		v
3	4					2		1							1	v
4	6.7				v	3										v
5	9.8							1								v
6	8.2					2										
7	4				v	1		1						1		
8	6.1				1	2		1								v
9	8.3					3		v								v
10	9.3					2		1								
11	9.1					3		v								
12	7					2										
13	3.7				v	1		v	v					v	1	
14	3.1					2		1						1		v
15	7.2					3			v					v	v	
16	8.8					3										
17	9.1					3										
18	9.3					1										
19	8.2					3										
20	7.6					2		1								
21	6.1					3								v	v	v
22	8				v	3										
23	8.3					3									v	
24	7.6					3		v								
25	4.1				1			2						1		v
26	4.1				v	1								1		
27	7.1					2								v		
28	7.4					3								1	v	
29	9.1					1										
30	5.1				v	3										
31	3.3							3						1		
32	3.3				1	v		1								
33	3.8				v	2		1						v	v	

sampling point	Depth (ft)	comments	*Myriophyllum spicatum* ,Eurasian water-milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum* ,Coontail	*Chara* ,Muskgrasses	*Elodea canadensis* ,Common waterweed	*Heteranthera dubia* ,Water star-grass	*Lemna minor* ,Small duckweed	*Najas flexilis* ,Bushy pondweed	*Nuphar variegata* ,Spatterdock	*Nymphaea odorata* ,White water lily	*Stuckenia pectinata* ,Sago pondweed	*Utricularia vulgaris* ,Common bladderwort	*Wolffia columbiana*,Common watermeal
34	6.5				v	v									3	v
35	7.7					3									v	
36	7.3				v	3		v								
37	4				1	1		1		v				1		v
38	3.2				1			2						1		
39	2.9				v	1		1						2		
40	8.4				v	3										v
41	6.5					3									v	
42	8.7					3										
43	7.2				v	3										v
44	5.2				v	2		2						v		v
45	4.4				v	1		v						1	1	
46	2.7				1			2	v	v				2		v
47	4.9				1	3	v							1		
48	4				v	v		3						v		
49	7.1				1	3										
50	8.9					3										
51	8.2					2										
52	7.3				v	3								1		
53	7.5				v	2		v						v	1	
54	3.2					v		v						1	3	
55		not navigable														
56	5.6				v	v	2	v		v				1		
57	3.8						v	1							v	
58	6.7				v	2								v		
59	7.8				v	3										v
60	8.7				v	3									v	
61	10.4				1	3										v
62	5.3					2		1							v	
63	4.7				v	1										
64	4.8					v		v						1		
65	5.5					2		2							v	
66	5.2				v	1		2						v	v	

sampling point	Depth (ft)	comments	*Myriophyllum spicatum* ,Eurasian water-milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum* ,Coontail	*Chara* ,Muskgrasses	*Elodea canadensis* ,Common waterweed	*Heteranthera dubia* ,Water star-grass	*Lemna minor* ,Small duckweed	*Najas flexilis* ,Bushy pondweed	*Nuphar variegata* ,Spatterdock	*Nymphaea odorata* ,White water lily	*Stuckenia pectinata* ,Sago pondweed	*Utricularia vulgaris* ,Common bladderwort	*Wolffia columbiana*,Common watermeal
67	5.7					2								v	v	
68		not navigable														
69	2				v	v		2						1		
70	5.4							2								
71	4.3				v	2		1								
72	7.7				v	3				v						v
73	8.2				1	3		1								v
74	8					1										
75	4.4				1	3										v
76	7.4				v	v		v	1	v				1		1
77	7					1		1								
78	6				1	2									v	v
79	6.2				1	3		1								1
80	6.6				1	3										v
81	5.5				1	3		1						1	v	1
82		not navigable														
83		not navigable														
84	4.5					v		v		1				2		
85	7.2				v	3								v		1
86	7.7					3		1								1
87	8.6				1	3										
88	4				1	3		v								1
89	3				1	1		2								v
90	5				1	3		1								1
91	6					1		2							v	
92	6.4					1		1								
93	7.2				1	2									1	v
94	6				1	1		2						1		v
95	3	not navigable														
96	4.5					v	1	2						v		
97	7.2					v		3						v		
98	8.6						v	2						v		
99	7.1				1	3										v

sampling point	Depth (ft)	comments	*Myriophyllum spicatum* ,Eurasian water-milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum* ,Coontail	*Chara* ,Muskgrasses	*Elodea canadensis* ,Common waterweed	*Heteranthera dubia* ,Water star-grass	*Lemna minor* ,Small duckweed	*Najas flexilis* ,Bushy pondweed	*Nuphar variegata* ,Spatterdock	*Nymphaea odorata* ,White water lily	*Stuckenia pectinata* ,Sago pondweed	*Utricularia vulgaris* ,Common bladderwort	*Wolffia columbiana*,Common watermeal
100	8.2				1	3				1						v
101	6.1					2		1								
102	7.1							1								
103	5.2				1	3		1						v	1	1
104	6.2					3		1							v	v
105	4.4				v	3				v				1	1	v
106	6				1	3		v								v
107	6.1				1	1		2		v				v		1
108	9				1	2				v						1
109		not navigable														
110	7.1						2	1		v				1		v
111	5.1					1		3						1		
112	4					v		2						1		
113	6.2				v	3		1								
114	6.8				1	3										1
115	6.5					3		1		1				v		v
116	7.1				v	1		2						1		v
117	4.2				1	3		1		v				v		1
118	7.5				1	2		2								1
119	5.5				v	3		1		v				1		v
120	8.1					1		2						v		
121	6.5				1	3		1								1
122	5				v	1		2								v
123		not navigable														
124	2.9						1	2						v		v
125	6.3					2		2								
126	8.1				1	3				v						1
127	6.2					3		1								
128	7.2				1	3				v				1		v
129	6.1				v	2		1						v		
130	2				v	2		2						v		v
131	7.5					1		1		v				2		v
132	5.5					3		1		1				1	v	v

sampling point	Depth (ft)	comments	*Myriophyllum spicatum* ,Eurasian water-milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum* ,Coontail	*Chara* ,Muskgrasses	*Elodea canadensis* ,Common waterweed	*Heteranthera dubia* ,Water star-grass	*Lemna minor* ,Small duckweed	*Najas flexilis* ,Bushy pondweed	*Nuphar variegata* ,Spatterdock	*Nymphaea odorata* ,White water lily	*Stuckenia pectinata* ,Sago pondweed	*Utricularia vulgaris* ,Common bladderwort	*Wolffia columbiana*,Common watermeal
133	4.9					3				v					v	1
134	4.4				1	3		1		1					1	1
135	7					3		1		v						1
136		not navigable														
137	6.6				1	v		v	1				v	2		v
138	2				v	v		2		1				v		
139	5				1	3				1						1
140	4.7				1	3				1						1
141	6.4				v	1		1		v				1		v
142	5.8				1			3						v		1
143		not navigable														
144	4.6							2		1				1		1
145	3.7				1	2		1		1						1
146	5.6					3				1						1
147	6					1		v		v						v
148	2					2		1		v						v
149		not navigable														
150	6.8					1		1								v
151	6.6				1	3										1
152	2				1	3										1
153	2.5				1	3		2	v							1
154	8.6					v			1					2		v
155		not navigable														
156	5.3				1			2		1	1			1		1
157	4.8					1		v		v						v
158	5.2					1		1		1				1		1
159	7.5					2		1		v					1	v
160	6.9															
161	3.6															
162	6.1															
163	3.4															
164	3.8				1	3		1						1		1
165	3.2				1	3		v								1

sampling point	Depth (ft)	comments	*Myriophyllum spicatum* ,Eurasian water-milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum* ,Coontail	*Chara* ,Muskgrasses	*Elodea canadensis* ,Common waterweed	*Heteranthera dubia* ,Water star-grass	*Lemna minor* ,Small duckweed	*Najas flexilis* ,Bushy pondweed	*Nuphar variegata* ,Spatterdock	*Nymphaea odorata* ,White water lily	*Stuckenia pectinata* ,Sago pondweed	*Utricularia vulgaris* ,Common bladderwort	*Wolffia columbiana*,Common watermeal
166	3.3					1		1						v		v
167	3.5				1	1		2								v
168	3.4				v	1		1	1					1		v
169		not navigable														
170	4.7				1	v		1		v				v		v
171	4.8					1		1						1		1
172	6.3					3		1								1
173		not navigable														
174		not navigable														
175		not navigable														
176	5.1				v	1		1								v
177	5					1		1								v
178	4.7				1	3		1		1						1
179	5				1	3										1
180	3.5				v	1		1		1						v
181		not navigable														
182		not navigable														
183		not navigable														
184	2				1	1		1		v						v
185	5.2					3		1		v				v		v
186	7					1										v
187	1				1	1		1		1					1	1
188		not navigable														
189		not navigable														
190		not navigable														
191		not navigable														
192		not navigable														
193		not navigable														
194		not navigable														
195		not navigable														
196	3.3		v		1	3		1		v			v			1
197	4.2				1	1		2	1	v				1		v
198	5.6				1	3		v		1						1

sampling point	Depth (ft)	comments	*Myriophyllum spicatum* ,Eurasian water-milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum* ,Coontail	*Chara* ,Muskgrasses	*Elodea canadensis* ,Common waterweed	*Heteranthera dubia* ,Water star-grass	*Lemna minor* ,Small duckweed	*Najas flexilis* ,Bushy pondweed	*Nuphar variegata* ,Spatterdock	*Nymphaea odorata* ,White water lily	*Stuckenia pectinata* ,Sago pondweed	*Utricularia vulgaris* ,Common bladderwort	*Wolffia columbiana*,Common watermeal
199	5.6				v	2		2	v	v				v		v
200	4.1				1	1		2		1						1
201	7.8				v	1		1		v						v
202	9.2					2										v
203	6.4				1	2				v						1
204	3				1	3		1		1				1		1
205		not navigable														
206		not navigable														
207		not navigable														
208		not navigable														
209		not navigable														
210		not navigable														
211		not navigable														
212	1				1	1		1		1						
213	1					1		1		1		v				v
214		not navigable														
215	1				1	1		1		1				1		
216	3.2		v		1	2		1	v				v	1		
217	6.2				1	3		1		1						1
218	3.4		v		1	3				1						1
219		not navigable														
220	5.3					3				1						1
221	7.5				v	1		1		v						1
222	5.7				v	3				v						v
223	6.5							1						1		
224		not navigable														
225		not navigable														
226	2.5				1	1				1						1
227	2.5				1	1		2		1						1
228	2					1				1						
229	2									1		v				1
230	1.5				1	1				1		v		1		
231		not navigable														

sampling point	Depth (ft)	comments	*Myriophyllum spicatum* ,Eurasian water-milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum* ,Coontail	*Chara* ,Muskgrasses	*Elodea canadensis* ,Common waterweed	*Heteranthera dubia* ,Water star-grass	*Lemna minor* ,Small duckweed	*Najas flexilis* ,Bushy pondweed	*Nuphar variegata* ,Spatterdock	*Nymphaea odorata* ,White water lily	*Stuckenia pectinata* ,Sago pondweed	*Utricularia vulgaris* ,Common bladderwort	*Wolffia columbiana*,*Common watermeal*
232	1				1			1		1				1		
233		not navigable														
234		not navigable														
235	5.7		v		1	3		v	v	1				v		1
236		not navigable														
237		not navigable														
238		not navigable														
239		not navigable														
240	6.4				v	3		1		1						1
241	3.9					1										v
242	4					1		1		1				v		v
243	2.7				1	1		3		1				2		1
244	1	no plants														
245	2.5				v	2		1		1						v
246	2.5				1	v				1						1
247	2.5			1	1	v				1				v		1
248		not navigable														
249		not navigable														
250		not navigable														
251	4.8			v	1	1			v	1	v			1		1
252		not navigable														
253		not navigable														
254	2.2				1	3		1		1						1
255	2.9				v	1				1				1		1
256	3.4				1	2				1				1		1
257	2.7				1			2		1				1		
258		not navigable														
259	2.4				1	1								1		v
260	2.8					1		2		v						v
261	4.9					1		1		1				v		1
262		not navigable														
263	1				1	1				v				1		v
264		not navigable														

sampling point	Depth (ft)	comments	*Myriophyllum spicatum* ,Eurasian water-milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum* ,Coontail	*Chara* ,Muskgrasses	*Elodea canadensis* ,Common waterweed	*Heteranthera dubia* ,Water star-grass	*Lemna minor* ,Small duckweed	*Najas flexilis* ,Bushy pondweed	*Nuphar variegata* ,Spatterdock	*Nymphaea odorata* ,White water lily	*Stuckenia pectinata* ,Sago pondweed	*Utricularia vulgaris* ,Common bladderwort	*Wolffia columbiana*,Common watermeal
265	2.1				1	1		1						2		1
266	2.7				1	2		1		v						v
267	4.2				1	1		2		1				v		1
268	3.5				v	1				v						v
269	2.7				1	1				1						1
270	3.5				1	1		1		1						1
271	3.2				v	1		1		1						1
272	2.6				1	1		1		1						1
273		not navigable														
274		not navigable														
275	4			v	1	3				1				1		1
276		not navigable														
277		not navigable														
278		not navigable														
279		not navigable														
280		not navigable														
281	3			v	1	3				1		v		1		1
282	3				1	3				v						v
283		not navigable														
284		not navigable														

Appendix C

Black Otter Lake Waterway Management Harvesting Operation Plan

Black Otter Lake Waterway Management Harvesting Operation Plan

March 12th[th] 2014

Prepared by Matthew Schroeder (BOLD Chairman) with input from Mark Voight (BOLD Treasurer), Mason Arnold (BOLD Secretary), Randall Curtis (BOLD Advisor)

Introduction

The following document is the proposed method of completing aquatic plant harvesting by the Black Otter Lake District Board and local volunteers in Black Otter Lake which is located in Hortonville, WI. The plant harvesting operation will be completed according to the following guidelines as approved by the Wisconsin Department of Natural Resources.

Objective and goals for the aquatic plant management activities include but are not limited to; making the lake more accessible for the Hortonville and the surrounding communities' recreational use, provide outlets and paths for a variety of recreational vehicles and reduce the overall density of the different invasive plant life.

Black Otter Lake is a 75 acre impoundment located in the village of Hortonville. Two tributary streams and multiple storm water culverts feed the lake. Black Otter Creek drains from the lake directly into the Black Otter Creek and ultimately the Wolf River.

Black Otter Lake contains two public boat launches; a village park, and are currently in development of the proposed canoe and kayak launch. These features of Black Otter Lake make it a substantial recreational destination for the people of Hortonville and the surrounding communities.

As the only recognized lake in Outagamie County with public access, Black Otter Lake is an important natural resource and is a staple to its local community.

Plant Harvester

Water depths will be measured prior to active harvesting in approved harvesting areas. A copy of the harvesting permit with a map of the approved harvesting areas will be maintained on the harvester. While the harvester is in operation, aquatic plant fragments are recovered by the harvester to the fullest extent that is allowed by the machine and its operating system. Concerns or complaints regarding plant fragments or cut vegetation left over from the plant harvester will be addressed and proper action will take place if such situations arise.

Operators

Prior to each harvesting season, each operator will be required to review the harvesting permit and agree to the conditions of this permit.

a. Harvester operators as well as aquatic plant managers will be educated to understand and identify the common nuisance and invasive aquatic plants in the water body.

b. Harvester operators will also be trained to inspect the areas prior to plant harvesting to be sure Eurasian Milfoil is not present.

c. Harvester operators will receive clear instructions on their assigned harvesting route. Routes will be marked with buoys.

d. Harvester operators will also be trained to know the limitations of the plant harvester, such as depth of operation and proper distance from protected areas and shorelines. Shallow water areas will be harvested no deeper than three feet as instructed and approved.

e. Harvester operators will also be trained to stop harvesting if the cutting heads hit below the surface of the lake or a moderate number of fish are encountered. Attempts will be made to remove all possible fish from the harvested plants.

f. Harvester operators will be trained to recognize and gauge the cutter head depth to help ensure proper and safe plant harvesting operations.

Fish

If moderate sums of young-of-the year panfish or game fish species are encountered, harvesting is to be stopped by the operator. This location is then to be documented and recorded.
The harvester will then move to another approved area and restart cutting the designated and marked routes. The area again will be checked for fish prior to continuing plant harvesting.
If the DNR would determine that a significant fish spawning area needs to be protected, those areas may be limited or completely withdrawn from the approved harvesting area in the future.

Depth

The harvester does not harvest plants in less than 3 feet of water to prevent the disruption of the bottom sediments, turbidity, and or damage to the cutting heads.

Area

Black Otter Lake

Harvesting Focus

a. Harvesting areas will be scouted out prior to the running of the plant harvester. Detailed maps and provided GPS coordinates will ensure that only approved and documented areas will be affected by the operation of the plant harvester.

b. Cutting of rooted submergent (below surface) nuisance aquatic plants will be done between June and August. Under no circumstances will emergent vegetation (plants that have leaves above the water's surface) be cut. Harvester operators will also collect floating (not rooted) plant life if found in the designated cutting areas. The harvester will stay at least two harvester widths away from emergent vegetation and water lilys.

    i. This is to provide nuisance relief for boat access, fishing lanes, and recreational boat vehicle routes as marked on the map provided.

c. Two harvesting primary lanes up to 30 feet wide will join and provide navigation routes from the landing to offer access the length of the lake from the town/dam at the northwest toward the railroad trestle at the southeast.

d. Two harvesting secondary lanes will be cut between 30 feet wide to provide access for canoe and kayaks. At no time should the harvester cut emergent vegetation and should stay at least two harvester lengths away from emergent plant life. These primary and secondary lanes are designated areas that are marked on the map provided.

Awareness
Communication of ongoing plant harvesting will be shared with the Village of Hortonville and the director of Public Works (Carl McCrary). The harvesting plan has positive support from the local and surrounding community members.

a. The harvesting plan and maps of the harvesting area will available to the public at each Black Otter Lake District Board meetings. Questions can be addressed at that time to the board or by contacting individual board members at a later time.

b. Maps of harvester activity and location of the cut lanes will be provided at the public boat launch and at the future canoe/kayak launch site.

Recordkeeping
Black Otter Lake District Board members and addition harvesting volunteers will maintain detailed records of harvesting dates, harvesting areas, types and amounts of aquatic plants harvested, and any fish that are encountered. Records will then be provided to the DNR at the end of each harvesting season.

Disposal Locations
Village of Hortonville Brush and Debris Waste Site (Enter Address Here). The composted plant matter will then be available for community members to pick up for individual plant/garden use.

Outagamie County WI GIS Map