DRAFT

Lilly Lake

Kenosha County, Wisconsin

Aquatic Plant Management Planning Project

June 2021

Official First Draft

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Funded by: Lilly Lake Protection & Rehabilitation District
Wisconsin Dept. of Natural Resources
(LPL171820)

Acknowledgements

This management planning effort was truly a team-based project and could not have been completed without the input of the following individuals:

Lilly Lake Planning Committee

Mike Adam
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Steve Rasinskis
Sheila Siegler
Kelly Wilson

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TABLE OF CONTENTS

FIGURES

TABLES

PHOTOS

MAPS

APPENDICES

1.0 INTRODUCTION

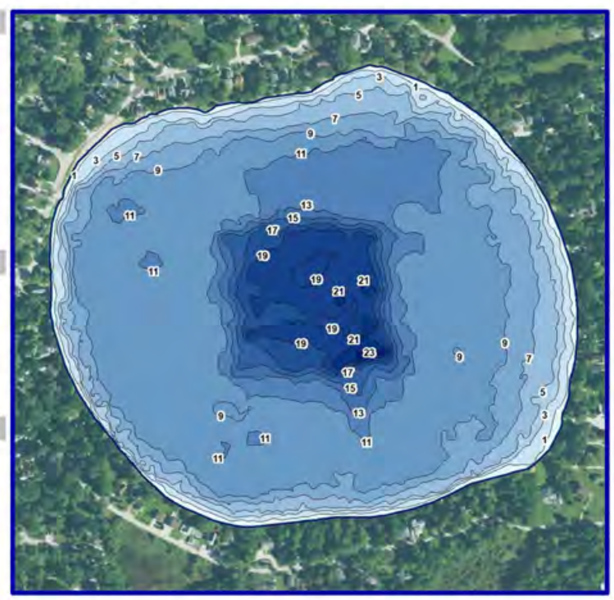
Photograph 1.0-1. Lilly Lake, Kenosha County, Wisconsin. Photo credit Onterra.

Lilly Lake is an 85-acre, oligo-mesotrophic deep seepage lake located in southeastern Wisconsin in Kenosha County (Photograph 1 and Map 1). The lake was found to have a maximum depth of 23 feet and a mean depth of 10 feet in 2020. While landlocked at present, it is believed Lilly Lake historically drained to nearby Basset Creek as there is a natural drainageway to the south (WI Dept. of Natural Resources).

Despite a high degree of urban development within the immediate shoreland zone and surrounding 128-acre watershed, Lilly Lake was found to have excellent water quality with high water clarity and low algal levels. The lake supports a lush and relatively unique plant community for a southern Wisconsin lake, most notably the presence of a large population of fern-leaf pondweed (*Potamogeton robbinsii*). Other dominant plant species include muskgrasses (*Chara* spp.) and white-stem pondweed (*P. praelongus*). The non-native, invasive aquatic plant hybrid watermilfoil (*Myriophyllum sibiricum* x *M. spicatum*) was also relatively abundant.

Figure 1.0-1. Lilly Lake facts.

Morphology	
LakeType	Deep Seepage
Surface Area (Acres)	85.4
Max Depth (feet)	23
Mean Depth (feet)	10
Perimeter (Miles)	1.3
Shoreline Complexity	1.1
Watershed Area (Acres)	128
Watershed to Lake Area Ratio	0.5:1
Water Quality	
Trophic State	Oligo-mesotrophic
Limiting Nutrient	Phosphorus
Avg Summer P (μg/L)	14.4
Avg Summer Chl-α (μg/L)	2.6
Avg Summer Secchi Depth (ft)	11.9
Vegetation (2020)	
Number of Native Species	18
NHI-Listed Species	None
Number of Exotic Species	7
Average Conservatism	6.2
Floristic Quality	22.4
Simpson's Diversity (1-D)	0.86



Lilly Lake Protection and Rehabilitation District (LLPRD) completed an aquatic plant management plan for Lilly Lake in 2009 (Aaron & Associates 2009). The non-native Eurasian watermilfoil was first verified in Lilly Lake in 1976 and was later confirmed in 2014 as hybrid watermilfoil, a cross between Eurasian watermilfoil and the native northern watermilfoil. Hybrid watermilfoil has been the primary plant of concern in Lilly Lake as it has grown to excessive levels in some areas, interfering with recreation and navigation. The LLPRD has completed annual herbicide treatments to alleviate these nuisance conditions.

Given aquatic plant assessments had not been completed in over ten years on Lilly Lake, the LLPRD was awarded a Wisconsin Department of Natural Resources (WDNR) Lake Management Planning grant in 2019 to update the lake's aquatic plant management plan. The goal of the studies completed in 2020 as part of this project were to document the current state of the lake's native and non-native aquatic plant communities, compare current data with historical surveys, and use this information to develop a plan for future management of the Lilly Lake ecosystem.

In addition to the collection of current aquatic plant data, the LLPRD also wanted to examine Lilly Lake in a more holistic manner to gain a broader understanding of the Lilly Lake ecosystem beyond the aquatic plant community. This included an assessment of the lake's current and historical water quality and an assessment of the current state of the lake's watershed. While an assessment of a sediment core collected from the lake to determine how water quality has changed over the past 150 years was originally proposed for this project, given the dredging that took place in the late 1970s, it was determined that the results from this analysis would likely be inconclusive. For this reason, the sediment core collection and analysis were not completed.

Despite a high degree of urban development along the lake's shoreline and within its watershed, Lilly Lake's water quality is considered excellent for Wisconsin's deep seepage lakes. The lake has higher water clarity and lower phosphorus and chlorophyll levels when compared to most of the lakes within the Southeast Wisconsin Till Plains ecoregion and lakes throughout the state. The lake supports a high-quality native aquatic plant community comprised largely of species that are considered relatively sensitive to disturbance (fern-leaf pondweed and white-stem pondweed).

The 2020 studies found that while the hybrid watermilfoil population had declined compared to the study completed in 2008, this species still comprises a large portion of Lilly Lake's aquatic plant community. Hybrid watermilfoil was observed forming dense, surface-matted colonies in near-shore areas around the lake. The point-intercept survey revealed that hybrid watermilfoil is also scattered throughout deeper areas of Lilly Lake's littoral zone, extending to a maximum rooting depth of 17 feet.

Assessment of the lake's curly-leaf pondweed population in 2020 found that the population is relatively small, comprised of a relatively small monotypic colony near the boat landing and scattered clumps and single plants elsewhere throughout the lake. Other non-native plants identified during the surveys included pale-yellow iris, purple loosestrife, narrow-leaved cattail, giant reed (*Phragmites*), and reed canary grass.

With the information gathered as part of this project, an Implementation Plan was developed by working with a planning committee comprised of Lilly Lake stakeholders. This Implementation Plan includes management goals and associated actions for how the LLPRD with enhance and protect the Lilly Lake ecosystem into the future.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa.

The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All this information is communicated through meetings that involve the lake group as a whole or a focus group called a Planning Committee. The highlights of this component are described below. Materials used during the planning process can be found in Appendix A.

General Public Meetings

The general public meetings were used to raise project awareness, gather comments, create the management goals and actions, and deliver the study results. While these meetings are typically held in person on a Saturday during the summer to maximize attendance and participation, due to the COVID-19 pandemic, the presentations were pre-recorded and posted to Onterra's YouTube channel for lake stakeholders to view. An email address was provided in the presentation to allow for viewers to submit any questions or comments regarding the project.

Kick-off Meeting

In August 2020, a pre-recorded project kick-off meeting presentation created by Onterra ecologist Brenton Butterfield was provided to the LLPRD for distribution to their membership. As of November 2020, the video had 255 views. Mr. Butterfield's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. At the end of the presentation, an email was provided for viewers to provide any comments or questions they had regarding the project.

Project Wrap-up Meeting

Scheduled for August 14, 2021.

Committee Level Meetings

Planning committee meetings, similar to general public meetings, were used to gather comments, create management goals and actions, and to deliver study results. These two meetings were open only to the planning committee and were held during the week. The first meeting was held virtually (via WebEx) on February 16, 2021. The first meeting was held following the completion of the draft report sections of the management plan. The planning committee members were supplied with the draft report sections prior to the meeting and much of the meeting time was utilized to detail the results, discuss the conclusions and initial recommendations, and answer committee questions. The objective of the first meeting was to fortify a solid understanding of their lake among the committee members. zThe second planning committee meeting was held virtually on February 23, 2021 and concentrated on the development of management goals and actions that make up the framework of the implementation plan.

Management Plan Review and Adoption Process

Has not yet occurred.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

Many types of analyses are available for assessing the condition of a particular lake's water quality. In this document, the water quality analysis focuses upon attributes that are directly related to the productivity of the lake. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. Specific forms of water quality analyses are used to indicate not only the health of the lake, but also to provide a general understanding of the lake's ecology and assist in management decisions. Each type of available analysis is elaborated on below.

As mentioned above, chemistry is a large part of water quality analysis. In most cases, listing the values of specific parameters really does not lead to an understanding of a lake's water quality, especially in the minds of non-professionals. A better way of relating the information is to compare it to lakes with similar physical characteristics and lakes within the same regional area. In this document, a portion of the water quality information collected Lilly Lake is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region (Appendix C). In addition, the assessment can also be clarified by limiting the primary analysis to parameters that are important in the lake's ecology and trophic state (see below). Three primary water quality parameters are focused upon in the water quality analysis:

> **Phosphorus** is the primary nutrient that regulates the growth of planktonic algae and some larger, vascular plants (macrophytes) in the vast majority of Wisconsin lakes. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.
>
> **Chlorophyll-*a*** is the green pigment in plants used during photosynthesis. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.
>
> **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most frequently employed and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrants (a Secchi disk) into the water and recording the depth just before it disappears from sight.

These three parameters are often correlated with one another. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water (Canter, Nelson and Everett 1994) (Dinius 2007) (Smith, Cragg and Croker 1991).

Trophic State

Total phosphorus, chlorophyll-*a*, and water clarity values are directly related to the trophic state of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: oligotrophic, mesotrophic, and finally eutrophic. Oligotrophic lakes have the lowest amounts of nutrients and biological productivity, and are generally characterized by having high water clarity and a lower abundance of aquatic plants. Mesotrophic lakes have moderate levels of nutrients and biological productivity and generally support more abundant aquatic plant growth. Eutrophic lakes have higher levels of nutrients and biological productivity, and generally have a high abundance of aquatic plants.

Most lakes will naturally progress through these states under natural conditions (i.e., not influenced by the activities of humans), but this process can take tens of thousands of years. Unfortunately, human development of watersheds and the direct discharge of nutrient-rich effluent has accelerated this natural aging process in many Wisconsin lakes, and this is termed cultural eutrophication. The excessive input of nutrients through cultural eutrophication has resulted in some lakes becoming hypereutrophic. Hypereutrophic lakes have the highest levels of nutrients and biological productivity. These lakes are typically dominated by algae, have very poor water clarity, and little if any aquatic plant growth.

It is important to note that both natural factors and human activity can affect a lake's trophic state, and that some lakes can be naturally eutrophic. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production.

However, through the use of a trophic state index (TSI), an index number can be calculated using phosphorus, chlorophyll-*a*, and Secchi disk depth values that represent the lake's position within the eutrophication process. This allows for a clearer understanding of the lake's trophic state while facilitating clearer long-term tracking. (Carlson 1977) presented a trophic state index that gained great acceptance among lake managers.

Limiting Nutrient

The limiting nutrient is the nutrient which is in shortest supply and controls the growth rate of algae and some larger vascular plants within the lake. This is analogous to baking a cake that requires four eggs, and four cups each of water, flour, and sugar. If the baker would like to make four cakes, he needs 16 of each ingredient. If he is short two eggs, he will only be able to make three cakes even if he has sufficient amounts of the other ingredients. In this scenario, the eggs are the limiting nutrient (ingredient).

In most Wisconsin lakes, phosphorus is the limiting nutrient controlling the production of plant biomass. As a result, phosphorus is often the target for management actions aimed at controlling plants, especially algae. The limiting nutrient is determined by calculating the nitrogen to phosphorus ratio within the lake. Normally, total nitrogen and total phosphorus values from the surface samples taken during the summer months are used to determine the ratio. Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 15:1, the lake is considered phosphorus limited; if it is less than 10:1, it is considered nitrogen limited. Values between these ratios indicate a transitional limitation between nitrogen and phosphorus.

Temperature and Dissolved Oxygen Profiles

Temperature and dissolved oxygen profiles are created simply by taking readings at different water depths within a lake. Although it is a simple procedure, the completion of several profiles over the course of a year or more provides a great deal of information about the lake. Much of this information relates to whether the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

Lake stratification occurs when temperature and density gradients are developed with depth in a lake. During stratification, the lake can be broken into three layers: The ***epilimnion*** is the surface layer with the lowest density and has the warmest water in the summer months and the coolest water in the winter months. The ***hypolimnion*** is the bottom layer the highest density and has the coolest water in the summer months and the warmest water in the winter months. The ***metalimnion***, often called the thermocline, is the layer between the epilimnion and hypolimnion where temperature changes most rapidly with depth.

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fish kills are often the result of insufficient amounts of dissolved oxygen. However, dissolved oxygen's role in lake management extends beyond this basic need by living organisms. In fact, its presence or absence impacts many chemical processes that occur within a lake.

Comparisons with Other Datasets

The WDNR document *Wisconsin 2018 Consolidated Assessment and Listing Methodology* (WDNR 2018) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's land cover. For this reason, the water quality of Lilly Lake is compared to lakes in the state with similar physical characteristics.

The WDNR classifies Wisconsin's lakes into ten natural communities based on size, hydrology, and depth (Figure 3.1-1). First, the lakes are classified into three main groups: (1) lakes and reservoirs less than 10 acres, (2) lakes and reservoirs greater than or equal to 10 acres, and (3) a classification that addresses special waterbody circumstances. The last two categories have several sub-categories that provide attention to lakes that may be shallow, deep, play host to cold water fish species or have unique hydrologic patterns. Overall, the divisions categorize lakes based upon their size, stratification characteristics, and hydrology. An equation developed by (Lathrop and Lillie 1980), which incorporates the maximum depth of the lake and the lake's surface area, is used to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

Seepage Lakes have no surface water inflow or outflow in the form of rivers and/or streams.

Drainage Lakes have surface water inflow and/or outflow in the form of rivers and/or streams.

> *Headwater drainage lakes* have a watershed of less than 4 square miles.
>
> *Lowland drainage lakes* have a watershed of greater than 4 square miles.

Using these criteria, Lilly Lake is classified as a deep (stratified) seepage lake (category 7). The water quality from Lilly Lake is compared to the water quality of other deep seepage lakes in Wisconsin.

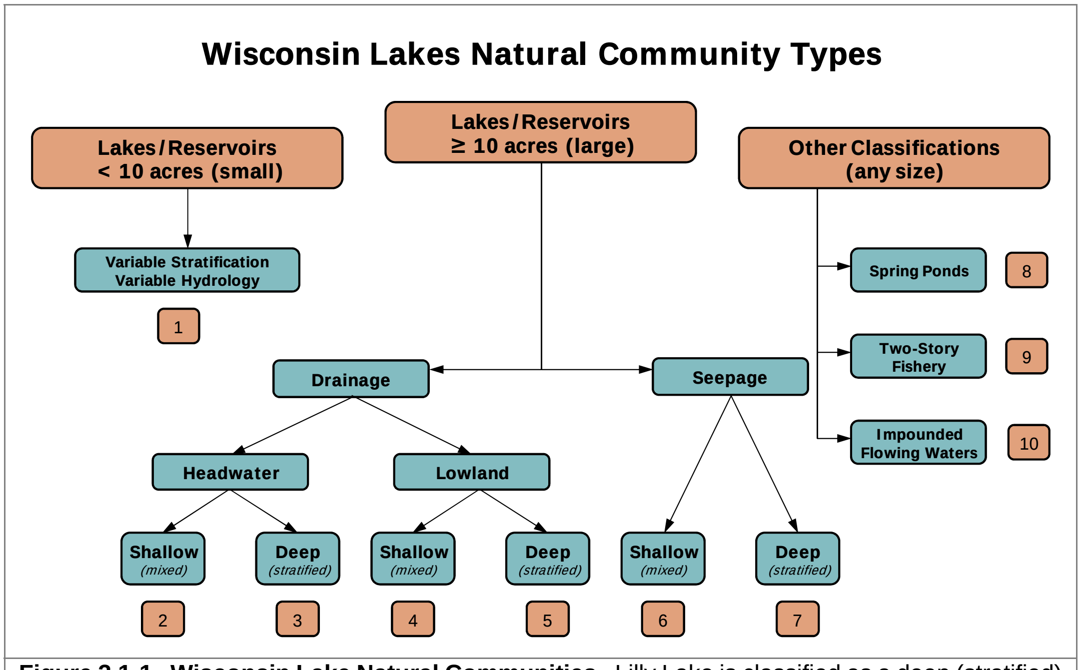


Figure 3.1-1. Wisconsin Lake Natural Communities. Lilly Lake is classified as a deep (stratified) seepage lake (Category 7). Adapted from WDNR 2017.

Garrison et al. 2008 developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for six of the lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state's ecoregions, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.1-2). Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Lilly Lake is within the Southeastern Wisconsin Till Plains (SWTP) ecoregion of Wisconsin (Figure 3.1-2).

The Wisconsin Consolidated Assessment and Listing Methodology document also helps stakeholders understand the health of their lake compared to other lakes within the state. Looking at pre-settlement diatom population compositions from sediment cores collected from numerous lakes around the state, they were able to infer a reference condition for each lake's water quality prior to human development within their watersheds. Using these reference conditions and current water quality data, the assessors were able to rank phosphorus, chlorophyll-*a*, and Secchi disk transparency values for each lake class into categories ranging from excellent to poor.

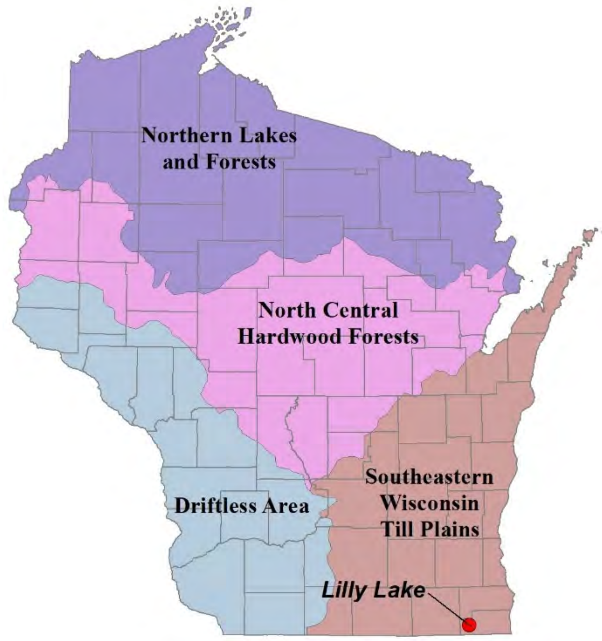


Figure 3.1-2. Location of Lilly Lake within the ecoregions of Wisconsin. After Nichols 1999.

These data along with data corresponding to statewide natural lake means, historical, current, and average data from Lilly Lake are displayed and discussed in the subsequent section. *Growing season* refers to data collected at any time between April and October, while *summer* refers to data collected in June, July, or August. These data were collected from near-surface samples as these represent the depths at which algae grow. The historical and current data presented in this section were collected by a combination of Lilly Lake volunteers through the WDNR Citizens Lake Monitoring Network and WDNR staff. Onterra did not collect any water quality data as part of this project.

Lilly Lake Water Quality Analysis

Limiting Plant Nutrient Lilly Lake

Using 2020 mid-summer nitrogen and phosphorus concentrations from Lilly Lake, a nitrogen:phosphorus ratio of 50:1 was calculated. This indicates that Lilly Lake is phosphorus limited, as are most of Wisconsin's lakes. In general, this means that phosphorus is the primary nutrient regulating algal growth within the lake, and increases in phosphorus will likely result in increased algal production and lower water clarity. Conservation of Lilly Lake's water quality means limiting anthropogenic sources of phosphorus to these lakes (i.e., shoreland development and runoff).

Total Phosphorus

Near-surface total phosphorus (TP) data from Lilly Lake are available from 1978-1982, 1998, 2002, and 2013-2020 (Figure 3.1-3). The data collected from 1978-1982 were collected as part of a two-year dredging project which removed 683,000 m^3 of sediment and deepened the maximum depth of lake from 6 to 22 feet (Dunst et al. 1984). During dredging in 1978 and 1979, TP concentrations increased due to sediment disturbance. Following dredging, phosphorus concentrations declined over the period from 1980-1982.

The weighted average TP concentration from 1998-2020 was 14.4 µg/L, falling into the *excellent* category for Wisconsin's deep seepage lakes (Figure 3.1-3). Summer TP concentrations in 2020 averaged 13.9 µg/L. Lilly Lake's average summer TP concentrations are slightly lower than the median concentration for Wisconsin's deep seepage lakes (15.0 µg/L) and significantly lower than the median TP concentration for lakes within the SWTP ecoregion (22.0 µg/L). While annual TP concentrations have been somewhat variable from 2013-2020, regression analysis indicated that there are no statistically valid trends (positive or negative) in growing season or summer TP concentrations over the period from 2013-2020 in Lilly Lake.

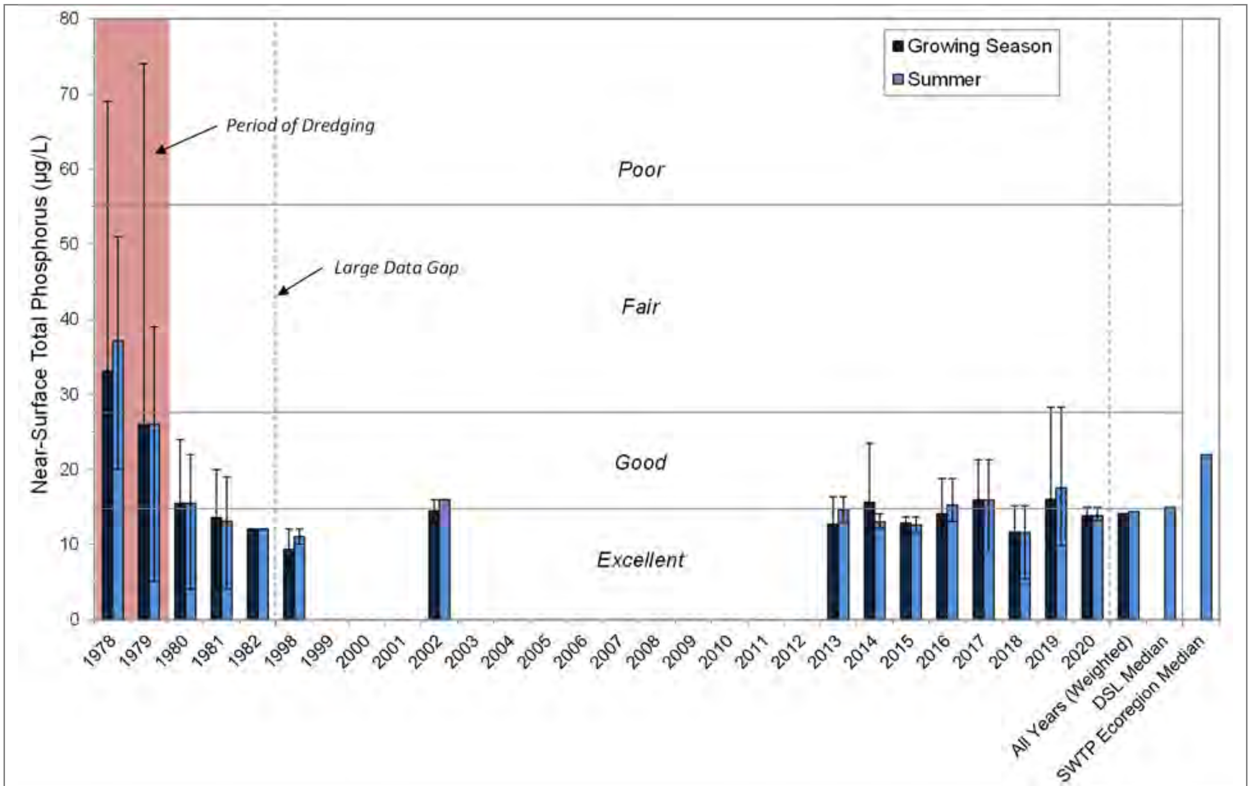


Figure 3.1-3. Lilly Lake average annual near-surface total phosphorus concentrations and median near-surface total phosphorus concentrations for statewide deep seepage lakes (DSL) and Southeast Wisconsin Till Plains (SWTP) ecoregion lakes. Weighted average calculated using data from 1998-2020. Phosphorus criteria for Wisconsin DSL lakes (WisCALM) displayed at right. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Chlorophyll-α

Chlorophyll-*a* concentrations, a measure of phytoplankton abundance, are available from Lilly Lake over the same time periods as TP (Figure 3.1-4). Like TP, chlorophyll-*a* concentrations were higher in 1978 and 1979, likely due to the increased level of nutrients that resulted from dredging. From 1998-2020, the weighted average summer chlorophyll-*a* concentration was 2.6 µg/L, falling into the *excellent* category for Wisconsin's deep seepage lakes. Lilly Lake's weighted average summer chlorophyll-*a* concentration is lower than the median concentration for Wisconsin's deep seepage lakes (3.6 µg/L) and for all lake types within the SWTP ecoregion (5.3 µg/L). Average summer chlorophyll-*a* concentrations were near average at 2.7 µg/L. Despite no detectable decreasing trend in phosphorus, there has been a slight decreasing trend in chlorophyll-*a* concentrations from 2013-2020. This may be due to changes in water levels, water temperatures, or a combination of these and other factors over this period.

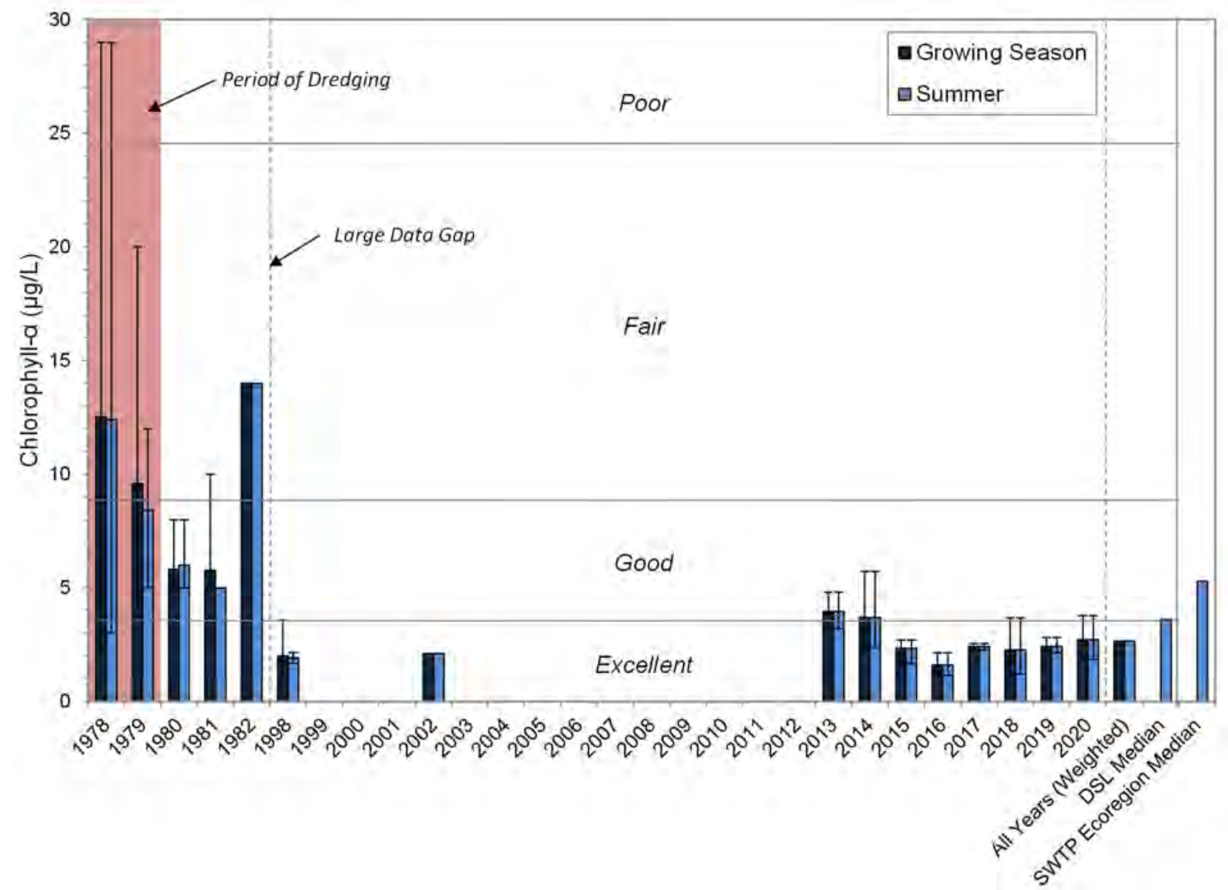


Figure 3.1-4. Lilly Lake average chlorophyll-α concentrations and median chlorophyll-α concentrations for statewide deep seepage lakes (DSL) and Southeast Wisconsin Till Plains (SWTP) ecoregion lakes. Weighted average calculated using data from 1998-2020. Chlorophyll criteria for Wisconsin DSL lakes (WisCALM) displayed at right. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Water Clarity

Water clarity monitoring using Secchi disk depths has been conducted in Lilly Lake in 1998, 2002, and 2012-2020 (Figure 3.1-5). Average summer Secchi disk depths have ranged from 10.5 feet in 2002 to 14.4 fee in 1998. The weighted summer average Secchi disk depth over this period was 11.9 feet, falling into the excellent category for Wisconsin's deep seepage lakes. Lilly Lake's average summer Secchi disk depth is higher than the median depth for Wisconsin's deep seepage lakes (11.2 feet) and the median depth for all lake types within the SWTP ecoregion (6.6 feet). The average growing season Secchi disk depth in 2020 was 14.7 feet while the average summer depth was 12.5 feet. On average, water clarity in Lilly Lake is highest in the spring and fall and lowest in mid-summer. Regression analysis revealed a slight increasing trend in growing season water clarity from 2012-2020. This increasing trend in water clarity corresponds to the decreasing trend measured in chlorophyll-*a* concentrations over this same period.

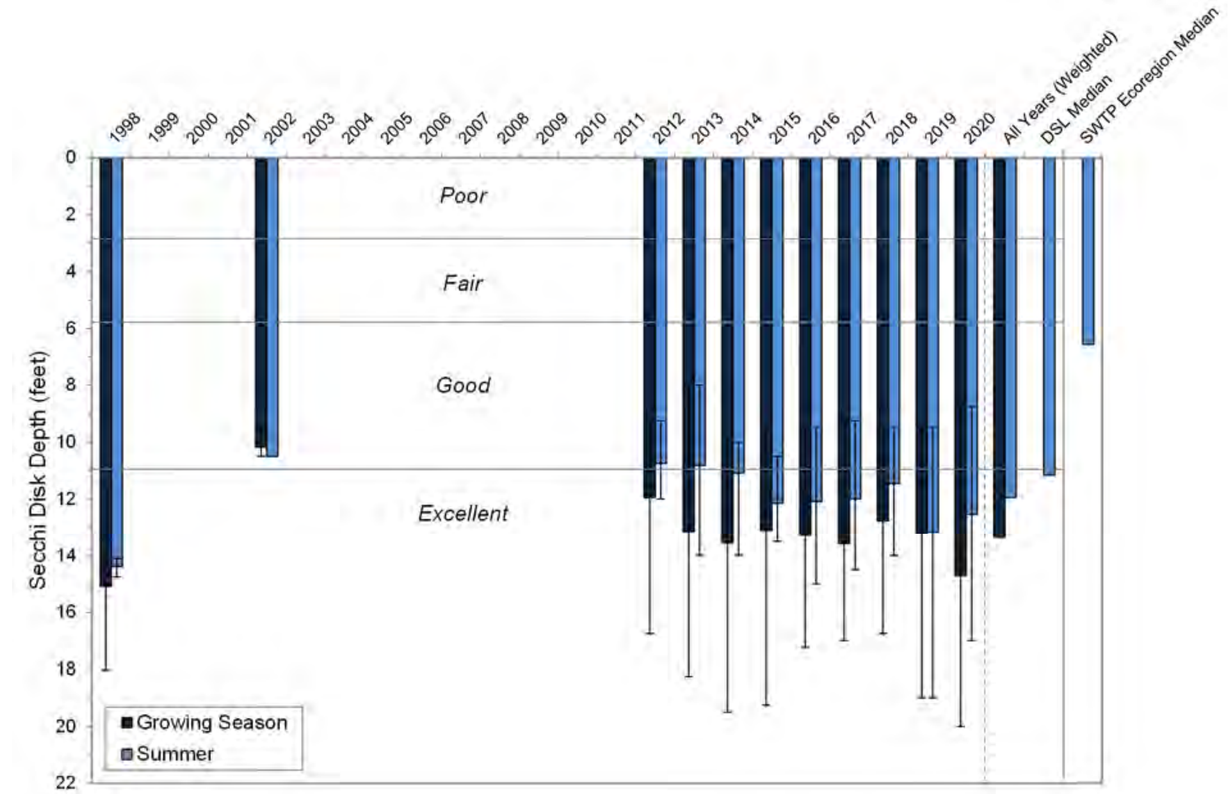


Figure 3.1-5. Lilly Lake average Secchi disk depths and median Secchi disk depths for statewide deep seepage lakes (DSL) and Southeast Wisconsin Till Plains (SWTP) ecoregion lakes. Weighted average calculated using data from 1998-2020. Secchi disk criteria for Wisconsin DSL lakes (WisCALM) displayed at right. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Lilly Lake Trophic State

The Trophic State Index (TSI) values for Lilly Lake were calculated using current and historical summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data (Figure 3.1-6). In general, the best values to use in judging a lake's trophic state are the biological parameters of total phosphorus and chlorophyll-*a* as Secchi disk transparency can be influenced by factors other than algae (e.g., dissolved organic material).

The data from Lilly Lake indicate that from 2013-2020, the lake has fluctuated between upper-oligotrophic to lower-mesotrophic. Based on the weighted mean from this time period, Lilly Lake can currently be classified as being in an oligo-mesotrophic state, and its productivity is lower when compared to Wisconsin's deep seepage lakes and all lake types within the SWTP ecoregion. In the late-1970s during the dredging of bottom sediments, due to higher levels of nutrients and algae, Lilly Lake would have been considered eutrophic.

The closer the TSI values for phosphorus, chlorophyll, and Secchi disk are to one another indicates a higher degree of correlation between these parameters. In some years, the TSI value for chlorophyll is lower than that for phosphorus, indicating chlorophyll concentrations are lower than expected given the concentration of phosphorus. Algal production in Lilly Lake is also likely limited by direct and indirect factors from the lake's aquatic plant community. As is discussed in the Aquatic Plant Section (Section 3.3), Lilly Lake supports abundant aquatic plant growth throughout most of the lake. Aquatic plants provide zooplankton, small planktonic crustaceans which feed on algae, refuge from predatory fish. The abundance of aquatic plants in Lilly Lake likely harbor a robust zooplankton community which feed upon and limit the growth of algae. In addition, the leaves and stems of aquatic plants also provide habitat for periphyton, a mixture of algae and other microbes which attach to aquatic plants and obtain nutrients from the water before they can be utilized by free-floating algal species. For these reasons, maintaining a healthy aquatic plant community in Lilly Lake is essential for maintaining the lake's excellent water quality.

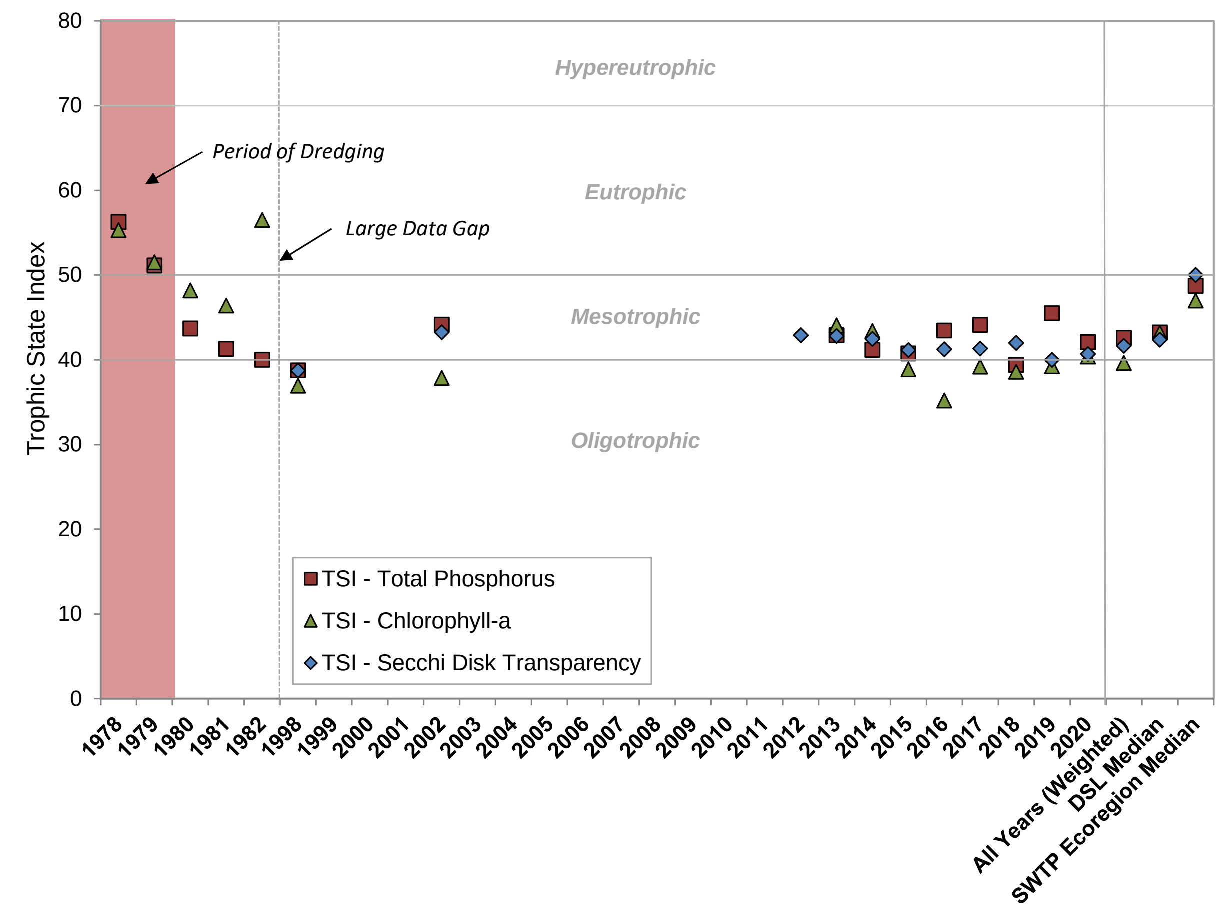


Figure 3.1-6. Lilly Lake Trophic State Index (TSI). Values calculated with summer month surface sample data using WDNR PUB-WT-193. Lilly Lake weighted average calculated using data from 1998-2020.

Temperature and Stratification in Lilly Lake

Temperature profiles were collected by the Lilly Lake Citizens Lake Monitoring Network volunteer on 11 occasions from April through September of 2020 (Figure 3.1-7). The temperature profile data showed that in late April, water temperatures were uniform from the surface to bottom, indicating spring mixing was occurring. By mid-May, the lake began to stratify with increasing surface water temperatures. The lake was clearly stratified at the end of May with a defined epilimnion, metalimnion, and hypolimnion and an approximately 4°C difference in surface and near-bottom water temperatures.

Surface water temperatures continued to warm through the end of July, while temperatures near the bottom remained relatively constant through mid-July. By the end of July, near-bottom temperatures had warmed, indicating warmer surface waters were beginning to mix down into deeper areas. In August, there was only a 1°C difference between surface and near-bottom water temperatures. In early September, water temperatures were relatively uniform from the surface to the bottom, indicating mixing of the of entire water column.

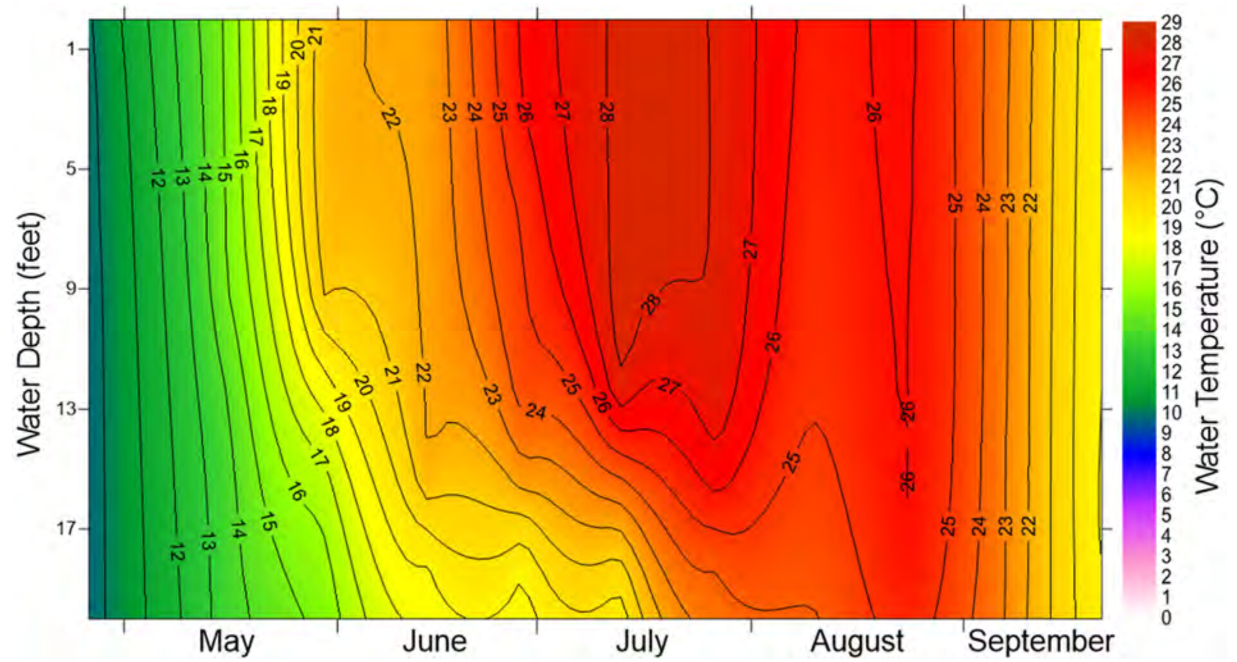


Figure 3.1-7. Lilly Lake 2020 temperature isopleth. Created using temperature profile data collected by Lilly Lake CLMN volunteer.

These temperature data indicate that Lilly Lake does not maintain thermal stratification over the course of the summer. While the lake was stratified from late-May through July, by August water temperatures were uniform throughout the water column indicating mixing. The Osgood Index (Osgood 1988) is used to determine the probability that a lake will remain stratified during the summer. This probability is estimated using the ratio of the lake's mean depth to its surface area.

Lakes with an Osgood Index of less than 4.0 are deemed polymictic, meaning they are too shallow to develop thermal stratification. Lakes with an Osgood Index value of greater than 8.0 are deemed dimictic, meaning they develop and maintain thermal stratification during the summer and do not mix until fall turnover. Lakes with an Osgood Index between 4.0 and 8.0 are deemed *intermediate*, meaning they are deep enough to develop thermal stratification but also have the capacity to periodically mix during the summer. Lilly Lake has an Osgood Index of 5.7, indicating its mixis type is intermediate, and this designation is supported by the 2020 temperature profile data.

3.2 Watershed Delineation

Two aspects of a lake's watershed are the key factors in determining the amount of phosphorus the watershed exports to the lake: 1) the size of the watershed, and 2) the land cover (land use) within the watershed. The impact of the watershed size is dependent on how large it is relative to the size of the lake. The watershed to lake area ratio (WS:LA) defines how many acres of watershed drains to each surface-acre of the lake. Larger ratios result in the watershed having a greater role in the lake's annual water budget and phosphorus load.

The type of land cover that exists in the watershed determines the amount of phosphorus (and sediment) that runs off the land and eventually makes its way to the lake. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to permeate the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas, minimize infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased phosphorus and pollutant loading which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations. For these reasons, it is important to maintain as much natural land cover (forests, wetlands, etc.) as possible within a lake's watershed to minimize the amount runoff (nutrients, sediment, etc.) from entering the lake.

In systems with lower WS:LA ratios, land cover type plays a very important role in how much phosphorus is loaded to the lake from the watershed. In these systems, the occurrence of agriculture or urban development in even a small percentage of the watershed (less than 10%) can unnaturally elevate phosphorus inputs to the lake. If these land cover types are converted to a cover that does not export as much phosphorus, such as converting row crop areas to grass or forested areas, the phosphorus load and its impacts to the lake may be decreased. In fact, if the phosphorus load is reduced greatly, changes in lake water quality may be noticeable, (e.g., reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

In systems with high WS:LA ratios, like those 10-15:1 or higher, the impact of land cover may be tempered by the sheer amount of land draining to the lake. Situations actually occur where lakes with completely forested watersheds have sufficient phosphorus loads to support high rates of algal production. In other systems with high ratios, the conversion of vast areas of row crops to vegetated areas (grasslands, meadows, forests, etc.) may not reduce phosphorus loads sufficiently to see a change in plant production. Both of these situations occur frequently in impoundments.

Regardless of the size of the watershed or the makeup of its land cover, it must be remembered that every lake is different and other factors, such as flushing rate, lake volume, sediment type, and many others, also influence how the lake will react to what is flowing into it. For instance, a deeper lake with a greater volume can dilute more phosphorus within its waters than a less voluminous lake and as a result, the production of a lake is kept low. However, in that same lake, because of its low flushing rate (a residence time of years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time and lead to a problem such as internal nutrient loading. On the contrary, a lake with a higher flushing rate (low residence time, i.e., days or weeks) may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

Lilly Lake Watershed

Being a seepage lake with no tributary inflow, Lilly Lake has a small watershed of 128 acres, yielding a watershed to lake area ratio of just 0.5:1 (Figure 3.2-1 and Map 2). This means that there are 0.5 acres of land draining to every 1.0 acre of Lilly Lake. The watershed to lake area ratio is exceptionally small, meaning that small changes in land use within the watershed have the potential to create significant changes to the lake's water quality.

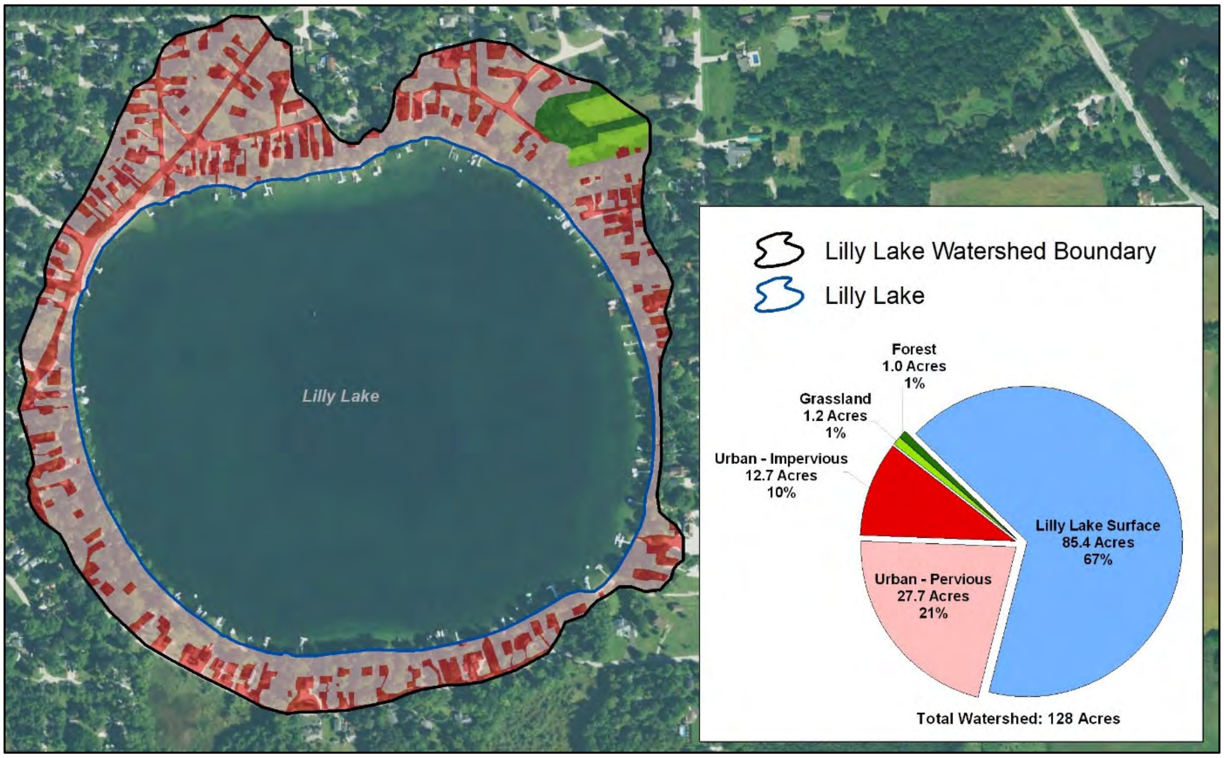


Figure 3.2-1. Lilly Lake watershed and land cover types. Watershed boundary delineated using Kenosha County 2017 1-foot DEM LIDAR data. Land cover determined using 2018 NAIP aerial imagery.

Using 2018 aerial imagery, the land cover within Lilly Lake's watershed was delineated. Approximately 67% of the watershed is comprised of the lake surface itself, 31% is comprised of urban development, 1% is comprised of forest, and 1% is comprised of grassland. The land within the surficial watershed is highly developed, primarily comprised of impervious urban areas (i.e., roads, driveways, homes, etc.) and pervious urban areas (lawns, etc.) (Figure 3.2-2). Small areas of more natural land cover including grassland and forest account for just 2% of the watershed. Despite the high degree of urban development within Lilly Lake's watershed, the lake's water quality is overall excellent for Wisconsin's deep seepage lakes. While there have likely been impacts and changes to the lake's water quality following development of the watershed, the fact most of the lake's water originates from groundwater is likely why water quality remains high. However, given the high degree of development within the watershed and along the lake's shoreline, efforts should be made to restore areas of the shoreline and immediate watershed to improve habitat and protect water quality.

As of a law passed in 2010, lawn fertilizers can no longer contain phosphorus. While this phosphorus ban is reducing phosphorus inputs to lakes, lawn fertilizers still contain other essential nutrients, such as nitrogen, which can fuel aquatic plant growth. Rooted aquatic plants, like most of those found in Lilly Lake, obtain phosphorus and nitrogen from the sediment. While lawn fertilizers may not be contributing phosphorus to Lilly Lake, they are likely contributing nitrogen and other nutrients which may bolster near-shore aquatic plant growth. In addition, herbicides and pesticides may also leach into Lilly Lake following application on shoreline lawns. The following section discusses some best management practices lakeshore property owners can implement to help improve lake habitat and water quality.

Wisconsin's Healthy Lakes & Rivers Action Plan

Starting in 2014, a program was enacted by the WDNR and UW-Extension to promote riparian landowners to implement relatively straight-forward shoreland restoration activities. This program provides education, guidance, and grant funding to promote installation of best management practices aimed to protect and restore lakes and rivers in Wisconsin. The program has identified five best practices aimed at improving habitat and water quality (Figure 3.2-2).

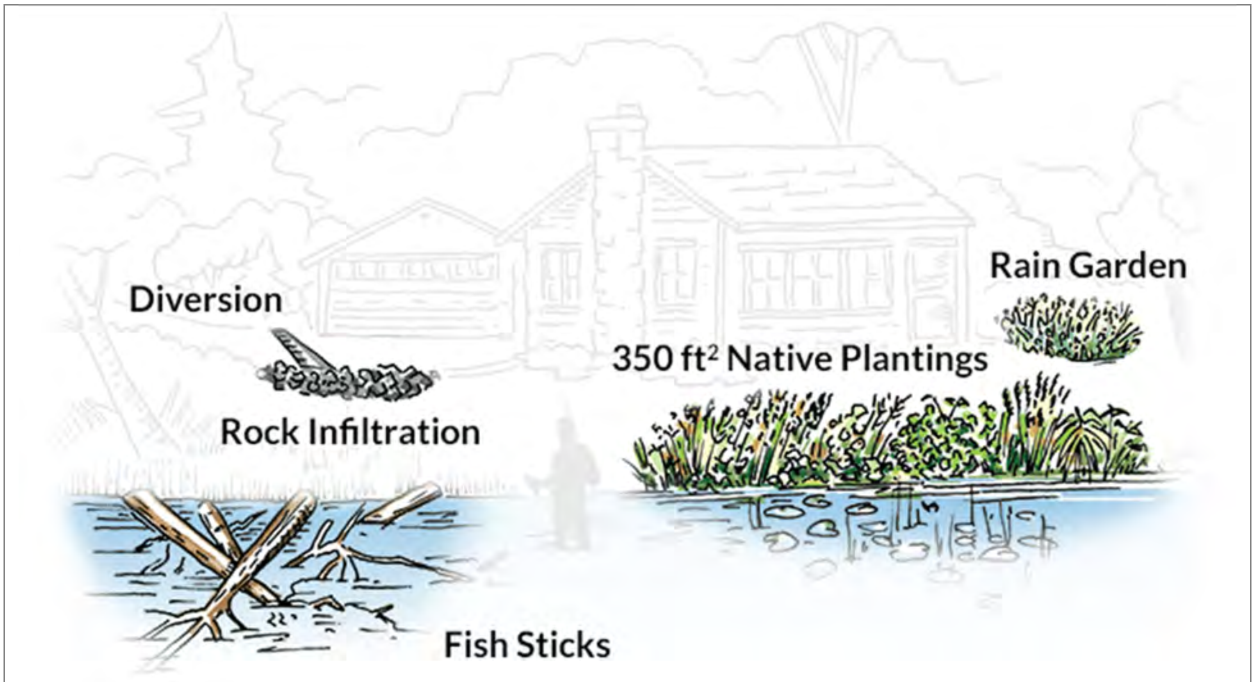


Figure 3.2-2. Healthy Lakes & Rivers 5 Best Practices. Illustration by Karen Engelbretson, extracted from healthylakeswi.com.

- Rain Gardens: This upland best practice consists of a landscaped and vegetated shallow depression aimed at capturing water runoff and allowing it to infiltrate into the soil.
- Rock Infiltration: This upland best practice is an excavated pit or trench, filled with rock, that encourages water to infiltrate into the soil. These practices are strategically placed at along a roof line or the downward sloping area of a driveway.
- Diversion: This best practice can occur in the transition or upland zone. These practices use berms, trenches, and/or treated lumber to redirect water that would otherwise move downhill into a lake. Water diversions may direct water into a Rock Infiltration or Rain Garden to provide the greatest reductions in runoff volumes.
- Native Plantings: This best practice aims to installing native plants within at least 350 square-foot shoreland transition area. This will slow runoff water and provide valuable habitat. One native planting per property per year is eligible.
- Fish Sticks: These in-lake best practices (not eligible for rivers) are woody habitat structures that provide feeding, breeding, and nesting areas for wildlife. Fish sticks consist of multiple whole trees grouped together and anchored to the shore. Trees are not felled

from the shoreline, as existing trees are valuable in place, but brought from a short distance or dragged across the ice. In order for this practice to be eligible, an existing vegetated buffer or pledge to install one is required.

The Healthy Lakes and Rivers Grant Program allows partial cost coverage for implementing best practices. Competitive grants are available to eligible applicants such as lake associations and lake districts. The program allows a 75% state cost share up to $1,000 per practice. Multiple practices can be included per grant application, with a $25,000 maximum award per year. Eligible projects need to be on shoreland properties within 1,000 feet of a lake or 300 feet from a river. The landowner must sign a Conservation Commitment pledge to leave the practice in place and provide continued maintenance for 10 years. More information on this program can be found here:

https://healthylakeswi.com/

It is important to note that this grant program is intentionally designed for relatively simple, low-cost, and shovel-ready projects, limiting 10% of the grant award for technical assistance. Larger and more complex projects, especially those that require engineering design components may seek alternative funding sources potentially through the County. Small-Scale Lake Planning Grants can provide up to $3,000 to help build a Healthy Lakes and Rivers project. Eligible expenses in this grant program are surveys, planning, and design.

3.3 Aquatic Plants

Introduction

Although the occasional lake user considers aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, the plants are actually an essential element in a healthy and functioning lake ecosystem. It is very important that lake stakeholders understand the importance of lake plants and the many functions they serve in maintaining and protecting a lake ecosystem. With increased understanding and awareness, most lake users will recognize the importance of the aquatic plant community and their potential negative effects on it.

Photograph 3.3-1. Example of emergent and floating-leaf communities.

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*). In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the periphyton attached to them as their primary food source. The plants also provide cover for feeder fish and zooplankton, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreland erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas where plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by phytoplankton, which helps to minimize nuisance algal blooms.

Under certain conditions, a few species may become a problem and require control measures. Excessive plant growth can limit recreational use by deterring navigation, swimming, and fishing activities. It can also lead to changes in fish population structure by providing too much cover for feeder fish resulting in reduced predation by predator fish, which could result in a stunted pan-fish population. Exotic plant species, such as Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing native plants and reducing species diversity. These species will be discussed further in depth in the Aquatic Invasive Species section. These invasive plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

When plant abundance negatively affects the lake ecosystem and limits the use of the resource, plant management and control may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods. No aquatic plant management plan should only contain methods to control plants, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

Aquatic Plant Management and Protection

Many times, an aquatic plant management plan is aimed at only controlling nuisance plant growth that has limited the recreational use of the lake, usually navigation, fishing, and swimming. It is important to remember the vital benefits that native aquatic plants provide to lake users and the lake ecosystem, as described above. Therefore, all aquatic plant management plans also need to address the enhancement and protection of the aquatic plant community. Below are general descriptions of the many techniques that can be utilized to control and enhance aquatic plants. Each alternative has benefits and limitations that are explained in its description. Please note that only legal and commonly used methods are included. For instance, the herbivorous grass carp (*Ctenopharyngodon idella*) is illegal in Wisconsin and rotovation,, a process by which the lake bottom is tilled, is not a commonly accepted practice. Unfortunately, there are no "silver bullets" that can completely cure all aquatic plant problems, which makes planning a crucial step in any aquatic plant management activity. Many of the plant management and protection techniques commonly used in Wisconsin are described below.

Important Note:
Even though most of these techniques are not applicable to Lilly Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake**.** The techniques applicable to Lilly Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now, including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that 30 feet. This action can be conducted up to 150 feet from shore. Please note that a permit is needed in all instances if wild rice is to be removed. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR.

Permits are required for chemical and mechanical manipulation of native and non-native plant communities. Large-scale protocols have been established for chemical treatment projects covering >10 acres or areas greater than 10% of the lake littoral zone and more than 150 feet from shore. Different protocols are to be followed for whole-lake scale treatments (≥160 acres or ≥50% of the lake littoral area). Additionally, it is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Manual Removal

Photograph 3.3-2. Example of aquatic plants that have been removed manually.

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however Wisconsin law states that all plant fragments must be removed. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The raking method entails the use of a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the undesired plants.

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width. Please note that the use of powered cutters may require a mechanical harvesting permit to be issued by the WDNR.

When using the methods outlined above, it is very important to remove all plant fragments from the lake to prevent re-rooting and drifting onshore followed by decomposition. It is also important to preserve fish spawning habitat by timing the treatment activities after spawning. In Wisconsin, a general rule would be to not start these activities until after June 15th.

Cost

Commercially available hand-cutters and rakes range in cost from $85 to $150. Power-cutters range in cost from $1,200 to $11,000.

Advantages	*Disadvantages*
• Very cost effective for clearing areas around docks, piers, and swimming areas. • Relatively environmentally safe if treatment is conducted after June 15th. • Allows for selective removal of undesirable plant species. • Provides immediate relief in localized area. • Plant biomass is removed from waterbody.	• Labor intensive. • Impractical for larger areas or dense plant beds. • Subsequent treatments may be needed as plants recolonize and/or continue to grow. • Uprooting of plants stirs bottom sediments making it difficult to conduct action. • May disturb benthic organisms and fish-spawning areas.

	• Risk of spreading invasive species if fragments are not removed.

Bottom Screens

Bottom screens are very much like landscaping fabric used to block weed growth in flowerbeds. The gas-permeable screen is placed over the plant bed and anchored to the lake bottom by staking or weights. Only gas-permeable screen can be used or large pockets of gas will form under the mat as the result of plant decomposition. This could lead to portions of the screen becoming detached from the lake bottom, creating a navigational hazard. Normally the screens are removed and cleaned at the end of the growing season and then placed back in the lake the following spring. If they are not removed, sediments may build up on them and allow for plant colonization on top of the screen. Please note that depending on the size of the screen a Wisconsin Department of Natural Resources permit may be required.

Cost

Material costs range between $.20 and $1.25 per square-foot. Installation cost can vary largely, but may roughly cost $750 to have 1,000 square feet of bottom screen installed. Maintenance costs can also vary, but an estimate for a waterfront lot is about $120 each year.

Advantages	*Disadvantages*
• Immediate and sustainable control. • Long-term costs are low. • Excellent for small areas and around obstructions. • Materials are reusable. • Prevents fragmentation and subsequent spread of plants to other areas.	• Installation may be difficult over dense plant beds and in deep water. • Not species specific. • Disrupts benthic fauna. • May be navigational hazard in shallow water. • Initial costs are high. • Labor intensive due to the seasonal removal and reinstallation requirements. • Does not remove plant biomass from lake. • Not practical in large-scale situations.

Water Level Drawdown

The primary manner of plant control through water level drawdown is the exposure of sediments and plant roots/tubers to desiccation and either heating or freezing depending on the timing of the treatment. Winter drawdowns are more common in temperate climates like that of Wisconsin and usually occur in reservoirs because of the ease of water removal through the outlet structure. An important fact to remember when considering the use of this technique is that only certain species are controlled and that some species may even be enhanced. Furthermore, the process will likely need to be repeated every two or three years to keep target species in check.

Cost

The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive. If a hydro-electric facility is operating on the system, the costs associated with loss of production during the drawdown also need to be considered, as they are likely cost prohibitive to conducting the management action.

Advantages	*Disadvantages*
• Inexpensive if outlet structure exists. • May control populations of certain species, like Eurasian watermilfoil for a few years. • Allows some loose sediment to consolidate, increasing water depth. • May enhance growth of desirable emergent species. • Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.	• May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant effects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed and reed canary grass. • Permitting process may require an environmental assessment that may take months to prepare. • Non-selective.

Mechanical Harvesting

Photograph 3.3-3. Mechanical harvester.

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 6 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor. Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the latter route is chosen, it is especially important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Cost

Equipment costs vary with the size and features of the harvester, but in general, standard harvesters range between $45,000 and $100,000. Larger harvesters or stainless-steel models may cost as much as $200,000. Shore conveyors cost approximately $20,000 and trailers range from $7,000 to $20,000. Storage, maintenance, insurance, and operator salaries vary greatly.

Advantages	***Disadvantages***
• Immediate results. • Plant biomass and associated nutrients are removed from the lake. • Select areas can be treated, leaving sensitive areas intact. • Plants are not completely removed and can still provide some habitat benefits. • Opening of cruise lanes can increase predator pressure and reduce stunted fish populations. • Removal of plant biomass can improve the oxygen balance in the littoral zone. • Harvested plant materials produce excellent compost.	• Initial costs and maintenance are high if the lake organization intends to own and operate the equipment. • Multiple treatments are likely required. • Many small fish, amphibians and invertebrates may be harvested along with plants. • There is little or no reduction in plant density with harvesting. • Invasive and exotic species may spread because of plant fragmentation associated with harvester operation. • Bottom sediments may be re-suspended leading to increased turbidity and water column nutrient levels.

Herbicide Treatment

The use of herbicides to control aquatic plants and algae is a technique that is widely used by lake managers. Traditionally, herbicides were used to control nuisance levels of aquatic plants and algae that interfere with navigation and recreation. While this practice still takes place in many parts of Wisconsin, the use of herbicides to control aquatic invasive species is becoming more prevalent. Resource managers employ strategic management techniques towards aquatic invasive species, with the objective of reducing the target plant's population over time; and an overarching goal of attaining long-term ecological restoration.

For submergent vegetation, this largely consists of implementing control strategies early in the growing season; either as spatially-targeted, small-scale spot treatments or low-dose, large-scale (whole lake) treatments. Treatments occurring roughly each year before June 1 and/or when water temperatures are below 60°F can be less impactful to many native plants, which have not emerged yet at this time of year. Emergent species are targeted with foliar applications at strategic times of the year when the target plant is more likely to absorb the herbicide.

While there are approximately 300 herbicides registered for terrestrial use in the United States, only 13 active ingredients can be applied into or near aquatic systems. All aquatic herbicides must be applied in accordance with the product's US Environmental Protection Agency (EPA) approved label. There are numerous formulations and brands of aquatic herbicides and an extensive list can be found in Appendix F of (Gettys, Haller and (eds) 2009).

Applying herbicides in the aquatic environment requires special considerations compared with terrestrial applications. WDNR administrative code states that a permit is required if, "you are standing in socks and they get wet." In these situations, the herbicide application needs to be completed by an applicator licensed with the Wisconsin Department of Agriculture, Trade and Consumer Protection. All herbicide applications conducted under the ordinary high water mark require herbicides specifically labeled by the United States Environmental Protection Agency

Aquatic herbicides can be classified in many ways. Organization of this section follows Netherland (2009) in which mode of action (i.e. how the herbicide works) and application techniques (i.e. foliar or submersed treatment) group the aquatic herbicides. The table below provides a general list of commonly used aquatic herbicides in Wisconsin and is synthesized from Netherland (2009).

The arguably clearest division amongst aquatic herbicides is their general mode of action and fall into two basic categories:

1. Contact herbicides act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but in some plants does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides act slower than contact herbicides, being transported throughout the entire plant and disrupting biochemical pathways which often result in complete mortality.

General Mode of Action		Compound	Specific Mode of Action	Most Common Target Species in Wisconsin
Contact		Copper	plant cell toxicant	Algae, including macro-algae (i.e. muskgrasses & stoneworts)
		Endothall	Inhibits respiration & protein synthesis	Submersed species, largely for curly-leaf pondweed; Eurasian water milfoil control when mixed with auxin herbicides
		Diquat	Inhibits photosynthesis & destroys cell membranes	Nusiance natives species including duckweeds, targeted AIS control when exposure times are low
Systemic	Auxin Mimics	2,4-D	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
		Triclopyr	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
	In Water Use Only	Fluridone	Inhibits plant specific enzyme, new growth bleached	Submersed species, largely for Eurasian water milfoil
	Enzyme Specific (ALS)	Penoxsulam	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
		Imazamox	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
	Enzyme Specific (foliar use only)	Glyphosate	Inhibits plant-specific enzyme (ALS)	Emergent species, including purple loosestrife
		Imazapyr	Inhibits plant-specific enzyme (EPSP)	Hardy emergent species, including common reed

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration and exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Much information has been gathered in recent years, largely as a result of an ongoing cooperative research project between the Wisconsin Department of Natural Resources, US Army Corps of Engineers Research and Development Center, and private consultants (including Onterra). This research couples quantitative aquatic plant monitoring with field-collected herbicide concentration data to evaluate efficacy and selectivity of control strategies implemented on a subset of Wisconsin lakes and flowages. Based on their preliminary findings, lake managers have adopted two main treatment strategies: 1) whole-lake treatments, and 2) spot treatments.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. This has been the strategy historically used on most Wisconsin systems.

Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (entire lake, lake basin, or within the epilimnion of the lake or lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. The application rate of a whole-lake treatment is dictated by the volume of water in which the herbicide will reach equilibrium. Because exposure time is so much longer, target herbicide levels for whole-lake treatments are significantly less than for spot treatments.

Cost

Herbicide application charges vary greatly between $400 and $1,500 per acre depending on the chemical used, who applies it, permitting procedures, and the size/depth of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • Herbicides can target large areas all at once. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian watermilfoil.	• All herbicide use carries some degree of human health and ecological risk due to toxicity. • Fast-acting herbicides may cause fish kills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them.

• Some herbicides can be used effectively in spot treatments. • Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g. mammals, insects)	• Many aquatic herbicides are nonselective. • Some herbicides have a combination of use restrictions that must be followed after their application. • Overuse of same herbicide may lead to plant resistance to that herbicide.

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as water hyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata),* respectively.

However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian watermilfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian watermilfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian watermilfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian watermilfoil.

Cost

Stocking with adult weevils costs about $1.20/weevil and they are usually stocked in lots of 1000 or more.

Advantages	***Disadvantages***
• Milfoil weevils occur naturally in Wisconsin. • Likely environmentally safe and little risk of unintended consequences.	• Stocking and monitoring costs are high. • This is an unproven and experimental treatment. • There is a chance that a large amount of money could be spent with little or no change in Eurasian watermilfoil density.

Wisconsin has approved the use of two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These beetles were imported from Europe and used as a biological control method for purple loosestrife. Many cooperators, such as county conservation departments or local UW-Extension locations, currently support large beetle rearing operations. Beetles are reared on live purple loosestrife plants growing in kiddy pools surrounded by insect netting. Beetles are collected with aspirators and then released onto the target wild population. For more information on beetle rearing, contact your local UW-Extension location.

In some instances, beetles may be collected from known locations (cella insectaries) or purchased through private sellers. Although no permits are required to purchase or release beetles within Wisconsin, application/authorization and release forms are required by the WDNR for tracking and monitoring purposes.

Cost

The cost of beetle release is very inexpensive, and in many cases is free.

Advantages	***Disadvantages***
• Extremely inexpensive control method. • Once released, considerably less effort than other control methods is required. • Augmenting populations many lead to long-term control.	• Although considered "safe," reservations about introducing one non-native species to control another exist. • Long range studies have not been completed on this technique.

Analysis of Current Aquatic Plant Data

Aquatic plants are an important element in every healthy lake. Changes in lake ecosystems are often first seen in the lake's plant community. Whether these changes are positive, such as variable water levels or negative, such as increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways. For example, there may be a loss of one or more species. Certain life forms, such as emergent or floating-leaf communities, may disappear from specific areas of the lake. A shift in plant dominance between species may also occur. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Lilly Lake; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the aquatic plant species, both native and non-native, that were located during the surveys completed in Lilly Lake in 2016. The list also contains the growth-form of each plant found (e.g. submergent, emergent, etc.), its scientific name, common name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in growth forms that are present, can be an early indicator of changes in the ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain aquatic plant species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of the whole-lake point-intercept survey completed on Lilly Lake, plant samples were collected from plots laid out on a grid that covered the lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. The occurrence of aquatic plant species is displayed as the *littoral frequency of occurrence*. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are within the maximum depth of plant growth (littoral zone), and is displayed as a percentage.

Floristic Quality Assessment

The floristic quality of a lake's aquatic plant community is calculated using its native *species richness* and their *average conservatism*. Species richness is the number of native aquatic plant species that were physically encountered on the rake during the point-intercept survey. Average conservatism is calculated by taking the sum of the coefficients of conservatism (C-values) of the native species located and dividing it by species richness. Every plant in Wisconsin has been assigned a coefficient of conservatism, ranging from 1-10, which describes the likelihood of that species being found in an undisturbed environment. Species which are more specialized and require undisturbed habitat are given higher coefficients, while species which are more tolerant of environmental disturbance have lower coefficients.

For example, algal-leaf pondweed (*Potamogeton confervoides*) is only found in nutrient-poor, acid lakes in northern Wisconsin and is prone to decline if degradation of these lakes occurs. Because of algal-leaf pondweed's special requirements and sensitivity to disturbance, it has a C-value of 10. In contrast, sago pondweed (*Stuckenia pectinata*) with a C-value of 3, is tolerant of disturbance and is often found in greater abundance in degraded lakes that have higher nutrient concentrations and low water clarity. Higher average conservatism values generally indicate a healthier lake as it is able to support a greater number of environmentally-sensitive aquatic plant species. Low average conservatism values indicate a degraded environment, one that is only able to support disturbance-tolerant species.

On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept surveys (equation shown below). This assessment allows the aquatic plant community of Lilly Lake to be compared to other lakes within the region and state.

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

Species Diversity

Species diversity is often confused with species richness. As defined previously, species richness is simply the number of species found within a given community. While species diversity utilizes species richness, it also takes into account evenness or the variation in abundance of the individual species within the community. For example, a lake with 10 aquatic plant species that had relatively similar abundances within the community would be more diverse than another lake with 10 aquatic plant species were 50% of the community was comprised of just one or two species.

An aquatic system with high species diversity is more stable than a system with a low diversity. This is analogous to a diverse financial portfolio in that a diverse aquatic plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. A lake with a diverse plant community is also better suited to compete against exotic infestations than a lake with a lower diversity. The diversity of a lake's aquatic plant community is determined using the Simpson's Diversity Index (1-D):

$$D = \sum (n/N)^2$$

where:
n = the total number of instances of a particular species
N = the total number of instances of all species and
D is a value between 0 and 1

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. The Simpson's Diversity Index value from Lilly Lake is compared to data collected by Onterra and the WDNR Science Services on 77 lakes withn the Southeast Wisconsin Till Plain ecoregion and on 392 lakes throughout Wisconsin.

Community Mapping

A key component of any aquatic plant community assessment is the delineation of the emergent and floating-leaf aquatic plant communities within each lake as these plants are often underrepresented during the point-intercept survey. This survey creates a snapshot of these important communities within each lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with future surveys. Examples of emergent plants include cattails, rushes, sedges, grasses, bur-reeds, and arrowheads, while examples of floating-leaf species include the water lilies. The emergent and floating-leaf aquatic plant communities in Lilly Lake were mapped using a Trimble Global Positioning System (GPS) with sub-meter accuracy.

Lilly Lake Aquatic Plant Survey Results

The first survey completed on Lilly Lake was an early-season aquatic invasive species (ESAIS) survey completed on June 4, 2020. The goal of this survey was to identify and assess any new or existing occurrences of invasive plant species in the lake, with a particular focus on species that are most likely to be observed at this time of year: curly-leaf pondweed and pale-yellow iris. During this survey, Onterra ecologists mapped areas of curly-leaf pondweed in Lilly Lake and also documented one occurrence of pale-yellow iris on the lake's eastern shore.

Hybrid watermilfoil, a cross between Eurasian and the native northern watermilfoil (verified in 2014), was also mapped during this survey to serve as a guide for mapping during the late-season AIS survey when hybrid watermilfoil is at its peak growth. During the 2020 surveys, additional non-native species were located including purple loosestrife, giant reed (*Phragmites*), reed canary grass, and narrow-leaved cattail. Given their ecological, sociological, and economic significance, the populations of these non-native plants in Lilly Lake are discussed in the subsequent Non-Native Aquatic Plants subsection.

The whole-lake point-intercept and emergent and floating-leaf plant community mapping surveys were conducted on Lilly Lake on July 31, 2020. The late-season AIS survey was completed on October 1, 2020. During these surveys, a total of 25 aquatic plant species were located, 18 of which are considered native to Wisconsin and seven of which are considered to be non-native, invasive species (Table 3.3-1). The species documented in Lilly Lake during surveys completed in 1967 and 2008 are also included in Table 3.3-1. The species recorded between the 2008 and 2020 surveys were relative similar. The completion of an emergent and floating-leaf plant mapping survey documented additional species growing in near-shore areas that were not documented in previous surveys. In total, 29 species have been recorded from Lilly Lake over the course of these three surveys.

Lakes in Wisconsin vary in their morphometry, water chemistry, substrate composition, and management, all factors which influence aquatic plant community composition. In July of 2020, Onterra ecologists completed an acoustic survey on Lilly Lake (bathymetric results on Map 1). The sonar-based technology records aquatic plant bio-volume, or the percentage of the water column that is occupied by aquatic plants at a given location. Data pertaining to Lilly Lake's substrate composition were also recorded during this survey. The sonar records substrate hardness, ranging from the hardest substrates (i.e., rock and sand) to the more flocculent, softer organic sediments.

Table 3.3-1. Aquatic plant species located in Lilly Lake during 1967, 2008, and 2020 aquatic plant surveys.

Growth Form	Scientific Name	Common Name	Status in Wisconsin	Coefficient of Conservatism	1967	2008	2020
Emergent	*Eleocharis erythropoda*	Bald spikerush	Native	3			I
	Iris pseudacorus	Pale-yellow iris	Non-Native Invasive	N/A			I
	Lythrum salicaria	Purple loosestrife	Non-Native - Invasive	N/A			I
	Phalaris arundinacea	Reed canary grass	Non-Native - Invasive	N/A			I
	Phragmites australis subsp. *australis*	Giant reed	Non-Native Invasive	N/A			I
	Schoenoplectus acutus	Hardstem bulrush	Native	5			I
	Schoenoplectus pungens	Three-square rush	Native	5			I
	Typha angustifolia	Narrow-leaved cattail	Non-Native Invasive	N/A			I
	Typha latifolia	Broad-leaved cattail	Native	1			I
Submergent	*Ceratophyllum demersum*	Coontail	Native	3	X	X	
	Chara spp.	Muskgrasses	Native	7	X	X	X
	Elodea canadensis	Common waterweed	Native	3	X		X
	Heteranthera dubia	Water stargrass	Native	6		X	X
	Myriophyllum sibiricum x M. spicatum	Hybrid watermilfoil	Non-Native - Invasive	N/A	X	X	X
	Najas flexilis	Slender naiad	Native	6	X	X	X
	Najas guadalupensis	Southern naiad	Native	7			X
	*Najas marina**	Spiny naiad	Non-Native - Potentially Invasive	N/A	X	X	
	Nitella spp.	Stoneworts	Native	7		X	
	Potamogeton amplifolius	Large-leaf pondweed	Native	7	X	I	
	Potamogeton crispus	Curly-leaf pondweed	Non-Native - Invasive	N/A			X
	Potamogeton gramineus	Variable-leaf pondweed	Native	7		I	
	Potamogeton illinoensis	Illinois pondweed	Native	6		I	X
	Potamogeton nodosus	Long-leaf pondweed	Native	5	X		I
	Potamogeton praelongus	White-stem pondweed	Native	8	X		X
	Potamogeton praelongus x P. amplifolius	White-stem x Large-leaf pondweed	Native	N/A			X
	Potamogeton robbinsii	Fern-leaf pondweed	Native	8		X	X
	Potamogeton strictifolius	Stiff pondweed	Native	8			X
	Potamogeton zosteriformis	Flat-stem pondweed	Native	6		X	X
	Stuckenia pectinata	Sago pondweed	Native	3	X	X	X
	Vallisneria americana	Wild celery	Native	6		X	X

X = Located on rake during point-intercept survey; I = Incidentally located; not located on rake during point-intercept survey
** = Observed but not verified*

Data regarding substrate hardness collected during the 2020 acoustic survey showed that substrate hardness varies widely in shallow areas of Lilly Lake with both the hardest and softest substrates in the lake occurring within 1 to 9 feet of water (Figure 3.3-1 and Map 3). Beyond 9 feet, substrate hardness was moderately soft. The shallow areas containing soft sediments were found to contain the highest biomass of aquatic plants (Figure 3.3-1 and Map 4), including the densest areas of hybrid watermilfoil (Map 14). Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in soft substrates, others only in sandy areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because of the different habitat types that are available.

The acoustic survey also recorded aquatic plant bio-volume throughout the entire lake. As mentioned earlier, aquatic plant bio-volume is the percentage of the water column that is occupied by aquatic plants. The 2020 aquatic plant bio-volume data are displayed in Figure 3.3-1 and Map 4. Areas where aquatic plants occupy most or all of the water column are indicated in red while areas of little to no aquatic plant growth are displayed in blue/black. The 2020 whole-lake point-intercept survey found aquatic plants growing to a maximum depth of 20 feet, slightly shallower than the maximum depth of 23 feet recorded in 2008. Aquatic plant abundance is high throughout all depths of the littoral zone. Aquatic plant growth is sparse in near-shore areas comprised of sand and in the deepest areas of the lake. Aquatic plants, mainly Eurasian watermilfoil, grew closest to the surface in near-shore areas comprised of soft organic sediments.

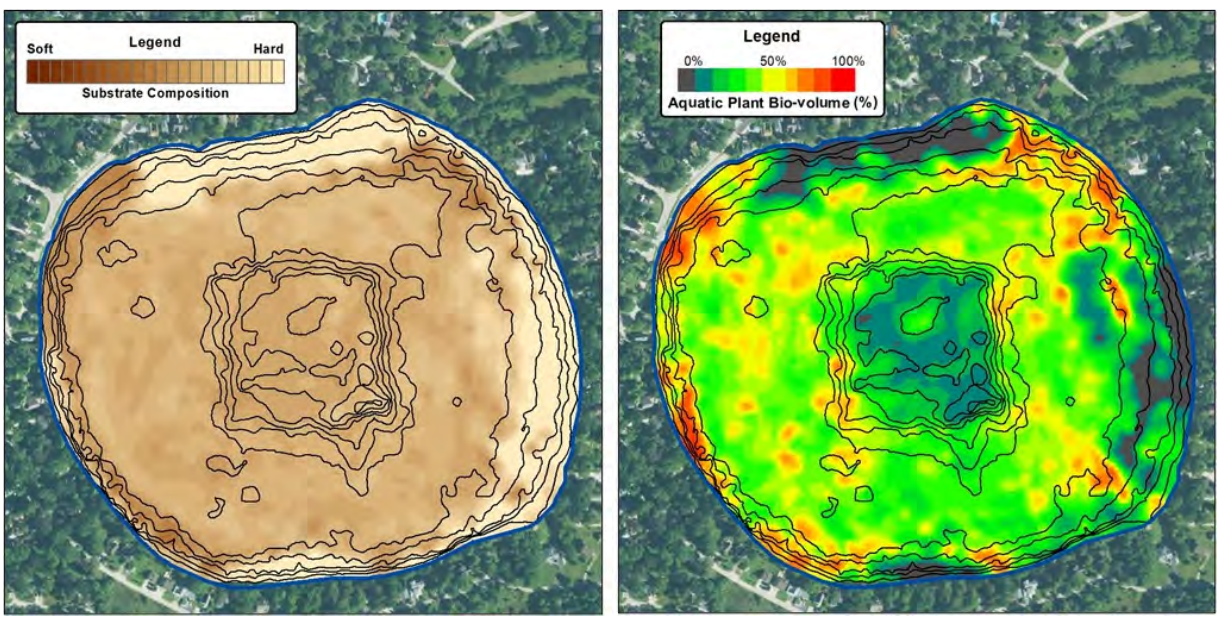


Figure 3.3-1. Lilly Lake spatial distribution of substrate hardness (left) and aquatic plant bio-volume (right). Created using data from July 2020 acoustic survey data. Contour lines represent two-foot increments.

As mentioned, aquatic plants were recorded growing to a maximum depth of 20 feet in 2020. Of the 213 point-intercept sampling locations that fell at or shallower than the maximum depth of plant growth (littoral zone), 207 (97%) contained aquatic vegetation. Aquatic plant rake fullness data collected in 2020 indicates that 9% of the 207 littoral sampling locations contained vegetation with a total rake fullness rating (TRF) of 1, 45% had a TRF rating of 2, and 43% had a TRF rating of 3 indicating aquatic plant biomass in Lilly Lake is high.

While the acoustic mapping is an excellent survey for understanding the distribution and levels of aquatic plant growth throughout the lake, this survey does not determine what aquatic plant species are present. Whole-lake point-intercept surveys are used to quantify the abundance of individual species within the lake. Of the 24 aquatic plant species located in Lilly Lake in 2020, 15 were encountered directly on the rake during the whole-lake point-intercept survey (Figure 3.3-2). The remaining nine species were located incidentally, meaning they were observed by Onterra ecologists while on the lake but they were not directly sampled on the rake at any of the point-intercept sampling locations. Incidental species typically include emergent and floating-leaf species that are often found growing on the fringes of the lake and submersed species that are relatively rare within the plant community. Of the 15 species directly sampled with the rake during the point-intercept survey, muskgrasses, fern-leaf pondweed, white-stem pondweed, and southern naiad were the four-most frequently encountered.

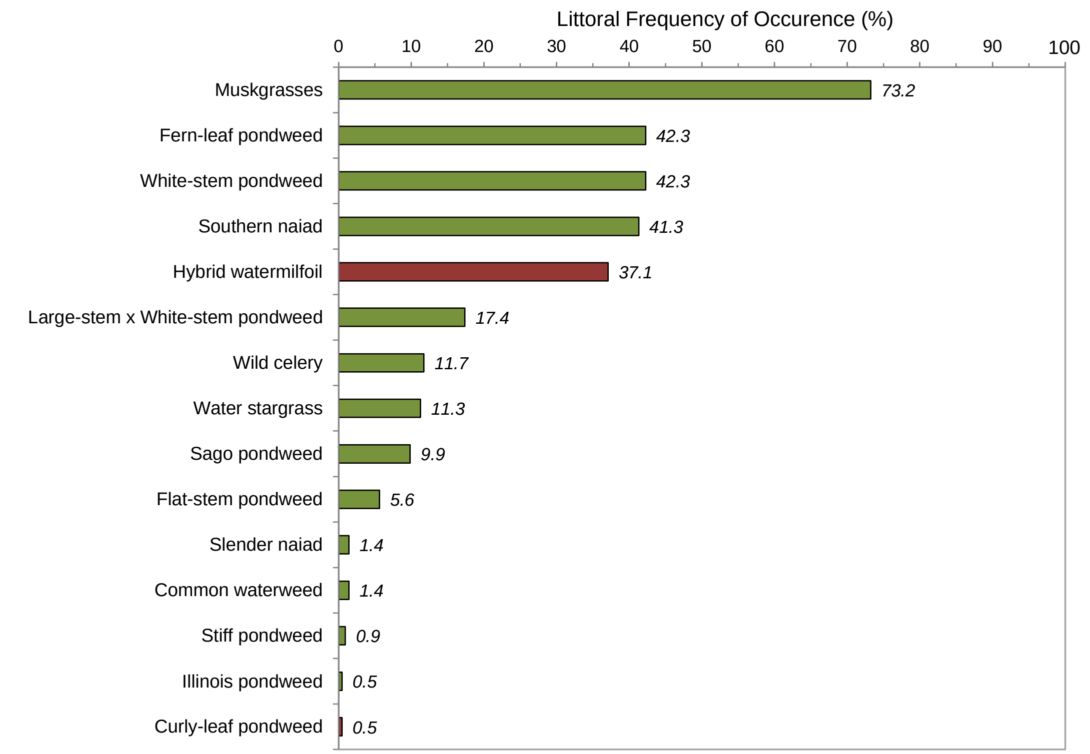


Figure 3.3-2. Littoral frequency of occurrence of aquatic plant species in Lilly Lake from July 2020 whole-lake point-intercept survey. Non-native plants indicated with red. Created using data from Onterra 2020 point-intercept survey. Number of littoral sampling points = 213.

Muskgrasses are a genus of macroalgae of which there are ten documented species in Wisconsin (Figure 3.3-3). In 2020, muskgrasses increased to a littoral occurrence of 73% from 27% in 2008, representing a statistically valid increase in occurrence of 174% (Chi-square $\alpha = 0.05$) (Figure 3.3-4). Muskgrasses were abundant in all areas of Lilly Lake and across all littoral depths in 2020 (Map 5). Dominance of the aquatic plant community by muskgrasses is common in hardwater, alkaline lakes, and these macroalgae have been found to more competitive against vascular plants (e.g., pondweeds, milfoils, etc.) in lakes with higher concentrations of calcium carbonate in the sediment (Kufel and Kufel 2002) (Wetzel 2001). Muskgrasses require lakes with good water clarity, and their large beds help to stabilize bottom sediments. Studies have also shown that muskgrasses sequester phosphorus in the calcium carbonate incrustations which from on these plants, aiding in improving water quality by making the phosphorus unavailable to phytoplankton (Coops 2002).

Fern-leaf pondweed was the second-most frequently encountered aquatic plant species in Lilly Lake in 2020 with a littoral frequency of occurrence of 42% (Figure 3.3-2 and 3.3-3). The occurrence of fern-leaf pondweed in 2020 was not statistically different from its occurrence of 47% in 2008 (Figure 3.3-4). In Wisconsin, fern-leaf pondweed is primarily found in lakes in the northern half of the state, and populations in southern Wisconsin are infrequent. Its range extends to the northernmost counties in northwest Illinois, so the population in Lilly Lake represents one of the southernmost fern-leaf pondweed populations in Wisconsin.

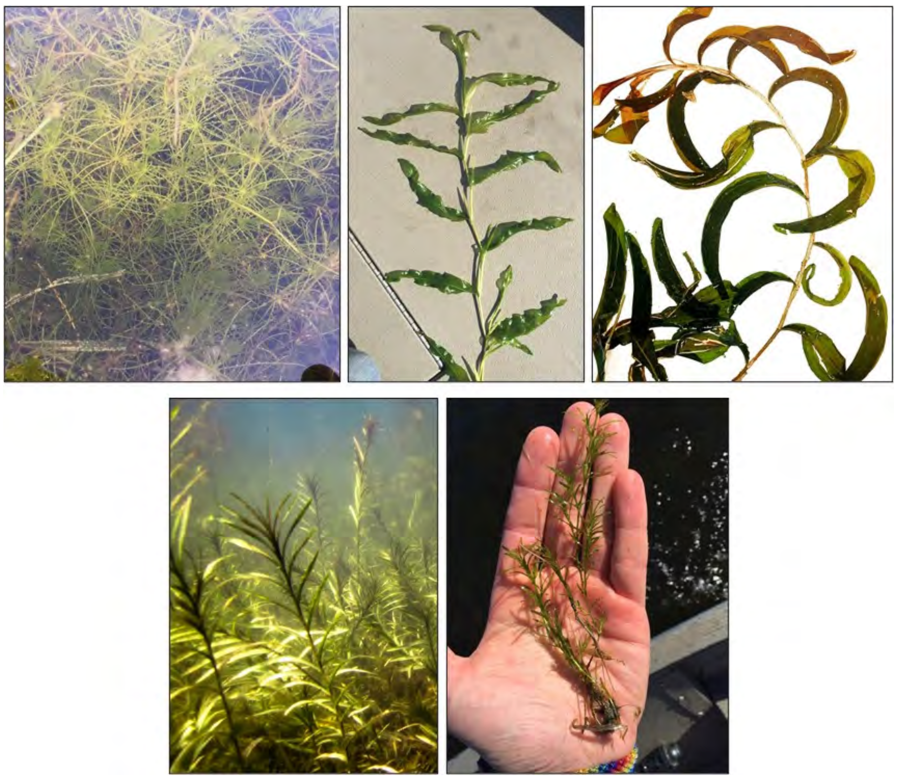


Figure 3.3-3. Five most frequently encountered aquatic plant species in Lilly Lake during the 2020 point-intercept survey. Clockwise from top left: muskgrasses (*Chara*), white-stem pondweed (*Potamogeton praelongus*), large-leaf x white-stem pondweed (*P. amplifolius x P. praelongus*), southern naiad (*Najas guadalupensis*), and fern-leaf pondweed (*P. robbinsii*). Photo credit Onterra.

As its name suggests, the arrangement of leaves along the stem give this plant a fern-like appearance. Fern-leaf pondweed typically develops large colonies over soft sediments which grow close to the lake bottom, and it is one of the deepest-growing vascular plants in Wisconsin. Large beds of fern-leaf pondweed provide excellent structural habitat for aquatic wildlife and help to prevent the suspension of the soft bottom sediments in which they grow. In Lilly Lake, the fern-leaf pondweed population has a ring-like distribution, inhabiting areas of moderate depths from 8.0-15.0 feet (Map 6).

The third-most frequently encountered aquatic plant in Lilly Lake in 2020 was white-stem pondweed with a littoral frequency of occurrence of 42% (Figure 3.3-2 and 3.3-3). White-stem pondweed is one of the larger species of pondweeds in Wisconsin, producing long, alternating leaves on an elongating stem which can grow up to 15 feet. Like other large-leaved pondweed species, white-stem pondweed provides excellent structural habitat for fish and other aquatic life, stabilizes bottom sediments, and dampens wave action. This species often produces abundant fruit which are an important source of food for birds and other wildlife.

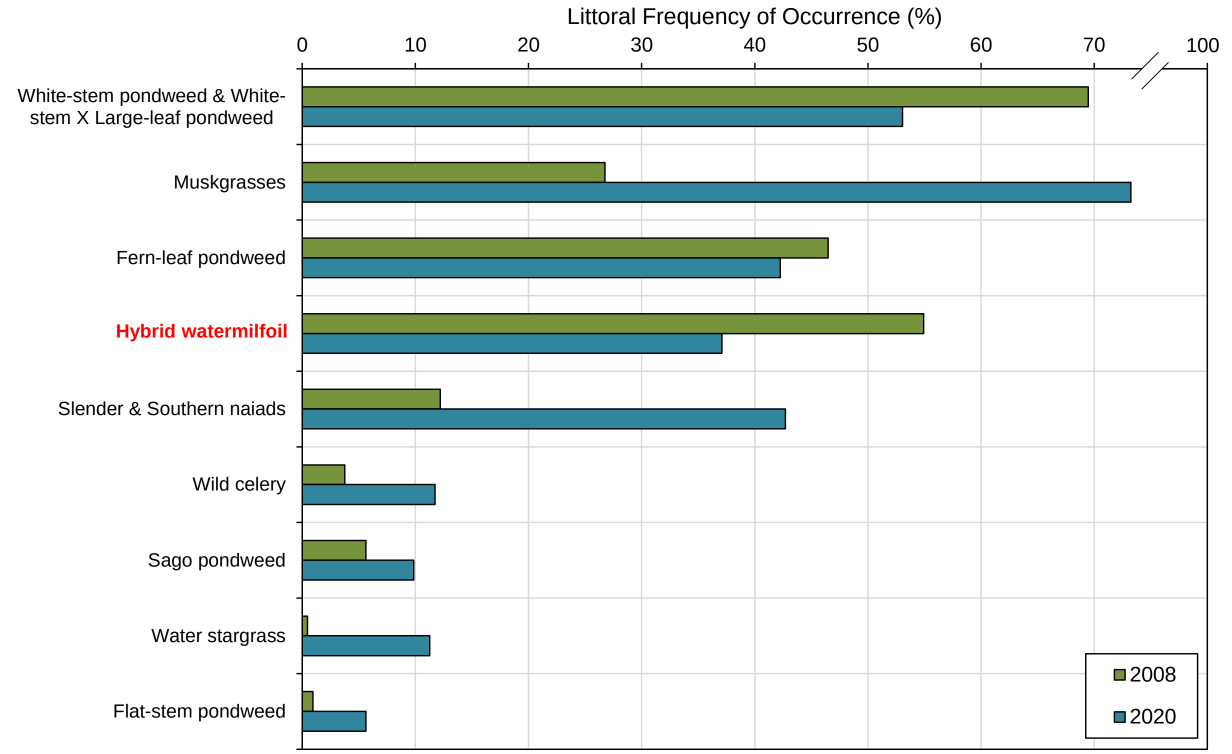


Figure 3.3-4. Littoral frequency of occurrence of most prevalent aquatic plant species in the 2008 and 2020 surveys of Lilly Lake. * = Statistically valid change in occurrence from 2008 (Chi-square α = 0.05). Non-native species indicated with red. Created using data from Aaron & Associates 2008 and Onterra 2020 point-intercept surveys. Only species with at least a 5% occurrence in one of the surveys are displayed.

In addition to white-stem pondweed, a hybrid pondweed was also observed in Lilly Lake that is believed to be a cross between white-stem pondweed and the native large-leaf pondweed (*P. amplifolius*) (Figure 3.3-2 and 3.3-3). While genetic analysis is needed to confirm this identification, these plants in Lilly Lake had characteristics of both species, and this is one of the more frequent pondweed hybrids encountered in Wisconsin lakes (Onterra obs.). While large-leaf pondweed was recorded in 2008, it was not observed in Lilly Lake in 2020.

For comparison with the 2008 data, the occurrence of white-stem pondweed and the hybrid pondweed were combined. This hybrid pondweed more closely resembles white-stem pondweed, and it is likely the hybrid was recorded as white-stem pondweed in 2008. The combined occurrence of these species in 2020 was 53% compared to an occurrence of 70% recorded for white-stem pondweed in 2008, representing a statistically valid decline in occurrence of 24% (Chi-square α = 0.05) (Figure 3.3-5). In 2020, like fern-leaf pondweed, white-stem and the hybrid pondweed had a ring-like distribution, inhabiting moderate depths from 8.0-14.0 feet (Map 7).

Southern naiad is one of five naiad species that can be found in Wisconsin, and in Lilly Lake, was the fourth-most frequently encountered aquatic plant species in 2020. Southern naiad was most common in areas of moderate depths of the littoral zone, from 7.0-14.0 feet of water (Map 8). Like other native aquatic plants, southern naiad provides beneficial structural habitat and sources of food. Unlike the other two native naiad species, southern naiad is a perennial, and green plants have been observed under the ice in winter. In 2008, southern naiad was not recorded; however, a higher occurrence of slender naiad was recorded. Both species are morphologically similar, and identification is often difficult. For comparison purposes with the 2008 data, the occurrences of slender and southern naiad in 2020 were combined. The occurrence of slender/southern naiad increased from 12% in 2008 to 43% in 2020, representing a statistically valid increase in occurrence of 250% (Figure 3.3-5).

The less frequently encountered native aquatic plants of wild celery, water stargrass (Photograph 3.3-4), and flat-stem pondweed also exhibited statistically valid increases in their occurrences between the 2008 and 2020 surveys (Figure 3.3-4). The occurrence of sago pondweed was not statistically different between 2008 and 2020. The distribution of the seven-most frequently encountered native aquatic plants in Lilly Lake in 2020 can be found on Maps 5 – 11.

Photograph 3.3-4. Water stargrass *(Heteranthera dubia*), a native aquatic plant, flowering in shallow near-shore areas of Lilly Lake. Photo credit Onterra.

The 2020 survey revealed the occurrences of some species in Lilly Lake have seen statistically valid changes in occurrence since 2008. However, these changes are not unexpected as the data that continues to be collected from Wisconsin lake's is revealing that aquatic plant communities are highly dynamic, and populations of individual species have the capacity to fluctuate, sometimes greatly, in their occurrence from year to year and over longer periods of time. These fluctuations can be driven by a combination of natural factors including variations in temperature, ice and snow cover (winter light availability), nutrient availability, water levels and flow, water clarity, length of the growing season, herbivory, disease, and competition (Lacoul and Freedman 2006). Adding to the complexity of factors which affect aquatic plant community dynamics, human-related disturbances such as the application of herbicides for non-native plant management, mechanical harvesting, watercraft use, and pollution runoff also affect aquatic plant community composition (Asplund and Cook 1997) (Lacoul and Freedman 2006).

Data collected during the 2008 and 2020 aquatic plant surveys was also used to complete a Floristic Quality Assessment (FQA) which incorporates the number of native aquatic plant species recorded on the rake during the point-intercept survey and their average conservatism. The data used for these calculations does not include any incidental species (visual observations) but only considers plants that were sampled on the rake during the survey. For instance, while a total of 18 native species were located in Lilly Lake in 2020, 13 were physically encountered on the rake while the remaining five species were located incidentally. Figure 3.3-5 displays the species richness, average conservatism, and floristic quality of Lilly Lake along with ecoregion and state median values.

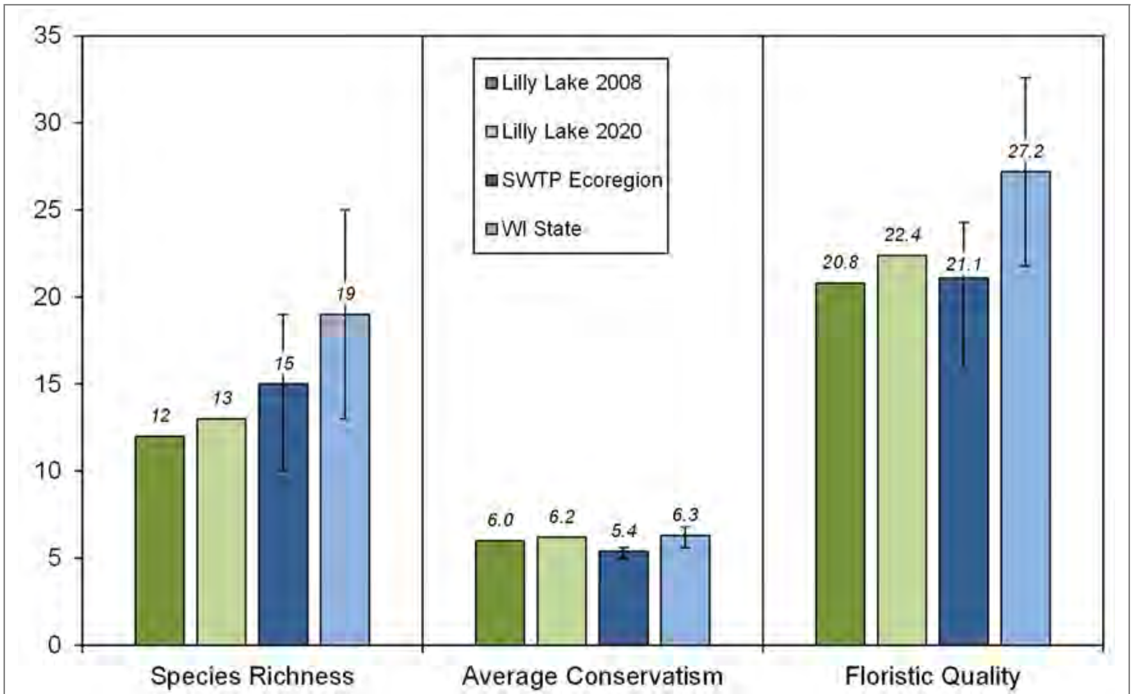


Figure 3.3-5. Floristic Quality Assessment (FQA) of Lilly Lake. Error bars indicate interquartile range. Created using data from Aaron & Associates 2008 and Onterra 2020 point-intercept surveys. Analysis follows Nichols (1999).

Lilly Lake's native plant species richness values of 12 in 2008 and 13 in 2020 fall below the median values for lakes within the SWTP ecoregion (15) and lakes across Wisconsin (19). However, Lilly Lake's average species conservatism of 6.0 in 2008 and 6.2 in 2020 falls above the SWTP median value of 5.4 and near the statewide value of 6.3. This indicates that Lilly Lake has a higher number of environmentally sensitive species (higher C-values) when compared to most lakes within the SWTP ecoregion. Using the species richness and average conservatism values, Lilly Lake's Floristic Quality Index was 22.4 in 2020, falling above the median value for lakes in the SWTP ecoregion (21.1) and below the median value for lakes statewide (27.2).

Studies have shown that the number of aquatic plant species present tends to increase with the area of suitable habitat as well as increasing *shoreline complexity* (Lacoul and Freedman 2006). Shoreline complexity is an index that relates the area of the lake to the perimeter of its shoreline. If a lake were a perfect circle, its shoreline complexity value would be 1.0. The farther a lake deviates from a perfect circle, the higher its shoreline complexity value is. Lakes with greater shoreline complexity harbor more areas that are sheltered from wind and wave action creating a greater diversity of habitats for aquatic plants. Lilly Lake is highly circular with a low shoreline complexity value of 1.1. The lake's low shoreline complexity and relatively uniform depth and substrate results in fewer habitat types for different aquatic plant species.

In addition, the lake's highly developed shoreline and recreational use also have impacts on the lake's aquatic plant community. Studies have also shown that watercraft can potentially impact aquatic plant communities through increased turbidity, turbulence, boat wake, and direct contact with propellers or boat hulls (Liddle and Scorgie 1980). Prop wash from watercraft have been documented to disturb bottom sediments to depths of up to 13 feet, and the resuspended sediments may reduce water clarity and photosynthetic rates (Yousef, McLellon and Zebuth 1980) (Davis and Brinson 1980). Given Lilly Lake's small size and relatively shallow depth, it is possible that prop wash and wave action from watercraft may exclude more sensitive aquatic plant species from establishing within the lake.

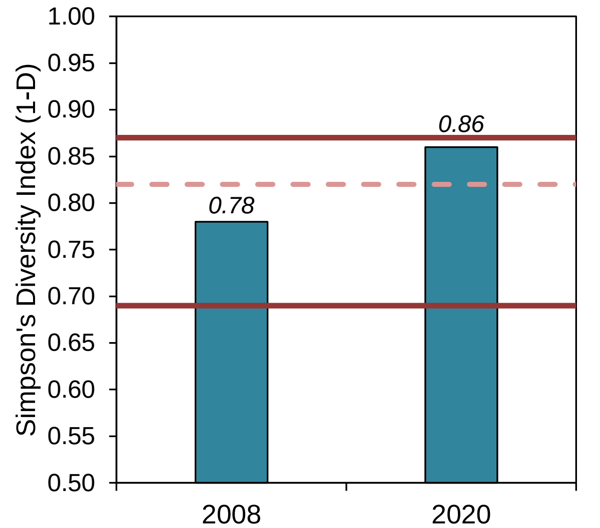


Figure 3.3-6. Simpson's Diversity Index for Lilly Lake. Solid lines indicate 25th and 75th percentiles for SWTP lakes; dashed line indicates median for SWPT lakes. Regional data created using Onterra & WDNR data. Lilly Lake values created using data from Aaron & Associates 2008 and Onterra 2020 point-intercept surveys.

Simpson's Diversity Index is a measure of both the number of aquatic plant species in a given community and their abundance. This measurement is important because plant communities with higher diversity are believed to be more resilient to disturbances and natural fluctuations that affect plant growth (e.g., changes water clarity, water levels, etc.). Plant communities with higher diversity also provide more diversity in habitat types and food sources for invertebrates, fish, and other wildlife. Higher species diversity leads to a healthier and more adaptive system that is resistant to disturbance and more stable over time. Unlike species richness which is simply the number of aquatic plant species within the community, species diversity considers how evenly those species are distributed throughout the community.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Lilly Lake's diversity values rank. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 77 lakes within the SWTP Ecoregion (Figure 3.3-6). The Simpson's Diversity Index values were calculated for Lilly Lake using the 2008 and 2020 point-intercept survey data. Lilly Lake's species diversity fell below the SWTP ecoregion median in 2008 with a value of 0.78. In 2020, diversity was found to have increased to 0.86, falling near the 75th percentile for lakes in the SWTP ecoregion. In other words, the probability that two sampling locations in Lilly Lake have different aquatic plant species increased from 78% in 2008 to 86% in 2020.

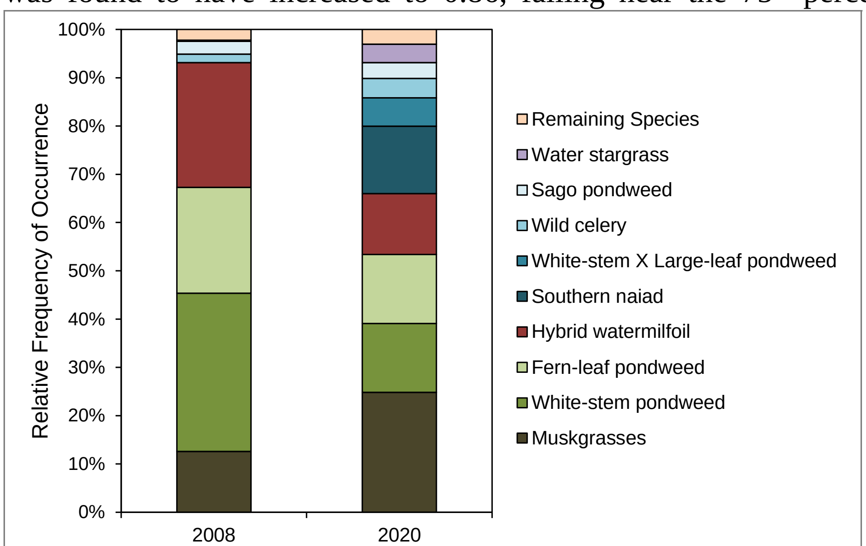


Figure 3.3-7. Relative frequency of occurrence of aquatic vegetation in Lilly Lake. Non-native species indicated with red. Created using data from Aaron & Associates 2008 and Onterra 2020 point-intercept surveys.

One way to visualize the diversity of Lilly Lake's plant community is to examine the relative frequency of occurrence of aquatic plant species (Figure 3.3-7). Relative frequency of occurrence is used to evaluate how often each plant species is encountered in relation to all the other species found. For example, while muskgrasses were found at 73% of the littoral sampling locations in Lilly Lake in 2020 (littoral occurrence), their relative frequency of occurrence was 25%. Explained another way, of 100 plants were randomly sampled from Lilly Lake in 2020, 25 of them would have been muskgrasses, 14 fern-leaf pondweed, 14 white-stem pondweed, etc.

In 2008, muskgrasses, white-stem pondweed, fern-leaf pondweed, and hybrid watermilfoil together comprised 88% of Lilly Lake's aquatic plant community, while in 2020 these four species comprised 66% of the plant community (Figure 3.3-7). The increase in occurrence of some of the less-frequently encountered species in 2020 resulted in increased evenness in species distribution, increasing species diversity in 2020. The dominance of the plant community by just four species in 2008 resulted in lower species diversity.

In 2020, Onterra ecologists also conducted a survey aimed at mapping emergent and floating-leaved plant communities in Lilly Lake. Emergent and floating-leaf plant communities are a wetland community type dominated by species such as cattails, bulrushes, and water lilies. Like submersed aquatic plant communities, these communities also provide valuable habitat, shelter, and food sources for organisms that live in and around the lake. In addition to those functions, floating-leaf and emergent plant communities provide other valuable services such as erosion control and nutrient filtration. These communities also lessen the force of wind and waves before they reach the shoreline which serves to lessen erosion. Their root systems also stabilize bottom sediments and reduce sediment resuspension. In addition, because they often occur in near-shore areas, they act as a buffer against nutrients and other pollutants in runoff from upland areas.

The 2020 survey found that Lilly Lake does not support any large communities of emergent and/or floating-leaf aquatic plants. The communities that are present are comprised of small, isolated colonies of emergent plants immediately adjacent to shore (Photograph 3.3-5 and Map 12). Eight emergent plant species were located in these communities, and included four native species and four non-native, invasive species (Table 3.3-1). The lack of larger emergent and floating-leaf aquatic plant communities in Lilly Lake is likely a function of its absence of sheltered backwater areas, high degree of shoreland development, and recreational use.

Photograph 3.3-5. Small emergent plant community in Lilly Lake comprised of the native broad-leaved cattail. Locations of these communities can be found on Map 12. Photo credit Onterra.

Given the limited occurrence of these native communities in Lilly Lake, they should be a focus of protection and enhancement. This is important to note because these communities are often negatively affected by recreational use and shoreland development. Radmoski and Goeman 2001 found a 66% reduction in vegetation coverage on developed shorelands when compared to the undeveloped shorelands in Minnesota lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelands.

Non-Native Aquatic Plants in Lilly Lake

Curly-leaf Pondweed (*Potamogeton crispus*)

Photograph 3.3-6. Curly-leaf pondweed plants (left), dominant colony in Lilly Lake in 2020 (upper right), and turion with newly-sprouted plants (lower right). Locations of CLP in Lilly Lake can be found on Map 13 Photo credit Onterra.

Curly-leaf pondweed (CLP; Photograph 3.3-6) was first documented in Lilly Lake in 2004. Curly-leaf pondweed's primary method of propagation is through the production of numerous asexual reproductive structures called turions. Once mature, these turions break free from the parent plant and may float for some time before settling and overwintering on the lake bottom. Once favorable growing conditions return (i.e., spring), new plants emerge and grow from these turions. Many of the turions produced by CLP begin to sprout in the fall and overwinter as small plants under the ice. Immediately following ice-out, these plants grow rapidly giving them a competitive advantage over native vegetation. Curly-leaf pondweed typically reaches its peak biomass by mid-June, and following the production of turions, most of the CLP will naturally senesce (die back) by mid-July.

If the CLP population is large enough, the natural senescence and the resulting decaying of plant material can release sufficient nutrients into the water to cause mid-summer algal blooms. In some lakes, CLP can reach growth levels which interfere with navigation and recreational activities. However, in other lakes, CLP appears to integrate itself into the plant community and does not grow to levels which inhibit recreation or have apparent negative impacts to the lake's ecology. Because CLP naturally senesces in early summer, surveys are completed early in the growing season in an effort to capture the full extent of the population. As mentioned earlier, the Early-Season AIS Survey on Lilly Lake was completed on June 4, 2020 to capture the full extent of the lake's CLP population.

The 2020 survey found that the CLP population in Lilly Lake is relatively small (Map 13). The population was comprised of an approximate 0.2-acre colony of dominant CLP immediately adjacent the public boat landing along with isolated small plant colonies, clumps of plants, and single plant occurrences mainly in the northeastern, northwestern, and southwestern areas of the lake. Given the smaller size of the plant population, it is not likely that the senescence of CLP in Lilly Lake has a detectable impact on the lake's water quality at this time.

Hybrid Watermilfoil (*Myriophyllum sibiricum* x *M. spicatum*)

Photograph 3.3-7. Hybrid watermilfoil (left) and dominant colonies in Lilly Lake near the public beach and boat landing in 2020. Locations of HWM in Lilly Lake can be found on Map 14. Photo credit Onterra.

Eurasian watermilfoil (EWM) is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties. Eurasian watermilfoil is unique in that its primary mode of propagation is not by seed but by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, EWM has two other competitive advantages over native aquatic plants: 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, and instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian watermilfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

Figure 3.3-8 shows a cross-section of a whorl of four EWM leaves. One of the primary ways to distinguish between different species of watermilfoils is to count the number of leaflets on each leaf. As shown on Figure 3.3-8, northern watermilfoil (green triangles) typically has leaflet counts under 23 whereas EWM typically has leaflet counts over 25. Hybrid watermilfoil (HWM) leaflet counts overlap with both these ranges, making field identification difficult. While leaflet counts can be a relatively definitive way to differentiate between EWM and northern watermilfoil, this method is less definitive in distinguishing HWM from EWM and northern watermilfoil. DNA testing is required to determine if a system has EWM vs HWM, often times having both.

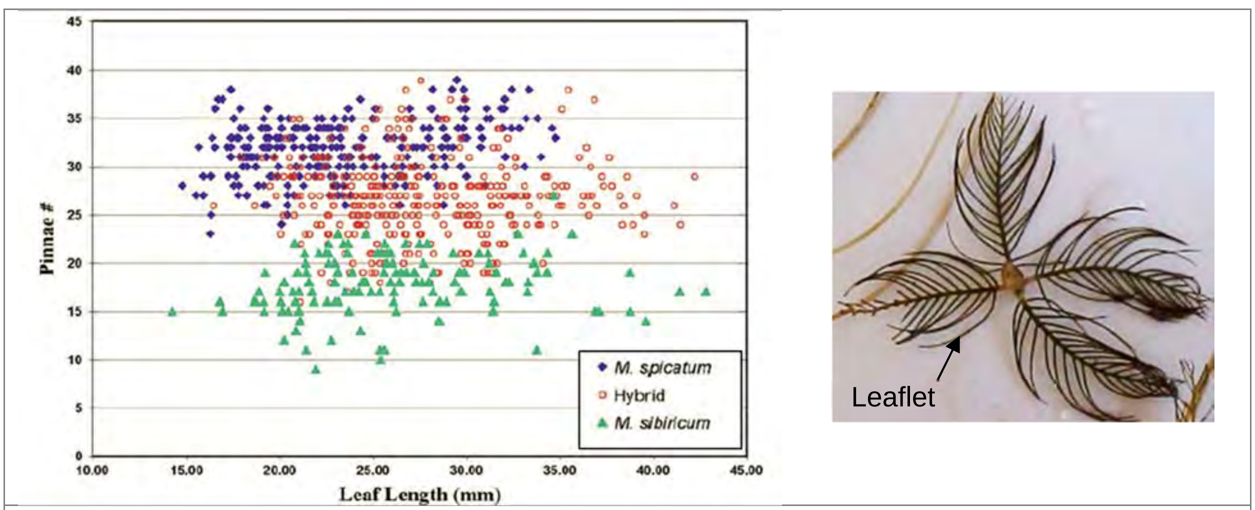


Figure 3.3-8. Pinnae (leaflet) counts from three watermilfoil species. Extracted and modified from (Moody and Les 2007). Leaf length spreads out the data but is not important here.

Eurasian watermilfoil was first documented in Lilly Lake in 1976. A sample collected in 2014 was genetically verified as HWM. Without a thorough genetic study of the invasive watermilfoil population of Lilly Lake, it is unknown if the lake contains only HWM or both EWM and HWM. Invasive watermilfoil genetic testing has advanced in recent years, and now it is possible to identify different strains of EWM/HWM exist in a lake. Unless specifically indicated, this report will use "HWM" when discussing the invasive milfoil population of Lilly Lake.

While the LLPRD has been conducting herbicide treatments on a near annual basis to control EWM, no treatments were conducted in 2020 to allow the full extent of the population to be assessed. The 2020 point-intercept survey found that HWM was the fifth-most frequently encountered aquatic plant species with a littoral frequency of occurrence of 37%, representing a statistically valid reduction in occurrence of 33% from its occurrence of 55% in 2008 (Figure 3.3-5). The point-intercept survey found that HWM is found throughout areas of Lilly Lake, including in deeper water to 17 feet. Lilly Lake's high water clarity allows for EWM (and native plants) to grow and colonize to deeper depths.

While the point-intercept survey is a valuable tool to understand the overall plant population of a lake, it does not offer a full account (census) of where a particular species exists in the lake to understand where recreation and navigation impairment exists and how to direct management activities. Within this project, a series of AIS mapping surveys allowed this level of data to be understood.

Following the same general methodologies as outlined for the Early-Season AIS Survey (for CLP mapping), the Late-Season HWM Mapping Survey is completed in late-summer when HWM is typically at its peak-biomass for the growing season. While HWM can be found throughout the littoral zone of Lilly Lake, approximately 8.0 acres of contiguous HWM colonies were mapped in Lilly Lake in 2020 (Figure 3.3-9 and Map 14). Approximately 2.5 acres were comprised of scattered HWM, 0.7 acres were comprised of dominant HWM (~50% coverage), 3.8 acres were comprised of highly dominant HWM (>50% coverage), and 1.0 acres were comprised of surface matted HWM (>50% coverage and matted on surface).

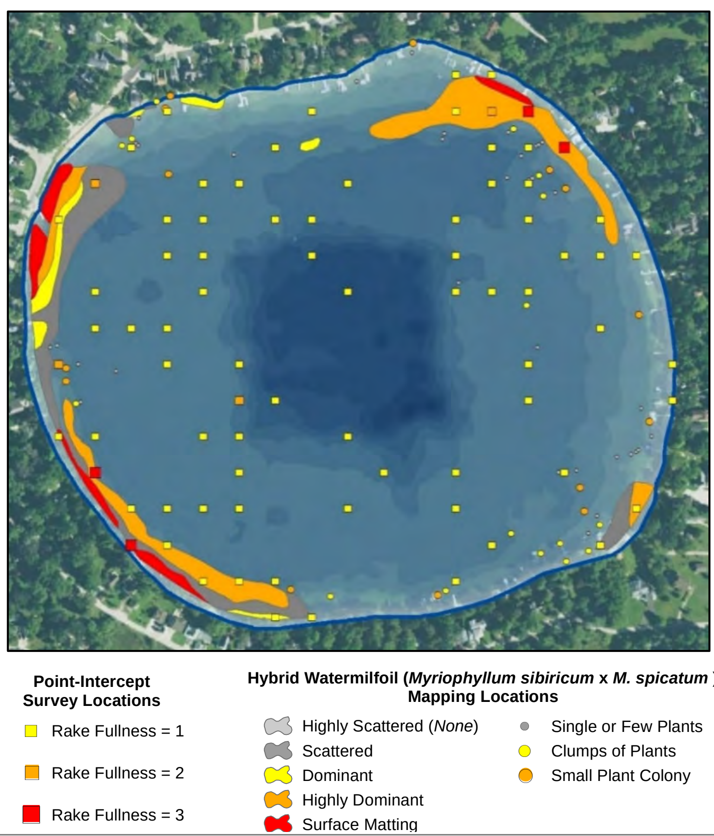


Figure 3.3-9. Lilly Lake 2020 hybrid watermilfoil locations. Hybrid watermilfoil mapped by Onterra on October 1, 2020. Point-intercept survey locations from July 31, 2020.

The largest and densest colonies were located along the lake's western and northeastern shorelines. The acreage of HWM is likely underestimated given the amount detected in deeper areas of the lake during the point-intercept survey. However, the combination of the visual-based meander survey and the point-intercept survey allows for a solid understanding of the current HWM population in Lilly Lake. Most of the surface-matted vegetation in near-shore areas which would interfere with recreation was attributable to HWM in 2020.

DNR Long-Term EWM Trends Monitoring Research Project

Starting in 2005, WDNR Science Services began conducting annual point-intercept aquatic plant surveys on a set of lakes to understand how EWM populations vary over time. This was in response to commonly held beliefs of the time that once EWM becomes established in a lake, its population would continue to increase over time. The ongoing collection of these data is showing that like other aquatic plants, EWM populations are dynamic. Annual changes in EWM frequency of occurrence have been documented in many lakes, including those that are not being actively managed for EWM control (no herbicide treatment or hand-harvesting program). Figure 3.3-10 shows the EWM populations of four unmanaged EWM lakes in the Southeastern Till Plains ecoregion in comparison. To clarify, these lakes have not conducted herbicide treatments or any other forms of strategic EWM management. As these data illustrate, the littoral occurrence of EWM can fluctuate widely from year to year and over longer periods of time.

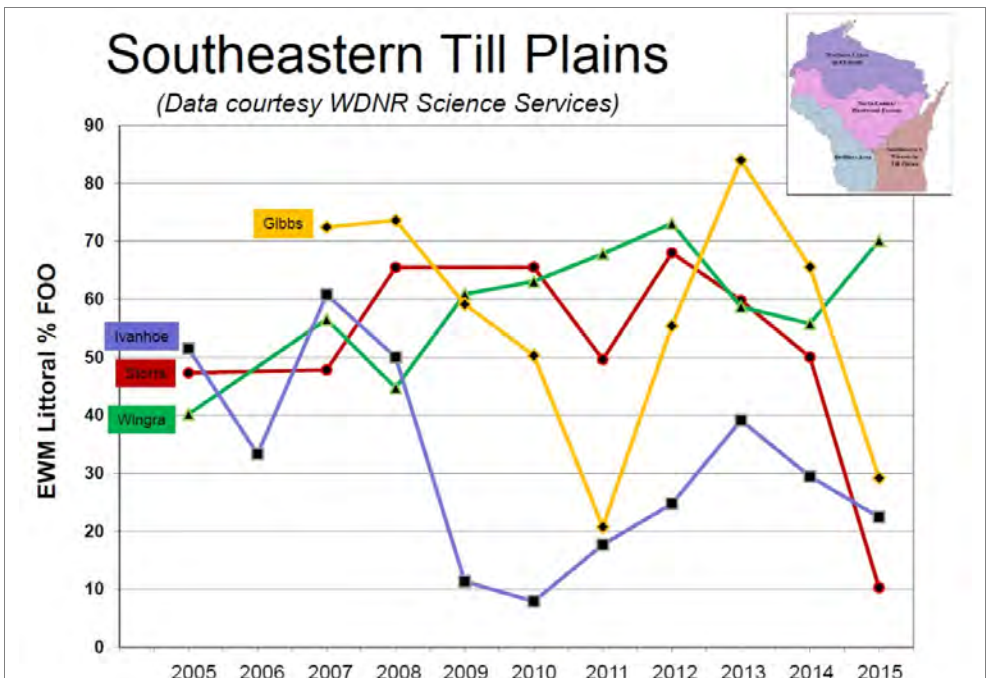


Figure 3.3-10. Littoral frequency of occurrence of unmanaged EWM populations in the Southeastern Till Plains ecoregion. Data provided by and used with permission from WDNR. For comparison, the littoral occurrence of HWM in Lilly Lake was 55% in 2008 and 37% in 2020.

The Science Behind the "So-Called" Super Weed (M. Nault 2016)

In 2015, the WDNR investigated the most recent point-intercept data from almost 400 Wisconsin Lakes that had confirmed EWM populations. These data show that approximately 65% of these lakes had EWM populations with a littoral frequency of occurrence of 10% or less (Figure 3.3-11). At these low population levels, there is not likely to be impacts to recreation and navigation, nor changes in ecological function. At the time of this writing, Lilly Lake's most recent point-intercept survey (2020) yielded a littoral occurrence of HWM at 37%. Only 25% of the lakes in the survey had EWM populations of 20% or higher. This may be due to the fact that the EWM population on some lakes may never reach that level or that management activities may have been enacted to suppress the EWM population to lower levels.

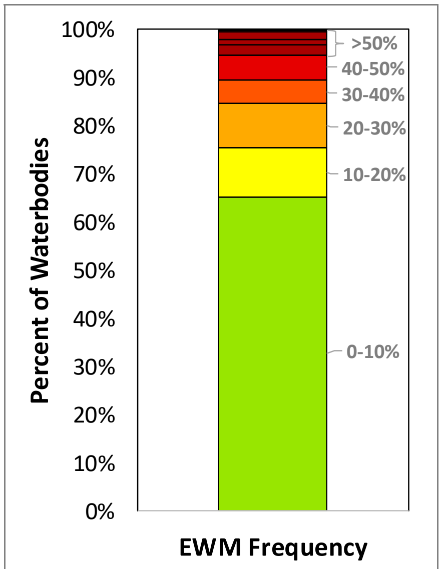


Figure 3.3-11. EWM littoral frequency of occurrence in 397 WI lakes with EWM populations. Data provided by and used with permission from WDNR.

AIS Management in Lilly Lake

The term Best Management Practice (BMP) is often used in environmental management fields to represent the management option that is currently supported by the latest science and policy. When used in an action plan, the term can be thought of as a placeholder with anticipation of having an evolving definition over time. For example, granular herbicides historically were a BMP that is no longer supported in most instances. Emerging science demonstrated that liquid treatments provided more consistent results at a fraction of the cost of granular products, larger application areas appeared to retain herbicide concentrations and exposure times better, and attention needed to be paid to the addition of individual spot treatments that may cumulatively function as a whole-lake treatment.

From an ecological perspective, whole-lake treatments are those where the herbicide may be applied to specific sites, but when the herbicide dissipates from where it was applied and reaches equilibrium within the entire mixing volume of water (of the lake, lake basin, or within the epilimnion of the lake or lake basin), it is at a concentration that is sufficient to cause mortality to the target plant within that entire treated volume. A recent article by Nault et al. 2018 investigated 28 large-scale herbicide treatments in Wisconsin and found that "herbicide dissipation from the treatment sites into surrounding untreated waters was rapid (within 1 day) and lake-wide low-concentration equilibriums were reached within the first few days after application."

Aquatic invasive plant species have been managed in Lilly Lake over time, with Table 3.3-2 showing the herbicide use history since 2004. Almost all of these actions would be considered spot treatments, with more recent 2,4-D treatments approaching levels that would have lake-wide impact. This concept will be subsequently explored in the HWM Management sub-section.

Table 3.3-2. Historical aquatic plant management activities on Lilly Lake. Information provided by WDNR and LLPRD.

Date	Herbicide Applied	Acres Treated	Amount Used	Pounds of 2,4-D Active Ingredient	Whole-Lake 2,4-D ppm ae	Epilimnetic 2,4-D ppm ae
6/22/2004	Copper Liquid Endothal Liquid Diquat Liquid	5.85	4 gallons			
8/26/2004	Copper Liquid Endothal Liquid Diquat Liquid	0.23	0.67 gallons			
	2,4-D Liquid	0.12	2 gallons			
6/29/2005	Copper Liquid Endothal Liquid Diquat Liquid	0.69	0.5 gallons			
6/26/2006	Copper Liquid Endothal Liquid Diquat Liquid	2.80	1.5 gallons			
5/22/2007	Copper Liquid Endothal Liquid Diquat Liquid	1.00	0.3 gallons			
	2,4-D Liquid	1.40	2.5 gallons			
6/2/2008	2,4-D Granular 2,4-D Liquid	2.00	50 lbs 9.0 gallons			
6/30/2008	Copper Liquid Endothal Liquid Diquat Liquid	0.25	0.5 gallons 0.25 gallons			
5/14/2009	2,4-D Liquid (DMA 4)	2.40	18.1 gallons	68.78	0.030	0.038
5/27/2010	Endothal Liquid	0.30	0.75 gallons			
	2,4-D Liquid (DMA 4)	3.60	18.75 gallons	71.25	0.031	0.039
5/24/2011	2,4-D Liquid (DMA 4)	1.75	9.75 gallons	37.05	0.016	0.020
6/13/2011	Endothal Liquid	0.70	2.2 gallons			
	2,4-D Liquid (DMA 4)	0.60	4.75 gallons	18.05	0.008	0.010
5/15/2012	Endothal Liquid	4.00	22.5 gallons			
7/2/2012	2,4-D Liquid (DMA 4)	7.40	40.5 gallons	153.9	0.068	0.085
6/13/2013	2,4-D Liquid (DMA 4)	5.30	34.25 gallons	130.15	0.057	0.072
5/21/2014	Endothal Liquid	0.20	10 gallons			
	2,4-D Liquid (DMA 4)	5.35	29 gallons	110.2	0.048	0.061
8/6/2014	2,4-D Liquid (DMA 4)	4.40	28.25 gallons	107.35	0.047	0.059
5/29/2015	Endothal Liquid	0.80	2.0 gallons			
	2,4-D Liquid (DMA 4)	4.90	26.5 gallons	100.7	0.044	0.056
6/8/2016	Endothal Liquid	0.10	0.4 gallons			
	2,4-D Liquid (DMA 4)	5.5.	34.5 gallons	131.1	0.058	0.072
	Diquat Liquid	0.10	0.225 gallons			
8/22/2016	2,4-D Liquid (DMA 4)	3.50	30 gallons	114	0.050	0.063
9/20/2016	2,4-D Liquid (DMA 4)	5.80	75 gallons	285	0.125	0.157
6/13/2017	2,4-D Granular (Navigate)	0.02	4 lbs			
	2,4-D Liquid (DMA 4)	6.40	41 gallons	155.8	0.069	0.086
	Endothal Liquid	0.50	1.5 gallons			
5/23/2018	2,4-D Liquid (DMA 4)	2.20	14.25 gallons	54.15	0.024	0.030
	2,4-D Liquid (Weedar 64)	4.00	35 gallons	133	0.059	0.073
	Endothal Liquid	0.12	0.5 gallons			
5/31/2019	2,4-D Liquid (Weedar 64)	6.10	50 gallons	190	0.084	0.105

Whole-lake 2,4-D concentration calculated using entire lake volume (842 acre-feet as determined from 2020 acoustic survey)

Epilimnetic 2,4-D concentration calculated using volume of early summer epilimnion (volume from 0-9 feet based on temperature profiles and 2020 acoustic data)

Curly-leaf Pondweed Management

The theoretical goal of CLP population management is to kill the plants each year before they are able to produce and deposit new turions. Not all of the turions produced each year sprout new plants the following year; many lie dormant in the sediment to sprout in subsequent years. This results in a sediment turion bank being developed. Normally a control strategy for an established CLP population includes multiple years of controlling the same area to deplete the existing turion bank within the sediment. In instances where a large turion base may have already built up because of a long-term presence in the system, lake managers and regulators question whether the repetitive annual herbicide strategies may be imparting more strain on the environment than the existence of the invasive species.

Historical management of CLP on Lilly Lake has been through localized spot treatments using a combination of endothall, diquat, and/or copper-based herbicides (Table 3.3-2). The manufacturer of endothall (UPL) generally does not support spot treatments less than 5.0 acres as these treatments are largely ineffective as the herbicide dissipates too rapidly to achieve the appropriate concentration-exposure time (CET) to cause CLP mortality. Adding additional active ingredients, such as diquat or copper, may increase effectiveness of some small spot treatments.

Research conducted by (Skogerboe et al. 2008) at the US Army Corps of Engineers Research and Development Center found that management strategies that fails to kill the entire CLP plant (including rhizomes and root crowns) does not prevent new turion formation. The research found that stressed CLP plants actually produced more turions, and when above-ground biomass has been removed, the plants produced turions in the sediment along the rhizomes (stick turions). This means that sub-lethal herbicide treatments could actually increase the population over time.

Although CLP has been present in Lilly Lake for at least 16 years, it is not widespread, and the population is mainly isolated to three areas. Given it has not achieved a larger population over this time period, it is likely that the CLP population will not impart a greater impact on the lake than what is currently present. Future CLP management will likely consist of spot treatments targeting locally dense areas of CLP, falling between the distinction of nuisance and population management as is subsequently discussed.

Invasive Watermilfoil Management

Invasive watermilfoil management is relatively straight forward compared to CLP management. The goal of invasive watermilfoil management is to kill the plant. While sexual reproduction (seeds) and asexual reproduction (turions in some HWM populations) do occur, their contribution to a lake-wide population is thought to be minimal. So unlike CLP management, one effective treatment is all that is needed. As a perennial plant, EWM/HWM is much harder to kill with herbicides compared to CLP. Contact herbicides, such as those discussed for CLP, may eliminate the aboveground biomass of EWM/HWM, but extensive storage reserves in the root crown will allow resprouting and rebound. Therefore, systemic herbicides that translocate throughout the plant into the root crown are required.

2,4-D is a weak-acid auxin mimic herbicide often used for invasive watermilfoil management. This herbicide gets translocated throughout the plant (acts systemically) and suppresses growth regulation hormones. Operationally, a lake-wide 2,4-D concentration above 0.1 ppm acid equivalent (ae) is considered by Onterra to represent a whole-lake treatment, assuming typical exposure time from herbicide degradation. Onterra has observed lake-wide impacts to some sensitive native plants when lake-wide concentrations were above 0.1 ppm ae; but being more durable, EWM impacts do not typically occur until lake-wide concentrations exceed 0.2 ppm ae. When prescribing whole-lake 2,4-D treatments, the traditional lake-wide target is 0.3 ppm ae with higher concentrations targeting more difficult populations.

Treatment records showing the amount of herbicide applied in Lilly Lake allowed for calculations to illustrate the potential whole-lake concentration of the 2,4-D active ingredient when lake-wide dispersion occurred (Table 3.3-2). For lakes that maintain thermal stratification, the herbicide only mixes within the warmer, upper layer of water (epilimnion) and does not mix into the colder, bottom layer (hypolimnion). Lilly Lake is polymictic as it stratifies in late spring and early summer and completely mixes by late-summer. Based on temperature and dissolved oxygen data from the lake, the lake was likely stratified during treatments that took place in late May or early June. Calculations conducted for Lilly Lake's historical treatments were based on the epilimnetic volume (volume of water between 0-9 feet).

The historical treatments that have occurred in Lilly Lake were all were all designed as localized spot-treatments. However, it is clear from the calculations that the more recent treatments that occurred from 2016-2019 likely resulted in lake-wide concentrations vulnerable to sensitive aquatic plants, but were at concentrations too low to cause significant impacts to durable species like HWM.

Future AIS Management Philosophy

There are three broad potential aquatic invasive species (AIS) population goals for consideration including a recommended action plan to help reach each of the goals. Each management goal will be discussed and considered for applicability during the planning meeting. During these discussions, conversation regarding risk assessment of the various management actions will also be presented. Onterra will provide extracted relevant chapters from the WDNR's *APM Strategic Analysis Document* to serve as an objective baseline for the LLPRD to weigh the benefits of the management strategy with the collateral impacts each management action may have on the Lilly Lake ecosystem. These chapters are included as Appendix E.

1. Let Nature Take its Course: On some lakes, invasive plant populations plateau or reduce without active management. Some lake groups decide to periodically monitor the AIS population, typically through an annual or semi-annual point-intercept survey, but do not coordinate active management (e.g., hand-harvesting or herbicide treatments). Individual riparians could choose to hand-remove the AIS within their recreational footprint, but the lake group would not assist financially or by securing permits if necessary. In most instances, the lake group may select an AIS population threshold or trigger where they would revisit their management goal if the population reached that level.

2. Nuisance Control: The concept of ecosystem services is that the natural world provides a multitude of services to humans, such as the production of food and water (provisioning), control of climate and disease (regulating), nutrient cycles and pollination (supporting), and spiritual and recreational benefits (cultural). Some lake groups acknowledge that the most pressing issues with their AIS population is the reduced recreation, navigation, and aesthetics compared to before the AIS became established in their lake. Particularly on lakes with large AIS populations that may be impractical or unpopular to target on a lake-wide basis, the lake group would coordinate (secure permits and financially support the effort) a strategy to improve the navigability within the lake. This is typically accomplished by targeting AIS populations in high-use parts of the through mechanical harvesting or spot herbicide treatments.

Most AIS management in southeastern Wisconsin would be considered nuisance management, where dense areas that are causing navigation or recreation issues are prioritized for management. Recent AIS treatments on Lilly Lake likely fall into this category. HWM is found throughout the entire littoral zone of Lilly Lake, but herbicide management has targeted dense areas near riparian properties. Mechanical harvesting would likely not be an effective management strategy on Lilly Lake given the densest and largest colonies are located immediately adjacent to shore in shallower water within and around piers.

3. Lake-Wide Population Management: Some believe that there is an intrinsic responsibility to correct for changes in the environment that are caused by humans. For lakes with AIS populations, that may mean to manage the AIS population at a reduced level with the perceived goal to allow the lake to function as it had prior to AIS establishment. Due to the inevitable collateral impacts from most forms of AIS management, lake managers and natural resource regulators question whether that is an achievable goal. The WDNR maintains a cost-share grant funding program for projects that aim to reduced established aquatic invasive species populations.

For newly introduced AIS populations, the entire population may be targeted through hand-harvesting or spot treatments. On more advanced or established populations, this may be accomplished through large-scale control efforts such as water-level drawdowns (not applicable to Lilly Lake) or whole-lake herbicide treatment strategies. Large-scale management can reduce HWM populations for several years, but will not eradicate it from the lake. Subsequent smaller scale management (e.g., hand-harvesting or spot treatments) is typically employed to slow the rebound of the population until another large-scale effort may be considered again.

Large-scale control efforts, especially using herbicide treatments, can be impactful of some native plant species as well as carry a risk of environmental toxicity. Some argue that the impacts of the control actions may have greater negative impacts to the ecology of the system than if the AIS population was not managed. Whole-lake treatment impacts typically occur when greater than 10% of the lake acreage is targeted at a time, with whole-lake impacts to some sensitive plants occurring at lower concentrations. Because of the relatively small size of Lilly Lake, targeting all of the colonized HWM (e.g., 8.0 acres in 2020) with herbicides at spot treatment use rates would likely add up to a whole-lake treatment.

Whole-lake HWM Management Discussion

In Wisconsin, most large-scale invasive watermilfoil treatments use liquid 2,4-D amine. Properly implemented large-scale 2,4-D herbicide treatments can be highly effective on pure-strain EWM populations, with minimal EWM being detected for a year or two following the treatment (Figure 3.3-12, left frame) on some systems. Some large-scale 2,4-D treatments have been effective at reducing EWM populations for 5-6 years following the application. In almost all HWM populations, rebound took less time and the rebounded populations were at much higher frequencies than EWM populations (Figure 3.3-12, right frame).

The concept of heterosis, or hybrid vigor, is important in regards to HWM management in Lilly Lake. The root of this concept is that hybrid individuals typically have improved function compared to their pure-strain parents. Hybrid watermilfoil typically has thicker stems, flowers prolifically, and grows faster than pure-strain EWM (LaRue et al. 2012). These conditions likely contribute to this plant being particularly less susceptible to biological (Enviroscience personal comm.) and chemical control strategies (Glomski and Nehterland 2010) (Poovey, Slade and Netherland 2007). In a recent study of 28 large-scale 2,4-D amine treatments in Wisconsin (Nault et al. 2018), HWM initial control was less and the longevity was shorter than pure-strain EWM control projects. Therefore, it appears that potentially most strains of HWM, but not all, are more tolerant of auxin-mimic herbicide treatments (e.g., 2,4-D, triclopyr) than pure-strain EWM.

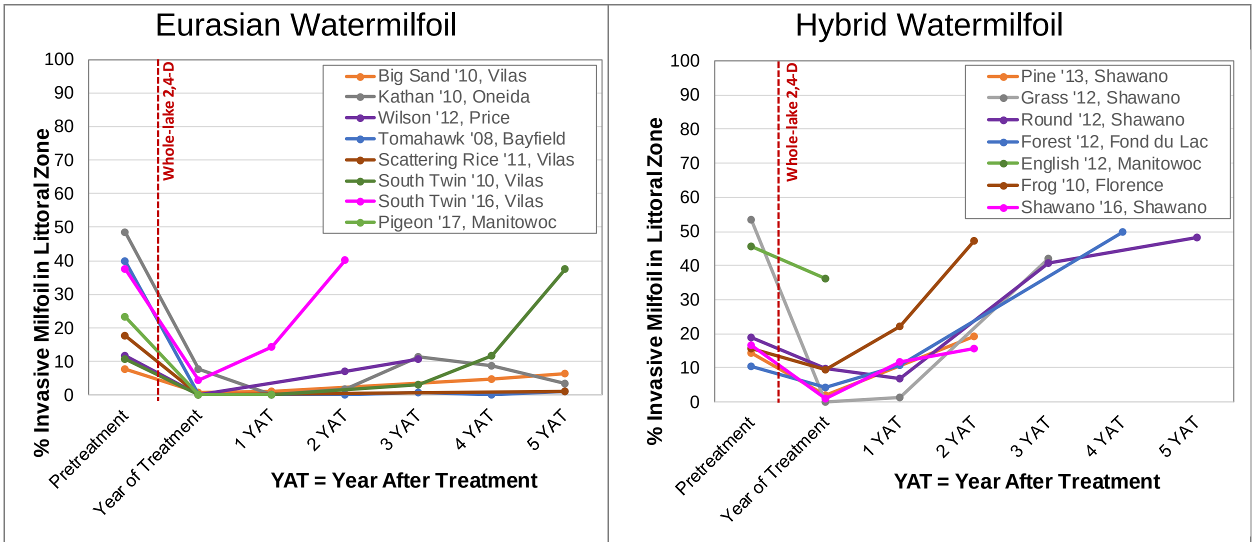


Figure 3.3-12. Littoral frequency of occurrence of invasive milfoil in lakes managed with large-scale 2,4-D treatments.

The 2,4-D use history of Lilly Lake may have resulted in more sensitive invasive watermilfoil strains being removed from the population resulting in a population of HWM in Lilly Lake that is 2,4-D tolerant, requiring repeat annual treatments. Therefore, based on the results of the past 2,4-D treatments on Lilly Lake as well as emerging data from other EWM/HWM control projects, the use of 2,4-D for future spot and/or whole-lake treatments will likely not be effective at controlling the HWM population.

A few lake groups have subsequently embraced alternative treatment strategies that are less commonly used in Wisconsin to targeted difficult invasive watermilfoil populations while attempting to preserve the valuable native plant community of the system. Three such herbicide use patterns are investigated below: 1) whole-lake 2,4-D/endothall, 2) whole-lake pelletized fluridone, and 3) spot treatments with short contact-exposure time requirements (CETs).

Whole-Lake 2,4-D & Endothall

In lakes that have both EWM and CLP, combination treatments of 2,4-D and endothall are common in spot treatment scenarios. The simultaneous exposure to endothall and 2,4-D has been shown to provide increased control of EWM in outdoor growth chamber studies (Madsen et al. 2010). A handful of HWM treatments in Wisconsin have conducted combination whole-lake 2,4-D/endothall treatment targeting approximately 0.25 ppm ae and 0.75 ppm ai, respectively with promising results of control and selectivity towards native plants. However, some of these treatments have had similarly quick target species recovery. Native aquatic plants in Lilly Lake that are particularly susceptible to this herbicide use include flat-stemmed pondweed (*Potamogeton zosteriformis*), other pondweeds (*Potamogeton* spp.) perhaps to a lesser degree, and slender naiad (*Najas flexilis*).

Whole-Lake Pelletized Fluridone

Fluridone is a systematic herbicide that disrupts photosynthetic pathways (carotenoid synthesis inhibitor). This herbicide requires long exposure times (>90 days) to cause mortality to HWM and therefore is only applicable to whole-lake use-patterns. Herbicide concentrations within the lake are kept at target levels by periodically adding additional herbicide (bump treatments) over the course of the summer based upon herbicide concentration monitoring results.

The use of fluridone has a checkered past in Wisconsin, as early implemented treatments (mid-2000s) resulted in native plant impacts that exceeded acceptable levels (Wagner et al. 2007). These collateral impacts are based upon liquid fluridone treatments, typically employed at 6 ppb with a bump treatment later in the summer to bring the concentration back up to 6 ppb. This fluridone use-pattern, commonly referred to as 6-bump-6, produces two relatively high herbicide pulses that taper off slowly as the herbicide degrades. Manufacturers of fluridone (SePRO) believe that the high herbicide pulses are the mechanism causing the native plant impacts (Dr. Mark Heilman, personal comm.).

A somewhat newer use-pattern of fluridone uses a pelletized product that gradually reaches a peak concentration over time (extended release) and results in a lower, sustained lake-wide herbicide concentration (2.0 to 3.0 ppb). This “low-and-long” fluridone strategy is most effective when concentrations can be maintained over 2.0 ppb for 120 days and when herbicide can still be detected in the lake the following ice-out approximately one year after the initial treatment took place.

Within a few limited Wisconsin field-trials, this use-pattern of fluridone appears to provide a similar level of efficacy as the 6-bump-6 approach, but with a lower (but still notable) magnitude of native plant impacts (Heath et al. 2018). In addition to HWM, native aquatic plants in Lilly Lake that are usually impacted by fluridone include the naiads (*Najas* spp.) and common waterweed (*Elodea canadensis*).

Spot Treatments with Short CET Herbicides

An alternative to whole-lake population control is targeting nuisance areas with spot treatments. As previously discussed, many spot treatments targeting invasive watermilfoils are limited to a single season of effectiveness. Some feel that the financial costs and ecological risks are not commensurate with the gains made from these seasonally effective treatments.

To gain multi-year HWM suppression, future spot herbicide treatments would likely need to consider herbicides (diquat, florpyrauxifen-benzyl, etc.) or herbicide combinations (2,4-D/endothall, diquat/endothall, etc.) thought to be more effective under short exposure situations than with traditional weak-acid auxin herbicides (e.g., 2,4-D, triclopyr). At the time of this writing, florpyrauxifen-benzyl (ProcellaCOR™), a combination of 2,4-D/endothall (Chinook®), and a combination of diquat/endothall (Aquastrike ™) are examples of herbicides with reported short exposure time requirements. Because 2,4-D, endothall, and diquat have been part of the herbicide use history of Lilly Lake, the following text will focus on providing information about ProcellaCOR™.

ProcellaCOR™ (florpyrauxifen-benzyl) is a relatively new herbicide that has shown some promise in spot treatments in Wisconsin Lakes. The manufacturer is currently working towards new formulations and guidance for whole-lake use patterns. ProcellaCOR™ is in a new class of synthetic auxin mimic herbicides (arylpicolinates) with short concentration and exposure time (CET) requirements compared to other systemic herbicides. Uptake rates of ProcellaCOR™ into EWM were two times greater than reported for triclopyr (Haug 2018)(Vassios et al. 2017). ProcellaCOR™ is primarily degraded by photolysis (light exposure), with some microbial degradation. The herbicide is relatively short-lived in the environment, with half-lives of 4-6 days in aerobic environments and 2 days in anerobic environments (WSDE 2017). The product has a high affinity for binding to organic materials (i.e., high KOC).

A series of spatially-targeted spot treatments with this chemistry may reduce nuisance conditions in high-use areas for multiple seasons post treatments. Because this herbicide is active at low concentrations, attention to additive impacts of multiple spot treatments in a given area should be discussed.

Pale-yellow Iris (Iris pseudacorus)

Pale-yellow iris (Photograph 3.3-8) is a large, showy iris with bright yellow flowers. Native to Europe and Asia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas forming large monotypic colonies and displacing valuable native wetland species. One large pale-yellow iris plant was located on the eastern shore of Lilly Lake in 2020 (Map 12). This plant should be removed, likely dug out with a shovel, including all of the below-ground rhizomes and disposed of in a landfill. Some individuals show sensitivity to the sap, so care should be taken to avoid contact with the skin when hand-removing the plant.

Photograph 3.3-8. Single pale-yellow iris plant located in Lilly Lake in 2020. Location in Lilly Lake can be found on Map 12. Photo credit Onterra.

Purple Loosestrife (Lythrum salicaria)

Photograph 3.3-9. Purple loosestrife. Location in Lilly Lake can be found on Map 12. Photo credit Onterra.

Purple loosestrife (Photograph 3.3-9) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930's, it has now spread to 70 of the state's 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments. In Lilly Lake, a few purple loosestrife plants were located along the lake's southeastern shoreline (Map 12). Like pale-yellow iris, given the isolated occurrences, these plants can be controlled by hand-removal and disposal (digging with shovel).

Giant or Common Reed (Phragmites australis subsp. australis)

Giant reed is a tall, perennial wetland grass. Two subspecies of giant reed can be found in Wisconsin. One, subspecies *americanus*, is considered native, while the other, subspecies *australis*, is considered non-native and invasive (Photograph 3.3-10). Introduced to the east coast of the United States sometime between the late 1700s and early 1800s, the non-native giant reed has been expanding its range westward ever since. It has the potential to form dense monocultures, displacing native vegetation and overtaking wetland areas.

Photograph 3.3-10. Non-native giant reed on a central Wisconsin lake. Location in Lilly Lake can be found on Map 12. Photo credit Onterra.

Photograph 3.3-11. Reed canary grass. Location in Lilly Lake can be found on Map 12. Photo credit Onterra.

The non-native subspecies of giant reed was located in four locations along Lilly Lake's shoreline in 2020 (Map 12). Three of these locations were on the lake's northern shoreline, while one was located on the lake's southwestern shoreline. Control of small occurrences of giant reed often involves cutting or mowing followed by an application of herbicide on the cut stems (imazapyr or glyphosate). It must be noted that the application of herbicides near water may require a permit.

Reed Canary Grass (Phalaris arundinacea)

Reed canary grass is another large, coarse perennial grass that can reach three to six feet in height (Photograph 3.3-11). Often difficult to distinguish from native grasses, this species forms dense, highly productive stands that vigorously outcompete native species. Unlike native grasses, few wildlife species utilize the grass as a food source, and the stems grow too densely to provide cover for small mammals and waterfowl. It grows best in moist soils such as wetlands, marshes, stream banks and lake shorelines. In Lilly Lake, one small colony of reed canary grass was located along the lake's northeastern shoreline (Map 11). Given its small size, this colony can likely be controlled via hand-pulling or digging.

Photograph 3.3-12. Colony of narrow-leaved cattail on Lilly Lake. Location in Lilly Lake can be found on Map 12. Photo credit Onterra.

Narrow-leaved Cattail (Typha angustifolia)

Narrow-leaved cattail is a perennial invasive wetland plant which invades shallow marshes and other wet areas (Photograph 3.3-12). Like Wisconsin's native broad-leaved cattail (*T. latifolia*), narrow-leaved cattail produces tall, erect, sword-like leaves that can grow nearly 10 feet tall. The leaves are generally narrower than broad-leaf cattail, typically 0.15-0.5 inches wide. Unlike broad-leaf cattail in which the male and female flowers are typically touching, there is typically a gap of 0.5-4.0 inches between the male and female flowers of narrow-leaved cattail.

One colony of narrow-leaved cattail was located along the northwestern shore of Lilly Lake in 2020 (Photograph 3.3-12 and Map 12). Given the isolated nature of this colony, the best method of control is likely the cutting of stems (both green and dead) in mid- to late-summer or early fall to below the water line. The following growing season, continually cut-back emerging stems to maintain them below the water for the remainder of the growing season. This process should be repeated until the plants do not reemerge.

Spiny Naiad (Najas marina)

Spiny naiad (Photograph 3.3-13) is an aquatic plant that is native to certain areas of North America but is not believed to be native to Wisconsin and is considered to be an invasive species. To date, known occurrences of spiny naiad in Wisconsin are in waterbodies in eastern and southeastern counties of the state. Under suitable conditions, this species can grow to excessive levels and create dense mats on the water's surface. Spiny naiad was observed in Lilly Lake during the 1967 and 2008 surveys but was not located during the surveys in 2020. While spiny naiad has been observed in these past surveys, it has not yet been verified (specimen collected and vouchered) by the WDNR. Two native naiad species (*N. flexilis* and *N. guadalupensis*) were observed in Lilly Lake in 2020.

Photograph 3.3-13. Spiny naiad. This non-native plant was observed in Lilly Lake in 1967 and 2008 but was not located in 2020. Its presence in Lilly Lake has not yet been verified by the WDNR. Photo credit Onterra.

4.0 SUMMARY AND CONCLUSIONS

The design of this project was intended to fulfill three objectives;

1) Collect and analyze baseline data regarding Lilly Lake's water quality, watershed, and aquatic plant community to gain a general understanding of the Lilly Lake ecosystem.
2) Collect detailed information regarding invasive aquatic and wetland plant species in Lilly Lake.
3) Develop an updated aquatic plant management plan with realistic and implementable management goals and actions to protect and enhance the Lilly Lake ecosystem for current and future generations.

These objectives were fulfilled during the project and have led to a greater understanding of the Lilly Lake ecosystem, the distribution of non-native plant species in the lake, the concerns and perceptions of Lilly Lake stakeholders, and the actions that need to be taken to conserve and enhance this important natural resource. The studies completed as part of this project found that Lilly Lake has excellent water quality despite being located in the highly-developed landscape of southern Wisconsin. Nutrient and algal levels are low and water clarity is high. The lake supports a high-quality native aquatic plant community, largely comprised of sensitive species like muskgrasses, white-stem pondweed, and fern-leaf pondweed. Fern-leaf pondweed is infrequent in southern Wisconsin as this species is most often found in the northern third of the state, and it likely represents one of the southernmost populations in Wisconsin.

The studies in 2020 found that Lilly Lake supports a relatively large hybrid watermilfoil (HWM) population, with the largest and densest colonies occurring in shallower, near-shore areas. However, HWM plants were found growing throughout the lake to a maximum rooting depth of 17 feet. The dense areas of HWM inhibit near-shore navigation and recreation in these areas as well as decrease the lake's aesthetic appeal. The history of annual, repeat treatments on Lilly Lake may have selected for an HWM population that is more tolerant of 2,4-D. The continued use of this herbicide will likely only result in seasonal control (plant injury), but will not result in longer-term, multi-year control (plant mortality).

An updated HWM management strategy was developed with the LLPRD and can be found in the subsequent Implementation Plan (Section 5.0). In addition to HWM, the non-native species of curly-leaf pondweed, purple loosestrife, pale-yellow iris, giant reed, narrow-leaved cattail, and reed canary grass were also located during 2020 surveys on Lilly Lake. The management of these non-native species is also discussed in the subsequent Implementation Plan section.

While this study did not assess Lilly Lake's immediate shoreland zone, the watershed assessment revealed this area of the lake and surrounding watershed contain a high degree of urban development. While Lilly Lake's water quality in terms of phosphorus, algal levels, and water clarity, other contaminants not assessed during this project such as pesticides, road salt, and fertilizers could be entering the lake from these areas. The Implementation Plan contains management strategies the LLPRD will use to protect and possibly restore shoreland areas around the lake.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented in this section was created through the collaborative efforts of the Lilly Lake Planning Committee, Onterra ecologists, Wisconsin Department of Natural Resources (WDNR) staff. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Lilly Lake stakeholders as portrayed by the members of the Planning Committee and the communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders. Please note that the listing order of these management goals is not indicative of priority.

Management Goal 1: Manage Existing and Prevent Future Introductions of Invasive Species in Lilly Lake and Surrounding Immediate Shoreland Zone

Management Action 1a:	Initiate hybrid watermilfoil (HWM) monitoring and control strategy on Lilly Lake.
Timeframe:	Initiate in 2021
Potential Funding:	WDNR Aquatic Invasive Species Established Population Control Grant
Facilitator:	LLPRD Board of Directors
Description:	The LLPRD has been managing Lilly Lake's HWM population on an annual basis primarily targeting the population with 2,4-D spot treatments. While some of these historical treatments have approached whole-lake levels, these treatments have at best resulted in seasonal control and have failed to achieve longer-term, multi-year control of the HWM population. It is likely that the long history of annual use of 2,4-D has selected for an HWM population that is more resistant to this herbicide. The surveys completed in 2020 found that HWM is widespread and well established in Lilly Lake, with the densest colonies found in shallow, near-shore areas where they interfere with lake access, recreation, and aesthetics (Map 14). These dense colonies encompass approximately 8.0 acres, and the 2020 point-intercept survey indicated HWM had a high littoral frequency of occurrence of 37%. During the strategic planning meetings with the LLPRD Planning Committee, Onterra outlined three broad potential HWM population perspectives for consideration including a recommended action plan to help reach of the goals. These potential goals included: 1) No coordinated active management of HWM (let nature take its course), 2) minimize navigation and recreation impediment (nuisance

control), or 3) reduce the HWM population on population or lake-wide level (lake-wide population management).

Given the level of HWM in Lilly Lake, the LLPRD does not want to take a *let nature take its course* approach and has elected to initiate an herbicide control strategy using a relatively new herbicide, ProcellaCOR™, in an effort to achieve longer-term control of the HWM population. A detailed discussion of ProcellaCOR™ can be found in Section 3.3; however, this herbicide has a shorter concentration and exposure time when compared to 2,4-D and has been shown to be highly effective at causing HWM mortality in spot-treatment scenarios.

The LLPRD understands the eradication of HWM from Lilly Lake is impossible with current management techniques available, and that the ultimate goal of this HWM management strategy is to maintain a population which imparts minimal to no detectable impacts to the lake's ecology, water quality, recreation, navigation, and aesthetics. In other words, the goal is to reduce or eliminate large, contiguous, monotypic colonies of HWM and maintain a population primarily comprised of single-plant occurrences.

The LLPRD would like to conduct a ProcellaCOR™ treatment to control the HWM population in Lilly Lake in 2022. The LLPRD will seek funding for HWM monitoring and management from 2022-2023 through a WDNR Aquatic Invasive Species Established Population Control grant. These grants are awarded to large-scale population management projects that will result in long-term, multi-season suppression of established populations of aquatic invasive species. In advance of the 2022 treatment, the LLPRD has contracted with Onterra to complete a whole-lake pre-treatment point-intercept survey and late-season HWM peak-biomass survey in 2021. The collection of these data will allow for the most accurate and effective treatment strategy to be developed. In addition, it will also allow for a determination of how effective the treatment was in terms of HWM control and any potential impacts to non-target native plant species.

The following outlines the steps HWM management and monitoring strategy from 2021-2023:

<u>2021 (Year Prior to Treatment)</u>

1. A whole-lake point-intercept survey is completed in mid-summer to quantify HWM and native plant populations ahead of proposed 2022 treatment

2. A late-season HWM peak-biomass survey is completed in late summer to map areas of HWM to guide creation of herbicide application areas.

3. LLPRD works with Onterra to apply for WDNR AIS-EPC grant for November 1, 2021 to aid in funding HWM control and monitoring efforts from 2022-2023.

The surveys completed on Lilly Lake in 2021would direct herbicide strategy development. It is likely that additional data from other ongoing management programs across the state will provide updated guidance on the use of ProcellaCOR™, a relatively new herbicide.

2022 (Year of Treatment)

4. Onterra provides draft of *2021 HWM Management Strategy Development Report* to Strategic Planning Committee in spring. This report will share the results of the 2021 field surveys as applicable to the design of the 2022 control strategy.

5. Strategic Planning Committee Teleconference: Following grant approval, a teleconference would be held in the spring of 2022 with all project partners to finalize the 2022 management and monitoring strategy.

6. A trained volunteer(s) would collect pretreatment temperature profiles to determine the influence of stratification on herbicide mixing volumes and final dosing strategies. These data will help direct pretreatment survey timing.

7. A pre-treatment survey is completed by Onterra (likely in May) to confirm the presence of HWM in proposed herbicide application areas and refine boundaries as appropriate.

8. Treatment occurs (likely in early June)

9. Trained volunteer(s) collect water samples at multiple locations and time intervals following the treatment to for herbicide concentration monitoring.

10. A *year of treatment* whole-lake point-intercept survey is completed to quantify initial impacts to HWM population and possible impacts to non-target native plant populations.

11. A *year of treatment* late-season HWM peak-biomass survey is completed to understand initial impacts to spatial distribution of HWM population.

12. Onterra creates *2022 HWM Management and Control Strategy Assessment Report* which will discuss initial treatment results as well as follow-up integrated pest management (e.g., hand-harvesting). This report will be available in late-2022 or early-2023.

<u>2023 (Year Following Treatment)</u>

13. A *year following treatment* whole-lake point-intercept survey is completed quantify overall impacts to HWM population and possible impacts to non-target native plant populations.

14. A *year following treatment* late-season HWM peak-biomass survey is completed to understand overall impacts to spatial distribution of HWM population.

15. Onterra creates *Final HWM Management and Control Strategy Assessment Report*, likely available in late 2023 or early 2024. Report would discuss overall project results and HWM management and monitoring strategy for 2024.

The success criteria of a large-scale treatment would be a 70% reduction in EWM littoral frequency of occurrence (LFOO) comparing point-intercept surveys from the *year prior to the treatment* to the *year after the treatment*. This means if the treatment occurs in 2022, the *year before treatment* would be 2021 and the *year after treatment* would be 2023. Regardless of treatment efficacy, a whole-lake treatment would not be conducted during the *year following the treatment*.

If a 70% reduction of EWM LFOO is achieved during the timeline outlined, it is likely that the lowered EWM population will last 3-5 years before additional large-scale management would be needed. Integrated pest management activities, such as hand-harvesting and herbicide spot treatments would be developed and presented in the final project report. If the 2022 management strategy does not meet the control goal criteria, the LLPRD would review their goal of reducing the lake-wide EWM population within the lake. Initially, this would include investigation of alternative herbicides and use-patterns.

Action Steps:

1. Retain qualified professional assistance to develop a specific project design utilizing the methods discussed above.
2. Apply for a WDNR Aquatic Invasive Species Grant based on developed project design.
3. Initiate control and monitoring plan.

Management Action 1b: Control aquatic plant growth in public swimming area and around public boat launch to enhance recreational opportunities and swimmer safety as needed.

Timeframe: Continuation of current effort.

Facilitator: LLPRD Board of Directors

Description: In an effort to improve recreational experience and increase safety for swimmers, the LLPRD will continue to control aquatic plant growth within the public swim area and around the public boat launch as needed. These treatments are small spot-treatments that encompass approximately 2.0 acres around the beach and boat launch. The LLPRD will work with the WDNR and contracted applicator to complete these treatments as needed. This treatment areas encompasses the majority of the lake's curly-leaf pondweed population, but other plants such as hybrid watermilfoil and native species are also present and contribute to the dense growth. Given the size of this treatment, impacts to plants would only be expected within and immediately surrounding the application area.

Action Steps:

1. Work with WDNR and herbicide applicator to conduct herbicide application as needed of dense aquatic plant growth near boat landing and public beach.

Management Action 1c: Control and monitor shoreland invasive wetland plants around Lilly Lake.

Timeframe: Initiate in 2021

Facilitator: LLPRD Board of Directors

Description: During the 2020 surveys of Lilly Lake, five invasive wetland plant species were located growing in shoreland areas around the lake. These include purple loosestrife, reed canary grass, giant reed, and narrow-leaved cattail. These species were not widespread and were found as single-plant or small colony occurrences (Map 12). The LLPRD will create an informational handout for district members that will provide information on how to identify and control these invasive plants on their property.

The occurrences of purple loosestrife, pale-yellow iris, and reed canary grass were comprised of single-plant occurrences. The best method of control for these plants at this time is by hand-removal, via digging the plants out and disposing of them in the landfill.

The colony of narrow-leaved cattail was slightly larger, but still likely lends itself to being controlled without the use of herbicides. Given the isolated nature the single colony located, the best method of control is likely the cutting of stems (both green and dead) in mid- to late-summer or early fall to below the water line. The following growing season, continually cut-back emerging stems to maintain them below the water for the remainder of the growing season. This process should be repeated until the plants do not reemerge. Similarly, the colonies of giant reed located were relatively small and can likely be controlled via mechanical means. Stalks can be cut and hand-pulled repeatedly until the plants do not reemerge.

Resources on identification and control of these invasive wetland plants can be found below:

- **Southeastern Wisconsin Invasive Species Consortium, Inc. (SEWISC):** https://sewisc.org/
- **Southeastern Wisconsin Regional Planning Commission (SEWRPC):** https://www.sewrpc.org/SEWRPC.htm
- **Wisconsin Department of Natural Resources (WDNR):** https://dnr.wisconsin.gov/topic/Invasives

Action Steps:

1. Create and distribute annual educational materials for Lilly Lake property owners on how to identify, monitor, and control invasive wetland plants on their property. Utilize resources above to obtain information for educational materials.
2. For additional information on identification, control, and monitoring, LLPRD can reach out to and work with local county, SEWISC, SEWRPC, and WDNR partners.

<u>Management Action 1d:</u> Investigate implementing Clean Boats Clean Waters paid and/or volunteer watercraft inspectors at Lilly Lake public boat landing.

Timeframe: Initiate in 2021

Facilitator: LLPRD Board of Directors

Potential Funding: WDNR AIS-Clean Boats Clean Waters Grant

Description: Clean Boats Clean Waters involves teams of volunteers and/or paid staff from the WDNR, Sea Grant, universities, and other organizations that help perform boat and trailer inspections, provide informational materials and educate lake users on how to prevent the spread of AIS. The LLPRD has never utilized watercraft inspectors at its public boat landing, but during the planning meeting it was discussed that they would like to revisit this topic.

Having inspectors at the boat landing, even for just high-use holiday weekends during the summer, may help prevent the introduction of a new invasive species to Lilly Lake (e.g., starry stonewort), and may also help prevent invasive species already established in Lilly Lake from being transported elsewhere. The WDNR offers Clean Boats Clean Waters grants which cover up to 75% of the total project costs, and provide up to $4,000 per boat landing.

Action Steps:

1. LLPRD to revisit discussion on having watercraft inspectors at the Lilly Lake boat landing during high-use weekends. Resources for this program can be found here: https://dnr.wisconsin.gov/topic/lakes/cbcw

Management Goal 2: Protect Current Water Quality Conditions

<u>Management Action 2a:</u>	Continue monitoring of Lilly Lake's water quality through the WDNR Citizens Lake Monitoring Network (CLMN) program.
Timeframe:	Continuation of current effort
Facilitators:	Mike Adam (current CLMN volunteer) and LLPRD board of directors.
Description:	Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. The Citizen Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. Volunteers from the LLPRD have been collecting total phosphorus, chlorophyll-*a*, and Secchi disk transparency data annually since 2013. The data collected by this volunteer-based program allowed for a determination that Lilly Lake's current water quality parameters are excellent for a deep seepage lake in Wisconsin, and that the lake has some of the best water quality for lakes in the southern part of the state. Continued monitoring of the lake's water quality will allow managers to determine if any negative trends start occurring and will allow for a better understanding of the lake's nutrient and algae dynamics over time. When a change in the collection volunteer occurs, Rachel Sabre (262.574.2133) or the appropriate WDNR/UW-Extension staff will need to be contacted to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is

also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:

1. Mike Adam and/or LLRPD board of directors appoints/recruits new water quality monitoring volunteer(s) as needed.
2. New volunteer(s) contact Rachel Sabre (262.574.2133) with the WDNR as needed.
3. Volunteer(s) report annual monitoring results to WDNR SWIMS database.
4. LLPRD presents annual water quality results to its membership at annual meetings and/or in newsletter releases.

Management Goal 3: Investigate Restoration of Developed Shoreland Areas Around Lilly Lake

Management Action 3a: Investigate the restoration of highly developed shoreland areas and implementation of other best management practices (e.g., rain gardens) on Lilly Lake to enhance habitat, reduce erosion, and protect water quality.

Timeframe: Initiate in 2021

Facilitator: LLPRD Board of Directors

Potential Funding: Healthy Lakes Grants; Lake Protection Grant

Description: While a shoreland assessment was not completed as part of this project, it is clear that the majority of shoreland areas around Lilly Lake are in a highly developed state, lacking natural riparian vegetation and habitat. The LLPRD will explore project opportunities and provide educational materials to lake property owners best management practices along lakeshore properties. The LLPRD can assist property owners in applying for grant applications. Educational materials for healthy shorelines and watercraft safety will be created to inform and educate property owners.

The LLPRD will begin investigating restoration projects that would qualify for Healthy Lakes grants to restore developed shorelands and implement best management practices (e.g., rain gardens and native plantings) on riparian properties. The WDNR's Healthy Lakes grants allow partial cost coverage for native plantings in transition areas. This reimbursable grant program is intended for relatively straightforward and simple projects. More advanced projects that require advanced engineering design may seek alternative funding opportunities, potentially through the county and the WDNR Lake Protection Grant Program. For a larger project that may include a number of properties, it may be more appropriate to seek funding through a WDNR Lake

Protection Grant. While more funding can be provided through a Lake Protection Grant and there are no limits to where that funding is utilized (e.g., technical, installation, etc.). However, the grant does require that the restored shorelines remain undeveloped in perpetuity.

The LLPRD should work with the WDNR's Heidi Bunk (262.574.2130) to initiate new Healthy Lake projects and research ideas for larger-scale projects to address shoreland restoration. The LLPRD should also work with the Kenosha County Land and Water Conservation Department to research other grant programs, shoreland restoration/preservation techniques, and other pertinent information that will aid the LLPRD.

Action Steps:

1. The LLPRD gathers appropriate information from entities listed in description.
2. The LLPRD provides property owners with informational resources on shoreland protection and restoration. Interested property owners may contact the LLPRD or WDNR for more information on shoreland restoration plans, financial assistance, and benefits of implementation.

Management Goal 4: Increase LLPRD's Capacity to Communicate with Lake Stakeholders and Facilitate Partnerships with Other Management Entities

Management Action 4a: Promote the conservation and enjoyment of Lilly Lake through stakeholder education.

Timeframe: Continuation and expansion of current efforts.

Facilitator: LLPRD Board or Directors

Description: Education represents an effective tool to address many lake challenges. The LLPRD regularly publishes and distributes a newsletter once or twice per year and maintains a district website. These modes of communication provide district members with lake-related information including current projects and updates, meeting times, and educational topics.

The LLPRD would like to maintain its capacity to reach out to and educate district members regarding Lilly Lake and its conservation. Education of lake stakeholders on all matters is important, and a list of educational topics that were discussed during the planning meetings along with others can be found below. These topics can be included within the district's newsletter, distributed as separate educational materials, and/or posted on the district's website. The LLPRD can also invite speakers to discuss lake-related topics or hold workshops for their members at their annual meetings. The LLPRD should also reach out to professionals from the WDNR, SEWRPC, and Kenosha County

Land and Water Conservation Department, etc. to obtain educational pieces for their newsletter.

During the planning meetings, it was also proposed that the LLPRD coordinate a "Introduction to Lilly Lake Day", where district members and other lake users could be introduced to the native and non-native plants of Lilly Lake, learn how water quality is monitored, and learn about lake conservation. Participants would be taken around the lake via pontoon boat to look at plants and see water quality monitoring demonstrations.

Example Educational Topics

- Aquatic invasive species identification, prevention, and management
- Boating regulations and responsible use
- Lake property and shoreland conservation and restoration
- Native aquatic plant conservation and importance in the aquatic community
- Importance of maintaining coarse woody habitat (CWH)
- Basic lake ecology (water quality, plants, fisheries, etc.)
- Effect of lawn fertilizers/pesticides on lakes
- Respect to and maintaining a safe distance from wildlife in the lake
- Water quality updates from Lilly Lake
- Fishing rules and regulations
- Catch-and-release fishing
- Septic system maintenance
- Noise, air, and light pollution
- Fireworks
- Minimizing disturbance to spawning fish

Action Steps:

1. LLPRD Board of Directors communicates lake-related information and educational materials to lake stakeholders through methods discussed in description.

<u>Management Action 4b:</u> Continue and enhance LLPRD's involvement with other entities that manage aspects of Lilly Lake and other conservation groups.

Timeframe: Continuation of current effort

Facilitator: LLPRD Board of Directors

Description: The LLPRD is dedicated to enhancing, preserving and protecting the quality of Lilly Lake for future generations through effective environmental and education policies. The LLPRD promotes policies and practices that protect the interests of Lilly Lake stakeholders and enhance their ability to maximize enjoyment of their shared resource.

The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. Some of these entities are tribal and governmental while other organizations rely on voluntary participation.

It is important that the LLPRD actively engage with all management entities to enhance the district's understanding of common management goals and to participate in the development of those goals. This also helps all management entities understand the actions that others are taking to reduce the duplication of efforts. Each entity will be specifically addressed in the table on the next pages:

Action Steps:

1. See table guidelines on the next pages.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Wisconsin Dept. of Natural Resources	Heidi Bunk Water Resource Management Specialist Heidi.Bunk@wisconsin.gov 262.574.2130	Oversees management plans, grants, all lake activities.	Every 5 years, or more as necessary.	Information on updating APM management plan (every 5 years) or to seek advice on other lake issues.
Wisconsin Dept. of Natural Resources	Craig Helker Water Resource Management Specialist Craig.Helker@wisconsin.gov 262.884.2357	Aquatic Plant Management for Kenosha County.	Every year regarding AIS management strategy or more as necessary.	APM permitting, strategy, etc.
Kenosha County Land and Water Conservation Dept.	Mark Jenkins Count Conservationist Mark.Jenks@kenoshacounty.org 262.857.1900	Lake monitoring, AIS, shoreland restoration, outreach efforts.	As needed.	Can provide assistance with shoreland restoration initiatives, AIS surveys, monitoring, etc.
Southeast Wisconsin Regional Planning Commission (SEWRPC)	Thomas Slawksi Chief Specialist-Biologist TSlawski@sewrpc.org 262.953.3263	Planning commission for seven county southeastern WI area.	As needed.	Can provide assistance with shoreland restoration initiatives, AIS surveys, monitoring, etc.
Southeast Wisconsin Invasive Species Consortium, Inc.	John Lunz President lunz65@att.net 414.702.7288	Coalition that promotes efficient and effective management of invasive species in eight county southeastern WI area.	As needed.	Can provide assistance and resources with AIS identification, monitoring, and control.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Lilly Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point on the lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected using WDNR Citizen Lake Monitoring Network (CLMN) protocols. All sample were collected by LLPRD members at near-surface depths in June, July, and August of 2020. All samples that required laboratory analysis were processed through the Wisconsin State Laboratory of Hygiene (SLOH). The parameters measured, sample collection timing, and designated collector are contained in the table below.

Parameter	June	July	August
Total Phosphorus	♦	♦	♦
Chlorophyll-*a*	♦	♦	♦
Total Nitrogen	●	●	●

♦ indicates samples collected as a part of the Citizen Lake Monitoring Network.
● indicates samples collected by volunteers under proposed project.

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Lilly Lake during a June 4, 2020 field visit, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Lilly Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in the Wisconsin Department of Natural Resource document, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry, and Analysis, and Applications (WDNR PUB-SS-1068 2010) was used to complete this study on Jule 31, 2020. A point spacing of 39 meters was used resulting in 225 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Lilly Lake (emergent and floating-leaved vegetation) were mapped using a Trimble Pro6T Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the point-intercept surveys and the community mapping surveys were recorded to provide a complete species list for the lake.

Representatives of all plant species located during the point-intercept and community mapping survey were collected, vouchered, and sent to the University of Wisconsin – Steven's Point Herbarium.

7.0 LITERATURE CITED

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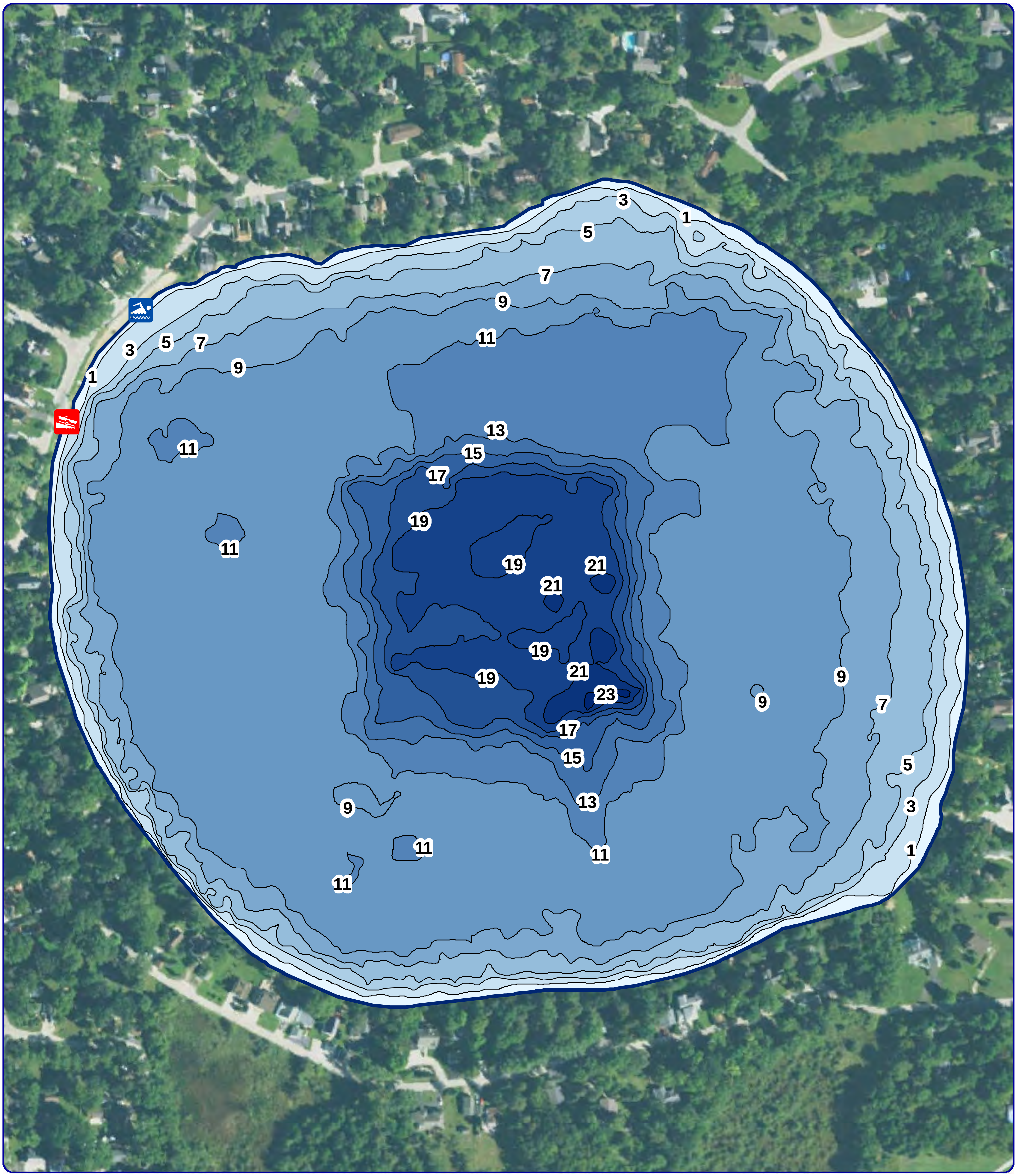

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Feet

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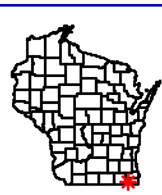
Sources:
Hydro: WDNR; modified by Onterra
Bathymetry: WDNR; digitized by Onterra
Orthophotgraphy: NAIP 2018
Map Date: November 4, 2020
Map Filename: Map1_Lilly_Location.mxd


Project Location in Wisconsin

Lilly Lake
85 acres (WDNR Definition)

Public Boat Landing

Public Beach

Map 1
Lilly Lake
Kenosha County, Wisconsin
Project Location

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Lilly Lake Watershed Boundary

Lilly Lake

Forest

Grassland

Urban - Impervious

Urban - Pervious

Map 2

Lilly Lake

Kenosha County, Wisconsin

Watershed Boundary & Landcover Types

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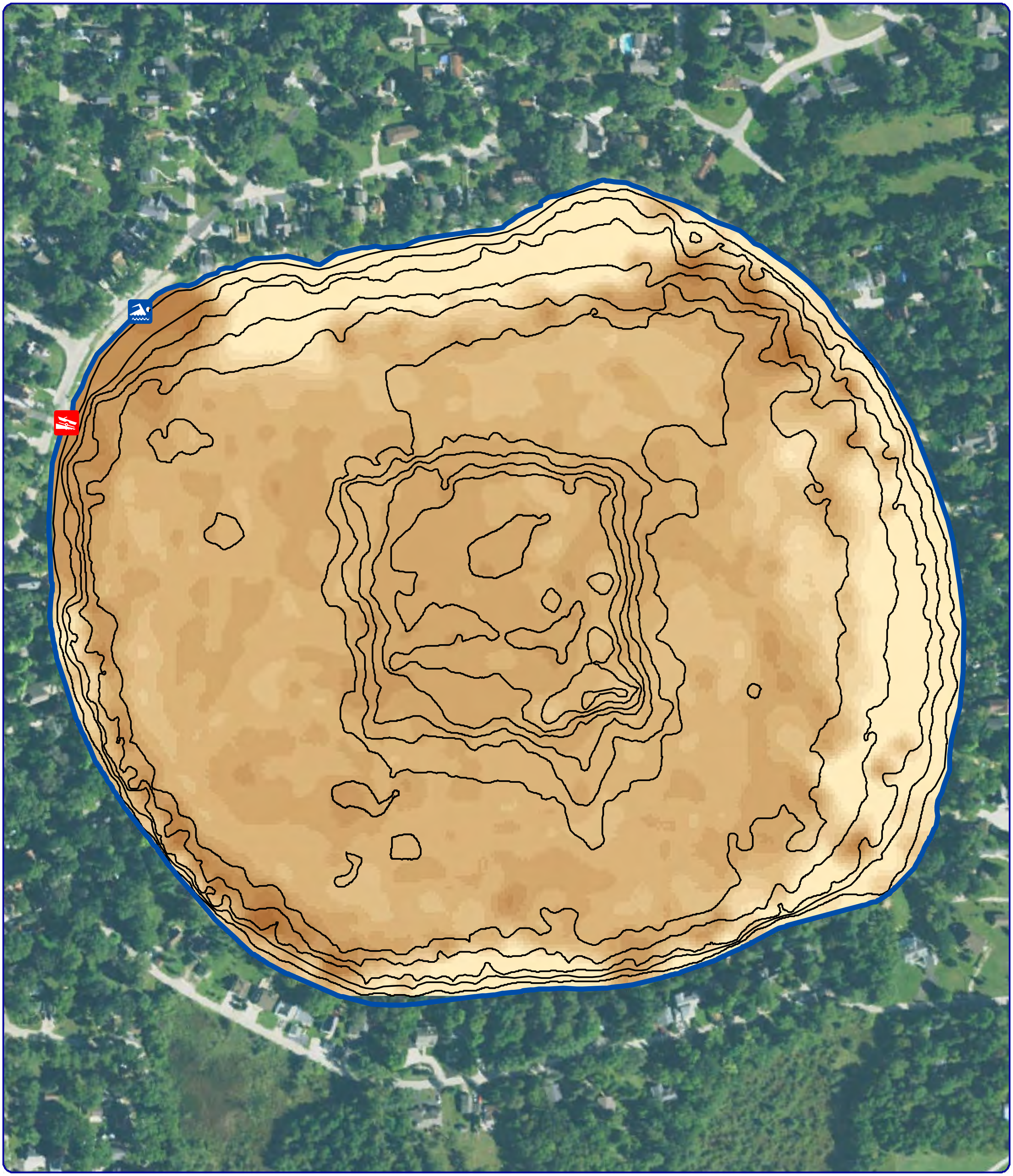
Map Date: November 4, 2020
Map Filename: Map2_Lilly_WS.mxd



Map 3

Lilly Lake

Kenosha County, Wisconsin

2020 Acoustic Survey: Substrate Hardness

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Legend

Soft — Hard

Substrate Composition

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Sources:
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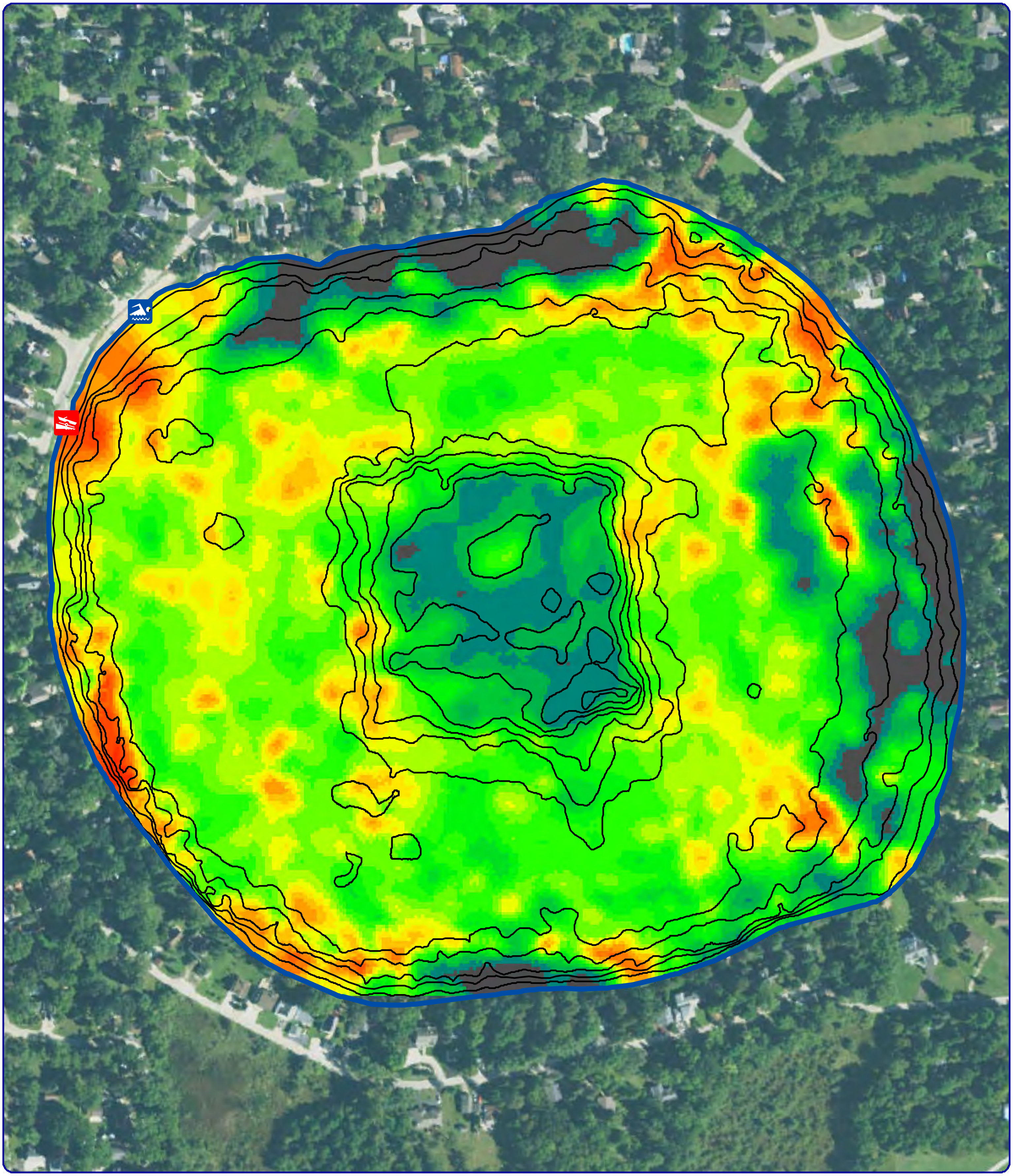
Orthophotography: NAIP, 2018
Substrate Hardness: Onterra, 2020; procesed by C-Map USA
Map Date: November 4, 2020 BTB
Filename: Map3_Lilly_SubHard_2020.mxd



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Sources:
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Substrate Hardness: Onterra, 2020;
procesed by C-Map USA
Map Date: November 4, 2020 BTB
Filename: Map4_Lilly_BioVol_2020.mxd

Legend

0% 50% 100%

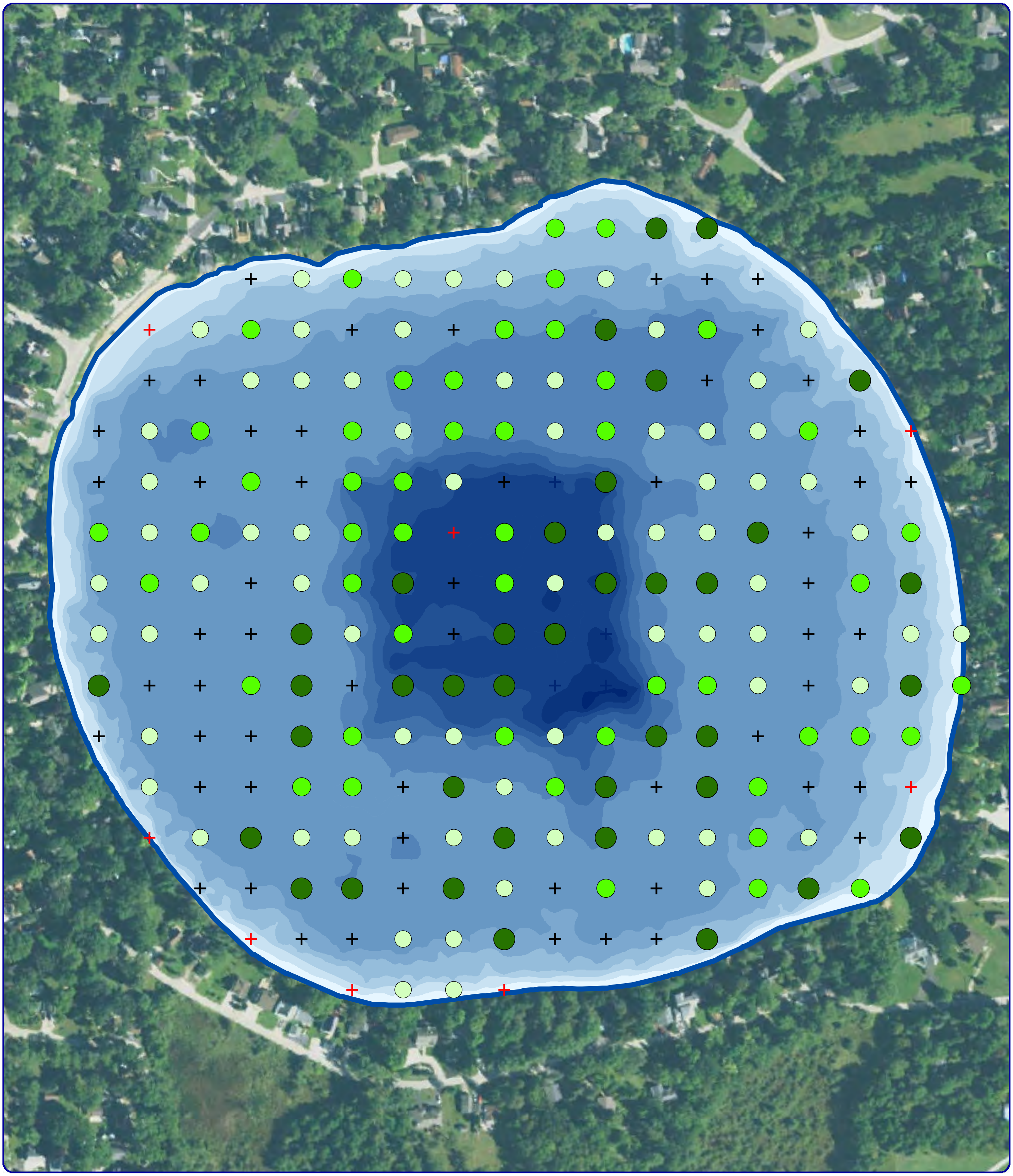
Aquatic Plant Bio-volume (%)

Map 4

Lilly Lake

Kenosha County, Wisconsin

2020 Acoustic Survey:
Aquatic Plant Bio-Volume



Muskgrasses (*Chara* spp.)

- \+ Not Present - Littoral Zone
- Rake Fullness = 1
- Rake Fullness = 2
- Rake Fullness = 3
- \+ Not Present - Profundal Zone
- \+ No Data - Non-Navigable, etc.

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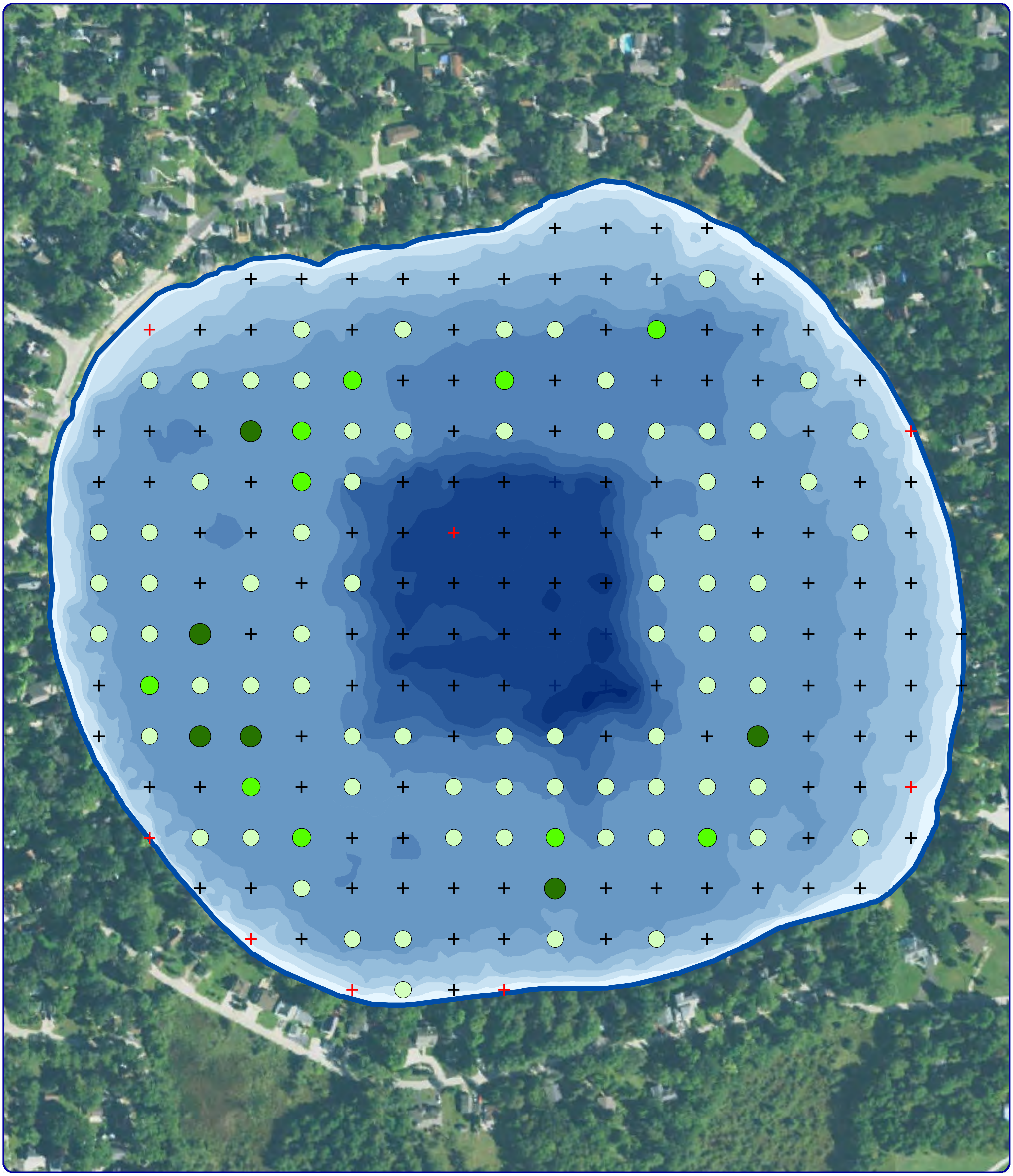
Map Date: November 4, 2020 BTB
Filename: Map5_Lilly_TRFPI_CHARA.mxd

Map 5

Lilly Lake

Kenosha County, Wisconsin

2020 Point-Intercept Survey
Muskgrass Locations



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Map Date: November 4, 2020 BTB
Filename: Map6_Lilly_TRFPI_POTRO.mxd

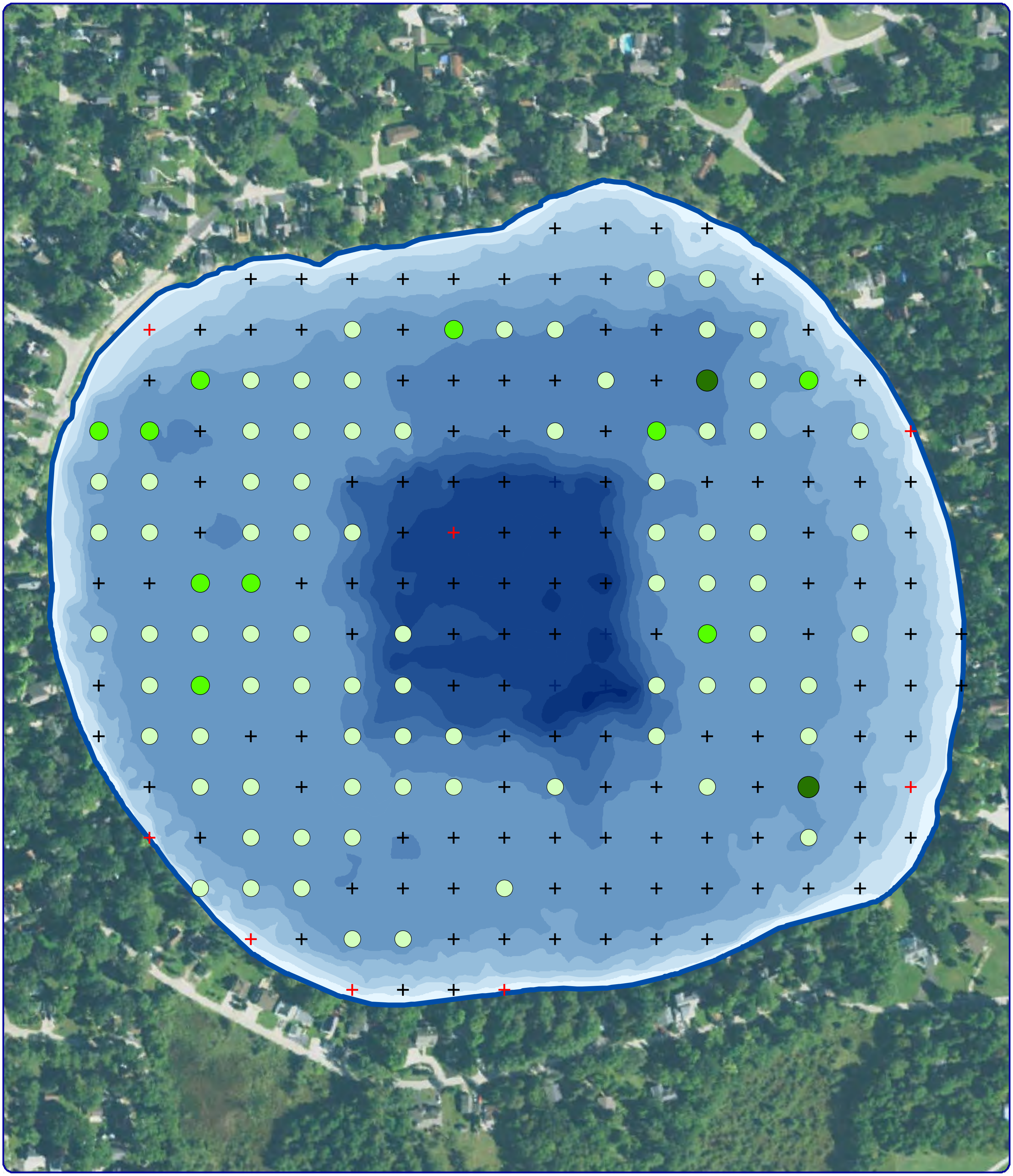
Fern-leaf Pondweed (*Potamogeton robbinsii*)

- \+ Not Present - Littoral Zone
- Rake Fullness = 1
- Rake Fullness = 2
- Rake Fullness = 3
- \+ Not Present - Profundal Zone
- \+ No Data - Non-Navigable, etc.

Map 6

Lilly Lake
Kenosha County, Wisconsin

2020 Point-Intercept Survey
Fern-leaf Pondweed Locations



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White-stem Pondweed (*Potamogeton praelongus*)

- Not Present - Littoral Zone
- Rake Fullness = 1
- Rake Fullness = 2
- Rake Fullness = 3
- Not Present - Profundal Zone
- No Data - Non-Navigable, etc.

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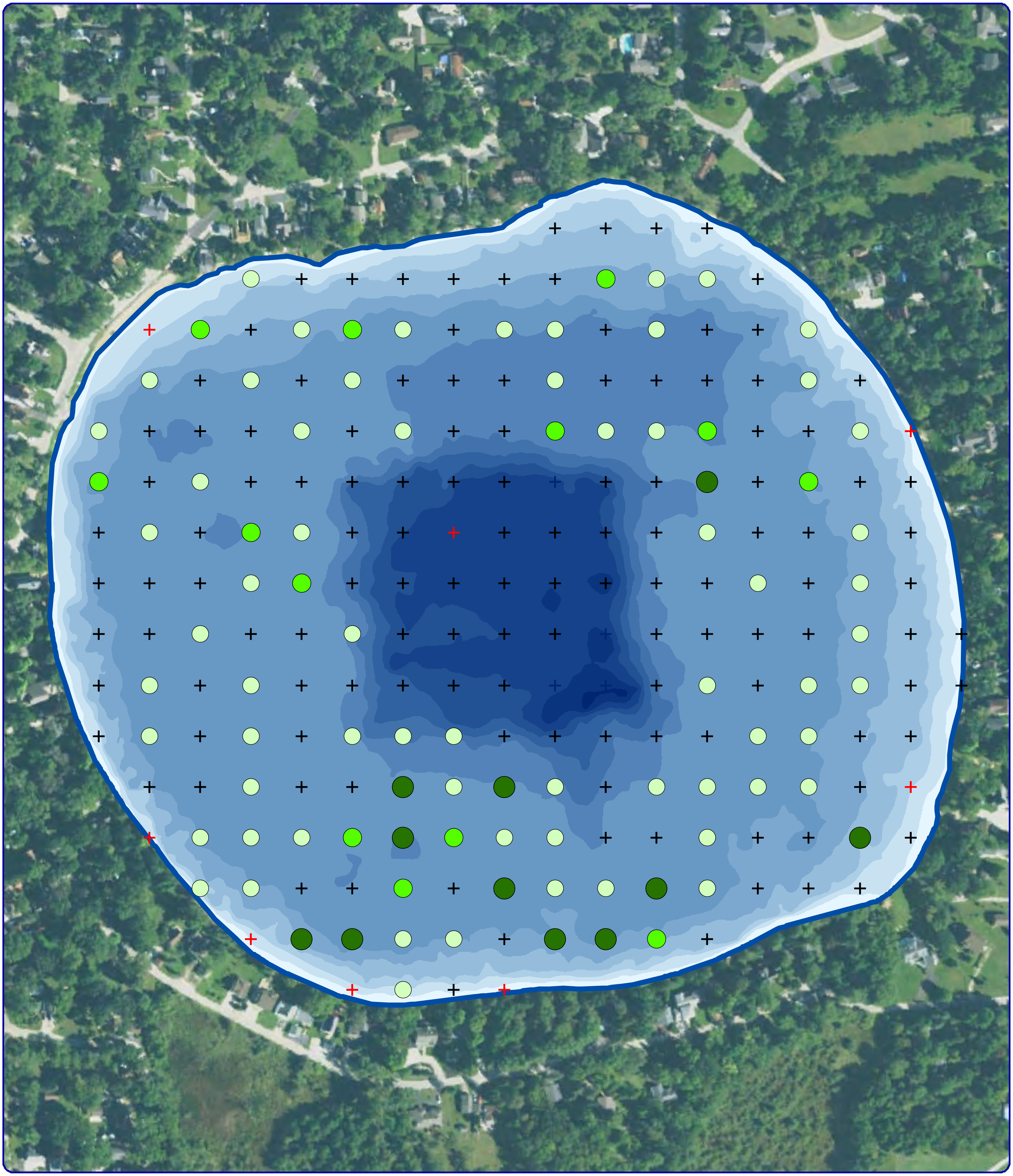
Map Date: November 4, 2020 BTB
Filename: Map7_Lilly_TRFPI_POTPR.mxd

Map 7

Lilly Lake

Kenosha County, Wisconsin

2020 Point-Intercept Survey
White-stem Pondweed Locations



Southern Naiad (*Najas guadalupensis*)

- \+ Not Present - Littoral Zone
- \+ Not Present - Profundal Zone
- \+ No Data - Non-Navigable, etc.
- Rake Fullness = 1
- Rake Fullness = 2
- Rake Fullness = 3

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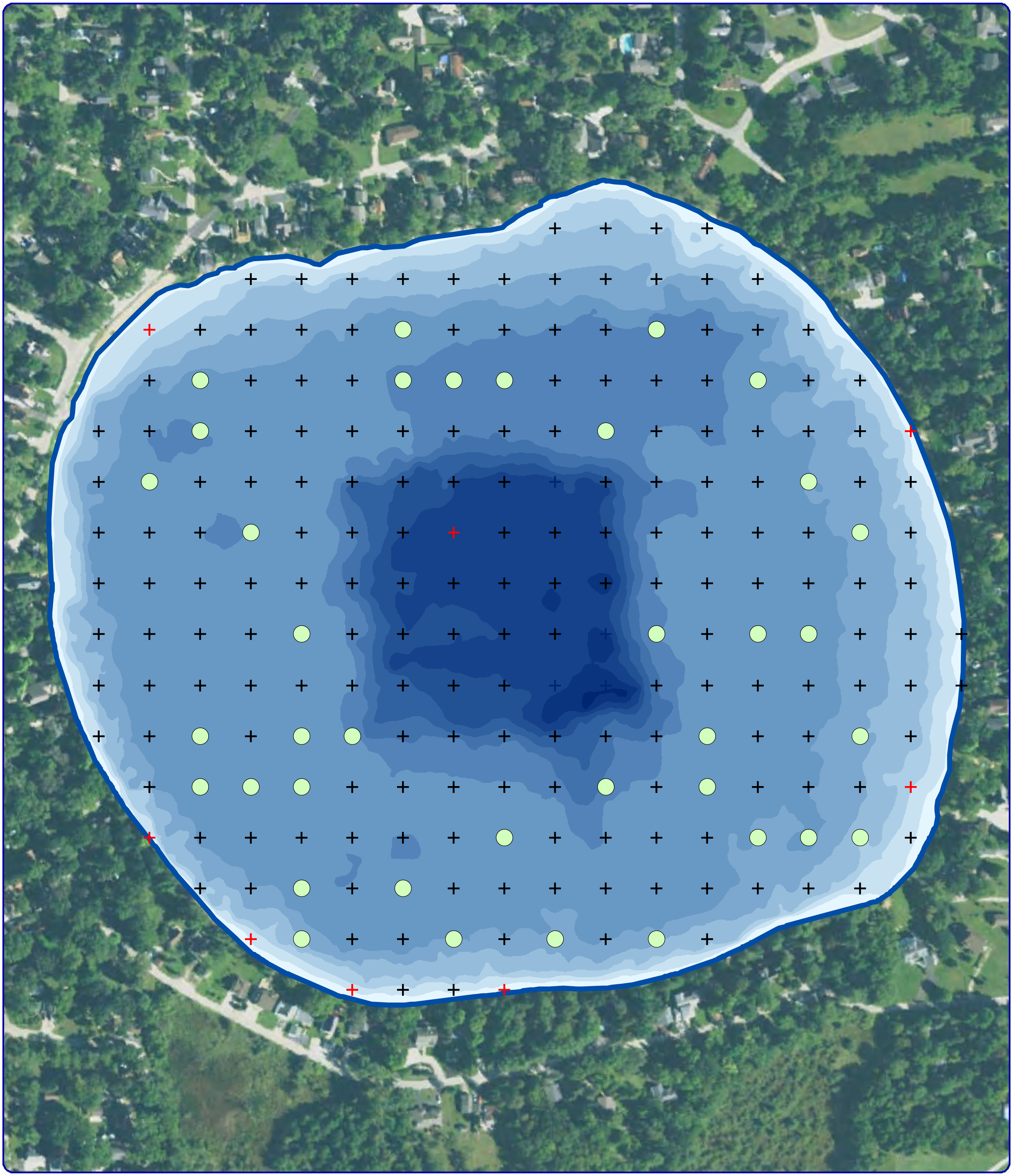
Map Date: November 4, 2020 BTB
Filename: Map8_Lilly_TRFPI_NAJGU.mxd

Map 8

Lilly Lake

Kenosha County, Wisconsin

2020 Point-Intercept Survey
Southern Naiad Locations



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Map Date: November 4, 2020 BTB
Filename: Map9_Lilly_TRFPI_POTAMxPOTPR.mxd

Large-leaf x White-stem Pondweed
(Potamogeton amplifolius x P. praelongus)

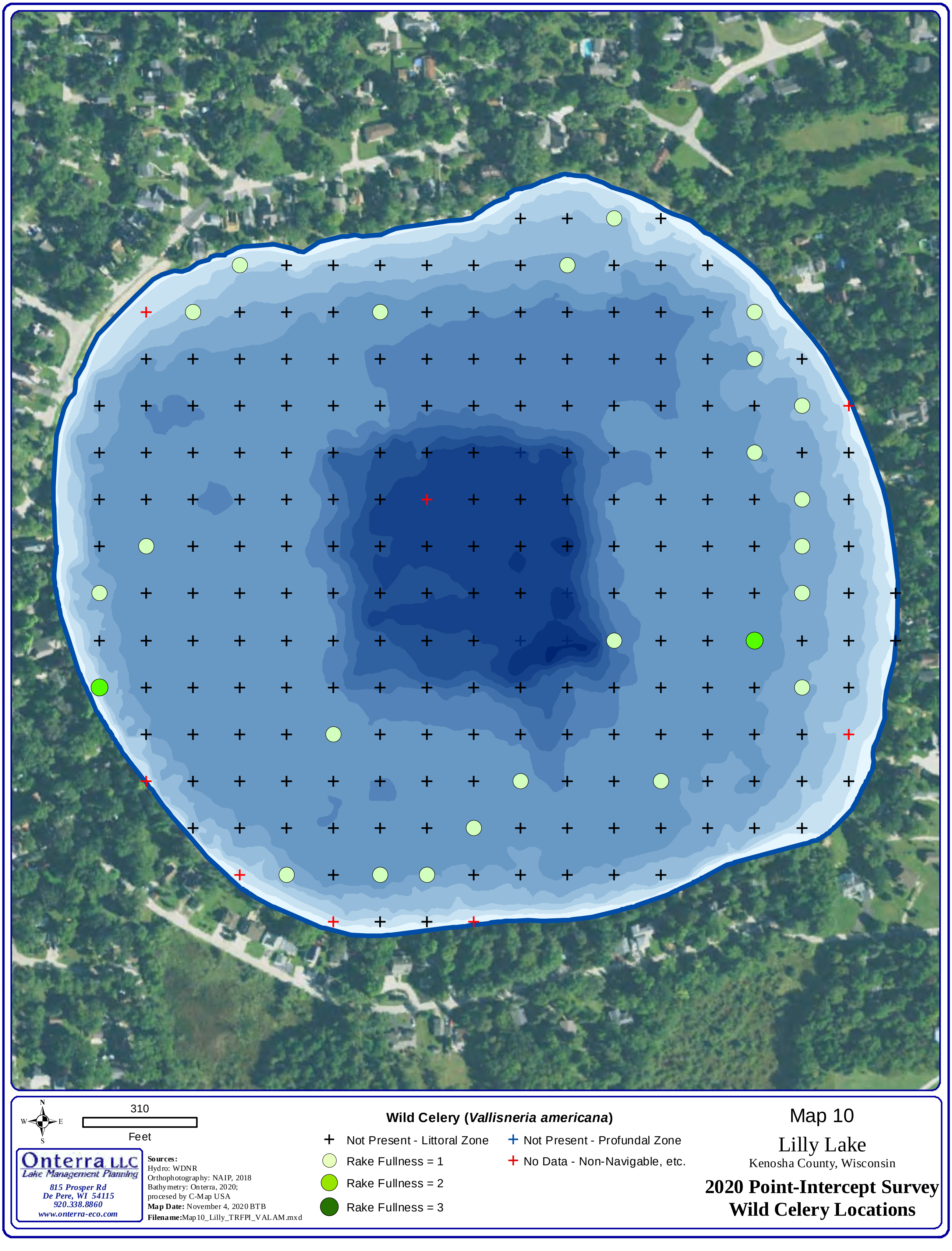
- + Not Present - Littoral Zone
- + Not Present - Profundal Zone
- Rake Fullness = 1
- + No Data - Non-Navigable, etc.
- Rake Fullness = 2
- Rake Fullness = 3

Map 9

Lilly Lake

Kenosha County, Wisconsin

2020 Point-Intercept Survey
Hybrid Pondweed Locations



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Sources:
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Orthophotography: NAIP, 2018
Bathymetry: Onterra, 2020;
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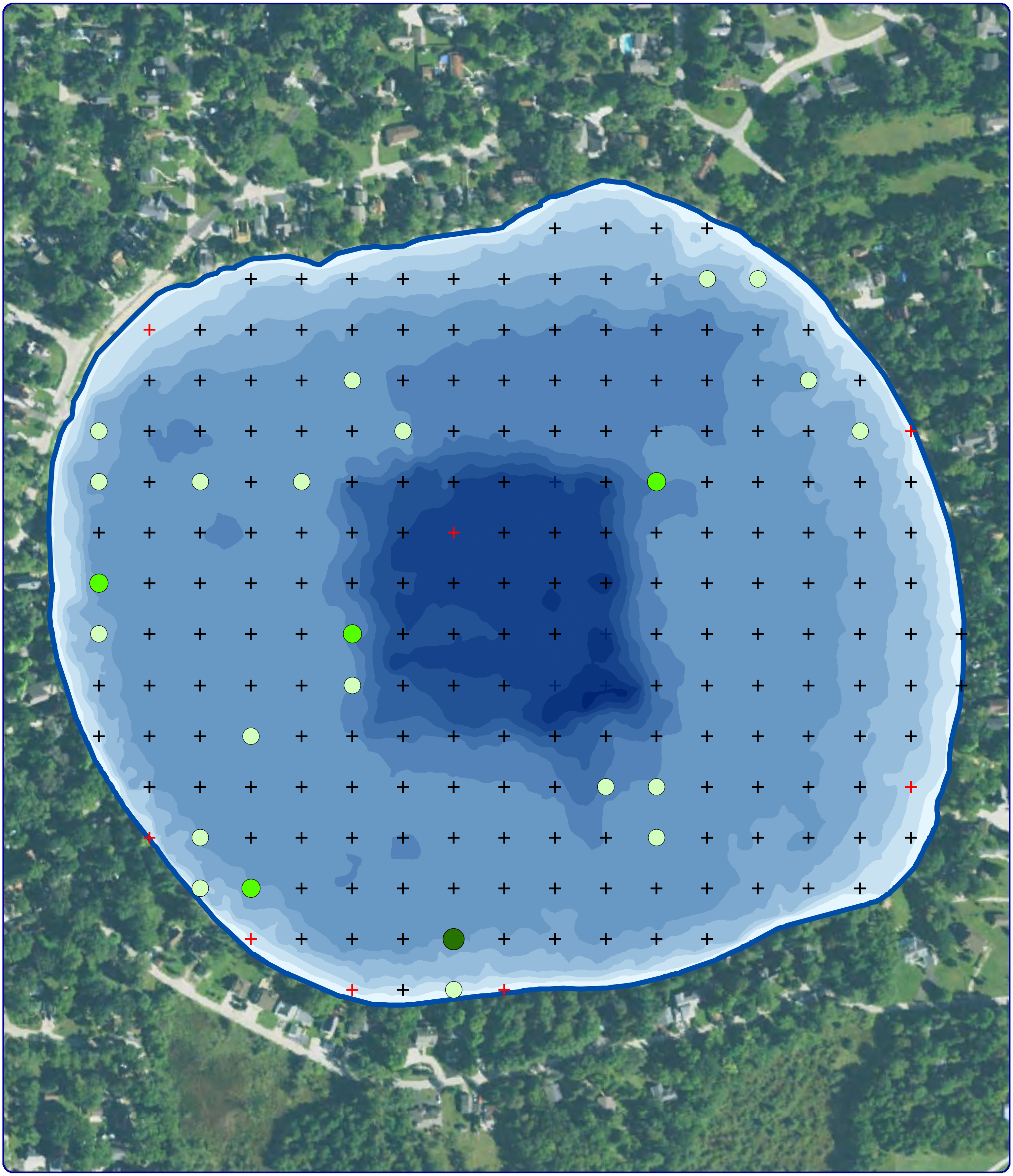
Map Date: November 4, 2020 BTB
Filename: Map10_Lilly_TRFPI_VALAM.mxd
Wild Celery (Vallisneria americana)
Not Present - Littoral Zone
Not Present - Profundal Zone
Rake Fullness = 1
No Data - Non-Navigable, etc.
Rake Fullness = 2
Rake Fullness = 3
Map 10
Lilly Lake
Kenosha County, Wisconsin
2020 Point-Intercept Survey
Wild Celery Locations



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Water Stargrass (*Heteranthera dubia*)

- Not Present - Littoral Zone
- Not Present - Profundal Zone
- Rake Fullness = 1
- No Data - Non-Navigable, etc.
- Rake Fullness = 2
- Rake Fullness = 3

Map 11

Lilly Lake

Kenosha County, Wisconsin

2020 Point-Intercept Survey
Water Stargrass Locations

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Bathymetry: Onterra, 2020;
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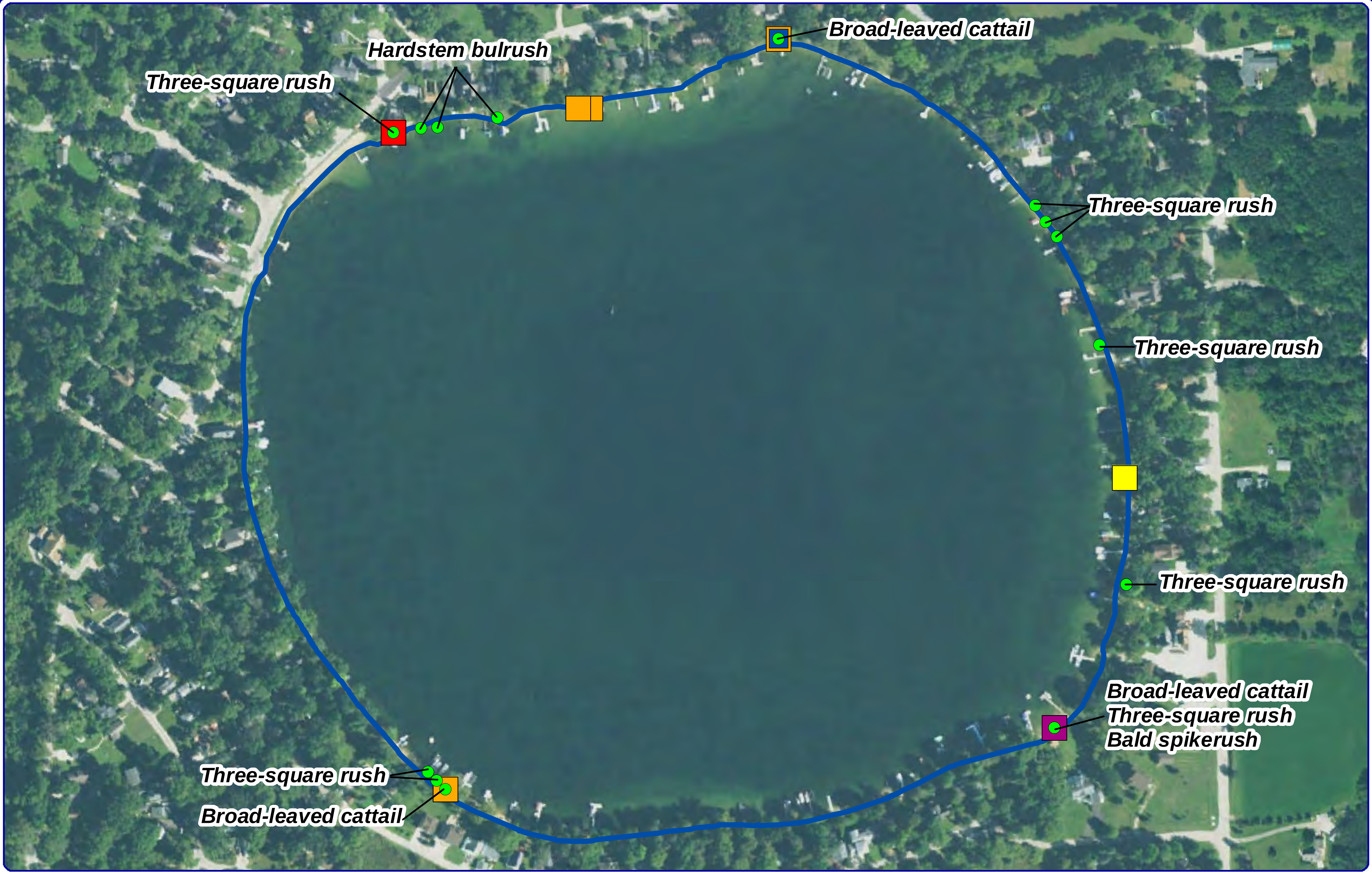
Map Date: November 4, 2020 BTB
Filename: Map11_Lilly_TRFPI_HETDU.mxd



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Emergent Community Type (No Floating-leaf Communities Present)

- Native
- Exotic - Giant Reed
- Exotic - Purple Loosestrife
- Exotic - Pale-yellow Iris
- Exotic - Narrow-leaved Cattail
- Exotic - Reed Canary Grass

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Sources:
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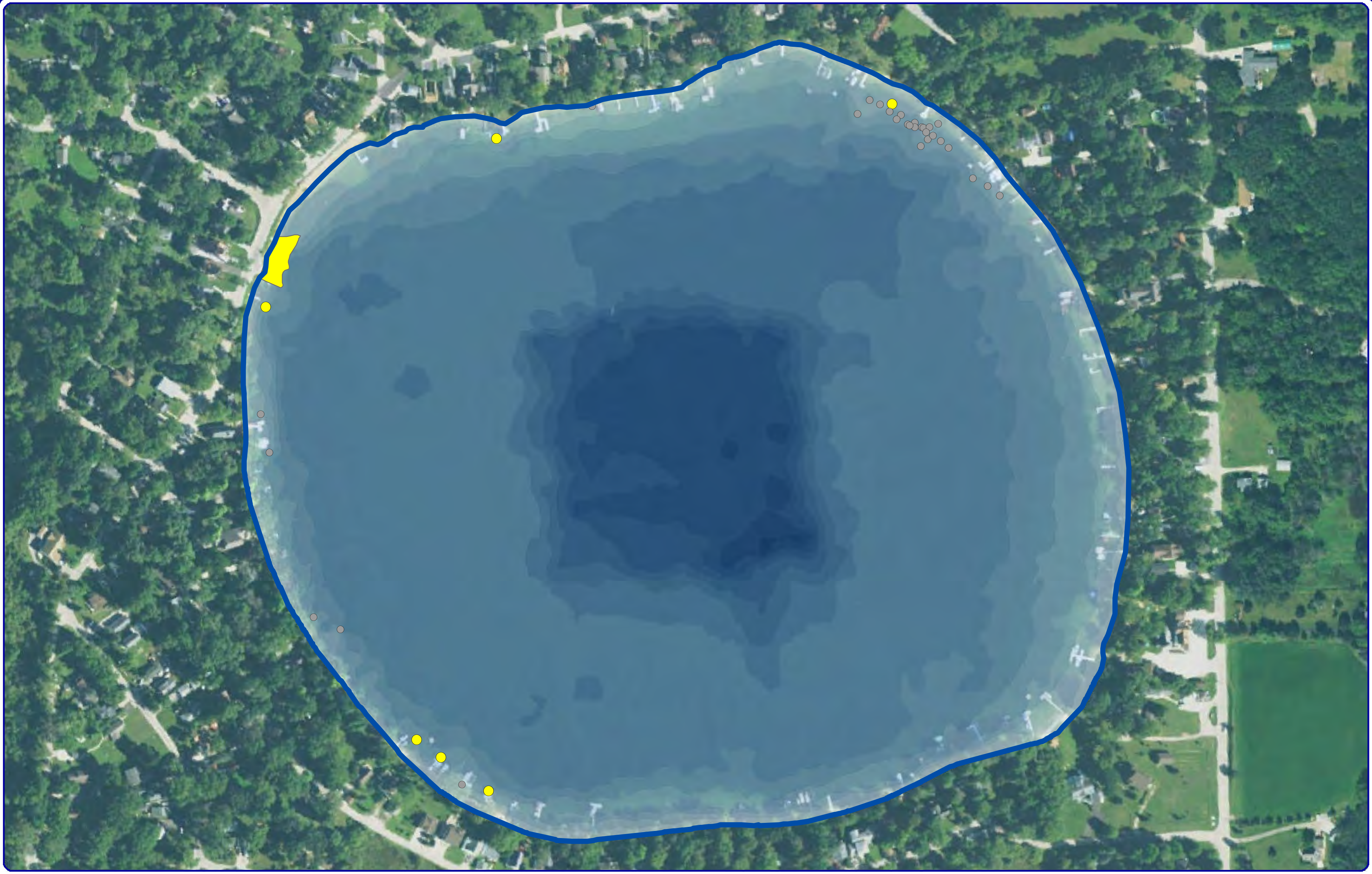
Orthophotgraphy: NAIP 2018
Map Date: November 4, 2020
Map Filename: Map12_Lilly_2020_Comm.mxd

Map 12
Lilly Lake
Kenosha County, Wisconsin

2020 Emergent Aquatic Plant Communities



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Sources:
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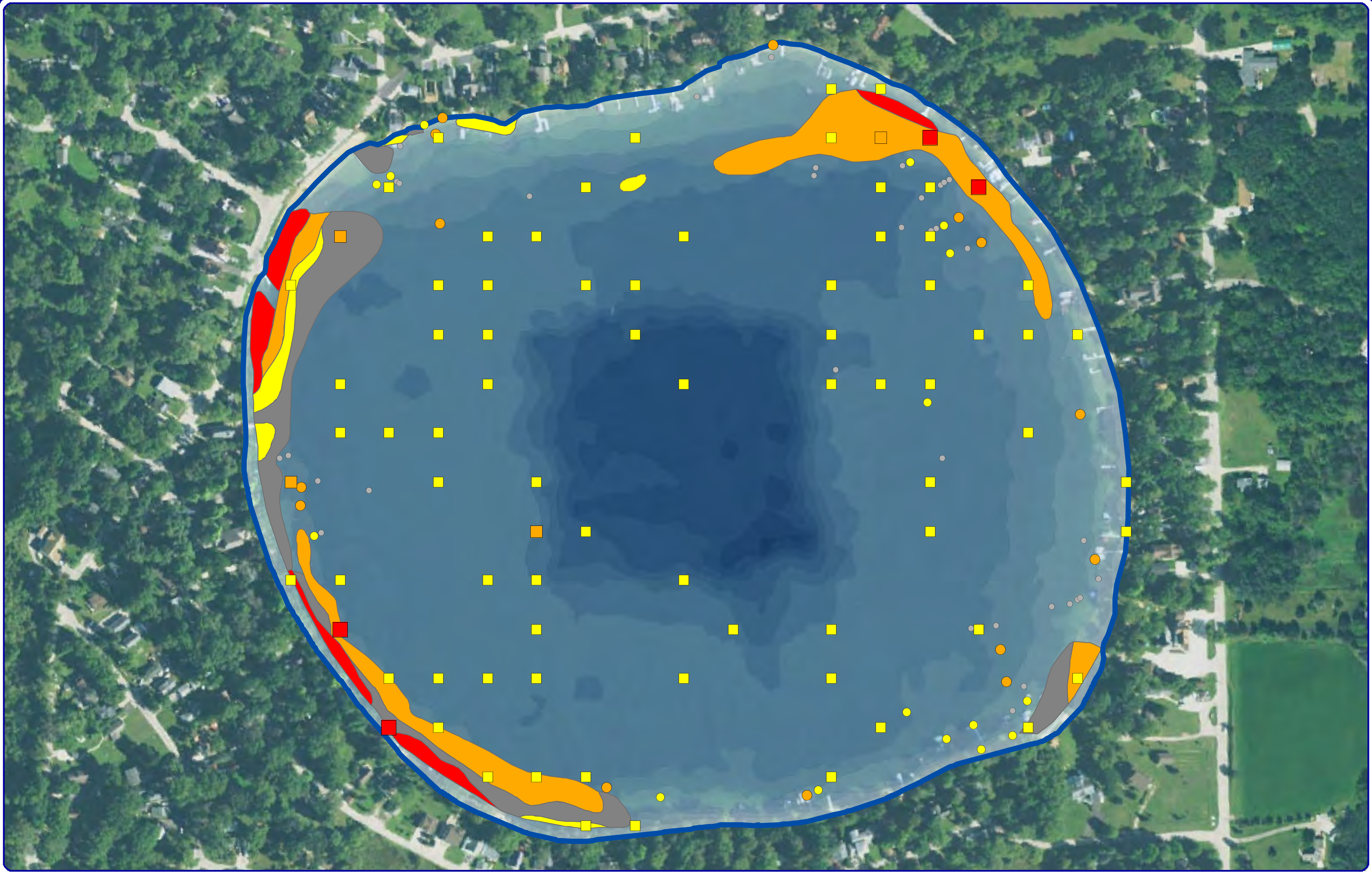
Map Date: November 4, 2020
Map Filename: Map13_Lilly_CLP_June20.mxd

Project Location in Wisconsin

Curly-leaf Pondweed (*Potamogeton crispus*)

- Highly Scattered (*None*)
- Scattered (*None*)
- Dominant
- Highly Dominant (*None*)
- Surface Matting (*None*)
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony (*None*)

Map 13
Lilly Lake
Kenosha County, Wisconsin
2020 Curly-leaf Pondweed Locations



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Point-Intercept Survey Locations

- Rake Fullness = 1
- Rake Fullness = 2
- Rake Fullness = 3

Hybrid Watermilfoil (*Myriophyllum sibiricum* x *M. spicatum*) Mapping Locations

- Highly Scattered (*None*)
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

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Sources:
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Map Date: November 4, 2020
Map Filename: Map14_Lilly_HWM_Oct20.mxd

Map 14
Lilly Lake
Kenosha County, Wisconsin

2020 Hybrid Watermilfoil Locations