Kelly Lake

Oconto County, Wisconsin

Comprehensive Management Plan

June 2019

Sponsored by:

Kelly Lake Advancement Association, Inc.

WDNR Grant Program

AEPP-479-16

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Onterra, LLC
Lake Management Planning

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

Kelly Lake Planning Committee

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1.0 INTRODUCTION

Kelly Lake, Oconto, is a 367-acre headwater drainage lake with a maximum depth of 41 feet and a mean depth of 11 feet. This meso-oligotrophic lake has a relatively small watershed when compared to the size of the lake. Kelly Lake contains 28 native plant species, of which muskgrasses are the most common plant. Two exotic plant species are known to exist in Kelly Lake.

Field Survey Notes

The clear water of Kelly Lake always makes surveys easy and enjoyable. The ability for plants within Kelly Lake to grow out to 25 feet is a testament to the clarity.

Photograph 1.0-1. Kelly Lake, Oconto County

Lake at a Glance - Kelly Lake

Morphology	
Acreage	367
Maximum Depth (ft)	41
Mean Depth (ft)	14
Shoreline Complexity	1.9
Vegetation	
Curly-leaf Survey Date	June 10, 2016
Comprehensive Survey Date	July 25, 2016
Number of Native Species	28
Threatened/Special Concern Species	-
Exotic Plant Species	Eurasian watermilfoil & Reed canary grass
Simpson's Diversity	0.79
Average Conservatism	6.3
Water Quality	
Trophic State	Meso-Oligotrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	8.4
Sensitivity to Acid Rain	Low sensitivity
Watershed to Lake Area Ratio	1:1

Kelly Lake is located within the Little River watershed and is surrounded by a moderate amount of agricultural land, as well as natural forests and wetlands. Kelly Lake, through its unnamed outlet stream drains to Kelly Brook, an ASNRI Endangered Threatened or Special Concern stream. The town of Suring (population 500-600 people) is located roughly 5 miles west of Kelly Lake. The lake has five public access boat launches. Two carry-in locations exist, one at Holt Park, which also offers picnic facilities, 48 camping spots, and a public fishing pier.

In 2012, Eurasian watermilfoil (EWM) was discovered within the lake. In 2015, genetic analysis was completed on several milfoil samples to confirm that a portion of this population is hybrid Eurasian/northern watermilfoil (HWM). Also in 2015, zebra mussels were confirmed to be established in Kelly Lake. Since the discovery of EWM in 2012, the Kelly Lake Advancement Association (KLAA) hired Onterra, LLC to complete a late-summer AIS survey to assess how much EWM/HWM is present in the lake and provide a recommendation for a management strategy.

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 of this information is communicated through multiple meetings that involve the lake group as a whole or a focus group called a Planning Committee, the completion of a stakeholder survey, and annual reports provided to the association.

The highlights of this component are described below. Materials used during the planning process can be found in Appendix A.

Kick-off Meeting

On August 13, 2016, a project kick-off meeting was held at the Romy's Holiday Inn at Kelly Lake to introduce the project to the general public. The meeting was announced through a mailing and personal contact by KLAA board members. The 38 attendees observed a presentation given by Tim Hoyman, an aquatic ecologist with Onterra. Mr. Hoyman'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. Further, Todd Hanke, a field technician with Onterra, LLC, presented updated AIS management information to the group regarding the two AIS-Early Detection and Response Grants the KLAA had received. The presentations were followed by a question and answer session.

Planning Committee Meeting I

On June 30, 2017, Tim Hoyman of Onterra met with members of the Kelly Lake Planning Committee and the WDNR for 2.5 hours. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed.

Planning Committee Meeting II

On October 9, 2017, Tim Hoyman met with the members of the Planning Committee to discuss the stakeholder survey results, recent EWM control results, and begin developing management goals and actions for the Kelly Lake management plan. Prior to the meeting the committee was provided a basic outline of management goals and actions that are commonly used in lake management plans within the North Central Hardwood Forests Ecoregion. This outline was used as the basis of discussion and as a demonstration of how the Kelly Lake Implementation Plan would be formatted.

Project Wrap-up Meeting

A project wrap-up meeting was held at the Holiday Inn on Saturday, May 18, 2019. Approximately 30 people attended the meeting where Tim Hoyman highlighted the results of the studies completed on Kelly Lake since 2013. Mr. Hoyman's presentation covered topics relating to water quality, watershed modeling, fisheries, shoreland and coarse woody habitat, and the many aquatic plant surveys completed on the lake. The management goals and associated actions making up the implementation were also covered. Following the presentation, near 45 minutes were spent answering questions from the Kelly Lake stakeholders that were in attendance.

Stakeholder Survey

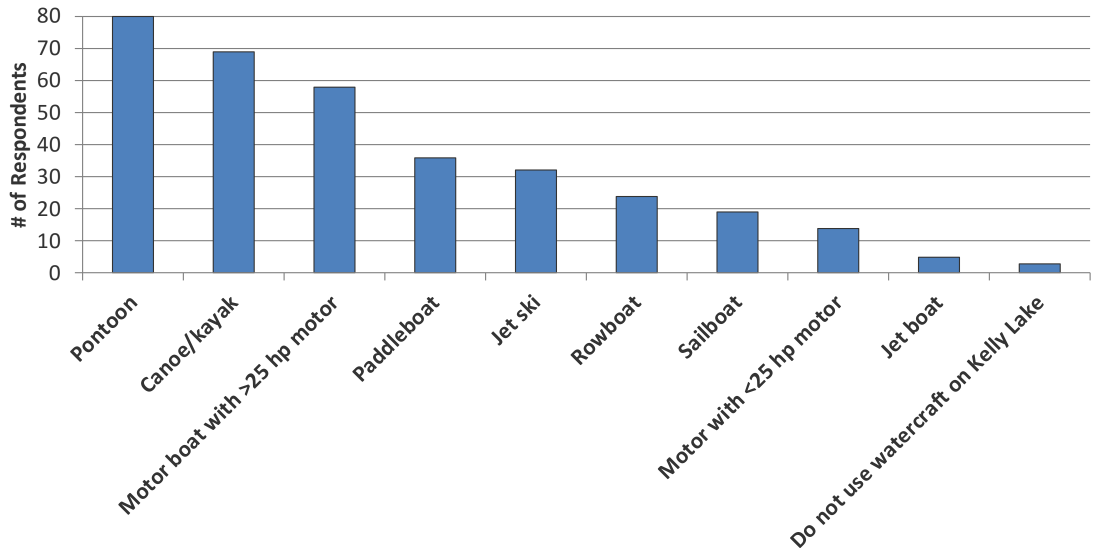
As a part of this project, a stakeholder survey was distributed to riparian property owners around Kelly Lake. The survey was designed by Onterra staff and the KLAA planning committee then reviewed by a WDNR social scientist. During February 2017, the eight-page, 36-question survey was posted online through Survey Monkey for property owners to answer electronically. If requested, a hard copy was sent to the property owner with a self-addressed stamped envelope for returning the survey anonymously. The returned hardcopy surveys were entered into the online version by a KLAA volunteer for analysis. Forty-five percent of the surveys were returned. Please note that typically a 60% response rate is required to portray population projections accurately, and make conclusions with statistical validity. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B. A general summary is discussed below with further results integrated within their appropriate sections throughout the management plan.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Kelly Lake. The majority of stakeholders (35%) live on the lake during the summer months only, while 30% are year-round residents and 30% visit on weekends throughout the year. Fifty-three percent of stakeholders have owned their property for over 25 years, and 33% have owned their property for zero to 15 years.

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect to these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. More than half of survey respondents indicate that they use either a pontoon boat, canoe/kayak, or motor boat with a 25 hp motor or larger, or a combination of these three vessels on Kelly Lake (Question 12). Paddleboats were also a popular option. On a largely recreated lake such as Kelly Lake, the importance of responsible boating activities is increased. The need for responsible boating increases during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the lake. As seen on Question 15, several of the top recreational activities on the lake involve boat use. Boat traffic was also listed as a factor potentially impacting Kelly Lake in a negative manner (Question 21), and was ranked 3rd on a list of stakeholder's top concerns regarding the lake (Question 22).

A concern of stakeholders noted throughout the stakeholder survey (see Question 22 and survey comments – Appendix B) was the introduction of aquatic invasive species to Kelly Lake and how the number of boat landings and boat traffic can affect their spread.

Question 12: What types of watercraft do you currently use on the lake?



Question 15: Please rank up to three activities that are important reasons for owning your property on or near the lake.

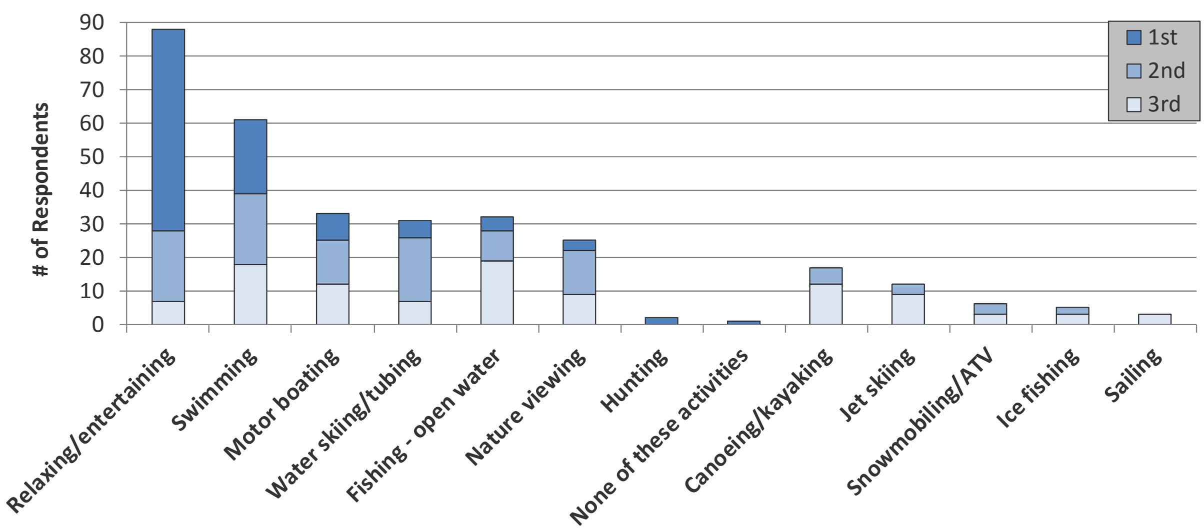
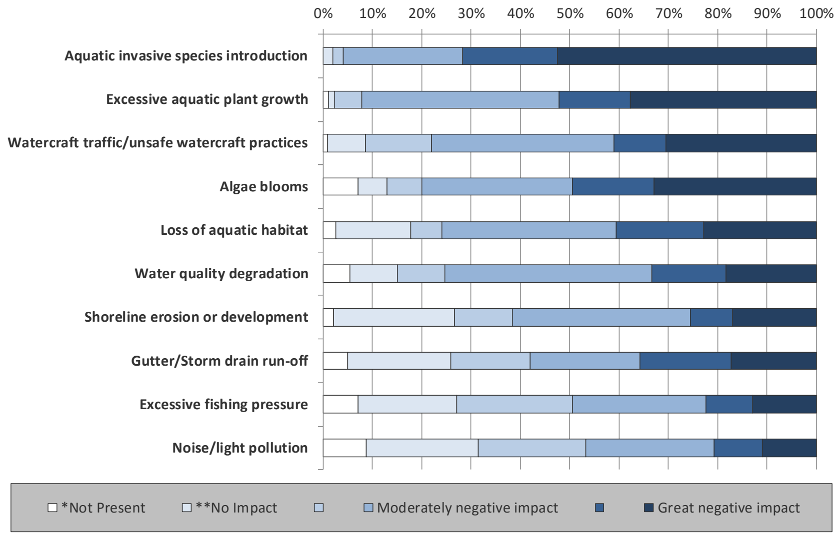


Figure 2.0-1. Select survey responses from the Kelly Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question 21: To what level do you believe these factors may be negatively impacting Kelly Lake?



Question 22: Please rank your top three concerns regarding Kelly Lake.

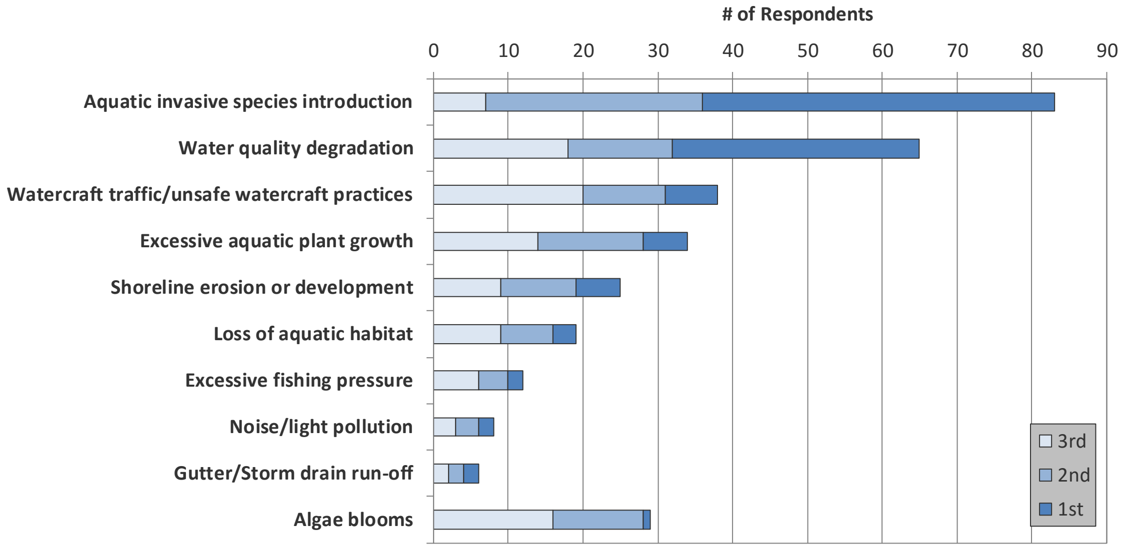


Figure 2.0-2. Select survey responses from the Kelly Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on 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 analysis 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 on Kelly 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 water quality parameters are focused upon in the Kelly Lake's water quality analysis:

Phosphorus is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both algae and macrophytes. 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 used 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 quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are interrelated. 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 et al. 1994, Dinius 2007, and Smith et al. 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. Every lake will naturally progress through these states and under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in many Wisconsin lakes. 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.

> Trophic states describe the lake's ability to produce plant matter (production) and include three continuous classifications: Oligotrophic lakes are the least productive lakes and are characterized by being deep, having cold water, and few plants. Eutrophic lakes are the most productive and normally have shallow depths, warm water, and high plant biomass. Mesotrophic lakes fall between these two categories.

However, through the use of a trophic state index (TSI), an index number can be calculated using phosphorus, chlorophyll-*a*, and clarity values that represent the lake's position within the eutrophication process. This allows for a more clear 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 macrophytes 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.

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. Internal nutrient loading is an excellent example that is described below.

Lake stratification occurs when temperature gradients are developed with depth in a lake. During stratification, the lake can be broken into three layers: The epilimnion is the top layer of water which is the warmest water in the summer months and the coolest water in the winter months. The hypolimnion is the bottom layer and contains the coolest water in the summer months and the warmest water in the winter months. The metalimnion, often called the thermocline, is the middle layer containing the steepest temperature gradient.

Internal Nutrient Loading

In lakes that support stratification, whether throughout the summer or periodically between mixing events, the hypolimnion can become devoid of oxygen both in the water column and within the sediment. When this occurs, iron changes from a form that normally binds phosphorus within the sediment to a form that releases it to the overlaying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. In lakes that mix periodically during the summer (polymictic lakes), this cycle can *pump* phosphorus from the sediments into the water column throughout the growing season. In lakes that only mix during the spring and fall (dimictic lakes), this burst of phosphorus can support late-season algae blooms and even last through the winter to support early algal blooms the following spring. Further, anoxic conditions under the winter ice in both polymictic and dimictic lakes can add smaller loads of phosphorus to the water column during spring turnover that may support algae blooms long into the summer. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algal blooms decades after external sources are controlled.

The first step in the analysis is determining if the lake is a candidate for significant internal phosphorus loading. Water quality data and watershed modeling are used to determine actual and predicted levels of phosphorus for the lake. When the predicted phosphorus level is well below the actual level, it may be an indication that the modeling is not accounting for all of phosphorus sources entering the lake. Internal nutrient loading may be one of the additional contributors that may need to be assessed with further water quality analysis and possibly additional, more intense studies.

Non-Candidate Lakes

- Lakes that do not experience hypolimnetic anoxia.
- Lakes that do not stratify for significant periods (i.e. days or weeks at a time).
- Lakes with hypolimnetic total phosphorus values less than 200 μg/L.

Candidate Lakes

- Lakes with hypolimnetic total phosphorus concentrations exceeding 200 μg/L.
- Lakes with epilimnetic phosphorus concentrations that cannot be accounted for in watershed phosphorus load modeling.

Specific to the final bullet-point, during the watershed modeling assessment, the results of the modeled phosphorus loads are used to estimate in-lake phosphorus concentrations. If these estimates are much lower than those actually found in the lake, another source of phosphorus must be responsible for elevating the in-lake concentrations. Normally, two possibilities exist: 1) shoreland septic systems, and 2) internal phosphorus cycling. If the lake is considered a candidate for internal loading, modeling procedures are used to estimate that load.

Comparisons with Other Datasets

The WDNR document *Wisconsin 2014 Consolidated Assessment and Listing Methodology* (WDNR 2013) 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 Kelly Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into ten natural communities (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, 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.

Because of its depth, small watershed and hydrology, Kelly Lake is classified as a deep headwater drainage lake (category 3 on Figure 3.1-1).

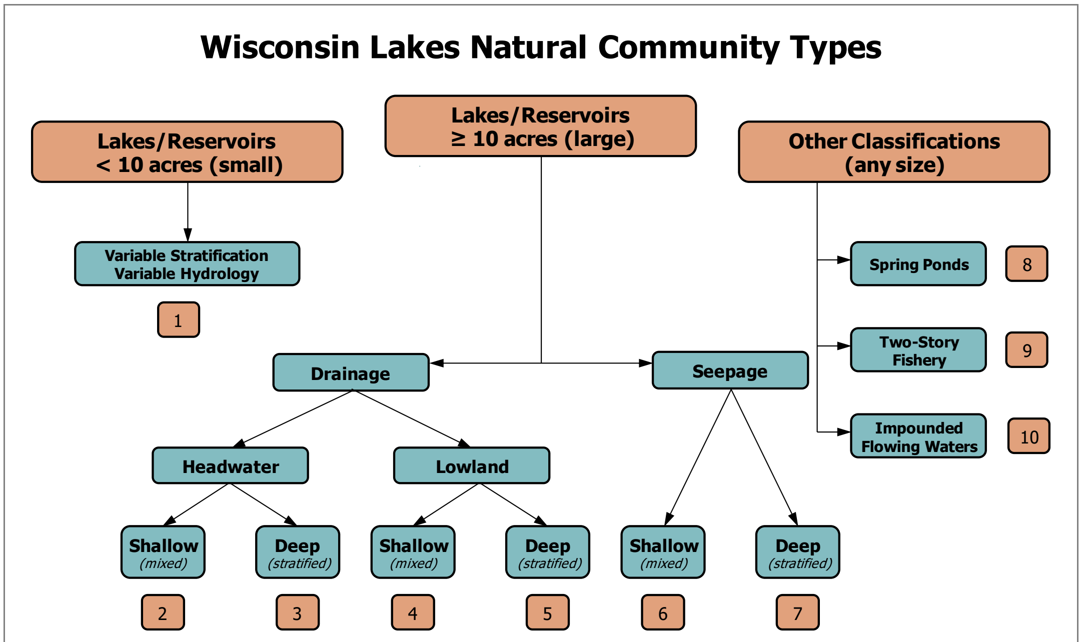


Figure 3.1-1. Wisconsin Lake Natural Communities. Adapted from WDNR 2013A.

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. Kelly Lake is within the Northcentral Hardwood Forests ecoregion.

The Wisconsin 2014 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.

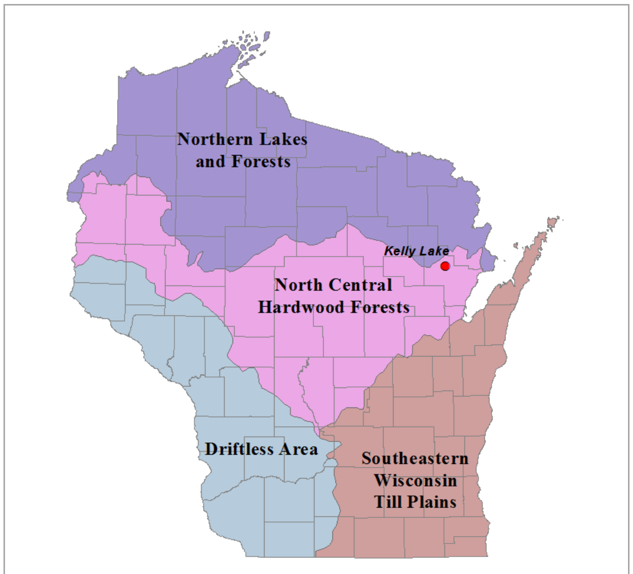


Figure 3.1-2. Location of Kelly Lake within the ecoregions of Wisconsin. After Nichols 1999.

These data along with data corresponding to statewide natural lake means, historic, current, and average data from Kelly Lake is displayed in Figures 3.1-3 - 3.1-5. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-*a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

Kelly Lake Water Quality Analysis

Kelly Lake Long-term Trends

As discussed previously, three water quality parameters are of most interest when assessing a lake's water quality: total phosphorus, chlorophyll-*a*, and Secchi disk transparency. Volunteers from Kelly Lake have been collecting some of these parameters on an annual basis since 1991, building a continual dataset that will yield valuable information on Kelly Lake's water quality through time.

Total Phosphorus

As discussed previously, phosphorus is the primary nutrient controlling the growth of phytoplankton in the majority of Wisconsin's lakes. To determine whether phosphorus is the limiting nutrient within a lake, the concentration of phosphorus is compared to the concentration of nitrogen. Using mid-summer total phosphorus and total nitrogen concentrations from Kelly Lake indicates that the lake is phosphorus-limited (Figure 3.1-3). The mid-summer nitrogen to phosphorus ratio was 39:1 in Kelly Lake. This ratio indicates that Kelly Lake is phosphorus-limited, and that increases in phosphorus inputs would likely result in increased phytoplankton production.

The average summer near-surface total phosphorus concentration was calculated for Kelly Lake using data collected as part of this project along with any available historical data. Near-surface total phosphorus data are available from Kelly Lake from 1982-1984, 2000, and 2008-2016 (Figure 3.1-3). The average total concentration from Kelly Lake ranged from 8.6 μg/L in 2013 to 34 μg/L in 2008. The weighted summer average for the whole time-period available is 13.3 μg/L. The summer average found in summer of 2016 was 15.1 which is slightly higher than the weighted summer average.

As illustrated in Figure 3.1-3, average annual growing season and summer near-surface total phosphorus values have been relatively consistent, falling into the *excellent* category for deep headwater drainage lakes; with the exception of 1982-1984 and 2008, in which both the growing season and summer total phosphorus concentrations fell within the *good* to *fair* categories. Data collected from 1982-1984 is slightly higher than total phosphorus concentrations collected more recently, it cannot be said if this represents a declining trend in total phosphorus over this time period. Due to only two samples being collected in 2008, one of which is 34 μg/L, it cannot be said if the total phosphorus concentration values were actually higher in 2008 or if due to such a high value that the average for 2008 is artificially inflated. Given the limited data, it cannot be determined if total phosphorus concentrations have changed over time.

Overall, the weighted average for both the growing season and summer near-surface total phosphorus concentrations fall within the *excellent* category for deep headwater drainage lakes in Wisconsin, and is lower than median total phosphorus concentrations for state-wide deep seepage lakes and for lakes within the Northcentral Hardwood Forests Ecoregion (Figure 3.1-3).

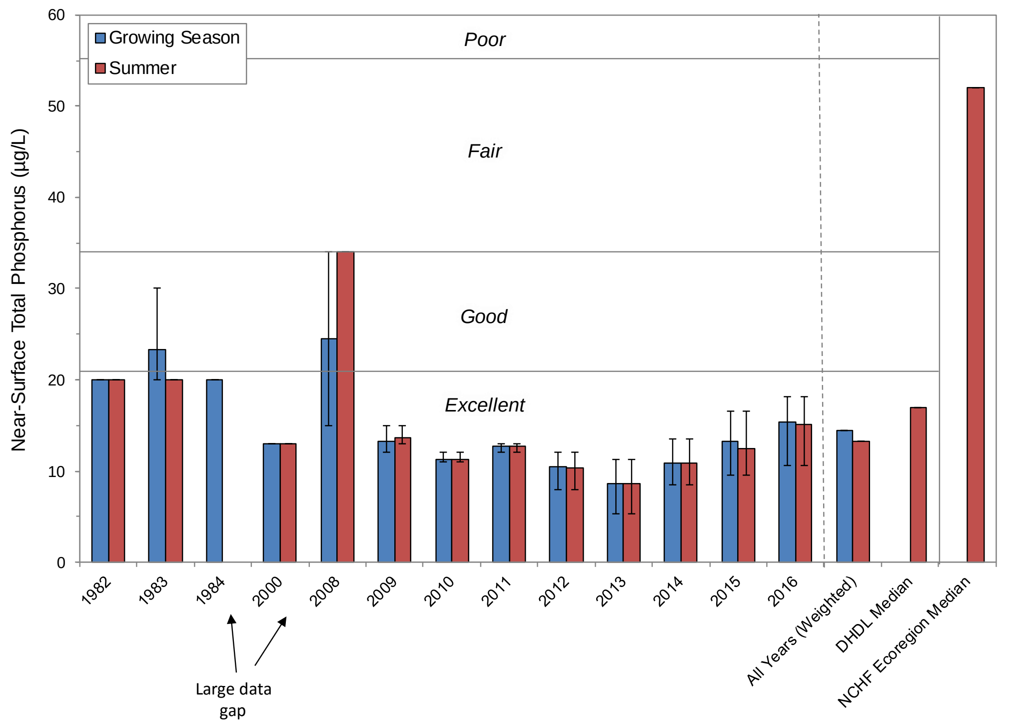


Figure 3.1-3. Kelly Lake, state-wide class 3 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Chlorophyll-α

As discussed earlier, chlorophyll-*a*, or the measure of free-floating algae within the water column, is usually positively correlated with total phosphorus concentrations. While phosphorus limits the amount of algae growth in the majority of Wisconsin's lakes, other factors also affect the amount of algae produced within the lake. Water temperature, sunlight, and the presence of small crustaceans called zooplankton, which feed on algae, also influence algal abundance.

Chlorophyll-*a* data are available from Kelly Lake from 1982-1984, 2000, and 2008-2016 with (Figure 3.1-4). A regression analysis indicated that the growing season and summer chlorophyll-*a* concentrations show a statistically significant decline from 2008-2016. Analysis before 2008 is difficult with the little amount of data available. Given the fact that chlorophyll-*a* has significantly declined from 2008-2016, but there is no corresponding decline in total phosphorus indicates that a factor outside of total phosphorus is causing the decline in chlorophyll-*a*. Remediation efforts within a lake's watershed are often completed to reduce phosphorus loads to lakes, which results in less algae and higher water clarity. Because chlorophyll-*a* concentrations are generally positively correlated with total phosphorus, this is the first area to look for an explanation for declining chlorophyll-*a* concentrations.

However, as discussed previously, near-surface total phosphorus concentrations have not exhibited this same pattern of decline over this time period, indicating the reduction in algal abundance is not due to a reduction in phosphorus. Prior to 2008, chlorophyll-*a* concentration data were not as prevalent and did not show a strong pattern, similar to phosphorus. This variability is to be expected given the varying concentrations of phosphorus from year to year, for previously reasons discussed. The average chlorophyll-*a* concentration from 1982-2000 was 4.2 µg/L. The average chlorophyll-*a* concentration from 2008-2016 is 2.9 µg/L. It is believed that the reduction in algal abundance observed in Kelly Lake over the past 8 years or so is a result of the establishment of a population of the non-native, invasive filter-feeding zebra mussel. Zebra mussels and their effects on Kelly Lake's water quality will be discussed in the next section

Trends analysis of the available chlorophyll-*a* concentrations from Kelly Lake indicate free-floating algae within the water is slightly decreasing over time. Overall, the weighted average for chlorophyll-*a* concentrations in Kelly Lake falls in the *excellent* category for Wisconsin's deep headwater drainage lakes, and is lower than both the median chlorophyll-*a* concentrations for state-wide deep seepage lakes and for lakes within the Northcentral Hardwood Forests Ecoregion (Figure 3.1-4).

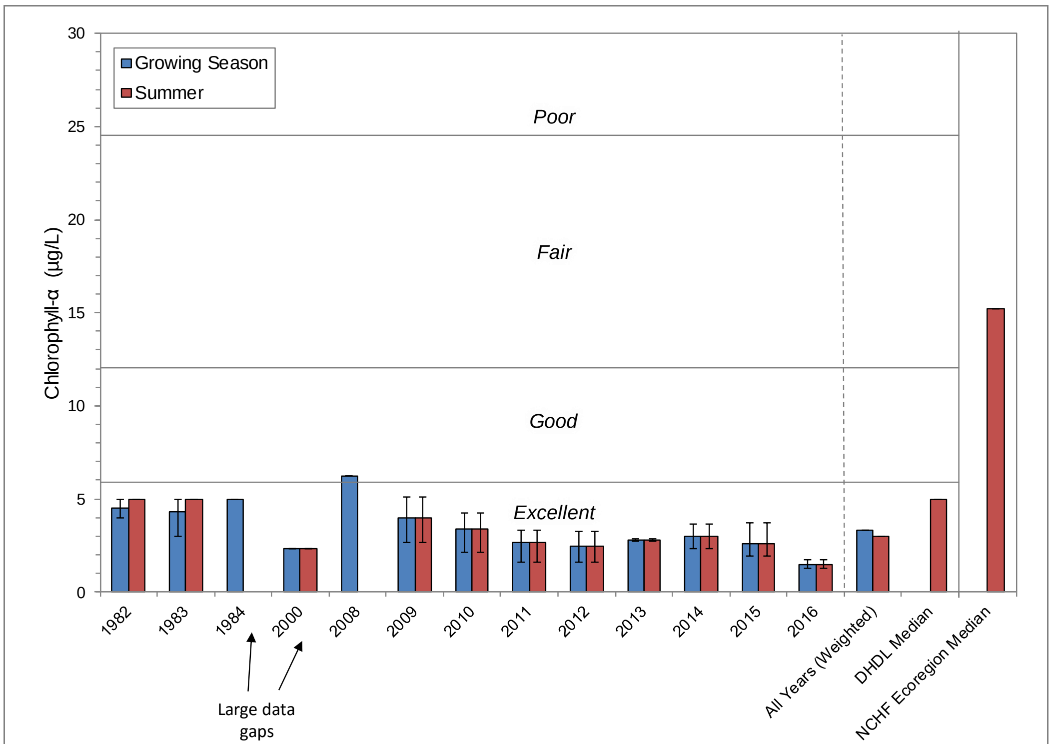


Figure 3.1-4. Kelly Lake, state-wide class 3 lakes, and regional chlorophyll-a concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Water Clarity

Secchi disk transparency data from Kelly Lake are available annually from 1991- 2016 (Figure 3.1-5). Average growing season transparency values range from 9.6 feet recorded in 2006 to 16.6 feet in 2003. The weighted summer average for all years (12.7 feet) was higher than the median for deep headwater drainage lakes (10.8 feet) as well as for all lakes within the NCHF ecoregion

(5.3 feet). Regression analysis indicated there was no significant trend occurring from 1991-2016, however, there was a statistically valid increasing trend from 2008-2016. This increase in water clarity starting in 2008 corresponds with the decrease of chlorophyll-*a*, which, again, can be the result of zebra mussel establishment. The higher water quality has, however, been measured historically, so continued monitoring of Kelly Lake will reveal if this increasing trend continues

As discussed in the previous section, water clarity in Wisconsin's lakes is primarily influenced by suspended particulates within the water, mainly phytoplankton. Abiotic suspended particulates, such as sediment, can also affect water clarity. However, *total suspended solids*, a measure of both biotic and abiotic suspended particles within the water, were below the limit of detection in Kelly Lake in 2016 indicating minimal amounts of suspended material within the water. Water clarity in Wisconsin's lakes can also be affected by dissolved compounds within the water.

Many lakes in the northern region of Wisconsin contain higher concentrations of natural dissolved organic acids that originate from decomposing plant material within wetlands in the lake's watershed. In higher concentrations, these dissolved organic compounds give the water a tea-like color or staining and decrease water clarity. A measure of water clarity once all of the suspended material (i.e. phytoplankton and sediments) have been removed, is termed *true color* and indicates the level of dissolved material within the water. True color values measured from Kelly Lake in 2016 was 5 SU (standard units), indicating the lake is *clear*. This low of a value confirms that the water clarity of Kelly Lake is mostly influenced by changes in chlorophyll-*a* from year to year.

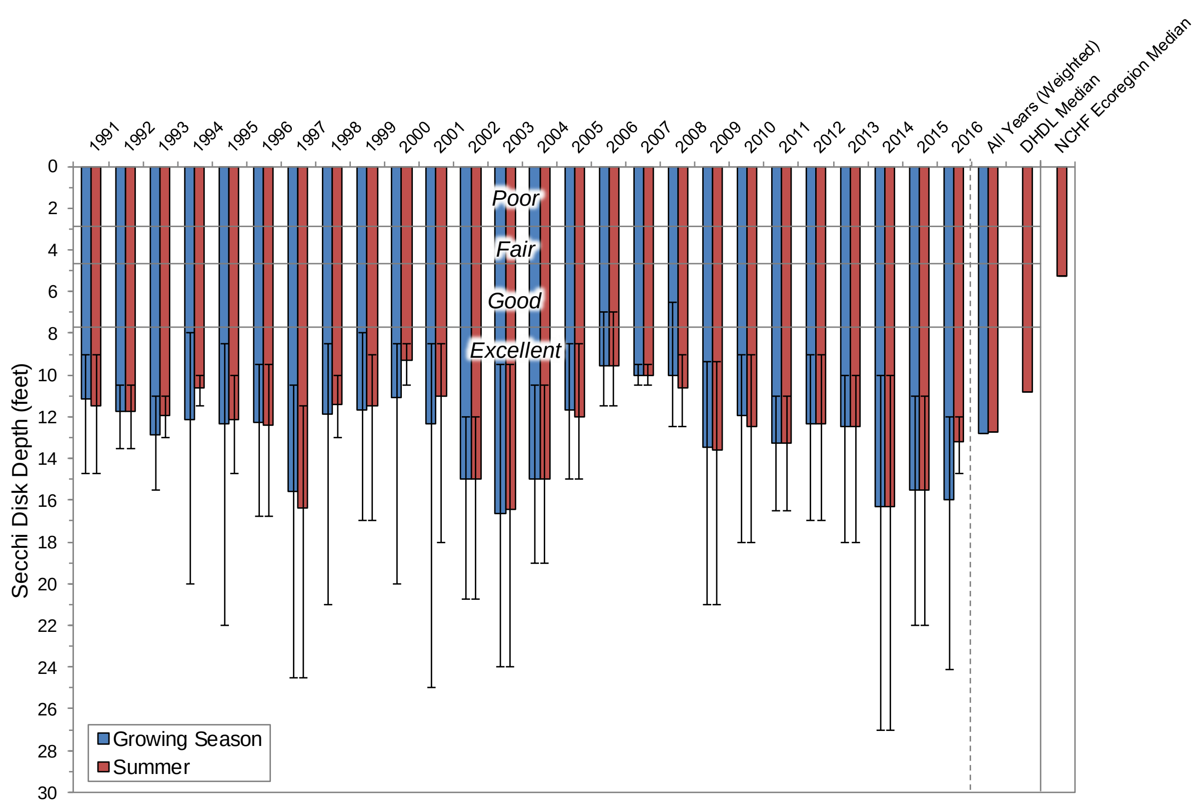


Figure 3.1-5. Kelly Lake, state-wide class 3 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Zebra Mussels in Kelly Lake

Photograph 3.1-1. Non-native zebra mussels (Dreissena polymorpha) attached to a native plain pocketbook mussel (Lampsilis cardium). Photo credit: Onterra, LLC.

Zebra mussels (*Dreissena polymorpha;* Photograph 3.1-1), first documented in Kelly Lake in 2015, are native to the Caspian, Black, and Azov Seas, and were introduced to the Great Lakes through the ballast water of trans-Atlantic shipping vessels in the mid- to late 1980s (Karatayev et al. 1997; Reed-Andersen et al. 2000). Since their introduction to the Great Lakes, zebra mussels have at present spread to 168 habitable inland waterbodies in Wisconsin (WDNR 2014). Like other invasive species, zebra mussels can drastically alter aquatic ecosystems and generate negative economic impacts by interfering with recreation, navigation, and industrial operations (Mellina et al. 1995; Reed-Andersen et al. 2000).

Zebra mussels require certain habitat requirements to establish and maintain a population. These requirements primarily include pH, calcium concentration, and suitable substrates (Ramcharan et al. 1992; Mellina et al. 1995). The commonly accepted pH range for zebra mussels is 7.0 to 9.0. Calcium concentrations of >12 mg/L are considered suitable for zebra mussels; however, waterbodies with calcium concentrations of >28 mg/L are considered to be highly susceptible to their establishment if they are introduced.

The pH and calcium concentration within a lake largely depends on the geology of the lake's surficial and ground watersheds. In 2016, samples collected from near Kelly Lake's surface had a pH value of 8.4 and a calcium concentration of 28.2 mg/L, indicating the environment within Kelly Lake is highly suitable for supporting a zebra mussel population. In addition, the whole-lake point-intercept surveys conducted by the WDNR in 2012 and Onterra in 2016, indicates that the first 12 feet of the lake's littoral zone is comprised of hard substrates (sand or rock), which can support the largest and densest populations of mussels (Reed-Andersen et al. 2000). Aquatic plants also provide habitat for zebra mussels (Reed-Andersen et al. 2000), and the 2016 point-intercept survey indicated that 80% of Kelly Lake's littoral zone is vegetated.

Numerous studies have shown that following the establishment of zebra mussels, many lakes experience increased water clarity as a result of decreased suspended material within the water from the filtering of zebra mussels (MacIsaac 1996; Karatayev et al. 1997; Reed-Andersen et al. 2000; Zhu et al. 2006). Zebra mussels are very efficient filter feeders, and water that has been filtered is almost entirely devoid of suspended particles (Karatayev et al. 1997). Even unwanted particles (e.g. clay particles) that pass through the zebra mussel are deposited to the sediment as pseudofeces (Karatayev et al. 1997).

In summary, this analysis of Kelly Lake's water quality data indicates that the establishment of zebra mussels is the cause of the observed decline in algal abundance and subsequent increase in water clarity over the past eight years. The decline in chlorophyll-*a* was apparent around the discovery of zebra mussels in Kelly Lake in 2015; however, it is believed they were most likely introduced to the lake some time before. Studies have shown that zebra mussels usually do not have detectable effects on the lake's ecosystem until their population rapidly expands about five to 10 years after their introduction (Karatayev et al. 1997). The detectable decoupling of the phosphorus-chlorophyll-*a* relationship in Kelly Lake appears to begin around when zebra mussels were discovered, indicating they were likely introduced to the lake sometime in the mid to late 2000s. Given Kelly Lake's proximity (~37 miles) to the Green Bay and Lake Michigan, it is not surprising that zebra mussels were introduced to the lake relatively shortly after their introduction to the Great Lakes. At present, there are no methods for controlling a lake-wide population of zebra mussels.

Kelly Lake Trophic State

Figure 3.1-8 contains the weighted average Trophic State Index (TSI) values for Kelly Lake. These TSI values are calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data collected as part of this project along with available historical data. In general, the best values to use in assessing a lake's trophic state are chlorophyll-*a* and total phosphorus, as water clarity can be influenced by other factors other than phytoplankton such as dissolved compounds within the water. The closer the calculated TSI values for these three parameters are to one another indicates a higher degree of correlation.

The weighted TSI values for Secchi disk and chlorophyll-*a* in Kelly Lake range from oligotrophic to mesotrophic (Figure 3.1-8). Total phosphorus ranges from oligotrophic to eutrophic. When compared to other deep headwater drainage lakes in Wisconsin, Kelly Lake is of lower productivity. The TSI values for all three parameters were relatively similar, indicating phytoplankton production is largely regulated by phosphorus availability and water clarity is largely influenced by phytoplankton abundance. In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, it can be concluded that Kelly Lake is in an oligo-mesotrophic state.

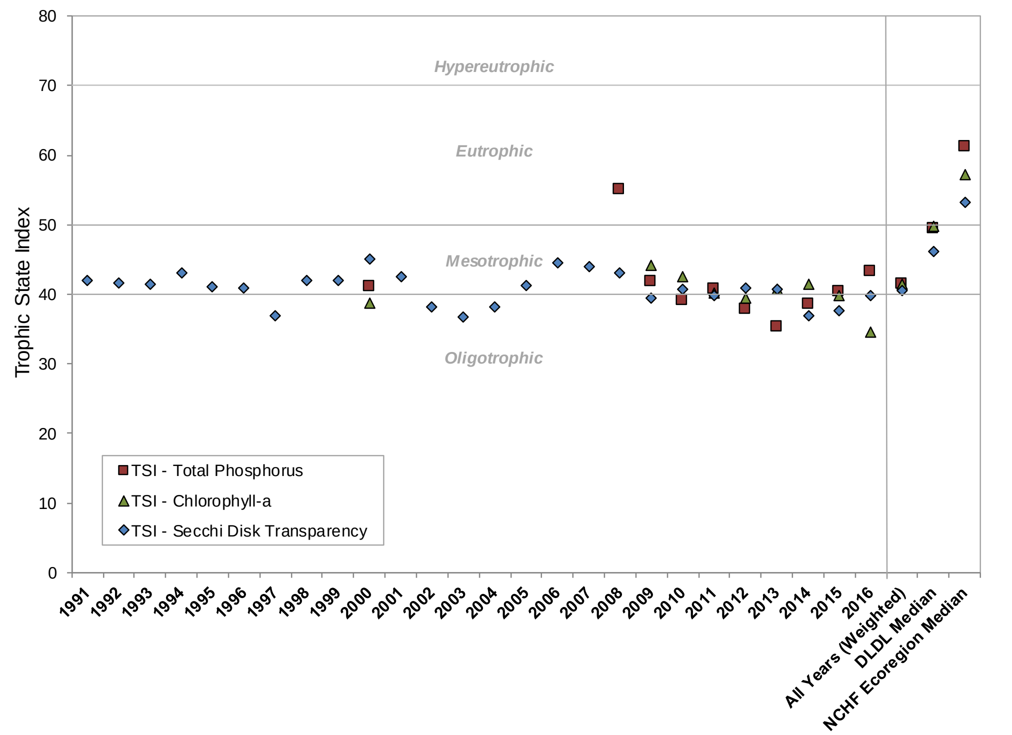


Figure 3.1-6. Kelly Lake, state-wide class 3 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193. Weighted average calculated using years when data for all three parameters were available.

Dissolved Oxygen and Temperature in Kelly Lake

Dissolved oxygen and temperature profile data were collected during each water quality sampling event conducted by Onterra ecologists. These data are displayed in Figure 3.1-7. Kelly Lake is *dimictic*, meaning the lake remains stratified during the summer (and winter) and completely mixes, or turns over, once in spring and once in fall. During the summer, the surface of the lake warms and becomes less dense than the cold layer below, and the lake thermally stratifies. Given Kelly Lake's deeper nature, wind and water movement are not sufficient during the summer to mix these layers together, only the warmer, upper layer will mix. As a result, the bottom layer of water no longer receives atmospheric diffusion of oxygen and decomposition of organic matter within this layer depletes available oxygen.

In fall, as surface temperatures cool, the entire water column is again able to mix, which re-oxygenates the hypolimnion. During the winter, the coldest temperatures are found just under the overlying ice, while oxygen gradually declines once again towards the bottom of the lake. In February of 2016, oxygen concentrations remained above 2.0 mg/L throughout the majority of the water column, indicating that fishkills as a result of winter anoxia are likely not a concern in Kelly Lake.

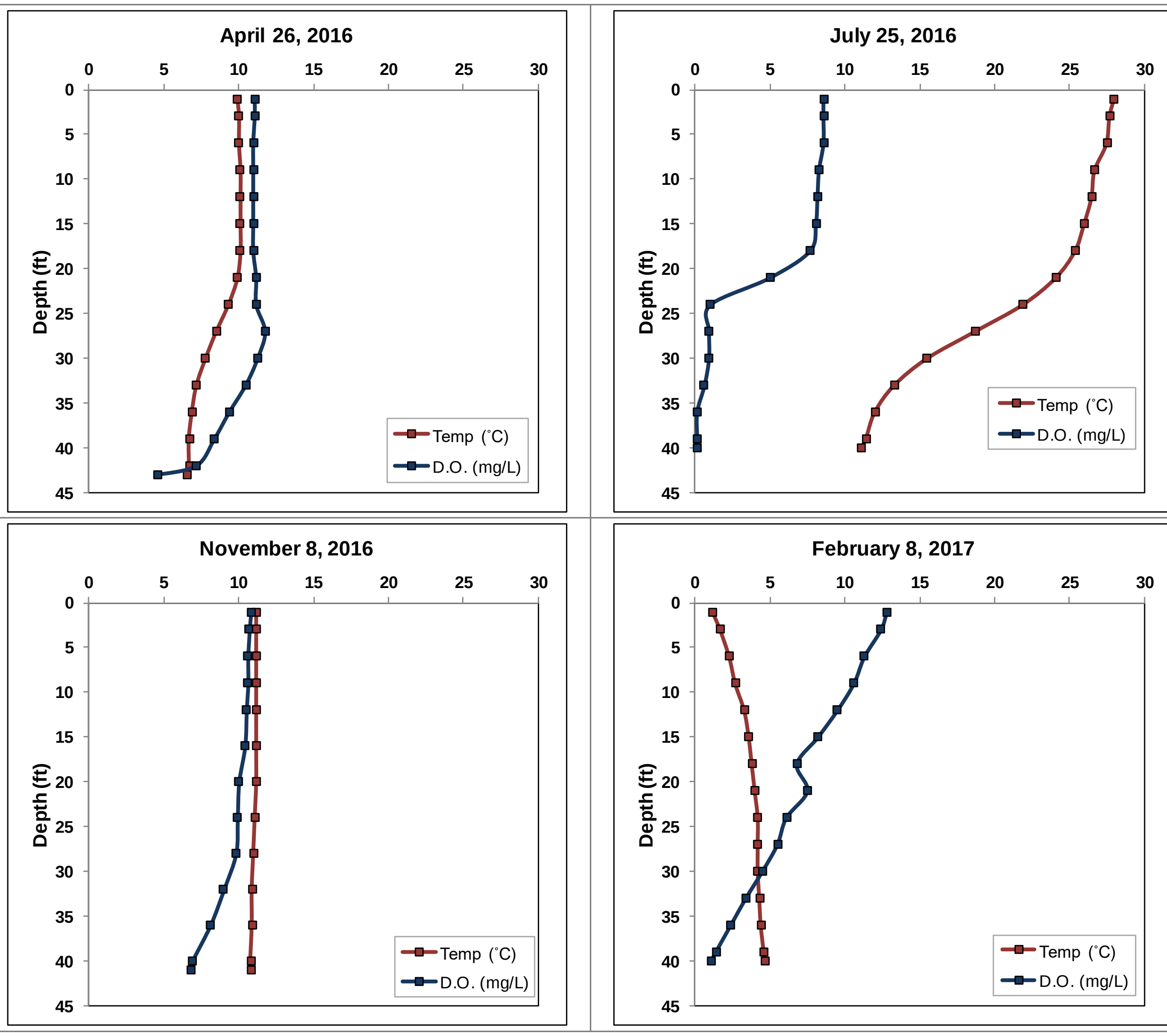


Figure 3.1-7. Kelly Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Kelly Lake

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Kelly Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited

(Shaw and Nimphius 1985). The pH of the water in Kelly Lake was found to be on the high side for the normal range of lakes within Wisconsin, with a value of 8.4, meaning Kelly Lake should be viewed as a marl lake.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Kelly Lake was measured at 112 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Kelly Lake's pH of 8.4 falls inside this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Kelly Lake was found to be 28.2 mg/L, falling within optimal range for zebra mussels.

Stakeholder Survey Responses to Kelly Lake Water Quality

As discussed in section 2.0, the stakeholder survey sent to Kelly Lake property owners asked many questions pertaining to perceptions of the lake and how it may have changed over the years. Of the 248 surveys distributed, only 112 (45%) were returned. Given the lower response rate, the responses to the following questions regarding water quality cannot be interpreted as being statistically representative of the population sampled. At best, the results may indicate possible trends and opinions about the stakeholder perceptions of water quality in Kelly Lake but cannot be stated with statistical confidence.

Figure 3.1-8 displays stakeholder survey responses to questions regarding stakeholder perceptions of Kelly Lake's water quality. When asked how they would describe the current water quality of Kelly Lake, 51% indicated *good*, 23% indicated *fair*, 19% indicated *excellent*, 5% indicated poor and 2% indicated *unsure*. As discussed in the previous section, the water quality parameters used to asses Kelly Lake's current water quality all fall within the *excellent* category for Wisconsin's deep headwater drainage lakes.

When asked how they believe the current water quality has changed since they first visited the lake, the largest proportion of 47% indicated it has *somewhat degraded*, 21% indicated *remained the same*, 10% indicated *somewhat improved*, 9% indicated *severely degraded*, 7% indicated *unsure*, and 6% indicated *greatly improved* (Figure 3.1-9). The historical water quality data from Kelly Lake do not indicate degrading water quality conditions. The proportion of stakeholders who indicated Kelly Lake's water quality has somewhat or severely degraded may be taking into account the introduction of Eurasian watermilfoil and/or zebra mussels or may have observed increases in aquatic plant abundance within the lake. Anecdotal reports indicate aquatic plant growth may have increased in certain areas of the lake, and these increases may be due to fluctuating water levels. But again, historical data indicate water quality has not been degrading over time in Kelly Lake.

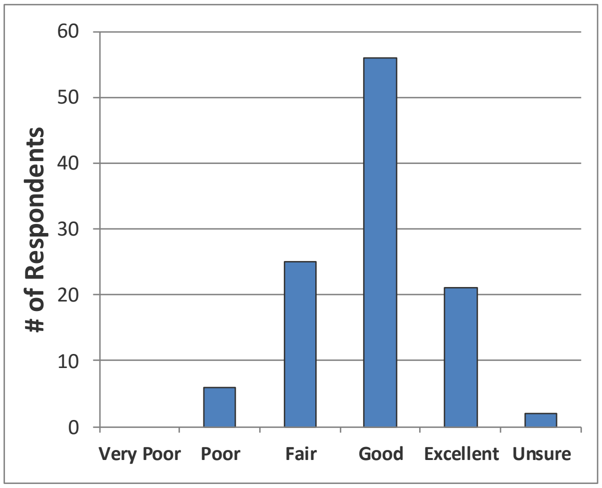


Figure 3.1-8. Stakeholder survey response Question #16. How would you describe the current water quality of Kelly Lake?

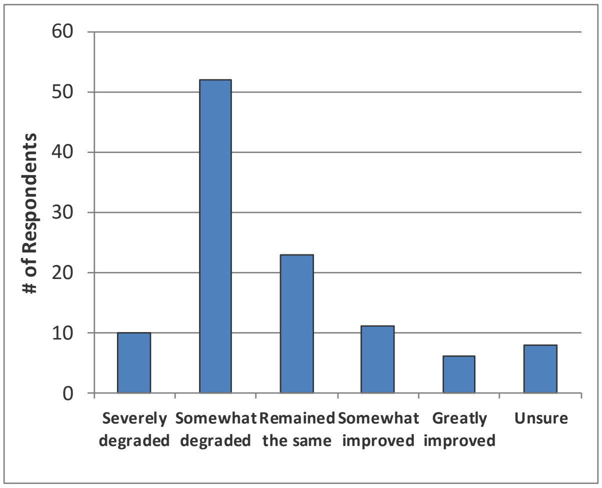


Figure 3.1-9. Stakeholder survey response Question #17. How as the water quality changed in Kelly Lake since you first visited the lake?

3.2 Watershed Assessment

Watershed Modeling

A lake's **flushing rate** is simply a determination of the time required for the lake's water volume to be completely exchanged. **Residence time** describes how long a volume of water remains in the lake and is expressed in days, months, or years. The parameters are related and both determined by the volume of the lake and the amount of water entering the lake from its watershed. Greater flushing rates equal shorter residence times.

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 plant 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.

A reliable and cost-efficient method of creating a general picture of a watershed's effect on a lake can be obtained through modeling. The WDNR created a useful suite of modeling tools called the Wisconsin Lake Modeling Suite (WiLMS). Certain morphological attributes of a lake and its watershed are entered into WiLMS along with the acreages of different types of land cover within the watershed to produce useful information about the lake ecosystem. This information includes an estimate of annual phosphorus load and the partitioning of those loads between the watershed's different land cover types and atmospheric fallout entering through the lake's water surface. WiLMS also calculates the lake's flushing rate and residence times using county-specific average precipitation/evaporation values or values entered by the user. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

Kelly Lake Watershed Assessment

Kelly Lake's total watershed encompasses approximately 836 acres (1.3 square miles) in Oconto County, yielding a watershed to lake area ratio of 1:1. In other words, approximately one acre of land drains to every one acre of Kelly Lake. According to WiLMS modeling, the lake's water is completely replaced every 9 years (residence time) or approximately 0.1 times per year (flushing rate).

When one lake feeds into another and phosphorus data are available from the upstream lake, the upstream lake can be modeled as a point source for the downstream lake. These lakes are modeled in series, with phosphorus outflow from the upstream lake estimated using total phosphorus concentrations and by estimating how much water is draining from the upstream lake to the downstream lake. Both Long and Round lakes drain into Kelly Lake; however, phosphorus data are only available from Round Lake. For modeling purposes, the lake's watershed was divided into two main subwatersheds, Kelly Lake's direct watershed and Round Lake's subwatershed (Map 2). Approximately 66% of Kelly Lake's watershed is composed of its direct watershed and 34% is composed of the Round Lake subwatershed (Figure 3.2-1).

Approximately 67% of Kelly Lake's direct watershed is composed of Kelly Lake's surface, 14% is composed of pasture/grass, 7% is composed of forest, 5% is composed of rural residential areas, 4% is composed of row crops, 2% is composed of wetlands, and 1% is composed of medium density urban areas (Figure 3.2-1). Round Lake's subwatershed is primarily composed of forest, wetlands, and row crop agriculture.

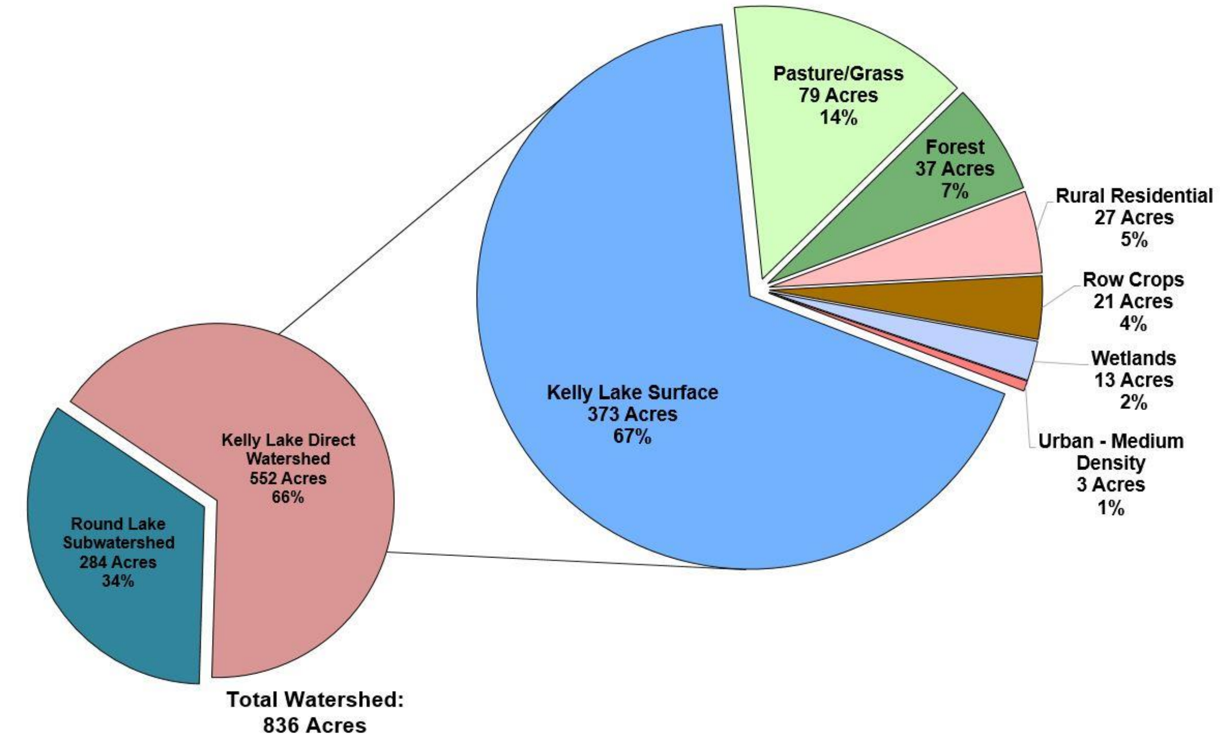


Figure 3.2-1. Kelly Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

Using the landcover described above, WiLMS was utilized to estimate the annual potential phosphorus load from Kelly Lake's direct watershed and the estimated outflow from Round Lake's subwatershed. It was estimated that approximately 161 pounds of phosphorus is delivered to Kelly Lake from its watershed on an annual basis (Figure 3.2-2).

Of the estimated 161 pounds being delivered annually to Kelly Lake, 92% is estimated to originate from its direct watershed (Figure 3.2-2). Within the direct watershed, 62% is estimated to originate from direct atmospheric deposition into the lake, 14% from pasture/grass, 11% row crop agriculture, 2% forest, 1% wetlands, 1% rural residential areas, and 1% medium density urban areas. Approximately 8% of the annual phosphorus load is estimated to originate from the Round Lake subwatershed (Figure 3.2-2).

Using predictive equations, WiLMS estimates that based on the potential annual phosphorus load, Kelly Lake should have a growing season mean total phosphorus concentration of approximately 19 µg/L. This predicted concentration is relatively similar to the measured growing season mean total phosphorus concentration of 14.4 µg/L. This indicates the lake's watershed and phosphorus inputs were modeled fairly accurately, although the slightly higher estimated phosphorus concentration indicates that the estimated annual phosphorus load of 161 pounds is slightly over estimated. Overall, the watershed modeling indicates that measured phosphorus concentrations in Kelly Lake are near expected levels based on the lake's watershed size and land cover composition. There are no indications that significant sources of unaccounted phosphorus are being loaded to the lake.

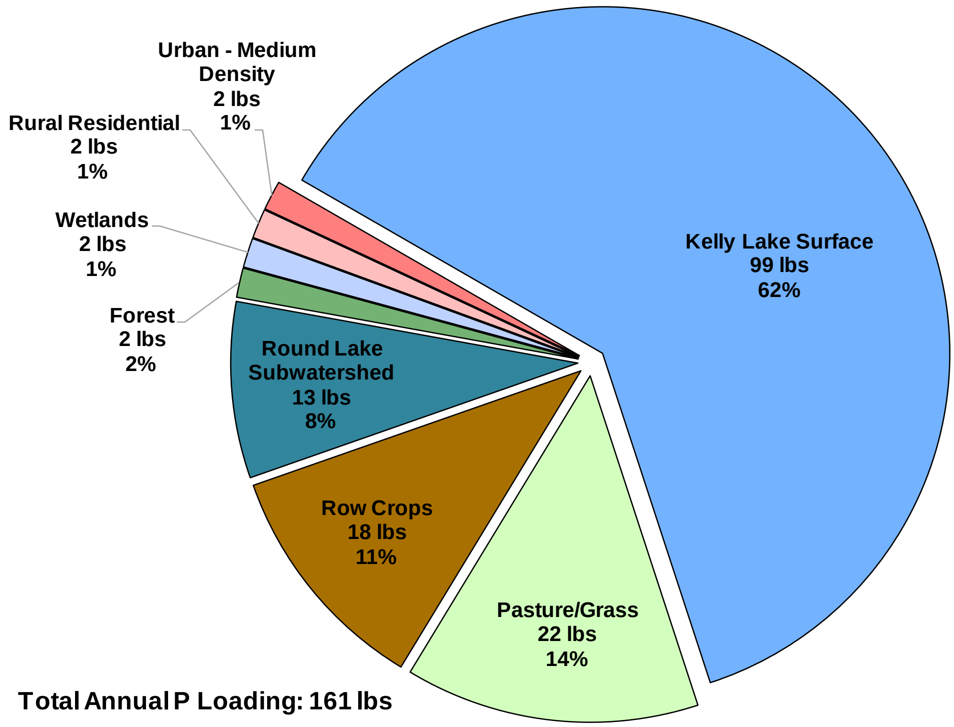


Figure 3.2-2. Kelly Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Shoreland Condition

The Importance of a Lake's Shoreland Zone

One of the most vulnerable areas of a lake's watershed is the immediate shoreland zone (approximately from the water's edge to at least 35 feet shoreland). When a lake's shoreland is developed, the increased impervious surface, removal of natural vegetation, and other human practices can severely increase pollutant loads to the lake while degrading important habitat. Limiting these anthropogenic (man-made) effects on the lake is important in maintaining the quality of the lake's water and habitat.

The intrinsic value of natural shorelands is found in numerous forms. Vegetated shorelands prevent polluted runoff from entering lakes by filtering this water or allowing it to slow to the point where particulates settle. The roots of shoreland plants stabilize the soil, thereby preventing shoreland erosion. Shorelands also provide habitat for both aquatic and terrestrial animal species. Many species rely on natural shorelands for all or part of their life cycle as a source of food, cover from predators, and as a place to raise their young. Shorelands and the nearby shallow waters serve as spawning grounds for fish and nesting sites for birds. Thus, both the removal of vegetation and the inclusion of development reduces many forms of habitat for wildlife.

Some forms of development may provide habitat for less than desirable species. Disturbed areas are often overtaken by invasive species, which are sometimes termed "pioneer species" for this reason. Some waterfowl, such as geese, prefer to linger upon open lawns near waterbodies because of the lack of cover for potential predators. The presence of geese on a lake resident's beach may not be an issue; however, the feces the geese leave are unsightly and pose a health risk. Geese feces may become a source of fecal coliforms as well as flatworms that can lead to swimmers' itch. Development such as rip rap or masonry, steel or wooden seawalls completely remove natural habitat for most animals, but may also create some habitat for snails; this is not desirable for lakes that experience problems with swimmers' itch, as the flatworms that cause this skin reaction utilize snails as a secondary host after waterfowl.

In the end, natural shorelines provide many ecological and other benefits. Between the abundant wildlife, the lush vegetation, and the presence of native flowers, shorelands also provide natural scenic beauty and a sense of tranquility for humans.

Shoreland Zone Regulations

Wisconsin has numerous regulations in place at the state level which aim to enhance and protect shorelands. Additionally, counties, townships and other municipalities have developed their own (often more comprehensive or stronger) policies. At the state level, the following shoreland regulations exist:

<u>**Wisconsin-NR 115: Wisconsin's Shoreland Protection Program**</u>

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted stricter shoreland ordinances. Passed in February of 2010, the final NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances. Counties were previously able to set their own, stricter, regulations to NR 115 but as of 2015, all counties have to abide by state regulations. Minimum requirements for each of these categories are described below. Please note that at the time of this writing, changes to NR 115 were last made in October of 2015 (Lutze 2015).

- Vegetation Removal: For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed 35 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. Vegetation removed must be replaced by replanting in the same area (native species only).

- Impervious surface standards: The amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. If a property owner treats their run off with some type of treatment system, they may be able to apply for an increase in their impervious surface limit.

- Nonconforming structures: Nonconforming structures are structures that were lawfully placed when constructed but do not comply with distance of water setback. Originally, structures within 75 ft of the shoreline had limitations on structural repair and expansion. Language in NR-115 allows construction projects on structures within 75 feet with the following caveats:
    - No expansion or complete reconstruction within 0-35 feet of shoreline
    - Re-construction may occur if the same type of structure is being built in the previous location with the same footprint. All construction needs to follow general zoning or floodplain zoning authority
    - Construction may occur if mitigation measures are included either within the existing footprint or beyond 75 feet.
    - Vertical expansion cannot exceed 35 feet

- Mitigation requirements: Language in NR-115 specifies mitigation techniques that may be incorporated on a property to offset the impacts of impervious surface, replacement of nonconforming structure, or other development projects. Practices such as buffer restorations along the shoreland zone, rain gardens, removal of fire pits, and beaches all may be acceptable mitigation methods.

Wisconsin Act 31

While not directly aimed at regulating shoreland practices, the State of Wisconsin passed Wisconsin Act 31 in 2009 in an effort to minimize watercraft impacts upon shorelines. This act prohibits a person from operating a watercraft (other than personal watercraft) at a speed in excess of slow-no-wake speed within 100 feet of a pier, raft, buoyed area or the shoreline of a lake. Additionally, personal watercraft must abide by slow-no-wake speeds while within 200 feet of these same areas. Act 31 was put into place to reduce wave action upon the sensitive shoreland zone of a lake. The legislation does state that pickup and drop off areas marked with regulatory markers and that are open to personal watercraft operators and motorboats engaged in waterskiing/a similar activity may be exempt from this distance restriction. Additionally, a city, village, town, public inland lake protection and rehabilitation district or town sanitary district may provide an exemption from the 100-foot requirement or may substitute a lesser number of feet.

Shoreland Research

Studies conducted on nutrient runoff from Wisconsin lake shorelands have produced interesting results. For example, a USGS study on several Northwoods Wisconsin lakes was conducted to determine the impact of shoreland development on nutrient (phosphorus and nitrogen) export to these lakes (Graczyk et al. 2003). During the study period, water samples were collected from surface runoff and ground water and analyzed for nutrients. These studies were conducted on several developed (lawn covered) and undeveloped (undisturbed forest) areas on each lake. The study found that nutrient yields were greater from lawns than from forested catchments, but also that runoff water volumes were the most important factor in determining whether lawns or wooded catchments contributed more nutrients to the lake. Groundwater inputs to the lake were found to be significant in terms of water flow and nutrient input. Nitrate plus nitrite nitrogen and total phosphorus yields to the ground-water system from a lawn catchment were three or sometimes four times greater than those from wooded catchments.

A separate USGS study was conducted on the Lauderdale Lakes in southern Wisconsin, looking at nutrient runoff from different types of developed shorelands – regular fertilizer application lawns (fertilizer with phosphorus), non-phosphorus fertilizer application sites, and unfertilized sites (Garn 2002). One of the important findings stemming from this study was that the amount of dissolved phosphorus coming off of regular fertilizer application lawns was twice that of lawns with non-phosphorus or no fertilizer. Dissolved phosphorus is a form in which the phosphorus molecule is not bound to a particle of any kind; in this respect, it is readily available to algae. Therefore, these studies show us that it is a developed shoreland that is continuously maintained in an unnatural manner (receiving phosphorus rich fertilizer) that impacts lakes the greatest. This understanding led former Governor Jim Doyle into passing the Wisconsin Zero-Phosphorus Fertilizer Law (Wis Statue 94.643), which restricts the use, sale, and display of lawn and turf fertilizer which contains phosphorus. Certain exceptions apply, but after April 1 2010, use of this type of fertilizer is prohibited on lawns and turf in Wisconsin. The goal of this action is to reduce the impact of developed lawns, and is particularly helpful to developed lawns situated near Wisconsin waterbodies.

Shorelands provide much in terms of nutrient retention and mitigation, but also play an important role in wildlife habitat. Woodford and Meyer (2003) found that green frog density was negatively correlated with development density in Wisconsin lakes. As development increased, the habitat for green frogs decreased and thus populations became significantly lower. Common loons, a bird species notorious for its haunting call that echoes across Wisconsin lakes, are often associated more so with undeveloped lakes than developed lakes (Lindsay et al. 2002). And studies on shoreland development and fish nests show that undeveloped shorelands are preferred as well. In a study conducted on three Minnesota lakes, researchers found that only 74 of 852 black crappie nests were found near shorelines that had any type of dwelling on it (Reed, 2001). The remaining nests were all located along undeveloped shoreland.

Photograph 3.3-1. Example of coarse woody habitat in a lake.

Emerging research in Wisconsin has shown that coarse woody habitat (sometimes called "coarse woody debris"), often stemming from natural or undeveloped shorelands, provides many ecosystem benefits in a lake. Coarse woody habitat describes habitat consisting of trees, limbs, branches, roots and wood fragments at least four inches in diameter that enter a lake by natural or human means. Coarse woody habitat provides shoreland erosion control, a carbon source for the lake, prevents suspension of sediments and provides a surface for algal growth which important for aquatic macroinvertebrates (Sass 2009). While it impacts these aspects considerably, one of the greatest benefits coarse woody habitat provides is habitat for fish species.

Coarse woody habitat has shown to be advantageous for fisheries in terms of providing refuge, foraging area, as well as spawning habitat (Hanchin et al 2003). In one study, researchers observed 16 different species occupying coarse woody habitat areas in a Wisconsin lake (Newbrey et al. 2005). Bluegill and bass species in particular are attracted to this habitat type; largemouth bass stalk bluegill in these areas while the bluegill hide amongst the debris and often feed upon many macroinvertebrates found in these areas, who themselves are feeding upon algae and periphyton growing on the wood surface. Newbrey et al. (2005) found that some fish species prefer different complexity of branching on coarse woody habitat, though in general some degree of branching is preferred over coarse woody habitat that has no branching.

With development of a lake's shoreland zone, much of the coarse woody habitat that was once found in Wisconsin lakes has disappeared. Prior to human establishment and development on lakes (mid to late 1800's), the amount of coarse woody habitat in lakes was likely greater than under completely natural conditions due to logging practices. However, with changes in the logging industry and increasing development along lake shorelands, coarse woody habitat has decreased substantially. Shoreland residents are removing woody debris to improve aesthetics or for recreational opportunities (boating, swimming, and, ironically, fishing).

National Lakes Assessment

Unfortunately, along with Wisconsin's lakes, waterbodies within the entire United States have shown to have increasing amounts of developed shorelands. The National Lakes Assessment (NLA) is an Environmental Protection Agency sponsored assessment that has successfully pooled together resource managers from all 50 U.S. states in an effort to assess waterbodies, both natural and man-made, from each state. Through this collaborative effort, over 1,000 lakes were sampled in 2007, pooling together the first statistical analysis of the nation's lakes and reservoirs.

Through the National Lakes Assessment, a number of potential stressors were examined, including nutrient impairment, algal toxins, fish tissue contaminants, physical habitat, and others. The 2007 NLA report states that "*of the stressors examined, poor lakeshore habitat is the biggest problem in the nations lakes; over one-third exhibit poor shoreline habitat condition*" (USEPA 2009). Furthermore, the report states that "*poor biological health is three times more likely in lakes with* *poor lakeshore habitat.*" These results indicate that stronger management of shoreline development is absolutely necessary to preserve, protect, and restore lakes. Shoreland protection will become increasingly important as development pressure on lakes continues to grow.

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects (Jennings et al. 2003). The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreland. Removal of native plants and dead, fallen timbers from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreland sediments vulnerable to wave action caused by boating and wind (Jennings et al. 2003, Radomski and Goeman 2001, and Elias & Meyer 2003). Many homeowners significantly decrease the number of trees and shrubs along the water's edge in an effort to increase their view of the lake. However, this has been shown to locally increase water temperatures, and decrease infiltration rates of potentially harmful nutrients and pollutants. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife (Scheuerell and Schindler 2004).

Photograph 3.3-2. Example of a biolog restoration site.

In recent years, many lakefront property owners have realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a shoreland buffer zone. The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping. Simply not mowing within the buffer zone does wonders to restore some of the shoreland's natural function.

Enhancement activities also include additions of submergent, emergent, and floating-leaf plants within the lake itself. These additions can provide greater species diversity and may compete against exotic species.

Cost

The cost of native, aquatic, and shoreland plant restorations is highly variable and depends on the size of the restoration area, the depth of buffer zone required to be restored, the existing plant density, the planting density required, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other sites may require erosion control stabilization measures, which could be as simple as using erosion control blankets and plants and/or seeds or more extensive techniques such as geotextile bags (vegetated retaining walls), geogrids (vegetated soil lifts), or bio-logs (see above picture). Some of these erosion control techniques may reduce the need for rip-rap or seawalls which are sterile environments that do not allow for plant growth or natural shorelines. Questions about rip-rap or seawalls should be directed to the local Wisconsin DNR Water Resources Management Specialist. Other measures possibly required include protective measures used to guard newly planted area from wildlife predation, wave-action, and erosion, such as fencing, erosion control matting, and animal deterrent sprays. One of the most important aspects of planting is maintaining moisture levels. This is done by watering regularly for the first two years until plants establish themselves, using soil amendments (i.e., peat, compost) while planting, and using mulch to help retain moisture.

Most restoration work can be completed by the landowner themselves. To decrease costs further, bare-root form of trees and shrubs should be purchased in early spring. If additional assistance is needed, the lakefront property owner could contact an experienced landscaper. For properties with erosion issues, owners should contact their local county conservation office to discuss cost-share options.

In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $1,400. The more native vegetation a site has, the lower the cost. Owners should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:

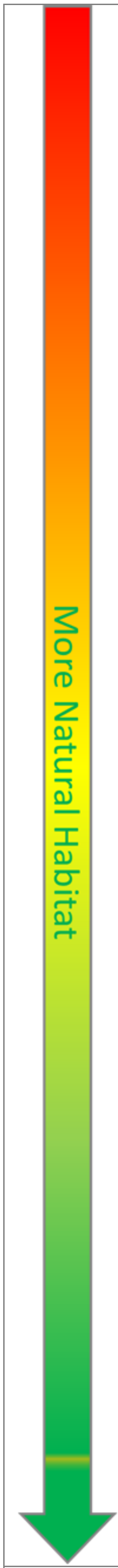
- Spring planting timeframe.
- 100' of shoreline.
- An upland buffer zone depth of 35'.
- An access and viewing corridor 30' x 35' free of planting (recreation area).
- Planting area of upland buffer zone 2- 35' x 35' areas
- Site is assumed to need little invasive species removal prior to restoration.
- Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
- Trees and shrubs planted at a density of 1 tree/100 sq. ft and 2 shrubs/100 sq. ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
- Turf grass would be removed by hand.
- A native seed mix is used in bare areas of the upland buffer zone.
- An aquatic zone with shallow-water 2 - 5' x 35' areas.
- Plant spacing for the aquatic zone would be 3 feet.
- Each site would need 70' of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- Soil amendment (peat, compost) would be needed during planting.
- There is no hard-armor (rip-rap or seawall) that would need to be removed.
- The property owner would maintain the site for weed control and watering.

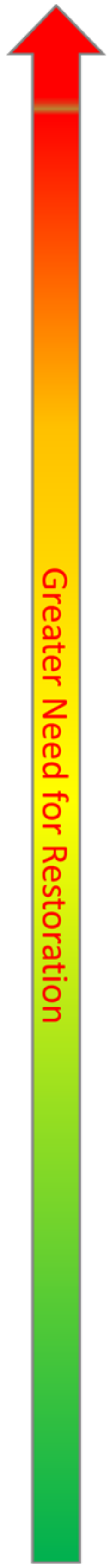
Advantages	*Disadvantages*
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreland erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Once native plants are established, they require less water, maintenance, no fertilizer; provide wildlife food and habitat, and natural aesthetics compared to ornamental (non-native) varieties. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Kelly Lake Shoreland Zone Condition

Shoreland Development

Kelly Lake's shoreland zone can be classified in terms of its degree of development. In general, more developed shorelands are more stressful on a lake ecosystem, while definite benefits occur from shorelands that are left in their natural state. Figure 3.3-1 displays a diagram of shoreland categories, from "Urbanized", meaning the shoreland zone is completely disturbed by human influence, to "Natural/Undeveloped", meaning the shoreland has been left in its original state.





	**Urbanized**: This type of shoreline has essentially no natural habitat. Areas that are mowed or unnaturally landscaped to the water's edge and areas that are rip-rapped or include a seawall would be placed in this category.
	**Developed-Unnatural**: This category includes shorelines that have been developed, but only have small remnants of natural habitat yet intact. A property with many trees, but no remaining understory or herbaceous layer would be included within this category. Also, a property that has left a small (less than 30 feet), natural buffer in place, but has urbanized the areas behind the buffer would be included in this category.
	**Developed-Semi-Natural**: This is a developed shoreline that is mostly in a natural state. Developed properties that have left much of the natural habitat in state, but have added gathering areas, small beaches, etc. within those natural areas would likely fall into this category. An urbanized shoreline that was restored would likely be included here, also.
	**Developed-Natural**: This category includes shorelines that are developed property, but essentially no modifications to the natural habitat have been made. Developed properties that have maintained the natural habitat and only added a path leading to a single pier would fall into this category.
	**Natural/Undeveloped**: This category includes shorelines in a natural, undisturbed state. No signs of anthropogenic impact can be found on these shorelines. In forested areas, herbaceous, understory, and canopy layers would be intact.

Figure 3.3-1. Shoreland assessment category descriptions.

On Kelly Lake, the development stage of the entire shoreland was surveyed during the Fall of 2016, using a GPS unit to map the shoreland. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreland on a property-by-property basis. During the survey, Onterra staff examined the shoreland for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.3-1.

Kelly Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 0.7 miles of natural/undeveloped and developed-natural shoreland were observed during the survey (Figure 3.2-4). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 2.7 miles of urbanized and developed–unnatural shoreland were observed. If restoration of the Kelly Lake shoreland is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreland lengths around the entire lake.

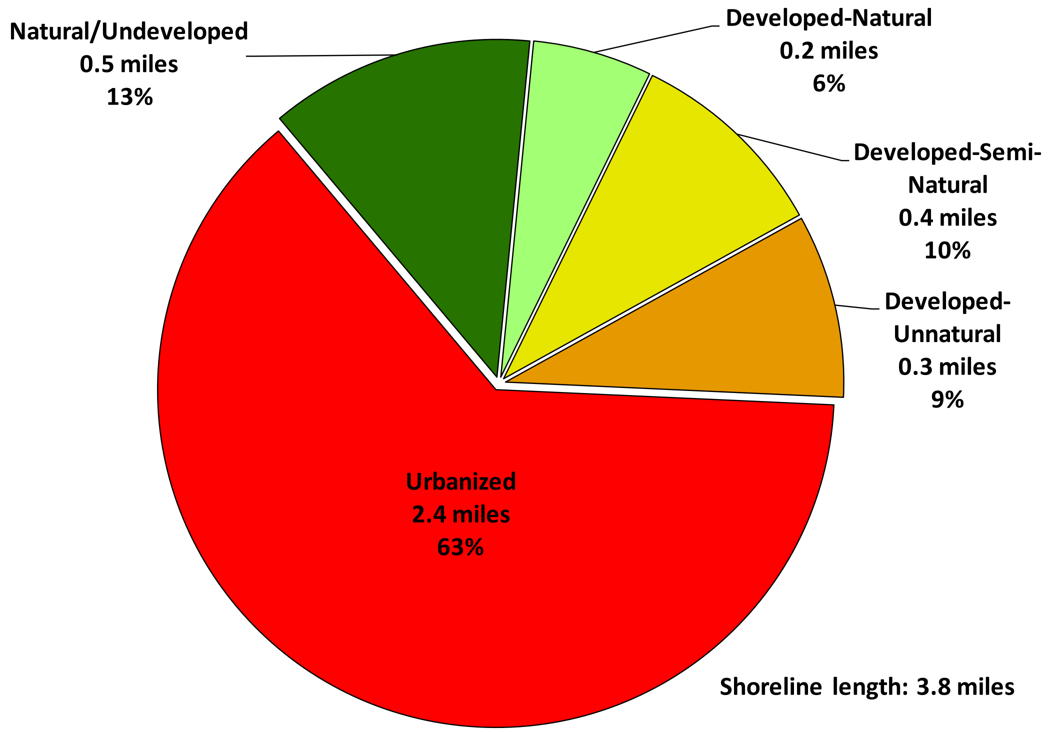


Figure 3.3-2. Kelly Lake shoreland categories and total lengths. Based upon a Fall 2016 survey. Locations of these categorized shorelands can be found on Map 3.

While producing a completely natural shoreland is ideal for a lake ecosystem, it is not always practical from a human's perspective. However, riparian property owners can take small steps in ensuring their property's impact upon the lake is minimal. Choosing an appropriate landscape position for lawns is one option to consider. Placing lawns on flat, un-sloped areas or in areas that do not terminate at the lake's edge is one way to reduce the amount of runoff a lake receives from a developed site. And, allowing tree falls and other natural habitat features to remain along a shoreline may result not only in reducing shoreline erosion, but creating wildlife habitat also.

Coarse Woody Habitat

Kelly Lake was surveyed in 2016 to determine the extent of its coarse woody habitat. A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey. Coarse woody habitat was identified, and classified in two size categories (2-8 inches diameter, >8 inches diameter) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed earlier, research indicates that fish species prefer some branching as opposed to no branching on coarse woody habitat, and increasing complexity is positively correlated with higher fish species richness, diversity and abundance.

During this survey, 35 total pieces of coarse woody habitat were observed along 3.8 miles of shoreline, which gives Kelly Lake a coarse woody habitat to shoreline mile ratio of 9:1. Locations of coarse woody habitat are displayed on Map 4. To put this into perspective, Wisconsin researchers have found that in completely undeveloped lakes, an average of 345 coarse woody habitat structures may be found per mile (Christensen et al. 1996).

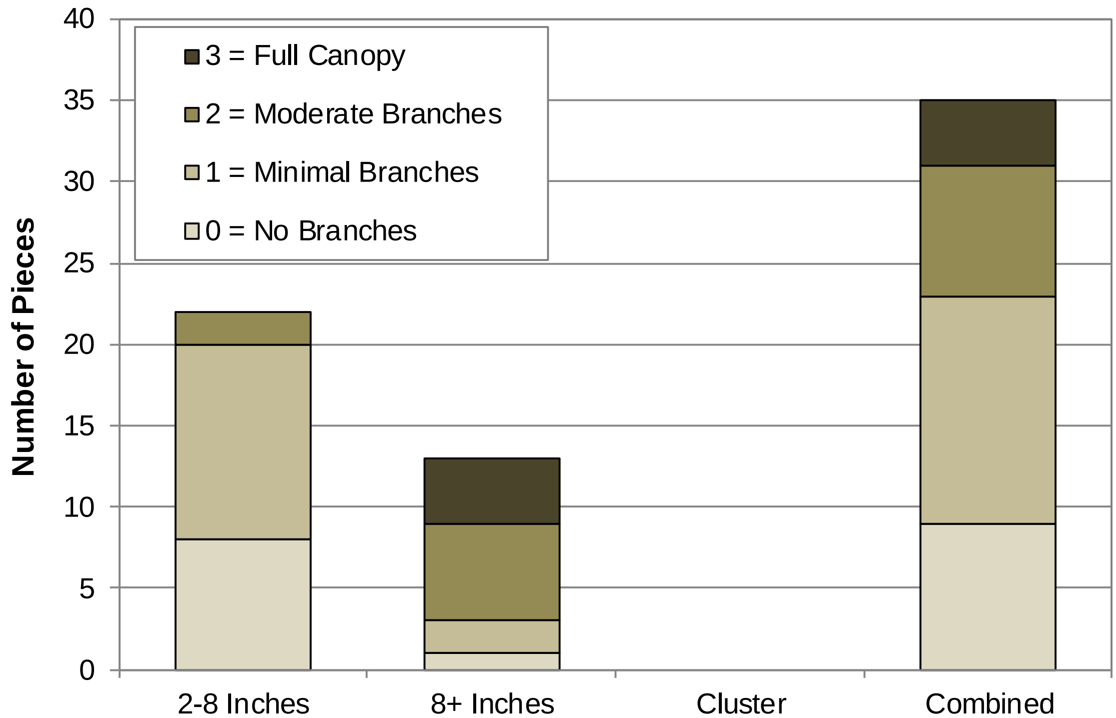


Figure 3.3-3. Kelly Lake coarse woody habitat survey results. Based upon a Fall 2016 survey. Locations of Kelly Lake coarse woody habitat can be found on Map 4.

3.4 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 3.4-1. 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

> **Important Note:**
> Even though most of these techniques are not applicable to Kelly 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 Kelly Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

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.

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 3.4-2. 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 3.4-3. 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

Photograph 3.4-4. Granular herbicide application.

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 et al. (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. • 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)	• All herbicide use carries some degree of human health and ecological risk due to toxicity. • Fast-acting herbicides may cause fishkills 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. • 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 emergents 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 Kelly 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 Kelly 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 Kelly 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 Kelly 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 Kelly Lake is compared to data collected by Onterra and the WDNR Science Services on 85 lakes withn the North Central Hardwood Forests 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 Kelly Lake were mapped using a Trimble Global Positioning System (GPS) with sub-meter accuracy.

Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotics, curly-leaf pondweed and Eurasian watermilfoil are the primary targets of this extra attention.

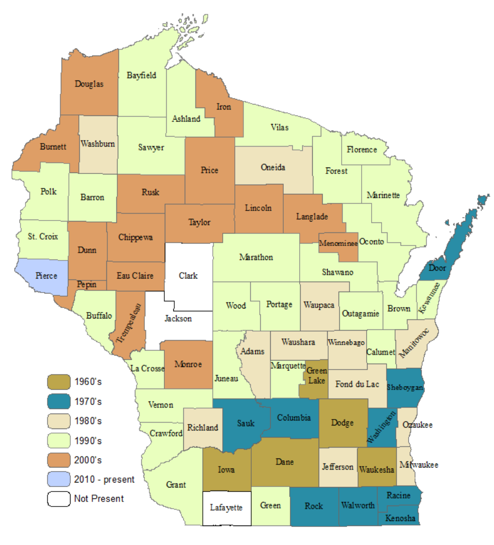


Figure 3.4-1. Spread of Eurasian watermilfoil within WI counties. WDNR Data 2011 mapped by Onterra.

Eurasian watermilfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.4-1). Eurasian watermilfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian watermilfoil 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, 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.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly – leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian watermilfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities within the lake. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

Because of its odd life-cycle, a special survey is conducted early in the growing season to inventory and map curly-leaf pondweed occurrence within the lake. Although Eurasian watermilfoil starts to grow earlier than our native plants, it is at peak biomass during most of the summer, so it is inventoried during the comprehensive aquatic plant survey completed in mid to late summer.

Aquatic Plant Survey Results

During the aquatic plant surveys completed on Kelly Lake in 2016, a total of 30 species of plants were located in Kelly Lake, two of which are considered non-native, invasive species: Eurasian watermilfoil and reed canary grass (Table 3.4-1). The aquatic plant species list also contains species recorded during whole-lake point-intercept surveys completed in 2012. Changes in species' abundance between these two surveys are discussed later in this section. On June 10, 2016, an Early-Season AIS Survey was completed on Kelly Lake that focused on locating and mapping potential occurrences of curly-leaf pondweed. This meander-based, visual survey did not locate any occurrences of this non-native plant. At present, curly-leaf pondweed either does not occur in Kelly Lake or exists at an undetectable level. Because the non-native plants found in Kelly Lake have the ability to negatively impact lake ecology, recreation, and aesthetics, the populations of these plants are discussed in detail within the Non-Native Aquatic Plants Section.

The whole-lake aquatic plant point-intercept survey and emergent and floating-leaf aquatic plant community mapping survey were conducted on Kelly Lake on July 25, 2016 by Onterra. Lakes in Wisconsin vary in their morphology, water chemistry, substrate composition, recreational use, and management, and all of these factors influence aquatic plant community composition. On August 29, 2016, Onterra ecologists completed an acoustic survey on Kelly Lake. 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 Kelly 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.

Data regarding substrate hardness collected during the 2016 acoustic survey revealed that Kelly Lake's average substrate hardness ranges from hard to moderately hard with deeper areas containing softer, more flocculent sediments (Figure 3.4-2 and Map 5). On average, the softest substrates (muck, marl) are found within 12 to 26 feet of water. The greatest transition between hard and softer substrates is found between 3 and 8 feet of water, with hardness declining rapidly with depth. In 28 feet of water and deeper, substrate hardness remains relatively constant. Figure 3.4-2 illustrates the spatial distribution of substrate hardness in Kelly Lake. 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.

Table 3.4-1. Aquatic plant species located on Kelly Lake during WDNR 2012 and Onterra 2016 surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2012 WDNR	2016 Onterra
Emergent	*Calla palustris*	Water arum	9		I
	Phalaris arundinacea	Reed canary grass	Exotic		I
	Pontederia cordata	Pickerelweed	9		I
	Sagittaria latifolia	Common arrowhead	3		I
	Schoenoplectus acutus	Hardstem bulrush	5		I
	Schoenoplectus pungens	Three-square rush	5		I
FL	*Nuphar variegata*	Spatterdock	6		X
	Nymphaea odorata	White water lily	6	X	X
	Persicaria amphibia	Water smartweed	5		I
	Sparganium fluctuans	Floating-leaf bur-reed	10		I
Submergent	*Bidens beckii*	Water marigold	8	X	X
	Ceratophyllum demersum	Coontail	3	X	X
	Chara spp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Myriophyllum sibiricum	Northern watermilfoil	7	X	X
	Myriophyllum spicatum	Eurasian watermilfoil	Exotic/Invasive	X	X
	Najas flexilis	Slender naiad	6	X	X
	Najas guadalupensis	Southern naiad	7	X	X
	Nitella spp.	Stoneworts	7	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton berchtoldii	Slender pondweed	7		X
	Potamogeton friesii	Fries' pondweed	8		X
	Potamogeton gramineus	Variable-leaf pondweed	7	X	X
	Potamogeton illinoensis	Illinois pondweed	6	X	X
	Potamogeton natans	Floating-leaf pondweed	5		I
	Potamogeton praelongus	White-stem pondweed	8	X	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X	
	Potamogeton strictifolius	Stiff pondweed	8	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Stuckenia pectinata	Sago pondweed	3	X	X
	Vallisneria americana	Wild celery	6	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X	

FL = Floating-leaf; FL/E = Floating-leaf and Emergent; S/E = Submergent and Emergent; FF = Free-floating
X = Located on rake during point-intercept survey

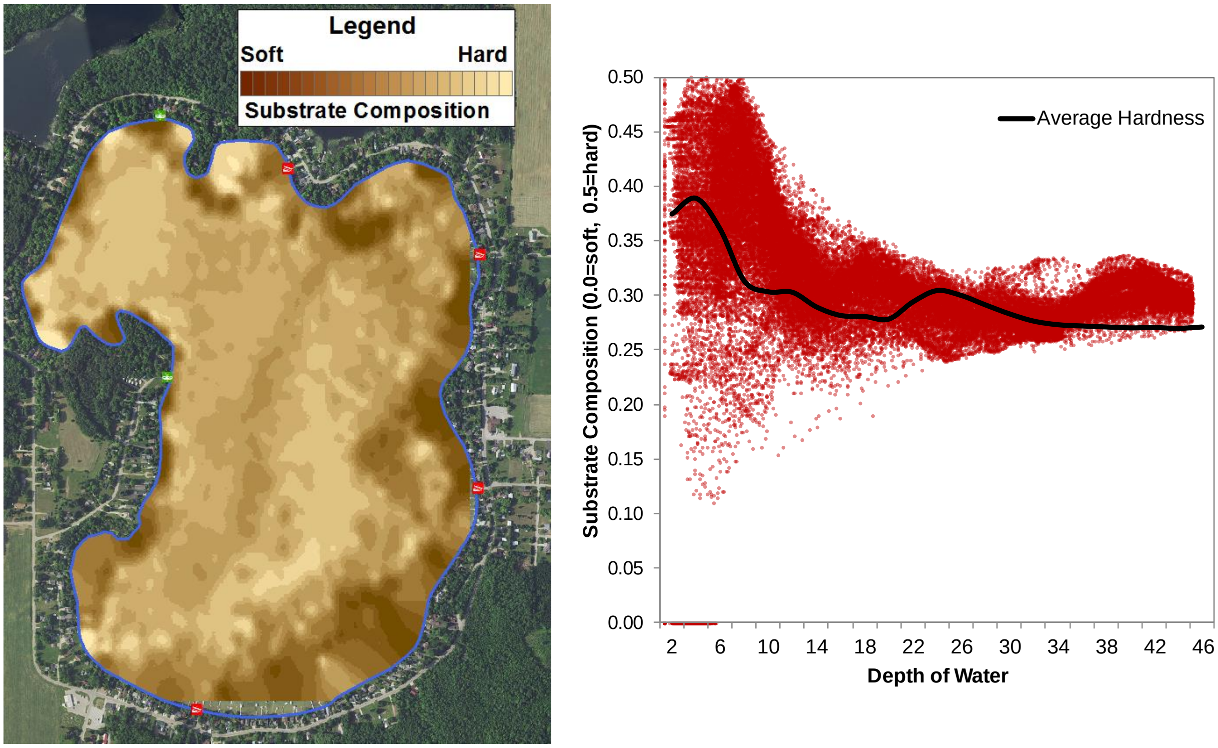


Figure 3.4-2. Kelly Lake spatial distribution of substrate hardness (left) and substrate hardness across water depth (right). Created using data from August 2016 acoustic survey.

The water quality data from Kelly Lake indicate the lake is classified as hardwater lake, a lake with a high concentration of dissolved minerals – particularly calcium. Lakes rich in calcium are often termed *marl lakes*. When dissolved calcium reaches a concentration at which the water can no longer dissolve additional calcium (saturation point), the calcium combines with carbonate forming calcium carbonate, or marl, and it precipitates out of the water. The soft sediments found in Kelly Lake are likely largely comprised of marl.

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 2016 aquatic plant bio-volume data are displayed in Figure 3.4-3 and Map 6. 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. The 2016 whole-lake point-intercept survey and acoustic survey found aquatic plants growing to a maximum depth of 25 feet, a testament to the high-water clarity found in Kelly Lake. However, the majority of aquatic plant growth occurred between two feet and 17 feet of water, and the presence of aquatic plants quickly diminished beyond 23 feet. Overall, the 2016 acoustic survey indicates that approximately 70% of Kelly Lake contains aquatic vegetation (Figure 3.4-3). The remaining area of the lake is too deep and does not receive adequate light to support aquatic plant growth.

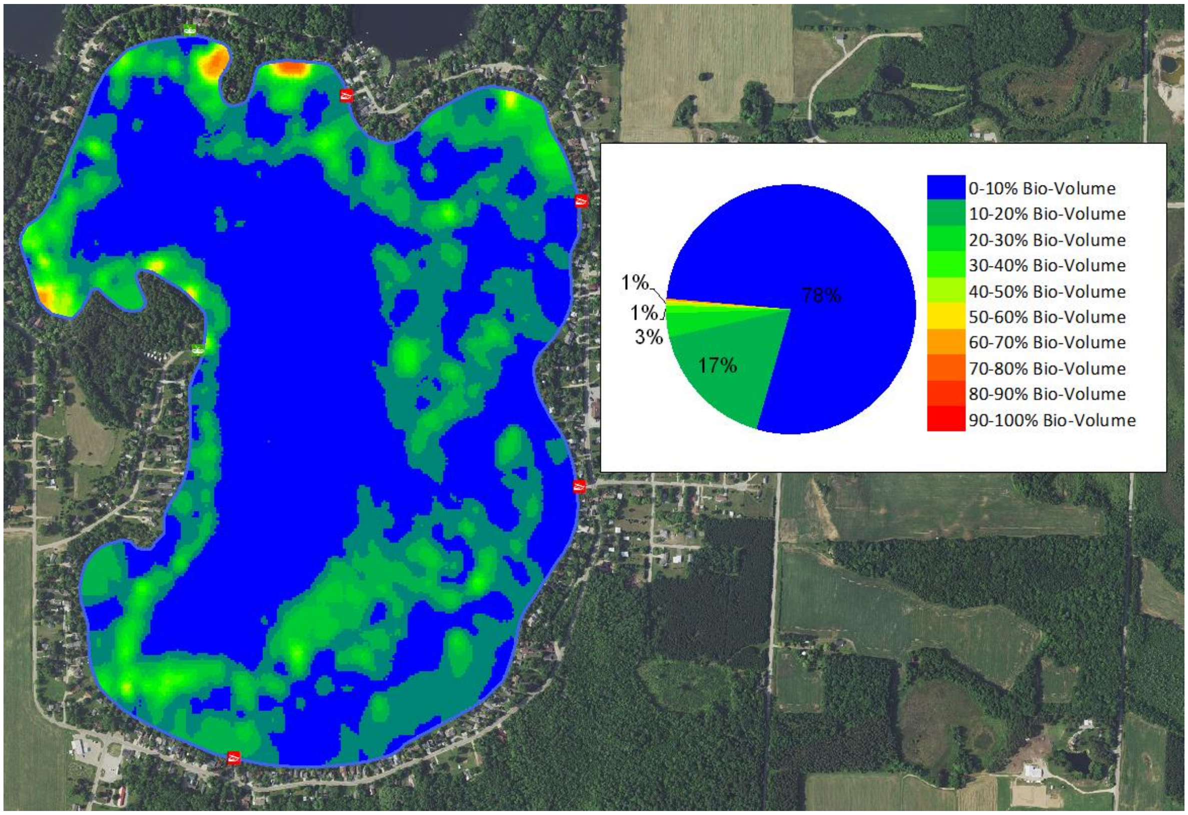


Figure 3.4-3. Kelly Lake 2016 aquatic plant bio-volume. Created using data from August 2016 acoustic survey.

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 comprise the aquatic plant community. Whole-lake point-intercept surveys are used to quantify the abundance of individual plant species within the lake. Of the 320 point-intercept sampling locations that fell at or shallower than the maximum depth of plant growth (the littoral zone) in 2016, approximately 80% contained aquatic vegetation. Aquatic plant rake fullness data collected in 2016 indicates that 44% of the 320 sampling locations contained vegetation with a total rake fullness rating (TRF) of 1, 21% had a TRF rating of 2, and 15% had a TRF rating of 3 (Figure 3.4-4). The TRF data indicates that where aquatic plants are present in Kelly Lake, they were not overly dense.

Of the 30 aquatic plant species located in Kelly Lake in 2016, 20 were encountered directly on the rake during the whole-lake point intercept survey. The remaining 10 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 these 20 species, muskgrasses were the most frequently encountered, followed by stoneworts, southern naiad, and variable-leaf pondweed (Figure 3.4-5).

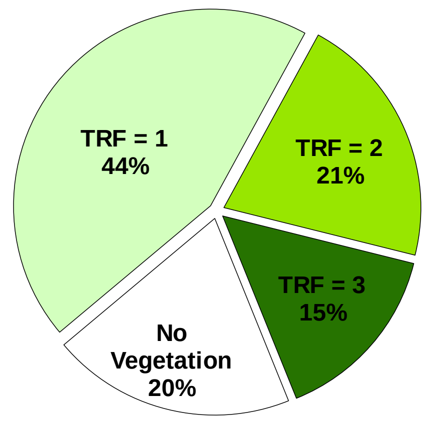


Figure 3.4-4. Kelly Lake 2016 aquatic vegetation total rake fullness (TRF) ratings within littoral areas. Created from data collected during the 2016 whole-lake aquatic plant point-intercept survey.

Photograph 3.4-5. The aquatic macroalgae muskgrasses (*Chara* spp.). Photo credit Onterra.

Muskgrasses are a genus of macroalgae of which there are seven species in Wisconsin (Photograph 3.4-5). In 2016, muskgrasses had a littoral frequency of occurrence of approximately 59% (Figure 3.4-5). Dominance of the aquatic plant community by muskgrasses is common in hardwater lakes like Kelly Lake, 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 stabilize bottom sediments. Studies have also shown that muskgrasses sequester phosphorus in the calcium carbonate incrustations which form on these plants, aiding in improving water quality by making the phosphorus unavailable to phytoplankton (Coops 2002). In Kelly Lake, muskgrasses were abundant across littoral depths in 2016.

Stoneworts, the second-most frequently encountered aquatic plant in Kelly Lake, like muskgrasses are a genus of macroalgae. The stems and branches of these plants are often bright green and semi-transparent. These plants were found growing in large beds along the bottom in Kelly Lake, where they are not likely seen from the surface. The fine, whorled branches of stoneworts provide excellent habitat for aquatic invertebrates and provide foraging and cover areas for fish. Stoneworts were found to be most dominant from 17 to 24 feet, the deepest portion of Kelly Lake's littoral zone. Finding stoneworts growing so deep is a testament to the high-water clarity and good water quality of Kelly Lake.

Southern naiad was the third-most frequently encountered aquatic plant in Kelly Lake in 2016 with a littoral frequency of occurrence of approximately 11% (Figure 3.4-5). Southern naiad is similar to slender naiad, and they are often difficult to separate. While southern naiad is native to North America, observations have been indicating that populations of this plant have been expanding and behaving invasively, particularly in northern Wisconsin lakes. It is not known if this behavior represents recent introductions of these plants to waterbodies where it was not found naturally, or if certain environmental conditions are favoring the expansion of southern naiad. In Kelly Lake, the littoral occurrence of southern naiad declined from 2012 to 2016, and this plant does not appear to be behaving aggressively within the lake at this time.

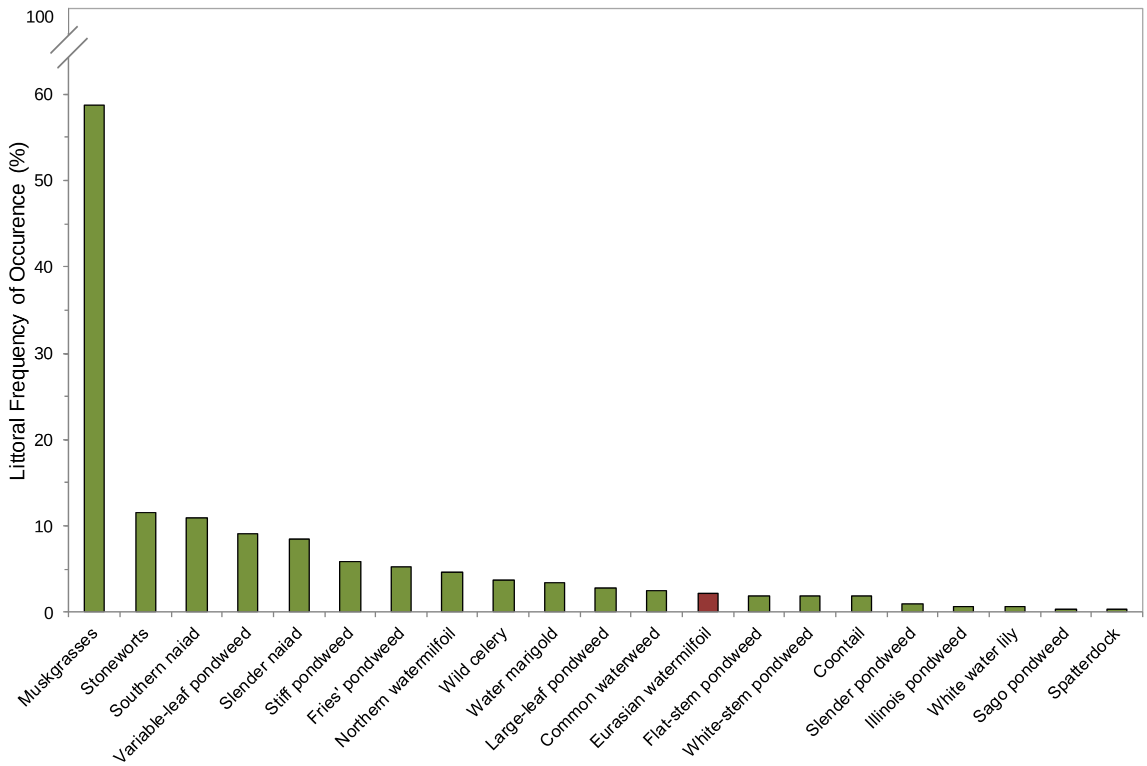


Figure 3.4-5. Kelly Lake aquatic plant littoral frequency of occurrence. Created using data from July 2016 surveys.

Variable-leaf pondweed, the fourth-most encountered species with a littoral frequency of 9%, is a submersed plant that produces a thin, cylindrical stem that has numerous branches (Figure 3.4-5). These branches produce linear leaves that grow anywhere from four to eleven centimeters long, and may produce three to seven veins per leaf. This plant also hybridizes easily with other pondweed (*Potamogeton*) species; thus, this plant can appear quite variable in size and shape and is named appropriately.

An aquatic plant point-intercept dataset is also available from 2012 in Kelly Lake, and the methodology and sampling locations were the same as the survey completed in 2016. The datasets from 2012 and 2016 can be statistically compared to determine if any significant changes in the overall occurrence of vegetation or in species' abundance have occurred over this time period. The littoral frequency of occurrence of vegetation in Kelly Lake in 2016 of 82% was not statistically different from its occurrence of 81% in 2012.

Figure 3.4-6 displays the littoral frequency of occurrence of aquatic plant species from the 2012 and 2016 point-intercept surveys. Only the species that had a littoral frequency of occurrence of at least 5% in one of the two surveys are displayed. In total, seven aquatic plant species exhibited statistically valid changes in their littoral frequency of occurrence between 2012 and 2016 (Figure

3.4-6). Eurasian watermilfoil, southern naiad, and variable-leaf pondweed all decreased in their littoral occurrence from 2012-2016, while slender naiad, stiff pondweed, and Fries' pondweed all increased in occurrence over this time period. The occurrences of northern watermilfoil, muskgrasses and stoneworts, and common waterweed were not statistically different over this time period. Muskgrasses and stoneworts were combined for this analysis due to their similar morphology during field identification.

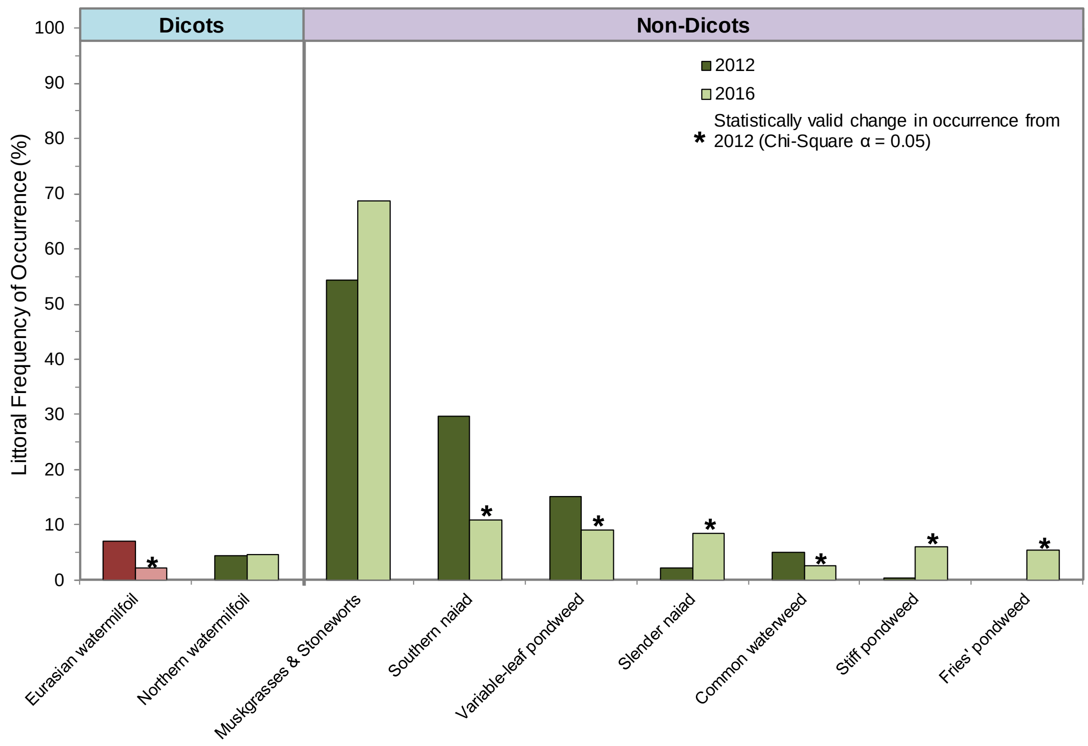


Figure 3.4-6. Kelly Lake aquatic plant littoral frequency of occurrence. Created using data from the 2012 WDNR and 2016 Onterra surveys.

Aquatic plant communities are dynamic and the abundance of certain species from year to year can fluctuate depending on climatic conditions, water levels, changes in clarity, herbivory, competition, and disease among other factors. Certain native aquatic plants can also decline following the implementation of herbicide applications to control non-native aquatic plants; however, the treatments completed to Eurasian watermilfoil in Kelly Lake have been small and are not believed to have been able to impact native plant populations on a lake-wide level. Rather, these observed reductions and increases in occurrence of certain species are believed to be due to varying interannual environmental conditions. Ongoing collection of aquatic plant data from Wisconsin's lakes shows that aquatic plant populations have the capacity to fluctuate widely on an interannual basis under natural conditions. It is not known what has driven the changes observed in Kelly Lake, but it is likely the result of a combination of primarily natural factors.

As discussed in the primer section, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 30 native aquatic plant species were located in Kelly Lake during the 2016 surveys, 20 were directly encountered on the rake during the point-intercept survey. Kelly Lake's native aquatic plant species richness in 2016 exceeded the median value for lakes within the North Central Hardwood Forests (NCHF) ecoregion and for lakes throughout Wisconsin (Figure 3.4-7). The species richness recorded in 2016 (20) was slightly higher than that recorded during the 2012 (19) point-intercept survey. The differences in the aquatic plant species list between these surveys can be viewed in Table 3.4-1.

The average conservatism of the 20 native aquatic plants recorded on the rake in 2016 was 6.3, falling above the median value (5.8) for lakes within the NCHF ecoregion and even with the median value (6.3) for lakes throughout Wisconsin (Figure 3.4-7). This indicates that Kelly Lake has a slightly higher number of native aquatic plant species with high conservatism values when compared to the majority of lakes within the NCHF ecoregion. Average conservatism in 2016 was higher when compared to the average conservatism values recorded in 2012 (6.2).

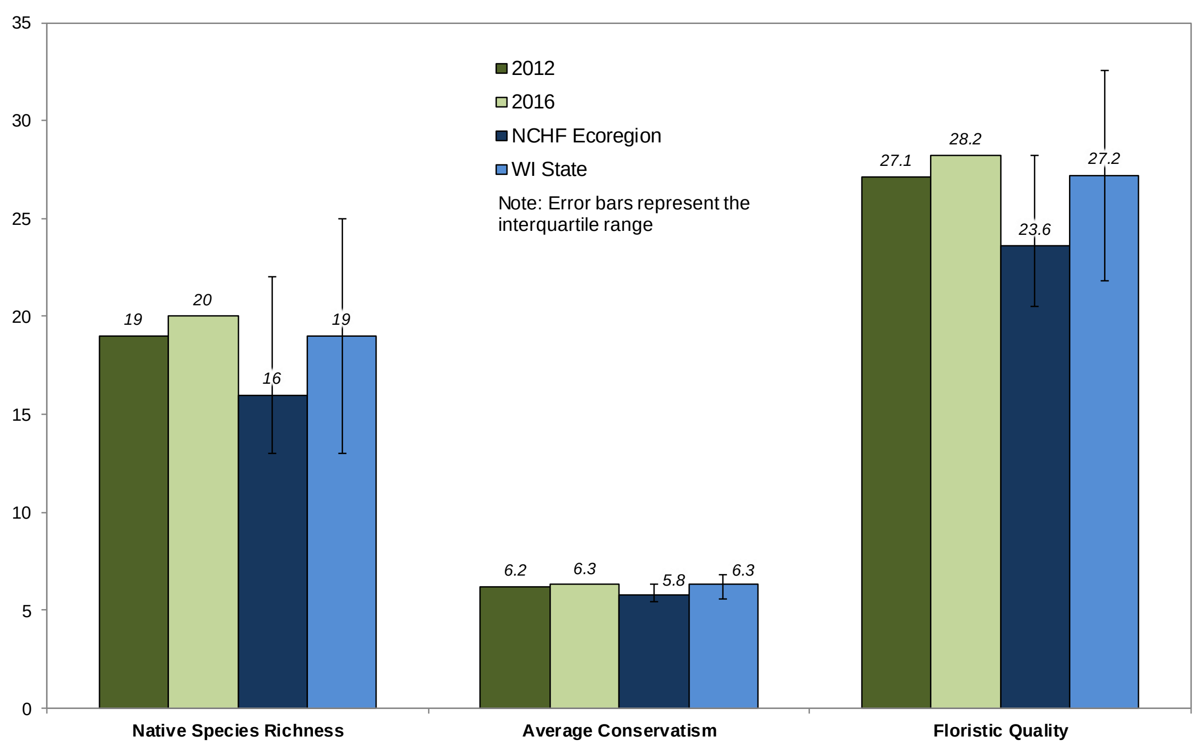


Figure 3.4-7. Kelly Lake Floristic Quality Analysis. Created using data from WDNR 2012 and Onterra 2016 whole-lake point-intercept surveys. Analysis follows Nichols (1999).

Using Kelly Lake's 2016 native aquatic plant species richness and average conservatism to calculate the Floristic Quality Index value yields a high value of 28.2, exceeding median values for lakes within the NCHF ecoregion and the state. This indicates that Kelly Lake's aquatic plant community is of higher quality in terms of species richness and community composition than the majority of lakes within the ecoregion and the state. Given that native species richness and average conservatism were higher in 2016 when compared to 2012, the 2016 Floristic Quality Index value was also higher than those calculated for 2012.

Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Kelly Lake contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

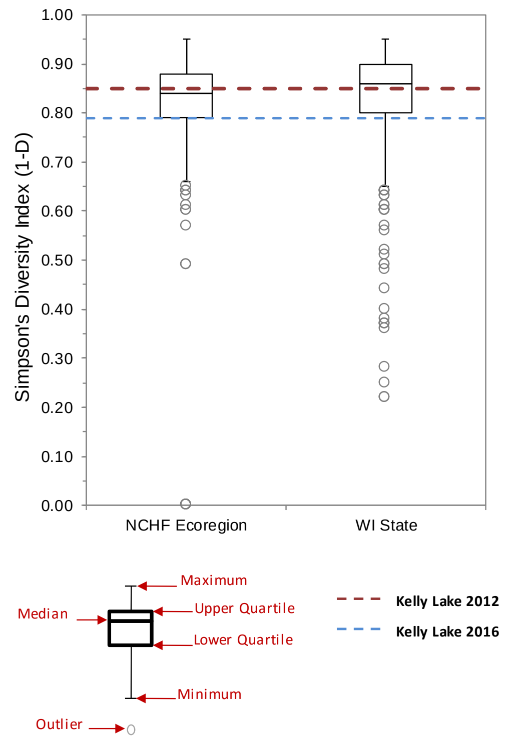


Figure 3.4-8. Kelly Lake species diversity index. Created using data from 2012 and 2016 aquatic plant surveys. Ecoregion data from 85 NCHF lakes collected by WDNR Science Services and Onterra.

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 Kelly Lake's diversity value ranks. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 85 lakes within the NCHF ecoregion (Figure 3.4-8). Using the data collected from the 2012 and 2016 point-intercept surveys, Kelly Lake's aquatic plant community is shown to have relatively low species diversity. Simpson's Diversity Index values were 0.85 in 2012 and 0.79 in 2016. These diversity value for 2012 is above the median value of 0.84 for lakes in the NCHF ecoregion while the 2016 value falls below the median for lakes in the NCHF ecoregion.

While Kelly Lake contains a high number of aquatic plant species, the majority of the plant community is comprised of just four species. One way to visualize Kelly Lake's lower species diversity is to look at the relative occurrence of aquatic plant species. Figure 3.4-9 displays the relative frequency of occurrence of aquatic plant species created from the 2016 whole-lake point-intercept survey and illustrates the relatively uneven distribution of aquatic plant species within the community. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population).

For instance, while muskgrasses had a littoral frequency of occurrence of 59%, their relatively frequency of occurrence was 43%. Explained another way, if 100 plants were sampled from Kelly Lake, 43 would be muskgrasses. Figure 3.4-9 illustrates that 58% of Kelly Lake's aquatic plant community was comprised of just three species in 2016: muskgrasses, stoneworts, and southern naiad. Despite having a higher number of aquatic plant species (species richness), the dominance of the plant community by a few number of species results in lower species diversity. As discussed previously, hardwater lakes rich in calcium like Kelly Lake are often dominated by muskgrasses which are able to outcompete other plants in these conditions. The lower species diversity in Kelly

Lake is not an indication of degraded conditions, but rather the result of calcium-rich conditions and the underlying geology around Kelly Lake.

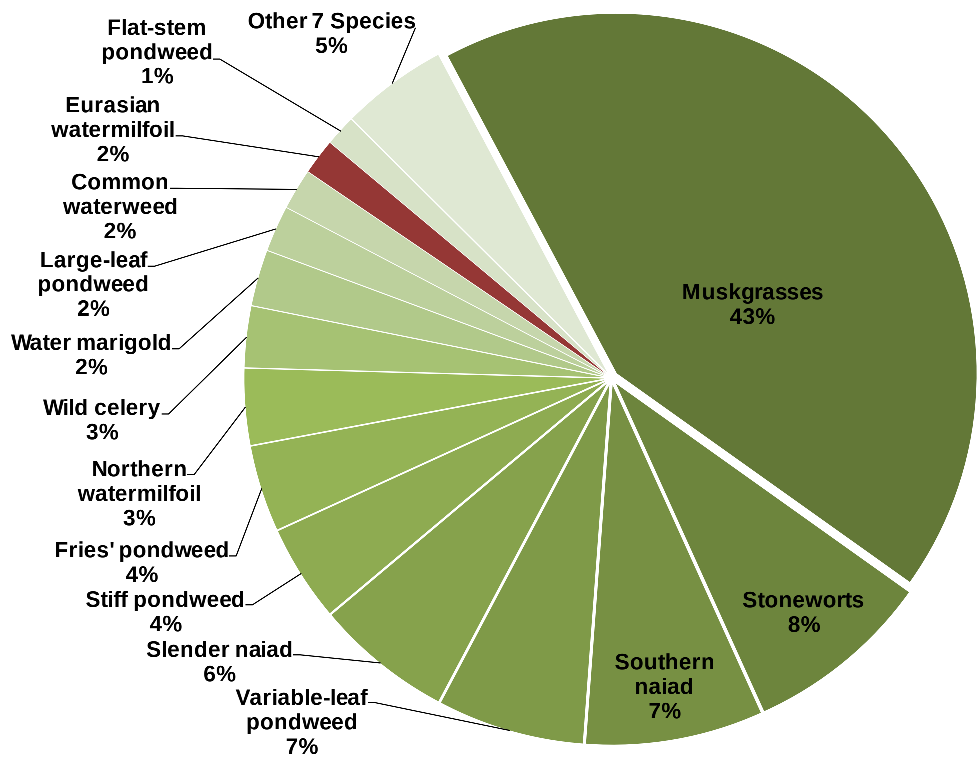


Figure 3.4-9. 2016 relative frequency of occurrence of aquatic plants in Kelly Lake Created using data from 2016 point-intercept survey.

The quality of Kelly Lake's plant community is also indicated by the number of native emergent and floating-leaf aquatic plant species located in 2016 (Table 3.4-1). The 2016 community mapping survey found that approximately 6.5 acres (1.7%) of the 367 acre-lake contain these types of plant communities (Table 3.4-2 and Map 7). Ten floating-leaf and emergent species were located on Kelly Lake, providing valuable structural habitat for invertebrates, fish, and other wildlife. These communities also stabilize lake substrate and shoreland areas by dampening wave action from wind and watercraft.

Table 3.4-2. Kelly Lake acres of plant community types. Created from August 2016 community mapping survey.

Plant Community	Acres
Emergent	0.2
Floating-leaf	2.9
Mixed Emergent & Floating-leaf	3.4
Total	6.5

Because the community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Kelly Lake. This is important because these communities are often negatively affected by recreational use and shoreland development.

Radomski 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 Plants in Kelly Lake

Eurasian watermilfoil & Hybrid watermilfoil

Photograph 3.4-6. Eurasian watermilfoil, a non-native, invasive aquatic plant. Photo credit Onterra.

Eurasian watermilfoil (*Myriophyllum spicatum*; EWM, Photograph 3.4-6) was first discovered in Kelly Lake in 2012 by the Oconto County Aquatic Invasive Species Coordinator. Its presence was also confirmed during a 2012 point-intercept survey conducted by the Wisconsin Department of Natural Resources (WDNR). Onterra, LLC was subsequently contacted in the late summer of 2012 to conduct an EWM peak-biomass survey, which documented much more EWM than was previously thought to exist in Kelly Lake. In 2015, a sample of milfoil was sent in to the Annis Water Resources Institute for genetic analysis to determine which species Kelly Lake contained. This sample tested as hybrid watermilfoil (*Myriophyllum sibiricum* X *spicatum*; HWM), the more aggressive form of EWM. Due to this determination, EWM and HWM can be used interchangeably for Kelly Lake.

In the fall of 2012, the Kelly Lake Advancement Association (KLAA) successfully applied for a WDNR AIS Early Detection and Response Grant to conduct comprehensive studies and create a plan to control the EWM population on Kelly Lake. An herbicide treatment strategy targeting 13.2 acres of EWM was implemented in the spring of 2013. Post treatment surveys conducted in 2013 showed the treatment met success criteria.

Professional and volunteer-based hand harvesting efforts were conducted in 2014 and 2015 in an effort to maintain the lowered EWM population within the lake. These efforts provided some limited control in the targeted areas but did not keep pace with the expanding EWM population in some parts of the lake. The 2016 strategy included a continued hand-harvesting program as well as one area of the lake to be targeted with an herbicide treatment using diquat. The 2016 hand-harvesting program was effective in the targeted areas whereas the herbicide treatment failed to meet control expectations. It is likely that the concentrations and exposure times surrounding the 2016 treatment of Kelly Lake were insufficient to cause EWM mortality. This may be partly due to the increased winds following the treatment causing increased dissipation, but perhaps mainly because of the small size of the treatment site was unable to hold CETs. Diquat also has a high affinity for binding with organic particles. In shallow waters where the application equipment creates disturbance of the lake bottom, the diquat being applied will quickly bind to the suspended particles and be instantly unavailable to cause impacts to the target plants.

The KLAA continued an active management regiment in 2017 including a spot herbicide treatment using liquid 2,4-D as well as professional hand-harvesting. A seven-acre spot treatment conducted in the northwest part of the lake provided effective control during 2017 with minimal EWM present in the site during the late-summer survey. Herbicide concentration monitoring collected in association with the treatment showed 2,4-D remained present in the application area for at least six hours after the treatment was completed and minimal herbicide was detected outside of the application area. Professional hand-harvesting efforts in 2017 totaled 15.4 cubic feet of EWM and provided some level of control in the targeted areas.

Based on the EWM population that was mapped in September 2017, professional hand-harvesting was recommended for 2018 as no areas were deemed appropriate for herbicide control. Monitoring surveys completed in 2018 showed the professional hand-harvesting actions provided a limited level of control in the targeted areas.

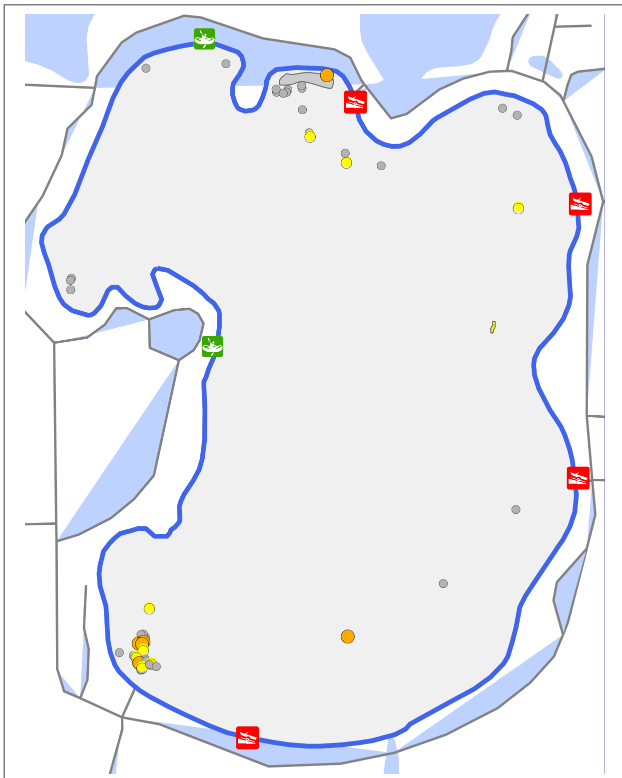


Figure 3.4-10. Kelly Lake 2017 Eurasian watermilfoil locations. Locations mapped during survey completed on September 15, 2017.

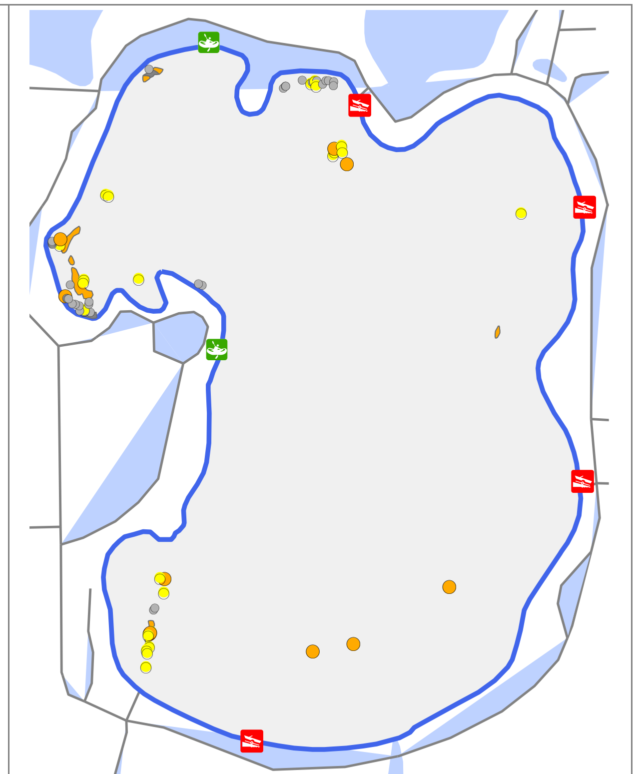


Figure 3.4-11. Kelly Lake 2018 Eurasian watermilfoil locations. Locations mapped during survey completed on August 31, 2018.

Overall, the lake-wide EWM population expanded somewhat between the early and late-summer surveys in 2018, however the overall footprint of the EWM population has remained relatively consistent over the past several years (Figure 3.4-10 & Figure 3.4-11. The proactive EWM management strategy that has occurred in Kelly Lake since its detection has kept the EWM population at relatively low levels. At these low levels, the majority of the EWM population is likely not causing measurable negative ecological impacts to the system nor diminishing the navigability, recreation, or aesthetics for the lake. The KLAA would like to continue a proactive management approach to EWM to keep the population low within the lake, preferably through an integrated pest management (IPM) approach. Within the Implementation Plan section of this management plan are goals and actions for managing the EWM population in Kelly Lake that will guide future management decisions. The 2018 Annual AIS Monitoring Report can be found in Appendix G.

Reed Canary Grass

Reed canary grass (*Phalaris arundinacea*) is a large, coarse perennial grass that can reach six feet in height. 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. Reed canary grass was observed along the western shore of Kelly Lake. Reed canary grass is difficult to eradicate; at the time of this writing there is no commonly accepted control method. This plant is quite resilient to herbicide applications. Small, discrete patches have been covered by black plastic to reduce growth for an entire season. However, the species must be monitored because rhizomes may spread out beyond the plastic.

Photograph 3.4-7. Colony of reed canary grass, a non-native invasive wetland grass. Photo credit Onterra.

Stakeholder Survey Responses to Aquatic Vegetation within Kelly Lake

As discussed in section 2.0, the stakeholder survey asks many questions pertaining to perception of the lake and how it may have changed over the years. Figures 3.4-11 and 3.4-12 display the responses of members of Kelly Lake stakeholders to questions regarding aquatic plants, their impact on enjoyment of the lake and if aquatic plant control is needed. When asked how often aquatic plant growth, during the open water season, negatively impacts the enjoyment of Kelly Lake, the majority of stakeholder survey respondents (45%) indicated *sometimes*, 27% indicated *rarely*, 15% indicated *often*, 8% indicated *never*, and 5% indicated *always* (Figure 3.4-11).

When asked if they believe aquatic plant control is needed on Kelly Lake, 84% of respondents indicated *definitely yes* and *probably yes*, 14% indicated that they were *unsure*, and 2% indicated *probably no* (Figure 3.4-12). The presence of AIS within Kelly Lake is well-known knowledge for the stakeholders so while aquatic plants do not generally impact user's enjoyment of the lake, stakeholders believe that control of AIS is needed. As is discussed in the Aquatic Plant Primer section, a number of management strategies are available for alleviating aquatic invasive species. The management strategy that will be taken to manage AIS in Kelly Lake is discussed within the Implementation Plan Section (Section 5.0).

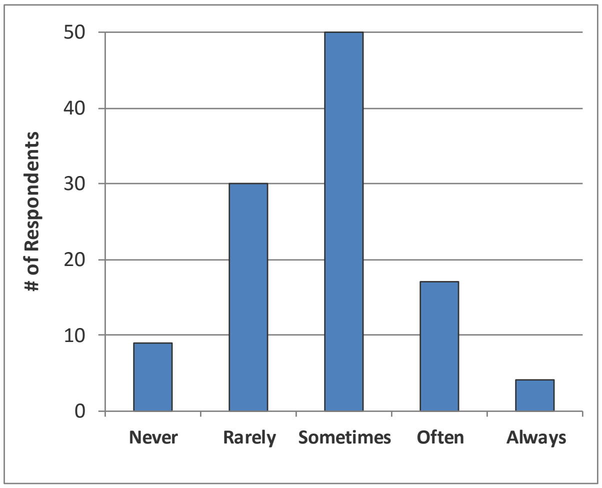


Figure 3.4-11. Stakeholder survey response Question #23. During open water season, how often does aquatic plant growth, including algae, negatively impact your enjoyment of Kelly Lake?

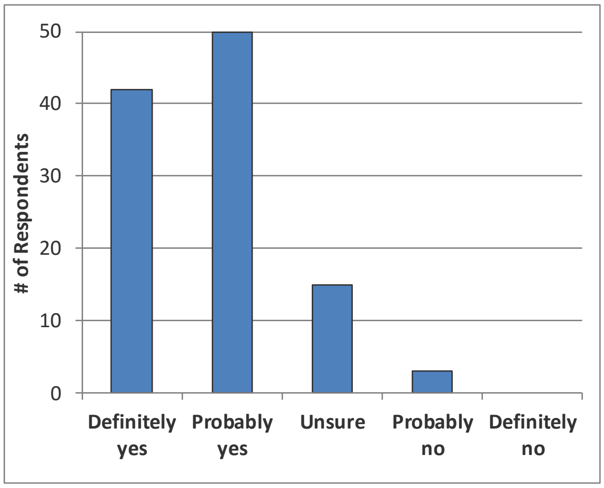


Figure 3.4-12. Stakeholder survey response Question #24. Do you believe aquatic plant control is needed on Kelly Lake?

3.5 Aquatic Invasive Species in Kelly Lake

As is discussed in section 2.0 Stakeholder Participation, the lake stakeholders were asked about aquatic invasive species (AIS) and their presence in Kelly Lake within the anonymous stakeholder survey. Onterra and the WDNR have confirmed that there are six AIS present (Table 3.5-1).

Table 3.5-1. AIS present within Kelly Lake

Type	Common name	Scientific name	Location within the report
Plants	Eurasian watermilfoil	*Myriophyllum spicatum*	Section 3.4 – Aquatic Plants
	Hybrid watermilfoil	*Myriophyllum sibiricum X spicatum*	Section 3.4 – Aquatic Plants
	Reed canary grass	*Phalaris arundinacea*	Section 3.4 – Aquatic Plants
Invertebrates	Zebra mussel	*Dreissena polymorpha*	Section 3.1 – Water Quality
	Banded mystery snail	*Viviparus georgianus*	Section 3.5 Aquatic Invasive Species
	Chinese mystery snail	*Cipangopaludina chinensis*	Section 3.5 Aquatic Invasive Species

Figure 3.5-1 displays the 13 aquatic invasive species that Kelly Lake stakeholders believe are in Kelly Lake. Only the species present in Kelly Lake are discussed below or within their respective locations listed in Table 3.5-1. While it is important to recognize which species stakeholders believe to present within their lake, it is more important to share information on the species present and possible management options. More information on these invasive species or any other AIS can be found at the following links:

- http://dnr.wi.gov/topic/invasives/
- https://nas.er.usgs.gov/default.aspx
- https://www.epa.gov/greatlakes/invasive-species

Aquatic Animals

Mystery snails

There are two types of mystery snails found within Wisconsin waters, the Chinese mystery snail (*Cipangopaludina chinensis*) and the banded mystery snail (*Viviparus georgianus*). Both snails can be identified by their large size, thick hard shell and hard operculum (a trap door that covers the snail's soft body). These traits also make them less edible to native predators. These species thrive in eutrophic waters with very little flow. They are bottom-dwellers eating diatoms, algae and organic and inorganic bottom materials. One study conducted in northern Wisconsin lakes found that the Chinese mystery snail did not have strong negative effects on native snail populations (Solomon et al. 2010). However, researchers did detect negative impacts to native snail communities when both Chinese mystery snails and the rusty crayfish were present (Johnson et al. 2009).

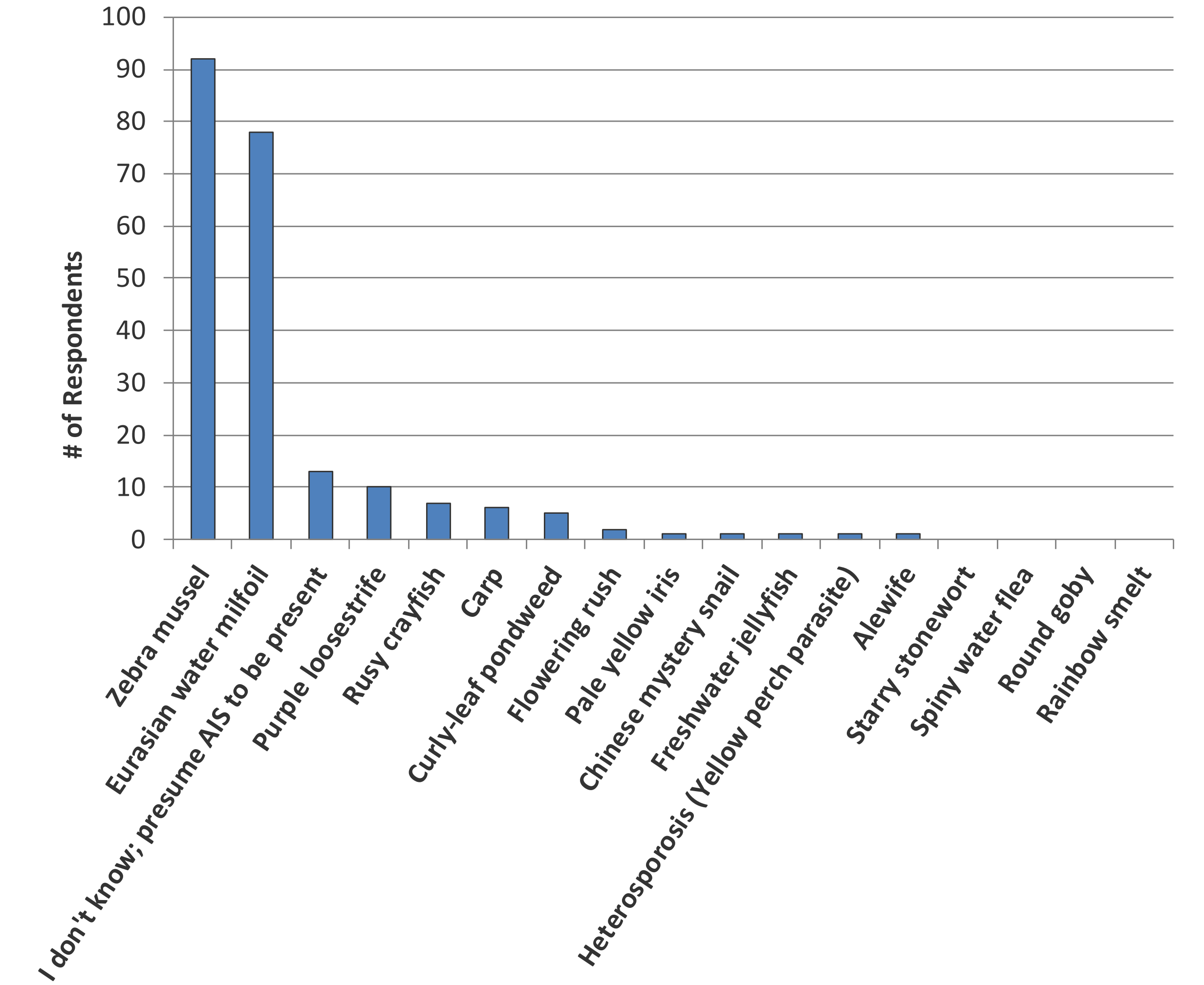


Figure 3.5-1. Stakeholder survey response Question #20. Which aquatic invasive species do you believe are in Kelly Lake?

3.6 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a summary of available data is included here as a reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the fisheries biologists overseeing Kelly Lake. The goal of this section is to provide an overview of the data that exists. Although current fish data were not collected as a part of this project, the following information was compiled based upon data available from the Wisconsin Department of Natural Resources (WDNR) (WDNR 2017) and personal communications with DNR Fisheries Biologist Tammie Paoli.

Kelly Lake Fishery

Energy Flow of a Fishery

When examining the fishery of a lake, it is important to remember what drives that fishery, or what is responsible for determining its mass and composition. The gamefish in Kelly Lake are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon algae and plants, and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscivores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscivorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 3.6-1.

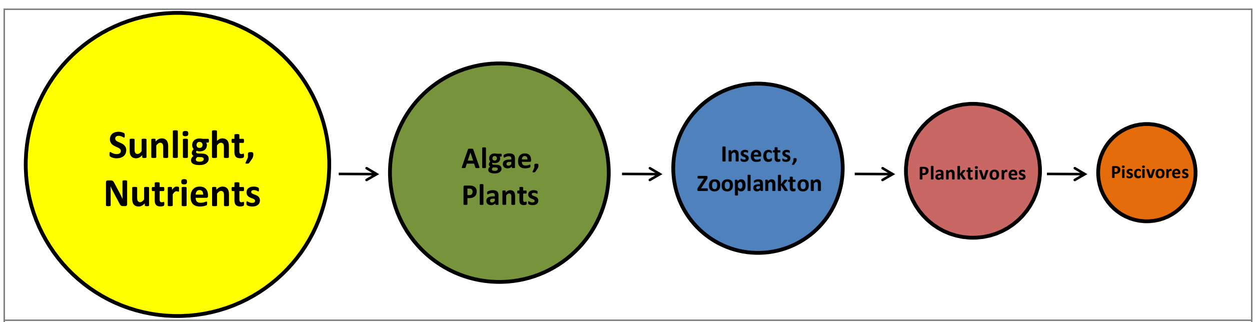


Figure 3.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Kelly Lake is a mesotrophic system, meaning it has moderate nutrient content and thus a moderate amount of primary productivity. This is relative to an oligotrophic system, which contains fewer nutrients (less productive) and a eutrophic system, which contains more nutrients (more productive). Simply put, this means Kelly Lake should be able to support an appropriately sized population of predatory fish (piscivores) when compared to eutrophic or oligotrophic systems. Table 3.6-1 shows the popular game fish present in the system. Additional species found in Kelly Lake include white sucker (*Catostomus commersonii*).

Table 3.6-1. Gamefish present in Kelly Lake with corresponding biological information (Becker, 1983).

Common/Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie (*Pomoxis nigromaculatus*)	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill (*Lepomis macrochirus*)	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Brown Bullhead (*Ameiurus nebulosus*)	5	Late Spring - August	Sand or gravel bottom, with shelter rocks, logs, or vegetation	Insects, fish, fish eggs, mollusks and plants
Green Sunfish (*Lepomis cyanellus*)	7	Late May - Early August	Shelter with rocks, logs, and clumps of vegetation, 4 - 35 cm	Zooplankton, insects, young green sunfish and other small fish
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Northern Pike (*Esox lucius*)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed (*Lepomis gibbosus*)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass (*Ambloplites rupestris*)	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass (*Micropterus dolomieu*)	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Warmouth (*Lepomis gulosus*)	13	Mid May - Early July	Shallow water 0.6 - 0.8 m, with rubble slightly covered with silt	Crayfish, small fish, odonata, and other invertebrates
Yellow Bullhead (*Ameiurus natalis*)	7	May - July	Heavy weeded banks, beneath logs or tree roots	Crustaceans, insect larvae, small fish, some algae
Yellow Perch (*Perca flavescens*)	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Survey Methods

In order to keep the fishery of a lake healthy and stable, fisheries biologists must assess the current fish populations and trends. To begin this process, the correct sampling technique(s) must be selected to efficiently capture the desired fish species. A common passive trap used is a fyke net (Photo 3.6-1). Fish swimming towards this net along the shore or bottom will encounter the lead of the net and be diverted into the trap and through a series of funnels which direct the fish further into the net. Once reaching the end, the fisheries technicians can open the net and sort the fish that were captured. Fyke nets were used on Kelly Lake in 2014 to identify/measure species present, make top caudal fin clips on gamefish species (for mark recapture population estimate) and to collect aging structures (Paoli 2015).

The other commonly used sampling method is electroshocking (Photograph 3.6-1). This is done, often at night, by using a specialized boat fit with a generator and two electrodes installed on the front touching the water. Once a fish comes in contact with the electrical current produced, *galvanotaxis* (stimulation of the nervous system in response to an electric current) transpires and involuntarily causes the fish to swim toward the electrodes. When the fish are in the vicinity of the electrodes, they undergo *narcosis* (stunned), making them easy for fisheries technicians to net and place into a livewell to recover. Contrary to what some may believe, electroshocking does not kill the fish and after being placed in the livewell fish generally recover within minutes. Electroshocking was conducted on Kelly Lake to recapture fish marked during spring fyke netting and depict the game and panfish populations (Paoli 2015).

Once fish are captured using the appropriate method, data such as count, species, length, weight, sex, tag number, and aging structures may be recorded or collected and the fish released. Fisheries biologists use this data to make recommendations and informed decisions on managing the future of the fishery.

Photograph 3.6-1. Fyke net positioned in the littoral zone of a Wisconsin Lake (left) and an electroshocking boat (right).

Fish Stocking

To assist in meeting fisheries management goals, the WDNR may stock fry, fingerling or adult fish in a waterbody that were raised in nearby permitted hatcheries (Photograph 3.6-2). Stocking of a lake may be done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. For Kelly Lake, yellow perch has been stocked by the Kelly Lake Sportsman's Club (KLSC) and walleye has also been regularly stocked by either the WDNR or KLSC (Paoli 2015). Tables 3.6-2 & 3.6-3 displays 1972-2016 stocking efforts of yellow perch and walleye in Kelly Lake.

Photograph 3.6-2. Large fingerling walleye (Photo Credit: WDNR).

Future stocking efforts of walleye will be consistent following Kelly Lakes' inclusion in the Wisconsin Walleye Initiative. The Initiative was made possible by the governor's office, Department of Natural Resources and statewide partners to maintain the walleye population in Wisconsin's lakes and improve walleye fisheries in lakes capable of sustaining the sportfish (WDNR 2014). Lakes chosen to be included were selected based upon anticipated fingerling survival, natural reproduction opportunities, public access, tribal interest (for ceded territory lakes) and potential impacts to tourism (WDNR 2014). Stocking rates are randomly assigned and Kelly Lake was selected to receive the top stocking rate (20 large fingerling walleye/acre) (Paoli 2015). Beginning in 2014 and in even years thereafter, Kelly Lake will receive the assigned stocking rate of walleye as funding allows (Paoli 2015).

Table 3.6-2. Stocking data available of Yellow Perch for Kelly Lake (2003-2018).

Year	Age Class	# Fish Stocked	Avg Fish Length (in)
2003	Adult (Broodstock)	2,745	8
2004	Fingerling	1,458	6
2005	Fingerling	1,069	6
2006	Fingerling	2,137	5
2007	Large Fingerling	3,450	7
2011	Large Fingerling	2,030	7
2012	Large Fingerling	2,742	7
2013	Yearling	3,475	7
2014	Yearling	5,000	7
2015	Yearling	5,000	7
2016	Large Fingerling	5,000	7
2017	Large Fingerling	3,099	7
2017	Adult (Broodstock)	1,894	8
2018	Fingerling	4,998	6

Table 3.6-3. Stocking data available of Walleye for Kelly Lake (1972-2018).

Year	Age Class	# Fish Stocked	Avg Fish Length (in)
1972	Fingerling	6,620	3.0
1974	Fingerling	30,000	3.0
1978	Fingerling	7,000	4.0
1989	Fingerling	1,800	6.0
1991	Fingerling	2,000	7.0
1992	Fingerling	8,323	3.0
1994	Fingerling	16,303	3.6
1995	Yearling	500	10.0
1996	Fingerling	14,954	1.6
1996	Fingerling	515	8.0
1997	Large Fingerling	16,000	2.7
1998	Small Fingerling	13,314	1.2
2000	Small Fingerling	16,000	1.7
2004	Small Fingerling	15,983	1.3
2004	Unknown	1,300	6.0
2005	Large Fingerling	893	
2006	Small Fingerling	12,625	1.4
2006	Large Fingerling	1,786	6.0
2007	Large Fingerling	3,150	8.0
2008	Small Fingerling	11,404	1.4
2008	Large Fingerling	2,300	7.0
2009	Large Fingerling	3,650	7.0
2011	Large Fingerling	1,027	7.0
2012	Large Fingerling	950	8.0
2013	Large Fingerling	1,450	9.0
2014	Large Fingerling	7,334	7.2
2016	Large Fingerling	7,337	7.9
2018	Large Fingerling	7141	7.9

Stocking data available of Black Crappie for Kelly Lake (2017-2018).

Year	# Fish Stocked	Avg Fish Length (in)
2017	1000	6
2018	982	6

Fish Populations and Trends

Utilizing the above-mentioned fish sampling techniques and specialized formulas, WDNR fisheries biologists can estimate populations and determine trends of captured fish species. These numbers provide a standardized way to compare fish caught in different sampling years depending on gear used (fyke net or electrofishing). This is one example of how data is analyzed by fisheries biologists to better understand the fishery and how it should be managed.

Based on data collected from the stakeholder survey (Appendix B), fishing was the fifth most important reason for owning property on or near Kelly Lake (Question #15), relaxing/entertaining was the first most important reason. Figure 3.6-2 displays the fish that Kelly Lake stakeholders enjoy catching the most.

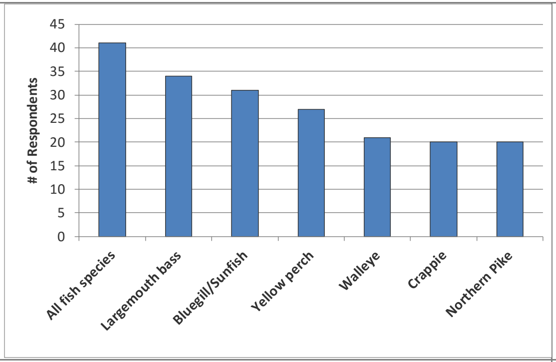


Figure 3.6-2. Stakeholder survey response Question #9. What fish species do you like to catch on Kelly Lake?

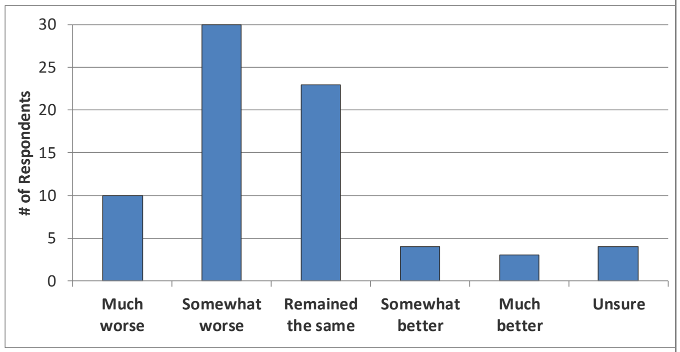


Figure 3.6-3. Stakeholder survey response Question #11. How has the quality of fishing changed on Kelly Lake since you have started fishing the lake?

Gamefish

The gamefish present on Kelly Lake represent different population dynamics depending on the species. The results for the stakeholder survey showed the majority of respondents who fish Kelly Lake, thought the quality of fishing has remained approximately the same or become worse since first starting to fish the lake (Figure 3.6-3). The Kelly Lake sportfish populations and growth rates reported in the WDNR 2014 Fisheries Report are listed below (Paoli 2015). The full 2014 WDNR Fisheries Report is also included with this report as Appendix F.

Walleye had a population estimate of 65 adults (0.2 per acre) in the 2014 survey. This population estimate is considered low and similar to the estimate from the 2001 survey. Growth rates are similar to northeast Wisconsin averages for walleye. No unclipped small walleye were captured, indicating natural reproduction is unlikely to be occurring in Kelly Lake.

Largemouth bass had a population estimate of 1,818 fish (5.0 per acre). Compared to other area lakes this is a very high population density. Growth rates are below the 2001 survey and northeast Wisconsin averages. The high population density, which increases competition for food within the species, may explain the below average growth rates.

Northern Pike had a population estimate of 145 adults (0.4 per acre). Minimal habitat for northern pike may partly explain this low density. Growth rates are slightly below the northeast Wisconsin averages.

Panfish

The panfish present in Kelly Lake exhibit different population dynamics depending on each individual species. Listed below are reported panfish species and the corresponding data conveyed by the WDNR after the 2014 survey.

Yellow perch growth rates, ages 4 – 6, were slightly below northeast Wisconsin averages. A total of 81 yellow perch were sampled in 2014.

Bluegill and black crappie growth rates were above the northeast Wisconsin average. A total of 191 bluegills and 40 black crappies were sampled in 2014.

Kelly Lake Fish Habitat

Substrate Composition

Just as forest wildlife require proper trees and understory growth to flourish, fish require certain substrates and habitat types to nest, spawn, escape predators, and search for prey. Lakes with primarily a silty/soft substrate, many aquatic plants, and coarse woody debris may produce a completely different fishery than lakes that are largely sandy/rocky, and contain few aquatic plant species or coarse woody habitat.

Substrate and habitat are critical to fish species that do not provide parental care to their eggs. Northern pike is one species that does not provide parental care to its eggs (Becker 1983). Northern pike broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Walleye is another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn and care for their eggs in muck as well.

According to the point-intercept survey conducted by Onterra in 2016, 66% of the substrate sampled in the littoral zone of Kelly Lake was soft sediments, 30% was sand with the remaining 4% composed of rock substrate.

Coarse Woody Habitat and Fish Sticks Program

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2006).

The "Fish sticks" program, outlined in the WDNR best practices manual, adds trees to the shoreland zone restoring fish habitat to critical near shore areas (WDNR 2014). Typically, every site has 3 – 5 trees which are partially or fully submerged in the water and anchored to shore (Photograph 3.6-3). The WDNR recommends placement of the fish sticks during the winter on ice when possible to prevent adverse impacts on fish spawning or egg incubation periods. The program requires a WDNR permit and can be funded through many different sources including the WDNR, County Land & Water Conservation Departments or partner contributions.

These projects are typically conducted on lakes lacking significant coarse woody habitat in the shoreland zone. During Onterra's 2016 coarse woody habitat survey, just nine coarse woody pieces per mile of shoreline were documented on the lake. Kelly Lake is an excellent candidate to install coarse woody habitat and the Kelly Lake Sportsman's Club has already taken advantage of the fish sticks program. During 2016, 15 trees were placed along Holt Park on Kelly Lake for the fish sticks project.

Photograph 3.6-3. Fish Stick Example. Photo courtesy of WDNR 2013

For walleye in particular, rock substrate has proved to be excellent spawning habitat. The Sportsman's Club and WDNR installed a rock spawning reef in 1989. However, upon recent observation from the WDNR, the rock reef had silted in leaving highly variable sized rocks, many being too large (>10in) to be used by walleye for spawning (Paoli 2015). To help alleviate this issue, the Kelly Lake Sportsmen's Club funded a project to add smaller sized rock (2 to 4 inches) over the existing reef in February of 2015 (Paoli 2015). In 2019, off of Holt Park, another walleye spawning reef, 100 X 30 foot, was installed.

Regulations and Management

Special fisheries regulations may occur in the future for Kelly Lake, specifically in terms of smallmouth and largemouth bass. The current regulation is a daily bag limit of 5 fish with a 14-inch minimum length limit on largemouth and smallmouth bass. The WDNR has recognized an overabundant population of small (less than 14-inch) largemouth bass which is causing below Wisconsin average growth rates (Paoli 2015). To help control this overabundant population, a rule change was proposed and passed at the Conservation Congress Spring 2017 Hearings. The new regulation changed the minimum length limit for largemouth bass to none and took effect during the 2018 fishing season. The purpose of this regulation is to increase harvest of small sized bass and improve growth rates by reducing competition (Paoli 2015). Table 3.6-4 displays the current (2017-2018) regulations for Kelly Lake gamefish species. For specific fishing regulations on all fish species, anglers should visit the WDNR website (*www. http://dnr.wi.gov/topic/fishing/regulations/hookline.html)* or visit their local bait and tackle shop to receive a free fishing pamphlet that contains this information.

Table 3.6-4. WDNR fishing regulations for Kelly Lake (2017-2018).

Species	Daily bag limit	Length Restrictions	Season
Panfish	25	None	Open All Year
Largemouth bass	5	None	May 6, 2017 to March 4, 2018
Smallmouth bass	5	14"	May 6, 2017 to March 4, 2018
Muskellunge and hybrids	1	40"	May 27, 2017 to November 30, 2017
Northern pike	5	None	May 6, 2017 to March 4, 2018
Walleye, sauger, and hybrids	5	15"	May 6, 2017 to March 4, 2018

Mercury Contamination and Fish Consumption Advisories

Freshwater fish are amongst the healthiest of choices you can make for a home-cooked meal. Unfortunately, fish in some regions of Wisconsin are known to hold levels of contaminants that are harmful to human health when consumed in great abundance. The two most common contaminants are polychlorinated biphenyls (PCBs) and mercury. These contaminants may be found in very small amounts within a single fish, but their concentration may build up in your body over time if you consume many fish. Health concerns linked to these contaminants range from poor balance and problems with memory to more serious conditions such as diabetes or cancer. These contaminants, particularly mercury, may be found naturally to some degree. However, the majority of fish contamination has come from industrial practices such as coal-burning facilities, waste incinerators, paper industry effluent and others. Though environmental regulations have reduced emissions over the past few decades, these contaminants are greatly resistant to breakdown and may persist in the environment for a long time. Fortunately, the human body is able to eliminate contaminants that are consumed however this can take a long time depending upon the type of contaminant, rate of consumption, and overall diet. Therefore, guidelines are set upon the consumption of fish as a means of regulating how much contaminant could be consumed over time.

General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 3.6-4. There is an elevated risk for children as they are in a stage of life where cognitive development is rapidly occurring. As mercury and PCB both locate to and impact the brain, there are greater restrictions on women who may have children or are nursing children, and also for children under 15.

Fish Consumption Guidelines for Most Wisconsin Inland Waterways

	Women of childbearing age, nursing mothers and all children under 15	**Women beyond their childbearing years and men**
Unrestricted*	-	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout
1 meal per week	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout	Walleye, pike, bass, catfish and all other species
1 meal per month	Walleye, pike, bass, catfish and all other species	Muskellunge
Do not eat	Muskellunge	-

**Doctors suggest that eating 1-2 servings per week of low-contaminant fish or shellfish can benefit your health. Little additional benefit is obtained by consuming more than that amount, and you should rarely eat more than 4 servings of fish within a week.*

Figure 3.6-4. Wisconsin statewide safe fish consumption guidelines. Graphic displays consumption guidance for most Wisconsin waterways. Figure adapted from WDNR website graphic (http://dnr.wi.gov/topic/fishing/consumption/)

Fishery Management & Conclusions

The WDNR’s recommendations for Kelly Lake are to encourage placement of fish sticks where possible to help alleviate from the highly-developed shoreline (Paoli 2015). Management should focus on reducing the population and improve growth structure of largemouth bass, which the future regulation of no minimum size limit should support (Paoli 2015). The next comprehensive survey by the WDNR for Kelly Lake is planned for 2024.

4.0 SUMMARY AND CONCLUSIONS

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

1) Collect baseline data to increase the general understanding of the Kelly Lake ecosystem.
2) Collect detailed information regarding invasive plant species within the lake, with the primary emphasis being on Eurasian watermilfoil.
3) Collect sociological information from Kelly Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

The three objectives were fulfilled during the project and have led to a good understanding of the Kelly Lake ecosystem, the folks that care about the lakes, and what needs to be completed to protect and enhance them.

Kelly Lake, like all lakes, is part of the larger landscape, which is made up of multiple ecosystems, like forests, wetlands, and of course the lake itself. Human activities in and around Kelly Lake impact the lake and disturb the natural function of the ecosystems. Deforestation, agriculture, wetland filling, shoreland development, road construction, and recreation on the lake all impact Kelly Lake negatively and can bring about habitat loss that directly impacts fish and wildlife, nutrification that increases plant growth, as well as the introduction of non-native species that can often act invasively. The primary function of a lake management plan is to minimize further impacts and correct past impacts as much as realistically possible with the intent of improving and protecting the lake. The first step in creating a lake management plan is gathering information about the lake, its watershed, and the people that enjoy and care for it. The second step is to use that information to create a realistic management plan that can be implemented by the group creating the plan, in this case, the Kelly Lake Advancement Association. Commonly, the management plan includes actions aimed at increasing the lake group's capacity to implement the plan they have devised. While there are common threads that run through most lake management plans, each plan is unique because each lake group is unique and each lake is as well.

The water of Kelly Lake enters the lake through groundwater, direct precipitation, and surface runoff. Measuring groundwater entering and leaving a lake is well beyond the need and scope of a management planning project such as this, but having a solid understanding of the quality of the water entering the lake from its watershed is needed to produce an effective plan. The watershed, also known as a drainage basin, is often the source of polluted water that impacts the lake by adding excessive amounts of plant nutrients and in some areas of the state, sediment. In the case of Kelly Lake phosphorus is of the main concern because it is the nutrient that ultimately controls plant growth in the lake. Kelly Lake's watershed is approximately the size of the lake itself so it is not receiving vast amounts of overland flow. Further, much of the water that drains off of the surrounding landscape flows through Long and/or Round Lake, settling out pollutants, before the water enters Kelly Lake. Some of the remaining areas of the watershed that drain directly to the lake, are currently in land cover types that do not typically add much phosphorus. Unfortunately, as discussed below, some of the land that is likely adding the most phosphorus to the lake is on its immediate shoreline.

Overall, Kelly Lake has excellent water quality. Based upon data collected over the past decade, the lake has very low phosphorus concentrations, which lead to typically low algal growth and excellent water clarity. Zebra mussels may be having an impact by filtering out algae and increasing water clarity, but sufficient data is not available to make that a solid conclusion. While at the surface, clearer water from less algae brought on by zebra mussels might seem a positive for the lake, in reality it is not. Zebra mussels impact a lake in many ways. One impact is by removing algae from the water column, but because zebra mussels are gluttonous feeders, meaning they continuously feed even when the nutrients are not needed, they tend to move energy and nutrients from the water column to the bottom sediments in the form of pseudofeces. That shift to the bottom sediments robs the nutrients and food energy from other organisms, like zooplankton, which are heavily consumed by young gamefish and feeder fish for full grown game fish. This can severely alter the food dynamics in the lake, which can in turn alter the fisheries. A more direct impact zebra mussels may have on the fishery is WNDR have observed zebra mussels utilizing the 2015 walleye spawning reef. Future surveys may determine if this is impacting the effectiveness of the reef for walleye.

As mentioned above, phosphorus is the primary nutrient of concern in Kelly Lake. While some phosphorus is needed so the lake plants, both vascular and algal, can grow and supply energy to the food chain, too much phosphorus can bring about over abundant plant growth. In some lakes, the excessive addition of phosphorus causes vascular plants to expand and become a nuisance to recreation. While in other lakes, the excessive phosphorus leads to algae blooms that reduce water clarity. While Kelly Lake's water quality is good currently, the biggest threat to it is the intense level of development around the lake. In 2016, a shoreland assessment was completed for Kelly Lake categorizing the shoreline from the water's edge to about 35 feet landward. Five categories were used from completely natural to completely urbanized. Approximately 63% of Kelly Lake's shoreline is classified as completely urbanized. Basically, those shoreline areas provide no filtering of the water as it runs off those shoreland properties. Further, those areas provide basically no fish or wildlife habitat in the most important area of a lake ecosystem. The buffering capacity and habitat value of those areas can be partially recovered through shoreland restorations utilizing the appropriate native vegetation for Kelly Lake's region of the state. While it is often difficult for shoreland property owners to accept the fact that their nicely kept lawn truly impacts the lake in a very negative way, it is often even more difficult to convince them that the property should be restored for the good of the lake. Restoring the shoreline of Kelly Lake to the greatest extent possible should be the primary objective of every property owner on Kelly Lake. The good news is that both the State of Wisconsin and Oconto County have programs in place to help design and pay for the proper restorations.

Multiple plant surveys have been completed on Kelly Lake over the past several years to not only monitor invasive species, but also create a better understanding of the native aquatic plants in the lake. The native plant community is very important in a lake ecosystem because they are not only the base of the food chain, but they also supply critical habitat to fish, wildlife, macroinvertebrates, and microinvertebrates. Further, the plants reduce shoreland erosion, minimize bottom sediment resuspension, and provide substrate for an important algal group called periphyton that are fed upon by countless aquatic organisms. Those organisms are then fed on by larger animals that feed the gamefish anglers aim to catch.

Kelly Lake's aquatic plant community is basically of good quality. The community has moderate species diversity and a few sensitive species exist in the lake. One area of concern is the low occurrence of floating-leaf and emergent vegetation within the lake. These types of aquatic plants provide specific habitat to some wildlife and fish species. Specifically, emergent vegetation is the preferred spawning habitat of perch and northern pike. Shoreland development and recreation boating have likely disturbed these communities throughout the decades and reduced their occurrence.

In 2012, the exotic submergent plant, Eurasian watermilfoil (EWM) found to exist in Kelly Lake. In 2015, a portion of that exotic population was verified through DNA analysis to be hybrid watermilfoil (HWM), which is a cross between Eurasian watermilfoil and the native northern watermilfoil. Since its discovery, the population has been monitored and an integrated control strategy, including hand-harvesting with snorkelers, hand-harvesting with a diver assisted suction harvester (DASH), and herbicide treatments, has kept the population in check. As with all aquatic plants, EWM/HWM populations increase and decrease naturally, so continued monitoring and flexible control strategies are important in keeping the exotic from causing ecological harm to the lake and/or negatively impacting recreation.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the KLAA Planning Committee and ecologist/planners from Onterra. It represents the path the KLAA will follow in order to meet their lake management goals. 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 Kelly Lake stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous 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.

Management Goal 1: Control Existing and Prevent Further Aquatic Invasive Species Infestations within Kelly Lake

Management Action:	Continue Clean Boats Clean Waters watercraft inspections at public access locations
Timeframe:	Continuation of current effort
Facilitator:	KLAA Planning Committee
Description:	Currently the KLAA monitors the five public boat landings using training provided by the Clean Boats Clean Waters program. Kelly Lake is a popular destination by recreationists and anglers, making the lake vulnerable to new infestations of exotic species. The intent of the boat inspections would not only be to prevent additional invasive species from entering the lake through its public access point, but also to prevent the infestation of other waterways with invasive species that originated in Kelly Lake. The goal is to cover the landings during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on lakes and educating people about how they are the primary vector of its spread. The KLAA has set a goal of 200 hours of annual volunteer-based watercraft inspections with focus on high-use periods such as weekends and holidays. In 2017, the KLAA conducted 209 hours of volunteer hours at the landings. To achieve maximum efficiency in educating boaters and for the convenience of those boaters, KLAA volunteers, with permission, will place CBCW stickers on the boat trailers of frequently inspected lake users.
Action Steps:	
	See description above as this is an established program.

Management Action:	Coordinate annual professional monitoring of EWM/HWM
Timeframe:	Continuation of current effort
Facilitator:	KLAA Planning Committee
Description:	An Early Season AIS (ESAIS) Survey would be conducted annually during June to setup that years' program. This survey would include a complete meander survey of the lake's littoral zone by professional ecologists and mapping using GPS technology. This survey would serve three main roles: 1) document the EWM population at the beginning of each growing season, 2) be used to propose hand-harvesting management for that summer, and 3) serve as a comparable dataset to compare to future surveys to understand EWM population changes over time. If the management strategy for a given year contains a professional hand-harvesting component and is paid for with WDNR grant funds, a late-season EWM mapping survey would be conducted to access the control strategy that took place.
Action Steps:	
	See description above as.

Management Action:	Conduct EWM/HWM population control using hand-harvesting (including DASH) and/or herbicide spot treatments.
Timeframe:	Continuation of current effort
Facilitator:	KLAA Planning Committee
Description:	The proactive EWM management strategy that has occurred in Kelly Lake since its detection has kept the EWM population at low levels. At these low levels, the EWM population is likely not causing measurable negative ecological impacts to the system nor diminishing the navigability, recreation, or aesthetics of the lake. The KLAA would like to continue on a proactive management approach to EWM to keep the population low within the lake, preferably with non-herbicide control options. *Hand-Harvesting* If the ESAIS Survey reveals areas of EWM that are comprised of *single plants* or *clumps of plants* and are not 'colonized', the KLAA will organize efforts to hand-remove the plants. Depending on the level of volunteerism and size of the EWM occurrences, the KLAA will determine if volunteer- or professional-based methods would be solicited. As discussed above, the hand-harvesting would occur following the June ESAIS Survey in roughly mid-June to mid-September. Conducting hand-harvesting earlier or later in the year can reduce the effectiveness

	of the strategy, as plants are more brittle and extraction of the roots more difficult. If a professional-based hand-harvesting method is chosen and WDNR funds are being used to offset the costs, a Late-Summer EWM Peak-Biomass Mapping Survey would take place following the hand-harvesting. If a Diver Assisted Suction Harvest (DASH) component is utilized, the KLAA and contracted firm would be responsible for the WDNR permit procedures. The contracted firm would be guided with GPS data from the consultant following the ESAIS Survey and would track their efforts (when, where, time spent, quantity removed) for post assessments. *Please see following management actions for more information regarding DASH use on Kelly Lake.* *Herbicide Spot Treatment* If the following trigger is met, the KLAA would consider conducting herbicide spot treatments: “colonized (polygons) areas where a sufficiently large treatment area can be constructed to hold concentration and exposure times.” It is believed that these areas are too large to be controlled using hand-harvesting techniques. It is likely that these areas may be small (3-5 acres) and would need to be conducted with herbicides that require short exposure times, such as diquat or herbicide combinations (diquat/endothall, 2,4-D/endothall, etc.). If large areas (>5 acres) or sites in protected parts of the lake are to be targeted with an herbicide spot treatment, more traditional systemic herbicides like 2,4-D may be appropriate. In late-winter, an herbicide applicator firm would be selected and a conditional permit application would be applied for from the WDNR. The herbicide treatment would occur when surface water temperatures are roughly below 60°F and active growth tissue is confirmed on the target plants. A pretreatment survey, a week or so prior to treatment, would be used to finalize the permit, potentially with adjustments, and dictate approximate ideal treatment timing Overall, the KLAA will evaluate the effectiveness of the management option, financial costs, and other factors to determine the control effort chosen.
Action Steps:	
	See description above

Management Action:	Investigate feasibility of constructing KLAA-owned and -operated Diver Assisted Suction Harvester (DASH).
Timeframe:	2019-2020
Possible Grant:	AIS-Established Population Control Grant
Facilitator:	KLAA Planning Committee

Description:	Contracted DASH harvesting services currently averages about $2,000/day and as a result, many lake groups are considering constructing or are already utilizing their own DASH units. AIS-Established Population Control Grant funds can be used to purchase a portion of the equipment needed to construct a DASH unit; however, the grant funds cannot be used to purchase a boat, motor, or trailer. Grant funds can be used to purchase pumps, miscellaneous supplies, and scuba gear. If any piece of equipment costs $5,000 or more, that equipment's cost must be depreciated over the extent of the grant period. While grant funds are available to aid in the building of the DASH unit, there are still large-ticket items that need to be obtained and specific training is required to operate the unit on the surface and especially below the surface. Further, a substantial and dedicated volunteer force must be assembled. Considering the current level of infestation and the areas and densities of those occurrences, the use of DASH harvesting would be the most effective method of controlling EWM in Kelly Lake; therefore, the KLAA will investigate the feasibility of constructing and utilizing their own DASH unit on Kelly Lake. This investigation will include the following elements: • Estimating construction costs including grant-funded and out-of-pocket expenses. • Determining if the KLAA membership has the expertise and skills to construct the DASH unit. • Investigating the skillsets and certifications required to operate the DASH unit (surface and sub-surface personnel). • Investigating liability and insurance needs. • Determining if the KLAA can supply sufficient volunteer time to operate the unit throughout the growing season. If the KLAA discovers that it is feasible to construct and operate an association-owned DASH unit, the association will apply for AIS-EPC funds to aid in the unit's construction costs and conduct a 3-year operation and monitoring program on Kelly Lake. The project would include professional monitoring and reporting in an effort to assist the KLAA in operating the unit effectively and efficiently.
Action Steps:	
	See description above

Management Action:	Conduct periodic quantitative vegetation monitoring on Kelly Lake.
Timeframe:	Point-Intercept Survey every 3-4 years, Community Mapping every 7-8 years
Possible Grant:	Small-Scale Lake Planning Grant or AIS-Education, Prevention, and Planning in <$10,000 category.
Facilitator:	KLAA Planning Committee
Description:	As part of the ongoing AIS management program, a whole-lake point-intercept survey will be conducted at a minimum once every 3-4 years. This will allow a continued understanding of the submergent aquatic plant community dynamics within Kelly Lake. Point-intercept surveys have been conducted on Kelly Lake in 2012 and 2016; therefore, the next point-intercept survey will be completed in 2019 or 2020, depending on the level of AIS management being completed. In order to understand the dynamics of the emergent and floating-leaf aquatic plant community in Kelly Lake, a community mapping survey would be conducted every 7-8 years. A community mapping survey was conducted on Kelly Lake in 2016 as a part of this management planning effort. The next community mapping survey will be completed between 2022 and 2024.
Action Steps:	
	See description above.

Management Goal 2: Maintain Current Water Quality Conditions

Management Action:	Monitor water quality through WDNR Citizens Lake Monitoring Network.
Timeframe:	Continuation of current effort.
Facilitator:	KLAA Planning Committee
Description:	Monitoring water quality is an important 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. Early discovery of negative trends may lead to the reason of why the trend is occurring. Volunteer water quality monitoring is currently being completed annually by Kelly Lake riparians through the Citizen Lake Monitoring Network (CLMN). The CLMN is a WDNR program in which volunteers are trained to collect water quality information on their lake. The KLAA currently monitors the deep hole site under the advanced CLMN program. This includes collecting Secchi disk transparency and dissolved oxygen readings, as well as sending in water chemistry samples (chlorophyll-a, and total phosphorus) to the Wisconsin State Laboratory of Hygiene for analysis. The samples are collected three

		times during the summer and once during the spring. It is 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). It will be the Board of Directors responsibility to ensure that a volunteer is prepared to communicate with WDNR representatives and collect water quality samples each year.
Action Steps:		
1.	Trained CLMN volunteer(s) collects data and report results to WDNR and to KLAA members during the annual meeting.	
2.	CLMN volunteer and/or the KLAA Planning Committee would facilitate new volunteer(s) as needed	
3.	Coordinator contacts Sandra Wickman (715.365.8951) to acquire necessary materials and training for new volunteer(s)	

Management Goal 3: Improve Lake and Fishery Resource by Protection and Restoring Shoreland Condition

Management Action:	Educate stakeholders on the importance of shoreland condition and shoreland restoration on Kelly Lake.
Timeframe:	Initiate 2019
Facilitator:	KLAA Planning Committee
Possible Grant	Descriptions can be found below.
Description:	As discussed in the Shoreland Condition Section (3.3), the shoreland zone of a lake is highly important to the ecology of a lake. When shorelands are developed, the resulting impacts on a lake range from a loss of biological diversity to impaired water quality. Because of its proximity to the waters of the lake, even small disturbances to a natural shoreland area can produce ill effects. Over 60% of Kelly Lake's shoreline is considered completely urbanized. This severely limits shoreland habitat, but it also reduces natural buffering of shoreland runoff and allows nutrients to enter the lake. Because property owners may have little experience with or be uncertain about restoring a shoreland to its natural state, the KLAA will provide information to shoreland property owners about how they can ease their property's impacts on the lake by implementing several types of restoration project on their property, such as restoring a native buffer area on a portion or all of their shoreline, creating a rain garden, installing a French drain, and/or diverting water from entering the lake in the first place. To foster a better understanding among Kelly Lake riparians, the KLAA has decided to take the following steps to increase shoreland restoration and related projects on Kelly Lake:

1. Educate riparians about the importance of healthy and natural shorelands.
2. Solicit 1-3 riparians to allow shoreland restoration, storm water runoff designs, or related projects on their property. This would include the possible restoration of the town-owned parklands.
3. The KLAA will work with Oconto County (Ken Dolata) or private entity to create design work. Small-scale WDNR grants and Oconto County funds may be sought to offset design costs.
4. Designs can be shared with KLAA members to provide further education of shoreland restoration projects.
5. Move forward with implementing shoreland restoration per the designs that were developed for those riparians that wish to have their shoreland restored. Project funding would be available through the WDNR's Healthy Lakes Initiative Grants and the Oconto County Cost Share Program (see below).
6. The KLAA's goal would be to have at least 2 shoreland restoration sites to serve as demonstration sites to encourage other riparians to follow same path of shoreland restoration.

The WDNR's Healthy Lakes Initiative Grant program allows 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 Oconto County.

- 75% state share grant with maximum award of $25,000; up to 10% state share for technical assistance
- Maximum of $1,000 per 350 ft^2 of native plantings (best practice cap)
- Implemented according to approved technical requirements (WDNR, County, Municipal, etc.) and complies with local shoreland zoning ordinances
- Must be at least 350 ft^2 of contiguous lakeshore; 10 feet wide
- Landowner must sign Conservation Commitment pledge to leave project in place and provide continued maintenance for 10 years
- Additional funding opportunities for water diversion projects and rain gardens (maximum of $1,000 per practice) also available

Oconto County's Cost Share Program distributes up to $20,000 each year in the form of a 70% match up to $2,500/project for shoreline

		restorations, diversions, rain gardens, and buffers. More information can be found at: https://www.co.oconto.wi.us/departments/?department=ee8e01dd251f&subdepartment=acd2c6db4768
Action Steps:		
	1.	Recruit facilitator from KLAA Planning Committee
	2.	Facilitator contacts the Oconto County Land Conservation department to gather information on initiating and conducting shoreland restoration projects. If able, the County Conservationist would be asked to speak to KLAA members about shoreland restoration at their annual meeting.
	3.	The KLAA would encourage property owners that have completed projects as a part of this initiative to allow their shorelines to serve as demonstration sites.

<u>Management Action:</u>	Coordinate with WDNR and private landowners to expand coarse woody habitat in Kelly Lake
Timeframe:	Initiate 2019
Possible Grant	Descriptions can be found below.
Facilitator:	KLAA Planning Committee
Description:	KLAA stakeholders must realize the complexities and capabilities of Kelly Lake ecosystem with respect to the fishery it can produce. With this, an opportunity for education and habitat enhancement is present in order to help the ecosystem reach its maximum fishery potential. Often, property owners will remove downed trees, stumps, etc. from a shoreland area because these items may impede watercraft navigation shore-fishing or swimming. However, these naturally occurring woody pieces serve as crucial habitat for a variety of aquatic organisms, particularly fish. The Shoreland Condition Section (3.3) and Fisheries Data Integration Section (3.6) discuss the benefits of coarse woody habitat in detail. In 2016, a coarse woody habitat enhancement project at the Town of Spruce park was completed by Oconto County, the Kelly Lake Sportsman's Club, and the local WDNR fisheries biologist, Tammie Paoli. Unfortunately, high water levels during spring 2017 dislodged the downed trees and they drifted away from shore and sank to the bottom. While the unusual outcome occurred, the overall project intent was sound. The KLAA will promote the The WDNR's Healthy Lakes Initiative Grant allows partial cost coverage for coarse woody habitat improvements (referred to as "fish sticks"). 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.
	• 75% state share grant with maximum award of $25,000; up to 10% state share for technical assistance
	• Maximum of $1,000 per cluster of 3-5 trees (best practice cap)
	• Implemented according to approved technical requirements (WDNR Fisheries Biologist) and complies with local shoreland zoning ordinances
	• Buffer area (350 ft^2) at base of coarse woody habitat cluster must comply with local shoreland zoning or:
	  ○ The landowner would need to commit to leaving the area un-mowed
	  ○ The landowner would need to implement a native planting (also cost share thought this grant program available)
	• Coarse woody habitat improvement projects require a general permit from the WDNR
	• Landowner must sign Conservation Commitment pledge to leave project in place and provide continued maintenance for 10 years

Action Steps:	
1.	Recruit facilitator from the KLAA Planning Committee (potentially same facilitator as previous management actions).
2.	Facilitator contacts Brenda Nordin (WDNR Lakes Coordinator) and Tammie Paoli (WDNR Fisheries Biologist) to gather information on initiating and conducting coarse woody habitat projects.
3.	The KLAA will encourage property owners that have enhanced coarse woody habitat to serve as demonstration sites.

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

Management Action:	Use education to promote lake protection and enjoyment through stakeholder education
Timeframe:	Continuation of current efforts
Facilitator:	KLAA Planning Committee
Description:	Education represents an effective tool to address many lake issues. The KLAA annually distributes a newsletter to the Kelly Lake Sanitary District membership and has developed a website (www.kellylake.org). These mediums allow for communication with association members, but increasing the level of communication is important within a management group because it facilitates the spread of important association news, educational topics, and even social happenings. The KLAA will continue to make the education of lake-related issues a priority. These may include educational materials, awareness events, and demonstrations for lake users as well as activities which solicit local and state government support. *Example Educational Topics* • Specific topics brought forth in other management actions • Aquatic invasive species identification • Basic lake ecology • Impacts of drought and low water levels • Sedimentation • Boating safety (promote existing guidelines, Use Information handout) • Swimmers itch • Shoreline habitat restoration and protection • Fireworks use and impacts to the lake • Noise and light pollution • Fishing regulations and overfishing • Minimizing disturbance to spawning fish • Recreational use of the lakes
Action Steps:	
	See description above as this is an established program.

Management Action:	Continue KLAA's involvement with other entities that have responsibilities in managing (management units) Kelly Lake
Timeframe:	Continuation of current efforts
Facilitator:	KLAA Planning Committee
Description:	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 governmental while others organizations rely on voluntary participation. It is important that the KLAA actively engage with all management entities to enhance the association'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 page:
Action Steps:	
	See table guidelines on the next pages.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Town of Spruce	Lisa Peitersen, Clerk (sprucetownclerk@gmail.com)	Kelly Lake falls within the Town of Spruce.	Once a year, or more as needed. May check website (https://www.co.oconto.wi.us/ municipalities/) for updates.	Town staff may be contacted regarding ordinance reviews or questions, and for information on community events.
Town of Brazeau	Jean Grosse, Clerk (920.897.3855)	The northernmost portion of Kelly Lake falls within the Town of Brazeau	As needed	Town staff may be contacted regarding ordinance reviews or questions, and for information on community events.
Kelly Lake Sportsman's Club	Cindy Brokiewicz (sampson.1@tds.net)	Supports the conservation of wildlife and its habitat in the Kelly Lake area	As needed	Can provide assistance in funding for projects around the lake.
Oconto County Lakes & Waterways Association	Mike Winius, President (mhwinius@gmail.com)	Protects Oconto Co. waters through facilitating discussion and education.	As needed. May check website (www.oclawa.org) for updates	Become aware of training or education opportunities, partnering in special projects, or networking on other topics pertaining to Oconto Co. waterways.
Timberland Invasives Partnership	Mitch Ives (715.799.5710 x3)	Oversees AIS monitoring and prevention activities locally.	Twice a year or more as issues arise.	Spring: AIS training and ID, AIS monitoring techniques Summer: Report activities
Oconto County Land and Water Conservation Dept.	Ken Dolata, Dept. Head (920.834.7152)	Oversees conservation efforts for land and water projects.	As needed	Can provide assistance with shoreland restorations and habitat improvements.
Wisconsin Department of Natural Resources	Tammie Paoli, Fisheries Biologist (715.582.5052)	Manages the fishery of Kelly Lake.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Brenda Nordin - 920.662.5141)	Oversees management plans, grants, and all lake activities.	Once a year, or more as issues arise.	Keep updated on lake management activities.
	Citizens Lake Monitoring Network contact (Brenda Nordin– 920.662.5141)	Provides training and assistance on CLMN monitoring, methods, and data entry.	Twice a year or more as needed.	Late winter: arrange for training as needed, in addition to planning out monitoring for the open water season. Late fall: report monitoring activities.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Kelly 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 which occurred twice during the summer. In addition to the samples collected by KLAA members, professional water quality samples were collected at subsurface (S) and near bottom (B) depths once in spring, summer, fall, and winter. Winter dissolved oxygen was determined with a calibrated probe and all samples were collected with a 3-liter Van Dorn bottle. Secchi disk transparency was also included during each visit.

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.

	Spring		**June**	**July**		**August**	**Fall**		**Winter**	
Parameter	**S**	**B**	**S**	**S**	**B**	**S**	**S**	**B**	**S**	**B**
Total Phosphorus	■	■	♦	■	■	♦	■	■	■	■
Dissolved Phosphorus	■	■							■	■
Chlorophyll-*a*	■		♦	■		♦	■			
Total Kjeldahl Nitrogen	■	■	●	■		●	■		■	■
Nitrate-Nitrite Nitrogen	■	■	●	■		●	■		■	■
Ammonia Nitrogen	■	■	●	■		●	■		■	■
Laboratory Conductivity	■	■		■	■					
Laboratory pH	■	■		■	■					
Total Alkalinity	■	■		■	■					
Total Suspended Solids	■	■					■	■	■	■
Calcium	■									

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

Watershed Analysis

The watershed analysis began with an accurate delineation of Kelly Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the National Land Cover Database (NLCD – Fry et. al 2011) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Kelly Lake during a June 10, 2016 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 Kelly 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 July 25, 2016. A point spacing of 62 meters was used resulting in approximately 389 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Kelly Lake (emergent and floating-leaved vegetation) were mapped using a Trimble GeoXT 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 and vouchered by the University of Wisconsin – Steven's Point Herbarium.

7.0 LITERATURE CITED

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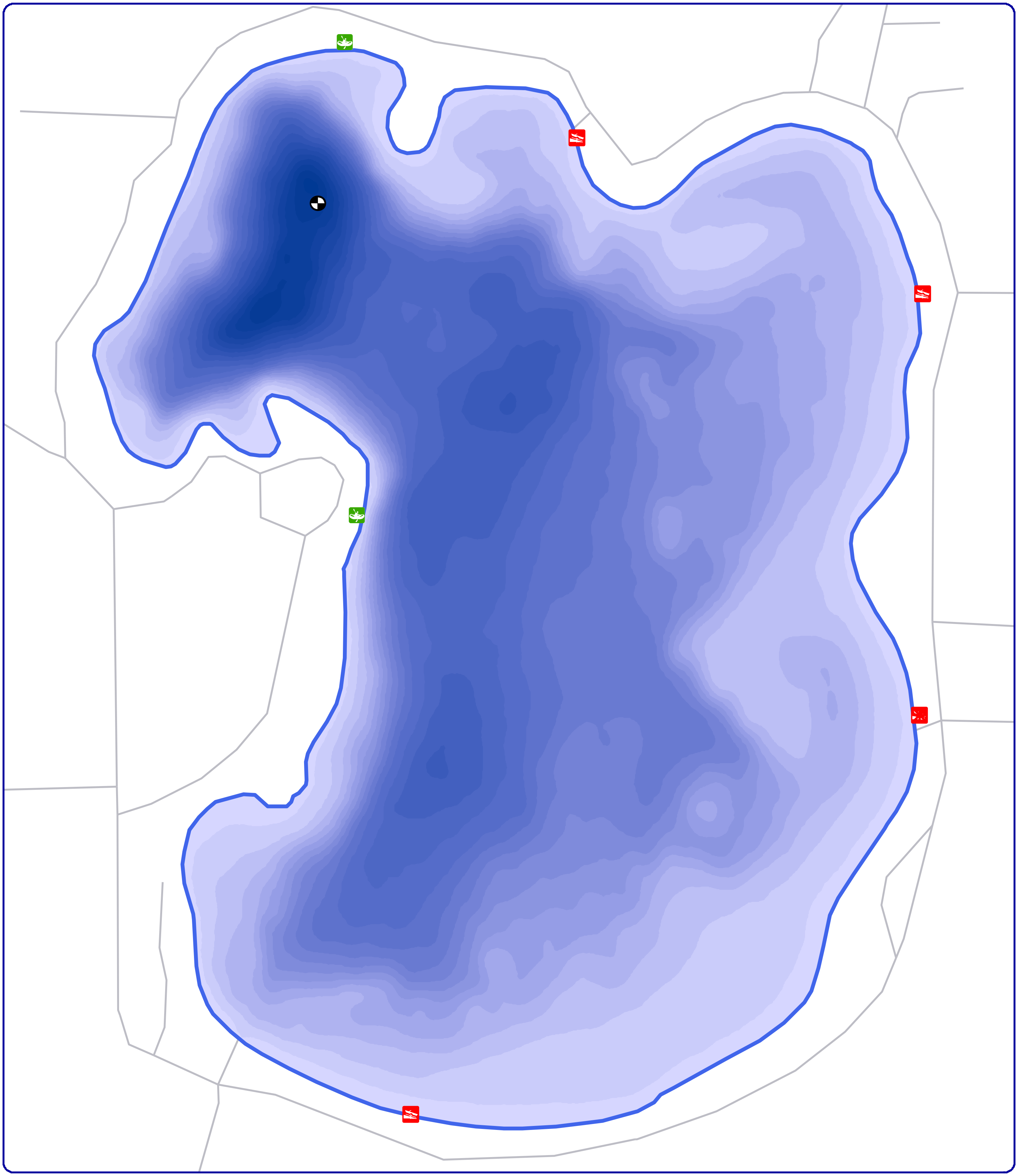


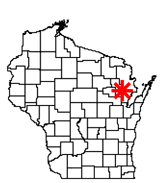
Map 1
Kelly Lake
Oconto County, Wisconsin

Project Location & Lake Boundary

650 Feet

Legend

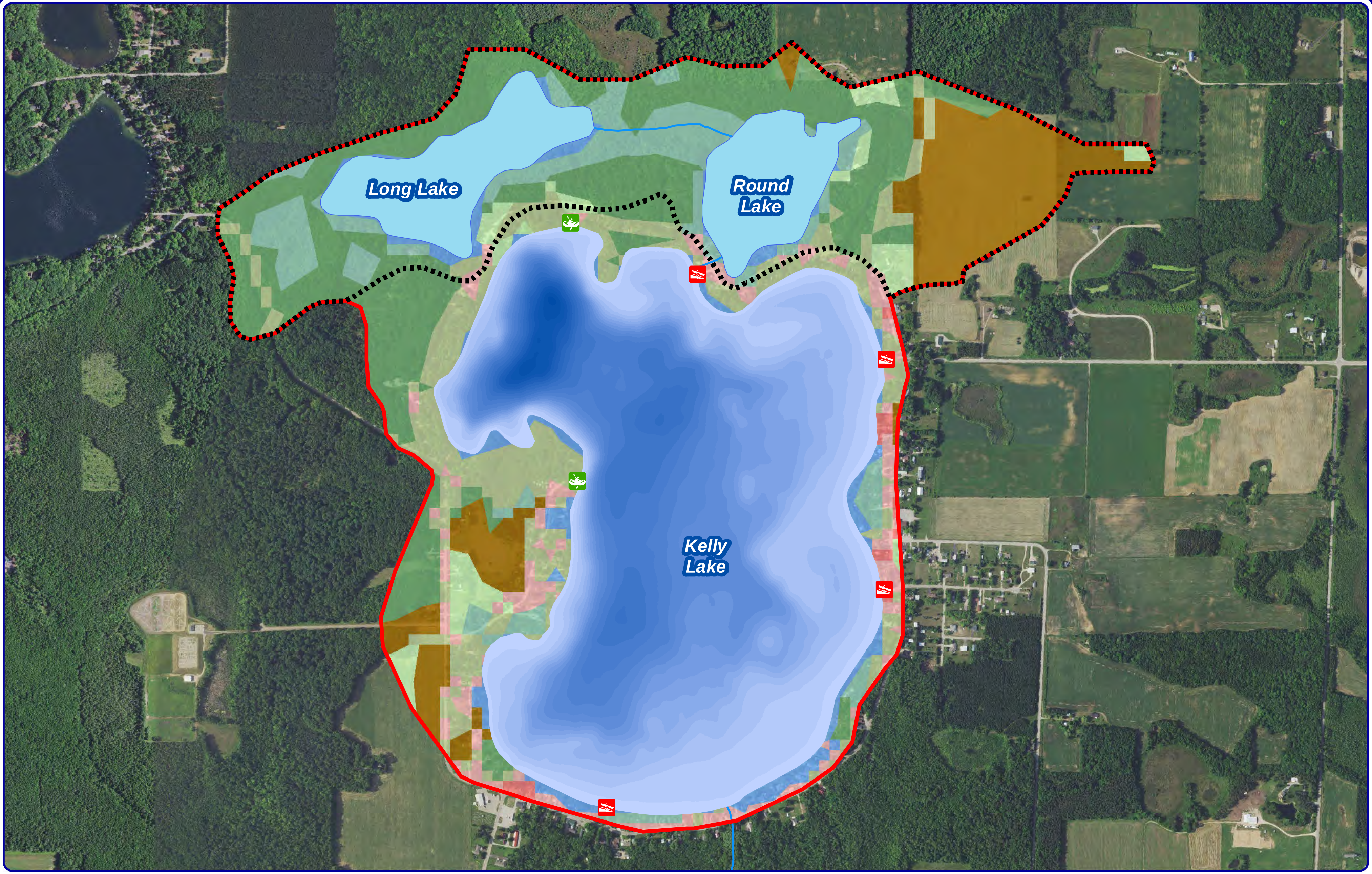
- Kelly Lake ~ 369 acres *WDNR Definition*
- Carry-In Public Access
- Public Access



Project Location in Wisconsin

Sources:
Roads and Hydro: WDNR
Map Date: November 3, 2015
Filename: KellyOconto_location_proposal.mxd

Onterra, LLC
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com



N
W E
S

1,200
Feet

Onterra, LLC
Lake Management Planning
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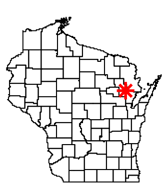
Sources:
Hydro: WDNR
Bathymetry: Onterra 2016
Orthophotography: NAIP 2015
Land Cover: NLCD 2011
Watershed Boundaries: Onterra 2016
Map Date: April 12, 2017
Filename: *Kelly_Watershed.mxd*



Project Location in Wisconsin

Legend

Land Cover Types

- Forest
- Forested Wetlands
- Wetlands
- Open Water
- Rural Open Space
- Pasture/Grass
- Row Crops
- Rural Residential
- Medium Density Urban

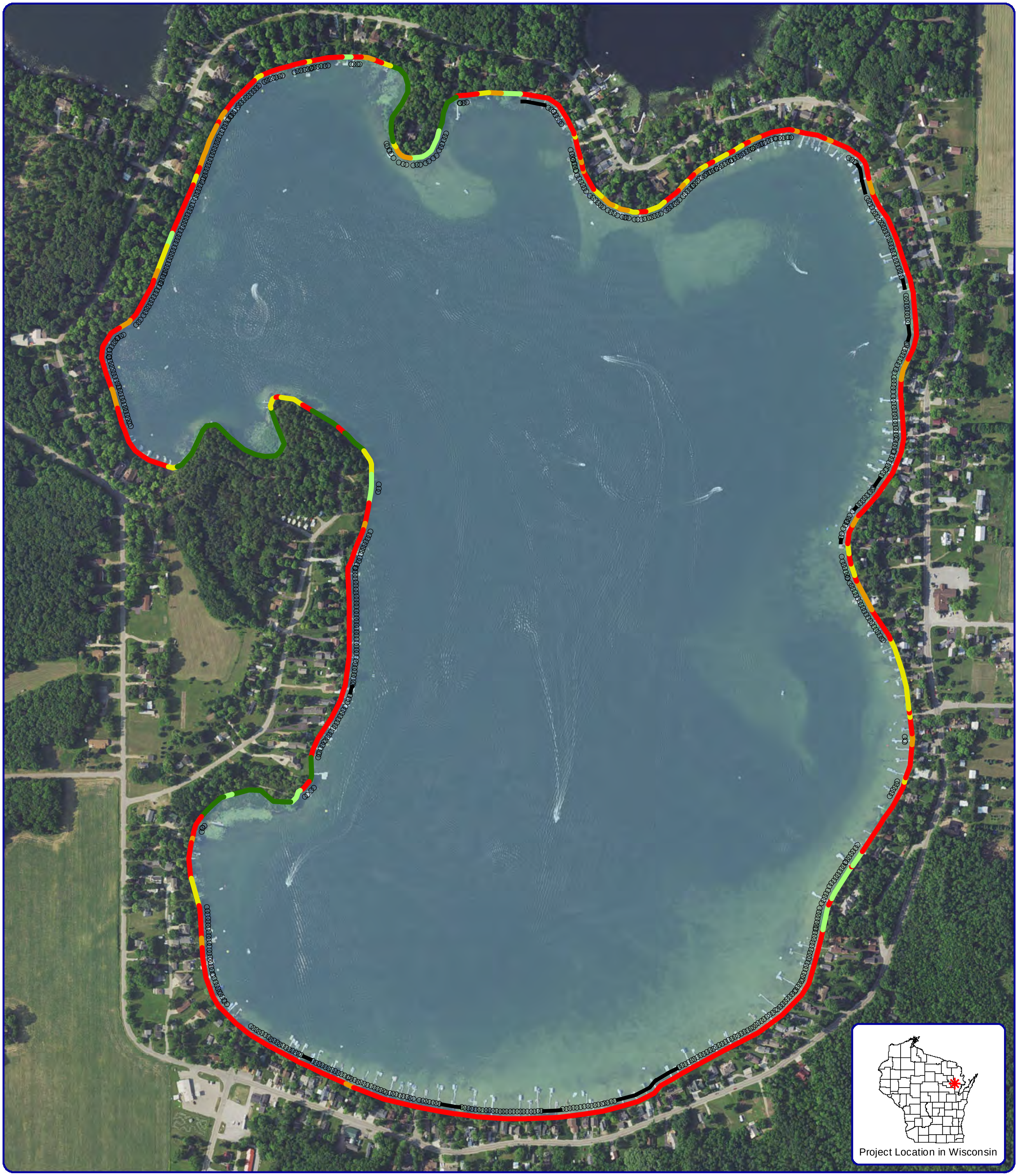
- Kelly Lake Watershed Boundary
- Round Lake Watershed Boundary
- River/Stream

Map 2

Kelly Lake

Oconto County, Wisconsin

Watershed & Land Cover Types



N
W E
S

660

Feet

Legend

Natural/Undeveloped
Developed-Natural
Developed-Semi-Natural
Developed-Unnatural
Urbanized

Seawall
Masonry/Wood/Metal
Rip-Rap

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Sources:
Roads and Hyrdo: WDNR
Orthophotograph: NAIP, 2015
Map Date: December 12, 2016
Filename: Kelly_ShorelandCondition_2016.mxd

Map 3

Kelly Lake

Oconto County, Wisconsin

2016 Shoreline Condition Assessment

N
W E
S

650

Feet

Legend

2-8 Inch Pieces	8+ Inch Pieces	Cluster of Pieces
No Branches	No Branches	No Branches
Minimal Branches	Minimal Branches	Minimal Branches
Moderate Branches	Moderate Branches	Moderate Branches
Full Canopy	Full Canopy	Full Canopy

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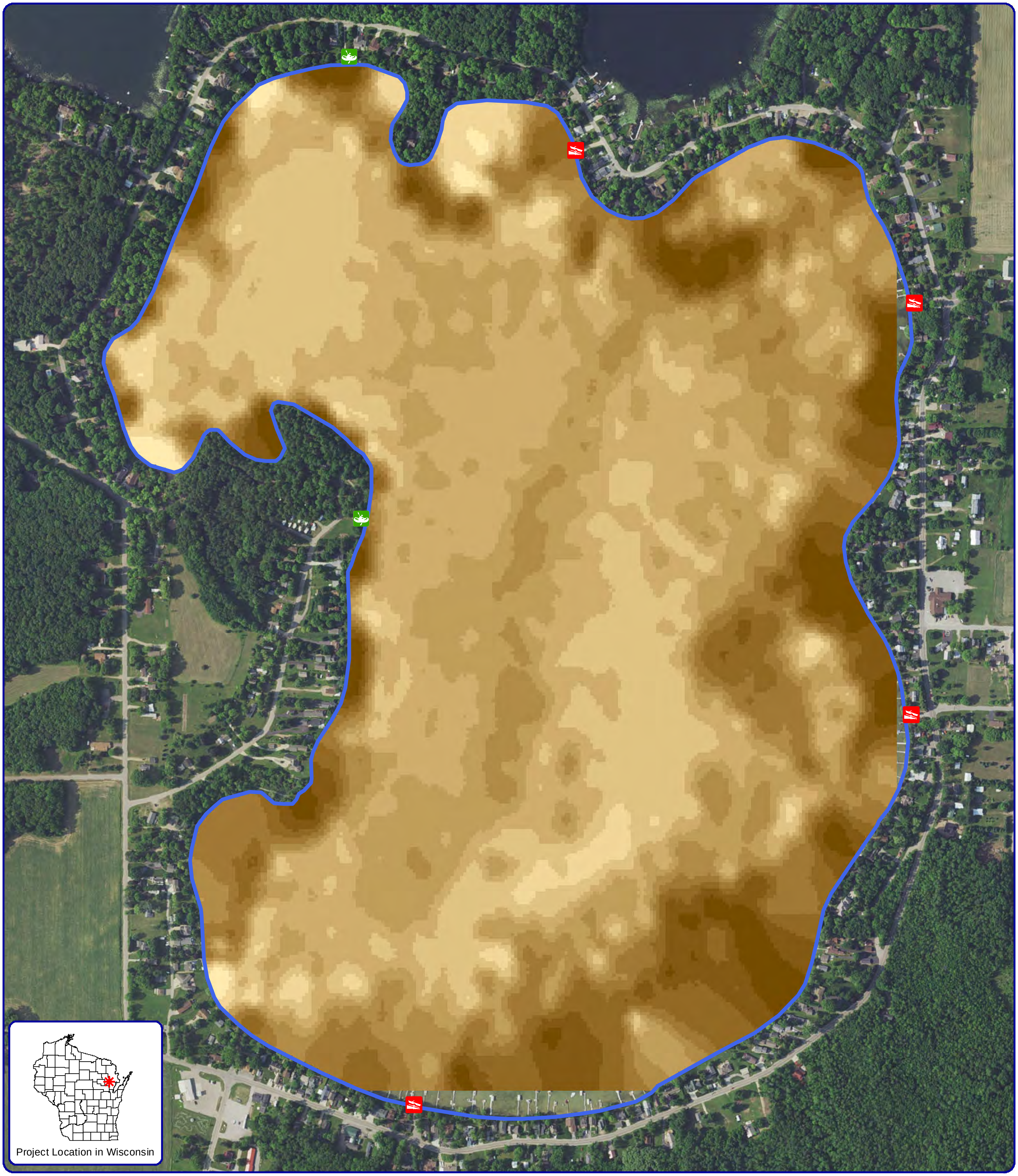
Sources:
Roads and Hyrdo: WDNR
Orthophotograph: NAIP 2015
Map Date: December 12, 2016
Filename: KellyOconto_CWH_2016.mxd

Map 4

Kelly Lake

Oconto County, Wisconsin

2016 Coarse Woody Habitat



N
W E
S

650

Feet

Legend

Soft **Hard**

Substrate Composition

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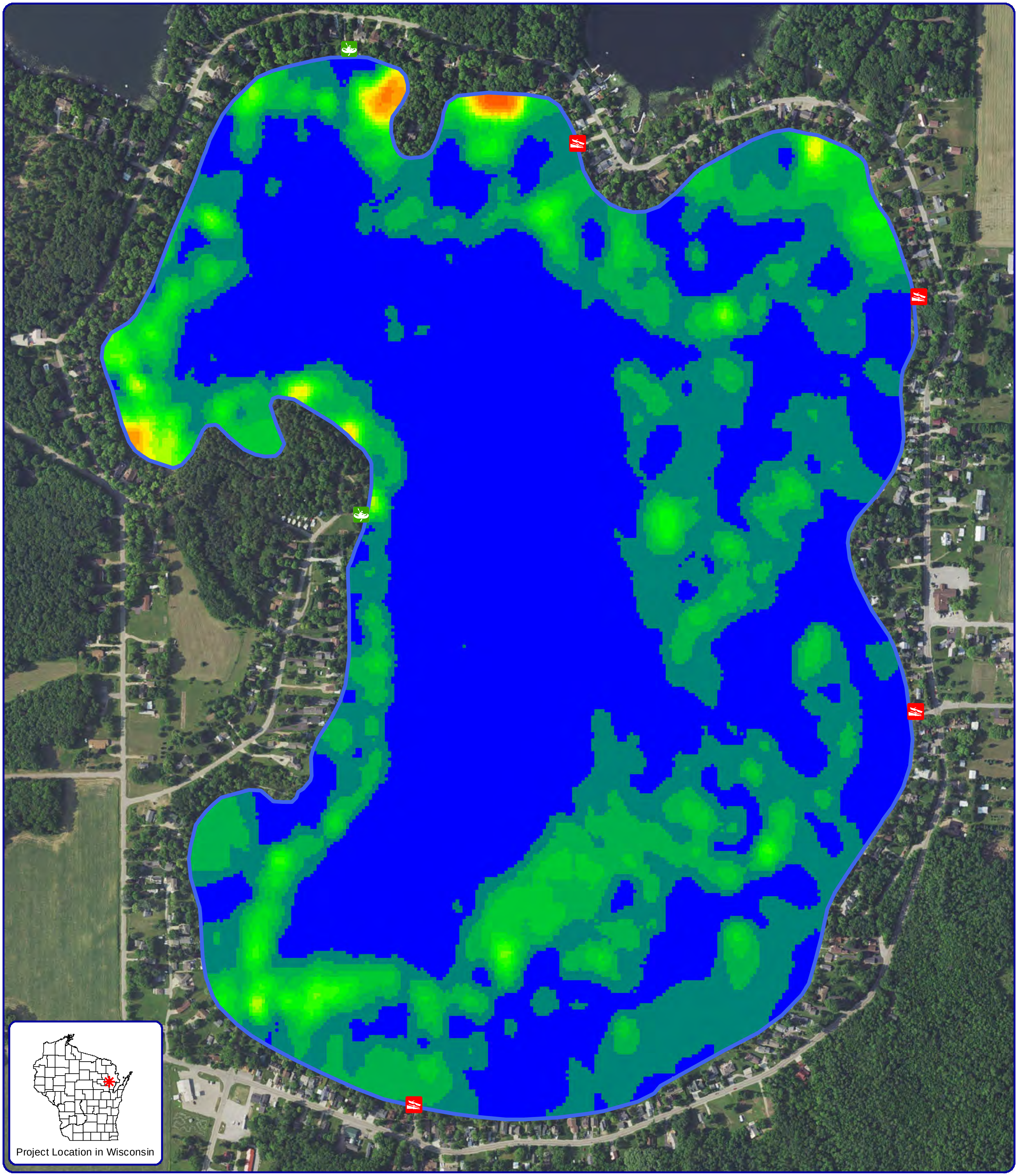
Sources:
Hydro: WDNR
Orthophotography: NAIP 2015
Substrate Hardness: Onterra, 2016
Map Date: April 4, 2017
Filename: Kelly_Acoustic_Sediment.mxd

Map 5

Kelly Lake

Oconto County, Wisconsin

2016 Bio-Acoustic Survey Results - Substrate Hardness



Map 6
Kelly Lake
Oconto County, Wisconsin

2016 Bio-Acoustic Survey Results - Aquatic Plant Bio-Volume

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Sources:
Hydro: WDNR
Orthophotography: NAIP 2015
Bio-Volume: Onterra, 2016
Map Date: April 4, 2017
Filename: Kelly_Acoustic_Veg.mxd

N
W E
S

700

Feet

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www.onterra-eco.com

Sources:
Roads and Hyrdo: WDNR
Aquatic Plants: Onterra, 2016
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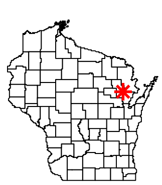
Filename: Kelly_Comm_2016.mxd



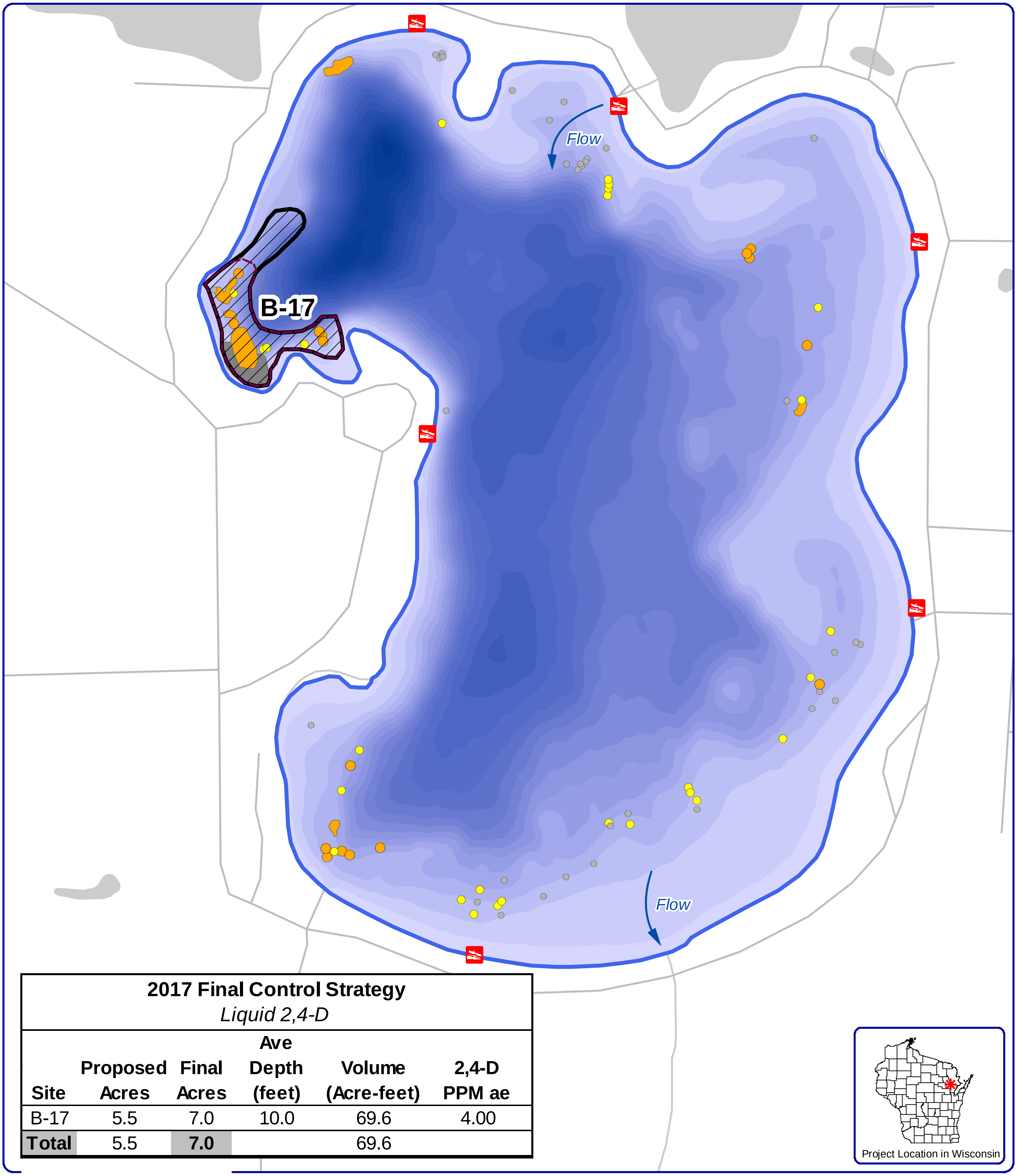
Project Location in Wisconsin

Legend

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent
- Reed canary grass

Map 7
Kelly Lake
Oconto County, Wisconsin
2016 Plant Survey: Community Mapping



2017 Final Control Strategy *Liquid 2,4-D*					
			Ave		
	Proposed	Final	Depth	Volume	2,4-D
Site	Acres	Acres	(feet)	(Acre-feet)	PPM ae
B-17	5.5	7.0	10.0	69.6	4.00
Total	5.5	**7.0**		69.6	

700
Feet

Legend

- 2017 Final Herbicide Treatment Area
- 2017 Preliminary Herbicide Treatment Area
- Concentration Monitoring Location

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815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hyrdo: WDNR
Bathymetry: Onterra, 2016
Orthophotography: NAIP, 2015
Plant Survey: Onterra, 2016-2017
Map Date: April 28, 2017
Filename: *KellyOconto_EWM_T2017Perm1.mxd*

Map 8
Kelly Lake
Oconto County, Wisconsin
Final EWM Control Strategy