Pelican Lake

Oneida County, Wisconsin

Comprehensive Management Plan

December 2013

Sponsored by:

Pelican Lake Property Owners Association, Inc.

WDNR Grant Program

LPL-1402-11 & LPL-1403-11

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Onterra LLC
Lake Management Planning

Pelican Lake

Oneida County, Wisconsin

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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:

Pelican Lake Planning Committee

Robert Mott
John Roberts
Sonja Roberts
Ed Erickson
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1.0 INTRODUCTION

Pelican Lake, Oneida County, is a 3,585-acre drainage lake with a maximum depth of 39 feet and a mean depth of 12.9 feet (Map 1). Water levels were artificially raised via the completion of the South Pelican Lake Dam in 1908 by the Wisconsin Valley Improvement Company to aid in augmenting flow downstream for hydroelectric power and flood control. This eutrophic lake has a relatively small watershed when compared to the size of the lake, with a watershed to lake area ratio of 3:1. The 2012 aquatic plant surveys revealed that Pelican Lake contains 50 native plant species, of which wild celery, flat-stem pondweed, and common waterweed are the most common plants. Two non-native species were located in 2012, and include Eurasian water milfoil and pink water lily.

Field Survey Notes

Observed some larger communities of hardstem bulrush on the northwest part of the lake.

The lake seems to have a mix of substrate types.

Photograph 1.0 -1 Pelican Lake, Oneida County

Lake at a Glance - Pelican Lake

Morphology	
Acreage	3,585
Maximum Depth (ft)	39
Mean Depth (ft)	12.9
Shoreline Complexity	3.8
Vegetation	
Curly-leaf pondweed Survey Date	June 15-17, 2011
Comprehensive Point-intercept Survey Date	August 22-24, 2011
Number of Native Species	50
Threatened/Special Concern Species	0
Exotic Plant Species	Eurasian water milfoil and pink water lily
Simpson's Diversity	0.92
Average Conservatism	6.2
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	7.0
Sensitivity to Acid Rain	Not sensitive
Watershed to Lake Area Ratio	3:1

The Pelican Lake Property Owners Association (PLPOA) was interested in creating a lake management plan for two primary reasons. First, they wanted to take a proactive approach and be prepared to react in the event that an aquatic invasive plant would become established in the lake. The PLPOA understood that the Wisconsin Department of Natural Resources (WDNR) could respond more quickly and accurately to address an invasive species establishment if the lake had a management plan in place. Second, the PLPOA recognized the value of gaining a better understanding of the Pelican Lake ecosystem and its current condition. In the end, the information obtained from these studies would help guide future PLPOA plans and programs, including their active volunteer monitoring program on the lake and at its boat landings throughout the Clean Boats Clean Waters Program.

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, and the completion of a stakeholder survey.

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

Kick-off Meeting
On July 16, 2011, a project kick-off meeting was held to introduce the project to the general public. The meeting was announced through a mailing and personal contact by PLPOA board members. The 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. The presentation was followed by a question-and-answer session.

Planning Committee Meeting I
On November 9, 2012 Eddie Heath of Onterra met with members of the Pelican Lake Property Owners Association. In advance of this meeting, a draft copy of the Results & Discussion Sections (3.0) was provided to attendees. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including the aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed.

Planning Committee Meeting II
On January 7, 2013, Eddie Heath met with seven members of the Planning Committee to discuss the stakeholder survey results and begin developing management goals and actions for the Pelican Lake Property Owners Association's Comprehensive Lake Management Plan. One of the major topics of discussion was related to EWM management and the development of thresholds (triggers) of when specific management actions would be enacted.

Project Wrap-up Meeting
On July 20, 2013 Tim Hoyman presented the study results along with the project's Implementation Plan to a packed crowd at the PLPOA's annual summer picnic/meeting. Mr. Hoyman answered many questions about the lake's ecology, Eurasian water milfoil monitoring and control, and the Association's chosen management actions.

Management Plan Review and Adoption Process

In April 2013 a draft of the Implementation Plan Section (5.0) was provided to the Planning Committee for review. The Implementation Plan Section of the first distributed draft of the management plan was created based upon integration of the Planning Committee's comments of that draft.

In June 2013, an official first draft of the Pelican Lake Management Plan was supplied to the WDNR, Oneida County, WVIC, and PLPOA Planning Committee for review. Comments were received from all entities, including the WDNR Lakes Specialist on November 22, 2013. This report reflects the integration of all comments received. The final report will be reviewed by the PLPOA Board of Directors and a vote to adopt the management plan will be held during the association's next annual meeting.

Stakeholder Survey

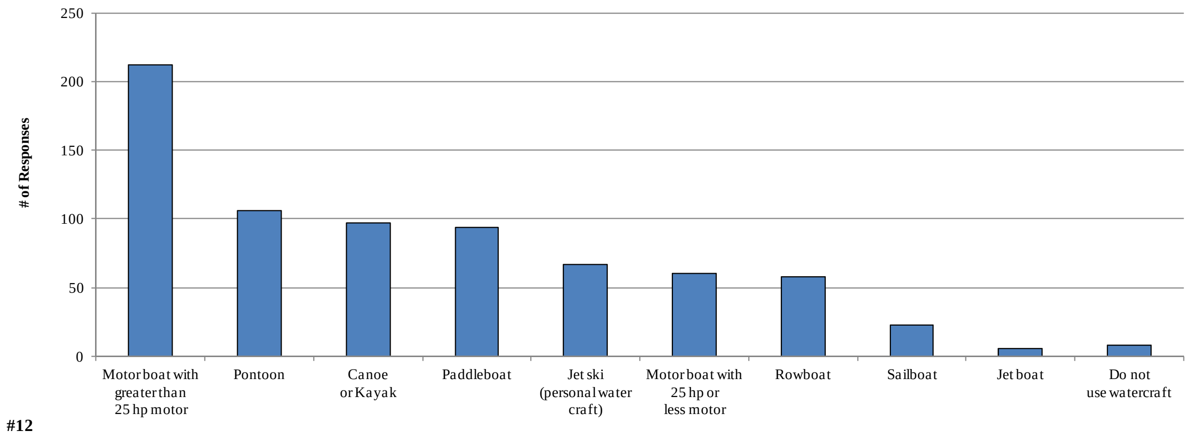
During January of 2012 a ten-page, 38-question survey was mailed to 486 riparian property owners in the Pelican Lake watershed. 61 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Pelican Lake Planning Committee. The data was summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan. A general summary is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people who use and care for Pelican Lake. The majority of stakeholders (34%) are seasonal residents, while 33% are year-round residents and 26% visit the lake on weekends throughout the year (Question #1). 59% of stakeholders have owned their property for over 15 years, and 39% have owned their property for over 25 years (Question #3).

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 large motor boat or pontoon boat on Pelican Lake (Question #12). Canoes/kayaks and paddleboats were also popular options. On a popular recreation lake such as Pelican Lake, the importance of responsible boating activities is important. The need for responsible boating increases during weekends, holidays, and during times of nice weather or good fishing conditions due to increased traffic on the lake. As seen on Question #13, several of the top recreational activities on the lake involve boat use. Within the survey, stakeholders did not highly rank boat traffic as a concern or potential factor affecting the lake in a negative manner (Questions #20 and #21).

Several concerns noted throughout the stakeholder survey (see Question #20, #21 and survey comments – Appendix B) were aquatic invasive species, excessive fishing pressure, loss of fish habitat and excessive aquatic plant growth. Issues pertaining to aquatic plants are included within the Aquatic Plant Section, while fisheries issues are explained in the Fisheries Data Integration Section. Both of these topics, as well as others, are discussed within the Summary & Conclusions section as well as within the Implementation Plan.

Question #12: What types of watercraft do you currently use on Pelican Lake?



Question #13: Please rank up to three activities that are important reasons for owning your property on or near Pelican Lake.

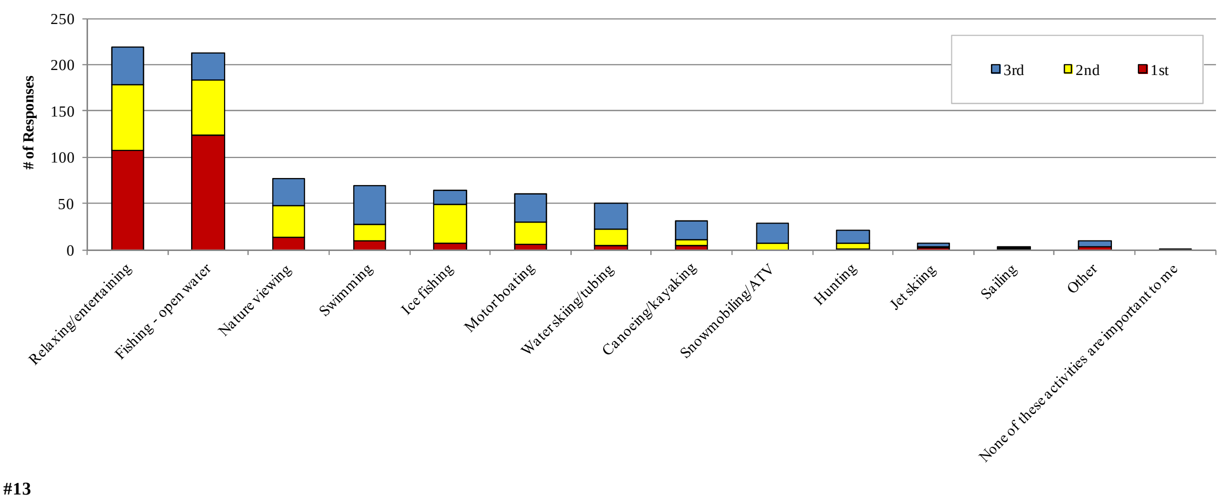
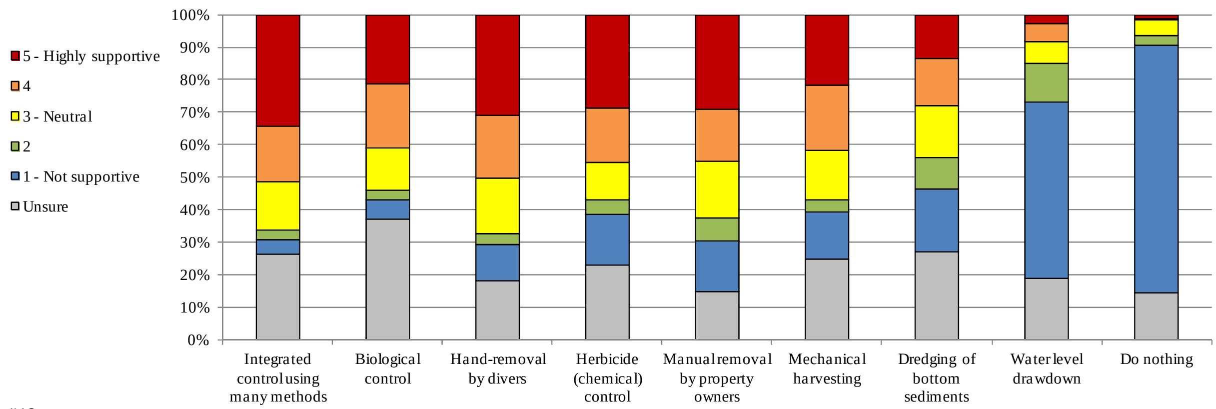


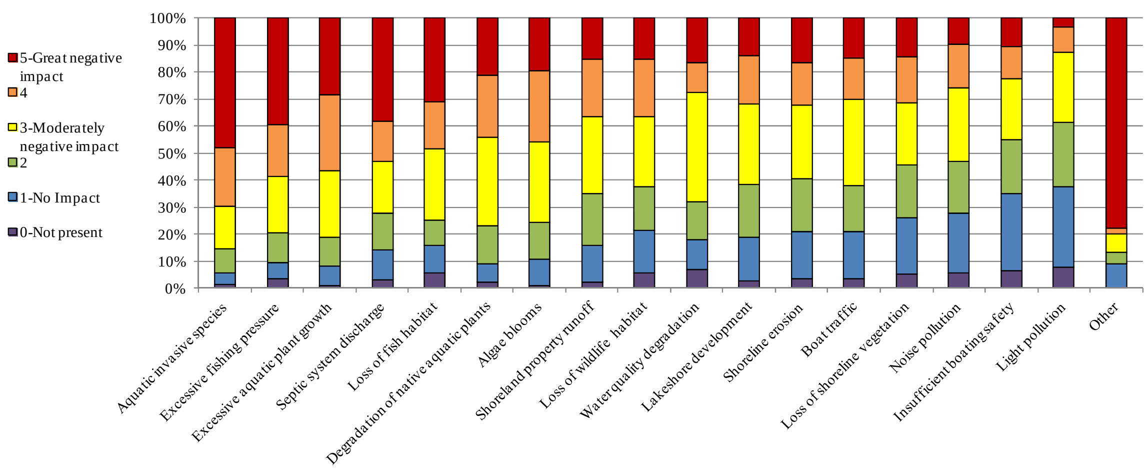
Figure 2.0-1. Select survey responses from the Pelican Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question #19: Invasive aquatic plants can be managed using many techniques. What is your level of support for the responsible use of the following techniques on Pelican Lake?



#19

Question #20: Please rank your top three concerns regarding Pelican Lake.



#20

Figure 2.0-2. Select survey responses from the Pelican 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 studying 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. Elaboration of the available analysis is 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 to lakes within the same regional area. In this document, a portion of the water quality information collected on Pelican 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 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 on in Pelican 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 a 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). There are three classifications for lakes:: 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.

Lake stratification occurs when temperature gradients are developed with respect to depth in a lake. During stratification the lake can be broken into three layers: The *epiliminion* 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

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fishkills 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 affects many chemical processes that occur within a lake. Internal nutrient loading, an excellent example, is described below.

Internal Nutrient Loading

In lakes that support strong stratification, 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 the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. This cycle continues year after year, termed "internal phosphorus loading", is a phenomenon that can support nuisance algae 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 screen non-candidate and candidate lakes following the general guidelines below:

Non-Candidate Lakes

- Lakes that do not experience hypolimnetic anoxia.
- Lakes that do not stratify for significant periods (i.e. months 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 2012 Consolidated Assessment and Listing Methodology (WDNR 2012A) 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 Pelican Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into six classifications (Figure 3.1-1).

First, the lakes are classified into two main groups: **shallow (mixed)** or **deep (stratified)**. Shallow lakes tend to mix throughout or periodically during the growing season and, as a result, remain well-oxygenated. Further, shallow lakes often support aquatic plant growth across most or all of the lake bottom. Deep lakes tend to stratify during the growing season and have the potential to have low oxygen levels in the bottom layer of water (hypolimnion). Aquatic plants are usually restricted to the shallower areas around the perimeter of the lake (littoral zone). 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.

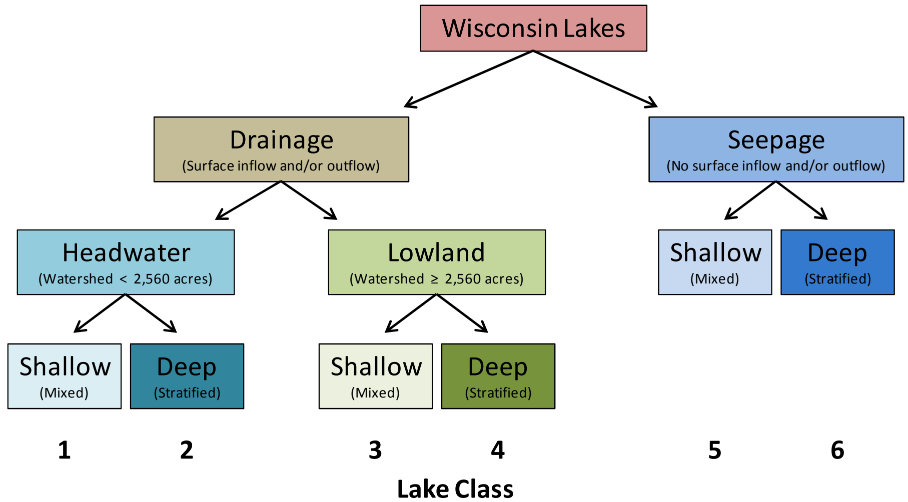


Figure 3.1-1. Wisconsin Lake Classifications. Pelican Lake is classified as a shallow (mixed), lowland drainage lake (Class 4). Adapted from WDNR 2012B.

The WDNR developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for each of the six 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. Pelican Lake is within the Northern Lakes and Forests ecoregion.

The Wisconsin 2012 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.

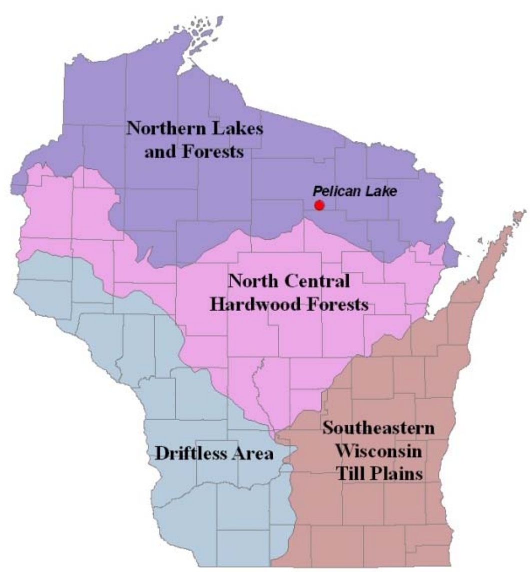


Figure 3.1-2. Location of Pelican Lake within the ecoregions of Wisconsin. After Nichols 1999.

Figures 3.1-3 - 3.1-8 display data from statewide natural lake means, along with historic and current data from Pelican Lake. 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.

Pelican Lake Water Quality Analysis

Pelican Lake Long-term Trends

As part of the stakeholder survey associated with this project, lake residents were asked questions regarding their perspectives on the water quality of Pelican Lake. Most respondents (84%) indicated they believed the water quality in the lake was either “Fair” or “Good” (Appendix B, Question #14). However, while the majority (44%) of respondents indicated the water quality has remained the same, a portion of respondents (35%) did indicate that they felt the water had “somewhat degraded” since they first visited the lake (Question #15). Water quality related concerns such as septic system discharge, algae blooms, shoreland property runoff and water quality degradation ranked moderately on a list of stakeholders’ concerns regarding Pelican Lake (Questions #20 and #21).

A great deal of data is available regarding the historical water quality on Pelican Lake This is valuable information because it provides a scientific basis for making management decisions for the system. Additionally, it helps to dispel perceptions lake stakeholders may have concerning the water quality in the system. Anecdotal accounts that the lake is “getting better” or “getting worse” can be proven or disproven by looking at data which analyzes these claims from a scientific perspective. The data has been collected by several agencies, such as the WDNR through their Lake Baseline Monitoring and Long Term Trend Monitoring programs and the Wisconsin Valley Improvement Corporation (WVIC), in addition to volunteer efforts by Pelican Lake riparians through the Citizen Lake Monitoring Network (CLMN). These data were collected primarily from SWIMS (WDNR Surface Water Integrated Monitoring System). Cathy Wendt of the WVIC provided further historic data collected from Pelican Lake as well.

Phosphorus is an essential nutrient and the most commonly analyzed nutrient when examining the water quality of a freshwater lake or stream. Total phosphorus, a measurement of both dissolved and particulate forms of this nutrient, has been monitored on Pelican Lake during the growing season and summer months continuously since 1988 with the exception of 2003 (Figure 3.1-3). Average annual summer concentrations largely fall within water quality categories of *Excellent* or *Good*. A weighted summer average over all years (28.8 µg/L) is lower than the median concentration for similar lakes statewide, though higher that the median value for lakes within the ecoregion. Fluctuations exist within the dataset, which can be attributed to environmental variability in precipitation, temperature, sunlight, etc.

In observing these data, a slight increasing trend is almost apparent. A trend line can be fitted to the almost continuous data collected between 1988 and 2011. Figure 3.1-4 indicates a weak to slightly moderate increase of average summer total phosphorus concentrations within this dataset (R^2 = 0.289). It is unclear whether the observed phenomenon is occurring due to natural environmental variability, or from more unnatural sources. Continued monitoring of this potential trend will be important.

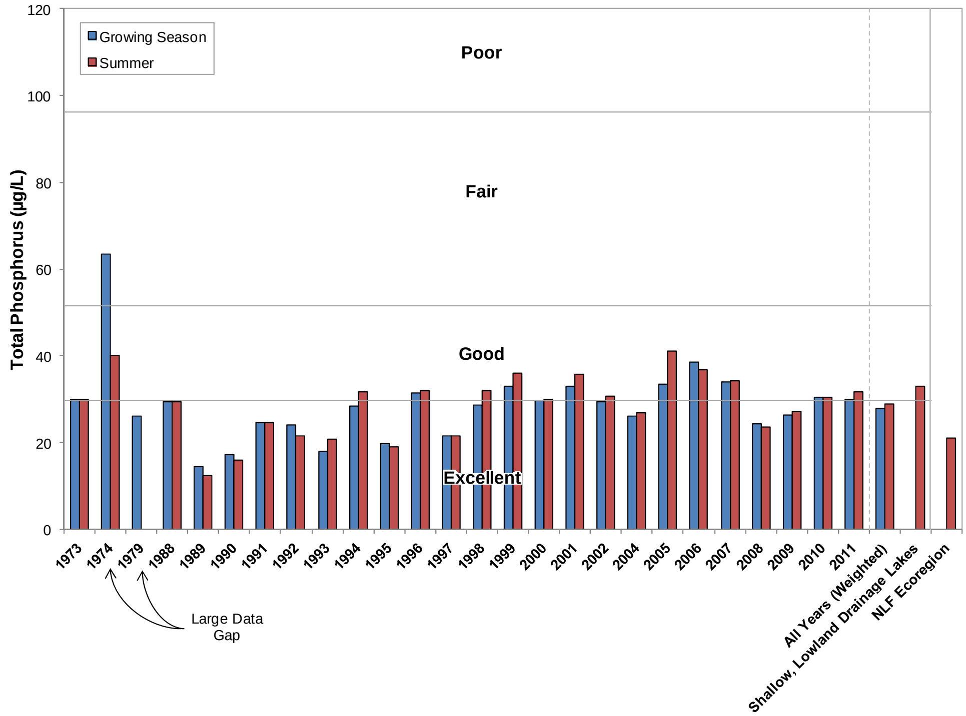


Figure 3.1-3. Pelican Lake, state-wide class 4 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR 2012A. Data compiled from SWIMS and WVIC databases.

Chlorophyll-*a*, the parameter measured to estimate algae abundance in the water, has been measured steadily since 1987. Again, fluctuations are present within the dataset, but concentrations remained relatively constant between 1988 and 2011, for which continuous chlorophyll-a data are available (3.1-4). Most chlorophyll-a values rank as *Good* or *Excellent*, including an average weighted across all years of available data. This weighted average ranks slightly above the median value for similar lakes state-wide and also above lakes found within the ecoregion. A 2003 average value of 36.1 µg/L is heavily influenced by an August 27 sample in which a value of 70.9 µg/L was obtained. It is unknown what may have spurred this algae bloom. 2003 was a rather dry year, as reported through precipitation data collected at the Rhinelander/Oneida County Airport. The only substantial rain event that occurred during the late summer was a 2.8 inch rainfall which was measured on July 26 – a month prior to the collection of this sample. A sample collected 14 days prior (August 13, 2003) showed chlorophyll-*a* at a concentration of 22.5 µg/L, which is a relatively substantial reading for this parameter, yet three times less than the August 27 sample. Phosphorus data, unfortunately, was not collected at all during 2003 so a correlation with this parameter is not able to be done. It is believed that conditions were conducive for algae growth, a bloom occurred, and that a bloom of this magnitude may be an infrequent event on Pelican Lake.

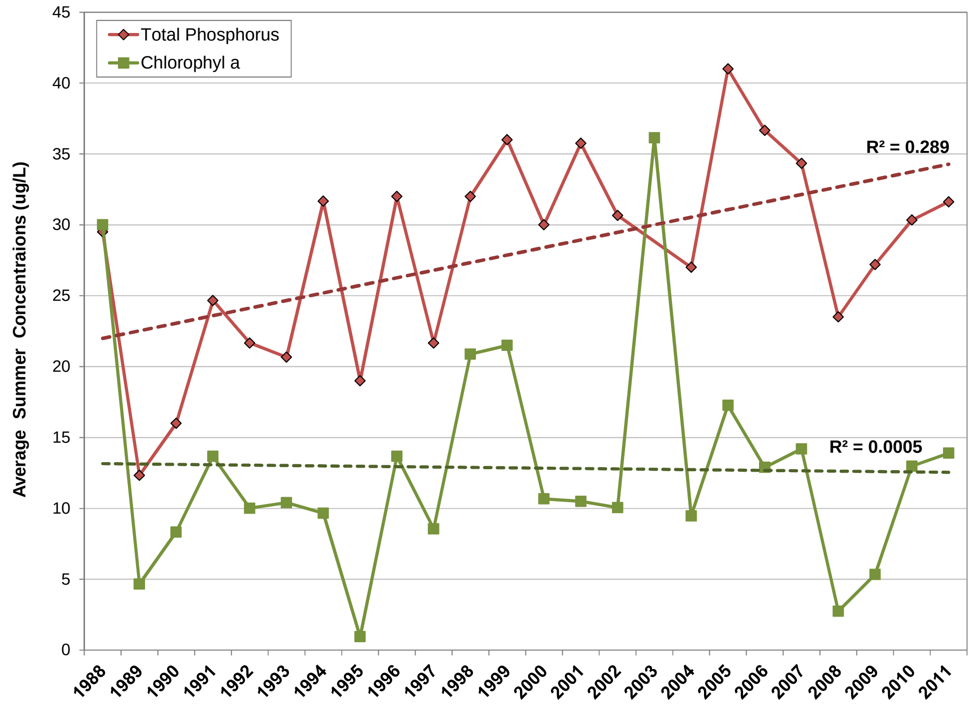


Figure 3.1-4. Pelican Lake average summer total phosphorus and chlorophyll-*a* trends. Calculated with summer month surface sample data. Data compiled from SWIMS and WVIC databases.

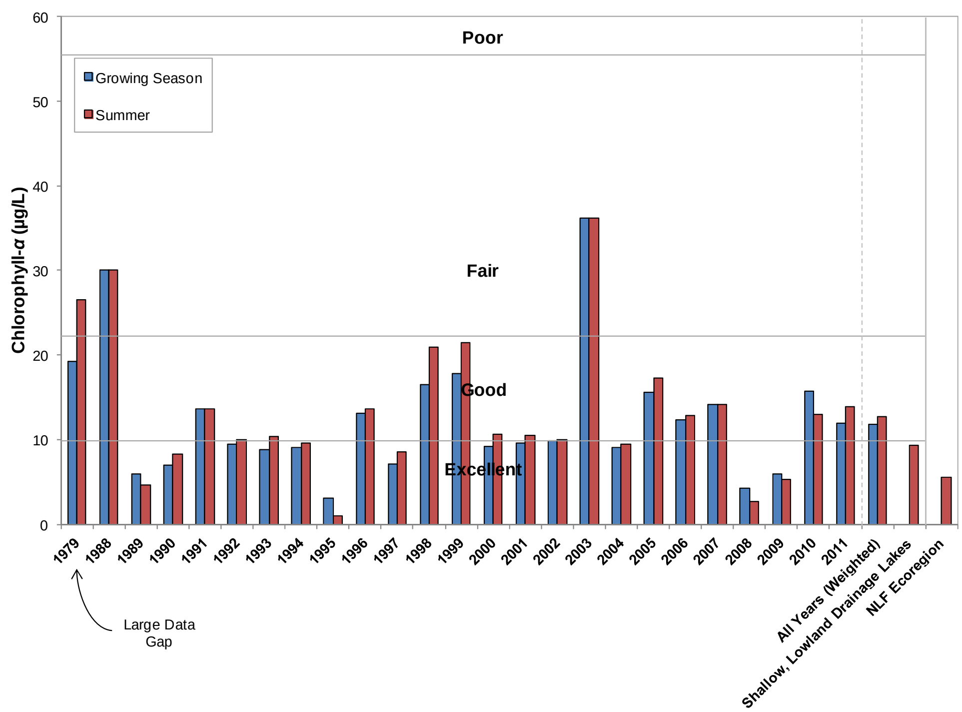


Figure 3.1-5. Pelican Lake, state-wide class 4 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR 2012A. Data compiled from SWIMS and WVIC databases.

Like the other two water quality parameters, Secchi disk clarity has been collected with good frequency since the late 1980s also. Secchi disk clarity values rank mostly within categories of *Good* and *Excellent*, and a weighted average of these data is greater than the median value for similar lakes state-wide and comparable, but less than the median for lakes within the ecoregion. Interestingly, in 2003 some of the shallowest Secchi disk clarity readings were recorded, with the smallest value across all years, 2.5 feet, being recorded on August 27. Recall from above that this is the date in which algae concentrations were recorded at their highest. Many parameters can influence the clarity of a lake; however, free-floating algae concentrations are likely the driver of water clarity on Pelican Lake.

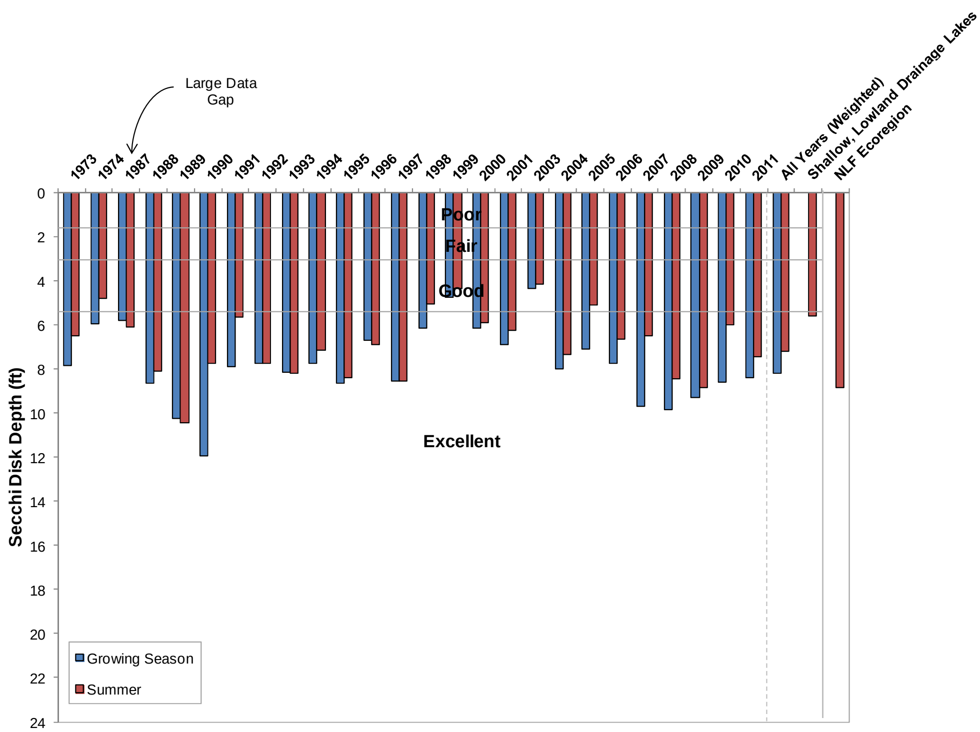


Figure 3.1-6. Pelican Lake, state-wide class 4 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR 2012A. Data compiled from SWIMS and WVIC databases.

Limiting Plant Nutrient of Pelican Lake

Using midsummer nitrogen and phosphorus concentrations from Pelican Lake, a nitrogen:phosphorus ratio of 24:1 was calculated. This finding indicates that Pelican Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that reducing phosphorus inputs to the lake may limit plant and algae growth within the lake.

Pelican Lake Trophic State

Figure 3.1-6 contains the TSI values for Pelican Lake. The TSI values calculated based upon Secchi disk, chlorophyll-*a*, and total phosphorus data range in values spanning from lower oligotrophic to eutrophic. 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 Pelican Lake is in a eutrophic state.

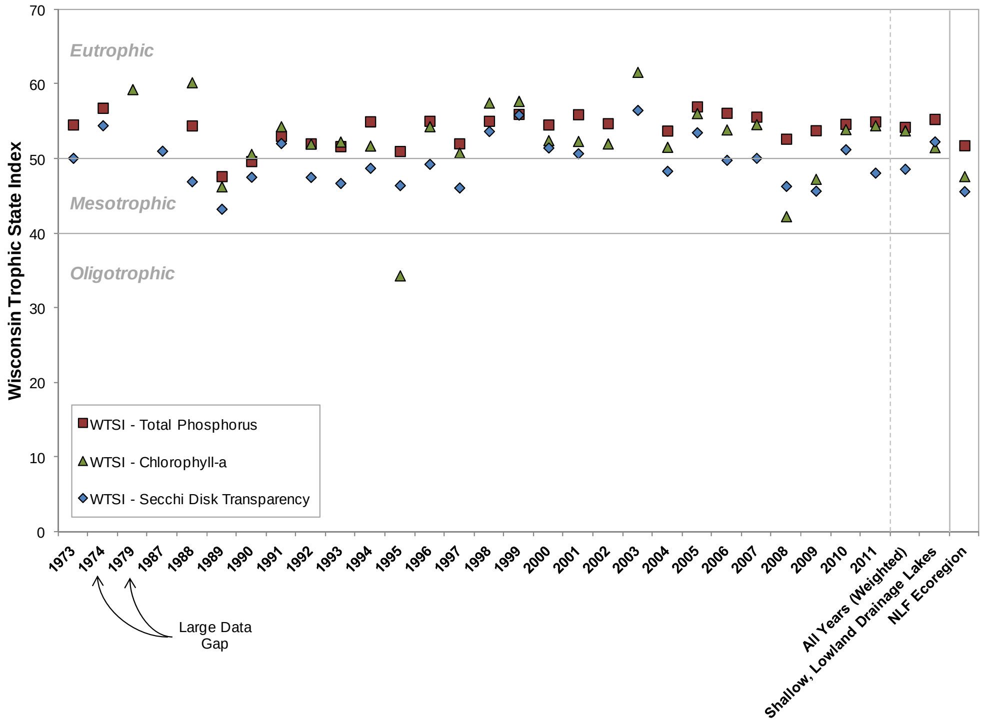


Figure 3.1-7. Pelican Lake, state-wide class 4 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193. Data compiled from SWIMS and WVIC databases.

Dissolved Oxygen and Temperature in Pelican Lake

Dissolved oxygen and temperature were measured during water quality sampling visits to Pelican Lake by Onterra staff. Profiles depicting these data are displayed in Figure 3.1-7.

Pelican Lake was found to be thoroughly mixed during the spring and fall months of 2011. During the winter, the lake is thermally stratified – the coldest water is found near the surface just under the ice while the warmer (denser) water sinks to the bottom of the lake. When the lake is thermally stratified, mixing between the two distinct layers does not occur. Within the bottom layer (hypolimnion), oxygen depletion occurs as bacteria decompose organic material. Although some oxygen depletion occurs, the oxygen monitoring that took place on March 7, 2012, indicates that sufficient oxygen exists within the upper and middle portions of the water column; therefore, winter fish kill is not thought to be an issue on Pelican Lake.

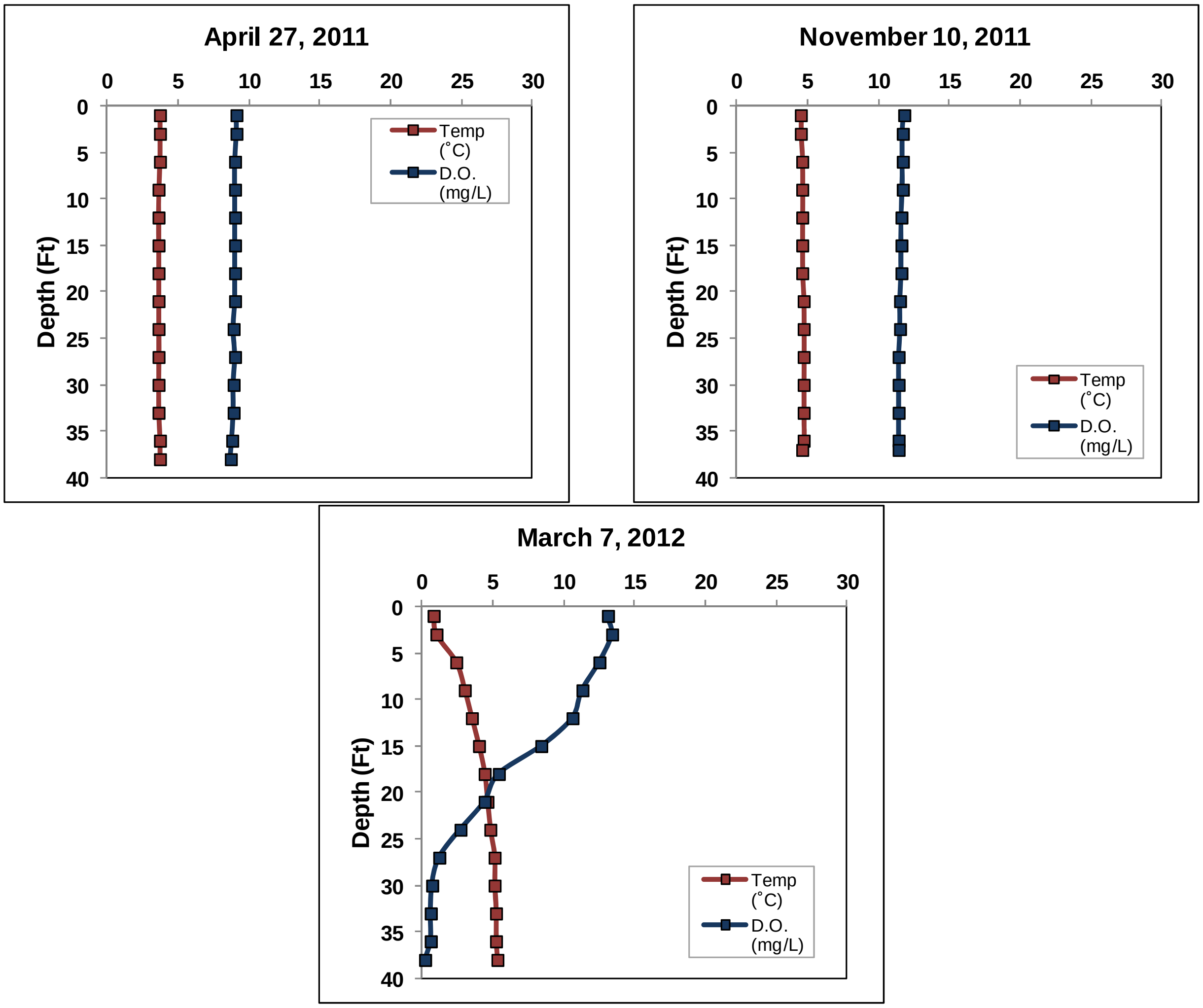


Figure 3.1-8. Pelican Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Pelican 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 Pelican 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 Pelican Lake was found to be neutral with a value of 7.0 at the lake's surface, and falls within the normal range for Wisconsin Lakes.

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 naturally slightly acidic 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 Pelican Lake was measured at 41.9 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and is not sensitive 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 which lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0 (Coen 2005), so Pelican Lake's pH of 7.0 falls within 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 Pelican Lake was found to be 12.1 mg/L, at the bottom of the optimal range for zebra mussels.

Researchers at the University of Wisconsin - Madison have developed an AIS suitability model called Smart Prevention (Vander Zanden and Olden 2008). In regards to zebra mussels, this model relies on measured or estimated dissolved calcium concentration to indicate whether a given lake in Wisconsin is suitable, borderline suitable, or unsuitable for sustaining zebra mussels. Within this model, suitability was estimated for approximately 13,000 Wisconsin waterbodies and is displayed as an interactive mapping tool (www.aissmartprevention.wisc.edu). Based upon this analysis, Pelican Lake was considered borderline suitable for mussel establishment.

Plankton tows were completed by Onterra staff during the summer of 2011 and these samples were processed by the WDNR for larval zebra mussels. No veligers (larval zebra mussels) were found within these samples.

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.

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 on 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 exceeding 10-15:1, 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 (high residence time, i.e., years), there may be a buildup of phosphorus in the sediments that could reach sufficient levels over time that internal nutrient loading may become a problem. 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 could 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, in order 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.

Pelican Lake Watershed Assessment

Pelican Lake has a watershed that covers 13,920 acres in total (Map 2). Like most of the lakes in the Northwoods of Wisconsin, Pelican Lake's watershed is predominately forested (5,098 acres or 37% of the total area) and includes large areas of wetlands (4,224 acres or 30%) (Figure 3.2-1). The lake's surface area (3,585 acres), at 26%, also makes up a considerable portion of the watershed. Pasture/grass lands, row crops, rural residential and medium density urban lands make up the remaining 7% of the watershed. Overall, the large watershed is not so large relative to the size of the lake; the watershed to lake area ratio is roughly 3:1.

As explained above, WiLMS may be utilized to estimate nutrient loading from various land cover types within a watershed. This exercise was conducted on Pelican Lake's watershed to determine that approximately 2,112 lbs. of phosphorus is input to the land on an annual basis (Figure 3.2-2). Interestingly, the largest source of phosphorus is the Pelican Lake surface, at 959 lbs. or slightly under one-half of the total phosphorus load. This occurs from atmospheric deposition of airborne particles through either dry (direct settlement) or wet (absorption of chemical compounds through rain) mechanisms. This type of phosphorus loading is largely uncontrollable at many scales because airborne phosphorus may be derived from farming activities, incinerators, motor vehicles, pesticide/fertilizer applications, quarry activities and/or natural events such as earthquakes and volcanoes that take place hundreds or thousands of miles away from Pelican Lake.

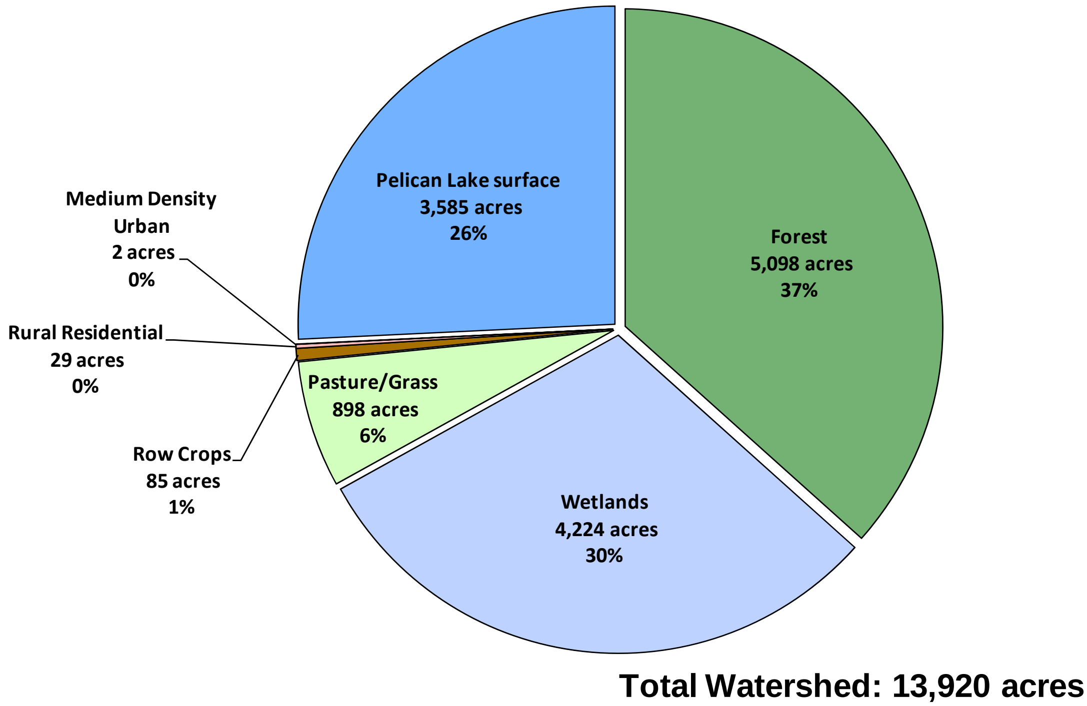


Figure 3.2-1. Pelican Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

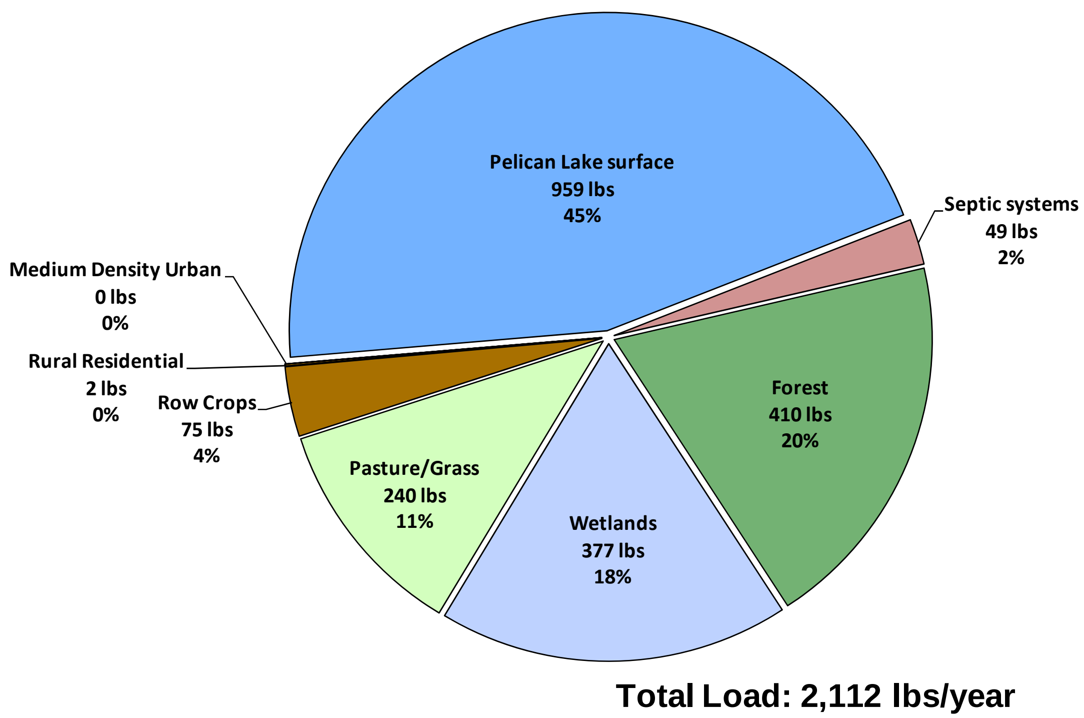


Figure 3.2-2. Pelican Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Examining the remaining land cover types, WiLMS estimated that forested land, which occupies 37% of the watershed, produces 20% of the annual phosphorus load to Pelican Lake (Figure 3.2-2). Wetlands (18%), pasture/grass lands (11%) and row crops (4%) contribute smaller quantities of phosphorus, while residential and urban areas contribute negligible portions overall. Utilizing property-owner use from the stakeholder survey, WiLMS also was able to estimate the input of phosphorus from septic systems located around the lake as well. This input was estimated to be 49 lbs, or roughly 2% of the overall load. In a scenario, half of the forested land in the watershed was converted to pasture/grass, a less vegetated land cover type. This resulted in a net increase of478 lbs of phosphorus to Pelican Lake, giving further testimony to the ecosystem benefits of heavily vegetated, natural land cover types such as forest and wetlands.

During ecosystem modeling procedures, it is routine to compare the values of actual field-measured variables with values that the model has predicted. WiLMS utilizes several predictive equations, which give an estimate of the phosphorus content of a lake in terms of either its growing season mean (GSM) or spring overturn value (SPO). These equations are based upon previous research conducted on lakes by numerous studies, and are used based upon the lake type. For example, for Pelican Lake, applicable equations would be those developed by Canfield-Bachman 1981 or Walker 1977. These studies were completed on northern, temperate climate lakes that are similar to Pelican Lake. Other equations may be utilized for shallow reservoirs, anoxic lakes, lakes with very small water loads, etc. The overall goal is to see how well the model "matches up" to what is observed through water quality monitoring. If the modeled variable's value is not close to the observed value, it is an indication that something else may be occurring within the lake that is not accounted for in the model.

Pelican Lake was modeled using these two equation sets – the Canfield-Bachman 1981 which looks at the total phosphorus GSM and the Walker 1977 which analyzes the modeled and observed total phosphorus SPO value (Appendix D). The Canfield-Bachman model predicted a GSM phosphorus concentration of 20 μg/L, which is 8 μg/L less than the actual GSM of 27.8 μg/L. However, the Walker 1977 model predicted a SPO value of 25 μg/L, which is similar to the actual observed SPO in 2011 of 27 μg/L. In summary, the spring phosphorus value was modeled accurately while the growing season mean model is somewhat inaccurate.

Sometimes, the discrepancy in a model such as this is due to the input of phosphorus from an unaccounted source. This may include things such as any point source discharge (industrial plant, sewerage outfall, etc.), septic system failure, or internal nutrient loading. Septic system failure, if it is occurring, is likely not significant enough to be affecting the lake to this degree. And with Pelican Lake's large shallow areas and large surface area, mixing of the water column occurs very often so internal nutrient loading from the bottom sediments is not possible. Relatively low hypolimnetic (bottom layer of water) total phosphorus values confirm that internal nutrient loading is not an issue. The constant mixing of the lake due to its morphology is likely impacting the growing season mean, and thus, the model. On a lake of this size, mixing of the shallow waters happens very regularly. Particulates from the sediment are in suspension more often, accounting for a higher than normal GSM. While the SPO model accounts for this, the GSM model is not able to account for particulates in suspension.

The WiLMS model predicted an annual phosphorus load of 2,112 lbs. While this annual load seems high, Pelican Lake's incredible water volume must be considered within this context. Pelican Lake is quite large in surface area, but also has several locations where its depth reaches

35 feet. For the modeling exercises, it was calculated that Pelican Lake holds 46,274 acre-feet, or 57,080,000 cubic meters of water. This is an incredible amount of water which is able to withstand an annual phosphorus load of this magnitude. In summary, the watershed surrounding Pelican Lake is in great shape; the land cover types are ideal for protecting the lake from excessive nutrient runoff and the annual phosphorus input is relatively moderate for a lake of this size and volume. Within the following section (3.3), attention is turned towards an area of the watershed that is often overlooked, but may be more influential to Pelican Lake's ecosystem – the immediate shoreland zone.

Pelican Lake Water Levels

Pelican Lake is one of 21 Wisconsin Valley Improvement Company (WVIC) water storage reservoirs used to maintain a nearly uniform flow of water as practicable in the Wisconsin river by storing surplus water in reservoirs for discharge when water supply is low to improve the usefulness of the rivers of the rivers for hydropower, flood control, and public use (Figure 3.2-3)

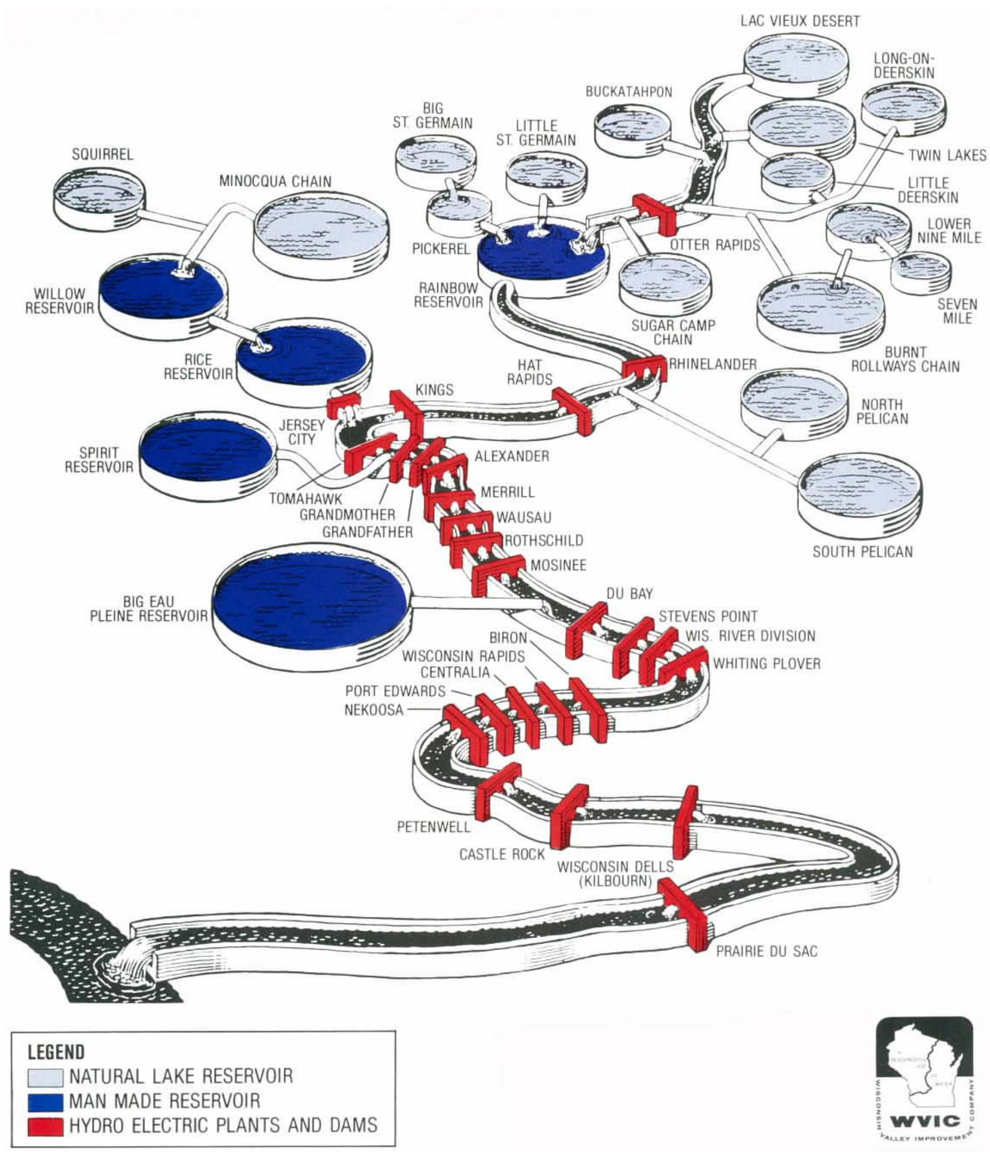


Figure 3.2-3. WVIC reservoir system. Adapted from WVIC website.

Hydroelectric power projects are licensed by the Federal Energy Regulatory Commission (FERC). As part of the FERC operation license, the minimum and maximum water levels are set for each waterbody. Natural lake reservoir water levels are maintained within a relatively narrow range in comparison to the five man-made reservoirs which exhibit changes of water levels that could span 10-20 feet in a single year. Pelican Lake is one of the natural lake reservoirs in the WVIC system, and has an operational range of 6 inches during the summer months. The water levels need to be kept between 1,591.98 and 1,5919.48 between April 1 and October 31 of each year. Winter drawdowns cannot exceed 1,589.98, which is two feet below full pool (WVIC 2013).

In addition to establishing a range of water levels, minimum outflows are also set to make sure the downstream riverine systems are not negatively impacted by abnormally low flows. Pelican Lake must maintain a minimum flow, such that the water control structure has a 1 inch gate opening.

3.3 Shoreland Condition Assessment

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) affects 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 swimmer's itch. Developments such as rip rap, 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 swimmer's itch, because 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:

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

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 more strict 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 of their own. County ordinances may be more restrictive than NR 115, but not less so (though Act 170 allows for less restrictive standards for existing non-conforming structures). These policy regulations require each county to amend ordinances for vegetation removal on shorelands, impervious surface standards, nonconforming structures and establishing mitigation requirements for development. Minimum requirements for each of these categories are described below. Please note that at the time of this writing, NR 115 is under review by the State of Wisconsin and updates will likely occur in February of 2014.

- Contact the county's regulations/zoning department for county-specific requirements.

- 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 the lesser of 30 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. A county may allow more than 15% impervious surface (but not more than 30%) on a lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner.

- 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. New 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 no other build-able location exists within 35-75 feet, dependent on the county.
  - 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: New 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, dependent on the county.

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. Ground-water 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 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 was 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 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.

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 is important for aquatic macroinvertebrates (Sass 2009). While it affects 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 areas 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 debris that was once found in Wisconsin lakes has disappeared. Prior to human establishment and development on lakes (mid to late 1800's), and due to logging practices, the amount of coarse woody habitat in lakes was likely greater than under completely natural conditions. 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). However, with continued education and lake stewardship in-lake habitat can be restored to Wisconsin lakes.

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 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, resulting in 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*".

The results indicate that stronger management of shoreline development is absolutely necessary to preserve, protect and restore lakes. This will become increasingly important as development pressure on lakes continue to steadily 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 who 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).

In recent years, many lakefront property owners have achieved 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

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Lake Management Planning

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 areas 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 landowners themselves. To decrease costs further, bare-root forms 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 time frame.
- 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 zones: two 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 (riprap 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 riprap 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.

Pelican Lake Shoreland Zone Condition

Shoreland Development

A lake’s shoreland zone can be classified in terms of its degree of development. In general, more developed shorelines are more stressful on a lake ecosystem, while definite benefits occur from shorelines that are left in their natural state. Figure 3.3-1 displays a diagram of shoreline categories, from “Urbanized,” meaning the shoreland zone is completely disturbed by human influence, to “Natural/Undeveloped,” meaning the shoreline 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 still 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 where 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. Shoreline assessment category descriptions.

On Pelican Lake, the shoreline condition of the entire lake was surveyed during the summer of 2011. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreline on a property-by-property basis. During the survey, Onterra staff examined the shoreline for signs of development, and assigned one of the five descriptive categories (Figure 3.3-2) to areas of the shoreland.

Pelican Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 3.8 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 3.3-2). 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, 6.6 miles of urbanized and developed–unnatural shoreline were observed. If restoration of the Pelican Lake shoreline 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 shoreline lengths around the entire lake.

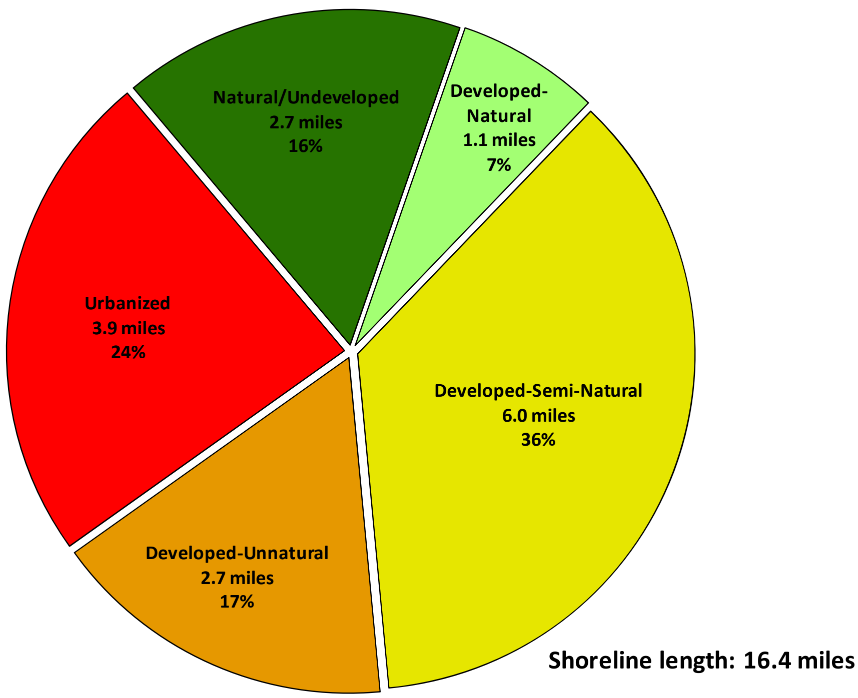


Figure 3.3-2. Pelican Lake shoreland categories and total lengths. Based upon a late summer 2011 survey. Locations of these categorized shorelands can be found on Map 3.

While producing a completely natural shoreline 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. Locating lawns on flat, unsloped 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.

Swimmer's Itch

Cercarea dermatitis or swimmer's itch is a type of skin reaction that is caused when the larval stage of a shistosome flatworm accidentally burrows into a human's skin when that person is spending time in the water (Figure 3.3-3). The skin reaction varies from one individual to another, but is usually accompanied by intense itching and a rash of small red bumps that look similar to insect bites. Each of the red bumps is caused by localized, inflammatory immune response to an individual parasite which will die within hours of entering into the skin. While perfectly harmless, it can greatly compromise the recreational value for those who enjoy spending time in the water. Young children seem to be more affected by this condition; as they typically spend more time in the water, have more sensitive skin, and have a tendency to spend more time in near-shore areas of the lake where the flatworms may be more concentrated.

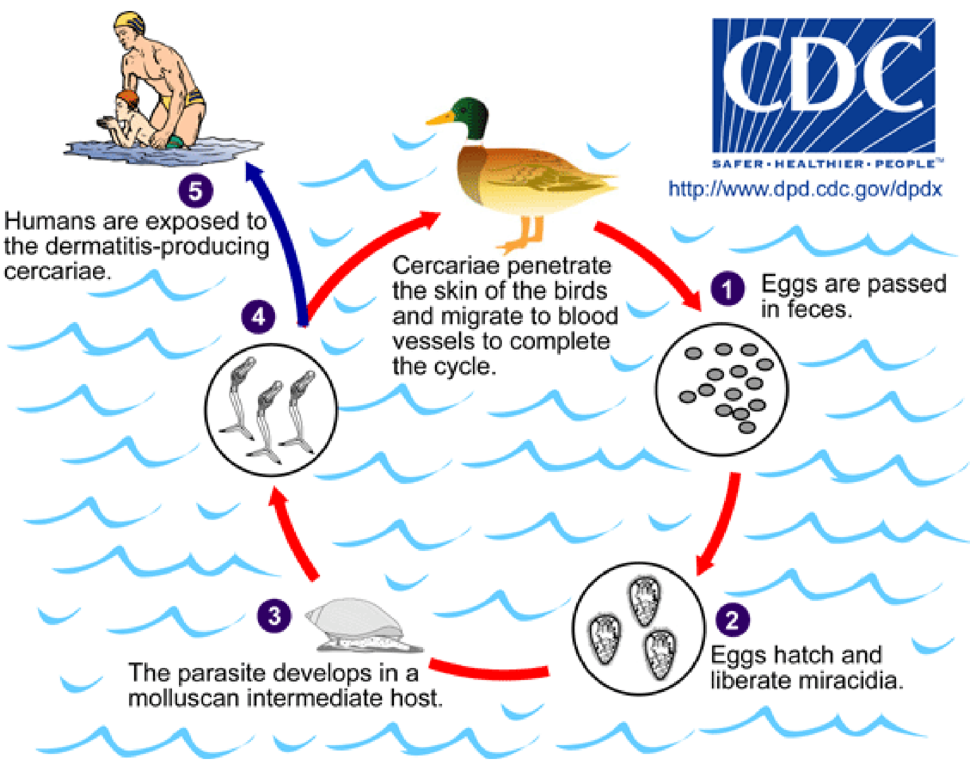


Figure 3.3-3. Swimmer's itch life cycle. Obtained directly from the Centers for Disease Control & Prevention website (CDC 2012).

The larval stage (cercariae) of this group of flatworms needs to burrow into the skin of certain bird species to complete its lifecycle❹. While the primary hosts are ducks, gulls, geese, swans, and red-winged blackbirds, other non-bird species (e.g. muskrats, mice) have also been shown to complete this parasite's life cycle. Mergansers have been known to have some of the highest infection rates of this group of parasites. After the flatworm matures in the bird host, it produces eggs that are released into the water through the bird's feces❶. The eggs hatch ❷ and the immature life stage (miracidia) of the parasite seeks out a snail host to continue maturation ❸. While not all snail species will suffice as intermediate hosts for the flatworms, nine or more species have been known to host flatworm species associated with swimmer's itch. Once the flatworm matures the larval cercaria emerges and seeks out a definitive host to complete the lifecycle. However, sometimes the cercariae accidently encounter a human and attempt to burrow into the skin ❺, causing the skin reaction discussed above.

Historically, molluscicides have been used to combat swimmer's itch by targeting the intermediate host, snails. The pesticides are non-selective towards snails, mussels, and other mollusks that play an integral part of the aquatic ecosystem. For that reason, along with the high expense and uncertain long-term consequences of applying these metal-based pesticides, this management technique has gone out of favor and typically is not permitted in Wisconsin.

However, there are some steps that can be taken to prevent or reduce the discomfort caused by swimmer's itch. The following summary list is based off information available on the WDNR's website (WDNR 2012B):

- Avoid spending time in shallow water, especially if swimmer's itch has been known to be a problem in the area.
- Avoid spending time in the water between noon and 2 p.m, during which cercariae are most prevalent.
- Towel off immediately after getting out of the water. Cercariae will not penetrate the skin until after the person leaves the water. There may be an opportunity to remove the parasite before this occurs.
- Discourage ducks and other waterfowl from congregating in or near swimming areas by keeping near-shore areas vegetated, and by avoiding feeding the birds.
- Avoid using riprap or seawalls along the shoreline, as this provides an excellent substrate for many snail species. Host snails are known to live on all types of substrate (sand, rock, mulch, vegetation) with an increased preference for sandy beaches.

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.

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 shoreline 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, thus 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 water-milfoil (*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 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, it 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 Pelican 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 Pelican Lake are discussed in the 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 those 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

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 dispose of 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.

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. • May require a WDNR permit

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 upon the timing of the treatment. Winter drawdowns are more common in temperate climates like those 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 hydroelectric 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 water-milfoil 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 (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*). • Permitting process may require an environmental assessment that may take months to prepare. • Unselective.

Mechanical Harvesting

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 and 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.

Chemical Treatment

The use of herbicides to control aquatic plants and algae is a technique that is widely used by lake managers. Traditionally, herbicides were used to control nuisance levels of aquatic plants and algae that interfere with navigation and recreation. While this practice still takes place in many parts of Wisconsin, the use of herbicides to control aquatic invasive species is becoming more prevalent. Resource managers employ strategic management techniques towards aquatic invasive species, with the objective of reducing the target plant's population over time; and an overarching goal of attaining long-term ecological restoration. For submergent vegetation, this largely consists of implementing control strategies early in the growing season; either as spatially-targeted, small-scale spot treatments or low-dose, large-scale (whole lake) treatments. Treatments occurring roughly each year before June 1 and/or when water temperatures are below 60°F can be less impactful to many native plants, which have not emerged yet at this time of year. Emergent species are targeted with foliar applications at strategic times of the year when the target plant is more likely to absorb the herbicide.

While there are approximately 300 herbicides registered for terrestrial use in the United States, only 13 active ingredients can be applied into or near aquatic systems. All aquatic herbicides must be applied in accordance with the product's US Environmental Protection Agency (EPA) approved label. There are numerous formulations and brands of aquatic herbicides and an extensive list can be found in Appendix F of Gettys 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, trageted 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 and migrates to adjacent areas, the concentrations are insufficient to cause significant affects. 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 $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • 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 water-milfoil. • Some herbicides can be used effectively in	• If not applied correctly, fast-acting herbicides may cause fishkills due to rapid plant decomposition. • 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 herbicides are nonselective.

spot treatments.	• Most herbicides have a combination of use restrictions that must be followed after their application. • Many herbicides are slow-acting and may require multiple treatments throughout the growing season. • Overuse may lead to plant resistance to herbicides

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.

<u>Milfoil Weevils – Eurasian Water Milfoil Bio-control</u>
However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil 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 water-milfoil 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 water milfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian water milfoil.

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 water-milfoil density.

<u>Galerucella Beetles – Purple Loosestrife Bio-control</u>
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 is required than other control methods. • Augmenting populations may 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 Pelican 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 species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific 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 life forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain 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 Pelican Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency of occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

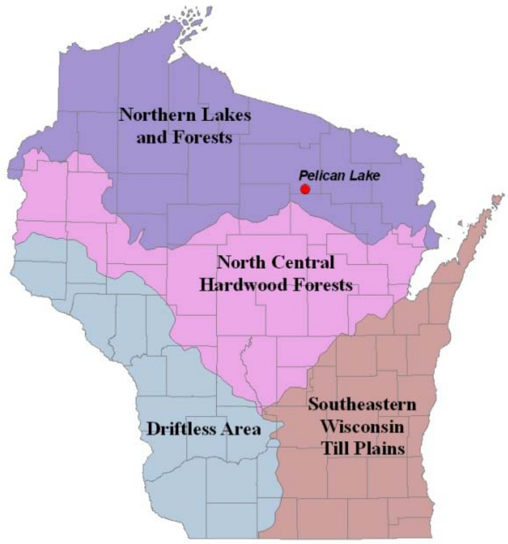


Figure 3.4-1. Location of Pelican Lake within the ecoregions of Wisconsin. After Nichols 1999.

In the end, this analysis indicates the species that dominate the plant community within the lake. Shifts in dominant plants over time may indicate disturbances in the ecosystem. For instance, low water levels over several years may increase the occurrence of emergent species while decreasing the occurrence of floating-leaf species. Introductions of invasive exotic species may result in major shifts as they crowd out native plants within the system.

Species Diversity and Richness

Species diversity is probably the most misused value in ecology because it is often confused with species richness. Species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because diversity also takes into account how evenly the species occur within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

A lake with high species diversity is much more stable than a lake with a low diversity. This is analogous to a diverse financial portfolio in that a diverse lake plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity.

Simpson's diversity index is used to determine this diversity in a lake ecosystem. Simpson's diversity (1-D) is calculated as:

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

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

Box Plot or box-and-whisker diagram graphically shows data through five-number summaries: minimum, lower quartile, median, upper quartile, and maximum. Just as the median divides the data into upper and lower halves, quartiles further divide the data by calculating the median of each half of the dataset.

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. Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to Pelican Lake. Comparisons will be displayed using boxplots that show median values and upper/lower quartiles of lakes in the same ecoregion (Water Quality section, Figure 3.1-2) and in the state. Please note for this parameter, the Northern Lakes and Forests Ecoregion data includes both natural and flowage lakes.

As previously stated, species diversity is not the same as species richness. One factor that influences species richness is the "development factor" of the shoreline. This is not the degree of human development or disturbance, but rather it is a value that attempts to describe the nature of the habitat a particular shoreline may hold. This value is referred to as the shoreline complexity. It specifically analyzes the characteristics of the shoreline and describes to what degree the lake shape deviates from a perfect circle. It is calculated as the ratio of lake perimeter to the circumference of a circle of area equal to that of the lake. A shoreline complexity value of 1.0 would indicate that the lake is a perfect circle. The further away the value gets from 1.0, the more the lake deviates from a perfect circle. As shoreline complexity increases, species richness increases, mainly because there are more habitat types, bays and back water areas sheltered from wind.

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Pelican Lake will be compared to lakes in the same ecoregion and in the state (Figure 3.4-1).

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.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake. For this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species' likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an native species that can act invasively, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. 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 survey and does not include incidental species or those encountered during other aquatic plan surveys.

Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; emergents include cattails, bulrushes, and arrowheads; floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

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 water milfoil are the primary targets of this extra attention.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.4-2). Eurasian water-milfoil 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 water-milfoil 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 water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

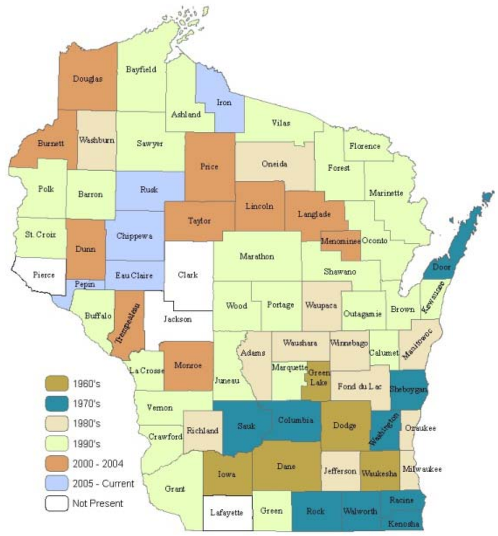


Figure 3.4-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900s that has an unconventional life cycle 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 water-milfoil, 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 water milfoil 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 which is completed in mid to late summer.

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. On June 15-17, 2011, a survey was completed on Pelican Lake that focused on curly-leaf pondweed. The survey was done at this time to find curly-leaf pondweed, if it were present in the lake, during its anticipated peak growth period. During the survey, two Onterra crews (four ecologists in two boats) meandered the littoral zone of the lake, intently looking for this AIS. While curly-leaf pondweed was not observed, one crew did spot a different invasive plant, Eurasian water milfoil, within the southwest corner of the lake. Discussion of exotic plant species takes place further below, at the end of the Aquatic Plant Section.

Several plant surveys were aimed at assessing the native aquatic plant species on Pelican Lake. On August 22-24 of 2011, three Onterra crews conducted a point-intercept survey on the lake. An additional survey was completed by Onterra on August 24, 2011, to create the aquatic plant community map which is discussed further below.

During the point-intercept and aquatic plant mapping surveys, 52 species of plants were located in Pelican Lake (Table 3.4-1). Two are considered non-native species: Eurasian water milfoil and *Nymphaea odorata var. rosea*, or what is commonly called a pink water lily. Aquatic plants were found in several different life forms: those that were emergent (rising above the surface of the water), submergent (remaining below the water's surface), floating yet rooted to the sediment, and those that are free-floating. Several species display characteristics of two life forms (e.g. submergent and emergent, or floating-leaf and emergent plants). Of the 50 native species found within the lake, 36 were found during the point-intercept survey and 14 were found during the community mapping survey or other surveys conducted over the course of this project (referred to as incidentals). The 36 species located within the point-intercept method are used in the analysis below.

Table 3.4-1. Aquatic plant species located on Pelican Lake during August 2011 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2011 (Onterra)
Emergent	Acorus calamus	Sweetflag	7	I
	Bolboschoenus fluviatilis	River bulrush	5	I
	Carex comosa	Bristly sedge	5	I
	Calla palustris	Water arum	9	I
	Carex lasiocarpa	Woollyfruit sedge	8	I
	Equisetum fluviatile	Water horsetail	7	X
	Eleocharis palustris	Creeping spikerush	6	X
	Iris versicolor	Northern blue flag	5	I
	Justica americana	Water willow	9	I
	Phragmites australis	Giant reed (native)	N/A	X
	Pontederia cordata	Pickerelweed	9	X
	Sagittaria latifolia	Common arrowhead	3	I
	Schoenoplectus tabernaemontani	Softstem bulrush	4	X
	Schoenoplectus acutus	Hardstem bulrush	5	X
	Typha spp.	Cattail spp.	1	I
	Zizania sp.	Wild rice Species	8	I
FL	Nymphaea odorata var. rosea	Water lily (pink)	Exotic	I
	Nymphaea odorata	White water lily	6	X
	Nuphar variegata	Spatterdock	6	X
	Polygonum amphibium	Water smartweed	5	I
FL/E	Sparganium fluctuans	Floating-leaf bur-reed	10	I
	Sparganium angustifolium	Narrow-leaf bur-reed	9	I
	Sparganium emersum	Short-stemmed bur-reed	8	I
	Sparganium eurycarpum	Common bur-reed	5	X
Submergent	Chara spp.	Muskgrasses	7	X
	Ceratophyllum demersum	Coontail	3	X
	Elodea canadensis	Common waterweed	3	X
	Isoetes sp.	Quillwort species	N/A	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	I
	Megalodonta beckii	Water marigold	8	X
	Myriophyllum sibiricum	Northern water milfoil	7	X
	Nitella sp.	Stoneworts	7	X
	Najas flexilis	Slender naiad	6	X
	Potamogeton friesii	Fries' pondweed	8	X
	Potamogeton illinoensis	Illinois pondweed	6	X
	Potamogeton praelongus	White-stem pondweed	8	X
	Potamogeton gramineus	Variable pondweed	7	X
	Potamogeton foliosus	Leafy pondweed	6	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X
	Potamogeton pusillus	Small pondweed	7	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton robbinsii	Fern pondweed	8	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Sagitaria sp. (rosette)	Arrowhead rosette	N/A	X
	Utricularia vulgaris	Common bladderwort	7	X
	Vallisneria americana	Wild celery	6	X
SE	Eleocharis acicularis	Needle spikerush	5	X
	Juncus pelocarpus	Brown-fruited rush	8	X
FF	Lemna turionifera	Turion duckweed	2	X
	Lemna trisulca	Forked duckweed	6	X
	Spirodela polyrhiza	Greater duckweed	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; I = Incidental Species

The sediment within littoral areas of Pelican Lake is very conducive for supporting a variety of aquatic plant types due to its variety. Data from the point-intercept survey indicate that approximately 46% of the sampling locations located within the littoral zone contained sand, while 33% of these locations contained muck, and 21% contained rock (Figure 3.4-2 and Map 4).

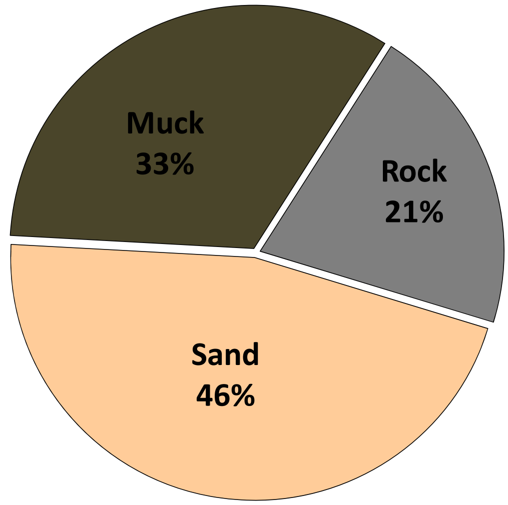


Figure 3.4-3. Pelican Lake proportion of substrate types within littoral areas. Created using data from an August 2011 aquatic plant point-intercept survey.

Approximately 52% of the point-intercept sampling locations that fell within the maximum depth of aquatic plant growth (15 feet), or the littoral zone, contained aquatic vegetation. Map 5 shows that the majority of the aquatic vegetation in Pelican Lake is located within the shallow bays and near-shore areas. As discussed in the water quality section, the water clarity in Pelican Lake is moderate, which allows sunlight penetration into deeper areas of the lake. This, in turn, allows for aquatic plant growth out to relatively deep areas of the lake. Although this is the case, Figure 3.4-3 shows that the majority of the aquatic vegetation growth in Pelican Lake remains between 1 and 8 feet.

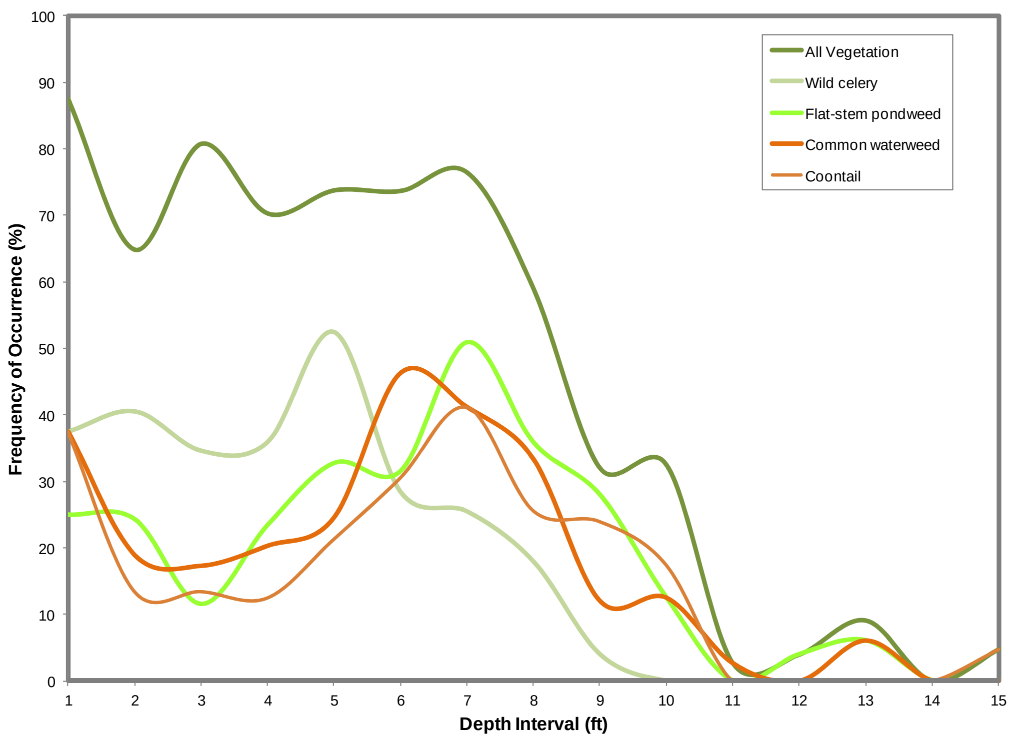


Figure 3.4-4. Frequency of occurrence at littoral depths for several Pelican Lake plant species. Created using data from August 2011 aquatic plant point-intercept survey.

Along with Eurasian water milfoil, one other milfoil species, northern water milfoil (*Myriophyllum sibiricum*), was found within Pelican Lake. Northern water milfoil is often falsely identified as Eurasian water milfoil because of its similar morphology and also its ability to take on a reddish appearance (much like Eurasian water milfoil does) as the plant reacts to sun exposure late in the growing season. This particular milfoil is, however, one of seven species that are native to Wisconsin. The invasive Eurasian water milfoil does have several characteristics that can be used to distinguish it from northern water milfoil though, including a difference in nodal spacing between leaf whorls and differences in leaflet counts. The feathery foliage of northern water milfoil traps filamentous algae and detritus, providing valuable invertebrate habitat. Because northern water milfoil prefers high water clarity, its populations are declining state-wide as lakes are becoming more eutrophic.

Aquatic plants can be placed in one of two general groups, based upon their form of growth and habitat preferences. These groups include the isoetid growth form and the elodeid growth form. Pelican Lake has both isoetid and elodeid species within its waters. Plants of the isoetid growth form are small, slow-growing, and inconspicuous submerged plants often resembling turf grass. They often have evergreen leaves located in a rosette and are usually found growing in sandy soils within the near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000). Pelican Lake holds several isoetid species (brown-fruited rush and needle spikerush) that are primarily located within shallow areas with a sandy or rocky substrate. The majority of plant species within Pelican Lake belong to the elodeid grouping. Elodeid plants have leaves on tall, erect stems which grow upwards into the water column and are often referred to as lake weeds by laypersons. Examples of Pelican Lake elodeid species include slender naiad, muskgrasses, wild celery, and different species of pondweeds.

Alkalinity is the primary water chemistry factor determining whether a lake is dominated by plant species of the isoetid or elodeid growth form (Vestergaard and Sand-Jensen 2000). Most elodeids are restricted to lakes of relatively higher alkalinity, as their carbon demand for photosynthesis cannot be met solely by the dissolved carbon dioxide (CO_2) present in the water, and they must acquire additional carbon through bicarbonate (HCO_3^-). While isoetids are able to grow in lakes of higher alkalinity, their short stature makes them poor competitors for light, and they are usually outcompeted and displaced by the taller elodeids. Thus, isoetids are most prevalent in lakes of low alkalinity where they can avoid competition from elodeids. However, in lakes with intermediate to high alkalinity levels, like Pelican Lake, we see a mixed community of both, with isoetids inhabiting the shallow, sandy/rocky areas and elodeids thriving in the deeper areas of softer sediment.

Of the 36 native aquatic plants found in Pelican Lake during the point-intercept survey, wild celery, flat-stemmed pondweed and common waterweed were the most common (Figure 3.3-4). Wild celery is a long, limp, ribbon-leaved turbidity-tolerant species that is a premiere food source for ducks, marsh birds, shore birds and muskrats. Animals may eat the entire plant, including the tubers that reside within the sediment. Flat-stem pondweed, as its name implies, is a freely branched plant with strongly flattened stems and long, stiff leaves. Flat-stem pondweed lacks floating leaves, a feature many plants in the *Potamogeton* genus have. This plant can be a locally important food source to many aquatic and terrestrial organisms. Common waterweed is able to obtain most of its nutrients through the water and thus does not produce extensive root systems. Sometimes, this plant may produce structures similar to roots (rhizoids) or become partially buried in the sediment. Because of this, the plant is susceptible to being easily uprooted and migrated by water-action and movement.

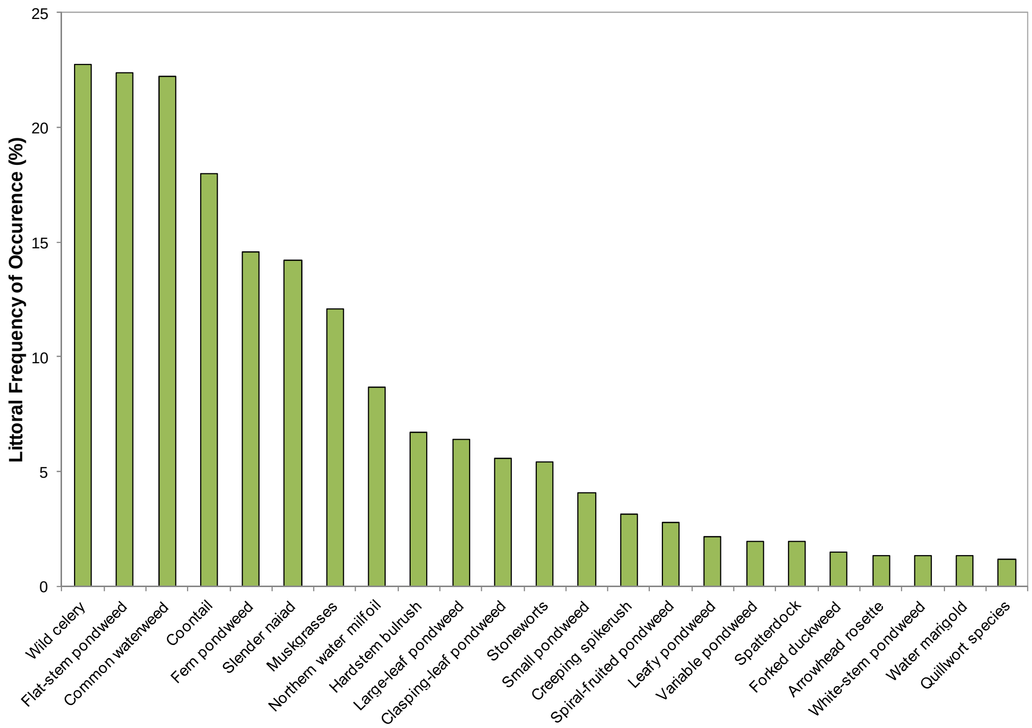


Figure 3.4-5 Pelican Lake aquatic plant littoral frequency of occurrence. Species with a occurrence greater than 1% are displayed. Created using data from August 2011 surveys.

The aquatic plants sampled during the point-intercept survey were found to vary in their abundance throughout the lake. As explained above in the Primer on Data Analysis and Data Interpretation Section, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Examination of Figure 3.4-4 shows that wild celery, flat-stem pondweed and common waterweed were all found at about 22-23% of littoral frequency. Because each sampling location may contain numerous plant species, relative frequency of occurrence is a tool that is utilized to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while wild celery was found at around 23% of the sampling locations in Pelican Lake, its relative frequency of occurrence is 12%. Explained another way, if 100 plants were randomly sampled from Pelican Lake, 12 of them would be slender naiad. Looking at relative frequency of occurrence (Figure 3.4-5), seven species comprise approximately 68% of the plant community in Pelican Lake.

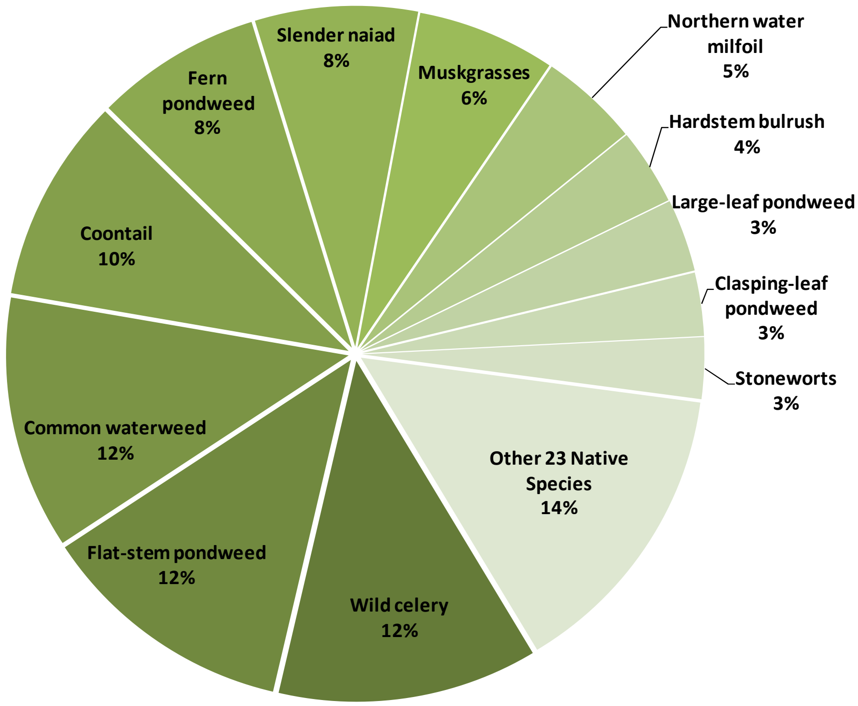


Figure 3.4-6 Pelican Lake relative plant littoral frequency of occurrence. Species with a occurrence greater than or equal to 3% are displayed. Created using data from August 2011 surveys.

As discussed previously, 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 during the point-intercept survey (36 species) and does not include incidental species. Figure 3.4-6 shows that the native species richness for Pelican Lake is above the Northern Lakes and Forests Ecoregion and Wisconsin State medians. The species that are present in Pelican Lake are indicative of moderately disturbed conditions. Data collected from the aquatic plant surveys show that the average conservatism value (6.2) is slightly below the Northern Lakes and Forest Lakes Ecoregion median value, but slightly higher than the Wisconsin state median (Figure 3.4-6). This indicates that some of the plant species found in Pelican Lake are considered sensitive to environmental disturbance, while some of the species present are typically found within ecosystems that have been disturbed by human presence.

Combining Pelican Lake's aquatic plant species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a high value of 37.1 (equation shown below); which is above the median values for the ecoregion and state (Figure 3.4-6), and illustrates the overall quality of Pelican Lake's plant community.

$$\text{FQI} = \text{Average Coefficient of Conservatism (6.2)} * \sqrt{\text{Number of Native Species (36)}}$$
$$\text{FQI} = 37.1$$

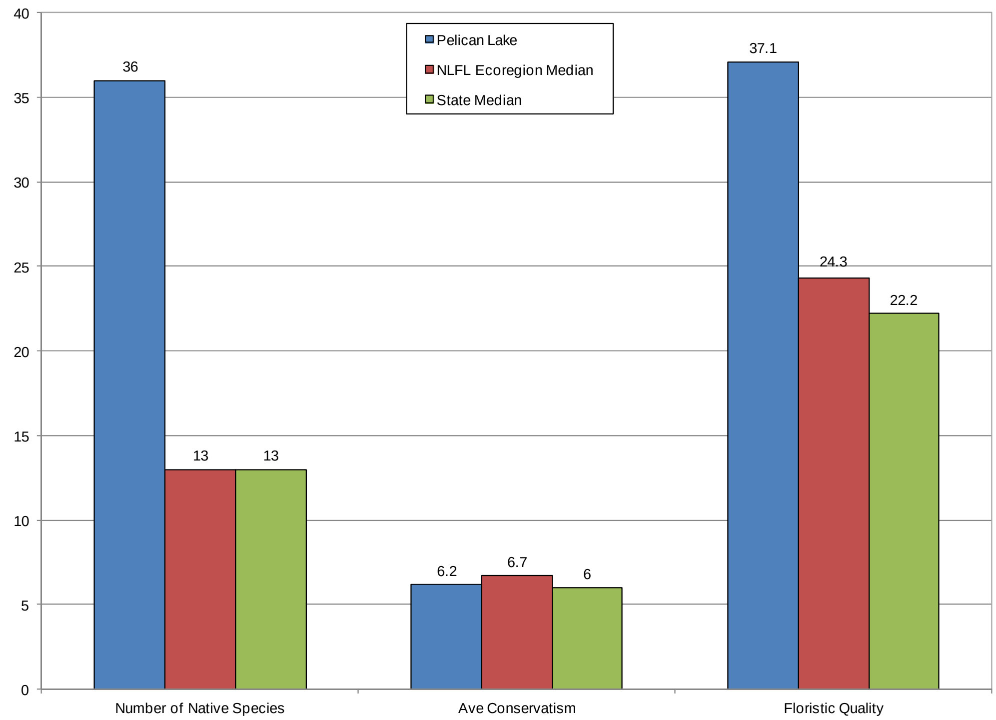


Figure 3.4-7. Pelican Lake Floristic Quality Assessment. Created using data from August 2011 aquatic plant surveys. Analysis following Nichols (1999) where NLFL = Northern Lakes and Forest Lakes Ecoregion.

Because Pelican Lake contains a high number of native aquatic plant species, one may assume that the aquatic plant community is also highly diverse. However, as discussed earlier, species diversity is not only influenced by the number of species present, but by how evenly the plant species are distributed within the community.

The aquatic plant community in Pelican Lake was found to be highly diverse, with a Simpson's diversity value of 0.92 (Figure 3.4-7). This value ranks above state and ecoregion upper quartiles. Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provide fish, zooplankton, macro-invertebrates, and other wildlife with diverse structural habitat and various sources of food.

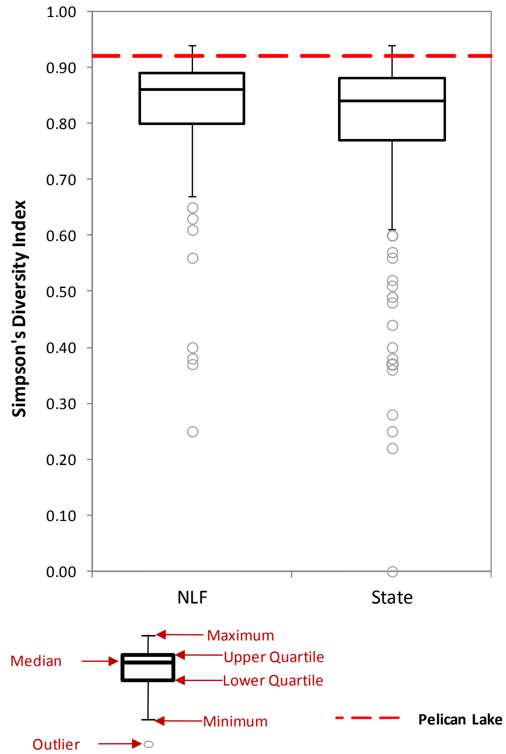


Figure 3.4-8. Pelican Lake species diversity index. Created using data from August 2011 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

The 2011 community map indicates that approximately 225.4 acres (6%) of the 3,585 acre-lake contain emergent and floating-leaf plant communities (Table 3.4-2 and Map 6). 24 floating-leaf and emergent species were located in Pelican Lake, providing valuable structural habitat for invertebrates, fish, and other wildlife. These communities also stabilize the substrate and shoreline areas by dampening wave action from wind and watercraft.

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 Pelican 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 shorelines when compared to the undeveloped shorelines 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 shorelines.

Table 3.4-2. Pelican Lake acres of plant community types. Created from August 2011 community mapping survey.

Plant Community	Acres
Emergent	124.3
Floating-leaf	6.8
Mixed Floating-leaf and Emergent	94.3
Total	225.4

Aquatic Plants of Concern – Common Reed Grass

Common Reed Grass

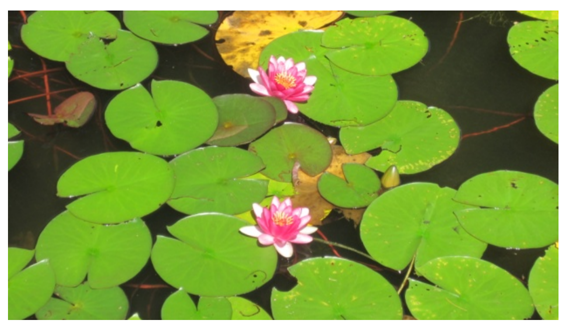
Phragmites australis subs. americanus, or, common reed grass, is a subspecies of a plant that can be found on every continent except Antarctica. It is believed that populations of common reed grass existed in pre-colonial Wisconsin, but exotic strains from Europe have been introduced and have invaded the genetic line of the native strain. Genetic identification of the plant is needed to determine whether the plant is of the native or non-native strain. A pressed specimen of this species from Pelican Lake was sent to Dr. Robert Freckman at the University of Wisconsin – Steven's Point where morphologically it appeared to be a native strain. The subspecies *americanus* is native to North America and typically does not display invasive behavior, as the exotic *Phragmites australis* does. These characteristics include towering, dense colonies that overtake native vegetation and replace it with a monoculture that provides inadequate food and habitat for wildlife.

Although this plant appears to be morphologically native, it is recommended that this population be monitored for expansion. The plant currently occupies relatively small areas along the northern and northwestern shorelines of the lake, where it is found mixed with large expanses of hardstem bulrush (Map 6). If it appears that the plant is spreading within the bulrushes or along the shorelines of Pelican Lake, the regional WDNR Lake Specialist should be contacted to coordinate the submission of plant specimens for genetic testing. If the common reed is determined to be an exotic strain, further management actions may follow.

Exotic Aquatic Plant Species in Pelican Lake

Water lily (pink)

During the 2011 point-intercept survey, Onterra ecologists came upon an occurrence of an exotic floating-leaf plant - *Nymphaea odorata var. rosea*, or what is commonly called a pink water lily. This is a floating-leaf species closely related to white water lily. It is a subspecies that is commonly found planted within small ornamental ponds or aquariums. It is popular in this arena due to the bright pink/rose-colored flower it produces. This colony was found to exist in only a single location. Currently, this variety of lily is considered non-native, though not necessarily invasive, as it is not thought to exhibit the aggressive, rapidly expanding qualities that invasive plants such as Eurasian water milfoil and curly-leaf pondweed display. During a September 2012 visit to the lake, Onterra ecologists visited the location of this lily species and determined that no expansion of the colony had occurred. Nevertheless, it is recommended that this non-native plant be manually removed from the lake and not given the chance to expand. Details regarding the management of this water lily are discussed within the Implementation Plan.



Photograph 3.4-1. *Nymphaea odorata var. rosea,* Pelican Lake.

Eurasian water milfoil

As mentioned above, Eurasian water milfoil was first discovered by Onterra ecologists during a June 15, 2011 curly-leaf pondweed survey. Crews scoured the immediate area, a shallow bay on the southwest side of the lake, and mapped numerous occurrences of the plant using sub-meter GPS technology (Map 7). Some areas were mapped with point-based mapping in which a GPS waypoint is taken to indicate a single or few plants, clump of plants, or a small plant colony. One particularly dense area was delineated using a polygon-mapping method in which the Onterra crew was able to drive their boat around the colony, continuously mapping its extent. Onterra staff made a follow-up visit to the lake on June 28 to place buoys around this particularly dense colony in an effort to reduce motorboat traffic here. One other occurrence of Eurasian water milfoil was observed, in the form of two plants located on the north side of the lake in shallow (2 feet) water (Map 7). These plants were carefully removed.

Photograph 3.4-2. Buoys placed by Onterra staff marking a dense EWM colony.

Following discussions between the PLPOA, WDNR, and Onterra ecologists during the winter of 2011/2012, an aggressive 14.6 acre herbicide treatment was planned for the spring of 2012. The treatment was conducted on two treatment areas, utilizing granular 2,4-D at a concentration of 3.0 ppm acid equivalent (Map 8). Onterra staff visited the treatment areas several days prior to herbicide application to verify the extents of the treatment areas in the event that colonial expansion had potentially occurred. Post-treatment surveys were conducted by Onterra on September 17, 2012 to determine the treatment's efficacy. During this survey, two crews meandered the entire littoral area of Pelican Lake while focusing intently upon the southwestern bay and the 2012 treatment areas. Few invasive plants were observed during this survey, indicating that the treatment in 2012 had been successful (Map 8).

Additional information about the EWM population and management activities is contained within the Pelican Lake EWM 2013 Annual Report (Appendix G).

As many who involve themselves with aquatic invasive species management know, controlling Eurasian water milfoil is a very difficult endeavor, with permanent removal (eradication) of this species from a lake ecosystem being essentially impossible. Continued monitoring, both volunteer and professional-based, as well as hand removal work and potentially future herbicide treatments will be necessary to combat this aggressive, invasive plant.

3.5 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here for 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 numerous fisheries biologists overseeing Pelican Lake. The goal of this section is to provide a brief overview of some of the data that exists, particularly in regard to specific issues (e.g. spear fishery, fish stocking, angling regulations, etc.) that were brought forth by the PLPOA stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2010 & GLIFWC 2010A and 2010B).

Pelican Lake Fishery

Pelican Lake Fishing Activity

Based upon data collected from the stakeholder survey (Appendix B), fishing was the second highest ranked important or enjoyable activity on Pelican Lake (Question #13). Nearly 58% of stakeholders have fished the lake for over 25 years (Question #8). Yellow perch, walleye and bluegill/sunfish were listed as the top species of fish the survey respondents indicated they enjoyed catching (Question #10). Approximately 43% of the respondents believed that the quality of fishing on the lake was "Fair," while about 30% believed the fishing is "Poor" or "Very Poor" (Question #9). The majority of survey respondents (76%) indicated that the fishing has gotten worse since they started fishing Pelican Lake (Question #11).

Table 3.5-1 shows the popular game fish that are present in the system. Management actions that have taken place and will likely continue on Pelican Lake, according to this plan include herbicide applications to control Eurasian water milfoil. In the future, these applications will occur in early spring when the water temperatures are between 50-60°F. It is important to understand the effect the chemical has on the spawning environment The chemical would be to remove the submergent plants that are actively growing at these low water temperatures. Yellow perch is a species that could potentially be affected by early season herbicide applications, as the treatments could eliminate nursery areas for the emerged fry of these species. Muskellunge is another species that may be impacted by early season treatments as water temperatures and spawning locations often overlap.

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 game fish in Pelican 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, 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 game fish, such as bass and walleyes, that are often sought after by anglers.

Table 3.5-1. Gamefish present in Pelican Lake with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Bullhead	*Ictalurus melas*	5	April - June	Matted vegetation, woody debris, overhanging banks	Amphipods, insect larvae and adults, fish, detritus, algae
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
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge	*Esox masquinongy*	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish, including other muskies, small mammals, shore birds, frogs
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 coarse 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, wave-washed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
White Bass	*Morone chrysops*	8	Late April - June	Running water of streams, windswept shorelines, sand, gravel, or rock	Crustaceans, insect larvae and other invertebrates, and fish
Yellow Bullhead	*Ameiurus natalis*	7	May - July	Heavily- 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

Table 3.5-2 Non-game fish present in Pelican Lake. Information obtained through WDNR field survey reports (WDNR 2010).

Common Name	Scientific Name	Common Name	Scientific Name
Bluntnose minnow	*Pimephales notatus*	Logperch	*Percina caprodes*
Burbot	*Lota lota*	Mimic shiner	*Notropis volucellus*
Common shiner	*Luxilus cornutus*	Mottled sculpin	*Cottus bairdi*
Creek chub	*Semotilus atromaculatus*	Northern Redbelly dace	*Phoxinus eos*
Emerald shiner	*Notropis atherinoides*	Spottail shiner	*Notropis hudsonius*
Fathead minnow	*Pimephales promelas*	Trout perch	*Percopsis omiscomaycus*
Golden shiner	*Notemigonus crysoleucas*	Western Blacknose dace	*Rhinichthys atratulus*
Iowa darter	*Etheostoma exile*	Pumpkinseed X Bluegill	*Lepomis gibbosus X Lepomis macrochirus*
Johnny darter	*Ethostoma nigrum*	White sucker	*Catostomus commersoni*

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 3.5-1.

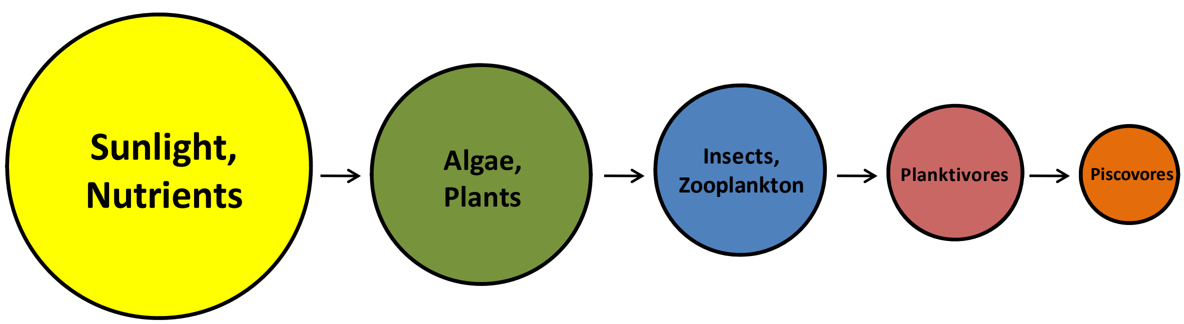


Figure 3.5-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Pelican Lake is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means Pelican Lake should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust.

Pelican Lake Spear Harvest Records

Approximately 22,400 square miles of northern Wisconsin were ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.5-2). Pelican Lake falls within the ceded territory based upon the Treaty of 1837. This allows for a regulated open water spear fishery by Native Americans on specified systems. Determining how many fish are able to be taken from a lake, either by spear harvest or angler harvest, is a highly regimented and dictated process. This highly structured procedure begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then a "total allowable catch" is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% (walleye) or 27% (muskellunge) of the lake's known or modeled population, but may vary on an individual lake basis due to other circumstances. In lakes where population estimates are out-of-date by 3 years, a standard percentage is used. The total allowable catch number may be reduced by a percentage agreed upon, by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level." Often, the biologists overseeing a lake cannot make adjustments due to the regimented nature of this process, so the total allowable catch often equals the safe harvest level. The safe harvest level is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest level is then multiplied by the percentage claimed by the Indian communities. This result is called the declaration, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal declaration and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

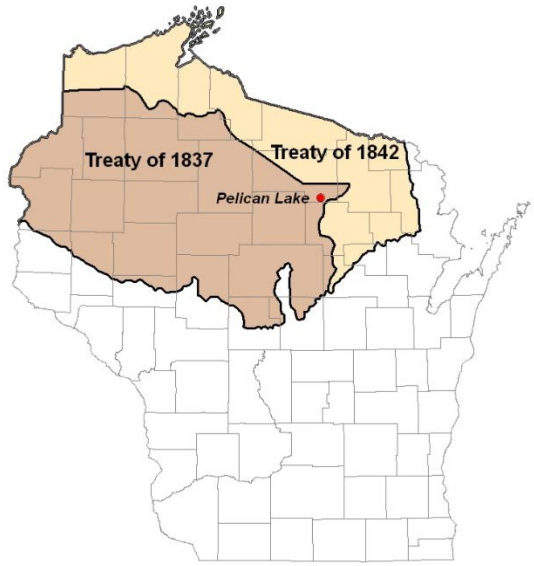


Figure 3.5-2. Location of Pelican Lake within the Native American Ceded Territory (GLIFWC 2010A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season; however, in practice, walleye and muskellunge are the only species harvested in significant numbers, so conservative quotas are set for other species. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2010B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly declaration is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the declaration is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller declarations. Starting with the 2011 spear harvest season, on lakes with a harvestable declaration of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

The Mole Lake tribe routinely harvests walleye and muskellunge during the open water spear season on Pelican Lake. Walleye open water spear harvest records are provided in Figure 3.5-3. One common misconception is that the spear harvest targets the large spawning females. Figure 3.5-3 shows that the opposite is true with only 11% of the total walleye harvest since 1998 comprised of female fish on Pelican Lake. Tribal spearers may only take two walleyes over 20 inches per nightly permit; one between 20 and 24 inches, and one of any size over 20 inches (GLIWC 2010B). This regulation limits the harvest of the larger, spawning female walleye.

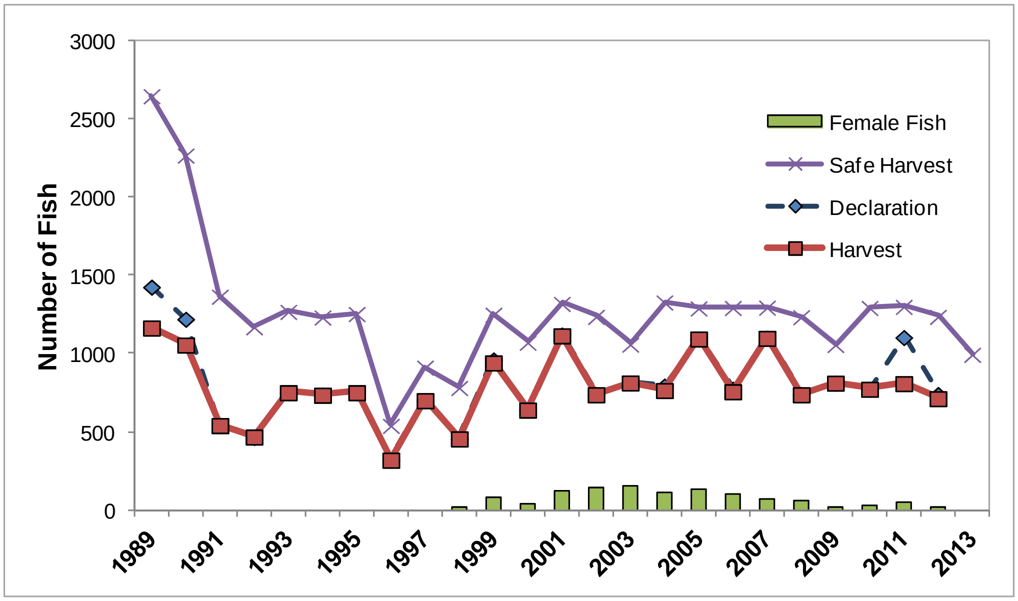


Figure 3.5-3. Walleye spear harvest data. Annual total walleye harvest and female walleye harvest are displayed since 1998 (data received from T. Cichosz, WDNR).

On lakes that are declared by Native American tribes for spear harvest, monitoring of the species of interest is conducted by both the GLIFWC and the WDNR. Periodically, these agencies will conduct population estimates to ensure that safe harvest levels are accurately assessed prior to the angling and spear harvest seasons. Figure 3.5-4 displays population estimates of walleye for four years between 1990 and 2011. A common way to depict fish populations is in numbers of fish per acre; for 1990, 2001, 2007 and 2011 walleye were estimated to be in abundances of 3.0, 2.8, 2.8 and 2.4 fish per acre, respectively.

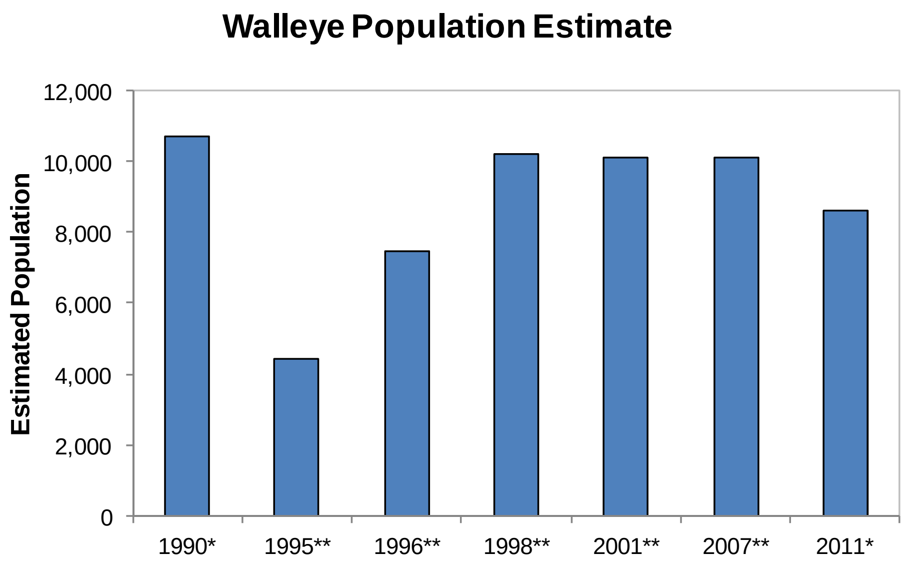


Figure 3.5-4. Estimated walleye population. Population estimates as a result of GLIFWC and WDNR surveys. Data provided by GLIFWC (**) and WDNR (*).

Figure 3.5-5 displays the Native American open water muskellunge spear harvest since 1998. Since 1998, an average of 13 muskellunge per year have been harvested during the open water spear fishery. The Mole Lake tribe has historically claimed a quota of 23 to 26 muskellunge on the lake, representing 57-59% of the safe harvest level. Spearers have harvested an average of 52% of their declaration during 1998-2012, although harvest rates have varied from 15% to 100% of the declared quota in this time period.

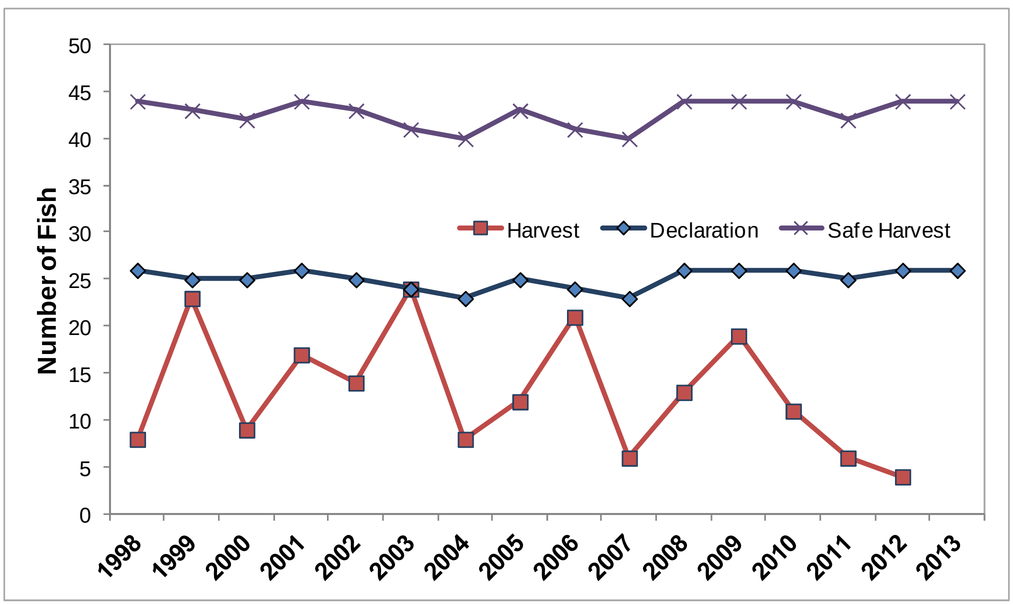


Figure 3.5-5. Muskellunge spear harvest data. Annual total muskellunge harvests are displayed since 1998 (data received from T. Cichosz, WDNR).

Pelican Lake Fish Stocking and Management

To assist in meeting fisheries management goals, the WDNR may stock fish in a waterbody if the fish were raised in a nearby permitted hatchery. Stocking of a lake is sometimes done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Fish can be stocked as fry, fingerlings or even as adults.

Stocking of walleye and muskellunge occurred historically in Pelican Lake. Stocking of walleye ceased in the mid-1980's, as biologists believe that natural reproduction of this species is occurring without difficulty. It is against WDNR policy to permit walleye stocking in lakes with adequate natural reproduction because the potential risks outweigh the benefits. Research has shown that stocking to supplement natural reproduction is usually ineffective. Second, in addition to inefficient spending of resources, the danger always exists that genetic strains may cross and produce undesirable traits in the population, or that parasites, pathogens or invasive species may be introduced when fish are stocked.

WDNR staff has begun collecting eggs from muskellunge sampled during spring netting trips. These eggs are hatched at the Art Oehmcke state fish hatchery to stock waterbodies in the state. Based upon survey findings in 2011 and 2012, WDNR biologists have decided to begin stocking muskellunge once again in Pelican Lake. In fall of 2012, the WDNR stocked 3,611 large fingerling muskellunge averaging 11.5 inches in length. These fish originated from Pelican Lake eggs that were taken to the Art Oehmcke hatchery. Because eggs will continue to be collected on a rotational basis from Pelican Lake muskellunge (every 3-5 years), WDNR biologists plan to stock muskellunge when this collection occurs.

The PLPOA raised money in the late 1990s-early 2000s to fund a private stocking program. Through conversations with WDNR, it was decided that panfish would be stocked as an alternative to stocking walleye, which was their original intent. Perch were stocked in 2001-2003, and bluegill stocked in 2004. A panfish survey was conducted in 2005 by the WDNR to evaluate the panfish stocking program, and make recommendations for future stocking activities (Appendix F – Panfish Survey report). At the conclusion of the study, it was discovered that bluegill abundances, growth rates and size structures were all above average, and that stocking bluegill was not necessary to assist the number or size structure of the overall population.

In 2011, WDNR biologists completed a comprehensive survey on the lake, aiming to assess all fish populations (Appendix F – Comprehensive Fisheries Survey). This study found good populations of all gamefish within the lake, including walleye, northern pike, largemouth bass, smallmouth bass, muskellunge and panfish. It was concluded that Pelican Lake is best managed for a diverse fishery including walleye, muskellunge, northern pike, bass and panfish. In particular, this fishery is managed with trophy muskellunge fish and quality-size potential for other species in mind. Interestingly, Pelican Lake also has the only white bass population in the area, which was introduced from the Lake Winnebago system.

The two WDNR reports in Appendix F contain specifics regarding the panfish and comprehensive survey studies, stocking records, and detailed management recommendations.

Pelican Lake Fishing Regulations

Because Pelican Lake is located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to Pelican Lake. In 2011, the daily bag limit remained at two walleye from the lake, with a minimum length requirement of 15”.

Pelican Lake is in the northern half of the muskellunge and northern pike management zone. Additionally, Pelican Lake is listed as an A1 trophy water for this species, meaning the lake has proven the ability to produce large muskellunge, though overall numbers may be relatively low. Muskellunge must be 50” to be harvested, with a daily bag limit of one fish, while no minimum length limit exists for northern pike and only 5 pike may be kept in a single day. For bass species, a catch-and-release season runs from the first Saturday in May to the third Saturday in June. Pelican Lake is listed as having a quality bass fishery and special regulations are set to enhance this fishery and promote predation on invasive rusty crayfish. Following this catch-and-release season, a single bass (largemouth or smallmouth) may be kept daily, and a minimum length limit of 18” exists. Statewide regulations apply for all other fish species.

Pelican Lake Substrate Type

According to the point-intercept survey conducted by Onterra, 46% of the substrate sampled in the littoral zone on Pelican Lake was sand, 33% was found to be muck, and the remaining 21% consisted of various sizes of rock (Map 4). Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Muskellunge is one species that does not provide parental care to its eggs (Becker 1983). Muskellunge 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 do not 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 in muck as well.

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 Pelican Lake ecosystem.
2) Collect detailed information regarding invasive plant species within the lake, with the primary emphasis on Eurasian water milfoil.
3) Collect sociological information from Pelican 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 Pelican Lake ecosystem, a better understanding of the views of the residents who participated in the information gathering components of the project, and what is needed to enhance and protect Pelican Lake.

Overall, the studies conducted on Pelican Lake indicate that the lake is in good health. Phosphorus, the nutrient of concern in most Wisconsin lakes, is not found in excess within the lake, as determined by over a decade's worth of monitoring. An analysis within the Water Quality Section indicates that concentrations are *Excellent* to *Good*, and comparable to similar lakes across the state and ecoregion. Many lakes across the state suffer from excessive phosphorus content; the results vary, but include nuisance conditions of aquatic plants as well as algae blooms that cover the surface of the lake like a blanket. The algae content of the lake (as monitored through chlorophyll-*a* abundance) is only slightly higher than the median for similar lakes across the state and for all regional lakes, and ranks as *Good* overall. The algal content within the lake seems to do little to affect the clarity of the lake, which ranks within the *Excellent* category for drainage lakes across the state.

A lake's water quality and quantity are often a reflection of the surrounding drainage basin, or watershed. Drainage lakes, such as Pelican Lake, may have large watersheds that contribute nutrients and sediments to the lake through surface water runoff. In Pelican Lake's case, however, the watershed is only three times larger than the lake. This limits the quantity of nutrients and sediments that the lake will receive. One of the concerning areas of the watershed that may be impacting the ecology of Pelican Lake in a negative manner is the immediate portion of the watershed – the shoreland zone. As described in the Shoreland Condition Section, roughly 6.6 miles of the 16.4 mile Pelican Lake shoreland were classified as Urbanized or Developed-Unnatural during a 2011 survey. Past and present research has indicated that the immediate shoreline provides many ecological services due to its being located at the interface between the aquatic and terrestrial environment. In regards to protecting Pelican Lake, conserving the existing natural shoreline and restoring areas of disturbed shoreline may be one of the best options at this time. Enhancing this shoreland condition will have an overall benefit to the ecosystem of Pelican Lake, which will include benefits to the lake's game fishery.

The aquatic plant community of Pelican Lake is unique, with a total of 52 native species found within the lake during multiple surveys. Through numerous analyses, it was determined that the diversity, richness and overall quality of Pelican Lake's aquatic plant community is of very high quality compared to similar lakes across the state and throughout the Northern Lakes and Forests

Ecoregion. A high quality aquatic plant community provides a multitude of ecological functions within a lake, including habitat for aquatic organisms such as fish and insects, uptake of nutrients that would otherwise feed algae growth, and limiting the spread of aquatic invasive plant species that are quick to colonize exposed substrates in lakes.

Despite having a quality aquatic plant community, the aggressive invasive plant, Eurasian water milfoil, has been able to establish itself in Pelican Lake. Discovered during 2011 Onterra surveys, the plant has spread to a relatively small and isolated area within the southwestern-most bay in Pelican Lake. It is fortunate that the invasive plant was discovered early in its infestation, as it is more easily controlled in this situation than if it were to spread to other areas of the lake. Immediately after its discovery, PLPOA members and WDNR officials were made aware of its presence and efforts were taken to reduce watercraft traffic through the densest area of Eurasian water milfoil growth. An aggressive herbicide treatment was enacted in early spring of 2012, and follow-up surveys later that summer indicated that the treatment had largely been successful with a good reduction in Eurasian water milfoil abundance.

Eradication of Eurasian water milfoil is certainly a difficult, if not impossible, task with what is currently known about aquatic invasive species management. The PLPOA has been incredibly proactive in minimizing the spread of aquatic invasive species to Pelican Lake, and taking efforts to control the ones that are present. The group has agreed to form an alliance with Oneida County Aquatic Invasive Species Coordinator Michele Sadauskas to properly monitor and document Eurasian water milfoil occurrence in the lake, as per outlines specified in the Implementation Plan. Additionally, the group will be monitoring communities of *Phragmites*, a large wetland emergent grass that has been located on Pelican Lake. At this time, it is believed the plant is a native strain of the genus; however, the large, dense colonies have PLPOA members concerned about the potential for it to spread further and overtake other areas of the near-shore zone. Ms. Sadauskas and PLPOA members will be working to document any expansion of this species within the lake. Additionally, samples of plant tissue and sediment contents will be sent to the Chicago Botanic Garden as part of a project to genetically identify the species and examine the substrate it grows in.

The productivity of the lake in terms of its water chemistry and aquatic plant community is perfect for producing a quality fishery. WDNR studies have shown that ample natural reproduction of top game fish species such as muskellunge and walleye occurs in Pelican Lake, and that populations of these species are ample. The lake currently boasts a trophy muskellunge fishery and a high quality fishery for other game fish. However, the fishery can be stressed by a number of factors, including heavy fishing pressure (as determined by a 2011-2012 creel survey), as well as a lack of diverse habitat and excessive shoreland development. It is important that those trying to improve the fishery of Pelican Lake understand the complex nature of these stressors, and work with stakeholders to make management decisions that will benefit the lake ecosystem, as opposed to harming it.

Through the process of this lake management planning effort, the PLPOA has learned much about their lake, both in terms of its positive and negative attributes. Overall, the lake is healthy, but there are several aspects which require attention. It is now the PLPOA's responsibility to maximize the positive attributes while minimizing the negative attributes as much as possible. The Implementation Plan that follows this section stems from discussions between Onterra ecologists and the PLPOA Planning Committee on which action items the association may implement to properly maintain and care for this resource.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the PLPOA Planning Committee and ecologist/planners from Onterra. It represents the path the PLPOA 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 Pelican 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 upon the condition of the lake, the availability of funds, the level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Increase the Pelican Lake Property Owners Association's Capacity to Communicate with Lake Stakeholders

Management Action: Enhance the PLPOA's involvement with other entities that manage aspects of Pelican Lake.

Timeframe: Continuation of current effort.

Facilitator: Pelican Lake Board of Directors

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 and agencies. It is important that the PLPOA 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. While not an inclusive list, the primary management units regarding Pelican Lake are the WDNR (fisheries, AIS, and lake management personnel), the Chamber of Commerce, Schoepke and Enterprise Townships, Oneida County Lakes & Rivers Association (OCLRA), Wisconsin Lakes, and Oneida County Land and Water Conservation Department. Each entity is specifically addressed in the table on the next page.

Action Steps:

1. See table guidelines on the next page.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Chamber of Commerce	General staff (715-487-5222)	Provides information and networking related to the advancement of the Pelican Lake community.	Once a year, or more as needed. May check website (http://www.pelicanlakewi.org/Home.html) for updates.	The Chamber of Commerce serves a valuable role in promoting local businesses, tourism, and community within the Pelican Lake area.
Oneida County Lakes & Rivers Association (OCLRA)	Secretary (Connie Anderson – 715.282.5798)	Protects Oneida Co. waters through facilitating discussion and education.	Twice a year or as needed.	Become aware of training or education opportunities, partnering in special projects, or networking on other topics pertaining to Oneida Co. waterways.
Oneida County AIS Coordinator	AIS Coordinator (Michele Saduaskas – 715.365.2750)	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 to Ms. Saduaskas.
Oneida County Land and Water Conservation Department	Conservation specialist (Jean Hansen – 715.365.2750)	Oversees conservation efforts for land and water projects.	Twice a year or more as needed.	Ms. Hansen may be contacted for information regarding cost assistance and technical expertise on conservation related efforts.
Town of Enterprise	Beth Kroeger (715.487.6132)	Part of Pelican Lake falls within the Town of Enterprise	As needed.	Town staff may be contacted regarding ordinance reviews or questions, and for information on community events.
Town of Schoepke	Karen Hagedorn (715.487.5875)	Part of Pelican Lake falls within the Town of Schoepke	As needed.	Town staff may be contacted regarding ordinance reviews or questions, and for information on community events.
Wisconsin Department of Natural Resources	Fisheries Biologist (John Kubisiak – 715.365.8919)	Manages the fishery of Pelican Lake.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Kevin Gauthier – 715.365.8937)	Oversees management plans, grants, all lake activities.	Once a year, or more as issues arise.	Information on updating a lake management plan (every 5 years) or to seek advice on other lake issues.
	Warden (Jim Jung – 715.365.8950)	Oversees regulations handed down by the state.	As needed. May call the WDNR violation tip hotline for anonymous reporting (1-800-847-9367, 24 hours a day).	Contact regarding suspected violations pertaining to recreational activity on Pelican Lake, include fishing, boating safety, ordinance violations, etc.
	Citizens Lake Monitoring Network contact (Sandra Wickman – 715.365.8951)	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.
Wisconsin Lakes	General staff (800.542.5253)	Facilitates education, networking and assistance on all matters involving WI lakes.	As needed. May check website (www.wisconsinlakes.org) often for updates.	PLPOA members may attend WL's annual conference to keep up-to-date on lake issues. WL reps can assist on grant issues, AIS training, habitat enhancement techniques, etc.

Management Action: Support an Educational Committee to promote public safety, community, quality of life and ecological understanding on Pelican Lake.

Timeframe: Begin 2013.

Facilitator: Pelican Lake Board of Directors.

Description: Education represents an effective tool to address issues that impact water quality, such as lake shore development, lawn fertilization, and other issues like air quality, noise pollution, and boating safety. An Educational Initiative will be created to promote lake protection through a variety of educational efforts.

Currently, the PLPOA periodically distributes two newsletters a year to association members. These newsletters allow for exceptional communication within the lake group. The association also maintains a website, and holds three meetings a year in which the 250-300 members are welcome to attend. This level of communication is important within a management group because it builds a sense of community while facilitating the spread of important association news and educational topics. It also encourages socialization of association members and provides a medium for the recruitment and recognition of volunteers. Perhaps most importantly, the dispersal of a well-written newsletter can be used as a tool to increase awareness of many aspects of lake ecology and management among association members. By doing this, meetings can often be conducted more efficiently and misunderstandings based upon misinformation can be avoided. Educational articles within the association newsletter may contain monitoring results and association management history, as well as other educational topics listed below. The PLPOA has also discussed distilling particular information provided within the management plan, such as the Shoreland Section (3.3), and providing it to new residents on the lake.

The PLPOA 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 treatment and monitoring updates
- Basic lake ecology
    - Water clarity and watershed connection
    - Role of phosphorus
- Boating ordinances (slow-no-wake rules)
- Pier rules
- Loon nesting
- Noise, air, and light pollution

- Shoreline habitat restoration and protection
- Septic system maintenance
- Fishing regulations and management updates

In particular, the PLPOA wishes to increase the level of distribution of science and ecology related material, so Pelican Lake property owners may have a better understanding of the complex nature of Pelican Lake. Partnerships with WDNR and UW Extension personnel can aid in the research and dissemination of science-based materials. Furthermore, this material would include methods that educate riparian property owners on how their properties impact the lake, and what can be done to minimize this impact.

Action Steps:

1. Recruit volunteers to form an Education Committee.
2. Investigate if WDNR small-scale Lake Planning Grant would be appropriate to cover initial setup costs.
3. The PLPOA Board of Directors will identify a base level of annual financial support for proposed educational activities.

<u>Management Action:</u> Increase volunteerism within the PLPOA.

Timeframe: Begin 2013.

Facilitator: Pelican Lake Board of Directors.

Description: Even with the many residences dotting the shoreland of Pelican Lake, the PLPOA has had some difficulty retaining volunteers for various lake-related tasks. One reason for this may be that only 33% of residents live on the lake year-round; the other Pelican Lake property owners visit the lake seasonally (34%), or on weekends throughout the year (26%) (Appendix B, Question #1).

The PLPOA has begun thinking about ways to improve the level of volunteerism on the Pelican Lake. While advertising through newsletters or websites is certainly convenient, it is not always a persuasive means. Often a door-to-door campaign, involving neighbors discussing the importance of volunteerism, is more effective as it builds a sense of teamwork and community through protecting a resource.

The PLPOA, in another attempt to increase volunteerism, is considering is a program which property owners would voluntarily join. As a member in this program, the lake resident would be required to either 1) volunteer their time in a required number of hours to an association-sponsored project, or, 2) donate a set amount of funds above and beyond what is required for association membership, etc. This “Fare or Share” program would give special recognition to those property owners who join. The program would benefit the management of Pelican Lake by providing a volunteer work force – either through the members who have joined or by paying workers through the funds collected from the program.

Action Steps:

1. See description above.

Management Goal 2: Maintain Current Water Quality Conditions

Management Action: Monitor water quality through WDNR Citizen Lake Monitoring Network.

Timeframe: Continuation of current effort.

Facilitator: Pelican Lake Board of Directors.

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 an explanation of why the trend is occurring.

The Citizen Lake Monitoring Network (CLMN) is a WDNR/UW Extension program in which volunteers are trained to collect data on Wisconsin's lakes are rivers. One aspect of the CLMN is the collection of water quality data. Water quality data has been actively collected on Pelican Lake by volunteers enrolled within the CLMN's advanced program. This program involves volunteers taking Secchi disk readings and water chemistry samples three times during the summer and once during the spring in the deep-hole location of the lake. This is the best location to sample water quality parameters because it gives a good representation of the conditions in the whole lake. So, efforts should be focused on this location, as opposed to data collection across multiple areas of the lake.

It is the responsibility of the current CLMN volunteer in conjunction with the PLPOA Board of Directors to coordinate new volunteers as needed. According to the stakeholder survey, 83 of 296 respondents indicated that they would be willing to participate in water quality monitoring (Appendix B, Question #31). When a change in the collection volunteer occurs, Sandra Wickman (715.365.8951) or the appropriate WDNR/UW Extension staff member should be contacted to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database by the volunteer and available through their Surface Water Integrated Monitoring System (SWIMS).

Action Steps:

1. Trained CLMN volunteer(s) collects data and report results to WDNR and to association members during annual meeting.

2. CLMN volunteer and/or PLPOA Board of Directors 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 Action: Restore highly developed shoreland areas on Pelican Lake.

Timeframe: Initiate 2013.

Facilitator: Pelican Lake Board of Directors.

Description: As discussed in the Shoreland Condition Section, 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. In 2011 the shoreland assessment survey indicated that 6.6 miles, or 41% of Pelican Lake's 16.4 mile shoreline, consists of Urbanized or Developed-Unnatural areas.

Fortunately, restoration of the shoreland zone can be less expensive, less time-consuming and much easier to accomplish than restoration efforts in other parts of the watershed. Cost-sharing grants and Oneida County staff devoted to these types of projects give private property owners the funds and informational resources to restore quality shoreland habitat to their lakeside residence. In fact, several riparian property owners have already completed restoration projects the lake.

Map 3 indicates the locations of Urbanized and Developed-Unnatural shorelands on Pelican Lake. These shorelands should be prioritized for restoration. A Board of Directors appointee will work with appropriate entities to research grant programs, shoreland restoration techniques and other pertinent information that will help the PLPOA restore shoreland areas. Because property owners may have little experience with restoring a shoreland to its natural state, properties with restoration on their shorelands could serve as demonstration sites. Other lakeside property owners could have the opportunity to view a shoreland that has been restored to a more natural state, and learn about the maintenance, labor, and cost-sharing opportunities associated with these projects. The Board of Directors appointee will oversee/plan demonstration tours, as well as be a point-of-contact, for Pelican Lake property owners who require more information on this topic.

Action Steps:

1. Recruit facilitator.
2. Facilitator receives proper shoreland restoration training through the UW Extension (Patrick Goggin - 715.365.8943, patrick.goggin@ces.uwex.edu)
3. Facilitator coordinates demonstration site tour (annual event or as needed) and serves as contact person for shoreland restoration questions. Facilitator puts interested parties in contact with Oneida County Land &

Water Conservation Department officials.

4. Property owners complete a Cost Share application and submit it to the Oneida County Land & Water Conservation Department.
5. Conservation specialist with Oneida County works with property owners to determine site eligibility, design plans, etc.

Management Action: Protect natural shoreland zones along Pelican Lake.

Timeframe: Initiate 2013.

Facilitator: Pelican Lake Board of Directors.

Description: Despite the ample developed shoreland that surrounds Pelican Lake, a fair amount (3.8 miles or 23%) of natural and developed-natural shorelands are present as well. It is therefore very important that owners of these properties become educated on the benefits their shoreland is providing to Pelican Lake, and that these shorelands remain in a natural state.

Map 3 indicates the locations of Natural and Developed-Natural shorelands on Pelican Lake. These shorelands should be prioritized for education initiatives and physical preservation. A Board of Directors appointed person will work with appropriate entities to research grant programs and other pertinent information that will aid the PLPOA in preserving the Pelican Lake shoreland. This would be accomplished through education of property owners, or direct preservation of land through implementation of conservation easements or land trusts that the property owner would approve of.

Valuable resources for this type of conservation work include the WDNR, UW-Extension and Oneida County Land & Water Conservation Department. Several websites of interest include:

- Wisconsin Lakes website: www.wisconsinlakes.org/shorelands)
- Conservation easements or land trusts: (www.northwoodslandtrust.org)
- UW-Extension Shoreland Restoration: http://www.uwex.edu/ces/shoreland/Why1/whyres.htm)
- WDNR Shoreland Zoning website: (http://dnr.wi.gov/topic/ShorelandZoning/)

Action Steps:

1. Recruit facilitator (potentially same facilitator as previous management action).
2. Facilitator receives proper shoreland restoration training through the UW Extension (Patrick Goggin - 715.365.8943, patrick.goggin@ces.uwex.edu)
3. Facilitator gathers appropriate information from sources described above.

This includes biological research, as well as grant/funding opportunities.

4. Facilitator assists residents that are interested in shoreland restoration with the process of contacting shoreland restoration specialists (public or private) and carrying out restoration plan.
5. Completed projects potentially considered as a "model' for other residents who may be interested in restoring their shorelands.

Management Goal 3: Enhance the Fishery of Pelican Lake

Management Action: Work with fisheries managers to enhance the fishery on Pelican Lake.

Timeframe: Ongoing.

Facilitator: Pelican Lake Board of Directors.

Description: The results of the stakeholder survey indicate that fishing is a popular activity on Pelican Lake. Open-water fishing was ranked 2nd on a list of reasons property owners reside on Pelican Lake (Appendix B, Question #13). Nearly 96% of survey respondents indicate they have fished on Pelican Lake (Question #7), and 58% of these same respondents have done so for longer than 25 years (Question #8).

However, the PLPOA and other riparian property owners have concerns over the fishery. 43% of survey respondents indicate the quality of fishing is only fair on the lake (#9), and 76% indicated that the quality of fishing has become either much or somewhat worse since they began fishing (Question #11). Finally, excessive fishing pressure was ranked highly as both a negative impact to the lake and a top concern (Questions #20 and 21).

Understanding the limitations and stresses on the Pelican Lake ecosystem is the first step in developing a solution to angler concerns. From here, realistic goals and actions may be developed. Part of this process involves educating Pelican Lake property owners on the fishery. Specifically, information within this document may be summarized and presented to residents through the Educational Initiative described in Management Goal 1. Residents must have an understanding of how much fishing pressure Pelican Lake receives, and how important diverse habitats (weedy bays, rocky areas, coarse woody habitat, etc.) are to the fishery. They also must understand how factors such as the relatively poor shoreland condition of the lake has negative consequences to the lake's ecosystem, and are eventually manifested through the fishery.

Pelican Lake is currently overseen by WDNR fisheries biologist John Kubisiak. In order to keep informed of survey studies that are occurring on Pelican Lake, a volunteer from the PLPOA should contact Mr. Kubisiak at least once a year (perhaps during the winter months when field work is not occurring) for a brief summary of activities.

Additionally, the PLPOA may discuss options for improving the fishery in Pelican Lake, which may include changes in angling regulations, habitat enhancements, or private stocking.

Action Steps:

1. See description above.

Management Action: Implement coarse woody habitat survey during next management plan update.

Timeframe: 2017-2018.

Facilitator: Pelican Lake Board of Directors.

Description: As previously discussed, Pelican Lake contains many areas of developed shoreland. 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 and Fisheries Data Integration Section discuss the benefits of coarse woody habitat in detail.

It is believed that Pelican Lake is likely lacking coarse woody habitat, a crucial form of habitat for fish. As part of a management plan update, the PLPOA will have a shoreland survey completed by professional ecologists in which data is collected on the location and types of coarse woody habitat that are present along the shoreline of the lake. Either before or after this survey is completed, the PLPOA may elect to work with John Kubisiak of the WDNR to improve coarse woody habitat along the shoreland of Pelican Lake through strategic tree-drops or other means. Please note that WDNR permits and approval would be required for this action to be taken.

Action Steps:

1. See description above.

Management Goal 4: Control Aquatic Invasive Species within Pelican Lake, and Prevent Their Transport To and From Other Lakes

Management Action: Enhance volunteer Eurasian water milfoil surveillance monitoring and hand removal program.

Timeframe: Begin 2013.

Facilitator: Pelican Lake Board of Directors.

Description: In lakes without AIS, early detection of pioneer colonies commonly leads to successful control and, in cases of very small infestations, possibly even eradication. Even in lakes where these plants occur, monitoring for new colonies is essential for successful control. PLPOA members have been trained on AIS identification and surveillance monitoring strategies and have been carrying out these activities for the past year. However, the PLPOA would like to enhance the framework of this program.

In order to assess the amount of Eurasian water milfoil in the system, the PLPOA would follow a monitoring strategy which involves volunteer involvement, as well as training and oversight by Oneida County Aquatic Invasive Species Coordinator Michele Sadauskas.

The PLPOA would use an "adopt-a-shoreline" approach where volunteers are responsible for surveying specified areas of the lake. In order for accurate data to be collected during these surveys, volunteers must be able to identify non-native species such as Eurasian water milfoil and curly-leaf pondweed. Distinguishing these plants from native look-a-likes is very important. PLPOA members would attend workshops led by Ms. Sadauskas to gain this training. Additionally, Ms. Sadauskas would annually train Pelican Lake volunteers on monitoring techniques, including watercraft navigation methodology, GPS spatial data collection, and aquatic plant identification. Data collected through these efforts would be transferred to professional consultants in accordance with the following Management Action to determine if control actions beyond hand-removal are warranted.

Action Steps:

1. See description above.

<u>Management Action:</u> Enact Eurasian water milfoil monitoring and control strategy.

Timeframe: Begin 2013.

Facilitator: Pelican Lake Board of Directors.

Description: As described in the Aquatic Plant Section, one of the most pressing threats to the health of Pelican Lake is Eurasian water milfoil. It is believed that this population has only recently been introduced, as evidenced by its localized occurrence and small biomass. However, it will take future monitoring to determine if this population rebounds quickly from management actions that took place in 2012 and 2013.

<u>Volunteer-based monitoring</u>

The Eurasian water milfoil strategy discussed by Onterra staff and PLPOA Planning Committee members involves both volunteer and professional monitoring. In 2014, professional monitoring of known Eurasian water milfoil locations is scheduled during early spring and late summer. This monitoring and a potential herbicide treatment are covered through a WDNR Aquatic Invasive Species Early Detection and Response grant. In 2014, PLPOA volunteers will conduct monitoring of the remaining areas of Pelican Lake, as discussed within the previous management action. Data will be collected for hand-harvesting operations, as well as transfer to professional consultants. Professional monitoring will occur on these areas under one of two scenarios: 1) the PLPOA believes that the amount of Eurasian water milfoil found warrants a control action beyond hand-removal, or, 2) a period of five years has passed from the previous professional survey.

At this time, management of Eurasian water milfoil populations is not done to eradicate Eurasian water milfoil from Pelican Lake, as that would be impossible. The objective is to reduce Eurasian water milfoil to more manageable levels. In other words, the goal is to reduce the amount of Eurasian water milfoil in Pelican Lake to levels that may be suitable for no treatment or hand removal efforts to keep it under control.

Professional surveying strategy

In 2014 and beyond, professional surveys will take place within the western bay of the lake where an early-established Eurasian water milfoil population occurs. If trained PLPOA volunteers locate other areas of colonized Eurasian water milfoil, this will trigger a survey by professionals to assess and map the Eurasian water milfoil within those areas as well. If professional mapping surveys reveal that the colonized Eurasian water milfoil is relatively isolated and contain dominant or greater (at least 50% aerial coverage) Eurasian water milfoil, the most feasible method of control will likely be herbicide applications – specifically, early spring treatments with an auxin-mimic herbicide like 2,4-D. The impacts to native submersed species are believed to occur when the non-native species reaches an aerial coverage of approximately 50%. Therefore, by minimizing the occurrence of these dense colonies, the impact on the lake's ecology and recreation will also be minimized. While 29% of stakeholders are not supportive of herbicide control on Pelican Lake, nearly 35% are supportive of this management technique, 14% are neutral and 22% are unsure about the matter (Appendix B, Question #24).

While less dense Eurasian water milfoil colonies (scattered and highly-scattered) may not have the same level of impact on the ecology of the lake, their potential for expansion, both in area and density, is of great concern to the PLPOA. In order to build from the success that was experienced from the early spring herbicide treatments of 2012 and 2013, the PLPOA would like to take an aggressive approach to Eurasian water milfoil management in the next five years This approach consists of targeting all areas of colonized Eurasian water milfoil. The PLPOA treatment threshold (trigger) would also extend to immediately adjacent areas of Eurasian water milfoil mapped with point-based techniques, with areas mapped as 'small plant colonies' being targeted if possible. Understanding that strong dilution effects create difficulty in very small treatments, the PLPOA would not treat areas less than 0.5 acres in size unless justified by the importance of preventing spread to other areas of the lake (very dense colony, new location, etc.). The PLPOA would also give consideration to hiring professional hand-removal consultants to remove Eurasian water milfoil where practical.

Monitoring is a key aspect of any aquatic invasive species control project, both to create the treatment areas and monitor the action's effectiveness. The monitoring would also facilitate the "tuning" or refinement of the control strategy as the control project progresses. It must be noted that this portion of the management plan (control plan) would be intended to span approximately 5-6 years before it would need to be updated to account for changes within the ecosystem. To complete this objective efficiently, a cyclic series of steps is used to plan and implement the treatment strategies. The series includes:

1. A lake-wide assessment of Eurasian water milfoil completed while the plant is at peak biomass (August-September)
2. Creation of control strategy for the following spring.
3. Verification and refinement of treatment plan immediately before control strategies are implemented
4. Completion of control strategy
5. Assessment of control strategy

Once Step 5 is completed, the process would begin again that same summer with the completion of a peak biomass survey. The survey results would then be used to create the next spring's control strategy (Step 2).

Two types of monitoring would be completed to determine treatment effectiveness: 1) quantitative monitoring using WDNR protocols, and, 2) qualitative monitoring using observations at individual treatment sites and on a treatment-wide basis. Results of both of these monitoring strategies would be used to create the subsequent treatment strategies. Comparing the monitoring results from the pretreatment and post treatment surveys would determine the effectiveness of the treatment on a site-by-site basis and on a treatment-wide basis (which in the case of a small lake, would likely be lake-wide). Qualitatively, a successful treatment on a particular site would include a reduction of exotic density, as demonstrated by a decrease in density rating. Quantitatively, a successful treatment would include a significant reduction in Eurasian water milfoil frequency following the treatments, as exhibited by at least a 50% decrease in exotic frequency from the pre- and post treatment point-intercept sub-sampling.

Action Steps:

1. See description above.

Management Action: Reduce occurrence of purple loosestrife on Pelican Lake shorelands.

Timeframe: Initiate in 2013.

Facilitator: Pelican Lake Board of Directors.

Description: Though not detected during Onterra's 2011 field surveys, purple loosestrife is known to occur along the Pelican Lake shoreland. Purple loosestrife is a perennial that is more resilient the longer it is allowed to grow in one location because its root crown becomes more robust. It also produces a seed bank which germinates years after the parent plant is controlled and requires continued management.

Manually-removing isolated purple loosestrife plants is likely the best control strategy at this time. Once the property owner grants permission to remove the plant, it should be dug out of the ground, roots and all. If flowers or seeds are present at the time of the extraction, the flower heads should be carefully cut off and bagged to make sure seeds don't inadvertently get spread around during removal. Plants and seed heads should either be burned or bagged and put into the garbage. Sources such as the UW-Extension and Oneida County Aquatic Invasive Species Coordinator will be used to provide expertise on purple loosestrife identification, as well as the proper time to perform management actions.

Important aspects of this management action will be the monitoring and record keeping that will occur in association with the control efforts. These records will include maps indicating infested areas and associated documentation regarding the actions that were used to control the areas, the timing of those actions, and the results of the actions. These maps and records will be used to track and document the successfulness of the program and to keep the PLPOA and other management entities updated.

Action Steps:

1. See description above.

Management Action: Monitor populations of common reed grass on Pelican Lake.

Timeframe: Initiate in 2013.

Facilitator: Pelican Lake Board of Directors.

Description: During Onterra's 2011 aquatic plant surveys, a species of common reed grass (genus *Phragmites*) was observed growing in roughly 2-3 feet of water in two locations in Pelican Lake (Map 6). Onterra staff collected samples of the plant and provided pressed specimens to Dr. Robert Freckmann at the University of Wisconsin – Stevens Point Herbarium. Morphologically, the specimens were identified as a native species of common reed, *Phragmites australis subs. americanus.* However, it is accepted in the scientific community that the native species is very difficult to tell apart from a non-native, invasive plant that has spread throughout most of Wisconsin – giant reed grass (*Phragmites australis*).

Even though the plants found to be on Pelican Lake seem to be native, they are forming dense colonies that concern the PLPOA. Oneida County Aquatic Invasive Species Coordinator Michele Sadauskas has agreed to assist the PLPOA in monitoring the extents of these colonies using GPS. Additionally, Ms. Sadauskas has indicated that she will be working with an arboretum to have the plant genetically identified, and sediment data near the colony examined which will help to understand the differences between the native and non-native strains of this plant.

Action Steps:

1. See description above.

<u>Management Action:</u> Remove pink water lily from Pelican Lake location.

Timeframe: Initiate in 2013.

Facilitator: Pelican Lake Board of Directors.

Description: During Onterra's 2011 aquatic plant surveys, a species of water lily was discovered that appeared much different than that which is normally encountered in Wisconsin Lakes. This water lily, *Nymphaea odorata var. rosea,* is a floating-leaf species closely related to white water lily. It is a subspecies that is commonly found planted within small ornamental ponds or aquariums and has bright pink flowers. The plant is considered non-native, though not necessarily invasive. Because little is known about its potential impact to native aquatic plants, the PLPOA will work proactively and remove this small and isolated colony from the lake, using hand-removal techniques. Follow-up monitoring in subsequent years will be required in order to determine if the plant colony has successfully been removed.

Action Steps:

1. See description above.

<u>Management Action:</u> Continue Clean Boats Clean Waters watercraft inspections at Pelican Lake public access locations.

Timeframe: Initiate in 2013.

Facilitator: Pelican Lake Board of Directors.

Description: Pelican Lake is a very popular destination for recreationalists and anglers, making the lake vulnerable to new infestations of exotic species. The PLPOA has been very diligent about spreading the message of aquatic invasive species and providing direct intervention of species entering Pelican Lake through their involvement in the Clean Boats Clean Waters program. Between 2004 and 2012, Clean Boats Clean Waters volunteers have monitored four landings on the lake, though the major focus has been placed on the State Landing on County Road G, and on Keeler's Landing on County Road Q. During this time

16, 206 and 8, 478 boats have been inspected; 33, 980 and 18, 566 people have been contacted; and 4, 598 and 3, 980 hours have been spent working at the State Landing and at Keeler's Landing, respectively.

Even though the PLPOA is experiencing volunteer fatigue, and some planning committee members have expressed concern over "bothering" watercraft operators by approaching them numerous times in a summer, the Clean Boats Clean Waters inspections must continue. Volunteer turnout may be bolstered in the future through the volunteer recruitment strategy enacted in Management Goal 1. Furthermore, PLPOA members have discussed creating a sticker that watercraft users may place on their watercraft, which would signify that they have been approached by Clean Boats Clean Waters personnel before and are aware of the threats aquatic invasive species pose to Wisconsin lakes.

The intent of the boat inspections is not only to prevent additional invasives from entering the lake through its numerous public access points, but also to prevent the infestation of other waterways with invasives that originated in Pelican Lake. The goal is be to cover the landings during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of aquatic invasive species on lakes and educating people about how they are the primary vector of its spread.

Action Steps:

1. Members of the PLPOA continue to periodically attend Clean Boats Clean Waters training sessions led by the Oneida County Aquatic Invasive Species Coordinator (Michele Saduaskas) to update their skills to current standards.
2. Work with Clean Boats Clean Waters staff to determine if a "Clean Boater" watercraft sticker is feasible for use.
3. Continue to conduct inspections during high-risk weekends.
4. Continue to report results to WDNR and PLPOA.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Pelican 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 once in spring and three times during the summer. In addition to the samples collected by PLPOA members, professional water quality samples were collected at subsurface (S) and near bottom (B) depths once in spring, winter, and fall. Although PLPOA members collected a spring total phosphorus sample, professionals also collected a near-bottom sample to coincide with the bottom total phosphorus sample. 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**	**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 Pelican 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 Pelican Lake during June 15-17, 2011 field visits, 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 Pelican 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 August 22-24, 2011. A point spacing of 115 meters was used, resulting in approximately 1,078 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Pelican 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 in order 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 – Stevens Point Herbarium. A set of samples was also provided to the PLPOA.

2012 Treatment Monitoring

The methodology used to monitor the 2012 herbicide treatments is included in the results section under the heading: *Treatment Monitoring.*

7.0 LITERATURE CITED

Becker, G.C. 1983. Fishes of Wisconsin. The University of Wisconsin Press. London, England.

Boston, H.L. and M.S. Adams. 1987. Productivity, growth, and photosynthesis of two small 'isoetid' plants, *Littorella uniflora*, and *Isoetes macrospora*. J. Ecol. 75: 333 – 350.

Canter, L.W., D.I. Nelson, and J.W. Everett. 1994. Public Perception of Water Quality Risks – Influencing Factors and Enhancement Opportunities. Journal of Environmental Systems. 22(2).

Carpenter, S.R., Kitchell, J.F., and J.R. Hodgson. 1985. Cascading Trophic Interactions and Lake Productivity. BioScience, Vol. 35 (10) pp. 634-639.

Carlson, R.E. 1977 A trophic state index for lakes. Limnology and Oceanography 22: 361-369.

Coen, A.N. 2005. A Review of Zebra Mussels' Environmental Requirements. A report for the California Department of Water Resources, Sacromento CA. San Francisco Estuary Institute, Oakland, CA.

Centers for Disease Control & Prevention (CDC). 2012. Cercaria dermatitis. Available at: www.dpd.cdc.gov/dpdx/HTML/CercarialDermatitis.htm. Last accessed December 2012.

Dinius, S.H. 2207. Public Perceptions in Water Quality Evaluation. Journal of the American Water Resource Association. 17(1): 116-121.

Elias, J.E. and M.W. Meyer. 2003. Comparisons of Undeveloped and Developed Shorelands, Northern Wisconsin, and Recommendations of Restoration. Wetlands 23(4):800-816. 2003.

Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, *PE&RS*, Vol. 77(9):858-864.

Garn, H.S. 2002. Effects of Lawn Fertilizer on Nutrient Concentration in Runoff from Two Lakeshore Lawns, Lauderdale Lakes, Wisconsin. USGS Water-Resources Investigations Report 02-4130.

Gettys, L.A., W.T. Haller, M. Bellaud. 2009. Appenix F of Biology and Control of Aquatic Plants: A Best Management Practices Handbook. 181-188.

Graczyk, D.J., Hunt, R.J., Greb, S.R., Buchwald, C.A. and J.T. Krohelski. 2003. Hydrology, Nutrient Concentrations, and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin, 1999-2001. USGS Water-Resources Investigations Report 03-4144.

Great Lakes Indian Fish and Wildlife Service. 2010A. Interactive Mapping Website. Available at http://www.glifwc-maps.org. Last accessed March 2010.

Great Lakes Indian Fish and Wildlife Service. 2010B. GLIFWC website, Wisconsin 1837 & 1842 Ceded Territories Regulation Summaries – Open-water Spearing. Available at http://www.glifwc.org/Enforcement/regulations.html. Last accessed March 2010.

Hanchin, P.A., Willis, D.W. and T.R. St. Stauver. 2003. Influence of introduced spawning habitat on yellow perch reproduction, Lake Madison South Dakota. Journal of Freshwater Ecology 18.

Jennings, M. J., E. E. Emmons, G. R. Hatzenbeler, C. Edwards and M. A. Bozek. 2003. Is littoral habitat affected by residential development and landuse in watersheds of Wisconsin lakes? Lake and Reservoir Management. 19(3):272-279.

Lathrop, R.D., and R.A. Lillie. 1980. Thermal Stratification of Wisconsin Lakes. Wisconsin Academy of Sciences, Arts and Letters. Vol. 68.

Lindsay, A., Gillum, S., and M. Meyer 2002. Influence of lakeshore development on breeding bird communities in a mixed northern forest. Biological Conservation 107. (2002) 1-11.

Netherland, M.D. 2009. Chapter 11, “Chemical Control of Aquatic Weeds.” Pp. 65-77 in *Biology and Control of Aquatic Plants: A Best Management Handbook*, L.A. Gettys, W.T. Haller, & M. Bellaud (eds.) Aquatic Ecosystem Restoration Foundation, Marietta, GA. 210 pp

Newbrey, M.G., Bozek, M.A., Jennings, M.J. and J.A. Cook. 2005. Branching complexity and morphological characteristics of coarse woody structure as lacustrine fish habitat. Canadian Journal of Fisheries and Aquatic Sciences. 62: 2110-2123.

Nichols, S.A. 1999. Floristic quality assessment of Wisconsin lake plant communities with example applications. Journal of Lake and Reservoir Management 15(2): 133-141

Panuska, J.C., and J.C. Kreider. 2003. Wisconsin Lake Modeling Suite Program Documentation and User’s Maunal Version 3.3. WDNR Publication PUBL-WR-363-94.

Radomski P. and T.J. Goeman. 2001. Consequences of Human Lakeshore Development on Emergent and Floating-leaf Vegetation Abundance. North American Journal of Fisheries Management. 21:46–61.

Reed, J. 2001. Influence of Shoreline Development on Nest Site Selection by Largemouth Bass and Black Crappie. North American Lake Management Conference Poster. Madison, WI.

Sass, G.G. 2009. Coarse Woody Debris in Lakes and Streams. In: Gene E. Likens, (Editor) Encyclopedia of Inland Waters. Vol. 1, pp. 60-69 Oxford: Elsevier.

Scheuerell M.D. and D.E. Schindler. 2004. Changes in the Spatial Distribution of Fishes in Lakes Along a Residential Development Gradient. Ecosystems (2004) 7: 98–106.

Shaw, B.H. and N. Nimphius. 1985. Acid Rain in Wisconsin: Understanding Measurements in Acid Rain Research (#2). UW-Extension, Madison. 4 pp.

Smith D.G., A.M. Cragg, and G.F. Croker.1991. Water Clarity Criteria for Bathing Waters Based on User Perception. Journal of Environmental Management.33(3): 285-299.

Spangler, G.R. 2009. “Closing the Circle: Restoring the Seasonal Round to the Ceded Territories”. Great Lakes Indian Fish & Wildlife Commission. Available at: *www.glifwc.org/Accordian_Stories/GeorgeSpangler.pdf*

United States Department of the Interior – Bureau of Indian Affairs. 2007. Fishery Status Update in the Wisconsin Treaty Ceded Waters. Fourth Edition.

United States Environmental Protection Agency. 2009. National Lakes Assessment: A Collaborative Survey of the Nation's Lakes. EPA 841-R-09-001. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C.

Vander Zanden, M.J. and J.D. Olden. 2008. A management framework for preventing the secondary spread of aquatic invasive species. Canadian Journal of Fisheries and Aquatic Sciences 65 (7): 1512-22.

Vestergaard, O. and K. Sand-Jensen. 2000. Alkalinity and trophic state regulate aquatic plant distribution in Danish lakes. Aquatic Botany. (67) 85-107.

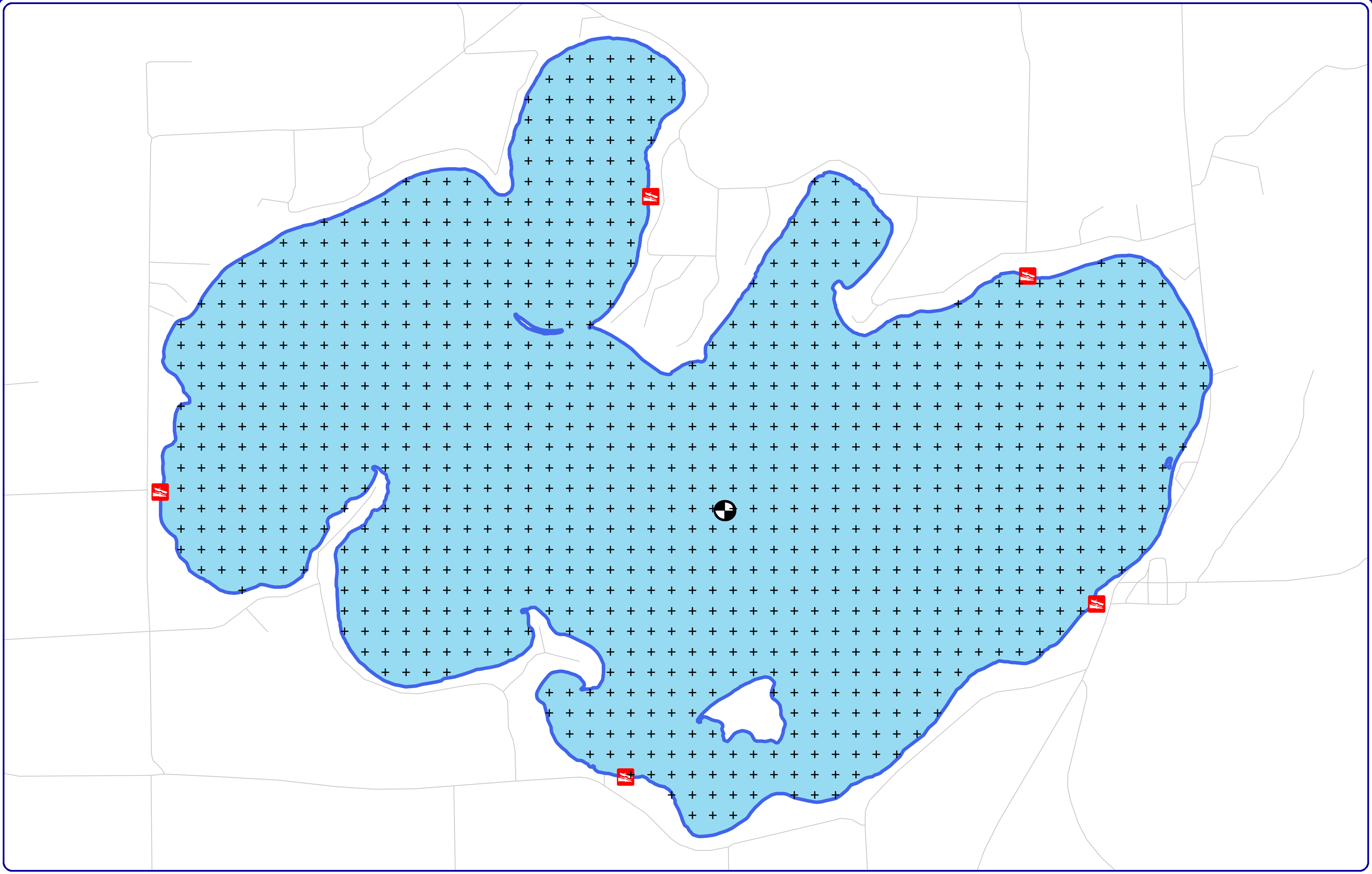
Wisconsin Department of Natural Resources. 2010. Bureau of Fisheries Management Fish Stocking Summaries. Available at: http://infotrek.er.usgs.gov/wdnr_public. Last accessed March 2010.

Wisconsin Department of Natural Resources (WDNR). 2012A. Wisconsin 2012 Consolidated Assessment and Listing Methodology (WisCALM). Bureau of Water Quality Program Guidance. Pub. 3200-2012-01

Wisconsin Department of Natural Resources (WDNR). 2012B. Swimmer's itch. Available at: http://dnr.wi.gov/lakes/swimmersitch/. Last accessed December 2012.

Wisconsin Valley Improvement Company (WVIC). 2013. Operations Plan. Available at: http://www.wvic.com/Content/Operations_Plan.cfm. Last accessed December 2013.

Woodford, J.E. and M.W. Meyer. 2003. Impact of Lakeshore Development on Green Frog Abundance. Biological Conservation. 110, pp. 277-284.



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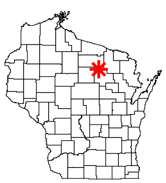


Project Location in Wisconsin

Legend

Pelican Lake ~ 3,545 Acres
WDNR Definition

Point-Intercept Survey Location
115-meter spacing, 1,078 total points

Water Quality Sampling Location

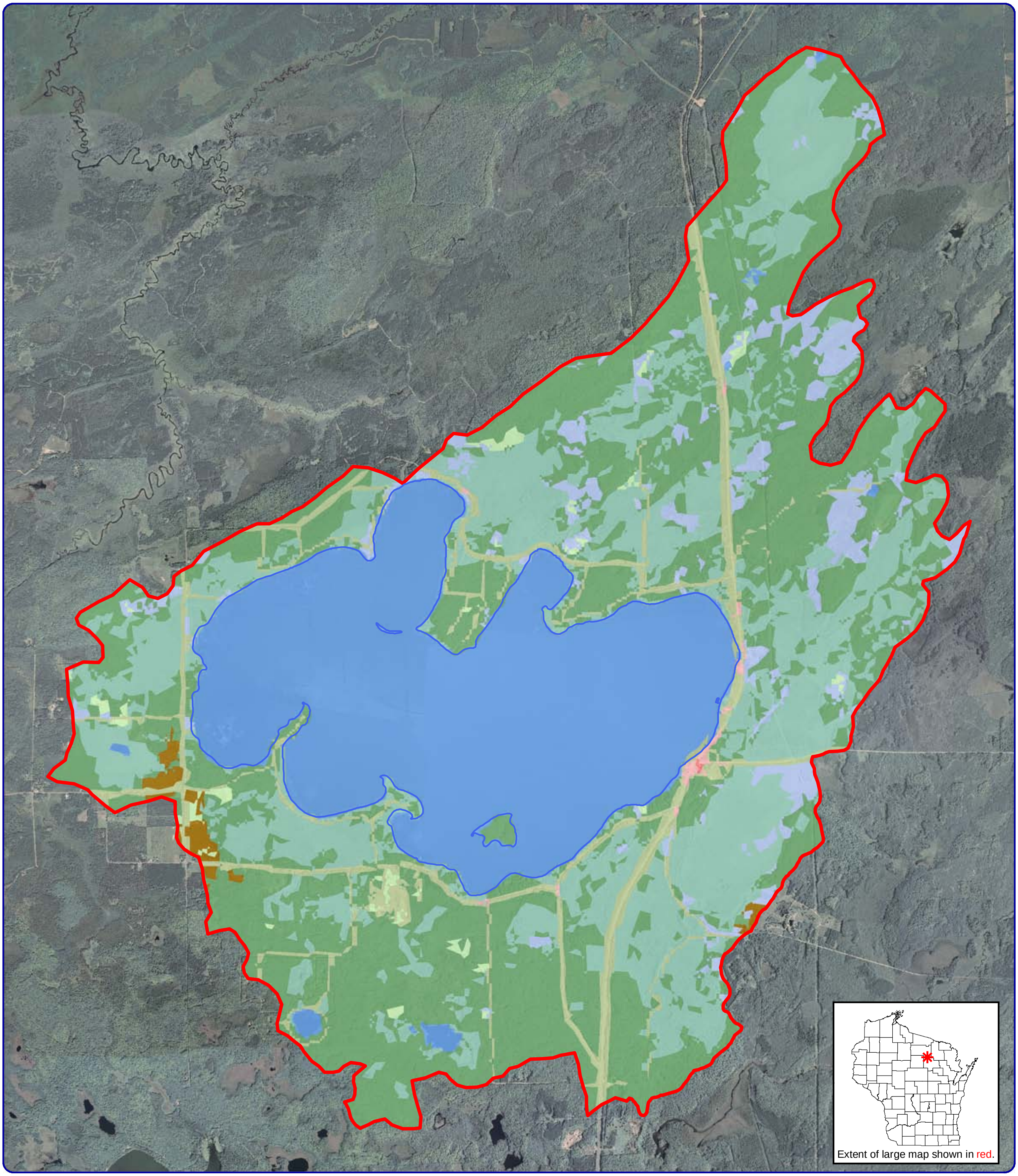
Public Access

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

Sources:
Roads and Hydro: WDNR
Map Date: October 6, 2012
Filename: Map1_Pelican_Location.mxd

Map 1
Pelican Lake
Oneida County, Wisconsin

Project Location & Lake Boundaries



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4,500
Feet

Legend

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

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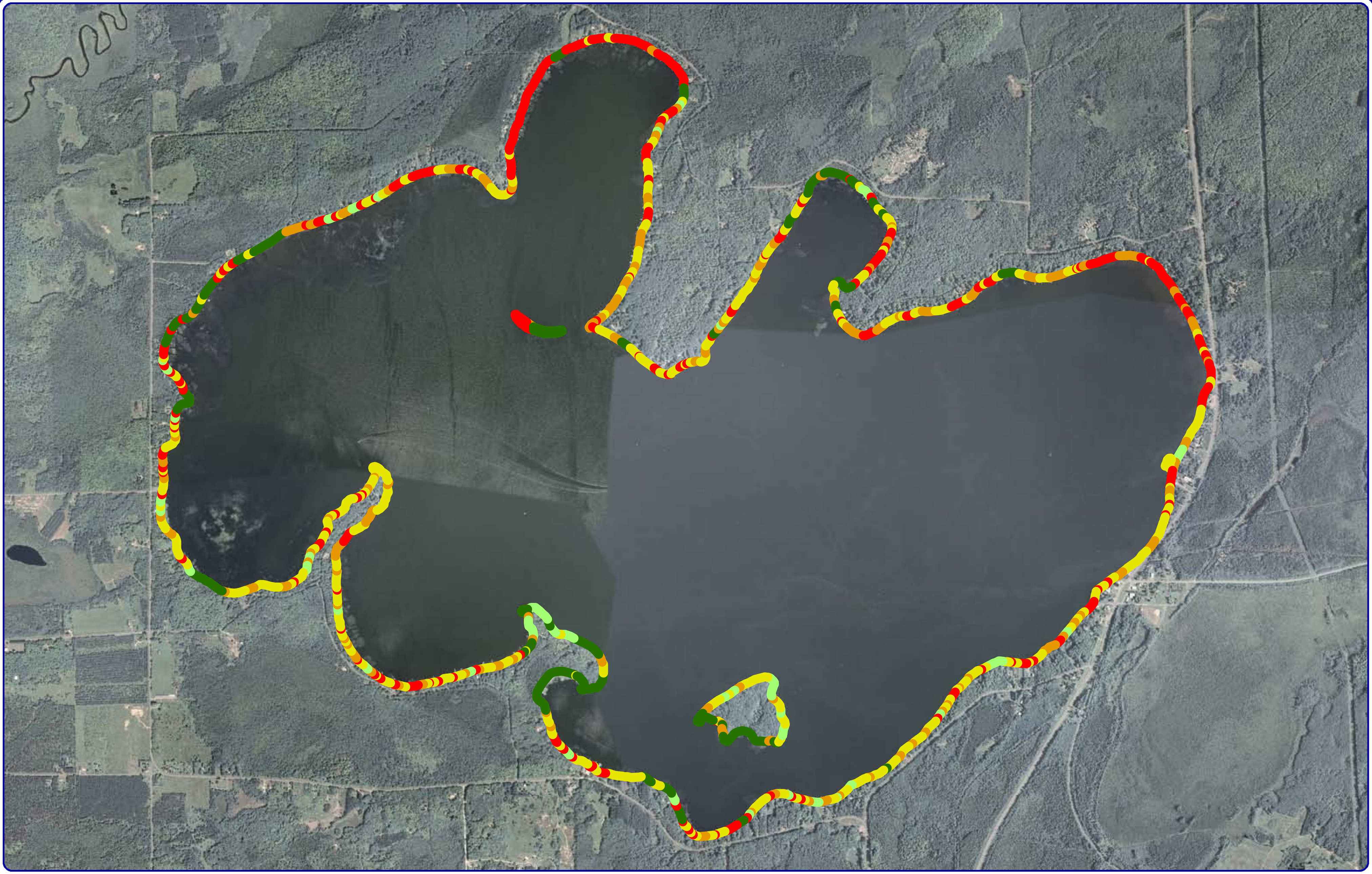
Source:
Watershed: WDNR & Onterra
Landcover: NLCD 2006
Hydro: WDNR
Orthophotography: NAIP, 2010
Map Date: October 6, 2012
File Name: Map2_Pelican_WS.mxd

Map 2
Pelican Lake
Oneida County, Wisconsin

Watershed and Land Cover Types



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2,400

Feet

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920.338.8860
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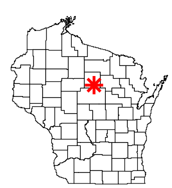
Sources:
Roads and Hydro: WDNR
Orthophotography: NAIP, 2010
Shoreline Assessment: Onterra, 2011
Map Date: October 6, 2012
Filename: Map3_Pelican_SA2011.mxd



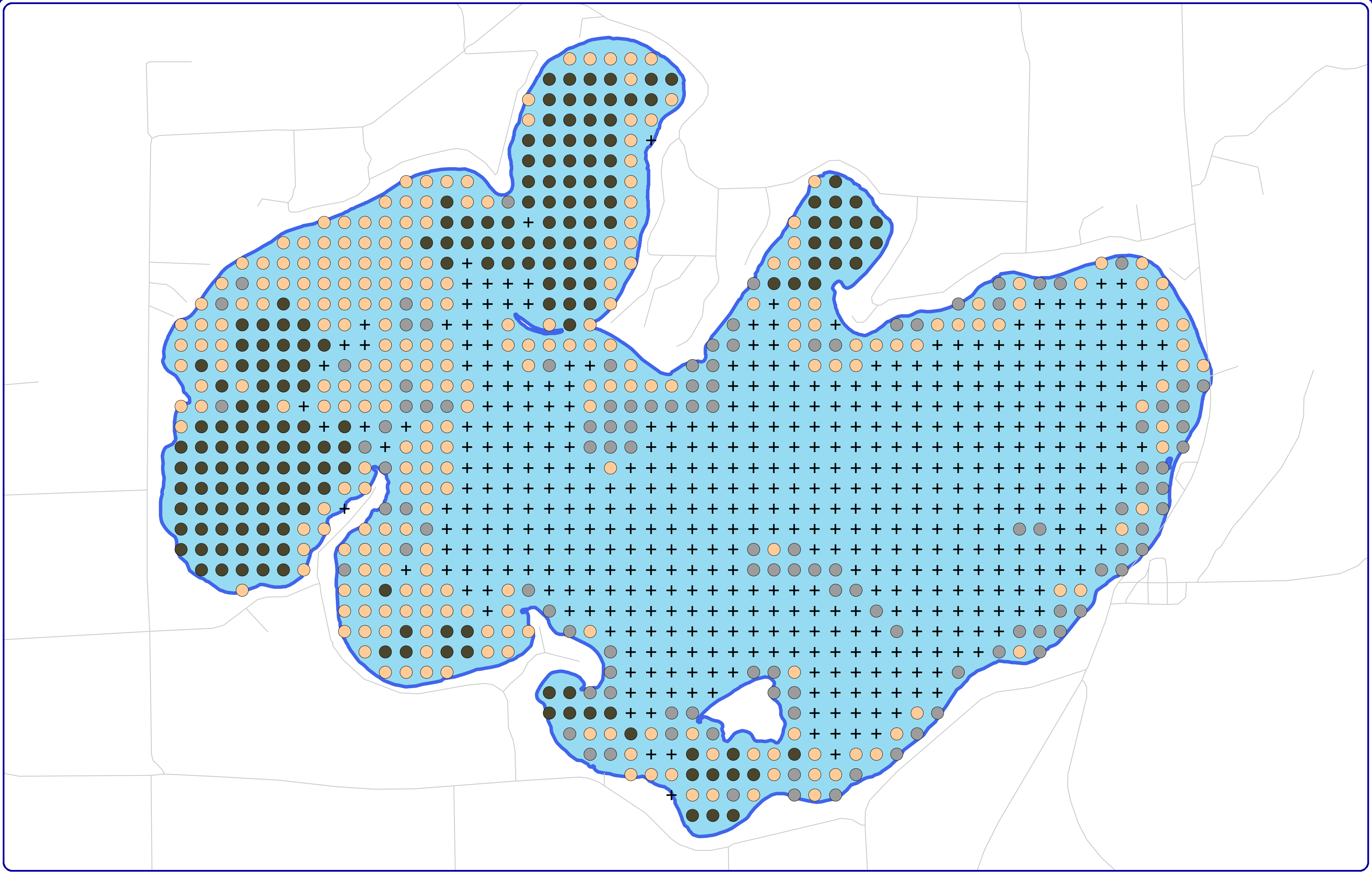
Project Location in Wisconsin

Legend

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

Map 3
Pelican Lake
Oneida County, Wisconsin

2011 Shoreline Condition



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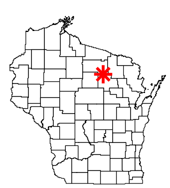

Project Location in Wisconsin

Point-intercept Sampling Locations

- + No Data (Too Deep or Non-navigable)
- Muck
- Sand
- Rock

Map 4

Pelican Lake

Oneida County, Wisconsin

2011 PI Survey: Substrate Types

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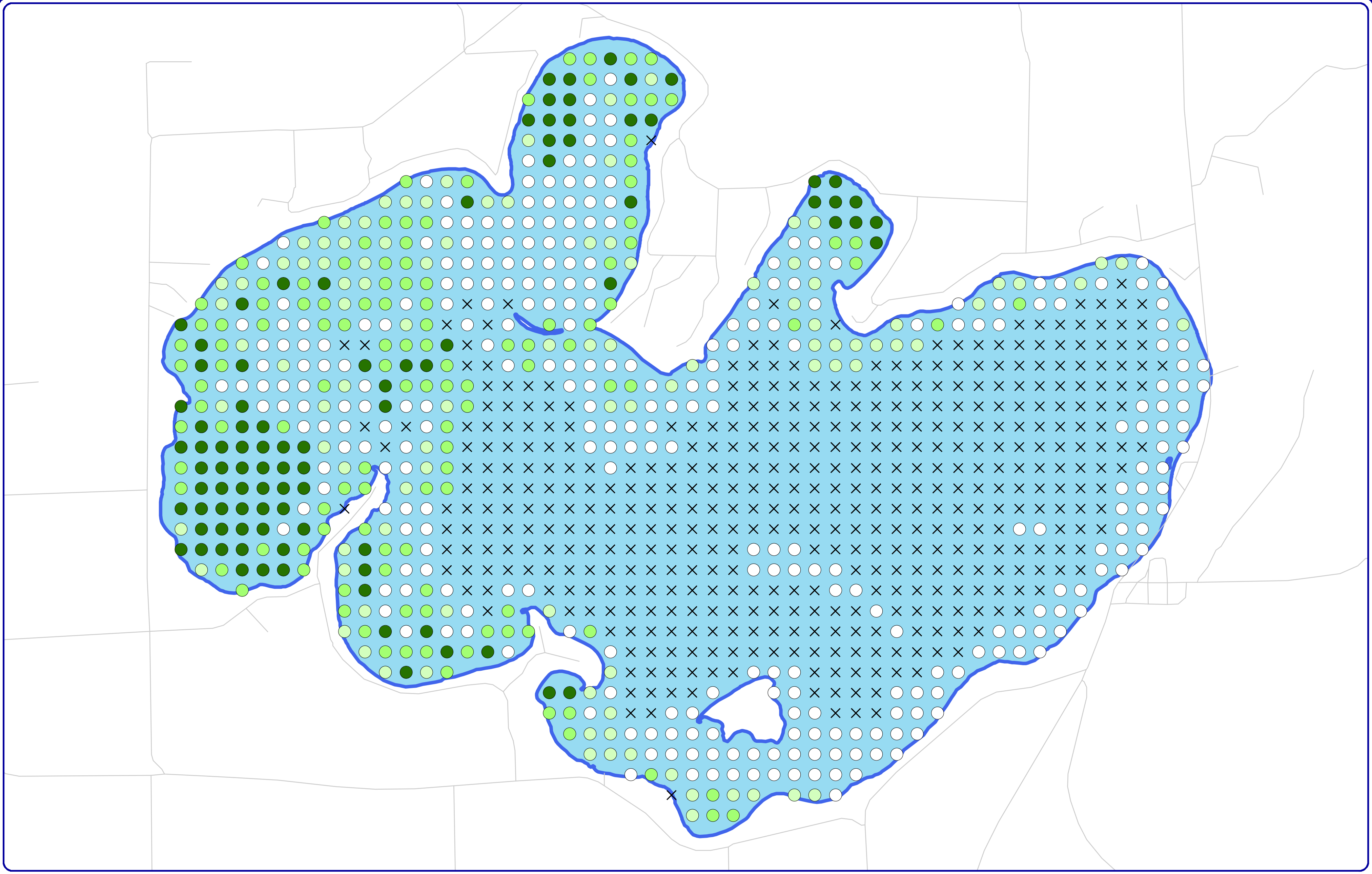
Sources:
Roads and Hydro: WDNR
Sediment: Onterra, 2011
Map Date: October 6, 2012
Filename: Map4_Pelican_SubstratePI.mxd



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Feet

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De Pere, WI 54115
920.338.8860
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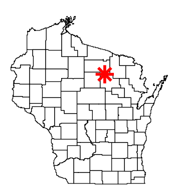
Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2011
Map Date: October 6, 2012
Filename: Map5_Pelican_TRFPI.mxd



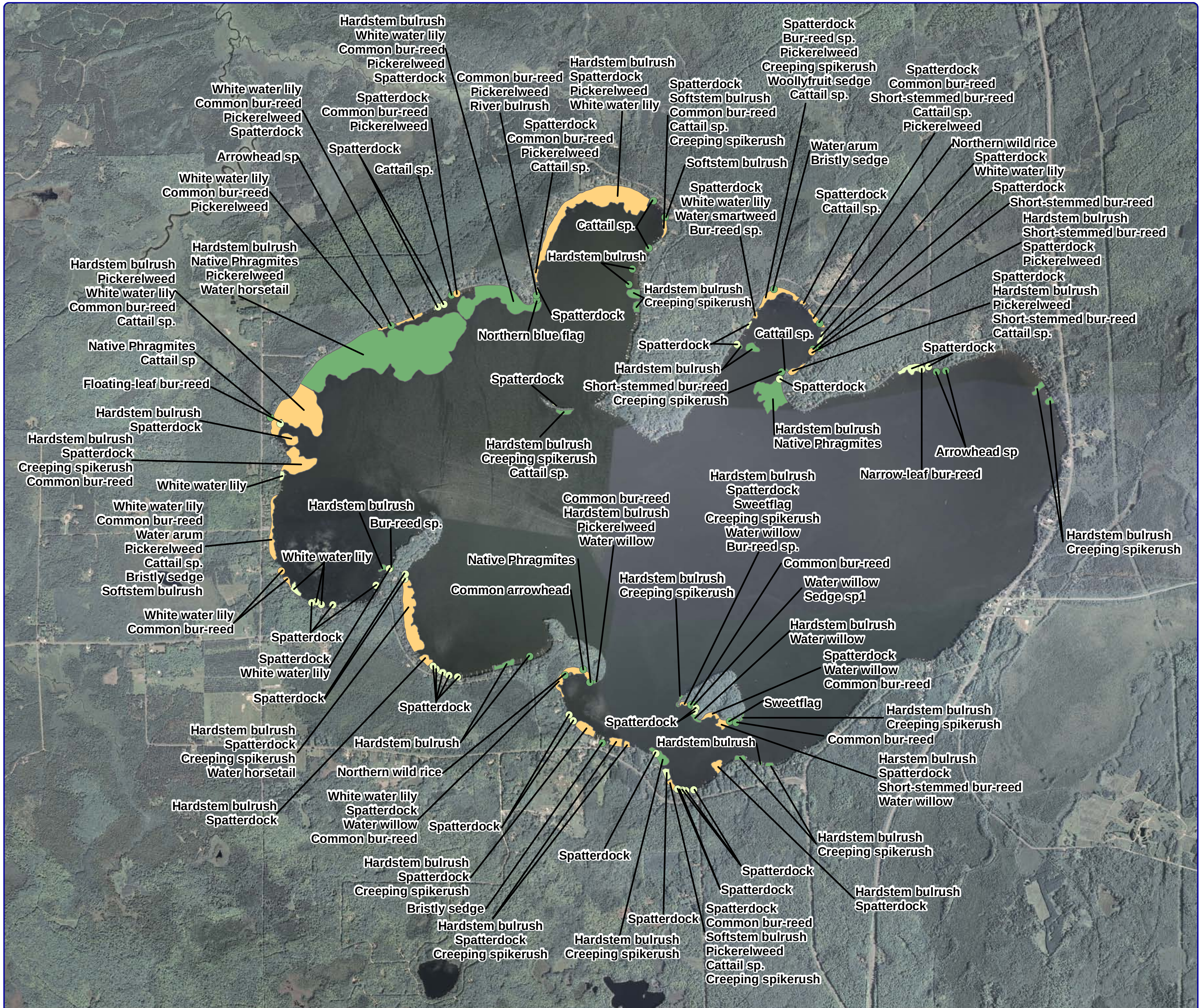
Project Location in Wisconsin

Point-intercept Sampling Locations

- Rake-fullness = 1
- Rake-fullness = 2
- Rake-fullness = 3
- Rake-fullness = 0 (*No vegetation*)
- No vegetation (*Too Deep or Non-navigabl*)

Map 5
Pelican Lake
Oneida County, Wisconsin

2011 PI Survey:
Aquatic Vegetation Distribution

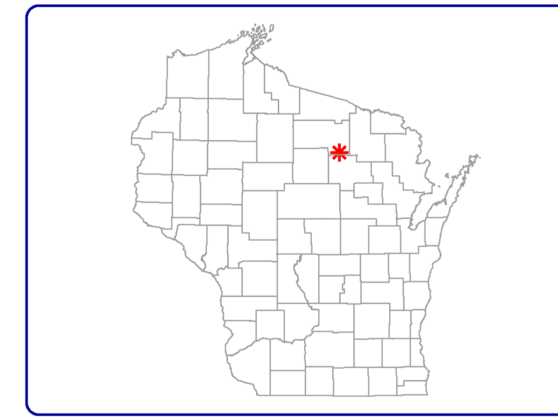


Map 6

Pelican Lake

Oneida County, Wisconsin

Aquatic Plant Communities



Project Location in Wisconsin

Small Plant Communities

- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities

- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Sources:
Orthophotography: NAIP, 2010
Aquatic Plants: Onterra, 2011
Data: Data Source

Map Date: October 6, 2012
Filename: Map6_Pelican_Comm_2011.mxd

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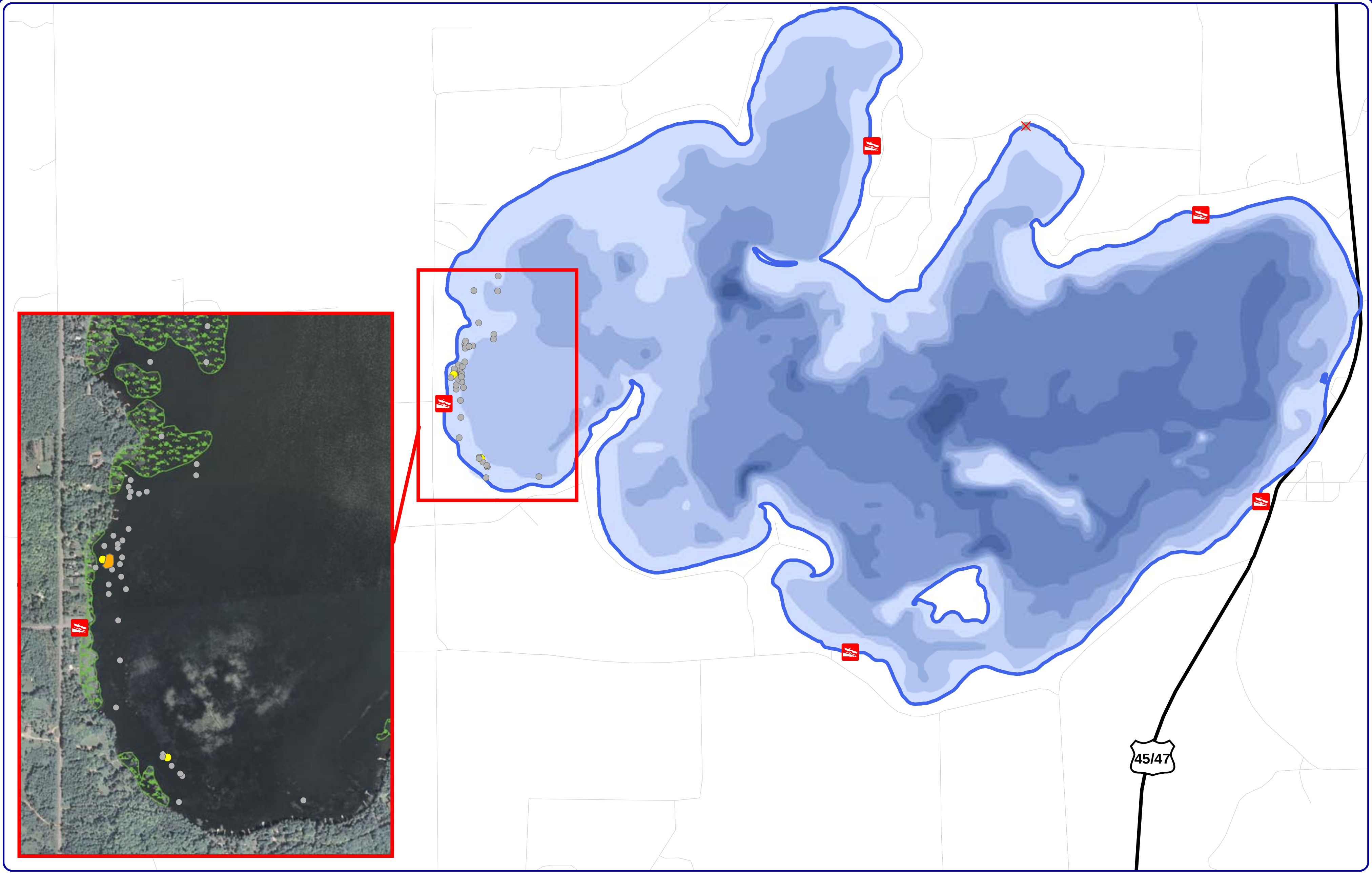

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Feet

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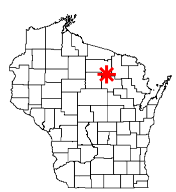
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plants: Onterra, 2011
Map Date: June 20, 2011
Filename: Map7_Pelican_EWM_June2011.mxd



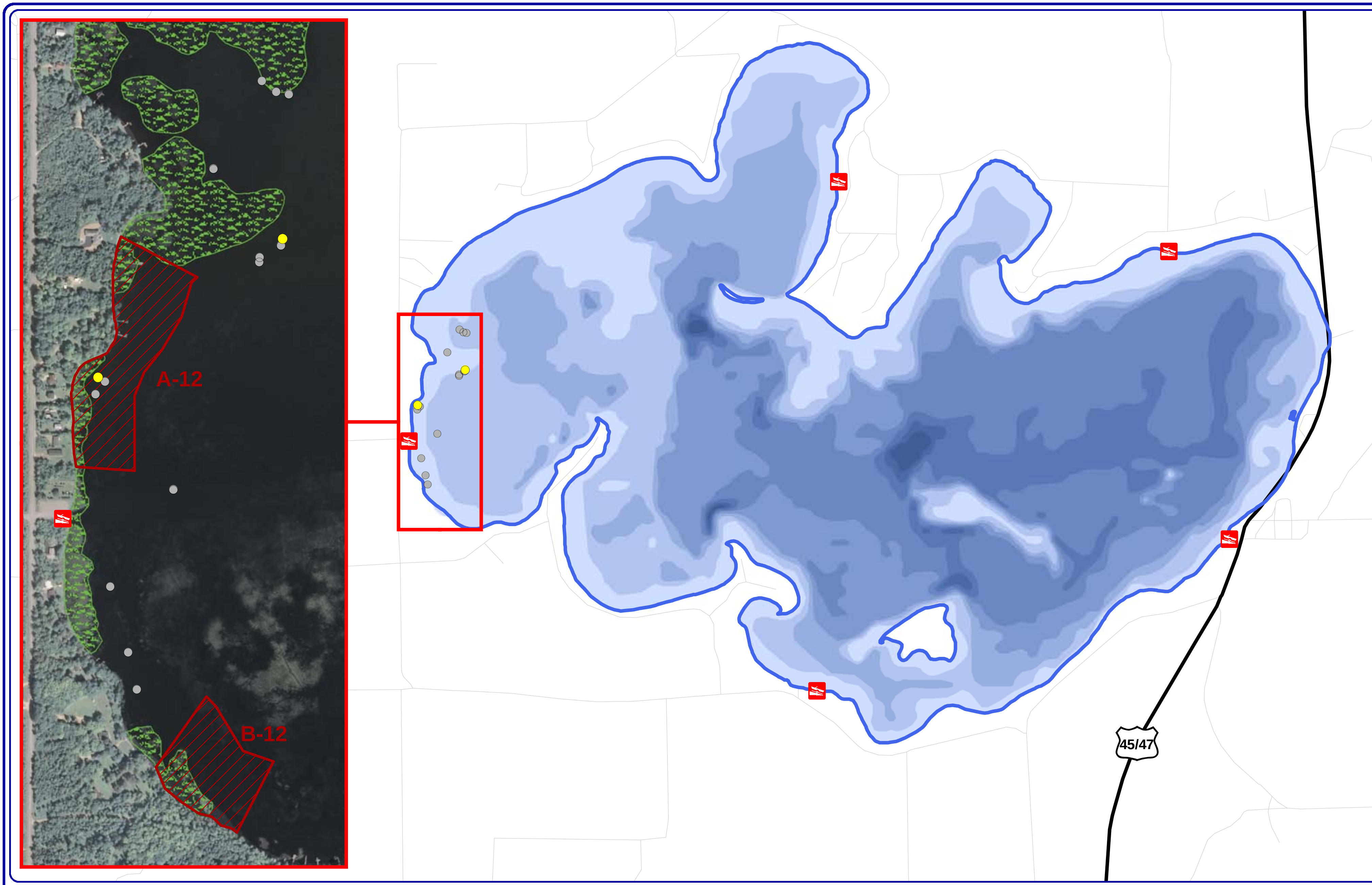
Project Location in Wisconsin

Legend

- Highly Scattered *(none found)*
- Scattered *(none found)*
- Dominant *(none found)*
- Highly Dominant
- Surface Matting *(none found)*
- Floating-leaf and/or Emergent Plant Colony
- Single Plant (*Hand Removed*)
- Single or Few Plants
- Clump of Plants
- Small Plant Colony
- Public Access

Map 7
Pelican Lake
Oneida County, Wisconsin

June 2011 EWM Survey Results



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2,750

Feet

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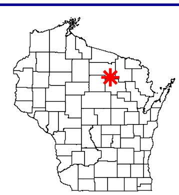
Sources:
Roads and Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plants: Onterra, 2012
Map Date: September 26, 2012
Filename: Map8_Pelican_EWM_Sept2012.mxd



Project Location in Wisconsin

Legend

- Highly Scattered *(none found)*
- Scattered *(none found)*
- Dominant *(none found)*
- Highly Dominant *(none found)*
- Surface Matting *(none found)*
- Single or Few Plants
- Clump of Plants
- Small Plant Colony *(none found)*
- Floating-leaf and/or Emergent Plant Colony
- 2012 Final Treatment Area

Map 8
Pelican Lake
Oneida County, Wisconsin

September 2012
EWM Survey Results