Shishebogama & Gunlock Lakes

Oneida and Vilas Counties, Wisconsin

Comprehensive Lake Management Plan

July 2012

Sponsored by:

Shishebogama and Gunlock Lakes Association

WDNR Grant Program

LPL-1286-09, LPL-1287-09, LPL-1288-09

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Lake Management Planning

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Funded by: Shishebogama and Gunlock Lake Association
Wisconsin Dept. of Natural Resources
LPL-1286-09, LPL-1287-09, LPL-1288-09

Acknowledgements

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

Shishebogama and Gunlock Lakes Planning Committee

Dennis Condon	Bob Schmidlman	George Zickert
Glenn Holcombe	Elaine Orstead	Bob Billings
Mike Sasse	Tom Koenen	Peter Taddy

Wisconsin Dept. of Natural Resources

Kevin Gauthier

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1.0 INTRODUCTION

Shishebogama Lake and Gunlock Lake are located along the Vilas and Oneida County border. Gunlock Lake is approximately 267 acres with a maximum depth of 26 feet. This lake flows into the approximately 700-acre Shishebogama Lake, which has a maximum depth of 42 feet. Together, this 967-acre headwater drainage system flows into the Tomahawk River.

Field Survey Notes

Many plant species observed during survey, no submergent exotic plants located.

Several occurrences of purple loosestrife discovered, some plants were hand-pulled. Giant reed spotted along shorelines in several areas (Note: this was later confirmed to be a native strain of this species).

Photograph 1.0-1 Large watershield community, Gunlock Lake, Vilas County

Lake at a Glance – Shishebogama and Gunlock Lakes

Morphology	
Acreage	267 (Shishebogama), 700 (Gunlock)
Maximum Depth (ft)	26 (Shishebogama), 42 (Gunlock)
Mean Depth (ft)	12 (Shishebogama), 16 (Gunlock)
Shoreline Complexity	8.4 (Shishebogama), 4.4 (Gunlock)
Vegetation	
Curly-leaf Survey Date	June 22 & 23, 2009
Comprehensive Survey Date	July 15 & 16, 2009
Number of Native Species	65 (Shishebogama), 56 (Gunlock)
Threatened/Special Concern Species	Vasey's Pondweed (Both Lakes)
Exotic Plant Species	Purple Loosestrife (Both Lakes)
Simpson's Diversity	0.94 (Both Lakes)
Average Conservatism	7.2 (Shishebogama), 6.9 (Gunlock)
Water Quality	
Trophic State	Middle / Upper Mesotrophic
Limiting Nutrient	Phosphous
Water Acidity (pH)	7.6 – 8.3
Sensitivity to Acid Rain	Low
Watershed to Lake Area Ratio	6:1 (Shishebogama), 4:1 (Gunlock)

The notion to establish an association for Shishebogama and Gunlock lakes began in the 1950's. At that time, one organization existed to oversee activities on both lakes. In the 1980's, membership declined, and the group disbanded. A few residents of Gunlock Lake then decided to start their own association, but by the early 1990's residents lost interest and the Gunlock Lake Association then dissolved.

In 1995, several lake property owners sought to revive the association again. Word spread of the new lake group and by end of summer 1996, the Shishebogama Lake Association was roughly 40 members strong. Gunlock residents were asked to join in 2002, and in 2005 the Association changed its name to include both waterbodies. Today, the Shishebogama and Gunlock Lakes Association (SGLA) includes 245 paid members, its highest membership ever.

Shishebogama and Gunlock Lakes is a highly sought after location amongst recreationists and anglers. In addition to the swimming beach adjacent to the main boat landing, two other public swimming beaches are located on the lakes. The system contains at least five functioning resorts, many with their own private landing. The 200-member Rockwood Country Club and 100-member Lakeland Village are also located on the system; each having their own private landing, swimming area, and fishing pier.

Shishebogama and Gunlock Lakes are located approximately 5 miles upstream of the Minocqua Chain of Lakes which is known to contain Eurasian water milfoil, curly-leaf pondweed, and purple loosestrife. The SGLA have been actively managing purple loosestrife on its shores utilizing biological control methods through a cooperative effort with the Minocqua-Kawaguesaga Lake Protection Association. Since the original beetle release, members of the SGLA have been rearing beetles for release on a single remaining colony near the channel between Shishebogama and Gunlock Lakes. At this time, this management action is believed to be successful, but a more comprehensive understanding of purple loosestrife populations need to be incorporated within the planning process to develop realistic management goals and associated management actions.

The SGLA completed the planning program for three main reasons: 1) to learn whether submersed exotic plants occur in their lakes, 2) to better understand the purple loosestrife infestation along its shores to aid in the coordination of its control, and 3) to understand their system's ecosystem more fully.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa. The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All of this information is communicated through multiple meetings that involve the lake group as a whole or a focus group called a Planning Committee, the completion of a stakeholder survey, and updates within the lake group's newsletter.

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

Kick-off Meeting

On June 6, 2009, a project kick-off meeting was held at the Arbor Vitae Town Hall. The presentation's purpose was to introduce the project to lake association members and the general public alike. The meeting was announced through a mailing and personal contact by Shishebogama and Gunlock Lakes Association board members. The 55 people in attendance were informed about the events that led to the initiation of the project. A presentation given by Tim Hoyman started with an educational component regarding general lake ecology and ending with a detailed description of the project including opportunities for stakeholders to be involved. Mr. Hoyman's presentation was followed by a question and answer session.

AIS Training Session

On June 18th of 2009, the SGLA hosted an aquatic invasive species (AIS) training session at Mr. Dennis Condon's residence. The two hour meeting was led by Tim Hoyman and Eddie Heath, who educated about 6 volunteers on various aquatic invasive species. These individuals were trained on field identification, and received knowledge on the various plants life cycles and control strategies.

Stakeholder Survey

During March 2010, a nine-page, 33-question survey was mailed to 324 riparian property owners in the Shishebogama and Gunlock Lakes watershed, based on properties listed by the county Register of Deeds. Because Native American property records are held by the Bureau of Indian Affairs, 4 residences were unintentionally left out of the mailing distribution. Sixty-six percent of the surveys were returned and those results were entered into a spreadsheet by members of the Shishebogama and Gunlock Lakes Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan.

Planning Committee Meeting

On August 3, 2010, Tim Hoyman and Eddie Heath of Onterra met with nine members of the SGLA Planning Committee for about 3¼ hours. Gretchen Watkins, a Water Resources Specialist with the Lac du Flambeau Tribe, was also in attendance. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including the stakeholder survey, aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed. Several concerns were raised by the committee, including recreational boating activities and the presence of purple loosestrife on the lake's shorelines. Overall, the committee members were happy to hear of the results of the project study, and together with Mr. Hoyman began formulating management goals and actions for the Shishebogama and Gunlock Lakes Management Plan.

Project Wrap-up Meeting

On August 21, 2010, the SGLA held a special meeting regarding the completion of the Shishebogama and Gunlock Lakes Management Planning Project. 51 people were in attendance at this meeting. Tim Hoyman presented the results of the many studies that had been completed on the lake since 2009. He also answered many questions about the lake and how it should be managed.

Management Plan Review and Adoption Process

In early-May 2011, a draft of the Management Plan was provided to the WDNR, GLIFWC, Oneida County, Vilas County, Lac du Flambeau Tribe, and SGLA Planning Committee for review. Within a few weeks, review was provided by the WDNR and GLIFWC in regards to the Fisheries Data Integration Section.

The WDNR Lake Specialist provided written comments to the draft management plan on June 1, 2012. This report reflects the integration of all comments received. The final report will be reviewed by the SGLA Board of Directors and a vote to adopt the management plan will be held during the association's next annual meeting.

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, not all chemical attributes collected may have a direct bearing on the lake's ecology, but may be more useful as indicators of other problems. Finally, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

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

Comparisons with Other Datasets

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 similar lakes in the area. In this document, a portion of the water quality information collected in Shishebogama and Gunlock Lakes (Appendix C) are compared to other lakes in the region and state. In addition, the assessment can also be clarified by limiting the primary analysis to parameters that are important in the lake's ecology and trophic state (see below). Three water quality parameters are focused upon in the Shishebogama and Gunlock Lakes 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).

Lillie and Mason (1983) is an excellent source of data for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Vilas County's lakes are included within the study's Northeast Region (Figure 3.1-1) and are among 242 lakes randomly sampled from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means and historic data from Shishebogama and Gunlock Lakes are displayed in Figures 3.1-2 – 3.1-7. Please note that the data in these graphs represent concentrations taken only during the growing season (April-October) from the deepest location in Shishebogama and Gunlock Lakes (Map 1). Since state and regional medians were calculated using summer (June, July, August) data, summer data for Shishebogama and Gunlock Lakes has also been displayed. 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 (see discussion under Internal Nutrient Loading on page 10).

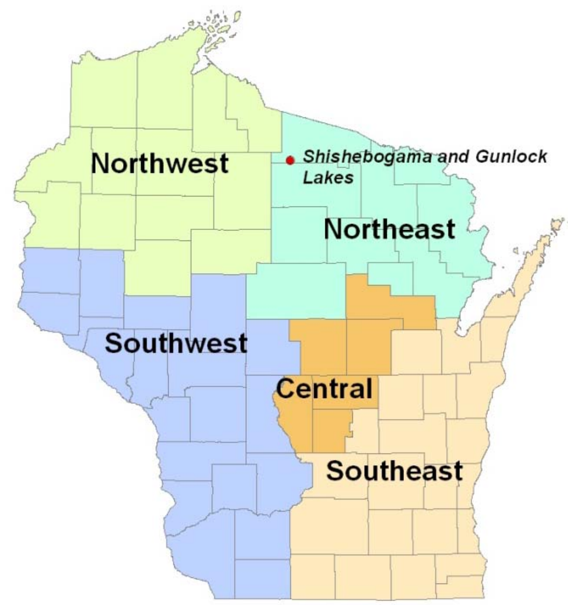

Figure 3.1-1. Location of Shishebogama and Gunlock Lakes within the regions utilized by Lillie and Mason (1983).

Apparent Water Quality Index

Water quality, like beauty, is often in the eye of the beholder. A person from southern Wisconsin that has never seen a northern lake may consider the water quality of their lake to be good if the bottom is visible in 4 feet of water. On the other hand, a person accustomed to seeing the bottom in 18 feet of water may be alarmed at the clarity found in the southern lake.

Lillie and Mason (1983) used the extensive data they compiled to create the *Apparent Water Quality Index* (WQI). They divided the phosphorus, chlorophyll-*a*, and clarity data of the state's lakes into ranked categories and assigned each a "quality" label from "Excellent" to "Very Poor". The categories were created based upon natural divisions in the dataset and upon their experience. As a result, using the WQI as an assessment tool is very much like comparing a particular lake's values to values from many other lakes in the state. However, the use of terms like, "Poor", "Fair", and "Good" bring about a better understanding of the results than just comparing averages or other statistical values between lakes. The WQI values corresponding to the phosphorus, chlorophyll-*a*, and Secchi disk values for Shishebogama and Gunlock Lakes are displayed on Figures 3.1-2 – 3.1-7.

Trophic State

Total phosphorus, chlorophyll-*a*, and water clarity values are directly related to the trophic state of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: oligotrophic, mesotrophic, and finally eutrophic. Every lake will naturally progress through these states and under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in many Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production. 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.

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

Carlson (1977) presented a trophic state index that gained great acceptance among lake managers. Because Carlson developed his TSI equations on the basis of association among water clarity, chlorophyll-*a*, and total phosphorus values of a relatively small set of Minnesota Lakes, researchers from Wisconsin (Lillie et. al. 1993), developed a new set of relationships and equations based upon the data compiled in Lillie & Mason (1983). This resulted in the Wisconsin Trophic State Index (WTSI), which is essentially a TSI calibrated for Wisconsin lakes. The WTSI is used extensively by the WDNR and is reported along with lake data collected by Citizen Lake Monitoring Network volunteers.

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 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 gradient.

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 impacts many chemical process that occur within a lake. Internal nutrient loading is an excellent example that 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 and is termed "internal phosphorus loading"; 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.

Shishebogama and Gunlock Lakes Water Quality Analysis

Shishebogama and Gunlock Lakes Long-term Trends

The historic water quality data that exists for Shishebogama Lake spans only the past 8-10 years, and spans a lesser amount of time for Gunlock Lake. Because of this limited dataset, is difficult to complete a reliable long-term trend analysis. This is unfortunate because having understanding of how the lake has changed over the years is always interesting and leads to sounder management decisions. According to the results of the stakeholder survey, approximately 92% of respondents consider the water quality of Shishebogama and Gunlock Lakes to be fair to excellent (Appendix B, Question #17); and the majority of stakeholders believe that the water quality in these lakes have remained the same (63.5 %) since they have owned their property (Appendix B, Question #18). The historic data that does exist shows that while there are fluctuations in a few parameters, the water quality appears to have remained the same over the past decade or so. Please note that water quality data for Gunlock Lake includes data taken by the Lac du Flambeau tribe.

As described above, three water quality parameters are of most interest; total phosphorus, chlorophyll-*a*, and Secchi disk transparency. Growing season values encompass data that were collected from April through October of a given year, while summer data includes data that were only collected during June, July, or August. For each parameter, a weighted average for all years was calculated, meaning that the years that had a larger number of sampling periods had greater influence, or added more weight, to the overall average value.

Total phosphorus data from Shishebogama Lake are contained in Figure 3.1-2, while values for Gunlock Lake are to be found in Figure 3.1-3. Examination of these data indicates that the total phosphorus level of Shishebogama Lake is low, especially when compared to lakes located within the Northeast Region and also natural lakes throughout the State of Wisconsin. In Gunlock Lake, the few years of phosphorus data only slightly exceed averages from similar lakes regionally and statewide. However, when observing phosphorus data from Shishebogama Lake in 2009, the values are slightly elevated when compared to previous years in the system, possibly due to natural (environmental or climatic) factors that occurred during that year. Regardless, phosphorus values in both Shishebogama and Gunlock Lakes fair well in comparison with similar lakes, and fall in the WQI category of *Good*.

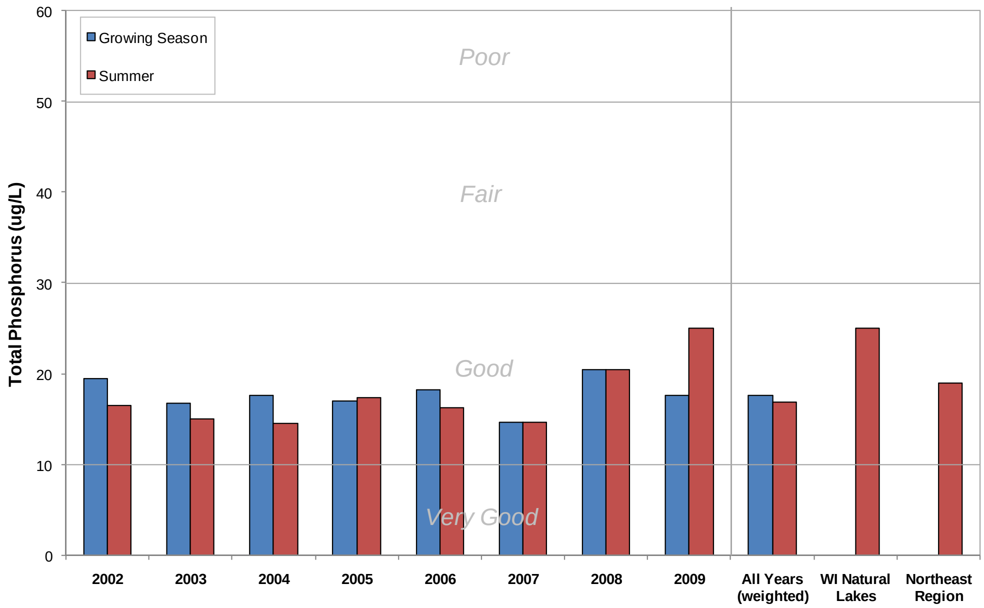

Figure 3.1-2. Shishebogama Lake, regional, and state total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

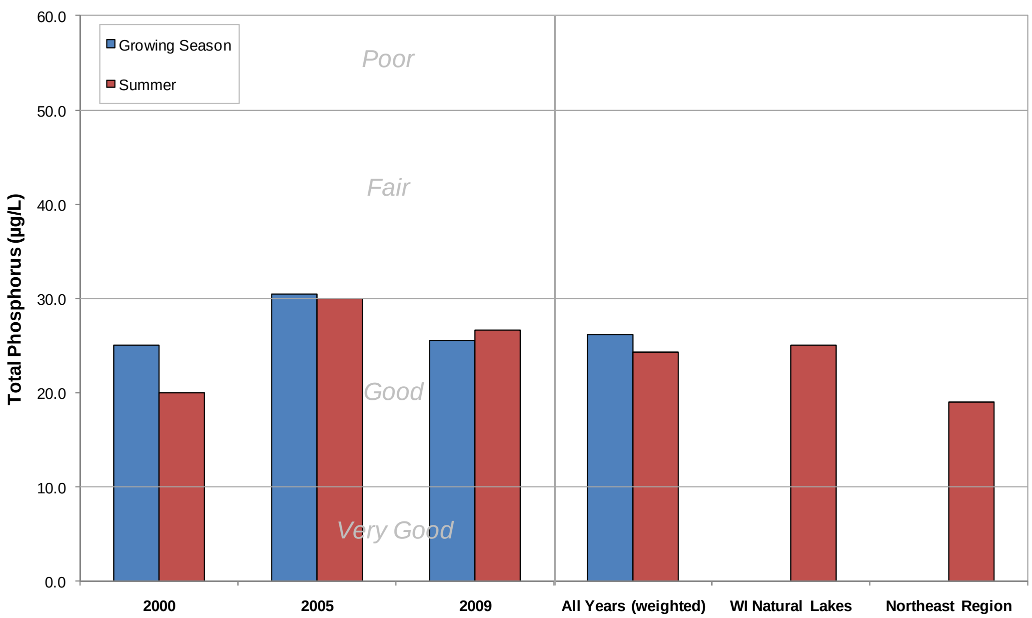

Figure 3.1-3. Gunlock Lake, regional, and state total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

In Shishebogama Lake, total phosphorus concentrations showed very little variability over the past 8 years. However, yearly averages in chlorophyll-*a* concentrations have fluctuated during this time (Figure 3.1-4). Although phosphorus is the determining nutrient for algal growth in

Shishebogama Lake (see Limiting Plant Nutrient below), other factors such as sunlight, temperature and stable conditions (light winds, minimal turbulence) are likely responsible for the varying algae growth observed in the chlorophyll-*a* dataset. A weighted average of this fluctuating annual data, which ranges between *Very Good* and *Good*, is still considerably less than averages seen both statewide and regionally. Three years of chlorophyll-*a* data from Gunlock Lake is also below averages seen statewide and regionally (Figure 3.1-5). It is important not to conclude there is a declining trend in chlorophyll-*a* concentrations from this data, as gaps exist in this dataset and we cannot be certain what concentrations were during these years.

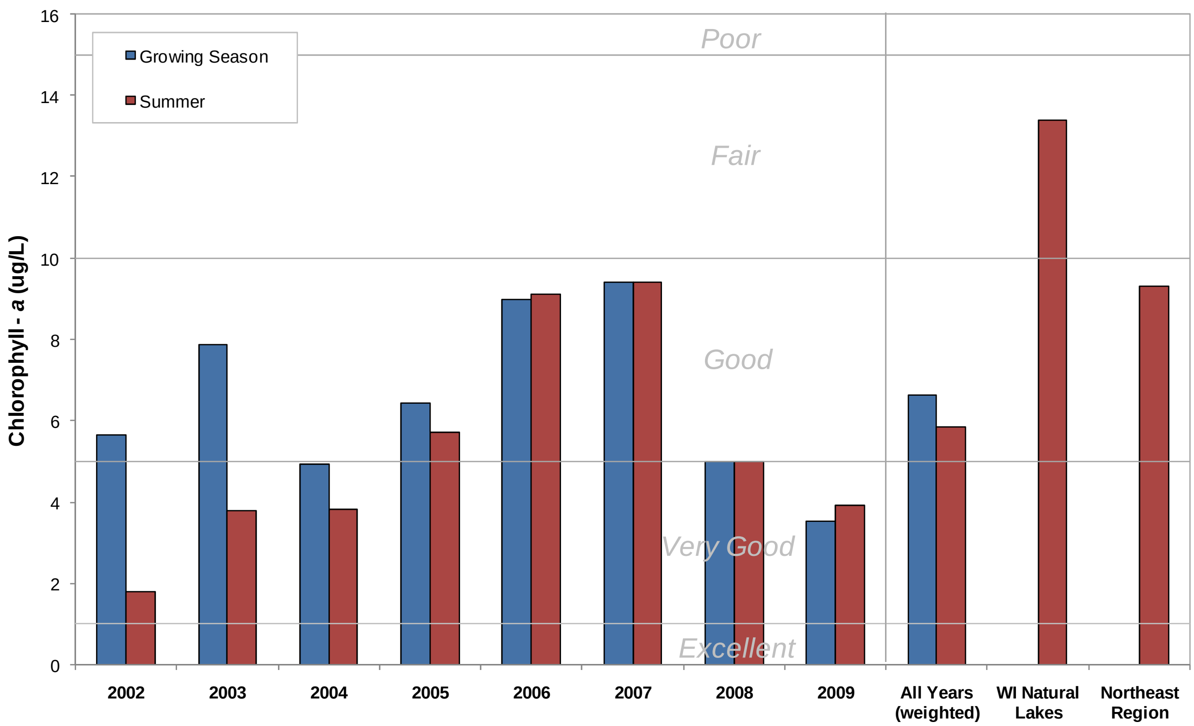

Figure 3.1-4. Shishebogama Lake, regional, and state chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

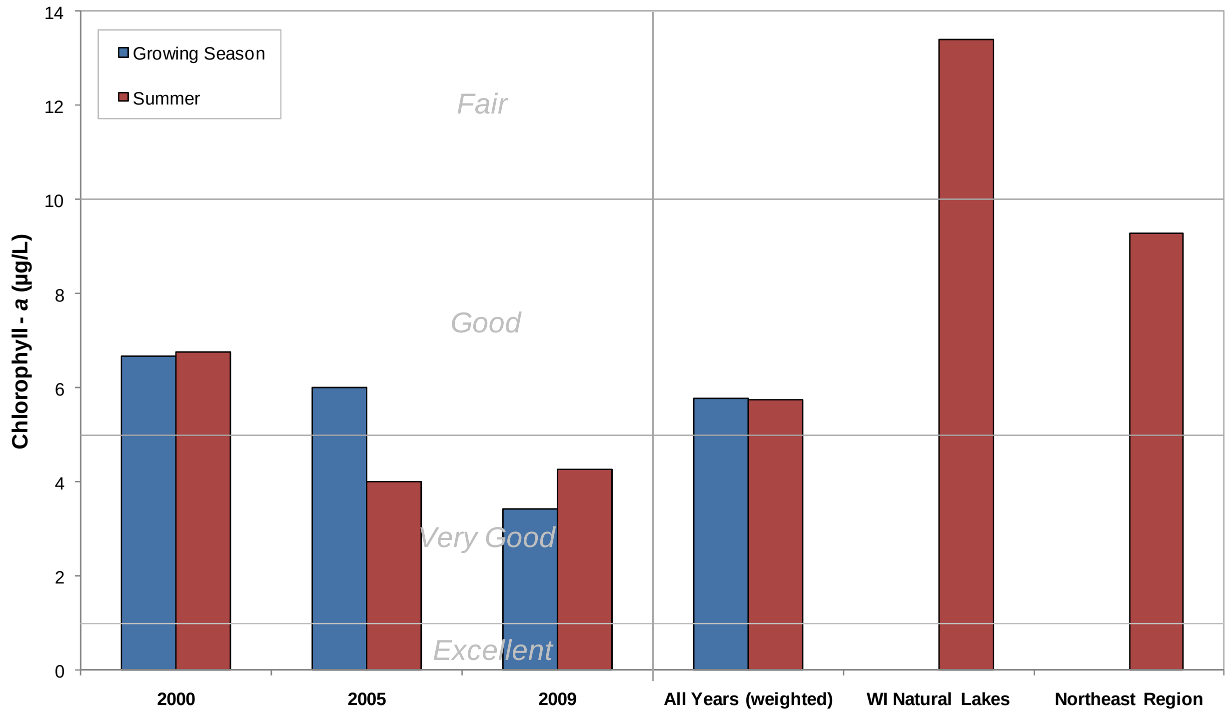

Figure 3.1-5. Gunlock Lake, regional, and state chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Of the three primary water quality parameters, Secchi disk clarity has been measured with the most frequency on both Shishebogama and Gunlock Lakes. On Shishebogama Lake, average annual Secchi disk values have fluctuated little in the past 12 years, and rank consistently as *Good* or *Very Good* along with recordings taken in 1979 and 1990 (Figure 3.1-6). These readings indicate that the average water clarity on Shishebogama Lake is greater than averages seen in other lakes both statewide and regionally.

Less Secchi disk clarity data has been collected on Gunlock Lake, including only two years in recent history (2008 and 2009) and several years during the early 1990's (Figure 3.1-7). Annual averages during these years fall mostly within the *Good* category. A weighted average across all years on record is slightly lower than averages seen in other lakes regionally, yet slightly higher than averages from lakes statewide.

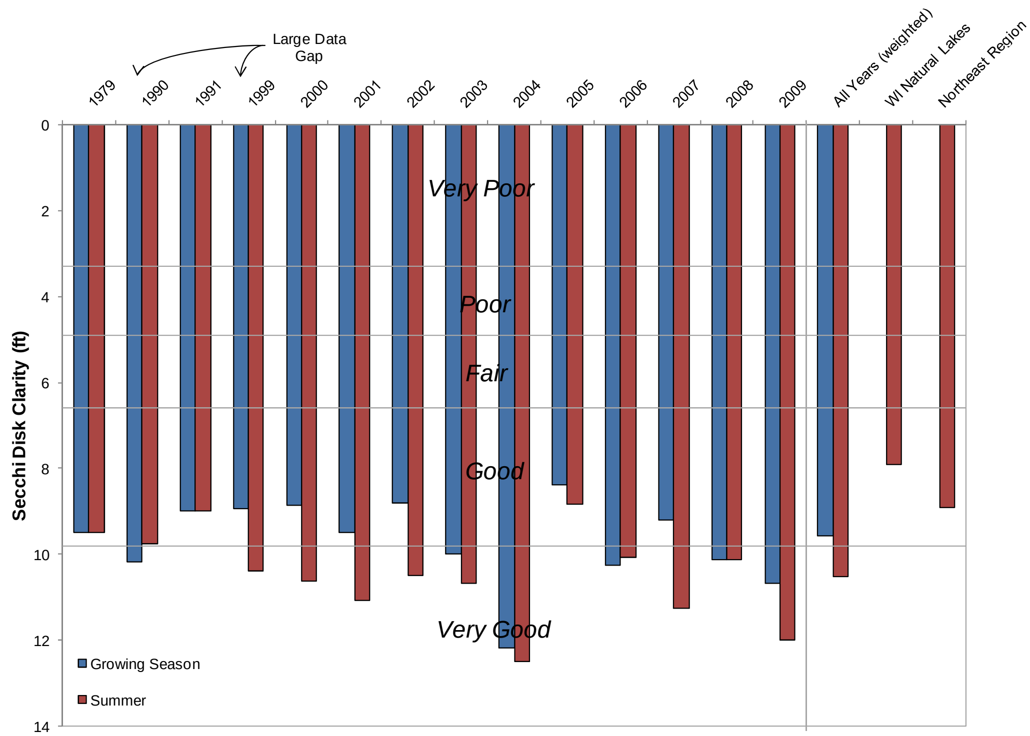

Figure 3.1-6. Shishebogama Lake, regional, and state Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

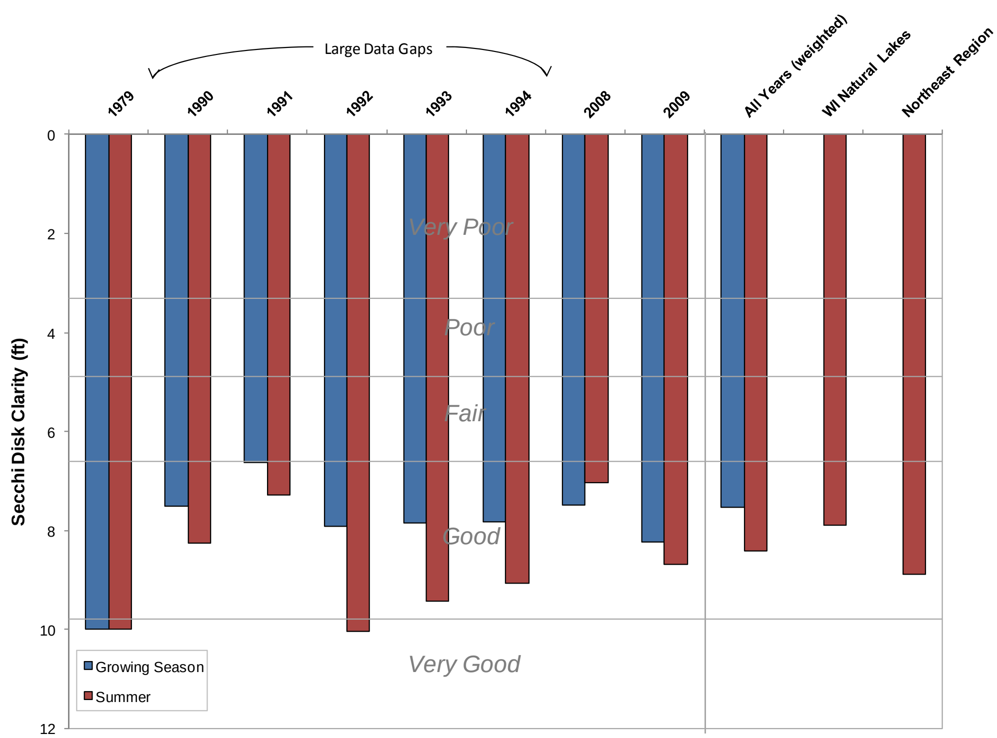

Figure 3.1-7. Gunlock Lake, regional, and state Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Limiting Plant Nutrient of Shishebogama and Gunlock Lakes

Using midsummer nitrogen and phosphorus concentrations from Shishebogama and Gunlock Lakes, a nitrogen:phosphorus ratio of 21:1 was calculated for Shishebogama and a ratio of 19:1 calculated for Gunlock. This finding indicates that both lakes are indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Shishebogama and Gunlock Lakes Trophic State

Figures 3.1-8 and 3.1-9 contain the WTSI values for Shishebogama and Gunlock Lakes. The WTSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from upper eutrophic to upper mesotrophic for Shishebogama Lake, and upper eutrophic to lower mesotrophic for Gunlock Lake. 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* WTSI values, it can be concluded that Shishebogama Lake is in a middle to upper mesotrophic state while Gunlock Lake is likely in an upper mesotrophic state.

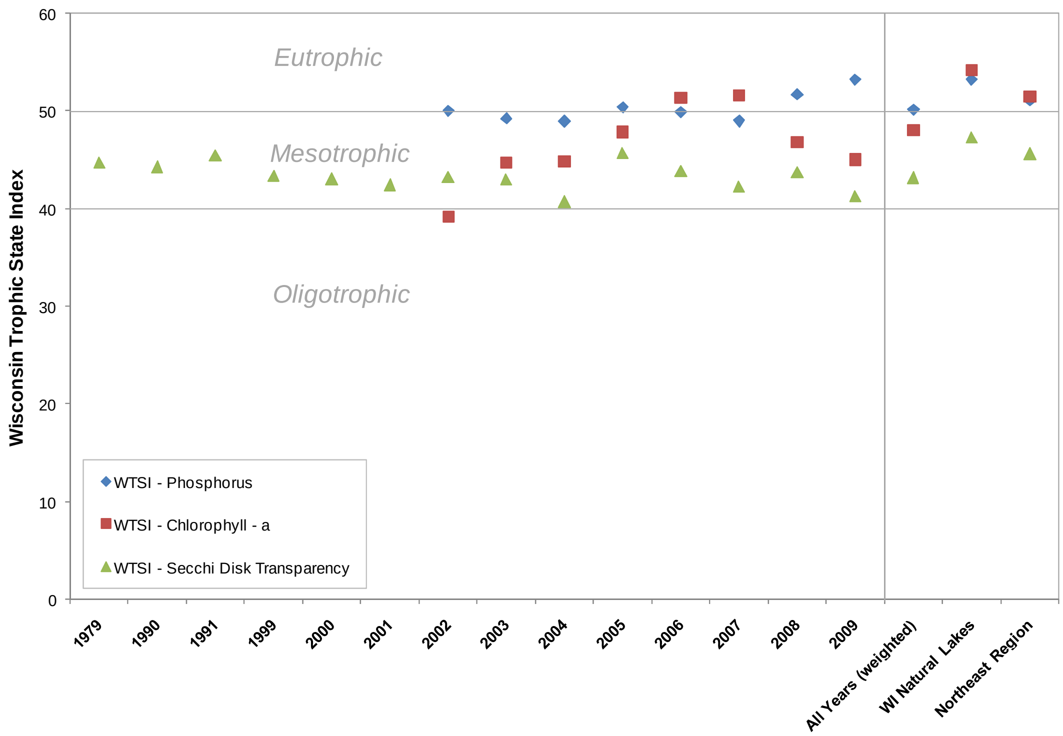

Figure 3.1-8. Shishebogama Lake, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993).

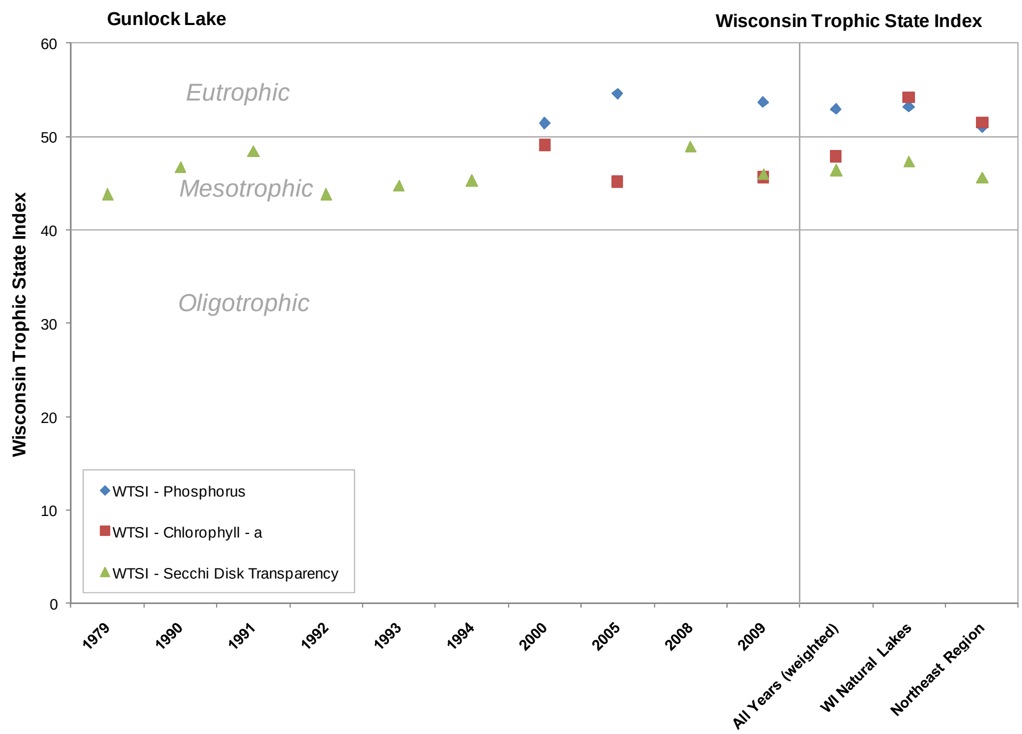

Figure 3.1-9. Gunlock Lake, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993).

Dissolved Oxygen and Temperature in Shishebogama and Gunlock Lakes

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Shishebogama and Gunlock Lakes by Onterra staff. Graphs of those data are displayed in Figure 3.1-10 (Shishebogama Lake) and Figure 3.1-11 (Gunlock Lake).

Both lakes were found to turnover completely in the spring and fall of 2009. During these seasons, energy from the wind stirs the water within the lake, mixing the warmer oxygenated water from the epilimnion with the colder water from the hypolimnion. As a result, the entire water column holds a steady temperature and oxygen concentration. Gunlock Lake turned over during July as well, and mixed during June in August. This is not uncommon in shallower lakes, as summer winds can mix these lakes but may not necessarily mix larger, deeper bodies of water.

In fact, both lakes held relatively high oxygen concentrations in fall of 2009, measuring in at over 10 mg/L. Several months later, in late February of 2010, these concentrations were still around 10 mg/L in the upper portions of the water column. In Shishebogama Lake, the concentrations slowly approached 0 mg/L as depth increased, but remained sufficiently high (>3 mg/L) even at 30 feet of depth to support most aquatic life. Although oxygen decreased more rapidly with depth in Gunlock Lake, the concentrations remained sufficiently high in the top 10 feet of the water column for aquatic life.

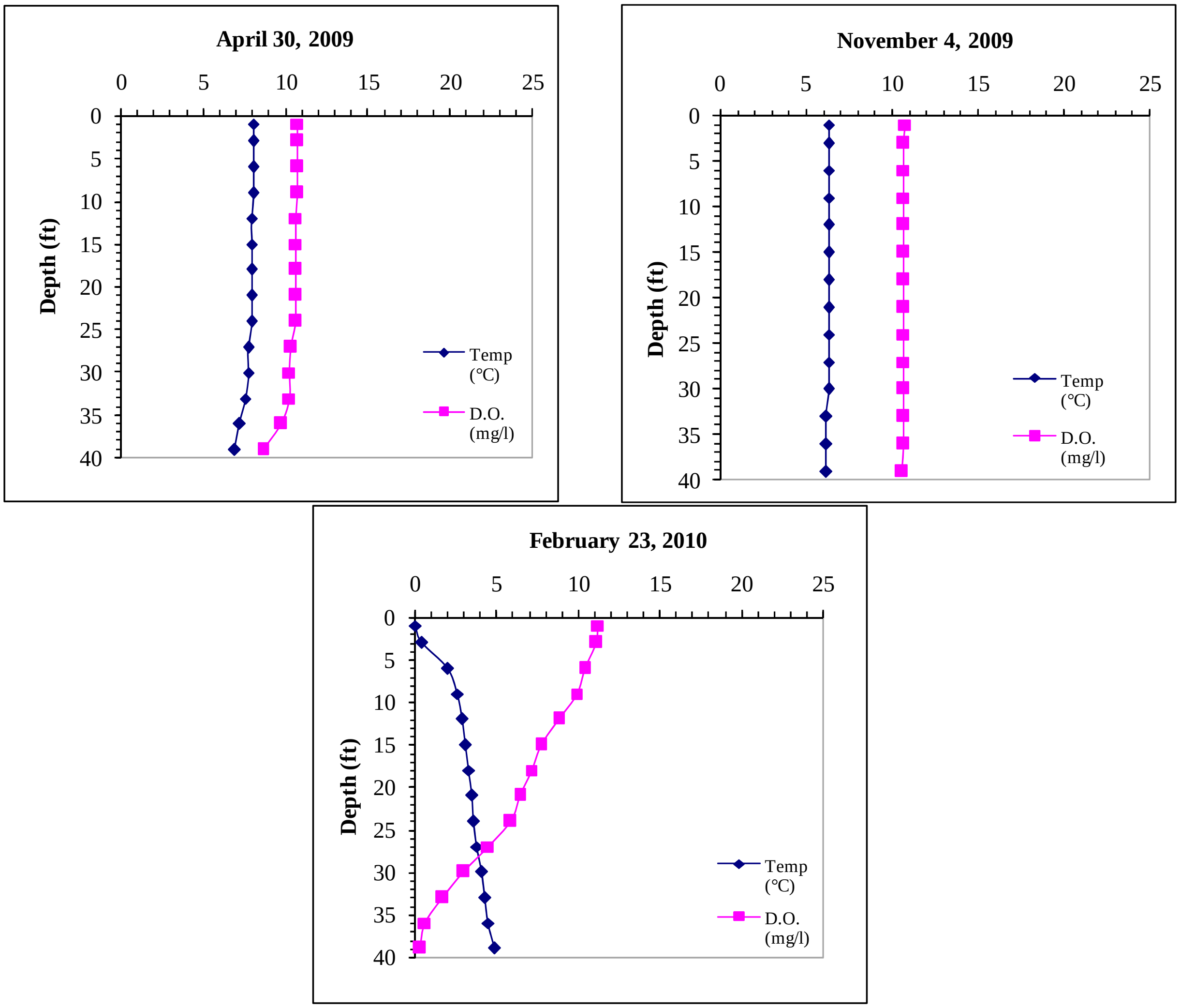

Figure 3.1-10. Shishebogama Lake dissolved oxygen and temperature profiles.

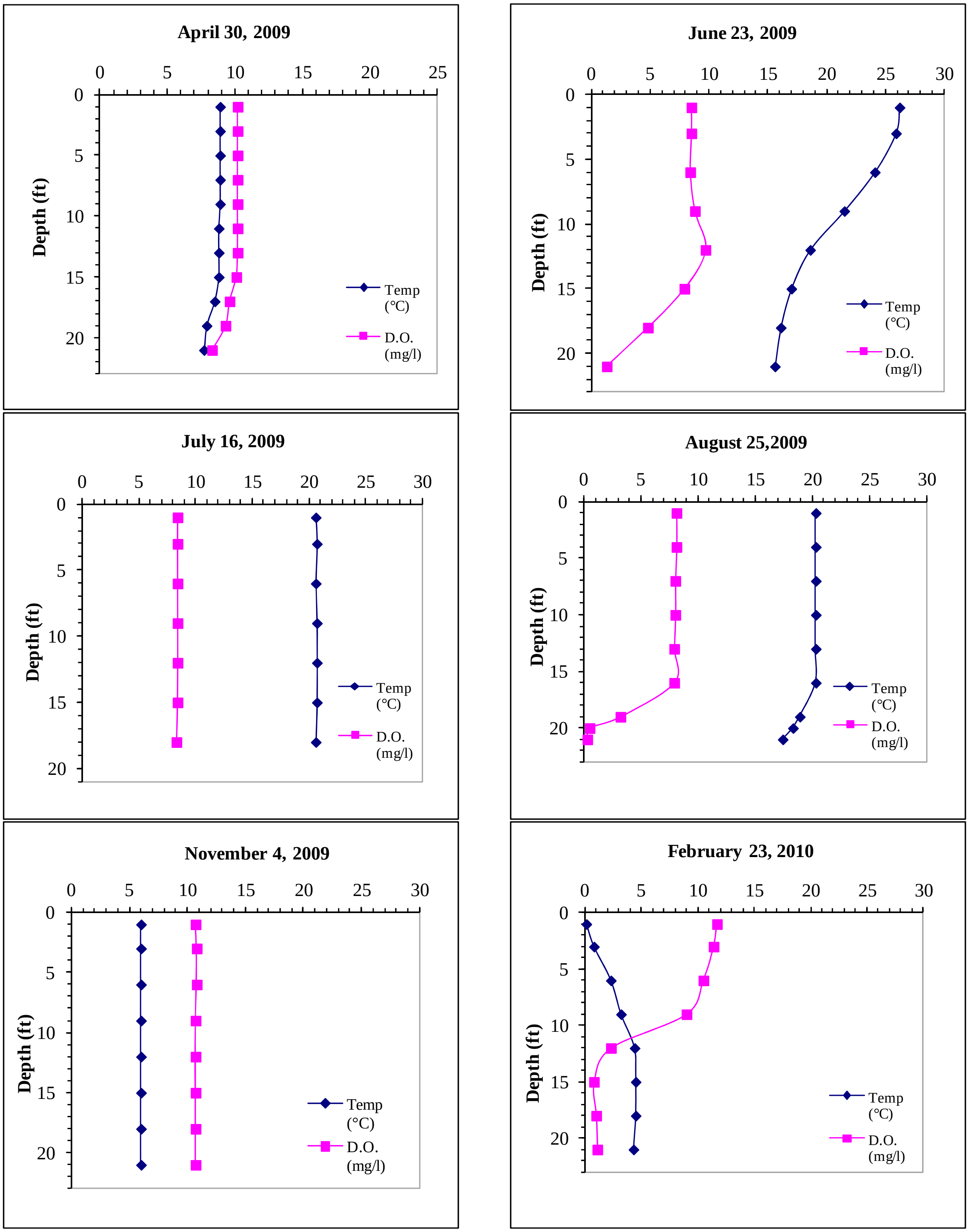

Figure 3.1-11. Gunlock Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Shishebogama and Gunlock Lakes

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 Shishebogama and Gunlock Lakes' water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, calcium, and total suspended solids.

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 et al. 2004). The pH of the water in Shishebogama and Gunlock Lakes was found to be near neutral to alkaline with surface values ranging from 7.1 to 8.3, 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 slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Shishebogama and Gunlock Lakes was 43.5 and 47.6 (mg/L as $CaCO_3$), respectively. This indicates that these lakes have a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Shishebogama and Gunlock Lakes' pH 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 Shishebogama Lake was found to be 13.5 mg/L, while Gunlock Lake's concentration was 15.0 mg/L, indicating a low susceptibility to zebra mussel establishment if they were instroduced.

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, Shishebogama and Gunlock Lakes are considered borderline suitable for mussel establishment.

Plankton tows were completed by Onterra staff during the summer of 2009 and these samples were processed by the WDNR for larval zebra mussels. Their analysis did not find any larval zebra mussels.

Total suspended solids (TSS) are a measure of inorganic and organic particles suspended in the water, and include everything from algae to clay particles. High TSS creates low water clarity, and prevents light from penetrating into the water to support aquatic plant growth. TSS was measured on Shishebogama and Gunlock Lakes during every Onterra water quality sampling event, and the data show that TSS was not detectable during any of the sampling events.

Lac du Flambeau Water Quality Standards

Under the Clean Water act, the US Environmental Protection Agency (EPA) is responsible for setting standards and carrying out provisions except in instances where a sovereign tribe requests that authority. The Lac du Flambeau Band of Lake Superior Chippewa Indians (LDF Tribe), along with the Mole Lake Band of Sokaogon Chippewa is one of the only two tribes in Wisconsin that have the authority to handle their own water quality standards program on reservation waterbodies (USEPA 2008). Additional information on the approved tribal water quality standards program can be found at: http://www.epa.gov/r5water/wqs5/wqstribes.htm

Acting in a capacity similar to the State of Wisconsin, in July 2010 the LDF Tribe has developed a surface water quality standards program and is authorized to carry out that program (USEPA 2010). This allows the LDF Tribe to use the developed water quality standards "for establishing any water quality based effluent limitations for any activity requiring a permit under the Clean Water Act that may result in a point source discharge into any waters on the reservation." The Lac du Flambeau Water Quality Standards (July 2010) can be found in its entirety at: http://water.epa.gov/scitech/swguidance/standards/wqslibrary/upload/ldf_wqs_0001_070110.pdf

3.2 Watershed Assessment

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.

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.

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 to the lake may be decreased. In fact, if the phosphorus load is reduced greatly, changes in lake water quality may be noticeable, (e.g. reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

In systems with high WS:LA ratios, like those 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 may 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 may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

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

Shishebogama and Gunlock Lakes' watershed covered a combined 5,875 acres, 1,291 of which surrounds Gunlock Lake and 4,585 of which surrounds Shishebogama Lake. Over half of each watershed is forested (54% in Shishebogama Lake's watershed, 58% in Gunlock's watershed), the remaining half of each watershed is split into several small land cover types (Figures 3.1-1 and 3.1-2). Wetlands make up approximately quarter of each watershed (27% and 20% of the watershed for Shishebogama and Gunlock Lakes, respectively) and the surface area of the lake is a substantial contributor in each watershed, as well (15% for the Shishebogama watershed, 21% for Gunlock's watershed). In Shishebogama Lake's watershed, pasture/grass (4%) and row crops (1%) make up the remaining land cover while the remaining 1% in Gunlock's watershed consists of pasture/grass. To summarize, each watershed consists mostly of forested land, but contains other land cover types which export minimal amounts of nutrients and sediment to the respective lake.

The watersheds surrounding Shishebogama and Gunlock Lakes are fairly small when compared to the size of these lakes. This creates a small to moderate watershed to lake area ratio for each lake, 6:1 for Shishebogama Lake and 4:1 for Gunlock Lake. As previously discussed, lakes which have a smaller watershed to lake area ratios are influenced heavily by the surrounding watershed in terms of their water quality. Fortunately both watersheds contain land cover types that are beneficial to the health of their respective lakes; however, the potential influence of the watershed over these lakes should be noted and considered for future land use planning.

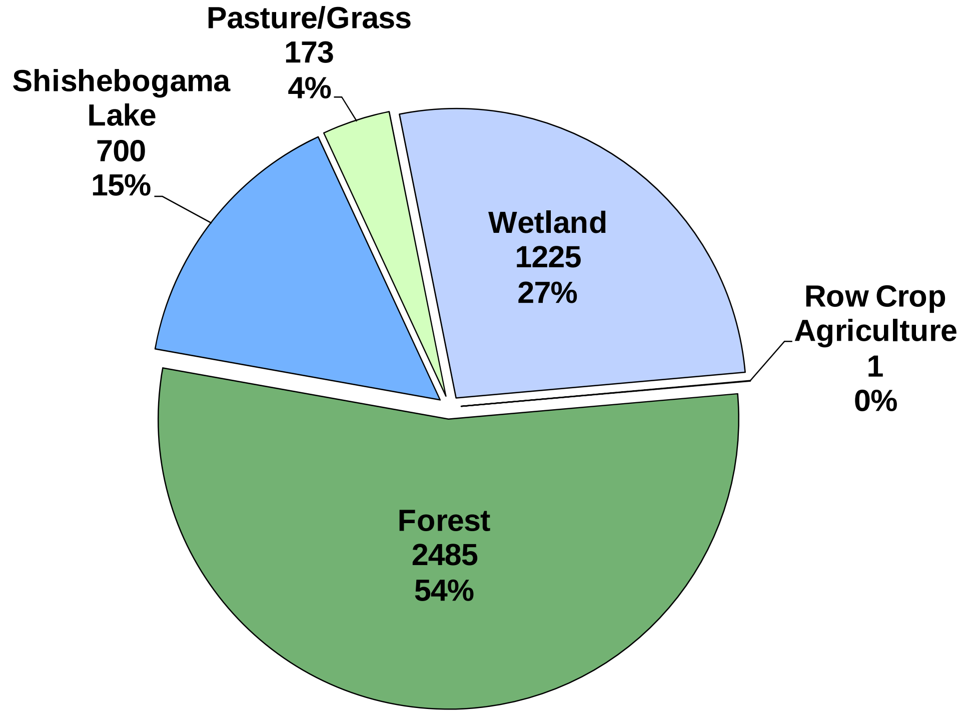

Figure 3.2-1. Shishebogama Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

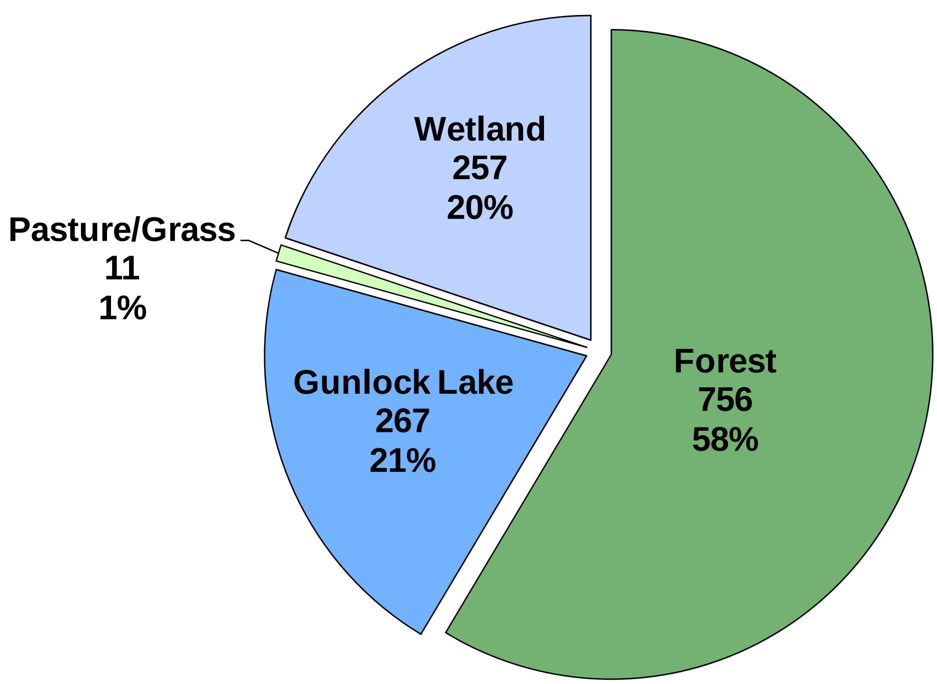

Figure 3.2-2. Gunlock Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

WiLMS modeling utilizing the land cover types and acreages found in Figures 3.2-1 and 3.2-2 resulted in an estimated annual phosphorus load of 630 lbs for Shishebogama Lake and 156 lbs for Gunlock Lake. Please note that the estimate for Shishebogama Lake includes phosphorus transported from Gunlock Lake to Shishebogama Lake through a small connecting channel. The annual phosphorus load for Shishebogama and Gunlock Lakes is small to moderate relative to the size of these lakes. Both lakes receive a fair amount of phosphorus input from forested land (32% of the annual load for Shishebogama Lake and 40% for Gunlock Lake) though this is the largest land use in both of these watersheds (Figures 3.2-3 and 3.2-4). Interestingly, atmospheric deposition on each lakes' surface accounts for substantial portions of the annual phosphorus load as well. The Shishebogama Lake surface collects 30% of the phosphorus load annually, while the Gunlock Lake surface collects 45% of the annual load and serves as the largest contributing source to this lake. Wetlands serve as the third largest contributing source in each system (17% of the load to Shishebogama Lake and 14% of the load to Gunlock Lake), while pasture/grassland supplies only a small portion of this annual load to each lake. Shishebogama Lake also receives a fair amount of its annual load (14%) from Gunlock Lake through a connecting channel, but receives a negligible (<1%) amount from the very little row crops that are found in the watershed.

Gunlock Lake may be classified as a spring lake in that it has no inlet, but does have an outlet into Shishebogama Lake. Shishebogama Lake is classified as a drainage lake because along with an outlet (Shishebogama Creek) the lake has an inlet from Gunlock Lake and also several intermittent tributary streams. The lakes are able to turn over their water in a moderate timeframe, with Shishebogama replacing 54% of its water in a year's time (a residence time of 1.8 years) and Gunlock replacing 41% of its water in a year (a residence time of 2.4 years). This natural flushing process helps to remove some pollutant buildup in the lake.

Both the Shishebogama and Gunlock Lake watershed are moderately sized, and hold land cover types that are ideal for protecting this natural resource. With this is mind, it is important to focus efforts of restoration on the most vulnerable area of these watersheds, the immediate shoreland zone. When a lake's shoreline is developed, the increased impervious surface, removal of natural vegetation, installation of septic systems, and other human practices can severally increase nutrient loads to the lake while degrading important habitat. Limiting these anthropogenic (man-made) affects on the lake is important in maintaining the current high quality of the lake's water and habitat.

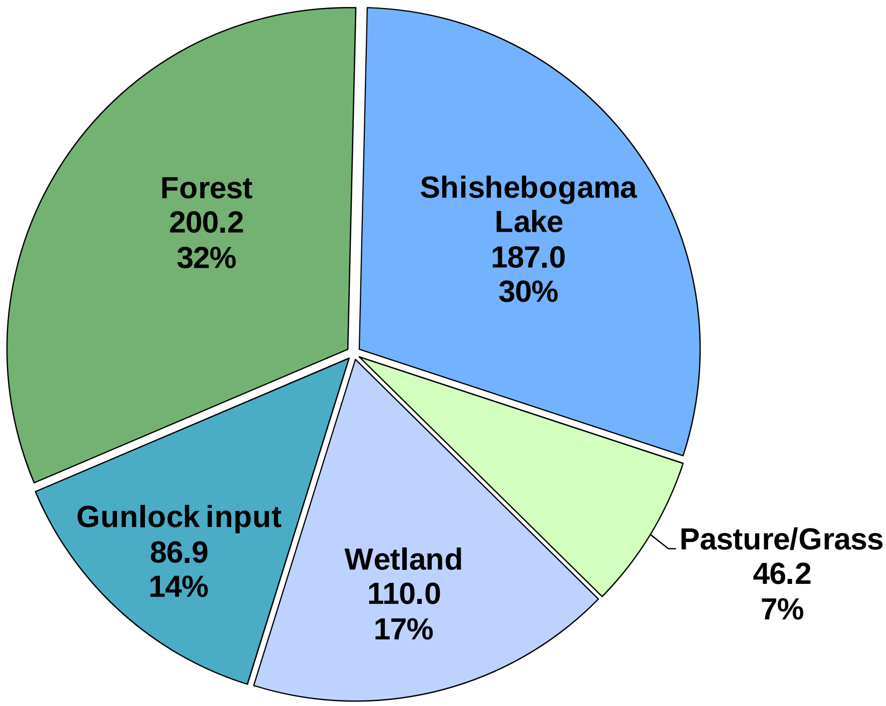

Figure 3.2-3. Shishebogama Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

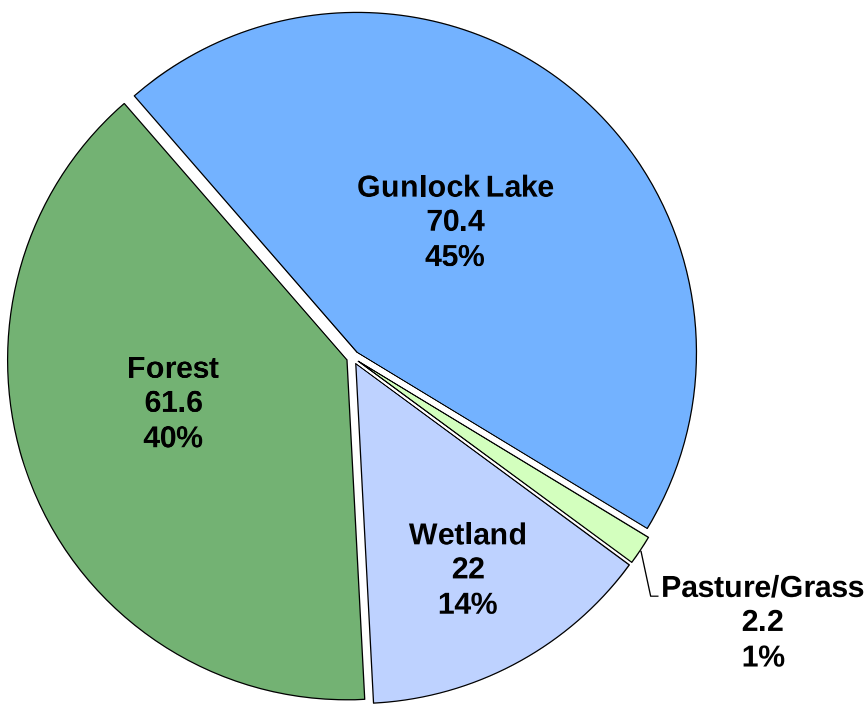

Figure 3.2-4. Gunlock Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Aquatic Plants

Introduction

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

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 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 numbers of predator fish and 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, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

Aquatic Plant Management and Protection

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

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

Permits

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

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

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects (Jennings et al. 2003). The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreline. 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 shoreline 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 realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a shoreland buffer zone. The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping. Simply not mowing within the buffer zone does wonders to restore some of the shoreland's natural function.

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

Cost

The cost of native, aquatic and shoreland plant restorations is highly variable and depend on the size of the restoration area, planting densities, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other factors may include extensive grading requirements, removal of shoreland stabilization (e.g., rip-rap, seawall), and protective measures used to guard the newly planted area from wildlife predation, wave-action, and erosion. In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $4,200.

- The single site used for the estimate indicated above has the following characteristics:
    - An upland buffer zone measuring 35’ x 100’.
    - An aquatic zone with shallow-water and deep-water areas of 10’ x 100’ each.
    - Site is assumed to need little invasive species removal prior to restoration.
    - Site has a moderate slope.
    - Trees and shrubs would be planted at a density of 435 plants/acre and 1210 plants/acre, respectively.
    - Plant spacing for the aquatic zone would be 3 feet.
    - Each site would need 100’ of biolog to protect the bank toe and each site would need 100’ of wavebreak and goose netting to protect aquatic plantings.
    - Each site would need 100’ of erosion control fabric to protect plants and sediment near the shoreline (the remainder of the site would be mulched).
    - There is no hard-armor (rip-rap or seawall) that would need to be removed.
    - The property owner would maintain the site for weed control and watering.

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreline erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • 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.

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

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

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

Cost

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

Advantages	*Disadvantages*
• Very cost effective for clearing areas around docks, piers, and swimming areas. • Relatively environmentally safe if treatment is conducted after June 15th. • Allows for selective removal of undesirable plant species. • Provides immediate relief in localized area. • Plant biomass is removed from waterbody.	• Labor intensive. • Impractical for larger areas or dense plant beds. • Subsequent treatments may be needed as plants recolonize and/or continue to grow. • Uprooting of plants stirs bottom sediments making it difficult to conduct action. • May disturb *benthic* organisms and fish-spawning areas. • Risk of spreading invasive species if fragments are not removed.

Bottom Screens

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

Cost

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

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

Water Level Drawdown

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

Cost

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

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

Costs

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

There are many herbicides available for controlling aquatic macrophytes and each compound is sold under many brand names. Aquatic herbicides fall into two general classifications:

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 does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. *Systemic herbicides* spread throughout the entire plant and often result in complete mortality if applied at the right time of the year.

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.

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.

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 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. Some herbicides are applied at a high dose with the anticipation that the exposure time will be short. Granular herbicides are usually applied at a lower dose, but the release of the herbicide from the clay carrier is slower and increases the exposure time.

Below are brief descriptions of the aquatic herbicides currently registered for use in Wisconsin.

Fluridone (Sonar®, Avast!®) Broad spectrum, systemic herbicide that is effective on most submersed and emergent macrophytes. It is also effective on duckweed and at low concentrations has been shown to selectively remove Eurasian water-milfoil. Fluridone slowly kills macrophytes over a 30-90 day period and is only applicable in whole lake treatments or in bays and backwaters were dilution can be controlled. Required length of contact time makes this chemical inapplicable for use in flowages and impoundments. Irrigation restrictions apply.

Diquat (Reward®, Weedtrine-D®) Broad spectrum, contact herbicide that is effective on all aquatic plants and can be sprayed directly on foliage (with surfactant) or injected in the water. It is very fast acting, requiring only 12-36 hours of exposure time. Diquat readily binds with clay particles, so it is not appropriate for use in turbid waters. Consumption restrictions apply.

Endothall (Hydrothol®, Aquathol®) Broad spectrum, contact herbicides used for spot treatments of submersed plants. The mono-salt form of Endothall (Hydrothol®) is more toxic to fish and aquatic invertebrates, so the dipotassium salt (Aquathol®) is most often used. Fish consumption, drinking, and irrigation restrictions apply.

2,4-D (Navigate®, DMA IV®, etc.) Selective, systemic herbicide that only works on broad-leaf plants. The selectivity of 2,4-D towards broad-leaved plants (dicots) allows it to be used for Eurasian water-milfoil without affecting many of our native plants, which are monocots. Drinking and irrigation restrictions may apply.

Triclopyr (Renovate®) Selective, systemic herbicide that is effective on broad leaf plants and, similar to 2,4 D, will not harm native monocots. Triclopyr is available in liquid or granular form, and can be combined with Endothal in small concentrations (<1.0 ppm) to effectively treat Eurasian water-milfoil. Triclopyr has been used in this way in Minnesota and Washington with some success.

Glyphosate (Rodeo®) Broad spectrum, systemic herbicide used in conjunction with a surfactant to control emergent and floating-leaved macrophytes. It acts in 7-10 days and is not used for submergent species. This chemical is commonly used for controlling purple loosestrife (*Lythrum salicaria*). Glyphosate is also marketed under the name Roundup®; this formulation is not permitted for use near aquatic environments because of its harmful effects on fish, amphibians, and other aquatic organisms.

Imazapyr (Habitat®) Broad spectrum, system herbicide, slow-acting liquid herbicide used to control emergent species. This relatively new herbicide is largely used for controlling common reed (giant reed, *Phragmites*) where plant stalks are cut and the herbicide is directly applied to the exposed vascular tissue.

Cost

Herbicide application charges vary greatly between $400 and $1000 per acre depending on the chemical used, the application rate, who applies it, permitting procedures, and the volume 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 spot treatments.	• Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them. • Many herbicides are nonselective. • 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 waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for either biocontrol insect.

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.

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

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

Cost

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

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

Analysis of Current Aquatic Plant Data

Aquatic plants are an important element in every healthy lake. Changes in lake ecosystems are often first seen in the lake's plant community. Whether these changes are positive, like variable water levels or negative, like increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways; there may be a loss of one or more species, certain life forms, such as emergents or floating-leaf communities may disappear from certain areas of the lake, or there may be a shift in plant dominance between species. 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 Shishebogama and Gunlock Lakes; 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 the comprehensive point-intercept surveys conducted in 2009 on Shishebogama and Gunlock Lakes, plant samples were collected from plots laid out on a grid that covered the entirety of each lake (Map 1). 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 for 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 of 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.

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

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 Mount Morris Lake. Comparisons will be displayed using boxplots that showing median values and upper/lower quartiles of lakes in the same ecoregion (Water Quality section, Figure 3.1-2) and in the state.

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.

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 Shishebogama and Gunlock Lakes will be compared to lakes in the same ecoregion and in the state (Figure 3.3-1).

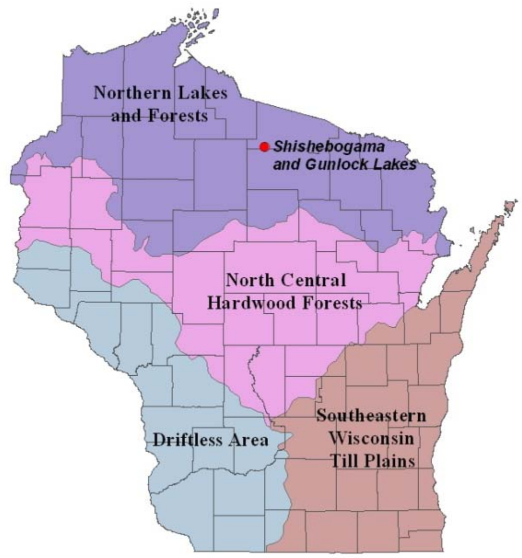

Figure 3.3-1. Location of Shishebogama and Gunlock Lakes within the ecoregions of Wisconsin. After Nichols 1999.

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 invasive native species, 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 plant 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; while emergents include cattails, bulrushes, and arrowheads, and 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 3.3-2). 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.

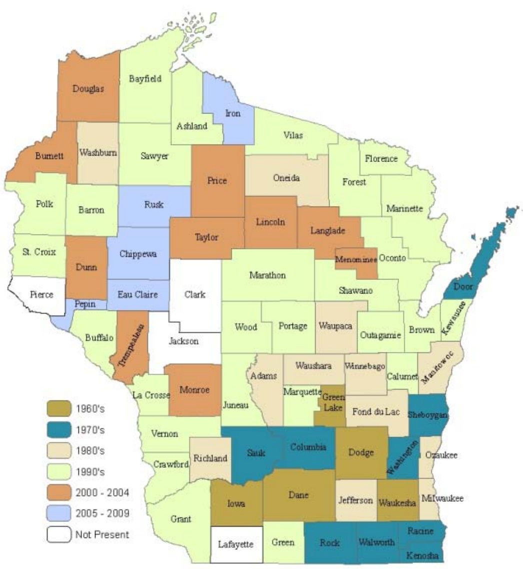

Figure 3.3-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2009 mapped by Onterra.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly – leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian 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 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 22nd and 23rd, 2009, a survey was completed on Shishebogama and Gunlock Lakes that focused upon curly-leaf pondweed. This meander-based survey did not locate any occurrences of curly-leaf pondweed. It is believed that this aquatic invasive species either does not occur in Shishebogama and Gunlock Lakes or exists at an undetectable level. The point intercept survey was conducted on Shishebogama and Gunlock Lakes on July 15th and 16th, 2009 by Onterra. Additional surveys were completed by Onterra on Shishebogama and Gunlock Lakes to create the aquatic plant community maps (Maps 3-5) on July 21st, 2009.

Median Value This is the value that roughly half of the data are smaller and half the data are larger. A median is used when a few data are so large or so small that they skew the average value to the point that it would not represent the population as a whole.

During the point-intercept and aquatic plant mapping surveys, 65 species of plants were located in Shishebogama Lake and 56 in Gunlock Lake (Tables 3.3-1 and 3.3-2). One of these species, purple loosestrife, was found along the shorelines of both lakes and is considered to be a non-native plant: Management of this invasive plant is discussed more in depth within the Implementation Plan. Fortunately, no submergent exotic invasive species (e.g. Eurasian water milfoil or curly-leaf pondweed) were located within the system during the aquatic plant surveys. Many nearby lakes contain Eurasian water milfoil, so there is a good chance that Shishebogama or Gunlock Lake has been exposed to fragments of this species carried in by transient boaters. Healthy plant communities, like those found in this system, make establishment of aquatic invasive species difficult. It should be noted that Vasey's pondweed, a species of special concern in Wisconsin, was observed occurring in both Shishebogama and Gunlock Lakes. Although this species is secure globally, it is "imperiled" in Wisconsin because of rarity (WDNR 2010).

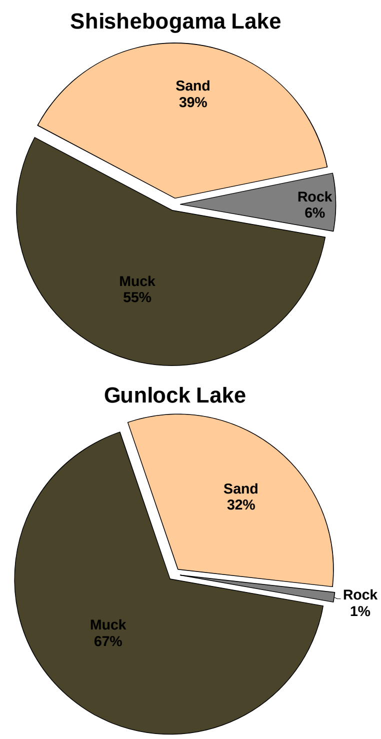

Figure 3.3-3. Proportions of substrate types within littoral areas of Shishebogama and Gunlock Lakes. Created using data from 2009 point-intercept surveys.

Sediment data gathered during the point-intercept surveys indicates that both Shishebogama and Gunlock Lake have similar proportions of substrate types, and that the majority of littoral areas of both lakes are comprised of organic sediments, or muck, (Figure 3.3-3). Organic sediments in combination with the clear water found in these lakes create a very conducive environment for supporting a lush aquatic plant community. In addition, the variation in sediment types creates a variety of habitats, which in turn leads to a species-rich plant community.

Table 3.3-1. Emergent, free-floating, floating-leaf, and floating-leaf/emergent aquatic plant species located on Shishebogama and Gunlock Lakes during July 2009 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism	Gunlock Lake	Shishebogama Lake
Emergent	*Calla palustris*	Water arum	9	I	I
	Carex comosa	Bristly sedge	5	I	I
	Carex lacustris	Lake sedge	6	X	I
	Carex lasiocarpa	Woollyfruit sedge	9	I	I
	Carex vesicaria	Blister sedge	7	I	I
	Dulichium arundinaceum	Three-way sedge	9	X	X
	Eleocharis palustris	Creeping spikerush	6	I	X
	Equisetum fluviatile	Water horsetail	7		X
	Juncus effusus	Soft rush	4		I
	Lythrum salicaria	Purple loosestrife	Exotic	I	I
	Phragmites australis subsp. americanus	Giant reed (native)	N/A		I
	Pontederia cordata	Pickerelweed	9	X	X
	Sagittaria cristata	Crested arrowhead	9	X	X
	Sagittaria latifolia	Common arrowhead	3	I	I
	Schoenoplectus acutus	Hardstem bulrush	5	X	X
	Schoenoplectus subterminalis	Water bulrush	9		X
	Schoenoplectus tabernaemontani	Softstem bulrush	4		X
	Typha angustifolia	Narrow-leaved cattail	1	X	
	Typha latifolia	Broad-leaved cattail	1	I	I
FF	*Lemna minor*	Lesser duckweed	5	X	X
	Lemna trisulca	Forked duckweed	6	X	X
	Spirodela polyrhiza	Greater duckweed	5	X	X
FL	*Brasenia schreberi*	Watershield	7	X	X
	Nuphar variegata	Spatterdock	6	X	X
	Nymphaea odorata	White water lily	6	X	X
FL/E	*Sparganium angustifolium*	Narrow-leaf bur-reed	9	X	X
	Sparganium emersum	Short-stemmed bur-reed	8	I	I
	Sparganium eurycarpum	Common bur-reed	5	I	X
	Sparganium fluctuans	Floating-leaf bur-reed	10	X	X

FF = Free-floating
FL = Floating leaf
FL/E = Floating leaf/emergent
X = Present on rake in Point-intercept Survey
I = Incidental

Table 3.3-2. Submergent and submergent/emergent aquatic plant species located on Shishebogama and Gunlock Lakes during July 2009 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism	Gunlock Lake	Shishebogama Lake
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X
	Ceratophyllum echinatum	Spiny hornwort	10		X
	Chara spp.	Muskgrasses	7	X	X
	Elatine minima	Waterwort	9	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Eriocaulon aquaticum	Pipewort	9		X
	Heteranthera dubia	Water stargrass	6	X	X
	Isoetes lacustris	Lake quillwort	8	X	X
	Lobelia dortmanna	Water lobelia	10		X
	Megalodonta beckii	Water marigold	8	X	X
	Myriophyllum alterniflorum	Alternate-flowered water milfoil	10		X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum tenellum	Dwarf water milfoil	10	X	X
	Myriophyllum verticillatum	Whorled water milfoil	8		X
	Najas flexilis	Slender naiad	6	X	X
	Nitella spp.	Stoneworts	7	X	X
	Potamogeton alpinus	Alpine pondweed	9	X	
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8		X
	Potamogeton foliosus	Leafy pondweed	6	X	
	Potamogeton friesii	Fries' pondweed	8	X	X
	Potamogeton gramineus	Variable pondweed	7	X	X
	Potamogeton hybrid sp	Potamogeton hybrid sp	N/A	X	X
	Potamogeton illinoensis	Illinois pondweed	6	X	X
	Potamogeton natans	Floating-leaf pondweed	5	X	
	Potamogeton praelongus	White-stem pondweed	8	X	X
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton spirillus	Spiral-fruited pondweed	8		X
	Potamogeton vaseyi	Vasey's pondweed	10	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Ranunculus aquatilis	White water-crowfoot	8	X	X
	Ranunculus flammula	Creeping spearwort	9	X	X
	Sagitaria sp. (rosette)	Arrowhead rosette	N/A	X	X
	Stuckenia pectinata	Sago pondweed	3		X
	Utricularia intermedia	Flat-leaf bladderwort	9	X	X
	Utricularia vulgaris	Common bladderwort	7	X	X
	Vallisneria americana	Wild celery	6	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X	X
	Juncus pelocarpus	Brown-fruited rush	8	X	X
	Sagittaria graminea	Grass-leaved arrowhead	9	I	I

S/E = Submergent/Emergent
X = Present on rake in Point-intercept Survey
I = Incidental

Both Shishebogama and Gunlock Lakes hold many different plant species within their waters and along their shorelines. Several of these species were found more often than others during the 2009 point-intercept survey. In Shishebogama Lake, the four most frequent species observed were coontail, small pondweed, fern pondweed, and stoneworts (Figure 3.3-4). Similarly, on Gunlock Lake, the top four species consisted of coontail, flat-stem pondweed, fern pondweed, and stoneworts (Figure 3.3-5).

Each of these species are unique, with distinguishing characteristics and traits that allow them to both compete with and compliment other organisms that share their environment. For example, coontail lacks true root structures and its locations are often subject to water movement and their tendency to become entangled in plants, rocks, or debris. Fern pondweed is usually a low-growing plant that was likely named after its palm-frond or fern-like appearance. This plant is known to provide habitat for smaller aquatic animals that are used as food by larger, predatory fishes. Stoneworts are plants included in the family *Characeae*, which are the largest and most complex forms of green algae. The fine, dense network of branches of these plants creates excellent habitat for aquatic invertebrates and small fish.

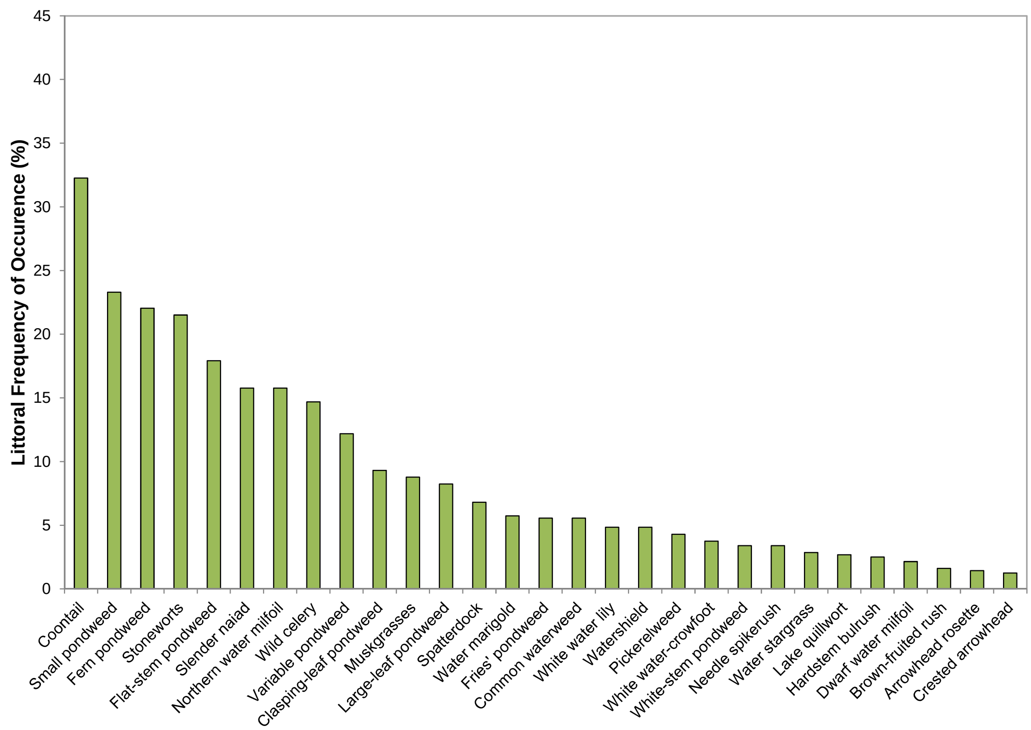

Figure 3.3-4. Shishebogama Lake aquatic plant littoral frequency of occurrence. Species with occurrence of <1% are not displayed. Created using data from July 2009 surveys.

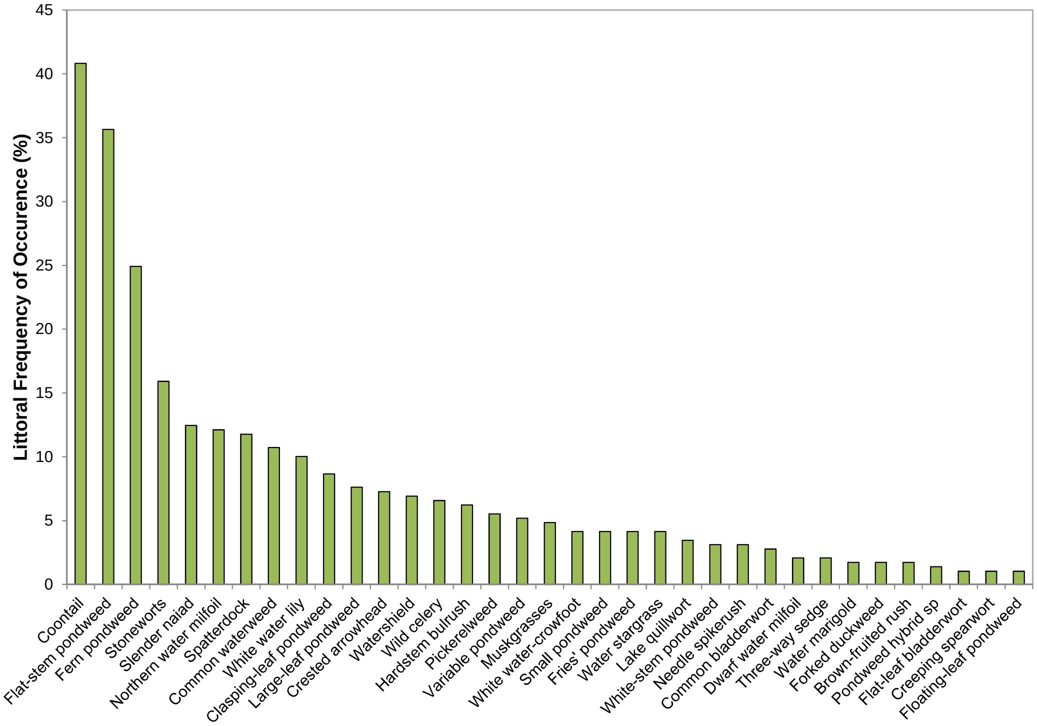

Figure 3.3-5. Gunlock Lake aquatic plant littoral frequency of occurrence. Species with occurrence of <1% are not displayed Created using data from July 2009 surveys.

As discussed in the primer section, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 65 native aquatic plant species were located in Shishebogama Lake during the 2009 surveys, 55 were encountered on the rake during the point-intercept survey. The native species encountered on the rake and their conservatism values were used to calculate the FQI of Shishebogama and Gunlock Lakes' aquatic plant communities (equation shown below).

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

Figure 3.3-6 compares the FQI values calculated from the 2009 point-intercept surveys on Shishebogama and Gunlock Lakes to the median values of lakes within Northern Lakes and Forests Ecoregion and Wisconsin. As illustrated, the native species richness and average conservatism values for both lakes exceed median values for both the ecoregion and the state (Figure 3.3-6). Combining each lakes' species richness and average conservatism values yields exceptionally high FQI values of 53.3 for Shishebogama Lake and 47.4 for Gunlock Lake, which both exceed the ecoregional and state medians (Figure 3.3-6). This indicates that the aquatic plant communities of Shishebogama and Gunlock Lakes are of higher quality than the majority of lakes within the Northern Lakes and Forests Ecoregion as well as the entire state of Wisconsin.

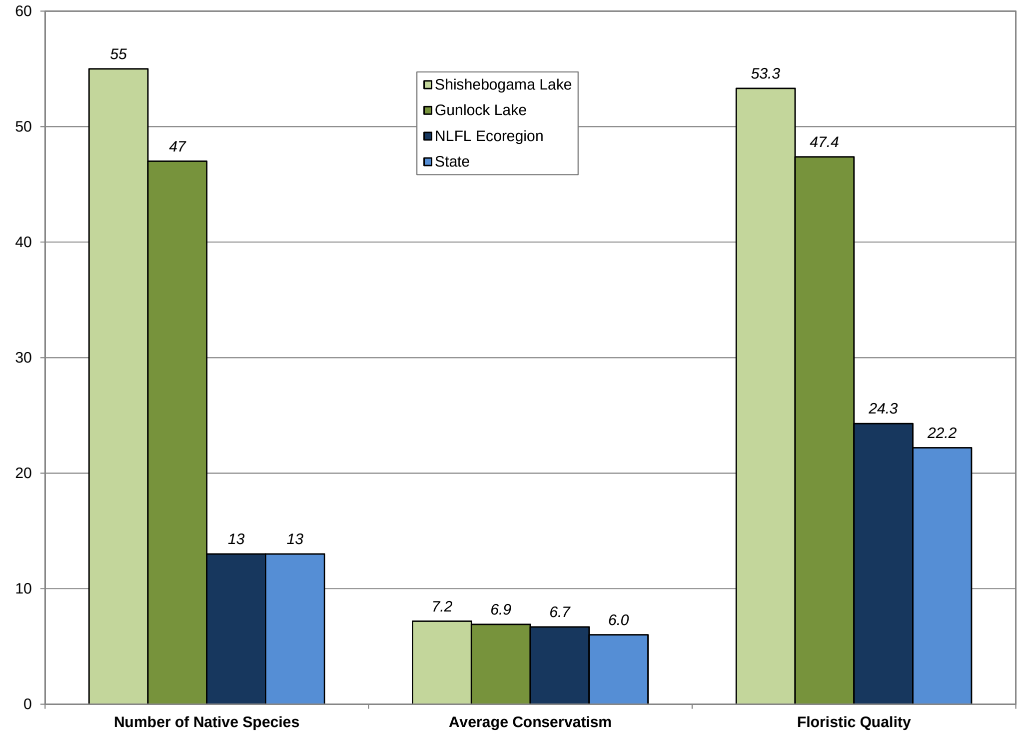

Figure 3.3-6. Shishebogama and Gunlock Lakes Floristic Quality Assessment. Created using data from 2009 point-intercept surveys.

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

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Shishebogama and Gunlock Lakes' diversity values rank. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLFL Ecoregion (Figure 3.3-7). Using the data collected from the 2009 point-intercept surveys, both Shishebogama and Gunlock Lakes' plant communities were shown to have high species diversity with Simpson's diversity values of

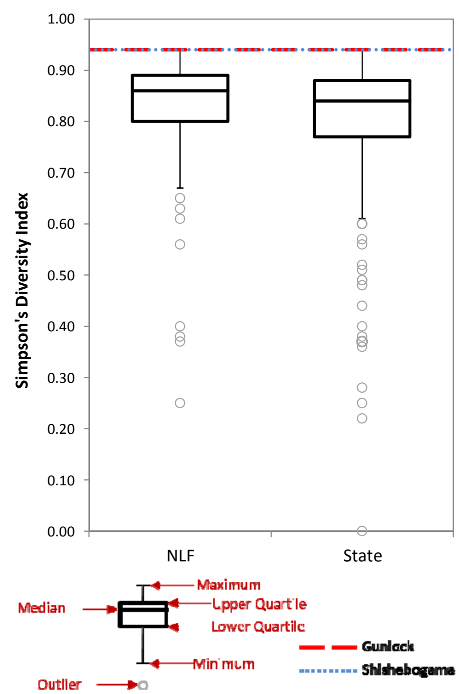

Figure 3.3-7. Shishebogama and Gunlock Lakes species diversity index. Created using data from 2009 point-intercept surveys.

0.94. These diversity values fall right on the maximum diversity value for lakes sampled within the ecoregion and the state (Figure 3.3-7), meaning that no lakes within the WDNR's surveys had a diversity value greater than 0.94. This value means that two individual aquatic plants were randomly sampled from either Shishebogama or Gunlock Lakes, there would be a 94% probability that they would be different species.

As explained previously 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 plant species is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while coontail was found at 32% of the littoral sampling locations in Shishebogama Lake, its relative frequency of occurrence is 12%. Explained another way, if 100 plants were randomly sampled from Shishebogama Lake, 12 of them would be coontail.

Figures 3.3-8 and 3.3-9 display the relative frequency of occurrence of aquatic plant species in Shishebogama and Gunlock Lakes from the 2009 point-intercept surveys and illustrate the relatively even distribution of species within the community; the aquatic plant communities are not overly dominated by a single or few species which creates a highly diverse community.

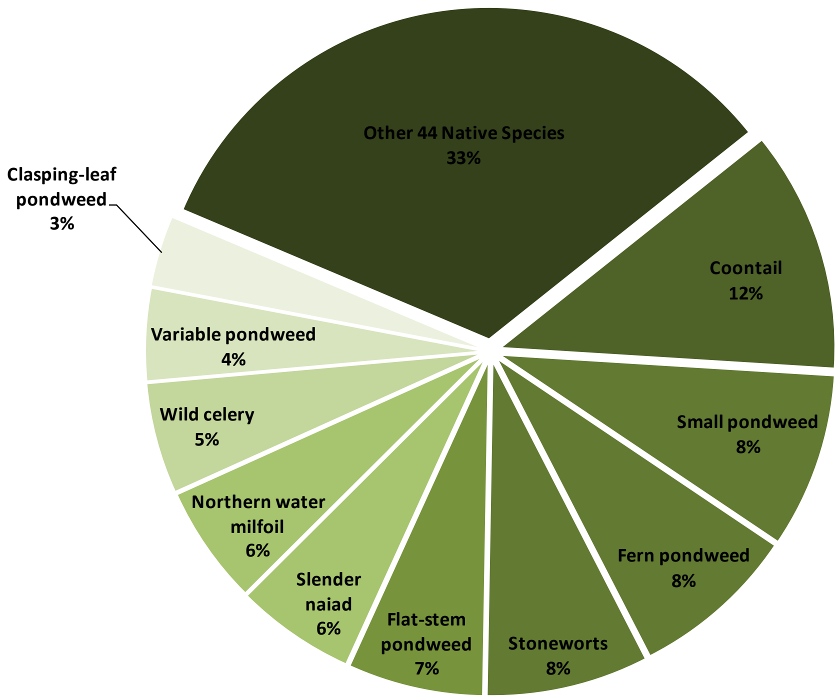

Figure 3.3-8. Shishebogama Lake aquatic plant relative frequency of occurrence. Created using data from July 2009 surveys.

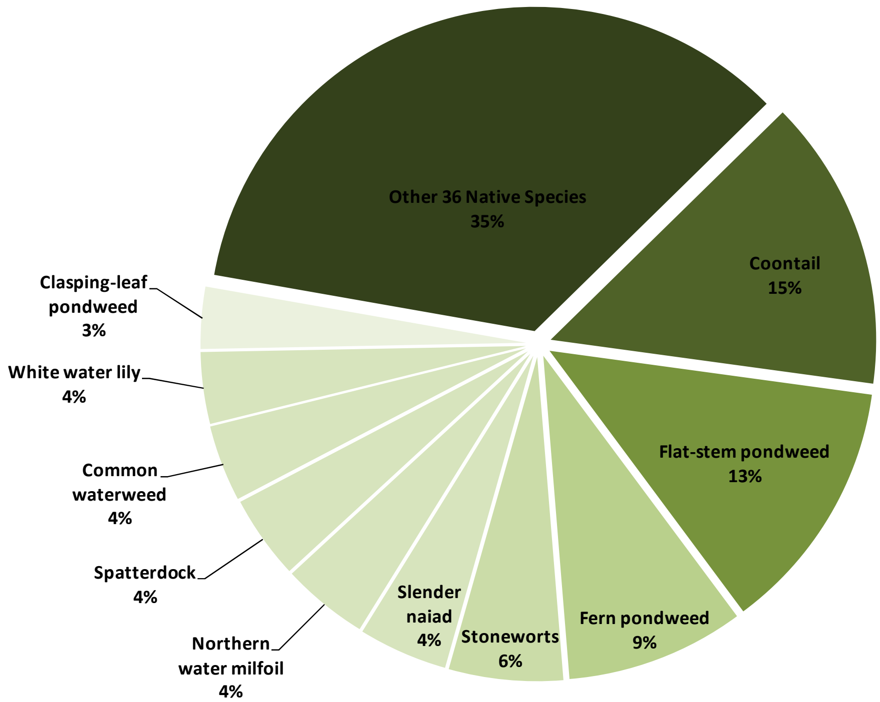

Figure 3.3-9. Gunlock Lake aquatic plant relative frequency of occurrence. Created using data from July 2009 surveys.

The quality of Shishebogama and Gunlock Lakes' aquatic plant communities are also indicated by the high incidence of emergent and floating-leaf plant communities that occur in the lakes. The 2009 community map indicates that approximately 73.9 acres (10.6%) of the 700-acre Shishebogama Lake and 43.7 acres (16.4%) of the 267-acre Gunlock Lake contain these types of plant communities (Table 3.3-3). Twenty-three floating-leaf and emergent species were located on Shishebogama Lake, and thirteen species of the same type located on Gunlock Lake. These plant communities provide valuable fish and wildlife habitat important to the ecosystem of the lake. These areas are particularly important during times of fluctuating water levels, since structural habitat of fallen trees and other forms of course-woody debris can become quite sparse along the shores of receding water lines.

Table 3.3-3. Shishebogama and Gunlock Lakes plant community types and acreage from the 2009 community mapping survey.

Lake	Plant Community	Acres
Shishebogama	Emergent	1.1
	Mixed Floating-leaf and Emergent	72.8
	Total	***73.9***
Gunlock	Emergent	0.9
	Mixed Floating-leaf and Emergent	42.8
	Total	***43.7***
	Grand Total	**117.6**

Continuing the analogy that the community map represents a 'snapshot' of the important plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Shishebogama and Gunlock Lakes. This is important, because these communities are often negatively affected by recreational use and shoreland development. A stakeholder survey of Shishebogama and Gunlock Lakes Association members indicates that motorboats with a 25 horsepower or greater motor are the most prevalent watercraft on the lake (Appendix B, Question #15). Additionally, stakeholders indicated throughout the survey that lakeshore development and boat traffic are of great concern and may be impacting the lake (Questions #22, #24, General Comments).

Many studies have documented the adverse effects of motorboat traffic on aquatic plants (e.g. Murphy and Eaton 1983, Vermaat and de Bruyne 1993, Mumma et al. 1996, Asplund and Cook 1997). In all of these studies, lower plant biomasses and/or declines and higher turbidity were associated with motorboat traffic. With regards to lakeshore development, Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. The researchers 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.

Overall, Shishebogama and Gunlock Lakes have high quality, exceptionally diverse aquatic plant communities which not only provide essential habitat for wildlife, but will help protect against any possible introductions of invasive plant species. These invasive plants are opportunistic, taking hold in openings where native vegetation has been disturbed or removed. While hand-removal of native aquatic plants is permitted, the WDNR in the Northern Region takes a protective approach towards native aquatic plants, and attempts to avoid any large-scale losses of them due to harvesting or chemical herbicides.

Historic Aquatic Plant Datasets

In 2007, as part of her Master's Degree Thesis at the UW-Stevens Point, Laura Canny studied the impacts of human development on aquatic macrophytes in two regions of Wisconsin. Gunlock Lake was included in this project, and in 2005 data regarding aquatic plants and water chemistry was collected from the lake. The aquatic plant data was collected along transect lines randomly placed around the lake. Although this data is not entirely comparable to data collected during the point-intercept survey of 2009, many similar species were collected between the two years.

Table 3.3-4. Aquatic plant species found in a 2005 Gunlock Lake survey. Note: Plants were sampled using a transect survey methodology. Data obtained from Laura Canny's Master's Thesis (UW Stevens Point, 2007).

Aquatic Plant Species Located in Gunlock Lake (2005)

Aquatic Moss	Creeping spikerush	Narrow-leaf bur-reed	Spiral-freuited pondweed	Wild Celery
Broad-leaved cattail	Dwarf water milfoil	Needle spikerush	Stiff pondweed	
Brown-fruited rush	Fern pondweed	Nitella spp.	Three-way sedge	
Carex spp.	Flat-stem pondweed	Northern water milfoil	Variable pondweed	
Chara spp.	Forked duckweed	Pickerelweed	Water arum	
Clasping-leaf pondweed	Fries' pondweed	Quillwort spp.	Water horsetail	
Common arrowhead	Greater duckweed	Rice cut grass	Water marigold	
Common bladderwort	Hardstem bulrush	Sagittaria spp. (rosette)	Water stargrass	
Common bur-reed	Illinois pondweed	Sagittaria spp.	Watershield	
Common watermeal	Large-leaf pondweed	Slender naiad	White water lily	
Common waterweed	Leafy pondweed	Small pondweed	White water crowfoot	
Coontail	Lesser duckweed	Spatterdock	White-stem pondweed	

3.4 Shishebogama and Gunlock Lakes Fishery

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. 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 2010).

Table 3.4-1. Gamefish present in the Shishebogama and Gunlock Lakes with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Black Crappie	*Pomoxis nigromaculatus*	7	May – June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, 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 pikes, 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 (ter. and aq.)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1cm-1m deep	Crustaceans, insect larvae, and other inverts
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
Yellow Perch	*Perca flavescens*	13	April - early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Shishebogama and Gunlock Lakes Fishing Activity

Table 3.4-1 (above) shows the popular game fish that are present in the system. Currently, management actions to control aquatic plant growth (native or non-native) have not been enacted on either Shishebogama or Gunlock Lake, and most stakeholder survey respondents feel unsure about aquatic plant control (Appendix B, Question #26). Although 92% of survey respondents indicated that native plant communities rarely impact their enjoyment of the lakes (Question #25) and non-native plant species have not been observed in the two lakes, should conditions change it will be important to understand how management of aquatic plants may impact fish species. Herbicide applications or mechanical harvesting should occur in May when the water temperatures are below 65°F. Species that spawn in late spring or early summer may be impacted as water temperatures and spawning locations often overlap, and vital nursery areas for emerged fry could become vulnerable. Again, please note that at this time intensive aquatic plant management is not recommended.

Based on data collected from the stakeholder survey (Appendix B), fishing was the highest ranked important or enjoyable activity on Shishebogama and Gunlock Lakes (Question #16). Approximately 89% of these same respondents believed that the quality of fishing on the lake was either fair to excellent (Question #10); and approximately 89% believe that the quality of fishing has remained the same or gotten worse since they have obtained their property (Question #11).

With regards to fishing practices, survey respondents do practice catch and release quite often, particularly on smallmouth bass, muskellunge, largemouth bass, and northern pike (Question #12). While catch and release fishing does occur on walleye, sunfish and crappie, these species are kept more often. These same respondents indicated on the survey that largemouth bass seem to be increasing in abundance, while walleye, muskellunge and northern pike seem to be decreasing in abundance, and little change has been noticed in the abundance of smallmouth bass and sunfish (Question #13). Survey respondents were equally mixed between responses of crappies decreasing in abundance and not changing in population size at all. Considering the size of these fish species, responses were approximately equally mixed between all species appearing smaller than in previous years or having changed little in their size structure (Question #14).

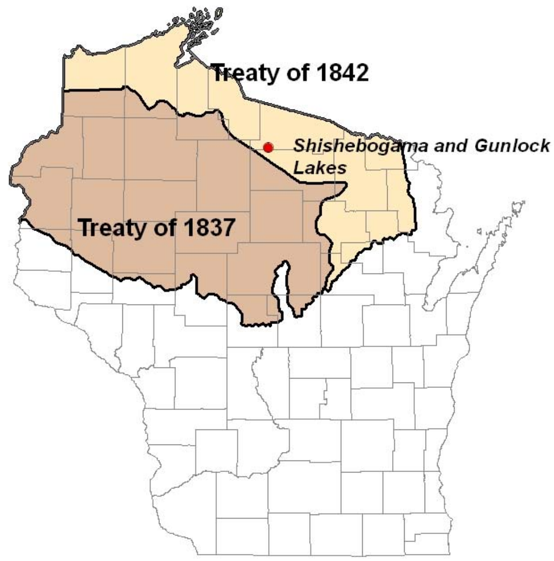

Figure 3.4-1. Location of Shishebogama and Gunlock Lakes within the Native American Ceded Territory (GLIFWC 2010A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.4-1). Lac Vieux Desert falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified off-reservation systems. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then an “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% of a lake's fishing stock, but may vary on an individual lake basis. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The allowable catch number is then 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”. The safe harvest 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 is then multiplied by the Indian communities claim percent, or declaration. This result is called the quota, 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 quota 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).

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The off-reservation 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 quota 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 quota is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller quotas. Starting with the 2011 spear harvest season, on lakes with a harvestable quota of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

All of Gunlock Lake and part of Shishebogama Lake are located within the boundaries of the Lac Du Flambeau tribe reservation (Map 8). This means that the Lac du Flambeau tribe may exercise both on-and off-reservation rights to spear muskellunge and walleye on these waters. On-reservation harvest reporting requirements do not follow the same methodologies as for off-reservation lakes (as described in detail above). According to GLIFWC biologists, off-reservation harvests have only been reported 4 years (3 walleyes in 1986, 22 walleyes in 1987, 3 walleyes in 1988, and 23 walleyes in 1991). Additionally, 4 muskellunge were harvested in 1987. The Lac du Flambeau tribe has indicated that on-reservation walleye and muskellunge harvest effort is quite low on Shishebogama and Gunlock Lakes and spear harvesting efforts are concentrated on other nearby Lac du Flambeau reservation waters which are better known as “walleye” lakes.

Because Shishebogama and Gunlock Lakes are located within ceded territory, special fisheries regulations may occur. In lakes within the Lac Du Flambeau reservation, there is a minimum length limit on walleye of 18 inches and the daily bag limit is 3. In these same waters, a minimum length limit is set at 40 inches for muskellunge. Each year, an adjusted walleye bag limit pamphlet is distributed by the WDNR which explains the more restrictive bag or length limits that may pertain to Shishebogama and Gunlock Lakes. Additionally, as part of managing the bass fishery in Gunlock Lake, the WDNR has set a length limit on both species (largemouth and smallmouth) of 18 inches with a daily bag limit of 1. In Shishebogama Lake, there is a minimum length limit of 14” for bass species, with a daily bag limit of 5 fish.

Shishebogama and Gunlock Lakes Fish Stocking

To assist in meeting fisheries management goals, fisheries managers may stock fish in a waterbody that were raised in nearby permitted hatcheries. 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.

The WDNR has stocked muskellunge and walleye in Shishebogama and Gunlock Lakes, though not as actively in recent years. Tables 3.4-2 and 3.4-3 displays both historic and more recent WDNR stocking efforts in Shishebogama and Gunlock Lakes, respectively. The Lac du Flambeau Tribe also indicates that they have historically stocked fish into Shishebogama and Gunlock Lakes, particularly in conjunction with the former Gunlock Lake Association.

Table 3.4-2. Shishebogama Lake stocking data available from the WDNR. Recent (post 1990) stocking displayed only.

Year	Species	# Fish Stocked	Size	Notes
1994	Muskellunge	100	Fingerling	
2007	Muskellunge	239		
2009	Muskellunge	349	Large fingerling	
1992	Walleye	400,000	Fry	LDF
1994	Walleye	533,200	Fry	LDF
1995	Walleye	500,000	Small fingerling	LDF
1997	Walleye	1,960	Fry	LDF
1998	Walleye	200,000	Fry	LDF
1999	Walleye	850,000	Small fingerling	LDF
1999	Walleye	71,602	Fry	
2000	Walleye	1,500,000	Fry	LDF
2001	Walleye	250,000	Small fingerling	LDF
2001	Walleye	71,687	Fry	
2002	Walleye	500,000	Fry	LDF
2003	Walleye	400,000	Small fingerling	LDF
2003	Walleye	71,575	Fry	
2004	Walleye	300,000	Small fingerling	LDF
2005	Walleye	35,947	Fingerling	
2006	Walleye	30,353	Large fingerling	LDF
2007	Walleye			
2007	Walleye	500,000	Fry	LDF
2008	Walleye	500,000	Fry	LDF
2009	Walleye	500,000	Fry	LDF
2009	Walleye	4,375	Fingerling	LDF
2009	Walleye	23,426	Small fingerling	

LDF: Indicates stocking was done by Lac Du Flambeau tribe

Table 3.4-3. Historic Gunlock Lake stocking data available from the WDNR from 1972 to present (WDNR 2010).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
1972	Muskellunge	Fingerling	1,500	7
1975	Muskellunge	Fingerling	319	9
1972	Walleye	Fry	500,000	1
1973	Walleye	Fry	440,000	
1974	Walleye	Fry	500,000	

Shishebogama and Gunlock Lakes Creel Surveys

Periodically, the WDNR will conduct creel surveys on Wisconsin lakes to gather information on the fishery. Creel surveys are a series of short, informal interviews with fisherman and are conducted right on the lake of interest. They provide valuable information on sport angler activities and their impacts on the fish populations of a waterbody. From this data, fisheries managers can determine trends in total catch and harvest for the lake, and also estimate the number of hours it takes anglers to catch a particular species of fish.

Table 3.4-4. Shishebogama Lake WDNR Creel Survey Summary (WDNR 2010)

Species	Year	Total Angler Effort / Acre (Hours)	Directed Effort / Acre (Hours)	Catch / Acre	Harvest / Acre
Largemouth Bass	1993	30.8	3.9	2.3	0.3
	2002	44.9	13	22.6	0.2
Muskellunge	1993	30.8	8.2	0.2	0.1
	2002	44.9	4.2	0.2	0
Northern Pike	1993	30.8	2.4	0.5	0.2
	2002	44.9	8.6	1.8	0.2
Smallmouth Bass	1993	30.8	2.4	0.5	0.1
	2002	44.9	6.8	4.6	0
Walleye	1993	30.8	3.2	0.2	0.1
	2002	44.9	11.6	2.5	0.1

Table 3.4-5. Gunlock Lake WDNR Creel Survey Summary (WDNR 2010)

Species	Year	Total Angler Effort / Acre (Hours)	Directed Effort / Acre (Hours)	Catch / Acre	Harvest / Acre
Largemouth Bass	1993	29.7	3.8	3.3	0.4
	2002	40.3	11.1	17.2	0.1
Muskellunge	1993	29.7	4.8	0.1	0
	2002	40.3	4.1	0.1	0
Northern Pike	1993	29.7	8	1.5	0.6
	2002	40.3	6.2	0.7	0.3
Smallmouth Bass	1993	29.7	2.6	0.2	0
	2002	40.3	6.3	1.8	0
Walleye	1993	29.7	1.1	0	0
	2002	40.3	5.8	1.8	0.1

Shishebogama and Gunlock Lakes Substrate Type

According to the point-intercept survey conducted by Onterra, 74% of the substrate sampled in the littoral zone on Shishebogama Lake was muck, with the remaining substrate classified as sand (20%) and rock (6%). On Gunlock Lake, 67% of the substrate was muck, followed by 32% sand and less than 1% rock (Map 6). 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 they do not get buried in sediment and suffocate. 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 Shishebogama and Gunlock Lakes ecosystem.
2) Collect detailed information regarding the presence of any invasive plant species within the lake, and gain an understanding about the extent of purple loosestrife along the lakes shoreline.
3) Collect sociological information from Shishebogama and Gunlock Lakes 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 much of the Shishebogama and Gunlock Lakes' ecosystem, the folks that care about the system, and what needs to be completed to protect and enhance it.

As learned during the course of this project, Shishebogama and Gunlock Lakes are two very healthy, productive, and clean waterbodies. There are a number of reasons why this is so, and the first begins with the watershed, or drainage basin contributing to these lakes. As mentioned in the Watershed Section, these watersheds are relatively small when compared to the size of their respective lake. Furthermore, about 80% of the land in each watershed can be categorized as either forest or wetland. Both of these land types benefit the quality of the lakes by filtering runoff water before it enters the lake, removing nutrients and sediment.

The clean water that is found in both Shishebogama and Gunlock Lakes is due in part to the watersheds condition. Secchi disk depths ranging from 9 to 13 feet confirm the transparency of the water in these lakes. The phosphorous content in the water column is moderate – not quite enough to spur intense algae blooms, as given by the chlorophyll-*a* content of the lakes; but enough to feed moderate algae production, which in turn supports the base of a healthy food chain. The nutrient content is also ample to support an incredibly diverse array of aquatic plants.

During Onterra's surveys, ecologists found 64 native plant species in Shishebogama Lake, and an also impressive 55 species in Gunlock Lake. As highlighted in the Aquatic Plant Section, there are many different species from a variety of community types – emergent, submergent, and floating-leaf. Shishebogama and Gunlock Lakes are somewhat unique in that they have an irregular shoreline, along with varied slopes and substrates and numerous back-bays which slow water movement. These various habitat characteristics contribute to the richness of the plant community by providing numerous conditions for many habitat specific species to flourish. The extraordinary diversity of the aquatic plant community, in turn, provides outstanding habitat for other aquatic species such as fish, insects, birds and mammals. Additionally, having a diverse and healthy aquatic plant community will help to prevent invasive submergent plants such as Eurasian water milfoil and curly-leaf pondweed.

From analyzing the results of the stakeholder survey, it is clear that lake stakeholders understand that Shishebogama and Gunlock Lakes are in good shape ecologically. There are a number of concerns that stakeholders have, including lakeshore development and aquatic invasive species. Additionally, it is apparent that user conflicts exist on the lake with respect to boating use. It must be remembered that there are many groups of people that are enjoying the lake the way they see fit. Common courtesy comes into play here – those wishing to operate larger boats and personal water craft must abide by State of Wisconsin boating regulations. These regulations include:

- It is illegal for vessels to operate at “excessive” speeds
- It is illegal to operate a boat or personal watercraft (PWC) within 100 feet of any dock, raft, pier, restricted area, swimmer or lake shoreline at greater than a no-wake speed.
- PWCs may not operate at greater than no-wake speed within 200 feet of a shoreline, and may only operate between sunrise and sunset.

\- *Wisconsin Boating Regulations and Handbook, 2010*

As eluded to above, current state law requires a slow-no-wake zone for PWC within 200 feet of the shoreline. This law was enacted for personal safety reasons as well as to reduce the impacts of PWCs, which can negatively affect near-shore ecosystems due to their ability to navigate in relatively shallow water. These areas are displayed in hatching on Map 7. A slow-no-wake bill (enacted as 2009 Wisconsin Act 31) took effect in February 2010 which establishes a slow-no-wake zone within 100 feet of the shoreline for all watercraft. Boating close to the shoreline can cause shoreline erosion, stir up lake bottom sediments causing turbidity, and release nutrients such as phosphorus which can contribute to algal growth. In addition, boating in these areas can be harmful to fish habitat as propellers uproot emergent plant populations. This 100 ft buffer is also displayed (as light red) on Map 7.

These are statewide minimum regulations. Local and lake specific regulations may apply for Shishebogama and Gunlock Lakes which are stricter. The SGLA currently has no-wake ordinances in effect in which vessels can only operate above no-wake speeds between the hours of 10 am and 8 pm on Shishebogama Lake and 9 am and 8 pm on Gunlock Lake. Bear in mind that these regulations set by the State of Wisconsin and also the SGLA serve a dual purpose – they work towards reducing user conflict on waterbodies, but also protecting the near shore areas of the lake.

As a result of the studies involved in this project, a good baseline understanding of this ecosystem exists. The results show that it is in great shape ecologically and the challenge that lays ahead for the SGLA and other entities that play a role in the management of Shishebogama and Gunlock Lakes is to keep the lakes in this condition. The Implementation Plan that follows this section highlights steps to preserve and maintain the quality of these lakes. These steps include obvious actions that will physically take place on the lake, such as continued water quality monitoring and aquatic invasive species monitoring. However, much of the important actions involved in preserving Shishebogama and Gunlock Lakes will take place over the phone lines, on the internet, and at summer SGLA picnics. Communication between lake stakeholders, local and state government agencies, and tribal biologists is a critical step to ensure that the lake is managed for the interests of all that use it. While it will be nearly impossible to please everyone entirely, these conversations must be had and compromises must be made in order to manage Shishebogama and Gunlock Lakes in a holistically, responsibly and ecologically sound manner.

5.0 IMPLEMENTATION PLAN

The intent of this project was to complete a *comprehensive* management plan for Shishebogama and Gunlock Lakes. As described in the proceeding sections, a great deal of study and analysis were completed involving many aspects of the ecosystem. This section stands as the actual “plan” portion of this document as it outlines the steps the SGLA will follow in order to manage Shishebogama and Gunlock Lakes, their watershed, and the association itself.

The implementation plan is broken into individual *Management Goals*. Each management goal has one or more management actions that if completed, will lead to the specific management goal in being met. Each management action contains a timeframe for which the action will be taken, a facilitator that will initiate or carry out the action, a description of the action, and if applicable, a list of prospective funding sources and specific actions steps.

Management Goal 1: Increase Shishebogama and Gunlock Lakes Association’s Capacity to Communicate with Lake Stakeholders

Management Action: Support an Education Committee to promote safe boating, water quality, public safety, and quality of life on Shishebogama and Gunlock Lakes.

Timeframe: Begin summer 2011

Facilitator: Board of Directors to form Education Committee

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

Currently, the SGLA regularly distributes newsletters to association members and has launched a website (www.shishgunlock.org) which allow for exceptional communication within the lake group. 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, educational topics, and even social happenings. It also 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 pieces within the association newsletter may contain monitoring results, association management history, as well as other educational topics listed below.

In addition to creating regularly published association newsletter a variety of educational efforts will be initiated by the Education Committee. 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 monitoring updates
- Boating safety and ordinances (slow-no-wake zones and hours)
- Catch and release fishing
- Littering (particularly on ice)
- Noise, air, and light pollution
- Shoreland restoration and protection
- Septic system maintenance
- Fishing Rules

Action Steps:

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

Management Goal 2: Facilitate Partnerships with Other Management Entities

Management Action: Enhance SGLA's involvement with other entities that have a hand in managing (management units) Shishebogama and Gunlock Lakes.

Timeframe: Begin summer 2011

Facilitator: Board of Directors to appoint SGLA representatives

Description: The mission statement of the SGLA is *to preserve and protect Shishebogama and Gunlock Lakes and their surroundings to enhance water quality, the fishery, boating safety, and the aesthetic values of the lake as a public recreational facility for today and for future generations*. The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. Some of these entities are governmental while others organizations are similar to the SGLA in that they rely on voluntary participation.

It is important that the SGLA 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 Shishebogama and Gunlock Lakes are the WDNR, Lac du Flambeau Town Lakes Committee (LDF TLC), Lac du Flambeau Tribe (LDF Tribe), Vilas County Land and Water Conservation Department (VCLWCD), the Vilas County Lakes Association (VCLA), Oneida County Land and Water Conservation Department (OCLWCD), and Oneida County Lakes and Rivers Association (OCLRA). Each entity will be specifically addressed below.

State of Wisconsin The WDNR is responsible for managing the natural resources of the State of Wisconsin. Primary interaction with the WDNR is from an advisory and regulatory perspective. The SGLA has worked closely with the Regional Lakes Coordinator (Kevin Gauthier – 715.365.8937) and that relationship should continue. Shishebogama and Gunlock Lakes contain a highly valued fishery. The SGLA should be in contact with the WDNR fisheries biologist (Steve Gilbert – 715.358.9229) at least once a year to discuss fish stocking plans and other pertinent fisheries-related issues. As discussed within the Fisheries Section, Shishebogama and Gunlock Lakes fall within the ceded territory based on the Treaty of 1842 (Figure 3.4-1). This treaty grants specific off-reservation rights to the Native American community including a regulated spear fishery. The WDNR fisheries biologists are involved with this process and a direct link to GLIFWC biologists is not necessary.

County and County-wide Associations While all of Gunlock Lake is within Vilas County, half of Shishebogama is in Vilas County and half is within Oneida County. Lake conservation specialists at the VCLWCD (Marquita Sheehan – 715.479.3721) and OCLWCD (Nancy Hollands – 715.369.7835) are available to discuss specific conservation projects applicable to Shishebogama and Gunlock Lakes. While it is important to foster a direct relationship with these entities, having SGLA representatives participating in county-wide associations such as the VCLA and the OCLRA is the best way to ensure the association gains from this pooled knowledgebase of lake management and awareness. These representatives would attend all meetings and in their absence, an alternate would take their spot. Within every SGLA newsletter (even if no meeting occurred), a permanent column (standing column) will be committed to a short summary of any meetings that occurred since the circulation of the last newsletter.

Tribe and Township Since all of Gunlock Lake and approximately half of Shishebogama Lake are within the Lac du Flambeau Reservation (Map 8), coordination between the SGLA and the LDF Tribe is critical to effectively manage both of these lakes. Likely the best way to keep continued contact with the LDF Tribe is through the LDF TLC. Currently a member of the SGLA is on the LDF TLC. Continued involvement in the LDF TLC needs to occur and would benefit from expanding the SGLA's involvement by having a representative from each lake being on the committee. Just as the approach taken with county-wide associations, the SGLA would have alternate representatives in place in the absence of the primary representative and meeting attendees would report a short summary within the standing column. If a meeting had not occurred since the last newsletter, that fact would be conveyed within the standing column.

Action Steps:

Please see description above.

Management Goal 3: Maintain Current Water Quality Conditions

<u>Management Action:</u> Monitor water quality through WDNR Citizens Lake Monitoring Network.

Timeframe: Continuation and expansion of current effort.

Facilitator: Planning Committee

Description: Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason as of why the trend is developing. The LDF Tribe collects water quality data on the system once every five years and that data is held within the EPA STORET (short for STOrage and RETrieval) database (www.epa.gov/storet).

Through the WDNR Citizen Lake Monitoring Network Program, volunteers from Shishebogama Lake (Thomas Koenen, Wayne Schroeder, and Pete Taddy) have collected Secchi disk clarities and volunteers from Gunlock Lake (Patrick Hayes) have collected Secchi disk clarities and water chemistry samples. The volunteer monitoring of the water quality is a large commitment and new volunteers may be needed in the future as the volunteer's level of commitment changes.

The WDNR should be approached regarding the expansion of the program on Shishebogama Lake to include water chemistry, as done on Gunlock Lake. The first step would be to contact Sandra Wickman (715.365.8951) to discover is space is available in the Citizen Lake Monitoring Network Program.

It is the responsibility of the Planning Committee to coordinate new volunteers as needed. When a change in the collection volunteer occurs, it will be the responsibility of the Planning Committee to contact Sandra Wickman or the appropriate WDNR/UW Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:

Please see description above.

<u>Management Action:</u> Reduce phosphorus and sediment loads from shoreland watershed to Shishebogama and Gunlock Lakes.

Timeframe: Begin 2011

Facilitator: Education Committee

Description: As the watershed section discusses, the Shishebogama and Gunlock Lakes watershed is in good condition; however, watershed inputs still need to be focused upon, especially in terms of the lake's shoreland properties. These sources include faulty septic systems, shoreland areas that are maintained in an unnatural manner, impervious surfaces.

On April 14th, 2009, Governor Doyle signed the "Clean Lakes" bill (enacted as 2009 Wisconsin Act 9) which prohibits the use of lawn fertilizers containing phosphorus. Phosphorus containing fertilizers were identified as a major contributor to decreasing water quality conditions in lakes, fueling plant growth. This law went into effect in April 2010. While this law also bans the display and sale of phosphorus containing fertilizers, educating lake stakeholders about the regulations and their purpose is important to ensure compliance.

To reduce these negative impacts, the SGLA will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include newsletter articles and guest speakers at association meetings.

Topics of educational items may include benefits of proper septic system maintenance, methods and benefits of shoreland restoration, including reduction in impervious surfaces, and the options available regarding conservation easements and land trusts.

Action Steps:

1. Recruit facilitator.
2. Facilitator gathers appropriate information from WDNR, UW-Extension, Vilas County, Oneida County, LDF Tribe, and other sources.
3. Facilitator summarizes information for newsletter articles and recruits appropriate speakers for association meetings.

Management Action: Complete Shoreland Condition Assessment as a part of next management plan update

Timeframe: Begin 2011

Facilitator: Board of Directors

Description: As discussed above, unnatural and developed shorelands can negatively impact the health of a lake, both by decreasing water quality conditions as well as removing valuable habitat for fish and other animal species that reside in and around the lake. Understanding the shoreland conditions around Shishebogama and Gunlock Lakes will serve as an educational tool for lake stakeholders as well as identify areas that would be suitable for restoration. Shoreland restorations would include both in-lake and shoreline habitat enhancements. In-lake enhancements would include the introduction of course woody debris in the littoral zone, a valuable fisheries habitat component around the shores of Shishebogama and Gunlock Lakes. Shoreline enhancements would include leaving 30-foot no-mow zones to act as a buffer between residences and the lake or by planting native herbaceous, shrub, and tree species as appropriate for Vilas and Oneida Counties in this sensitive area. Ecologically high-value areas delineated during the survey would also be selected for protection, possibly through conservation easements or land trusts (www.northwoodslandtrust.org).

Projects that include shoreline condition assessment and restoration activities will be better qualified to receive state funding in the future. These activities could be completed as an amendment to this management plan and would be appropriate for funding through the WDNR small-scale Lake Planning Grant program.

Action Steps: See description above.

Management Goal 4: Prevent Aquatic Invasive Species Introductions to Shishebogama and Gunlock Lakes

Management Action: Continue Clean Boats Clean Waters watercraft inspections at Shishebogama and Gunlock Lake public access

Category: Prevention & Education

Timeframe: In progress

Facilitator: Planning Committee

Description: At this time, Shishebogama and Gunlock Lake are believed to be free of Eurasian water milfoil and curly-leaf pondweed. At this time, the only invasive species known to exist in the system include purple loosestrife and Chinese mystery snail.

Members of the SGLA have been trained on Clean Boats Clean Waters (CBCW) protocols and complete boat inspections at the public landings on a regular basis. Because this system is currently free of exotic species, the intent of the boat inspections is to prevent additional invasives from entering the lake through its public access point. The goal would be to cover the landing during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on our lakes and educating people about how they are the primary vector of its spread. In 2009, 285 boats were inspected during over 255 hours of watercraft inspections. A portion of these hours have been collected by or contributed to the LDF TLC Aquatic Invasive Species Education, Protection, and Planning Grant-funded CBCW program.

In addition to continuing these efforts, an Education Initiative comprised of developing materials and programs that will promote clean boating and responsible use of these waters (See Education Goal).

Action Steps:

1. Members of association periodically attend Clean Boats Clean Waters training session through the volunteer AIS Coordinator (Erin McFarlane – 715.346.4978) to update their skills to current standards.
2. Training of additional volunteers completed by those trained during the summer of 2011.
3. Begin inspections during high-risk weekends
4. Report results to WDNR and SGLA
5. Promote enlistment and training of new of volunteers to keep program fresh.

Management Action: Coordinate annual volunteer monitoring for Aquatic Invasive Species
Timeframe: Ongoing
Facilitator: Planning Committee
Description: In lakes without Eurasian water milfoil and other invasive species, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. During the summer of 2009, a group of volunteers were trained by Onterra staff on identification of target species and native look-a-likes, proper use of GPS for recording aquatic plant occurrences, note taking, and transfer of data. Currently, the group already performs a considerable amount of Eurasian water milfoil monitoring on its own; therefore, the framework for such a volunteer network is essentially in place. Called “Sweeps,” the SGLA volunteers monitor the entire area of the system in which plants grow (littoral zone) annually in search of Eurasian water milfoil as well as other non-native plant species. This program uses an “adopt-a-shoreline” approach where volunteers are responsible for surveying specified areas of the system.

The SGLA has been actively managing purple loosestrife on its shores utilizing biological control methods through a cooperative effort with the Minocqua-Kawaguesaga Lake Protection Association. Since the original beetle release, members of the SGLA have been rearing beetles for release on a single remaining colony near the channel between Shishebogama and Gunlock Lakes. At this time, this management action is believed to be successful. A single purple loosestrife plant was observed and hand removed on Shishebogama Lake (Map 5) during the July 2009 community mapping survey. Other purple loosestrife occurrences were noted in the wetland margins of the Gunlock Channel as it enters Shishebogama Lake (Map 3). It is possible that other purple loosestrife occurrences were missed (false negative) as this plant would have been early in its flowering season. During volunteer surveillance monitoring, continued attention to be paid to purple loosestrife.

Action Steps:

1. Volunteers from SGLA update their skills by attending a training session conducted by WDNR/UW-Extension through the AIS Coordinator for Vilas (Ted Ritter – 715.479.3738) or Oneida County.
2. Trained volunteers recruit and train additional association members.
3. Complete lake surveys following protocols.
4. Report results to WDNR and SGLA.

Management Action: Initiate aquatic invasive species rapid response plan upon exotic infestation
Timeframe: Initiate upon exotic infestation
Facilitator: Planning Committee with professional help as needed
Description: In the event that an aquatic invasive species is located by the trained volunteers, the areas would be marked using GPS and would serve as *focus areas* for professional ecologists. Those focus areas would be surveyed by professionals during that plant species peak growth phase (late summer for Eurasian water

milfoil, early summer for curly-leaf pondweed) and the results would be used to create a prospective treatment strategy for the following spring. Eurasian water milfoil is the primary aquatic invasive species being managed in this region of the state and the following paragraphs will contain specific information pertaining to this species.

Small isolated infestations of Eurasian water milfoil can most appropriately controlled using manual removal methods, likely through scuba or snorkeling efforts. The responsible use of this technique is well supported by SGLA stakeholders as indicated by approximately 86% of stakeholder survey respondents indicating that they are at least moderately supportive of a manual removal program (Appendix B, Question #27). In order for this technique to be successful, the entire plant (including the root) needs to be removed from the lake. During manual extraction, careful attention would need to be paid to all plant fragments that may detach during the control effort.

At this time, the most feasible method to control larger infestations is through herbicide applications, specifically, early-spring treatments with 2,4-D. Likely as a condition of the WDNR herbicide application permit, a spring refinement and verification survey by professionals would precede the treatment as well as post treatment surveys to evaluate the control action. Just over half (54%) of SGLA stakeholders were not supportive of an herbicide control program (Appendix B, Question #27). Depending on the level of support for an herbicide control program at the time of Eurasian water milfoil population discovery, if the population is too large to be controlled using manual removal techniques, the SGLA needs to be educated on potential alternative strategies and/or not doing anything. Ninety stakeholder survey respondents indicated that they would like to learn more about aquatic invasive species control methods (Appendix B, Question #28).

If large populations of Eurasian water milfoil are located, a formal monitoring strategy consistent with the WDNR document, Aquatic Plant Community Evaluation with Chemical Manipulation (Draft), would need to accompany the herbicide application. This form of monitoring is required by the WDNR for all large scale herbicide applications (exceeding 10 acres in size or 10% of the area of the water body that is 10 feet or less in depth and treatment areas that are more than 150 feet from shore) and grant-funded projects where scientific and financial accountability are required.

The LDF Tribe and the LDF TLC have created an official Aquatic Invasive Species Rapid Response Plan that is hosted on the Town of Lac du Flambeau website (www.tn.lacduflambeau.wi.gov). Successful partnerships between all stakeholders are important to formulate and implement a successful response and control program.

As stated in the Water Quality Section, the LDF Tribe is authorized to initiate water quality standards. Under the Clean Water Act, all pesticide applications required a National Pollutant Discharge Elimination System (NPDES) permit.

While specific permits are adapted for Wisconsin (WPDES), the US EPA is the permitting authority on the Lac du Flambeau Reservation (cfpub.epa.gov/npdes). All of Gunlock Lake and part of Shishebogama Lake are within the Lac du Flambeau Reservation. Herbicide application permits will likely be required from the WDNR and the US EPA (Brian Bell – 312.886.0981).

Action Steps:

1. Engage all stakeholders in the process.
2. Retain consultant to map aquatic invasive species occurrences.
3. Determine control strategy based upon professional findings.
4. Association obtains the proper permits to implement management action. The UW Extension Lake List is a great resource for locating an herbicide applicator or a company that can conduct removal of Eurasian water milfoil using scuba methods (www.uwsp.edu/cnr/uwexlakes/lakelist/businessSearch.asp).
5. Association updates management plant to reflect changes in control strategy.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Shishebogama and Gunlock Lakes (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 Shishebogama and Gunlock Lakes Association members, professional water quality samples were collected at subsurface (S) and near bottom (B) depths once in spring, winter, and fall. Although Shishebogama and Gunlock Lakes Association 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.

The diamond shape indicates samples collected as a part of the Citizen Lake Monitoring Network and the circle indicates samples collected under the proposed project funding. The winter samples were collected by Onterra. Winter dissolved oxygen was determined with a calibrated probe and all samples were collected with a 3-liter Van Dorn bottle.

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were conducted on both Shishebogama and Gunlock Lakes on June 22 and 23, 2009 during 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. In the event that colonies were located, they would be mapped utilizing a Trimble GPS with sub-meter accuracy. However, no curly-leaf pondweed was observed.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on both Shishebogama and Gunlock Lakes 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 "Appendix C" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin, (April, 2008) was used to complete this study on July 15, 16 and 21, 2009. Based upon advice from the WDNR, the following point spacing and resulting number of points comprised the surveys:

Lake	Point-intercept Resolution	Number of Points	2010 Survey Dates
Shishebogama	54 meters	967	July 15, 16, 21
Gunlock	47 meters	481	July 15, 16, 21

Community Mapping

On July 21, 2009, the aquatic vegetation community types within Shishebogama and Gunlock Lakes (emergent and floating-leaved vegetation) were mapped using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the point-intercept surveys and the community mapping surveys were recorded to provide a complete species list for the lake.

Representatives of all plant species located during the point-intercept and community mapping survey were collected and vouchered by the University of Wisconsin – Steven's Point Herbarium. A set of samples was also provided to the SGLA.

Watershed Analysis

The watershed analysis began with an accurate delineation of the systems 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 Wisconsin initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) 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)

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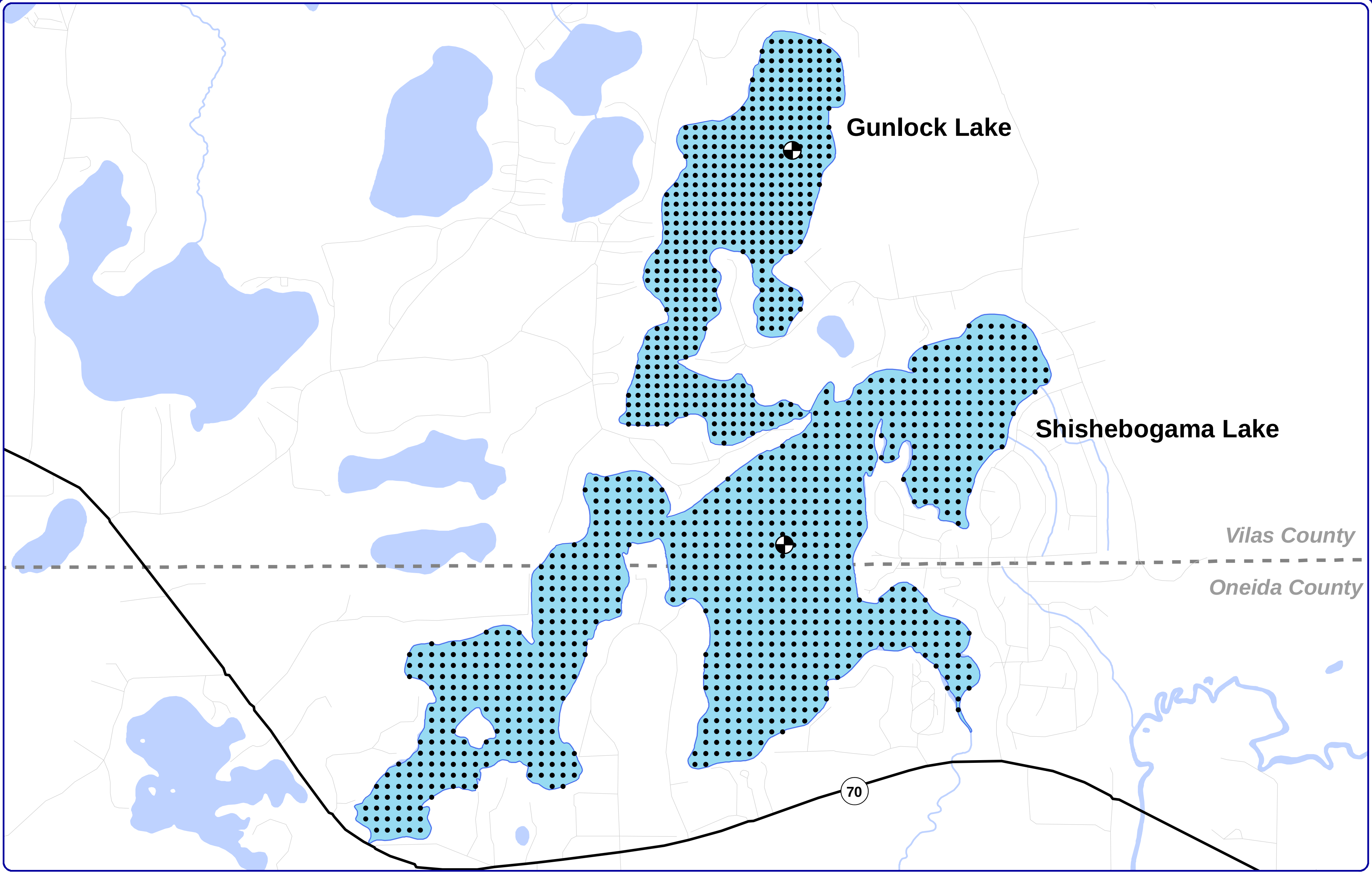

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Feet

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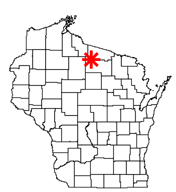
Sources:
Roads & Hydro: WDNR
Point-intercpet Locations: WDNR
Map date: December 15, 2008



Project Location in Wisconsin

Legend

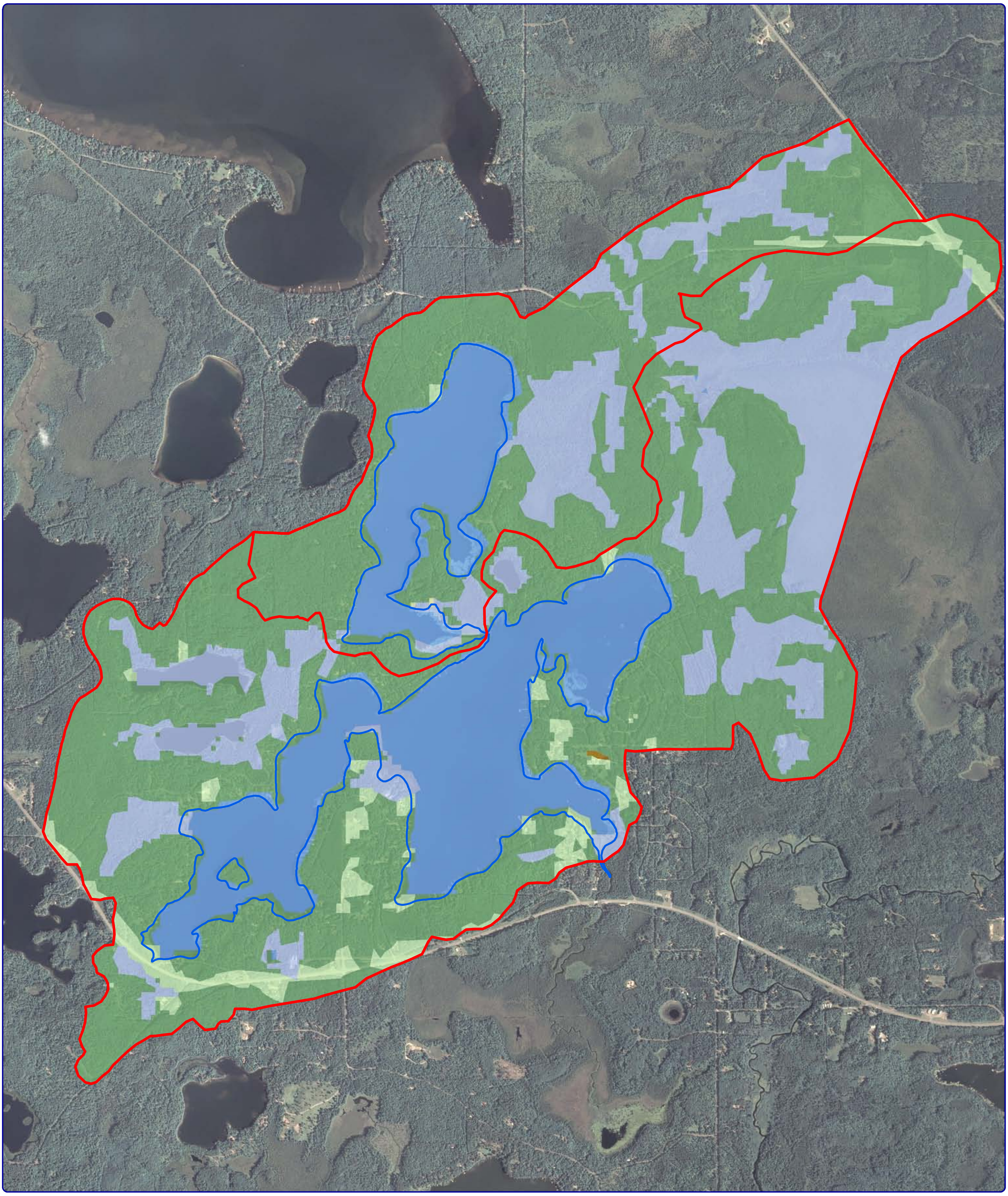
- Point-intercept Sample Location
  Gunlock: 47-meter spacing, 481 total locations
  Shishebogama: 54-meter spacing, 967 total locations
- Gunlock and Shishebogama Lakes
  WDNR Definition
- Water Quality Sample Location

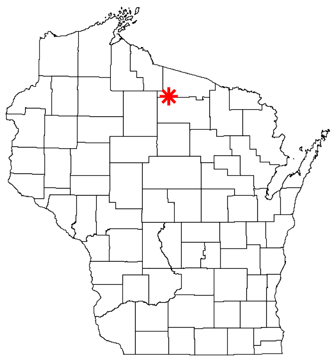
Map 1

Gunlock and Shishebogama Lakes

Oneida & Vilas Counties, Wisconsin

Project Location, Lake Boundaries & Water Quality Sampling Location





Project Location in Wisconsin

Legend

Watershed Boundary

Land Cover Types

Pasture/Grass

Forest

Open Water

Wetland

Row Crop Agriculture

Map 2

Shishebogama and Gunlock Lakes

Oneida & Vilas Counties, Wisconsin

Watershed and Land Cover types

Sources:
Watershed: WDNR & Onterra
Landcover: WISCLAND
Roads & Hydro: WDNR
Orthophotography: NAIP, 2010
Map Date: July 30, 2010

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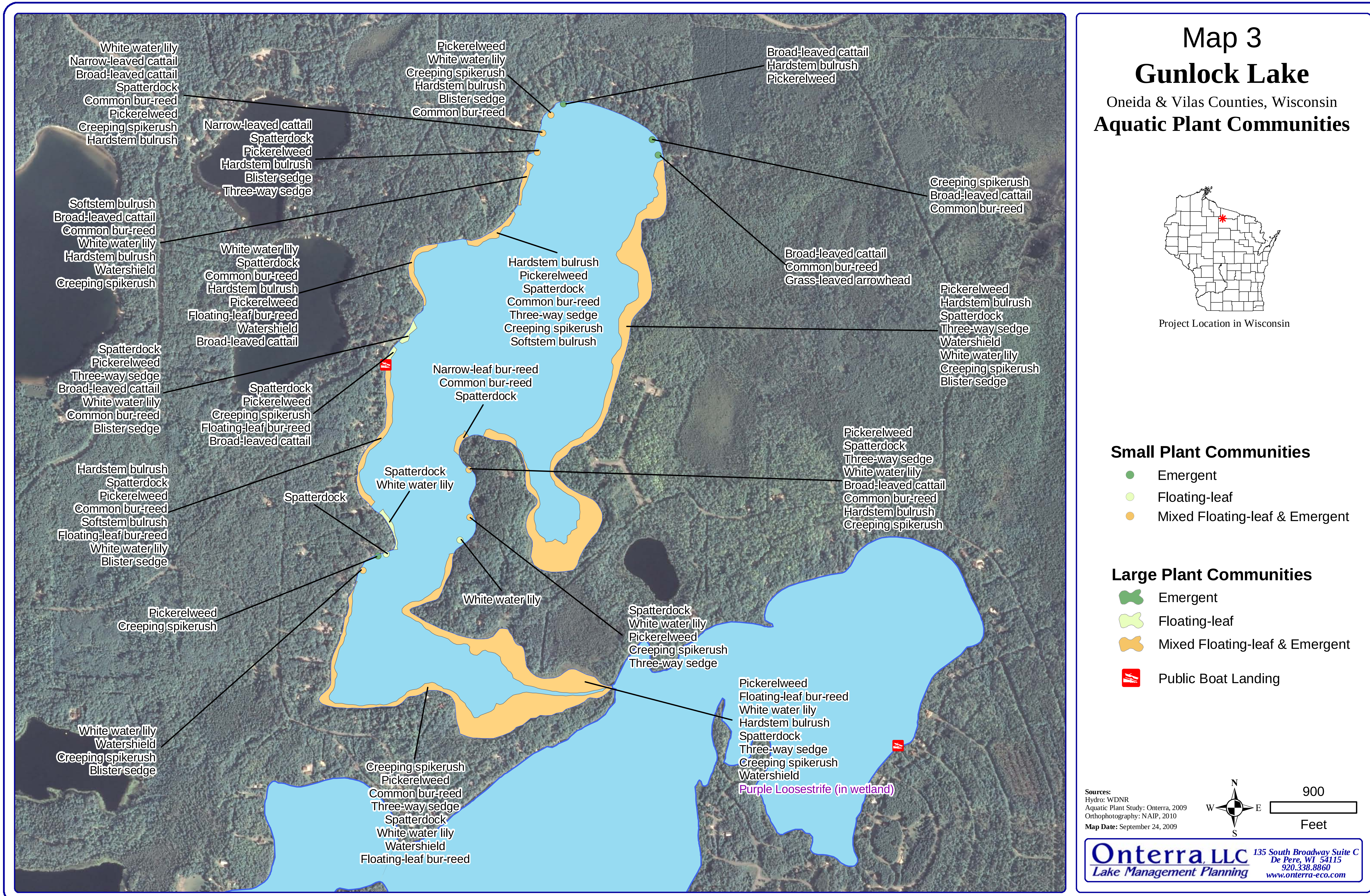
Map 3
Gunlock Lake
Oneida & Vilas Counties, Wisconsin
Aquatic Plant Communities
Project Location in Wisconsin
Small Plant Communities
Emergent
Floating-leaf
Mixed Floating-leaf & Emergent
Large Plant Communities
Emergent
Floating-leaf
Mixed Floating-leaf & Emergent
Public Boat Landing
Sources:
Hydro: WDNR
Aquatic Plant Study: Onterra, 2009
Orthophotography: NAIP, 2010
Map Date: September 24, 2009
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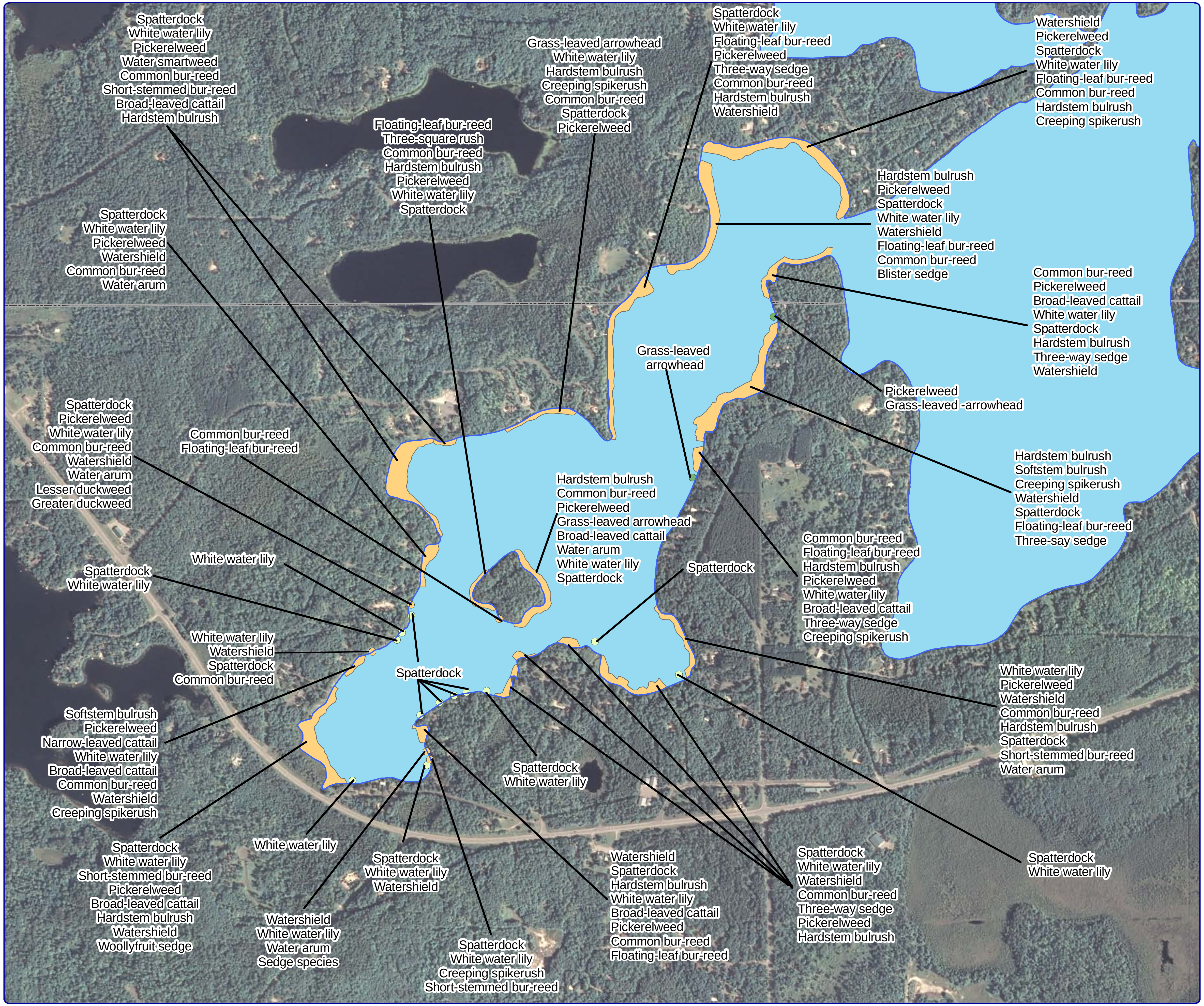
White water lily
Narrow-leaved cattail
Broad-leaved cattail
Spatterdock
Common bur-reed
Pickerelweed
Creeping spikerush
Hardstem bulrush
Pickerelweed
White water lily
Creeping spikerush
Hardstem bulrush
Blister sedge
Common bur-reed
Broad-leaved cattail
Hardstem bulrush
Pickerelweed
Narrow-leaved cattail
Spatterdock
Pickerelweed
Hardstem bulrush
Blister sedge
Three-way sedge
Creeping spikerush
Broad-leaved cattail
Common bur-reed
Softstem bulrush
Broad-leaved cattail
Common bur-reed
White water lily
Hardstem bulrush
Watershield
Creeping spikerush
White water lily
Spatterdock
Common bur-reed
Hardstem bulrush
Pickerelweed
Floating-leaf bur-reed
Watershield
Broad-leaved cattail
Hardstem bulrush
Pickerelweed
Spatterdock
Common bur-reed
Three-way sedge
Creeping spikerush
Softstem bulrush
Broad-leaved cattail
Common bur-reed
Grass-leaved arrowhead
Pickerelweed
Hardstem bulrush
Spatterdock
Three-way sedge
Watershield
White water lily
Creeping spikerush
Blister sedge
Spatterdock
Pickerelweed
Three-way sedge
Broad-leaved cattail
White water lily
Common bur-reed
Blister sedge
Narrow-leaf bur-reed
Common bur-reed
Spatterdock
Spatterdock
Pickerelweed
Creeping spikerush
Floating-leaf bur-reed
Broad-leaved cattail
Pickerelweed
Spatterdock
Three-way sedge
White water lily
Broad-leaved cattail
Common bur-reed
Hardstem bulrush
Creeping spikerush
Hardstem bulrush
Spatterdock
Pickerelweed
Common bur-reed
Softstem bulrush
Floating-leaf bur-reed
White water lily
Blister sedge
Spatterdock
White water lily
Spatterdock
Pickerelweed
Creeping spikerush
White water lily
Spatterdock
White water lily
Pickerelweed
Creeping spikerush
Three-way sedge
Pickerelweed
Floating-leaf bur-reed
White water lily
Hardstem bulrush
Spatterdock
Three-way sedge
Creeping spikerush
Watershield
Purple Loosestrife (in wetland)
White water lily
Watershield
Creeping spikerush
Blister sedge
Creeping spikerush
Pickerelweed
Common bur-reed
Three-way sedge
Spatterdock
White water lily
Watershield
Floating-leaf bur-reed



Map 4
Shishebogama Lake West

Oneida & Vilas Counties, 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
- Public Boat Landing

Sources:
Hydro: WDNR
Aquatic Plant Study: Onterra, 2009
Orthophotography: NAIP, 2010
Map Date: September 24, 2009

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Feet

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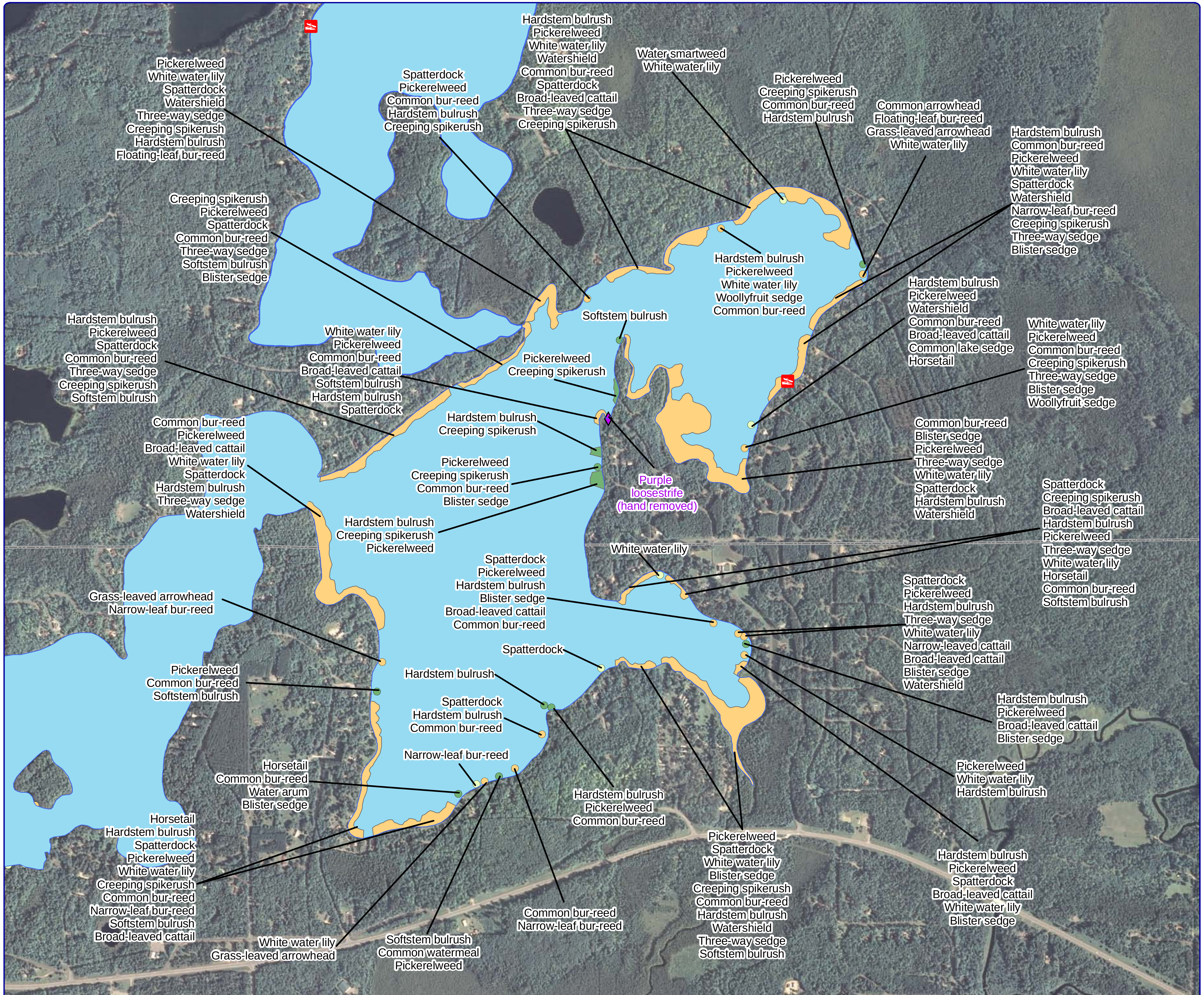
Map 5
Shishebogama Lake East

Oneida & Vilas Counties, 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

Public Boat Landing

Sources:
Hydro: WDNR
Aquatic Plant Study: Onterra, 2009
Orthophotography: NAIP, 2010
Map Date: September 24, 2009

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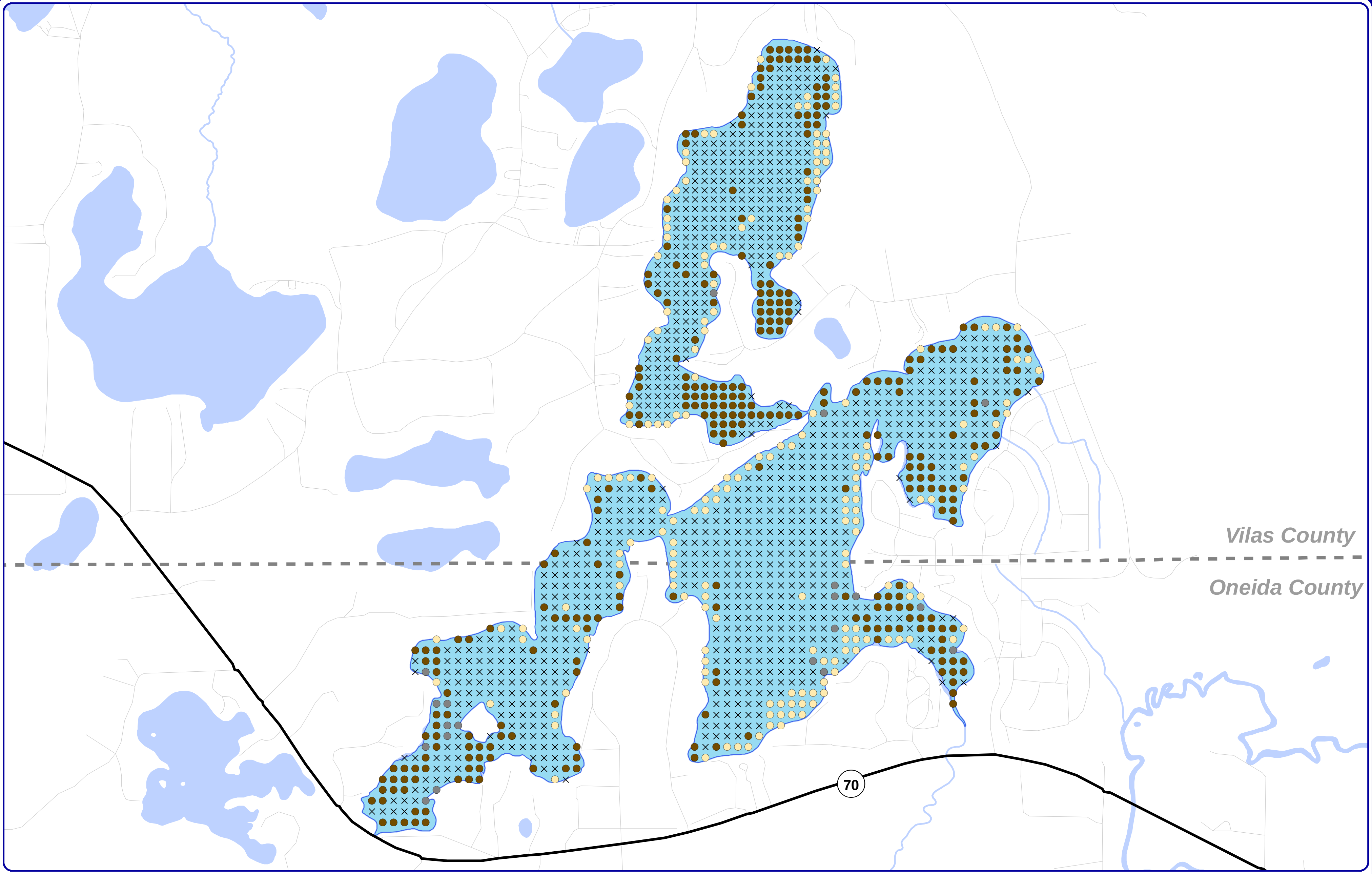

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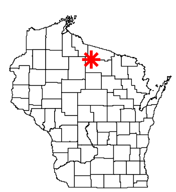
Sources:

Roads & Hydro: WDNR

Point-intercpet Locations: WDNR

Sediment Determinations: Onterra, 2009

Map date: December 15, 2008



Project Location in Wisconsin

Legend

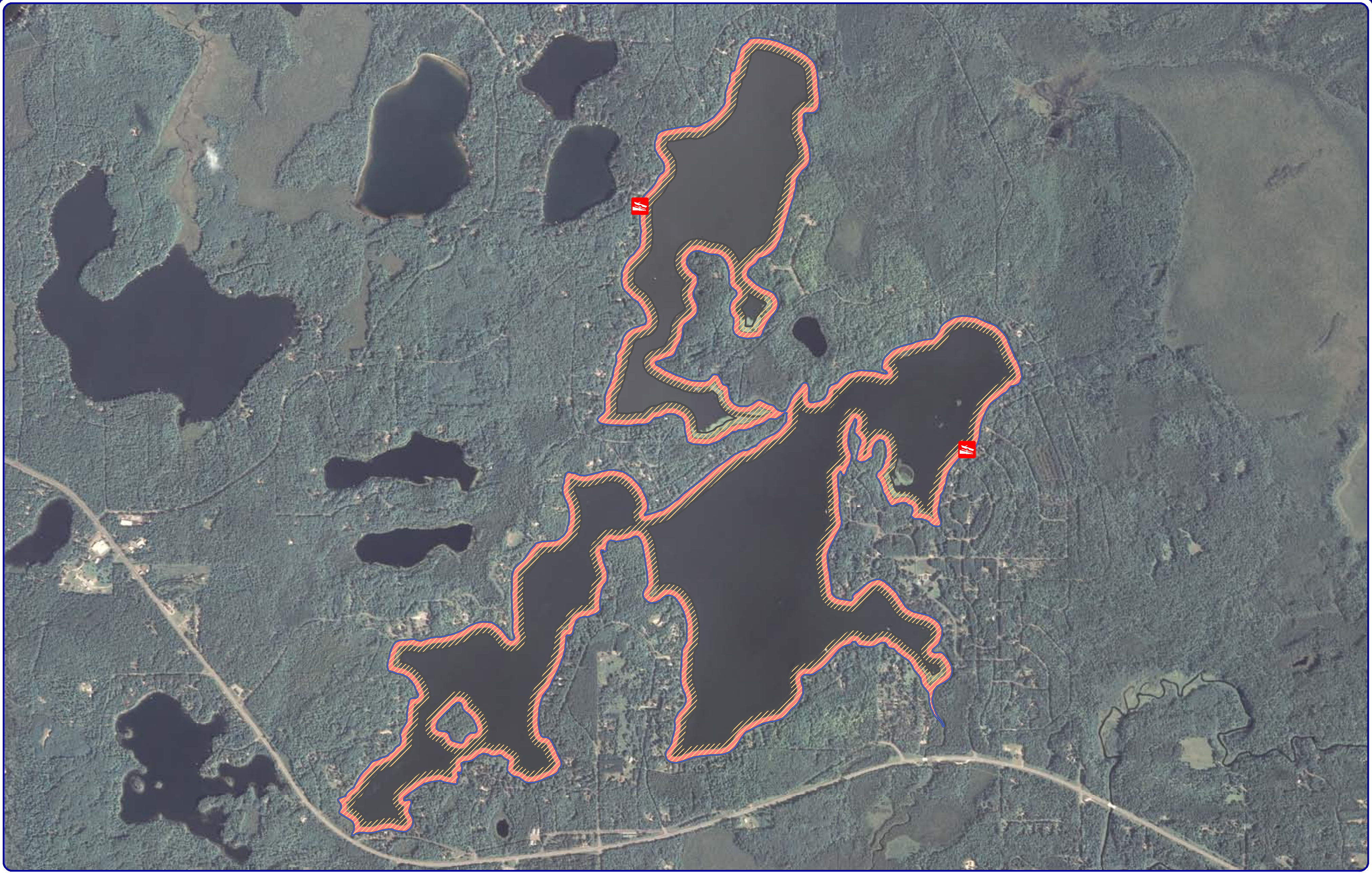
- Muck
- Rock
- Sand
- × No data collected - too shallow or too deep

Map 6

Gunlock and Shishebogama Lakes

Oneida & Vilas Counties, Wisconsin

Sediment Types at Point-Intercept Locations



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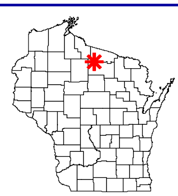
Sources:
Orthophotography: NAIP, 2010
Map date: December 15, 2008



Project Location in Wisconsin

Legend

Motorized Boat
Slow-No-Wake Area (100-ft)

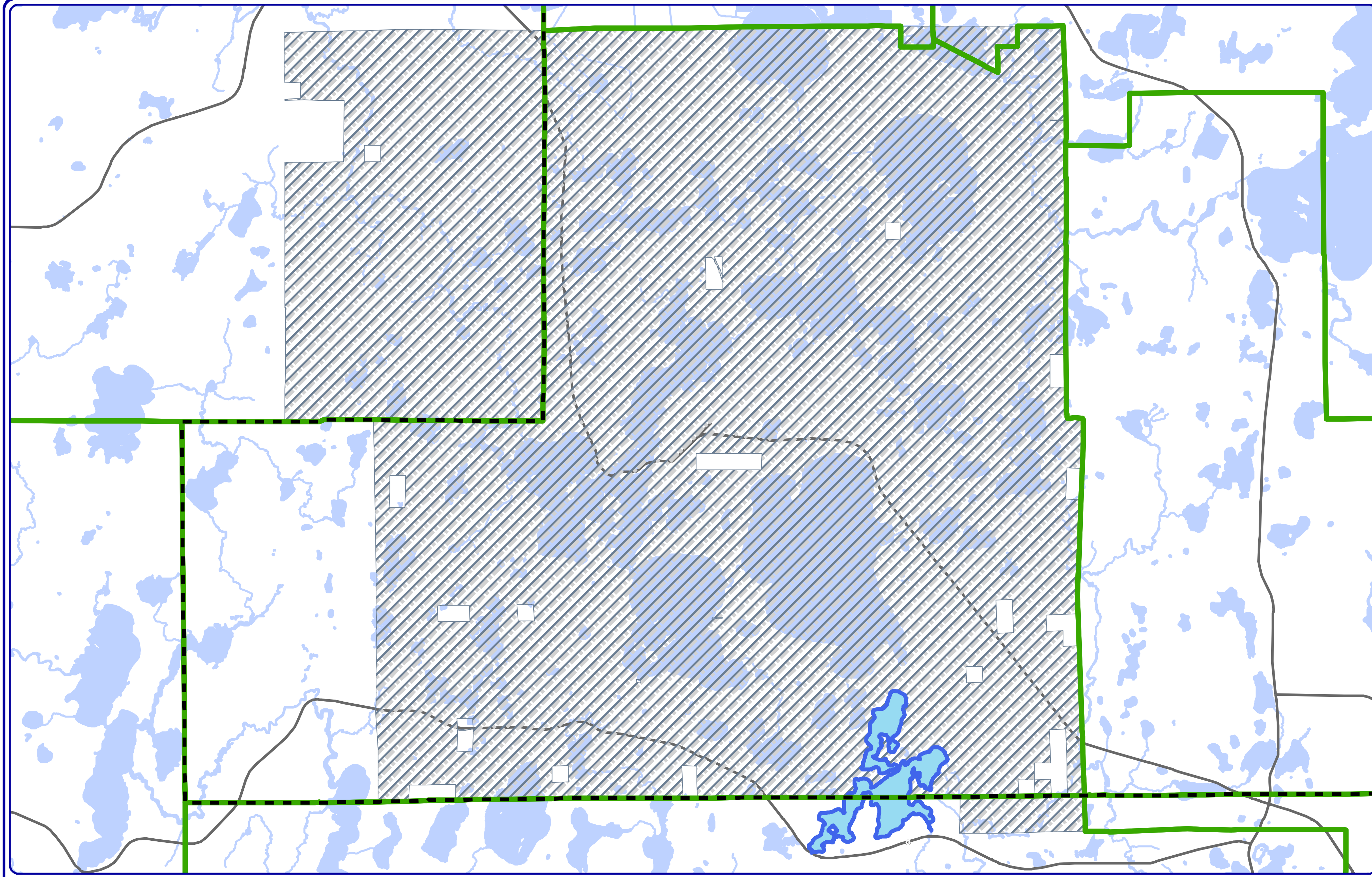
Personal Watercraft
Slow-No-Wake Area (200-ft)

Map 7

Gunlock and Shishebogama Lakes

Oneida & Vilas Counties, Wisconsin

Watercraft Regulation Areas



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Miles

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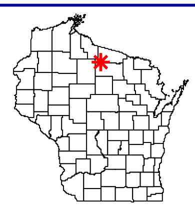
Sources:
Roads & Hydro: WDNR
Map date: December 15, 2008



Project Location in Wisconsin

Legend

Gunlock and Shishebogama Lakes
WDNR Definition

Lac du Flambeau Reservation
Source: USGS GAP shapefile, 1998
(representation and not legally binding)

County Line

Township Line

Map 8

Gunlock and Shishebogama Lakes

Oneida & Vilas Counties, Wisconsin

Project Location, Tribal Land & Local Political Boundaries