Frog and Bass Lakes

Florence County, Wisconsin

Comprehensive Management Plan

April 2013

Sponsored by:

Frog and Bass Lakes Association

WDNR Grant Program

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Onterra LLC
Lake Management Planning

Frog and Bass Lakes

Florence County, Wisconsin

Comprehensive Management Plan

April 2013

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Larry Yark
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Tina Wessel
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Wisconsin Dept. of Natural Resources

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1.0 INTRODUCTION

Frog and Bass Lakes, Florence County, are seepage lakes with adjusted surface areas of approximately 17.5 and 21.0 acres, respectively (Map 1). These mesotrophic lakes have a relatively large watershed when compared to the size of each lake. Frog and Bass Lakes contain 22 native plant species between them, of which muskgrasses are the most common plant in Frog Lake and white-stem pondweed is the most common in Bass Lake.

Field Survey Notes

Both Frog and Bass Lakes are fairly clear-watered, seepage lakes. Both experiencing low water levels.

During community mapping survey on Bass Lake, we spotted a badger swimming from the north shoreline across the lake.

Photograph 1.1 Bass Lake, Florence County

Lake at a Glance – Frog and Bass Lakes

		Frog Lake	Bass Lake
Morphology	**Acreage**	27 (17.5 in 2010)	21
	Max. Depth (ft)	21 (15 in 2010)	16 (10 in 2010)
	Volume (Acre-ft)	137	143.5
	Mean Depth (ft)	7.8	7.0
Vegetation	**Curly-leaf Survey Date**	June 14, 2010	
	Comprehensive Survey Date	August 12, 2010	
	Number of Native Species	15	18
	Non-Native Species	EWM (Hybrid)	None
	Threatened/Special Concern Species	None	None
Water Quality	**Trophic State**	Mesotrophic	
	Limiting Nutrient	Phosphorus	
	pH	9.3 – 9.6	9.5 – 9.9
	Watershed to Lake Area Ratio	23:1	9:1

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 July 24, 2010, a project kick-off meeting was held to introduce the project to the general public. The meeting was announced through a mailing and personal contact by Frog and Bass Lakes Association board members. The attendees observed a presentation given by Eddie Heath, an aquatic ecologist with Onterra. Mr. Heath's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation was followed by a question and answer session.

Stakeholder Survey

During November 2010, an eight-page, 29-question survey was mailed to 21 riparian property owners around Bass Lake and 24 property owners around Frog Lake. 52 percent of the surveys were returned from Bass Lake, and 67 percent of the surveys were returned from Frog Lake. Those results were entered into a spreadsheet by members of the Frog and Bass 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 I

On June 30th, 2011, Eddie Heath of Onterra met with ten members of the Frog and Bass Lake Association Planning Committee. The WDNR Lake Coordinator was invited but was unable to be in attendance. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including, Hybrid water milfoil treatment results, aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed.

Planning Committee Meeting II

On August 4th, 2011, Eddie Heath met with five members of the Planning Committee to discuss the stakeholder survey results and begin developing management goals and actions for the Frog and Bass Lake Association's Comprehensive Lake Management Plan. Also in attendance was Kevin Gauthier, WDNR Lakes Coordinator. One of the major topics of discussing was related to EWM management and possible enrollment into an experimental research program involving the use of a biological control method.

Project Wrap-up Meeting

To occur during the late-summer of 2013.

Management Plan Review and Adoption Process

In October 2012, a draft of the Implementation Plan was provided to the Planning Committee for review. The Implementation Plan Section of this report is based upon integration of the Planning Committee's comments of that draft.

In November 2012, a draft of the Frog and Bass Lakes Comprehensive Management Plan was supplied to the WDNR, Florence County, and the FBLA Planning Committee for review. A small amount of comments were received from the FBLA Planning Committee and were integrated into this final document. Official reviews were received from the WDNR Lakes Specialist (James Kreitlow) and WDNR Fisheries Biologist (Greg Matzke). Onterra addressed comments and finalized the management plan in April 2013. Formal acceptance of the plan by the FBLA will occur through a vote held at the first annual meeting held following the distribution of this document.

Stakeholder Survey

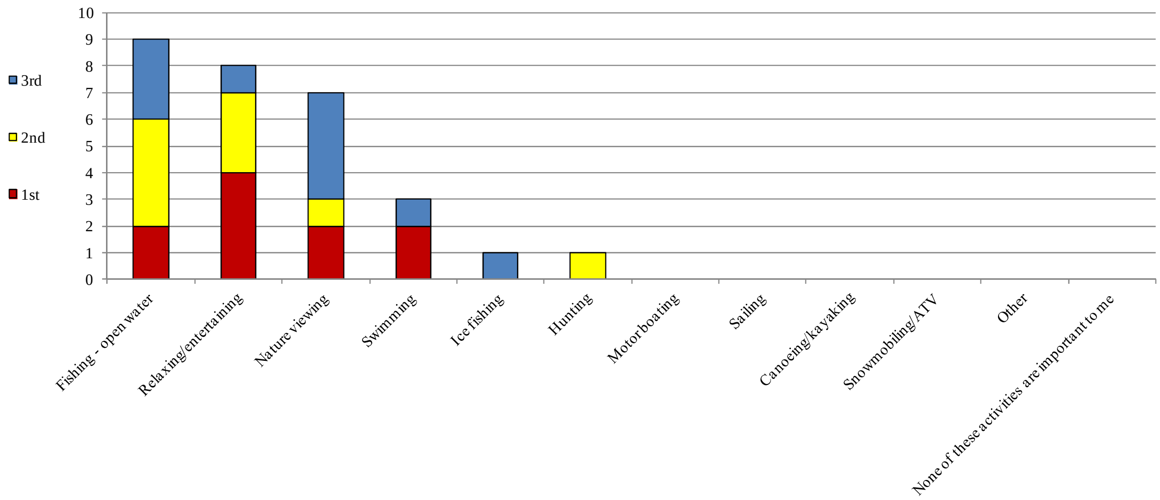
During November 2010, an eight-page, 29-question survey was mailed to 21 riparian property owners around Bass Lake and 24 property owners around Frog Lake. 52 percent of the surveys were returned from Bass Lake, and 67 percent of the surveys were returned from Frog Lake. Those results were entered into a spreadsheet by members of the Frog and Bass 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 and a general summary is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Frog and Bass Lakes. The majority of stakeholders are year-round residents on Bass Lake, while the majority of Frog Lake residents visit their lake on weekends throughout the year (Question #1). 60% of stakeholders have owned their property for over 25 years on Frog Lake, while on Bass Lake there is a mix residency time for property owners (Question #2).

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. Not surprisingly, the vast majority of residents on both lakes indicate that passive watercrafts (canoes, kayaks, rowboats and paddleboats) are what they commonly use on their lake (Question #12). As seen on Question #13, several of the top recreational activities on the lake involve boat use.

Lake residents on both Frog and Bass lakes noted concerns about aquatic plants on their lake. However, the concerns between the two lakes are quite different. Frog Lake residents noted aquatic invasive species as their top concern, while the concerns of Bass Lake residents revolve around excessive native plant growth (Question #20). These concerns were referenced within the survey question comments as well (Survey comments – Appendix B). These issues are discussed within the Aquatic Plant Section as well as the Summary & Conclusions section and Implementation Plan.

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



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

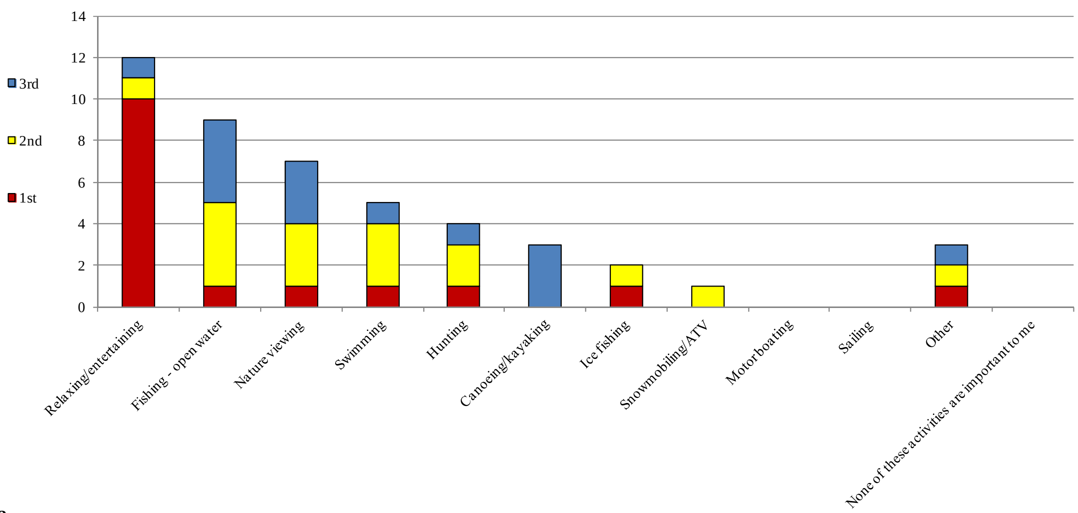
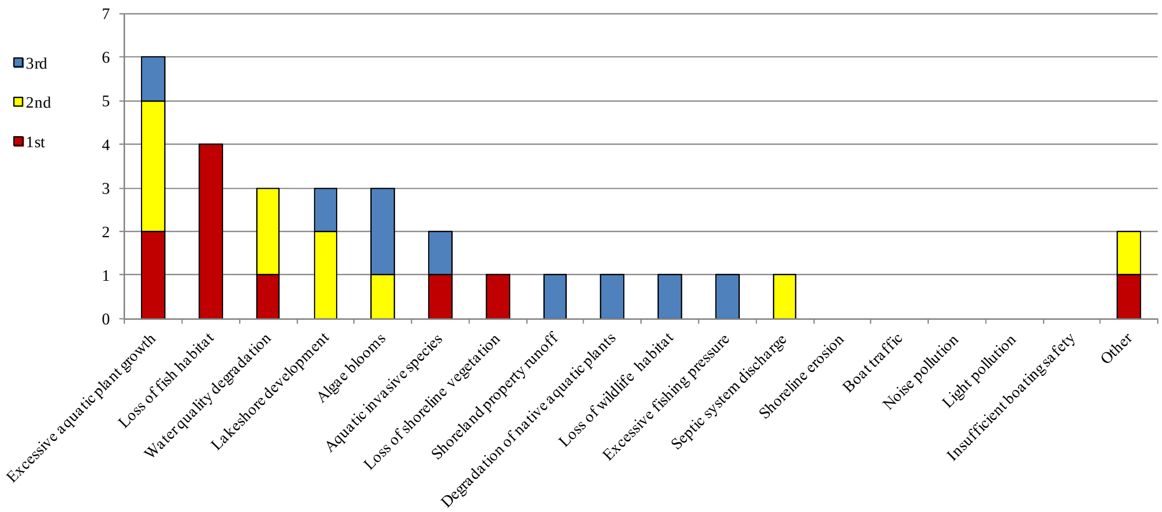


Figure 2.0-1. Select survey responses from Frog and Bass Lake Stakeholder Surveys. Additional questions and response charts may be found in Appendix B.

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



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

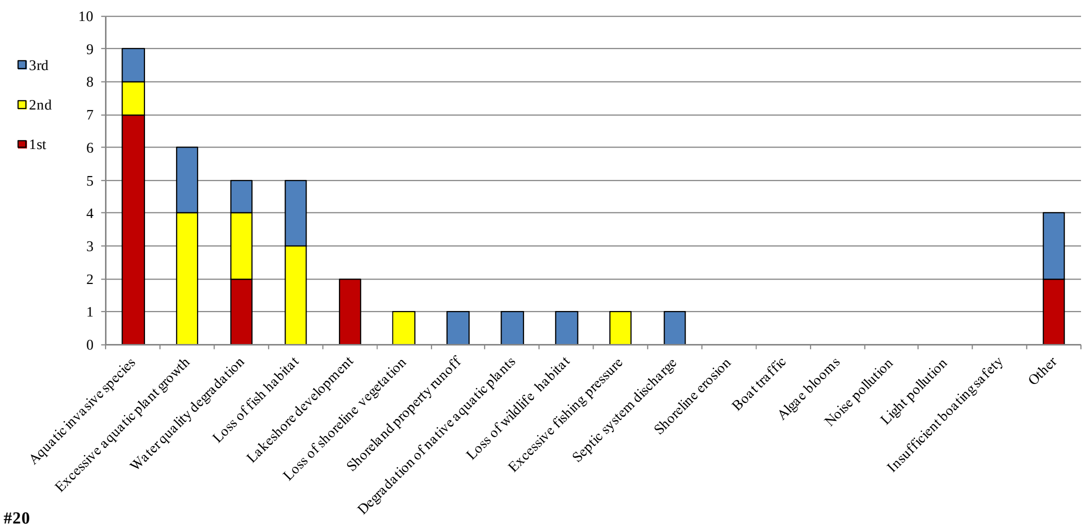

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Figure 2.0-2. Select survey responses from Frog and Bass Lake Stakeholder Surveys, continued. Additional questions and response charts may be found in Appendix B.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, 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.

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

Trophic State

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

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

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

Limiting Nutrient

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

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

Temperature and Dissolved Oxygen Profiles*

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

> **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.

*Lack of summer months temperature/dissolved oxygen profiles and hypolimnetic phosphorus data prevents these analyses from being performed. The explanation provided under this heading is strictly for the information of the reader.

Comparisons with Other Datasets

The WDNR publication *Implementation and Interpretation of Lakes Assessment Data for the Upper Midwest* (WDNR 2008) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's land cover. For this reason, the water quality of Frog and Bass Lakes will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into 6 classifications (Figure 3.1-1).

First, the lakes are classified into two main groups: shallow (mixed) or deep (stratified). Shallow lakes tend to mix throughout or periodically during the growing season and as a result, remain well-oxygenated. Further, shallow lakes often support aquatic plant growth across most or the entire lake bottom. Deep lakes tend to stratify during the growing season and have the potential to have low oxygen levels in the bottom layer of water (hypolimnion). Aquatic plants are usually restricted to the shallower areas around the perimeter of the lake (littoral zone). An equation developed by Lathrop and Lillie (1980) that incorporates the maximum depth of the lake and the lake's surface area is used to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

> **Seepage Lakes** have no surface water inflow or outflow in the form of rivers and/or streams.
>
> **Drainage Lakes** have surface water inflow and/or outflow in the form of rivers and/or streams.
>
> > *Headwater drainage* lakes have a watershed of less than 4 square miles.
> >
> > *Lowland drainage* lakes have a watershed of greater than 4 square miles.

Frog Lake, despite lower water levels in 2010, is still classified as a deep (stratified), seepage lake, while Bass Lake with a shallower maximum depth of 10 feet in 2010, is now classified as a shallow (mixed), seepage lake (Figure 3.1-1).

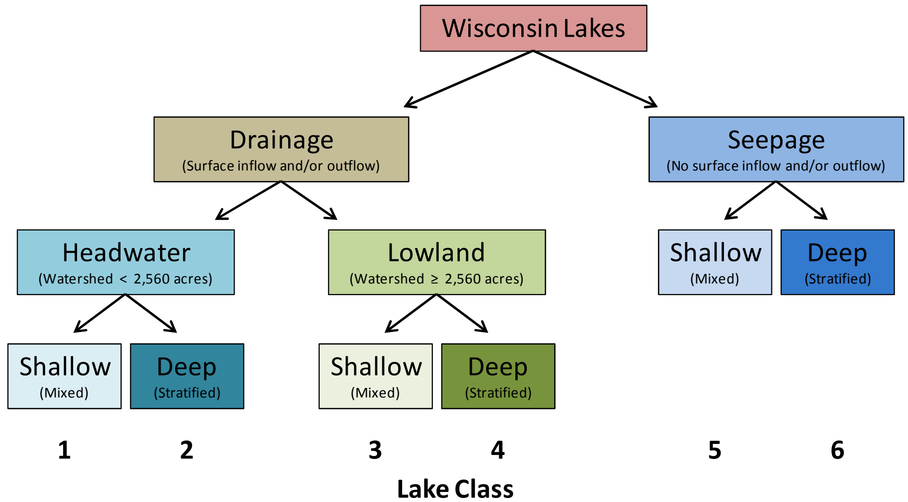

Figure 3.1-1. Wisconsin Lake Classifications. Frog Lake is classified as a deep (stratified), seepage lake (Class 6), and Bass Lake is classified as a shallow (mixed), seepage lake (Class 5). Adapted from WDNR PUB-SS-1044 2008.

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

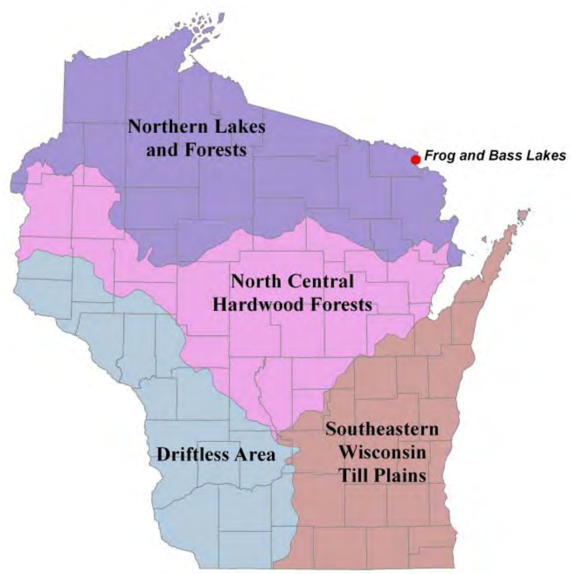

Figure 3.1-2. Location of Frog and Bass Lakes within the ecoregions of Wisconsin. After Nichols 1999.

The Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM), created by the WDNR, is another useful tool in helping lake stakeholders understand the health of their lake compared to others within the state. Looking at pre-settlement diatom population compositions from sediment cores collected from numerous lakes around the state, they were able to infer a reference condition for each lake's water quality prior to human development within their watersheds. Using these reference conditions and current water quality data, they were able to rank phosphorus, chlorophyll-*a*, and Secchi disk transparency values for each lake class into categories ranging from excellent to poor.

These data along with data corresponding to statewide natural lake means, historic, current, and average data from Frog and Bass Lakes are displayed in Figures 3.1-3 - 3.1-6. Please note that the data in these graphs represent concentrations taken only during the growing season (April-October). Since state and regional medians were calculated using summer (June, July, August) data, summer data for Frog and Bass 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.

Frog and Bass Lakes Water Quality Analysis

Frog and Bass Lakes Long-term Trends

As described above, in terms of scientific water quality monitoring, there are three water quality parameters of most interest: total phosphorus, chlorophyll-*a*, and Secchi disk transparency. A very limited amount of water quality data exists for both Frog and Bass Lakes. Secchi disk data is available from Frog Lake since 2007, while 2010 was the first year any if these water quality parameters have been collected on Bass Lake. With this small data set spanning a very short period of time, it is impossible to interpret any possible long-term changes in water quality within Frog and Bass Lakes.

The summer of 2010 was the first year that total phosphorus and chlorophyll-*a* concentrations have been measured in Frog and Bass Lakes. Examination of these data indicate that Frog Lake phosphorus concentrations were slightly higher in 2010 than on Bass Lake, but both are fairly similar and fall within the "Good" category for each of their respective lake types (Figure 3.3-3). Chlorophyll-*a* values were also very similar among the two lakes, with Frog Lake's falling the "Good" category for deep, seepage lakes and Bass Lake's falling in the "Excellent" category for shallow, seepage lakes (Figure 3.3-4).

Secchi disk clarity data has been collected on Frog Lake since 2007, while Secchi disk data is only available from 2009-2010 on Bass Lake. Secchi disk clarity values on Frog Lake ranged from the "Excellent" to "Good" category with the average values for all years falling in the "Excellent" category (Figure 3.3-5). On Bass Lake, Secchi disk values were slightly lower and fell within the "Good" category overall (Figure 3.3-6).

With the water quality data that is available for Frog and Bass Lakes it is not possible at this time to determine if water quality over time has degraded, remained constant, or improved. However, the data that is available falls within "Good" and "Excellent" categories for deep, seepage lakes in Wisconsin. Continual monitoring in the future will allow a better understanding of any linear or annual trends that may be occurring in these lakes, but at the present time the water quality of Frog and Bass Lakes is comparable to other lakes within the ecoregion and the state.

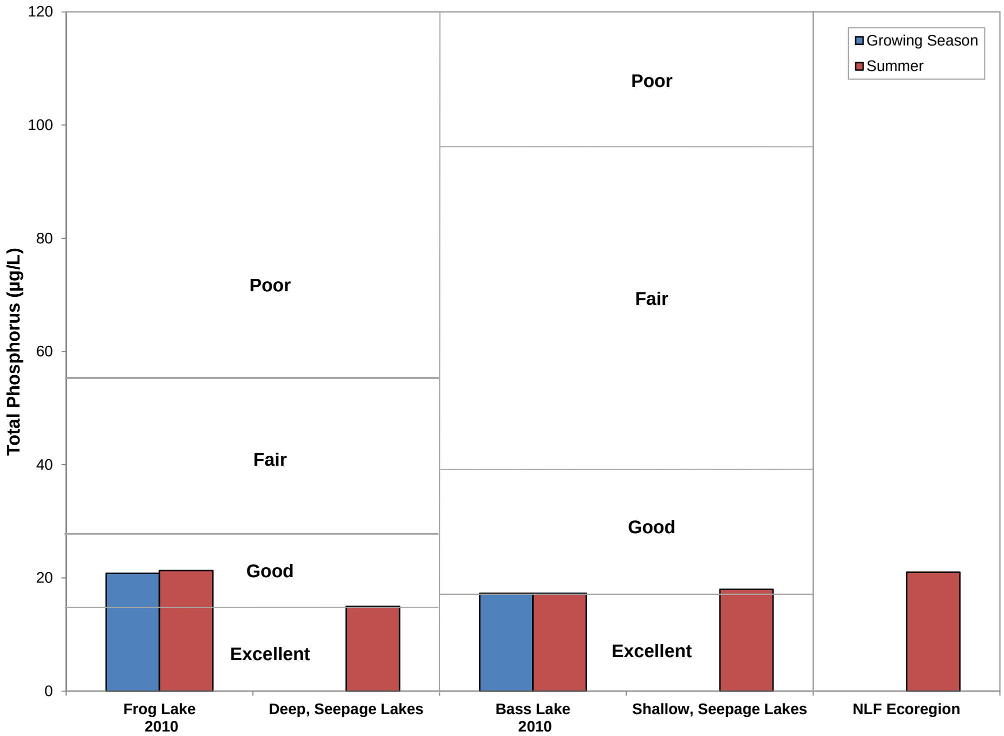

Figure 3.1-3. Frog and Bass Lakes 2010, state-wide deep and shallow seepage lakes, and regional total phosphorus concentrations. Mean values calculated with 2010 summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

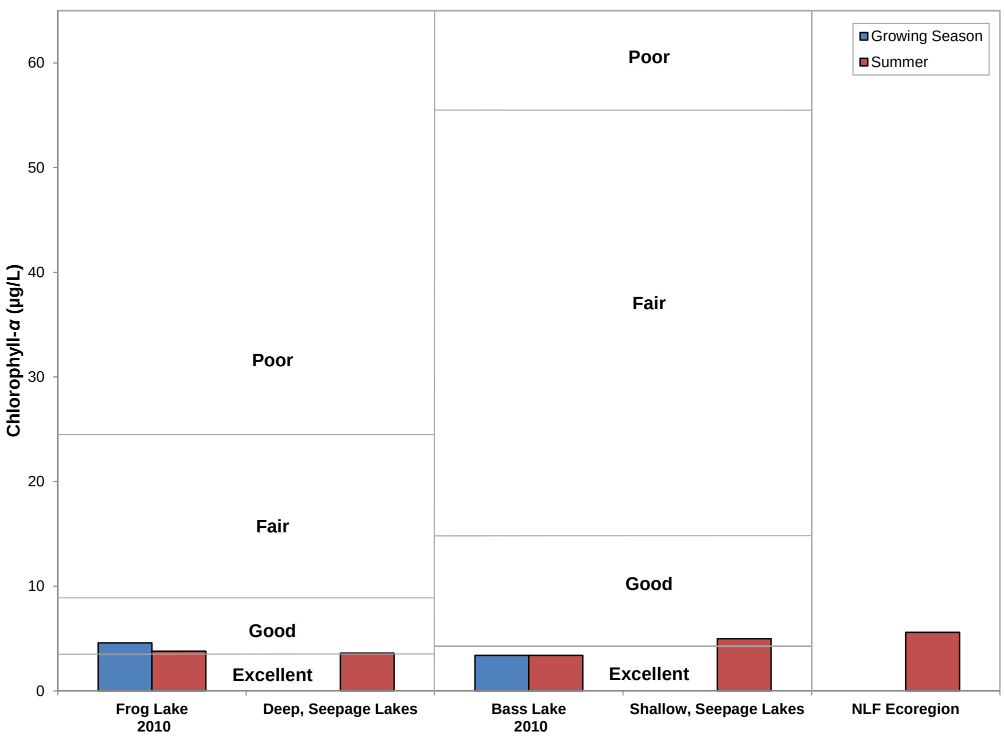

Figure 3.1-4. Frog and Bass Lakes 2010, state-wide deep and shallow seepage lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with 2010 summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

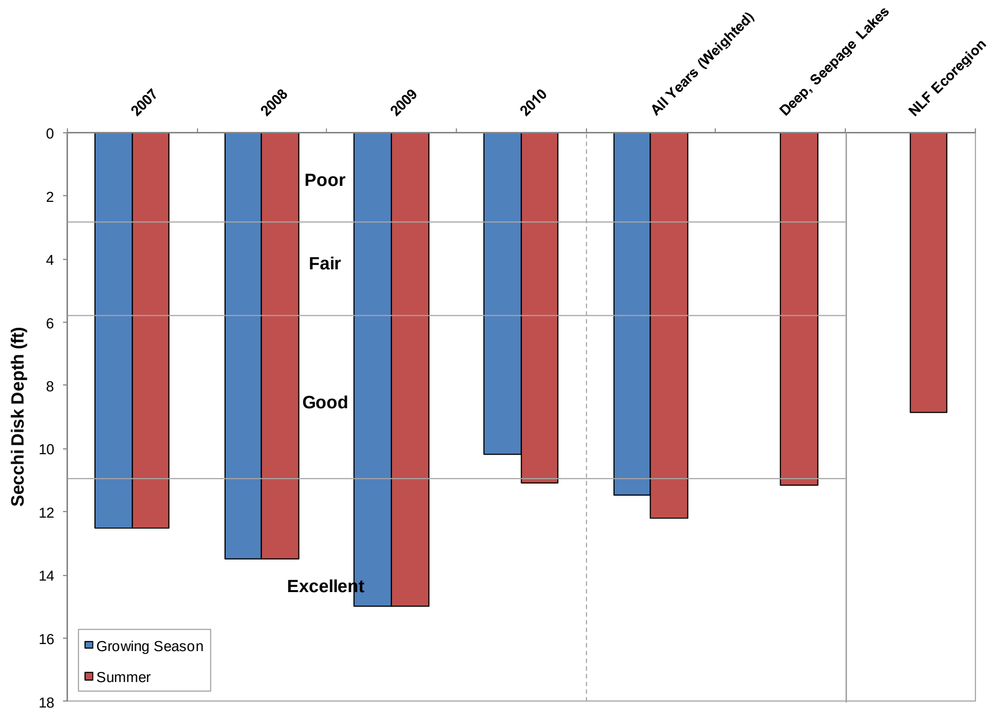

Figure 3.1-5. Frog Lake, state-wide deep seepage lakes, and regional Secchi disk values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

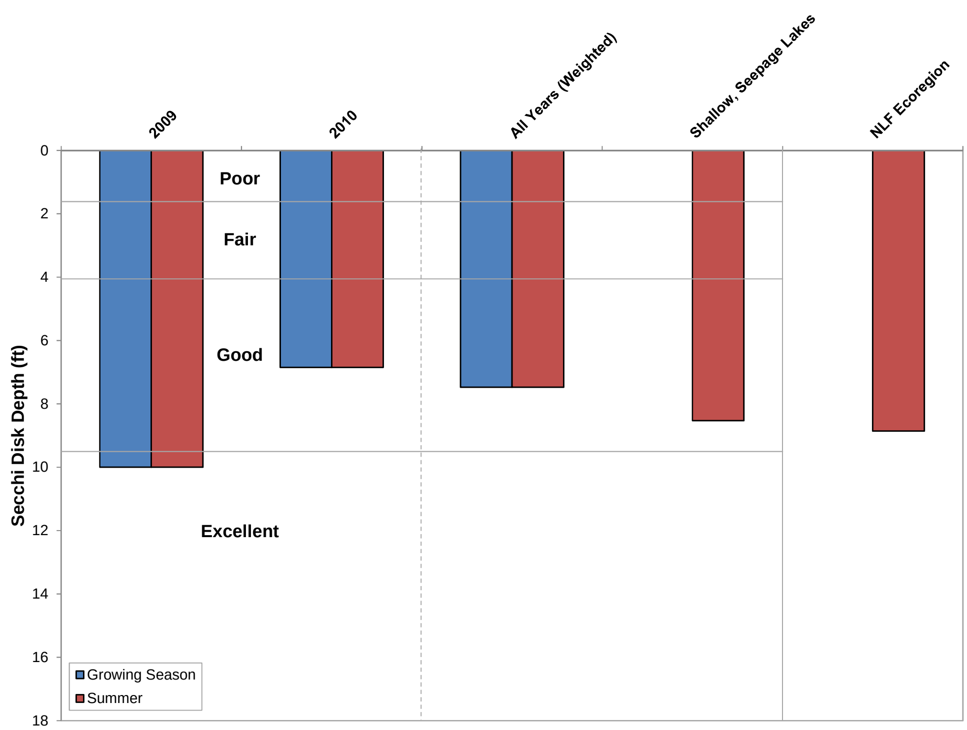

Figure 3.1-6. Bass Lake, state-wide shallow seepage lakes, and regional Secchi disk values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Frog and Bass Lakes

Using mid-summer nitrogen and phosphorus concentrations, nitrogen:phosphorus ratios of 48:1 and 68:1 were calculated for Frog and Bass Lakes, respectively. This finding indicates that the two 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 these lakes.

Frog and Bass Lakes Trophic State

In general, the best values to use in judging a lake's trophic state are the biological parameters; chlorophyll-*a* and total phosphorus. In both Bass and Frog Lakes, those values ranged around the mid 40's, indicating that the lakes are middle mesotrophic, or mildly productive.

Dissolved Oxygen and Temperature in Frog and Bass Lakes

Dissolved oxygen and temperature data was collected on Frog and Bass Lakes during each summer month. The data collected in April of 2009 indicate that both lakes mixed thoroughly. As Figure 3.1-7 indicates, in mid June, Frog Lake was slightly stratified with about a one degree Celsius difference in temperature from the surface to the bottom. Dissolved oxygen also decreased with depth but did not drop below 2 mg/L. In July, there again was a one degree change in temperature from surface to bottom. Dissolved oxygen suddenly dropped below 6 feet and it is believed that the probe may have hit bottom. In August, there was about a six degree temperature difference from the surface to the bottom and dissolved oxygen fell below 2 mg/L at 13 feet.

Figure 3.1-8 shows that the temperature and dissolved oxygen in the shallower Bass Lake remained relatively uniform within each month. Dissolved oxygen did not drop below 2 mg/L during any of the sampling periods. However, when the water in Bass Lake is at or near the ordinary high water mark, the lake likely stratifies during the summer months.

Additional Water Quality Data Collected at Frog and Bass Lakes

The Water Quality Section is primarily centered on parameters that are associated with 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 Frog and Bass Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw and Nimphius 1985). The pH of the water in Frog and Bass

Lakes were found to be alkaline with values of 9.3-9.6 and 9.6-9.9. These values fall within the higher 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 of Frog and Bass was not survey during this project.

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 Frog Lake's 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 of Frog Lake was found to be 26.4 mg/L, falling in the moderately susceptible category, while Bass Lake was found to be 9.0 mg/L, falling into the low susceptibility category for zebra mussel establishment.

In addition, 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, Frog and Bass Lakes are considered to be suitable for mussel establishment. Plankton tows were completed by Onterra staff during the summer of 2010 and these samples were processed by the WDNR for larval zebra mussels. Their analysis returned a negative result for the presence of these exotic species.

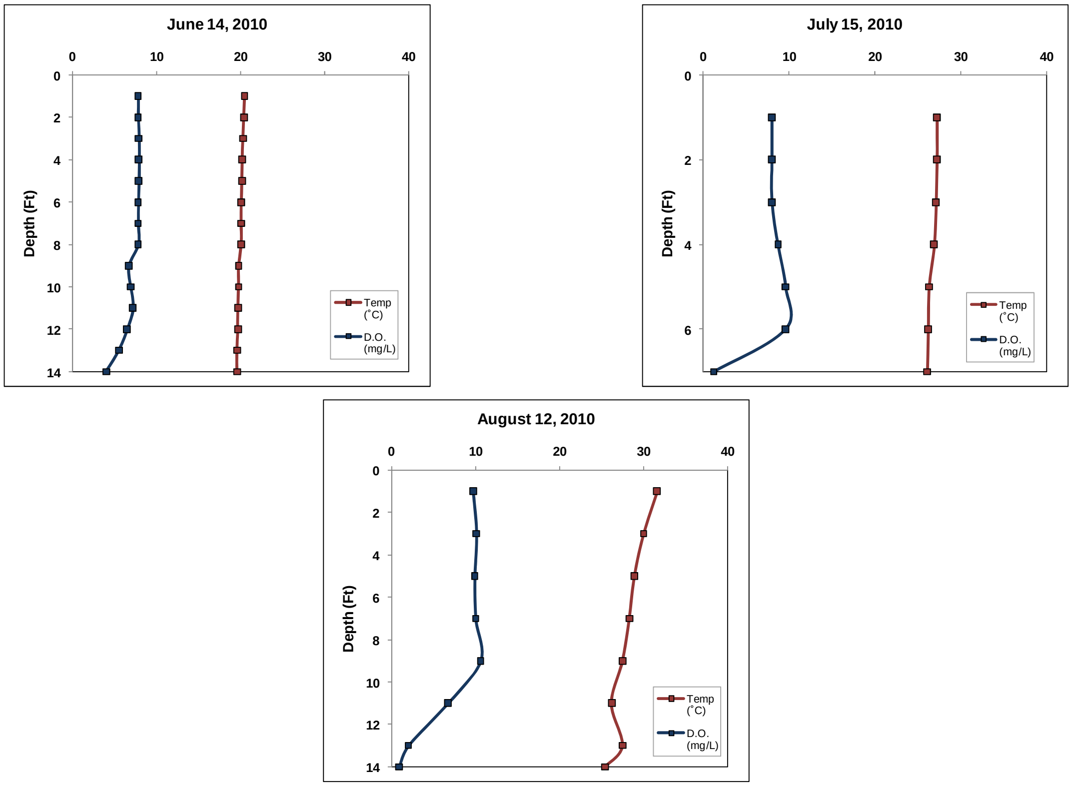

Figure 3.1-7. Frog Lake dissolved oxygen and temperature profiles.

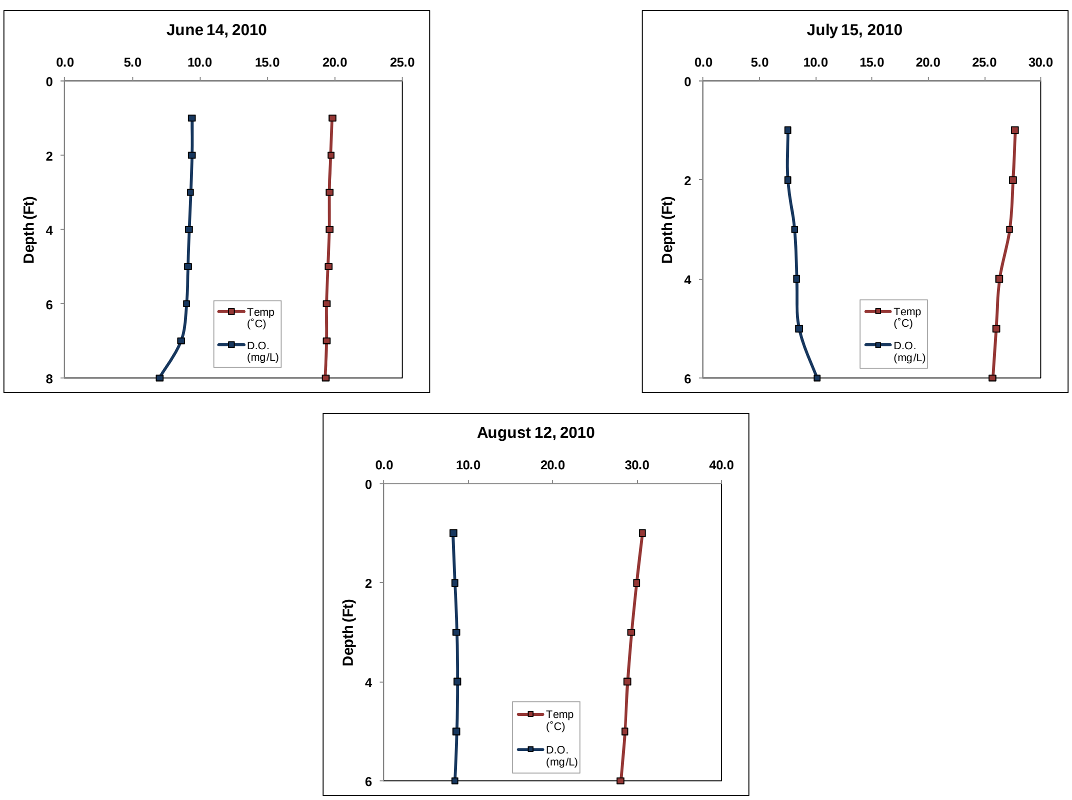

Figure 3.1-8. Bass Lake dissolved oxygen and temperature profiles.

3.2 Watershed Assessment

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

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

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

In systems with lower WS:LA ratios, land cover type plays a very important role in how much phosphorus is loaded to the lake from the watershed. In these systems the occurrence of agriculture or urban development in even a small percentage of the watershed (less than 10%) can unnaturally elevate phosphorus inputs to the lake. If these land cover types are converted to a cover that does not export as much phosphorus, such as converting row crop areas to grass or forested areas, the phosphorus load and its impacts 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.

Frog and Bass Lakes each have similar watersheds that vary slightly in size. Bass Lake's watershed is 199 acres, and consists mostly of forested land (85%), Bass Lake (10%), and small areas of wetlands and pasture/grass (Figure 3.2-1). Frog Lake's watershed is a bit larger (412 acres) and includes large tracts of forest (89%) along with pasture/grass, Frog Lake and small amounts of wetlands (Figure 3.2-2). Watershed delineations and land cover types are illustrated for Frog and Bass Lakes in Map 2. Given that the lakes are so small, the relatively larger watersheds that surround them make for a larger watershed to lake area ratio. Bass Lake's ratio is 9:1, while Frog Lake's ratio is even larger at 23:1. As previously discussed, in systems with a watershed to lake area ratio greater than 10-15:1, the amount of land within the watershed overshadows the type of land it encompasses in terms of the environmental impact on the lake; therefore, although both lakes have watersheds with land cover types that contribute little phosphorus on an acre-by-acre basis, the size of each lake's watershed contributes sufficient phosphorus to keep the lakes mildly productive.

The type of land cover within the Frog and Bass Lakes' watersheds is preferable to reducing nutrient and sediment input to the lakes. WiLMS modeling utilizing all land cover types and acreages found in Figures 3.2-1 and 3.2-2 resulted in an estimated annual phosphorus load of 17.6 lbs for Bass Lake and 39.6 lbs for Frog Lake. Both lakes include large percentages of forested land within their watersheds. This land cover type is the largest phosphorus exporter in each watershed, with 75% and 72% of the annual phosphorus load being attributed to forested land in Bass and Frog Lake, respectively (Figures 3.2-3 and 3.2-4). In Bass Lake, atmospheric deposition of phosphorus accounts for the last 25% of the annual load (wetlands and pasture/grass contribute negligible amounts). The remaining 28% of Frog Lake's phosphorus load is split between pasture/grass (17%) and the lake surface (11%).

The annual phosphorus load to each of these lakes is fairly minimal, which is to be expected for lakes of this size with a large amount of forested land within their watersheds. 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.

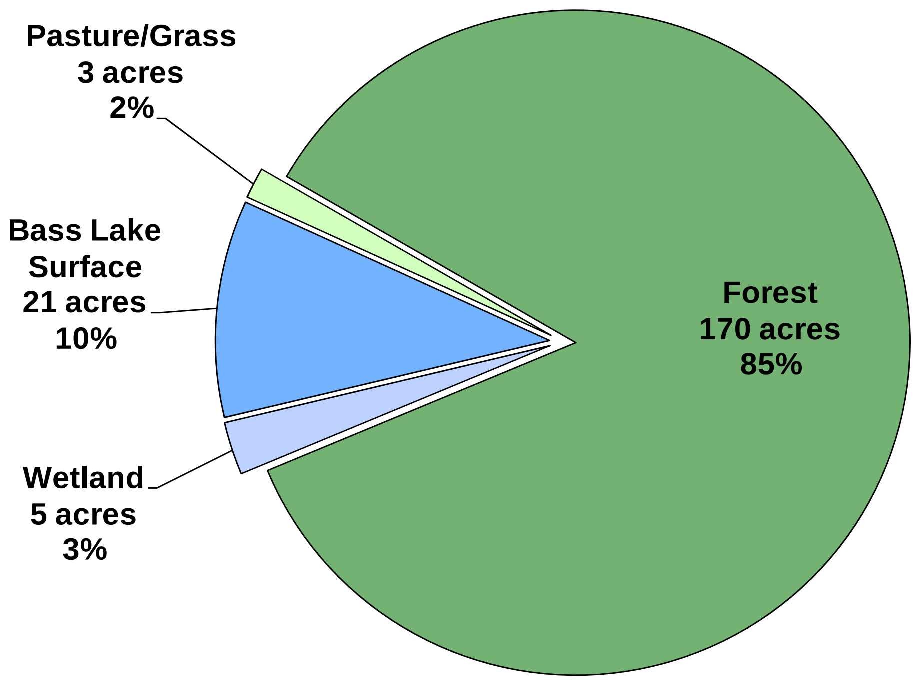

Figure 3.2-1. Bass Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

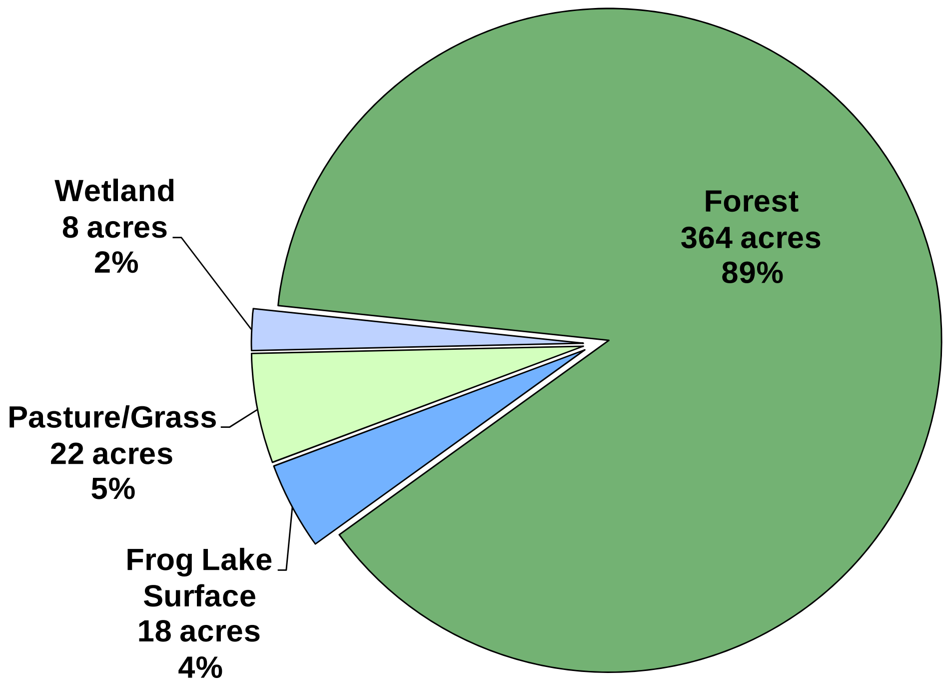

Figure 3.2-2. Frog Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

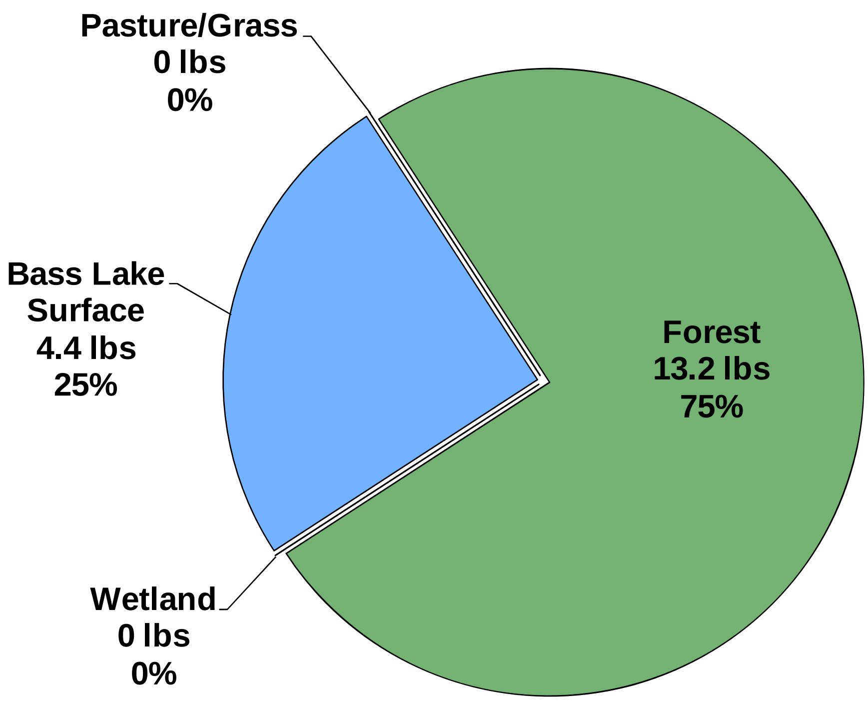

Figure 3.2-3. Bass Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

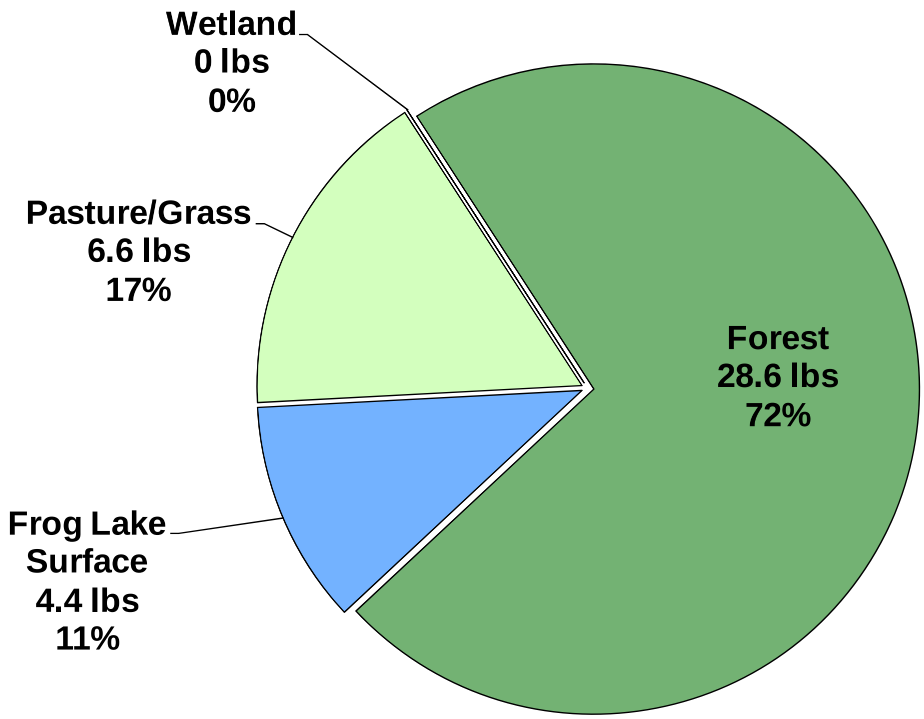

Figure 3.2-4. Frog Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Shoreland Condition Assessment

The Importance of a Lake's Shoreland Zone

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

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

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

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

Shoreland Zone Regulations

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

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted more strict shoreland ordinances. Passed in February of 2010, the final NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances of their own. County ordinances may be more restrictive than NR 115, but not less so. These policy regulations require each county to amend ordinances for vegetation removal on shorelands, impervious surface standards, nonconforming structures and establishing mitigation requirements for development. Minimum requirements for each of these categories are as follows (Note: counties must adopt these standards by February 2014, counties may not have these standards in place at this time):

- <u>Vegetation Removal</u>: For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed the lesser of 30 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. Vegetation removed must be replaced by replanting in the same area (native species only)..
- <u>Impervious surface standards</u>: The amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. A county may allow more than 15% impervious surface (but not more than 30%) on a lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner.

- <u>Nonconforming structures</u>: Nonconforming structures are structures that were lawfully placed when constructed but do not comply with distance of water setback. Originally, structures within 75 ft of the shoreline had limitations on structural repair and expansion. New language in NR-115 allows construction projects on structures within 75 feet with the following caveats:
  - No expansion or complete reconstruction within 0-35 feet of shoreline
  - Re-construction may occur if no other build-able location exists within 35-75 feet, dependent on the county.
  - Construction may occur if mitigation measures are included either within the footprint or beyond 75 feet.
  - Vertical expansion cannot exceed 35 feet

- <u>Mitigation requirements</u>: New language in NR-115 specifies mitigation techniques that may be incorporated on a property to offset the impacts of impervious surface, replacement of nonconforming structure, or other development projects. Practices such as buffer restorations along the shoreland zone, rain gardens, removal of fire pits, and beaches all may be acceptable mitigation methods, dependent on the county.
- Contact the county's regulations/zoning department for all minimum requirements.

<u>**Wisconsin Act 31**</u>

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

Shoreland Research

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

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

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

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

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

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

National Lakes Assessment

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

Through the National Lakes Assessment, a number of potential stressors were examined, including nutrient impairment, algal toxins, fish tissue contaminants, physical habitat, and others.

The 2007 NLA report states that "*of the stressors examined, poor lakeshore habitat is the biggest problem in the nations lakes; over one-third exhibit poor shoreline habitat condition*" (USEPA 2009). Furthermore, the report states that "*poor biological health is three times more likely in lakes with poor lakeshore habitat*".

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

Native Species Enhancement

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

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

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

Cost

The cost of native, aquatic, and shoreland plant restorations is highly variable and depends on the size of the restoration area, the depth of buffer zone required to be restored, the existing plant density, the planting density required, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other sites may require erosion control stabilization measures, which could be as simple as using erosion control blankets and plants and/or seeds or more extensive techniques such as geotextile bags (vegetated retaining walls), geogrids (vegetated soil lifts), or bio-logs (see above picture). Some of these erosion control techniques may reduce the need for rip-rap or seawalls which are sterile environments that do nott allow for plant growth or natural shorelines. Questions about rip-rap or seawalls should be directed to the local Wisconsin DNR Water Resources Management Specialist. Other measures possibly required include protective measures used to guard newly planted area from wildlife predation, wave-action, and erosion, such as fencing, erosion control matting, and animal deterrent sprays. One of the most important aspects of planting is maintaining moisture levels. This is done by watering regularly for the first two years until plants establish themselves, using soil amendments (i.e., peat, compost) while planting, and using mulch to help retain moisture.

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

- In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $1,400. The more native vegetation a site has, the lower the cost. Owner's should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:
  - Spring planting timeframe.
  - A 100' of shoreline.
  - An upland buffer zone depth of 35'.
  - An access and viewing corridor 30' x 35' free of planting (recreation area).
  - Planting area of upland buffer zone 2- 35' x 35' areas
  - Site is assumed to need little invasive species removal prior to restoration.
  - Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
  - Trees and shrubs planted at a density of 1 tree/100 sq ft and 2 shrubs/100 sq ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
  - Turf grass would be removed by hand.
  - A native seed mix is used in bare areas of the upland buffer zone.
  - An aquatic zone with shallow-water 2 - 5' x 35' areas.
  - Plant spacing for the aquatic zone would be 3 feet.

- Each site would need 70’ of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- Soil amendment (peat, compost) would be needed during planting.
- There is no hard-armor (rip-rap or seawall) that would need to be removed.
- The property owner would maintain the site for weed control and watering.

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

Frog and Bass Shoreland Zone Condition

Shoreland Development

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

Urbanized: This type of shoreline has essentially no natural habitat. Areas that are mowed or unnaturally landscaped to the water's edge and areas that are rip-rapped or include a seawall would be placed in this category.

Developed-Unnatural: This category includes shorelines that have been developed, but only have small remnants of natural habitat yet intact. A property with many trees, but no remaining understory or herbaceous layer would be included within this category. Also, a property that has left a small (less than 30 feet), natural buffer in place, but has urbanized the areas behind the buffer would be included in this category.

Developed-Semi-Natural: This is a developed shoreline that is mostly in a natural state. Developed properties that have left much of the natural habitat in state, but have added gathering areas, small beaches, etc within those natural areas would likely fall into this category. An urbanized shoreline that was restored would likely be included here, also.

Developed-Natural: This category includes shorelines that are developed property, but essentially no modifications to the natural habitat have been made. Developed properties that have maintained the natural habitat and only added a path leading to a single pier would fall into this category.

Natural/Undeveloped: This category includes shorelines in a natural, undisturbed state. No signs of anthropogenic impact can be found on these shorelines. In forested areas, herbaceous, understory, and canopy layers would be intact.

Figure 3.3-1. Shoreline assessment category descriptions.

On Frog and Bass Lakes, the development stage of the entire shoreline was surveyed during late summer of 2011, using a GPS unit to map the shoreline (Map 3). Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreline on a property-by-property basis. During the survey, Onterra staff examined the shoreline for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.3-1.

Frog Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 2,686 feet of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 3.3-2). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 1,300 feet of urbanized and developed–unnatural shoreline were observed. If restoration of the Frog Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreline lengths around the entire lake.

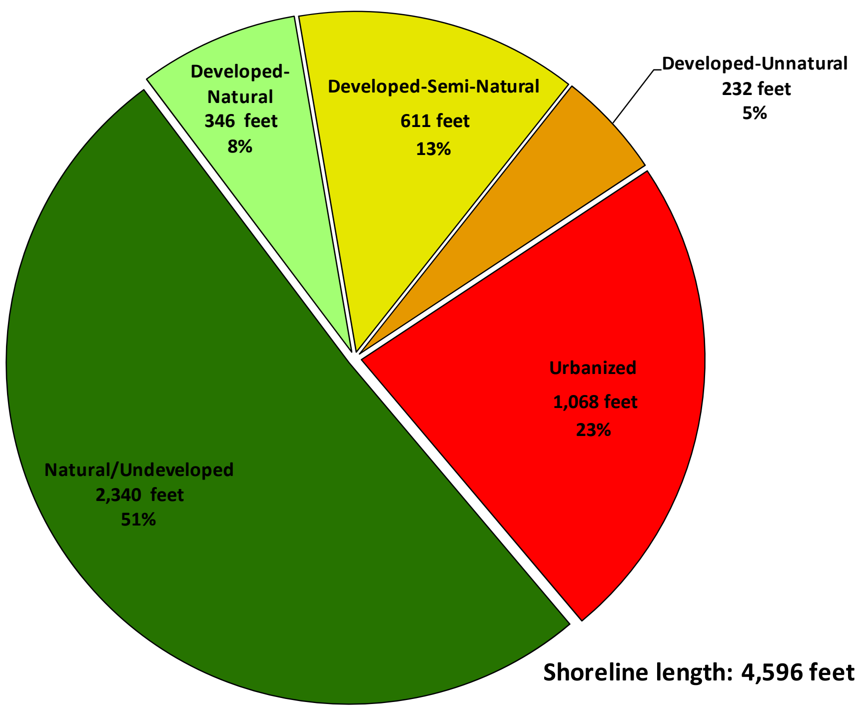

Figure 3.3-2. Frog Lake shoreland categories and total lengths. Based upon a late summer 2011 survey. Locations of these categorized shorelands can be found on Map 3.

Bass Lake has stretches of shoreland that fit all of the five shoreland assessment categories as well. In all, 2,597 feet of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 3.3-3). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 884 feet of urbanized and developed–unnatural shoreline were observed. If restoration of the Bass Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreline lengths around the entire lake.

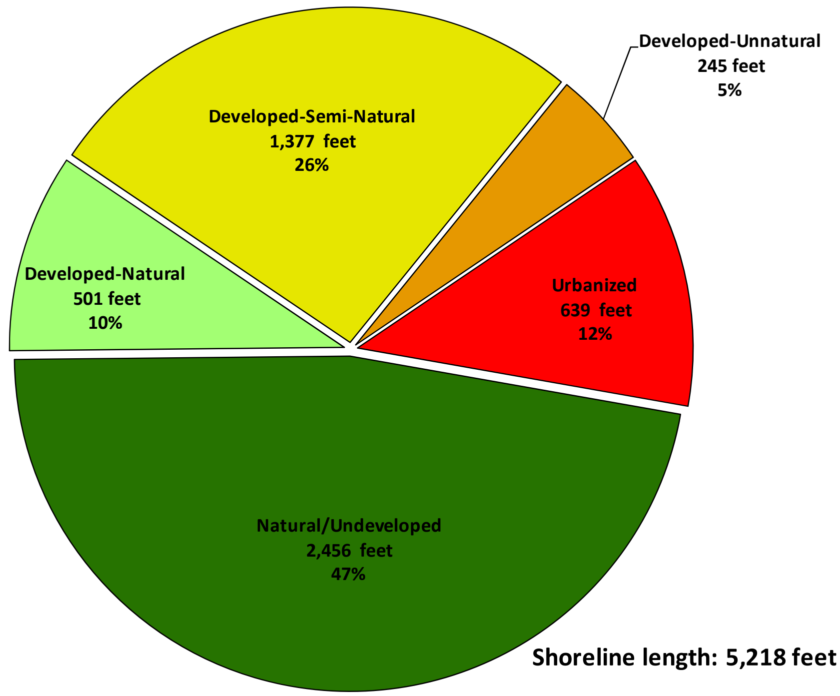

Figure 3.3-3. Bass Lake shoreland categories and total lengths. Based upon a late summer 2011 survey. Locations of these categorized shorelands can be found on Map 3.

3.4 Aquatic Plants

Introduction

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

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

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

When plant abundance negatively affects the lake ecosystem and limits the use of the resource, plant management and control may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods. No aquatic plant management plan should only contain methods to control plants, 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 Frog or Bass 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 Frog and Bass Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

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

Permits

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

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

Manual Removal

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 effects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*). • Permitting process may require an environmental assessment that may take months to prepare. • Unselective.

Mechanical Harvesting

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes 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.

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

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

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

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

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

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

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

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

Cost

Herbicide application charges vary greatly between $400 and $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil. • Some herbicides can be used effectively in 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 water hyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*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, such as variable water levels or negative, such as increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways. For example, there may be a loss of one or more species. Certain life forms, such as emergents or floating-leaf communities, may disappear from specific areas of the lake. A shift in plant dominance between species may also occur. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on both Frog and Bass 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 and 2010 on Frog and Bass Lakes, plant samples were collected from plots laid out on a grid that covered the entire system (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

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

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to Frog and Bass Lakes. 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. Please note for this parameter, the Northern Lakes and Forests Ecoregion data includes both natural and flowage lakes.

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

Floristic Quality Assessment

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

Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an 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 plan surveys.

Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; 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 3.4-1). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

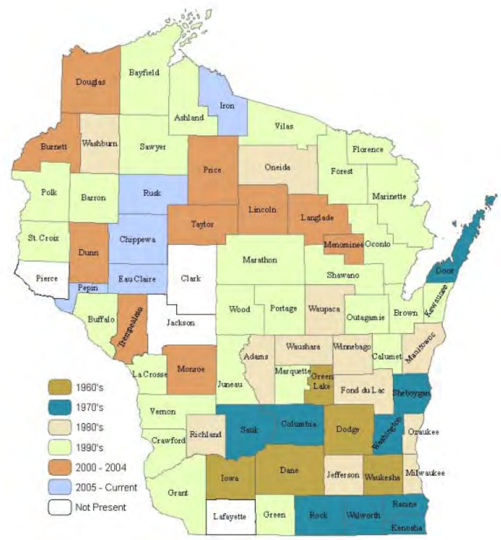

Figure 3.4-1. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 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 14, 2010, a survey was completed on Frog and Bass Lakes that focused upon curly-leaf pondweed. This meander-based survey did not locate any occurrences of this invasive plant. It is believed that curly-leaf pondweed either does not occur in Frog and Bass Lakes or exists at an undetectable level.

Littoral Zone is the area of a lake where sunlight is able to penetrate down to the sediment and support aquatic plant growth.

The comprehensive aquatic plant point-intercept surveys were conducted by Florence County on Bass Lake in the summer of 2009 and on Frog Lake in the summer of 2010. Additional surveys targeted at mapping emergent and floating-leaf aquatic vegetation were also completed on August 12, 2010 by Onterra to create the aquatic plant community maps (Maps 5 & 6). During the point-intercept and aquatic plant mapping surveys, a total of 22 aquatic plant species were located on Frog and Bass Lakes (Table 3.4-1), including the non-native Hybrid water milfoil in Frog Lake. Exhibiting some morphological characteristics of the native species northern water milfoil, the Eurasian water milfoil in Frog Lake was sent to the Annis Water Resources Institute at Grand Valley State University in Michigan for DNA analysis. Their results confirmed that the milfoil present in Frog Lake is a hybrid between Eurasian water milfoil (*Myriophyllum spicatum*) and the native northern water milfoil (*Myriophyllum sibiricum*). Northern water milfoil collected from Bass Lake was also sent in for analysis, and results indicated that it was pure northern water milfoil. Control strategies were implemented in 2010 on Frog Lake in an attempt to control this invasive species and will be discussed in the next section.

Table 3.4-1. Aquatic plant species located on Frog and Bass Lakes during 2009 and 2010 surveys. Created using data from Florence County 2009 and 2010 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	Frog Lake	Bass Lake
Emergent	*Carex viridula*	Little green sedge	6	I	
	Dulichium arundinaceum	Three-way sedge	9	I	I
	Juncus brevicaudatus	Narrow-panicle rush	6		I
	Sagittaria latifolia	Common arrowhead	3	I	I
	Schoenoplectus purshianus	Pursh's bulrush	9		I
	Schoenoplectus tabernaemontani	Softstem bulrush	4	I	I
	Typha sp.	Cattail sp.	1	I	I
FL	*Nuphar variegata*	Spatterdock	6		I
	Nymphaea odorata	White water lily	6	X	
Submergent	*Chara sp.*	Muskgrasses	7	X	X
	*Myriophyllum sibiricum**	Northern water milfoil	7		X
	*Myriophyllum sibiricum X M. spicatum**	Northern X Eurasian water milfoil	Exotic	X	
	Najas flexilis	Slender naiad	6	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton gramineus	Variable pondweed	7	X	X
	Potamogeton praelongus	White-stem pondweed	8		X
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton strictifolius	Stiff pondweed	8	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Stuckenia pectinata	Sago pondweed	3	X	
	Vallisneria americana	Wild celery	6	X	X
SE	*Eleocharis acicularis*	Needle spike-rush	5		X

*FL = Floating-leaf; SE = Submergent and Emergent; * Identification confirmed via DNA analysis*
X = Present on the rake during Florence County point-intercept survey; I = Incidental species

The overall environment of Frog and Bass Lakes is very conducive for supporting a lush aquatic plant community. The combination of nutrient-rich, organic substrates (muck) and clear water creates ideal conditions for aquatic plants. As determined from the point-intercept surveys, muck is the dominant substrate type in both lakes, with a smaller proportion being comprised of sand and rock (Figure 3.4-2). Map 4 illustrates that the areas of sand and rock were mainly located in shallow areas near shore. Lowering water levels may also increase aquatic plant growth. As the water level drops, light is able to penetrate to areas of the lake that may have once been too deep allowing plants to colonize. Shallower water also means plants will have an easier time growing closer to the surface. Floating-leaf and emergent species, such as lily pads, also may expand lakeward with the falling water levels

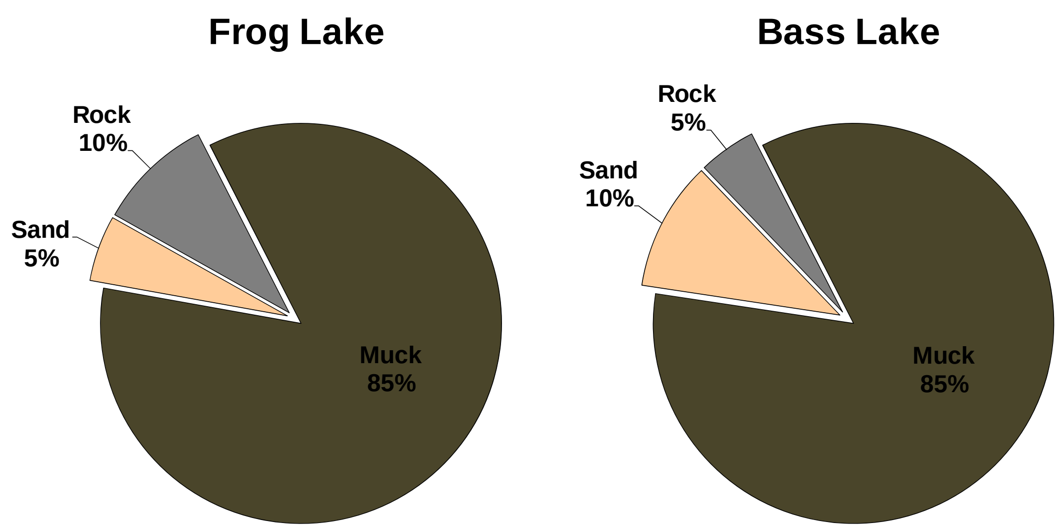

Figure 3.4-2 Frog and Bass Lakes proportion of substrate types. Created using data from Florence County 2009 and 2010 surveys.

Florence County located aquatic plants growing to a depth of 15 feet in both Frog and Bass Lakes during their point-intercept surveys. While Florence County recorded depths of 14 and 15 feet at a number of point-intercept locations during their 2009 survey of Bass Lake, Onterra ecologists were only able to find a maximum depth of 10 feet in 2010 when looking for the deep hole. Of the point-intercept locations that fell within the maximum depth of plant growth, approximately 74% on Frog Lake and 92% on Bass Lake contained aquatic vegetation, indicating that both lakes are highly vegetated. Map 5 illustrates that the entire area of both lakes supports aquatic plant growth, or both lakes are entirely comprised of littoral area. Figures 3.4-3 and 3.4-4 display the frequency of occurrence of the four-most frequently encountered aquatic plant species across water depths in Frog and Bass Lakes, and show that there is a high occurrence of aquatic vegetation across all depths.

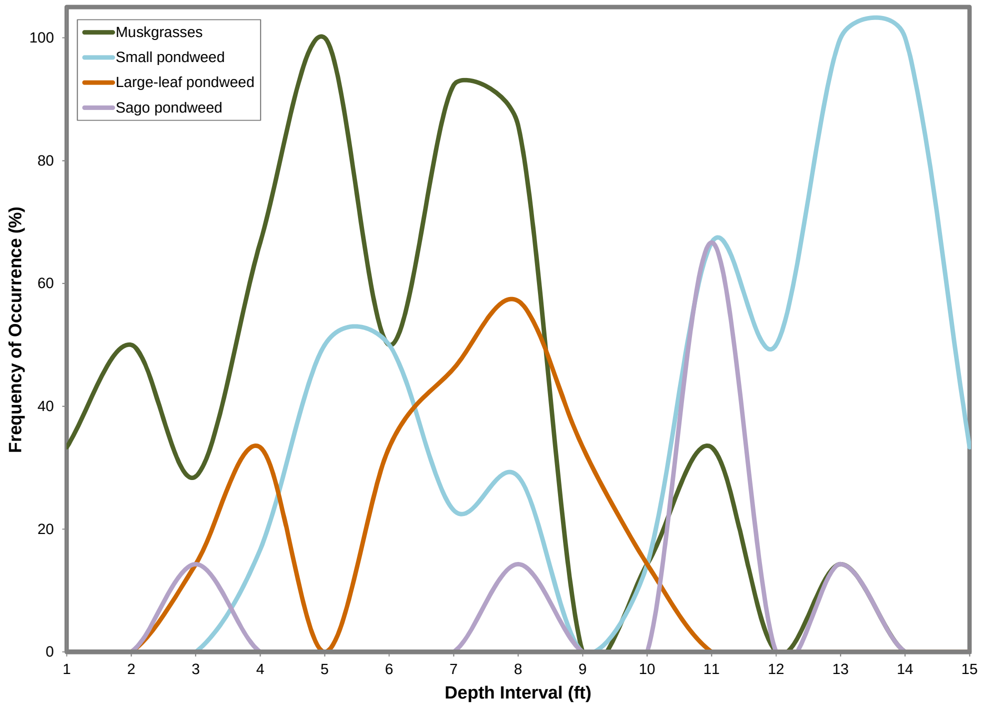

Figure 3.4-3. Frequency of occurrence over water depth of four-most frequently encountered aquatic plant species in Frog Lake. Created using data from 2010 Florence County point-intercept survey. Lines are smoothed to ease visualization.

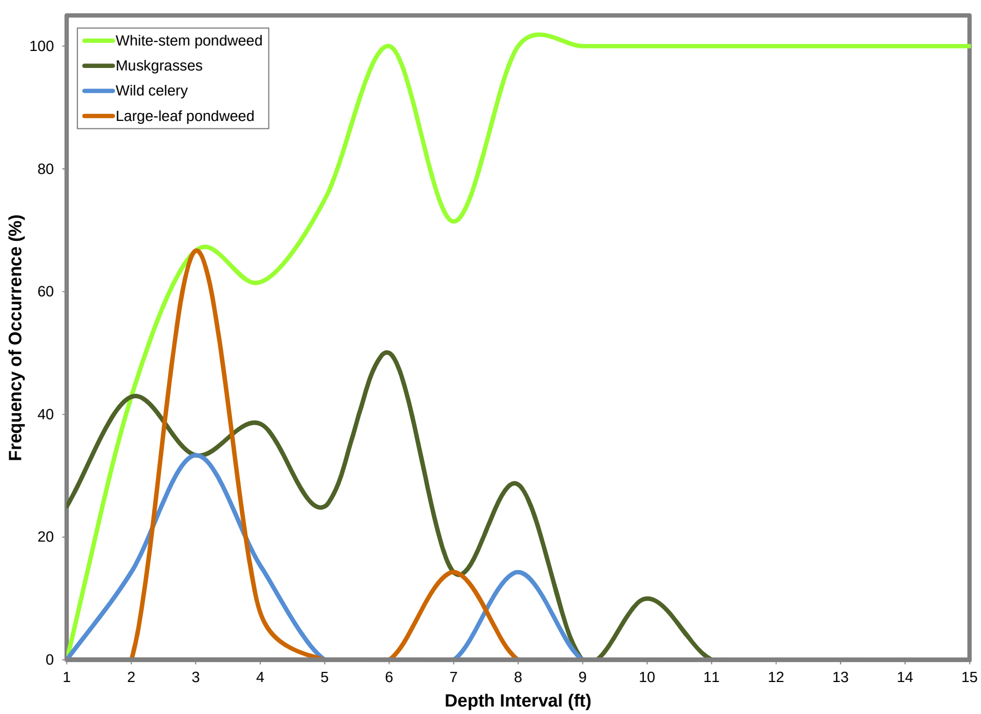

Figure 3.4-4. Frequency of occurrence over water depth of four-most frequently encountered aquatic plant species in Bass Lake. Created using data from 2009 Florence County point-intercept survey. Lines are smoothed to ease visualization.

Muskgrasses, small pondweed, and large-leaf pondweed were the most frequently encountered aquatic plants during Florence County's 2010 point-intercept survey on Frog Lake (Figure 3.4-5). Muskgrasses, also referred to as skunk cabbage because of the obvious odor they exude, are not vascular plants but a group of macroalgae that tend to thrive and cover the bottom of lakes with higher alkalinity. Their branching-structure provides excellent habitat for aquatic insects, fish, and other wildlife. Small pondweed is one of several pondweed species that exists in Wisconsin. As its name suggests, this species has small, narrow leaves which provide structural habitat for aquatic organisms while its seeds provide a source of food. In contrast to small pondweed, large-leaf pondweed, also known as musky cabbage, has the largest leaves of any pondweed species in Wisconsin and provides excellent cover for both small and larger fish alike.

Interestingly, a species not located in Frog Lake, white-stem pondweed, was the most frequently encountered species on Bass Lake during Florence County's 2009 point-intercept survey (Figure 3.4-6). In fact, this species was recorded at approximately 80% of the point-intercept sampling locations. This species is one of the first native aquatic plants seen growing in the spring and usually has produced fruit by mid-summer, providing valuable habitat and food for wildlife. It is hard to speculate what conditions are favoring this species' abundance in Bass Lake while it is absent in Frog Lake given their close proximity and similar water chemistry/substrate characteristics. Muskgrasses were the second-most frequently encountered species in Bass Lake, followed by wild celery (Figure 3.4-6). Wild celery is a common native plant that has long, tape-like leaves emerging from a basal rosette. The leaves, tubers, and banana-shaped fruit containing numerous seeds provide food to numerous organisms, most notably migratory waterfowl.

In a stakeholder survey sent to association members, nine of the eleven association member respondents on Bass Lake indicated that excessive aquatic plant growth is the number one factor negatively impacting the lake, and 10 indicated that aquatic plants often or always interfere with their enjoyment on Bass Lake. Similarly on Frog Lake, 12 of the 16 association member respondents indicated that aquatic invasive species was the top factor negatively impacting the lake while excessive aquatic plant growth was the second. However, while they indicated aquatic plant growth interfered with their enjoyment on the lake, it was not to the degree indicated on Bass Lake.

It is unrealistic to quantitatively define the term "nuisance," as this designation is subjective by nature. However, WDNR Science Services researchers indicate that nuisance levels of certain plant species likely occur when their frequency of occurrences exceed 35% (Alison Mikulyuk, personal comm.). Plants that can potentially cause nuisance conditions are those that can grow dense and grow to and/or near the water surface. In Frog Lake, muskgrasses were the only plants that exceed this arbitrary benchmark, while small pondweed populations fell just below this threshold (Figure 3.4-5). However, during the 2010 surveys on Frog Lake, both of these plants were observed to be growing well below the water's surface and likely not a cause of recreational interference. Muskgrasses generally do not grow very high in the water column, and instead form extensive mats along the lake bottom. While small pondweed can grow relatively tall and dense, it is not often considered a nuisance due its thin-leaf structure. In addition, Figure 3.4-3 indicates that this species was mainly found growing in deeper water (10-15 feet). While below the nuisance threshold, large-leaf pondweed and Hybrid water milfoil were observed to be growing near the surface in some areas of Frog Lake, and may interfere with navigation in these areas.

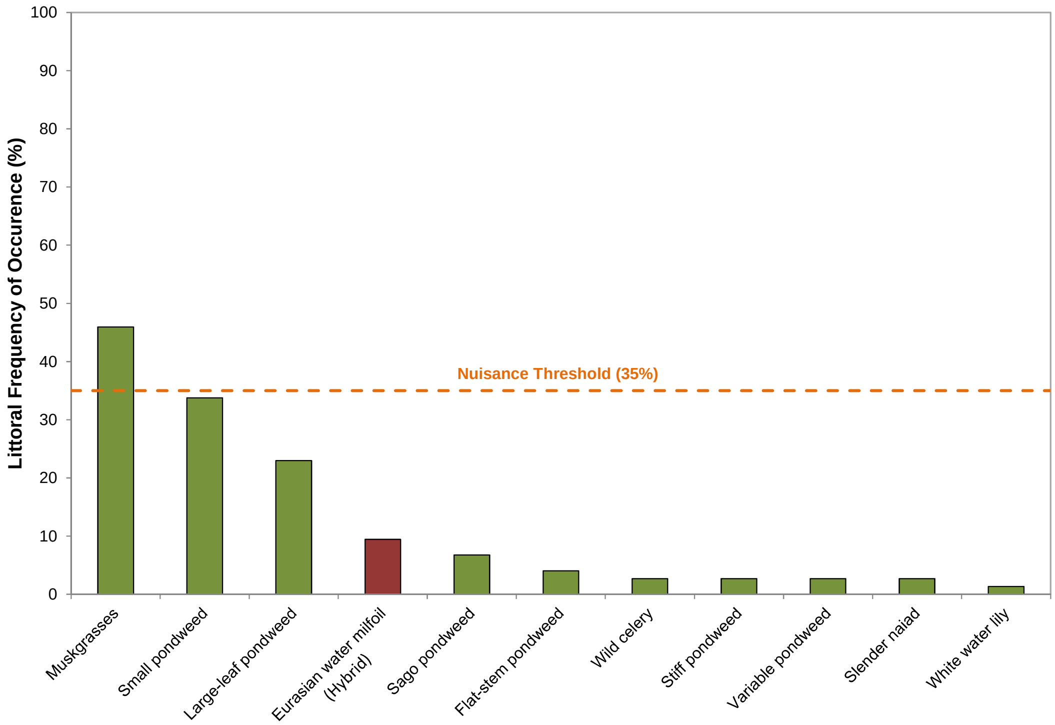

Figure 3.4-5. Frog Lake aquatic plant littoral occurrence analysis. Created using data from Florence County 2010 survey. Exotic species indicated with red.

In 2009, white-stem pondweed was the only aquatic plant species in Bass Lake to exceed the nuisance threshold (Figure 3.4-6). Often growing to the surface to flower, this species has the potential to impact navigation at these levels. As Figure 3.4-4 shows, white-stem pondweed is abundant across all depths in Bass Lake. During Onterra's 2010 surveys, abundant white-stem pondweed populations were observed and it was noted that their densities were likely interfering with recreation. Low water levels likely compound the problem with white-stem pondweed now being able to reach the surface in once deeper areas of lake.

The density of white-stem pondweed within Bass Lake was captured from the rake-fullness ratings recorded during the 2009 point-intercept survey. These data show that white-stem pondweed had a rake-fullness rating of 2 at 65% of the 86 point-intercept sampling locations visited (Figure 3.4-7), indicating a relatively high density.

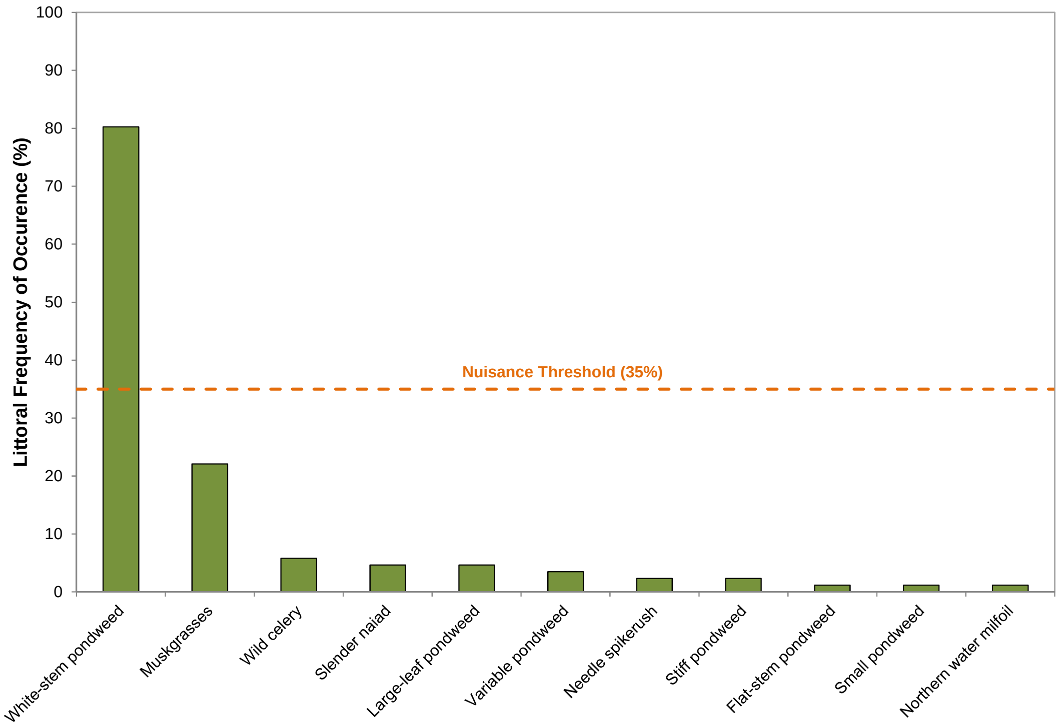

Figure 3.4-6. Bass Lake aquatic plant littoral occurrence analysis. Created using data from Florence County 2009 survey. Exotic species indicated with red.

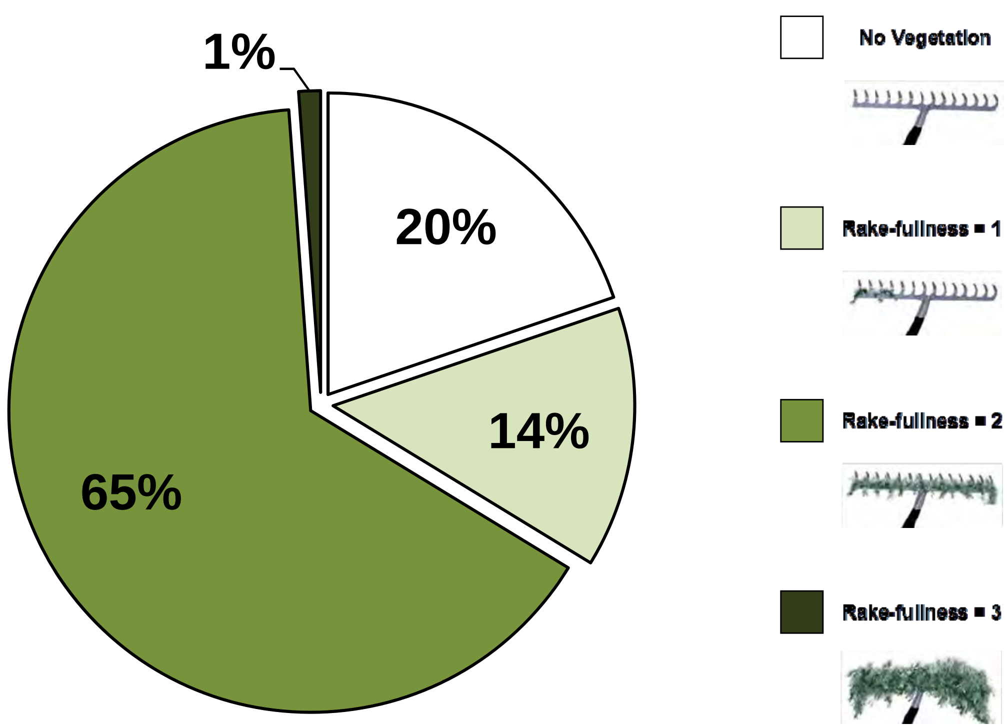

Figure 3.4-7. White-stem pondweed rake-fullness ratings from Bass Lake. Created using data from Florence County 2009 survey.

As discussed previously, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 15 and 18 native aquatic plant species were located in Frog and Bass Lakes during the 2009 and 2010 surveys, only 10 and 11 were encountered on the rake during the Florence County point-intercept survey, respectively. These native species encountered on the rake and their conservatism values were used to calculate the FQI of Frog and Bass Lakes' aquatic plant communities (equation shown below).

FQI = Average Coefficient of Conservatism * √ Number of Native Species

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.

Figure 3.3-8 compares the FQI values of Frog and Bass Lakes' aquatic plant communities to median values of lakes within the Northern Forests and Lakes Ecoregion as well as the entire state. The native species richness for Frog Lake (10) and Bass Lake (12) is slightly below the Northern Lakes and Forests Ecoregion and Wisconsin State medians (Figure 3.4-8). The data collected from the Florence County point-intercept surveys indicate although they have slightly fewer species than most lakes, the quality of their plant communities is comparable to other lakes within the ecoregion and the state (Figure 3.4-8).

Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food. Frog and Bass Lakes contain a moderate number of aquatic plant species. Recall that species richness is not the same as species diversity. Species diversity is influenced by how evenly the plant species are distributed within the community. Using Florence County's survey data, Frog Lake was found to have a moderate Simpson's diversity index value of 0.78 and Bass Lake a relatively low value of 0.58. In other words, if two individual plants were randomly sampled from Frog Lake's plant community, there would be a 78% probability that the two individuals would be of different species, while in Bass this would be 58%.

In general, smaller lakes tend to have fewer aquatic plant species because not only is there less area, but they usually have fewer habitat types to support different species. While a method of characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion maybe compared to provide an idea of how Frog and Bass Lakes' diversity values rank. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the Northern Lakes and Forests Ecoregion (Figure 3.4-9). Frog Lake's diversity value falls within the bottom 25% for lakes in the Northern Lakes and Forests Ecoregion and in the bottom 50% for lakes within the state, while the lower diversity value of Bass Lake's community would be considered an outlier – or its value deviates markedly from the rest of the WDNR's dataset (Figure 3.4-9).

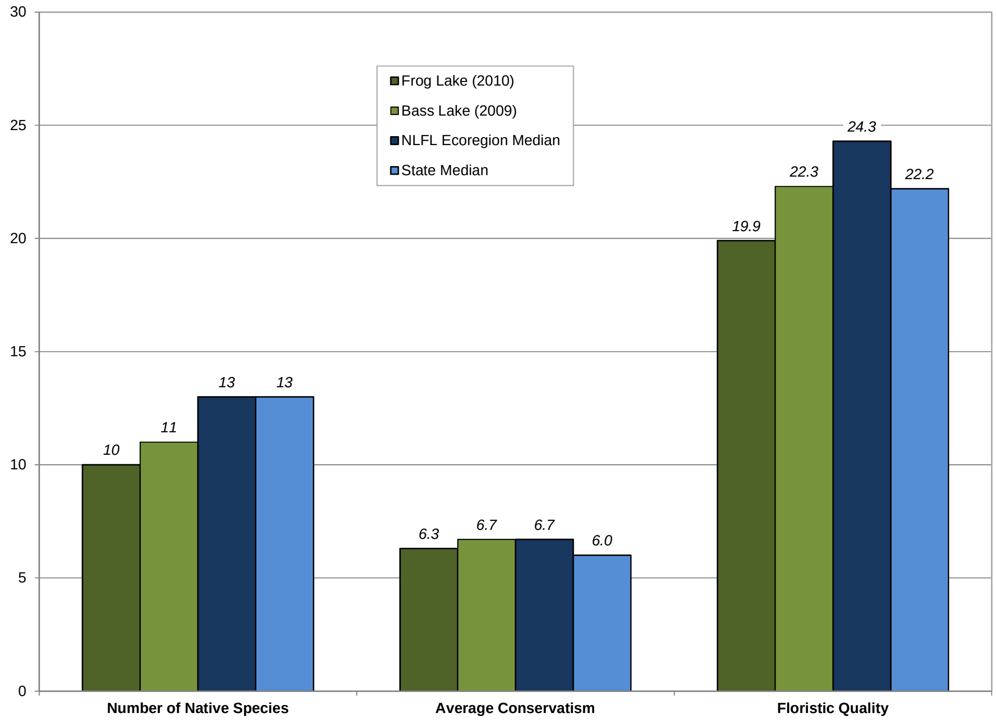

Figure 3.4-8. Frog and Bass Lakes Floristic Quality Assessment. Created using data from Florence County 2009 and 2010 surveys. Analysis follows Nichols (1999).

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 white-stem pondweed was located at 80% of the sampling locations in Bass Lake in 2009, its relative frequency of occurrence is 62%. Explained another way, if 100 plants were randomly sampled from Bass Lake, 62 of them would be white-stem pondweed.

Figure 3.3-10 displays the relative frequency of occurrence of aquatic plant species from the 2009 point-intercept survey on Bass Lake and the 2010 point-intercept survey on Frog Lake and illustrates the uneven distribution

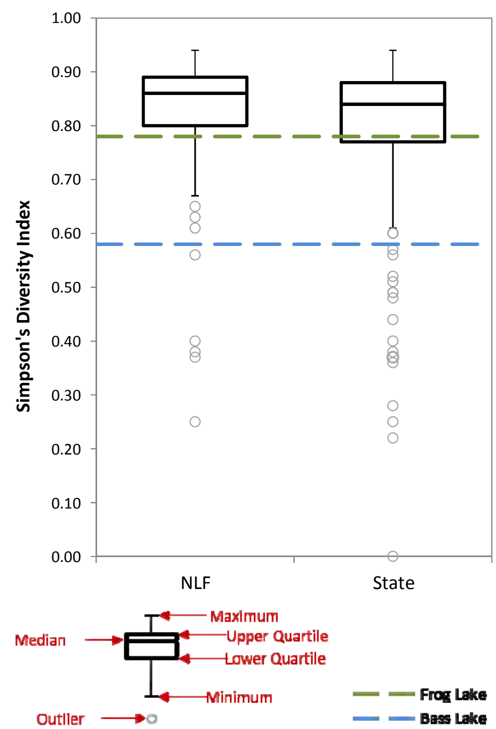

Figure 3.4-9. Frog and Bass Lakes species diversity index. Created using data from Florence County 2009 and 2010 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

of species, or low species diversity in these lakes. In Frog Lake, muskgrasses, small pondweed, and large-leaf pondweed together comprise 76% of the lake's plant community, while just two plants, white-stem pondweed and muskgrasses, comprise nearly 80% of Bass Lake's aquatic plant community (Figure 3.4-10).

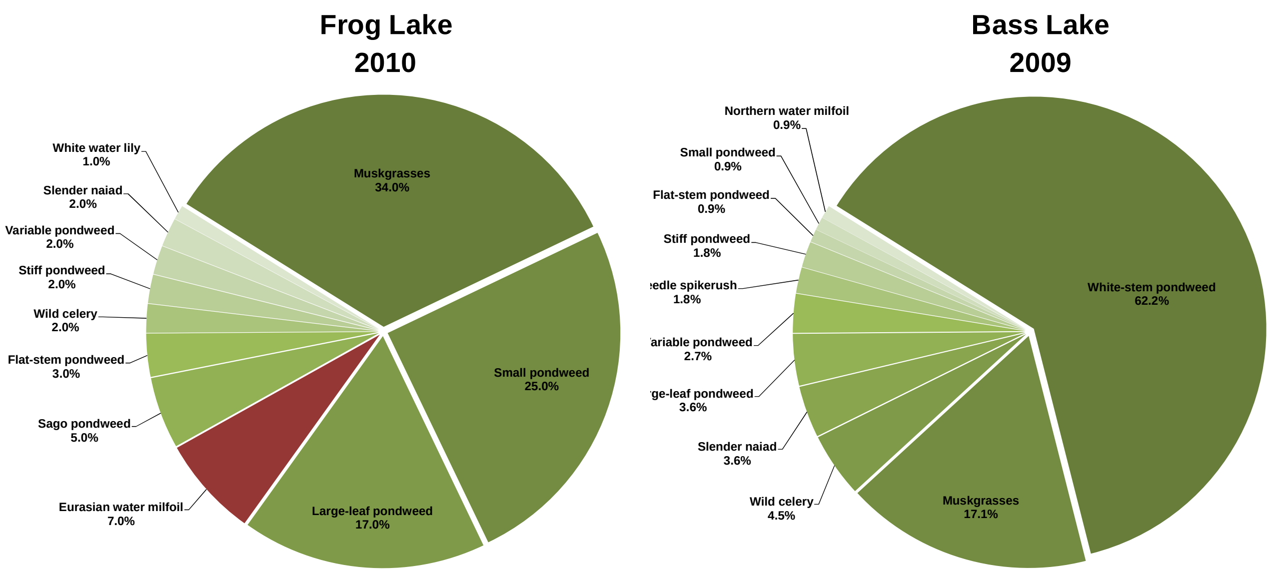

Figure 3.4-10. Frog and Bass Lakes aquatic plant relative occurrence analysis. Created using data from Florence County 2009 and 2010 surveys. Exotic species indicated with red.

The quality of Frog and Bass Lakes plant communities is also indicated by the high incidence of emergent and floating-leaf plant communities (Maps 6 & 7). The 2010 community map indicates that approximately 2.5 acres (9%) of Frog Lake and 3.0 acres (14%) of Bass Lake contain these types of plant communities (Table 3.4-2). Nine floating-leaf and emergent species were located on Frog and Bass Lakes, which provide valuable fish and wildlife habitat. These areas are important in maintaining the integrity of the lake ecosystem, particularly during periods of low water level when course-woody debris becomes located above the receding water line.

Table 3.4-2. Frog and Bass Lakes acres of floating-leaf and emergent plant community types from the 2010 community mapping survey.

	Acres	
Plant Community	**Frog Lake**	**Bass Lake**
Floating-leaf	2.5	1.4
Emergent	0.0	0.0
Mixed Floating-leaf and Emergent	0.0	1.6
Total	**2.5**	**3.0**

Continuing the analogy that the community map represents a 'snapshot' of the important floating-leaf and emergent plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Frog and Bass Lakes, especially regarding their change with fluctuating water levels. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Frog Lake Hybrid water milfoil (hybrid) Control Efforts

Introduction

In February of 2010, the FBLA received a WDNR Lake Planning Grant to create a Lake Management Plan for both lakes, as well as monitor Hybrid water milfoil Hybrid water milfoil herbicide treatments conducted in 2010 on Frog Lake. Hybrid water milfoil was first discovered in September of 2002 in Frog Lake, and was later confirmed by the WDNR as a hybrid species. Onterra was contracted in 2009 to complete a survey for Hybrid water milfoil, and during this survey discovered a dense infestation of the plant throughout most of the lake, with the lakes shallow east side holding particularly dense stands of the exotic plant (Map 8). Water clarity is quite good in Frog Lake, and Hybrid water milfoil can be found growing out to 14 feet of water.

A treatment strategy was devised for Frog Lake in 2010 using a liquid formulation of 2,4-D (Map 9). Although applied directly to areas of Hybrid water milfoil, this herbicide quickly diffuses through the system and reaches an equilibrium concentration within the entire volume of the lake. The dose of this herbicide is determined such that when it reaches equilibrium, it is at a sufficient level to impact the Hybrid water milfoil population. It was proposed and then finalized that the lake would be treated with 2,4-D at a target concentration of 0.250 ppm acid equivalent (ae) in order to achieve “good” control of Hybrid water milfoil without sacrificing substantial damage to the native plant community.

Like many other seepage lakes in this region, Frog Lake’s water level is considerably lower than normal. Understanding the volume of the lake is an important component for properly determining the herbicide dose. Unfortunately, bathymetry data is not available for Frog Lake. During the spring pretreatment survey conducted on April 27, 2010, Onterra ecologists collected data that allowed an accurate understanding of the shoreline at that time (Maps 1 & 9). The modified lake area was separated into multiple quadrants and using the point-intercept survey results form 2009, an average depth for each of these areas was established. Water volumes were calculated within each quadrant and added together to equate to the volume of the lake.

Herbicide applications were conducted by Bonestroo, Inc on May 13, 2010. On the application date, the applicator reported that the surface water temperature was 56°F and the winds were 10-15 mph out of the west.

2010 Treatment Monitoring

The goal of herbicide treatments is to maximize target species (Hybrid water milfoil) mortality while minimizing impacts to valuable native aquatic plant species. Monitoring herbicide treatments and defining their success incorporates both quantitative and qualitative methods. As the name suggests, quantitative monitoring involves comparing number data (or quantities) such as plant frequency of occurrence before and after the control strategy is implemented. Qualitative monitoring is completed by comparing observational data such as Hybrid water milfoil colony density ratings before and after the treatments.

On Frog Lake, quantitative evaluation was made through the collection of point-intercept data at a whole-lake level, since it was known that the herbicide would disperse throughout the entire lake. Frog Lake was surveyed by then Florence County AIS Coordinator Maureen Ferry with the help of FBLA volunteers on August 3-4, 2009 and August 13, 2010. Quantitatively, a treatment is deemed to be successful if the Hybrid water milfoil frequency following the treatments is statistically reduced by at least 50%. Further, a noticeable decrease in rake-fullness ratings within the fullness categories of 2 and 3 should be observed and preferable, there would be no rake tows exhibiting a fullness of 2 or 3 during the post treatment surveys.

Spatial data reflecting Hybrid water milfoil locations were collected by Onterra using a sub-meter Global Positioning System (GPS) during the late summers of 2009 and 2010, when this plant is assumed to be at its peak biomass or growth stage. Comparisons of these surveys are used to qualitatively evaluate the 2010 herbicide treatment on Frog Lake. Qualitatively, a successful treatment on a particular site would include a reduction of Hybrid water milfoil density as demonstrated by a decrease in density rating (e.g. highly dominant to dominant). In terms of a treatment as a whole, at least 75% of the acreage treated that year would decrease by one level of density as described above for an individual site.

Many actions are taken to reduce the chance for herbicide to impact native aquatic species, including the determination of the herbicide type and concentration along with the time of year that the herbicide is applied. While 2,4-D is thought to be selective towards broad-leaf (dicot) species at traditional concentrations and exposure times, emerging data from the WDNR and USACE suggests that some narrow-leaf (monocot) species may also be impacted by this herbicide. For this reason, it is important to monitor treatments to not only understand the impacts upon Hybrid water milfoil, but also to determine the response from the native plant community.

2010 Treatment Results

In 2009, the eastern part of Frog Lake was shown to contain contiguous areas of dominant and highly dominant Hybrid water milfoil colonies (Map 8). Much of the rest of the lake consisted of spotty single Hybrid water milfoil plants and clumps of plants. Following the treatment at the beginning of the summer, lake residents were quite pleased with the initial treatment results and could hardly find any Hybrid water milfoil within the lake when looking from the surface. The plants that were observed were, as residents described, “knocked down” within the water column. Onterra staff confirmed this observation in a June 14, 2010 visit to the lake. However as the summer progressed, the presumably injured remaining Hybrid water milfoil rebounded and during the late-summer post treatment survey was observed erect in the water column.

When comparing the Hybrid water milfoil within these treatment areas between 2009 and 2010, it is apparent that the occurrence and density of Hybrid water milfoil decreased (Maps 8 & 10). Hybrid water milfoil was not observed along the west, north, or southern shorelines of the lake where it had occurred sporadically the prior summer. What was once labeled as ‘dominant’ and ‘highly dominant’ Hybrid water milfoil colonies along the lake’s east side in summer of 2009 were observed to be densities of highly scattered and scattered in summer 2010, with only two small areas of dominant Hybrid water milfoil growth (Maps 8 & 10). It can be safely stated that each delineated colony within the lake was reduced by one density level, and therefore these results meet and surpass the qualitative success criteria (75% reduction) for the 2010 treatment.

During the 2009 summer point-intercept survey, Hybrid water milfoil was located at 15.8% of the point-intercept sampling locations (Table 3.4-3). Following the treatment during August 2010, Hybrid water milfoil was located at approximately 9.5% of point-intercept locations. Unfortunately, this 40.1% reduction in Hybrid water milfoil is not statistically valid, and although it is close, does not meet the predetermined lake-wide quantitative success criteria (50% reduction in occurrence). A major factor influencing this result is the relatively small sample size (N=76 in 2009, N=75 in 2010) which accompanies a relatively small lake.

A rake-fullness rating of 1-3 was used to determine the abundance of Hybrid water milfoil at each point-intercept location. Figure 3.4-11 displays the lake-wide proportions of Hybrid water milfoil rake-fullness ratings from the 2009 and 2010 point-intercept surveys. The figure indicates that the number of point-intercept locations containing Hybrid water milfoil decreased, and the number of samples in the rake-fullness rating of 1 and 3 decreased as well. However, it should be noted that these occurrences are only slight in their degree of change.

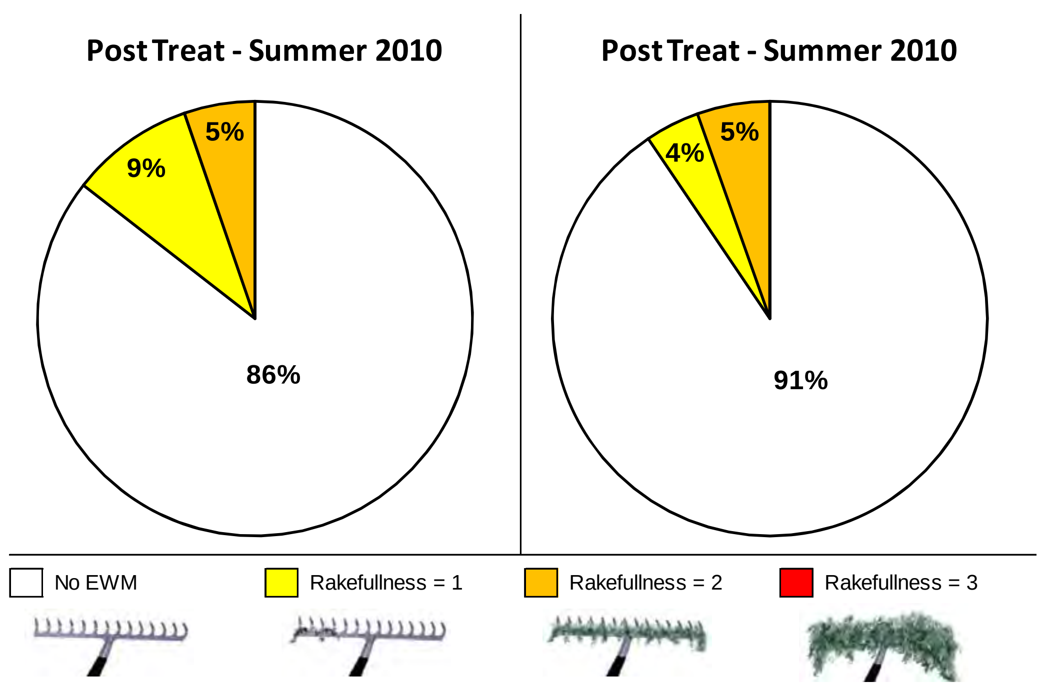

Figure 3.4-11. Lake-wide proportions of Hybrid water milfoil rake-fullness ratings from point-intercept sampling locations on Frog Lake. Created using data from 2009 and 2010 Florence County point-intercept surveys.

As Table 3.4-3 shows, three native monocot species (slender naiad, stiff pondweed and leafy pondweed) experienced statistically valid decreases in their frequency of occurrence between 2009 and 2010 (far right column). These three monocot species were at one time not thought to be particularly susceptible to dicot-selective herbicides. However, emerging data gathered recently from lakes with similar large-scale liquid treatments suggests that some non-dicot species of plants may be vulnerable to decline as a result of the treatment after all. A point-intercept survey conducted by the WDNR in 2011 revealed that all of these native plants rebounded to their pretreatment levels.

Table 3.4-3. Statistical comparison of aquatic plant frequency data from Frog Lake. Comparisons are made using 2005 WDNR and 2009 and 2010 Florence County summer point-intercept surveys.

						2005-2009		2009-2010	
	Scientific Name	Common Name	2005 FOO	2009 FOO	2010 FOO	% Change	Direction	% Change	Direction
Dicots	*Myriophyllum spicatum*	Eurasian water milfoil	3.0	15.8	9.5	431.6	▲	-40.1	▽
	Nymphaea odorata	White water lily	8.9	1.3	1.4	-85.2	▼	2.7	△
	Nuphar variegata	Spatterdock	5.0	0.0	0.0	-100.0	▼	0.0	-
	Utricularia gibba	Creeping bladderwort	5.0	0.0	0.0	-100.0	▼	0.0	-
	Brasenia schreberi	Watershield	1.0	0.0	0.0	-100.0	▽	0.0	-
	Utricularia vulgaris	Common bladderwort	1.0	0.0	0.0	-100.0	▽	0.0	-
Non-dicots	*Nitella sp.*	Stoneworts	19.8	0.0	0.0	-100.0	▼	0.0	-
	Potamogeton gramineus	Variable pondweed	12.9	2.6	2.7	-79.6	▼	2.7	△
	Potamogeton pusillus	Small pondweed	1.0	23.7	33.8	2292.1	▲	42.6	△
	Chara sp.	Muskgrasses	40.6	50.0	45.9	23.2	△	-8.1	▽
	Potamogeton amplifolius	Large-leaf pondweed	12.9	19.7	23.0	53.3	△	16.4	△
	Potamogeton zosteriformis	Flat-stem pondweed	5.0	9.2	4.1	86.1	△	-56.0	▽
	Potamogeton natans	Floating-leaf pondweed	3.0	1.3	0.0	-55.7	▽	-100.0	▽
	Stuckenia pectinata	Sago pondweed	3.0	3.9	6.8	32.9	△	71.2	△
	Heteranthera dubia	Water stargrass	1.0	0.0	0.0	-100.0	▽	0.0	-
	Najas flexilis	Slender naiad	1.0	63.2	2.7	6278.9	▲	-95.7	▼
	Potamogeton foliosus	Leafy pondweed	1.0	5.3	0.0	431.6	△	-100.0	▼
	Potamogeton strictifolius	Stiff pondweed	1.0	22.4	2.7	2159.2	▲	-87.9	▼
	Schoenoplectus subterminalis	Water bulrush	1.0	0.0	0.0	-100.0	▽	0.0	-
	Small Pondweeds Combined		3.0	30.3	35.1	918.9	▲	0.0	△
	Vallisneria americana	Wild celery	0.0	0.0	2.7	0.0	-	100.0	△

2005 N = 101, 2009 N = 76, 2010 N = 74

FOO = Frequency of Occurrence

▲ or ▼ = Statistically Different (Chi-square; α = 0.05)

△ or ▽ = Not Statistically Different (Chi-square; α = 0.05)

As stated previously, Frog Lake was one many lake selected for herbicide concentration monitoring. Water sampling was lead by the Engineer Research and Development Center, a division of the USACE, and collected by a Frog Lake volunteer (Map 9). Published data states that to get "good control" (60 to 75% reduction) of Hybrid water milfoil, a concentration of 0.5 ppm 2,4-D acid equivalent (ae) with an exposure time of 72 hours is needed. Concentrations remained above the target of 0.250 ppm ae through seven days after treatment, averaging 0.289 ppm ae. 14 days after treatment, the average the lake wide mean concentration was 0.200 ppm ae, and by 27 days after the treatment the herbicide degraded to undetectable levels. While published data currently does not exist about the exposure time required to get control at lower doses, the concentrations that were sustained in Frog Lake in the days following herbicide application were thought at that time to have been more effective based upon results collected on other Wisconsin lakes during 2009 and 2010. Appendix F contains the USACE report with more detail regarding the herbicide concentration sampling study on Frog Lake.

As indicated within the USACE report, there are a number of factors that may have contributed to the lack of control observed, including water pH and genetics. A pH reading collected on June 2, 2010 shows that pH levels ranged from 9.4 at the surface to 9.6 at 12 feet. Ester formulations such as Navigate are stated on the manufacturer's label as being less effective at pH levels greater than 8.0. This is due to a faster dissociation of the ester into that acid 2,4-D formulation. However, the herbicide used (DMA IVM®) is an amine formulation and as indicated by a similar product's fact sheet (Sculpin G®), "amine formulation is not affected by high pH water."

Some researchers are beginning to look at matching Hybrid water milfoil genetics to effective herbicide rates. Some genetic strains, possibly even hybrids, may require higher herbicide concentrations to reach satisfactory levels of efficacy. The Hybrid water milfoil within Frog Lake has been tested for genetic strain and has been confirmed as being a hybrid (Hybrid water milfoil crossed with native milfoil species). Whole-lake herbicide treatments conducted around the state of Wisconsin in 2011 and 2012 typically targeted Hybrid water milfoil at 0.300 ppm ae and hybrid water milfoil at 0.350 ppm ae (or higher);. These are much higher use rates than the 0.250 ppm ae whole-lake dose that was targeted on Frog Lake in 2010.

2005 Granular 2,4-D Treatment

A 15 acre granular 2,4-D treatment (Navigate at 100 lbs per acre) was conducted on Frog Lake in 2005, which was considered by all accounts to be quite successful at reducing Hybrid water milfoil populations on the lake. Assuming the lake was 3 feet higher in 2005, the volume of the lake at the time of treatment was calculated using a similar method to what was used to setup the 2010 treatment. Knowing the amount of herbicide used, back-calculations indicate that this would have resulted in a whole-lake concentration of 0.435 ppm ae if evenly spread throughout the lake. This puts perspective on why the 2005 herbicide treatment was thought to be more successful than in 2010 – it was at a significantly higher dose.

A point-intercept survey was conducted the summer directly following the 2005 treatment by the WDNR. Although there is not pretreatment survey to compare against, some determinations can be made. No treatments occurred during the four years following 2005 and an understanding of the long term impacts from the 2005 treatment can be made by looking at the 2009 data. After 4 years, Hybrid water milfoil populations rebounded in Frog Lake to 15.8% and reached the level that prompted FBLA members to initiate a control strategy. Likely heavily impacted by the high 2,4-D dose in 2005, slender naiad rebounded astonishingly to over 63% in 2009. This plant was similarly impacted as a result of the 2010 treatment and again has rebounded to 54% by one year following the treatment (2011). Unfortunately so has the Hybrid water milfoil, being located in over 22% of the lake in 2011 as reported by the point-intercept survey.

Map 11 and Map 12 show the continued progression of the Hybrid water milfoil population in Frog Lake. In 2012, approximately 70% of Frog Lake contains colonized Hybrid water milfoil, most of which exhibiting a dominant or greater density rating. This is a considerably more advanced population that observed during the summer of 2009 (Map 8).

Perspective Involvement within an Experimental Milfoil Weevil Project

The Frog and Bass Lakes Association along with Onterra, WDNR, and the Army Corps of Engineers decided to forgo a treatment in 2011 to gather more information from Frog Lake and other similar projects around the state. This was due to a large amount of uncertainty about what strategy to employ next. Emerging theories regarding insufficient herbicide dose in targeting hybrid water milfoil were beginning to take hold. However, this theory had not yet been tested and the FBLA wanted more assurance before moving forward in 2011.

First presented to the FBLA by Kevin Gauthier (WDNR Lakes Coordinator) at the second Planning Committee Meeting, WDNR and UW-Extension researchers were investigating using Frog Lake within a 5-year research project aimed at using a native biologic control (milfoil weevils) to combat Hybrid water milfoil. As discussed above, the milfoil weevil is normally not a WDNR grant-eligible method of controlling Hybrid water milfoil as its efficacy is not fully understood. But if Frog Lake was entered into this experimental project, part of the project costs would be covered by a grant. The FBLA was interested in learning more about the project and representatives from the FBLA attended a preliminary meeting held at the Rhinelander WDNR office in December 2011. They were encouraged by the meeting and decided that they would enroll in the experimental project starting in 2012 if asked to participate.

Unfortunately for the FBLA, they learned in late-March 2012 that they were not included within the experimental weevil project because of the fact that the EWM within Frog Lake is a hybrid variety. One of the principal investigators of the project, Susan Knight, noted that the lakes containing hybrid milfoil were excluded from the project "because it is possible that hybrid plants may have different diameter stems than Eurasian water-milfoil and could affect the degree of damage to the plants by the weevils." It was later conveyed by Cortney Marquette from Enviroscience, Inc, the firm that propagates and sells milfoil weevils, which weevils will not actively bore into the thicker stems of flowering Hybrid water milfoil. As is the case on Frog Lake, hybrid water milfoil is a prolific flowerer and therefore lakes containing hybrid milfoil may not be good candidates for biological control.

Future Treatment Strategy

Prior to the knowledge of the experimental weevil project, Onterra ecologists learned about an opportunity to have the Hybrid water milfoil from Frog Lake "screened" for tolerance to some common aquatic herbicides. Onterra ecologists collected approximately 600 live strands of milfoil from Frog Lake as well as English Lake (Manitowoc County, WI) in August of 2011 and sent them to SePRO and the USACE for herbicide resistance testing. Cultures of these plants were grown, and then experimental groups were exposed to varying concentrations of either 2,4-D amine or triclopyr. While the results are still preliminary, the overall conclusion of the study is that hybrid water milfoil from both English and Frog Lakes appeared to be less responsive to both 2,4-D and triclopyr herbicides (SePRO, unpublished data).

English Lake shares some similarities with Frog Lake, most notably that they are both small lakes that contain hybrid water milfoil. Both lakes also conducted whole-lake 2,4-D treatments in 2010 with limited success and therefore decided to forgo treatment in 2011. While Frog Lake pursued the option of entering into the weevil research project, English Lake planned a whole-lake treatment in 2012 using a higher dose of 2,4-D. It's important to note that the English Lake treatment strategy is much more complex than Frog Lake due to issues of thermal stratification in the 85-foot deep lake. While the results of the plant surveys and herbicide concentration monitoring are not available at this time, preliminary indications show a much more effective treatment in 2012. However, the 2012 whole-lake 2,4-D treatment did not completely eliminate the Hybrid water milfoil from English Lake and the English Lake Protection and Rehabilitation District will likely conduct an whole-lake treatment strategy in 2013, possibly using different herbicides or combinations of herbicides.

Bass Lake Milfoil

Members of the Frog and Bass Lake Association indicated that a milfoil species suspect of being Hybrid water milfoil (thought likely to be the hybrid variety which exists in Frog Lake) was located in Bass Lake.

During a survey of Bass Lake conducted in September 2009, Onterra ecologists did not locate plants resembling Hybrid water milfoil or the hybrid found in Frog Lake and their initial thoughts were that the milfoil species observed was northern water milfoil (Map 13). This was based on morphological characteristics able to be discerned in the field, and there are large amounts of overlap in the identifying characteristics of northern water milfoil, Hybrid water milfoil, and the hybrid. Dried specimens were prepared and sent to be verified by the University of Wisconsin Herbarium. However, they were unable to say for certain that this milfoil was not the hybrid, so the specimens were sent to laboratory in Michigan for DNA analysis. Their analysis confirmed that the milfoil located in Bass Lake is the native species northern water milfoil (*Myriophyllum sibiricum*).

3.5 Frog and Bass Lakes Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of readily available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the WDNR fisheries biologists overseeing Frog and Bass Lakes.

The goal of this section is to provide a summary overview of some of the data that exists, particularly in regards to specific issues (e.g. stocking, angling regulations, etc) that were brought forth by the FBLA stakeholders within the stakeholder survey and other planning activities.

Table 3.5-1. Gamefish present in Frog and Bass Lakes with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Walleye	*Sander vitreus*	18	Mid April - early May	Rocky, wavewashed 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

Frog and Bass Lakes Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the highest ranked important or enjoyable activity on Bass Lake (Question #13 – Bass Lake Survey) and the second highest ranked important or enjoyable activity on Frog Lake (Question #13 – Frog Lake Survey). On Bass Lake, approximately 82% of respondents believed that the quality of fishing on the lake is either poor or very poor (Question #10) and that the quality of fishing has become somewhat to much worse since they began fishing the lake (Question #11). About 55% of Frog

Lake stakeholders described the quality of fishing as poor or very poor, and about 67% of these respondents believe that the quality of fishing has gotten worse since they began fishing the lake (Question #11).

Table 3.5-1 (above) shows the popular game fish that are present in the system. Management actions that have taken place and will likely continue on Frog Lake according to this plan include herbicide applications to control Hybrid water milfoil. These applications will occur in May or early June when the water temperatures are below 65°F. It is important to understand the effect the chemical has on the spawning environment which would be to remove the submergent plants that are actively growing at these low water temperatures. Yellow perch is a species that could potentially be affected by early season herbicide applications, as the treatments could eliminate nursery areas for the emerged fry of this species.

Frog and Bass Lakes are located within the northern region of the largemouth and smallmouth bass management zones. In this region, bass harvest is limited to 5 fish daily, with a minimum length limit of 14”. Additionally, these lakes are located within the northern region of the muskellunge and northern pike management zone. Northern pike harvest is limited to 5 fish daily with no minimum length limit exists. For some Florence County lakes that are located within Native American ceded territory, special walleye fishing regulations may exist due to a Native American open water spear harvest. Frog and Bass Lakes are located on the eastern side of Florence County, outside of ceded territory, so only statewide regulations govern the walleye fishery here. Currently, statewide regulations include a 5 fish daily bag limit, with a minimum length of 15”.

Frog and Bass Lakes Fish Stocking and Management

To assist in meeting fisheries management goals, the WDNR 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.

Historical stocking activity (late 1950’s and 1960’s) in Frog Lake includes walleye fingerlings, and also small forage fish to provide prey for the walleye. The WDNR has not stocked Frog Lake since 1960, however in 1992, 1993, and 1994, small quantities (100 – 200) of walleye fingerlings were stocked privately. According to WDNR fish biologist Greg Matzke, past efforts to turn Frog and Bass Lakes into “walleye lakes” have generally been unsuccessful. Because of this, further stocking of walleye would have to be funded privately, and also permitted by the WDNR.

Frog and Bass Lakes host populations of northern pike, bass species and also panfish species. Due to the small size of these lakes and the limited fishing pressure they receive, WDNR fish biologists believe the populations should be self-sustaining. These lakes are not actively managed by the WDNR due to their self-sustaining nature and small size with limited public access. In 1976, WDNR biologists concluded following netting surveys that largemouth bass and northern pike populations were expanding (at the expense of walleye). They concluded that well established populations of these predator species, when reached, would reduce the abundant forage species that dominated the lake and allow for a balanced fishery and greater recreational fishing opportunity.

Frog and Bass Lakes Substrate Type

According to the 2009 point-intercept survey conducted by Maureen Ferry, Florence County AIS Coordinator, 85% of the substrate sampled in the littoral zone on Bass Lake was muck, with 10% found to be sand and 5% found to be rock (Map 4 and Figure 3.4-2 in Aquatic Plant Section). 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. Walleye and northern pike spawn in this manner (Becker 1983). 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

One of the primary goals of the Frog and Bass Lakes Comprehensive Management Planning Project was to collect baseline data and information regarding the lake's aquatic plant community, its water quality, and its drainage basin. The majority of the aquatic plant surveys were completed during the summers of 2009-2010, with additional plant surveys in Frog Lake focused on Hybrid water milfoil being completed in 2009-2012. Water quality sampling was also conducted in 2010 and analysis of those data was completed concurrently with modeling of the lake's watershed. Overall, the water quality and watershed studies and associated analysis indicate that the Frog and Bass Lakes are in good health aside from the fact that both lakes are experiencing extremely low water levels due to low participation within the past decade.

Some areas of Frog and Bass Lakes, have a great deal of sediment, decaying vegetation, and marl that has built up over the course of the lakes' lives. Combine that with some of the lowest water levels in the past decade or so and it is not surprising that some areas of lake are difficult to navigate through in a boat. Although it was never officially brought forth within the planning process, it is known that some shoreland property owners believe that dredging the lake bottom would be an appropriate method to correct this perceived problem. Not only would this be a very expensive remedy, but obtaining permits from the WDNR would be difficult because of the ecological impacts dredging has on a lake. The most important of these impacts would be the increased risk of invasive plant infestation within the dredged areas. Studies completed as a part of this project led to the conclusion that Hybrid water milfoil do not exist within the Bass Lake at this time. Obviously the native plants would be removed with the sediments during the dredging operations, which would leave those areas completely open to invasive species establishment. Once an invasive species is established in an area of a lake, it is difficult to keep it from invading other areas of the lake; therefore, dredging even a small area of Bass Lake would put the entire lake at risk. Dredging activities conducted in Frog Lake would almost certainly soon be colonized with Hybrid water milfoil.

Twenty-one native aquatic plant species were found during the summer 2009-2010 surveys, which is high level of species richness when compared to other lakes in the state and ecoregion. This is particularly interesting considering the small size of these two lakes. In general, smaller lakes like Frog and Bass Lakes tend to have fewer aquatic plant species because not only is there less physical area in each lake, but that area usually has fewer habitat types to support different species. However, the species diversity of the lakes was found to be quite low due to the lakes plant population being primarily dominated by one or two species. Natural disturbances such as low water levels or unnatural disturbances such as Hybrid water milfoil infestation (Frog Lake) may be contributing to the uneven plant distribution.

These disturbances likely have favored some species while others cannot endure such changes. Onterra's experience working on flowage system that have large, unnatural water level fluctuations due to hydroelectric power operations has shown that aquatic invasive species like Hybrid water milfoil do particularly well in these disturbed conditions. As a pioneering species, Hybrid water milfoil can claim large areas of a system relative quickly that are relatively open niches as native plants are unable to cope with the changing environment.

Hybrid water milfoil populations in Frog Lake are currently at levels that can have long term and irreversible impacts on the aquatic ecosystem, not to mention the recreational interference that are caused by the immense plant biomass in much of the lake. The navigational issues of Frog Lake are further confounded by the fact that most watercrafts on this small lake utilize electric motors or no motors. The concept of heterosis, or hybrid vigor, is important in regards to Hybrid water milfoil management on Frog Lake. The root of this concept is that hybrid individuals typically have improved function compared to its pure-strain parents. As stated within the Aquatic Plant Section, hybrid water milfoil typically has thicker stems and is a prolific flowerer. These conditions likely contribute to this plant being particularly less susceptible to biological and chemical control strategies. As discussed within the planning phase of this project, the FBLA (and other managing entities) must realize that in order to effectively control the hybrid water milfoil in Frog Lake, aggressive herbicide strategies will need to be implemented which could have increased collateral effects to the native aquatic plant community compared with more-typical use rates employed for pure-strain Eurasian water milfoil control projects.

5.0 IMPLEMENTATION PLAN

The intent of this project was to complete a *comprehensive* management plan for the Frog and Bass Lakes Association. 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 FBLA will follow in order to manage Frog and Bass 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 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 Frog and Bass Lake Association's Capacity to Communicate with Lake Stakeholders

Management Action: Support an Education Committee to promote water quality, public safety, and quality of life on Frog and Bass Lakes

Timeframe: Continuation of current efforts

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 and noise pollution. Education is also an important tool to dispel myths and untruths that may exist. An Education Committee will be created to promote lake protection through a variety of educational efforts.

Currently, the FBLA semi-periodically distributes an educational mailing via email to association members. 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 a 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. This committee will also investigate the creation of an association website and/or other social media such as Facebook. This will directly increase the association's ability to communicate with interested stakeholders by allowing them to post information and social messages.

Example Educational Topics:

Specific topics brought forth in other management actions
Aquatic invasive species monitoring updates
Catch and release fishing
Noise, air, and light pollution
Shoreland restoration and protection
Septic system maintenance
Fishing Regulations
Litter and fireworks
Water levels – investigate historic information relating to water levels, set staff gauge to be monitored on a regular basis.

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 FBLA Board will identify a base level of annual financial support for educational activities to be undertaken by the Education Committee.

Management Goal 2: Maintain Current Water Quality Conditions

Management Action: 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. The lack of this type of historical information hampered the water quality analysis during this project. Early discovery of negative trends may lead to the reason as of why the trend is developing. The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. Since 2008, Secchi disk transparency data has been collected on Frog Lake as a part of the CLMN program, but no data collection occurs on Bass Lake.

Volunteers trained by the WDNR as a part of the CLMN program begin by collecting Secchi disk transparency data for at least one year, then if the WDNR has availability in the program, the volunteer may enter into the *advanced program* and collect water chemistry data including chlorophyll-a, and total phosphorus. The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. Note: as a part of this program, these data are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS).

At a minimum, CLMN volunteers collecting Secchi disk data should be in place on both lakes. Currently, the advanced CLMN program is not accepting additional lakes to participate in the program. However, it is important to get volunteers on board with the base Secchi disk data CLMN program so that when additional spots open in the advanced monitoring program, volunteers from the FBLA will be ready to make the transition into more advanced monitoring.

Winter dissolved oxygen levels were not measured on Frog and Bass Lake as a part of the current study. However, the low water levels of the lake and the high productivity (plant abundance) bring forth concerns about winter fish kills caused by winter anoxia. One such event was reported during the winter of 1995-96. If increasing concerns about these levels exist within the FBLA, the association should either purchase a dissolved oxygen probe or create an arrangement with Florence County Land Conservation Department. This would allow this parameter to be monitored in conjunction with the regularly scheduled CLMN water sample collection. A WDNR small-scale Lake Planning Grant would be applicable for the costs of the equipment purchase.

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 (715.365.8951) or the appropriate WDNR/UW Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer.

Periodic professional water quality analysis may also be sought for Frog and Bass Lakes. If future water chemistry parameters are collected, it is recommended to follow the sampling methodologies included within the Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM) (WDNR 2009).

Action Steps:

Please see description above.

<u>Management Action:</u> Reduce phosphorus and sediment loads from shoreland watershed to Frog and Bass Lakes

Timeframe: Begin 2012

Facilitator: Education Committee

Description: As the watershed section discusses, the Frog and Bass 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 FBLA will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lakes. This will include newsletter articles/special mailings 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, Florence County, Florence County Lakes and Rivers Association and other sources.
3. Facilitator summarizes information for newsletter articles/special mailings and recruits appropriate speakers for association meetings.

Management Goal 3: Reduce Hybrid water milfoil Occurrences within Frog Lake

Management Action: Initiate Short-term Herbicide Control Strategy on Frog Lake

Timeframe: Begin 2013

Facilitator: Association Board

Funding Possibility: Extension of current AIS Rapid Response Grant

Description: In 2009, 2010. 2011, and 2012; Hybrid water milfoil was mapped throughout much of the littoral zone around Frog Lake (Maps 8, 10, 11, 12). While many questions were answered following the herbicide treatment that took place in 2010, more questions were raised as to why the efficacy of the treatment was not as expected. Studies being conducted by SePRO and the USACE have shed light upon some of these questions and point the FBLA in a direction of an answer to their Hybrid water milfoil control issues

Using information gained from the 2010 treatment study and current studies being conducted as it becomes available, the FBLA has elected (formal vote of the general membership) to consider conducting a whole-lake herbicide treatment in 2013. Ongoing discussions are currently being held between Onterra, the WDNR, the USACE, and FBLA stakeholders to develop a course of action for 2013. Extracted from *Frog Lake Proposed 2013 Strategy Report* (Appendix G), a report that aided in the comprehensive discussions held between Onterra and the WDNR Technical Review Team, below is the alternative analysis completed to determine the appropriate control strategy for Frog Lake in 2013.

<u>Auxin Herbicide Combination – 2,4-D & Triclopyr</u>: Combination applications of 2,4-D and triclopyr are theorized to have additive, and potentially synergistic, effects compared to when the respective herbicide components are used independently. Granular herbicide products containing roughly 4:1 parts 2,4-D to triclopyr are commercially available, although only narrowly used in Wisconsin due to the relatively high cost of the product compared to 2,4-D. However, their use has increased in difficult treatment situations where 2,4-D and/or triclopyr use history has not proven effective. Combination whole-lake liquid 2,4-D/triclopyr treatment strategies have been discussed as potential options for HWM control. To date, data has only been made available from one auxin combination treatment. Preliminary results are mixed regarding a Waushara County lake that conducted a combination 2,4-D and triclopyr whole lake treatment in 2012 (0.30/0.10 ppm ae).

The preliminary results of the tolerance testing completed by SePRO indicate that the HWM strain(s) tested from Frog Lake were less responsive to both 2,4-D and triclopyr than a pure EWM reference strain. For that reason, Frog Lake may not be a good candidate for a field trial of using a combination of these herbicides.

<u>Auxin and Endothall Combination – 2,4-D & Endothall</u>: Similar to combining auxin herbicides together, an additive or a synergistic advantage is theorized when combining 2,4-D and endothall. The simultaneous exposure to endothall and 2,4-D have been shown to provide increased control of EWM in outdoor growth chamber studies (Madsen et. al 2010). However, this research investigated use patterns that involve 24-48 hours of exposure time, not days to weeks of exposure time as are anticipated for Frog Lake. As discussed above, this is the option being pursued by English Lake to combat the HWM population in this lake.

To date, only two combination 2,4-D/endothall field trials have occurred within Wisconsin that included the rigorous monitoring needed to evaluate treatment efficacy and selectivity (i.e. Half Moon Lake, Eau Claire County and Loon Lake, Shawano County) . Both of these treatments targeted what are thought to be pure-strain EWM populations. The Half Moon Lake treatment was highly effective at long-term control of EWM; however, the observed 2,4-D concentrations (approximately 0.350 ppm ae) may have been sufficient on their own for EWM control. Relatively substantial native plant occurrence declines were also observed in association with this treatment. Two years of EWM control were observed in Loon Lake in association with a combination 2,4-D (0.15 ppm ae) and endothall (0.20 ppm ae), however EWM populations during 2012 were at pretreatment levels despite active management occurring.

<u>Slow Acting Enzyme Inhibitor Herbicide – Fluridone</u>. Fluridone is a systemic herbicide that disrupts photosynthetic pathways (carotene inhibitor). Because the herbicide degrades via photolysis (some microbial degradation may also occur) and requires long exposure times (>30 days) to cause mortality to

EWM, adding additional herbicide ("bump treatment") a few weeks following the initial application may be required based upon herbicide concentration monitoring results. Fluridone is commonly used in many parts of the United States, particularly for EWM and hydrilla control, but is often critiqued because of reduced selectivity towards native plants. Research indicates that common waterweed and coontail may be particularly impacted by fluridone treatments; however neither of these species are present in Frog Lake. As use rates of auxin herbicides have evolved into large-scale treatments, the lack of selectivity arguably mimics past data from fluridone treatments. More commonly used in Michigan, the standard fluridone use pattern involves applying the herbicide at 6 parts per billion (ppb) and following up with an additional "booster" or "bump" treatment at approximately 3 weeks following the treatment. The goal of the bump treatment would be to bring the level of fluridone in the lake back up to 6 ppb. This use pattern is commonly referred to as a "6-bump-6". Herbicide concentration samples would be collected and sent to the herbicide manufacture for rapid testing to determine the dose of the bump application. Please note that this would be separate from the herbicide concentration samples that would be collected by volunteers in association with the WDNR and USACE ongoing research project. The target concentration of fluridone would be discussed with the WDNR and USACE further if this method is pursued.

While preliminary research has identified a hybrid milfoil strain(s) from a lower peninsula of Michigan lake that expressed reduced susceptibility to fluridone, additional tolerance testing completed by SePRO indicate that the HWM strain(s) tested from Frog Lake showed a "classically susceptible response" to fluridone (Dr. Mark Heilman, personal comm.). For that reason, Frog Lake would be an ideal candidate for a whole-lake, low-dose fluridone treatment.

At the time of this report, it appears that moving forward with a whole-lake fluridone treatment on Frog Lake in 2013 is the most appropriate option. While the use of fluridone has not occurred on natural lakes in Wisconsin in approximately a decade, it is widely used throughout the Midwest for EWM control. A justified concern that surrounds the herbicide treatment strategy involves the impact on the native aquatic plant community of the lake. While the native plant community of Frog Lake has remained relatively constant over time, it is not appropriate to sacrifice its long-term integrity in order to meet the AIS control strategy goals. Emerging data from the ongoing WDNR and USACE research project indicates that several of the species present in Frog Lake are particularly sensitive to 2,4-D when utilized in whole-lake treatment scenarios: muskgrasses, naiads, thin-leaved pondweeds, and possibly large leaf pondweed. While not without risk of injury, these species may be more tolerant to fluridone at the application rate discussed above.

As occurred in association with the 2010 whole-lake treatment, the aquatic plant community would be monitored using both quantitative and qualitative methodologies. Along with volunteer-based herbicide concentration monitoring, additional monitoring, such as water clarity, dissolved oxygen, and water temperature, will also be discussed prior to implementation of the control action.

Action Steps:

1. The FBLA learns more about the potential costs of the treatment options outlined above and how the FBLA would be able to fund the project.
2. Retain consultant to map aquatic invasive species occurrences and oversee 2013 hybrid water milfoil treatments and monitoring.
3. FBLA, with help from an herbicide applicator if applicable, obtains the proper permits to implement management action.
    a. WDNR Plant Management and Protection Program:
    www.dnr.state.wi.us/lakes/plants
    b. The UW Extension Lake List is a great resource for locating an herbicide applicator:
    www.uwsp.edu/cnr/uwexlakes/lakelist/businessSearch.asp

<u>Management Action:</u> Initiate Long-term Control Strategy on Frog Lake
Timeframe: Begin 2014
Facilitator: Association Board
Funding Possibility: AIS Established Population Control Grant or AIS Education, Prevention, and Planning Grant
Description: It should be noted that it is highly unlikely that any single herbicide treatment will completely control the EWM in Frog Lake. The objective is to bring the invasive species down to more easily controlled levels. In other words, the goal is to reduce the amount of Hybrid water milfoil to levels that would only require spot herbicide treatment or hand-removal methods to keep them under control. To complete this objective efficiently, a cyclic series of steps is used to plan and implement the treatment strategies. The series includes:

1. A lake-wide assessment of Hybrid water milfoil completed while the plant is at peak biomass (August-September)
2. Creation of control strategy for the following spring.
3. Verification and refinement of treatment plan immediately before control strategies are implemented (not applicable to whole-lake treatments).
4. Completion of control strategy
5. Assessment of control strategy

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

The impacts to native submersed species are believed to occur when the non-native species reaches an aerial coverage of approximately 50% (dominance). Therefore, by minimizing the occurrence of these dense stands, the exotic's impact on the lake's ecology will also be minimized. An aggressive approach to Hybrid water milfoil management would occur during the multi-year control project where all colonies found to contain dominant densities of Hybrid water milfoil will warrant treatment. Adjacent areas of lesser Hybrid water milfoil density would also be treated in order to adequately target the entire area. Due to the small area and volume of Frog Lake, careful attention will be given to spot treatments such that they don't have unintended whole-lake effects. The FBLA might learn that if herbicide control methods are utilized, whole-lake treatment strategies may be the only effective strategy due to the physical parameters of Frog Lake.

If Hybrid water milfoil populations are brought down to levels requiring smaller treatments of specific colonies, treatment monitoring activities would follow protocols currently being developed by the WDNR and in general, use guidance supplied in Aquatic Plant Community Evaluation with Chemical Manipulation (2010 Draft). This form of monitoring is required for all large-scale herbicide applications (exceeding 10 acres in size or 10% of the littoral zone) and grant-funded projects where scientific and financial accountability are required.

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

Action Steps:

1. Retain qualified professional assistance to develop a specific project design utilizing the cyclic series of steps discussed above.
2. Initiate control plan
3. Revisit control plan in 5-7 years
4. Update management plan to reflect changes in control needs and those of the lake ecosystem.

Management Goal 4: Preventing Additional AIS Introductions into Frog and Bass Lakes

Management Action: Initiate *modified* Clean Boats Clean Waters watercraft inspections at Frog and Bass Lakes

Timeframe: Begin summer 2013

Facilitator: Board of Directors to form Education Committee

Description: Considering Bass Lake does not have a public access and Frog Lake's public access is a largely unused carry-in access location, the outstanding mode of non-native species introduction is likely through the private access points that are located around the lake and utilized by lake residents and their guests. This potentially makes the lake more vulnerable to exotic introduction than a lake with a single, public access that could be more easily monitored. As a result, boats are not inspected and many water users are not aware of AIS issues. Education represents a good tool to address these issues. Approximately 95% of respondents to the stakeholder survey indicated that the FBLA has kept them at least adequately informed regarding the management of Frog Lake (Appendix B, Question #27), demonstrating their ability to convey information to stakeholders. In general, this would be conducted by 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.

One component of the education process would to inform Frog and Bass Lake riparians about the need to inspect the boats that use their properties for access. This action would not only work to prevent additional invasives from entering the Frog Lake, but also to prevent the infestation of Bass Lake or other area waterbodies with invasives that originated in Frog Lake.

Action Steps: See description above.

<u>Management Action:</u> Initiate volunteer-based monitoring of aquatic invasive species.
Timeframe: Start 2012
Facilitator: FBLA volunteers
Description: In lakes without Hybrid 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. Even in lakes where these plants occur, monitoring for new colonies is essential to successful control.

Volunteers from the FBLA would monitor aquatic invasive species within Frog and Bass Lakes after receiving training through Florence County Land Conservation Department, Florence County Lakes and Rivers Association (FCLRA) or the WDNR, as appropriate. Initial training would include identification of target species and native look-a-likes and expand to proper use of GPS for recording aquatic plant occurrences, note taking, and transfer of spatial data. Currently, the group already performs a considerable amount of Hybrid water milfoil monitoring on its own; therefore, the framework for such a volunteer network is essentially in place.

Over the course of the project, it is anticipated that a core group of FBLA volunteers with considerable levels of dedication to the continued monitoring program would emerge.

Action Steps: See description above.

<u>Management Action:</u> Initiate aquatic invasive species rapid response plan upon new 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 during the monitoring activities discussed in the previous Management Action, the location would be marked (GPS or buoy); and suspect specimens would be collected in a sealed plastic bag and brought to Florence County Land Conservation Department, WDNR, or lake management consultant for verification. If confirmed to be an aquatic invasive species, the locations would be conveyed to one of the organizations/entities listed above. While this management action is primarily aimed at potential Hybrid water milfoil infestation in Bass Lake, it could also be applied for additional AIS infestation to Frog Lake (e.g. curly-leaf pondweed, hydrilla, etc.).

Those focus areas would be surveyed by professionals during that plant species peak growth phase (late summer for Hybrid water milfoil, early summer for curly-leaf pondweed) and the results would be used to create a prospective control strategy for the following spring. Hybrid water milfoil is the primary aquatic invasive species requiring attention within this management action and the following paragraphs will contain specific information pertaining to this species.

Small isolated infestations of Hybrid water milfoil can most appropriately be controlled using manual removal methods, likely through scuba or snorkeling efforts. The responsible use of this technique is supported by FBLA stakeholders as indicated within the stakeholder survey (Appendix B, Question #23). 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.

If Hybrid water milfoil occurrences exceed the amount that can be manually removed, the plants need to be professionally surveyed and mapped. During the fall/winter following the professional mapping survey, a control strategy would be developed. At this time, the most feasible method to control larger infestations is through herbicide applications, specifically early-spring spot treatments with 2,4-D. If this method is selected, the cyclic events listed within the Management Action: *Initiate Long-term Control Strategy on Frog Lake*, will be followed.

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. Initiate hand-removal methods as applicable with guidance from the Hand Removal Pamphlet co-authored by the Lumberjack Resource Conservation & Development (RC&D) Council, Inc. & Golden Sands RC&D Council, Inc (2012)
5. Association, with help from an herbicide applicator if applicable, obtains the proper permits to implement management action.
    a. WDNR Plant Management and Protection Program:

www.dnr.state.wi.us/lakes/plants

b. The UW Extension Lake List is a great resource for locating an herbicide applicator:
www.uwsp.edu/cnr/uwexlakes/lakelist/businessSearch.asp

6. Association updates management plan 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 Frog and Bass Lakes (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in Frog and Bass Lakes that would most accurately depict the conditions of the lake (Map 1). Samples were collected near the surface using an integrated sampler (top 6 feet of water column). Sampling occurred three times during summer. Samples were kept cool and preserved with acid following standard protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included the following:

Parameter	June	July	August
	S	S	S
Total Phosphorus	●	●	●
Chlorophyll-*a*	●	●	●
Total Kjeldahl Nitrogen	●	●	●
Nitrate-Nitrite Nitrogen	●	●	●
Ammonia Nitrogen	●	●	●
Calcium		●	

In addition, during each sampling event Secchi disk transparency was recorded and a temperature and dissolved oxygen profile was completed using a Hach probe.

Watershed Analysis

The watershed analysis began with an accurate delineation of Frog and Bass Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the 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)

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on the Frog and Bass Lakes during a June 14, 2010 field visit, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on the system to characterize the existing communities within each lake and included inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in the Wisconsin Department of Natural Resource document, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry, and Analysis, and Applications (WDNR PUB-SS-1068 2010) was used to complete the studies. Point-intercept surveys completed on Bass Lake in 2009 were completed by Florence County on August 18 and August 26 with the aid of FBLA volunteers. Point-intercept surveys completed in 2009 and 2010 were also completed by Florence County with FBLA assistance on August 3-4, 2009 and August 13, 2010. Point-intercept surveys conducted in 2011 were completed by the WDNR Rhinelander office on July 26, 2011.

Community Mapping

On August 12, 2010, the aquatic vegetation community types within each lake (emergent and floating-leaved vegetation) were mapped using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the community mapping surveys were vouchered by the University of Wisconsin – Stevens Point Herbarium.

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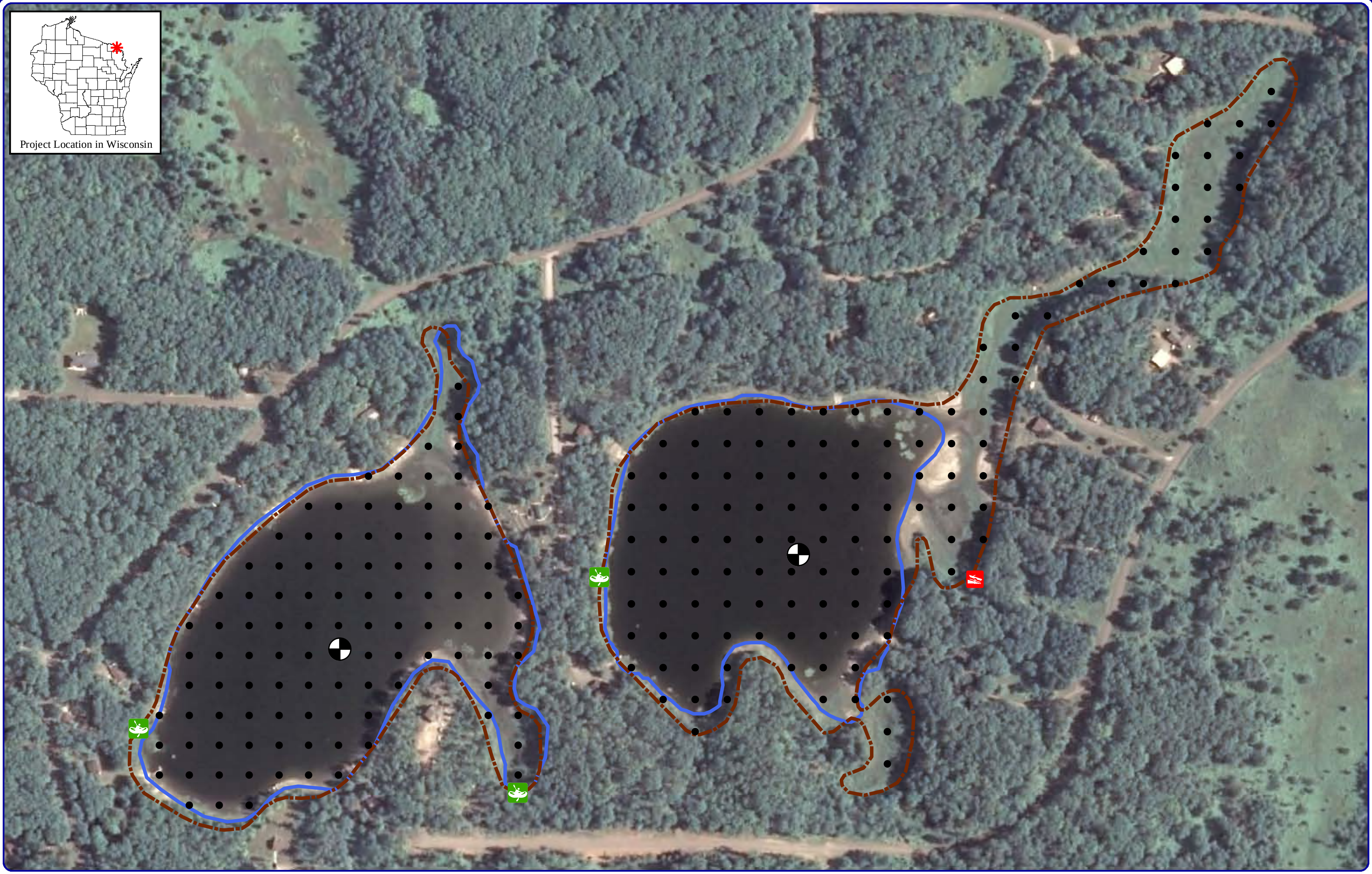

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Sources:
Roads and Hydro: WDNR
Modified Hydro: Onterra, 2010
Orthophotography: NAIP, 2010
Map Date: June 23, 2011
File Name: Map1_FrogBass_Location.mxd

Legend

Frog Lake ~ 27 acres
Bass Lake ~ 21 acres
WDNR Definition

Frog Lake - Field adjusted: Onterra May 2010 ~ 17.5 acres
Bass Lake - Adjusted using NAIP 2010 Orthophoto ~ 21 acres

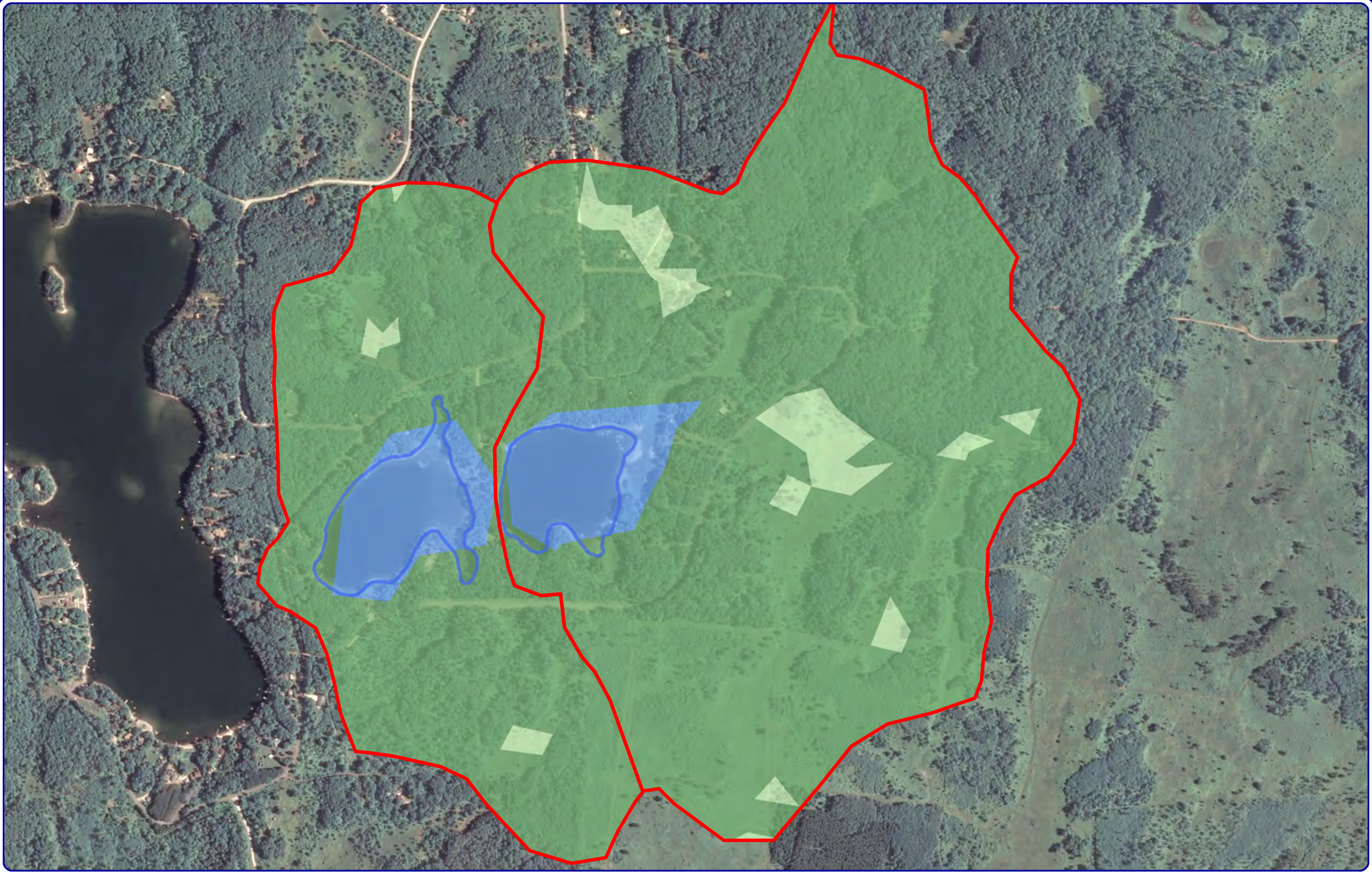
Point-Intercept Survey Location
Frog - 30-meter spacing, 125 total points
Bass - 28-meter spacing, 106 total points

Water Quality Site

Carry-in Access Location

Public Boat Landing

Map 1
Frog & Bass Lakes
Florence County, Wisconsin
Project Location & Water Quality Sampling Locations



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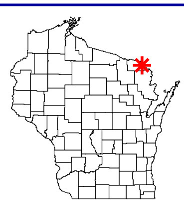
<Bol>Sources:</Bol>
Watershed: WDNR & Onterra
Landcover: WISCLAND
Hydro: WDNR
Orthophotography: NAIP, 2010
Map Date: June 23, 2011
Filename: Map2_FrogBass_Watershed.mxd



Project Location in Wisconsin

Legend

Watershed Boundary

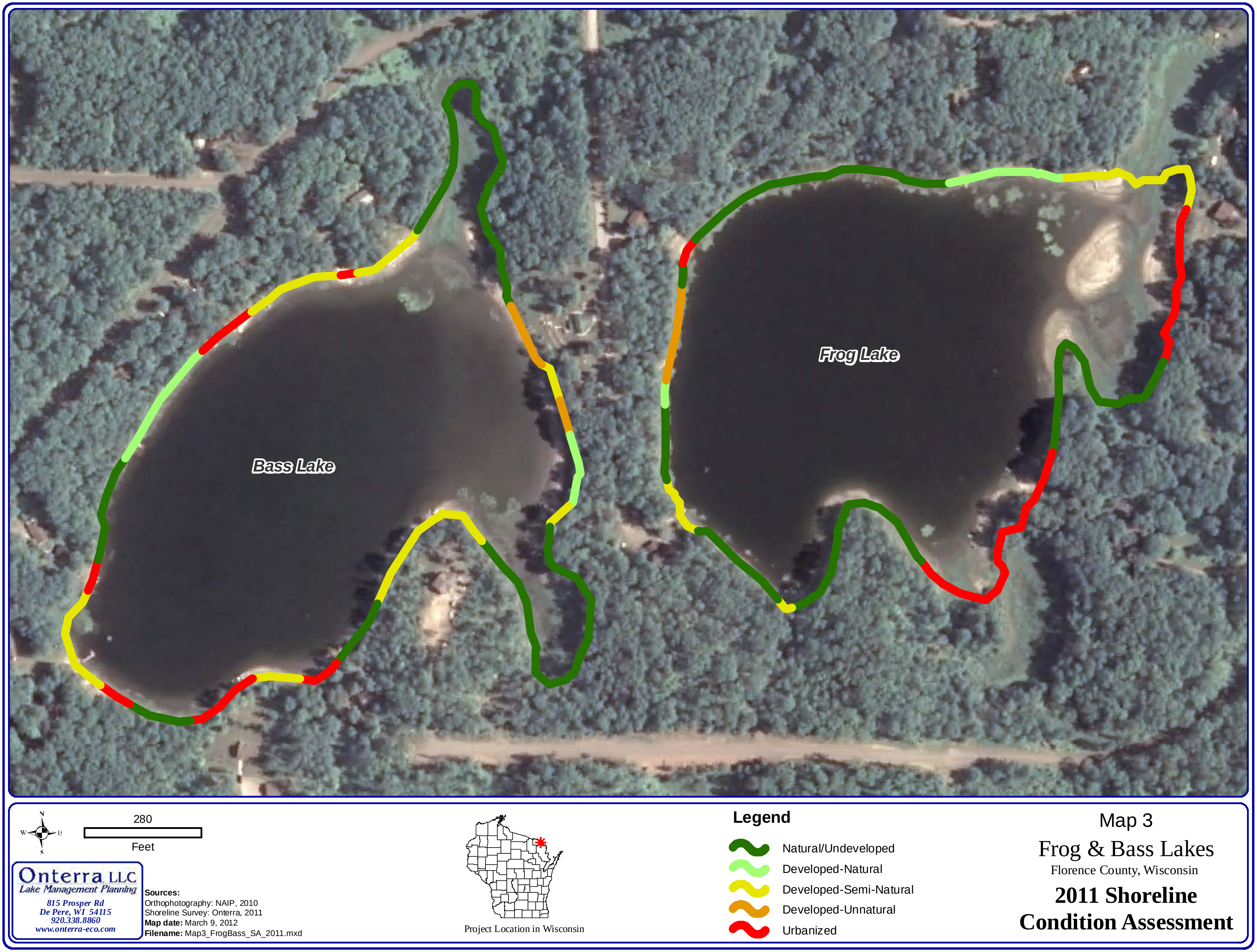
Land Cover Types

Pasture/Grass
Open Water
Forest
Wetland

Map 2

Frog & Bass Lakes
Florence County, Wisconsin

Watershed and Land Cover Types



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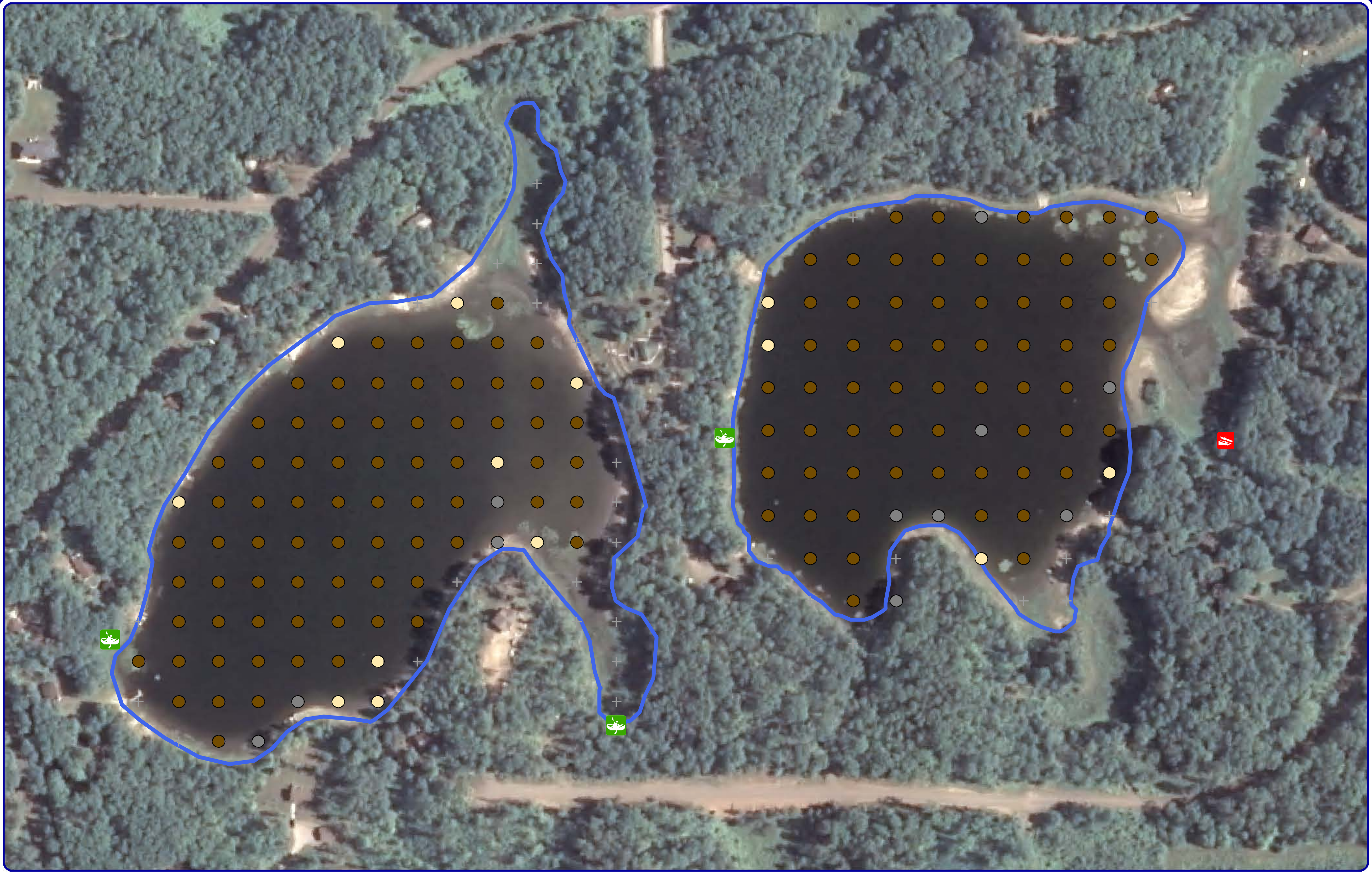
Sources:
Orthophotography: NAIP, 2010
Shoreline Survey: Onterra, 2011
Map date: March 9, 2012
Filename: Map3_FrogBass_SA_2011.mxd

Map 3
Frog & Bass Lakes
Florence County, Wisconsin
2011 Shoreline Condition Assessment



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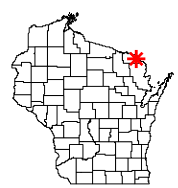
Sources
Roads and Hydro: WDNR
Sediment Information: Maureen Ferry, Florence Co. (Bass Lake 2009) & Onterra (Frog Lake, 2010)
Map Date: June 15, 2011
File Name: Map4_FrogBass_Sed_Types.mxd



Project Location in Wisconsin

Legend

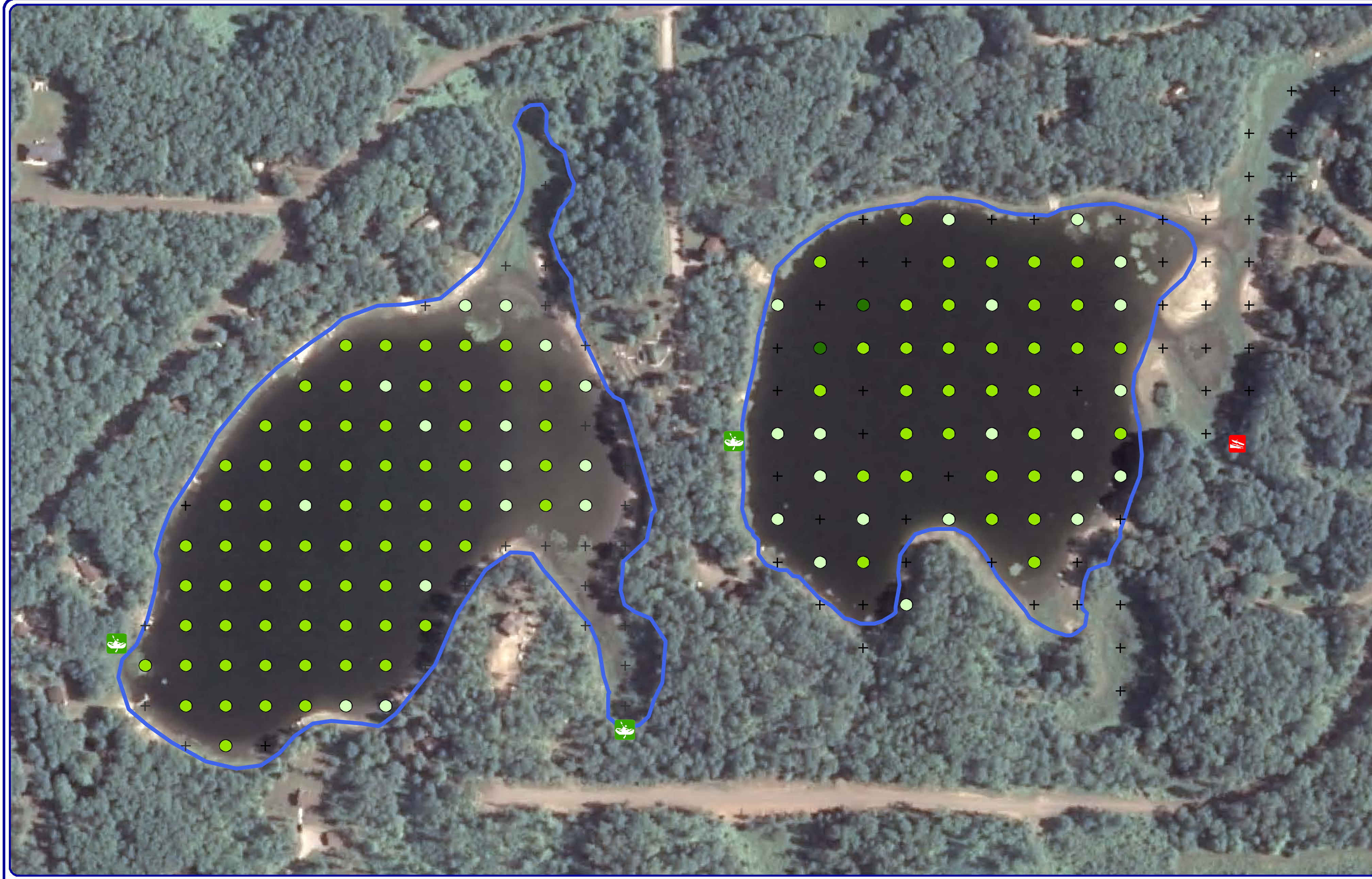
- Muck
- Rock
- Sand
- No data collected - too shallow or too deep
- Carry-in Access Location
- Public Boat Landing

Map 4

Frog & Bass Lakes

Florence County, Wisconsin

Sediment Types at Point-Intercept Locations



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Feet

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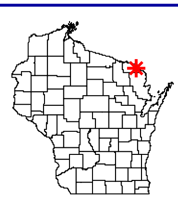
Sources
Roads and Hydro: WDNR
Aquatic Plant Survey: Maureen Ferry, Florence Co. (Bass Lake 2009. Frog Lake 2010)
Map Date: June 15, 2011
File Name: Map5_FrogBass_Sed_Types.mxd



Project Location in Wisconsin

Legend

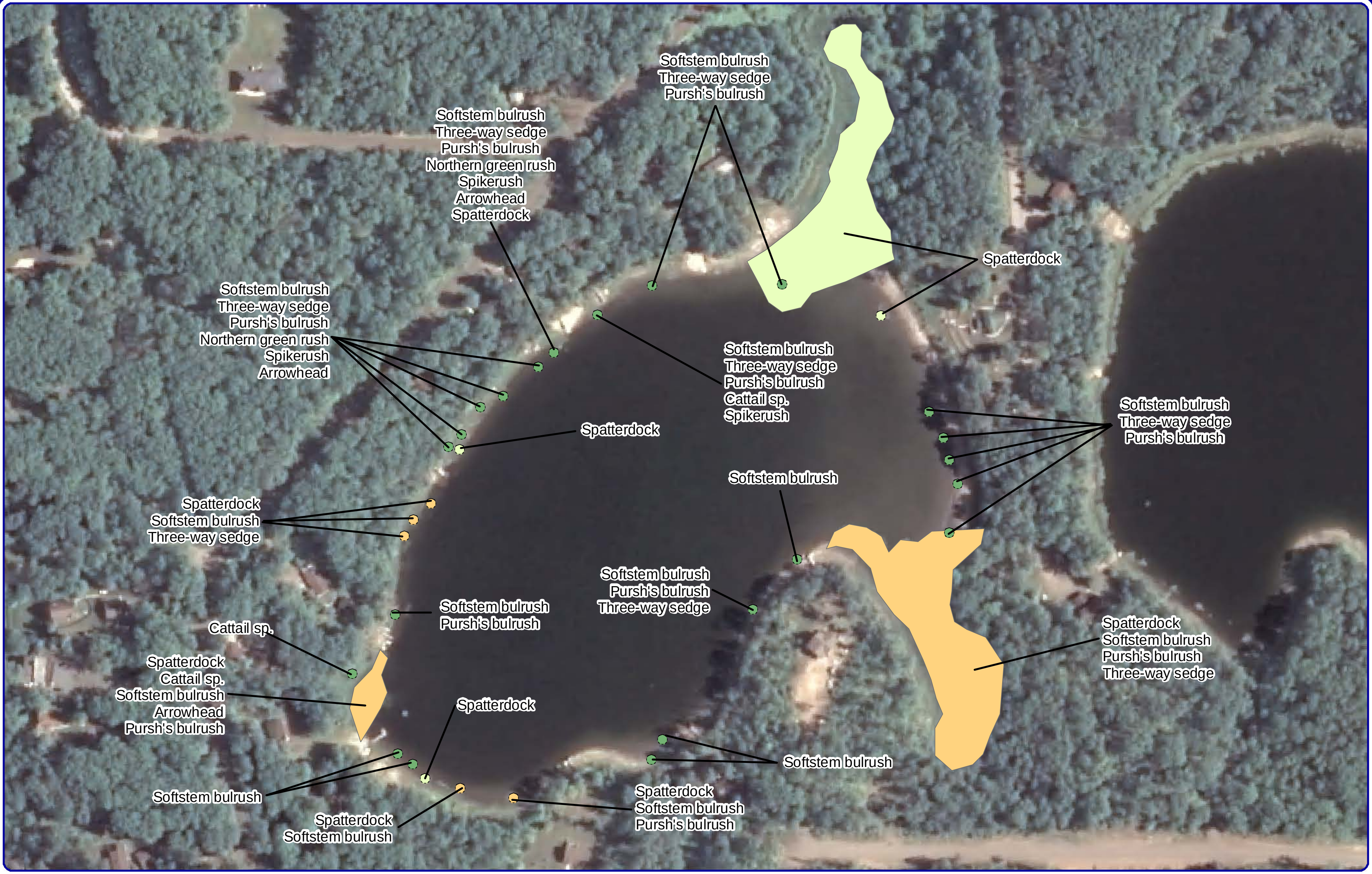
- Rake-fullness = 1
- Rake-fullness = 2
- Rake-fullness = 3
- No Vegetation or Non-navigable

Map 5

Frog & Bass Lakes

Florence County, Wisconsin

PI Survey: Aquatic Plant Distribution

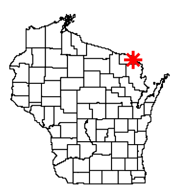


250

Feet

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

Sources:
Orthophotography: NAIP, 2010
Aquatic Plant Survey: Onterra, 2010
Map date: September 9, 2010
File Name: Map6_Bass_Comm_2010.mxd



Project Location in Wisconsin

Legend

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

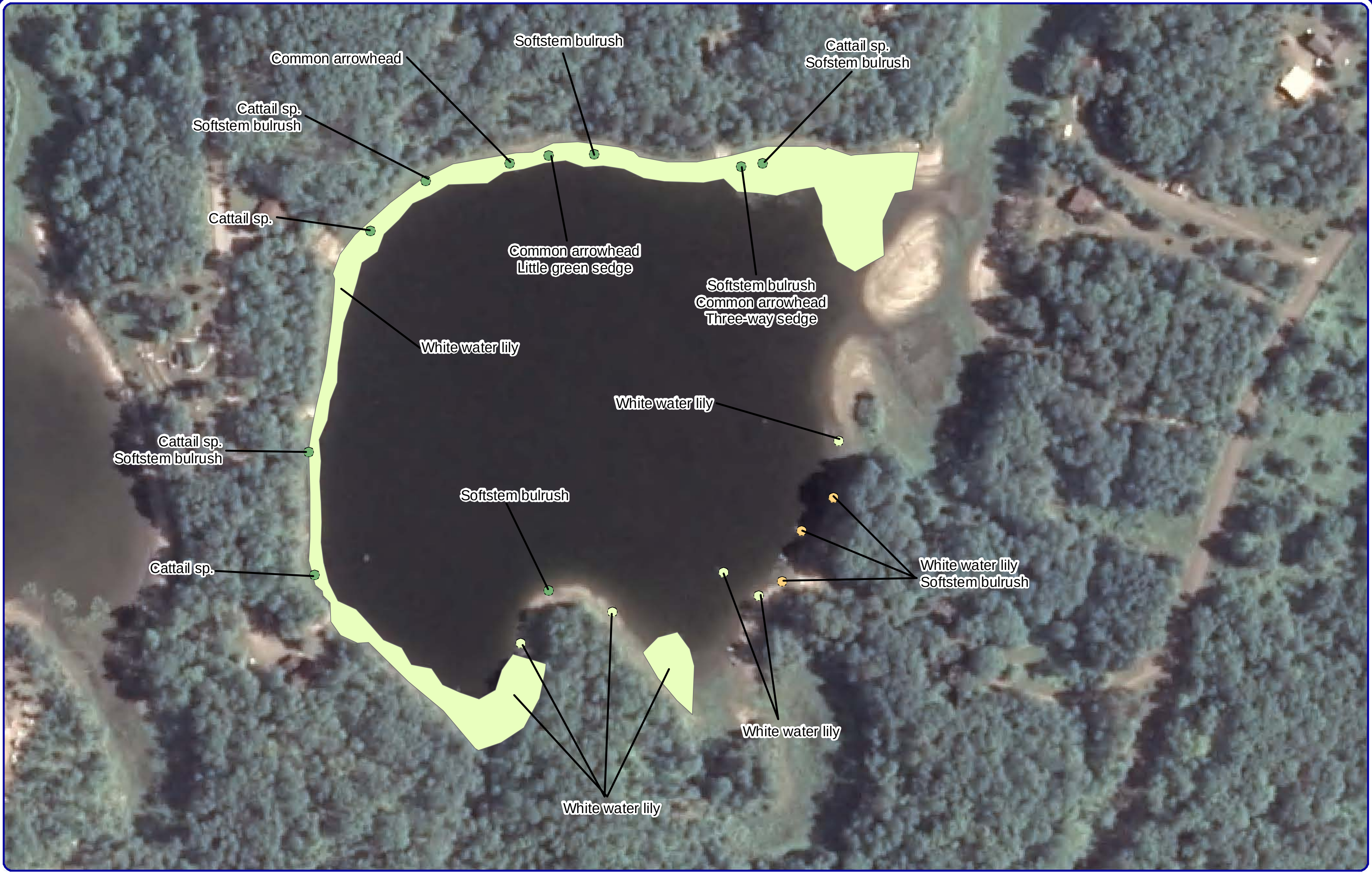
Large Plant Communities
- Emergent *(None found)*
- Floating-leaf
- Mixed Floating-leaf & Emergent

Map 6

Bass Lake

Florence County, Wisconsin

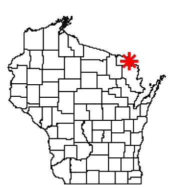
Aquatic Plant Communities



225
Feet

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

Sources:
Orthophotography: NAIP, 2010
Aquatic Plant Survey: Onterra, 2010
Map date: September 9, 2010
File Name: Map7_Frog_Comm_2010.mxd



Project Location in Wisconsin

Legend

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

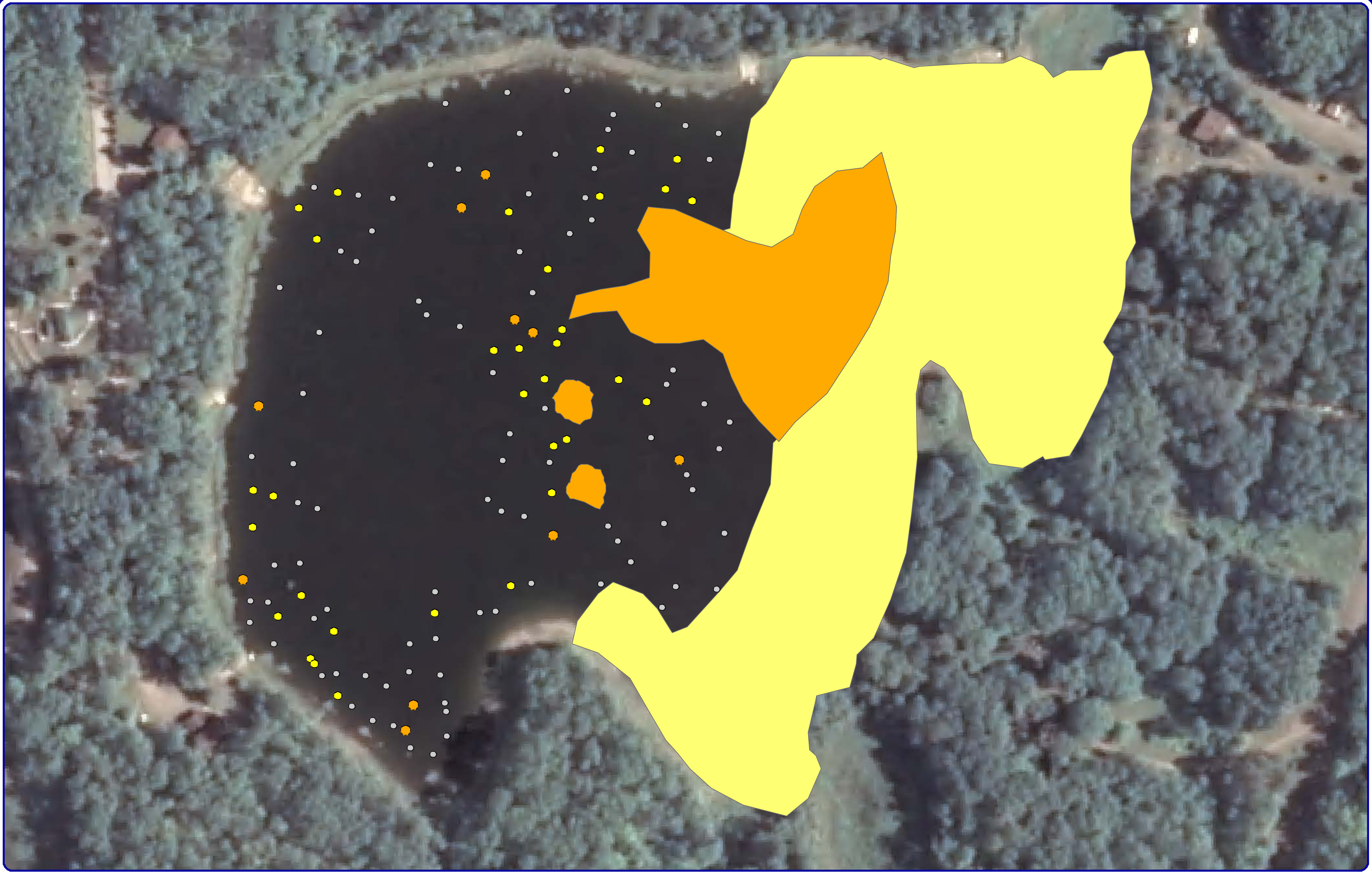
Large Plant Communities
- Emergent *(None found)*
- Floating-leaf
- Mixed Floating-leaf and Emergent *(None found)*

Map 7

Frog Lake

Florence County, Wisconsin

Aquatic Plant Communities

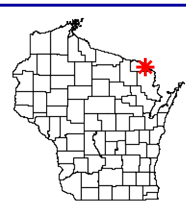


200

Feet

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

Sources:
Roads and Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plants: Onterra, 2009
Map Date: October 6, 2009
File Name: Map8_Frog_EWM_PB_Sept09.mxd



Project Location in Wisconsin

Legend

EWM Small Colony (Sept 2009)

- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

EWM Large Colony (Sept 2009)
~ 9.3 acres

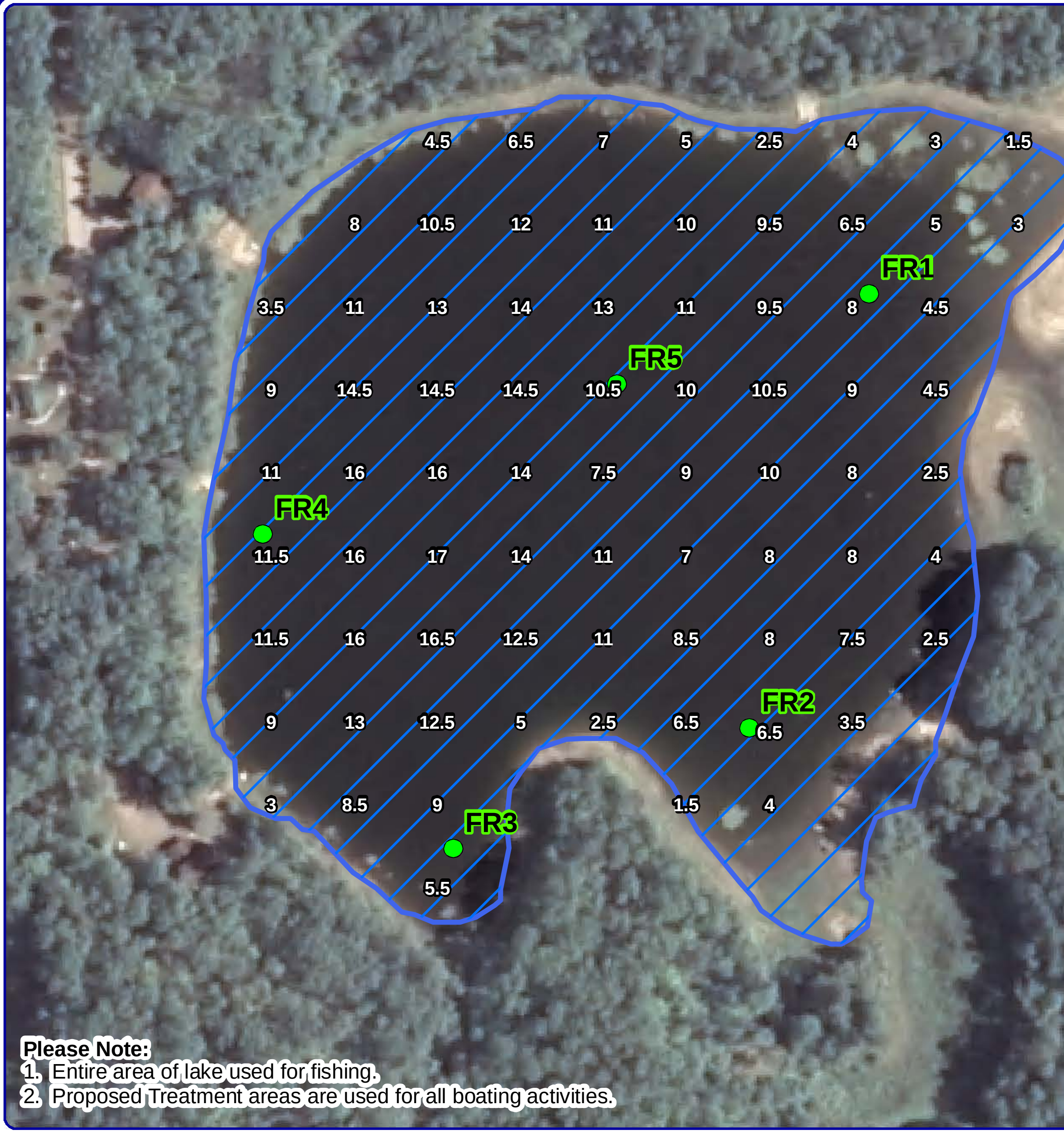
- Highly Scattered *(none found)*
- Scattered *(none found)*
- Dominant
- Highly Dominant
- Surface Matting *(none found)*

Map 8

Frog Lake

Florence County, Wisconsin

2009 EWM Survey Results



2010 FinalTreatment Areas

Calculated Lake-wide Concentration - 0.250 ppm

Site	Acres	Ave Depth* (feet)	Volume** (acre-feet)
Whole-lake	17.5	7.8	136.5

** reduced average depth of PI locations by 1 foot to account for lower water levels since PI survey date and spring 2010*

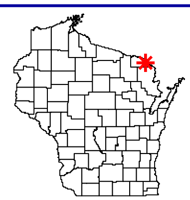
*** volume calculated based on acres times average depth*

200

Feet

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

Sources:
Roads and Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plants: Onterra, 2009
Point-intercept Survey: Florence County, 2009
Map Date: November 3, 2009
File Name: Map9_Frog_T2009_EWMTrt_Perm1.mxd



Project Location in Wisconsin

Legend

- Lake boundaries and Treatment Area — Adjusted May 2010
- # Depth at Point-Intercept Sample Location during August 2009
- Herbicide Concentration Sample Location

Map 9

Frog Lake

Florence County, Wisconsin

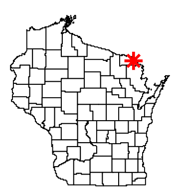
2010 Final EWM Treatment Areas

200

Feet

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

Sources:
Roads and Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plants: Onterra, 2010
Map Date: January 3, 2011
File Name: Map10_Frog_2010_PB.mxd



Project Location in Wisconsin

Legend

Eurasain Water Milfoil *(Mapped August 2010)*

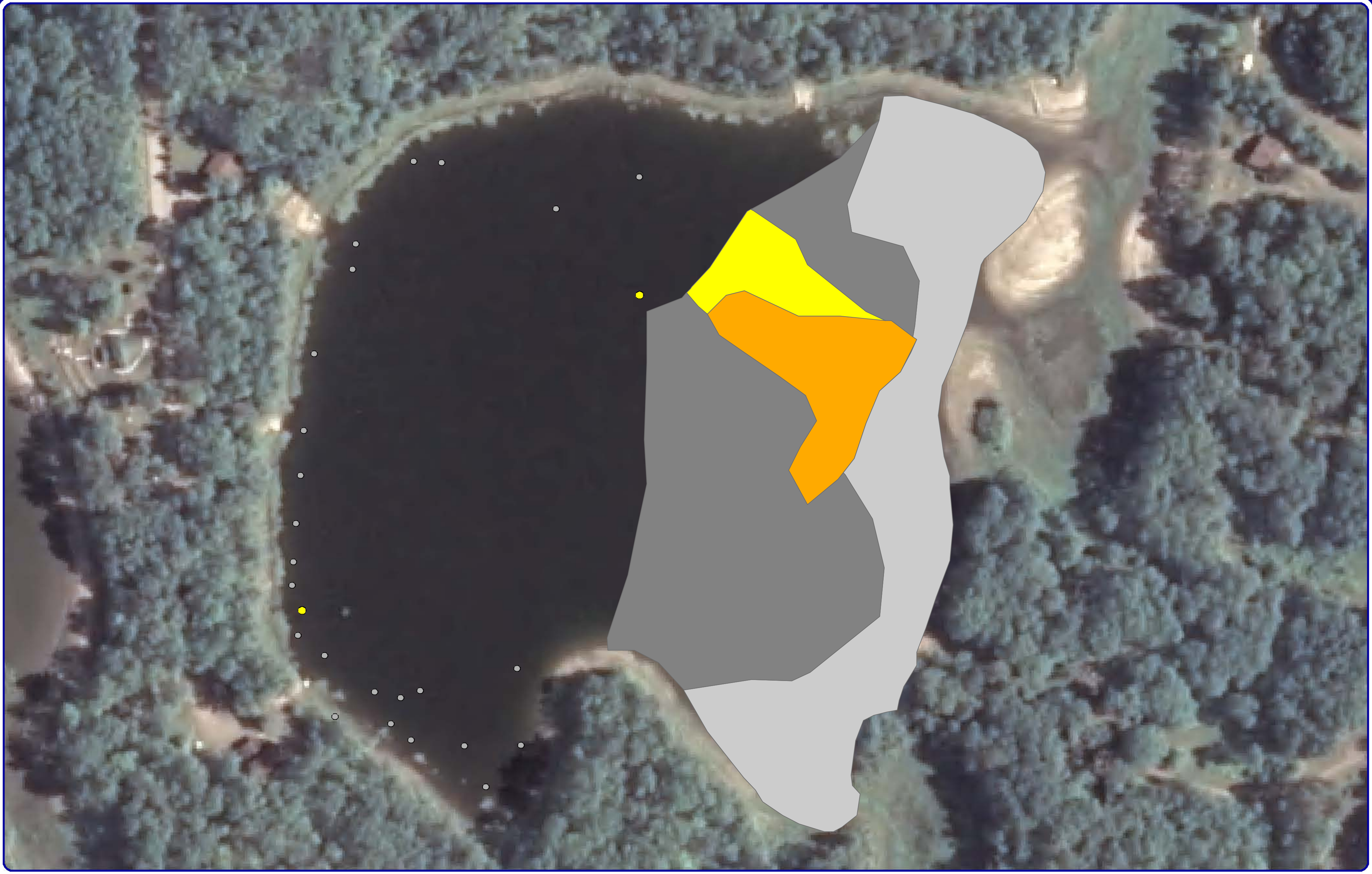
- Highly Scattered *(1.87 acres)*
- Scattered *(4.16 acres)*
- Dominant *(0.61 acres)*
- Highly Dominant *(none found)*
- Surface Matting *(none found)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

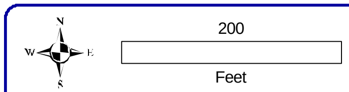
Map 10

Frog Lake

Florence County, Wisconsin

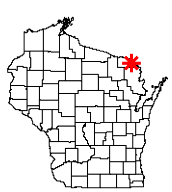
2010 EWM Survey Results





Onterra LLC
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Aquatic Plant Survey: Onterra, 2011
Orthophotography: NAIP, 2010
Map date: November 22, 2011



Project Location in Wisconsin

EWM Survey Results
(Mapped August 2011)

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting *(none found)*
- Single or Few Plants
- Clumps of Plants

Map 11
Frog Lake
Florence County, Wisconsin

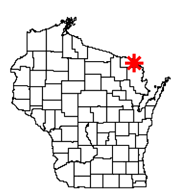
2011 EWM Survey Results

200

Feet

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

Sources:
Aquatic Plant Survey: Onterra, 2012
Orthophotography: NAIP, 2010
Map date: October 16, 2012



Project Location in Wisconsin

EWM Survey Results
(Mapped September 2012)

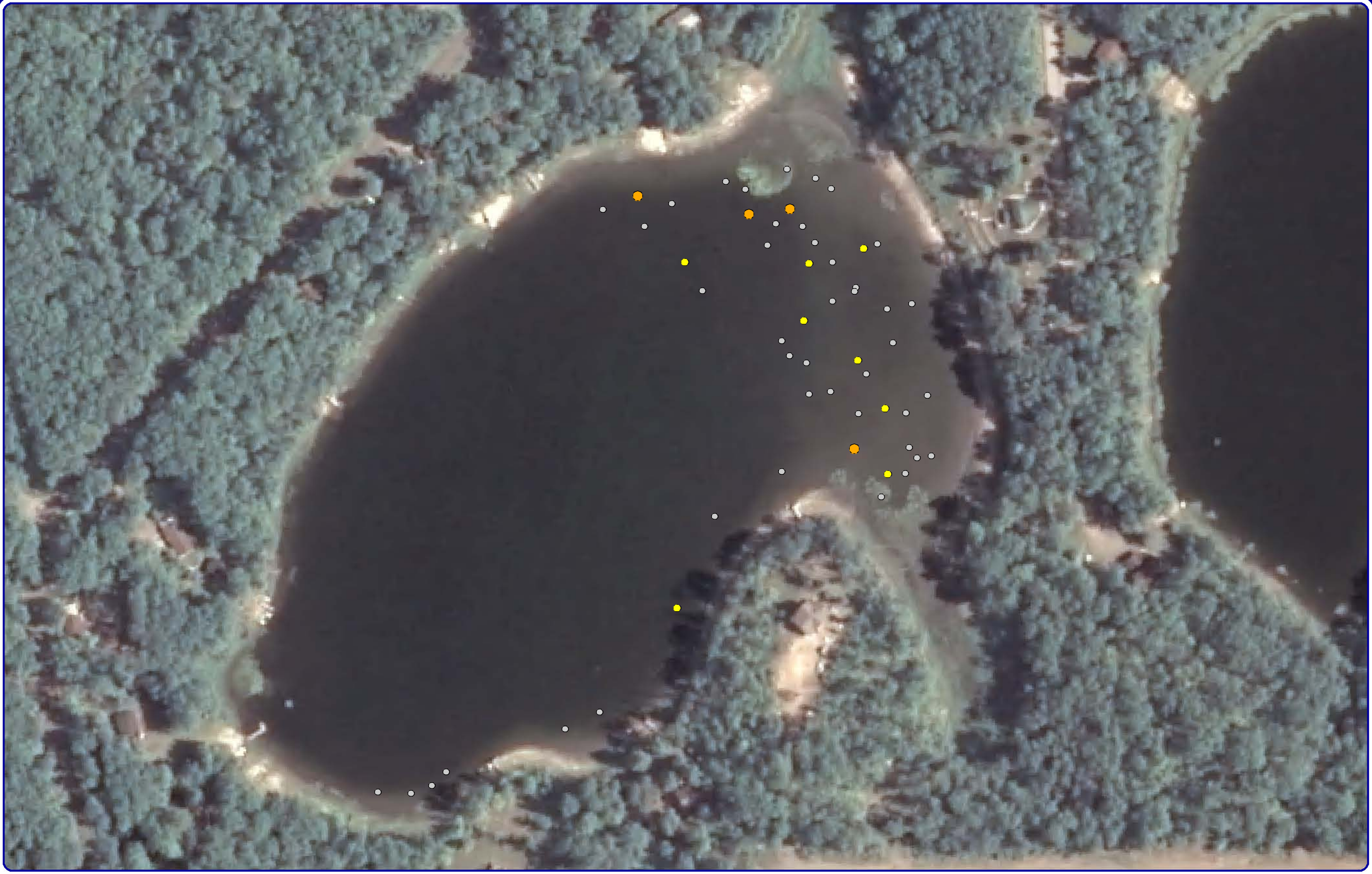
- Highly Scattered *(none found)*
- Scattered
- Dominant
- Highly Dominant
- Surface Matting

Map 12

Frog Lake

Florence County, Wisconsin

2012 EWM Survey Results



200

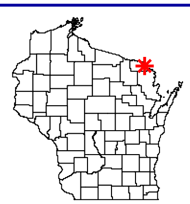
Feet

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

Sources:
Roads and Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plants: Onterra, 2009

Map Date: October 6, 2009

File Name: Map11_Bass_NWM_PB_Sept09.mxd



Project Location in Wisconsin

Legend

Northern Water Milfoil Small Colony (Sept 2009)

- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

Map 13
Bass Lake
Florence County, Wisconsin

Northern Water Milfoil Survey Results