Enterprise Lake

Langlade County, Wisconsin

Comprehensive Lake Management Plan

September 2011

Sponsored by:

Enterprise Lake Protection & Rehabilitation District

WDNR Lake Planning Grant Program

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

Onterra LLC
Lake Management Planning

Enterprise Lake

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Created by: Tim Hoyman & Eddie Heath
Onterra, LLC
De Pere, WI

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Enterprise Lake Protection & Rehabilitation District

Mr. Dave Schlapman
Mr. John Stensland
Mr. Tim Lehman
Mr. Brian Lotz
Ms. Barb Schlapman
Ms. Robii Heighway
Mr. Walter Rugland

Wisconsin Dept. of Natural Resources

Mr. Kevin Gauthier
Mr. Kyle McLaughlin
Mr. Dave Seibel

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INTRODUCTION

Enterprise Lake, Langlade County, is 505-acre drainage lake with a maximum depth of 27 feet and mean depth of approximately 10 feet (Map 1). This headwater lake's outlet (Enterprise creek) meets up with the Pelican River (from the uninfected Pelican Lake) before reaching the Wisconsin River.

Enterprise Lake, by virtue of its size, is a popular recreational lake and fishing destination. Arguably, it is this factor which has caused Enterprise Lake to become infested with invasive species. In July 2005, the Enterprise Lake Protection and Rehabilitation District (ELPRD) formed an Invasive Species Committee during their annual meeting. That weekend, a crew headed by the committee's chairperson, Barb Schlapman, found Eurasian water milfoil (EWM) in Enterprise Lake. They immediately contacted the Wisconsin Dept. of Natural Resources (WDNR) to verify the identification and explore their options. Lori Regni, WDNR, sent the specimen to UW-Stevens Point for positive identification and briefed the group on the Aquatic Invasive Species Rapid Response Grant Program. Management actions aimed at reducing the amount and density of Eurasian water milfoil in the lake through 2,4-D chemical applications have occurred annually since.

With the uncertainty of the how Eurasian water milfoil was impacting their lake, the ELPRD decided to move toward more of an ecosystem-approach of managing their lake. They were awarded a WDNR Planning Grant to provide financial support for the planning project.

The primary goal of this project was to complete a *Comprehensive Management Plan* for Enterprise Lake. Studies designed to collect baseline information concerning the lake's water quality, its native and non-native plant communities, and its watershed were used with historic data concerning those components and that of the lake's fishery to reach conclusions regarding the health and function of the lake as an ecosystem. That information, along with information obtained through the efforts for the stakeholder participation component was combined to devise a long-term and realistic management plan for Enterprise Lake.

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. Stakeholders were also informed about how their use of the lake's shorelands and open water areas impact the lake. Stakeholder input regarding the development of this plan was obtained through communications and meetings with the Enterprise Lake Protection & Rehabilitation District and via a stakeholder survey. A description of each stakeholder participation event can be found below, while supporting materials can be found in Appendix A.

Kick-off Meeting

On June 30, 2007 the ELPRD held a special meeting to inform district members and other interested parties about the lake management planning project the district was undertaking. During the meeting, Eddie Heath, an ecologist with Onterra, presented information about lake eutrophication, native and non-native aquatic plants, the importance of lake management planning, and the goals and components of the Enterprise Lake management planning project. It was anticipated that the management plan would largely focus on Eurasian water milfoil; therefore, the history of Eurasian water milfoil treatments on Enterprise Lake was discussed. At this meeting, Eddie announced that a stakeholder survey would soon be sent to district members and riparians to better understand the views of Enterprise Lake stakeholders.

Stakeholder Survey

During March 2008, a five-page, 22-question survey was mailed to 144 Enterprise Lake stakeholders. The mailing included all riparian property owners and all off lake members of the ELPRD. Over 50% of the surveys were returned and those results were entered into an Onterra-provided spreadsheet by members of the ELPRD Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meeting and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan.

Planning Committee Meeting

On April 26, 2008, Eddie Heath met with five members of the Enterprise Lake Planning Committee for a little over 4½ hours. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including, Eurasian water milfoil treatment results, aquatic plant inventories, water quality analysis, watershed modeling, and the stakeholder survey were presented and discussed. Eurasian water milfoil control was presented as the primary concern of the planning committee.

Management Plan Review and Adoption Process

In May 2008, a preliminary draft of the Enterprise Lake Management Plan was supplied to the WDNR. An official first draft was provided to the WDNR and the ELPRD Planning Committee the following month (June 2008). Comments were received from the planning committee within a few weeks after the draft report was made available.

The WDNR provided written comments to the draft management plan on September 5, 2011. This report reflects the integration of WDNR and ELPRD comments. The final report will be reviewed by the ELPRD Board of Directors and a vote to adopt the management plan will be held during the district's next annual meeting.

RESULTS & DISCUSSION

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 very 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. Six 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 analysis is elaborated on below.

Judging the quality of lake water can be difficult because lakes display problems in many different ways. 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. To complete this task, three water quality parameters are focused upon within this document:

> **Phosphorus** is a 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.

Each of these parameters is also 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; however, 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 most Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the health of their lake over time. Yet, classifying a lake into one of three trophic states does not give clear indication of where a lake really exists in its trophic progression. To solve this problem, the parameters described above can be used in an index that will specify a lake's trophic state more clearly and provide a means for which to track it over time.

The complete results of these three parameters and the other chemical data that were collected at Enterprise Lake can be found in Appendix C. The results and discussion of the analysis and comparisons described above can be found in the paragraphs and figures that follow.

Comparisons with Other Datasets

Lillie and Mason (1983) is an excellent source for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Langlade County lakes are included within the study's Northeast Region (Figure 1) and are among 242 lakes randomly picked from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means, historic, current, and average data from Enterprise Lake are displayed in Figures 2-4. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-a data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

Figure 1. Location of Enterprise Lake within the regions utilized by Lillie and Mason (1983).

Apparent Water Quality Index

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

Lillie and Mason (1983) used the extensive data they compiled to create the *Apparent Water Quality Index* (WQI). They divided the phosphorus, chlorophyll-*a*, and clarity data of the state's lakes in to ranked categories and assigned each a "quality" label from "Excellent" to "Very Poor". The categories were created based upon natural divisions in the dataset and upon their experience. As a result, using the WQI as an assessment tool is very much like comparing a particular lake's values to values from many other lakes in the state. However, the use of terms like, "Poor", "Fair", and "Good" bring about a better understanding of the results than just comparing averages or other statistical values between lakes. The WQI values corresponding to the phosphorus, chlorophyll-*a*, and Secchi disk values for Enterprise Lake are displayed on Figures 2-4.

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 process can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in many Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production. However, through the use of a *trophic state index* (TSI), a 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 clearer understanding of the lake's trophic state while facilitating understandable long-term tracking.

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

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

The WTSI is used extensively by the WDNR and is reported along with lake data collected by Citizen Lake Monitoring Network volunteers. The methodology is also used in this document to analyze the past and present trophic state of Enterprise Lake.

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 is going to need 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 concerns whether or not the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, 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.

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.

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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.

Without data pertaining to hypolimnetic phosphorus values, the role that internal nutrient loading has on a lake's nutrient budget cannot be determined. Without dissolved oxygen profiles during the summer months, it is unknown whether the lake experiences hypolimnetic anoxia. Further studies would be needed to understand the role of internal nutrient loading in Enterprise Lake.

Enterprise Lake Water Quality Analysis

The historic water quality data that exists for Enterprise Lake is largely from the last decade, so it is difficult to complete a reliable long-term trend analysis. This is unfortunate because having understanding of how the lake has changed over the years is always interesting and leads to sounder management decisions. According to the results of the stakeholder survey, roughly 94% of respondents consider the water quality of Enterprise Lake to be fair to excellent (Appendix B, Question #10); and the majority of stakeholders believe that the lake's water quality has remained the same (61 %) since they have owned their property (Appendix B, Question #15). The historic data that does exist, mostly transparency data, shows that while there are fluctuations, the water quality appears to have remained relatively the same over the past decade or so.

As described above, three water quality parameters are of most interest; total phosphorus, chlorophyll-*a*, and Secchi disk transparency. Total phosphorus data from Enterprise Lake are contained in Figure 2. Examination of these data indicates that the total phosphorus level of Enterprise Lake is good, especially when compared to other lakes in the region and within the state. While it may appear that total phosphorus values have been increasing since 2004, it cannot necessarily be considered a trend, especially in the context of the 1974 data.

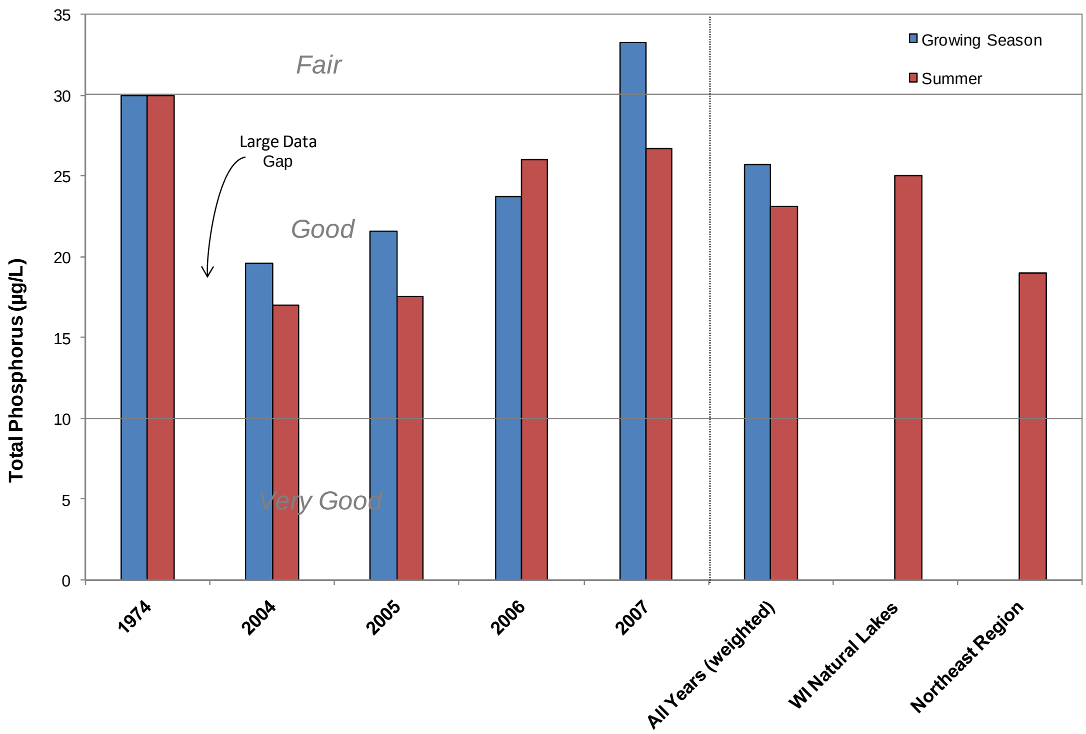

Figure 2. Enterprise Lake total phosphorus concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

The data follows the normal phosphorus/chlorophyll-*a* relationship in that the good to fair phosphorus values within Enterprise Lake have lead to similar chlorophyll *a* values (Figure 3). In addition, Enterprise Lake's chlorophyll-*a* values are only slightly above ecoregion means and correspond with a lower Eutrophic trophic state within the WTSI analysis (Figure 5).

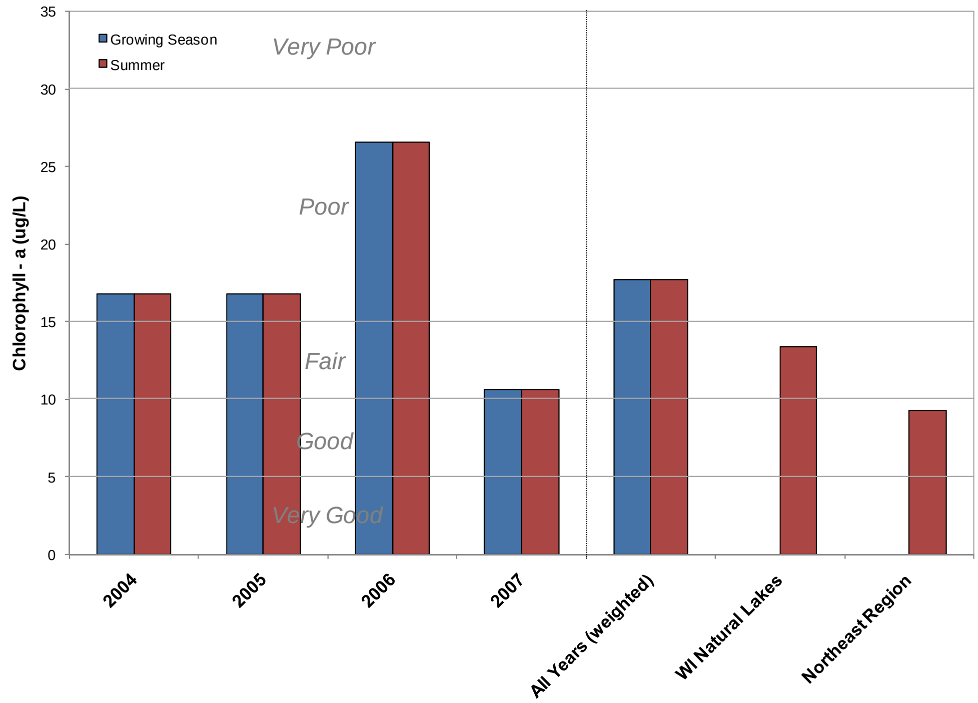

Figure 3. Enterprise Lake chlorophyll-*a* concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

All of the Secchi disk transparency averages from Enterprise Lake are slightly lower than those of the ecoregion and the state. Along with the potential for relatively abundant algae based upon the total phosphorus concentrations, the contributing watershed holds many acres of wetland and pine forests (see Watershed Section). These land types contribute weak, organic acids that are the by-product of the decomposition of organic materials. These acids are harmless, but tend to discolor water to the point which clarity can be decreased and have a brownish color. As alluded to above, there really is no trend towards improved or degraded water quality within the dataset and as with most lakes, the clarity of Enterprise Lake fluctuates from year-to-year.

In summary, the current and historic data indicate that the water quality of Enterprise Lake has seen minor levels of fluctuation over the course of the past decade, but all indicate that the water quality within the lake is good to very good. The primary reason for this level of water quality is the watershed that drains to the lake. That aspect of the Enterprise Lake ecosystem is discussed in detail within the Watershed Section.

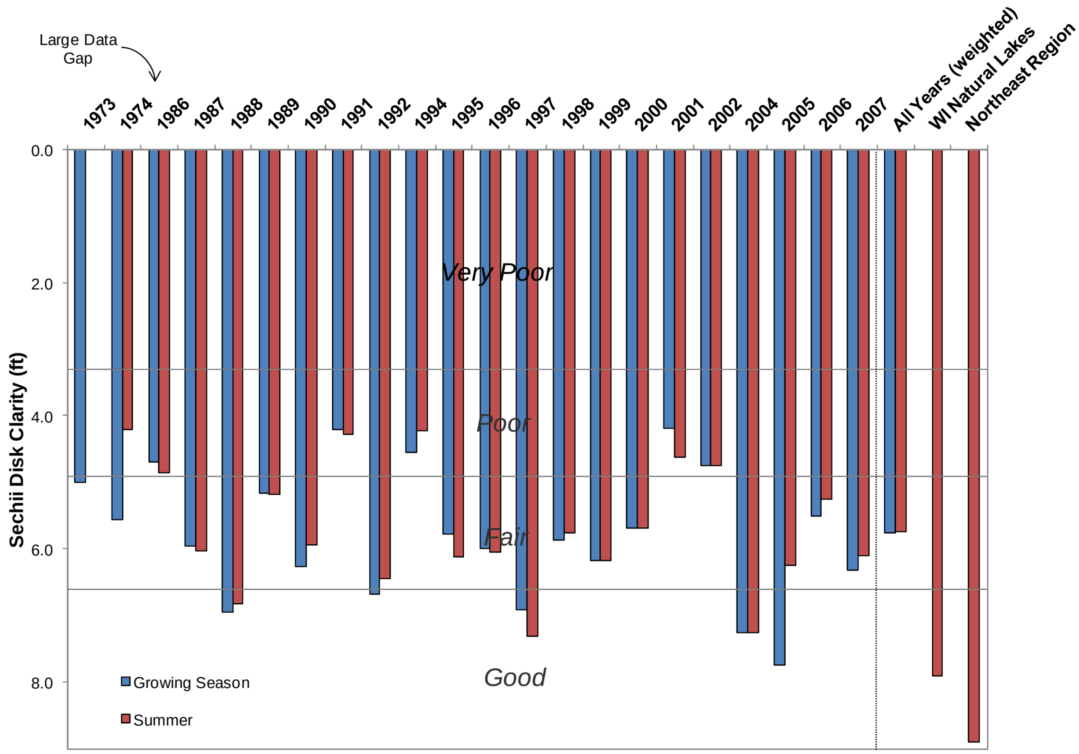

Figure 4. Enterprise Lake Secchi disk transparency values. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

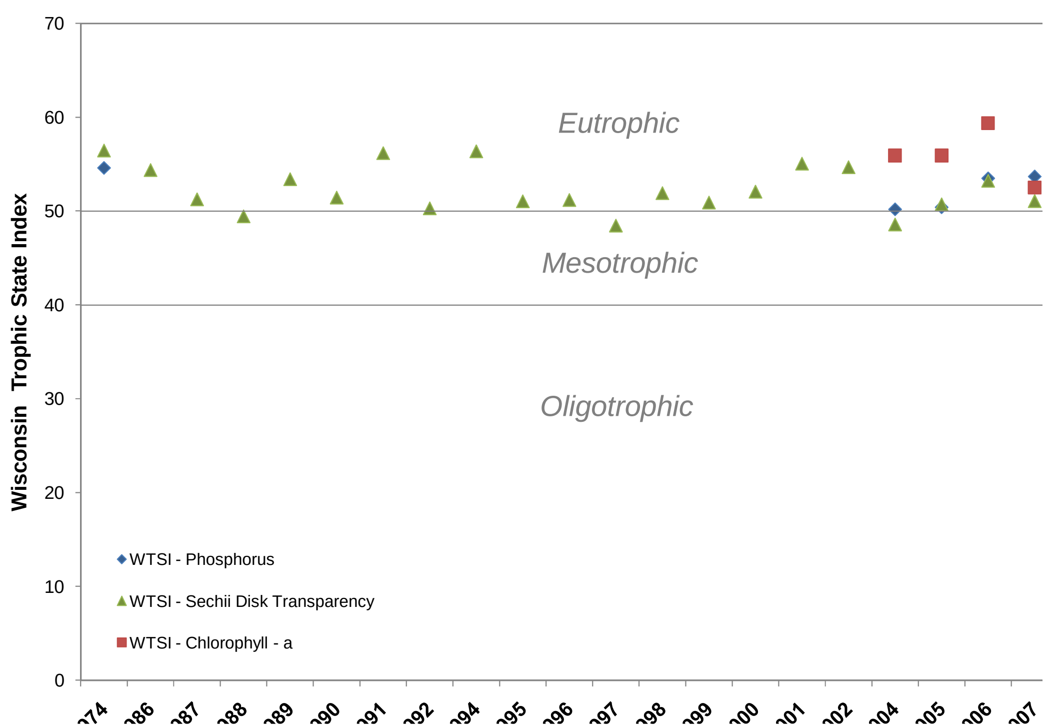

Figure 5. Enterprise Lake Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993).

Enterprise Lake Trophic State

Figure 5 displays the Wisconsin Trophic State Index (WTSI) (Lillie et al. 1993) values calculated from average surface levels of chlorophyll-*a*, total phosphorus, and Secchi disk transparencies measured during the summer months in Enterprise Lake. The WTSI values indicate that the lake's productivity ranges from lower Eutrophic to upper mesotrophic. Being that the WTSI values are calculated with the same parameters discussed above, it is not surprising that the trophic state values for the lake follow the same pattern discussed earlier.

Limiting Plant Nutrient of Enterprise Lake

Midsummer nitrogen and phosphorus concentrations collected during 2007 were 755 μg/L and 30 μg/L, respectively. These figures yield a nitrogen:phosphorus ratio of 25:1, indicating that Enterprise Lake is strongly phosphorus limited. This is also the case with the vast majority of Wisconsin lakes.

Internal Nutrient Loading in Enterprise Lake

Sufficient data were not collected as a part of this project to truly determine if internal loading is a significant source of nutrients within Enterprise Lake. While sufficient temperature and dissolved oxygen data were collected, the lack of bottom phosphorus data prevents internal loading from being estimated. However, as discussed in the watershed section, there is no evidence that there are unaccounted sources of phosphorus to the lake; therefore, internal nutrient loading is likely not a significant source of phosphorus to Enterprise Lake at this time.

Dissolved Oxygen and Temperature in Enterprise Lake

Dissolved oxygen and temperature information was collected by Onterra staff in late winter of 2007. Barbara Katz of the Enterprise Lake CLMN collected temperature data during spring and summer of 2007 years as well. Graphs of the most recent (2007) data are displayed in Figure 6.

Based on the temperature profiles, Enterprise Lake was found to mix well in the spring, and remain mixed throughout the summer months. This is not uncommon in lakes that are moderately shallow. Energy from the wind is sufficient to mix the lake from top to bottom, which results in keeping the entire water column at nearly the same temperature. In late winter of 2007, dissolved oxygen levels were found to be very high (<15 mg/L) just under the ice; and remained above 3.0 mg/L down to 15 feet. (Figure 6). Generally, it is believed that oxygen levels of at least 3.0 mg/L are required to sustain most aquatic life found in northern Wisconsin lakes. However, WDNR fisheries biologists believe that sport-fish species can tolerate oxygen levels as low as 1.0 mg/L for a period of 3-4 weeks. It appears that the majority of the water column holds more than enough oxygen to support aquatic organisms.

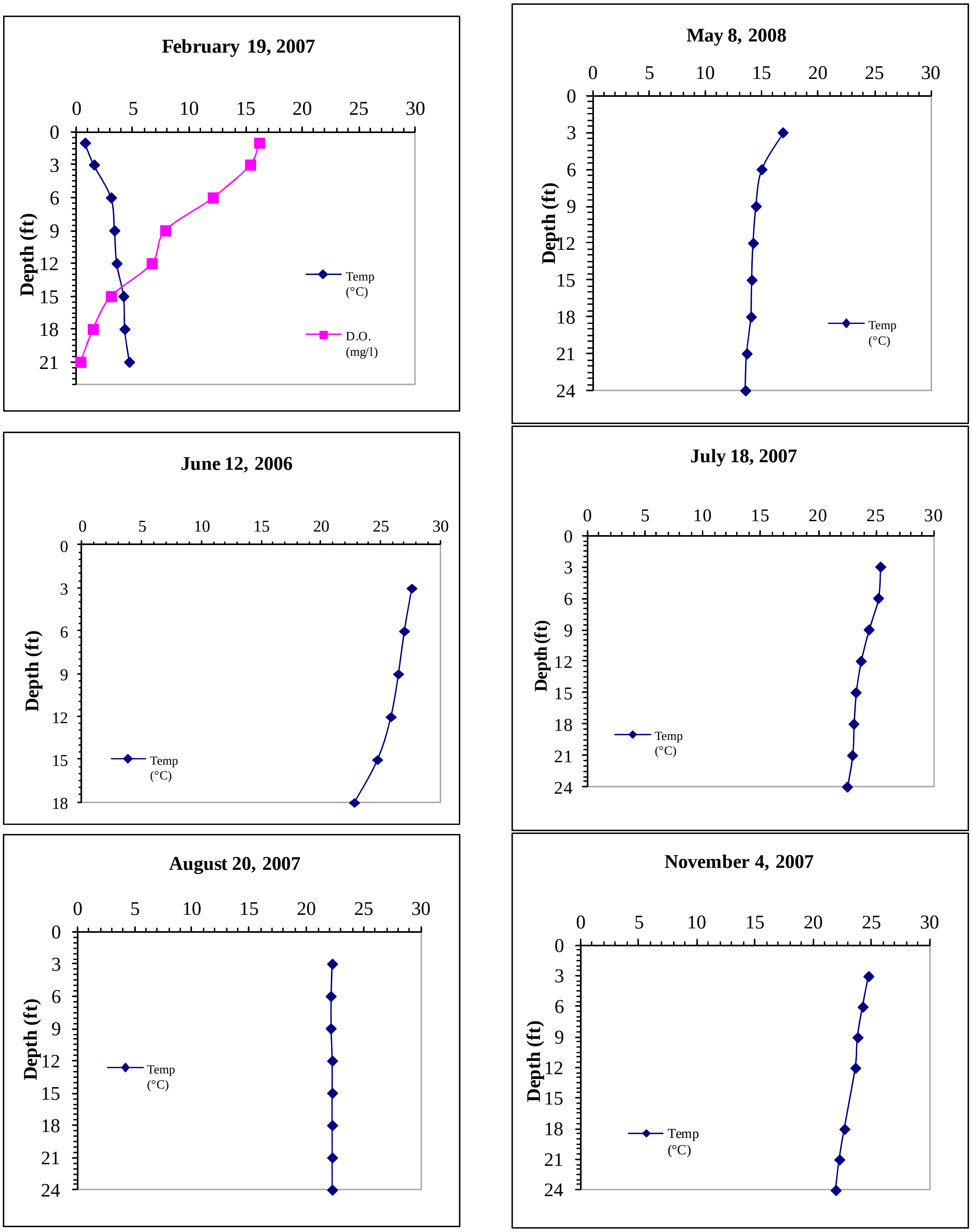

Figure 6. Enterprise Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Enterprise Lake

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

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw et al. 2004). The pH in of Enterprise Lake was found to be slightly alkaline with a value of 7.2, and falls within the normal range for Wisconsin Lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Enterprise Lake was found to be approximately 16.0 mg/L as $CaCO_3$, indicating that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Watershed Analysis

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 will be lessened. 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, there may be a build 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 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 useful 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.

The Enterprise Lake watershed (Map 2) is approximately 3,839 acres (including the lake's surface area), which yields a watershed to lake area ratio of 7:1. While this ratio is not extremely high, it is approaching the level where the watershed would be the dominating factor in determining the lake's water quality. Fortunately, the Enterprise watershed is dominated by forested areas (Figure 7), which as mentioned above, export a minimal amount of the phosphorus to the lake. The second highest cover type is wetland, another cover that exports minimal loads of phosphorus to the lake. The stained water of Enterprise Lake is the direct result of having forests and wetlands dominate the watershed's the landscape. The dark color of the water is caused by dissolved organic acids which are the byproduct of the decomposition of leaves and other plant materials. These organic acids are not harmful to the lake and are also responsible for the foam that may appear on the lake's shoreline during windy days that produce choppy conditions on the lake.

Using the land cover acreages displayed in Figure 7, WiLMS modeling estimates the annual phosphorus load entering the lake through its watershed to be approximately 418 lbs. A little less than half of that load originates in forested areas (Figure 8) and a third of it enters the lake directly through its surface from atmospheric fallout. Therefore, roughly 81% of the phosphorus that enters Enterprise Lake via its watershed are from sources that should not (forested) or cannot (lake surface) be changed. Although this means that for the most part the Enterprise Lake watershed need not be improved on a large scale, it also means that impacts from the immediate shoreland watershed become even more important. In other words, if the vast majority of the lake's watershed is contributing a minimal amount of phosphorus to the lake and does not require management, then areas such as the immediate shoreland become even more important in controlling the phosphorus loads. Installation and maintenance of shoreland buffer areas, use of phosphorus-free fertilizers, reductions in impervious surfaces all become important aspects in minimizing the amount of phosphorus entering the lake.

Analysis of the Enterprise Lake estimated annual phosphorus load (418 lbs) using the WiLMS Phosphorus Prediction and Uncertainty Analysis Module indicates that the phosphorus load entering the lake from its watershed does not account for the concentrations found in the water column. Essentially, the actual water column phosphorus concentrations are *slightly* higher than expected based upon the watershed modeling. This means that there is likely another *small* source of phosphorus impacting the lake that is not accounted for in the watershed. Likely sources include shoreland septic systems, shoreland runoff, and internal nutrient loading (see water quality section for an explanation). The most likely source of the three is internal nutrient loading, which with the correct assemblage of water quality data can be estimated through modeling. Unfortunately, the required data were not collected as a part of this project. Completing the modeling effort would be relatively simple and either confirm or rule-out internal loading as the additional source of phosphorus to the lake. The data required would call for a moderately intense sampling effort spanning a single growing season. If internal loading were found not to be the additional phosphorus source, then further studies could be conducted to investigate the other less likely sources.

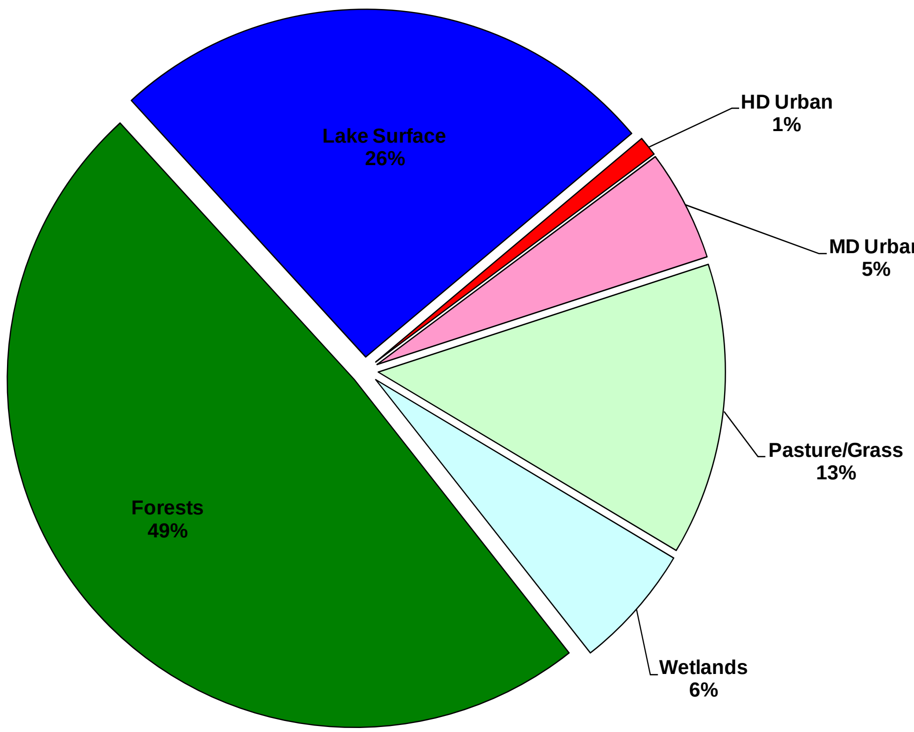

Figure 7. Enterprise Lake watershed land cover types. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR 1998).

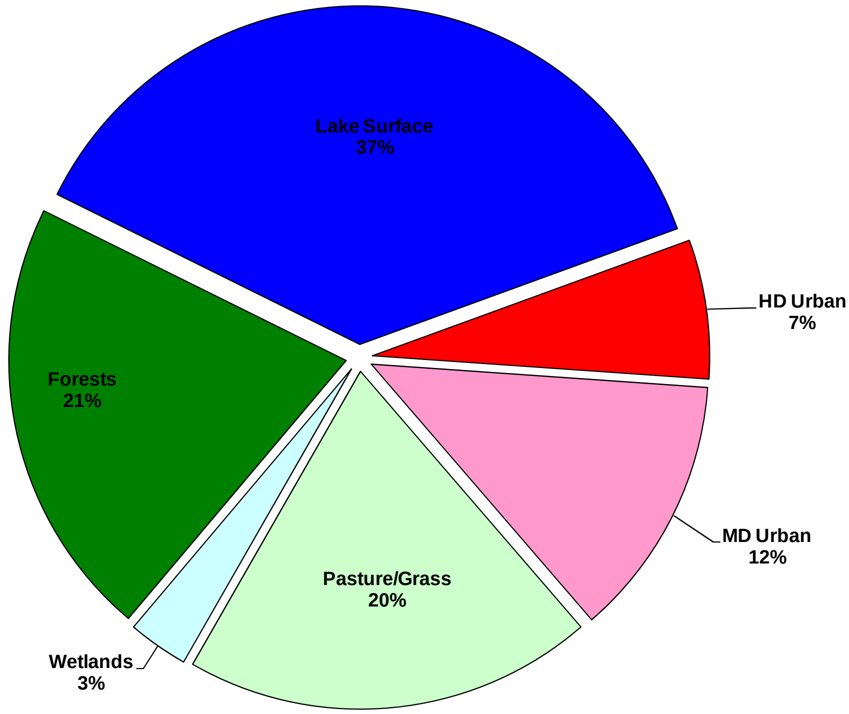

Figure 8. Enterprise Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Enterprise Lake Fishery

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) WDNR 2007 & GLIFWC 2007).

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

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1cm-1m deep	Crustaceans, insect larvae,and other inverts
Black Bullhead	*Ictalurus melas*	5	April - June	Matted vegetation, woody debris, overhanging banks	Amphipods, insect larvae and adults, fish, detritus, algae
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pikes, crayfish, small mammals, water fowl, frogs
Muskellunge	*Esox masquinongy*	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskellunges, small mammals, shore birds, frogs
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Smallmouth Bass	*Micropterus dolomieu*	13	Mid May - June	Nests more common on North and West shorelines, over gravel	Small fish including other bass, crayfish, insects (aq. and ter)
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Yellow Perch	*Perca flavescens*	13	April - Early May	Sheltered areas, emergent and submergent vegetation	Small fish, aquatic invertebrates
Walleye	*Sander vitreus*	18	Mid April - Early May	Rocky, wave-washed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish

Based on data collected from the stakeholder survey (Appendix B, Question #6), fishing was the activity most often ranked first as the most important or enjoyable on Enterprise Lake. Over 85% of these same respondents believed that the quality of fishing on Enterprise Lake was either fair or poor and approximately 95% believe that the quality of fishing has remained the same or gotten worse since they have obtained their property.

Table 1 shows the popular game fish that are present in the system. Management actions that have taken place and will likely continue on Enterprise Lake according to this plan include herbicide applications to control EWM. These applications occur in May when the water temperatures are below 60°F. It is important to understand the effect the chemical has on the spawning environment which would be to remove broad-leaf (dicot) submergent plants that are actively growing at these low water temperatures. Yellow perch is one species that could be affected by early season herbicide applications.

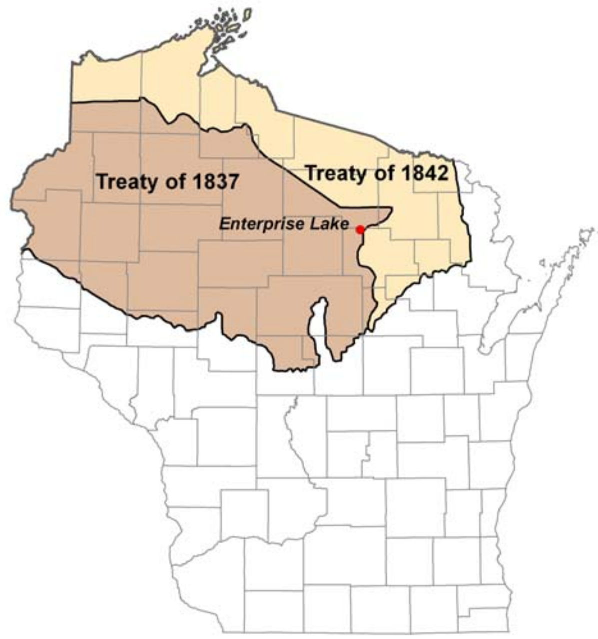

Figure 9. Location of Enterprise Lake within the Native American Ceded Territory (GLIFWC 2007). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 9). Enterprise Lake falls within the ceded territory based on the Treaty of 1837. This allows for a regulated open water spear fishery by Native Americans on specified systems. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then an "allowable catch" is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% of a lake's fishing stock, but may vary on an individual lake basis. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The allowable catch number is then reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level". The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent, or declaration. This result is called the quota, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal quota and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2 fish daily bag limit for hook-and-line anglers (USDI 2007).

Spearers target muskellunge, walleye, during the open water season, and occasionally also harvest northern pike, and bass. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2010B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly quota is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the quota is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller quotas. Starting with the

2011 spear harvest season, on lakes with a harvestable quota of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

The Sokaogon Chippewa (Mole Lake) tribe exercises their rights to spear on Enterprise Lake. Spearers are able to harvest walleye, northern pike, and bass. The spear harvest is monitored by a maintained by a nightly permit system and a complete monitoring of the harvest. Creel clerks and wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) were measured and sexed. An updated nightly quota is determined each morning by 9 a.m. based on the data collected from the successful spearers.

Walleye harvest records are provided in Table 2. One common misconception noted from the stakeholder survey (Appendix B – Written Comments) is that the spear harvest targets the large spawning females. Table 2 clearly shows that the opposite is true with only 8.9% of the total walleye harvest (101 fish) since 1998 comprising female fish on Enterprise Lake.

Table 2. Spear harvest data of walleye from GLIFWC annual reports for Enterprise Lake (Krueger 1998-2006).

Year	Total	% Quota	Mean Length* (in)	% Male*	% Female*	% Unknown*
1998	169	98.8	13.6	93.6	4.7	0.0
1999	104	87.4	13.3	95.2	4.8	0.0
2000	167	97.1	14.2	97.0	1.2	1.8
2001	120	96.8	14.2	84.2	10.8	5.0
2002	187	99.5	15.3	86.1	13.4	0.5
2003	104	83.2	14.8	69.2	0.0	30.8
2004	175	100.0	15.9	78.3	17.1	4.0
2005	69	59.5	15.7	75.4	14.5	10.1
2006	40	100.0	14.1	92.5	7.5	0.0

*Based on Measured Fish

Walleye is prized game fish in northern Wisconsin and can be found in Enterprise Lake. As stated above, Enterprise Lake is located within ceded territory and special fisheries regulations occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to Enterprise Lake. On Enterprise Lake, there is no minimum length limit on walleye, but only one fish over 14 inches is allowed. A fisheries survey in 2005 indicated that walleye abundances were low (0.8 per acre) for a naturally reproducing walleye populations. It is believed that implementing a protected slot size of 14-18 inches and only one fish allowed over 18 inches, the adult walleye population will increase. This proposed fishery rule change has been presented during the 2008 WDNR Annual Spring Fish and Wildlife Rule Hearings (WDNR 2008).

Although other fish species are able to be harvested by the spear fishery, only four muskellunge and one small mouth bass have been harvested since 1998 (Table 3).

Muskellunge have been actively stocked in recent years by the WDNR (Table 4) in an effort to influence the populations of these species. Based on a fisheries study completed in 2005-06, adult muskellunge (30 inches and larger) abundance was 0.38 per acre. This abundance is considered good for a population with little or no natural reproduction. However, the ELPRD would like to increase the size quality of the muskellunge fishery. Currently, a 34 inch minimum length limit is in affect on the lake and it has been presented at the WDNR Annual Spring Fish and Wildlife Rule Hearings to increase the minimum length to 50 inches (WDNR 2008).

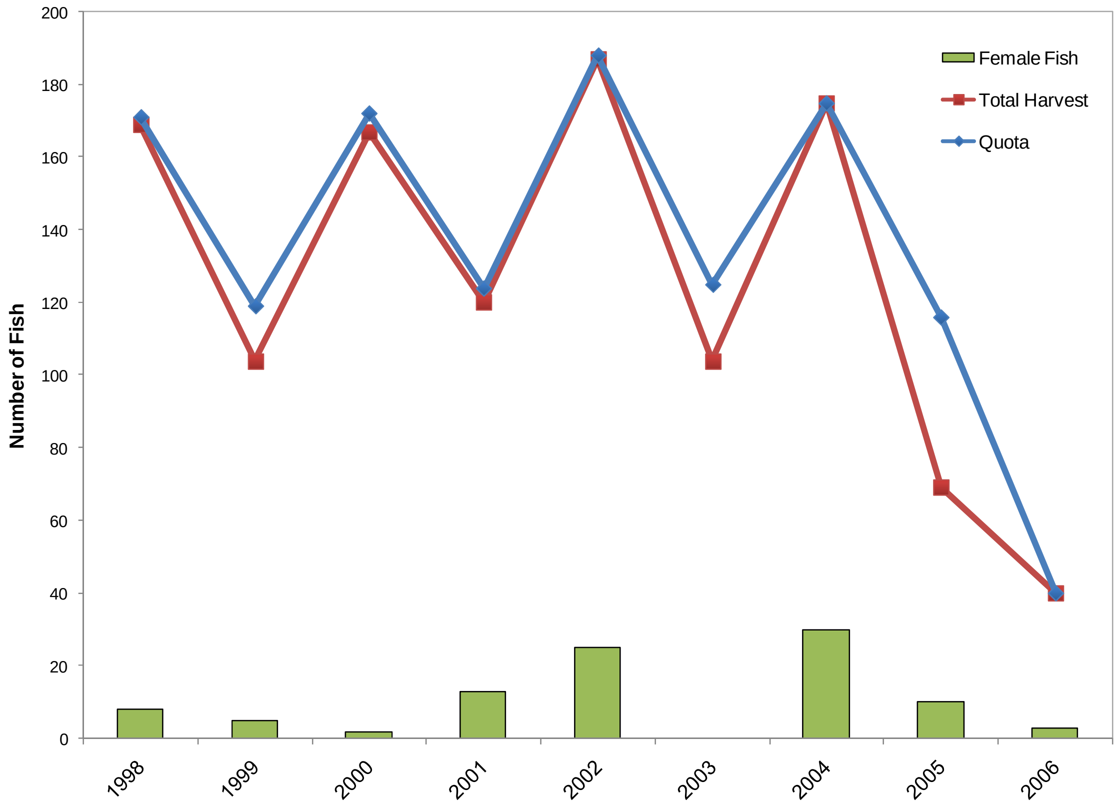

Figure 10. Walleye spear harvest data. Annual total walleye harvest, walleye quotas, and female walleye harvest are displayed since 1998 from GLIFWC annual reports for Enterprise Lake (Krueger 1998-2006)

Table 3. Spear harvest data of non-walleye gamefish from GLIFWC annual reports for Enterprise Lake (Krueger 1998-2006).

Year	Species	Quota	Total	Mean Length* (in)
1998	Muskellunge	7	4	34.7
1998	Smallmouth Bass	n/a	1	17.9
1999	Muskellunge	7	0	n/a
2000	Muskellunge	6	0	n/a
2001	Muskellunge	6	0	n/a
2002	Muskellunge	6	0	n/a
2003	Muskellunge	7	0	n/a
2004	Muskellunge	7	0	n/a
2005	Muskellunge	7	0	n/a
2006	Muskellunge	7	0	n/a

*Based on Measured Fish

Table 4. Fish stocking data available from the WDNR from 1972 to 2006 (WDNR 2007)

Year	Species	Age Class	# Fish Stocked
1973	Muskellunge	Fingerling	1,000
1975	Muskellunge	Fingerling	500
1977	Muskellunge	Fingerling	1,000
1979	Muskellunge	Fingerling	1,000
1981	Muskellunge	Fingerling	100
1982	Muskellunge	Fingerling	1,000
1984	Muskellunge	Fingerling	1,000
1986	Muskellunge	Fingerling	1,000
1988	Muskellunge	Fingerling	1,000
1989	Muskellunge	Fingerling	1,000
1991	Muskellunge	Fingerling	1,000
1993	Muskellunge	Fingerling	1,000
1995	Muskellunge	Fingerling	61
1997	Muskellunge	Large Fingerling	500
2000	Muskellunge	Large Fingerling	1,004
2001	Muskellunge	Large Fingerling	502
2003	Muskellunge	Large Fingerling	505
2005	Muskellunge	Large Fingerling	505

Aquatic Plants

Introduction

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

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

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

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

Aquatic Plant Management and Protection

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

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

Permits

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

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

Native Species Enhancement

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

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

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

Cost

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

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

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreline erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used.

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 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.	• Requires WDNR permit. • Installation may be difficult over dense plant beds and in deep water. • Not species specific. • Disrupts benthic fauna. • May be navigational hazard in shallow water. • Initial costs are high. • Labor intensive due to the seasonal removal and reinstallation requirements. • Does not remove plant biomass from lake. • Not practical in large-scale situations.

Water Level Drawdown

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

Cost

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

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

Mechanical Harvesting

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

Costs

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

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

Chemical Treatment

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

1. *Contact herbicides* act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. *Systemic herbicides* spread throughout the entire plant and often result in complete mortality if applied at the right time of the year.

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

Applying herbicides in the aquatic environment requires special considerations compared with terrestrial applications. WDNR administrative code states that a permit is required if "you are standing in socks and they get wet." In these situations, the herbicide application needs to be completed by an applicator licensed with the Wisconsin Department of Agriculture, Trade and

Consumer Protection. All herbicide applications conducted under the ordinary high water mark require herbicides specifically labeled by the United States Environmental Protection Agency.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Some herbicides are applied at a high dose with the anticipation that the exposure time will be short. Granular herbicides are usually applied at a lower dose, but the release of the herbicide from the clay carrier is slower and increases the exposure time.

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

> <u>Fluridone</u> (Sonar®, Avast!®) Broad spectrum, systemic herbicide that is effective on most submersed and emergent macrophytes. It is also effective on duckweed and at low concentrations has been shown to selectively remove Eurasian water-milfoil. Fluridone slowly kills macrophytes over a 30-90 day period and is only applicable in whole lake treatments or in bays and backwaters were dilution can be controlled. Required length of contact time makes this chemical inapplicable for use in flowages and impoundments. Irrigation restrictions apply.
>
> <u>Diquat</u> (Reward®, Weedtrine-D®) Broad spectrum, contact herbicide that is effective on all aquatic plants and can be sprayed directly on foliage (with surfactant) or injected in the water. It is very fast acting, requiring only 12-36 hours of exposure time. Diquat readily binds with clay particles, so it is not appropriate for use in turbid waters. Consumption restrictions apply.
>
> <u>Endothall</u> (Hydrothol®, Aquathol®) Broad spectrum, contact herbicides used for spot treatments of submersed plants. The mono-salt form of Endothall (Hydrothol®) is more toxic to fish and aquatic invertebrates, so the dipotassium salt (Aquathol®) is most often used. Fish consumption, drinking, and irrigation restrictions apply.
>
> <u>2,4-D</u> (Navigate®, DMA IV®, etc.) Selective, systemic herbicide that only works on broad-leaf plants. The selectivity of 2,4-D towards broad-leaved plants (dicots) allows it to be used for Eurasian water-milfoil without affecting many of our native plants, which are monocots. Drinking and irrigation restrictions may apply.
>
> <u>Triclopyr</u> (Renovate®) Selective, systemic herbicide that is effective on broad leaf plants and, similar to 2,4 D, will not harm native monocots. Triclopyr is available in liquid or granular form, and can be combined with Endothal in small concentrations (<1.0 ppm) to effectively treat Eurasian water-milfoil. Triclopyr has been used in this way in Minnesota and Washington with some success.
>
> <u>Glyphosate</u> (Rodeo®) Broad spectrum, systemic herbicide used in conjunction with a *surfactant* to control emergent and floating-leaved macrophytes. It acts in 7-10 days and is not used for submergent species. This chemical is commonly used for controlling

purple loosestrife (*Lythrum salicaria*). Glyphosate is also marketed under the name Roundup®; this formulation is not permitted for use near aquatic environments because of its harmful effects on fish, amphibians, and other aquatic organisms.

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

The use of herbicides for aquatic plant control in northern Wisconsin is largely for the control of aquatic invasive species and not for nuisance levels of native plants. Initially released by the WDNR during the summer of 2007, Aquatic Plant Management Strategy Northern Region has a goal to "not issue permits for chemical or large-scale mechanical control of native aquatic plants – develop general permits as appropriate or inform applicants of exempted activities."

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 waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla* *verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for either biocontrol insect.

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

Cost

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

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

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

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

Cost

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

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

Analysis of Current Aquatic Plant Data

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

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

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in life-forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Enterprise Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, relative frequency of occurrence is used to describe how often each species occurred in the plots that contained vegetation. 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

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.

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 Enterprise Lake will be compared to lakes in the same ecoregion and in the state (Figure 11).

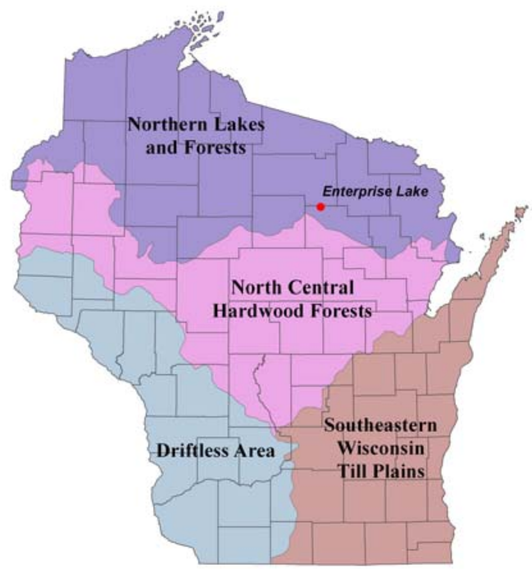

Figure 11. Location of Enterprise Lake within the ecoregions of Wisconsin. After Nichols 1999.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality.

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.

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.

Aquatic Plant Survey Results

A point-intercept survey aquatic plant survey was conducted by Wisconsin Department of Natural Resources Science Services in August 2005. That survey identified 27 aquatic plant species within Enterprise Lake with two species being non-native and invasive in Wisconsin: Eurasian water milfoil and curly-leaf pondweed.

In June 2007, a survey was completed that focused upon curly-leaf pondweed since its presence had been documented during the WDNR's 2005 survey. This meander-based survey did not locate any occurrences of curly-leaf pondweed. The single location in which curly-leaf pondweed was observed at during the 2005 survey was visited during all plant surveys as a part of the project. It is believed that this aquatic invasive species either does not occur in Enterprise Lake or exists at an undetectable level.

An additional survey was completed by Onterra to create the aquatic plant community maps (Map 3) during August 2008. Table 5 shows the aquatic plants found in Enterprise Lake, which is a combination of those identified by the WDNR in 2005 and Onterra in 2008.

Special Note: Two additional species were located after this management plan was finalized, but before printing: spiny hornwort and Farwell's water milfoil, both of which are listed as Special Concern in Wisconsin.

Common waterweed and stoneworts (Figure 12) are the most abundant plants within Enterprise Lake, together accounting for over 43% of the relative frequency of plants found within the lake. Because Enterprise Lake has a very high number of aquatic plant species within the lake, one may assume that the lake would also have a very high diversity. The relative uneven distribution of these two species throughout the lake (relative frequency) has an influence on the diversity metric. Enterprise lake exhibits a moderately high diversity (Simpson's = 0.87). Other common species that occur throughout much of the lake include wild celery and coontail (Figure 12). During the survey in 2005, Eurasian water milfoil's was the 12th most abundant plant but is now assumed to be more frequent.

Large purple bladderwort, a species of special concern in Wisconsin, was found in Enterprise Lake. Although this species is secure globally, it is rare or uncommon in Wisconsin, with less than 100 occurrences of this plant known state-wide.

Combining, the high species richness of the aquatic plants within the lake with their relatively high coefficient of conservatisms value, the FQA indicates that floristic quality of Enterprise Lake (Figure 13) is excellent, especially when compared to median values for the state and ecoregion. As described above, floristic quality utilizes average conservatism value for all of the native species found in the lake and the total number of those 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.

The Enterprise Lake average conservatism values are higher than the state and ecoregion medians. This indicates that many of the species present in the lake are indicative of an undisturbed system. This is not a surprise considering Enterprise Lake has vast portions of undeveloped shoreline and has slow no wake areas protecting the native flora. Combining the number of species with the plant community is outstanding as evidenced by the very high floristic quality and high index of diversity. The quality is also indicated by the high incidence of emergent and floating leaf plant communities that occur in many areas of the lake (Map 3). 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. Many studies have documented the adverse affects of motorboat traffic on aquatic plants (e.g. Murphy and Eaton 1983, Vermaat and de Bruyne 1993, Mumma et al. 1996, Asplund and Cook 1997). In all of these studies, lower plant biomasses and/or declines and higher turbidity were associated with motorboat traffic.

Table 5. Aquatic plant species located in Enterprise Lake during the 2005 and 2008 point-intercept survey.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)
E	*Eleocharis palustris*	Creeping spikerush	6
	*Pontederia cordata**	Pickerelweed	9
	*Pontederia cordata**	Softstem bulrush	9
	*Schoenoplectus tabernaemontani**	Softstem bulrush	4
	*Sagittaria latifolia**	Common arrowhead	3
	*Dulichium arundinaceum**	Three-way sedge	9
	*Equisetum fluviatile**	Water horsetail	7
	*Carex lacustris**	Lake sedge	6
	*Calla palustris**	Water arum	9
	*Lythrum salicaria**	Purple loosestrife	Exotic
	*Typha spp.**	Cattail species	1
	*Sparganium angustifolium**	Narrow-leaf bur-reed	9
	*Carex retrorsa**	Knotsheath sedge	6
FL	*Brasenia schreberi*	Watershield	7
	Nuphar variegata	Spatterdock	6
	Nymphaea odorata	White water lily	6
FL/E	*Sparganium fluctuans*	Floating-leaf bur-reed	10
Submergent	*Potamogeton crispus*	Curly-leaf pondweed	Exotic
	Ceratophyllum demersum	Coontail	3
	Chara sp.	Muskgrasses	7
	Elodea canadensis	Common waterweed	3
	Isoetes sp.	Quillworts	8
	Megalodonta beckii	Water marigold	8
	Myriophyllum heterophyllum	Various-leaved water milfoil	7
	Myriophyllum spicatum	Eurasian water milfoil	Exotic
	Myriophyllum tenellum	Dwarf water milfoil	10
	Najas flexilis	Slender naiad	6
	Najas gracillima	Northern naiad	7
	Nitella sp.	Stoneworts	7
	Potamogeton amplifolius	Large-leaf pondweed	7
	Potamogeton pusillus	Small pondweed	7
	Potamogeton richardsonii	Clasping-leaf pondweed	5
	Potamogeton robbinsii	Fern pondweed	8
	Potamogeton spirillus	Spiral-fruited pondweed	8
	Potamogeton strictifolius	Stiff pondweed	8
	Utricularia purpurea	Large purple bladderwort	9
	Vallisneria americana	Wild celery	6
	*Potamogeton natans**	Floating-leaf pondweed	5
	*Eriocaulon aquaticum**	Pipewort	9
S/E	*Eleocharis acicularis*	Needle spikerush	5

E = Emergent
FL = Floating Leaf
FL/E = Floating Leaf and Emergent
S/E = Submergent and Emergent
* = Incidental

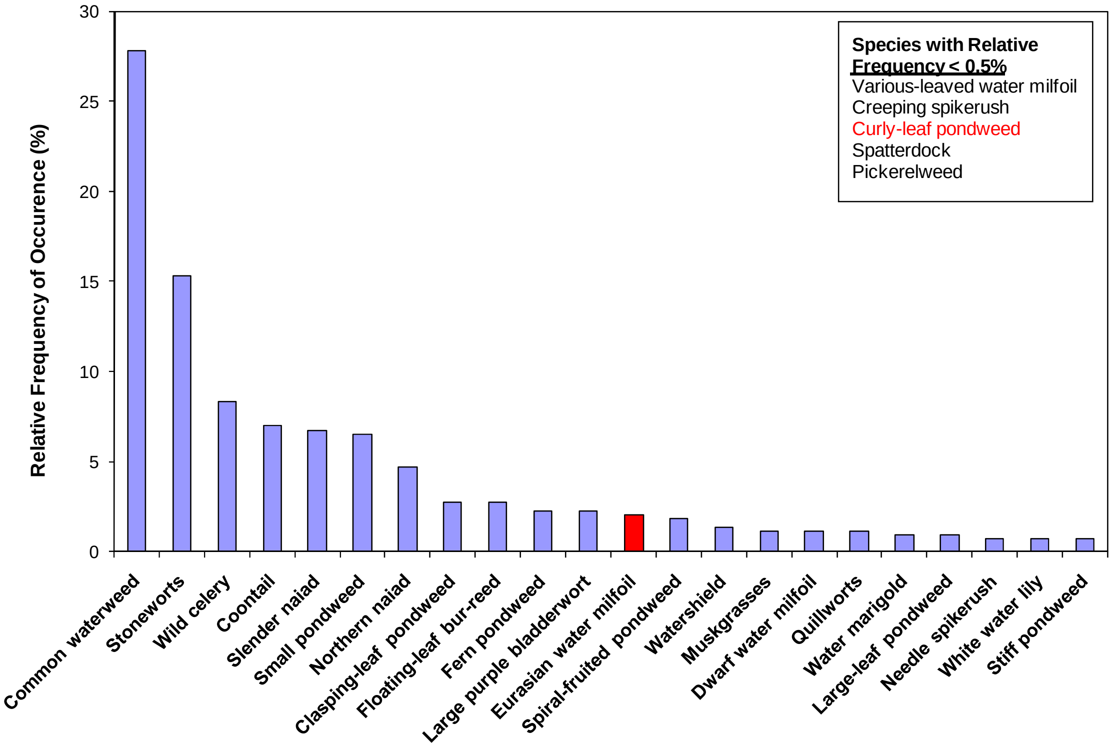

Figure 12. Enterprise Lake aquatic plant occurrence analysis of 2005 survey data. Exotic species indicated with red.

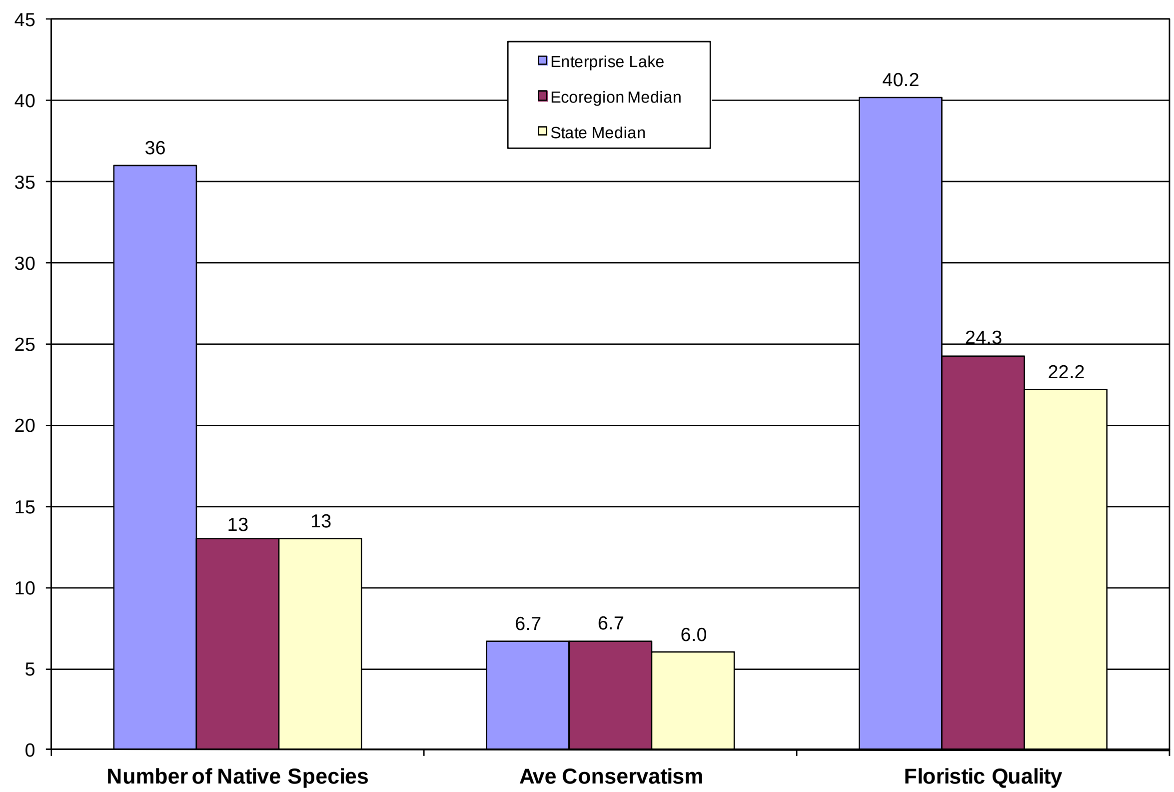

Figure 13. Enterprise Lake Floristic Quality Assessment of 2005 and 2008 survey data. Analysis following Nichols 1999.

Non-native Aquatic Plants

At the start of the project, the ELPRD was primarily concerned with two plants, Eurasian water milfoil and curly-leaf pondweed. During 2005, Eurasian water milfoil was discovered by members of the district's invasive species committee. Later that summer, WDNR research conducted a point-intercept survey yielding Eurasian water milfoil in nine sample locations. Curly-leaf pondweed was also located in one sample location during this survey.

Curly-leaf Pondweed

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 almost immediately following ice-out, giving the plant a significant jump on native vegetation. 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.

A meander survey was completed on June 28, 2007 in search of this invasive plant. No curly-leaf pondweed was observed during this study and it is concluded that curly-leaf pondweed is most likely not present in the lake and if it is present, it is at an undetectable level.

Eurasian water milfoil

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 14). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads mostly 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,

Figure 14. Spread of Eurasian water milfoil within WI counties. WDNR Data 2006 mapped by Onterra.

reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

As a part of this project, the 2007 herbicide treatment of Eurasian water milfoil was monitored according to current WDNR protocols (April 2007) to provide analysis of treatment efficacy and to satisfy the chemical application permit issued by the WDNR. The following text was modified from the treatment report detailing the 2007 treatment.

2007 Treatment Report

Combining the data available from the 2006 peak-biomass Eurasian water milfoil survey conducted by Schmidt's Aquatic Plant Control (SAPC) and the WDNR ISS point-intercept survey, a preliminary treatment area of approximately 20.2 acres (Map 4) was used to obtain a conditional chemical application permit from the WDNR. During May, these focus areas were surveyed to produce accurate delineations of the colonies and ultimately to refine the treatment areas. Eurasian water milfoil was located in many of the focus areas and using a sub-meter Global Positioning System (GPS) datacollector, the Eurasian water milfoil occurrences were marked (Map 5). Using these data and the data from the 2006 peak-biomass survey, 15.0 acres were recommended to be treated with 2,4-D at 100 pounds/acre. We provided the necessary data to the applicator, Schmidt's Aquatic Plant Control, and an application of Navigate (2,4-D) was completed on May 8, 2007 at 100 lbs/acre. The winds were light (0-5 mph) and the water temperature was 12.2°C (54°F). To aid in our understanding of the treatment, the applicator provided the approximate application path which is generated by his onboard GPS (Map 5).

Treatment Monitoring

Determining the success or failure of chemical treatments on Eurasian water milfoil is often a difficult task because the criteria used in determining success or failure is ambiguous. Most people involved with Eurasian water milfoil management, whether professionals or laypersons, understand that the eradication of Eurasian water milfoil from a lake, or even a specific area of a lake, is nearly, if not totally, impossible. Most understand that achieving control is the best criteria for success. During the surveys reported on here, two different methods of evaluation were used to understand the level of control that was achieved by the chemical treatment. A qualitative assessment was determined for each treatment site by comparing detailed notes of pre- and post treatment observations and spatial data were collected with the a sub-meter GPS data collector. A quantitative assessment of the treatment was also made by collecting data at 58 point-intercept sample locations on Enterprise Lake (Appendix F). At these locations, Eurasian water milfoil presence and rake fullness was documented as well as water depth and substrate type. Native plant abundances were also determined at each plot during the pre- and post treatment surveys; however, these data are only lightly discussed here because comparisons between early spring samples and summer samples are not fully valid due to the lifecycles of these species.

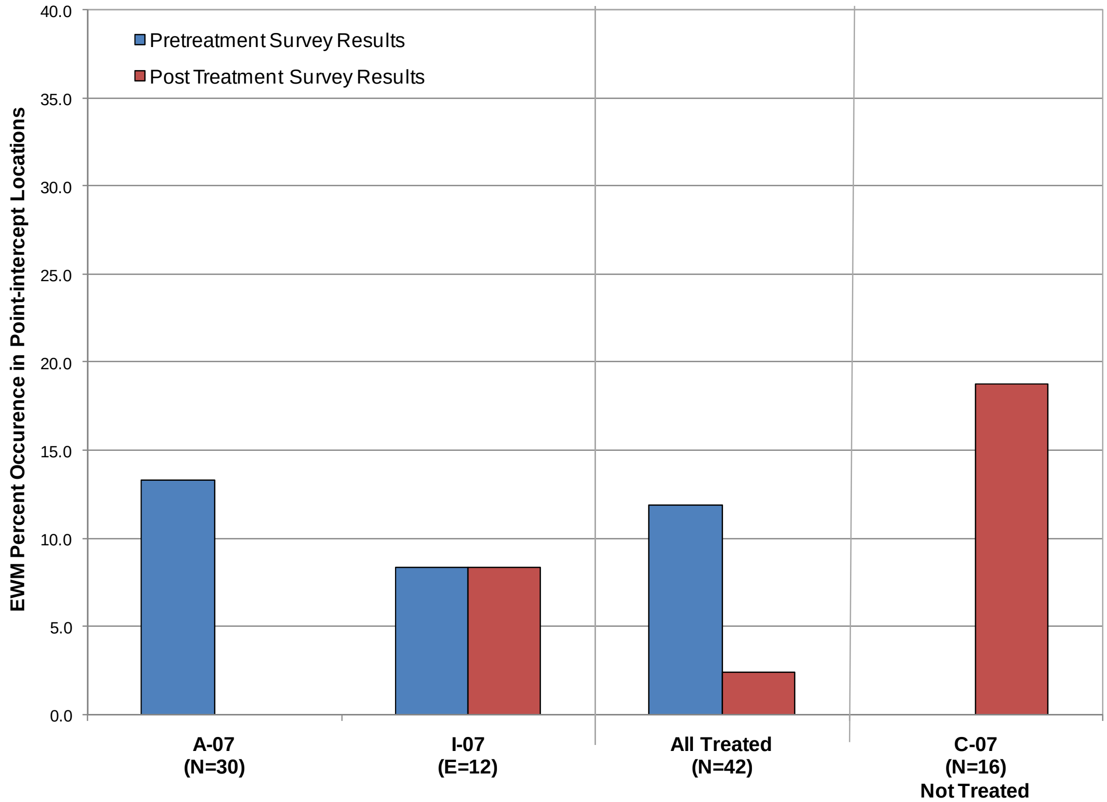

Figure 15. Eurasian water milfoil percent occurrence in point-intercept locations displayed based on treatment site. Please note the vertical axis maximum value is 40%.

Pretreatment Survey – May 2-3, 2007

The purpose of this survey was to refine the treatment areas used in the conditional permit to more accurately and effectively coordinate the control method. The weather conditions on both days were sunny and windy. Eurasian water milfoil was difficult to view from the surface, especially in deep water, due to the stained water and the windy conditions. The surface water temperature and the ambient air temperature were both approximately 55°F. The use of an aqua scope and submersed underwater camera were used to help observe Eurasian water milfoil occurrences. It has always been our opinion that the pretreatment survey is not the proper time to discover new locations of Eurasian water milfoil, but to gain an understanding of the known occurrences of the plant.

Site A Heavier Eurasian water milfoil was observed along the western part of this treatment area (Map 4) between 3-6 feet of water. The use of a submersed video camera confirmed these observations. Four of the 30 point-intercept sub-sample locations (13.3%) contained Eurasian water milfoil (Figure 15). Using the submersed video camera, there appeared to be much more Eurasian water milfoil in Site A than the rake tows suggest.

Site B Eurasian water milfoil was not observed growing in this treatment site at the time of the survey but was recommended for treatment based on the data collected by SAPC during the 2006 peak-biomass survey.

Site C No Eurasian water milfoil was located during this survey and it was not recommended for treatment. Sixteen point-intercept locations were visited in hopes of locating Eurasian water milfoil within this preliminary treatment site and would provide useful data as a control site (Figure 15).

Site D One occurrence of Eurasian water milfoil was observed in this location after numerous random rake tows were conducted within the treatment site (Map 4). Based upon advice by SAPC, a treatment was recommended. No quantitative sub-sampling was conducted.

Sites E & F No Eurasian water milfoil was located in these preliminary treatment sites but a treatment was recommended based on the previous year's peak-biomass survey and consultation with SAPC. No sub sampling occurred at these treatment sites.

Site G Many large clumps of Eurasian water milfoil were observed in this central part of this treatment area growing around the 3-6 foot depth ranges (Maps 4, 5). This treatment area was reduced in size and no sub-sampling monitoring occurred within this treatment site.

Site H Numerous occurrences of Eurasian water milfoil were located within this treatment site and its extents were modified to encompass them (Map 5). No sub-sampling occurred at this treatment site.

Site I Very little Eurasian water milfoil was observed from the surface, but numerous large clumps were discovered while slowly transversing the area with a submersed video camera. Eurasian water milfoil occurrences were marked and the treatment area was refined to encompass all these locations. This was the deepest of the treatment areas with plants growing in excess of 11 feet of water. Although only one of the 12 sub-sampling locations (8.3%) contained Eurasian water milfoil (Figure 15), qualitative survey methods documented a heavier density of Eurasian water milfoil.

Site J A few occurrences of Eurasian water milfoil were located within this treatment site and its extents were modified slightly to encompass them (Map 5). No sub-sampling occurred at this treatment site.

Post Treatment & Peak-biomass Eurasian water milfoil Survey – August 2, 2007

During this survey, all treatment areas were visited to determine the efficacy of the chemical application. The conditions were sunny and calm with Eurasian water milfoil growth reaching the surface making viewing Eurasian water milfoil relatively effortless. All point-intercept sample locations were re-visited and data were collected in the same manner as during the pretreatment survey.

Because the ELPRD was involved in a management planning process, a peak-biomass Eurasian water milfoil survey was conducted at this time to provide an accurate account of all Eurasian water milfoil locations within the lake to aid in coordinating the 2008 management actions. Please note that these recommendations are provided within this section.

Site A-07 A few occurrences of Eurasian water milfoil were observed growing throughout the treatment area, with the heaviest occurrences on the western edge (Map 6) including a 40-foot diameter colony growing along the edge of a floating-leaf species community. Eurasian water milfoil was not present in the point-intercept monitoring after the treatment (Figure 15). A portion of this treatment area is recommended for treatment in 2008 (Map 5, Site H-08), but the entire area treated in 2007 will remain a focus area for the pretreatment survey.

Site B-07 A few Eurasian water milfoil clumps were mapped growing just lakeward from this treatment site and a 2008 treatment is recommended to encompass these locations (Map 6, Site J-08). Heavier amounts of Eurasian water milfoil were observed growing west of this treatment area, tucked against (and slightly within) a floating-leaf/emergent plant community in a shallow bay (Map 6, Site I-08).

Site C-07 This site was not treated in 2007 (Maps 4, 5), but scattered amounts of Eurasian water milfoil were located during the post treatment survey (Map 6). Three of the 16 point-intercept locations (18.8%) contained Eurasian water milfoil at the time of this survey (Figure 1). A small grouping of plants was located to the north of this area (Map 6, Site L-08) within a navigation lane through a floating-leaf community. Treatments are recommended for both these areas (Map63, Sites K-08 & L-08).

Sites D, E, & F-07 Except for a single plant located in Site F-07, these treatment sites were completely void of Eurasian water milfoil. Two areas of concern were mapped in the vicinity of the 2007 treatment areas and both areas are recommended for treatment in 2008 (Map 6, Sites M-08 & N-08).

Site G-07 Only a few Eurasian water milfoil plants remained in this site after the treatment (Map 6). However, many colonies were mapped near the boat landing and five treatment areas were created to mangage these occurrences (Map 6, Sites A-08, B-08, C-08, D-08, & E-08). The Eurasian water milfoil in the eastern part of A-08 was the densest found during the peak-biomass survey.

Site H-07 A small clump of Eurasian water milfoil was located on the shallow margins of this treatment area (Map 6). Many native plants were observed in this treatment site including an overwhelming amount of large purple bladderwort, a species of special concern. A follow-up treatment is not recommended at this time.

Site I-07 Eurasian water milfoil growth could be observed almost to the surface within this treatment site, despite the water depth exceeding 11 feet in spots. Through the use of a submersed video camera, more occurrences were located. There was a definite reduction in Eurasian water milfoil occurrences within this treatment site, but numerous plants still remained. The point-intercept sub-sampling yielded the same percent occurrence (8.3%) of Eurasian water milfoil during this survey as the pretreatment survey. A roughly half-acre treatment is recommended for 2008 (Map 6, Site F-08) to encompass a relatively tight collection of Eurasian water milfoil occurrences.

Site J-07 A few Eurasian water milfoil plants were observed on the northeastern edge of this treatment area with a moderately dense colony of Eurasian water milfoil located just outside the treatment area (Map 6). Site G-08 is recommended for treatment in 2008, being constructed to encompass these Eurasian water milfoil occurrences.

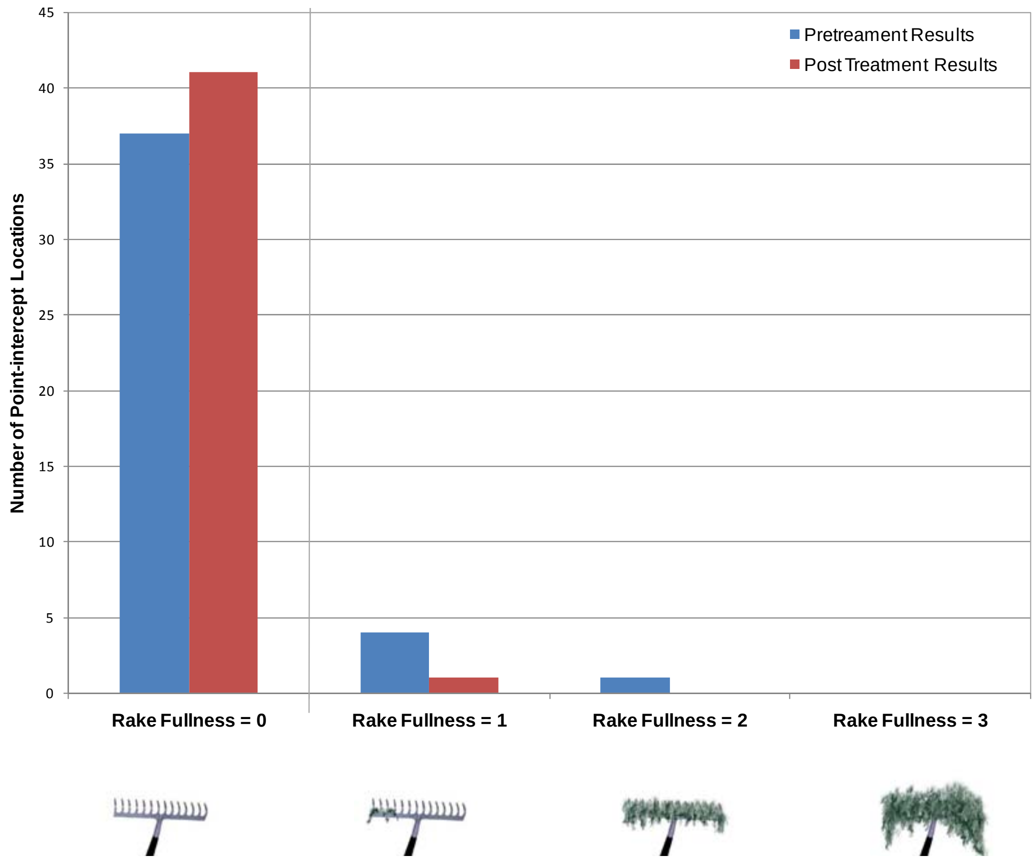

Figure 16. Eurasian water milfoil rake fullness distribution within treated areas on Enterprise Lake.

Conclusions and recommendations

Before the treatment on Enterprise Lake, 11.9% of the point-intercept locations contained Eurasian water milfoil and 4.8% contained Eurasian water milfoil after the treatment (Figure 1). A rake fullness rating of 1-3 was used to determine abundance of the Eurasian water milfoil at each location. Figure 16 displays the number of point-intercept locations exhibiting each of the rake fullness ratings within the areas treated on Enterprise Lake. The figure shows that of the 5 locations that contained Eurasian water milfoil before the treatment (Figure 15, 11.9%), all but one of those sites had a rake fullness rating of 1 (Figure 16). These data suggest a light density of Eurasian water milfoil plants within the treatment areas, as expected with a relatively new Eurasian water milfoil infestation in a lake, and may be a reason why the treatment was so effective. The post treatment survey yields only 1 sample location containing Eurasian water milfoil (Site I-07), with it displaying a rake fullness rating of 1 (Figure 16).

Although Site C-07 (Map 14) was not recommended for treatment in 2008, the point-intercept sub-sampling monitoring data was collected and served as an unintentional *control group*, allowing predictions to be made about untreated Eurasian water milfoil. The post treatment survey yielded Eurasian water milfoil in 18.8% of the locations within this site compared to zero in the pretreatment survey (Figure 15). Ten of the 16 locations are contained by the proposed treatment for 2008 (Appendix F Map) and by sampling these same points, a more valid comparison of the treatment affects on native and non-native plant species within this treatment area will be allowed.

Map 7 displays the GPS tracklog from the pretreatment survey. Please note that points were taken every 30 seconds and may over simplify the path taken. With SAPC August 2006 Eurasian water milfoil locations loaded into the sub-meter GPS technology described above, Onterra ecologists navigated to these locations and visually scoured the areas looking for Eurasian water milfoil (Map 7). Although the conditions of the lake during the pretreatment survey where not ideal (weather conditions and water clarity), the lake bottom of Site C-07 could easily be observed. It can be stated with confidence that there was no Eurasian water milfoil growing within this treatment site at the time of the May 2007 pretreatment survey. It is very likely that the Eurasian water milfoil found, and in quantities that were mappable with polygons, during the August 2007 survey was the same Eurasian water milfoil located by SAPC during August 2006. This may be a perfect example of what laypersons often claim about the inability to locate even known locations of Eurasian water milfoil during the early spring surveys. The data presented on Map 4, specifically the inset, clearly demonstrates these claims. Although it may appear that the same could be said about locations other than Site C-07, the level of confidence due to the water depth, water clarity, and weather conditions may have allowed Eurasian water milfoil to escape detection (false-negative). These data also clearly demonstrate the validity of SAPC's August 2006 survey, after it may have been questioned when Eurasian water milfoil at the provided locations could not be found during spring 2007.

With the relatively short-lived nature of the herbicide, there is absolutely no reason to place chemicals where Eurasian water milfoil plants are not actively growing. But if the Eurasian water milfoil is truly not emerging until a later date, a subsequent chemical treatment's impact on non-target, native species becomes greater. The solution to the underlying question of, 'what should be done' remains unknown. Perhaps the observations of Site C-07 indicate a fault in the survey/treatment timing currently being utilized, at least on a site-by-site basis. However, this may be negligible on a larger scale since a successful treatment was documented on Enterprise Lake in 2007.

Perhaps allowing professional license to dictate survey/treatment timing in special instances would provide additional effectiveness of the treatments, but quite possibly increase the collateral damage to non-target species. It is important to remember that the purpose of the treatment is to slow or stop Eurasian water milfoil from displacing native species and disrupting the balance of the ecosystem. Without intervention, an argument could be made that over time, Eurasian water milfoil would displace the non-target species and alter the balance of the ecosystem. Although it is never the intent of the treatments to impact native species, it is important to remember that these non-target impacts can only be considered in the context of the areas treated and not on a *lake-wide* basis. In other words, the impact of the treatments on a non-target species in the treatment areas cannot be extrapolated to the entire population of that plant within the lake, unless it is only found in locations where there is Eurasian water milfoil. The same cannot be said for Eurasian water milfoil, because by targeting Eurasian water milfoil within the lake, it is intentionally being impacted on a lake-wide basis. One may claim that an impact to non-target natives may leave a 'whole' where pioneer infestations of Eurasian water milfoil can take hold. The herbicide currently being used (Navigate®: 2,4-D) is broad-leaf (dicot) specific and as long as a particular treatment site is not dominated by broad-leaf natives, native monocots (which most aquatic plants are) will provide ample competition to ward off the non-native threat.

Conclusions made from comparing quantitative pretreatment survey data to post treatment survey data need to be understood in the context that the plants are at different phases of their lifecycle during each of the surveys. Most native plants should be at very low biomass (or not even started growing yet) during the spring survey and at their peak growth during the August survey. However, it is important to understand the effects of the dicot-specific herbicide on some of the broad-leaved natives. Table 6 shows a limited reduction in the percent occurrence of coontail. Because this plant is not rooted and is largely influenced by water movement, the observed reduction is not of a concern, especially in light of its highly common status in this and many regional waterbodies. Large purple bladderwort, as stated earlier, is a species of special concern and an observed reduction in its occurrence would be disconcerting. However, this species increased its occurrence in the treatment areas and a cursory look at the data may lead one to believe that this species responded favorably to the reduction in Eurasian water milfoil competition. This conclusion is not truly valid without having comparative data from the same time period in 2006, and even then an argument of annual variations could be made. In addition to the floating-leaf species found in Table 6 (white water lily and watershield), floating-leaf bur-reed and spatterdock were observed within the treatment areas.

Table 6. Percent occurrence of native dicots from the point-intercept survey.

	% Occurrence	
Species	**Pretreatment Results**	**Post Treatment Results**
Coontail	26.2	11.9
Large purple bladderwort	7.1	47.6
White water lily	0.0	19.0
Watershield	2.4	2.4

It is perceived that the control achieved on a *treatment-wide* level from the 2007 chemical treatments conducted on Enterprise Lake was high. Site A-07 contained a few occurrences of Eurasian water milfoil in one area which are suggested for treatment in 2008. Site I-07, the deepest of the sites, also had obtained a few occurrences of Eurasian water milfoil, but these were more isolated. A small treatment area is recommended for 2008 and its final position and size will be highly dependent on data collected during the spring 2008 pretreatment survey. The only caveat to the success of the 2007 treatment is that almost 10 acres are recommended for treatment in 2008, most of which is comprised of Eurasian water milfoil locations not discovered during the Spring 2007 survey. It is highly unlikely that these are all new occurrences of Eurasian water milfoil and special attention will need to be paid to coordinating the timing of the 2008 pretreatment survey and subsequent treatment. If the spring 2008 survey verifies the Eurasian water milfoil located during the 2007 peak-biomass survey and the 2008 treatment impacts mimic those observed in 2007, lake-wide control of Eurasian water milfoil on Enterprise Lake will be achieved.

2008 Pretreatment Survey – May 9, 12, 14, 2008

Unfortunately, the level of control perceived from the 2007 treatment may have been over estimated. Several factors lead to ineffective treatments including depth of plants, density of plants, and size of treatment area. The results of the 2008 pretreatment survey indicate that although many of the shallow (less than 5 feet) treatment areas were successful, the deeper treatment areas contained much Eurasian water milfoil (Map 8). Most notably are sites F-08 and M-08, where Eurasian water milfoil was observed growing out to 12 feet of water. With a greater volume of water existing in deeper water, a higher dose of herbicide is needed to ensure the concentration is adequate to cause depth to the target plants. Based on successes from similar lakes where Eurasian water milfoil is located growing in deep water, all treatment areas with average depths exceeding 5 feet were advised to be treated at a higher herbicide dose (150 lbs/acre).

Because of larger than anticipated treatment areas and higher costs associated with increased herbicide dosage, ELPRD was constrained by their budget. This has forced the district to prioritize the areas which were treated in 2008. Because of its proximity to the public boat landing, Site B-08 was treated. Site M-08 was also treated due to its popularity as a recreation location.

Special Note: Ongoing treatments have been occurring since this draft was written in June 2008. This information is provided within the 2009-2011 annual treatment reports. The final treatment acreages are included as the following: 2008 – 10.1 acres (Map9), 2009 – 53.2 acres (Map 10), 2010 – 32.6 acres (Map 11), and 2011 – 4.3 acres (Map 12). Only a single EWM occurrence was located during the summer 2011 EWM surveys.

SUMMARY AND CONCLUSIONS

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

1) Collect baseline data to increase the general understanding of the Enterprise Lake ecosystem.
2) Collect detailed information regarding invasive plant species within the lake with a primary focus on Eurasian water milfoil.
3) Collect sociological information from Enterprise Lake watershed inhabitants regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

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

Data primarily collected by volunteers from the ELPRD and analyzed as a part of this project, indicates that the water quality of Enterprise Lake is in good condition. The concentrations of chlorophyll-*a* and total phosphorus indicate that the lake is highly productive. Although only limited historic water quality data exists for Enterprise Lake, it appears that the concentrations of chlorophyll-*a* and phosphorus have remained relatively stable indicating a healthy lake. The stability of the water quality is also indicated by the stakeholder survey, as 60% of the respondents (Appendix B, Question #11) indicated the water quality has remained the same since they obtained their property. Continued collection of water quality data is important as it will build the dataset and make future long-trend analysis more reliable.

In general, many people equate good water quality with high water transparency. Enterprise Lake exhibits a brownish staining due to coniferous forests in the lake's watershed. Although limiting the amount of nutrients entering the lake will reduce algal production and increase water clarity, the natural staining of the lake will never allow Enterprise Lake to have crystal clear water. Over 85% of survey respondents believed the water quality of the lake to be fair or slightly better (Appendix B, Question #10), possibly indicating the respondents understanding of their lakes stained condition.

Enterprise Lake's water quality is largely influenced by its watershed, with over 7 acres of land draining to each surface-acre of the lake. Fortunately, the vast majority of the lake's watershed is comprised of wetland and forest. These cover types contribute the smallest amount of phosphorus and indicate that the watershed is in excellent shape. Because of the condition of Enterprise Lake's watershed, near shore phosphorus inputs from faulty septic systems and landscaped shorelines become the largest potential to influence the water quality of the lake.

The use of modeling on the Enterprise Lake watershed indicates that a small phosphorus source is not accounted for. While septic system failure and fertilizer use in the near shore areas may be the sources of the phosphorus, fully understanding their impacts are expensive and controversial. The role of internal nutrient dynamics within the lake is the easiest and most cost effective factor to investigate. At this time an important aspect of the water quality data that is lacking is the availability of phosphorus concentrations from the lake's hypolimnion during summer stratification, which prevented the modeling of potential internal nutrient loads. Although internal loading may not be a significant source of phosphorus in the lake's nutrient budget at this time, it would be good to document its potential now for use in comparisons in the future.

As discussed in the Aquatic Plant section, the native plant community of Enterprise Lake is of moderately high diversity and of high quality. The lake contains a healthy and rare population of large purple bladderwort as well as healthy floating-leaf and emergent plant communities. Unfortunately, this outstanding plant community is threatened by the growth and expansion of Eurasian water milfoil.

Studies conducted since 2005 have documented that Eurasian water milfoil is spreading to new areas in the lake. At this point the Eurasian water milfoil has not been found to form dense and matted colonies, but is approaching this level in some areas. Although early attempts to control Eurasian water milfoil through herbicide application techniques were initially thought to be successful, lake-wide control of Eurasian water milfoil in Enterprise Lake has not been documented. Currently, the location of Eurasian water milfoil within the lake is understood better than ever before. Incomplete treatment of Eurasian water milfoil occurrences and inadequate concentration of herbicides are factors that have contributed to only moderate successes in its management. A more comprehensive treatment strategy was devised for 2008, however much later than needed for the district to secure funds to initiate.

Aquatic invasive species are believed to be the largest factor negatively impacting Enterprise Lake (Appendix B, Question #14 & 15). While almost 70% of riparians are in favor of the responsible use of herbicides on Enterprise Lake, it is noted that approximately 20% of respondents were not in favor of herbicide use; however, to date there have not been any documented opposition to the treatments (Appendix B, Question #18). The use of biological control was shown to be the most supported technique to be used on the lake, however it is believed that this management technique was supported in the context of purple loosestrife control. The ELPRD has been successfully educating its members on the control options for purple loosestrife as the district actively controls purple loosestrife along its shores. Further education of lake stakeholders on the use of milfoil weevils to control Eurasian water milfoil should occur in order to help riparians make educated decisions about different management actions in the future. Milfoil weevils are still unproven and quite costly. Not doing anything was the least supported management action for the lake.

Other common control alternatives are infeasible and/or impractical for use in Enterprise Lake. Water level drawdown is infeasible because a sufficient water control structure does not exist on the lake; therefore, pumping would be required. Mechanical harvesting would accelerate the Eurasian water milfoil's spread through fragmentation. Currently, there is too much Eurasian water milfoil to be controlled by hand-harvesting, but in the future, this may be an appropriate technique to use in conjunction with herbicide application.

Because of the large return rate of the surveys (54%) (Appendix B), the stakeholder survey for Enterprise Lake can be used as a powerful tool to understand the perceptions of the lake's stakeholders. One positive observation of the survey is stakeholders ranked 4 passive recreational activities as their most enjoyable on Enterprise Lake (Appendix B, Question #6). The two most popular watercraft types on the lake were a canoe/kayak and motor boat with greater than a 25 horsepower motor (Appendix B, Question #5), indicating that Enterprise Lake is a popular location for active and passive recreation types. All forms of recreation can be enjoyed on Enterprise Lake if done in a responsible manner. Existing slow no wake areas preserve the ecology of sensitive areas of Enterprise Lake along with providing a location for passive activities to take place. As indicated by the stakeholder survey, relaxing/entertaining is the second most enjoyable activity on the lake (Appendix B, Question #6). The implementation of slow no wake hours may further reduce user conflict by allowing riparians to enjoy sunrises and sunsets without the noises caused by high-speed watercraft traffic.

IMPLEMENTATION PLAN

The intent of this project was to complete a *comprehensive* management plan for Enterprise Lake. As described in the sections above, a great deal of analysis was completed involving many aspects of the Enterprise Lake ecosystem.

Management Goal 1: Increase Enterprise Lake Protection & Rehabilitation District's Capacity to Communicate Information with Lake Stakeholders

Management Action: Develop district website
Timeframe: Begin summer 2008
Facilitator: Planning Committee to form Education Committee
Description: The ELPRD is motivated to create a website for the district where information, such as this, could be posted along with fostering unity amongst district members. The website will be constructed in an easy-to-use format to ensure stakeholders of all levels of computer literacy will have access to the information posted.
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. Facilitators gather appropriate information relating to website development and event organization.

Management Goal 2: Maintain Current Water Quality Conditions

Management Action: Monitor water quality through WDNR Citizens Lake Monitoring Network
Timeframe: Ongoing
Facilitator: Planning Committee
Description: Currently monitoring of water quality is conducted by an ELPRD volunteer through the program's advanced protocol. It is important to continue this monitoring as early discovery of negative trends may lead to the reason as to why the trend is developing. The volunteer monitoring of the water quality is a large commitment and new volunteers may be needed in the future as the volunteer's level of commitment changes. It is the responsibility of the Planning Committee to coordinate new volunteers as needed. Note: as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.
Action Steps:

Please see description above.

Management Action: Understand nutrient dynamics within the lake including internal nutrient loading.
Timeframe: Ongoing
Facilitator: Planning Committee with professional monitoring as needed

Description: As discussed in the water quality section and the summary and conclusion section, the water quality parameters investigated during this study did not allow for a complete understanding of nutrient dynamics within the lake. Additional parameters that need investigation include: 1) total phosphorus concentrations at near surface and near bottom depths during the growing season and 2) dissolved oxygen concentrations within the water column during the growing season.

Action Steps:

1. Retain consultant to create study design
2. Obtain WDNR grant
    a. Purchase LDO probe for the district
    b. Consultant trains volunteer on LDO use and data collection
    c. Consultant collects appropriate water quality data
    d. Consultant analyzes and reports results

Management Action: Reduce phosphorus and sediment loads from immediate watershed.
Timeframe: Begin 2008
Facilitator: Planning Committee to form Education Committee
Description: Enterprise Lake has a moderately large watershed draining to it and as a result, the impacts that are most controllable at this time originate along the lake's immediate shoreline. These sources include faulty septic systems, the use of phosphorus-containing fertilizers, shoreland areas that are maintained in an unnatural manner, and impervious surfaces. To reduce these impacts, the ELPRD will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. Educational information will be available on the website, sent to district members as a part of their newsletter or within a special mailing, and/or provided at district events like the annual boat parade or a lake fair.

Topics of educational items may include benefits of good septic system maintenance, methods and benefits of shoreland restoration, including reductions in impervious surfaces. Projects that include shoreline condition assessment and restoration activities will be better qualified to receive state funding in the future. These activities could be completed as an amendment to this management plan and would be appropriate for funding through the WDNR small-scale Lake Planning Grant program. Ecologically high-value areas delineated during the survey would also be selected for protection, possibly through conservation easements or land trusts (www.northwoodslandtrust.org).

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Action Steps:

1. Recruit facilitators
2. Facilitators summarize educational material collected from WDNR, UW-Extension, and County Land Conservation sources for the creation of informative materials
3. Facilitators disperse materials to stakeholders

Management Goal 3: Control Aquatic Invasive Species within Enterprise Lake

<u>Management Action:</u> Reduce occurrence of purple loosestrife on Enterprise Lake shorelands
Timeframe: Ongoing
Facilitator: Invasive Species Committee
Description: Purple loosestrife can be found in low occurrence along the shorelands of Enterprise Lake and has been successfully controlled in the past using hand-removal techniques. Information sources, such as the WDNR, UW-Extension, Langlade County Land Conservation Department, and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) will be used to properly identify purple loosestrife and provide guidance on the proper time to perform management actions.

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

Action Steps:
1. Recruit new members to begin monitoring and control efforts
2. Group completes field surveys to identify infested areas
3. Initiate applicable control methods
4. Monitor results and reapply control as necessary
5. Keep WDNR and ELPRD informed regarding program results

<u>Management Action:</u> Continue Clean Boats Clean Waters watercraft inspections at Enterprise Lake Public Boat Landing.
Timeframe: In progress
Facilitator: Planning Committee
Description: Currently the ELPRD monitors the public boat landing using training provided by the Clean Boats Clean Waters program. Enterprise Lake is a popular destination by recreationists and anglers, making the lake vulnerable to new infestations of exotic species. Although the lake already contains aquatic invasive species, it is still important to minimize the chance of new infestations of aquatic invasive species to be introduced to the lake and ensure that Enterprise Lake is not the source of aquatic invasive species for other waterbodies.

Action Steps:
1. Members of district attend Clean Boats Clean Waters training session (completed during spring of 2007)
2. Training of additional volunteers completed by those trained during 2007
3. Begin inspections during high-risk weekends
4. Report results to WDNR and ELPRD
5. Promote enlistment and training of new of volunteers to keep program fresh

<u>Management Action:</u> Coordinate annual volunteer monitoring of Aquatic Invasive Species
Timeframe: Start 2008
Facilitator: Planning Committee
Description: In lakes without Eurasian water milfoil, 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. Although the intensity of Eurasian water milfoil in Enterprise Lake requires professionally conducted surveys, Eurasian water milfoil occurrences mapped by the volunteers will be used as supplemental information for the professional monitoring efforts.

Action Steps:

1. Recruit volunteers to conduct field surveys
2. Retain consultant to coordinate monitoring strategy
3. Obtain WDNR grant
    a. Purchase GPS unit for district
    b. Consultant trains volunteers on GPS use and data collection
    c. Consultant trains volunteers on native/non native species identification
    d. Volunteers transfer data to consultant for integration and graphical representation

<u>Management Action:</u> Control Eurasian water milfoil infestation on Enterprise Lake using herbicide applications.
Timeframe: Initiate 2008
Facilitator: Planning Committee with professional help as needed
Description: As described in the Aquatic Plant section and elaborated upon within the Summary and Conclusions, Enterprise Lake is believed to currently contain approximately 30 acres of Eurasian water milfoil. At this time, the most feasible method of control is herbicide applications, specifically, early-spring treatments with 2,4-D. The responsible use of this technique is well supported by Enterprise Lake stakeholders as indicated by approximately 70% of stakeholder survey respondents indicating that they are at least moderately supportive of an herbicide control program (Appendix B, Question #18).

Although the results of the stakeholder survey indicate that biological control is the most supported management technique (Question #18), it is believed that the respondents are referring to the use of *Galleracella* spp. beetles to control purple loosestrife and not milfoil weevils to control Eurasian water milfoil.

Treatment success of granular 2, 4-D at 100 lbs/acre on Eurasian water milfoil was documented in 2007 on low density, relatively shallow colonies of Eurasian water milfoil. Eurasian water milfoil assessments located plants at greater depths than those treated in 2007 and an understanding of the factors that influence chemical concentrations will prove to be important in selecting the appropriate dose of herbicide to be applied.

The objective of this management action is not to eradicate Eurasian water milfoil from Enterprise Lake, as that would be impossible. The objective is to bring Eurasian water milfoil down to more easily controlled levels. In other words, the goal is to reduce the amount of Eurasian water milfoil in Enterprise Lake to levels that would only require spot treatments to keep the exotic 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 lakewide assessment of Eurasian water milfoil completed while the plant is at peak biomass (July or August).
2. Creation of treatment strategy for the following spring.
3. Verification and refinement of treatment plan immediately before treatments are implemented.
4. Completion of treatments.
5. Assessment of treatment results (summer after treatment).

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 treatment strategy.

Obviously, monitoring is a key aspect of the cycle, both to create the treatment strategy and monitor its effectiveness. The monitoring would also facilitate the "tuning" or refinement of the treatment strategy as the control project proceeds. It must be remembered, that this portion of the management plan (control plan) would be intended to span approximately 5 years, before it would need to be updated to account for changes within the ecosystem. The ability to tune the treatment strategies is important because it would allow for the most effective results to be achieved within the plan's life span.

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. The quantitative strategies include sampling plants, both Eurasian water milfoil and native species, at predetermined locations (points) within treatment areas, while the qualitative monitoring includes the determination of Eurasian water milfoil abundance based upon a continuum of density. The density continuum ranges from non-detectable levels of Eurasian water milfoil to what is considered a monoculture where Eurasian water milfoil is essentially the only plant that exists in the area. Both monitoring types would be completed before and after the treatments (pretreatment surveys and post treatment surveys). 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. Finally, a lakewide plant survey (point-intercept survey) would be completed after this management action is completed (5 years) to determine the effectiveness of the intense control program.

Success Criteria

Determining the effectiveness of the treatment program is impossible unless specific success criteria (goals) are set before beginning the program. For this control program, the criteria would be evaluated at three levels

1. Treatment area (site specific)
2. Annual treatment (treatment wide)
3. Control program

Treatment Area

Qualitatively, a successful treatment on a particular site would include a reduction of Eurasian water milfoil density as demonstrated by a decrease in density rating.

Quantitatively, a successful treatment on a specific-site level would include a significant reduction in Eurasian water milfoil frequency following the treatments as exhibited by at least a 50% decrease in Eurasian water milfoil frequency from the pre- and post treatment point-intercept sub-sampling. In other words, if the Eurasian water milfoil frequency of occurrence before the treatment was 40%, the post treatment frequency would need to be 20% or lower for the treatment to be considered a success for that particular site. Further, there would be a noticeable decrease in rake fullness ratings within the fullness categories of 2 and 3.

Annual Treatment

Qualitatively, success would be achieved annually when 75% of the treatment areas are reduced by a density rating (as described above).

Similar to the site specific evaluation, annual treatment success would be observed when a 50% decrease in Eurasian water milfoil frequency from the sub-sampling occurs. Preferably, there would be no rake tows completed during the post treatment surveys exhibiting a fullness of 2 or 3.

Control Program

At the end of the project, it is hoped that no Eurasian water milfoil colonies would exist over *density=1*. Ecological function of a particular area is thought to be greatly reduced when Eurasian water milfoil becomes the dominant plant which corresponds to a *density=1* rating.

The control program would be quantitatively evaluated by recompleting the whole-lake point-intercept survey at the end of the project and observing a reduction in frequency of Eurasian water milfoil.

Control Program Specifics

This control program is anticipated to span 5 treatment years. Although it is very difficult, if not impossible, to accurately estimate how many acres of Eurasian water milfoil will need to be treated for some number of years in the future, it is obviously needed for budgeting purposes. Based upon the Eurasian water milfoil surveys completed in recent years and the results of recent treatments, a conservative estimate of treatment acreages is listed below. It is conservative in anticipation of some areas requiring treatment for multiple years to reduce densities as discussed in the success criteria.

Project Year	Treatment Year	Estimated Acreage
2009	1	40
2010	2	30
2011	3	25
2012	4	20
2013	5	10

Project Funding Assistance
Funds from the Wisconsin Department of Natural Resources Aquatic Invasive Grant Program will be sought to partially fund this control program and other elements of this management plan. Specifically, funds would be applied for under the Established Infestation Control Project classification.

Action Steps:

1. Retain qualified professional assistance to develop a specific project design utilizing the cyclic series of steps discussed above.
2. Apply for a WDNR Established Infestation Control Grant based on developed project design.
3. Initiate control plan
4. Revisit control plan in 5 years
5. Update management plan to reflect changes in control needs and those of the lake ecosystem.

Management Action: Monitor native and non-native aquatic plants on a lake wide basis in Enterprise Lake.
Timeframe: Initiate 2013
Facilitator: Planning Committee with professional help as needed
Description: Much of the discussion within the study results pertaining to treatment effectiveness revolve around monitoring that was completed in and near the known locations of Eurasian water milfoil colonies, of which the majority are treatment areas. Although repeating these surveys at specific times of the year can lead to an understanding of how the native and non-native plant communities are reacting to the treatments, that data can only be used to make those determinations within the treatment areas and cannot be extrapolated to the effects on the entire lake. This is especially true of the non-target (native) plants. To determine the effects of the control program on a lake wide basis, a survey must be completed that inventories the lake's entire plant community.

The crux of this action will be the repeat completion of the whole lake point-intercept survey completed in 2005. The data collected during the 2013 survey will be compared with the 2005 data with the intent of determining the success of the control plan on a lake wide basis and the impact of it on the native plant community of Enterprise Lake.

Action Steps:

Please see description above.

Management Goal 4: Minimize User Conflicts

Management Action: Investigate creation and enforcement of slow-no-wake hours on Enterprise Lake.

Timeframe: Begin 2008

Facilitator: Planning Committee

Description: Like most lakes, Enterprise Lake is visited by numerous user groups that recreate on the lake in different ways. Some lake users prefer more passive recreation like, swimming, fishing, or paddling; while others prefer more active recreation, like jet skiing, motor boating, and waterskiing. Question #6 of the stakeholder survey indicates that both passive and active forms of recreation are popular on the lake. Occasionally the use by these different groups overlaps and causes conflicts. Ten of the 77 returned surveys listed the use of jet skis within the comments section as negatively impacting Enterprise Lake. Also, boat traffic was identified by almost 80% of respondents as a factor that negatively impacted their lake (Question #15). An appropriate remedy to these conflicts is setting certain hours of the day aside on a lake for more passive forms of recreation.

The intent of this management action would be to investigate the *possibility* of creating slow-no-wake hours for Enterprise Lake. This would include the collection of stakeholder opinions regarding the idea and preliminary discussions with the Town of Elcho regarding the development of ordinances.

Action Steps:

See description above.

Management Action: Gain an understanding of water levels on Enterprise Lake

Timeframe: Initiate 2008

Facilitator: Planning Committee to recruit volunteer

Description: Six of the 77 returned surveys indicated water levels as a factor that negatively impacts Enterprise Lake. Although most of the survey respondents indicated that water levels should be higher, during the planning meeting associated with this project, it was indicated that there are is also a subset of riparians that believe the water level is too high.

According to the WDNR's dam database shapefile (damxpoin.shp), Enterprise Lake contains a water control structure at its outlet. In actuality, the water control structure is a series of culverts (see photo below) that allow water to flow under Outlet Drive. Apparently, it is a relatively common belief among riparians that beaver activity on the lake's outlet (Enterprise Creek) has the largest influence on Enterprise Lake's water levels.

As a natural part of the ecosystem, beavers are able to influence water levels and potentially create user conflicts. However, the influence of beavers on the water levels of a lake is often over-estimated. WDNR regulations (NR12) clearly state that aside from legal harvest of beavers by a licensed trapper, beaver control will be permitted only when property damage is documented.

At the current time, only anecdotal data exists relating to water levels on Enterprise Lake. It is understood that historic data exists relating to water levels, possibly including a metal benchmark located near the lake's inlet. Setting a staff gauge near the lake's outlet will allow lake user's to have a more accurate understanding of their lake's water levels.

Action Steps:

1. Planning Committee investigates historic information relating to water level and sets a staff gauge.
2. Planning Committee recruits multiple volunteers so water levels can be recorded on a weekly basis.
3. A water level database is collected.
4. Volunteers graphically report water levels at the district's annual meeting.

Photo 1. Culverts under Outlet Drive. The picture shows that the road may function as an earthen dam to control the boundaries of the lake, but flow is only minimally restricted by these three large culverts. This location is most likely the appropriate place to put a staff gauge.

METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Enterprise Lake (e.g., elevated phosphorus levels, etc.). Water quality was monitored at the deepest point in Enterprise Lake (Map 1). Volunteer collected surface samples were taken with a 6-foot integrated sampler. Sampling occurred once in fall, three times during summer. All 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:

Water Quality Sample Parameters and Timing. ♦ indicates samples collected as a part of the Citizen Lake Monitoring Network. ● indicates additional samples collected by management planning project *Winter sample collected by Onterra. Winter dissolved oxygen determined with calibrated probe and all samples collected with a 3-liter Van Dorn bottle. Surface samples were collected at 3 feet below water surface and bottom samples were taken approximately 3 feet off the bottom.

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

In addition, during each sampling event Secchi disk transparency was recorded.

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Enterprise Lake during a June 28, 2007 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. Submersed aquatic video was used on an area that once contained this plant species.

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

"Appendix C" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin, (April, 2005) was used by the WDNR to complete this study in August 2005. A point spacing of 60 meters was used resulting in approximately 563 points.

Community Mapping – Scheduled June 2008

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

2007 Treatment Monitoring

The methodology used to monitor the 2007 herbicide treatments is included within the results section under the heading: *Treatment Monitoring.*

Watershed Analysis

The watershed analysis began with an accurate delineation of Enterprise 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)

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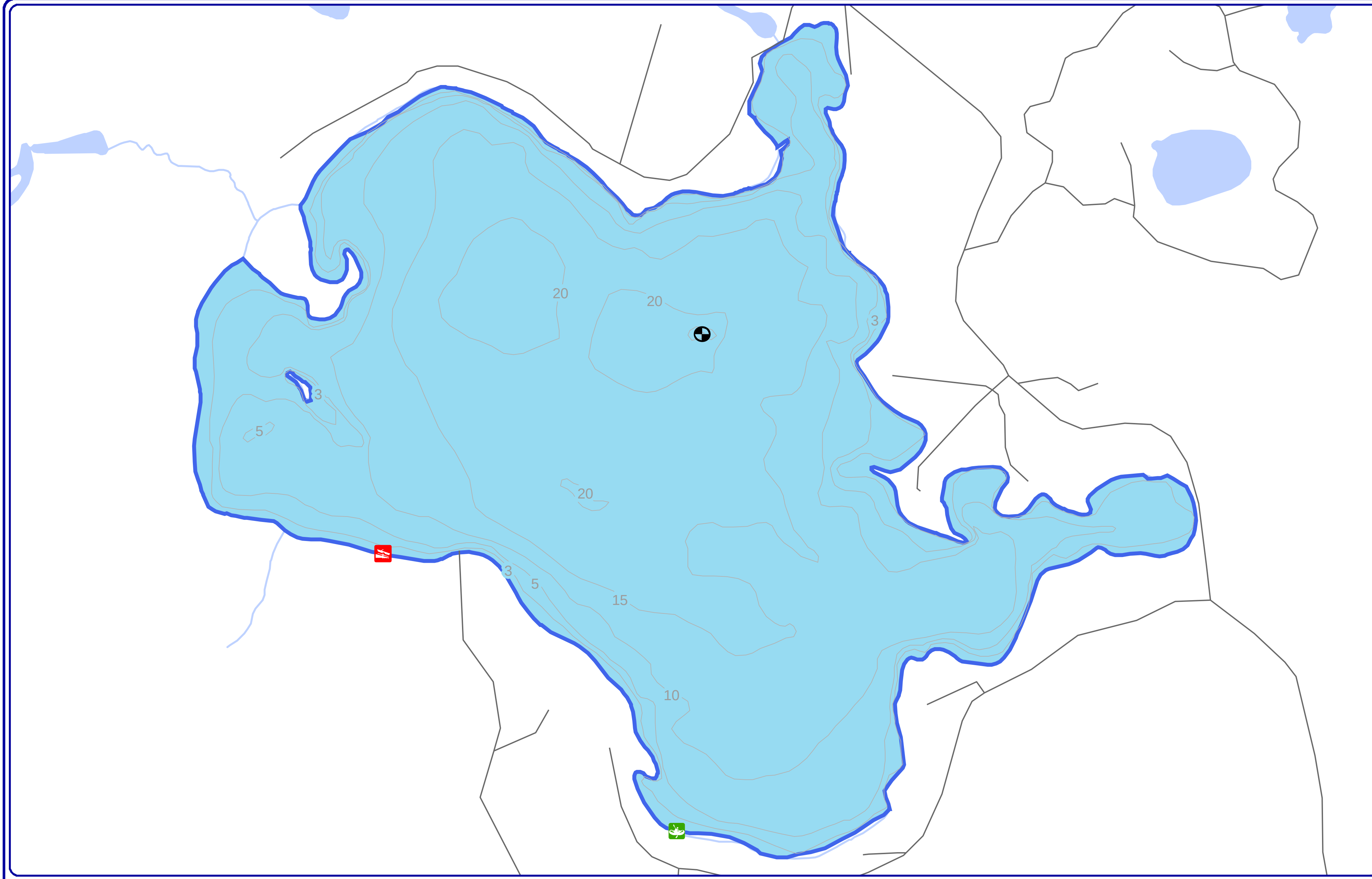

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Feet

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De Pere, WI 54115
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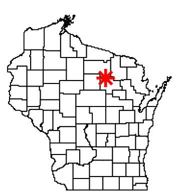
Sources:
Roads and Hydro: WDNR
Modified Hydro: Onterra, 2010
Orthophotography: NAIP, 2010
Map Date: June 23, 2011
File Name: Map1_FrogBass_Location.mxd



Project Location in Wisconsin

Legend

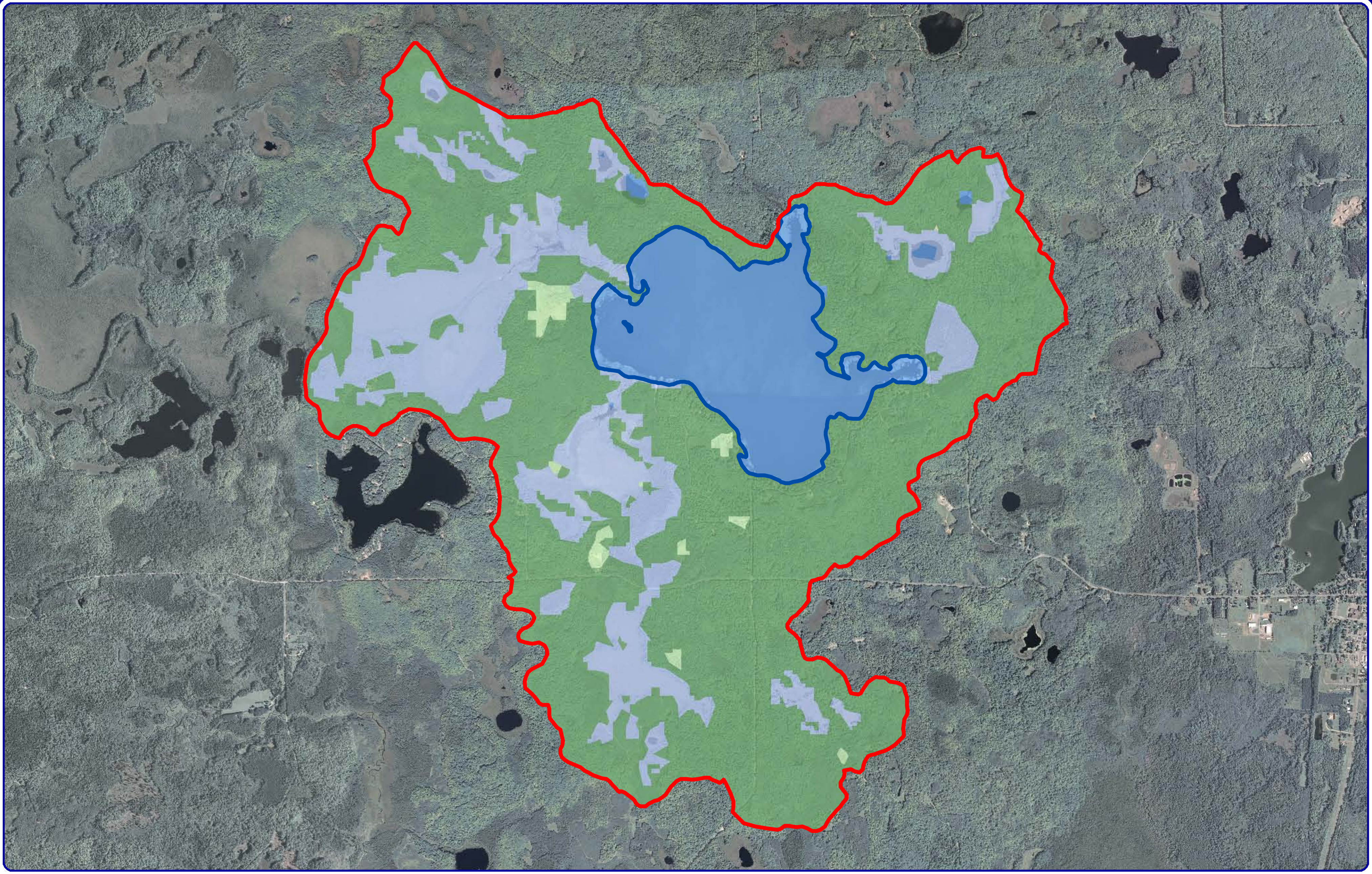
Enterprise Lake - 505 acres
WDNR Definition
Water Quality Sampling Location
Carry-in Access Location
Public Boat Landing

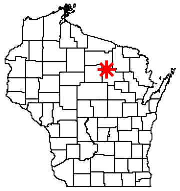
Map 1

Enterprise Lake

Langlade County, Wisconsin

Project Location &
Water Quality Sampling Site





Project Location in Wisconsin

Legend

Watershed Boundary

Land Cover Types

- Pasture/Grass
- Forest
- Open Water
- Wetland

Map 2

Enterprise Lake

Langlade County, Wisconsin

Watershed and Land Cover Types

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De Pere, WI 54115
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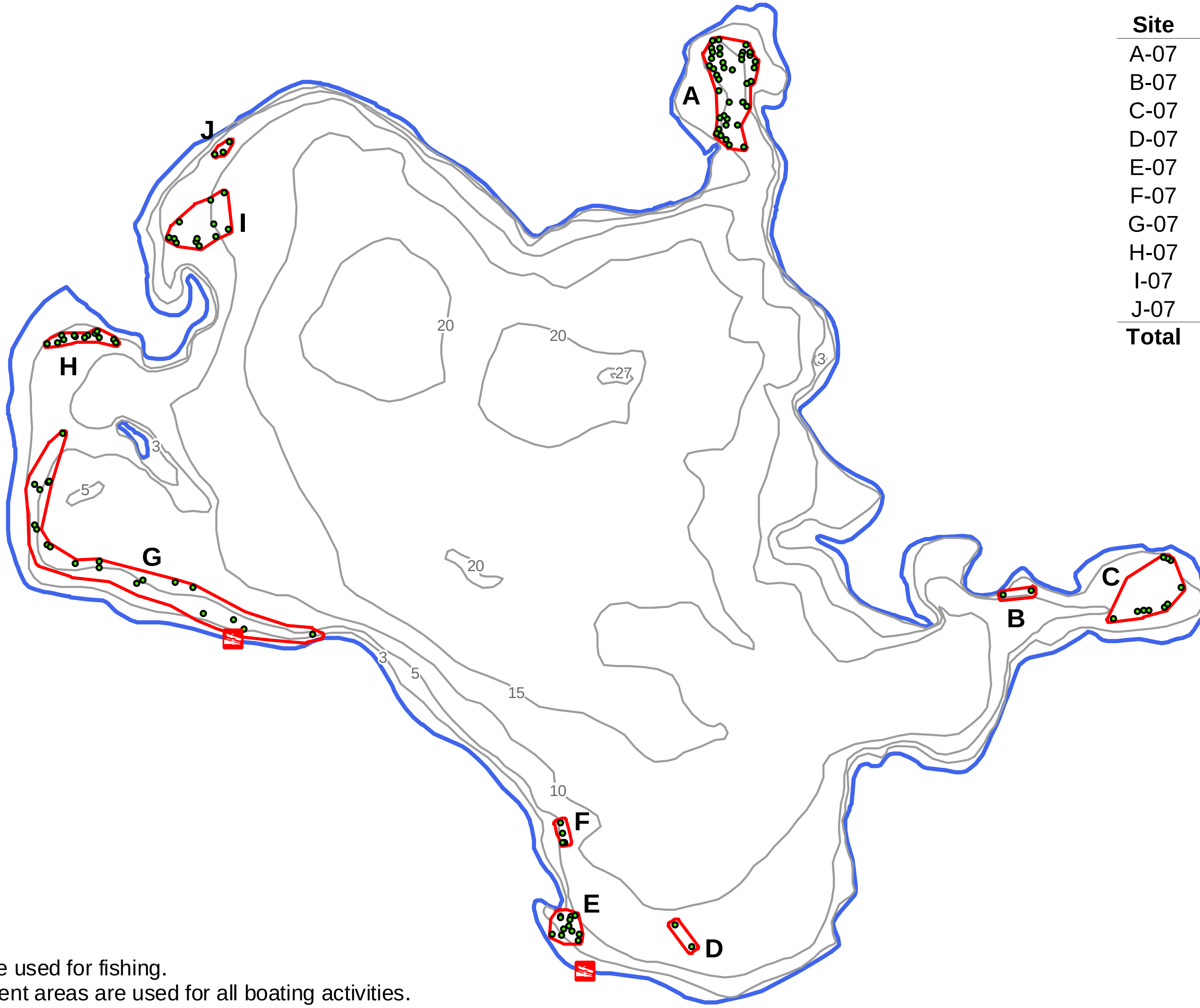
<Bol>Sources:</Bol>
Watershed: WDNR & Onterra
Landcover: WISCLAND
Hydro: WDNR
Orthophotography: NAIP, 2010
Map Date: October 14, 2011
Filename: Map2_Ent_Watershed.mxd



Site	Acres	Ave Z (ft)
A-07	3.8	5
B-07	0.3	4
C-07	2.9	4
D-07	0.4	7
E-07	0.9	4
F-07	0.3	5
G-07	8.4	4
H-07	0.7	4
I-07	2.3	7
J-07	0.2	6
Total	**20.2**	

Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.

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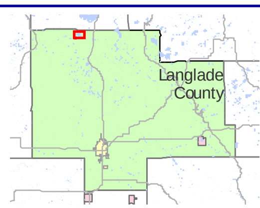
Sources:
Roads & Hydro: WDNR
Aquatic Plants: Schmidt, 2006
Bathymetry: WDNR (Digitized by Onterra)
Map date: February 15, 2007



Extent of large map shown in red.

Legend

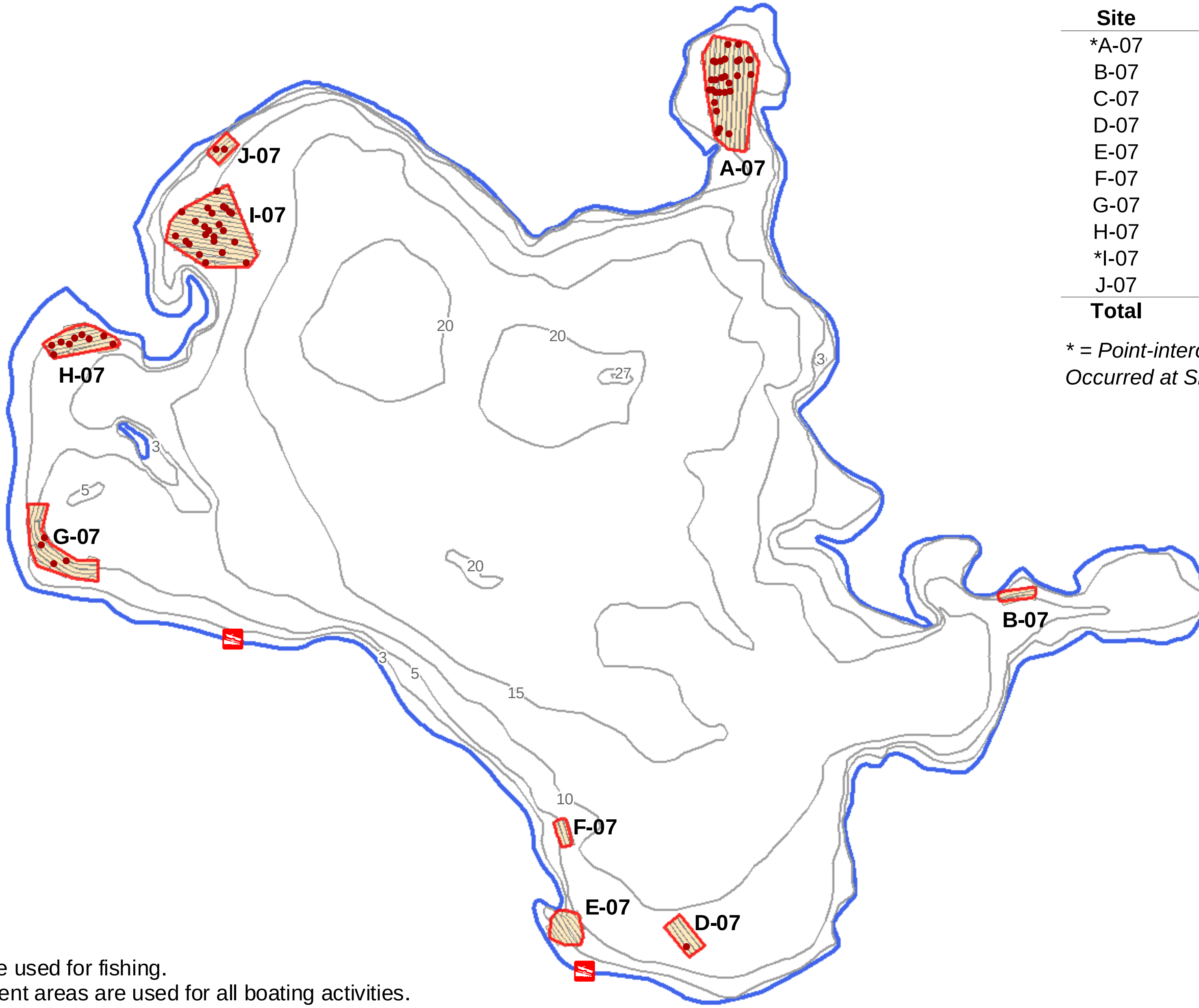
- EWM - WDNR P-I Survey (2005)
- EWM - SAPC Survey (Fall 2006)
- Proposed EWM Treatment Area

Map 4

Enterprise Lake

Langlade County, Wisconsin

2007 Proposed
EWM Treatment Areas
Used for Conditional Permit



Site	Acres	Ave Z (ft)
*A-07	4.5	5
B-07	0.3	4
C-07	Dropped	
D-07	0.7	7
E-07	0.9	4
F-07	0.3	5
G-07	1.9	4
H-07	1.5	4
*I-07	4.5	9
J-07	0.4	6
Total	**15.0**	

** = Point-intercept Sub-sampling Occurred at Site, See Appendix A.*

Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.

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Feet

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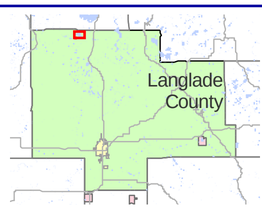
Sources:
Roads & Hydro: WDNR
Aquatic Plants: Onterra, May 2007
Application Path: SAPC, 2007
Bathymetry: WDNR (Digitized by Onterra)
Map date: May 6, 2007



Extent of large map shown in red.

Legend

- EWM Location — Mapped by Onterra - May 2007
- 2007 Final EWM Treatment Area
- Approximate Herbicide Application Path

Map 5

Enterprise Lake

Langlade County, Wisconsin

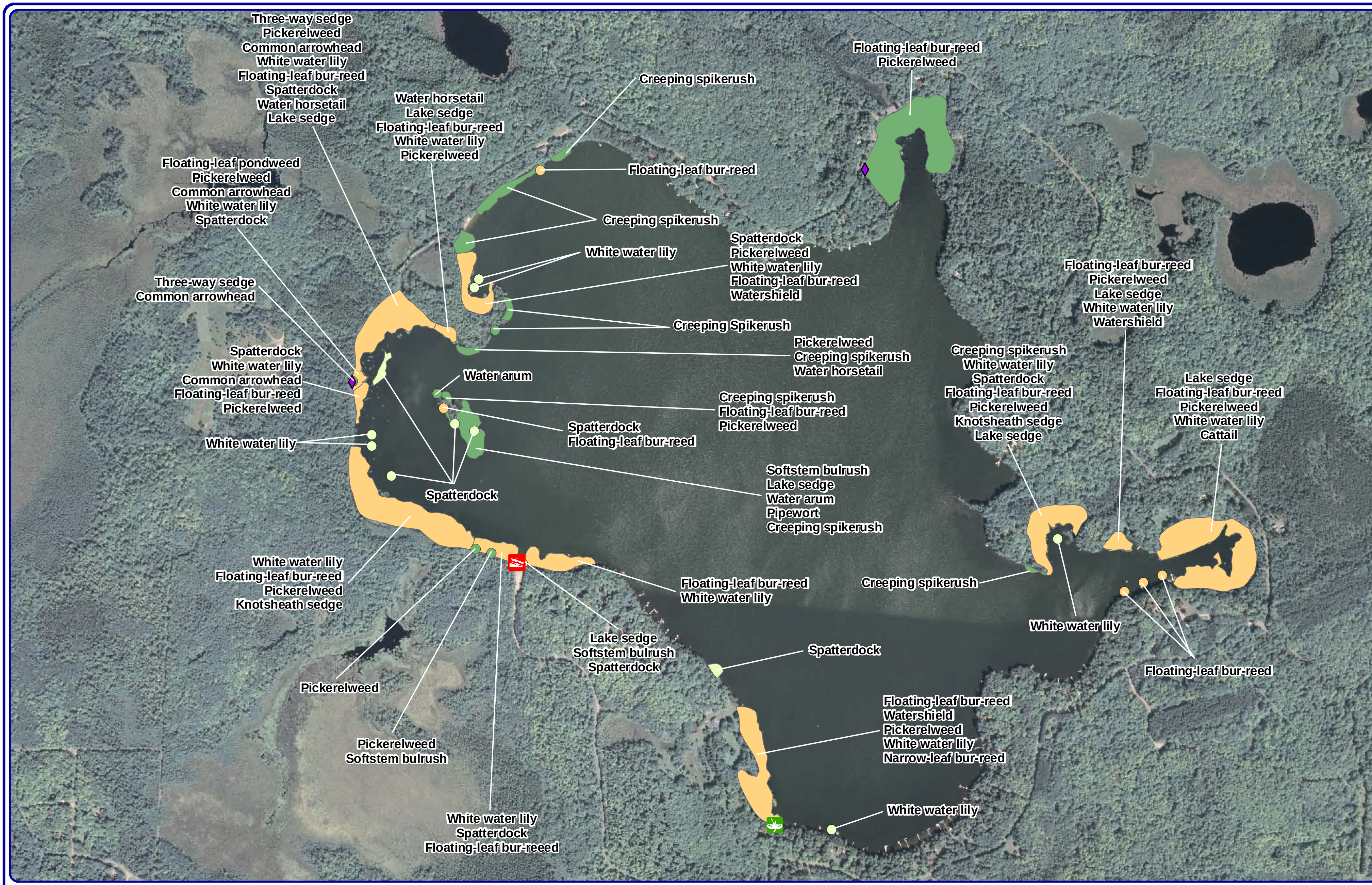
2007 Finalized Eurasian Water Milfoil Treatment Areas

Map 5

Enterprise Lake

Langlade County, Wisconsin

Aquatic Plant Communities



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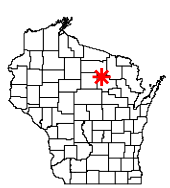
Small Plant Communities

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

Large Plant Communities

- Emergent
- Floating-leaf
- Mixed Floating-leaf and Emergent



Project Location in Wisconsin

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Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
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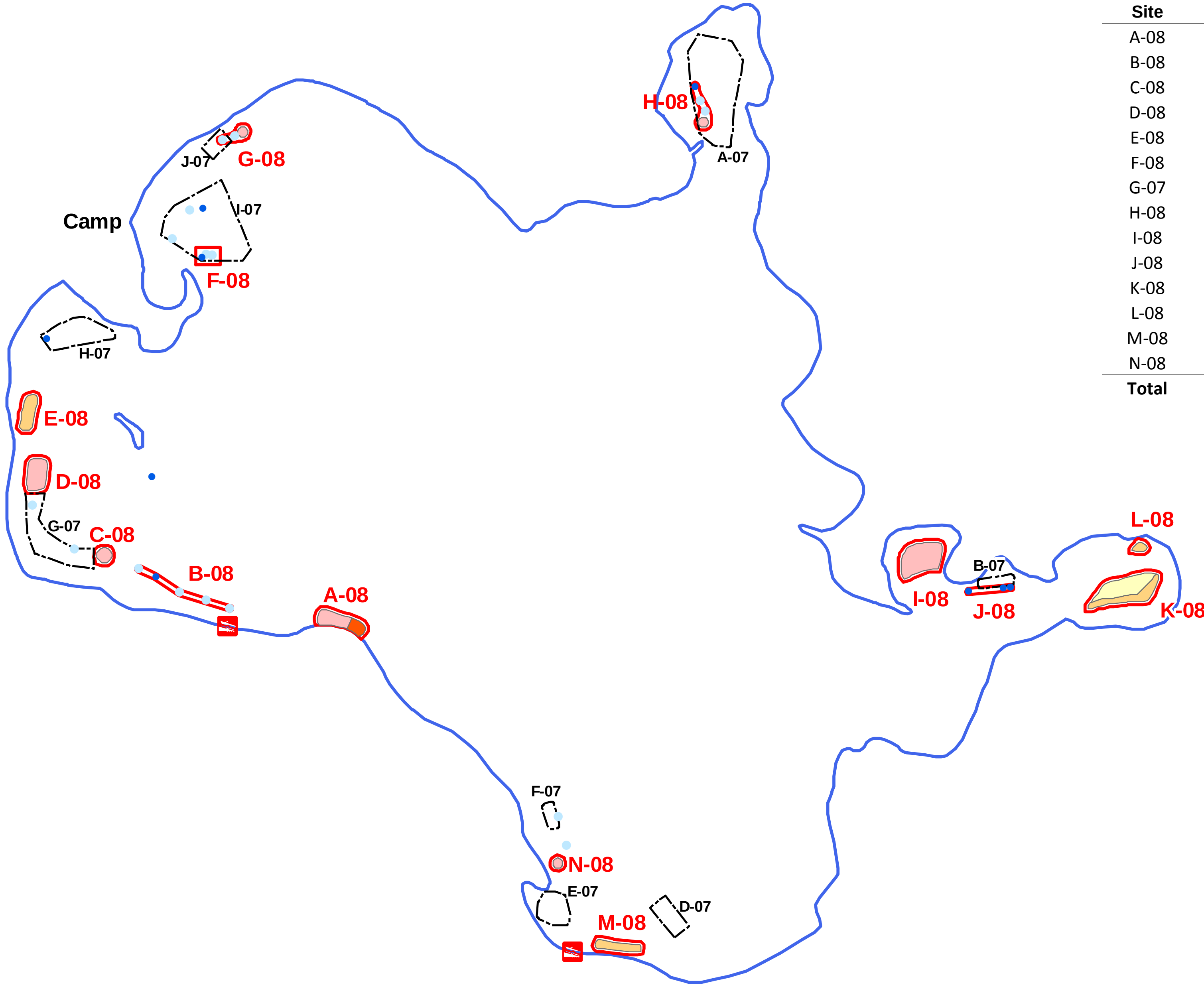
Sources:
Orthophotography: NAIP, 2010
Aquatic Plant Survey: Onterra, 2008
Map date: October 14, 2011
File Name: Map5_Ent_Comm_2008.mxd



Site	Acres	Ave Z (ft)
A-08	0.9	5
B-08	0.6	7
C-08	0.3	6
D-08	0.9	6
E-08	0.7	6
F-08	0.4	9
G-07	0.4	6
H-08	0.5	5
I-08	1.5	4
J-08	0.3	5
K-08	2.0	5
L-08	0.2	5
M-08	0.7	5
N-08	0.2	6
Total	**9.6**	

N W E S

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Feet

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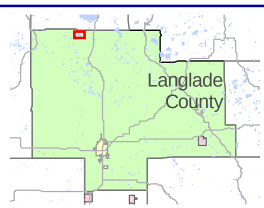
Sources:
Roads & Hydro: WDNR
Aquatic Plant Survey: Onterra, August 2007
Map date: December 10, 2007



Extent of large map shown in red.

Legend

May 2007 Chemical Treatment Area

Proposed 2008 Treatment Area

EWM Small Colony (August '07)
- Single or Few Plants
- Many Plants or Clumps of Plants

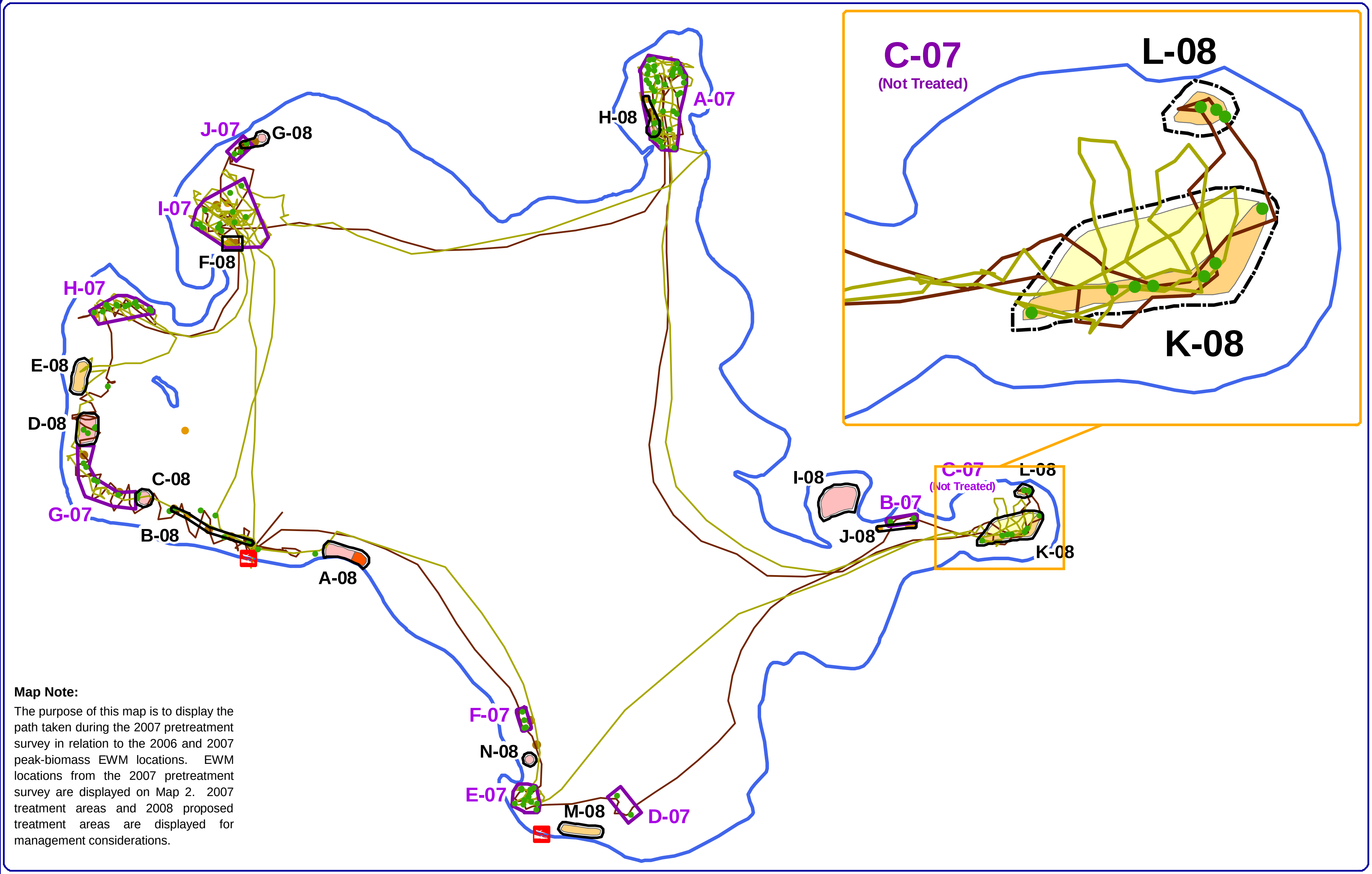
EWM Large Colony (August '07)
- Highly Scattered
- Scattered
- Density = 1
- Density = 2
- Density = 3 (None Mapped)

Map 6

Enterprise Lake

Langlade County, Wisconsin

2007 Peak-biomass EWM Locations & 2008 Proposed Treatment Areas



Map Note:

The purpose of this map is to display the path taken during the 2007 pretreatment survey in relation to the 2006 and 2007 peak-biomass EWM locations. EWM locations from the 2007 pretreatment survey are displayed on Map 2. 2007 treatment areas and 2008 proposed treatment areas are displayed for management considerations.

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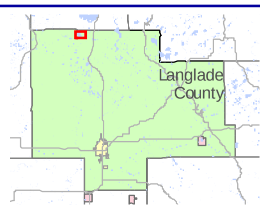
Sources:
Roads & Hydro: WDNR
2006 Aquatic Plant Survey: SAPC
2007 Aquatic Plant Survey: Onterra

Map date: December 10, 2007



Extent of large map shown in red.

Legend

SAPC - Aug '06 EWM Occurence

Treatment Sites

2007 Treatment Areas Treated May 8, 2007

2008 Proposed Treatment Areas

EWM Large Colony (Onterra, Aug '07)

- Highly Scattered
- Scattered
- Density = 1
- Density = 2
- Density = 3 (None Mapped)

EWM Small Colony (Onterra, Aug '07)

- Clumps of Plants
- Single or Few Plants

Tracklog: 2007 Pretreatment Survey

- Day 1 (May 1, 30-second interval)
- Day 2 (May 2, 30-second interval)

Map 7

Enterprise Lake

Langlade County, Wisconsin

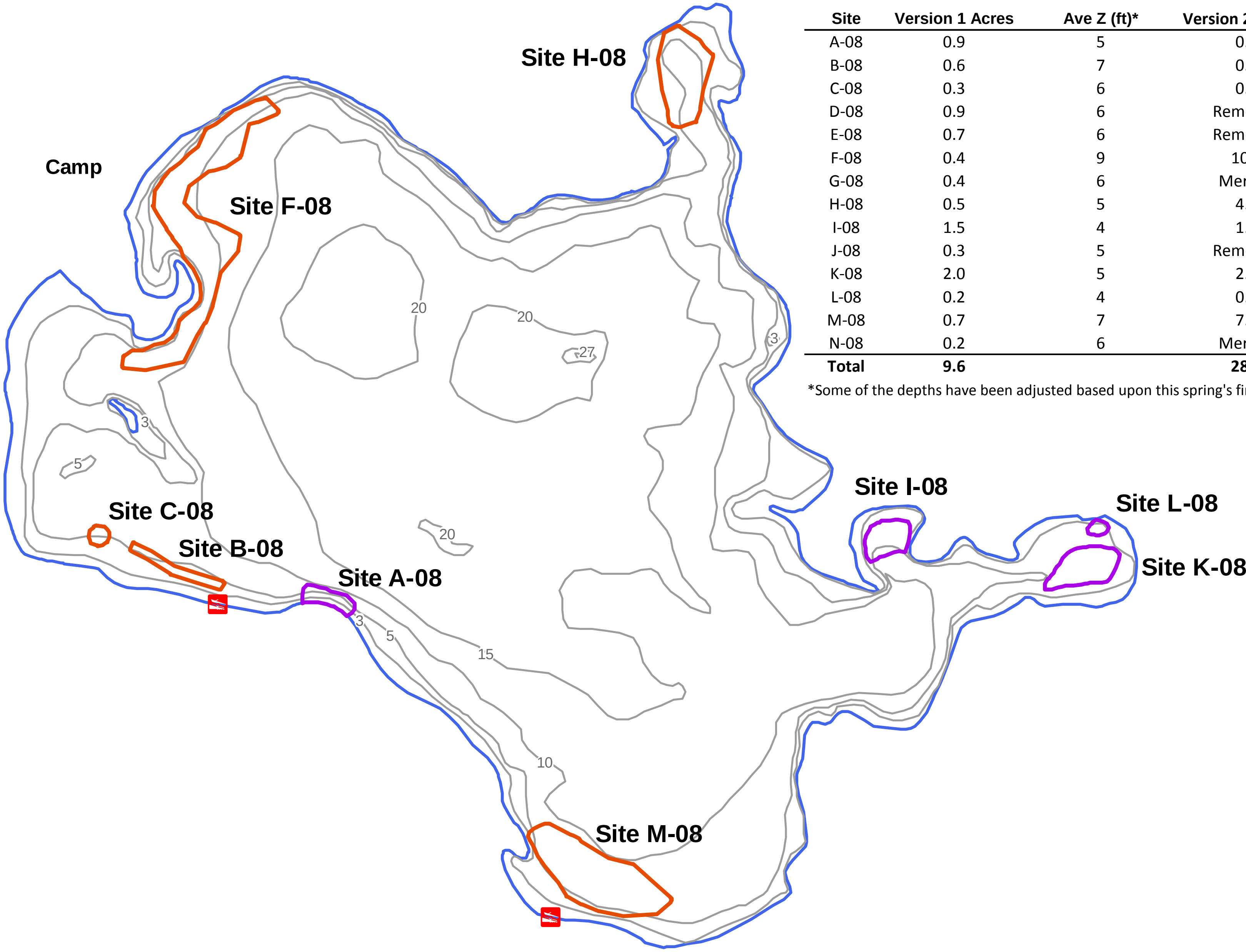
2006 & 2007

Eurasian Water Milfoil

Peak-biomass Survey Results

Site	Version 1 Acres	Ave Z (ft)*	Version 2 Acres	Recommended Dose
A-08	0.9	5	0.9	100 lbs/acre
B-08	0.6	7	0.9	150 lbs/acre
C-08	0.3	6	0.3	150 lbs/acre
D-08	0.9	6	Removed	
E-08	0.7	6	Removed	
F-08	0.4	9	10.9	150 lbs/acre
G-08	0.4	6	Merged	
H-08	0.5	5	4.1	150 lbs/acre
I-08	1.5	4	1.5	100 lbs/acre
J-08	0.3	5	Removed	
K-08	2.0	5	2.3	100 lbs/acre
L-08	0.2	4	0.2	100 lbs/acre
M-08	0.7	7	7.0	150 lbs/acre
N-08	0.2	6	Merged	
Total	**9.6**		**28.1**	

*Some of the depths have been adjusted based upon this spring's findings.



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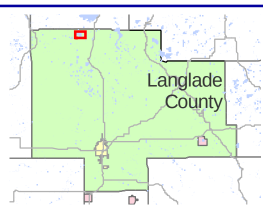
Sources:
Roads & Hydro: WDNR
Bathymetry: WDNR (Digitized by Onterra)
Aquatic Plant Surveys: Onterra, 2007 & 2008

Map date: May 13, 2008



Extent of large map shown in red.

Legend

Recommended Dose

100 lbs/acre

150 lbs/acre

Map 8

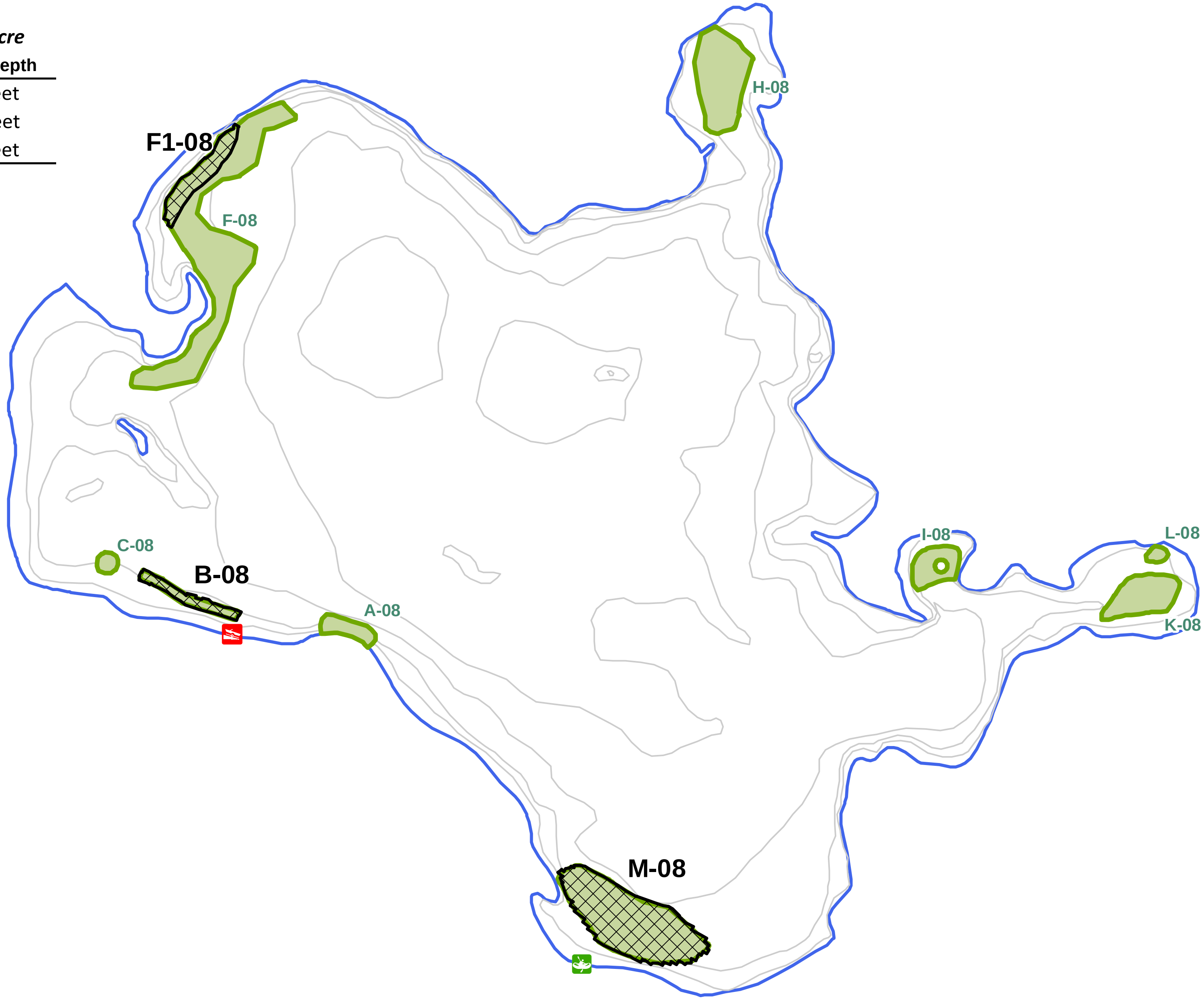
Enterprise Lake

Langlade County, Wisconsin

Eurasian Water Milfoil
2008 Treatment Areas

Final Treatment Areas - 150 lbs/acre

Site	Acres	Ave Depth
B-08	1	5 feet
F1-08	1.8	6-feet
M-08	7.3	6 feet
Total	***10.1***	



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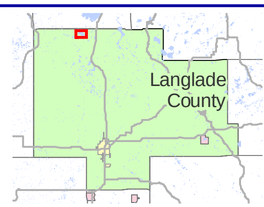
Sources:
Roads & Hydro: WDNR
Bathymetry: WDNR (Digitized by Onterra)
Aquatic Plant Surveys: Onterra, 2008

Map date: December 19, 2008

File Name: Map 2_Ent_EWMTreat_RecandFinal.mxd



Extent of large map shown in red.

Legend

2008 Permited Treatment Area

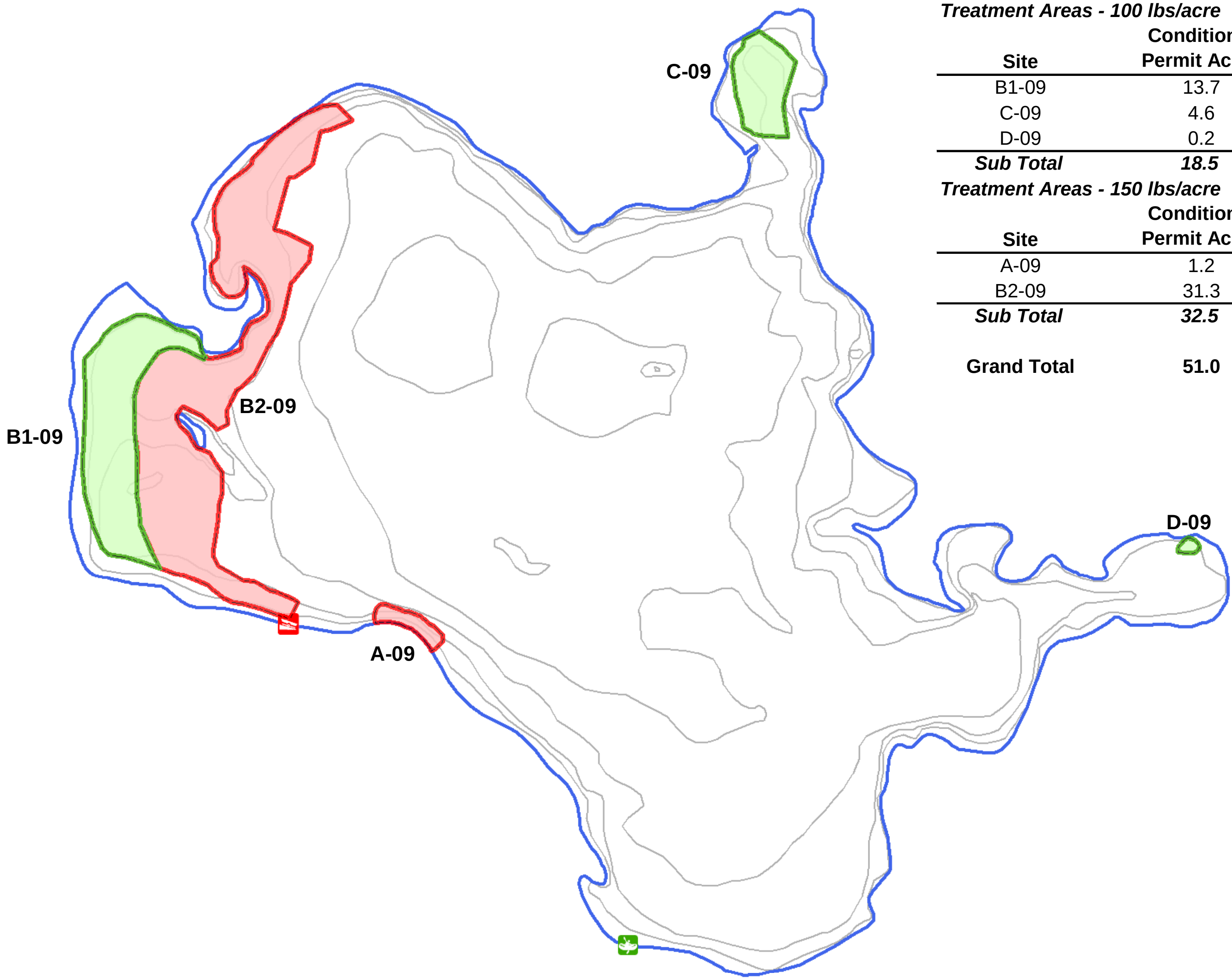
2008 Final Treatment Area

Map 9

Enterprise Lake

Langlade County, Wisconsin

2008 Final Eurasian Water Milfoil Treatment Areas



Treatment Areas - 100 lbs/acre

Site	Conditional Permit Acres	Final Permit Acres	Ave Depth
B1-09	13.7	13.7	5 feet
C-09	4.6	4.8	5 feet
D-09	0.2	0.2	5 feet
Sub Total	***18.5***	***18.7***	

Treatment Areas - 150 lbs/acre

Site	Conditional Permit Acres	Final Permit Acres	Ave Depth
A-09	1.2	1.2	6 feet
B2-09	31.3	33.3	9 feet
Sub Total	***32.5***	***34.5***	
Grand Total	**51.0**	**53.2**	

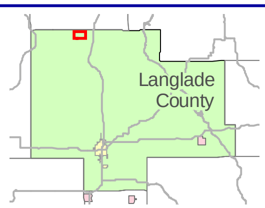
N W E S

1,100

Feet

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

Sources:
Roads & Hydro: WDNR
Aquatic Plant Survey: Onterra 2008-09
Bathymetry: WDNR (Digitized by Onterra)
Map date: May 14, 2009
File Name: Ent_t2009_EWMTrt_Perm1.mxd



Extent of large map shown in red.

Legend

2009 Final Treatment Area (100 lbs/acre)

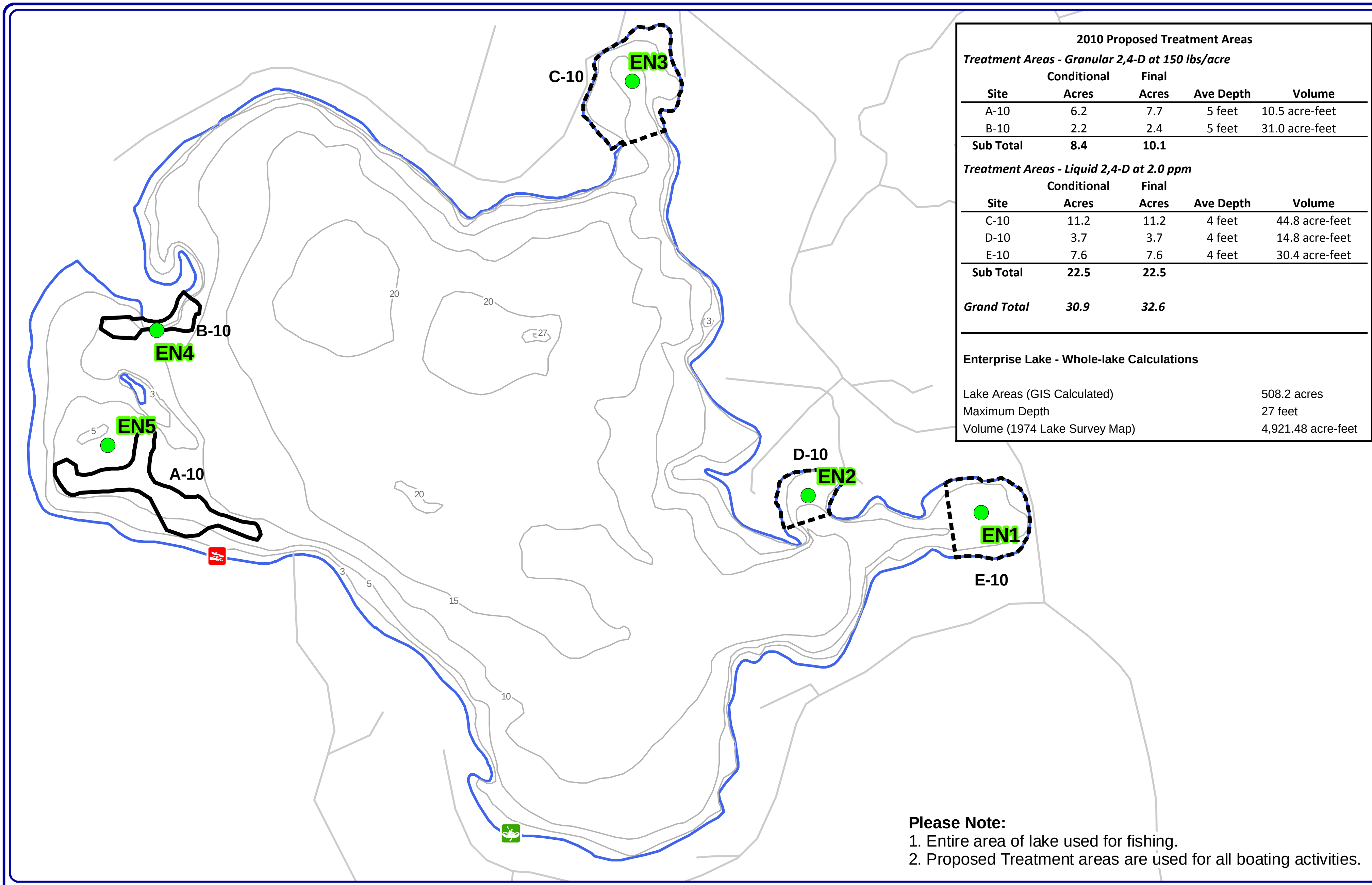
2009 Final Treatment Area (150 lbs/acre)

Map 10

Enterprise Lake

Langlade County, Wisconsin

2009 Final Eurasian Water Milfoil Treatment Areas



2010 Proposed Treatment Areas

Treatment Areas - Granular 2,4-D at 150 lbs/acre

Site	Conditional Acres	Final Acres	Ave Depth	Volume
A-10	6.2	7.7	5 feet	10.5 acre-feet
B-10	2.2	2.4	5 feet	31.0 acre-feet
Sub Total	**8.4**	**10.1**		

Treatment Areas - Liquid 2,4-D at 2.0 ppm

Site	Conditional Acres	Final Acres	Ave Depth	Volume
C-10	11.2	11.2	4 feet	44.8 acre-feet
D-10	3.7	3.7	4 feet	14.8 acre-feet
E-10	7.6	7.6	4 feet	30.4 acre-feet
Sub Total	**22.5**	**22.5**		
Grand Total	***30.9***	***32.6***		

Enterprise Lake - Whole-lake Calculations

Lake Areas (GIS Calculated)	508.2 acres
Maximum Depth	27 feet
Volume (1974 Lake Survey Map)	4,921.48 acre-feet

Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.

N W E S

1,000

Feet

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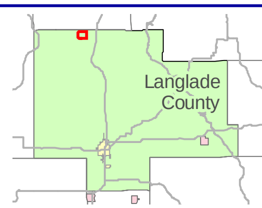
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Aquatic Plant Survey: Onterra 2009
Bathymetry: WDNR (Digitized by Onterra)
Map date: April 30, 2010
File Name: Ent_T2010_EWMTrt_Perm1.mxd



Extent of large map shown in red.

Legend

Liquid 2, 4-D

Granular 2, 4-D (150 lbs/acre)

Residual Sampling Location

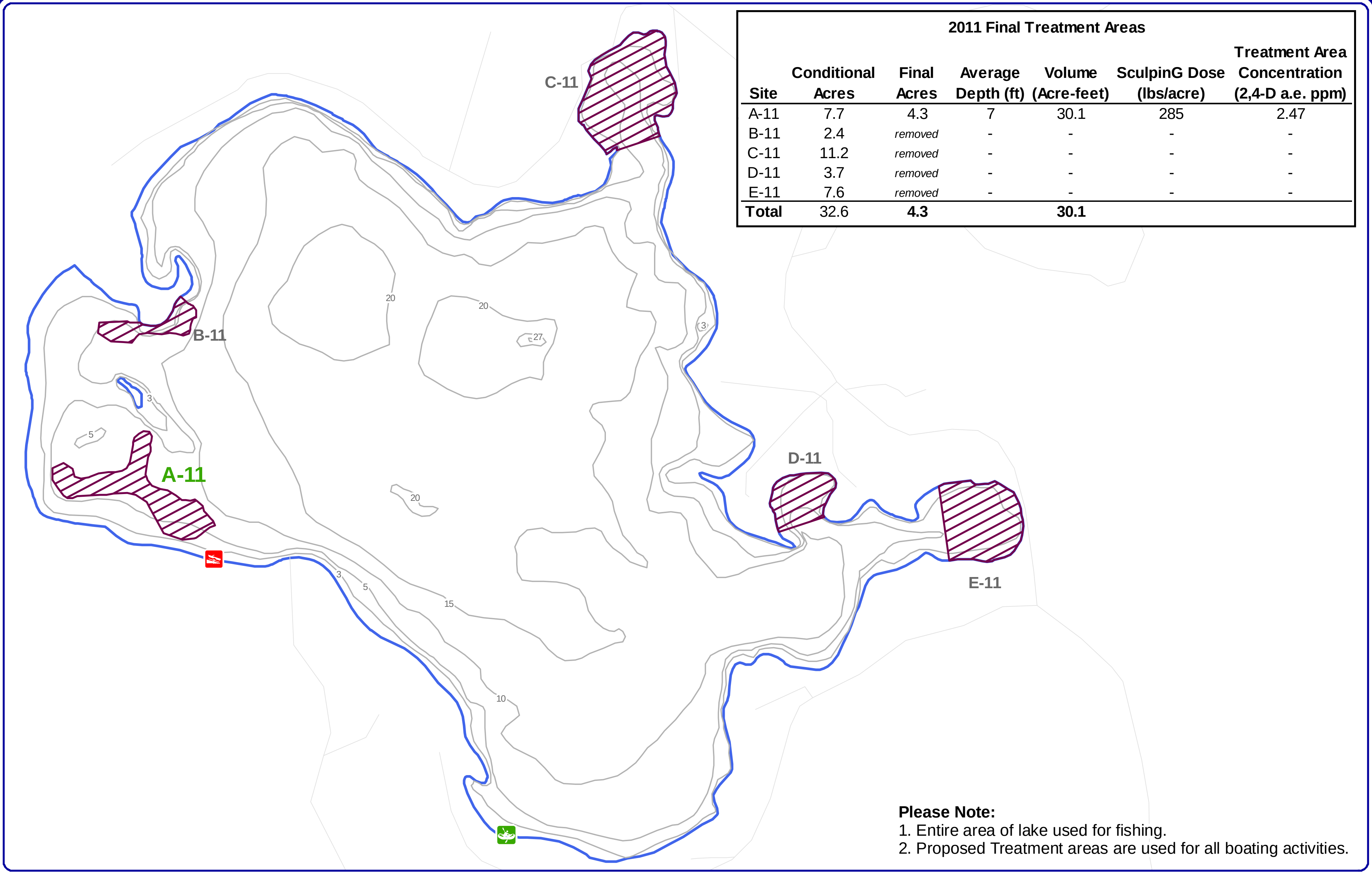
Map 11

Enterprise Lake

Langlade County, Wisconsin

2010 Final Eurasian Water Milfoil Treatment Areas

2011 Final Treatment Areas						
Site	Conditional Acres	Final Acres	Average Depth (ft)	Volume (Acre-feet)	SculpinG Dose (lbs/acre)	Treatment Area Concentration (2,4-D a.e. ppm)
A-11	7.7	4.3	7	30.1	285	2.47
B-11	2.4	*removed*	-	-	-	-
C-11	11.2	*removed*	-	-	-	-
D-11	3.7	*removed*	-	-	-	-
E-11	7.6	*removed*	-	-	-	-
Total	32.6	**4.3**		**30.1**		

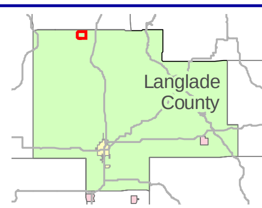


Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.

1,000
Feet

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

Sources:
Roads & Hydro: WDNR
Aquatic Plant Survey: Onterra 2011
Bathymetry: WDNR (Digitized by Onterra)
Map date: May 25, 2011
File Name: Ent_T2011_EWMTrt_Perm1.mxd



Extent of large map shown in red.

Legend

Final EWM Treatment Area
Conditonal EWM Treatment Area

Map 12
Enterprise Lake
Langlade County, Wisconsin
2011 Final Eurasian Water Milfoil Treatment Areas