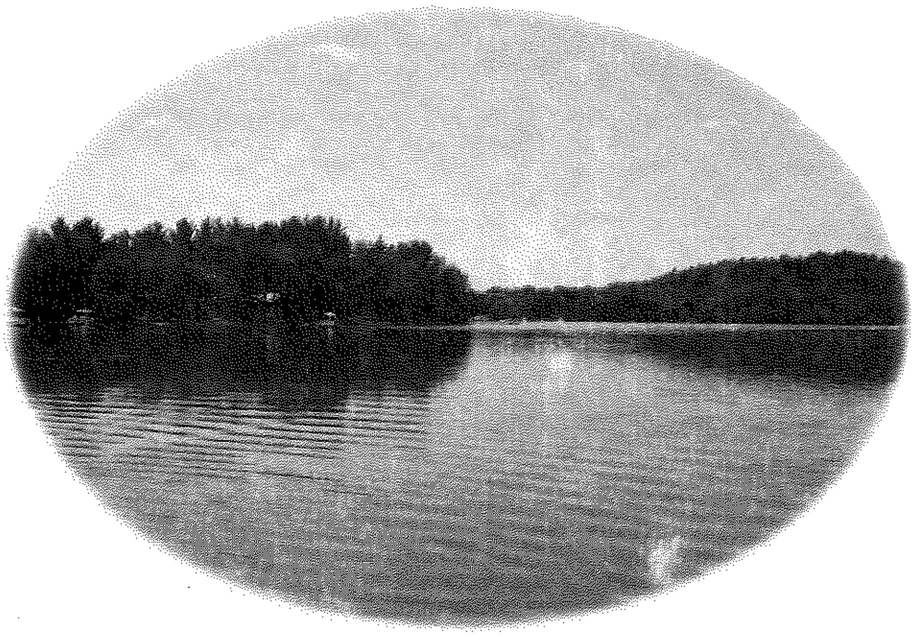
Porters Lake

Waushara County, Wisconsin

Comprehensive Management Plan



December 2007

Sponsored by:

Porters Lake Management District

&

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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

Porters Lake

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Created by: Tim Hoyman
Onterra, LLC
De Pere, WI

Funded by: Porters Lake Management District
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Acknowledgements

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

Porters Lake Management District
Pat Doyle
Don Dalton
Dave Hansen
Jay Blevins

Wisconsin Dept. of Natural Resources
Mark Sesing
Scott Bunde
David Bartz
Al Niebur

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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 impacts the lake. Stakeholder input regarding the development of this plan was obtained through communications and meetings with the Porters Lake Management District (PLMD) and the district's Planning Committee. A description of each stakeholder participation event can be found below, while supporting materials can be found in Appendix A.

Kick-off Meeting

On July 29, 2006 the PLMD 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, Tim Hoyman presented information about lake eutrophication, native and non-native aquatic plants, and the importance of lake management planning. He also discussed the goals and components of the lake management planning project and how the planning process will proceed with the help of the Planning Committee.

The meeting was well attended and was held in a causal setting on the deck of Don Dalton, the lake group's president. Questions and discussion after Tim's presentation ranged from water quality concern's to the lake's snapping turtle population.

Planning Committee Meeting

A meeting with the PLMD Planning Committee was held at Pat Doyle's cottage on February 24, 2007. Despite a storm that dropped over 6 inches of snow the night before, five members of the committee attended the three-hour meeting. The meeting started with Tim Hoyman making an in-depth presentation of the study results and conclusions. The presentation was followed with a question and answer session along with discussion of what the group believed should be the primary goals of the Porters Lake Management Plan. The meeting was concluded with creating management actions that would help the group to meet the goals they had created.

Implementation Plan Review

In May 2007, a draft of the Summary and Conclusions sections and the Implementation Plan were circulated to the PLMD Planning Committee for review prior to the Wrap-up meeting held the following month. As a result of the review, minor changes and clarifications were made to the Implementation Plan, including adjustments to the timeline and to the individuals that would facilitate certain management actions.

Project Wrap-up Meeting

On June 3, 2007, a meeting was held with the membership of the PLMD in order to describe the study results and introduce the Implementation Plan the Planning Committee had created. Turnout was good with nearly 30 people attending 2 ½-hour meeting. Tim Hoyman presented an overview of the project and its objectives. He also highlighted the results and conclusions that were developed from the many studies that were completed on Porters Lake. Tim's presentation concluded with a description of the Implementation Plan that was developed with the Planning Committee. The meeting was concluded with a discussion that lasted approximately 45 minutes.

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 highly 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.

Comparisons with Other Datasets

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

Phosphorus is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both *algae* and *macrophytes*. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.

Chlorophyll-*a* is the green pigment in plants used during *photosynthesis*. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.

Secchi disk transparency is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are interrelated. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water.

Lillie and Mason (1983) is an excellent source of data for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Waushara County lakes are included within the study's Central Region (Figure 1) and are among 44 lakes randomly sampled from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means and historic data from Porters are displayed in Figures 2-5. Please note that the data in Figures 3-5 represent values collected only during the summer months (June-August) from the deepest location in Porters Lake (Map 1). Furthermore, the phosphorus and chlorophyll-*a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments (see discussion under Internal Nutrient Loading).

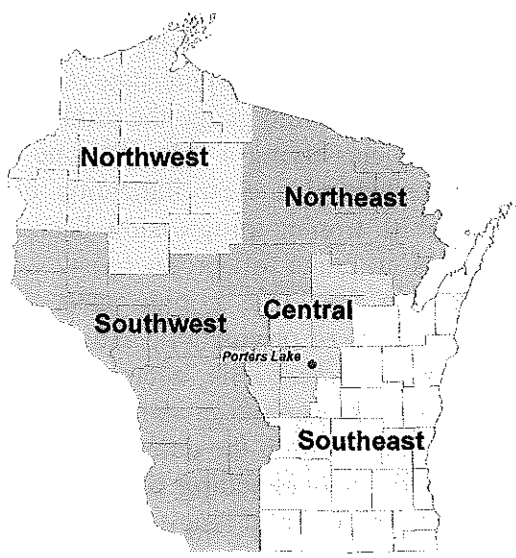


Figure 1. Location of Porters Lake within the regions utilized by Lillie and Mason (1983).

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 nearly pristine 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 Porters Lake are displayed on Figures 3-5.

Trophic State

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

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

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fishkills are often the result of insufficient amounts of dissolved oxygen. However, dissolved oxygen's role in lake management extends beyond this basic need by living organisms. In fact, its presence or absence impacts many chemical process that occur within a lake. Internal nutrient loading is an excellent example that is described below.

Internal Nutrient Loading

In lakes that support strong stratification, the hypolimnion can become devoid of oxygen both in the water column and within the sediment. When this occurs, iron changes from a form that normally binds phosphorus within the sediment to a form that releases it to the overlaying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algae blooms decades after external sources are controlled.

The first step in the analysis is determining if the lake is a candidate for <u>significant</u> 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, other sources of phosphorus besides surface flows must be responsible for elevating the in-lake concentrations. If we assume the surface flow loads are relatively accurate, then *normally* two primary possibilities exist; 1) shoreland septic systems, and 2) internal phosphorus cycling.

If the lake is considered a candidate for internal loading, modeling procedures are used to estimate that load.

Porters Lake Water Quality Analysis

Porters Lake Long-term Trends

Although some data exists for Porters Lake over the past decade or so, much of it is not comparable to the data collected and summarized as a part of Lillie and Mason (1983). This is the case because, as mentioned above, the data summarized by Lillie and Mason was collected only during the summer month while the majority of the lakes were stratified. Much of the data collected by Porters Lake volunteers was collected during spring and fall turnover events (Figure 2). While these data present a relatively good understanding of the total phosphorus content of the lake, they do not lend themselves as well to trophic state analysis as data collected during the summer months. Summer month data works well, because it is collected during the peak of the growing season, as opposed to the very beginning and end as the turnover samples do. Further, by including only epilimnetic samples, we are able to concentrate the analysis on the area of the lake where production actually occurs, which of course is the foundation of trophic state analysis.

The turnover data collected within the last decade fluctuates over the years, but remains in the same the range as the data collected during the remainder of the growing season (Figure 3). The highest level was recorded during the 2005 overturn. An explanation of this unusually high value is difficult to find without data from earlier in the season and from different water depths.

Summer total phosphorus concentrations collected during this study and previously (Figure 3), fall within the WQI's "good" range and are below mean values for Wisconsin's natural lakes and just slightly below that of the Central Region's average. Unfortunately, the only summer chlorophyll-*a* values were collected as a part of this project in 2006 (Figure 4). Those values are considered very good and well below the means for the state and region.

There is much more Secchi disk clarity data available for the Porters Lake than any other parameter (Figure 5). The dataset stretches back to 1979, but is most consistent from the mid 1980's. During the extent of the dataset, the clarity values fluctuate between good and very good and as with the chlorophyll-*a* values, are much better than state and region means.

Overall, the water quality of Porters Lake is very good. Although there is an obvious relationship between the three parameters, as discussed above, the relationship between chlorophyll-*a* and total phosphorus is not as obvious as with many lakes. In other words, while the total phosphorus values would be considered low, the chlorophyll-*a* values collected during 2006 do not appear to be as high as they could be if the relationship were strong. This is likely the case because *total* phosphorus values include all types of phosphorus, whether it is dissolved in the water, being utilized in the DNA of microscopic crustacean, or sorped to an iron molecule or particulate marl. As a result, even if total phosphorus values may appear to be sufficient to support more algae, this may not actually be the case because much of phosphorus is tied up in a form unusable by the algae. This is often the case in marl lakes like Porters because so much of the phosphorus is sorped to the particulate marl in the water column, which renders it unusable by most forms of algae.

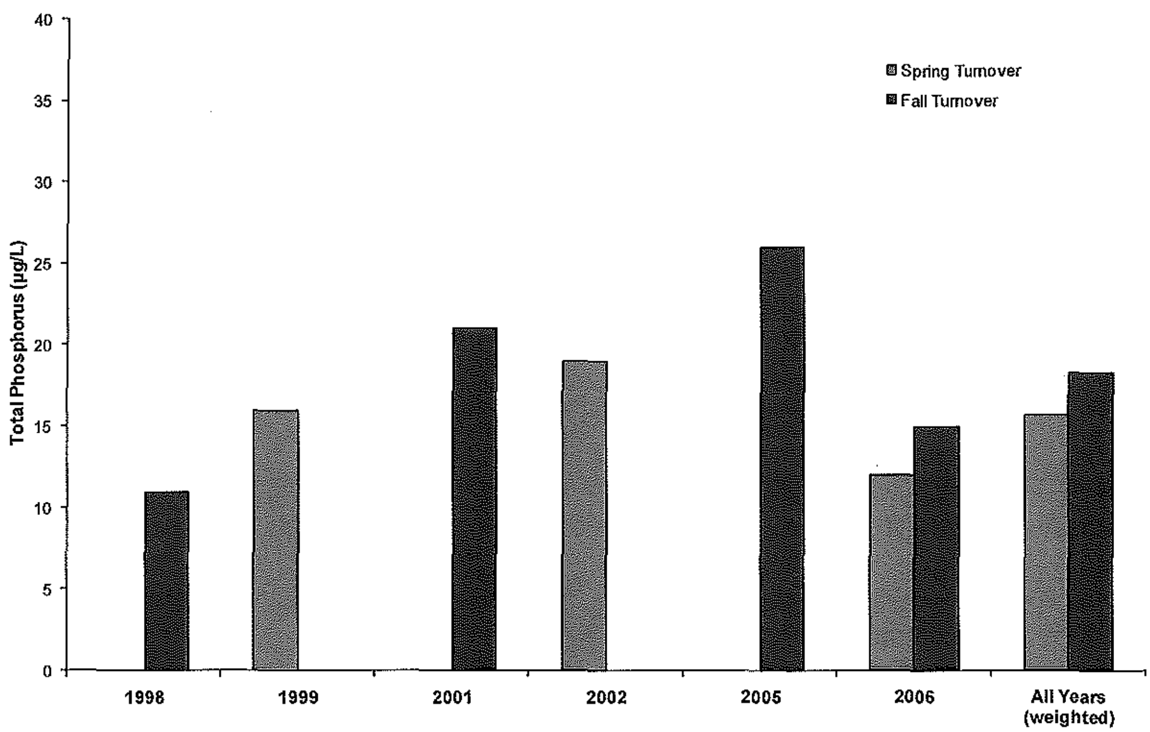


Figure 2. Porters Lake total phosphorus values during spring and fall turnover events. Data collected by volunteers as a part of UWSP Water Quality Task Force Program.

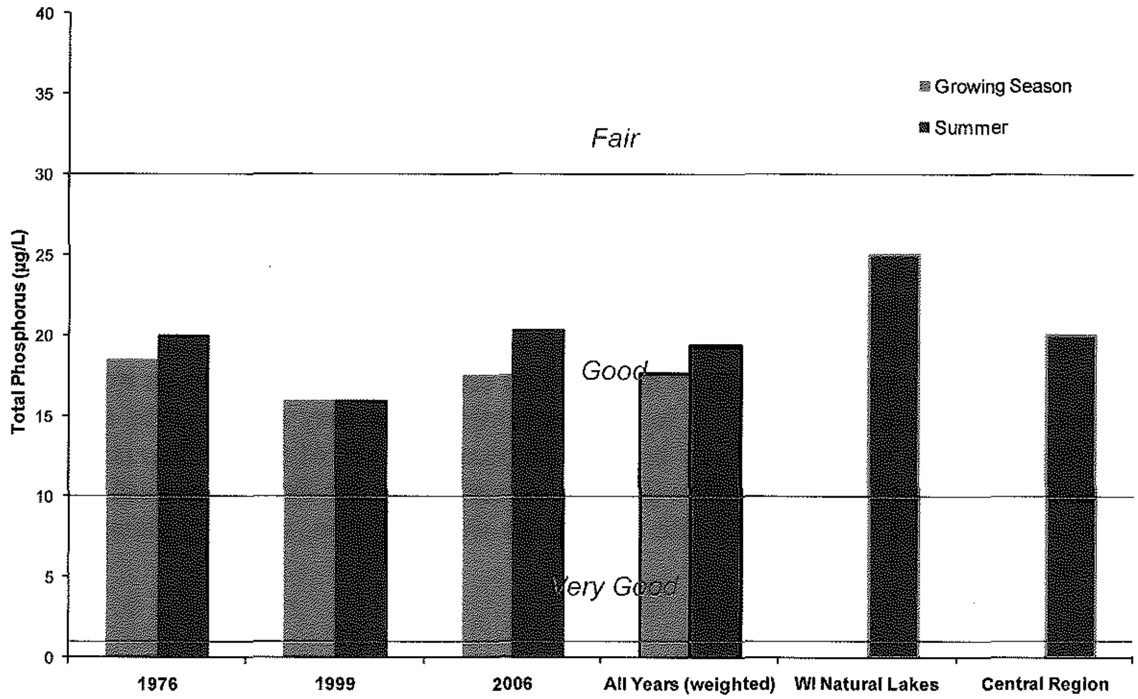


Figure 3. Porters Lake, regional and state total phosphorus concentrations. Means calculated with surface samples. Regional and state data Lillie and Mason (1983).

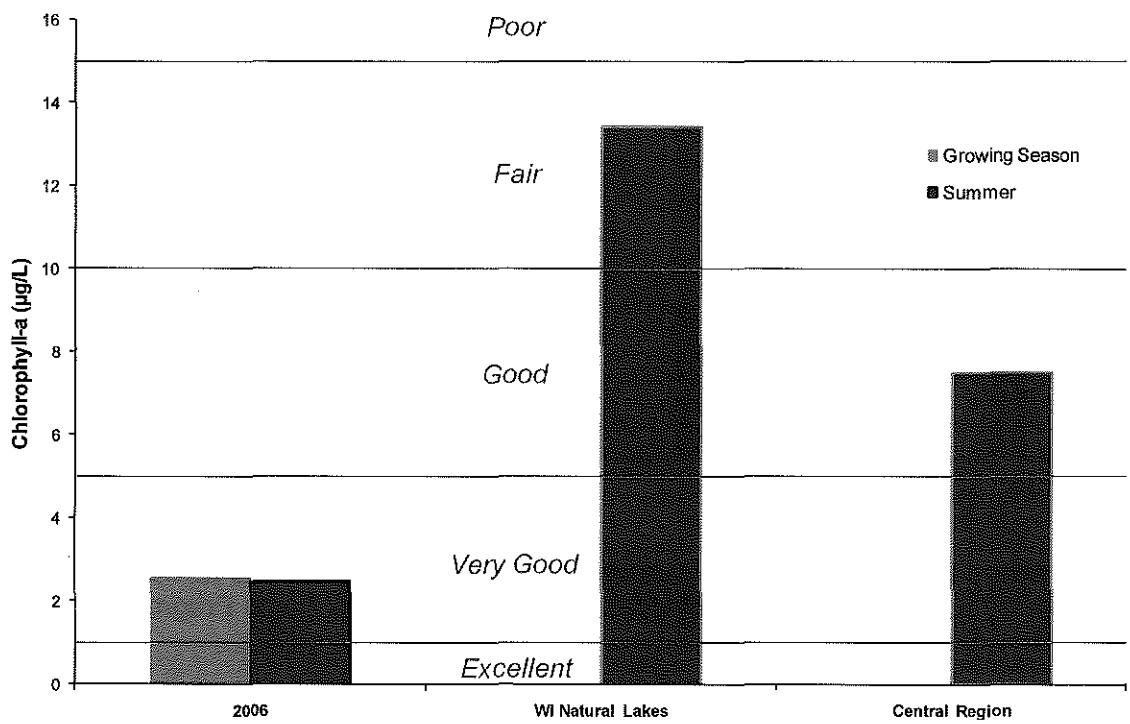


Figure 4. Porters Lake, regional and state chlorophyll-*a* concentrations. Means calculated with surface samples. Regional and state data Lillie and Mason (1983).

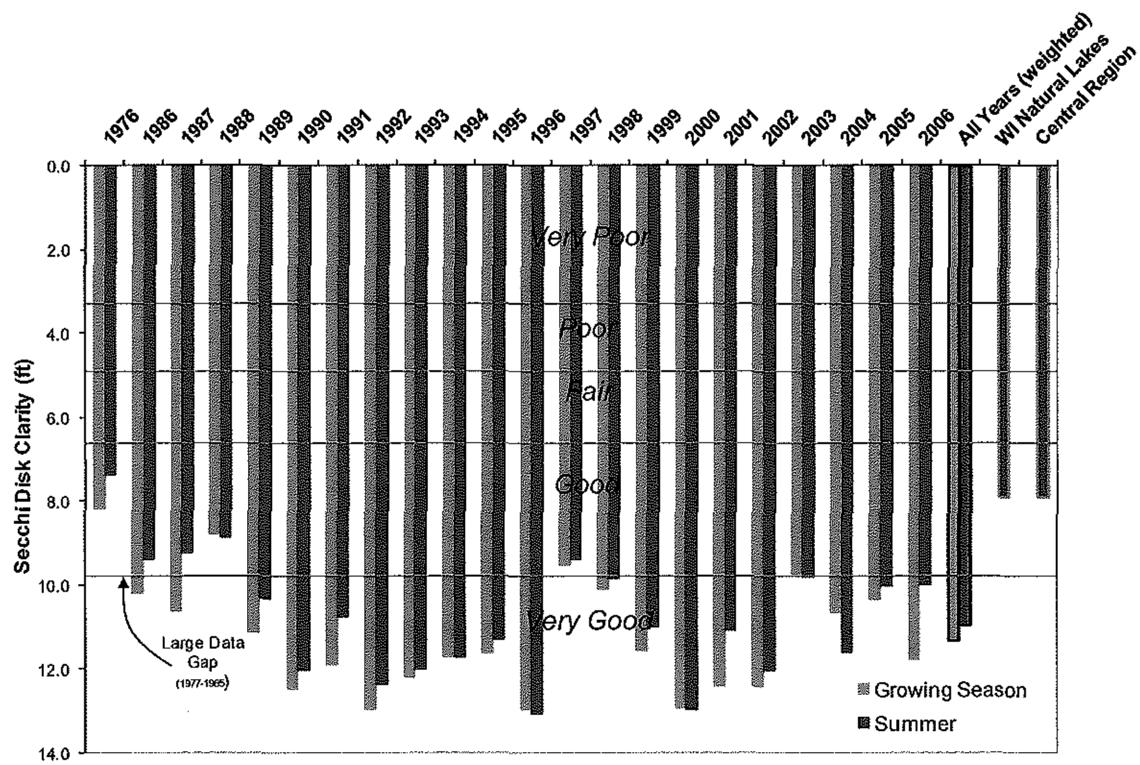


Figure 5. Porters Lake, regional and state Secchi disk clarity values. Regional and state data Lillie and Mason (1983).

Porters Lake Trophic State

As discussed above, it is unfortunate that more useable historic phosphorus and chlorophyll-*a* data does not exist for the lake because although the Secchi disk data is helpful, the other parameters would lead to more solid conclusions regarding the trophic state of Porters Lake, both currently and in the past. Figure 6 contains the WTSI values for existing Porters Lake data and those from regional and state means. Looking at the values calculated with clarity, Porters Lake appears to be on the lower side of mesotrophic over the past two decades. The chlorophyll-*a* values collected during 2006 seem to also support this trophic state. However, the two points created with phosphorus appear to place the lake in more of a eutrophic or productive state. The discrepancy between these two sets of data is related to the discussion above regarding the availability of phosphorus for algal production. Again, there is enough phosphorus to support more algae, but it is not in a form that they can utilize.

To describe the trophic state of Porters Lake, the WTSI values from all three parameters must be considered. While the chlorophyll-*a* and clarity WTSI values are quite low, it is unrealistic to overlook the phosphorus content of the lake; therefore, the trophic state of Porters Lake must between these two extremes and considered as mesotrophic (moderately productive).

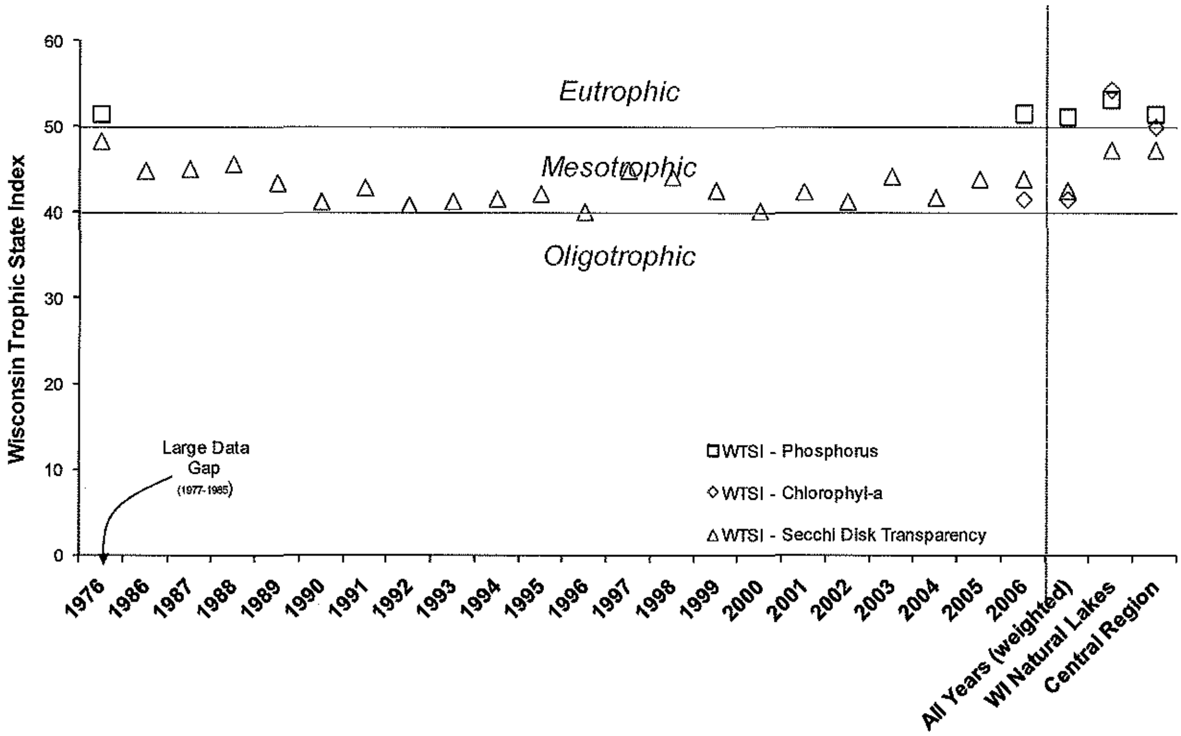


Figure 6. Porters Lake, regional and state Wisconsin Trophic State Index values. Values calculated with summer month surface values. Regional and state values from Lillie and Mason (1983). Calculations following Lillie, et al. (1993).

Limiting Plant Nutrient of Porters Lake

The nitrogen to phosphorus ratio calculated with mean total nitrogen and total phosphorus data collected during the 2006 growing season is 54:1. As outlined above, this indicates that plant production in Porters Lake would be strongly limited by the availability of phosphorus.

Dissolved Oxygen and Temperature in Porters Lake

Dissolved oxygen and temperature profiles completed on Porters Lake indicate that the lake stratifies during the summer and winter months (Figure 7). Being roughly 18 feet deep, the stratification is not strong during any of these times. The data also indicate that the bottom layer (hypolimnion) of the lake does not become anoxic (devoid of oxygen) allowing the entire water column to support aquatic life throughout the year.

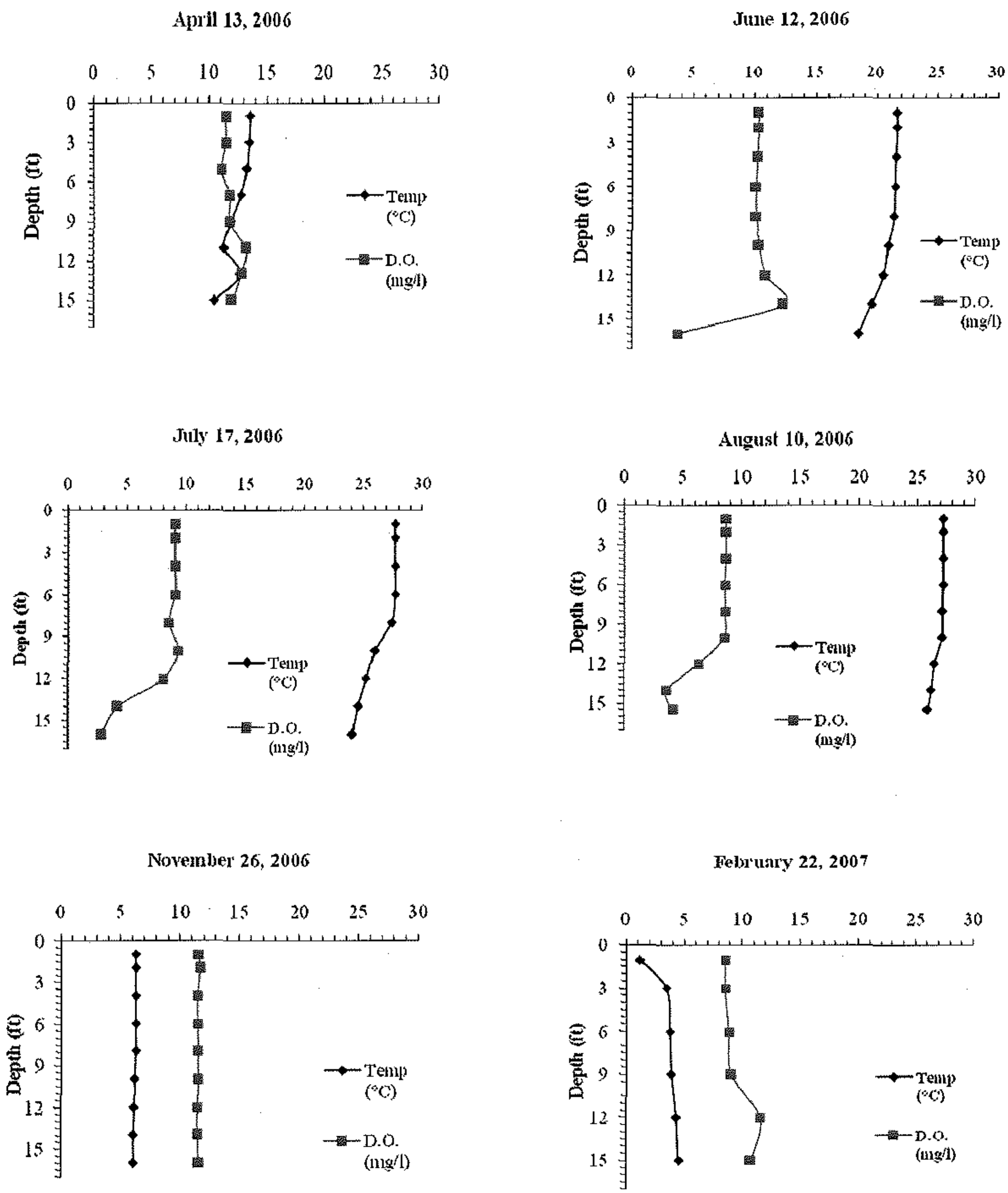


Figure 7. Porters Lake dissolved oxygen and temperature profiles collected during 2006 and 2007.

Internal Nutrient Loading

At this time is does not appear that Porters Lake is susceptible to internal nutrient loading based upon the fact that it hypolimnion does not become anoxic during either the summer or winter months.

Watershed Analysis

The watershed of a lake includes any land that naturally drains precipitation to the lake. Also called the drainage basin, a lake's watershed may or may not be its primary source of water. In all cases, as the water drains from the land into the lake, it picks up sediment, nutrients, and substances. The amount and type of these substances is mostly controlled by how the land is used within the drainage basin. Each type of land use (land cover) allows a portion of the water that falls on it to penetrate into the soil. The remaining portion flows off of the land to the lake. In most cases, the precipitation that is allowed to become surface runoff, the more pollution it is going to carry to the lake. Two common land cover types in Wisconsin typify the extremes of this relationship; agricultural row crops and forests. Row crops, such as corn and soybeans, leave a great deal of soil exposed and as a result, upwards of 90% of the precipitation that falls on this type of land cover can become surface runoff. To the contrary, forest lands allow about 90% of the precipitation to permeate the soil, recharging groundwater levels and producing very little surface runoff. Because of the reduction of surface runoff, it takes approximately 11 acres of forest to provide the same amount of phosphorus to a lake as just one acre of row crops. Obviously, row crops and other high phosphorus load producing land covers lead to higher production rates within the waterbodies they drain to. However, when a lake's watershed is large relative to the lake, even favorable land cover types can cumulatively lead to high phosphorus loads to the lake. With this is the scenario, it is often difficult and in some cases, impossible, to control nutrient levels and production within the lake by making changes within the watershed.

The watershed of Porters Lake is very small at approximately 77 acres (Map 2). The watershed to lake area ratio for Porters Lake is very low at 1:1. Figure 8 and Map 2 show the types of land cover that are found in the Porters Lake watershed. Most of the land draining to the watershed is forested, with much of the remaining acreage being in grasslands or pastures and light development. Small portions of the watershed are in row crops and wetlands.

Based upon modeling completed with the Wisconsin Lakes Modeling Suite (WiLMS), the watershed of Porters Lake, including the surface area of the lake itself, loads roughly 31 lbs. of phosphorus to the lake annually. The amount of phosphorus each land cover type contributes to the load is displayed in Figure 9. Interestingly, the greatest amount of phosphorus enters the lake through atmospheric fallout. In other words, rain and dust entering the lake through its surface is its largest source of phosphorus. Pasture/grasslands are the second largest contributors, followed by row crops, forests, and rural development. The discussion in the paragraph above regarding the relative amounts of phosphorus that forest and row crop areas add to a lake is very apparent in the Porters Lake watershed as these areas contribute roughly the same amount of phosphorus to the lake in spite of the large differences in their relative acreages found in Figure 8.

Overall, this analysis indicates that the watershed of Porters Lake is in good condition and contributing a very small amount of phosphorus to the lake annually. The most harmful changes in the watershed would include increased development along the lake's shoreline and a reduction in forested acreage. If either or both of these changes occurred to a large extent, the annual phosphorus load to the lake could be increased significantly and changes in the lake's water quality would likely be apparent.

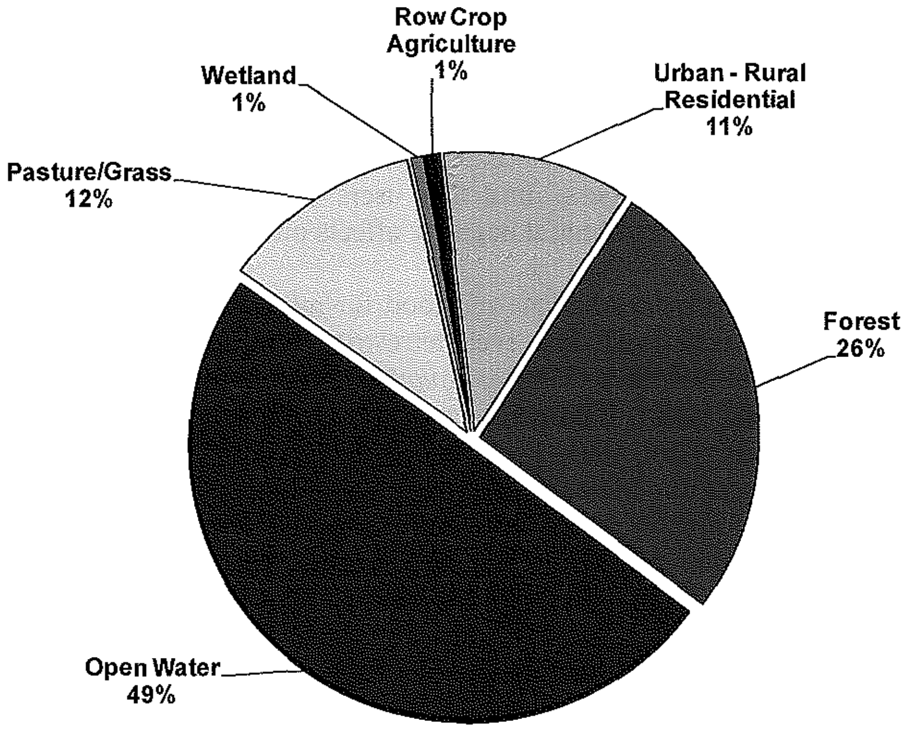


Figure 8. Porters Lake watershed land cover types.

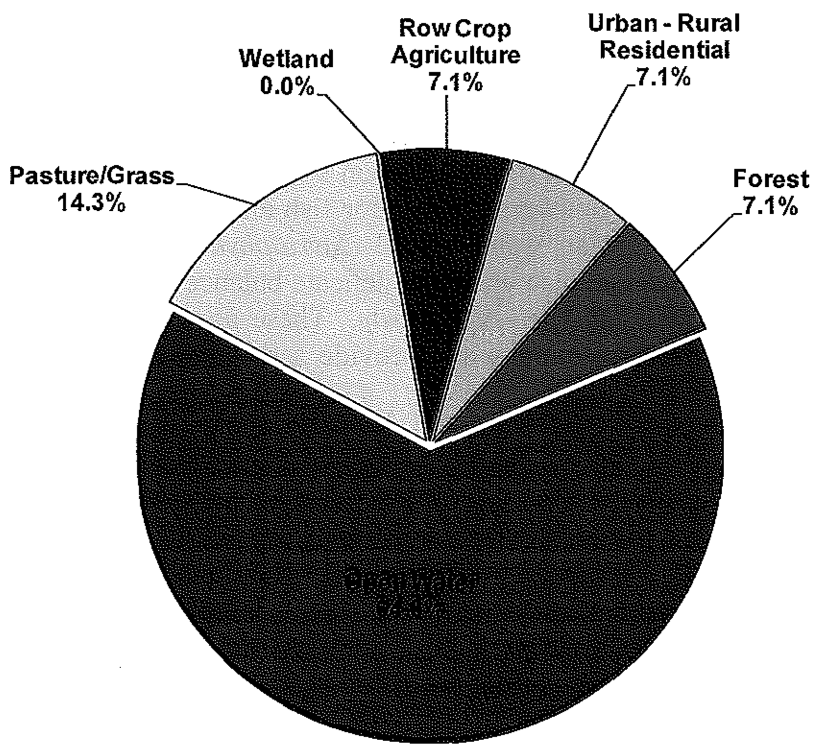


Figure 9. Porters Lake phosphorus loading based upon land cover type.

Aquatic Plants and the Lake Ecosystem

Although some lake users consider aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, they are actually an essential element in a healthy and functioning lake ecosystem. It is very important that the 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 affects 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 were 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.

Introduction to 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.

Please note: Even though Porters Lake does not suffer from nuisance levels of exotic or native plants, this section has been included to provide general information to Porters Lake stakeholders in hopes of raising their awareness about these techniques and their applicability in the management of lakes and aquatic plants.

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 length. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR. 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. 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. 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.

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 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

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 resuspension 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.

Disadvantages

Property owners need to be educated on the benefits of native plant restoration before they are willing to participate.
Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in.
Monitoring and maintenance are required to assure that newly planted areas will thrive.
Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Manual Removal

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

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width.

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 $1200 to $11,000.

Advantages

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.

Disadvantages

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 harvest remaining plants
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 are about $120 each year.

Advantages

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.

Disadvantages

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.

Advantages

Inexpensive if outlet structure exists.
May control populations of certain species, like Eurasian water-milfoil for up to two years.
Allows some loose sediments to consolidate.
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.

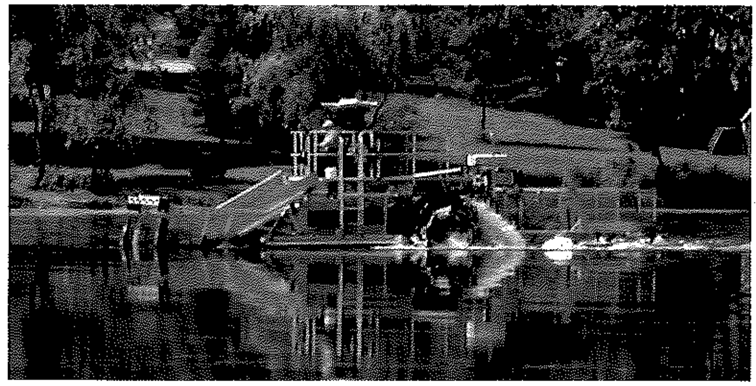
Disadvantages

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 requires an environmental assessment that may take months to prepare.
Unselective.

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 later 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

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.

Disadvantages

Initial costs and maintenance are high if the lake organization intends to own and operate the equipment.
Multiple treatments may be required during the growing season because lower portions of the plant and root systems are left intact.
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.
Larger harvesters are not easily maneuverable in shallow water or near docks and piers.
Bottom sediments may be resuspended 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.

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>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.

<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>Endothal</u> (Hydrothol®, Aquathol®) Broad spectrum, contact herbicides used for spot treatments of submersed plants. The mono-salt form of Endothal (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®, Aqua-Kleen®, 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 apply.

Advantages

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.

Disadvantages

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.

Cost

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

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 not 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. Wisconsin is also using two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These biocontrol insects are not covered here because purple loosestrife is predominantly a wetland species.

Advantages

Milfoil weevils occur naturally in Wisconsin.
This is likely an environmentally safe alternative for controlling Eurasian water-milfoil.

Disadvantages

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.

Cost

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

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, two aquatic plant surveys were completed on Porters Lake; the first looked strictly for curly-leaf pondweed, and the second inventoried all aquatic species found in the lake. 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 loses 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 Porters 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 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 Porters Lake will be compared to lakes in the same ecoregion and in the state.

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

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

Community Mapping

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

Exotic Plants

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

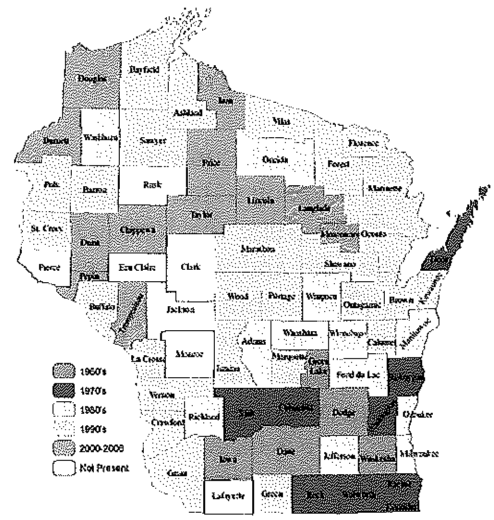


Figure 10. Spread of Eurasian water milfoil throughout Wisconsin counties. Map created by Onterra with 2006 WDNR data.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 10). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

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

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

2006 Surveys

The aquatic plant surveys completed in 2006 located 37 species within Porters Lake (Figure 11, Table 1); of these, 35 were native species and one, purple loosestrife, was an exotic. The plant community of Porters Lake is clearly dominated by muskgrasses, which are actually macroalgae and not true vascular plants (Figure 11). Muskgrasses do very well in clear, calcium-rich systems like Porters Lake. Although muskgrasses are prevalent and reduce the evenness of species distribution a bit, Porters Lake still contains relatively high species diversity (Simpson Diversity Index: 0.88).

The aquatic plant community map of Porter Lake (Map3) shows the many emergent and floating-leaf species that exist within the lake. These species are important habitat for fish and wildlife that utilize the lake. The loss of these communities would be a sure sign of change within the lake and would have a negative impact on the ecology of the system. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Importantly, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with the loss of vegetation.

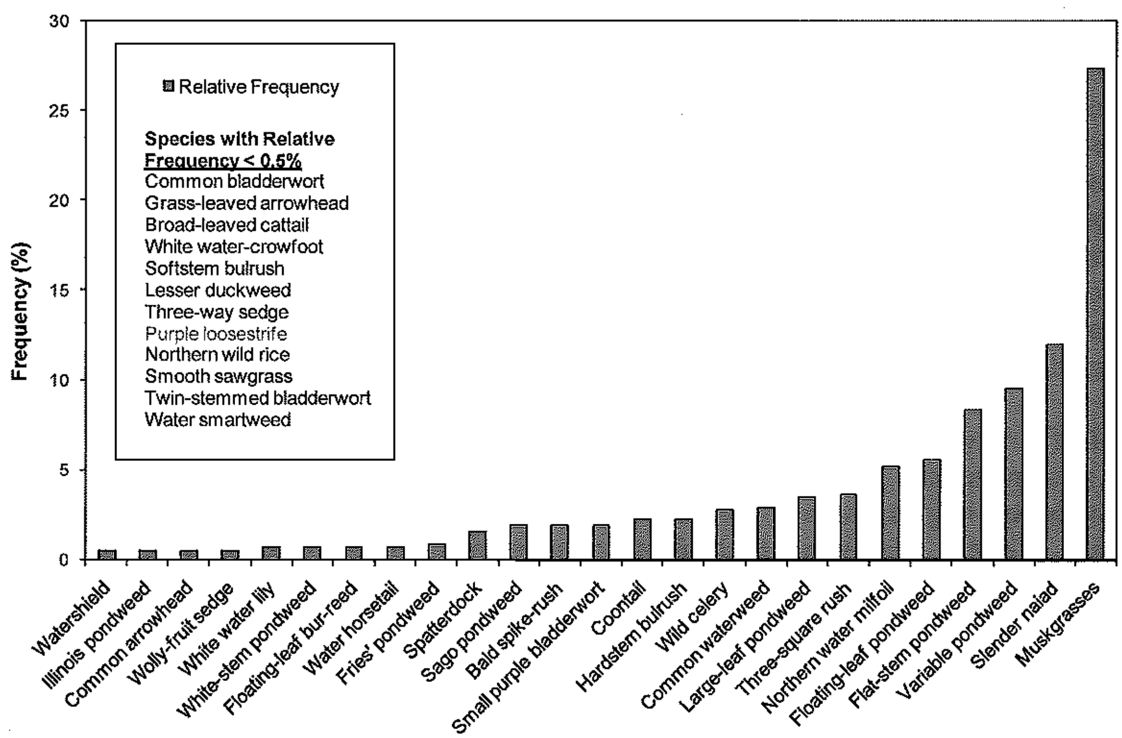


Figure 11. Porters Lake occurrence analysis results. Created with data collected during 2006 aquatic plant surveys.

Table 1. Aquatic plant species located in Porters Lake during the 2006 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)
Emergent	*Carex lasiocarpa*	Wolly-fruit sedge	9
	Dulichium arundinaceum	Three-way sedge	9
	Eleocharis erythropoda	Bald spike-rush	3
	Equisetum fluviatile	Water horsetail	7
	*Cladium mariscoides**	Smooth sawgrass	10
	*Lythrum salicaria**	Purple loosestrife	Exotic
	Sagittaria latifolia	Common arrowhead	3
	Schoenoplectus acutus	Hardstem bulrush	5
	Schoenoplectus pungens	Three-square rush	5
	Schoenoplectus tabernaemontani	Softstem bulrush	4
	Typha latifolia	Broad-leaved cattail	1
	*Zizania palustris**	Northern wild rice	8
FF	*Lemna minor*	Lesser duckweed	5
FL	*Brasenia schreberi*	Watershield	7
	Nuphar variegata	Spatterdock	6
	*Polygonum amphibium**	Water smartweed	5
	Nymphaea odorata	White water lily	6
FL/E	*Sparganium fluctuans*	Floating-leaf bur-reed	10
Submergent	*Ceratophyllum demersum*	Coontail	3
	Chara sp.	Muskgrasses	7
	Elodea canadensis	Common waterweed	3
	Myriophyllum sibiricum	Northern water milfoil	7
	Najas flexilis	Slender naiad	6
	Potamogeton amplifolius	Large-leaf pondweed	7
	Potamogeton gramineus	Variable pondweed	7
	Potamogeton illinoensis	Illinois pondweed	6
	Potamogeton natans	Floating-leaf pondweed	5
	Potamogeton praelongus	White-stem pondweed	8
	Potamogeton friesii	Fries' pondweed	8
	Potamogeton zosteriformis	Flat-stem pondweed	6
	Ranunculus aquatilis	White water-crowfoot	8
	Stuckenia pectinata	Sago pondweed	3
	Utricularia resupinata	Small purple bladderwort	9
	Utricularia vulgaris	Common bladderwort	7
	*Utricularia geminiscapa**	Twin-stemmed bladderwort	9
	Vallisneria americana	Wild celery	6
S/E	*Sagittaria graminea*	Grass-leaved arrowhead	9

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

As mentioned above, the floristic quality of Porters Lake is quite high and is probably a result of a combination of factors. First, shoreland of the lake is not completely developed and many of

the areas that are developed are left in a somewhat natural state. Second, Porters Lake is a slow-no-wake at all times. 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 1996, Asplund 2000, Asplund and Cook 1997). In all of these studies, lower plant biomasses and/or declines and higher turbidity were associated with motorboat traffic. In Porters Lake, watercraft use likely has very little impact on the lake's plant community and as a result, the community is outstanding.

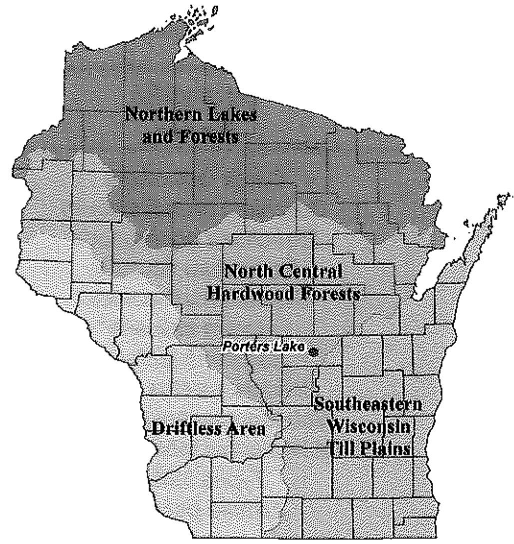


Figure 12. Location of Porters Lake within the ecoregions of Wisconsin. After Nichols 1999.

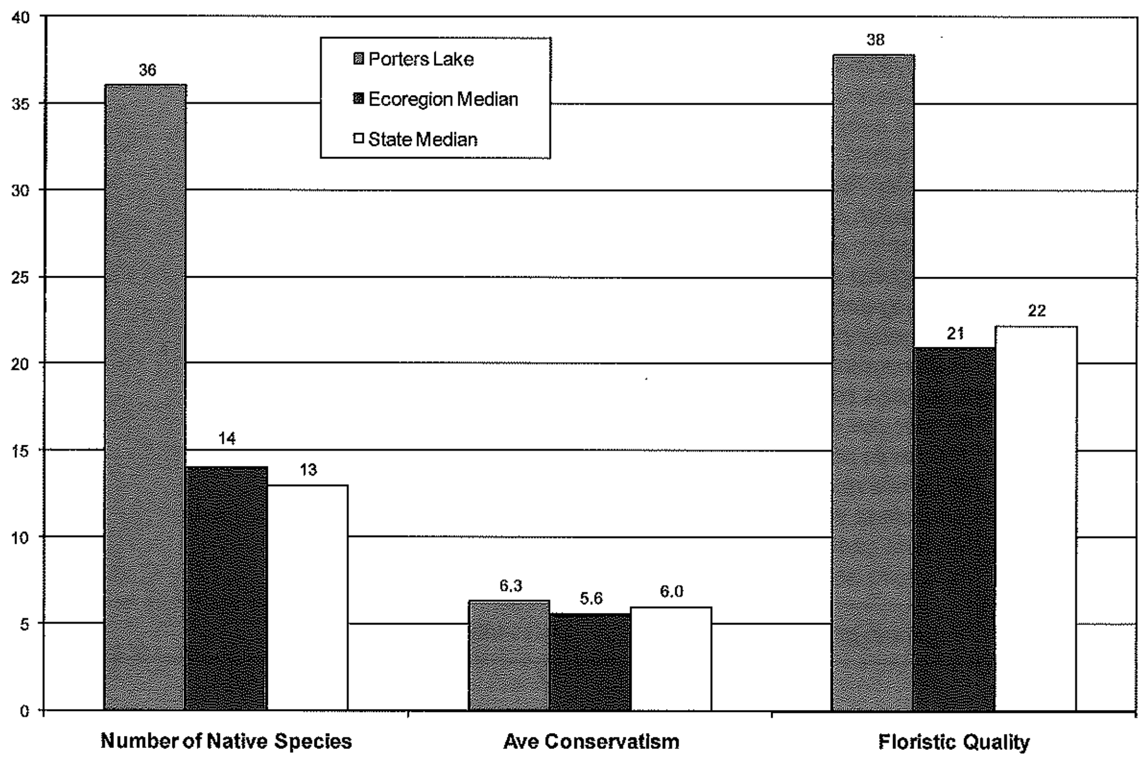


Figure 13. Porters Lake Floristic Quality Assessment. Developed with 2006 aquatic plant data following Nichols (1999).

Porters 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 (Niebur 1994, WDNR 1996 (unpublished), BFMHP 2007). A summary report from a 1994 boomshocking (electrofishing) survey is provided in Appendix E, written by Al Niebur, WDNR Fisheries Biologist. In addition, raw data from a similar boomshocking event from 1996 was provided by the WDNR and was analyzed in this report. Fish stocking data is available from the Bureau of Fisheries Management and Habitat Protection website (BFMHP 2007); however it is believed to be incomplete. Their records indicate that largemouth bass were stocked once in 1986 and northern pike were stocked three times in the late 1980's. The 1994 summary report mentions "bass fingerlings (being stocked) in recent years" and walleyes being stocked "occasionally." This report also mentions that a stocking permit, presumably for largemouth bass, was denied by the WDNR in 1993.

Table 2 lists the gamefish present in Porters Lake. The non-gamefish species composition of the lake is unknown except for the emerald shiner and blackchin shiner which were indentified from the 1994 boomshocking survey.

Table 2. Gamefish present in Porters Lake with corresponding biological information (Becker, 1983).

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pikes, crayfish, small mammals, water fowl, frogs
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3-0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (ter. and aq.)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1cm-1m deep	Crustaceans, insect larvae, and other inverts
Yellow Perch	*Perca flavescens*	13	April - early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates
Yellow Bullhead	*Ameiurus natalis*	7	May - July	Heavy weeded banks, beneath logs or tree roots	Crustaceans, insect larvae, small fish, some algae

Anecdotal reports from PLMD members state that the populations of largemouth bass and bluegill are on the forefront of their concerns as bluegills are "small and stunted" and largemouth bass are "rarely caught over 14 inches" (Appendix E). Figure 14 displays the fish species caught during the two field surveys. The most readily caught species was bluegill with relatively similar proportions between the two years. Largemouth bass were also prevalent with similar proportions of total catch being observed in 1994 and 1996. Niebur suggests that bluegill and largemouth bass condition and reproduction appeared to be "more than adequate."

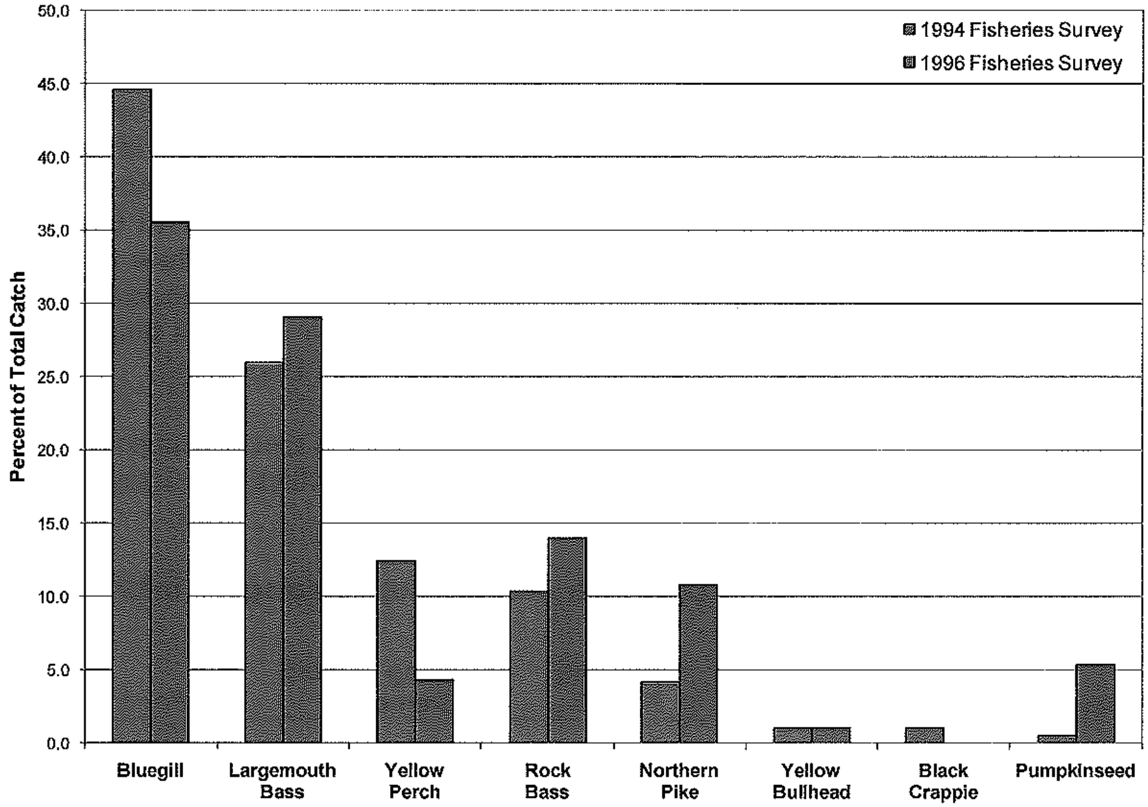


Figure 14. Percent of total catch of fish species from boomshocking field surveys completed by the WDNR in 1994 and 1996.

Figures 15 and 16 show the size structure of largemouth bass and bluegill, respectively. Only a few largemouth bass individuals were observed over 14 inches in the surveys, with the average from both surveys being below 12 inches (Table 2). Although this supports claims made by PLMD members regarding small largemouth bass, claims made regarding bluegill size structure does not seem to be supported. Figure 16 does not show a disproportionate amount of smaller bluegill from the surveys which would be indicative of a stunted bluegill population, Actually, there appears to be a good representation of all size structures including almost half (48%) of the surveyed bluegills being over 7 inches in 1996 (Figure16).

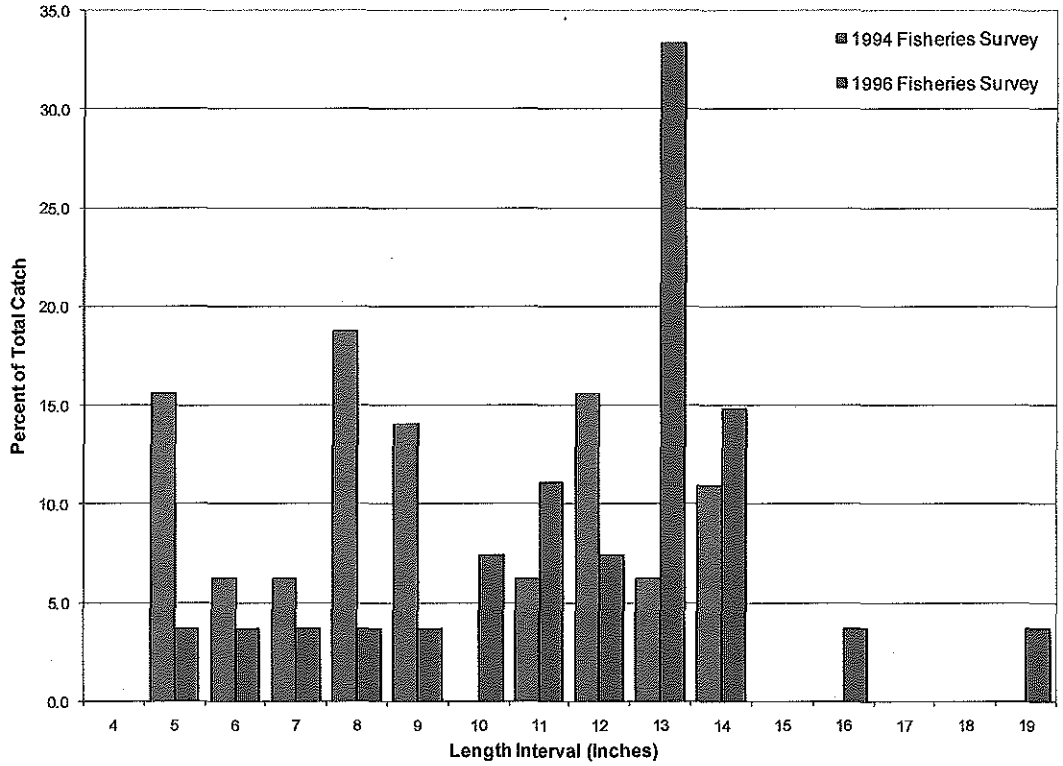


Figure 15. One-inch length intervals for largemouth bass listed as percent of total catch from boomshocking field surveys completed by the WDNR in 1994 and 1996.

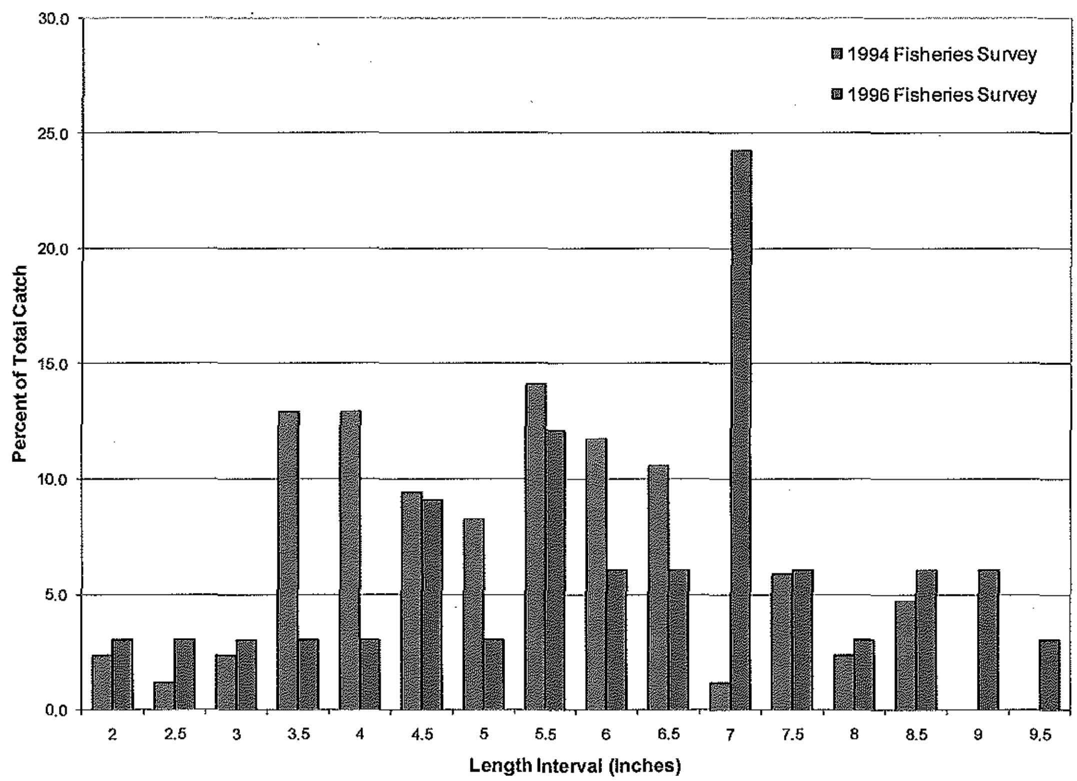


Figure 16. Half-inch length intervals for bluegill listed as percent of total catch from boomshocking field surveys completed by the WDNR in 1994 and 1996.

Table 3. Mean length (inches) and range of fish species sampled during 1994 and 1996 boomshocking surveys.

	1994			1996		
	N	Mean	Range	N	Mean	Range
Bluegill	86	5.4	2.0-8.9	33	5.9	1.5-9.1
Largemouth bass	50	10.0	5.0-14.9	27	11.7	5.1-19.0
Yellow perch	24	5.6	4.1-7.9	4	7.4	6.0-9.4
Rock bass	20	5.9	3.7-8.4	13	6.1	3.7-8.2
Northern pike	8	13.4	8.0-21.0	10	16.7	14.4-20.7
Yellow bullhead	2	—	—	1	—	—
Black crappie	2	—	—	0	—	—
Pumpkinseed	1	—	—	5	5.7	3.9-7.0

— = Not Available

The conclusions made in this section are based on information that is lacking replicate and current data. A fish netting survey is tentatively scheduled for Porters Lake during 2008, but may be postponed due to more pressing threats to fish populations state-wide (e.g. VHS). Extrapolating data collected during the boomshocking events to the fish population of Porters Lake is not valid and without the aid of mark-recapture surveys, the fish population levels cannot be determined. However, the data available is valid to understand fish population size composition.

In the Water Quality Section of this report, Porters Lake is suggested to be mesotrophic with relatively low chlorophyll-*a* levels and moderate total phosphorus concentrations. This allows Porters Lake to have good water clarity, but inhibits its ability to support the large fish biomass that eutrophic lakes can support. Consistent with Niebur's recommendations, overexploitation and predatory pressures are most likely the primary forces shaping the fishery in Porters Lake. The survey data clearly shows that largemouth bass between 10 and 14 inches are abundant, but decline to almost zero once they reach 14 inches. It is most likely not a coincidence that the minimum size limit on largemouth bass is 14 inches. Volunteer catch-and-release practices need to be implemented to increase the size structure of largemouth bass. Stocking of largemouth bass should only occur if the populations are shown to be low since stocking can be potentially counterproductive to increasing a population's size structure.

Increasing the size structure of predatory fish, such as the largemouth bass, will drastically affect the population of panfish such as yellow perch and bluegill. Especially in a small lake like Porters Lake, a large panfish population can result in a 'stunted' size structure. The increased predation pressures will decrease population levels to those that can support fewer, larger panfish. Because of their shape (dorsal-ventrally flattened), bluegill are not a common diet item of largemouth bass but are predated on by northern pike. An increase in northern pike populations will contribute to a larger size structure of bluegill, barring overexploitation of the this panfish.

SUMMARY AND CONCLUSIONS

One of the primary goals of Porters Lake Comprehensive Management Planning Project was to collect baseline data and information regarding the lake's aquatic plant community, its water quality, and its drainage basin. Aquatic plant surveys were completed during the summer of 2006, while water quality sampling was conducted beginning in the spring of 2006 and ending in the winter of 2007. Analysis of those data was completed concurrently with modeling of the lake's watershed during the winter of 2006/2007. Overall, the studies and analysis indicate that Porters Lake is in good health.

The water quality of the lake would be considered generally to be very good. Trophic analysis indicates that the lake is moderately productive and based upon chlorophyll-*a* and total phosphorus concentrations from 2006, the lake is in a middle mesotrophic state.

Thirty-six native aquatic plant species were found during the summer 2006 surveys, which is an outstanding level of species richness when compared to other lakes in the state and ecoregion. Furthermore, the species diversity of the lake was found to be quite high and Floristic Quality Analysis indicates that Porter Lake's plant community is much like that of a relatively undisturbed system (FQI=38). One contributing factor in the lake's healthy plant community is likely the fact that with exception of very limited amounts of purple loosestrife, there were no aquatic invasive species (AIS) found within the lake.

As mentioned above, the water quality of Porters Lake is very good. This is not a surprise based upon the condition and limited size of its watershed. The watershed to lake area ratio (WS:LA) for Porters Lake is 1:1; meaning that there is roughly one acre of land draining to each acre of lake surface area. In general, lakes with WS:LA values lower than 12:1 have less water quality problems than lakes with higher ratios. Another positive of the Porters Lake watershed is that only a very small amount of it is currently used for row crop agriculture (<1%).

The fishery of Porters Lake is dominated by largemouth bass, northern pike, and panfish (bluegill, yellow perch, and rock bass). Based on data collected in 1994 and 1996, the largemouth bass size structure is comprised mainly of smaller fish and the bluegill size structure is adequately represented by all size classes, albeit smaller than anglers would like to see. Consistent with WDNR recommendations for Porters Lake, a volunteer catch-and-release strategy of largemouth bass will increase the size structure of this species as well as contribute to the increasing the size structure of panfish. Increasing the population of northern pike in the lake will also aid in the increase in size structure of the lake's panfish, specifically for bluegill. Future stocking of Porter's Lake should only be conducted if a fish's population is shown to be low to decrease the affects that stocking has on size structure composition. Ultimately, the fishery of Porters Lake will benefit from more current and comprehensive fisheries data being collected to aid in its management.

Basically, it comes down to the fact that Porters Lake is healthy because of its watershed size and condition and because non-native plants, such as Eurasian water milfoil and curly-leaf pondweed are not believed to occur within it. With the exception of continued efforts in controlling the purple loosestrife, there really are no other apparent management actions involving control or ecosystem modification required to keep Porters Lake healthy. Unfortunately, the preceding statement may lead some Porters Lake stakeholders to believe that nothing needs to be done to keep the lake healthy. That would be true if management options were not available to protect and preserve the lake, however there are many.

In reality, the management of Porters Lake may be much more difficult than managing a lake with an exotics infestation or poor water quality resulting from agriculture within the watershed. In those cases, the stakeholders have a goal that is attainable by completing some type of management action or a series of management actions. In the case of Porters Lake, nothing has really been done to manage the lake in the past, yet it is in good health, so motivating stakeholders to alter their behavior or conduct management actions aimed at protecting the lake may be difficult. The primary management goal for Porters Lake must be to keep the lake in its current healthy state. In order to meet that goal, the Porters Lake Management District cannot sit idly by - it must act. The district must motivate its members and other stakeholders to minimize their impacts to the lake. In turn, the district must prove to these stakeholders that their efforts are not in vane and are helping to keep the lake healthy. In order to prove that the management is working, the district must monitor the condition of the lake and relay those results to the stakeholders.

Finally, this report would not be complete if the concept of marl (calcium carbonate, $CaCO_3$) precipitation in Porters Lake was not discussed. In some lakes, often known as *marl* lakes, carbonate values are sufficient to cause the precipitation of marl from the water column. Marl deposits can build up and cause some areas of a lake to become shallower over time. Porters Lake experiences a significant amount of marl precipitation, which gives the lake its striking bluish- green color. The marl formation also pulls phosphorus out of the water column and locks it in the sediments reducing algal production which helps keeps the water clear.

Some areas of Porters Lake have a great deal of marl that has built up over the course of the lake's life. Combine that with some of the lowest water levels in the past decade or so and it is not surprising that some areas of lake are difficult to navigate through in a boat. Although it was never officially brought forth within the planning process, it is known that some shoreland property owners believe that dredging the lake bottom would be an appropriate method to correct this perceived problem. Not only would this be a very expensive remedy, but obtaining permits from the WDNR would be difficult because of the ecological impacts dredging has on a lake. The most important of these impacts would be the increased risk of invasive plant infestation within the dredged areas. Studies completed as a part of this project led to the conclusion that Eurasian water milfoil and curly-leaf pondweed do not exist within the lake at this time. However, when the high numbers of area lakes that are infested with these species are considered, it is likely that invasive species have been introduced to Porters Lake on numerous occasions, but were prevented from establishing by the lake's high-quality native plant community. Obviously the native plants would be removed with the sediments during the dredging operations, which would leave those areas completely open to invasive species establishment. Once an invasive species is established in an area of a lake, it is difficult to keep it from invading other areas of the lake; therefore, dredging even a small area of Porters Lake would put the entire lake at risk.

IMPLEMENTATION PLAN

As discussed in the Summary and Conclusions Section, Porters Lake was found to be a healthy lake ecosystem. With the exception of purple loosestrife, there are no known exotics, the water quality is good, and the watershed is not suspect of negatively impacting the lake. Although this is very good news for the lake, it does mean that motivating the lake's stakeholders to take action to keep the lake healthy may be difficult. This is often the case because maintaining the status quo means doing nothing different than what has been done in the past. However, with increased threats of exotics and rising shoreland development, doing nothing is not going to protect the lake from degradation. The correct attitude is to be proactive by acting to prevent the negative impacts through monitoring, communication, and stakeholder education.

The Implementation Plan outlined below focuses upon preserving Porters Lake in its current state. The plan aims to protect the native habitat by not only preventing the spread of exotics, but also by preserving the current state of lake's aquatic plant community and water quality by limiting in-lake and shoreland impacts. Each management action naturally falls into one or more of three categories; prevention, education, or early detection. Essentially, these categories describe a three-pronged approach that will be used to meet the district's goal of preserving Porters Lake.

Prevention Actions include those designed to directly prevent the introduction of exotics and those that prevent degradation of the plant communities through in-lake processes from anthropogenic sources.

Education Actions are those designed to inform lake users about their impacts on lakes. The educational initiatives may be aimed at lake users that access lake through its public landing or those that are current or perspective riparians.

Early Detection
Early detection actions are included to increase the chances that pioneer infestations of exotic plants are found early thereby increasing the chance of effective control or possibly eradication.

Management Goal 1: Maintain Current Water Quality Conditions

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

Category: Early Detection

Timeframe: Begin Summer 2008, if possible.

Facilitator: Combined effort of current Secchi disk collector and water quality collector.

Description: Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason as of why the trend is developing. A volunteer from Porters Lake has been collecting Secchi disk clarities for over 20 years. A second volunteer has been collecting water quality data through the UW-Stevens Point Water and Environmental Analysis Laboratory program that calls for only spring and fall overturn samples to be collected. Although that water quality data are useful in tracking long-term trends within the lake, more in depth data collection, including samples collected during the summer growing season, would be more useful in tracking the lake's water quality. In order to collect the data referred to above, the efforts should be combined within the WDNR Citizens Lake Monitoring Network and the advanced water quality protocol should be followed.

Action Steps:

1. Volunteers contact Mark Sesing, WDNR to arrange for training and equipment.
2. Volunteers collect data and report results to WDNR and to district members during annual meeting.

Management Action: Reduce phosphorus and sediment loads from immediate watershed.

Category: Education & Prevention

Timeframe: Begin 2008

Facilitator: Planning Committee to recruit volunteer or form Education Committee

Description: Porters Lake has a small 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 district will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include news letter articles and guest speakers at district meetings. This action will also include participation in Waushara County shoreland restoration programs as deemed appropriate by the Waushara County Land Conservation and Zoning Department and the Porters Lake Management District.

Action Steps:

1. Recruit facilitator.
2. Facilitator gathers appropriate information from WDNR, UW-Extension, Waushara County and other sources.
3. Facilitator summarizes information for newsletter articles and recruits appropriate speakers for district meetings.

Management Action: Investigate purchase of undeveloped shoreland property.
Category: Prevention
Timeframe: Begin 2009
Facilitator: Board of Directors
Description: There are undeveloped shoreland properties around Porters Lake that could be placed within a perpetual easement with the WDNR or some other conservation group. By doing this, these shoreland areas would be protected from development and its adverse impacts on lakes. The WDNR will provide financial assistance to qualified lake groups for the purchase of shoreland properties through their Lake Protection Grant Program. In fact, this program provides 75% cost matching up to $200,000 for eligible projects.

There is much upfront work required for the grant application, so the first step should be to estimate the value of the property and using that information decide if the PLMD would be able to raise the local share. If so, the WDNR should be contacted for more information on what tasks would need to be completed in order to apply for a grant.

Action Steps:

1. See description above.

Management Goal 2: Prevent Introduction and Establishment of Aquatic Invasive Species within Porters Lake

Management Action: Initiate *modified* Clean Boats Clean Waters watercraft inspections at Porters Lake public access
Category: Prevention & Education
Timeframe: In progress
Facilitator: Planning Committee
Description: With the exception of purple loosestrife, Porters Lake is believed to be free of aquatic invasive species. Initiating a modified program of watercraft inspections based upon the WDNR Clean Boats Clean Waters program will help to reduce the chance that the other exotic species, such as Eurasian water milfoil, zebra mussels, and curly-leaf pondweed would be introduced to the lake. Porters Lake is not considered a primary fishing-destination in Waushara County and because it is a slow-no-wake lake, it is not visited on a frequent basis by lake users that do not have property on the lake; therefore, a modified inspection program aimed at the most busy weekends of the year would be targeted for watercraft inspections by volunteers from Porters Lake.

Action Steps:

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

Management Action: Reduce occurrence of purple loosestrife on Porters Lake shorelands.
Category: Prevention & Early Detection
Timeframe: In progress
Facilitator: Mr. David Hansen
Description: David Hansen has been monitoring and facilitating control efforts of purple loosestrife on Porters Lake shorelands for 7 years and has brought the occurrence of the plant down considerably.
Action Steps:

1. Recruit members to continue monitoring and control efforts
2. Group completes surveys
3. Initiate applicable control methods
4. Monitor results and reapply control as necessary

Management Action: Initiate volunteer-based monitoring of aquatic invasive species.
Category: Education, Prevention, & Early Detection
Timeframe: 2008
Facilitator: Planning Committee
Description: Early detection of invasive plant species within a lake increases the chances of control and possible eradication of the species as opposed to discovering an exotic once it becomes well established. Using trained volunteers is a feasible method to monitor for the occurrence of these unwanted species. The keys to success are proper training and persistence by the lake group.
Action Steps:

1. Volunteers from PLMD attend training session conducted by WDNR/UW-Extension (completed spring 2007)
2. Trained volunteers recruit and train additional district members
3. Complete lake surveys following protocols
4. Report results to WDNR and PLMD

Management Goal 3: Increase Communication and Lake Management Action Tracking Capacity of Porters Lake Management District

Management Action: Create biannual or greater frequency newsletter.
Category: Education
Timeframe: 2008
Facilitator: Planning Committee to recruit volunteers
Description: Regularly published newsletters allow for exceptional communication within a lake group. This level of communication is important within a management group because it builds a sense of community while facilitating the spread of important district news, educational topics, and even social happenings. It also provides a medium for the recruitment and recognition of volunteers.

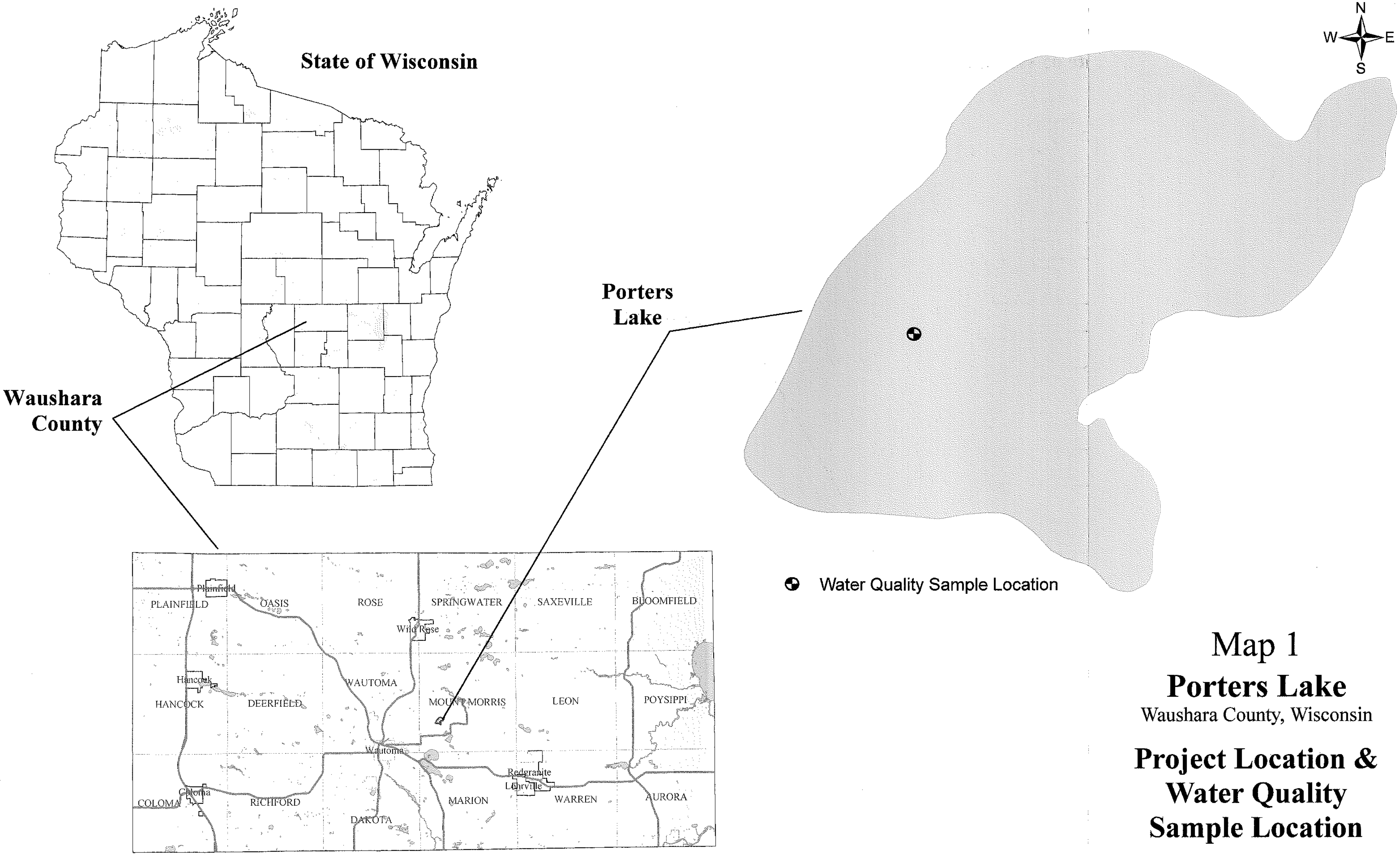
A WDNR Small-scale Planning Grant would be an applicable source of matching funds for the start-up costs of the district newsletter.

Action Steps:

1. Volunteers for Newsletter Committee recruited by Planning Committee
2. Newsletter Committee meets to create list of regular and special columns.
3. Volunteers sought to provide articles for regular and special columns.
4. Committee creates and distributes first Porters Lake Newsletter

Management Action: Create and maintain *Porters Lake Management Binder*
Category: Education, Prevention, and Early Detection
Timeframe: 2008
Facilitator: Planning Committee
Description: Lake groups often form to cooperatively manage a lake's plants, water quality, and/or fishery. Unfortunately, these groups often do not maintain useable records of the actions they take or the results of the actions. The tracking of management actions and their outcome is important in effectively and efficiently managing a lake ecosystem because it will help to assure that only successful actions are carried out repeatedly. Maintenance of the binder will also serve as a reference for future participants in the district.
Action Steps:

1. Create binder with tabs for different categories of the management actions (e.g., fish stocking, AIS monitoring, water quality monitoring, watercraft inspection results, purple loosestrife monitoring and control, etc.)
2. District board member maintains binder.



Map 1

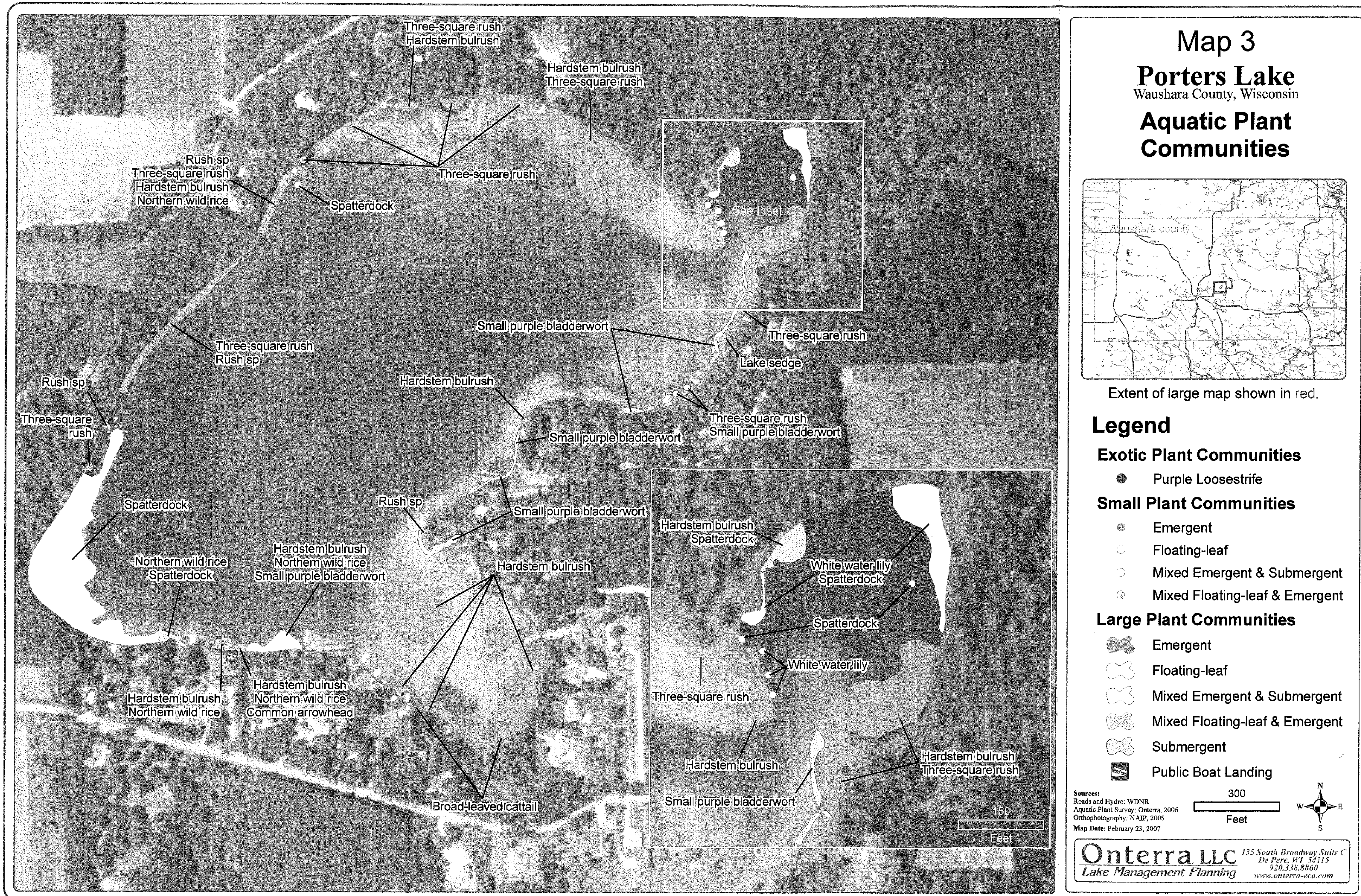
Porters Lake

Waushara County, Wisconsin

Project Location & Water Quality Sample Location

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


Map 2
Porters Lake
Waushara County, Wisconsin
Watershed and
Land Cover Types
Waushara County
Extent of large map shown in red.
Legend
Watershed Boundary
Land Cover Types
Urban - Rural Residential
Row Crop Agriculture
Pasture/Grass
Forest
Open Water
Wetland
N
W
E
S
800
Feet
Sources:
Orthophotography: 2005 NAIP
Roads and Hydro: WDNR
Land Cover: ECRPC/Waushara County (Onterra Modified)
Map Date: February 23, 2007
Onterra, LLC
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com



Map 3
Porters Lake
Waushara County, Wisconsin
Aquatic Plant Communities
Waushara county
Extent of large map shown in red.
Legend
Exotic Plant Communities
Purple Loosestrife
Small Plant Communities
Emergent
Floating-leaf
Mixed Emergent & Submergent
Mixed Floating-leaf & Emergent
Large Plant Communities
Emergent
Floating-leaf
Mixed Emergent & Submergent
Mixed Floating-leaf & Emergent
Submergent
Public Boat Landing
Sources:
Roads and Hydro: WDNR
Aquatic Plant Survey: Onterra, 2006
Orthophotography: NAIP, 2005
Map Date: February 23, 2007
300
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S
Onterra LLC
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com
Three-square rush
Hardstem bulrush
Hardstem bulrush
Three-square rush
Rush sp
Three-square rush
Hardstem bulrush
Northern wild rice
Three-square rush
Spatterdock
See Inset
Three-square rush
Rush sp
Small purple bladderwort
Three-square rush
Lake sedge
Rush sp
Three-square rush
Hardstem bulrush
Three-square rush
Small purple bladderwort
Small purple bladderwort
Spatterdock
Rush sp
Small purple bladderwort
Northern wild rice
Spatterdock
Hardstem bulrush
Northern wild rice
Small purple bladderwort
Hardstem bulrush
Hardstem bulrush
Northern wild rice
Hardstem bulrush
Northern wild rice
Common arrowhead
Broad-leaved cattail
Hardstem bulrush
Spatterdock
White water lily
Spatterdock
Spatterdock
White water lily
Three-square rush
Hardstem bulrush
Hardstem bulrush
Three-square rush
Small purple bladderwort
150
Feet

METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Porters Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in the lake (Map 1) and samples were collected with a 3-liter Van Dorn bottle at the subsurface (S) and near bottom (B). Sampling occurred once in spring, fall, and winter and three times during summer. Samples were kept cool and preserved with acid following normal protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included the following:

	Spring		June		July		August		Fall		Winter	
Parameter	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Total Phosphorus	●	●	●	●	●	●	●	●	●	●	●	●
Dissolved Phosphorus	●	●			●	●					●	●
Chlorophyll <u>a</u>	●		●		●		●		●			
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 and a temperature, pH, conductivity, and dissolved oxygen profile was be completed using a Hydrolab DataSonde 5.

Aquatic Vegetation

A quantitative aquatic vegetation survey was conducted during July 5 & 6, 2006 using the point-intercept method as described in "Appendix C" of the Wisconsin Department of Natural Resource document, <u>Aquatic Plant Management in Wisconsin - Draft</u>, (April 25, 2005) was be used to complete the study. Based upon advice from the WDNR, a point spacing of 40 meters was used resulting in approximately 207 points (Appendix D). Furthermore, all species found outside the set points were recorded to provide a complete species list for the lake.

Watershed Analysis

The watershed analysis began with an accurate delineation of Porters 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 East Central Regional Planning Commission were then combined to determine the preliminary watershed land cover classifications. The land cover data within the watershed were then field verified and updated during spring 2006. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003).

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A

APPENDIX A

Stakeholder Participation Materials

Porters Lake Comprehensive Management Plan

Project Kick-Off Meeting

July 29, 2006 12:00 PM

Don Dalton Residence - 6850 Porters Lake Road

Aquatic ecologist, Tim Hoyman of Onterra, speaks to a lake group in Waushara County about their lake management plan. Public participation will be integral part of the Porters Lake project.

The Porters Lake Management District has received two grants from the Wisconsin Department of Natural Resources to partially fund the completion of a comprehensive management plan for Porters Lake. The project has two primary objectives, the first being the completion of an in-depth study including multiple plant surveys, water quality sampling, and watershed investigations; the second being the completion of a realistic management plan for the lake and its watershed. Most of the studies will be completed during this spring, summer and fall. The tasks associated with the analysis of the data will be completed during the fall and winter. The project will also incorporate opportunities for stakeholder education and input, which are both very important components of all lake management planning efforts. The first opportunity for your participation in the process will be at the Project Kick-off Meeting to be held on Saturday, July 29th at 12:00 pm at the Dalton Residence.

Onterra, LLC, a lake management planning firm out of De Pere, has been hired to lead the project. During the meeting Tim Hoyman, an Aquatic Ecologist with Onterra, will describe the project and its importance. His presentation will include a description of the project's components, a quick course on general lake ecology, and a breakdown of how the District's Planning Committee will be involved in the plan's completion. So, please plan on attending the meeting and do not hesitate to ask questions or make comments.

Porters Lake Management District

Porters Lake Comprehensive Management Planning Project

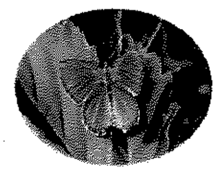
Kick-off Meeting

July 29, 2006

Timothy A. Hoyman, CLM
Onterra LLC

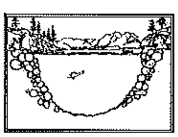
Presentation Outline

- Introduction to Lake Ecology
- Current Lake Project
  - Goals
  - Components
  - Process

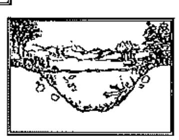


General Lake Ecology

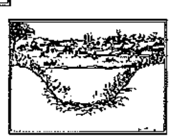
Eutrophication



Oligotrophic



Mesotrophic

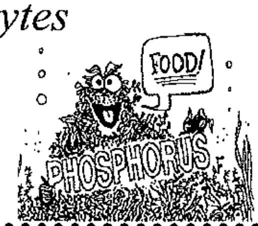


Eutrophic

General Lake Ecology

Phosphorus

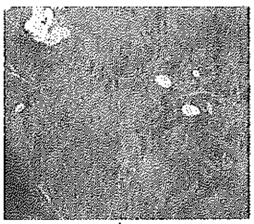
- *Limiting Nutrient*
- *Controls Plant Abundance*
  - *Algae*
  - *Macrophytes*



General Lake Ecology

Aquatic Plants

- *Exotic Plants*
- *Native Plants*



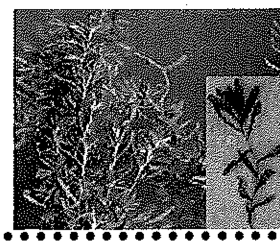
Onterra LLC

General Lake Ecology

Exotic Plants

Eurasian Water Milfoil

Curly-leaf Pondweed



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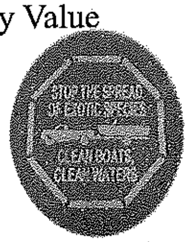
General Lake Ecology

Consequences of Exotic Plants

- ➢Competition with Natives
  - ➢Monotypic Community
- ➢Decreased Recreational Value
- ➢Decreased Property Value



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General Lake Ecology

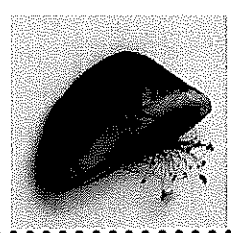
Zebra & Quagga Mussels

Native to Black and Caspian Sea Region of Europe

Entered Great Lakes in 1988

Compete with young fish for food

Preventing introduction is key



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Current Project

Study Plan & Goals

- Collect & Analyze Data
- Construct Long-Term & Useable Plan

Study Components

- Public Participation
- Watershed Modeling
- Water Quality
- Aquatic Vegetation
  - Curly-leaf Survey
  - Comprehensive Survey
- Plan Development

Current Project

Planning Process

Planning Committee Meetings

- Study Results
- Conclusions & Initial Recommendations
- Management Goals
- Management Actions
  - Timeframe
  - Facilitator(s)

Porters Lake Management District

Porters Lake Comprehensive Management Planning Project

Planning Meeting I

February 24, 2007

Timothy A. Hoyman, CLM

Onterra LLC
Lake Management Planning

Water Quality

Phosphorus
(Limiting Plant Nutrient)

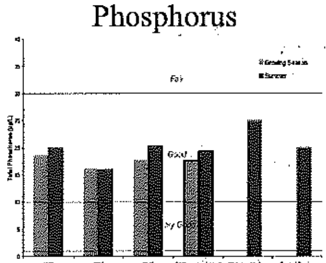
Chlorophyll-*a*
(Algal Abundance)

Water Clarity
(Secchi Disk)

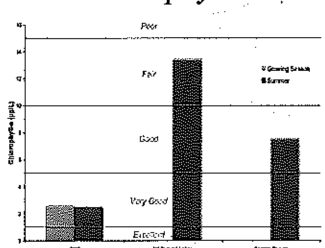
Onterra LLC

Water Quality

Phosphorus



Chlorophyll *a*



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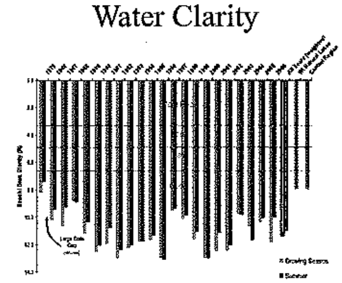
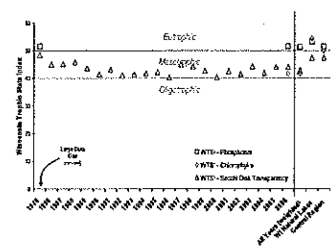
Water Quality

Water Clarity

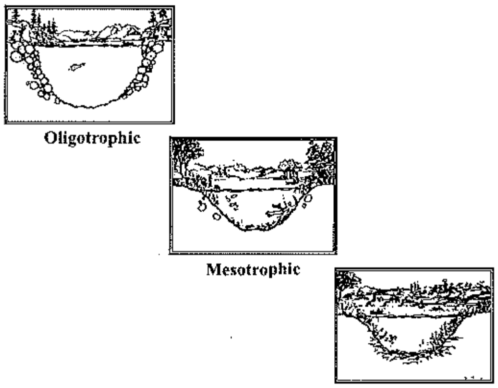


Trophic State



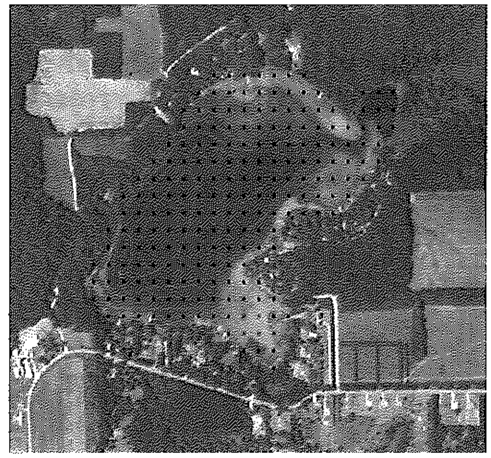
Onterra LLC

Eutrophication



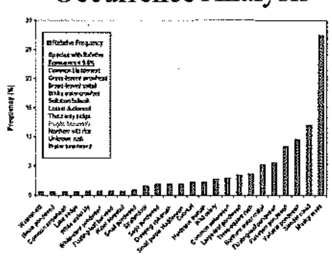
Aquatic Plants

Point-Intercept Study

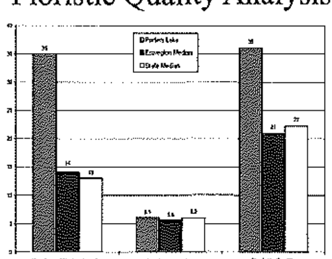


Aquatic Plants

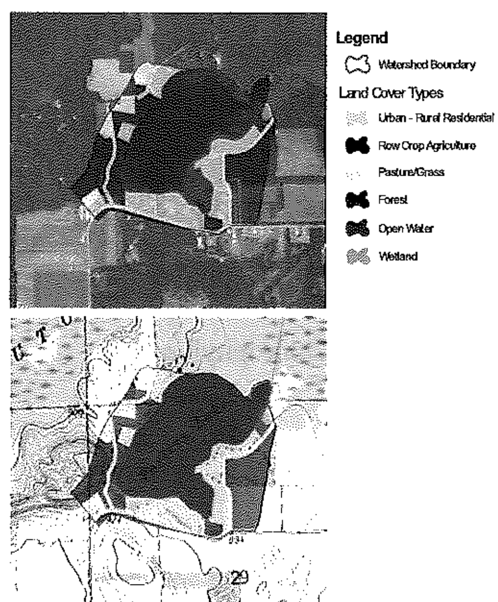
Occurrence Analysis



Floristic Quality Analysis

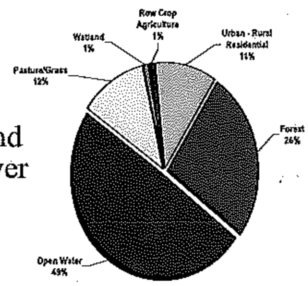


Watershed

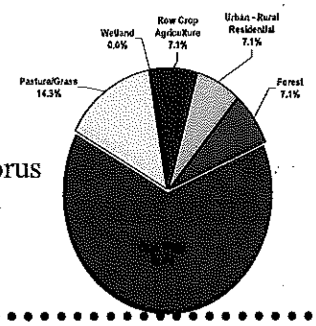


Watershed

Land Cover



Phosphorus Load



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Planning Process

Planning Committee Meetings

- Study Results
- Conclusions & Initial Recommendations
- Management Goals
- Management Actions
  - Timeframe
  - Facilitator(s)

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Implementation Plan

Protection Mode

The Most Difficult Plan to Implement

- Course of action can seem undefined
- Status quo equals success
  - Goal is already met
  - Motivation can be difficult
- Volunteer involvement is essential

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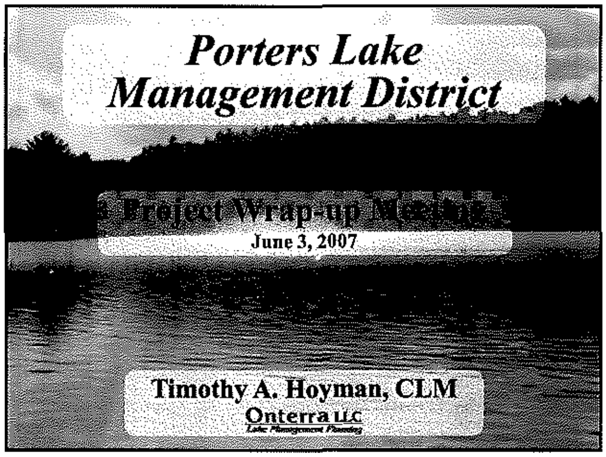
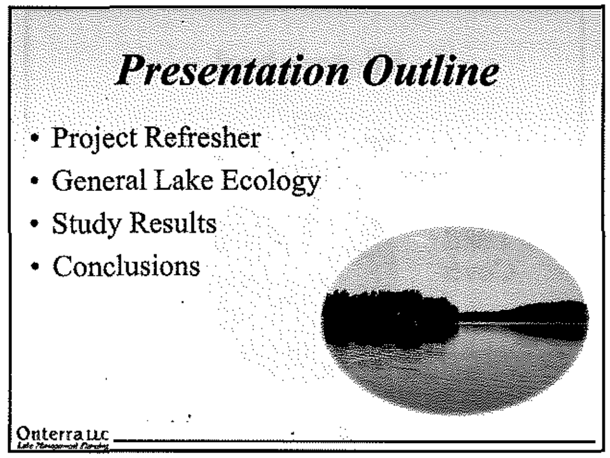
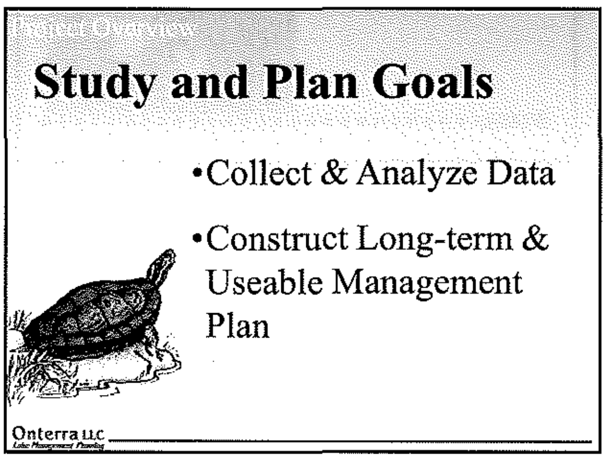
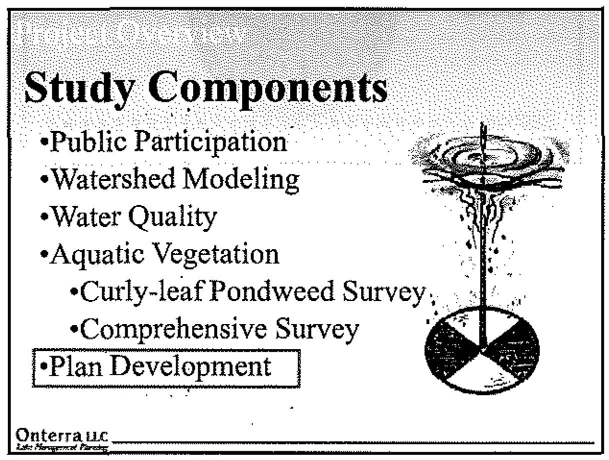
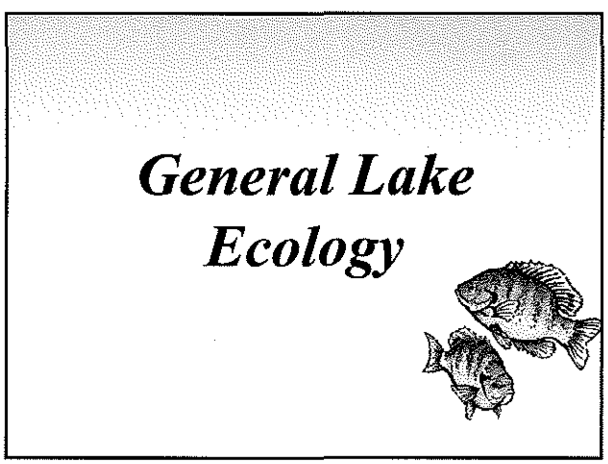
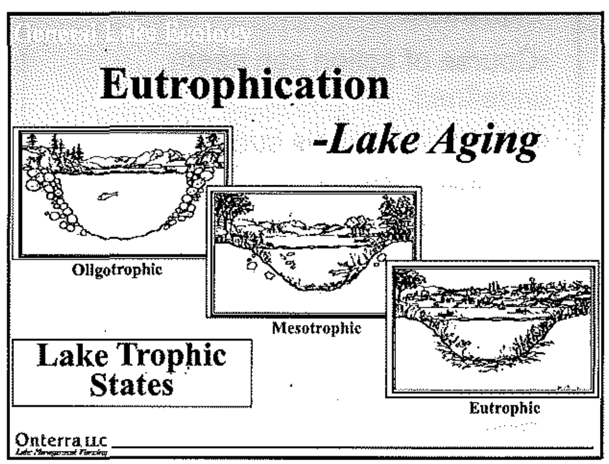

Porters Lake
Management District
Project Wrap-up Meeting
June 3, 2007
Timothy A. Hoyman, CLM
Onterra LLC

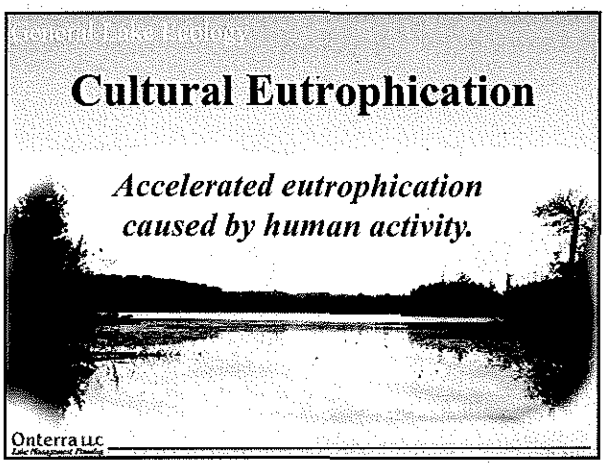

Presentation Outline
• Project Refresher
• General Lake Ecology
• Study Results
• Conclusions
Onterra LLC

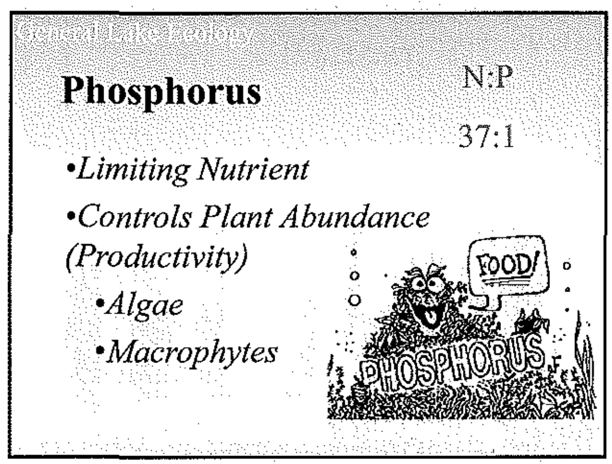

Project Overview
Study and Plan Goals
•Collect & Analyze Data
•Construct Long-term & Useable Management Plan
Onterra LLC

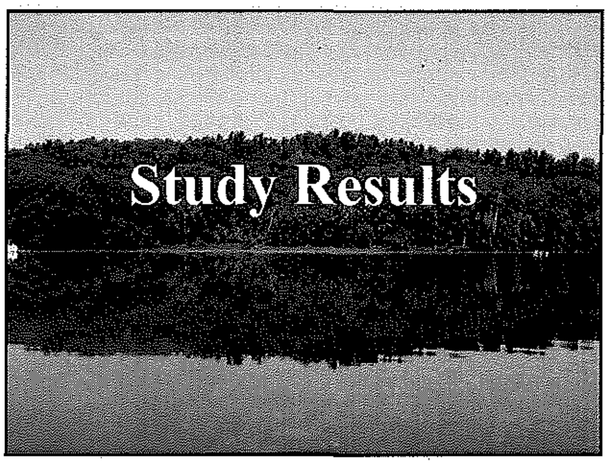

Project Overview
Study Components
•Public Participation
•Watershed Modeling
•Water Quality
•Aquatic Vegetation
•Curly-leaf Pondweed Survey
•Comprehensive Survey
•Plan Development
Onterra LLC

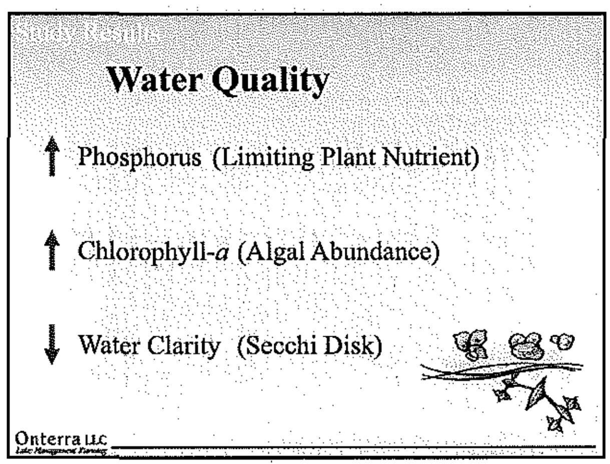

General Lake
Ecology

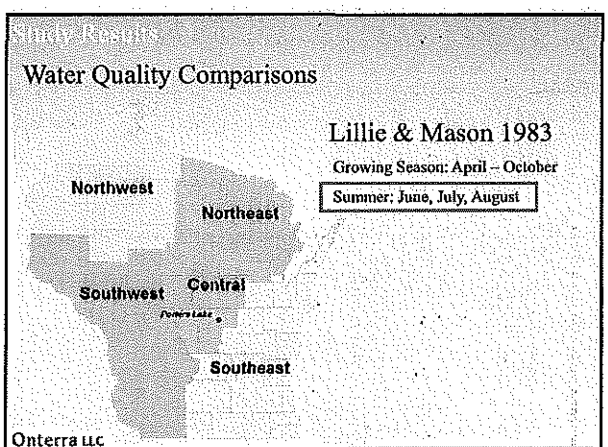

General Lake Ecology
Eutrophication
-Lake Aging
Oligotrophic
Mesotrophic
Eutrophic
Lake Trophic States
Onterra LLC

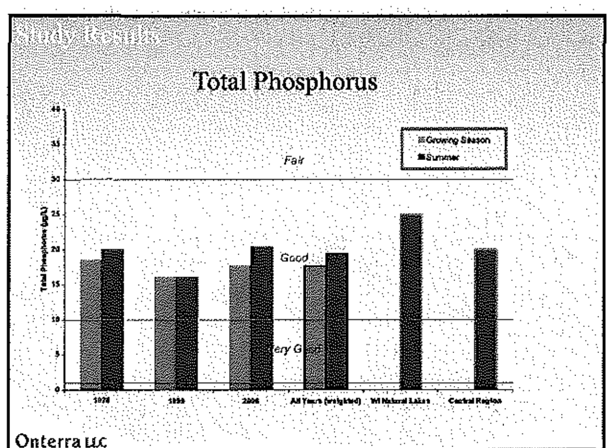

General Lake Ecology
Cultural Eutrophication
Accelerated eutrophication caused by human activity.
Onterra LLC

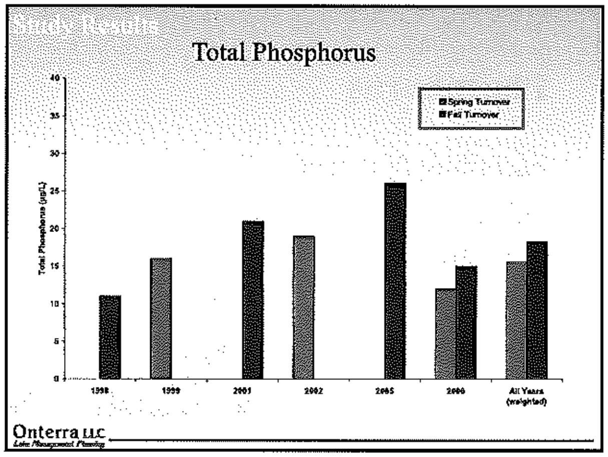

General Lake Ecology
Phosphorus
N:P
37:1
•Limiting Nutrient
•Controls Plant Abundance (Productivity)
•Algae
•Macrophytes
FOOD!
PHOSPHORUS

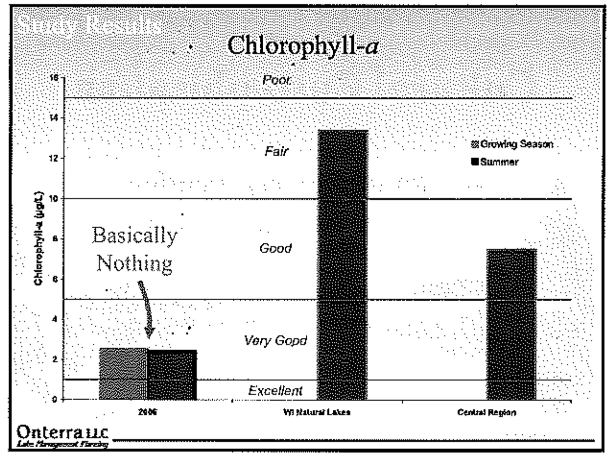

Study Results

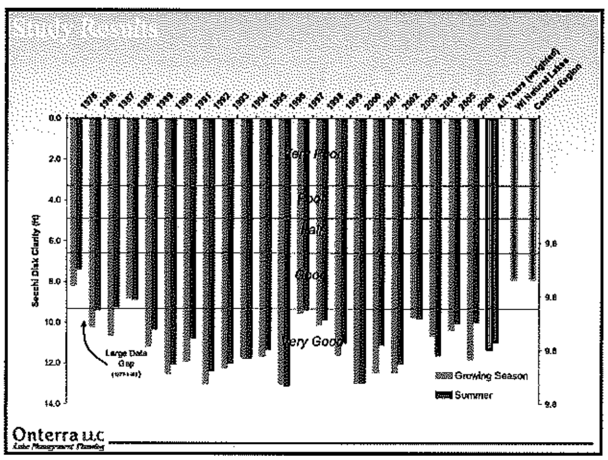

Study Results
Water Quality
Phosphorus (Limiting Plant Nutrient)
Chlorophyll-a (Algal Abundance)
Water Clarity (Secchi Disk)
Onterra LLC

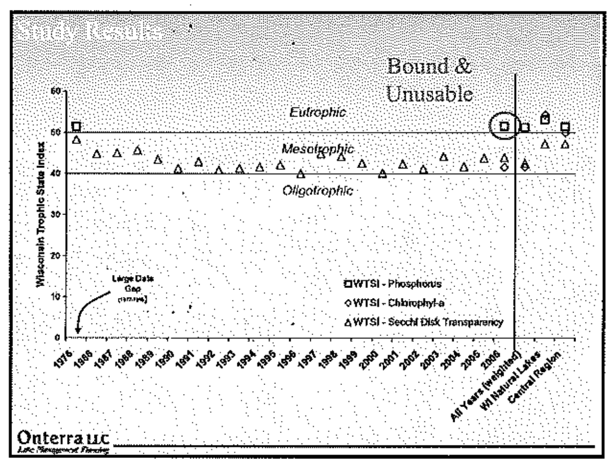

Study Results
Water Quality Comparisons
Lillie & Mason 1983
Growing Season: April – October
Summer: June, July, August
Northwest
Northeast
Southwest
Central
Porters Lake
Southeast
Onterra LLC


Study Results
Total Phosphorus
Growing Season
Summer
Fair
Good
Onterra LLC

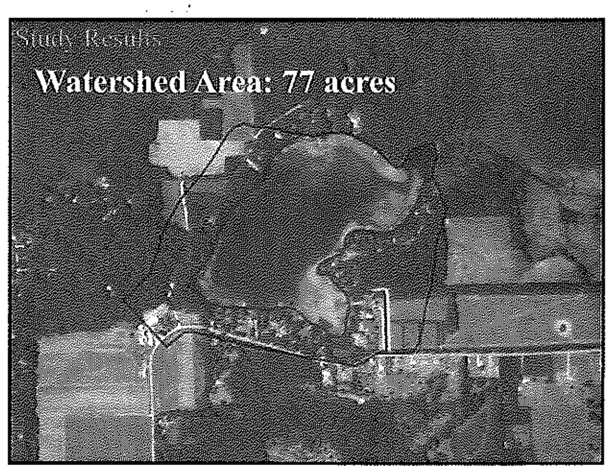

Study Results
Total Phosphorus
Spring Turnover
Fall Turnover
Onterra LLC

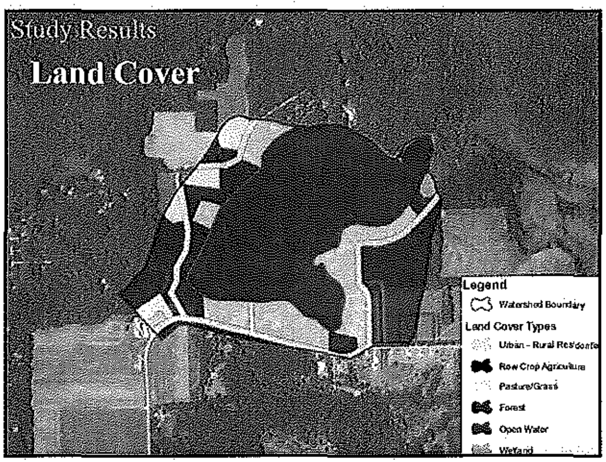

Study Results
Chlorophyll-a
Poor
Fair
Good
Very Good
Excellent
Basically Nothing
Growing Season
Summer
Onterra LLC

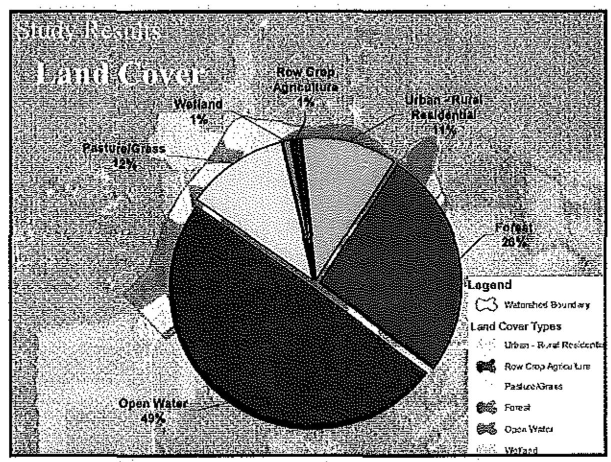

Study Results
Very Poor
Poor
Fair
Good
Very Good
Large Data Gap
Growing Season
Summer
Onterra LLC

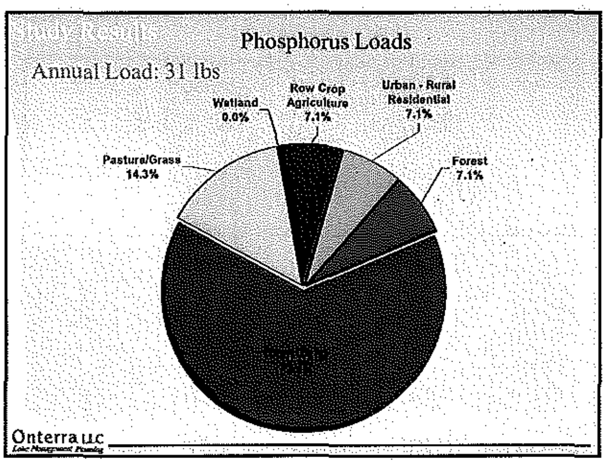

Study Results
Bound & Unusable
Eutrophic
Mesotrophic
Oligotrophic
Wisconsin Trophic State Index
Large Data Gap
WTSI - Phosphorus
WTSI - Chlorophyll-a
WTSI - Secchi Disk Transparency
All Years (weighted)
WI Natural Lakes
Central Region
Onterra LLC

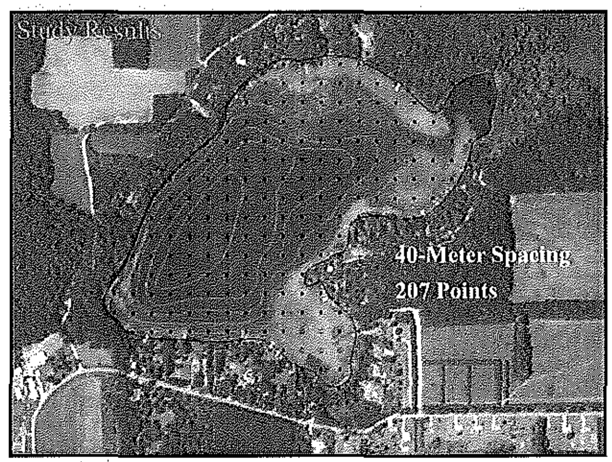

Study Results

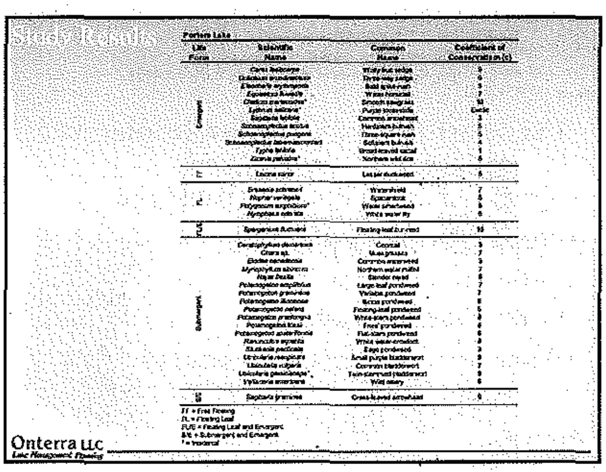

Study Results
Watershed Area: 77 acres

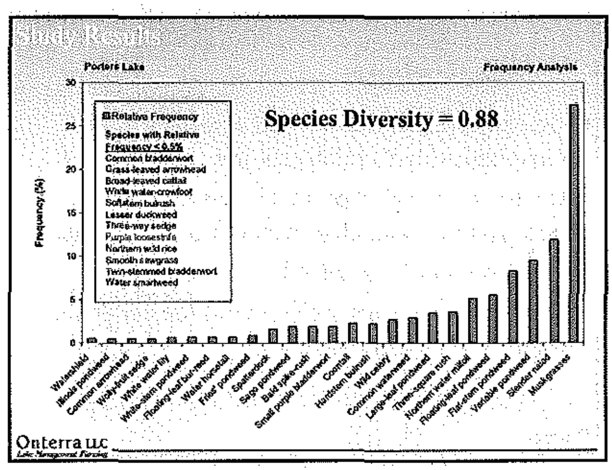

Study Results
Land Cover
Legend
Watershed Boundary
Land Cover Types
Urban - Rural Residential
Row Crop Agriculture
Pasture/Grass
Forest
Open Water
Wetland

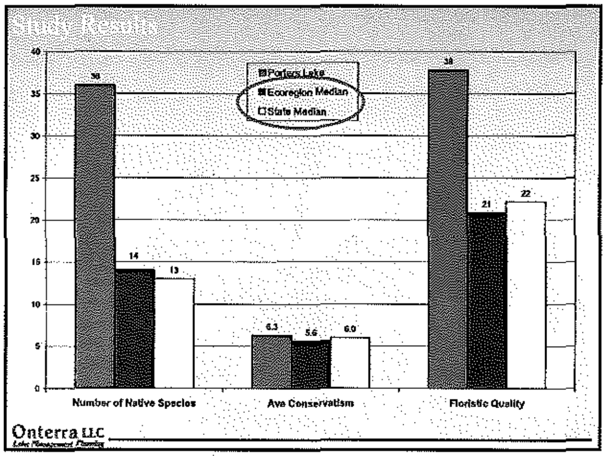

Study Results
Land Cover
Row Crop Agriculture 1%
Wetland 1%
Urban - Rural Residential 11%
Pasture/Grass 12%
Forest 26%
Open Water 49%
Legend
Watershed Boundary
Land Cover Types
Urban - Rural Residential
Row Crop Agriculture
Pasture/Grass
Forest
Open Water
Wetland

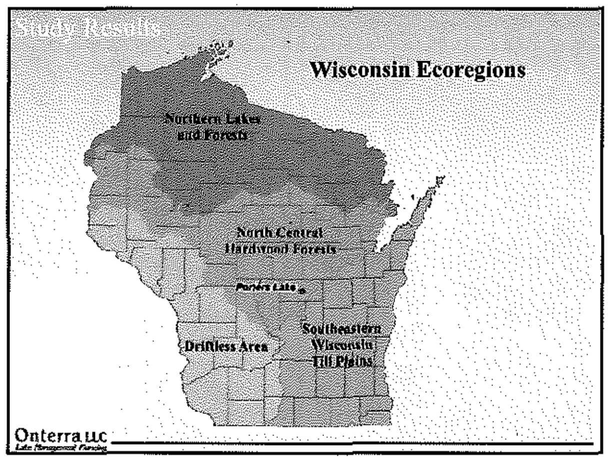

Study Results
Phosphorus Loads
Annual Load: 31 lbs
Wetland 0.0%
Row Crop Agriculture 7.1%
Urban - Rural Residential 7.1%
Pasture/Grass 14.3%
Forest 7.1%
Onterra LLC

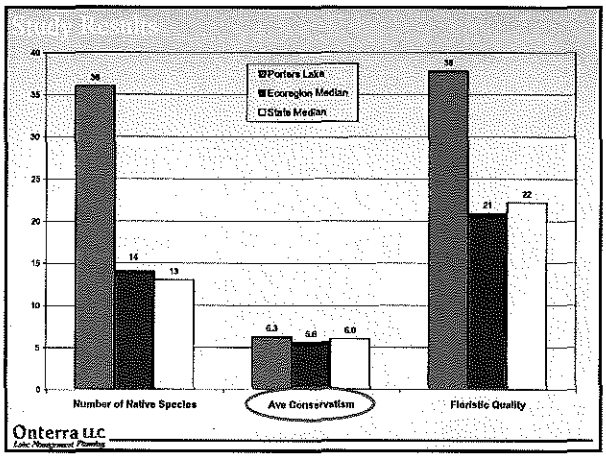

Study Results
40-Meter Spacing
207 Points

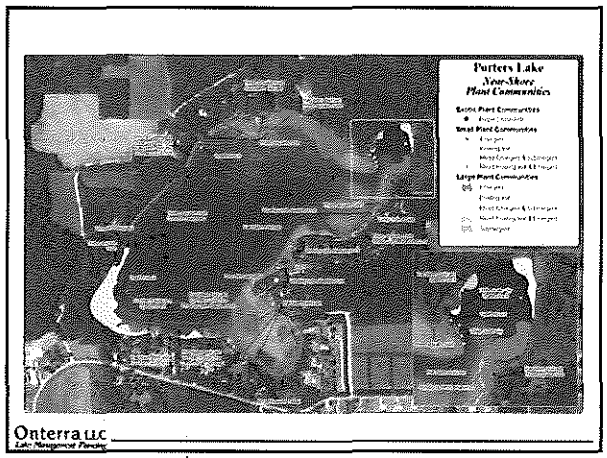

Study Results
Porters Lake
Onterra LLC


Study Results
Porters Lake
Frequency Analysis
Species Diversity = 0.88
Relative Frequency
Species with Relative Frequency <0.5%
Common bladderwort
Grass-leaved arrowhead
Broad-leaved cattail
White water-crowfoot
Softstem bulrush
Lesser duckweed
Three-way sedge
Purple loosestrife
Northern wild rice
Smooth sawgrass
Twin-stemmed bladderwort
Water smartweed
Frequency (%)
Onterra LLC









Study Results

Conclusions

- Marl precipitation and small watershed keep phosphorus levels relatively low.
- Relatively low phosphorus levels lead to low mesotrophic state, clear water, minimal plants.
- Plant community is excellent.
- No invasive species located with the exception of minimal purple loosestrife.

Porters Lake is Very Healthy!

Onterra LLC

Protection Mode

The Most Difficult Plan to Implement

- Course of action can seem undefined
- Status quo equals success
  - Goal is already met
  - Motivation can be difficult
- Volunteer involvement is essential

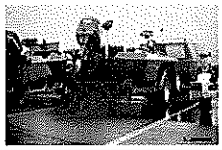
Onterra LLC

The Plan

Protection Mode

Three-prong Approach

- Education
- Prevention
- Early Detection



Onterra LLC

Implementation Plan

Goal 1: Maintain Current Water Quality Conditions

Management Actions

1. Monitor water quality through WDNR Citizens Lake Monitoring Network
2. Reduce sediment and phosphorus loads from immediate shoreland watershed.

Onterra LLC

Implementation Plan

Goal 2: Prevent Introduction and Establishment of Aquatic Invasive Species within Porters Lake

Management Actions

1. Initiate modified Clean Boats Clean Waters watercraft inspections at Porters Lake public access.
2. Reduce occurrence of purple loosestrife on Porters Lake Shoreland.
3. Initiate volunteer-based monitoring for Aquatic Invasive Species (AIS).

Onterra LLC

Implementation Plan

Goal 3: Increase Communication and Lake Management Action Tracking Capacity of Porters Lake Management District

Management Actions

1. Create biannual or greater frequency newsletter..
2. Create and maintain Porters Lake Management Binder

Onterra LLC

Thank You

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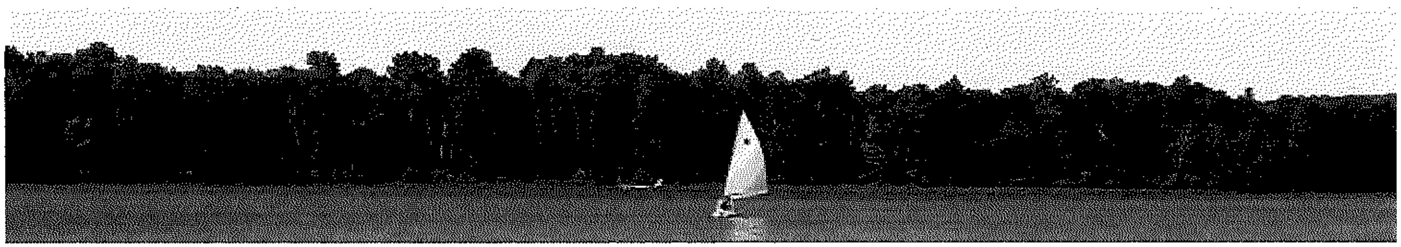
Wisconsin Lakes Partnership

UW Extension

Onterra LLC

Porters Lake, Waushara County, Wisconsin



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Contact us at:
info@porterslake.org

Lake Management Plan

On June 3, 2007 Tim Hoyman of Onterra, LLC presented the summary, conclusions and next steps of our Lake Management Plan. The good news is that the lake is in excellent health. The challenge is that there continue to be more and more threats to lakes and it will require diligence on all of our parts
to help protect the quality of our lake.

The final report is still being prepared. However, you can click here to view the information that Tim presented at the meeting. (PDF Format - Requires Adobe Reader)

B

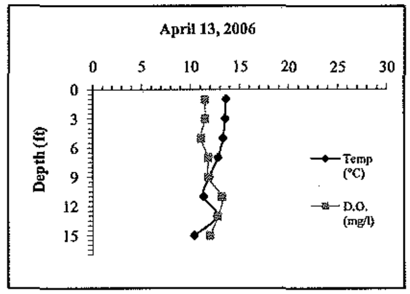
APPENDIX B

Water Quality Data

Porters Lake

Date:	04-13-06	Max Depth (ft):	15.5
Time:	10:50	PorLS Depth (ft):	3.0
Weather:	100% Clouds, 62°F, No Breeze	PorLB Depth (ft):	13.0
Ent:	EJH Verf:	Secchi Depth (ft):	15.2

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	13.6	11.5	9.1	286
3.0	13.5	11.5	9.1	286
5.0	13.3	11.1	8.9	288
7.0	12.8	11.8	9.0	287
9.0	11.9	11.8	8.8	288
11.0	11.3	13.2	8.8	286
13.0	12.7	12.8	8.8	287
15.0	10.4	12.0	8.9	287



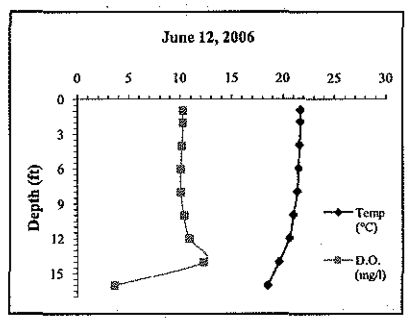
Parameter	PorLS	PorLB
Total P (µg/L)	12.000	10.000
Dissolved P (µg/L)	2.000	3.000
Chl a (µg/L)	1.85	
TKN (µg/L	780.00	840.00
NO3+NO2-N (µg/L)	84.000	74.000
NH3-N (µg/L)	238.000	241.000
Total N (µg/L)	864.00	914.00
Lab Cond. (µS/cm)	293	295
Lab pH	8.43	8.43
Alkal (mg/l CaCO3)	144	145
Total Susp Sol (mg/l)	ND	ND
Calcium (mg/l)	28.4	

TAH & EJH Conducted Fieldwork

Porters Lake

Date:	06-12-06	Max Depth (ft):	17.7
Time:	12:41	PorLS Depth (ft):	3.0
Weather:	10% Clounds, 68°F, Breezy	PorLB Depth (ft):	15.0
Ent:	EJH Verf:	Secchi Depth (ft):	8.6

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	21.7	10.3	9.2	248
2.0	21.7	10.3	9.3	249
4.0	21.6	10.2	9.3	249
6.0	21.5	10.1	9.3	249
8.0	21.4	10.1	9.4	249
10.0	21.0	10.4	9.4	247
12.0	20.6	10.9	9.3	281
14.0	19.6	12.3	9.1	264
16.0	18.5	3.7	7.4	341



Parameter	PorLS	PorLB
Total P (µg/L)	16.000	24.000
Dissolved P (µg/L)		
Chl a (µg/L)	3.12	
TKN (µg/L	800.00	920.00
NO3+NO2-N (µg/L)	ND	ND
NH3-N (µg/L)	45.000	79.000
Total N (µg/L)	800.00	920.00
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l CaCO3)		
Total Susp Sol (mg/l)	ND	ND
Calcium (mg/l)		

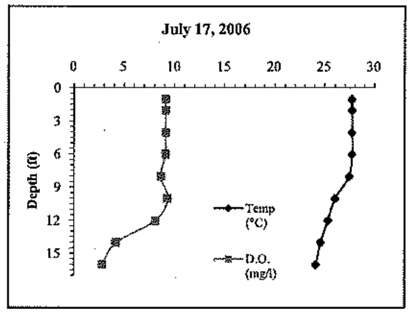
EJH & TAH Conducted Fieldwork

Porters Lake

Date: 07-17-06
Time: 10:45
Weather: 80% Clouds, 80°F
Ent: EJH Verf:

Max Depth (ft): 16.4
PorLS Depth (ft): 3.0
PorLB Depth (ft): 15.0
Secchi Depth (ft): 9.8

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	27.7	9.1	9.7	238
2.0	27.7	9.1	9.7	238
4.0	27.7	9.1	9.7	238
6.0	27.7	9.1	9.7	238
8.0	27.4	8.6	9.7	238
10.0	26.0	9.3	9.7	237
12.0	25.3	8.1	9.6	242
14.0	24.6	4.2	9.0	259
16.0	24.1	2.8	8.2	297



Parameter	PorLS	PorLB
Total P (µg/L)	28.000	26.000
Dissolved P (µg/L)	2.000	ND
Chl a (µg/L)	2.31	
TKN (µg/L	1040.00	1160.00
NO3+NO2-N (µg/L)	ND	ND
NH3-N (µg/L)	50.000	92.000
Total N (µg/L)	1040.00	1160.00
Lab Cond. (µS/cm)	237	255
Lab pH	9.10	8.50
Alkal (mg/l CaCO3)	117	124
Total Susp Sol (mg/l)	ND	3
Calcium (mg/l)		

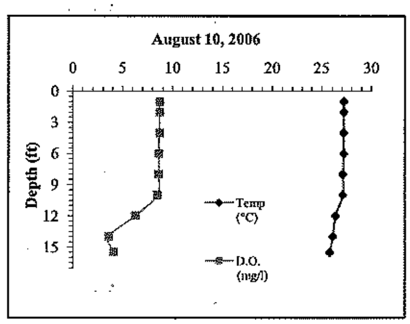
TAH & EJH Conducted Fieldwork

Porters Lake

Date: 08-10-06
Time: 13:00
Weather: 90% Clouds, 80°F, Breezy
Ent: EJH Verf:

Max Depth (ft): 16.7
PorLS Depth (ft): 3.0
PorLB Depth (ft): 15.0
Secchi Depth (ft): 11.6

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	27.2	8.7	9.3	243.0
2.0	27.2	8.7	9.3	243.0
4.0	27.2	8.7	9.3	243.0
6.0	27.2	8.6	9.3	243.0
8.0	27.1	8.6	9.4	243.0
10.0	27.1	8.5	9.4	244.0
12.0	26.4	6.3	9.2	250.0
14.0	26.1	3.6	9.3	248.0
15.5	25.8	4.1	8.9	252.0



Parameter	PorLS	PorLB
Total P (µg/L)	17.00	16.00
Dissolved P (µg/L)		
Chl a (µg/L)	1.92	
TKN (µg/L	1100.00	1210.00
NO3+NO2-N (µg/L)	ND	ND
NH3-N (µg/L)	53.000	130.000
Total N (µg/L)	1100.00	1210.00
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l CaCO3)		
Total Susp Sol (mg/l)	ND	2
Calcium (mg/l)		

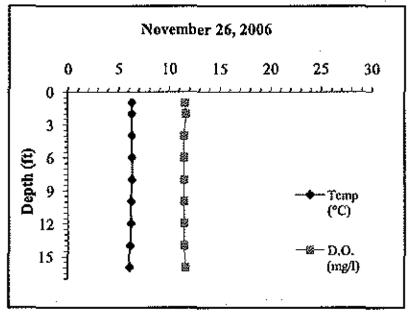
SLOH received sample with ice melted, TAH & AAH conducted fieldwork

Porters Lake

Date: 10-26-06
Time: 12:55
Weather: 100% Clouds, 48°F, Light Breeze
Ent: EJH Verf:

Max Depth (ft): 17.0
PorLS Depth (ft): 3.0
PorLB Depth (ft): 15.0
Secchi Depth (ft): 13.8

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	6.3	11.6	8.8	268.0
2.0	6.3	11.7	8.9	268.0
4.0	6.3	11.5	8.9	268.0
6.0	6.3	11.5	9.0	268.0
8.0	6.3	11.5	9.0	269.0
10.0	6.2	11.5	9.0	269.0
12.0	6.2	11.5	9.0	269.0
14.0	6.1	11.5	9.1	267.0
16.0	6.1	11.6	9.1	268.0



Parameter	PorLS	PorLB
Total P (µg/L)	15.000	
Dissolved P (µg/L)		
Chl a (µg/L)	3.53	
TKN (µg/L		
NO3+NO2-N (µg/L)		
NH3-N (µg/L)		
Total N (µg/L)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l CaCO3)		
Total Susp Sol (mg/l)	ND	4
Calcium (mg/l)		

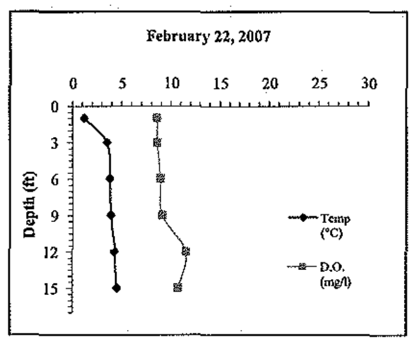
TSS had low sample volume at lab. TAH & AAH Conducted Fieldwork.

Porters Lake

Date: 02-22-07
Time: 10:15
Weather: Windy, 95% Clouds, 20°F
Ent: EJH Verf:

Max Depth (ft): 17.9
PorLS Depth (ft): 3.0
PorLB Depth (ft): 17.5
Secchi Depth (ft): 15.4

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	1.2	8.6	8.1	317
3.0	3.5	8.6	8.2	330
6.0	3.8	8.9	8.2	332
9.0	3.9	9.1	8.3	331
12.0	4.3	11.5	8.6	334
15.0	4.5	10.7	8.4	342



Parameter	PorLS	PorLB
Total P (µg/L)	21.000	11.000
Dissolved P (µg/L)	0.000	5.000
Chl a (µg/L)		
TKN (µg/L	1210.00	1170.00
NO3+NO2-N (µg/L)	84.000	75.000
NH3-N (µg/L)	492.000	424.000
Total N (µg/L)	1294.00	1245.00
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l CaCO3)		
Total Susp Sol (mg/l)	ND	ND
Calcium (mg/l)		

Samples Collected by EJH, TAH. Ice Depth: 8 inches

Water Quality Data

2006-2007 Parameter	Surface Count	Surface Mean	Bottom Count	Bottom Mean
Secchi Depth (feet)	6	12.4		
Total P (µg/L)	6	18.167	5	17.400
Dissolved P (µg/L)	3	1.333	2	4.000
Chl a (µg/L)	5	2.546	0	
TKN (µg/L	5	986.000	5	1060.000
NO3+NO2-N (µg/L)	2	84.000	2	74.500
NH3-N (µg/L)	5	175.600	5	193.200
Total N (µg/L)	5	1019.600	5	1089.800
Lab Cond. (µS/cm)	2	265.000	2	275.000
Lab pH	2	8.765	2	8.465
Alkal (mg/l CaCO3)	2	130.500	2	134.500
Total Susp Sol (mg/l)	0		3	3.000
Calcium (µg/L)	1	28.4	0	

Wisconsin Trophic State Index (WTSI)

Year	TP	Chla	SD
1976	51.45		48.31
1986			44.84
1987			45.05
1988			45.65
1989			43.46
1990			41.25
1991			42.89
1992			40.86
1993			41.30
1994			41.61
1995			42.16
1996			40.06
1997			44.86
1998			44.15
1999			42.56
2000			40.18
2001			42.42
2002			41.26
2003			44.20
2004			41.76
2005			43.88
2006	51.58	41.49	43.93
All Years (weighted)	51.22	41.49	42.60
WI Natural Lakes	53.19	54.23	47.33
Central Region	51.45	49.88	47.33

Morphological / Geographical Data

Parameter	Value
Acreage	75.6
Volume (acre-feet)	488
Perimeter (miles)	1.8
Shoreland Development	1.48
Maximum Depth (feet)	17
County	Waushara County
WBIC	246900
Lillie Mason Region(1983)	Central Region
Nichols Ecoregion(1999)	NCSE

Watershed Data

WiLMS Class	Acreage	kg/yr	lbs/yr
Forest	39.9	1	2.2
Open Water	75.6	9	19.8
Pasture/Grass	17.8	2	4.4
Row Crops	1.5	1	2.2
Urban - Rural Residential	16.6	1	2.2
Wetland	1.1	0	0.0

Watershed to Lake Area 1:1

Year	Secchi (feet) Growing Season Count	Secchi Growing Season Mean	Secchi Summer Count	Secchi Summer Mean	Chlorophyll a (µg/L) Growing Season Count	Chl a Growing Season Mean	Chl a Summer Count	Chl a Summer Mean	Phosphorus (µg/L) Growing Season Count	Phosphorus Growing Season Mean	Phosphorus Summer Count	Phosphorus Summer Mean
1976	2	8.20	1	7.38					2	18.500	1	20
1986	15	10.22	9	9.39								
1987	9	10.64	2	9.25								
1988	5	8.80	4	8.88								
1989	8	11.16	3	10.33								
1990	7	12.50	6	12.04								
1991	8	11.91	4	10.75								
1992	5	13.00	4	12.38								
1993	7	12.21	5	12.00								
1994	4	11.75	4	11.75								
1995	11	11.66	9	11.31								
1996	8	13.00	6	13.08								
1997	8	9.53	6	9.38								
1998	7	10.11	5	9.85								
1999	5	11.60	3	11.00					1	16.00	1	16.00
2000	18	12.96	10	12.98								
2001	10	12.45	7	11.11								
2002	10	12.43	8	12.03								
2003	13	9.77	11	9.82								
2004	12	10.67	6	11.63								
2005	8	10.38	7	10.04								
2006	5	11.8	3	10.0	5	2.55	2	2.45	5	17.60	3	20.33
All Years (weighted)		11.3		11.0				2.5		17.6		19.4
WI Natural Lakes				7.9				13.4				25
Central Region				7.9				7.5				20

Year	Phosphorus (µg/L) Spring Turnover Count	Phosphorus Spring Turnover Mean	Phosphorus Fall Turnover Count	Phosphorus Fall Turnover Mean	Nitrogen (µg/L) Spring Turnover Count	Nitrogen Spring Turnover Mean	Nitrogen Fall Turnover Count	Nitrogen Fall Turnover Mean
1976								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998			1	11.0			1	1000.0
1999	1	16.0			1	1010.0		
2000								
2001			1	21.0			1	1080.0
2002	1	19.0			1	1140.0		
2003								
2004					1	1120.0		
2005				26.0			1	1270.0
2006	1	12.00	1	15.00	1	864.00		
All Years (weighted)		15.7		18.3		1033.5		1116.7
WI Natural Lakes								
Central Region								

C

APPENDIX C

Watershed Analysis WiLMS Results

Date: 2/23/2007 Scenario: Porters Current

Lake Id: **Porters Current**

Watershed Id: Porters Current

Hydrologic and Morphometric Data

Tributary Drainage Area: 76.9 acre
Total Unit Runoff: 10.30 in.
Annual Runoff Volume: 66.0 acre-ft
Lake Surface Area <As>: 75.6 acre
Lake Volume <V>: 488.0 acre-ft
Lake Mean Depth <z>: 6.5 ft
Precipitation - Evaporation: 3.2 in.
Hydraulic Loading: 86.2 acre-ft/year
Areal Water Load <qs>: 1.1 ft/year
Lake Flushing Rate <p>: 0.18 1/year
Water Residence Time: 5.66 year
Observed spring overturn total phosphorus (SPO): 12 mg/m^3
Observed growing season mean phosphorus (GSM): 17.6 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	1.5	0.50	1.00	3.00	4.3	0	1	2
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	17.8	0.10	0.30	0.50	15.3	1	2	4
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	0.0	0.30	0.50	0.80	0.0	0	0	0
Rural Res (>1 Ac)	16.6	0.05	0.10	0.25	4.8	0	1	2
Wetlands	1.1	0.10	0.10	0.10	0.3	0	0	0
Forest	39.9	0.05	0.09	0.18	10.3	1	1	3
Lake Surface	75.6	0.10	0.30	1.00	65.0	3	9	31

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	0.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	11.6	31.1	89.6	100.0
Total Loading (kg)	5.3	14.1	40.6	100.0
Areal Loading (lb/ac-year)	0.15	0.41	1.19	
Areal Loading (mg/m^2-year)	17.23	46.14	132.86	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	4.9	10.9	22.2	100.0
Total NPS Loading (kg)	2.2	4.9	10.1	100.0

Phosphorus Prediction and Uncertainty Analysis Module

Date: 2/23/2007 Scenario: **Porters Current**
Observed spring overturn total phosphorus (SPO): 12.0 mg/m^3
Observed growing season mean phosphorus (GSM): 17.6 mg/m^3
Back calculation for SPO total phosphorus: 0.0 mg/m^3
Back calculation GSM phosphorus: 0.0 mg/m^3
% Confidence Range: 70%
Nurenberg Model Input - Est. Gross Int. Loading: 0 kg

Lake Phosphorus Model	**Low** Total P (mg/m^3)	**Most Likely** Total P (mg/m^3)	**High** Total P (mg/m^3)	**Predicted** -Observed (mg/m^3)	**% Dif.**
Walker, 1987 Reservoir	21	56	161	38	216
Canfield-Bachmann, 1981 Natural Lake	14	27	52	9	51
Canfield-Bachmann, 1981 Artificial Lake	15	26	44	8	45
Rechow, 1979 General	1	4	11	-14	-80
Rechow, 1977 Anoxic	24	63	183	45	256
Rechow, 1977 water load<50m/year	5	14	40	-4	-23
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	18	47	136	35	292
Vollenweider, 1982 Combined OECD	14	31	75	16	108
Dillon-Rigler-Kirchner	11	31	88	19	158
Vollenweider, 1982 Shallow Lake/Res.	11	26	65	11	74
Larsen-Mercier, 1976	15	39	113	27	225
Nurnberg, 1984 Oxic	9	24	70	6	34

Lake Phosphorus Model	**Confidence** Lower Bound	**Confidence** Upper Bound	**Parameter** Fit?	**Back** Calculation (kg/year)	**Model** Type
Walker, 1987 Reservoir	30	123	Tw	0	GSM
Canfield-Bachmann, 1981 Natural Lake	8	78	FIT	1	GSM
Canfield-Bachmann, 1981 Artificial Lake	8	75	FIT	1	GSM
Rechow, 1979 General	2	9	L qs	0	GSM
Rechow, 1977 Anoxic	34	139	FIT	0	GSM
Rechow, 1977 water load<50m/year	7	31	FIT	0	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	21	108	FIT	0	SPO
Vollenweider, 1982 Combined OECD	14	65	FIT	0	ANN
Dillon-Rigler-Kirchner	16	67	P L qs p	0	SPO
Vollenweider, 1982 Shallow Lake/Res.	12	55	FIT	0	ANN
Larsen-Mercier, 1976	22	85	P Pin	0	SPO
Nurnberg, 1984 Oxic	11	55	qs	0	ANN

D

APPENDIX D

2006 Aquatic Plant Survey Data

Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	Brasenia schreberi	Carex lasiocarpa	Ceratophyllum demersum	Chara sp.	Dulichium arundenacea	Eleocharis palustris	Elodea canadensis	Equisetum	Lemna minor	Myriophyllum sibiricum	Najas flexilis	Nuphar variegata	Nymphaea odorata	Potamogeton amplifolius	Potamogeton gramineus	Potamogeton illinoensis	Potamogeton praelongus	Potamogeton pusillus	Potamogeton zosteriformis	Potamongeton natans	Ranunculus aquatilis	Sagittaria graminea	Sagittaria latifolia	Scheonplectus pungens	Schoenoplectus acutus	Schoenoplectus tabernaemontani	Sparganium fluctuans	Stuckenia pectinata	Typha latifolia	Utricularia respunita	Utricularia vulgaris	Vallisneria americana
1	1	-89.22708	44.09427	m	p					3								1						1		1												
2	1	-89.22708	44.09463	m	p					3								2																				
3	1	-89.22707	44.09499	m	p				1	3								2						2														
4	1	-89.22659	44.09390	m	p					1		1		1			1				1								1									
5	2	-89.22658	44.09426	m	p				1				1			1					2				1													
6	3	-89.22658	44.09462	m	p				2	2							1	1								1												1
7	1	-89.22657	44.09498	m	p				1	3					1			2						2		1												
8	2	-89.22657	44.09534	m	p					2								1								1												
9	1	-89.22656	44.09570	m	v					3			1								1						1										1	
10	1	-89.22609	44.09390	m	p					2		1					1	1			1								1	1								
11	3	-89.22608	44.09426	m	p					1							1			1																		
12	7	-89.22608	44.09462	m	p					2						1																						
13	8	-89.22607	44.09498	m	p								2			1																						
14	10	-89.22607	44.09534	m	p					2						1																						
15	9	-89.22606	44.09570	m	p					2															1					1								
16	3	-89.22606	44.09606	m	p					3							1				1																	1
17	1	-89.22605	44.09642	m	p					3		1					1				1																	
18	1	-89.22559	44.09390	m	v					1		1				1	1				1									1								
19	3	-89.22558	44.09426	m	p					2										2																		
20	9	-89.22558	44.09462	m	p				1	2						1							2															
21	14	-89.22557	44.09498	m	p					3																												

Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	Brasenia schroberi	Carex lasiocarpa	Ceratophyllum demersum	Chara sp.	Dulichium arundenacea	Eleocharis palustris	Elodea canadensis	Equisetum	Lemna minor	Myriophyllum sibiricum	Najas flexilis	Nuphar variegata	Nymphaea odorata	Potamogeton amplifolius	Potamogeton gramineus	Potamogeton illinoensis	Potamogeton praelongus	Potamogeton pusillus	Potamogeton zosteriformis	Potamongeton natans	Ranunculus aquatilis	Sagittaria graminea	Sagittaria latifolia	Scheonoplectus pungens	Schoenoplectus acutus	Schoenoplectus tabernaemontani	Sparganium fluctuans	Stuckenia pectinata	Typha latifolia	Utricularia respunita	Utricularia vulgaris	Vallisneria americana
22	13	-89.22557	44.09534	m	p																																	
23	12	-89.22556	44.09570	m	p				1	2															1													
24	8	-89.22556	44.09606	m	p					1															1													
25	7	-89.22555	44.09642	m	p					2						2	1			1																		1
26	1	-89.22555	44.09678	m	p					3			1		1						1																	
27	1	-89.22509	44.09389	m	p					2							1				1																	
28	6	-89.22508	44.09425	m	p					2						1	2																					
29	10	-89.22508	44.09461	m	p					2						1									2													
30	15	-89.22507	44.09497	m	r																				2													
31	17	-89.22507	44.09533	m	r																																	
32	17	-89.22506	44.09569			Deep																																
33	16	-89.22506	44.09605	m	r					2															1													
34	12	-89.22505	44.09641	m	r					2						1																						
35	8	-89.22505	44.09677	m	p					2																												1
36	3	-89.22504	44.09713	m	p					2											1			1														
37	2	-89.22459	44.09389	m	p					2							1							1														
38	6	-89.22458	44.09425	m	p					2						1	1				1					1												
39	7	-89.22458	44.09461	m	p					1						1	1								1													
40	8	-89.22457	44.09497	m	p																				1													
41	17	-89.22457	44.09533			Deep																																
42	18	-89.22456	44.09569			Deep																																

Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	*Brasenia schreberi*	*Carex lasiocarpa*	*Ceratophyllum demersum*	*Chara sp.*	*Dulichium arundenacea*	*Eleocharis palustris*	*Elodea canadensis*	*Equisetum*	*Lemna minor*	*Myriophyllum sibiricum*	*Najas flexilis*	*Nuphar variegata*	*Nymphaea odorata*	*Potamogeton amplifolius*	*Potamogeton gramineus*	*Potamogeton illinoensis*	*Potamogeton praelongus*	*Potamogeton pusillus*	*Potamogeton zosteriformis*	*Potamongeton natans*	*Ranunculus aquatilis*	*Sagittaria graminea*	*Sagittaria latifolia*	*Scheonplectus pungens*	*Schoenoplectus acutus*	*Schoenoplectus tabernaemontani*	*Sparganium fluctuans*	*Stuckenia pectinata*	*Typha latifolia*	*Utricularia respunita*	*Utricularia vulgaris*	*Vallisneria americana*
43	19	-89.22456	44.09605			Deep																																
44	17	-89.22455	44.09641			Deep																																
45	12	-89.22455	44.09677	m	r					2						1																						
46	8	-89.22454	44.09713	m	p					2										1																		1
47	1	-89.22454	44.09749	m	v					3						1									1													
48	1	-89.22409	44.09389	m	p					2			1								1					1												
49	8	-89.22408	44.09425	m	p					3																												
50	11	-89.22408	44.09461	m	r					2			1			1																						
51	14	-89.22407	44.09497	m	r					2			1				1																					
52	15	-89.22407	44.09533	m	r																				2													
53	16	-89.22406	44.09569			Deep																																
54	17	-89.22406	44.09605			Deep																																
55	17	-89.22405	44.09641			Deep																																
56	17	-89.22405	44.09677			Deep																																
57	12	-89.22404	44.09713	m	r					2															1													
58	7	-89.22404	44.09749	m	p					3																												
59	5	-89.22404	44.09785	m	p					3										1	1																	
60	1	-89.22403	44.09821	m	p					3		1						1			1					1												1
61	2	-89.22359	44.09388	m	p					1																												
62	6	-89.22358	44.09424	m	p					1							1			1														1				
63	12	-89.22358	44.09460	m	r					1			1				1								1													

Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	*Brasenia schreberi*	*Carex lasiocarpa*	*Ceratophyllum demersum*	*Chara sp.*	*Dulichium arundenacea*	*Eleocharis palustris*	*Elodea canadensis*	*Equisetum*	*Lemna minor*	*Myriophyllum sibiricum*	*Najas flexilis*	*Nuphar variegata*	*Nymphaea odorata*	*Potamogeton amplifolius*	*Potamogeton gramineus*	*Potamogeton illinoensis*	*Potamogeton praelongus*	*Potamogeton pusillus*	*Potamogeton zosteriformis*	*Potamongeton natans*	*Ranunculus aquatilis*	*Sagittaria graminea*	*Sagittaria latifolia*	*Scheonplectus pungens*	*Schoenoplectus acutus*	*Schoenoplectus tabernaemontani*	*Sparganium fluctuans*	*Stuckenia pectinata*	*Typha latifolia*	*Utricularia respunita*	*Utricularia vulgaris*	*Vallisneria americana*
64	11	-89.22357	44.09496	m	r				1				2												1													
65	12	-89.22357	44.09532	m	r					2							1								1									1				
66	15	-89.22356	44.09568	m	r																				1													
67	15	-89.22356	44.09604	m	r																																	
68	16	-89.22355	44.09640	m	r																				1													
69	17	-89.22355	44.09676			Deep																																
70	12	-89.22355	44.09712	m	r					1			1												1													
71	12	-89.22354	44.09748	m	r					1			2			1									1													
72	8	-89.22354	44.09784	m	p					3										1					1													
73	3	-89.22353	44.09820	m	p					3											1					1												
74	1	-89.22353	44.09856	m	v				1	2		1					1													1								1
75	1	-89.22309	44.09388	m	v					2				1			1				1									1	1							
76	4	-89.22308	44.09424	m	p					1							1			1					1	1								1				
77	4	-89.22308	44.09460	m	p					2						1				1					1									1				
78	11	-89.22307	44.09496	m	r					1						1	2																					
79	11	-89.22307	44.09532	m	r					3						1	1																					
80	11	-89.22306	44.09568	m	r					2			2												1								2					
81	11	-89.22306	44.09604	m	r					1															2													
82	12	-89.22305	44.09640	m	r																				2								1					
83	12	-89.22305	44.09676	m	r					3																												
84	13	-89.22305	44.09712	m	r								3												1													

Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	Brasenia schreberi	Carex lasiocarpa	Ceratophyllum demersum	Chara sp.	Dulichium arundenacea	Eleocharis palustris	Elodea canadensis	Equisetum	Lemna minor	Myriophyllum sibiricum	Najas flexilis	Nuphar variegata	Nymphaea odorata	Potamogeton amplifolius	Potamogeton gramineus	Potamogeton illinoensis	Potamogeton praelongus	Potamogeton pusillus	Potamogeton zosteriformis	Potamongeton natans	Ranunculus aquatilis	Sagittaria graminea	Sagittaria latifolia	Scheonplectus pungens	Schoenoplectus acutus	Schoenoplectus tabernaemontani	Sparganium fluctuans	Stuckenia pectinata	Typha latifolia	Utricularia respunita	Utricularia vulgaris	Vallisneria americana
85	12	-89.22304	44.09748	m	r					3							1								2													
86	7	-89.22304	44.09784	m	p					2						1									1													
87	4	-89.22303	44.09820	m	p					1											1				1													
88	2	-89.22303	44.09856	m	p					3																												
89	1	-89.22302	44.09892	m	v					2		1		1											1					1		1	1			1		
90	1	-89.22259	44.09352	m	v					1																					1							
91	3	-89.22259	44.09388	m	p																																	
92	3	-89.22258	44.09424	m	p					1																1												
93	3	-89.22258	44.09460	m	p					1										1																		
94	4	-89.22257	44.09496	m	p					2							1				1																	
95	7	-89.22257	44.09532	m	p					3							2				1																	
96	11	-89.22256	44.09568	m	r					2			1			1	1																					
97	12	-89.22256	44.09604	m	r					1			1			2									2													
98	12	-89.22256	44.09640	m	r					1						1									2													
99	12	-89.22255	44.09676	m	r					1						1									2													
100	11	-89.22255	44.09712	m	p																		1		1													
101	4	-89.22254	44.09748	m	p				1	3										1	1																	
102	4	-89.22254	44.09784	m	p					3											1	1																
103	2	-89.22253	44.09820	m	p					2										1	1				1									1				
104	2	-89.22253	44.09856	m	v					2											1													1				
105	1	-89.22252	44.09892	m	v					2				1					1						1					1		1	1			1		

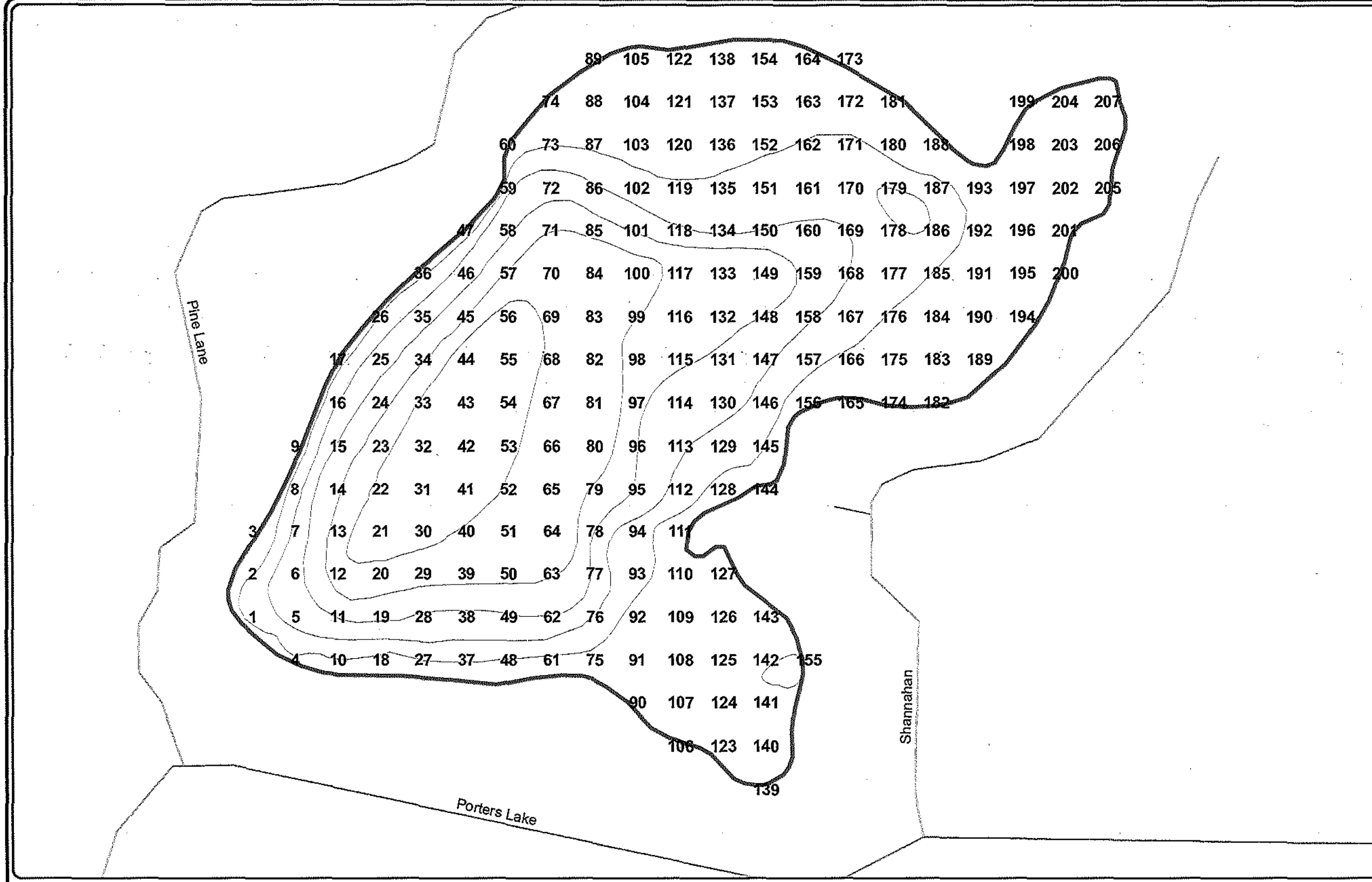
Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	*Brasenia schreberi*	*Carex lasiocarpa*	*Ceratophyllum demersum*	*Chara sp.*	*Dulichium arundenacea*	*Eleocharis palustris*	*Elodea canadensis*	*Equisetum*	*Lemna minor*	*Myriophyllum sibiricum*	*Najas flexilis*	*Nuphar variegata*	*Nymphaea odorata*	*Potamogeton amplifolius*	*Potamogeton gramineus*	*Potamogeton illinoensis*	*Potamogeton praelongus*	*Potamogeton pusillus*	*Potamogeton zosteriformis*	*Potamongeton natans*	*Ranunculus aquatilis*	*Sagittaria graminea*	*Sagittaria latifolia*	*Scheonplectus pungens*	*Schoenoplectus acutus*	*Schoenoplectus tabernaemontani*	*Sparganium fluctuans*	*Stuckenia pectinata*	*Typha latifolia*	*Utricularia respunita*	*Utricularia vulgaris*	*Vallisneria americana*
106	2	-89.22210	44.09315	m	v					1							1									1								1				
107		-89.22209	44.09351			Shallow																																
108		-89.22209	44.09387			Shallow																																
109	2	-89.22208	44.09423	m	v					1											1																	
110	1	-89.22208	44.09459	m	v					1																												
111	1	-89.22207	44.09495	m	v					1																				1								
112	1	-89.22207	44.09531	m	v					3																												
113	7	-89.22206	44.09567	m	p					1							2			1																		
114	8	-89.22206	44.09603	m	r					1							2			1					1													
115	10	-89.22206	44.09639	m	r											1									3													
116	11	-89.22205	44.09675	m	r					1						1	1																					
117	10	-89.22205	44.09711	m	r					2							3																					
118	6	-89.22204	44.09747	m	p					3							1				1																	
119	5	-89.22204	44.09783	m	p					2							1				1																	
120	4	-89.22203	44.09819	m	p					3											1																	
121	1	-89.22203	44.09855	m	v					2							1				1													2				
122	1	-89.22202	44.09891	m	v					1							1				1									1								
123	1	-89.22160	44.09315	m	v					2											1																	
124		-89.22159	44.09351			Shallow																																
125		-89.22159	44.09387			Shallow																																
126	1	-89.22158	44.09423	m	v					1							1								1													

Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	*Brasenia schreberi*	*Carex lasiocarpa*	*Ceratophyllum demersum*	*Chara sp.*	*Dulichium arundenacea*	*Eleocharis palustris*	*Elodea canadensis*	*Equisetum*	*Lemna minor*	*Myriophyllum sibiricum*	*Najas flexilis*	*Nuphar variegata*	*Nymphaea odorata*	*Potamogeton amplifolius*	*Potamogeton gramineus*	*Potamogeton illinoensis*	*Potamogeton praelongus*	*Potamogeton pusillus*	*Potamogeton zosteriformis*	*Potamongeton natans*	*Ranunculus aquatilis*	*Sagittaria graminea*	*Sagittaria latifolia*	*Scheonplectus pungens*	*Schoenoplectus acutus*	*Schoenoplectus tabernaemontani*	*Sparganium fluctuans*	*Stuckenia pectinata*	*Typha latifolia*	*Utricularia respunita*	*Utricularia vulgaris*	*Vallisneria americana*
127	1	-89.22158	44.09459	m	v																																	
128	1	-89.22157	44.09531	m	v																									1								
129	2	-89.22157	44.09567	m	v					3							1																					
130	11	-89.22156	44.09603	m	r					1							1																					
131	10	-89.22156	44.09639	m	r					1							1								1													
132	9	-89.22155	44.09675	m	r																																	
133	11	-89.22155	44.09711	m	r																		1															
134	7	-89.22154	44.09747	m	p					2							2				1																	
135	4	-89.22154	44.09783	m	p					2																1												
136	2	-89.22153	44.09819	m	v					1																												
137	1	-89.22153	44.09855	m	v					2											1													1				
138	1	-89.22152	44.09891	m	v					1																												
139	1	-89.22110	44.09279	m	v		1			1																												
140	1	-89.22110	44.09315	m	v		2			1																												
141		-89.22109	44.09351			Shallow																																
142	1	-89.22109	44.09387	m	v					1							1		1							1					1							
143	1	-89.22108	44.09423	m	v					1																1				1	1					1		
144	1	-89.22107	44.09531	m	v					1		1					1				1																	
145	2	-89.22107	44.09567	m	p					2																												
146	2	-89.22106	44.09603	m	p					2											1															1		
147	4	-89.22106	44.09639	m	p					3							1																	1				1

Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	*Brasenia schreberi*	*Carex lasiocarpa*	*Ceratophyllum demersum*	*Chara sp.*	*Dulichium arundenacea*	*Eleocharis palustris*	*Elodea canadensis*	*Equisetum*	*Lemna minor*	*Myriophyllum sibiricum*	*Najas flexilis*	*Nuphar variegata*	*Nymphaea odorata*	*Potamogeton amplifolius*	*Potamogeton gramineus*	*Potamogeton illinoensis*	*Potamogeton praelongus*	*Potamogeton pusillus*	*Potamogeton zosteriformis*	*Potamongeton natans*	*Ranunculus aquatilis*	*Sagittaria graminea*	*Sagittaria latifolia*	*Scheonplectus pungens*	*Schoenoplectus acutus*	*Schoenoplectus tabernaemontani*	*Sparganium fluctuans*	*Stuckenia pectinata*	*Typha latifolia*	*Utricularia respunita*	*Utricularia vulgaris*	*Vallisneria americana*
148	8	-89.22105	44.09675	m	p					1						1	2								1													1
149	9	-89.22105	44.09711	m	r					1							2			1					1													
150	8	-89.22104	44.09747	m	p					1							2			1																		
151	2	-89.22104	44.09783	m	v					3											1				1	1												
152	2	-89.22103	44.09819	m	p					3																												
153	2	-89.22103	44.09855	m	v					3											1																	
154	1	-89.22102	44.09891	m	v					1																				1						1		
155	1	-89.22059	44.09386	m	v					1							1														1				1			
156	1	-89.22056	44.09602	m	v					1							1				1															1		
157	2	-89.22056	44.09638	m	p					3																				1								
158	4	-89.22055	44.09674	m	p					3							1			1	1					1												1
159	6	-89.22055	44.09710	m	p					1						2	2			1					1													1
160	4	-89.22054	44.09746	m	p					1						1				2	1					1												1
161	3	-89.22054	44.09782	m	p					2												1																
162	2	-89.22053	44.09818	m	p					3											1																	
163	3	-89.22053	44.09854	m	v					3											1																	
164	1	-89.22052	44.09890	m	v					1																				2								
165	1	-89.22006	44.09602	m	v					1		1																		1								
166	2	-89.22006	44.09638	m	v					3							1				1																	
167	2	-89.22005	44.09674	m	p					3											1																	1
168	3	-89.22005	44.09710	m	p					3										1			1			1								1				

Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	Brasenia schreberi	Carex lasiocarpa	Ceratophyllum demersum	Chara sp.	Dulichium arundenacea	Eleocharis palustris	Elodea canadensis	Equisetum	Lemna minor	Myriophyllum sibiricum	Najas flexilis	Nuphar variegata	Nymphaea odorata	Potamogeton amplifolius	Potamogeton gramineus	Potamogeton illinoensis	Potamogeton praelongus	Potamogeton pusillus	Potamogeton zosteriformis	Potamongeton natans	Ranunculus aquatilis	Sagittaria graminea	Sagittaria latifolia	Scheonplectus pungens	Schoenoplectus acutus	Schoenoplectus tabernaemontani	Sparganium fluctuans	Stuckenia pectinata	Typha latifolia	Utricularia respunita	Utricularia vulgaris	Vallisneria americana
169	3	-89.22004	44.09746	m	p					3											1																	
170	3	-89.22004	44.09782	m	p					2																1												
171	2	-89.22003	44.09818	m	v					2						1					1										1							
172	2	-89.22003	44.09854	m	v					1											1										1							
173	1	-89.22002	44.09890	m	v																									2								
174	1	-89.21956	44.09602	m	v					1		1																	1	1								
175	2	-89.21956	44.09638	m	p					2																												
176	2	-89.21955	44.09674	m	v					2											1																	
177	2	-89.21955	44.09710	m	p					1																1												
178	2	-89.21954	44.09746	m	p																1	1			1	1												1
179	2	-89.21954	44.09782	m	p				1	2							1				1																	
180	2	-89.21953	44.09818	m	v					2																					1							
181	1	-89.21953	44.09854	m	v					1																					1					1		
182	1	-89.21906	44.09601	m	v					1							1																					
183	2	-89.21906	44.09637	m	v					2							1				1																	
184	2	-89.21905	44.09673	m	v								1													1												
185	2	-89.21905	44.09709	m	v					1																1												
186	2	-89.21904	44.09745	m	v					2							1								1	1												1
187	2	-89.21904	44.09781	m	p					1																												
188	1	-89.21903	44.09817	m	v					1																				1								
189	1	-89.21856	44.09637	m	v					1		1					1											1		1						1		

Number	Depth (ft)	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Note	Brasenia schreberi	Carex lasiocarpa	Ceratophyllum demersum	Chara sp.	Dulichium arundenacea	Eleocharis palustris	Elodea canadensis	Equisetum	Lemna minor	Myriophyllum sibiricum	Najas flexilis	Nuphar variegata	Nymphaea odorata	Potamogeton amplifolius	Potamogeton gramineus	Potamogeton illinoensis	Potamogeton praelongus	Potamogeton pusillus	Potamogeton zosteriformis	Potamongeton natans	Ranunculus aquatilis	Sagittaria graminea	Sagittaria latifolia	Scheonoplectus pungens	Schoenoplectus acutus	Schoenoplectus tabernaemontani	Sparganium fluctuans	Stuckenia pectinata	Typha latifolia	Utricularia respunita	Utricularia vulgaris	Vallisneria americana
190	2	-89.21855	44.09673	m	v					1							1									1												
191	2	-89.21855	44.09709	m	v					1							1				1					1												
192	2	-89.21854	44.09745	m	p					1							1				1					1												
193	1	-89.21854	44.09781	m	v					1																												
194	1	-89.21805	44.09673	m	v		1	1		2	1						1													1						1		
195	2	-89.21805	44.09709	m	v			1		2							1				1									1						1		
196	1	-89.21804	44.09745	m	v					2											1																	
197	2	-89.21804	44.09781	m	v												1								1													
198	2	-89.21803	44.09817	m	v												2								1	2												
199	1	-89.21803	44.09853	m	v												1														1							
200	1	-89.21755	44.09708	m	v																																	
201	1	-89.21754	44.09744	m	v			1			1								1												1					1		
202	1	-89.21754	44.09780	m	v																										1							
203	2	-89.21753	44.09816	m	v												2									1												
204	1	-89.21753	44.09852	m	v				1								1									1												
205	1	-89.21704	44.09780	m	v				1								1		1		1																	
206	1	-89.21704	44.09816	m	v				1				1				2	1								1												1
207	1	-89.21703	44.09852	m	v												1									1					1							

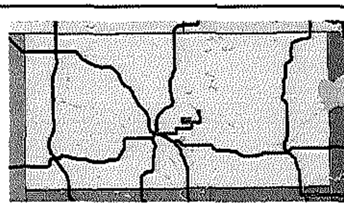


N W E S

400
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 Plants: Onterra, 2005
Bathymetry: WDNR, Digitized by Onterra
Map date: February 23, 2007


Extent of large map shown in red.

Legend

\# Point-intercept Sample Location

Appendix D

Porters Lake

Waushara County, Wisconsin

Point-intercept Sample Locations

E

APPENDIX E

Fisheries Data (1994 WDNR Boomshocking Fisheries Assessment)

CORRESPONDENCE/MEMORANDUM **State of Wisconsin**

Date: October 26, 1994

To: Porter's Lake File

From: Al Niebur - Wautoma Fish Management

Subject: Boomshocking Fisheries Assessment

The following report is a summary of data collected from night boomshocking in Porter's Lake, on 25 October, 1995.

cc: Ron Bruch - Oshkosh Area Fisheries Biologist

Porters Lake Fisheries Assessment

Night Boomshocking - October, 1994

Introduction:

Porter's lake is a 97 acre drainage lake located in the township of Mt. Morris in Waushara County. The lake has an average depth of 4 feet and a maximum depth 18 feet. An outlet drains into the Willow Creek on the northeast end of the lake.

Fish management chemically treated Porters lake in 1961 and has conducted several followup surveys. The last comprehensive survey was conducted in 1981 and indicated a well balanced fish community with largemouth bass and bluegill as the major predator and prey, respectively. More recently, Fisheries Research has completed a study of northern pike survival as related to different hatchery rearing techniques.

The Porter's Lake Association has expressed concerns that the fishery is declining. Most of their concerns are focused on abundance and size of largemouth bass and bluegills. According to their membership, largemouth bass size and numbers "are the worst they've been in years.....all the bluegills are small and stunted and largemouth bass are rarely caught over 14 inches." To address their concerns, they have stocked largemouth bass fingerlings in recent years. In addition, walleyes were stocked occasionally. Evidently, their efforts have not produced any results since they have not seen any improvements to date.

In 1993 a stocking permit was denied by DNR fisheries management. Recent fishery surveys and research studies conducted in Central Wisconsin lakes show reproduction and recruitment are not the limiting factors for most largemouth bass and bluegill populations. In some cases, poor size structure of bass and bluegills is related to overexploitation. Overharvest of the predators (largemouth bass) can lead to greater abundance of their prey (bluegills). With a lack of predators the bluegill population explodes. Competition for food and space occurs, eventually leading to a population of numerous and small fish.

Nonetheless, this is only one scenario out of many. Every lake is different and has its own set of unique characteristics and problems. The goal of this survey is to document if there truly is a stunted overabundant bluegill population and if there is adequate largemouth bass reproduction.

Objectives:

Collect data on species community, relative abundance, and size structure.

Methods:

On 25 October, 1994 a boomshocking survey was conducted during the evening on Porter's Lake. One pass along the entire shoreline of the lake was electrofished. All fish were dip netted, counted, measured for length, and returned to the lake. Water temperature was 49 degrees Farenheit. Boomshocker was operated with pulsed DC at 250 volts and 3 amps.

Results and Discussion:

Several species were sampled in Porter's Lake including: largemouth bass, northern pike, bluegill, black crappie, yellow perch, rock bass, yellow bullhead, pumpkinseed, emerald shiner, and blackchin shiner.

Bluegill were the most abundant (CPE = 86/hour) species sampled making up 45% of the electrofishing catch. Bluegill size ranged from 2.0 to 8.9 inches with a mean size of 5.4-inches. A modal peak was observed at 5.5-inches (Fig. 2). Although weights were not taken it appeared that the fish condition was excellent and growth was not a problem. Bluegill young-of-year were not sampled but were observed in high abundance.

Largemouth bass was the most abundant (CPE = 50/hour) gamefish species sampled making up 26% of the electrofishing catch. Largemouth bass size ranged from 5.0 to 14.9 inches with a mean of size of 10-inches. A modal peak could not be discerned due to small sample size. Recruitment does not appear to be a problem with the abundance of smaller individuals in the 5.0 to 9.0-inch range (Fig 2).

Northern pike were the only other gamefish captured. Eight northern pike were captured and 30+ individuals were observed ahead of the boat. Other panfish species were captured in lesser numbers (Fig. 1).

Management Recommendations:

- Electrofishing conditions were not ideal and probably did not give the most accurate description of the fishery. However, from the sample we collected it was very evident that the bluegill exhibited good size structure with several individuals in the 7-8 inch range. Growth does not appear to be a problem for bluegills or largemouth bass.

- Largemouth bass reproduction appears to be more than adequate. A majority of our electrofishing catch were smaller individuals (5-9 inches). More than likely, these fish were the result of hatches in 1991-1993. In addition, I observed several spawning areas with old nests from this years spawning season.

- General comparisons to the survey conducted in 1981 indicate that the fish community has not changed appreciably. All species captured during the 1981 survey were present in our survey. Largemouth bass reproduction was noted in past surveys as "adequate" with the presence of all age classes.

- In spring of 1995, if funding and manpower are available, a followup boomshocking survey will be used to collect additional information on the fishery of Porter's Lake. Hopefully, with a larger sample size a more accurate description can be made of the largemouth bass and bluegill populations.

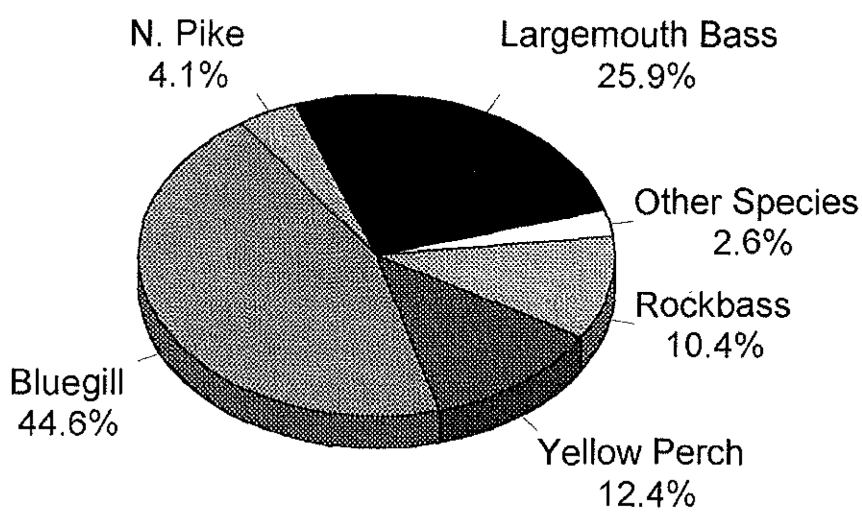
- Stocking is not a good management practice when it is not needed. A common misperception is that "stocking can't hurt anything, why not do it anyway." In Porter's Lake it was evident that largemouth bass reproduction was adequate. Adding more predators could negatively affect other species in the fish community.

- For the time being, I recommend that Catch and Release of larger (>14 inches) bass be emphasized on Porter's Lake. Within the past few years the lake has undergone several new developments and with its close proximity to Wautoma it is readily accessible. More than likely, the lake receives an unusually high amount of fishing pressure. By spring of 1995, our Office will have Catch and Release signs that can be posted at the boat launch. A rule change is not in order until enough biological information is collected to make a good recommendation.

Table 1. Length statistics for fish species captured during night electrofishing on Porters Lake, October, 19

Species	Mean	S.E.	Std. Dev.	Mode	Min.	Max.	N
Largemouth Bass	10.0	0.462	3.269	5.5	5.0	14.9	50
Northern Pike	13.4	1.939	5.484	8.1	8.0	21.0	8
Bluegill	5.4	0.167	1.550	5.0	2.0	8.9	86
Black Crappie	-	-	-	-	-	-	2
Yellow Perch	5.6	0.189	0.927	5.1	4.1	7.9	24
Rock Bass	5.9	0.290	1.296	6.0	3.7	8.4	20
Yellow Bullhead	-	-	-	-	-	-	2
Pumpkinseed	-	-	-	-	-	-	1

Figure 1. Species community in Porters Lake. Graph based on data collected from night electrofishing, October, 1994.



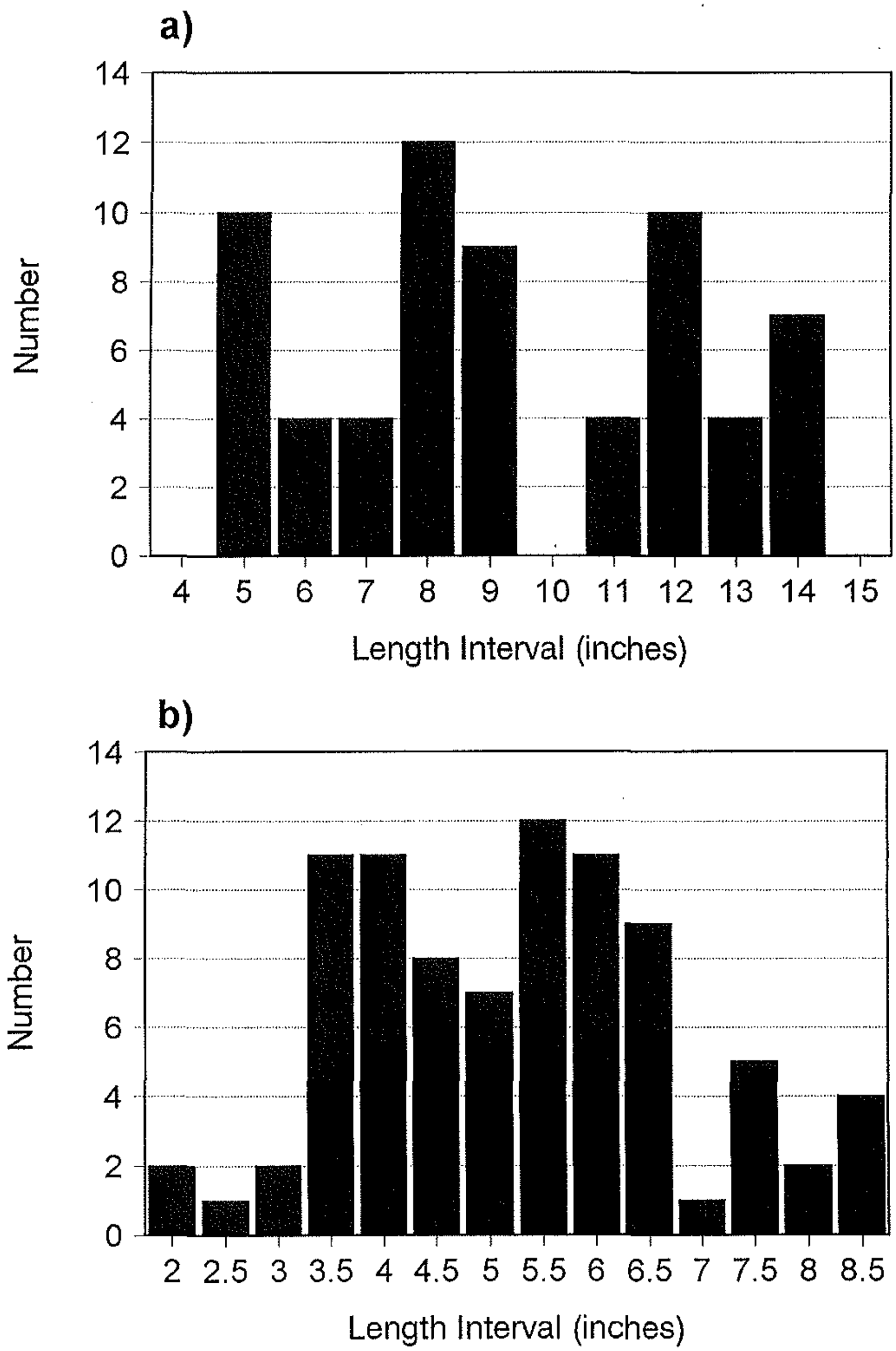


Figure 2. Length frequency distributions for a) largemouth bass and b) bluegill taken from electrofishing catch in Porters Lake, October, 1994.