Red Lakes

Shawano County, Wisconsin

Comprehensive Management Plan

March 2008

Sponsored by:

Red Lakes Protection & Rehabilitation District

&

Wisconsin Department of Natural Resources Lake Management Grant Program

(LPL-1098-06 & LPL-1099-06)

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Lake Management Planning

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INTRODUCTION

Upper and Lower Red Lakes, Shawano County, were created through damming of the Red River in 1880 and 1965, respectively. Upper Red Lake is approximately 188 acres with a maximum depth of 15 feet and a mean depth of 6 feet. Lower Red Lake is approximately 240 acres with a maximum depth of 28 feet and mean depth of 7 feet. In 1990, the Red Lakes Association was created by shoreland property owners to facilitate the management of both lakes. In 1991 studies were completed on both lakes to provide baseline data for the development of lake management plans for the lake. In general, the studies indicated that both lakes tend to be mesotrophic to eutrophic as a result of their large watershed to lake area ratios. The studies also found that both lakes contain nuisance levels of aquatic plant growth and much of that growth was water milfoil. Although it was not positively distinguished within the study reports, it is believed that much of the milfoil was Eurasian water milfoil. The management plans recommended general improvements to the watershed to reduce nutrient and sediment loading, continued monitoring of water quality and macrophytes, and multiple plant control methods, including mechanical harvesting.

In 1994, the Red Lakes Association purchased harvesting equipment and harvested macrophytes in both lakes using volunteer labor with an annual budget of approximately $1800. By 2000 many riparians perceived a continued deterioration in both lakes and as a result, the association's membership dwindled. To counteract this problem, the Red Lakes Association reevaluated its direction with the help of the Wisconsin Department of Natural Resources (WDNR). In October of the year, the association decided to pursue the planting of milfoil weevils with the assistance of EnviroScience of Ohio.

Although preliminary plant survey results indicated that the weevils were reducing Eurasian water milfoil densities, it was felt among association members that sufficient control was not achieved to combat the milfoil's influence on navigation and other forms of recreation. As a result, the association began harvesting operations in both lakes during the summer of 2003.

In response to higher harvesting costs, the Red Lakes Association decided to pursue the creation of a management district. In 2004, the Red Lakes Management District (RLMD) was created. Later that same year, its first operating budget was created with a portion of its funds being ear-marked for a project aimed at updating the management plans for both lakes.

Although the Eurasian water milfoil infestation of both lakes certainly spurred the idea of updating the management plans among district members, it was certainly not the only reason. The RLMD felt that the outdated plans did not provide ample guidance on the management of the lakes as an ecosystem. They were concerned about watershed impacts, changes in water quality, and of course, the affect of non-native species on native habitat, the lakes' fisheries, and recreational use. Furthermore, harvesting activities on the lakes raised concerns regarding the effects this may have on the health of the lakes and the expectations of the district members concerning how much and what areas of the lakes should be harvested.

STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. Stakeholders were also informed about how their use of the lake's shorelands and open water areas impact the lake. Stakeholder input regarding the development of this plan was obtained through communications and meetings with the Red Lakes Management District (RLMD). A description of each stakeholder participation event can be found below, while supporting materials can be found in Appendix A. David LeMere, the authorized representative of the Red Lakes planning project, has continually updated the RLMD board of directors on the status of the planning project.

Newsletters and Special Mailings

A newsletter article written by the RLMD in spring 2006 introduced the planning process that was underway. This article mentioned that a Kick-off Meeting would occur and that the RLMD would need to solicit stakeholder input to create a successful lake management plan. In May 2006, a special mailing was sent to district members announcing the Kick-off Meeting and explaining the important components that would be discussed at the meeting.

Kick-off Meeting

On June 3, 2006 the RLMD held a special meeting to inform association members and other interested parties about the lake management planning project the association was undertaking. During the meeting, Tim Hoyman, an ecologist with Onterra, presented information about lake eutrophication, native and non-native aquatic plants, the importance of lake management planning, and the goals and components of the Red Lakes management planning project. It was anticipated that the management plan would largely focus on invasive species and mechanical harvesting; therefore previous to the meeting, a preliminary harvest plan was devised with the help of David LeMere. This interim harvesting plan was presented at this meeting and was discussed with meeting attendees.

Project Update

In September 2006, a project update was sent to all RLMD members. Along with discussing the preliminary findings of the field surveys conducted that summer, the report also discussed some initial conclusions related to exotic species, watershed size, and macrophyte abundance.

Special Planning Meeting

On February 21, 2007, Tim Hoyman of Onterra and the RLMD met with multiple WDNR representatives (water regulation specialists, fisheries biologists, aquatic plant specialists) and local hydroelectric dam operators to discuss the feasibility of a winter water level drawdown aimed at controlling the exotic species found within the Red Lakes. Although many important topics were discussed at this meeting, ultimately the high cost of supplementing the hydroelectric facility for their losses of power-generating revenue made this management option impractical.

Planning Committee Meetings I & II

Eight planning committee members met with Tim Hoyman on April 16, 2007. The primary focus of this meeting was to discuss the role of the planning committee and to deliver the initial study results and conclusions to the committee. . During this meeting, study components

including aquatic plant inventories and water quality and watershed analysis were presented and discussed.

The goal of the second meeting, held on May 25, 2007, was to construct realistic management goals for the Red Lakes. Devising a realistic mechanical harvesting plan for the lakes was discussed in detail during this meeting.

Wrap-up Meeting

A public meeting was held on June 9, 2007 in which Tim Hoyman detailed the findings of the project's studies and discussed the management plan for the Red Lakes. During this meeting, attendees reviewed the proposed mechanical harvesting plan that is included within the Implementation Plan Section of this document.

RESULTS & DISCUSSION

Lake Water Quality

Judging the quality of lake water can be difficult because lakes display problems in many different ways. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region, and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water. To complete this task, three water quality parameters are focused upon within this document:

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

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

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

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

Each of these parameters is also directly related to the *trophic state* of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: *oligotrophic*, *mesotrophic*, and finally *eutrophic*. Every lake will naturally progress through these states; however, under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in most Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the health of their lake over time. Yet, classifying a lake into one of three trophic states does not give clear indication of where a lake really exists in its trophic progression. To solve this problem, the parameters described above can be used in an index that will specify a lake's trophic state more clearly and provide a means for which to track it over time.

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

Comparisons with Other Datasets

Lillie and Mason (1983) is an excellent source for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Shawano County lakes are included within the study's Central Region (Figure 1) and are among 44 lakes randomly picked from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means, historic, current, and average data from the Red Lakes are displayed in Figures 2-9. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-a data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

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

Unfortunately, very little historic water quality data exists for the Red Lakes; therefore long-term trend analysis is impossible. However, using data collected during this study and others conducted during the early 1990's, it can be seen that total phosphorus levels for both lakes would be considered *Fair* to *Good* and better than other Wisconsin Impoundments (Figures 2 & 3). During 2006, phosphorus values in Lower Red Lake were slightly higher than those found in Upper Red Lake. This trend is reversed when the 1991 data is examined, leading to the conclusion that both lakes have relatively the same phosphorus concentrations occurring within them and the values fluctuate a bit from year to year.

Chlorophyll-*a* values for both lakes appear to remain in the *Fair* to *Good* range over the two studies, and like the phosphorus values, are much better than what is normally found in a Wisconsin impoundment (Figures 4 and 5). It must also be stated that these chlorophyll-*a* values could be much higher considering the amount of phosphorus that enters the Red Lakes through their watersheds. This is discussed more within the Summary and Conclusions Section.

Following the relationship between chlorophyll-*a* and water clarity as presented above, both lakes have *Fair* to *Good* Secchi disk transparencies. The fluctuations seen in Lower Red Lake over the course of the dataset are likely related to rain fall amounts during those years, with lower precipitation rates likely resulting in better transparency because of reduced nutrient loadings to the lake.

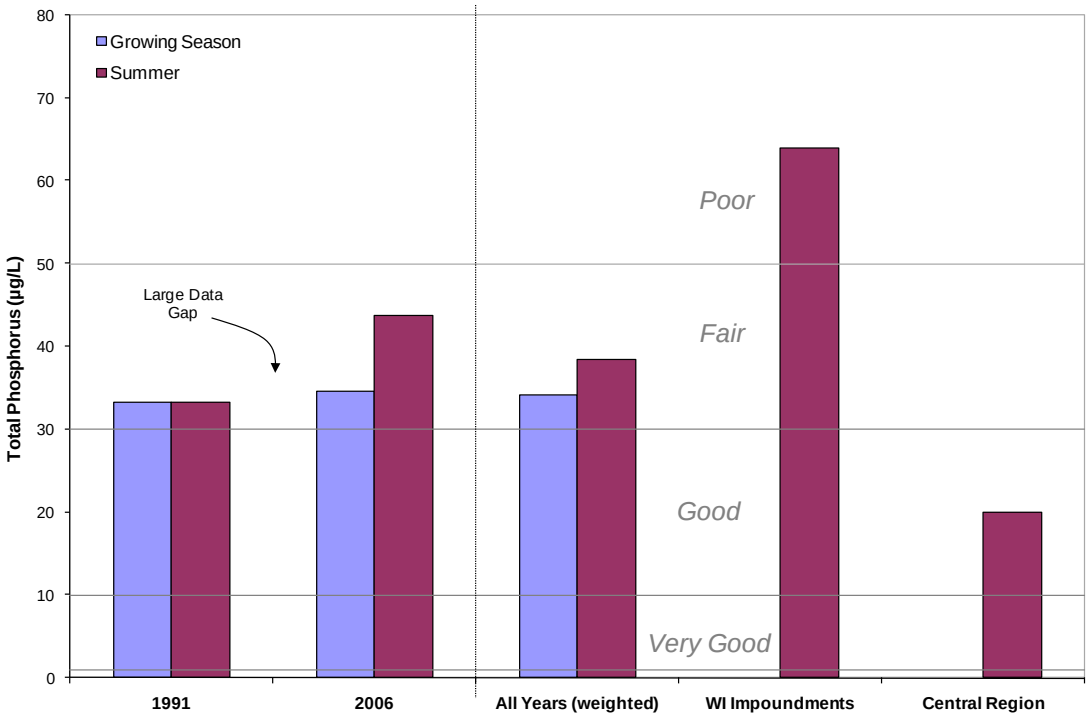


Figure 2. Upper Red Lake total phosphorus concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

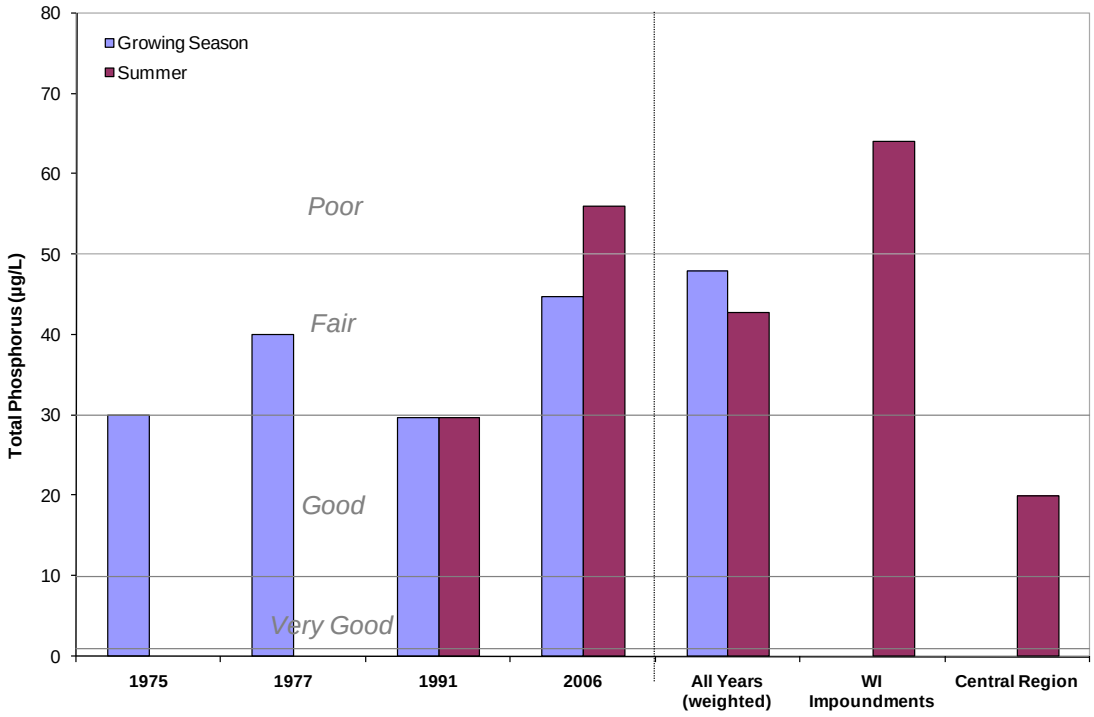


Figure 3. Lower Red Lake total phosphorus concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

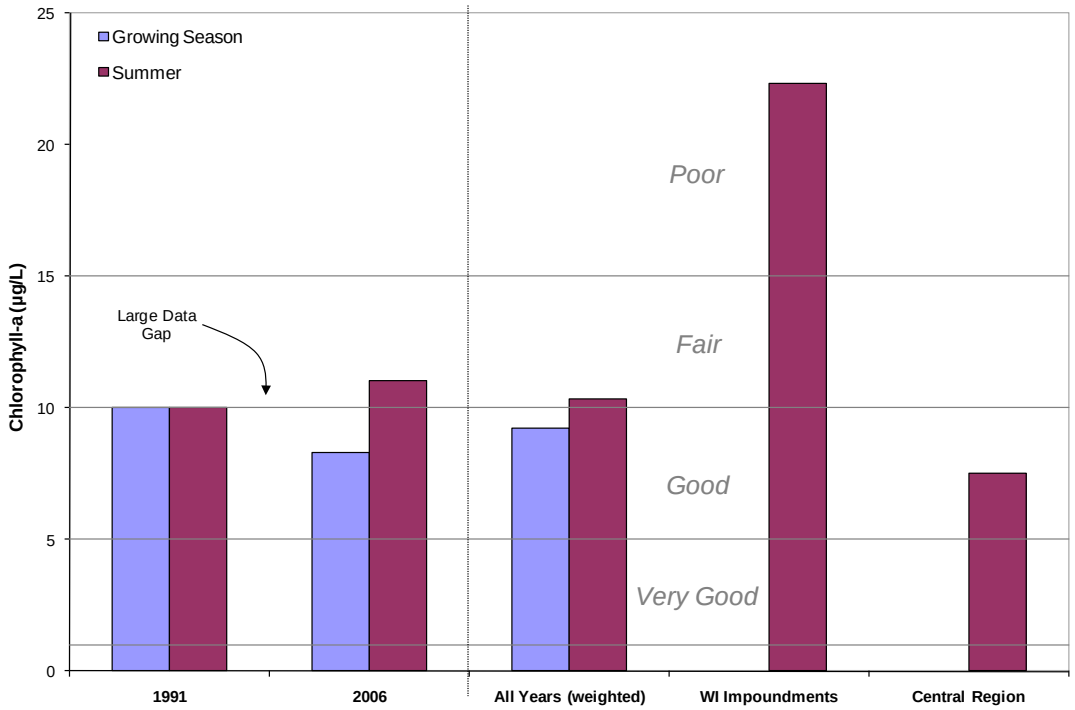


Figure 4. Upper Red Lake chlorophyll-*a* concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

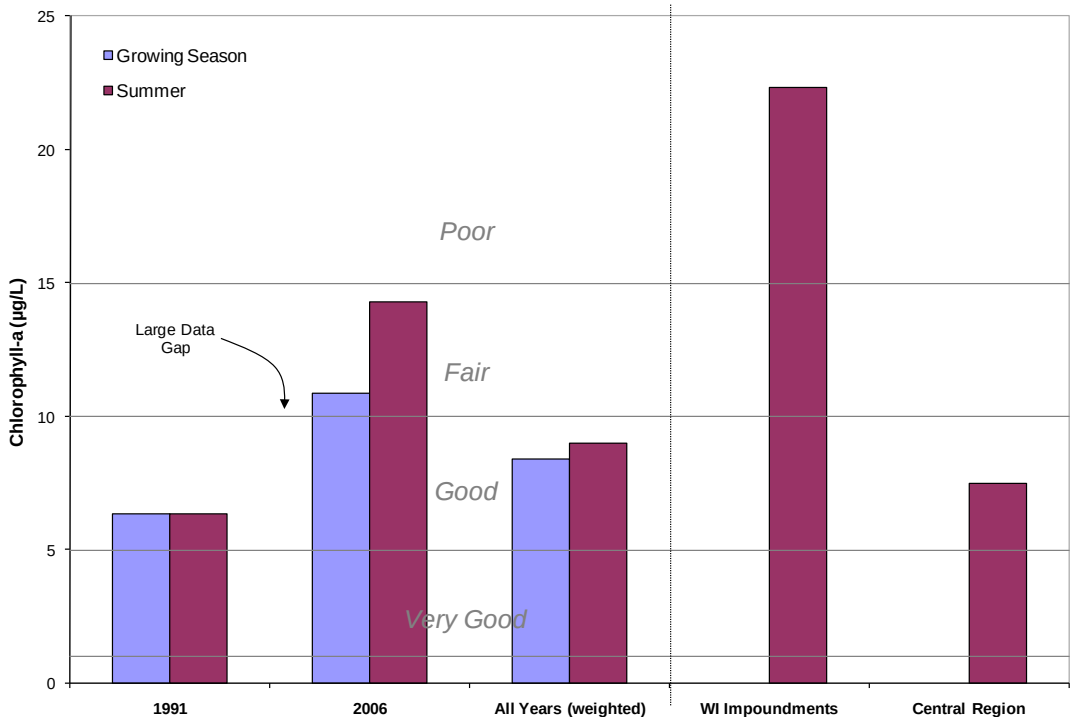


Figure 5. Lower Red Lake chlorophyll-*a* concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

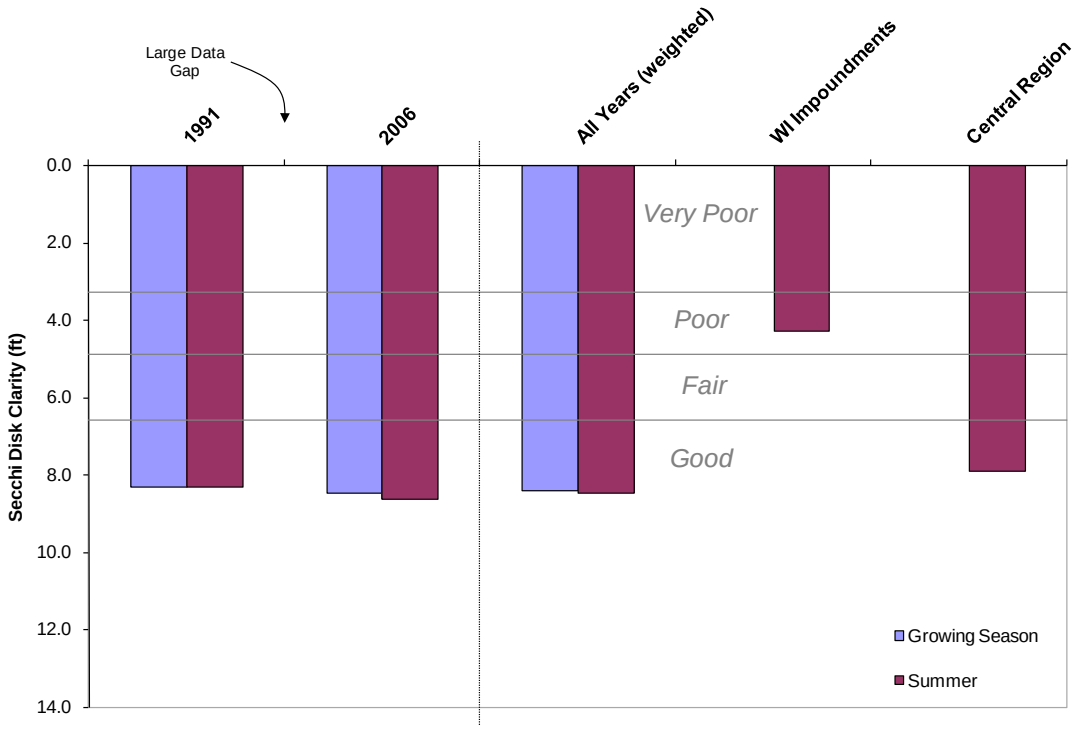


Figure 6. Upper Red Lake, regional, and state Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

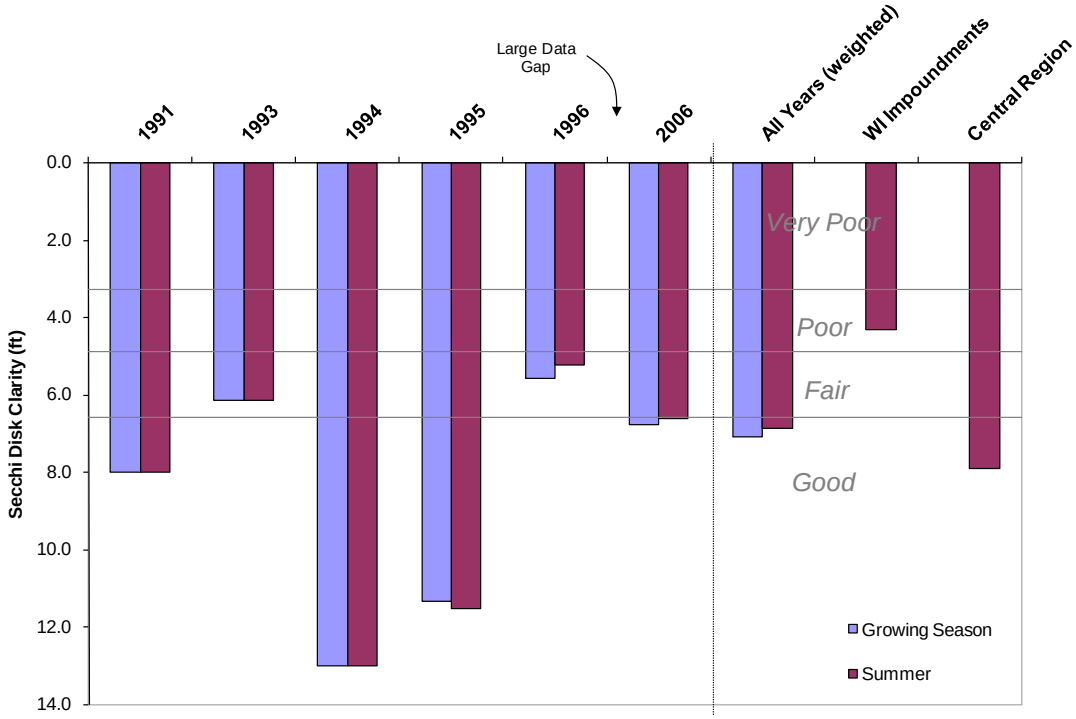


Figure 7. Lower Red Lake, regional, and state Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Red Lakes Trophic State

Figures 8 and 9 display the Wisconsin Trophic State Index (WTSI) (Lillie et al. 1993) values calculated from average surface levels of chlorophyll-*a*, total phosphorus, and Secchi disk transparencies measured during the summer months in the Red Lakes. The WTSI is based upon the widely used Carlson Trophic State Index (TSI) (Carlson 1977), but is specific to Wisconsin lakes. In essence, a trophic state index is a mathematical procedure that assigns an index number that corresponds to a lake's trophic state based upon three common lake parameters; chlorophyll-*a*, Secchi disk transparency, and total phosphorus. The WTSI is used extensively by the WDNR and is reported along with lake data collected by WDNR Citizen Lake Monitoring Network volunteers.

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.

The trophic state of a lake is directly related to its production, more precisely – primary production. It is simply a classification based upon the lake's capacity to produce plants in the form of algae and macrophytes. The WTSI values for both Red Lakes indicate that they are both eutrophic. This means that both lakes are very productive and have sufficient nutrient levels to support high plant biomass.

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 units 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.

Using nitrogen and phosphorus values collected during the growing season (April-October) on Upper and Lower Red Lakes, it is evident that both lakes are phosphorus limited. Both lakes had high nitrogen to phosphorus ratios with Upper Red's being 34:1 and Lower Red's being 28:1.

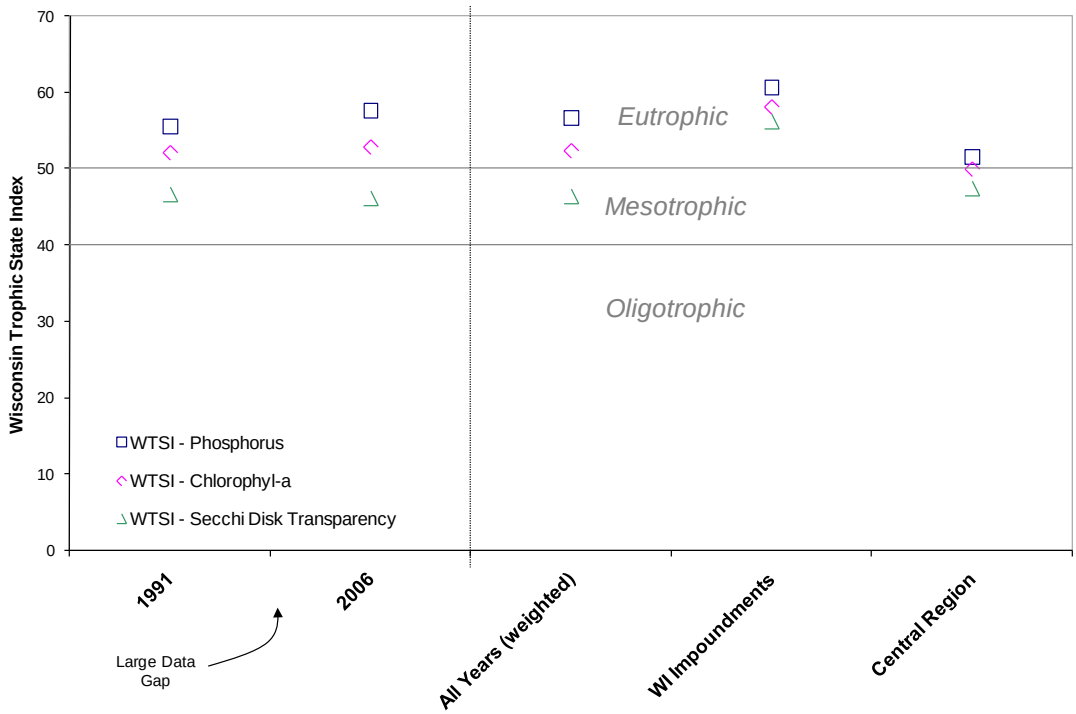


Figure 8. Upper Red Lake, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie, et al. (1993).

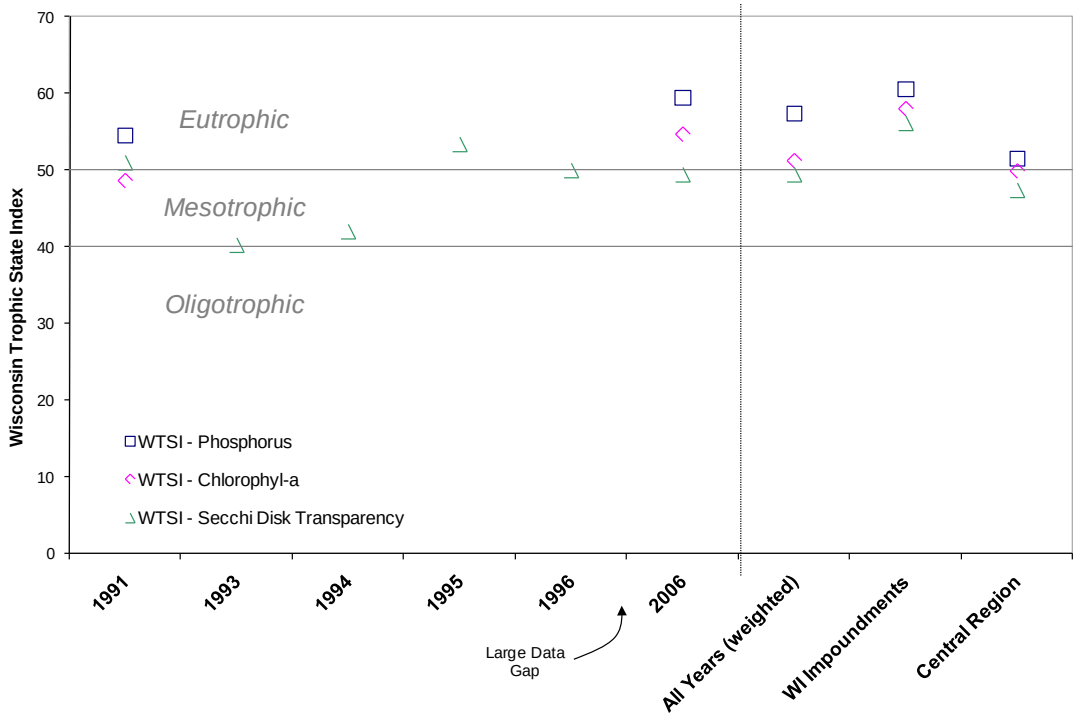


Figure 9. Lower Red Lake, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie, et al. (1993).

Watershed Analysis

Upper Red Lake and Lower Red Lake share much of the same geography in their watersheds (Map 2). However, Lower Red Lake watershed not only includes the entire watershed of Upper Red Lake (85,161 acres), but also additional drainage area entering the lake through Miller Creek (19,500 acres) and overland on its south shore (667 acres). In total, Lower Red Lake has 105,327 acres draining to it. Both of these large watersheds drain to relatively small lakes resulting in very high watershed to lake area ratios. The watershed to lake area ratio describes how much land area drains to each surface-acre of lake. In general, lakes with higher ratios tend have greater amounts of phosphorus being loaded to them and when the ratio exceeds 10: or 15:1, the watershed is the predominate source of phosphorus. Upper Red Lake's watershed to lake area ratio is 413:1, while Lower Red Lake's is 499:1. As mentioned above, these are very high ratios, but are not uncommon in impoundments, especially for a hydroelectric impoundment that relies upon high water flows for the generation of electricity.

The size of the drainage area is not the only factor determining the amount of phosphorus entering a lake- land cover (land use) within the watershed is also very important. Heavily vegetated areas, such as forests and grasslands export the least amount of phosphorus because the majority of the precipitation that falls on them penetrates the soil and enters the groundwater. This creates very little surface runoff to carry sediment and nutrients to the lake. Land uses with little vegetative cover, such as agricultural areas (especially row crops) and urban areas tend to allow much of the precipitation that falls on them to become surface runoff, while very little enters the groundwater. As the water moves over the surface of these land covers, it picks up sediment and nutrients which are eventually delivered to the lake.

Map 2 shows the land coverage of the Red Lakes watershed and Figure 10 summarizes it using percentages. Nearly 50% of Upper Red Lake's watershed is in forest, with another 3% in row crops and a much smaller amount in some type of detectable urban development. Over 80% of the land draining to Lower Red Lake travels through Upper Red Lake first. Less than a percent of the Lower Lake's watershed is in row crops and over 12% of it is in forest.

Phosphorus load modeling using standard export coefficients contained in the Wisconsin Lake Modeling Suite (WiLMS, Appendix C) resulted in an estimated annual phosphorus load of approximately 13,737 lbs. (6.86 tons) for Upper Red Lake (Figure 11). Interestingly, while only 3% of the Upper Red watershed contains row crops, that land cover type accounts for nearly 17% of the phosphorus load, and while the forested areas occupy nearly half of the watershed, they only account for less than a quarter of the annual load. Areas of the watershed covered in grasses and pastures, account for nearly half of the annual load.

The annual phosphorus load entering Upper Red Lake was used in other models to estimate in-lake phosphorus levels, including growing season, annual, and spring turnover means. To check the alignment of the model, those estimates were compared to corresponding data collected in Upper Red Lake during 2006 and indicated that the phosphorus load generated by WiLMS to be in line with phosphorus loads that would be commonly found in other man-made systems. In other words, a load of 13,737 lbs is a reasonable assessment of the amount of phosphorus that enters Upper Red Lake annually.

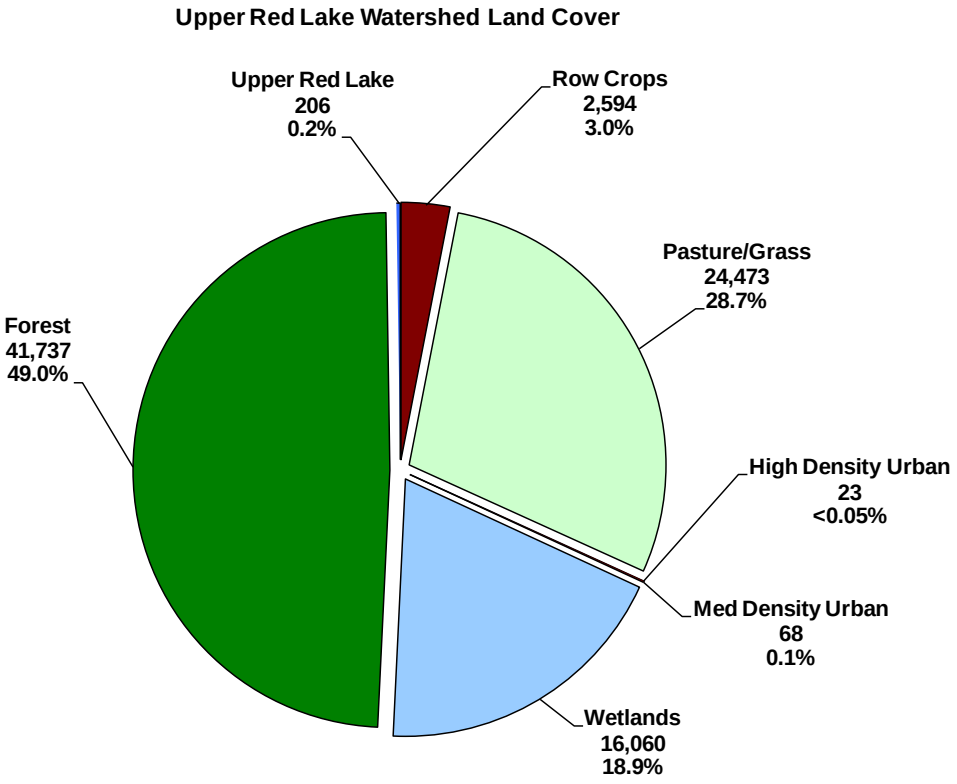
Modeling of the Lower Red Lake's annual phosphorus load is a little more difficult because the contribution from Upper Red Lake must be accounted for in the estimate. In doing this, the outflow of Upper Red Lake is considered a point-source of phosphorus entering Lower Red Lake within the WiLMS modeling. WiLMS calculates the annual input of phosphorus by multiplying the average outflow concentration by the outflow's annual discharge volume. In natural systems, the outlet of the lake is at about the elevation of the lake's surface, allowing for surface sample concentrations of total phosphorus to be used as the average concentration of the outflow waters.

The first attempt at modeling Lower Red Lake's annual phosphorus load utilized the method outlined above and resulted in an unrealistically low estimate when compared to values actually found in the lake. This underestimate occurred because much of the water flowing from Upper Red to Lower Red Lake does not come from Upper Red's surface waters, but instead originates from the lake's hypolimnetic (bottom) layer which supports much higher phosphorus levels (see Internal Nutrient Loading discussion in Water Quality Section). Using strictly hypolimnetic outflow concentrations over estimated the loading value to the same extent the previous scenario underestimated it. However, averaging the surface (epilimnetic) and hypolimnetic load values from Upper Red Lake resulted in excellent comparisons between actual and predicted phosphorus concentrations for Lower Red Lake.

Using the methodology described above, the annual phosphorus load entering Lower Red Lake was estimated to be approximately 13,189 lbs. (6.6 tons). Like the load entering Upper Red Lake, this would be considered a very high load for a lake of this size. Figure 11 shows how much each watershed source contributes to the total load of phosphorus entering Lower Red Lake. Naturally, the largest source by far is Upper Red Lake as its watershed makes up over 80% of the land draining to Lower Red Lake (Figure 10). However, it should be noted that not all of the phosphorus that enters Upper Red Lake makes its way down to Lower Red. In fact, WiLMS modeling indicated that about 13,737 lbs. of phosphorus enters Upper Red Lake, but only 10,424 lbs actually makes its way to Lower Red Lake. This means that about 1.5 tons of phosphorus settles in Upper Red Lake before it enters Lower Red Lake on an annual basis.

In some lake ecosystems, modifications to the watershed can significantly lower phosphorus loads entering a lake. Implementation of best management practices (BMP's) reduce nutrients and other pollutants in runoff, and as a result reduce the amounts of those substances that enter the lake downstream. However, as discussed in the beginning of this section, land cover is not the only factor determining the amount of phosphorus that enters a lake; watershed size is also very important. To demonstrate the impact the large watershed to lake area ratio has on the phosphorus load entering Upper Red Lake, regardless of the land cover within it, additional modeling was completed using WiLMS. In this scenario, the row crops that exist within the Upper Red Lake watershed were converted to forest within the model, while all other factors remained the same.

Using the forested watershed, the annual phosphorus load to Upper Red Lake was nearly cut in half to 7,020 lbs. (3.5 tons). While this is obviously a significant decrease in phosphorus entering the lake, the lake would still be considered highly productive and support its current level of plant growth. In the end, it is the immense size of the Red Lakes watershed that supports the high nutrient levels within the lake.



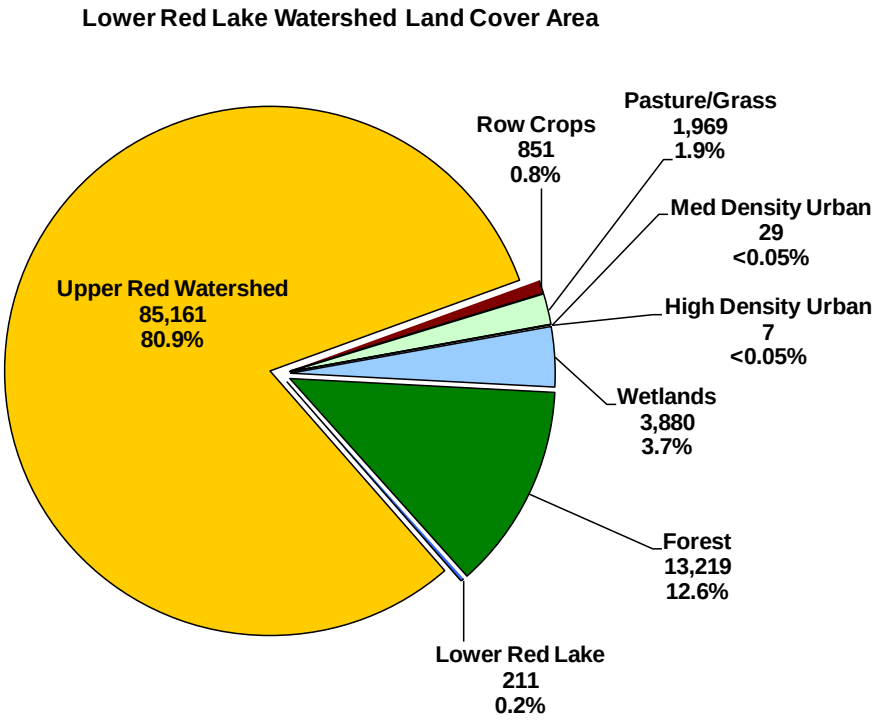
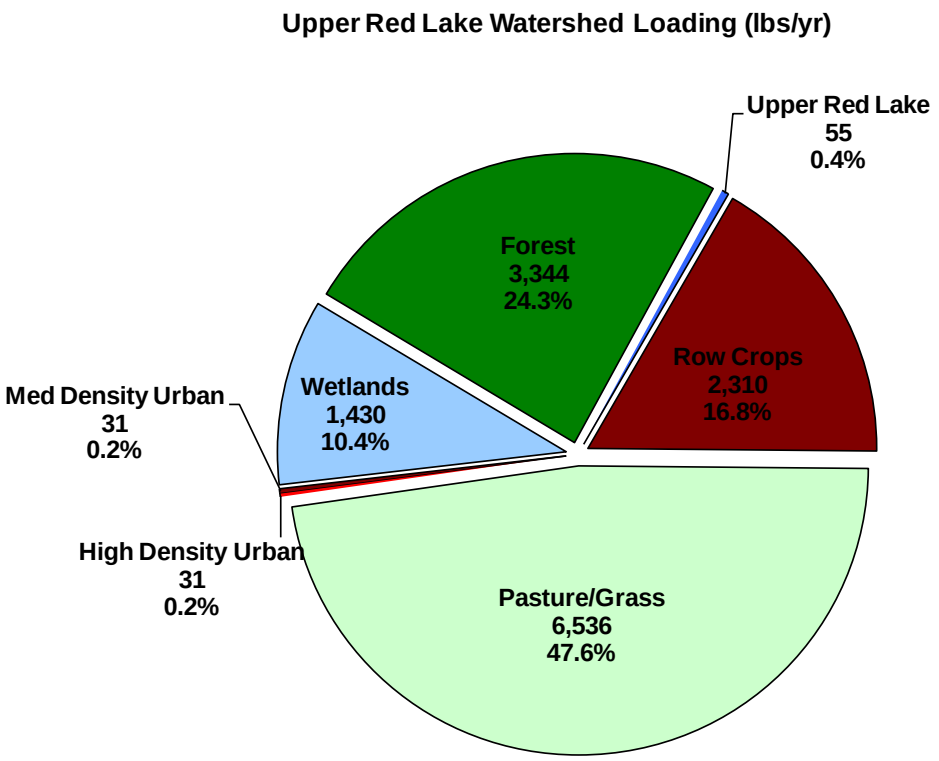


Figure 10. Upper and Lower Red Lakes watershed land cover. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR 1998).



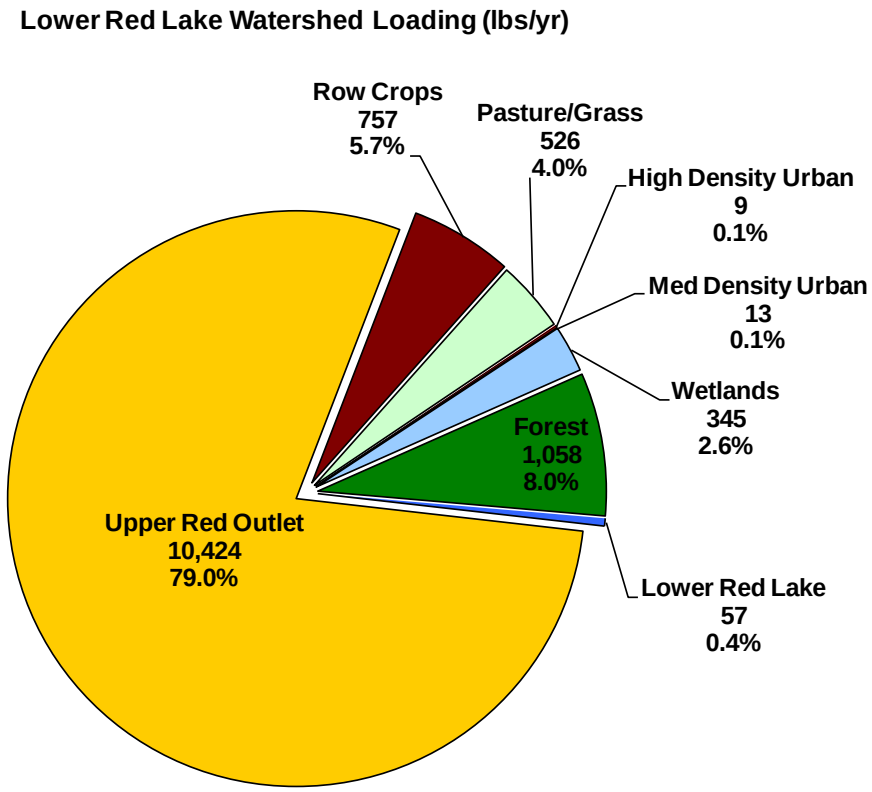


Figure 11. Upper and Lower Red Lakes phosphorus loading based upon land cover type. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

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 where plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by *phytoplankton*, which helps to minimize nuisance algal blooms.

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

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

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 all of these techniques may not be applicable to the Red Lakes, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake**.** The techniques applicable to the Red Lakes are located in the management section.

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 of the shoreland's natural function.

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

Cost

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

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

Advantages

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 could be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive. If the waterbody is part of a hydro-electric power generating system, reimbursement of lost revenues could be extremely 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 or if reimbursement of hydro-electric revenue is necessary.
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.

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

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

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

Endothal (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.

2,4-D (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 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 detectable and provide critical information for management decisions.

As described in more detail in the methods section, two aquatic plant surveys were completed on Upper and Lower Red Lakes. The first searched 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 losses of individual species, or changes in life-forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Red lakes, plant samples were collected from plots laid out on grids that covered the lakes. 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 relative to the other plants. These values are presented in percentages and if all of the values were summed, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and that value was described 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 term 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.

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.

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

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of the Red Lakes are compared to lakes in the same ecoregion and in the state (Figure 12).

Figure 12. Location of the Red lakes within the ecoregions of Wisconsin. After Nichols 1999.

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

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 completely visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

Exotic Plants

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

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 13). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

Figure 13. Spread of Eurasian water milfoil within WI counties. WDNR Data 2006 mapped by Onterra.

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

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

2006 Red Lakes Aquatic Plant Surveys

As mentioned above, numerous plant surveys were completed as a part of this project. The first survey, one aimed strictly at curly-leaf pondweed was completed in June 2006. Point-intercept surveys were conducted on Lower Red Lake on July 10-12 and on Upper Red Lake on July 18-20. The results of the point-intercept surveys provided much of the information used within this report and is discussed below in detail. Also on these dates in July, surveys were completed to create the Red Lakes aquatic plant community map (Map 3)

During the aquatic plant surveys conducted by Onterra on the Red Lakes, 28 native plant species were located on Upper Red Lake and 29 on Lower Red Lake (Figures 14-16). Combining the two lakes, a total of 31 native aquatic plant species were located in the system along with two non-native species: Eurasian water milfoil and curly-leaf pondweed (Table 1). Although the Red Lakes plant community exhibits a high species richness, the plant distribution throughout the lake (relative frequency) is fairly uneven reflecting a moderately high species diversity (Simpson's diversity = 0.90 for both lakes). The Red Lakes is an excellent example of a system that has high species richness, but is not highly diverse. This is true because the Red Lakes are highly dominated by three or four species (Figures 14 & 15). The dominant species within the lakes are coontail, Eurasian water milfoil, common waterweed, and free-floating species (duckweeds).

Overall, the FQA indicates that floristic quality of the Red Lakes (Figure 16) is good, especially when compared to median values for the state and ecoregion. As described above, floristic quality utilizes average conservatism value for all of the native species found in the lake and the total number of those species. Obviously, the high species richness of the lakes is the major factor contributing to its high floristic quality even though the Red Lake's average conservatism values are below the state and ecoregion medians.

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

The low average conservatism values observed within the Red Lakes indicates that many of the species present in the lakes are indicative of a disturbed system. This is not a surprise considering the Red Lakes are man-made impoundments that have vast portions of developed shoreline and contain multiple non-native plant species. Still, the lake's plant community is healthy as evidenced by the high floristic quality and moderately high index of diversity. The exceptional health of the lakes' plant communities is also indicated by the high incidence of emergent communities that occur in many areas of the lakes (Map 3). Although the lakes contain healthy emergent plant communities, spatterdock was the only floating-leaf species located within the lakes. While Upper Red Lake contained multiple spatterdock communities, only a few occurrences exist in Lower Red Lake, all near the Miller Creek inlet (Map 3). Emergent and floating-leaf communities are often used as indicators of ecosystem health,

because these communities are often negatively affected by recreational use and shoreland development. The profound lack of diversity of floating-leaf species with the system is perplexing, compounded by the low abundances found in Lower Red Lake.

Table 1. Aquatic plant species located in Upper and Lower Red Lakes during the 2006 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	Lower Red Lake	Upper Red Lake
Emergent	*Carex comosa*	Bristly sedge	5	I	
	Eleocharis erythropoda	Bald spike-rush	3		X
	Iris virginica	Southern blue flag	5	I	I
	Sagittaria latifolia	Common arrowhead	3	X	X
	Schoenoplectus pungens	Three-square rush	5	X	
	Schoenoplectus tabernaemontani	Softstem bulrush	4	X	I
	Typha angustifolia	Narrow-leaved cattail	1	X	
	Typha latifolia	Broad-leaved cattail	1	X	I
FL/E	*Sparganium eurycarpum*	Common bur-reed	5	X	X
FL	*Nuphar variegata*	Spatterdock	6	X	X
Free-Floating	*Lemna minor*	Lesser duckweed	5	X	X
	Lemna trisulca	Forked duckweed	6	X	X
	Spirodela polyrrhiza	Greater duckweed	5	X	X
	Wolffia borealis	Dotted watermeal	6	X	X
	Wolffia columbiana	Common watermeal	5	X	X
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X
	Chara sp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Heteranthera dubia	Water stargrass	6		X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	X	X
	Najas guadalupensis	Southern naiad	7	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton crispus	Curly-leaf pondweed	Exotic	X	X
	Potamogeton natans	Floating-leaf pondweed	5	X	X
	Potamogeton praelongus	White-stem pondweed	8	X	
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Ranunculus aquatilis	White water-crowfoot	8	X	
	Stuckenia pectinata	Sago pondweed	3	X	X
	Vallisneria americana	Wild celery	6	X	X
FL/S	*Sagittaria graminea*	Grass-leaved arrowhead	9	X	

I = Incidental
FL/E = Floating-leaf emergent
FL = Floating-leaf
FL/S = Floating-leaf submergent

A combination of two factors are likely the primary contributors to the Red Lakes exceptionally high species richness; 1) the fact that much of what is now considered to be a lake was originally a wetland, and 2) the fluctuating water levels on an annual and seasonal basis. Natural, undisturbed wetlands normally hold diverse plant communities. Remnants of the Red Lakes origins as a wetland still exist in the lakes' emergent plant community. The system's fluctuating water levels also contribute by allowing the emergent species to grow prolifically around the lake (Map 3). Although these areas are very important to the lake's health, they can, in some

occasions, reach nuisance levels and impact recreational enjoyment of the lake. Striking a balance between the needs of lake users and those of the lake is often a challenge.

The Red Lakes contain an extremely high biomass of macrophytes. Of the point-intercept locations that were sampled (excluding those that were too deep for plant growth or were unreachable), 98% on Lower Red Lake and 99% on Upper Red Lake contained submergent species. This demonstrates that all areas of the Red Lakes are suitable for the growth of submergent plant species. Some lakes exhibit a variety of substrate types, including rock and sand, which inhibit plant growth. Sediment type was recorded at each point-intercept location sampled and aside from less than ten locations on both lakes, all were considered muck.

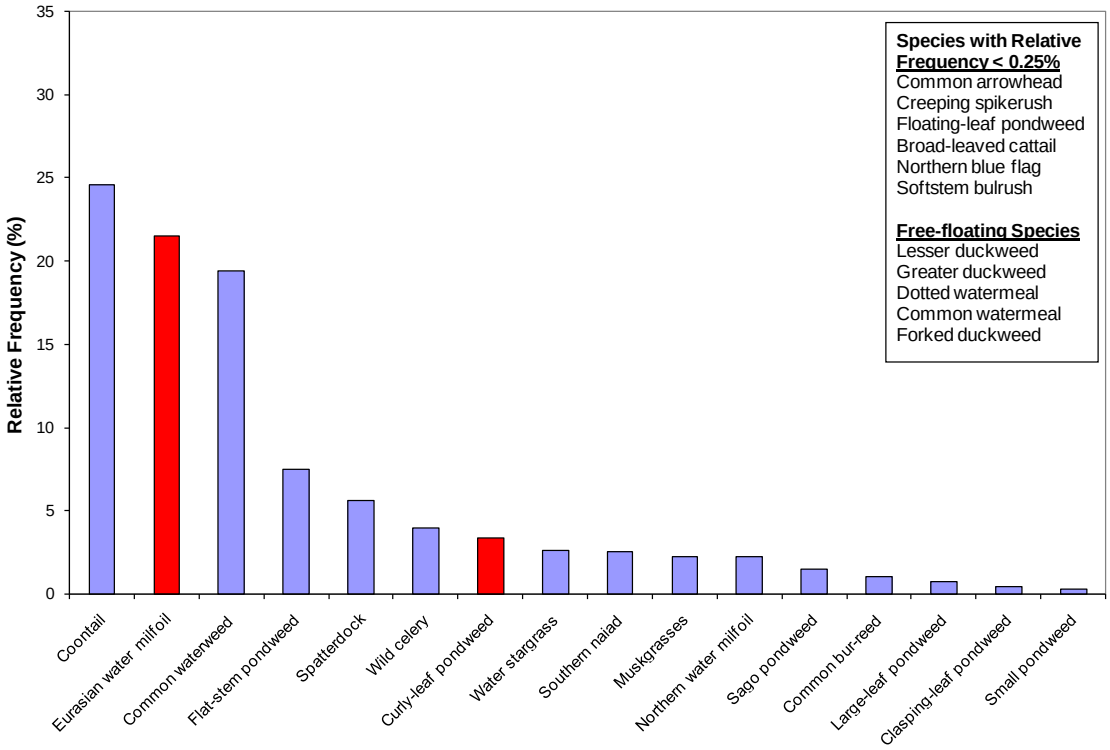


Figure 14. Upper Red Lake's aquatic plant occurrence analysis of 2006 survey data. Exotic species indicated with red.

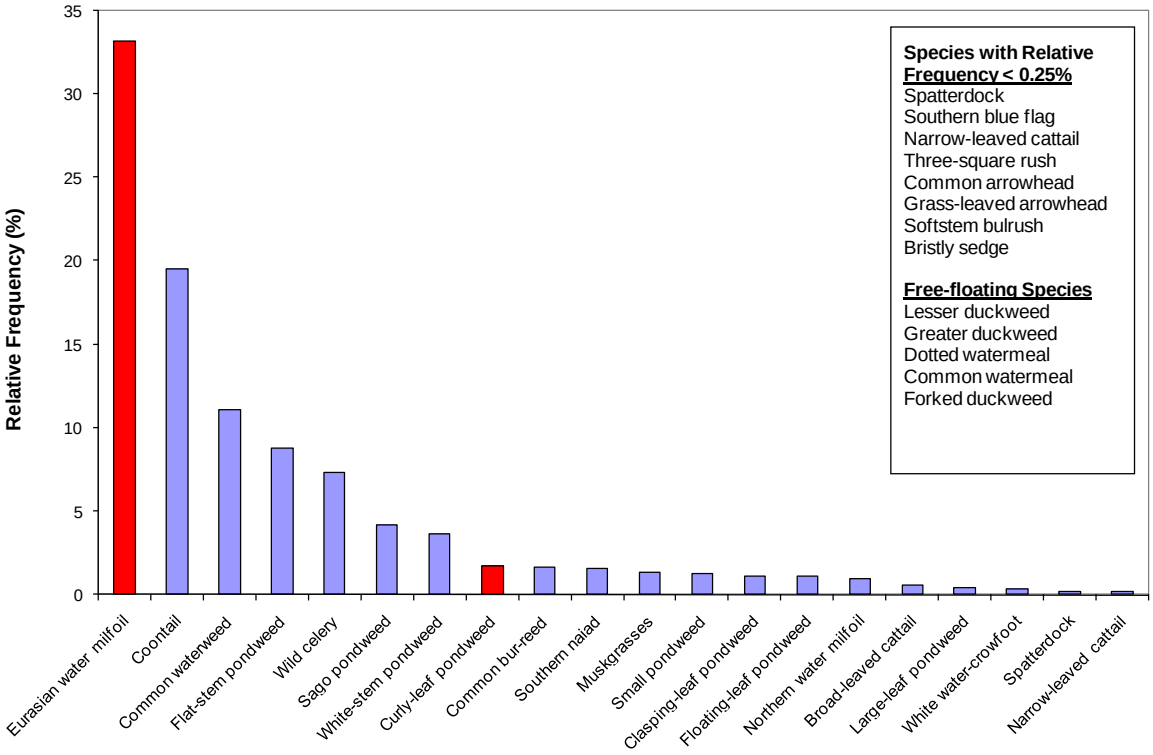


Figure 15. Lower Red Lake's aquatic plant occurrence analysis of 2006 survey data. Exotic species indicated with red.

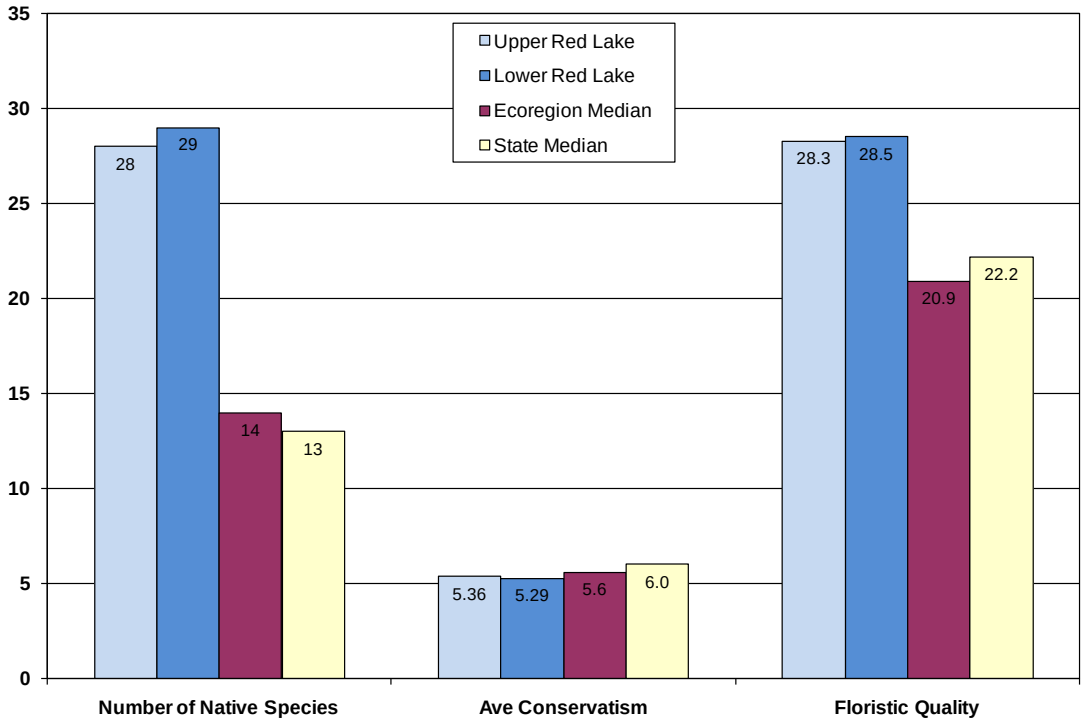


Figure 16. **Red Lakes Floristic Quality Assessment.** Developed with 2006 aquatic plant data**.**

Exotic Plant Species

Curly-leaf Pondweed

A meander survey of the Red Lakes was completed on June 6-8, 2006 expressly for mapping curly-leaf pondweed occurrences. The survey results are contained in Map 4 and indicate that approximately 62% of the surface area of Lower Red Lake and 81% of Upper Red Lake contain map-able amounts of curly-leaf pondweed, including areas that contained scattered occurrences to areas that were obviously dominated by the plant. Much of the curly-leaf pondweed had died back by the time the point-intercept plant survey occurred (mid-July), but it was still shown to be one of the top 10 most abundant plants with the lakes (Figure 14-15).

Along with navigational difficulties, the mid-summer die off of curly-leaf pondweed can lead to elevated phosphorus levels and depending on the lake, these can fuel to algal blooms. Figure 17 displays surface concentrations of total phosphorus in the system during the extent of the study. Because the lakes have such a large watershed and an extremely low retention time, it is almost impossible to single out the role the seasonal curly-leaf pondweed die off had on total phosphorus concentrations. A typical phosphorus spike associated with such die off would be observed in early- to mid-July. It is possible that a more profound phosphorus spike occurred earlier in July, but escaped detection. A more comprehensive study of the water quality of the Red Lakes specifically aimed at detecting changes in phosphorus concentrations surrounding curly-leaf pondweed die off may lead to a better understanding of the process, but little options in terms of management are available for such a large infestation.

Figure 17. Red Lakes surface total phosphorus concentrations during portions of 2006 & 2007.

Eurasian Water Milfoil

Along with curly-leaf pondweed, Eurasian water milfoil was found to occur in nearly all areas of the Red Lakes (Map 5), with approximately 90% of the point-intercept locations on Lower Red Lake and 81% of the point-intercept locations on Upper Red Lake containing the exotic plant. Relative frequency analysis of the Red Lakes shows that Eurasian water milfoil is the most dominant species in Lower Red Lake (Figure 15) and the second most dominant species in Upper Red Lake (Figure 14). Based on Figure 18, it can also be noted that Eurasian water milfoil is found in dense quantities within many parts of the system (Map 5). Consistent with qualitative observations, this figure indicates that proportionately more dense areas of Eurasian water milfoil exist in Lower Red Lakes.

In some lakes, Eurasian water milfoil occurs in dense colonies, while in others its extents are limited to a scattering in certain areas of the lake. In both of these cases, Eurasian water milfoil may be limited by depth or substrate type. As stated above, the Red Lakes are almost entirely comprised of a mucky substrate. Also, very little area within the lakes are too deep for plant growth (Map 5). The lack of restrictions on Eurasian water milfoil growth has caused this plant to expand to nuisance levels within almost every area of the system and as a result, is actively managed by the RLMD using mechanical harvesting methods.

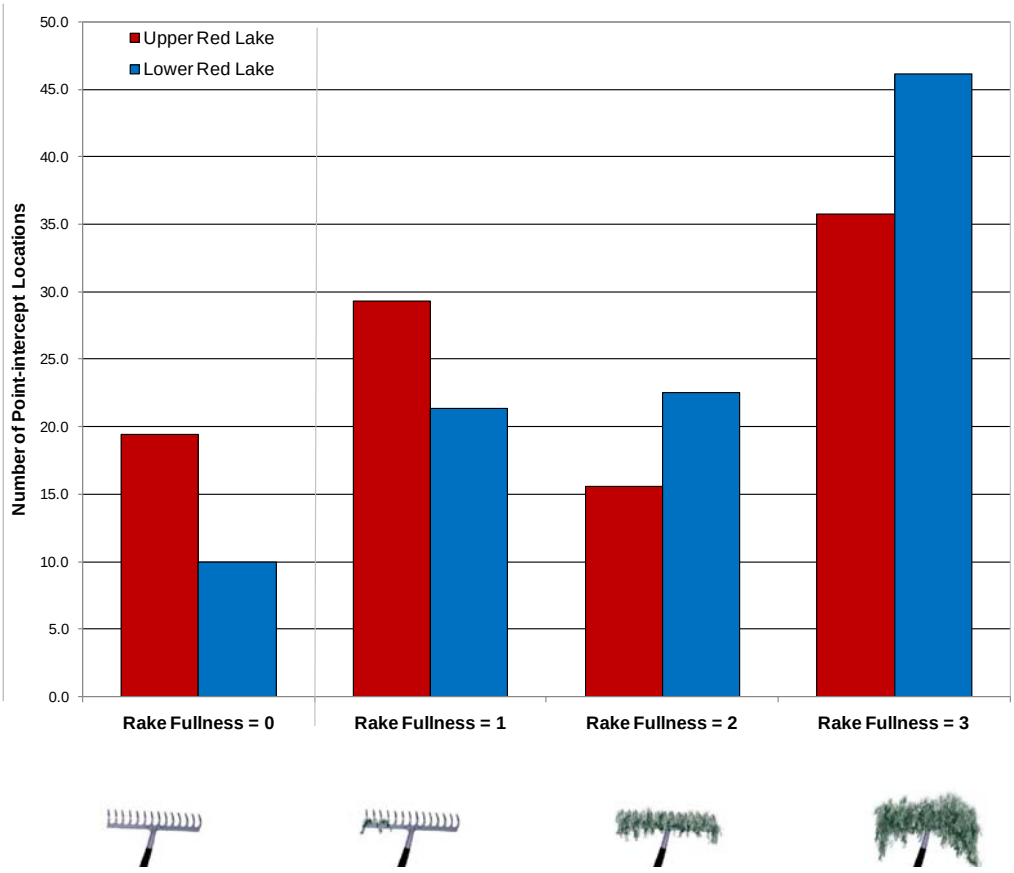


Figure 18. EWM rake fullness distribution from 2006 point-intercept surveys on the Red Lakes.

Although officially documented by the WDNR in 1994, Eurasian water milfoil may have been present in the Red Lakes for much longer. Lake Management Plans created for Upper and Lower Red Lake in 1992 indicate that the macrophyte community of the lakes were dominated by 'milfoil' (IPS 1992a & 1992b), but was not indentified to the species level. Although a native species of milfoil (northern water milfoil) does exist within the lakes, it is presumed that the majority of the 'milfoil' indicated by these surveys was Eurasian water milfoil. Mechanical harvesting actions have taken place on the Red Lakes since 1994 aimed at controlling nuisance levels of aquatic plants, specifically Eurasian water milfoil and curly-leaf pondweed. Harvesting activities typically play a large role in the spread of Eurasian water milfoil, as well as curly-leaf pondweed within a lake. However, these plants may have already existed in all areas of the lakes.

Based on advice from the WDNR, the RLMD pursued the planting of milfoil weevils with the assistance of EnviroScience. The first stocking of 16,000 weevils within three sites on Upper Red Lake took place in April 2001. All harvesting on Upper Red Lake was suspended while it continued on Lower Red Lake. A survey completed in August indicated a 47% reduction in Eurasian water milfoil density on Upper Red Lake. These findings were supported by riparian observations of a marked difference in the amount of milfoil in the weevil areas. Based upon these results and those reported at Loon Lake, the association sponsored the introduction of 16,000 more weevils on three sites in Lower Red Lake during 2002. In order to prevent counter-acting the weevil introductions, all harvesting was suspended on Lower Red Lake as they were in Upper Red Lake the previous year. Preliminary reports indicated that milfoil density was reduced, however long term control was not observed and the use of milfoil weevils as a management tool ceased on the lake. The RLMD resumed their harvesting activities on both lakes in 2003.

Red Lakes Fisheries

In depth discussion of fisheries information and management is beyond the scope of this project. However, the WDNR completed numerous fish surveys on Upper and Lower Red Lakes during 2007. Summary reports of these surveys are contained in Appendix E.

SUMMARY AND CONCLUSIONS

At the foundation of any thought regarding the Red Lakes ecosystem, it must be remembered that Upper and Lower Red Lakes are man-made systems and that they are not necessarily going to be comparable to natural lakes, nor are they going to be able to be managed like natural lakes. This is important because many lake users believe that impoundments and lakes are basically the same thing and as result, believe that they can have the same expectations for both types of systems. In reality, there are many differences between impoundments and natural lakes and those differences need to be considered when developing a realistic and useable lake management plan.

In Wisconsin, impoundments are found to have higher nutrient levels than natural lakes (Lillie and Mason 1983). The Red Lakes are no different, because as discussed in the water quality section, both Upper and Lower Red Lakes have relatively high phosphorus levels. The levels are not as high as those found in many other impoundments, but they are still high enough to support a great amount of plant biomass. Fortunately, that plant biomass is not exhibited by high rates of algal production as is the case with many other lake systems. In fact, the Red Lakes both showed fair algal chlorophyll-*a* levels during the summer of 2006. These low rates of algal production helped the lakes support fair to good water clarities as indicated by Secchi disk depths that are better than the majority of Wisconsin impoundments.

As mentioned above, the high phosphorus levels found in the Red Lakes are not shown in high algal biomass levels, but instead within the lakes' extremely high levels of vascular plant biomass. Although many high quality plants exist in the lakes, both lakes are nearly dominated by exotic species throughout the growing season; first in the early summer by curly-leaf pondweed and then by Eurasian water milfoil as the growing season continues. By the beginning of July, the considerable amount of Eurasian water milfoil canopies in almost all areas that it exists, which exasperates the exotics problem in terms of navigation and native habitat. The matted surface is a perfect area for filamentous algae to thrive and is a catch-all for free-floating species such as duckweeds. All of this adds up to a great amount of water surface area that is non-navigable and likely alters the underlying water's dissolved oxygen levels and pH.

Even with the morose description in the paragraph above, it must be noted that the native plant community in the Red Lakes system is relatively healthy in terms of diversity and floristic quality. During the 2006 surveys, both Upper and Lower Red Lakes were discovered to have species richness values exceeding those of the majority of lakes in the state and the North Central Lakes and Flowages Ecoregion. Although many of the species within the lakes are indicative of disturbed systems, when that fact is considered with each lake's high level of species richness, it can be concluded that the native plant community of the lakes is still of greater quality than most of the lakes in the state and ecoregion. This is important because it draws attention to the fact that even though both lakes have problems with exotic plant infestations, they both contain an amazing degree of quality plant habitat. It is that quality habitat that supports the lakes' fishery and brings about a certain amount of natural aesthetics that often shines beyond that of the exotics problem.

In the beginning of this section, the fact that natural lakes and impoundments are different was brought to the forefront of the discussion. Of all the differences, including sediment structure, sediment origin, and morphology, the fact that impoundments generally have much higher

watershed area to lake area ratios than those found in natural lakes, is likely the most important. As the acreage of watershed draining to each acre of lake increases, the amount of nutrients being loaded to that lake also increases. At some point, depending on the lake's volume, the ratio is so high that the lake is likely to have sufficient nutrient loads entering it to create a scenario where the lake is highly productive (eutrophic) regardless of land cover that exists in the watershed. In other words, the lake will have excessive nutrient levels regardless if its watershed is completely forested or almost entirely in agriculture. For most lakes, that ratio probably occurs between 10:1 and 15:1. The watershed to lake area ratios of Upper and Lower Red Lakes are both over 400:1. This means that even if the watersheds of the lake were completely forested, as demonstrated in the watershed section for Upper Red Lake, that they would both still support very high levels of plant production.

Managing a lake in that situation can be difficult because in terms of the overall watershed, there are no options to significantly reduce nutrient loads in hopes of reducing aquatic plant growth. The fact of the matter is that the Red Lakes are bound to be productive systems because of their geographic point of creation on the landscape of Shawano County. While their large drainage basins assure that there will be plenty of water to turn the turbines in the hydroelectric plants, they also assure that there will be sufficient nutrients to fuel incredible amounts of macrophytic aquatic plant growth. As described above, Red Lake stakeholders are fortunate that the lakes are dominated by macrophytic growth instead of algal growth. If the other case were true, the lakes would resemble pea soup throughout much of the year because of the malodorous algal blooms that would develop. Once a lake is in an algae-dominated state, or turbid state, it is very difficult to bring it back to a macrophyte dominated state, or clear state. The macrophytes that occur in both lakes, regardless if they are native species or not, are responsible for maintaining each lake's current clear state. The macrophytes are important in suppressing algal dominance by competing for nutrients and light, while providing cover for microscopic animals that graze heavily upon algae.

It is obvious that the macrophytes of the Red Lakes system play an important role in the system's ecology and that the current level of plant biomass is there to stay. Therefore a goal of significantly reducing plant biomass on a long-term basis is not only improbable, but also undesired because of the ramifications it may have on water clarity by allowing algal growth to occur uncontrolled. Instead, the management goals need to focus on reducing the impact of the current level of plant growth on the desired use of the lakes and the system's ecological health.

Many alternatives exist for altering a lake's plant community on a large-scale basis; including herbicides, water level drawdown, mechanical harvesting, and dredging. In reality, only two of these methods would be feasible for Upper and Lower Red Lakes - mechanical harvesting and water level drawdown. Use of herbicides to reduce exotic growth is impractical on this system because of the cost and the likely negative impact it would have on the dissolved oxygen levels within the lakes. Treating the acres of Eurasian water milfoil that occurs on the Red Lakes would cost tens of thousands of dollars. In fact, treating half of each lake's surface area, or a total of approximately 215 acres would cost $101,050 at the average rate of $470/acre for a granular 2,4-D treatment. Not only is that quite expensive for a single treatment, but it must be remembered that the treatment would not eradicate the Eurasian water milfoil from those areas and that in fact, much of the area would require retreatment in the near future just to keep the plant in control. Most importantly, killing off that much biomass and its subsequent

decomposition, would likely cause significant decreases in dissolved oxygen within the lakes and may even reach the point where a serious fishkill may occur.

Dredging large areas of either or both lakes in hopes of removing plant biomass and retarding regrowth would be pointless. First, the average cost of hydraulic dredging of lake bottom sediments run between $5.00 and $15.00 per cubic yard, including engineering and removal (IEPA 1998). If an acre of one of the lakes were dredged to be 3 feet deeper, it would cost approximately $48,400 dollars at an average of $10.00/yd^3. In the end, the dredged areas would likely be quickly recolonized by the exotics because of their tendency to grow extremely well in disturbed areas.

Drawing water levels down to channel flow during the winter months and allowing the exposed sediments to dry and freeze, would likely benefit the lakes by killing large areas of Eurasian water milfoil. This may negatively impact curly-leaf pondweed too, but research has shown that each lake's curly-leaf pondweed population responds differently to winter drawdown so an accurate prediction is difficult. Considering only the impacts to Eurasian water milfoil; a winter drawdown would likely result in a reduction of Eurasian water milfoil over much of each lake's area and a positive response by the lakes' native plant community. A winter drawdown can be completed on most impoundments for very little money; unfortunately, this is not the case with Upper and Lower Red Lakes. In fact, the power generating capacity of the two hydroelectric facilities is sufficient to generate nearly $240,000 worth of electricity during the months the drawdown would be completed. The necessary reimbursement of those costs makes the drawdown infeasible at this time. However, this alternative needs to be kept on the active list of possibilities for future management of the Red Lakes as no one knows what changes the future may bring.

At this time, the only truly practical alternative for non-native plant management in the Red Lakes is mechanical harvesting. Although this is not a long-term solution to the non-native plant infestation on the lakes, it does provide many benefits regarding the lakes' use and their ecology. By creating navigation channels and larger open areas, lake users are able to recreate on the lakes, including pleasure boating and fishing. Furthermore, the creation of these areas also helps to maintain a healthy fishery by creating a more productive hunting environment for sight-feeding fish such as bass, walleye, and pike.

Finally, the conclusions of this study should not be misconstrued to mean that the management of the Red Lakes to be a healthy and beneficial aquatic ecosystem is a moot point. In reality, no lake is in perfect condition to support all ecological functions and forms of recreation. Just like no human is in perfect health and we must all manage our health as best as we can; the Red Lakes must be managed to be the best that they can be too. Minimization of excessive nutrient and sediment runoff from the lakes' shoreland properties, prevention of the introduction of additional aquatic invasive species, protection of existing aquatic and terrestrial habitat, and the increased capacity of the RLPRD communication capacity with its members and municipal partners, are just a few management actions that need to be undertaken by the district to make the Red Lakes be the best they can be.

IMPLEMENTATION PLAN

The overall goal of this implementation plan is to make Upper and Lower Red Lakes the best they can be. Meaning that by using the resources available, the Red Lakes Protection and Rehabilitation will work to make the Red Lakes healthy and useable for reasonable recreation. Specifically the district will aim to increase public accessibility, improve the fisheries environment, maintain water quality, prevent further introductions of aquatic invasive species, and improve wildlife both in and around the lakes. The Implementation Plan outlined below is designed to meet this overall goal by fulfilling four specific Management Goals.

Funding opportunities are included for each management action as applicable. Additional information can be obtained by contacting the WDNR or by visiting the WDNR Community Financial Assistance website (http://dnr.wi.gov/org/caer/cfa/cfindex.html).

Management Goal 1: Maintain Current Water Quality Conditions

Management Action: Monitor water quality through WDNR Citizens Lake Monitoring Network.
Timeframe: Begin Summer 2008
Facilitator: Board of Commissioners to recruit one or more volunteers
Description: Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason as of why the trend is developing. The WDNR Citizens Lake Monitoring Network involves two levels of water monitoring. First, volunteers are trained to collect water clarity values using a Secchi disk. After being involved in the first level monitoring for a year, the WDNR will train volunteers to collect water quality samples as a part of their advanced monitoring program.
Action Steps:

1. Volunteers contact Jim Reyburn, 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.
Timeframe: Begin 2008
Funding Prospects: WDNR Small-scale Lake Management Planning Grant
Facilitator: Board of Commissioners to recruit volunteer or form Education Committee
Description: The Red Lakes have very large watersheds draining to them 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.

Action Steps:

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

Management Action: Investigate methods to lower Upper Red Lake's contribution to Lower Red Lake's annual phosphorus load.

Timeframe: Begin 2009

Funding Prospects: WDNR Small-scale Lake Management Planning Grant for initial investigation and WDNR Lake Protection Grant for diagnostic/feasibility studies.

Facilitator: Board of Commissioners

Description: Modeling of the Red Lakes phosphorus loads indicated that a large amount of phosphorus may enter Lower Red Lake from Upper Red Lake because much of Upper Red's outflow originates in the lake's bottom water layer (hypolimnion). These hypolimnetic waters are much richer in phosphorus during much of the year compared to surface layers. Discovering a method to remove or divert this phosphorus load would reduce the overall phosphorus load to Lower Red Lake.

Action Steps:

1. Use Small-Scale Grant funds to conduct periodic sampling of Upper Red Lake outfall waters over the course of two or more years.
2. If water quality testing indicates that high phosphorus waters are originating from the hypolimnion of Upper Red Lake, a consulting engineer should be contacted to discuss possible removal or diversion alternatives.

Management Goal 2: Control Current Exotic Species and Prevent Further Introduction of Aquatic Invasive Species within the Red Lakes

Management Action: Initiate educational program aimed at informing Red Lakes users about aquatic invasive species prevention

Funding Prospects: WDNR Aquatic Invasive Species Grants

Timeframe: Begin Immediately

Facilitator: Planning Committee to begin and taken over later by Education Committee

Description: Although two aquatic invasive species are impacting the Red Lakes, many more exist that do not occur within the lakes. The RLPRD intends to educate member and nonmember lake users about aquatic invasive species and the prevention of their introduction to the Red Lakes and other systems. The first priority of this educational initiative will be the dissemination of information regarding Viral Hemorrhagic Septicemia virus (VHS).

Action Steps:

1. Members of Planning Committee contact WDNR regarding information regarding VHS and how best they can distribute it.
2. Planning Committee creates and disseminates information on VHS including signage at public boat landings.

3. Planning Committee or Board of Directors recruits volunteer or forms Education Committee to carry on initiative.

Management Action: Increase recreational use and improve fishery habitat through planned and permitted mechanical harvesting activities
Funding Prospects: WDNR Recreational Boating Facilities Grant (for additional equipment)
Timeframe: Begin 2007
Facilitator: Board of Commissioners
Description: Mechanical harvesting will be completed following the plans displayed in Maps 7 and 8. Currently, the district operates a single set of equipment that it rotates between the two lakes and there is some concern that the cutting patterns displayed in Maps 7 and 8 will not realistically be able to be cut by a single harvester. To remedy this, the district proposes to purchase an Aquarius Systems Model 620 aquatic plant harvester, trailer, shore conveyor, and a 30-yard, medium duty truck. Through the use of this equipment and its larger capacity, the district will increase its harvesting efficiency by 35%.

The RLPRD understands the value of native aquatic plants in the Red Lakes and has designed the harvesting patterns displayed in Maps 7 and 8 to protect those species by not cutting existing floating-leaf and emergent vegetation stands. The district is also concerned about the impact of the harvesting activities on the fish and wildlife of the Red Lakes. Therefore, on an annual basis the district will review its harvesting pattern, taking into consideration the concerns of stakeholders regarding fish and wildlife impacts and modify the cutting pattern to minimize the affect on these resources.

Action Steps:
1. Follow harvesting plans on Maps 7 and 8
2. Revise plan as needed to protect aquatic and terrestrial habitat and animals.

Management Goal 3: Improve Native Habitat In and Around the Red Lakes

Management Action: Create Wildlife and Habitat Improvement Committee
Funding Prospects: WDNR Stewardship Grant (Knowles-Nelson)
Timeframe: Begin 2007
Facilitator: Burt Grover
Description: The primary purpose of this committee would be to improve native habitat in and around the Red Lakes. Prospective projects may include tree plantings, trail construction, bird house installation, and shoreland restorations. The committee will work to complete at least one project a year.

Action Steps:
1. Assemble committee
2. Create list of goals and projects
3. Seek funding opportunities from county and state sources.

Management Goal 4: Increase District Communication Capacity

Management Action: Create biannual or greater frequency newsletter.
Timeframe: In progress
Funding Prospects: WDNR Small-scale Lake Management Planning Grant
Facilitator: David L. LeMere, Chairperson
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.
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 Red Lakes Newsletter

METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in the Red Lakes (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in Upper Red Lake and at a location in Lower Red Lake that would most accurately depict the conditions of the lake (Map 1). 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 standard protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included the following:

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

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

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on the Red Lakes during June 6-8, 2006 field visits, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on the system to characterize the existing communities within each lake and included inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in "Appendix C" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin - Draft, (April 20, 2006) was used to complete the studies. Based upon advice from the WDNR, the following point spacing and resulting number of points comprised the surveys:

	Point-intercept Resolution	Number of Points	Survey Dates
Upper Red Lake	50-meter	321	July 18-20, 2006
Lower Red Lake	40-meter	493	July 10-12, 2006

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

Watershed Analysis

The watershed analysis began with an accurate delineation of the Red Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the Wisconsin initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

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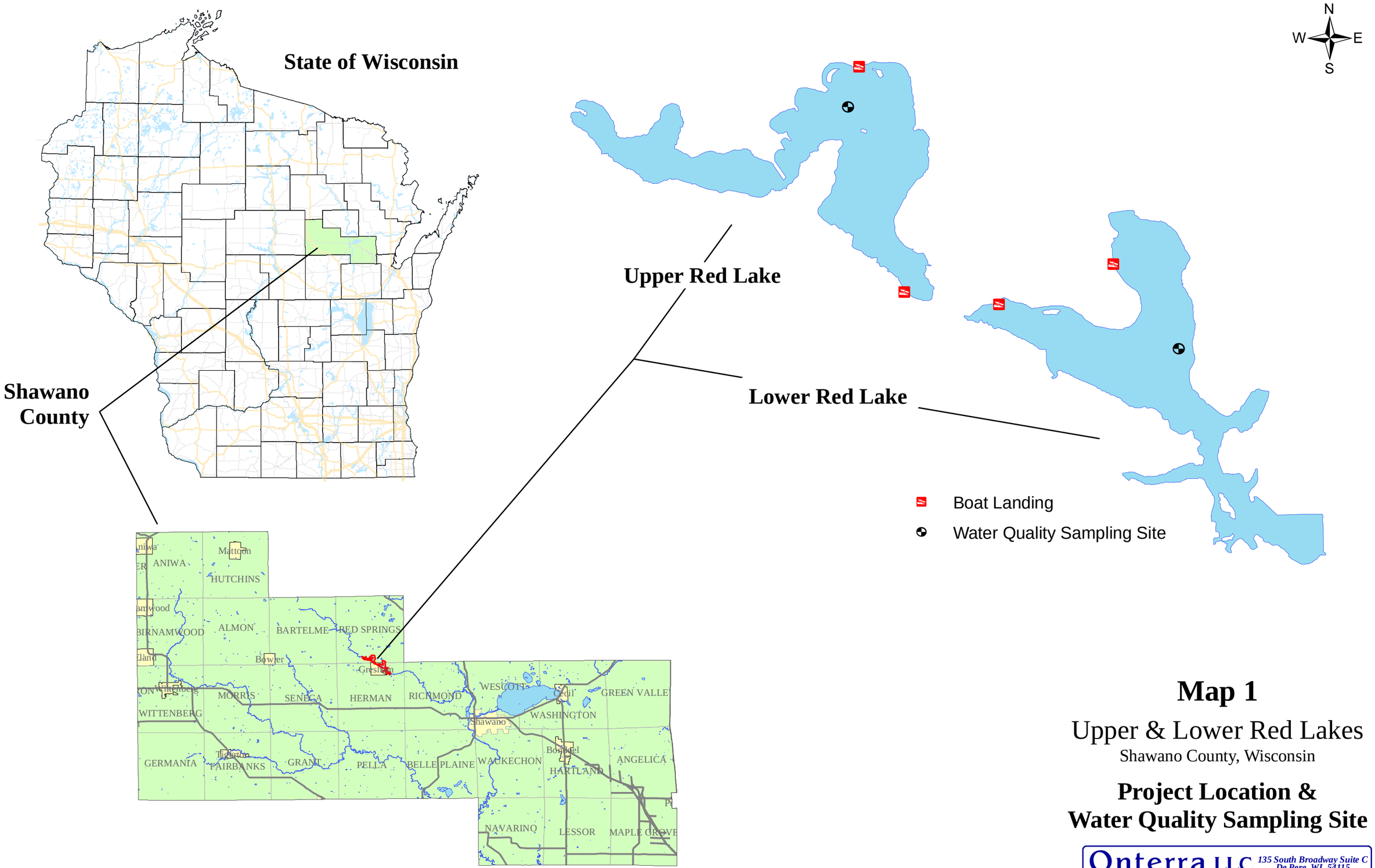


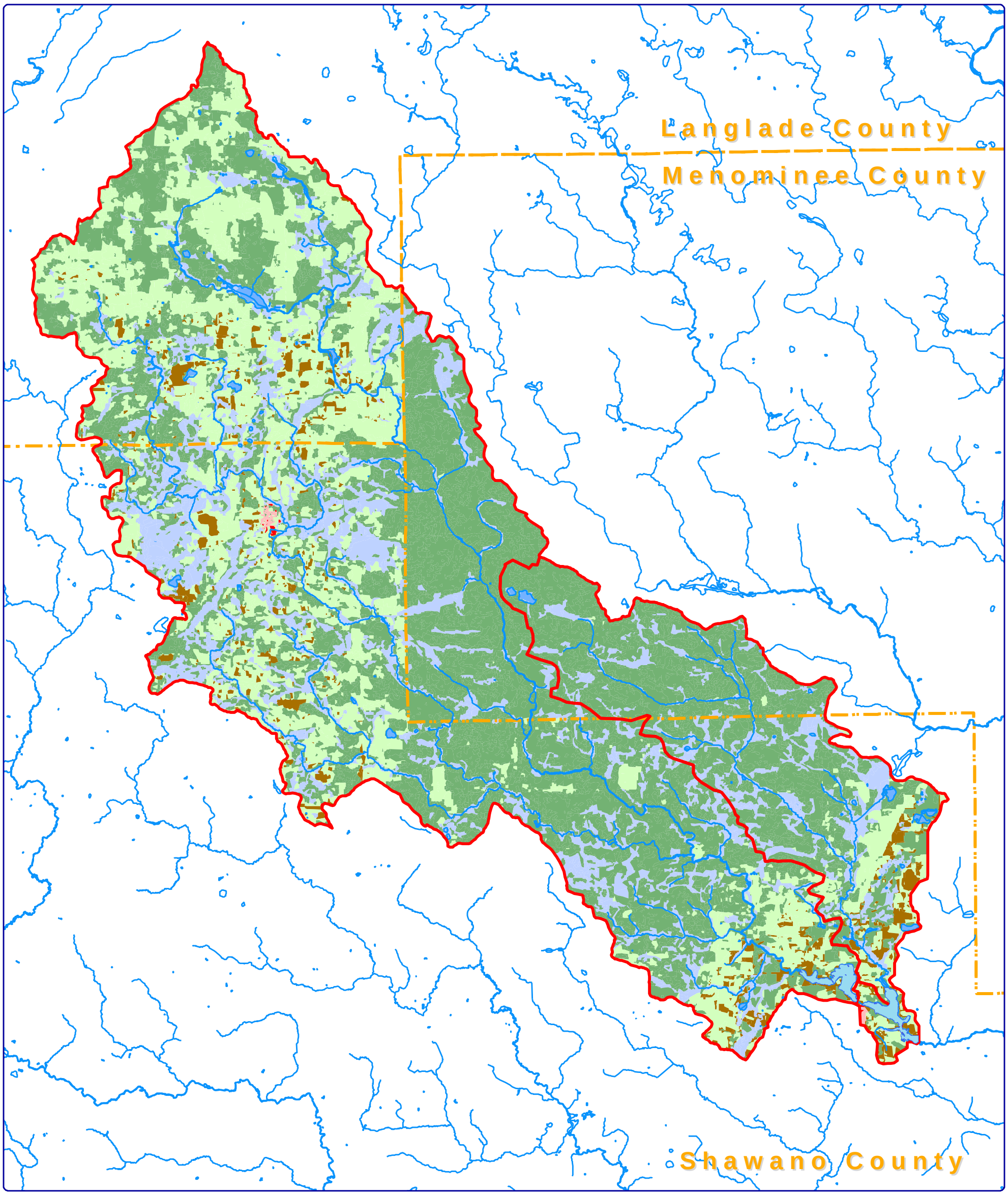
Map 1

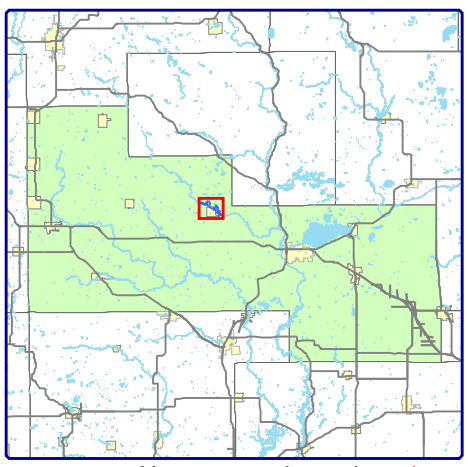
Upper & Lower Red Lakes

Shawano County, Wisconsin

Project Location & Water Quality Sampling Site

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





Extent of large map shown in red.

Sources:
Watershed: Onterra
Landcover: WISCLAND
Roads & Hydro: WDNR

Map date: March 20, 2008

Legend

Land Cover Types

- Row Crop Agriculture
- Pasture/Grass
- Forest
- Open Water
- Wetland
- High Intensity Urban
- Medium Intensity Urban
- Watershed Boundary
- River/Creek

N
W E
S

11,000
Feet

Map 2

Upper & Lower Red Lakes

Shawano County, Wisconsin

Watershed and Land Cover Types

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Lake Management Planning
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De Pere, WI 54115
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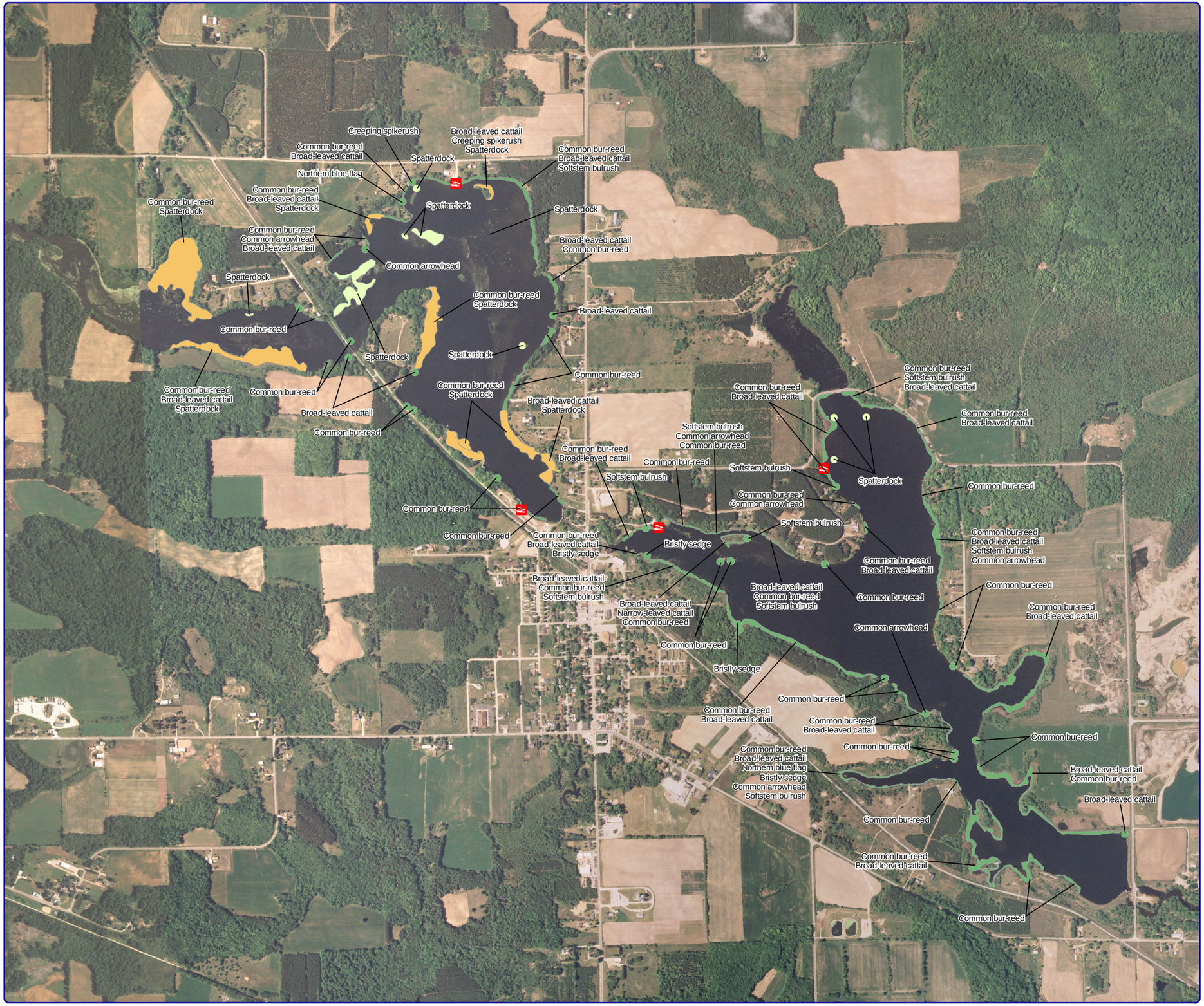

Map 3
Upper & Lower Red Lakes

Shawano County, Wisconsin

Aquatic Plant Communities

Extent of large map shown in red.

Legend

Small Plant Communities

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

Large Plant Communities

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

- Public Boat Landing

1,200
Feet

N
W E
S

Sources:
Data: Roads and Hydro: WDNR
Aquatic Plant Survey: Onterra 2006
Orthophotography: NAIP, 2005
Map Date: February 12, 2007

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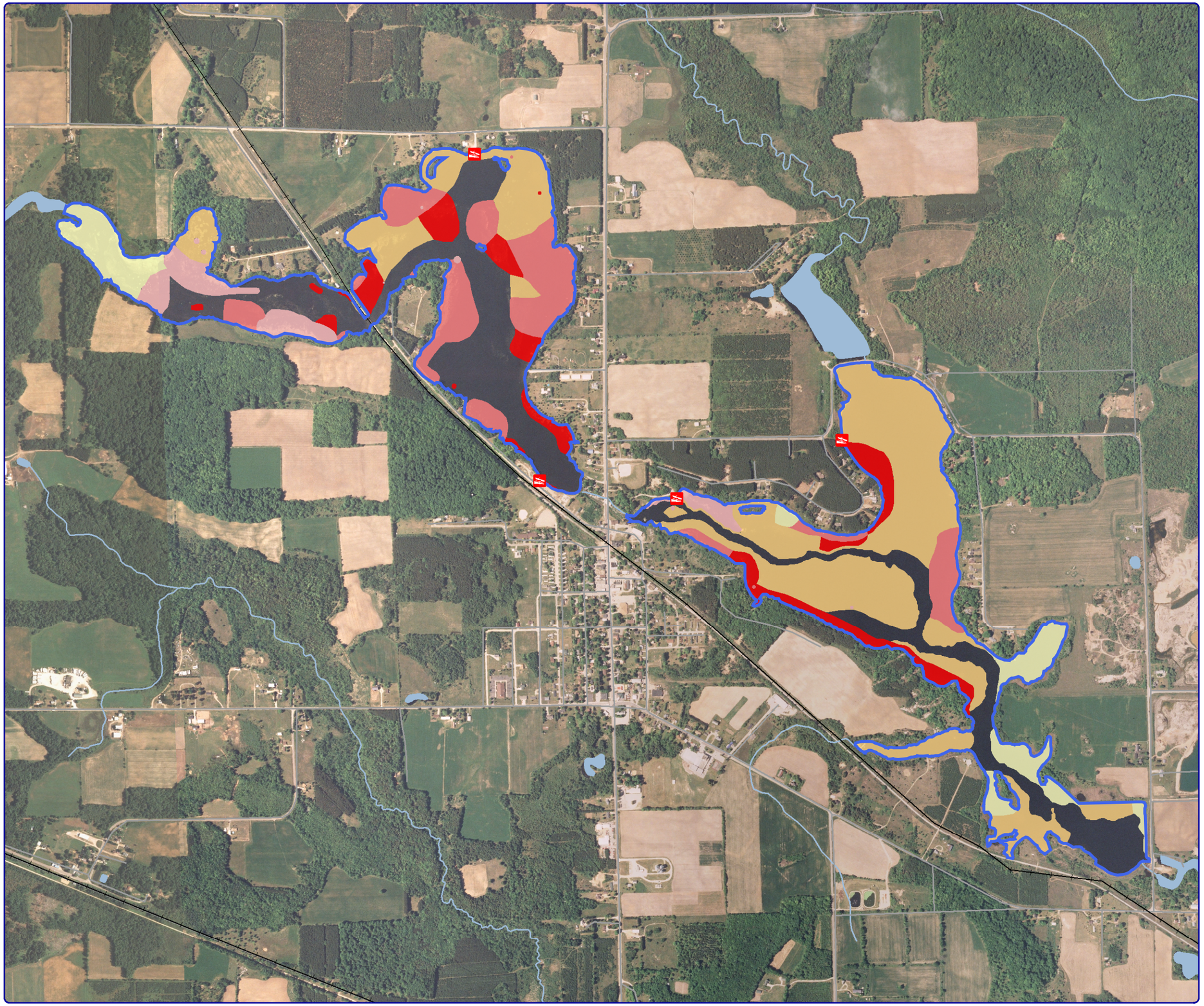
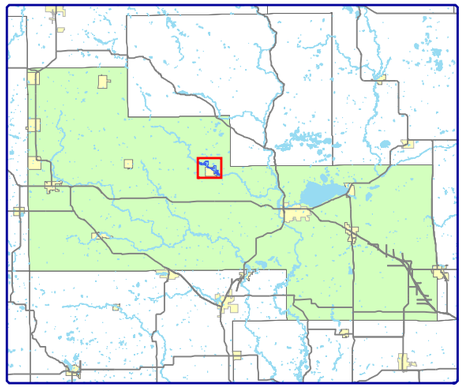


Map 4
Upper & Lower Red Lakes
Shawano County, Wisconsin

Curly-leaf Pondweed Locations



Extent of large map shown in red.

Legend

Curly-leaf Pondweed Locations

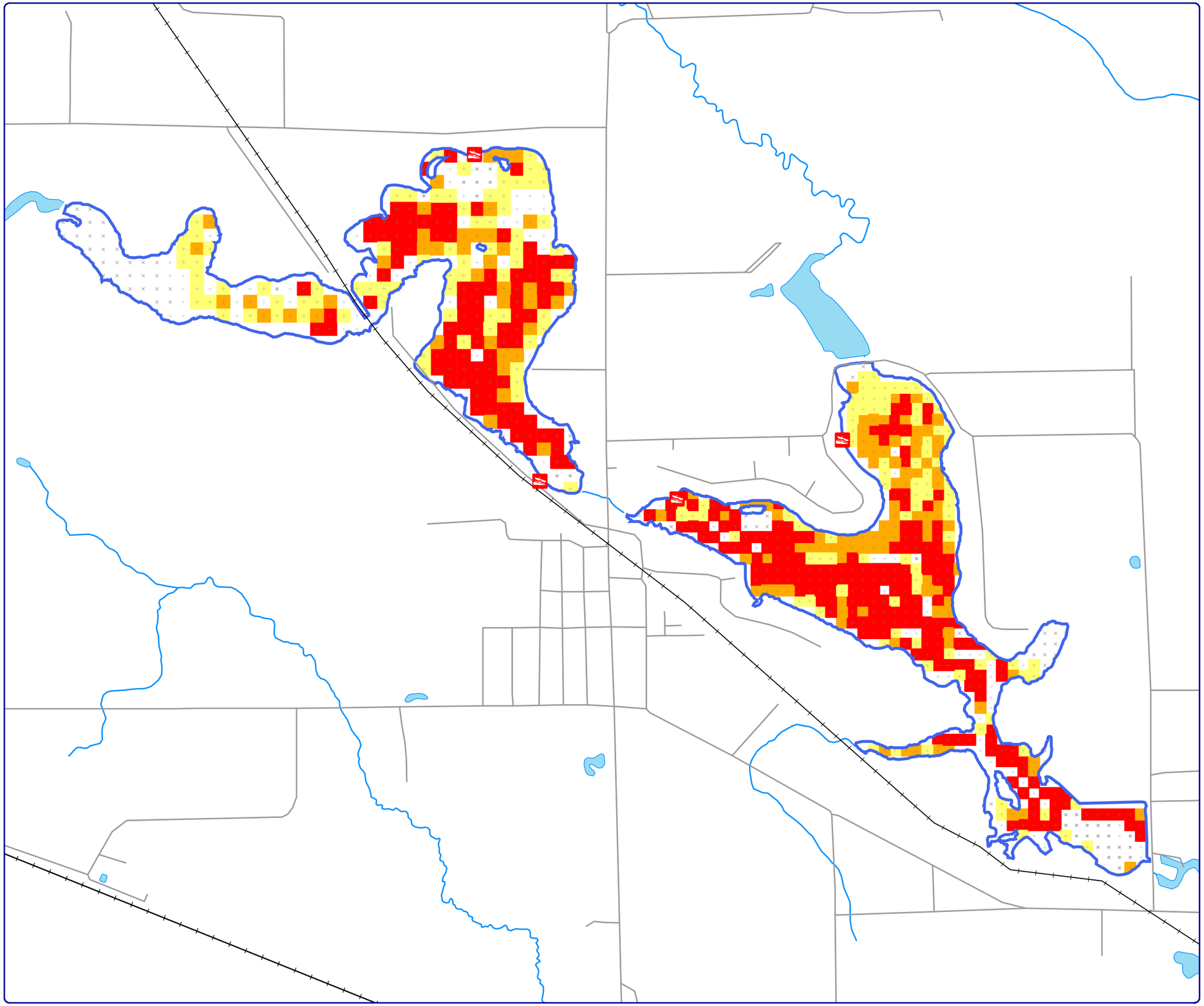
- Highly Scattered
- Scattered
- Density = 1
- Density = 2
- Density = 3

1,200
Feet

N
W E
S

Sources:
Data: Roads and Hydro: WDNR
Aquatic Plant Survey: Onterra, 2006
Map Date: October 19, 2006

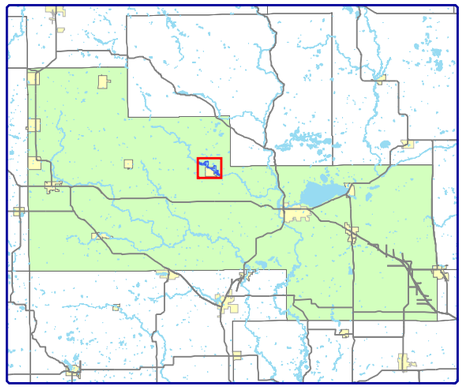
Onterra LLC
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com



Map 5
Upper & Lower Red Lakes

Shawano County, Wisconsin

Eurasian Water Milfoil Locations



Extent of large map shown in red.

Legend

EWM Rake Fullness

- × Unreachable
- × Too Deep
- + No EWM at Location
- + Rake Fullness = 1
- + Rake Fullness = 2
- + Rake Fullness = 3

1,200
Feet

N
W E
S

Sources:
Data: Roads and Hydro: WDNR
Aquatic Plant Survey: Onterra 2006
Map Date: December 1, 2007

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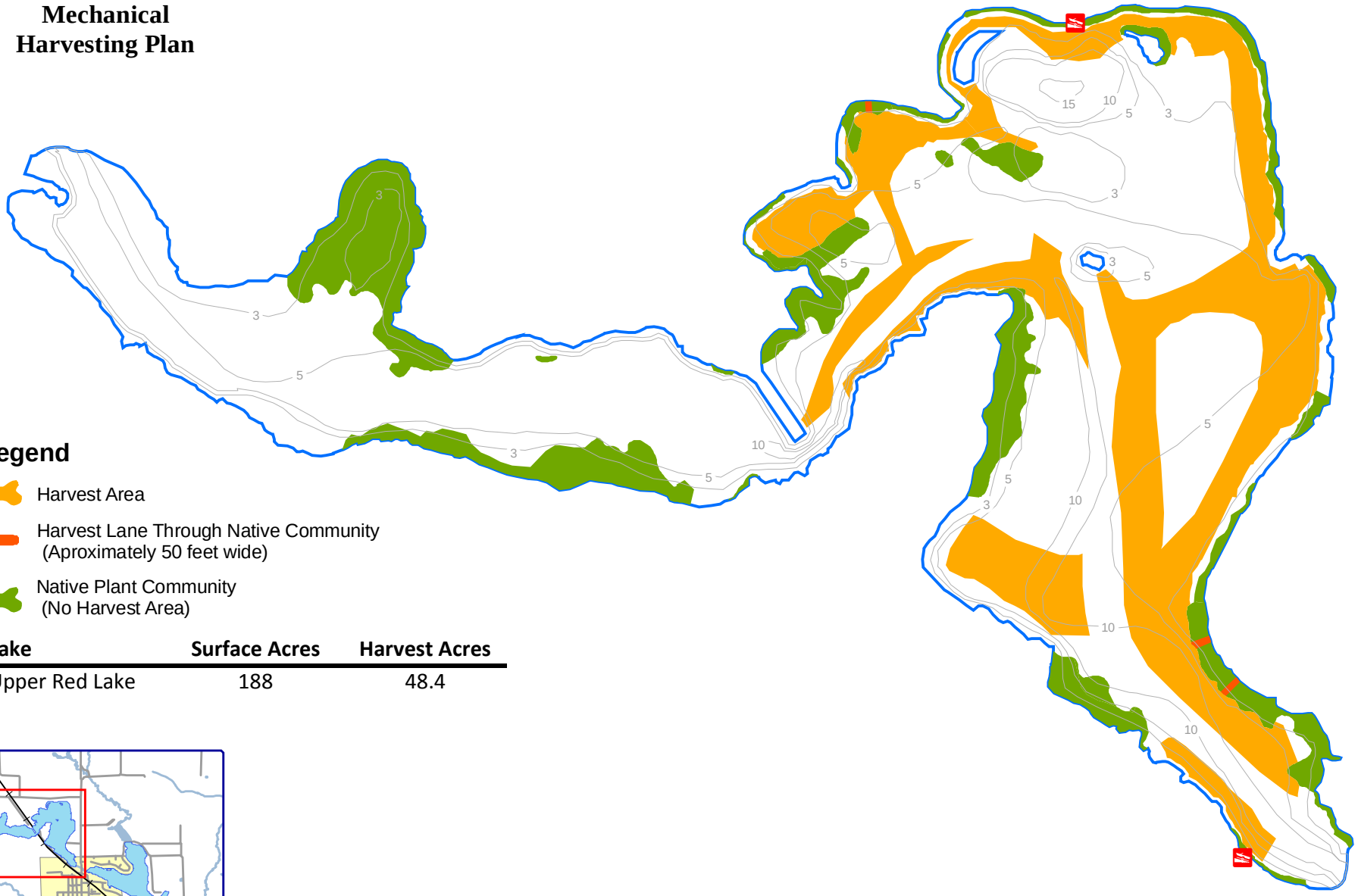
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Map 6

Upper Red Lake

Shawano County, Wisconsin

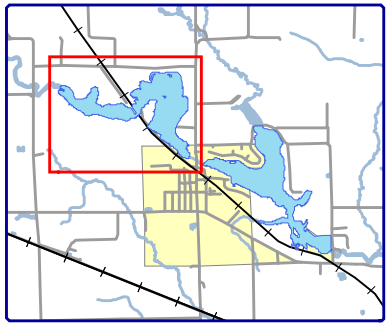
Mechanical Harvesting Plan



Legend

- Harvest Area
- Harvest Lane Through Native Community (Aproximately 50 feet wide)
- Native Plant Community (No Harvest Area)

Lake	Surface Acres	Harvest Acres
Upper Red Lake	188	48.4



Extent of large map shown in red.

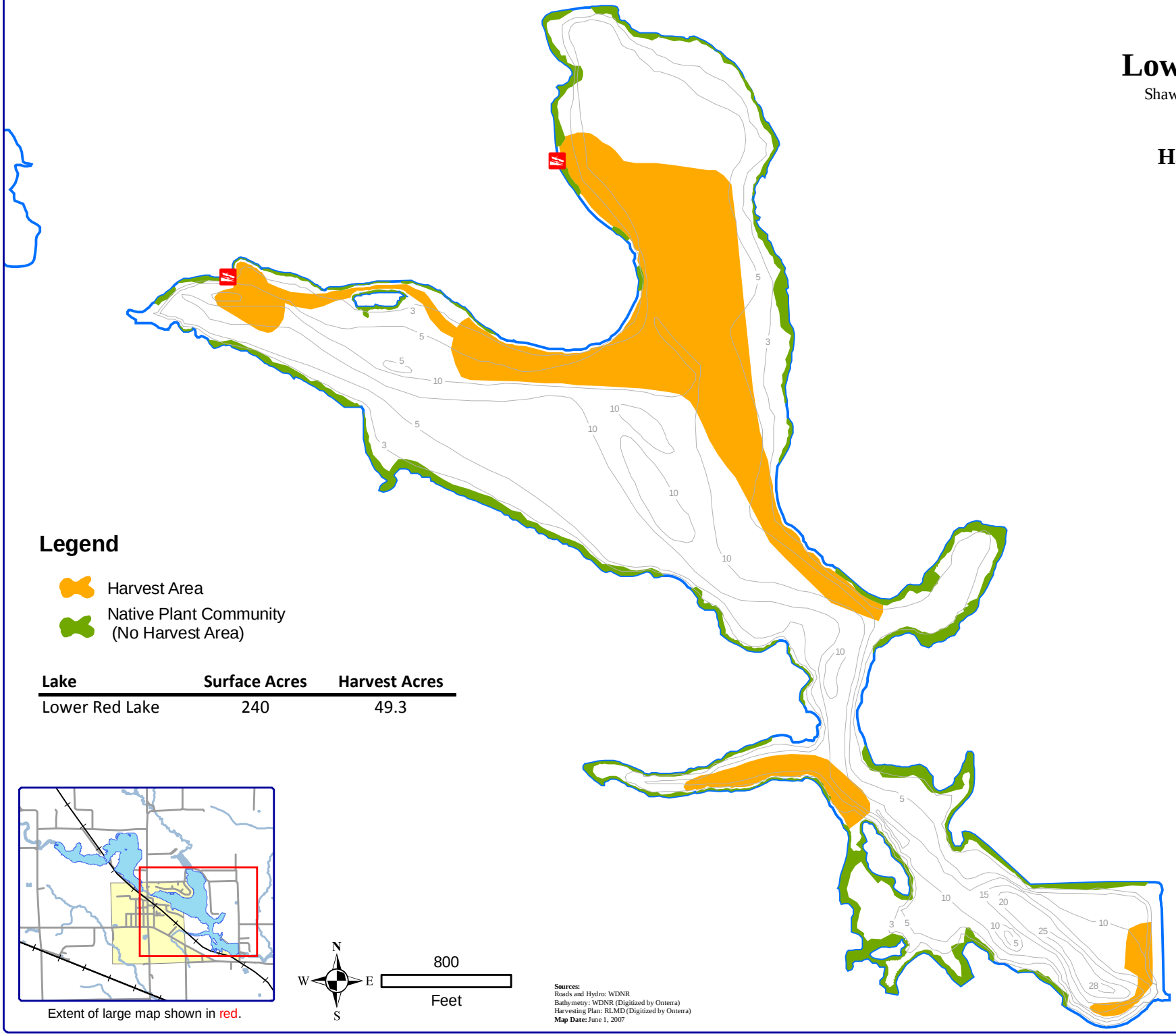
N W E S

700 Feet

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR (Digitized by Onterra)
Harvesting Plan: RLMD (Digitized by Onterra)
Map Date: December 1, 2007

Map 7
Lower Red Lake
Shawano County, Wisconsin

Mechanical Harvesting Plan



Legend

- Harvest Area
- Native Plant Community (No Harvest Area)

Lake	Surface Acres	Harvest Acres
Lower Red Lake	240	49.3

Extent of large map shown in red.

N
W E
S

800
Feet

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR (Digitized by Onterra)
Harvesting Plan: RLMD (Digitized by Onterra)
Map Date: June 1, 2007

A

APPENDIX A

Public Participation Materials

Red Lake's District News Letter

This Picture highlights a Lone Ice Fisherman on the Upper Red after a Febuary Snow Fall.

It has been a long winter, but the Ice fishermen have had a great time on our Red Lake's. The fishing has been very good and we have made the sport section highlights in the Green Bay Press Gazette and Appleton Post Crescent. Our lakes are truely a popular ice fishing destination in Northeastern Wisconsin, and for good reason they have an above average fishery for all of us to enjoy.

Lake Planning Grant Update

We are very pleased to announce that we have been awarded two State Lake Study Grants, one each for the Upper and Lower Red Lake's. These Grants will provide the scientific data on our lake's ecology that we will need to develop a technically sound improvement plan that gives us a high degree of probability for success. When this study is completed we will also have the required foundation neccessary to qualify for other State Grant money for lake improvement projects. This will be the first important step in improving our beautiful Red Lake's.

We will kick-off the Red Lakes Comprehensive Management Planning Project at our Spring meeting.

This meeting will be held June 3, from 10:00 AM - 12:00PM at the Herman Town Hall.

Please try to make the meeting. We will have the project leader, Aquatic Ecologist Tim Hoyman there to share the projects goals and what will happen this year. Tim will also be able to answer any question you may have about the project and our lakes.

At this meeting we will also be gathering your input to this summers weed cutting plan for both the Upper and Lower Red Lakes.

Wanted Part-time Weed Cutters

Pay is $10.00 and hour, work hours are flexable. The person must have a valid drivers license, and be able to operate large equipment and perform light maintenance. To apply call Dave LeMere at 787-3717

WEEDs , WEEDS, WEEDS

Lake weeds make excellent mulch. Nothing beats adequaltely mulching for your garden plot.. A 6 inch layer of lake weeds will provide excellent weed control, they decompose quickly and they are high in nutrients. They also have high moisture retention and best of all they are free to all District members. We will deliver lake weeds to District members on a first come first serve basis from mid-June through mid-September free of cost. Non-District members can have weeds delivered at the cost of transportation to their site. To take advantage of this great deal call Dave LeMere at 715-787-3717

We Need Your Help

We plan on publishing a news letter twice a year and would like to have a variety of stories related to our Lakes.

If you have any stories, or pictures relating to our Red Lakes please let us know. Do you have any old stories relating to the history of the Red Lakes!. Pictures of that big fish or a nice catch of fish. Do you want to introduce a new district member who has moved into the area. Everything and anything that you think would be of interest to the community would be greatly appreciated. I will be willing to take interviews and write the articles. So don't hesitate to contact Dave LeMere at 787-3717

Red Lakes Management District
P.O. Box 140
Gresham Wis. 54128

Mark your Calendars
Our District Meeting Schedules

Spring District Meeting
June 3, 10:00AM-12:00PM at the Herman Town Hall
- Weed Cutting Plan for summer
- Kick off the Lake Study

Fall District Meeting
August 26, 10:00AM - 12:00PM at the Red Springs Town Hall.
- Election of Commissioners
- Review and approve our annual budget for 2007

Your District Commissioners

David LeMere - Chairperson 787-3717
Art Krause - Treasurer 787-4302
Wayne Buettner - Secretary 787-3682
Dan Boucher 787-3785
Bert Grover 787-3323

Apointed Commissioners

Marshall Giese 787-3217
Richard Giese 787-3480

Red Lakes Comprehensive Lake Management Plan
Project Kick-Off Meeting
June 3, 2006 10:00 am – Herman Town Hall

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

The Red Lakes Management District has received two grants from the Wisconsin Department of Natural Resources to partially fund the completion of a comprehensive management plan for Upper and Lower Red Lakes. The project has two primary objectives, the first being the completion of an in-depth studies including multiple plant surveys, water quality sampling, and watershed investigations; the second being the completion of a realistic management plan covering both lakes and their 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, June 3rd at 10:00 am at the Herman Town Hall.

Onterra, LLC, a lake management planning firm out of De Pere, has been hired to lead the project. During the meeting, aquatic ecologists from Onterra will describe the project and its importance. Their presentation will include a description of the project's components, a quick course on lake ecology, and breakdown of how the District's Planning Committee will be involved in the plan's completion. The preliminary harvest plan used to gain our harvesting permit from the Wisconsin Department of Natural Resources will also be on display and discussed during the meeting. So, please plan on attending the meeting and do not hesitate to ask questions or make comments.

Red Lakes Management District

Red Lakes Comprehensive Management Planning Project Kick-off Meeting

June 3, 2006

Timothy A. Hoyman, CLM
Onterra LLC
Lake Management Planning

1

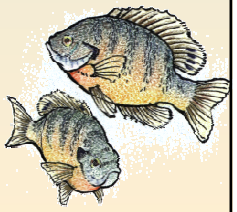
Presentation Outline

- Introduction to Lake Ecology
- Current Lake Project
  - Goals
  - Components
  - Process
- Preliminary Harvest Plan

Onterra LLC
Lake Management Planning

2

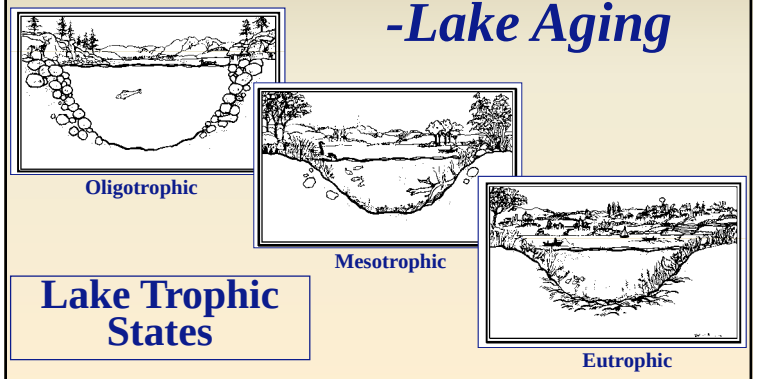
General Lake Ecology



3

General Lake Ecology

Eutrophication -Lake Aging



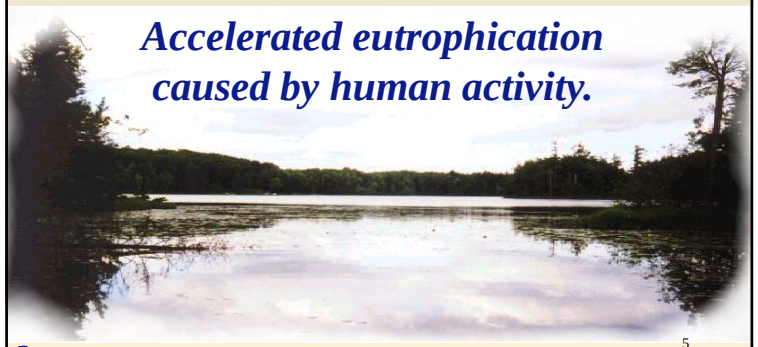
Lake Trophic States

Onterra LLC
Lake Management Planning

4

General Lake Ecology

Cultural Eutrophication



Accelerated eutrophication caused by human activity.

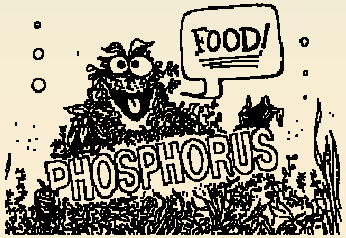
Onterra LLC
Lake Management Planning

5

General Lake Ecology

Phosphorus

- *Limiting Nutrient*
- *Controls Plant Abundance (Productivity)*
  - *Algae*
  - *Macrophytes*



6

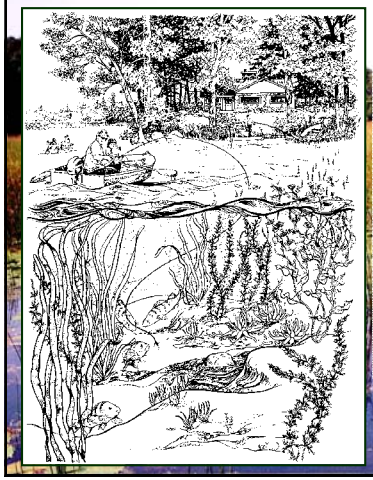
General Lake Ecology

Aquatic Plants (macrophytes)

- *Native Plants*
- *Exotic Plants (non-native)*

7

Native Aquatic Plants



- Base of the Food Web
- Cover (not only fish)
- Nursery
- Sediment Stabilization

8

General Lake Ecology

Non-native Aquatic Plants

Curly-leaf Pondweed

Onterra LLC

9

General Lake Ecology

Non-native Aquatic Plants

Eurasian Water-Milfoil

Onterra LLC

10

General Lake Ecology

Consequences of Exotics

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

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General Lake Ecology

Zebra Mussel & 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

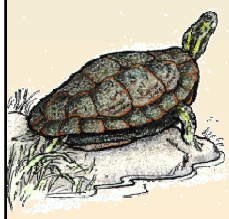
Onterra LLC

12

Current Project

Study and Plan Goals

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



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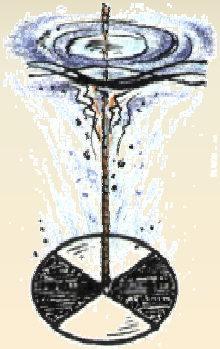
14

Current Project

Study Components

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



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15

Current Project

Planning Process

Planning Committee Meetings

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

↓

Implementation Plan

Onterra LLC

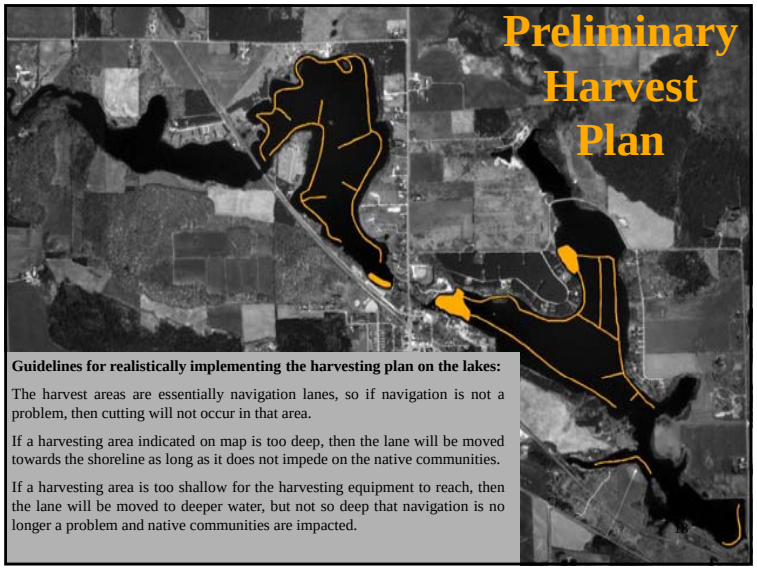
16

Current Project

Your Participation is Important to the Success of this Project

Onterra LLC
Lake Management Planning

17



Guidelines for realistically implementing the harvesting plan on the lakes:

The harvest areas are essentially navigation lanes, so if navigation is not a problem, then cutting will not occur in that area.

If a harvesting area indicated on map is too deep, then the lane will be moved towards the shoreline as long as it does not impede on the native communities.

If a harvesting area is too shallow for the harvesting equipment to reach, then the lane will be moved to deeper water, but not so deep that navigation is no longer a problem and native communities are impacted.

Red Lakes Comprehensive Management Planning

Project Update – September 2006

Submitted By: Eddie Heath, Aquatic Ecologist, Onterra

The end of August signals that another field season on the lakes will be ending soon. Because of the large number of hot, sunny days, this summer was much an exceptional year for aquatic plant growth. Although this may have been a slight inconvenience for some riparians, it was a good summer to perform our necessary studies.

The first goal of the Red Lakes Comprehensive Management Planning Project is to collect the necessary data and analyze this data in order to learn fact-based information about the lake. The majority of the data needed for this goal has already been collected and will soon be analyzed to help us reach the second goal – assisting the district in creating an implementable management plan.

The curly-leaf pondweed (CLP) study was completed on June 6-8. The findings of this survey show that CLP is scattered across most areas of both lakes. Extensive mapping was completed to identify the densities of this invasive plant and will result in the creation of a map depicting CLP densities through color gradients.

The comprehensive aquatic plant study was completed on Upper and Lower Red Lakes during July. We spent nearly 45 hours over 8 days assessing the lake's plant communities. A portion of this study used the point-intercept method where we sampled aquatic plants at predetermined points on each lake (see map). 307 points were sampled on Lower Red Lake and 314 points were sampled on Upper Red Lake. Not all of the points were visited because some areas of the lakes are too deep for plant growth and some areas were too shallow for boating. At each point that was sampled, we identified all of the plants and their densities as well as recorded depth and bottom type. These results will be the bulk of the aquatic plant data used in the lake management plan.

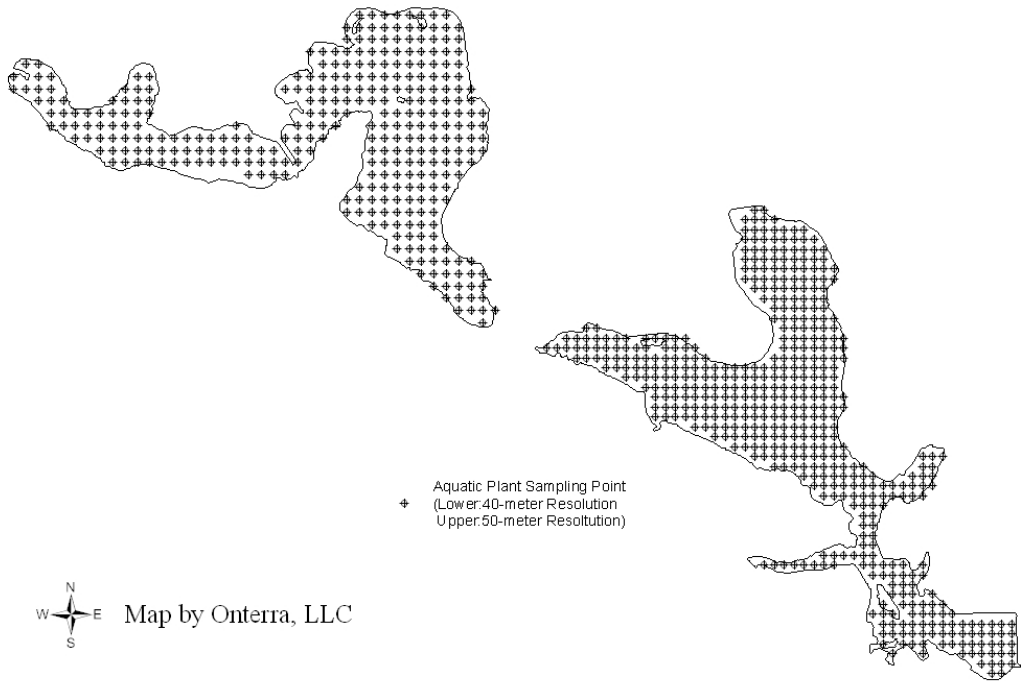
A second portion of the study included mapping of aquatic plant communities throughout the lake. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these plant types. Examples of submergent plants include wild celery and pondweeds; while emergents include cattails, bulrushes, and arrowheads; and floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf species lend themselves well to mapping, while submergents are much more difficult because they are often not visible from the surface and most species are often mixed throughout much of the lake. Emergent and floating leaf communities are generally the first to react to changes in lakes and baseline information relating to these communities will be helpful in determining changes in the lakes due to future conditions and management actions.

During the point-intercept portion of the study, preliminary analysis shows that Eurasian water milfoil (EWM) occurs across both lakes and in many areas was shown to be quite dense. Although the data has not been fully analyzed, it seems that chemical treatment of EWM is likely not a practical option on a lake-wide basis. Chemical treatments in

localized areas can be quite effective but whole lake treatments are far too costly and pose serious permitting road blocks. Other management actions may be needed to reduce the density of EWM in the lakes. It is important to note that it is impossible to eradicate EWM from the Red Lakes and reducing the densities of this invasive serve as a more realistic goal. Most importantly, many interesting native plants were observed in these lakes and it is important to create an environment in the lake for these natives to flourish and continue to provide the foundations of the ecosystems that support the excellent fishing conditions your lakes have.

In addition to studying the lakes' plant communities, we have also been monitoring various physical and chemical conditions in the lakes. Much of the chemical data analysis has yet to arrive from the Wisconsin State Laboratory of Hygiene. A delineation of the Red Lakes watershed and an evaluation of the land-use types within the watershed will soon be completed. Understanding the impacts that land-use types have on a system may provide options for limiting the amount of nutrients entering the lakes. However, flowages tend to have much larger watersheds than other lakes and therefore larger inputs of nutrients.

Taking into consideration the plant community data and the size of the watershed, it is safe to say that the Red Lakes are a highly productive system and can support a large amount of plants. Plant densities will always be quite large in these lakes. There is no silver bullet for combating the detriment of the non-native plants in this system and all management actions will need careful consideration.



Agenda
Red Lakes Management Planning Meeting

February 21, 2007 9:00am
Shawano County Courthouse Board Room

Meeting Premise: The Red Lakes are currently infested with Eurasian water milfoil and curly-leaf pondweed. Considering both lakes are flowages, with their water levels controlled by dams, drawdown for control of exotics is a potential management option. While drawdown itself is not a difficult concept, the completion of such an alternative may be. The intent of this meeting is to explore the feasibility and potential requirements of completing this action on the Red Lakes system.

Meeting Topics

1. Applicability of drawdown for controlling exotics in the Red Lakes
    a. Red Lakes exotics
    b. Depth
    c. Natives
    d. Fishery
2. WDNR Permitting
    a. Requirements
    b. Timeline
3. WDNR Lake Protection Grants
    a. What can the funds be used for?
    b. Plan requirements
4. Village of Gresham
    a. Hydroelectric dams
    b. Participation in planning and implementation
5. Miscellaneous
    a. Obtaining stakeholder buy-in
    b. Realistic timeline for drawdown

Red Lakes P & R District

Red Lakes Comprehensive Management Planning Project

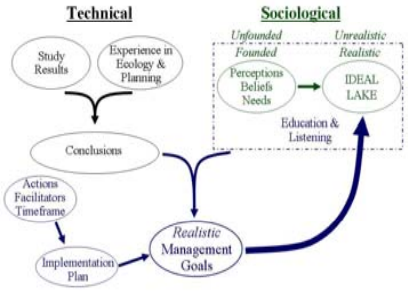
Planning Meeting I

April 16, 2007

Timothy A. Hoyman, CLM

Onterra LLC

The Planning Process



Water Quality Comparisons

Aquatic Plant Comparisons

Water Quality

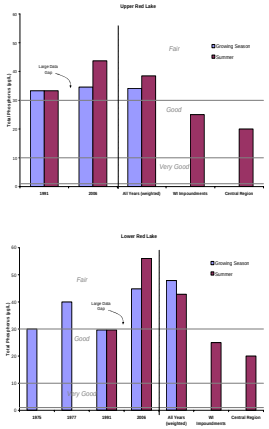
Phosphorus
(Limiting Plant Nutrient)

Chlorophyll-*a*
(Algal Abundance)

Water Clarity
(Secchi Disk)

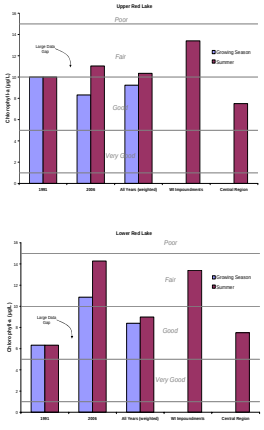
Water Quality

Phosphorus



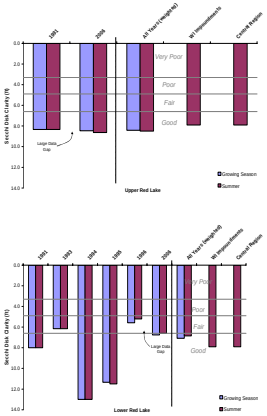
Water Quality

Chlorophyll *a*



Water Quality

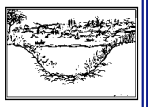
Water Clarity



Eutrophication

Oligotrophic

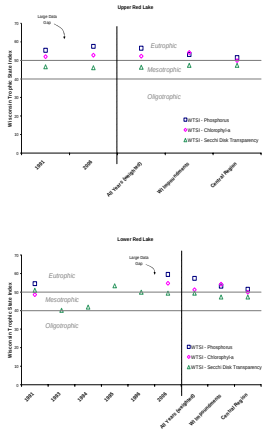
Mesotrophic



Eutrophic

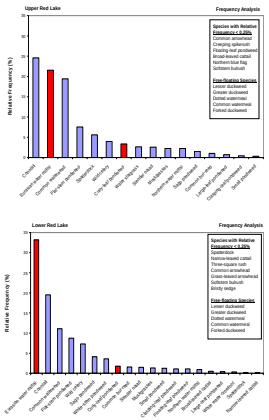
Water Quality

Trophic State



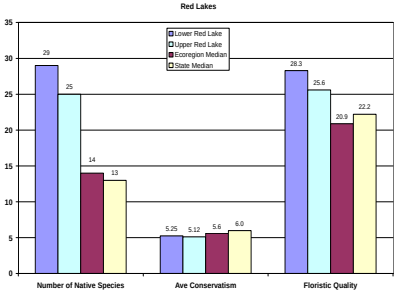
Aquatic Plants

Occurrence Analysis



Aquatic Plants

Floristic Quality Analysis



Conclusions

Water Quality & Aquatic Plants

- The Red Lakes are relatively shallow and productive impoundments.
- The productivity of the lakes are evident in the incredible amount of macrophyte growth in both lakes.
- Much of the macrophyte growth is in the form of exotic plant species.
- Although Drawdown would be an applicable technique for reducing exotic abundance, it is not even remotely feasible at this time.
- The phosphorus driving the productivity likely originates in the watershed.

Red Lakes Protection & Rehabilitation District

Wrap-up Meeting
June 9, 2007

Timothy A. Hoyman, CLM
Onterra LLC

Presentation Outline

- Project Refresher
- General Lake Ecology
- Study Results
- Conclusions

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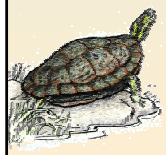
Project Overview

Study and Plan Goals



- Collect & Analyze Data
- Construct Long-term & Useable Management Plan

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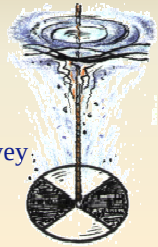
Project Overview

Study Components

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



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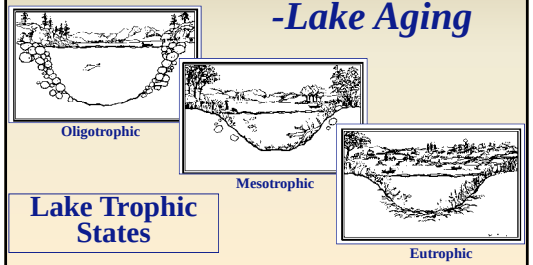
General Lake Ecology

5

General Lake Ecology

Eutrophication

-Lake Aging



Lake Trophic States

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General Lake Ecology

Cultural Eutrophication

Accelerated eutrophication caused by human activity.

7

General Lake Ecology

Phosphorus

N:P
Upper Red 34:1
Lower Red 28:1

- *Limiting Nutrient*
- *Controls Plant Abundance (Productivity)*
  - *Algae*
  - *Macrophytes*

8

General Lake Ecology

Aquatic Plants (macrophytes)

- *Native Plants*
- *Exotic Plants (non-native)*

9

Study Results

10

Study Results

Water Quality

↑ Phosphorus (Limiting Plant Nutrient)

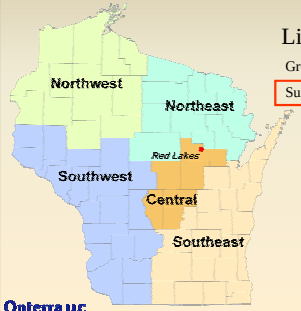
↑ Chlorophyll-*a* (Algal Abundance)

↓ Water Clarity (Secchi Disk)

11

Study Results

Water Quality Comparisons

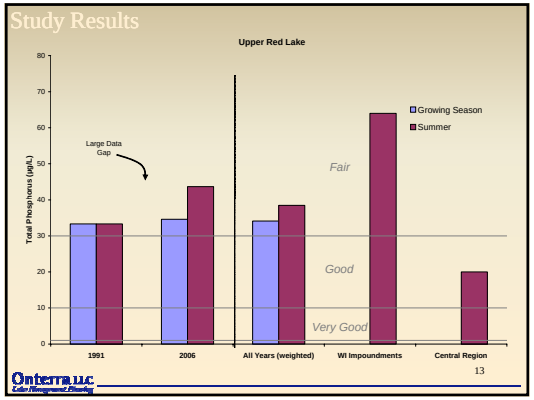


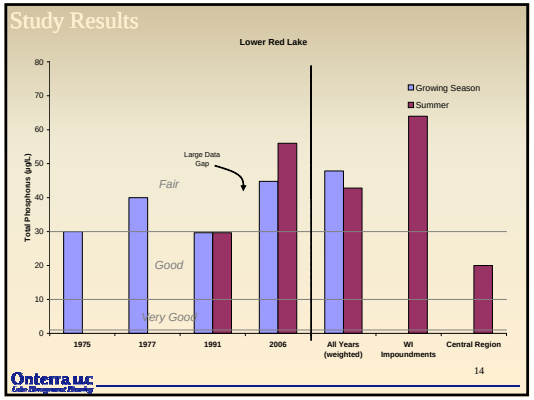
Lillie & Mason 1983

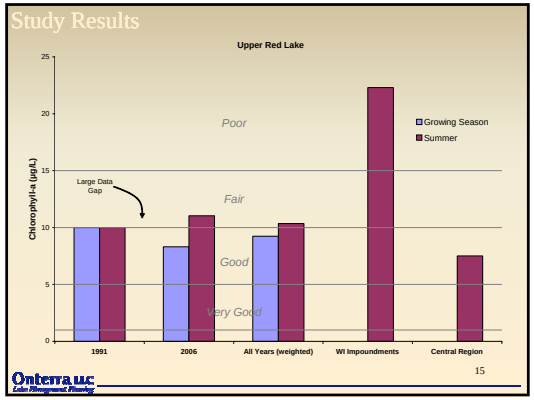
Growing Season: April – October

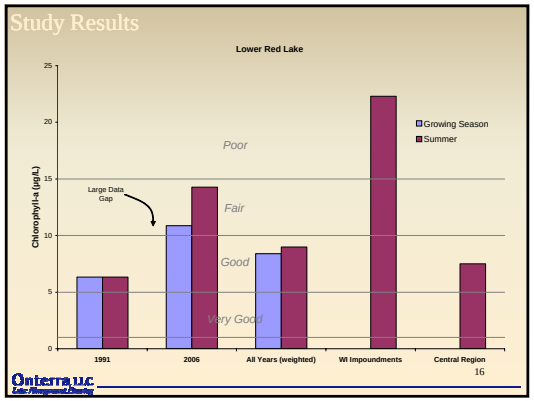
Summer: June, July, August

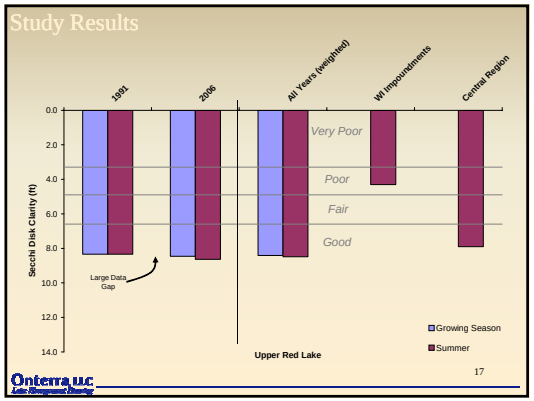
12

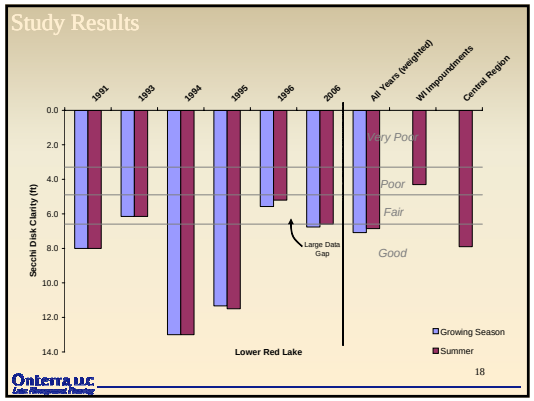

Study Results
Upper Red Lake
Total Phosphorus (µg/L)
Large Data Gap
Fair
Good
Very Good
Growing Season
Summer
1991
2006
All Years (weighted)
WI Impoundments
Central Region
13

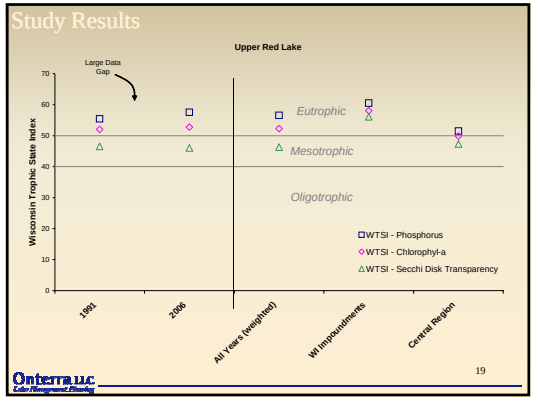

Study Results
Lower Red Lake
Total Phosphorus (µg/L)
Large Data Gap
Fair
Good
Very Good
Growing Season
Summer
1975
1977
1991
2006
All Years (weighted)
WI Impoundments
Central Region
14

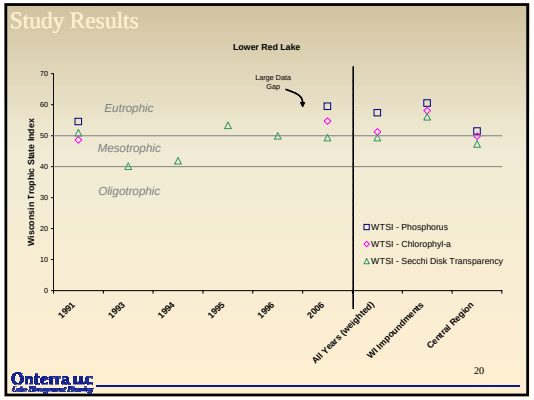

Study Results
Upper Red Lake
Chlorophyll-a (µg/L)
Large Data Gap
Poor
Fair
Good
Very Good
Growing Season
Summer
1991
2006
All Years (weighted)
WI Impoundments
Central Region
15

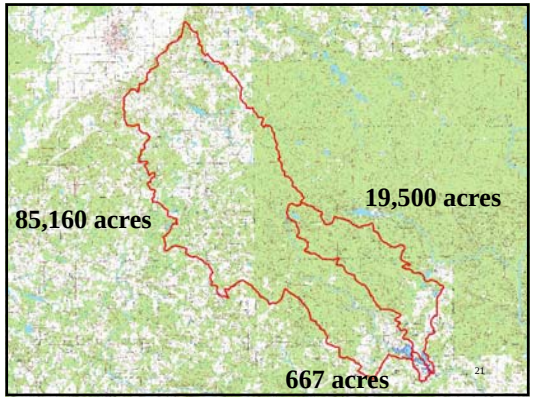

Study Results
Lower Red Lake
Chlorophyll-a (µg/L)
Large Data Gap
Poor
Fair
Good
Very Good
Growing Season
Summer
1991
2006
All Years (weighted)
WI Impoundments
Central Region
16

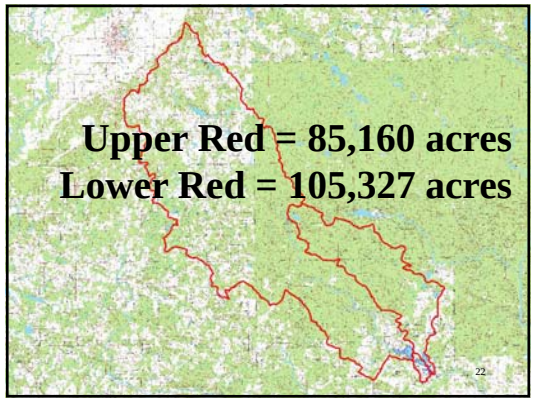

Study Results
Secchi Disk Clarity (ft)
1991
2006
All Years (weighted)
WI Impoundments
Central Region
Very Poor
Poor
Fair
Good
Large Data Gap
Upper Red Lake
Growing Season
Summer
17

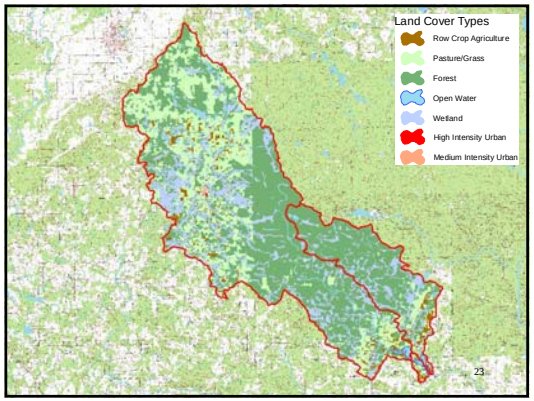

Study Results
Secchi Disk Clarity (ft)
1991
1993
1994
1995
1996
2006
All Years (weighted)
WI Impoundments
Central Region
Very Poor
Poor
Fair
Good
Large Data Gap
Lower Red Lake
Growing Season
Summer
18

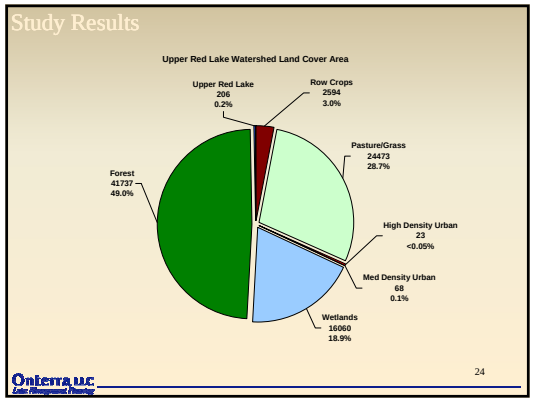

Study Results
Upper Red Lake
Large Data Gap
Eutrophic
Mesotrophic
Oligotrophic
Wisconsin Trophic State Index
WTSI - Phosphorus
WTSI - Chlorophyl-a
WTSI - Secchi Disk Transparency
1991
2006
All Years (weighted)
WI Impoundments
Central Region
19

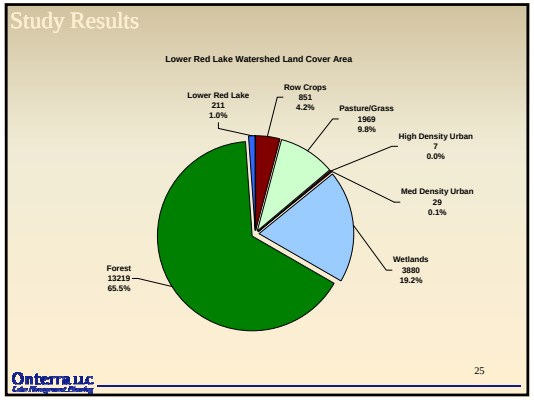

Study Results
Lower Red Lake
Large Data Gap
Eutrophic
Mesotrophic
Oligotrophic
Wisconsin Trophic State Index
WTSI - Phosphorus
WTSI - Chlorophyl-a
WTSI - Secchi Disk Transparency
1991
1993
1994
1995
1996
2006
All Years (weighted)
WI Impoundments
Central Region
20

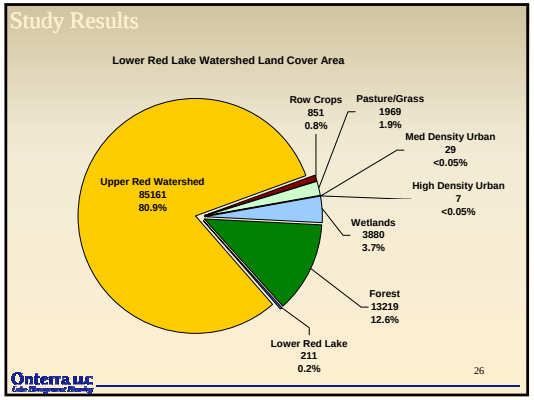

85,160 acres
19,500 acres
667 acres
21

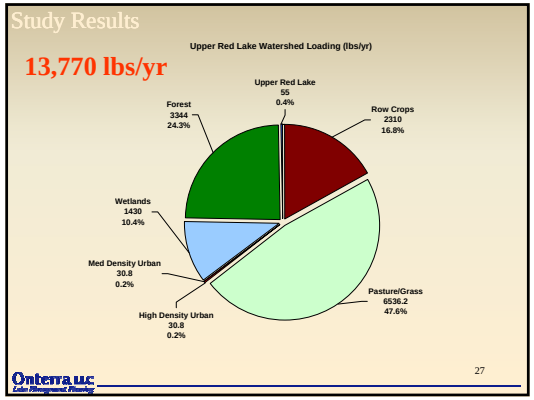

Upper Red = 85,160 acres
Lower Red = 105,327 acres
22

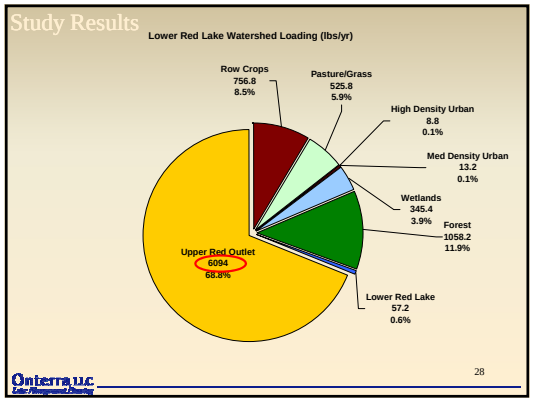

Land Cover Types
Row Crop Agriculture
Pasture/Grass
Forest
Open Water
Wetland
High Intensity Urban
Medium Intensity Urban
23

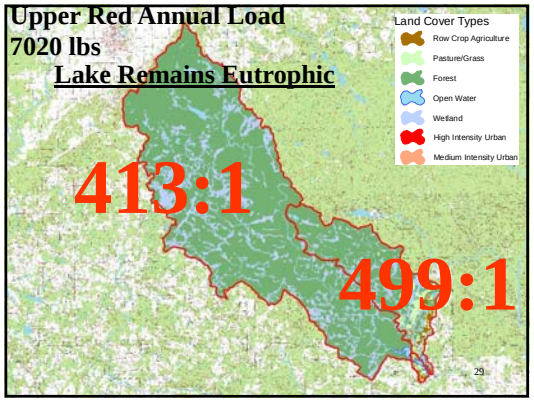

Study Results
Upper Red Lake Watershed Land Cover Area
Upper Red Lake 206 0.2%
Row Crops 2594 3.0%
Pasture/Grass 24473 28.7%
Forest 41737 49.0%
High Density Urban 23 <0.05%
Med Density Urban 68 0.1%
Wetlands 16060 18.9%
24

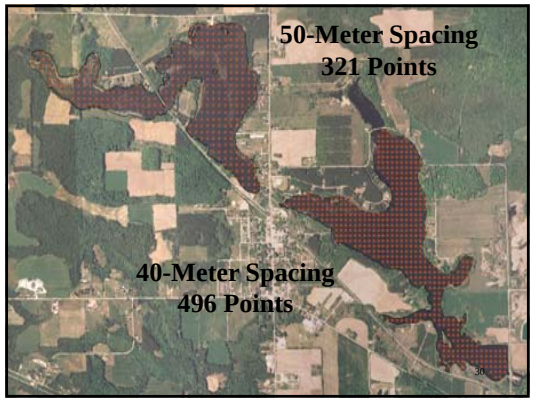

Study Results
Lower Red Lake Watershed Land Cover Area
Lower Red Lake 211 1.0%
Row Crops 851 4.2%
Pasture/Grass 1969 9.8%
High Density Urban 7 0.0%
Med Density Urban 29 0.1%
Wetlands 3880 19.2%
Forest 13219 65.5%
25


Study Results
Lower Red Lake Watershed Land Cover Area
Row Crops 851 0.8%
Pasture/Grass 1969 1.9%
Med Density Urban 29 <0.05%
High Density Urban 7 <0.05%
Wetlands 3880 3.7%
Forest 13219 12.6%
Lower Red Lake 211 0.2%
Upper Red Watershed 85161 80.9%
26


Study Results
Upper Red Lake Watershed Loading (lbs/yr)
13,770 lbs/yr
Upper Red Lake 55 0.4%
Forest 3344 24.3%
Row Crops 2310 16.8%
Wetlands 1430 10.4%
Med Density Urban 30.8 0.2%
High Density Urban 30.8 0.2%
Pasture/Grass 6536.2 47.6%
27


Study Results
Lower Red Lake Watershed Loading (lbs/yr)
Row Crops 756.8 8.5%
Pasture/Grass 525.8 5.9%
High Density Urban 8.8 0.1%
Med Density Urban 13.2 0.1%
Wetlands 345.4 3.9%
Forest 1058.2 11.9%
Upper Red Outlet 6094 68.8%
Lower Red Lake 57.2 0.6%
28


Upper Red Annual Load
7020 lbs
Lake Remains Eutrophic
413:1
499:1
Land Cover Types
Row Crop Agriculture
Pasture/Grass
Forest
Open Water
Wetland
High Intensity Urban
Medium Intensity Urban
29


50-Meter Spacing
321 Points
40-Meter Spacing
496 Points
30

Study Results

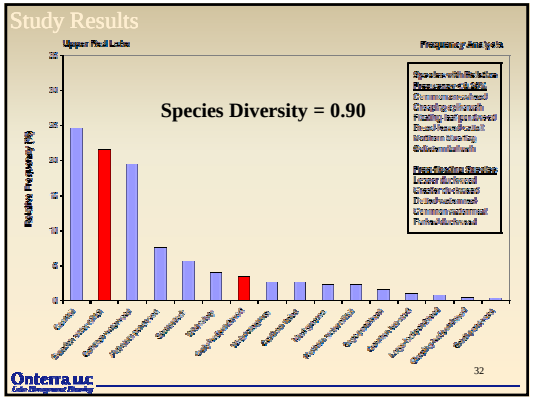
Red Lakes

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	Lower Red Lake	Upper Red Lake
Emergent	*Carex comosa*	Bristly sedge	5	I	
	Eleocharis erythropoda	Bald spike-rush	3		X
	Iris virginica	Southern blue flag	5	I	I
	Sagittaria latifolia	Common arrowhead	3	X	X
	Schoenoplectus pungens	Three-square rush	5	X	
	Schoenoplectus tabernaemontani	Softstem bulrush	4	X	I
	Typha angustifolia	Narrow-leaved cattail	1	X	
	Typha latifolia	Broad-leaved cattail	1	X	I
FL,FLE	*Sparganium eurycarpum*	Common bur-reed	5	X	X
FL	*Nuphar variegata*	Spatterdock	6	X	X
Free-Floating	*Lemna minor*	Lesser duckweed	5	X	X
	Lemna trisulca	Forked duckweed	6	X	X
	Spirodela polyrhiza	Greater duckweed	5	X	X
	Wolffia borealis	Dotted watermeal	6	X	X
	Wolffia columbiana	Common watermeal	5	X	X
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X
	Chara sp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Heteranthera dubia	Water stargrass	6		X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	X	X
	Najas guadalupensis	Southern naiad	7	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton crispus	Curly-leaf pondweed	Exotic	X	X
	Potamogeton natans	Floating-leaf pondweed	5	X	X
	Potamogeton praelongus	White-stem pondweed	8	X	
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Ranunculus aquatilis	White water-crowfoot	8	X	
	Stuckenia pectinata	Sago pondweed	3	X	X
	Vallisneria americana	Wild celery	6	X	X
FLS	*Sagittaria graminea*	Grass-leaved arrowhead	9	X	

I = Incidental
FLE = Floating-leaf emergent
FL = Floating-leaf
FLS = Floating-leaf submergent

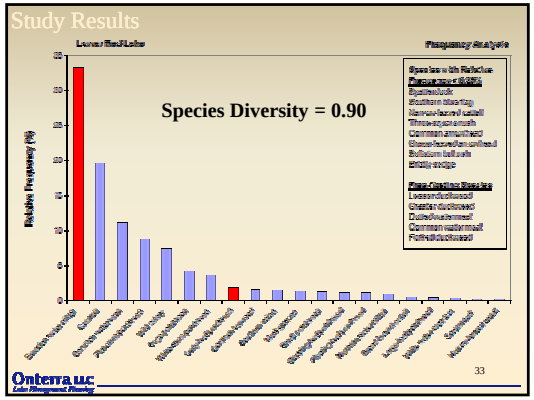
Onterra LLC Lake Management Planning 31

Study Results



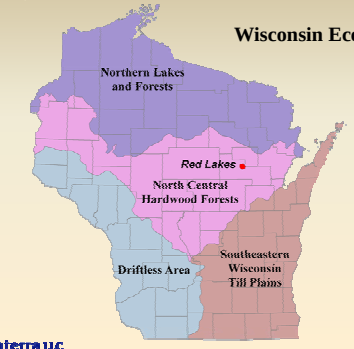
Onterra LLC Lake Management Planning 32

Study Results



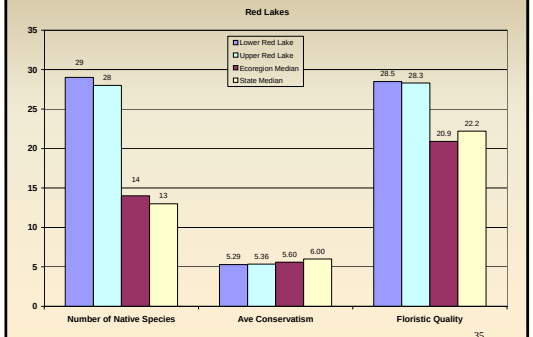
Onterra LLC Lake Management Planning 33

Study Results

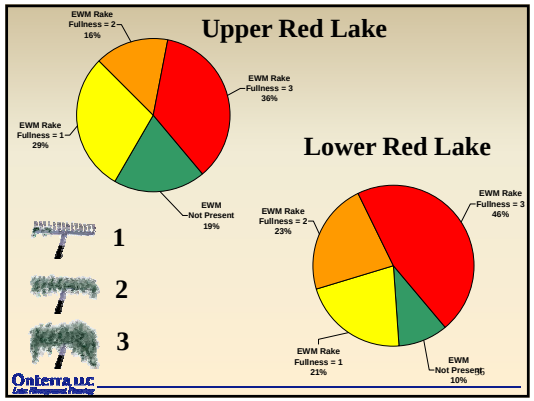


Onterra LLC Lake Management Planning 34

Study Results



Onterra LLC Lake Management Planning 35



Onterra LLC Lake Management Planning 36

Study Results

Conclusions

- The Red Lakes are eutrophic *and* shallow lakes.
- The system's productivity is exhibited by a high macrophyte biomass
- Much of the plant biomass is in the form exotic plants.
- Significant changes in watershed will not significantly lower plant production.

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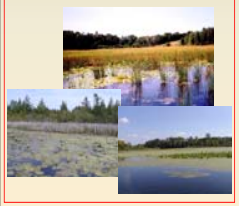
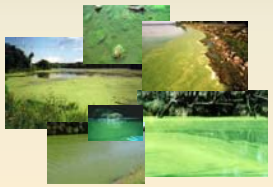
Shallow Lakes are Special

Clear State



Turbid State



Aquatic Plants are Important

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Study Results

Conclusions

- Native plant populations of both lakes are of higher quality and diversity, but indicative of a disturbed system.
- Winter water level drawdown would be good alternative to reduce Eurasian water milfoil and possibly enhance native populations.
- Cost of hydroelectric reimbursement makes drawdown not feasible at this time.

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Study Results

Drawdown Costs

Hydro Generation ($.075/KWH)	
Upper (1,824,072 KWH)	$136,805
Lower (1,334,499 KWH)	$100,087
Monitoring	$12,000
Fish Re-stocking	$20,000
10% Contingency	$26,888
Project Total	**$295,780**

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Implementation Plan

Goal 1: Maintain Current Water Quality Conditions

Management Actions

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

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Implementation Plan

Goal 2: Control Current Exotic Species and Prevent Further Introduction of Aquatic Invasive Species within the Red Lakes

Management Actions

1. Initiate educational program aimed at informing Red Lakes users about aquatic invasive species prevention.
2. Increase recreational use and improve fishery habitat through planned and permitted mechanical harvesting activities.

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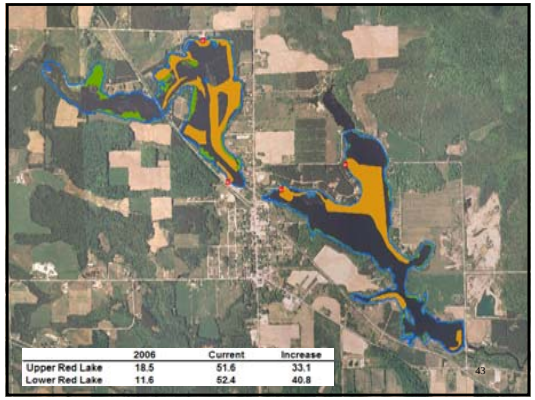

	2006	Current	Increase
Upper Red Lake	18.5	51.6	33.1
Lower Red Lake	11.6	52.4	40.8

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Implementation Plan

Goal 3: Improve Native Habitat In and Around the Red Lakes

Management Actions

1. Create Wildlife and Habitat Improvement Committee

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Implementation Plan

Goal 4: Increase District Communication and Management Capacity

Management Actions

1. Create biannual or greater frequency newsletter.

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Thank You

Many of the graphics used in this presentation were supplied by:

Wisconsin Lakes Partnership

UW Extension

Wisconsin Dept. of Natural Resources

Onterra LLC

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B

APPENDIX B

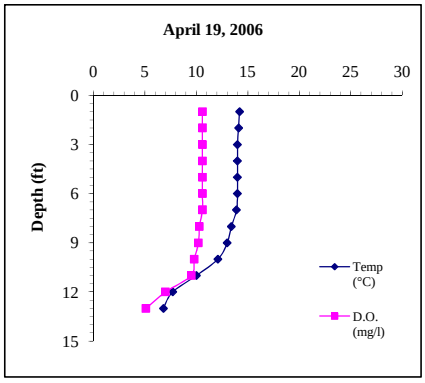
Water Quality Data

Upper Red Lake

Date: 04-19-06
Time: 13:45
Weather: 90% Clouds, Windy, 12°C
Ent: EJH **Verf:**

Max Depth (ft): 14.2
URLS Depth (ft): 1.5
URLB Depth (ft): 12.0
Secchi Depth (ft): 7.2

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	14.2	10.6	8.6	310
2.0	14.1	10.6	8.6	311
3.0	14.0	10.6	8.6	312
4.0	14.0	10.6	8.6	312
5.0	14.0	10.6	8.7	312
6.0	14.0	10.6	8.7	312
7.0	13.9	10.6	8.7	312
8.0	13.4	10.3	8.7	314
9.0	13.0	10.2	8.7	314
10.0	12.1	9.8	8.5	317
11.0	10.0	9.5	8.3	334
12.0	7.7	7.0	7.9	381
13.0	6.8	5.1	7.8	389



Parameter	URLS	URLB
Total P (µg/L)	26.0	33.0
Dissolved P (µg/L)	ND	ND
Chl a (µg/L)	7.05	
TKN (µg/L	610.0	610.0
NO3+NO2-N (µg/L)	437.0	368.0
NH3-N (µg/L)	23.0	ND
Total N (µg/L)	1047.0	978.0
Lab Cond. (µS/cm)	319	375
Lab pH	8.46	8.16
Alkal (mg/l CaCO3)	147.0	171.0
Total Susp Sol (mg/l)	2.0	3.0
Calcium (mg/l)	38.0	

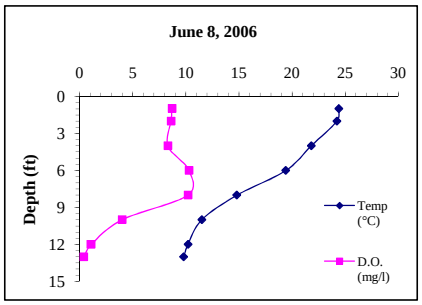
Sample Collected by EJH

Upper Red Lake

Date: 06-08-06
Time: Noon
Weather: Full Sun, 85°F
Ent: EJH **Verf:**

Max Depth (ft): 13.6
URLS Depth (ft): 1.5
URLB Depth (ft): 11.0
Secchi Depth (ft): 7.6

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	24.4	8.7	8.8	332
2.0	24.2	8.6	8.8	332
4.0	21.8	8.3	8.6	344
6.0	19.4	10.3	8.6	344
8.0	14.8	10.2	8.3	276
10.0	11.5	4.0	7.9	283
12.0	10.2	1.1	7.8	290
13.0	9.8	0.4	7.9	303



Parameter	URLS	URLB
Total P (µg/L)	56.0	30.0
Dissolved P (µg/L)		
Chl a (µg/L)	5.82	
TKN (µg/L	690.0	640.0
NO3+NO2-N (µg/L)	195.0	341.0
NH3-N (µg/L)	58.0	29.0
Total N (µg/L)	885.0	981.0
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l CaCO3)		
Total Susp Sol (mg/l)	ND	ND
Calcium (mg/l)		

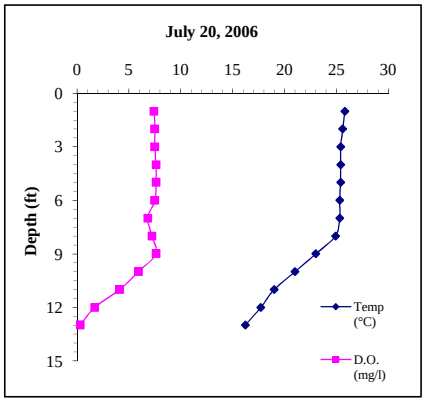
Samples collected by EJH, CS

Upper Red Lake

Date: 07-20-06
Time: 10:30
Weather: Full sun and Windy, 80°F
Ent: EJH **Verf:**

Max Depth (ft): 13.8
URLS Depth (ft): 1.5
URLB Depth (ft): 12.0
Secchi Depth (ft): 11.5

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	25.8	7.4	9.0	326
2.0	25.6	7.5	9.1	327
3.0	25.4	7.5	9.1	326
4.0	25.4	7.6	9.0	326
5.0	25.4	7.6	9.0	326
6.0	25.3	7.5	9.1	326
7.0	25.3	6.8	8.9	329
8.0	24.9	7.2	9.0	328
9.0	23.0	7.6	8.8	320
10.0	21.0	5.9	8.4	316
11.0	19.0	4.1	8.2	316
12.0	17.7	1.7	8.0	319
13.0	16.2	0.3	7.9	324



Parameter	URLS	URLB
Total P (µg/L)	34.0	69.0
Dissolved P (µg/L)	4.0	22.0
Chl a (µg/L)	4.80	
TKN (µg/L	570.0	970.0
NO3+NO2-N (µg/L)	ND	ND
NH3-N (µg/L)	36.0	113.0
Total N (µg/L)	570.0	970.0
Lab Cond. (µS/cm)	324	321
Lab pH	8.50	7.94
Alkal (mg/l CaCO3)	152.0	152.0
Total Susp Sol (mg/l)	ND	ND
Calcium (mg/l)		

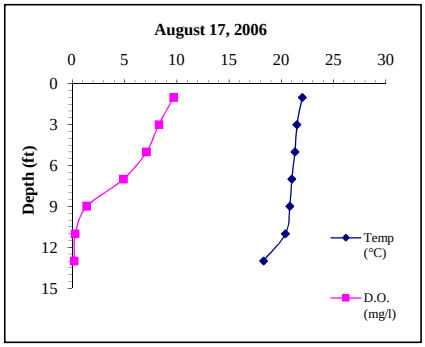
Samples Collected by EJH, CS. SLOH received sample with ice melted

Upper Red Lake

Date: 08-17-06
Time: 15:30
Weather: Full Sun, No Wind, 68°F
Ent: EJH **Verf:**

Max Depth (ft): 13.7
URLS Depth (ft): 1.5
URLB Depth (ft): 12.0
Secchi Depth (ft): 6.8

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	22.0	9.7	8.9	324
3.0	21.5	8.3	8.6	327
5.0	21.3	7.1	8.4	331
7.0	21.0	4.9	8.2	334
9.0	20.8	1.4	7.8	331
11.0	20.4	0.3	7.6	318
13.0	18.3	0.2	7.6	370



Parameter	URLS	URLB
Total P (µg/L)	41.0	279.0
Dissolved P (µg/L)		
Chl a (µg/L)	22.50	
TKN (µg/L	760.0	1820.0
NO3+NO2-N (µg/L)	221.0	ND
NH3-N (µg/L)	ND	767.0
Total N (µg/L)	782.5	1820.0
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l CaCO3)		
Total Susp Sol (mg/l)	ND	10.0
Calcium (mg/l)		

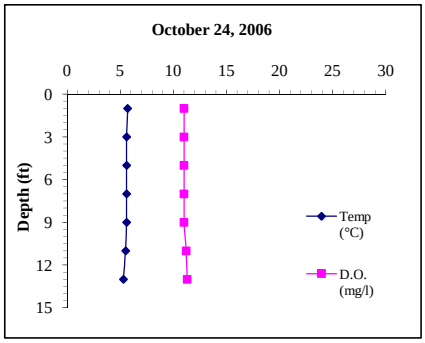
Samples Collected by TAH, MJH.

Upper Red Lake

Date: 10-24-06
Time: 13:00
Weather: 80% Sun, 40°F
Ent: EJH **Verf:**

Max Depth (ft): 14.0
URLS Depth (ft): 1.5
URLB Depth (ft): 12.0
Secchi Depth (ft): 9.2

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	5.7	11.0	8.3	327
3.0	5.6	11.0	8.3	327
5.0	5.6	11.0	8.4	327
7.0	5.6	11.0	8.4	326
9.0	5.6	11.0	8.5	325
11.0	5.5	11.2	8.5	324
13.0	5.3	11.3	8.5	324



Parameter	URLS	URLB
Total P (µg/L)	16.0	15.0
Dissolved P (µg/L)		
Chl a (µg/L)	1.38	
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	ND
Calcium (mg/l)		

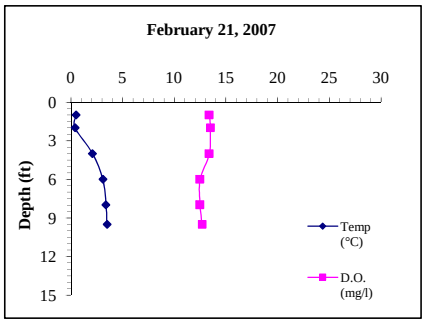
Samples Collected by EJH

Upper Red Lake

Date: 02-21-07
Time: Noon
Weather: 60% Sun, 36°F
Ent: EJH **Verf:**

Max Depth (ft): 10.8
URLS Depth (ft): 3.0
URLB Depth (ft): 9.5
Secchi Depth (ft): 10.8 Hit bottom

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	0.5	13.4	7.5	447
2.0	0.4	13.5	7.5	445
4.0	2.1	13.4	7.7	462
6.0	3.1	12.5	7.7	487
8.0	3.4	12.5	7.8	456
9.5	3.5	12.7	7.9	455



Parameter	URLS	URLB
Total P (µg/L)	11.0	20.0
Dissolved P (µg/L)	ND	ND
Chl a (µg/L)		
TKN (µg/L	ND	250.0
NO3+NO2-N (µg/L)	1940.0	1850.0
NH3-N (µg/L)	17.0	8.0
Total N (µg/L)	1940.0	2100.0
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l CaCO3)		
Total Susp Sol (mg/l)	ND	0.0
Calcium (mg/l)		

Samples Collected by EJH, TAH, MG. Ice: 2.9 ft.

Water Quality Data

2006-07	Surface		Bottom	
Parameter	Count	Mean	Count	Mean
Secchi Depth (feet)	6	8.9		
Total P (µg/L)	6	30.667	6	74.333
Dissolved P (µg/L)	3	1.333	3	7.333
Chl a (µg/L)	5	8.310	0	
TKN (µg/L	5	526.000	5	858.000
NO4+NO3-N (µg/L)	5	558.600	5	511.800
NH3-N (µg/L)	5	26.800	5	183.400
Total N (µg/L)	5	1044.900	5	1369.800
Lab Cond. (µS/cm)	2	321.500	2	348.000
Lab pH	2	8.480	2	8.050
Alkal (mg/l CaCO3)	2	149.500	2	161.500
Total Susp Sol (mg/l)	6	0.333	6	2.167
Calcium (µg/L)	1	38	0	

Wisconsin Trophic State Index (WTSI)			
Year	TP	Chla	SD
1991	55.42	52.03	46.56
2006	57.53	52.77	46.05
All Years (weighted)	56.55	52.29	46.30
WI Impoundments	60.51	58.05	56.10
Central Region	51.45	49.88	47.33

Morphological / Geographical Data

Parameter	Value
Acreage	188
Volume (acre-feet)	1096
Perimeter (miles)	4.75
Shoreland Development	2.47
Maximum Depth (feet)	15
County	Shawano County
WBIC	329900
Lillie Mason Region(1983)	Central Region
Nichols Ecoregion(1999)	NCSE

Watershed Data

WiLMS Class	Acreage	kg/yr	lbs/yr
Row Crops	2594	1050	2310
Pasture/Grass	24473	2971	6536
HD Urban	23	14	31
MD Urban	68	14	31
Wetlands	16060	650	1430
Forest	41737	1520	3344
Open Water	206	25	55

Watershed to Lake Area 499 :1

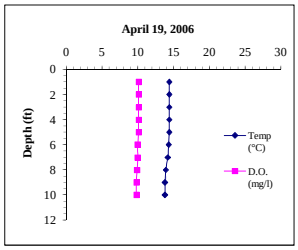
	Secchi (feet)				Chlorophyll a (µg/L)				Phosphorus (µg/L)			
	Growing Season		Summer		Growing Season		Summer		Growing Season		Summer	
Year	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean
1991	3	8.3	3	8.3	6	10.0	6	10.0	3	33.3	3	33.3
2006	5	8.5	3	8.6	5	8.3	3	11.0	5	34.6	3	43.7
All Years (weighted)		8.4		8.5		9.2		10.3		34.1		38.5
WI Impoundments				4.3				22.3				64.0
Central Region				7.9				7.5				20.0

Lower Red Lake

Date: 04-19-06
Time: 14:50
Weather: 90% Clouds, Windy, 12°C
Ent: EJH **Verf:**

Max Depth (ft): 11.1
LRLS Depth (ft): 1.5
LRLB Depth (ft): 9.0
Secchi Depth (ft): 6.0

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	14.4	10.1	8.5	303
2.0	14.4	10.1	8.5	302
3.0	14.4	10.1	8.5	303
4.0	14.4	10.1	8.5	307
5.0	14.4	10.1	8.5	309
6.0	14.3	10.0	8.6	310
7.0	14.2	10.0	8.6	315
8.0	13.9	9.9	8.6	315
9.0	13.8	9.8	8.6	315
10.0	13.8	9.8	8.6	315



Parameter	LRLS	LRLB
Total P (µg/L)	37.0	28.0
Dissolved P (µg/L)	ND	ND
Chl a (µg/L)	10.30	
TKN (µg/L	720.0	620.0
NO3+NO2-N (µg/L)	425.0	492.0
NH3-N (µg/L)	22.0	29.0
Total N (µg/L)	1145.0	1112.0
Lab Cond. (µS/cm)	307	321
Lab pH	8.39	8.38
Alkal (mg/l CaCO3)	140.0	147.0
Total Susp Sol (mg/l)	3.0	3.0
Calcium (mg/l)	37.8	

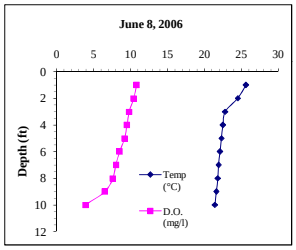
Samples Collected by EJH.

Lower Red Lake

Date: 06-08-06
Time: Noon
Weather: Full Sun, 85°F
Ent: EJH **Verf:**

Max Depth (ft): 11.2
LRLS Depth (ft): 1.5
LRLB Depth (ft): 9.0
Secchi Depth (ft): 5.6

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	25.6	10.8	9.3	270
2.0	24.5	10.4	9.2	311
3.0	22.8	9.8	9.1	323
4.0	22.5	9.5	9.1	330
5.0	22.3	9.2	9.0	333
6.0	22.1	8.5	9.0	335
7.0	21.9	8.0	9.0	340
8.0	21.8	7.6	9.0	340
9.0	21.6	6.5	8.9	337
10.0	21.4	3.9	8.5	327



Parameter	LRLS	LRLB
Total P (µg/L)	70.0	42.0
Dissolved P (µg/L)		
Chl a (µg/L)	5.90	
TKN (µg/L	700.0	640.0
NO3+NO2-N (µg/L)	132.0	223.0
NH3-N (µg/L)	18.0	108.0
Total N (µg/L)	832.0	863.0
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l CaCO3)		
Total Susp Sol (mg/l)	2.0	3.0
Calcium (mg/l)		

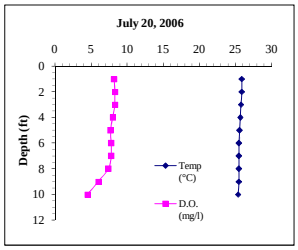
Samples collected by EJH, CS

Lower Red Lake

Date: 07-20-06
Time: 9:56
Weather: Full sun and Windy, 80°F
Ent: EJH **Verf:**

Max Depth (ft): 11.2
LRLS Depth (ft): 1.5
LRLB Depth (ft): 9.0
Secchi Depth (ft): 8.9

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	25.9	8.2	9.2	324
2.0	25.9	8.3	9.2	324
3.0	25.8	8.3	9.2	321
4.0	25.7	8.0	9.3	309
5.0	25.6	7.7	9.2	312
6.0	25.5	7.8	9.2	327
7.0	25.5	7.8	9.1	330
8.0	25.5	7.4	9.1	331
9.0	25.5	6.0	9.0	334
10.0	25.4	4.5	8.8	331



Parameter	LRLS	LRLB
Total P (µg/L)	39.0	36.0
Dissolved P (µg/L)	4.0	4.0
Chl a (µg/L)	6.22	
TKN (µg/L	450.0	540.0
NO3+NO2-N (µg/L)	ND	38.0
NH3-N (µg/L)	17.0	36.0
Total N (µg/L)	450.0	578.0
Lab Cond. (µS/cm)	320	330
Lab pH	8.53	8.31
Alkal (mg/l CaCO3)	151.0	156.0
Total Susp Sol (mg/l)	ND	2.0
Calcium (mg/l)		

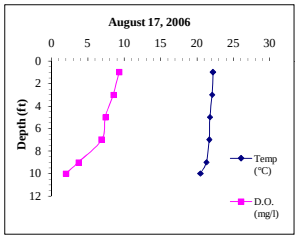
Samples Collected by EJH, CS. SLOH received sample with ice melted

Lower Red Lake

Date: 08-17-06
Time: 14:00
Weather: Full Sun, No Wind, 68°F
Ent: EJH **Verf:**

Max Depth (ft): 11.2
LRLS Depth (ft): 1.5
LRLB Depth (ft): 9.5
Secchi Depth (ft): 5.3

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	22.2	9.3	8.9	320
3.0	22.1	8.5	8.8	323
5.0	21.8	7.4	8.7	327
7.0	21.7	6.9	8.6	326
9.0	21.3	3.7	8.1	303
10.0	20.5	2.0	7.7	273



Parameter	LRLS	LRLB
Total P (µg/L)	59.0	33.0
Dissolved P (µg/L)		
Chl a (µg/L)	30.70	
TKN (µg/L	1020.0	770.0
NO3+NO2-N (µg/L)	232.0	240.0
NH3-N (µg/L)	17.0	92.0
Total N (µg/L)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l CaCO3)		
Total Susp Sol (mg/l)	2.0	2.0
Calcium (mg/l)		

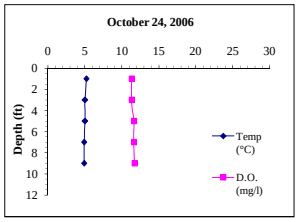
Samples Collected by TAH, MJH.

Lower Red Lake

Date: 10-24-06
Time: Noon
Weather: 80% Sun, 40°F
Ent: EJH **Verf:**

Max Depth (ft): 11.0
LRLS Depth (ft): 1.5
LRLB Depth (ft): 9.5
Secchi Depth (ft): 8.0

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	5.2	11.3	8.2	241
3.0	5.0	11.3	8.4	307
5.0	5.0	11.6	8.6	308
7.0	4.9	11.6	8.7	313
9.0	4.9	11.7	8.7	314



Parameter	LRLS	LRLB
Total P (µg/L)	19.0	12.0
Dissolved P (µg/L)		
Chl a (µg/L)	1.22	
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	ND
Calcium (mg/l)		

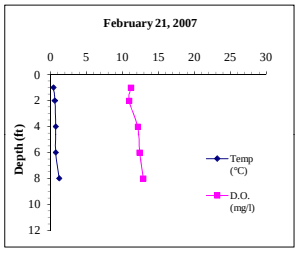
Samples Collected by EJH

Lower Red Lake

Date: 02-21-07
Time: 13:30
Weather: 60% Sun, 36°F
Ent: EJH **Verf:**

Max Depth (ft): 9.0
LRLS Depth (ft): 3.0
LRLB Depth (ft): 6.5
Secchi Depth (ft): 9.0 Hit bottom

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	0.4	11.2	7.4	409
2.0	0.6	10.9	7.4	399
4.0	0.7	12.1	7.6	438
6.0	0.7	12.4	7.6	444
8.0	1.2	12.9	7.8	435



Parameter	LRLS	LRLB
Total P (µg/L)	14.0	12.0
Dissolved P (µg/L)	5.0	3.0
Chl a (µg/L)		
TKN (µg/L	ND	23.0
NO3+NO2-N (µg/L)	2003.0	1980.0
NH3-N (µg/L)	49.0	28.0
Total N (µg/L)	2003.0	2003.0
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, MG. Ice: 1.8 ft.

Water Quality Data

2006-07	Surface		Bottom	
Parameter	Count	Mean	Count	Mean
Secchi Depth (feet)	6	7.1		
Total P (µg/L)	6	39.667	6	27.167
Dissolved P (µg/L)	2	4.500	2	3.500
Chl a (µg/L)	5	10.868	0	
TKN (µg/L	4	722.500	5	518.600
NO4+NO3-N (µg/L)	4	698.000	5	594.600
NH3-N (µg/L)	5	24.600	5	58.600
Total N (µg/L)	4	1107.500	4	1139.000
Lab Cond. (µS/cm)	2	313.500	2	325.500
Lab pH	2	8.460	2	8.345
Alkal (mg/l CaCO3)	2	145.500	2	151.500
Total Susp Sol (mg/l)	3	2.333	4	2.500
Calcium (µg/L)	1	37.8	0	

Wisconsin Trophic State Index (WTSI)			
Year	TP	Chla	SD
1991	54.52	48.61	50.94
1993			40.15
1994			41.92
1995			53.34
1996			49.92
2006	59.47	54.70	49.37
All Years (weighted)	57.38	51.23	49.37
WI Impoundments	60.51	58.05	56.10
Central Region	51.45	49.88	47.33

Morphological / Geographical Data

Parameter	Value
Acreage	240
Volume (acre-feet)	1601
Perimeter (miles)	6.27
Shoreland Development	2.89
Maximum Depth (feet)	28
County	Shawano County
WBIC	327800
Lillie Mason Region(1983)	Central Region
Nichols Ecoregion(1999)	NCSE

Watershed Data

WiLMS Class	Acreage	kg/yr	lbs/yr
Row Crops	0.0	0	0
Pasture/Grass	0.0	0	0.0
HD Urban	0.0	0	0.0
MD Urban	0.0	0	0.0
Wetlands	1060.0	650	1430.0
Forest	68895.0	2509	5519.8
Open Water	206	25	55.0

Watershed to Lake Area 413 :1

	Secchi (feet)				Chlorophyll a (µg/L)				Phosphorus (µg/L)			
	Growing Season		Summer		Growing Season		Summer		Growing Season		Summer	
Year	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean
1975									1	30.0		
1977									1	40.0		
1991	3	8.0	3	8.0	6	6.3	6	6.3	3	29.7	3	29.7
1993	5	6.2	5	6.2								
1994	1	13.0	1	13.0								
1995	3	11.3	1	11.5								
1996	10	5.6	6	5.2								
2006	5	6.8	3	6.6	5	10.87	3	14.27	5	44.80	3	56.0
All Years (weighted)		7.1		6.9		8.4		9.0		47.9		42.8
WI Impoundments				4.3				22.3				64.0
Central Region				7.9				7.5				20.0

C

APPENDIX C

Watershed Analysis WiLMS Results

Date: 5/25/2007 Scenario: Upper Red Current

Lake Id: Upper Red
Watershed Id: Red River

Hydrologic and Morphometric Data

Tributary Drainage Area: 84955.0 acre
Total Unit Runoff: 10.8 in.
Annual Runoff Volume: 76459.5 acre-ft
Lake Surface Area <As>: 206 acre
Lake Volume <V>: 1096 acre-ft
Lake Mean Depth <z>: 5.3 ft
Precipitation - Evaporation: 4.6 in.
Hydraulic Loading: 76538.5 acre-ft/year
Areal Water Load <qs>: 371.5 ft/year
Lake Flushing Rate <p>: 69.83 1/year
Water Residence Time: 0.01 year
Observed spring overturn total phosphorus (SPO): 26 mg/m^3
Observed growing season mean phosphorus (GSM): 34.6 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	2594	0.50	1.00	3.00	16.8	525	1050	3149
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	24473	0.10	0.30	0.50	47.6	990	2971	4952
HD Urban (1/8 Ac)	23	1.00	1.50	2.00	0.2	9	14	19
MD Urban (1/4 Ac)	68	0.30	0.50	0.80	0.2	8	14	22
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	16060	0.10	0.10	0.10	10.4	650	650	650
Forest	41737	0.05	0.09	0.18	24.3	845	1520	3040
Lake Surface	206.0	0.10	0.30	1.00	0.4	8	25	83

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)		0.3	0.5	0.8	
# capita-years	0.0				
% Phosphorus Retained by Soil		98	90	80	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	6692.5	13765.4	26269.6	100.0
Total Loading (kg)	3035.7	6243.9	11915.8	100.0
Areal Loading (lb/ac-year)	32.49	66.82	127.52	0.0
Areal Loading (mg/m^2-year)	3641.46	7489.84	14293.50	0.0
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)	6674.2	13710.2	26085.8	100.0
Total NPS Loading (kg)	3027.4	6218.9	11832.4	100.0

Phosphorus Prediction and Uncertainty Analysis Module

Date: 5/25/2007 Scenario: Upper Red Current
Observed spring overturn total phosphorus (SPO): 26.0 mg/m^3
Observed growing season mean phosphorus (GSM): 34.6 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	29	59	112	24	69
Canfield-Bachmann, 1981 Natural Lake	30	60	110	25	72
Canfield-Bachmann, 1981 Artificial Lake	28	54	94	19	55
Rechow, 1979 General	25	51	97	16	46
Rechow, 1977 Anoxic	28	58	111	23	66
Rechow, 1977 water load<50m/year	N/A	N/A	N/A	N/A	N/A
Rechow, 1977 water load>50m/year	26	54	103	19	55
Walker, 1977 General	29	59	113	33	127
Vollenweider, 1982 Combined OECD	24	44	75	14	46
Dillon-Rigler-Kirchner	26	53	101	27	104
Vollenweider, 1982 Shallow Lake/Res.	20	37	65	7	23
Larsen-Mercier, 1976	29	59	113	33	127
Nurnberg, 1984 Oxic	28	59	112	24	69

Lake Phosphorus Model	Confidence Lower Bound	Confidence Upper Bound	Parameter Fit?	Back Calculation (kg/year)	Model Type
Walker, 1987 Reservoir	34	98	Tw	0	GSM
Canfield-Bachmann, 1981 Natural Lake	19	173	FIT	1	GSM
Canfield-Bachmann, 1981 Artificial Lake	17	156	FIT	1	GSM
Rechow, 1979 General	29	86	FIT	0	GSM
Rechow, 1977 Anoxic	34	96	FIT	0	GSM
Rechow, 1977 water load<50m/year	N/A	N/A	N/A	N/A	N/A
Rechow, 1977 water load>50m/year	37	84	FIT	0	GSM
Walker, 1977 General	29	107	FIT	0	SPO
Vollenweider, 1982 Combined OECD	21	79	Tw	0	ANN
Dillon-Rigler-Kirchner	31	87	P L p	0	SPO
Vollenweider, 1982 Shallow Lake/Res.	18	66	Tw	0	ANN
Larsen-Mercier, 1976	36	96	P Pin p	0	SPO
Nurnberg, 1984 Oxic	30	104	L	0	ANN

Date: 5/25/2007 Scenario: Upper Red Row Crop to Forest

Lake Id: Upper Red
Watershed Id: Red River

Hydrologic and Morphometric Data

Tributary Drainage Area: 84955.0 acre
Total Unit Runoff: 10.80 in.
Annual Runoff Volume: 76459.5 acre-ft
Lake Surface Area <As>: 206.0 acre
Lake Volume <V>: 1096.0 acre-ft
Lake Mean Depth <z>: 5.3 ft
Precipitation - Evaporation: 4.6 in.
Hydraulic Loading: 76538.5 acre-ft/year
Areal Water Load <qs>: 371.5 ft/year
Lake Flushing Rate <p>: 69.83 1/year
Water Residence Time: 0.01 year
Observed spring overturn total phosphorus (SPO): 26.0 mg/m^3
Observed growing season mean phosphorus (GSM): 34.6 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre	Low	Most Likely	High	Loading %	Low	Most Likely	High
	(ac)	|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	0	0.10	0.30	0.50	0.0	0	0	0
HD Urban (1/8 Ac)	0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	0	0.30	0.50	0.80	0.0	0	0	0
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	16060.0	0.10	0.10	0.10	20.4	650	650	650
Forest	68895	0.05	0.09	0.18	78.8	1394	2509	5019
Lake Surface	206.0	0.10	0.30	1.00	0.8	8	25	83

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)	4524.7	7020.2	12681.0	100.0
Total Loading (kg)	2052.4	3184.3	5752.0	100.0
Areal Loading (lb/ac-year)	21.96	34.08	61.56	
Areal Loading (mg/m^2-year)	2461.91	3819.72	6899.81	
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)	4506.3	6965.0	12497.2	100.0
Total NPS Loading (kg)	2044.0	3159.3	5668.7	100.0

Phosphorus Prediction and Uncertainty Analysis Module

Date: 5/25/2007 Scenario: 16
Observed spring overturn total phosphorus (SPO): 26.0 mg/m^3
Observed growing season mean phosphorus (GSM): 34.6 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	20	32	57	-3	-9
Canfield-Bachmann, 1981 Natural Lake	20	31	55	-4	-12
Canfield-Bachmann, 1981 Artificial Lake	19	29	50	-6	-17
Rechow, 1979 General	17	26	47	-9	-26
Rechow, 1977 Anoxic	19	30	54	-5	-14
Rechow, 1977 water load<50m/year	N/A	N/A	N/A	N/A	N/A
Rechow, 1977 water load>50m/year	18	27	50	-8	-23
Walker, 1977 General	19	30	54	4	15
Vollenweider, 1982 Combined OECD	18	25	41	-5	-17
Dillon-Rigler-Kirchner	17	27	49	1	4
Vollenweider, 1982 Shallow Lake/Res.	14	20	34	-10	-33
Larsen-Mercier, 1976	19	30	54	4	15
Nurnberg, 1984 Oxic	19	30	54	-5	-14

Lake Phosphorus Model	Confidence Lower Bound	Confidence Upper Bound	Parameter Fit?	Back Calculation (kg/year)	Model Type
Walker, 1987 Reservoir	20	51	Tw	0	GSM
Canfield-Bachmann, 1981 Natural Lake	10	89	FIT	1	GSM
Canfield-Bachmann, 1981 Artificial Lake	9	84	FIT	1	GSM
Rechow, 1979 General	16	43	FIT	0	GSM
Rechow, 1977 Anoxic	20	48	FIT	0	GSM
Rechow, 1977 water load<50m/year	N/A	N/A	N/A	N/A	N/A
Rechow, 1977 water load>50m/year	21	41	FIT	0	GSM
Walker, 1977 General	16	53	FIT	0	SPO
Vollenweider, 1982 Combined OECD	13	45	Tw	0	ANN
Dillon-Rigler-Kirchner	18	43	P L p	0	SPO
Vollenweider, 1982 Shallow Lake/Res.	11	35	Tw	0	ANN
Larsen-Mercier, 1976	20	47	P Pin p	0	SPO
Nurnberg, 1984 Oxic	17	51	L	0	ANN

Date: 5/25/2007 Scenario: Lower Red Current (URL Surface Outfall)

Lake Id: Lower Red
Watershed Id: Full

Hydrologic and Morphometric Data

Tributary Drainage Area: 19955.0 acre
Total Unit Runoff: 10.80 in.
Annual Runoff Volume: 17959.5 acre-ft
Lake Surface Area <As>: 211.0 acre
Lake Volume <V>: 1601.0 acre-ft
Lake Mean Depth <z>: 7.6 ft
Precipitation - Evaporation: 4.6 in.
Hydraulic Loading: 94571.7 acre-ft/year
Areal Water Load <qs>: 448.2 ft/year
Lake Flushing Rate <p>: 59.07 1/year
Water Residence Time: 0.02 year
Observed spring overturn total phosphorus (SPO): 37.0 mg/m^3
Observed growing season mean phosphorus (GSM): 44.8 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre	Low	Most Likely	High	Loading %	Low	Most Likely	High
	(ac)	|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	851.0	0.50	1.00	3.00	8.6	172	344	1033
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	1969.0	0.10	0.30	0.50	5.9	80	239	398
HD Urban (1/8 Ac)	7.0	1.00	1.50	2.00	0.1	3	4	6
MD Urban (1/4 Ac)	29.0	0.30	0.50	0.80	0.1	4	6	9
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	3880.0	0.10	0.10	0.10	3.9	157	157	157
Forest	13219.0	0.05	0.09	0.18	12.0	267	481	963
Lake Surface	211.0	0.10	0.30	1.00	0.6	9	26	85

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %
Red Lake Outlet	94400000.0	0.0	2770.0	0.0	68.8

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)	1524.0	8879.4	5846.7	100.0
Total Loading (kg)	691.3	4027.7	2652.0	100.0
Areal Loading (lb/ac-year)	7.22	42.08	27.71	
Areal Loading (mg/m^2-year)	809.58	4716.89	3105.85	
Total PS Loading (lb)	0.0	6106.7	0.0	68.8
Total PS Loading (kg)	0.0	2770.0	0.0	68.8
Total NPS Loading (lb)	1505.2	2716.2	5658.4	31.2
Total NPS Loading (kg)	682.7	1232.1	2566.7	31.2

Phosphorus Prediction and Uncertainty Analysis Module

Date: 5/25/2007
Observed spring overturn total phosphorus (SPO): 37.0 mg/m^3
Observed growing season mean phosphorus (GSM): 44.8 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	5	32	21	-13	-29
Canfield-Bachmann, 1981 Natural Lake	6	32	21	-13	-29
Canfield-Bachmann, 1981 Artificial Lake	6	29	20	-16	-36
Rechow, 1979 General	5	27	18	-18	-40
Rechow, 1977 Anoxic	5	30	20	-15	-33
Rechow, 1977 water load<50m/year	N/A	N/A	N/A	N/A	N/A
Rechow, 1977 water load>50m/year	5	27	18	-18	-40
Walker, 1977 General	5	31	20	-6	-16
Vollenweider, 1982 Combined OECD	6	26	18	-15	-37
Dillon-Rigler-Kirchner	5	29	19	-8	-22
Vollenweider, 1982 Shallow Lake/Res.	4	21	14	-20	-49
Larsen-Mercier, 1976	5	31	20	-6	-16
Nurnberg, 1984 Oxic	5	31	21	-14	-31

Lake Phosphorus Model	Confidence Lower Bound	Confidence Upper Bound	Parameter Fit?	Back Calculation (kg/year)	Model Type
Walker, 1987 Reservoir	13	45	Tw	0	GSM
Canfield-Bachmann, 1981 Natural Lake	10	92	FIT	1	GSM
Canfield-Bachmann, 1981 Artificial Lake	9	84	FIT	1	GSM
Rechow, 1979 General	11	40	FIT	0	GSM
Rechow, 1977 Anoxic	13	42	FIT	0	GSM
Rechow, 1977 water load<50m/year	N/A	N/A	N/A	N/A	N/A
Rechow, 1977 water load>50m/year	14	33	FIT	0	GSM
Walker, 1977 General	11	50	FIT	0	SPO
Vollenweider, 1982 Combined OECD	9	44	FIT	0	ANN
Dillon-Rigler-Kirchner	12	41	P L	0	SPO
Vollenweider, 1982 Shallow Lake/Res.	7	35	FIT	0	ANN
Larsen-Mercier, 1976	14	42	P Pin p	0	SPO
Nurnberg, 1984 Oxic	12	48	L	0	ANN

Date: 4/6/2008 Scenario: Lower Red Lake w/ Red Lake Hypolimnetic Outfall (Ave of surf and hypol.)

Lake Id: Lower Red
Watershed Id: Full

Hydrologic and Morphometric Data

Tributary Drainage Area: 19955.0 acre
Total Unit Runoff: 10.80 in.
Annual Runoff Volume: 17959.5 acre-ft
Lake Surface Area <As>: 211.0 acre
Lake Volume <V>: 1601.0 acre-ft
Lake Mean Depth <z>: 7.6 ft
Precipitation - Evaporation: 4.6 in.
Hydraulic Loading: 94247.4 acre-ft/year
Areal Water Load <qs>: 446.7 ft/year
Lake Flushing Rate <p>: 58.87 1/year
Water Residence Time: 0.02 year
Observed spring overturn total phosphorus (SPO): 37.0 mg/m^3
Observed growing season mean phosphorus (GSM): 44.8 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre	Low	Most Likely	High	Loading %	Low	Most Likely	High
	(ac)	|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	851.0	0.50	1.00	3.00	5.7	172	344	1033
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	1969.0	0.10	0.30	0.50	4.0	80	239	398
HD Urban (1/8 Ac)	7.0	1.00	1.50	2.00	0.1	3	4	6
MD Urban (1/4 Ac)	29.0	0.30	0.50	0.80	0.1	4	6	9
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	3880.0	0.10	0.10	0.10	2.6	157	157	157
Forest	13219.0	0.05	0.09	0.18	8.0	267	481	963
Lake Surface	211.0	0.10	0.30	1.00	0.4	9	26	85

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %
Red Lake Outlet	9.4E+007	0.0	4738	0.0	79.0

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)	1524.0	13218.1	5846.7	100.0
Total Loading (kg)	691.3	5995.7	2652.0	100.0
Areal Loading (lb/ac-year)	7.22	62.65	27.71	
Areal Loading (mg/m^2-year)	809.58	7021.65	3105.85	
Total PS Loading (lb)	0.0	10445.4	0.0	79.0
Total PS Loading (kg)	0.0	4738.0	0.0	79.0
Total NPS Loading (lb)	1505.2	2716.2	5658.4	21.0
Total NPS Loading (kg)	682.7	1232.1	2566.7	21.0

Phosphorus Prediction and Uncertainty Analysis Module

Date: 4/6/2008
Observed spring overturn total phosphorus (SPO): 37.0 mg/m^3
Observed growing season mean phosphorus (GSM): 44.8 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	5	46	20	1	2
Canfield-Bachmann, 1981 Natural Lake	6	47	21	2	4
Canfield-Bachmann, 1981 Artificial Lake	6	42	20	-3	-7
Rechow, 1979 General	5	40	18	-5	-11
Rechow, 1977 Anoxic	5	46	20	1	2
Rechow, 1977 water load<50m/year	N/A	N/A	N/A	N/A	N/A
Rechow, 1977 water load>50m/year	5	41	18	-4	-9
Walker, 1977 General	5	46	20	9	24
Vollenweider, 1982 Combined OECD	6	36	18	-5	-12
Dillon-Rigler-Kirchner	5	43	19	6	16
Vollenweider, 1982 Shallow Lake/Res.	4	29	14	-12	-29
Larsen-Mercier, 1976	5	46	20	9	24
Nurnberg, 1984 Oxic	5	47	21	2	4

Lake Phosphorus Model	Confidence Lower Bound	Confidence Upper Bound	Parameter Fit?	Back Calculation (kg/year)	Model Type
Walker, 1987 Reservoir	18	69	Tw	0	GSM
Canfield-Bachmann, 1981 Natural Lake	15	135	FIT	1	GSM
Canfield-Bachmann, 1981 Artificial Lake	13	121	FIT	1	GSM
Rechow, 1979 General	15	61	FIT	0	GSM
Rechow, 1977 Anoxic	18	68	FIT	0	GSM
Rechow, 1977 water load<50m/year	N/A	N/A	N/A	N/A	N/A
Rechow, 1977 water load>50m/year	19	55	FIT	0	GSM
Walker, 1977 General	15	77	FIT	0	SPO
Vollenweider, 1982 Combined OECD	12	63	FIT	0	ANN
Dillon-Rigler-Kirchner	17	64	P L	0	SPO
Vollenweider, 1982 Shallow Lake/Res.	9	50	FIT	0	ANN
Larsen-Mercier, 1976	19	67	P Pin p	0	SPO
Nurnberg, 1984 Oxic	16	76	L	0	ANN

D

APPENDIX D

2006 Aquatic Plant Survey Data

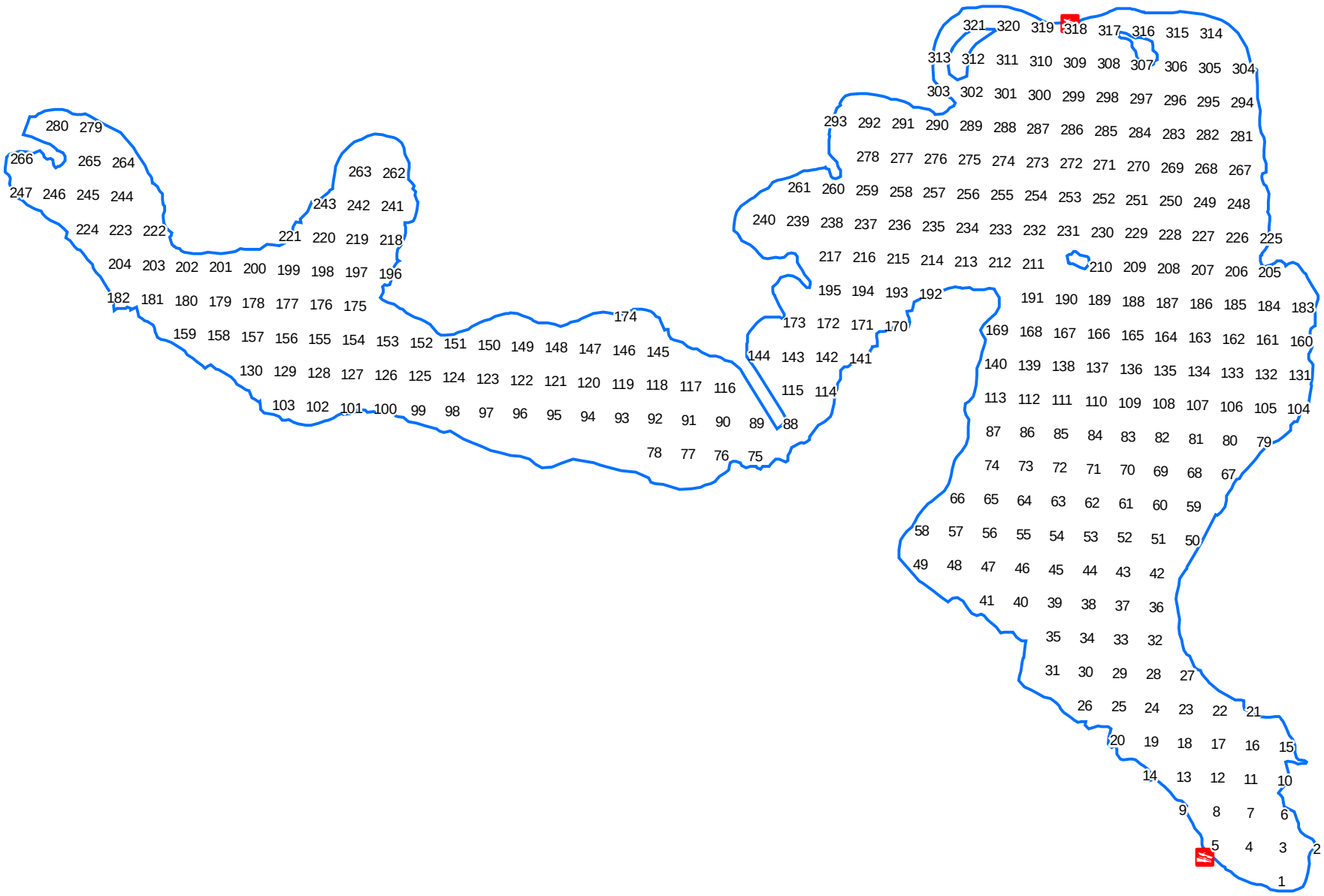
Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Heteranthera dubia*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Sagittaria latifolia*	*Eleocharis accicularis*	*Lemna trisulca*	*All Free-Floating Species*	*Potamogeton natans*
1	-88.7887274	44.85462253	4		m	p	1				1	1	3							1						1	
2	-88.7880853	44.85506582																									
3	-88.788718	44.85507254	14	Too Deep																							
4	-88.7893507	44.85507925	14	Too Deep																							
5	-88.7899833	44.85508595	7		m	p					1	2	3													1	
6	-88.7887086	44.85552254	4		m	p	3				2	2				1										1	
7	-88.7893412	44.85552925	6		m	p	3				1																
8	-88.7899739	44.85553596	10		m	p						2	1														
9	-88.7906066	44.85554266																									
10	-88.7886991	44.85597255																									
11	-88.7893318	44.85597926	5		m	p	3				3	1															
12	-88.7899645	44.85598597	4		m	p	2	1				2														1	
13	-88.7905971	44.85599267	7		m	p	3				1	3	1														
14	-88.7912298	44.85599937																									
15	-88.7886897	44.85642256		Ureachable																							
16	-88.7893224	44.85642927	3		m	p	3				3	1			1	1										1	
17	-88.789955	44.85643597	6		m	p	3				1	1															
18	-88.7905877	44.85644268	8		m	p	3					1															
19	-88.7912204	44.85644938	6		m	p	3				1	3	1														
20	-88.7918531	44.85645607																									
21	-88.7893129	44.85687928																									
22	-88.7899456	44.85688598	2		m	p			2		1	3														1	
23	-88.7905783	44.85689268	5		m	p	3			1	3	2														1	
24	-88.791211	44.85689938	9		m	p	3				1	2															
25	-88.7918437	44.85690608	6		m	p	3					1														1	
26	-88.7924763	44.85691277	2		m	p	2		1	2	2	3														1	
27	-88.7905689	44.85734269	2		m	p			2			3	3													1	
28	-88.7912016	44.85734939	7		m	p	3				2	3														1	
29	-88.7918342	44.85735609	9		m	p	3				1	3															
30	-88.7924669	44.85736278	5		m	p	3				1	1														1	
31	-88.7930996	44.85736947	3		m	p	3	1			1	3														1	
32	-88.7911921	44.8577994	3		m	p	1				1	3	1			2					1					1	1
33	-88.7918248	44.85780609	10		m	p	2					2	2														
34	-88.7924575	44.85781279	7		m	p	3					3	1			1										1	
35	-88.7930902	44.85781948	7		m	p	3		1		1	1								1						1	
36	-88.7911827	44.85824941	3		m	p	1				2	1				3										1	
37	-88.7918154	44.8582561	9		m	p	3					3	1														
38	-88.7924481	44.85826279	9		m	p	3				1	3															
39	-88.7930808	44.85826948	6		m	p	3				1	3														1	
40	-88.7937135	44.85827617	9		m	p	3					3														1	
41	-88.7943462	44.85828285	6		m	p	3					3				1										1	
42	-88.7911733	44.85869941	2		m	p	1			3	2	1	2													1	
43	-88.791806	44.85870611	5		m	p	2				3	3	2													1	
44	-88.7924387	44.8587128	7		m	p	3				1	1														1	
45	-88.7930714	44.85871949	6		m	p	3					1															
46	-88.7937041	44.85872618	6		m	p	3					2														1	
47	-88.7943368	44.85873286	8		m	p	3					3														1	
48	-88.7949695	44.85873954	8		m	p	3					3														1	
49	-88.7956022	44.85874621	3		m	p	1	1			1	1				1										1	
50	-88.7905312	44.85914272	1		m	p		1		2		1	1	3						2						1	
51	-88.7911639	44.85914942	4		m	p	2				2	2	1							1	1					1	
52	-88.7917966	44.85915612	4		m	p	2				2	3														1	
53	-88.7924293	44.85916281	4		m	p	3				2	2														1	
54	-88.793062	44.8591695	4		m	p					1	1														1	
55	-88.7936947	44.85917618	9		m	p	3			1	1	3														1	
56	-88.7943274	44.85918287	6		m	p	3					2														1	
57	-88.7949601	44.85918954	7		m	p	3					3														1	
58	-88.7955928	44.85919622	5		m	p	1				1	1														1	
59	-88.7905218	44.85959273	2		m	p	1		2		1	1		3								2				1	
60	-88.7911545	44.85959943	4		m	p	3				3	2														1	
61	-88.7917872	44.85960612	4		m	p	3				2	2														1	
62	-88.7924199	44.85961282	3		m	p	2				1															1	1
63	-88.7930526	44.85961951	7		m	p	3				1	3														1	
64	-88.7936853	44.85962619	9		m	p	1					1	1														
65	-88.794318	44.85963287	6		m	p	3					3														1	
66	-88.7949507	44.85963955	3		m	p	2					2				1										1	
67	-88.7898796	44.86003603	2		m	p	1			1	2	2				1										1	
68	-88.7905123	44.86004273	3		m	p	2				1	3														1	
69	-88.7911451	44.86004943	3		m	p	3				1	3														1	
70	-88.7917778	44.86005613	5		m	p	3				1	3														1	
71	-88.7924105	44.86006282	10		m	p	1					1														1	

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Heteranthera dubia*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Sagittaria latifolia*	*Eleocharis acicularis*	*Lemna trisulca*	*All Free-Floating Species*	*Potamogeton natans*
72	-88.7930432	44.86006951	5		m	p	3				1	1														1	
73	-88.7936759	44.8600762	6		m	p	3					2														1	
74	-88.7943086	44.86008288	4		m	p	3				1	3														1	
75	-88.7987376	44.86012956	8		m	p					1	1													1		
76	-88.7993704	44.86013621	7		m	p					1	3															
77	-88.8000031	44.86014287	5		m	p	3					3														1	
78	-88.8006358	44.86014951	2		m	p	3									1										1	
79	-88.7892375	44.86047933																									
80	-88.7898702	44.86048604	3		m	p	1				1	3				1										1	
81	-88.7905029	44.86049274	3		m	p	3				2	2		2		1										1	
82	-88.7911356	44.86049944	3		m	p	3				1	2	1													1	
83	-88.7917684	44.86050614	8		m	p	1				1	3														1	
84	-88.7924011	44.86051283	9		m	p	1					3														1	
85	-88.7930338	44.86051952	4		m	p	3				1	3														1	
86	-88.7936665	44.86052621	5		m	p	3				1	3														1	
87	-88.7942992	44.86053289	2		m	p	1		1		2	3				1										1	
88	-88.7980956	44.86057291																									
89	-88.7987283	44.86057957	6		m	p					1	2															
90	-88.799361	44.86058622	7		m	p	1	1			1	3								1							
91	-88.7999937	44.86059287	3		m	p	3					3														1	
92	-88.8006265	44.86059952	3		m	v	2	1			3	3														1	
93	-88.8012592	44.86060617	2		m	v	1	1			3	2														1	
94	-88.8018919	44.86061281	4		m	v	2				1	3				1										1	
95	-88.8025246	44.86061944	4		m	v	1				1	2				1				1							
96	-88.8031573	44.86062608	2		m	v	2				1	2														1	
97	-88.8037901	44.86063271	2		m	p	1	1	1		2	2					1									1	
98	-88.8044228	44.86063933																									
99	-88.8050555	44.86064596	2		m	v	1					1								2						1	
100	-88.8056882	44.86065257	4		m	p		1	1			1				1				1						1	
101	-88.806321	44.86065919	4		m	p					2	1				2						1				1	
102	-88.8069537	44.8606658																									
103	-88.8075864	44.86067241																									
104	-88.7885953	44.86092263																									
105	-88.789228	44.86092934	2		m	p	2				2	1			1	2					2					1	
106	-88.7898608	44.86093604	3		m	p	3				1	3				2										1	
107	-88.7904935	44.86094275	4		m	p	2					3														1	
108	-88.7911262	44.86094945	4		m	p	3				2	2								2						1	
109	-88.7917589	44.86095614	7		m	p	2					2															
110	-88.7923917	44.86096284	7		m	p						3															
111	-88.7930244	44.86096953	4		m	p	3				1	1														1	
112	-88.7936571	44.86097621	5		m	p	3					1														1	
113	-88.7942898	44.8609829	2		m	p			3		2	3										3				1	
114	-88.7974535	44.86101626	1		s	p	1					1								1							
115	-88.7980862	44.86102292	4		m	p	3					3				1										1	
116	-88.7993517	44.86103623	6		m	p					1	1														1	
117	-88.7999844	44.86104288	3		m	p	2					3				1											
118	-88.8006171	44.86104953	3		m	v	1	1			3	3														1	
119	-88.8012498	44.86105617	3		m	p	1	1				3								1						1	
120	-88.8018826	44.86106281																									
121	-88.8025153	44.86106945	3		m	v	1	1			3	3														1	
122	-88.803148	44.86107609	2		m	v					3	1								1						1	
123	-88.8037808	44.86108272	2		m	v	2	1			3	2								2							
124	-88.8044135	44.86108934	6		m	p					1	1															
125	-88.8050462	44.86109596	3		m	v	2				1	1															
126	-88.8056789	44.86110258	3		m	v	1	1			1	1								2							
127	-88.8063117	44.8611092	2		m	p	1	1			2	3														1	
128	-88.8069444	44.86111581																									
129	-88.8075771	44.86112242		Ureachable																							
130	-88.8082099	44.86112903		Ureachable																							
131	-88.7885859	44.86137263	2		m	p	2				1	1				2						1				1	
132	-88.7892186	44.86137934	3		m	p	3				1	3				1										1	
133	-88.7898513	44.86138605	3		m	p	3					3				1										1	
134	-88.7904841	44.86139275	4		m	p	2				2	2														1	
135	-88.7911168	44.86139946	4		m	p	3				1	1									1						
136	-88.7917495	44.86140615	4		m	p	2				1	1															
137	-88.7923823	44.86141285	4		m	p	3				1	1	1													1	
138	-88.793015	44.86141953	4		m	p	3				1	3														1	
139	-88.7936477	44.86142622	5		m	p	3				1	3														1	
140	-88.7942804	44.8614329	2		m	p	1		3		1	3										1				1	
141	-88.7968114	44.8614596	1		m	p	1				1	1														1	
142	-88.7974441	44.86146626	3		m	v	1	1				2				1										1	

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Heteranthera dubia*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Sagittaria latifolia*	*Eleocharis acicularis*	*Lemna trisulca*	*All Free-Floating Species*	*Potamogeton natans*
143	-88.7980768	44.86147293	4		m	p	1					3														1	
144	-88.7987096	44.86147958	4		m	p	1	1			1	3														1	
145	-88.8006078	44.86149954	3		m	p	1	1			3	3								1						1	
146	-88.8012405	44.86150618	4		m	p	3																			1	
147	-88.8018732	44.86151282	3		m	p		1			1	1								3						1	
148	-88.802506	44.86151946	14	Too Deep																							
149	-88.8031387	44.86152609	5		m	p	1				3	2								1						1	
150	-88.8037714	44.86153272	6		m	p					1	1								1						1	
151	-88.8044042	44.86153935	4		m	v			2		1	1								1						1	
152	-88.8050369	44.86154597	2		m	v	1	2	2		2	1								1						1	
153	-88.8056696	44.86155259	2		m	v		2	2		2	2								1						1	
154	-88.8063024	44.86155921	1		m	v	1	1	1		2	1								1						1	
155	-88.8069351	44.86156582	1		m	v					1	1						1		1						1	
156	-88.8075678	44.86157243		Ureachable																							
157	-88.8082006	44.86157904		Ureachable																							
158	-88.8088333	44.86158564		Ureachable																							
159	-88.809466	44.86159224		Ureachable																							
160	-88.7885764	44.86182264	3		m	p	1				1	1														1	
161	-88.7892092	44.86182935	4		m	p	1			1		3									1					1	
162	-88.7898419	44.86183606	3		m	p	3				3	3														1	
163	-88.7904746	44.86184276	4		m	p	3					3														1	
164	-88.7911074	44.86184946	5		m	p	3					3															
165	-88.7917401	44.86185616	5		m	p	1				1	1	1													1	
166	-88.7923728	44.86186285	5		m	p	3				1	3														1	
167	-88.7930056	44.86186954	6		m	p	2				2	2	1													1	
168	-88.7936383	44.86187623	4		m	p	1				1	3														1	
169	-88.7942711	44.86188291	2		m	p	1		3			3										1				1	
170	-88.7961693	44.86190294	2		m	p				1	1	3														1	
171	-88.796802	44.86190961	8		m	p					1	2														1	
172	-88.7974347	44.86191627	5		m	p	3					3														1	
173	-88.7980675	44.86192293																									
174	-88.8012312	44.86195619	4		m	p						1														1	
175	-88.8062931	44.86200922	2		m	v	1	1	1		1	1				1										1	
176	-88.8069258	44.86201583	3		m	v		1			3	3															
177	-88.8075586	44.86202244	2		m	v		1			3	1				1										1	
178	-88.8081913	44.86202905		Ureachable																							
179	-88.808824	44.86203565		Ureachable																							
180	-88.8094568	44.86204225		Ureachable																							
181	-88.8100895	44.86204884		Ureachable																							
182	-88.8107223	44.86205543		Ureachable																							
183	-88.788567	44.86227265	4		m	p	3				3	3				1										1	
184	-88.7891997	44.86227936	4		m	p	3				3	3				1										1	
185	-88.7898325	44.86228606	4		m	p	3				3	3														1	
186	-88.7904652	44.86229277	5		m	p	3				1	1				1										1	
187	-88.791098	44.86229947	5		m	p	1				1	3														1	
188	-88.7917307	44.86230617																									
189	-88.7923634	44.86231286	5		m	p	2				1															1	
190	-88.7929962	44.86231955	9		m	p					3	3															
191	-88.7936289	44.86232624	3		m	p	1				1	3														1	
192	-88.7955271	44.86234627	1		m	p	1			1	1	1				1										1	
193	-88.7961599	44.86235295	7		m	p					3	1														1	
194	-88.7967926	44.86235962	4		m	p	3																			1	
195	-88.7974254	44.86236628	3		m	p	2		1		2	2														1	
196	-88.805651	44.86245261	1		m	v			2			3				1						2				1	
197	-88.8062838	44.86245923	2		m	v	1	1			1	2				2										1	
198	-88.8069165	44.86246584	4		m	p	1	1	1		2	2														1	
199	-88.8075493	44.86247245	1		m	p			1		1	3				1										1	
200	-88.808182	44.86247906		Ureachable																							
201	-88.8088148	44.86248566		Ureachable																							
202	-88.8094475	44.86249226		Ureachable																							
203	-88.8100802	44.86249885		Ureachable																							
204	-88.810713	44.86250544		Ureachable																							
205	-88.7891903	44.86272936	3		m	p	1			1	3	3														1	
206	-88.7898231	44.86273607	2		m	p					1			1		2	1				2					1	
207	-88.7904558	44.86274278	3		m	p	3				3	3								1						1	
208	-88.7910885	44.86274948	4		m	p	1			3	3	3				1										1	
209	-88.7917213	44.86275617	4		m	p	2		1		3	3														1	
210	-88.792354	44.86276287	3		m	p	1	1	1		3	3														1	
211	-88.7936195	44.86277624	4		m	p	2				1	2	1													1	
212	-88.7942523	44.86278293	3		m	p	1			3	1	1				1										1	
213	-88.794885	44.86278961	7		m	p	2				1	2	1													1	

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Heteranthera dubia*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Sagittaria latifolia*	*Eleocharis acicularis*	*Lemna trisulca*	*All Free-Floating Species*	*Potamogeton natans*
214	-88.7955178	44.86279628	4		m	p	2	1			1	3				1										1	
215	-88.7961505	44.86280295	4		m	p	3				1	1														1	
216	-88.7967833	44.86280962	5		m	p	3					3														1	
217	-88.797416	44.86281629	4		m	p	1				1	3														1	
218	-88.8056417	44.86290262	3		m	p	1	1			1	3				1		1								1	
219	-88.8062745	44.86290924	2		m	p	2		1			1		1		3					1					1	
220	-88.8069072	44.86291585	3		m	v	1	2	1		1	3				2										1	
221	-88.80754	44.86292246		Ureachable																							
222	-88.810071	44.86294886		Ureachable																							
223	-88.8107037	44.86295546		Ureachable																							
224	-88.8113365	44.86296204		Ureachable																							
225	-88.7891809	44.86317937	1		m	p				1	3	3										2				1	
226	-88.7898136	44.86318608	2		m	p				3	1			3	1						2						
227	-88.7904464	44.86319278	2		m	p			2	2	1	1			2					2						1	
228	-88.7910791	44.86319948	3		m	p	1		2	2		2			1											1	
229	-88.7917119	44.86320618	4		m	p	3		1		3	3				1	1									1	
230	-88.7923446	44.86321287	4		m	p	2		1		2	2				1										1	
231	-88.7929774	44.86321956	5		m	p	2				3	3														1	
232	-88.7936101	44.86322625	5		m	p	2				1	2														1	
233	-88.7942429	44.86323293	4		m	p	3					3														1	
234	-88.7948756	44.86323961	5		m	p	3					3														1	
235	-88.7955084	44.86324629	7		m	p	2					3														1	
236	-88.7961411	44.86325296	2		m	p	3				1	3														1	
237	-88.7967739	44.86325963	2		m	p	3		1		1	3														1	
238	-88.7974066	44.8632663	4		m	p	3		2		2	2				2										1	
239	-88.7980394	44.86327296	3		m	p	3					3														1	
240	-88.7986721	44.86327962																									
241	-88.8056324	44.86335263																									
242	-88.8062652	44.86335925	2		m	p	1		2		1	3				3										1	
243	-88.8068979	44.86336586	1		m	p	1		2			3				2										1	
244	-88.8106945	44.86340547		Ureachable																							
245	-88.8113272	44.86341205		Ureachable																							
246	-88.81196	44.86341864		Ureachable																							
247	-88.8125927	44.86342522		Ureachable																							
248	-88.7898042	44.86363608	2		m	p	1		2	2	1		3	1					1		1					1	
249	-88.7904369	44.86364279	2		m	p	2	2	2			3				2										1	
250	-88.7910697	44.86364949	2		m	p			1	3					2	1					2					1	
251	-88.7917025	44.86365619	3		m	p			1	2	1									2						1	
252	-88.7923352	44.86366288	3		m	p	1		2		1	1				2										1	
253	-88.792968	44.86366957	4		m	p	1				3	3														1	
254	-88.7936007	44.86367626	3		m	p					3	3														1	
255	-88.7942335	44.86368294	5		m	p	3				1	3														1	
256	-88.7948662	44.86368962	4		m	p	3		1			3														1	
257	-88.795499	44.8636963	4		m	p	3				1	3														1	
258	-88.7961317	44.86370297	3		m	p	3				1	3														1	
259	-88.7967645	44.86370964	4		m	p	3					3				1										1	
260	-88.7973973	44.8637163	4		m	p	3				1	3				1										1	
261	-88.79803	44.86372297	3		m	p	3				1	3				1										1	
262	-88.8056231	44.86380264	2		m	p	2	1	1			1		2		3										1	
263	-88.8062559	44.86380926	2		m	p	1		2			2				3		1			1					1	3
264	-88.8106852	44.86385548		Ureachable																							
265	-88.811318	44.86386206		Ureachable																							
266	-88.8125835	44.86387523		Ureachable																							
267	-88.7897948	44.86408609	2		m	p				3	1	1	2	3	2	1					1						
268	-88.7904275	44.8640928	2		m	p			1	3		1		1	1		1				1						
269	-88.7910603	44.8640995	2		m	p				2	1	1		2	2						1					1	
270	-88.791693	44.86410619	2		m	p	1		2	2	1	1				1										1	
271	-88.7923258	44.86411289	2		m	p	2		2		3	2				2										1	
272	-88.7929586	44.86411958	4		m	p	3				3	2				1										1	
273	-88.7935913	44.86412626	3		m	p	1		1		3					3										1	
274	-88.7942241	44.86413295	4		m	p	3		1		1	3														1	
275	-88.7948568	44.86413963	2		m	p	3		1	1		3														1	
276	-88.7954896	44.8641463	4		m	p	2		1		2	1	1													1	
277	-88.7961224	44.86415298	4		m	p	3					2														1	
278	-88.7967551	44.86415965	3		m	p	3				1	1														1	
279	-88.8113087	44.86431207		Ureachable																							
280	-88.8119415	44.86431866		Ureachable																							
281	-88.7897853	44.8645361	1		m	p				3	1			3			1		1							1	
282	-88.7904181	44.8645428	1		m	p				3	1			3	1						1					1	
283	-88.7910509	44.8645495	2		m	p			2	3	2				2						1					1	
284	-88.7916836	44.8645562	2		m	p	1		2	3	3	2			3	2			1							1	

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Heteranthera dubia*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Sagittaria latifolia*	*Eleocharis accicularis*	*Lemna trisulca*	*All Free-Floating Species*	*Potamogeton natans*
285	-88.7923164	44.86456289	10		m	p	1				1	1														1	
286	-88.7929492	44.86456958	14	Too Deep																							
287	-88.7935819	44.86457627	10		m	p					1	1				1											
288	-88.7942147	44.86458296	6		m	p	1				1	2				1										1	
289	-88.7948475	44.86458964	3		m	p	1					3														1	
290	-88.7954802	44.86459631	14	Too Deep																							
291	-88.796113	44.86460298	4		m	p	1				1	1				1										1	
292	-88.7967457	44.86460965	3		m	p	1		1		1	1				1										1	
293	-88.7973785	44.86461632																									
294	-88.7897759	44.8649861	1		m	p	1			1	2	2	1								1					1	
295	-88.7904087	44.86499281	1		m	p	1			1	2	2		1	2	1			1		1					1	
296	-88.7910414	44.86499951	3		m	p	1		1	1	3	3		1		1	1									1	
297	-88.7916742	44.86500621	2		m	p	1		1	1	3	3		1		1										1	
298	-88.792307	44.8650129	12	Too Deep																							
299	-88.7929398	44.86501959	14	Too Deep																							
300	-88.7935725	44.86502628	14	Too Deep																							
301	-88.7942053	44.86503296	13		m	p						2														1	
302	-88.7948381	44.86503964	3		m	v	2																			1	
303	-88.7954708	44.86504632																									
304	-88.7897665	44.86543611	3		m	p	1			1	2	2									1					1	
305	-88.7903993	44.86544282	3		m	p	1		1	3	1	1		3	1	1	1				1					1	
306	-88.791032	44.86544952	3		m	p	3		1	2	3	3		3		1					1					1	
307	-88.7916648	44.86545621	1		m	p	1				1	1										1	1	2		1	2
308	-88.7922976	44.86546291	12	Too Deep																							
309	-88.7929303	44.8654696	13	Too Deep																							
310	-88.7935631	44.86547629	6		m	p	1				1	3															
311	-88.7941959	44.86548297	11		m	p						3														1	
312	-88.7948287	44.86548965																									
313	-88.7954614	44.86549633	2		m	p	3				3	3										2	2			1	
314	-88.7903898	44.86589282	4		m	p	1			1	2	2		2		1										1	
315	-88.7910226	44.86589952	4		m	p	2			3	2	2		2		1										1	
316	-88.7916554	44.86590622	4		m	p	2		1		2	2				1										1	
317	-88.7922882	44.86591292	4		m	p	2				2	1									1					1	
318	-88.7929209	44.86591961	2		m	p				2	2			3		1										1	
319	-88.7935537	44.86592629	1		m	p				2	1			3	2	1										1	
320	-88.7941865	44.86593298	3		m	p	3				3	3														1	
321	-88.7948193	44.86593966	3		m	p	1				1	3														1	



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Onterra LLC
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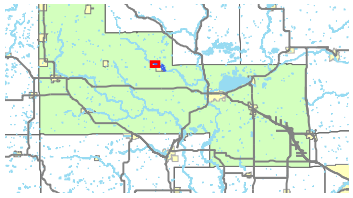
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Sample Locations: Onterra
Map date: March 20, 2008



Extent of large map shown in red.

Legend

Point-intercept Sample Location

Public Boat Landing

Appendix D

Upper Red Lake

Shawaon County, WI

Point-intercept Sample Locations

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton praelongus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Schoenoplectus pungens*	*Sagittaria latifolia*	*Sagittaria graminea*	*Schoenoplectus tabernaemontani*	*Typha latifolia*	*Ranunculus aquatilis*	*Typha angustifolia*	*Lemna trisulca*	*FFs*	*Potamogeton natans*
1	-88.7624528	44.84154533	8		m	p	2					1				1																
2	-88.7629588	44.84155081	14	Too Deep																												
3	-88.761939	44.84189985	11		m	r																										
4	-88.762445	44.84190533	18	Too Deep																												
5	-88.7629511	44.84191081	15	Too Deep																												
6	-88.7634571	44.84191629	25	Too Deep																												
7	-88.7619313	44.84225985	10		m	r																										
8	-88.7624373	44.84226533	12	Too Deep																												
9	-88.7629433	44.84227082	17	Too Deep																												
10	-88.7634494	44.8422763	24	Too Deep																												
11	-88.7639554	44.84228178	15	Too Deep																												
12	-88.7644614	44.84228725	1		s	v	1			2	1			2		1						1										
13	-88.7664854	44.84230914	1		m	v				2	1			2	1					1		1										
14	-88.7680035	44.84232552	1		m	v				1		2		2	1																	1
15	-88.7619236	44.84261985	8		m	p	3					1																				
16	-88.7624296	44.84262534		Too Deep																												
17	-88.7629356	44.84263082	12		m	r																										
18	-88.7634417	44.8426363	14	Too Deep																												
19	-88.7639477	44.84264178	21	Too Deep																												
20	-88.7644537	44.84264726	15	Too Deep																												
21	-88.7649597	44.84265273	16	Too Deep																												
22	-88.7654657	44.8426582	10		m	p	1																									
23	-88.7664777	44.84266914	1		m	v				2				2	1					1		1										
24	-88.7669838	44.8426746	1		m	v				1	1			2	2	1				1												
25	-88.7674898	44.84268007	1		m	v	1							2	1							1										
26	-88.7685018	44.84269099	1		m	v					2		2			1											1				1	1
27	-88.7619159	44.84297985	3		m	p	3																								1	
28	-88.7624219	44.84298534	4		m	p	3																								1	
29	-88.7629279	44.84299082	11		m	r																										
30	-88.763434	44.8429963	12	Too Deep																												
31	-88.76394	44.84300178	14	Too Deep																												
32	-88.764446	44.84300726	23	Too Deep																												
33	-88.764952	44.84301273	23	Too Deep																												
34	-88.765458	44.84301821	18	Too Deep																												
35	-88.765964	44.84302367	5		m	p	3					1				1																
36	-88.7664701	44.84302914	2		m	v	3			1	2	1				1																
37	-88.7669761	44.84303461	4		m	v	3				1	1																				
38	-88.7674821	44.84304007	4		m	v	3					1																				
39	-88.7679881	44.84304553	2		m	v	3				2		1																		1	1
40	-88.7684941	44.84305099	1		m	v				2	1		1		1					1	1										1	1
41	-88.7619082	44.84333986	2		m	p	2			2	1			1																	1	
42	-88.7624142	44.84334534	6		m	p	3					1																			1	
43	-88.7629202	44.84335083	5		m	p	3																								1	
44	-88.7634263	44.84335631	4		m	p	3					1																			1	
45	-88.7639323	44.84336179	5		m	p	3																									
46	-88.7644383	44.84336726	6		m	p	3					2				2																
47	-88.7649443	44.84337274	21	Too Deep																												
48	-88.7654503	44.84337821	17	Too Deep																												
49	-88.7659564	44.84338368	8		m	p	3					1																				
50	-88.7664624	44.84338915	9		m	r	1					1	1																			
51	-88.7669684	44.84339461	5		m	p	3					2																				
52	-88.7674744	44.84340007	2		m	v	2				2				1	2																
53	-88.7679804	44.84340553	2		m	v	2	2		1	2									1	1										1	
54	-88.7684865	44.84341099	2		m	v	1			1	2				1	1				1											1	1
55	-88.7649366	44.84373274	2		m	v	1			2	1											1										
56	-88.7654426	44.84373821	4		m	p	3																									
57	-88.7659487	44.84374368	6		m	p	3					1																				
58	-88.7664547	44.84374915	12		m	r																										
59	-88.7669607	44.84375461	6		m	p	3																									
60	-88.7679728	44.84376554		Unreachable																												
61	-88.7684788	44.843771	1		m	v	1				3				1	1			1	1	1	1					1				1	1
62	-88.7689848	44.84377645		Unreachable																												
63	-88.765435	44.84409821	2		m	v	3				1	1				1																
64	-88.765941	44.84410368	4		m	p	3																							1		
65	-88.766447	44.84410915	4		m	p	3																									
66	-88.766953	44.84411462	13		m	r																										
67	-88.7674591	44.84412008	5		m	p	3					1																				
68	-88.7684711	44.844131		Unreachable																												
69	-88.7659333	44.84446369		Unreachable																												
70	-88.7669454	44.84447462	5		m	p	3					1																				
71	-88.7674514	44.84448008	13		m	r																										
72	-88.7679574	44.84448555	4		m	p	3					2																				
73	-88.7669377	44.84483462	1		m	v	2			1	1	1		2		1															1	
74	-88.7674437	44.84484009	6		m	p	3					1																				
75	-88.7679497	44.84484555	13		m	r																										
76	-88.766424	44.84518916		Unreachable																												
77	-88.76693	44.84519463	1		m	v	2				2	1				1															1	
78	-88.767436	44.84520009	2		m	v	3				1	1				1																
79	-88.7679421	44.84520555	6		m	p	3					1																				

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton praelongus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Schoenoplectus pungens*	*Sagittaria latifolia*	*Sagittaria graminea*	*Schoenoplectus tabernaemontani*	*Typha latifolia*	*Ranunculus aquatilis*	*Typha angustifolia*	*Lemna trisulca*	*FFs*	*Potamogeton natans*
80	-88.7684481	44.84521101	6		m	p	3					1																				
81	-88.7689541	44.84521647	12		m	r																										
82	-88.7664163	44.84554917		Unreachable																												
83	-88.7674284	44.84556009	1		m	v	1				2																				1	
84	-88.7679344	44.84556556	4		m	v	3				1					1																
85	-88.7684404	44.84557101	6		m	p	3																									
86	-88.7689465	44.84557647	7		m	p	3																									
87	-88.7694525	44.84558193	11		m	r						1																				
88	-88.7709706	44.84559828	2		m	v	2			1	1	1		2								1										
89	-88.7714767	44.84560372	4		m	p	2			1	2	1																				
90	-88.7719827	44.84560916	6		m	p	1				1	3																				
91	-88.7724888	44.84561461	5		m	p	2					2							1													
92	-88.7729948	44.84562004	5		m	p	2					1				1			2													
93	-88.7735008	44.84562548	2		m	v	1					2			1	2		1	1													
94	-88.7740069	44.84563092	3		m	v	2					2				1			2													
95	-88.7745129	44.84563635	1		m	v	1					1				1									1	1					1	
96	-88.7689388	44.84593648	7		m	p	3					1																				
97	-88.7694449	44.84594193	11		m	r																										
98	-88.7699509	44.84594738	6		m	p	3					2																				
99	-88.7704569	44.84595283	4		m	v	3																									
100	-88.770963	44.84595828	4		m	v	3				1	1				1															1	
101	-88.771469	44.84596373	3		m	v	3									1															1	
102	-88.7689311	44.84629648	5		m	v	3				2																					
103	-88.7694372	44.84630193	11		m	r	1					1																				
104	-88.7689235	44.84665648	2		m	r	1				2	1																				
105	-88.7694295	44.84666194	10		m	r						2																				
106	-88.7689158	44.84701649	11		m	r																										
107	-88.7694219	44.84702194	9		m	p	2					1																				
108	-88.7689081	44.84737649	12		m	r																										
109	-88.7694142	44.84738194	6		m	p	3					1																				
110	-88.7683944	44.84773104		Unreachable																												
111	-88.7689005	44.84773649	12		m	r																										
112	-88.7694065	44.84774195	6		m	p	3					2				1																
113	-88.7699126	44.8477474	5		m	p	3					2																				
114	-88.7663625	44.84806919		Unreachable																												
115	-88.7668685	44.84807465	1		m	v	1	1			2	2		2	2																	
116	-88.7673746	44.84808012	1		m	v	1				3			1	1	1																
117	-88.7678807	44.84808558	2		m	v	2			1	2	1			1	1																
118	-88.7683867	44.84809104	2		m	v	3			1	1	1			1	1																
119	-88.7688928	44.8480965	9		m	r						2	1																			
120	-88.7693989	44.84810195	6		m	p	3					2																				
121	-88.7699049	44.8481074	6		m	p	3																								1	
122	-88.770411	44.84811285	1		m	r	1			1	1	1			1	3																
123	-88.770917	44.8481183	1		m	v				1						1																3
124	-88.7714231	44.84812375	2		m	v				1	1	1																			1	3
125	-88.7658487	44.84842372		Unreachable																												
126	-88.7663548	44.84842919		Unreachable																												
127	-88.7668609	44.84843466	1		m	v	1			1			1	1	2	1				1	1											
128	-88.7673669	44.84844012	1		m	v				1	1	1	2	1		1					1											
129	-88.767873	44.84844558	1		m	v	1			1	2				1	1					1											
130	-88.7683791	44.84845104	1		m	v	3									2																
131	-88.7688851	44.8484565	9		m	r						1																				
132	-88.7693912	44.84846195	10		m	r	1					2																				
133	-88.7698973	44.84846741	7		m	p	3																								1	
134	-88.7704033	44.84847286	6		m	p	3																									
135	-88.7709094	44.84847831	6		m	p	3																									
136	-88.7714155	44.84848375	3		m	p	3				1	1																				
137	-88.7719215	44.8484892	2		m	p	1			2	1			2	1	1			1												1	
138	-88.765841	44.84878373		Unreachable																												
139	-88.7663471	44.84878919		Unreachable																												
140	-88.7668532	44.84879466		Unreachable																												
141	-88.7688775	44.8488165	1		m	v	1									1															1	
142	-88.7693835	44.84882196	11		m	r																										
143	-88.7698896	44.84882741	10		m	r																										
144	-88.7703957	44.84883286	11		m	r																										
145	-88.7709017	44.84883831	11		m	r	1					1																				
146	-88.7714078	44.84884376	5		m	p	3																									
147	-88.7719139	44.8488492	6		m	p	3																								1	
148	-88.7724199	44.84885464	4		m	p	3	1		1		1				1																
149	-88.7658334	44.84914373		Unreachable																												
150	-88.7663394	44.8491492		Unreachable																												
151	-88.7693759	44.84918196	1		m	v	3									1															1	
152	-88.7698819	44.84918741	3		m	p	3					1																				
153	-88.770388	44.84919287	5		m	p	3					1																			1	
154	-88.7708941	44.84919831	8		m	p	2					2																				
155	-88.7714001	44.84920376	6		m	p	3					1																		1		
156	-88.7719062	44.8492092	7		m	p	3																								1	
157	-88.7724123	44.84921465	11		m	r	1																									
158	-88.7729184	44.84922008	2		m	p	3	1		1					1	1																

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton praelongus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Schoenoplectus pungens*	*Sagittaria latifolia*	*Sagittaria graminea*	*Schoenoplectus tabernaemontani*	*Typha latifolia*	*Ranunculus aquatilis*	*Typha angustifolia*	*Lemna trisulca*	*FFs*	*Potamogeton natans*
159	-88.7734244	44.84922552	2		m	p	2			1	1	1			1	2																
160	-88.7739305	44.84923096	1		r	p	1			3	1								1													
161	-88.7653196	44.84949826		Unreachable																												
162	-88.7658257	44.84950373		Unreachable																												
163	-88.7663317	44.8495092		Unreachable																												
164	-88.7703803	44.84955287		Unreachable																												
165	-88.7708864	44.84955832	8		m	p	2					1																				
166	-88.7713925	44.84956376	6		m	p	3				1	1																			1	
167	-88.7718986	44.84956921	7		m	p	3																								1	
168	-88.7724046	44.84957465	11		m	r																										
169	-88.7729107	44.84958009	11		m	r																										
170	-88.7734168	44.84958553	10		m	r	1														1										1	
171	-88.7739229	44.84959096	3		m	p	3																									
172	-88.774429	44.84959639	3		m	p	3																							1		
173	-88.774935	44.84960182	3		m	p	3								1																	
174	-88.7703727	44.84991287	1		m	v	3			1	1											1									1	
175	-88.7708788	44.84991832	2		m	v	3			1	1	1				1															1	
176	-88.7713848	44.84992377	5		m	p	3					1																			1	
177	-88.7718909	44.84992921	8		m	p	3																									
178	-88.772397	44.84993465	9		m	p	3										2															
179	-88.7729031	44.84994009	8		m	p	3					1																				
180	-88.7734092	44.84994553	5		m	p	3																								1	
181	-88.7739152	44.84995096	5		m	p	3																									
182	-88.7744213	44.8499564	5		m	p	3																							1		
183	-88.7749274	44.84996183	4		m	p	3																									
184	-88.7754335	44.84996726	3		m	p	3																									
185	-88.7759396	44.84997268	2		m	p	2			3	1				1	1			1													
186	-88.7708711	44.85027832	2		m	v	2			2	1					1															1	
187	-88.7713772	44.85028377	2		m	p	2			2	1	1	1																		1	
188	-88.7718833	44.85028921	10		m	r						1	1																			
189	-88.7723893	44.85029466	9		m	p	3																									
190	-88.7728954	44.8503001	8		m	p	3					1																			1	
191	-88.7734015	44.85030553	6		m	p	3																									
192	-88.7739076	44.85031097	5		m	p	3																								1	
193	-88.7744137	44.8503164	6		m	p	3					1																				
194	-88.7749198	44.85032183	6		m	p	2					1																				
195	-88.7754258	44.85032726	5		m	p	3					1																				
196	-88.7759319	44.85033269	4		m	p	2			1	1						1														1	
197	-88.776438	44.85033811	3		m	p	3			1	1				1		1															
198	-88.7769441	44.85034353	2		m	p	1			2	1				1	1			1		1											
199	-88.7708634	44.85063833	2		m	v	2			1	1				1	2				1											1	
200	-88.7713695	44.85064377	3		m	p	3				1	1				1															1	
201	-88.7718756	44.85064922	10		m	r							1																			
202	-88.7723817	44.85065466	8		m	p	3					1																				
203	-88.7728878	44.8506601	7		m	p	3					1																			1	
204	-88.7733939	44.85066554	9		m	p	1																									
205	-88.7739	44.85067097	5		m	p	3																								1	
206	-88.774406	44.85067641	6		m	p	3																									
207	-88.7749121	44.85068184	6		m	p	3					1																			1	
208	-88.7754182	44.85068727	6		m	p	3																									
209	-88.7759243	44.85069269	8		m	p	2					2																				
210	-88.7764304	44.85069812	6		m	p	3				1	1																		1		
211	-88.7769365	44.85070354	5		m	p	3					1																		1		
212	-88.7774426	44.85070896	3		m	p	1			3	1	1				1			1												1	
213	-88.7779487	44.85071437	2		m	p	1			2	1	1				1			1		1										1	
214	-88.7708558	44.85099833	2		m	v	3			2	1	1			1																1	
215	-88.7713619	44.85100378	5		m	p	2					1																			1	
216	-88.771868	44.85100922	8		m	p	2										2															
217	-88.7723741	44.85101466	9		m	r	1					3																				
218	-88.7728801	44.8510201	7		m	p	3																								1	
219	-88.7733862	44.85102554	6		m	p	3					1																				
220	-88.7738923	44.85103098	10		m	r						3					1															
221	-88.7743984	44.85103641	6		m	p	3																									
222	-88.7749045	44.85104184	6		m	p	3					1																			1	
223	-88.7754106	44.85104727	6		m	p	3					1																		1		
224	-88.7759167	44.8510527	6		m	p	1				1	1					3														1	
225	-88.7764228	44.85105812	7		m	p	3																									
226	-88.7769289	44.85106354	4		m	p	3																							1		
227	-88.7774349	44.85106896	4		m	p	3				1																					
228	-88.777941	44.85107438	4		m	p	3			2																					1	
229	-88.7784471	44.85107979	3		m	p	2			1		1			1	1												1			1	
230	-88.7789532	44.85108521	2		m	p	2			1	1	1			1	1			1		1										1	
231	-88.7794593	44.85109062	2		m	p	2			2	1					1												1			1	
232	-88.7799654	44.85109603	2		m	p	2	1			1	1																1			1	
233	-88.770342	44.85135289		Unreachable																												
234	-88.7708481	44.85135833	2		m	v	3				1					2															1	
235	-88.7713542	44.85136378	5		m	p	3					1																			1	
236	-88.7718603	44.85136923	9		m	r	2					1					2															
237	-88.7723664	44.85137467	8		m	p	1					2																				

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton praelongus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Schoenoplectus pungens*	*Sagittaria latifolia*	*Sagittaria graminea*	*Schoenoplectus tabernaemontani*	*Typha latifolia*	*Ranunculus aquatilis*	*Typha angustifolia*	*Lemna trisulca*	*FFs*	*Potamogeton natans*
238	-88.7728725	44.85138011	7		m	p	3																									
239	-88.7733786	44.85138555	6		m	p	3																									
240	-88.7738847	44.85139098	8		m	p	3																									
241	-88.7743908	44.85139641	7		m	p	3																									
242	-88.7748969	44.85140184	6		m	p	3					1																				
243	-88.775403	44.85140727	7		m	p	3																							1		
244	-88.7759091	44.8514127	7		m	p	3					1																		1		
245	-88.7764151	44.85141812	7		m	p	3					1																		1		
246	-88.7769212	44.85142355	6		m	p	3					1																				
247	-88.7774273	44.85142897	7		m	p	3					1																			1	
248	-88.7779334	44.85143438	6		m	p	3					1																			1	
249	-88.7784395	44.8514398	6		m	p	3																								1	
250	-88.7789456	44.85144521	4		m	p	3					1																			1	
251	-88.7794517	44.85145062	4		m	p	3																								1	
252	-88.7799578	44.85145603	3		m	p	3	1			1	2																			1	
253	-88.7703344	44.85171289	1		m	v	2			2	3																					1
254	-88.7708405	44.85171834	4		m	p	3				2		1																			
255	-88.7713466	44.85172379	5		m	p	3					2																			1	
256	-88.7718527	44.85172923	6		m	p	3																									
257	-88.7723588	44.85173467	8		m	p	1					1																				
258	-88.7728648	44.85174011	9		m	p	3																									
259	-88.7733709	44.85174555	6		m	p	3																							1		
260	-88.773877	44.85175098	8		m	p	3																									
261	-88.7743831	44.85175642	7		m	p	3																									
262	-88.7748892	44.85176185	8		m	p	3					1																				
263	-88.7753953	44.85176728	7		m	p	3					1																				
264	-88.7759014	44.8517727	7		m	p	3																									
265	-88.7764075	44.85177813	6		m	p	3																									
266	-88.7769136	44.85178355	7		m	p	3																								1	
267	-88.7774197	44.85178897	6		m	p	3					1																			1	
268	-88.7779258	44.85179439	5		m	p	3					1																			1	
269	-88.7784319	44.8517998	6		m	p	3																								1	
270	-88.778938	44.85180522	6		m	p	3																								1	
271	-88.7794441	44.85181063	4		m	p	3					1																			1	
272	-88.7799502	44.85181603	4		m	p	3	1				2																			1	
273	-88.7708328	44.85207834	3		m	v	3				2																				1	
274	-88.7713389	44.85208379	5		m	p	3					1																			1	
275	-88.771845	44.85208923	6		m	p	3																									
276	-88.7723511	44.85209468		Too Deep																												
277	-88.7728572	44.85210012	9		m	p	1					2																				
278	-88.7733633	44.85210555	11		m	r							2																			
279	-88.7738694	44.85211099	12		m	r																										
280	-88.7743755	44.85211642	11		m	r							2																			
281	-88.7748816	44.85212185	9		m	p	1																									
282	-88.7753877	44.85212728	7		m	p	3																									
283	-88.7758938	44.85213271	6		m	p	2																							1		
284	-88.7763999	44.85213813	12		m	p	1																									
285	-88.776906	44.85214355	8		m	p	1																									
286	-88.7774121	44.85214897	12		m	r	1					2																				
287	-88.7779182	44.85215439	6		m	p	3																									
288	-88.7784243	44.85215981	8		m	p	3																									
289	-88.7789304	44.85216522	8		m	p	3																								1	
290	-88.7794365	44.85217063	8		m	p	2					1																				
291	-88.7799426	44.85217604	6		m	p	3					1																			1	
292	-88.7804487	44.85218145	4		m	p	2	2		1	1	1		1		1															1	
293	-88.7708251	44.85243835	2		s	v	2			1	3				1	2																
294	-88.7713313	44.85244379	4		m	p	3					1	3																			
295	-88.7718374	44.85244924	6		m	p	3																									
296	-88.7723435	44.85245468	9		m	p	3																									
297	-88.7728496	44.85246012	7		m	p	3																									
298	-88.7733557	44.85246556	7		m	p	3																									
299	-88.7738618	44.85247099	7		m	p	2																									
300	-88.7743679	44.85247643	6		m	p	2					1																				
301	-88.774874	44.85248186	6		m	p	2																									
302	-88.7753801	44.85248729	6		m	p	2										2															
303	-88.7758862	44.85249271	6		m	p	2																									
304	-88.7763923	44.85249814	7		m	p	2																									
305	-88.7768984	44.85250356	6		m	p	2																									
306	-88.7774045	44.85250898	8		m	p	2																									
307	-88.7779106	44.8525144	7		m	p	2					1																				
308	-88.7784167	44.85251981	6		m	p	3					1																				
309	-88.7789228	44.85252522	7		m	p	3					1																				
310	-88.7794289	44.85253064	8		m	p	3																								1	
311	-88.779935	44.85253604	10		m	r																										
312	-88.7804411	44.85254145	6		m	p	3					1																			1	
313	-88.7809472	44.85254685	3		m	p	3	1				1																				
314	-88.7814533	44.85255226	2		m	p	3	1				1																			1	
315	-88.7708175	44.85279835	2		s	v	1			2	1		1		1	3																
316	-88.7713236	44.8528038	2		m	p	3			2	1	1					1															

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton praelongus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Schoenoplectus pungens*	*Sagittaria latifolia*	*Sagittaria graminea*	*Schoenoplectus tabernaemontani*	*Typha latifolia*	*Ranunculus aquatilis*	*Typha angustifolia*	*Lemna trisulca*	*FFs*	*Potamogeton natans*
317	-88.7718297	44.85280924	5		m	p	2					2				1	1															
318	-88.7723358	44.85281468	9		m	p	3																									
319	-88.7728419	44.85282012	7		m	p	3					1																				
320	-88.773348	44.85282556	6		m	p	2				1						1															
321	-88.7738541	44.852831	7		m	p	2																							1		
322	-88.7743602	44.85283643	6		m	p	2																									
323	-88.7748663	44.85284186	4		m	p	2																									
324	-88.7753724	44.85284729	2		m	p	2			1	1	1																			1	
325	-88.7758785	44.85285272	2		m	p	2			1	1	1					1														1	
326	-88.7763846	44.85285814	2		m	p	1			1		1				1																
327	-88.7768908	44.85286356	2		m	p	2																1							1		
328	-88.7773969	44.85286898	2		m	p	3					1																		1		
329	-88.777903	44.8528744	2		m	p	3					1																			1	
330	-88.7784091	44.85287982	2		m	p	3					1																			1	
331	-88.7789152	44.85288523	3		m	p	3				1	1			1	1															1	
332	-88.7794213	44.85289064	4		m	p	3																								1	
333	-88.7799274	44.85289605	4		m	p	3															1									1	
334	-88.7804335	44.85290146	4		m	p	3									1															1	
335	-88.7809396	44.85290686	1		m	p	1			2		1																		1		
336	-88.7814457	44.85291226	10		m	p				2																						
337	-88.7819518	44.85291766	6		m	p	3					1																			1	
338	-88.7824579	44.85292306	4		m	p	3																								1	
339	-88.7703037	44.8531529		Unreachablenre																												
340	-88.7708098	44.85315835	1		s	v	2			2	1				1			1		1												
341	-88.7713159	44.8531638	3		m	p	3					1					1															
342	-88.771822	44.85316924	5		m	p	2					2																				
343	-88.7723282	44.85317469	9		m	p	3										1															
344	-88.7728343	44.85318013	8		m	p	3																									
345	-88.7733404	44.85318556	6		m	p	2										1															
346	-88.7738465	44.853191	7		m	p	2																									
347	-88.7773892	44.85322899	1		m	p	1					2										1									1	
348	-88.7778954	44.8532344	3		m	p	1				1	2				2															1	
349	-88.7784015	44.85323982	2		m	p	3				1	1																				
350	-88.7789076	44.85324523	4		m	p	3				1	1																			1	
351	-88.7794137	44.85325064		Unreachablenre																												
352	-88.7799198	44.85325605		Unreachablenre																												
353	-88.7804259	44.85326146		Unreachablenre																												
354	-88.780932	44.85326686	3		m	p	3					1																			1	
355	-88.7814381	44.85327227	6		m	p	3					1																			1	
356	-88.7819442	44.85327767	12		m	p																										
357	-88.7824503	44.85328306	6		m	p	3																								1	
358	-88.7829565	44.85328846	4		m	p	3																								1	
359	-88.7834626	44.85329385	4		m	p	3					1																			1	
360	-88.7839687	44.85329924		Unreachablenre																												
361	-88.7702961	44.85351291		Unreachablenre																												
362	-88.7708022	44.85351836	1		s	v	1			1					1	1		1	1	1												
363	-88.7713083	44.8535238	3		m	p	2			1						1	1															
364	-88.7718144	44.85352925	5		m	p	2																									
365	-88.7723205	44.85353469	9		m	p	2					2																				
366	-88.7728266	44.85354013	8		m	p	1					1					1															
367	-88.7733327	44.85354557	6		m	p	2																									
368	-88.7778877	44.85359441	1		m	p						2										1					1				1	
369	-88.7783939	44.85359982	5		m	p	1				1	3																				
370	-88.7789	44.85360524	1		m	p	2				2	1			1	1					1											
371	-88.7794061	44.85361065		Unreachablenre																												
372	-88.7804183	44.85362146		Unreachablenre																												
373	-88.7809244	44.85362687	2		m	p	3	1		1	1																				1	
374	-88.7814305	44.85363227	3		m	p	2				1	2				1															1	
375	-88.7819366	44.85363767	2		m	p	3	1				1																			1	
376	-88.7824428	44.85364307	11		m	r	1					1																				
377	-88.7829489	44.85364846	10		m	p	1			2																				1		
378	-88.783455	44.85365386	8		m	p	1			1	1	1																		1		
379	-88.7839611	44.85365925	8		m	p	3					2																			1	
380	-88.7844672	44.85366464	8		m	p	2			1		1	1																	1		
381	-88.7849733	44.85367002	6		r	p	3																									
382	-88.7854794	44.85367541	6		r	p				1																						
383	-88.7702884	44.85387291		Unreachablenre																												
384	-88.7707945	44.85387836	1		s	v	1			1	1				1	1		1	1	1												
385	-88.7713006	44.85388381	2		m	v	2						1		1		1															
386	-88.7718067	44.85388925	4		m	p	3																									
387	-88.7723129	44.85389469	8		m	p	1					1					2															
388	-88.772819	44.85390013	8		m	p	3					2																				
389	-88.7733251	44.85390557	6		m	p	2																									
390	-88.7783862	44.85395983		Unreachablenre																												
391	-88.7788924	44.85396524	2		m	p	3				1																				1	
392	-88.7793985	44.85397065	1		m	p	2			1	1	1				1												1			1	
393	-88.7799046	44.85397606	2		m	p	2	1			1	1																	1		1	
394	-88.7804107	44.85398147	2		m	p	2																						1		1	
395	-88.7814229	44.85399228	2		r	v	3				1	1										1		1							1	

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton praelongus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Schoenoplectus pungens*	*Sagittaria latifolia*	*Sagittaria graminea*	*Schoenoplectus tabernaemontani*	*Typha latifolia*	*Ranunculus aquatilis*	*Typha angustifolia*	*Lemna trisulca*	*FFs*	*Potamogeton natans*
396	-88.7819291	44.85399768	2		m	p	3				1	1																				
397	-88.7824352	44.85400307	3		m	p	1			1		1																			1	
398	-88.7829413	44.85400847	4		m	p	3					1																			1	
399	-88.7834474	44.85401386	8		m	p	1			2		1																				
400	-88.7839535	44.85401925	8		m	p	3	1		1	1	1				1																
401	-88.7844596	44.85402464	12		m	r																										
402	-88.7707869	44.85423836	1		s	v	1	1		1					1	1		1	1	1		1										
403	-88.771293	44.85424381	2		m	p	3					1				1	1															
404	-88.7717991	44.85424925	2		m	p	1					2																				
405	-88.7723052	44.8542547	7		m	p	1					1																				
406	-88.7728113	44.85426014	7		m	p	3																									
407	-88.7733174	44.85426558	6		m	p	3																									
408	-88.7829337	44.85436847	2		m	p	2				1	1										2									1	
409	-88.7834398	44.85437387	4		m	p	3			1		1				1															1	
410	-88.7707792	44.85459837	1		m	v	1				1				2	2						1										
411	-88.7712853	44.85460381	2		m	p	2			1	1	1			1	1	1															
412	-88.7717914	44.85460926	3		m	p	1									2																
413	-88.7722976	44.8546147	8		m	p	1				1	2					1															
414	-88.7728037	44.85462014	7		m	p	2																									
415	-88.7733098	44.85462558	6		m	p	2																									
416	-88.7738159	44.85463101	5		m	p	1				2	2																				
417	-88.7712777	44.85496382	2		m	v	2			2	1	1			1	1																
418	-88.7717838	44.85496926	3		m	p	1				1	1				2	1															
419	-88.7722899	44.8549747	7		m	p	2					1					1															
420	-88.772796	44.85498014	6		m	p	2					2					1															
421	-88.7733022	44.85498558																														
422	-88.7738083	44.85499102	5		m	p	1					3				1																
423	-88.77127	44.85532382	2		m	v	1			2	1	1			1	1																
424	-88.7717761	44.85532926	2		m	v	2				2	1					1															
425	-88.7722823	44.85533471	7		m	p	1					2																				
426	-88.7727884	44.85534015	6		m	p	3																									
427	-88.7732945	44.85534559	7		m	p	2																									
428	-88.7738006	44.85535102	9		m	p	1					1																				
429	-88.7743068	44.85535646	4		m	p	2					2																				
430	-88.7712623	44.85568382	2		m	v	2			1	1					1															1	
431	-88.7717685	44.85568927	3		m	p	1				3	1				1																
432	-88.7722746	44.85569471	7		m	p	2					3																				
433	-88.7727807	44.85570015	6		m	p	3					1																				
434	-88.7732869	44.85570559	8		m	p						1																				
435	-88.773793	44.85571103	6		m	p	2				1																					
436	-88.7742991	44.85571646	4		m	p	2																									
437	-88.7748053	44.85572189	2		m	p	2				1																					
438	-88.7707486	44.85603838	1		m	v	1	1		1	2	1				1						1					1				1	
439	-88.7712547	44.85604383	1		m	v	2				2	1																				
440	-88.7717608	44.85604927	2		m	p	1				2	1					1															
441	-88.772267	44.85605471	5		m	p	2					1					1															
442	-88.7727731	44.85606015	6		m	p	1					1					2															
443	-88.7732792	44.85606559	5		m	p	2					1																				
444	-88.7737854	44.85607103	6		m	p	3																									
445	-88.7742915	44.85607646	2		m	p	2																									
446	-88.7747976	44.8560819	3		m	p	2				1						1															
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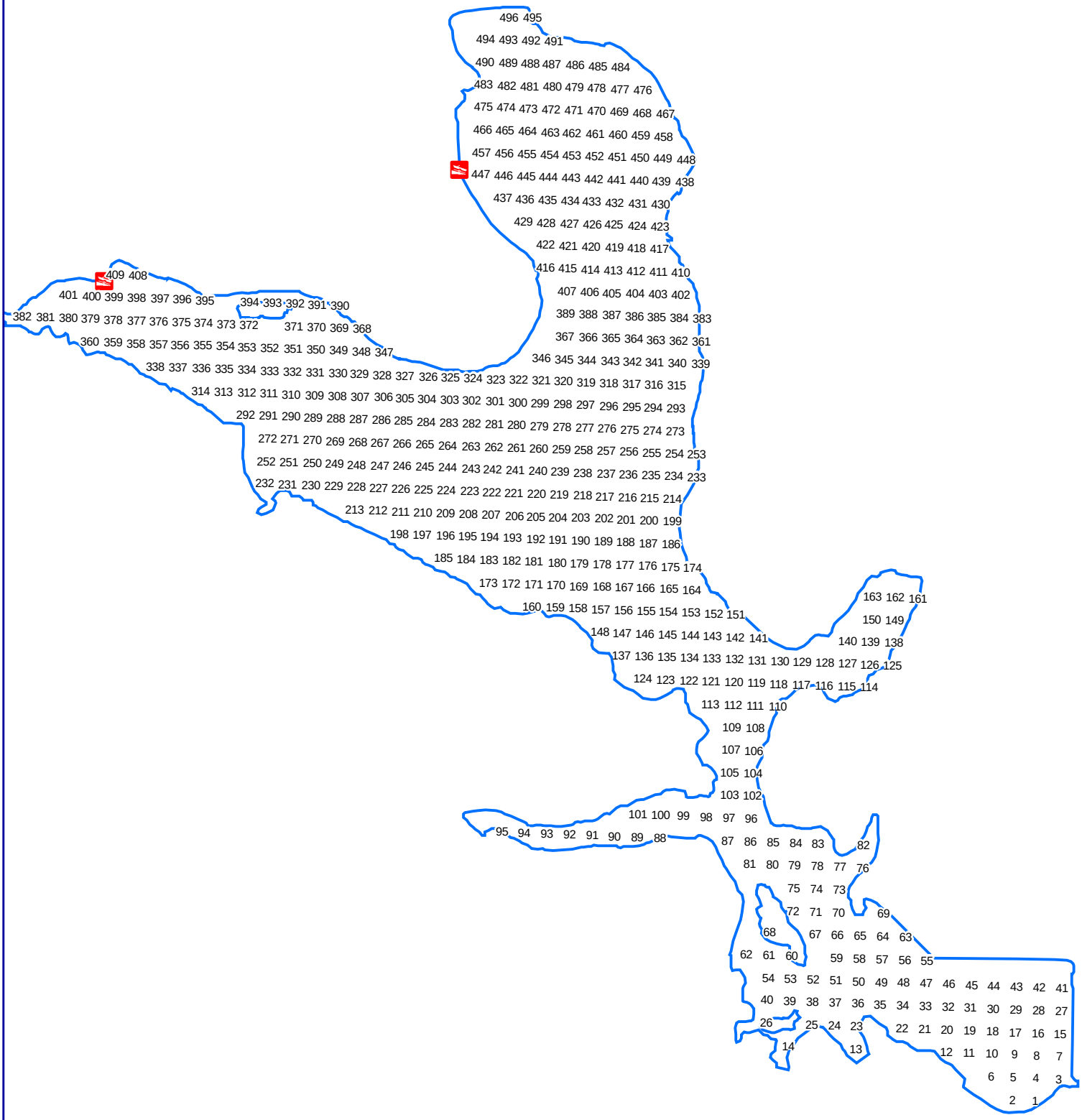
448	-88.7707409	44.85639838	1		m	v	1				3	1				1						1					1				1	2
449	-88.771247	44.85640383	2		m	v	1	1		1	2	2				1															1	
450	-88.7717532	44.85640927	2		m	v	2				2	1			1	2	1														1	
451	-88.7722593	44.85641472	7		m	p	2										1															
452	-88.7727654	44.85642016	5		m	p	3					1					1														1	
453	-88.7732716	44.8564256	3		m	p	3	2				1																				
454	-88.7737777	44.85643103	4		m	p	3					2																			1	
455	-88.7742839	44.85643647	4		m	p	3																								1	
456	-88.77479	44.8564419	3		m	p	2				1	1					1															
457	-88.7752961	44.85644733	2		m	p	1		1	2	1	2				1	1														1	
458	-88.7712394	44.85676383	2		m	v	2	1		1	2	1			1	2															1	
459	-88.7717455	44.85676928	2		m	v	3			1						2															1	
460	-88.7722517	44.85677472	3		m	p	1	1			2	1				2	1															
461	-88.7727578	44.85678016	5		m	p	2					2					1														1	
462	-88.7732639	44.8567856	3		m	p	3				1	2					1															
463	-88.7737701	44.85679104	4		m	p	2					2																			1	
464	-88.7742762	44.85679647	4		m	p	2				1	2																			1	
465	-88.7747824	44.8568019	3		m	p	2				1	1																				
466	-88.7752885	44.85680733	3		m	p	1			2						1															1	
467	-88.7712317	44.85712384	1		m	v	1	1		1	2	1										1									1	
468	-88.7717379	44.85712928	2		m	p	3				2	1				1	1														1	
469	-88.772244	44.85713472	3		m	p	1				1	1				2	1														1	
470	-88.7727501	44.85714017	4		m	p	3				1	1				1	1															
471	-88.7732563	44.8571456	3		m	p	3																								1	
472	-88.7737624	44.85715104	3		m	p	1					2																			1	
473	-88.7742686	44.85715647	4		m	p	1					2				1																
474	-88.7747747	44.85716191	4		m	p	1					3																				

Sampling Point	Latitiude (Decimal Degrees)	Longitude (Decimal Degrees)	Depth (ft)	Comments	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	*Myriophyllum spicatum*	*Potamogeton crispus*	*Nuphar variegata*	*Vallisneria americana*	*Elodea canadensis*	*Ceratophyllum demersum*	*Najas flexilis*	*Chara sp.*	*Stuckenia pectinata*	*Potamogeton zosteriformis*	*Potamogeton praelongus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Myriophyllum sibiricum*	*Sparganium eurycarpum*	*Schoenoplectus pungens*	*Sagittaria latifolia*	*Sagittaria graminea*	*Schoenoplectus tabernaemontani*	*Typha latifolia*	*Ranunculus aquatilis*	*Typha angustifolia*	*Lemna trisulca*	*FFs*	*Potamogeton natans*
475	-88.7752809	44.85716734	2		m	p	1			2		2			1																1	1
476	-88.7717302	44.85748928	2		m	p	1			1	3	1			1	2																
477	-88.7722363	44.85749473	2		m	p	2				2	1			1	1															1	
478	-88.7727425	44.85750017	2		m	p	3					1				1															1	
479	-88.7732486	44.85750561	2		m	p	2					1					1														1	
480	-88.7737548	44.85751104	2		m	p	1					3																			1	
481	-88.7742609	44.85751648	2		m	p	1				1	2				1	1														1	
482	-88.7747671	44.85752191	3		m	p	1					2				1															1	
483	-88.7752732	44.85752734	1		m	v	1			2	1		1	3	1												1				1	
484	-88.7722287	44.85785473	2		m	p	1				2	1			1	1															1	1
485	-88.7727348	44.85786017	2		m	p	1			1	2	2				2															1	
486	-88.773241	44.85786561	2		m	p	1			1	1	1			1	2															1	
487	-88.7737471	44.85787105	2		m	p	1		1		1	2				2															1	
488	-88.7742533	44.85787648	2		m	p	1				2					2															1	
489	-88.7747594	44.85788191	2		m	p	1				2					2															1	
490	-88.7752656	44.85788734	2		m	p	2				3					1															1	
491	-88.7737395	44.85823105	1		m	v				1	2	2				1						1									1	1
492	-88.7742457	44.85823649	1		m	v	1			1	2	2				2															1	
493	-88.7747518	44.85824192	1		m	v	1			1	1	2				2															1	



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Feet

Onterra LLC
Lake Management Planning
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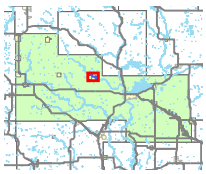
Sources:
Roads & Hydro: WDNR
Sample Locations: Onterra
Map date: March 20, 2008



Extent of large map shown in red.

Legend

Point-intercept Sample Location

Public Boat Landing

Appendix D

Lower Red Lake

Shawaon County, WI

Point-intercept Sample Locations

E

APPENDIX E

Red Lake Fish Survey Summary Reports

Upper Red Lake Fish Survey
Summary Report – 2007

In 2007, the Department of Natural Resources conducted a comprehensive fish survey of Upper Red Lake in order to provide direction for the future fisheries management of this lake. The following report is a brief summary of all activities conducted, general fisheries information and future management options for Upper Red Lake. A more comprehensive report will be completed later this spring. In the meantime, if you have any questions, please contact: Al Niebur, DNR Fisheries Biologist , 647 Lakeland Road, Shawano, Wisconsin, 54166. Phone: 715-526-4227

Comprehensive Fish Survey – What is it?

A comprehensive fish survey is an assessment of the entire fish community in a lake. Different survey methods are used to sample all the different fish species that inhabit a lake (including the smaller forage fish). Fyke-netting and boomshocking are the primary fish capture methods; however, seines and other gear are also utilized. Once fish are captured, information can be collected as it relates to species composition, abundance, size structure, age classes, growth, survival, and reproductive success.

DNR fisheries crew removing fish from fyke-net.

The following surveys were conducted on Upper Red Lake:

Fyke Netting after ice-out: This survey is conducted to target spawning northern pike, walleye and yellow perch.

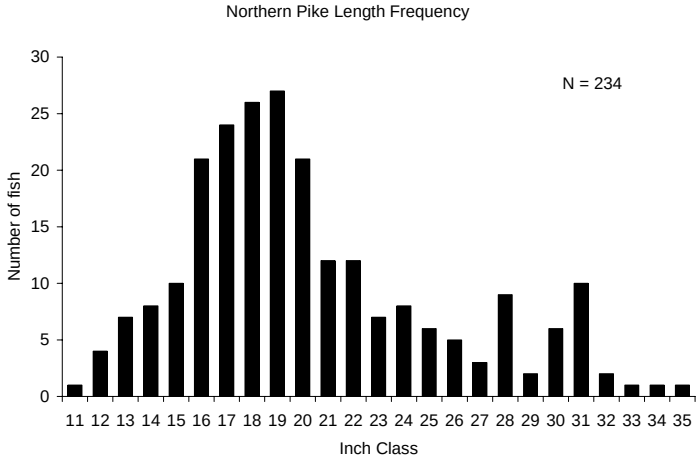
Boomshocking: This survey is conducted at night and is used to target largemouth bass and recapture fish that were marked during fyke netting. Other species are also collected. We also use this gear in the fall to check for newly hatched young of year (YOY) gamefish.

Late Spring Fyke Netting: This survey is conducted to target pre-spawn centrarchids (e.g. bluegills, pumpkinseed) and other panfish.

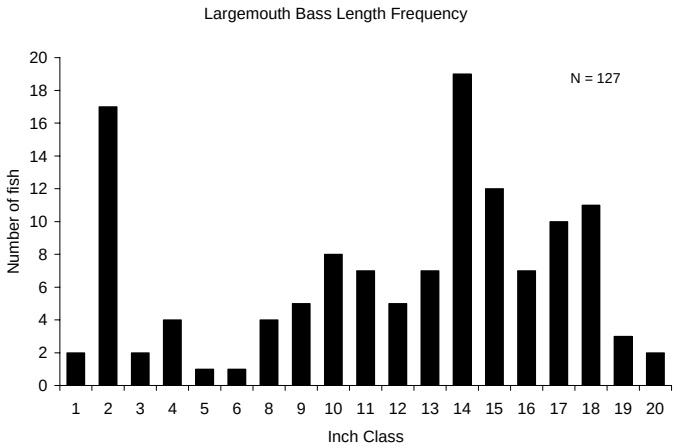
Summer Mini Fyke-Netting: Smaller version of fyke-net used to capture newly hatched YOY gamefish, panfish and minnow species.

Gamefish Summary

Northern pike was the dominant gamefish sampled in Upper Red Lake. A total of 232 pike were captured during our surveys with length ranges of 13.4 – 35.0 inches and a mean length of 23.5 inches. Abundance was above average when compared to other impoundments in the area and has remained similar to past surveys. A population estimate of 1689 (9.0 pike/acre) was calculated from mark/recapture surveys. Size structure was above average with over 38% of catch greater than 21 inches in length and 14% over 28 inches. Only two trophy sized (≥34.0 inches) were captured. Size structure indexes have remained relatively similar to past surveys.



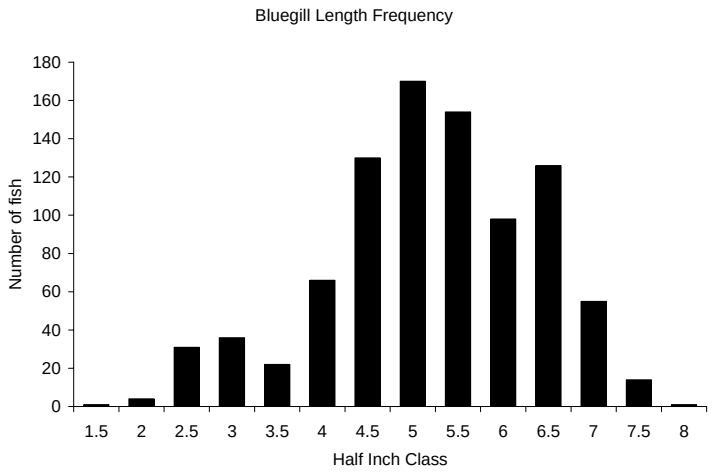
Largemouth bass were found in slightly below average abundance and comprised a small portion of the predator (gamefish) population. Size structure was above average with length ranges of 1.9- 20.5 inches and a mean length of 12.0 inches. Approximately 45% of stock size bass sampled were greater than the legal size of 14.0 inches. Trophy sized (> 18.0 inches) comprised 16% of the catch. Growth was slightly below average with bass attaining legal size by the end of their 6th summer. Bass size structure and abundance have remained relatively constant when compared to past surveys and are above average when compared to other area lakes.



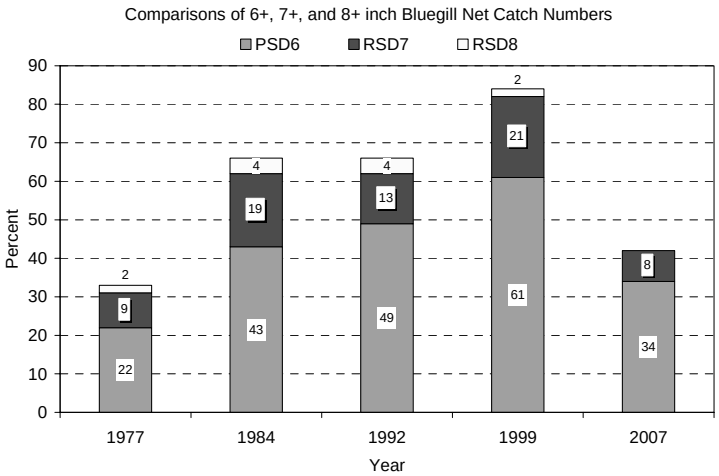
Musky were sampled in low numbers. Our survey captured 6 in total with length ranges of 21.3 – 42.0 inches and mean length of 37.8 inches.

Panfish Summary

Bluegill was the dominant panfish sampled in Upper Red Lake. A total of 6992 were captured during spring surveys. Abundance appeared to be above average when compared to other water bodies in the area. Size structure was average with 34% greater than harvestable size (6.0 inches) and with less than 1% over 8.0 inches in length. Size structure indexes appear to have declined since the last survey conducted in 1999. Growth was below average with most bluegills reaching catchable size (6.0 inches) by their 5th year.



Black crappie was found in above average abundance and comprised a significant portion of the prey (panfish) catch. A total of 861 were captured during spring surveys. Size structure was below average with length ranges of 4- 11.1 inches and a mean length of 5.3 inches. Most of crappies captured were the result of strong year classes produced in 2004 and 2005. In the next few years these fish should produce a decent fishery.

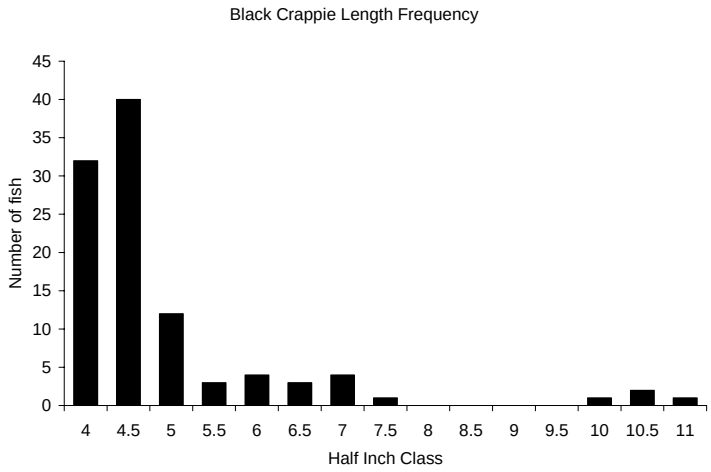


Yellow perch were found in low abundance and comprised a very small portion of the prey (panfish) catch. Only 32 were captured during spring surveys. Yellow perch numbers have declined significantly when compared to past surveys.

Other prey species sampled in lesser numbers included: rockbass, pumpkinseed, brown bullhead, yellow bullhead, white sucker, warmouth, golden shiner, shorthead redhorse and common shiner.

Management Recommendations

Overall, the fishery in Upper Red Lake could be considered above average when compared to other lakes in the area. It supports a diverse fishery that can produce both quantity and quality gamefish. The northern pike and largemouth bass population could be considered one of the highest quality fisheries in the area. Perhaps, the only concern is the declining size structure of bluegill and other panfish since the last survey and the loss of recreational use during mid-summer months.



Management Options:

- Maintain northern pike abundance and size structure. The current northern pike fishery could be considered one of the best fisheries in the area. Population abundance is adequate and size structure was phenomenal. Upper Red Lake appears to receive a fair amount of fishing pressure and I believe the fish refuge area above the railroad trestle maintains the fishery as well as the decline in fishing pressure/harvest while the lake is inundated with vegetation over the summer months.
- Maintain largemouth bass abundance and size structure. Largemouth bass populations were in good condition and appear to be providing a high quality fishery. The high abundance of bluegill and dense growths of aquatic vegetation benefits this particular gamefish.
- Bluegill size structure appears to have declined from past surveys but is still within acceptable levels. Abundance is still at very high levels. This may be a product of the dense growths of aquatic vegetation, especially Eurasian Milfoil, which may be interfering with predator/prey interaction. Management options may include actions to increase open spaces for predation of overabundant bluegills.
- Musky abundance was low and periodic stocking should be continued to maintain this population
- Conduct spring netting and electrofishing surveys on a routine basis (5-6 year rotation) to monitor fish populations.
- Periodic drawdown to reduce aquatic plant densities. This option would require cooperation/coordination with local affected public and dam owners. Drawdown may be beneficial in opening up more space and habitat for predation of overabundant bluegill population. It may also improve recreational fishing opportunities during the mid-summer months (June-September) that are typically choked with aquatic vegetation.

Lower Red Lake Fish Survey
Summary Report – 2007

In 2007, the Department of Natural Resources conducted a comprehensive fish survey of Lower Red Lake in order to provide direction for the future fisheries management of this lake. The following report is a brief summary of all activities conducted, general fisheries information and future management options for Lower Red Lake. A more comprehensive report will be completed later this spring. In the meantime, if you have any questions, please contact: Al Niebur, DNR Fisheries Biologist , 647 Lakeland Road, Shawano, Wisconsin, 54166. Phone: 715-526-4227

Comprehensive Fish Survey – What is it?

A comprehensive fish survey is an assessment of the entire fish community in a lake. Different survey methods are used to sample all the different fish species that inhabit a lake (including the smaller forage fish). Fyke-netting and boomshocking are the primary fish capture methods, however, seines and other gear are also utilized. Once fish are captured, information can be collected as it relates to species composition, abundance, size structure, age classes, growth, survival, and reproductive success.

DNR fisheries crew removing fish from fyke-net.

The following surveys were conducted on Lower Red Lake:

Fyke Netting after ice-out: This survey is conducted to target spawning northern pike, walleye and yellow perch.

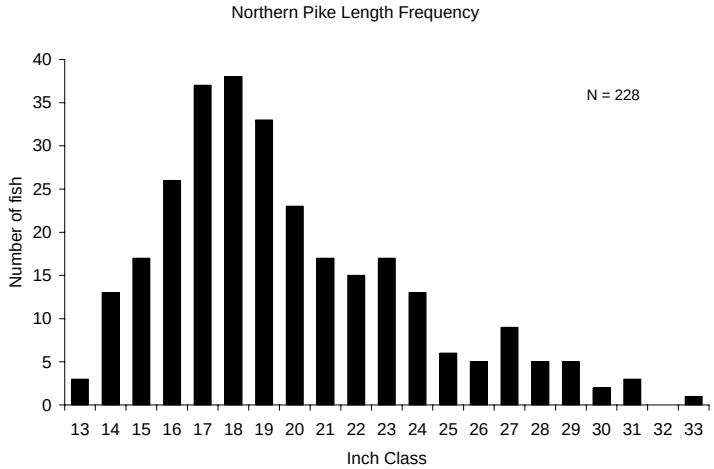
Boomshocking: This survey is conducted at night and is used to target largemouth bass and recapture fish that were marked during fyke netting. Other species are also collected. We also use this gear in the fall to check for newly hatched young of year (YOY) gamefish.

Late Spring Fyke Netting: This survey is conducted to target pre-spawn centrarchids (e.g. bluegills, pumpkinseed) and other panfish.

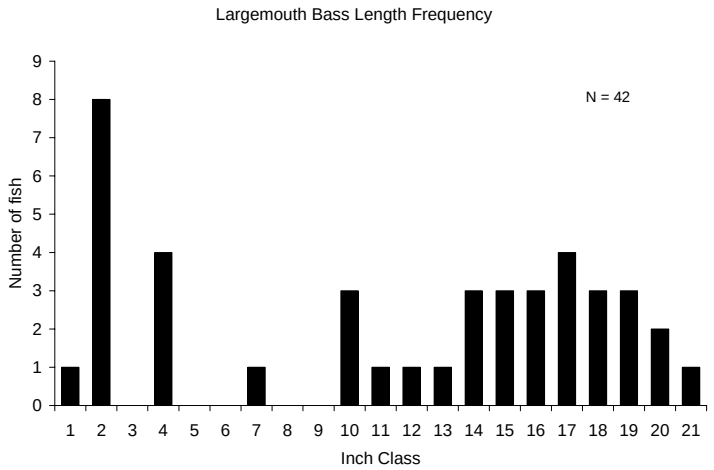
Summer Mini Fyke-Netting: Smaller version of fyke-net used to capture newly hatched YOY gamefish, panfish and minnow species.

Gamefish Summary

Northern pike was the dominant gamefish sampled in Lower Red Lake. A total of 288 pike were captured during our surveys with length ranges of 13.7 – 33.4 inches and a mean length of 19.1 inches. Abundance was below average when compared to other impoundments in the area. A population estimate of 974 (4.1 pike/acre) was calculated from mark/recapture surveys. Relative abundance has increased significantly from the last survey. Size structure was average with over 34% of catch greater than 21 inches in length and 11% over 26 inches. No trophy size ($\geq$ 34.0 inches) pike were captured. Size structure indexes for quality size (21 inches) pike have declined over the past two surveys.

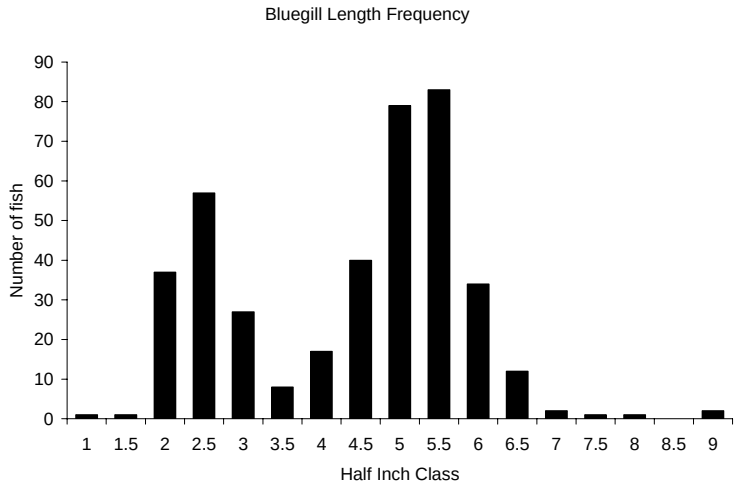


Largemouth bass were found in low abundance and comprised a small portion of the predator (gamefish) population. Size structure was above average with length ranges of 7.5- 21.5 inches and a mean length of 15.9 inches. Approximately 68% of stock size bass sampled were greater than the legal size of 14.0 inches. Trophy sized (> 18.0 inches) comprised 30% of the catch. Growth was slightly below average with bass attaining legal size by the end of their 6th summer.



Panfish Summary

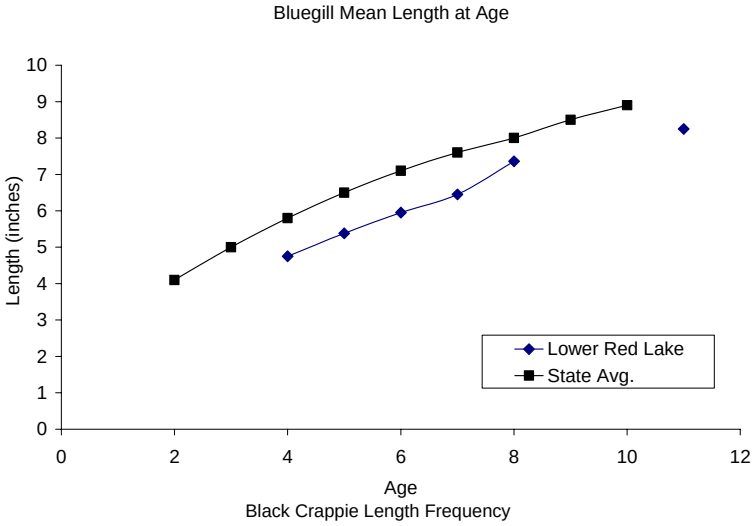
Bluegill was the dominant panfish sampled in Lower Red Lake. A total of 1464 were captured during spring surveys. Abundance appeared to be above average when compared to other water bodies in the area. Size structure was below average with only 20% greater than harvestable size (6.0 inches) and with less than 2% over 7.0 inches in length. Size structure indexes have not changed significantly since the last survey conducted in 1999. In addition, growth was below average with most bluegills reaching catchable size (6.0 inches) by their 6th year. Condition (measure of weight vs. length standard) was very poor.



Black crappie was found in average and comprised a small portion of the prey (panfish) catch. A total of 186 were captured during spring surveys. Size structure was above average with length ranges of 4.1- 13.3 inches and a mean length of 8.2 inches. Growth was extremely poor with most crappies reaching catchable size (>8.0 inches) after 7 summers of growth.

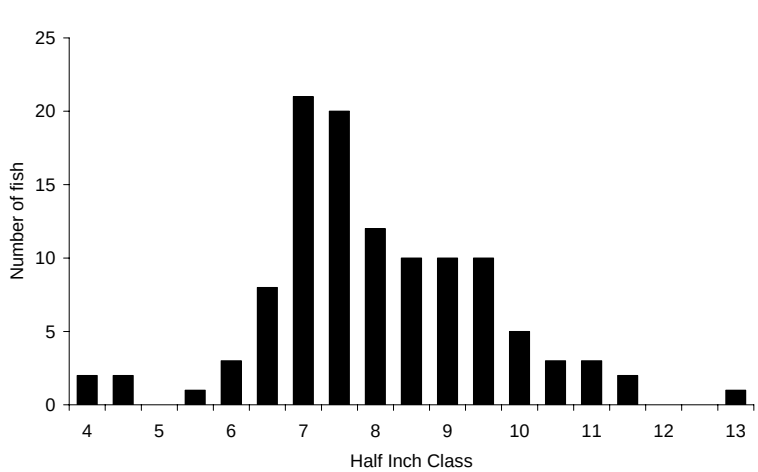
Bullhead species were found in high abundance and comprised a large portion of the net catch. A total of 816 bullheads (predominantly brown bullhead) were captured during spring surveys. Brown bullhead size structure was above average with length ranges of 10.2- 14.1 inches and a mean length of 12.5 inches.

Other species sampled in lesser numbers included: rockbass, pumpkinseed, yellow perch, white sucker, green sunfish, golden shiner, and walleye.



Management Recommendations

The fishery in Lower Red Lake could be considered average when compared to other lakes in the area. It supports quality largemouth bass and northern pike populations. Of concern is the chronic poor size structure and growth of bluegill, crappie and other panfish. As with Upper Red Lake, the dense growths of aquatic vegetation are most likely inhibiting predator/prey interactions, however it appears that this problem is more extensive in Lower Red Lake. Also, plant choked conditions are affecting recreational use of the impoundment during mid-summer months.



Management Options:

- Maintain northern pike and largemouth bass abundance and size structure. Northern pike abundance has declined over recent years but is still at acceptable levels.

- Bluegill size structure and growth have been in a chronically poor condition for several years. Abundance is at high levels and is most likely causing severe competition for limited food resources. Management options may include actions to increase open spaces for predation of overabundant bluegills and bring this population back into balance. This may also have a positive impact on other species that are experiencing similar problems.

- Conduct spring netting and electrofishing surveys on a routine basis (5-6 year rotation) to monitor fish populations.

- Periodic drawdown to reduce aquatic plant densities. This option would require cooperation/coordination with local affected public and dam owners. Drawdown may be beneficial in opening up more space and habitat for predation of overabundant bluegill population. It may also improve recreational fishing opportunities during the mid-summer months (June-September) that are typically choked with aquatic vegetation.