MARL LAKE

WAUSHARA COUNTY, WISCONSIN

COMPREHENSIVE LAKE MANAGEMENT PLAN

Prepared for

Marl Lake District

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SUMMARY

A comprehensive study of Marl Lake, Waushara County, Wisconsin (Figure 1) was completed during 2002 and 2003. The study was completed to provide information concerning the lake and its watershed so a comprehensive lake management plan could be written for the lake. Funding for this study and the development of the plan was provided by the Wisconsin Department of Natural Resources Lake Management Grant Program and the Marl Lake Protection and Rehabilitation District.

The data from this study were analyzed with data collected during past studies and yielded the following major results:

- Current and historic water quality analysis indicates that the water quality of Marl Lake has fluctuated over the past two decades, but in recent years has been good or very good.
- The current trophic state of Marl Lake is on the lower to mid mesotrophic level.
- Marl Lake stratifies during the winter and summer months and although the hypolimnion may become anoxic, fishkills are not a great concern because the majority of the lake volume is well oxygenated.
- Although Marl Lake does not have a highly diverse plant community that is indicative of an undisturbed system, Floristic Quality Assessment analysis indicates that it is of higher quality than most lakes in the ecoregion and state.
- Reed canary grass was the only exotic plant found in Marl Lake.
- Modeling indicated that drainage from agricultural row crops likely contributes the greatest phosphorus load to Marl Lake.

Major recommendations to the Marl Lake District include the following:

- The best way to protect the water quality of Marl Lake is to minimize the external sources that feed phosphorus to the lake
- Contacting the county conservationist was recommended to discover ways that runoff from agricultural areas could be minimized within the Marl Lake watershed.
- Septic system inspections were recommended to identify and replace faulty septic systems that may be adding phosphorus to the lake.
- Continued lake user education was also stressed as a means to raise awareness of everyone's role in protecting Marl Lake as an important natural resource.

INTRODUCTION

Marl Lake, located in Waushara County (Figure 1), is a small, seepage lake containing 41 acres of water surface. It has a mean depth of approximately 16 feet and a maximum depth of 35 feet. In 1988 a group of lake residents successfully petitioned Waushara County to form the Marl Lake District. The initial motivation for the formation of the District was brought about by concerns over animal waste pollution entering the lake from a nearby dairy operation.

Since the creation of the Marl Lake District, its members have worked hard on their own and through partnerships with the Wisconsin Department of Natural Resources (WDNR), Waushara County, and private landowners to not only minimize the effects of the above mentioned farm, but also to protect the lake in other ways. For instance, the District understands that in the last 20 years 16 lakes within Waushara County have been infested with Eurasian water-milfoil (*Myriophyllum spicatum*) and that there is a tremendous possibility of their lake becoming colonized with Eurasian water-milfoil also. As a preventative measure, the District has posted signs at the lake's sole boat landing warning users about the exotic species and asking them to thoroughly inspect their boats and trailers before off-loading to the lake. The District also sponsored the development of an aquatic plant management plan through a WDNR Lake Planning Grant in 1996.

The purpose of the project reported on here was to collect additional information concerning lake water quality, aquatic vegetation, and influences of the lake's watershed. These data along with the data previously collected were then used to create a lake management plan specific to the needs of Marl Lake and the Marl Lake District. This document is a combination of the final report and the lake management plan.

Notes on the Format of this Document

This document serves two purposes; 1) it fulfills the requirements for final reporting of a study that was partially funded through a Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant, and 2) it is the Lake Management Plan for Marl Lake. Care has been taken to keep the technical aspects of the document on laymen's terms as much as possible. To facilitate the ease of reading, certain topics are expanded upon and technical terms are defined in a glossary. Furthermore, the reporting of specific data is kept to a minimum within the text, but is wholly contained within the appendices. The appendices also contain the glossary mentioned above (terms contained in the glossary are italicized within the text).

The study contained four major components, watershed analysis, aquatic vegetation, water quality, and education. Each section of the report and plan are generally separated into these four components.

For ease of reading and document compilation, the large format (11"x17") maps are contained near the end of this report.

RESULTS AND DISCUSSION

Lake Water Quality

Judging the quality of lake water can be difficult because lakes display problems in different ways. However, concentrating on certain 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:

1. **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 growth rates of the plants within the lake.

2. **Chlorophyll-*a*** is the pigment in plants that is used during *photosynthesis*. Chlorophyll-*a* concentrations indicate algal abundance within a lake.

3. **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 comprehend. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring lake health. 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 inter-related. 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 measured above can be used in an index that will indicate a lake's trophic state more clearly.

The complete results of these three parameters and the other chemical data that were collected at Marl Lake can be found in Appendix A. 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. Waushara County lakes are included within the study's Central Region 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 means, historical, current, and average data from Marl Lake are displayed in Figures 2-4. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-November) or summer months in the deepest location in the lake (Figure 1). Furthermore, the phosphorus and chlorophyll-*a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments (see section on internal nutrient loading).

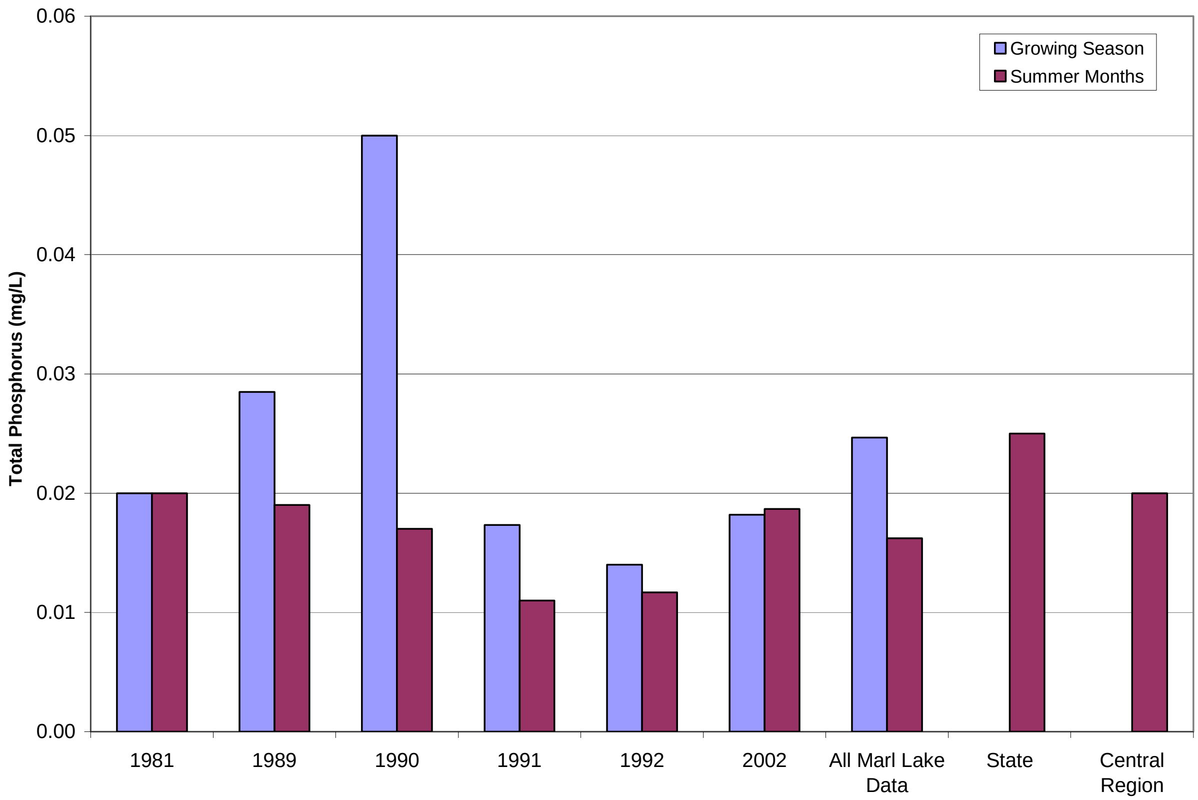

Figure 2. Mean total phosphorus concentrations from Marl Lake, state and central region. All means were calculated from surface samples. Growing season includes April-October measurements

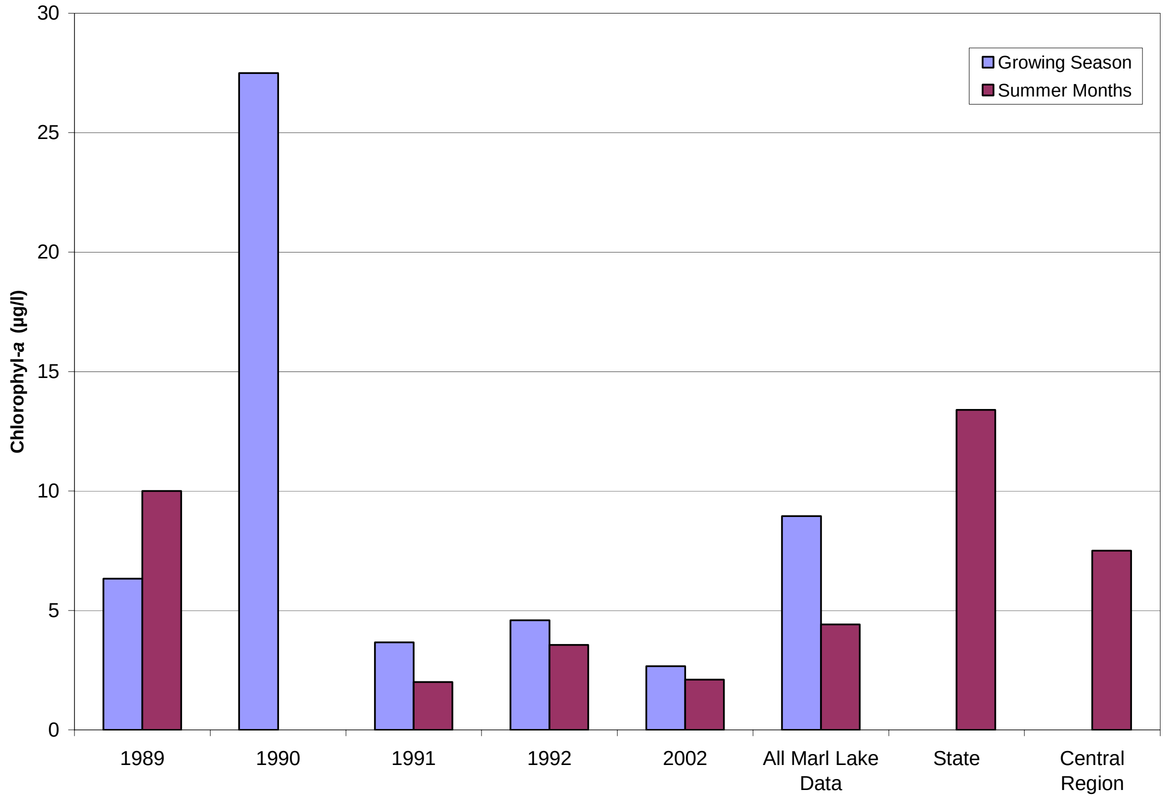

Figure 3. Mean chlorophyll-*a* concentrations from Marl Lake, state and central region. All means were calculated from surface samples. Growing season includes April-October measurements

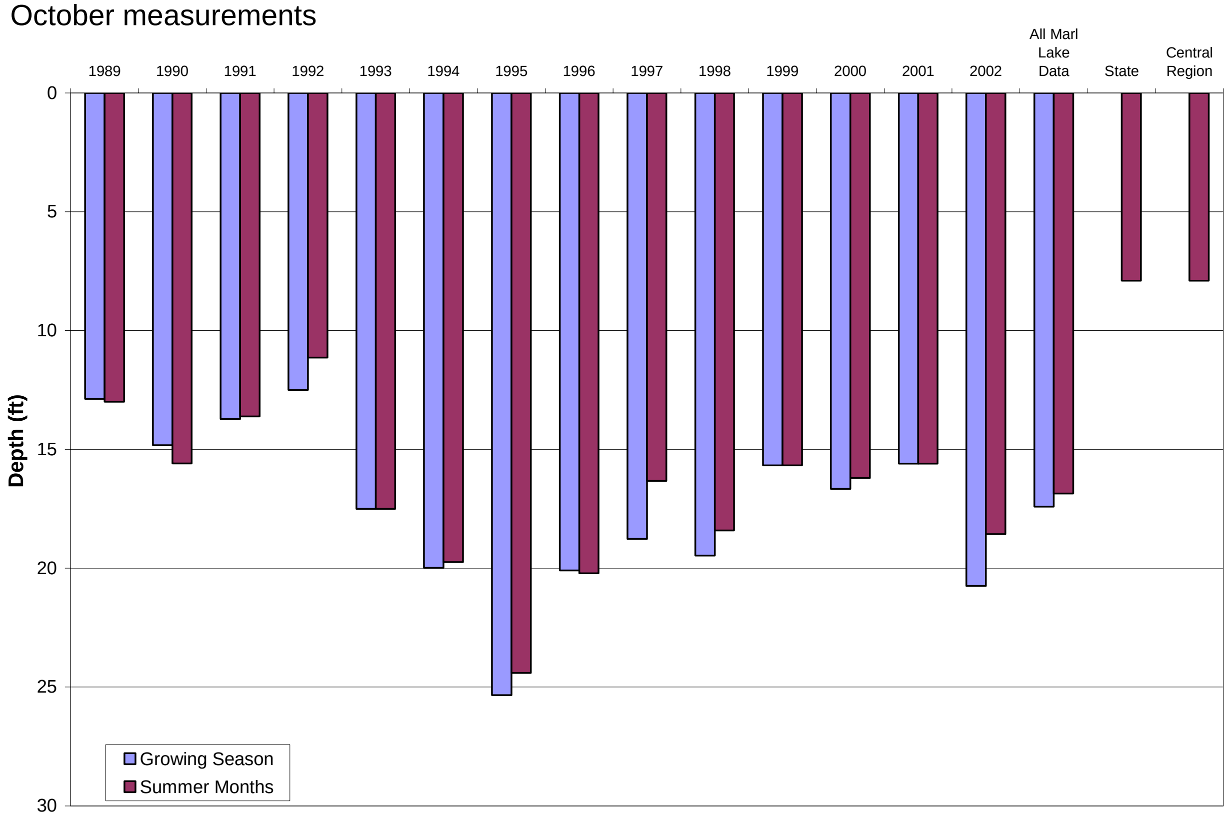

Figure 4. Mean Secchi disk transparencies from Marl Lake, state and central region. Growing season includes April-October measurements

Considering the full set of Marl Lake data (historic and current), it is clear that the values for these three parameters can fluctuate greatly over time. This is normal because so many factors affect these parameters on a seasonal and annual basis. Precipitation, cloud-cover, nutrient forms (particulate, dissolved), lake use, and other factors, all determine the concentration of chlorophyll-*a* and phosphorus and affect water clarity. With the exception of the growing season chlorophyll-*a* and phosphorus means from 1990, all of the means fall into the "good" range within the Water Quality Index (WQI) developed by Lillie and Mason (1983) (Table 1). All the Secchi disk transparency means fall into the "very good" or "excellent" categories. The high growing season means for chlorophyll-*a* and phosphorus from 1990 may be a bit misleading because the data collected during April of 1990 (one of three samples available to calculate the mean) was very high for both parameters. This may have been a temporary phenomenon caused by a large amount of precipitation falling within the watershed causing the phosphorus levels to increase, leading to increased algae. It is obvious that it was only temporary because both parameters decreased to normal levels during the summer.

Table 1. Water Quality Index (WQI) developed by Lillie and Mason (1983) for Wisconsin Lakes. Multiply meters (m) by 0.305 to get feet and divide mg/m^3 by 1000 to get mg/l.

	Approximate Equivalents				
WQI	**Water Clarity (m)**	**Water Clarity (ft)**	**Chlorophyll-a (µg/l)**	**Total Phosphorus (mg/m^3)**	**WTSI***
Excellent	>6	>19.7	<1	<1	>34
Very Good	3.0-6.0	9.8-19.7	1-5	1-10	34-44
Good	2.0-3.0	6.6-9.8	5-10	10-30	44-50
Fair	1.5-2.0	4.9-6.6	10-15	30-50	50-54
Poor	1.0-1.5	3.3-4.9	15-30	50-150	54-60
Very Poor	<1.0	<3.3	>30	>150	<60

*Calculated from water clarity values.

Overall, when compared to the WQI values in Table 1, the data found in Figures 2-4 indicate that the water quality of Marl Lake is quite good and that there is no clear evidence of changes in water quality over the past 2 or so decades. This is good news because there was concern over rising phosphorus levels in the late 1980's and early 1990's (Wisconsin Department of Natural Resources 1990). However, the data contained in Figure 2 indicate that the levels have decreased or remained the same. One of the data points that concerned the author was the phosphorous concentration recorded during April 1990 (mentioned above) of 0.010 mg/l, the highest level recorded for the surface waters of Marl Lake. Within the document, he mentions that further data analysis would determine if the reading is an anomaly; apparently it was.

The data displayed in Figures 2-4 also indicate that, in general, the phosphorus and chlorophyll-*a* concentrations within Marl Lake are below those found in the state and the central region. Comparisons of water transparency show the water of Marl Lake has been consistently much clearer than that found in other lakes within the region and state.

Lake Trophic State and Limiting Nutrient

Figure 5 contains 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 Marl Lake. The WTSI is based upon the widely used Carlson Trophic State Index (TSI) (Carlson 1977), but is specific to Wisconsin lakes. The WTSI is used extensively by the WDNR and is reported along with lake data collected by Self-Help Volunteers. The phosphorus data indicate that for the most part, Marl Lake fluctuates within a mesotrophic/eutrophic state. Yet, the chlorophyll-*a* and water clarity values indicate the lake is much closer to an oligotrophic state. Based on the relationship between these parameters described above, we would expect to find similar trophic values for all three parameters. One explanation may be that the *limiting nutrient* within Marl Lake is not phosphorus. However, this is not likely because the summer *nitrogen to phosphorus ratios* are normally well over 60:1; indicating a very strong phosphorus limitation for algal production. It is likely that the phosphorus is unusable by the algae because it is bound to marl that is precipitating within the lake. In fact, dissolved phosphorus, the form algae use, were below detectable levels during the spring and midsummer samples. So, the same compound that gives Marl Lake its incredible bluish-green color also functions to precipitate phosphorus out of the water column where it can be utilized by algae.

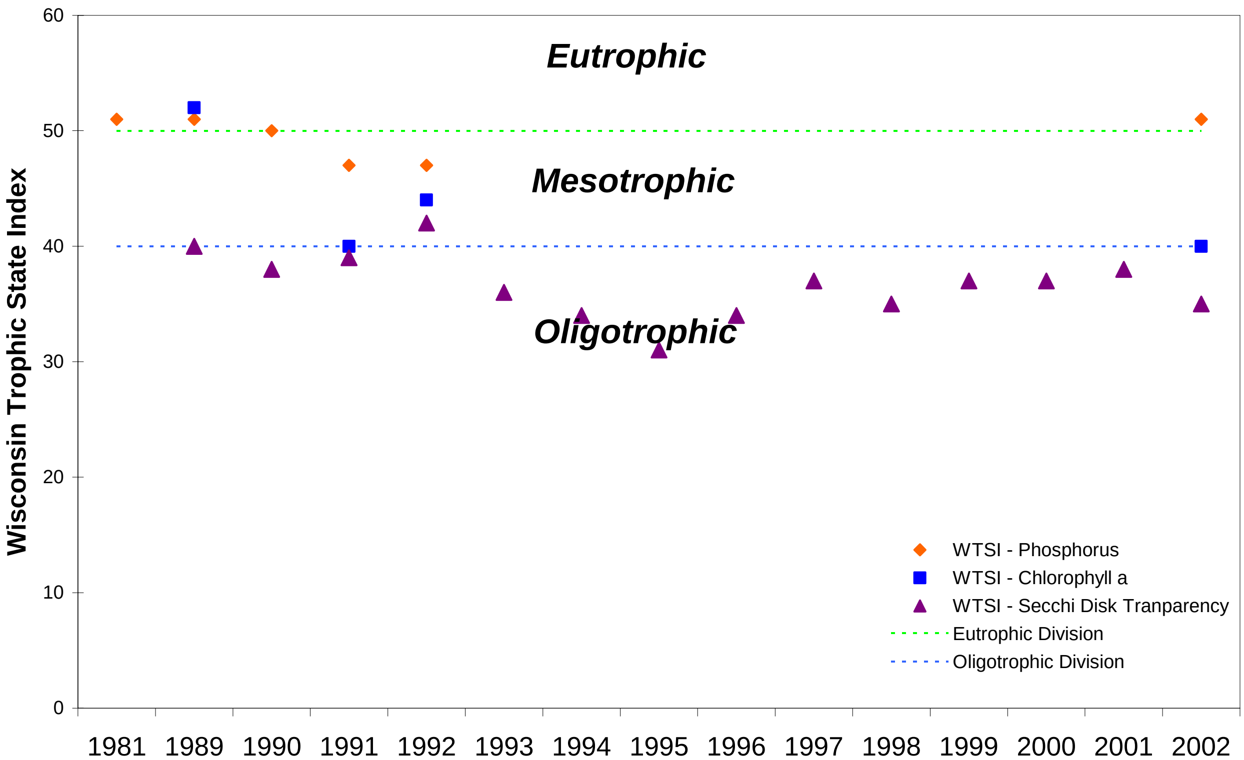

Figure 5. Wisconsin Trophic State Index results for Marl Lake.

Internal Phosphorus Loading

Wisconsin Internal Load Estimator analysis indicates that internal phosphorus load is between 1 and 16 lbs each year. However, considering the average concentrations of phosphorus within the lake and the continuous precipitation of phosphorus from the water column by marl formation, it is very likely that the internal load is much closer to the lower end of this range. Furthermore, the Phosphorus Prediction and Uncertainty Analysis Module of the Wisconsin Lake Modeling Suite (WiLMS) indicated that observed levels of phosphorus within Marl Lake are much lower than expected through the modeling of the watershed inputs (see section on Watershed Analysis). This also indicates that internal loading within Marl Lake is likely negligible.

Temperature and Dissolved Oxygen

The temperature and dissolved oxygen profiles (Figure 6) completed during this study at Marl Lake, indicate the lake does stratify during the summer and winter months and that oxygen levels within the *hypolimnion* can be depleted producing *anoxic* conditions. In many lakes, this is a concern because these anoxic conditions can lead to fishkills. However, this is likely not a concern for Marl Lake because even during these stratified periods, well over half of the lake's volume is well-oxygenated.

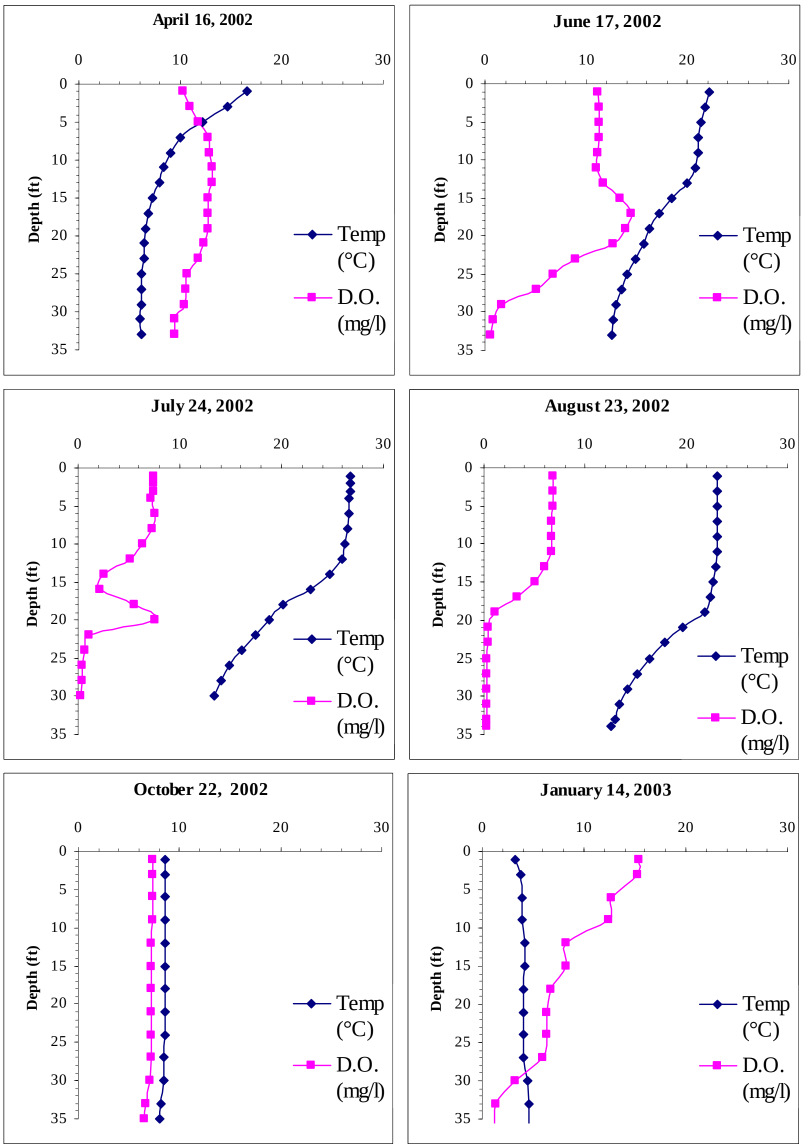

Figure 6. Results of temperature and dissolved oxygen profiles for Marl Lake.

Aquatic Vegetation

Although many 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, 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 *Zizania palustris*) both serve as excellent food sources for ducks and geese. In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the *periphyton* attached to them as their primary food source. The plants also provide cover for feeder fish and *zooplankton*, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreline erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas were plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by *phytoplankton*, which helps to minimize nuisance algal blooms.

Under certain conditions, plant populations 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 biomass negatively affects the lake ecosystem and limits the use of the resource, plant management 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.

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 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, grass carp (*Ctenopharyngodon idella*) are illegal in Wisconsin and rotovation is not commonly used. Unfortunately, there are no “wonder drugs” 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. Although all of these techniques may not be applicable to Marl Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why they are or are not applicable.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many new aquatic plant management regulations. The rules for the new regulations have been set forth by the WDNR as NR 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 along the shoreline and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within the 30 feet. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR. 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 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. 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.

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 are 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 grading requirements, removal of shoreland stabilization (e.g., rip-rap, seawall), measures used to protect 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 $4,050.

- 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.

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.

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 taken out, rather the plants are cut similar to mowing a lawn. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The other cutting method entails a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the 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 rerooting 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 recolonization on top of the screen.

Cost

Material costs range between $.20 and $1.25 per square-foot. Installation costs vary greatly depending on the size of the area to be covered and the depth of overlaying water.

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.
Installation in deep water may require SCUBA.
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.

Water Level Drawdown

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

Cost

The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive.

Advantages

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

Other work, like dock and pier repair and/or dredging 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.
Drastically upsets lake ecosystem with significant effects on fish and other aquatic wildlife.
Adjacent wetlands may be altered due to lower water levels.
Disrupts recreational, hydroelectric, irrigation and water supply uses.
May enhance the spread of certain undesirable species, like common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*).
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 10 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 very 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.
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.

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®) 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. 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*).

Diquat (Reward®, Weedtrine-D®) Broad spectrum, contact herbicide that is effective on all aquatic plants and can be sprayed directly on to 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, 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 $250 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. 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, Wisconsin's climate is a bit harsh for these two invasive plants, so we do not use 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 to 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 $1.00/weevil and they are usually stocked in lots of 1000 or more.

Nutrient Reduction

Every plant, whether it is algal or vascular, requires nutrients to grow. The three primary, macronutrients include phosphorus, nitrogen, and carbon. Under normal conditions, lakes in Wisconsin are phosphorus limited and occasionally, nitrogen limited. In other words, one of these nutrients is in short enough supply that it controls plant growth. If more of the nutrient is added to the system, the plant population expands; if the nutrient is taken away, the plant population decreases. However, rooted, vascular plants will not respond to nutrient reductions in the open water as quickly as algal populations will because they have the ability to take up nutrients from the sediment, and unfortunately, there is not a method currently available that will reduce or deactivate phosphorus and nitrogen in lake sediments. Nevertheless, it should be the goal of every lake organization to promote the minimization of all sources of nutrients and pollution entering the lake, whether they are in the form of a *nonpoint-source pollution* like runoff from agricultural and residential lands or *point-source pollution*, like an agricultural drain tile or storm sewer outfall. The reduction of these pollutants will slow the filling of the lake and reduce plant growth in the long-term.

Analysis of Current and Historic Plant Data

We found 30 aquatic plant species within Marl Lake during the survey that was conducted during the summer of 2002 (Table 2). Of these species, one is considered to be exotic, reed canary grass (*Phalaris arundinacea*). Reed canary grass is an invasive grass common to wetlands and often the shorelines of Wisconsin. It was originally recommended for planting in wet farmlands so the farmers could use the “wasted areas” to produce a crop. It has since spread to many areas of the state.

Excluding reed canary grass, Marl Lake has a *species richness* of 29. This is much higher when compared to the *median value* of other lakes within the same ecoregion and the state (Figures 7 and 8). Species richness should not be confused with species diversity. Richness is simply the number of species, while diversity is an index of the number of species and their respective abundances relative to the other species. A diverse plant community has many species that are equally abundant. Although Marl Lake has a very high species richness, the relative frequency of occurrence (Figure 9) and coverage (Figure 10) data indicate that it is only a marginally diverse community because it is largely dominated by only a few species, such as northern water-milfoil (*Myriophyllum sibiricum*), muskgrass (*Chara sp.*) and pondweeds (*Potamogeton spp*).

Two aquatic plant surveys were completed in addition to the most current inventory fulfilled for this study. The methods for the earlier inventories differed from the methods used for this study in that they were completed via rake tows and not through in-situ observations as with the current inventory (see Methods Section). This fact must be taken into account during the analysis and the reader should realize that differences may not just be attributable only to actual changes overtime.

Table 2. Aquatic plant species occurring in Marl Lake during 2002 survey. Species are broken into community type and include coefficients of conservatism used in Floristic Quality Assessment.

	Scientific Name	Common Name	Coefficient of Conservatism (C)	Notes
Emergent	*Carex comosa*	Bristly sedge	5	
	Typha latifolia	Broad-leaved cattail	1	
	Sagittaria latifolia	Common arrowhead	3	
	Eupatorium perfoliatum	Common boneset	4	
	Lycopus americanus	Common water horehound	2	
	Leersia oryzoides	Cut grass	3	
	Scirpus acutus	Hardstem bulrush	5	
	Eleocharis acicularis	Needle spikerush	5	
	Juncus tenuis	Path rush	1	
	Phalaris arundinacea	Reed canary grass		Exotic
	Salix exigua	Sandbar willow	1	
	Carex vulpinoidea	Sedge	1	
	Juncus effusus	Soft stemmed rush	3	
	Scirpus validus	Softstem bulrush	4	
Floating-leaf	*Nuphar variegata*	Spatterdock	6	
	Polygonum amphibium	Water smartweed	5	
	Nymphaea odorata	White water-lily	6	
	Wolffia columbiana	Common watermeal	5	
	Lemna minor	Small duckweed	5	
Submergent	*Elodea canadensis*	Common waterweed	3	
	Ceratophyllum demersum	Coontail	3	
	Potamogeton zosteriformis	Flat-stem pondweed	6	
	Potamogeton natans	Floating-leaf pondweed	5	
	Potamogeton illinoensis	Illinois pondweed	6	
	Potamogeton nodosus	Long-leaf pondweed	7	
	Chara sp.	Muskgrasses	7	
	Myriophyllum sibiricum	Northern water milfoil	7	
	Potamogeton pectinatus	Sago pondweed	3	
	Najas flexilis	Slender naiad	6	
	Zosterella dubia	Water stargrass	6	

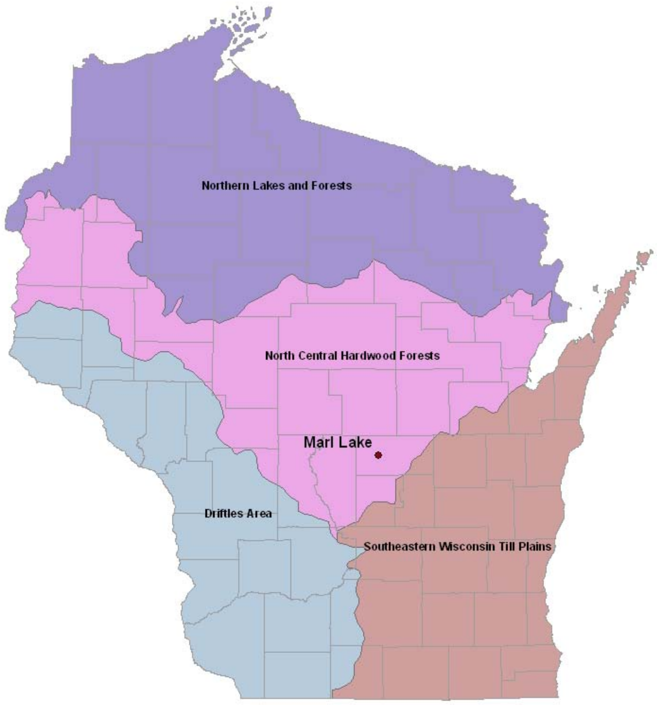

Figure 7. Location of Marl Lake relative to the ecoregions of Wisconsin after Nichols 1999 and Omernick and Gallant 1988.

The Floristic Quality Assessment (FQA) (see Methods Section) indicates that Marl Lake has a relatively high quality plant community that is made up of many species that are normally found in disturbed systems. Essentially, the FQA uses species conservatism, or its likelihood of occurring in an undisturbed system, along with the number of native species found in the lake to calculate the system's Floristic Quality Index (FQI). The average species conservatism (Figure 8) for the survey data from this study is slightly lower than those found during the other surveys on Marl Lake and those calculated for the ecoregion and the state. This means that the species that were located in the lake are likely to be found in more disturbed systems – systems with development and other forms of *anthropogenic* influences. However, the great variety of species found during the 2002 survey resulted in a high FQI for the lake, indicating that although the lake is moderately disturbed, it still supports an excellent aquatic plant community. The high occurrence of emergents around nearly the entire lake is also indication of Marl Lake's healthy aquatic plant community.

Two areas of the lake support excellent aquatic plant communities that are likely used a great deal by the Marl Lake fishery for spawning, nursery, cover, and feeding requirements. The largest of these areas is located on the northwest end of the lake and is indicated on Figure 11 as the "Species Rich Area", while the other, smaller area, is located in the small bay east of the boat landing (Transect 14). The larger area contained nearly every species found throughout the rest of the lake from all three plant community types (submergent, emergent, and floating-leaved). Although the other area was clearly dominated by water star-grass (*Zosterella dubia*), and water-lilies (*Nuphar variegata* and *Nymphaea odorata*), it still contains many other species of emergent and submergent plants that indicate it is a high-quality area.

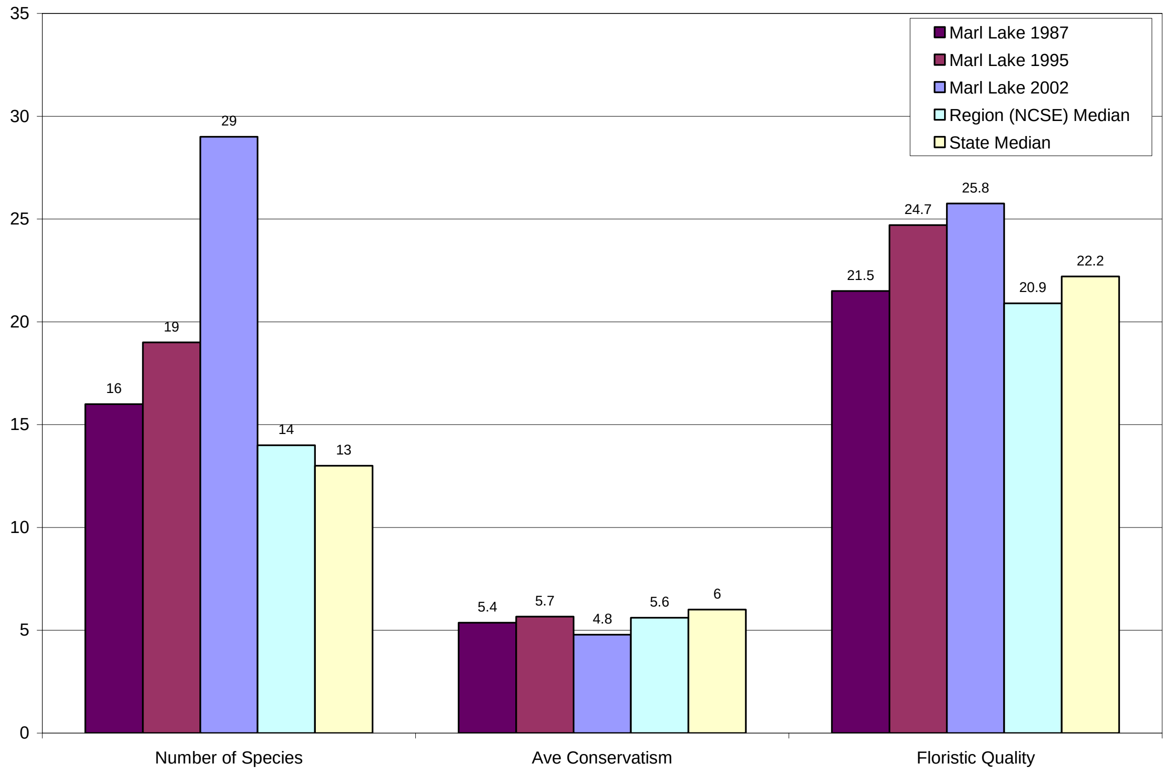

Figure 8. Floristic Quality Assessment (FQA) results for current and historic datasets of Marl Lake, the ecoregion and state. The ecoregion results shown are a combination of results from the North Central Hardwood Forest and Southeastern Wisconsin Till Plains ecoregions (Nichols 1999).

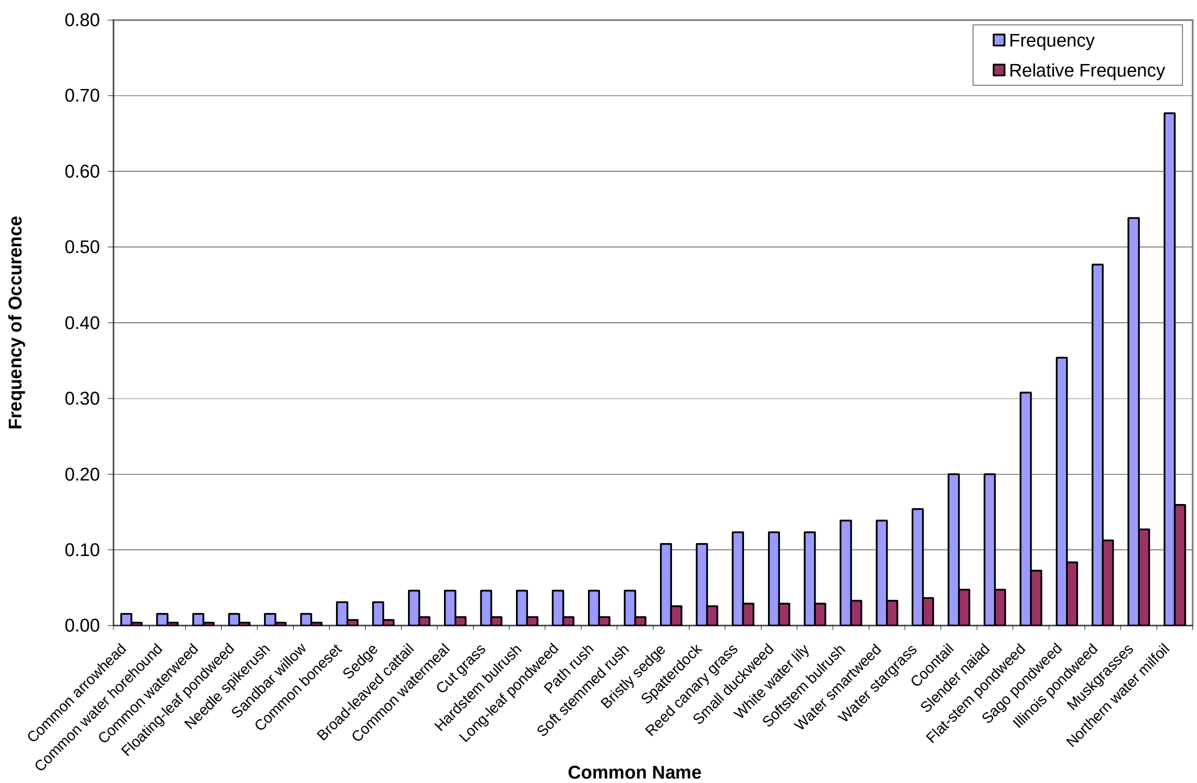

Figure 9. Frequency results for current survey results at Marl Lake.

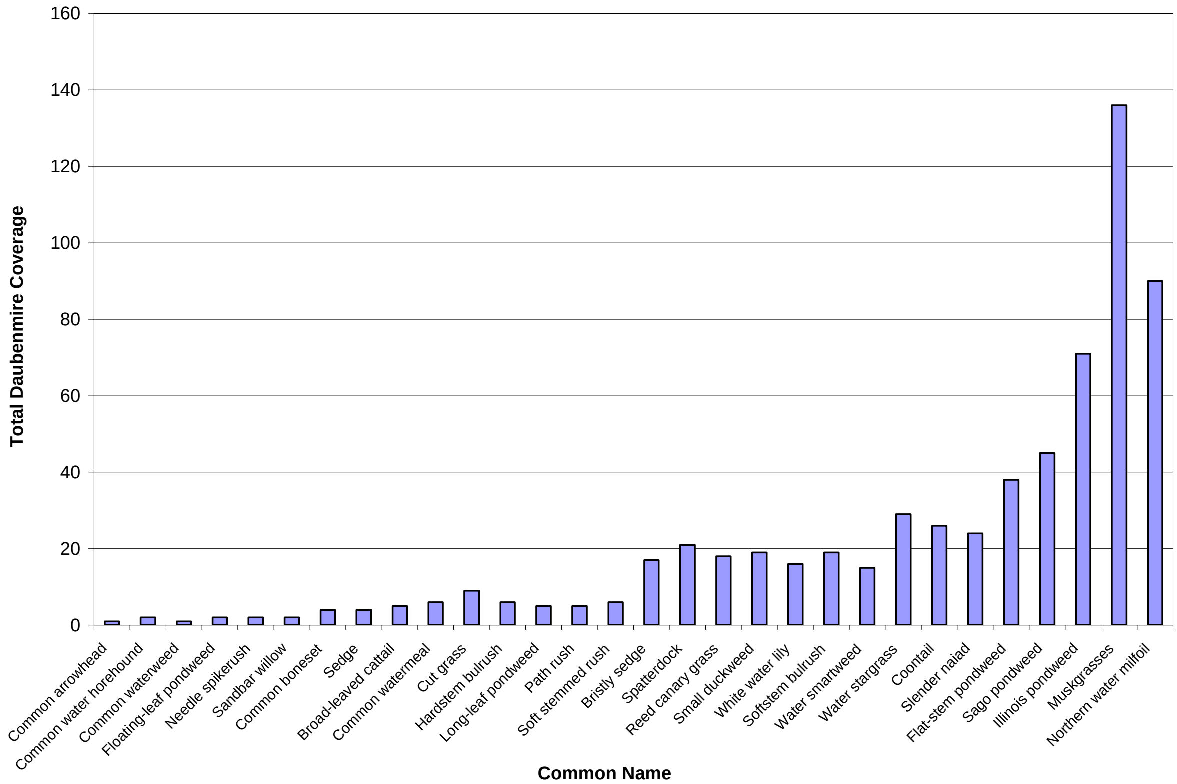

Figure 10. Total Daubenmire coverage results for current survey results at Marl Lake

Watershed Analysis

The Marl Lake watershed is approximately 324 acres, which yields a favorable watershed to lake area ratio of 7.9:1. In general, lakes with a ratio greater than 10:1 tend to have management problems that revolve around excessive amounts of phosphorus and/or sediments that enter the lake from its drainage basin. This is true because as the drainage area increases, so does the amount of nutrients and sediments that are delivered to the lake. This is not to say that every lake with a watershed to lake area ratio greater than 10:1 experiences problems, because the amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to infiltrate into the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas reduce infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations.

Field-verified land use data for the Marl Lake watershed are displayed in Figures 12 and 13. Currently, the majority of land within the Marl Lake watershed is either forested or in grassland/pasture. As mentioned above, fully vegetated areas produce very little surface runoff; in fact, these areas allow 60-80% or greater of the precipitation that falls on them to infiltrate the ground. Having a large proportion of the watershed in these land use types does a great deal to prevent excessive phosphorus loading to the lake.

Modeling results of the land use types listed are shown in Figure 14. The most noticeable source is row crops. Although this land use category only accounts for roughly 10% of the total watershed acreage, it loads the greatest amount of phosphorus to the lake. Fortunately, there are many ways of controlling this type of loading (see Recommendations Section).

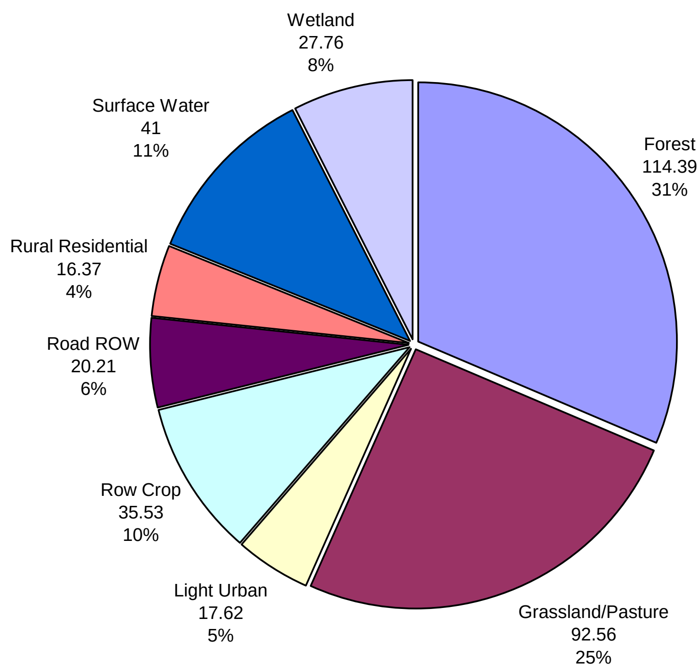

Figure 13. Land use types and associated acreages within the Marl Lake watershed. Percentages indicate percent of total watershed acreage.

Although it only accounts for approximately 2% of the total estimated load entering the lake, septic tank inputs are always a concern around lakes, especially in the soils around Marl Lake. These soils, called Plainfield sand (USDA 1989), are excellent for conveying effluent away from conventional septic system drainfields, but do very little for the filtering of contaminants, including phosphorus. This unfiltered phosphorus can easily enter the groundwater and move into the lake.

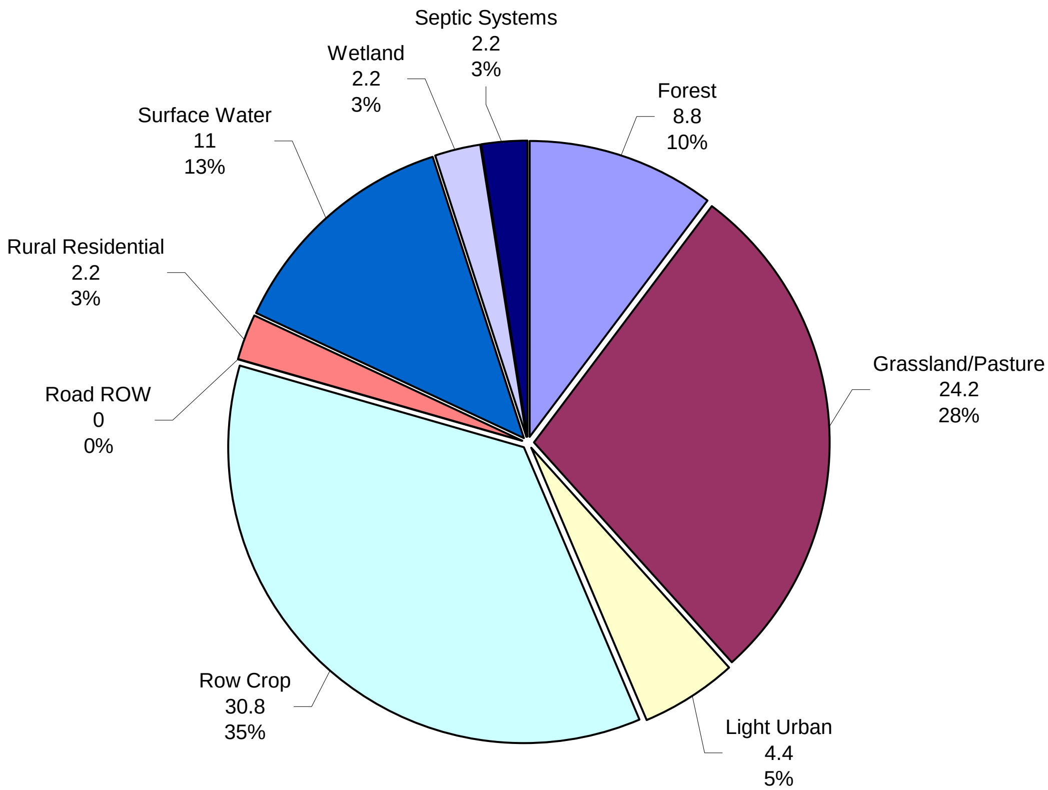

Figure 14. Estimated phosphorus loading values for the Marl Lake watershed. Loads are listed in lbs/yr of phosphorus. Percentages indicate percent of total external phosphorus load.

RECOMMENDATIONS

Lake Water Quality

Water Quality Protection

As outlined in the Results and Discussion Section, the water quality of Marl Lake appears to have remained consistently good to very good over the past two decades; therefore, there are no steps that need to be taken to correct in-lake problems. The most appropriate plan is to protect the current water quality of the lake through implementation of the recommendations stated in the Watershed and Aquatic Vegetation sections.

Water Quality Monitoring

Continuous water quality monitoring is an essential component in any lake management plan. Long-term datasets help lake managers detect subtle trends in water quality that cannot be detected with only a year or season's worth of data. Important parameters to include are, chlorophyll-*a*, total phosphorus, Secchi disk transparency, and dissolved oxygen profiles. The Secchi disk information is currently being collected on an annual basis through the efforts of the District's Self-Help Volunteers and should definitely continue. The other data would not necessarily need to be collected on an annual basis, but should be collected at least every three years. The additional data collection over Secchi disk transparency could be implemented in one of the following fashions:

- The Wisconsin Department of Natural Resources has recently initiated a volunteer sampling program through their Small-scale Lake Planning Grant program. Through this program, a lake organization can receive the equipment and chemicals necessary to collect phosphorus and chlorophyll-*a* data for five years. Applications for this grant program are only accepted during the August cycle. For more information, please contact your local WDNR Lakes Coordinator.
- The Water and Environmental Analysis Lab (WEAL) of UW-Stevens Point offers many lake monitoring packages through their Lake Water Quality Program. The Chlorophyll and Phosphorus Monitoring Program would be the most appropriate for use at Marl Lake. Through this program, a volunteer from the District would collect water samples using equipment and chemicals supplied by WEAL and then ship them to WEAL for analysis. For more information please visit: https://www.uwsp.edu/cnr/etf/Lake.htm.
- A natural resource consultant could be contracted to collect periodic samples from Marl Lake and then have them analyzed by a certified lab. If this course were followed, the District should be sure to hire a qualified consultant that would provide annual reports containing results and discussions on the data collected.

Aquatic Vegetation

The survey and subsequent analysis indicated no major concerns with the plant community within Marl Lake; however, two minor concerns may exist. The first deals with possible navigability problems resulting from the abundant plant populations on the northwest side of the lake (between Transects 5 and 8, Figure 11). The best remedy for these areas is manual removal by hand, rake, or cutter. Remember, all dislodged plant material must be removed from the lake and that each property owner can only clear 30 continuous feet of shoreline, measured parallel to the water's edge, from their property. There are no restrictions on how far out from the shoreline the 30-foot wide area can extend, but the 30-foot width must include piers, boat hoists, and swimming structures. Mechanical or chemical means of plant control in these areas are not appropriate because of the area's size, the low level of development in those areas, and habitat value the areas provide.

The second concern deals with possibility that the plant that has been identified as native northern water-milfoil may, in fact, be a hybrid between northern water-milfoil and the exotic Eurasian water-milfoil (*Myriophyllum spicatum*). Separation of these species can, at times, be difficult because their morphologies are very similar. During the fall of 2000, Ms. Mary Gansberg, a water resource biologist with the WDNR, sent samples of the species in question to Stan Nichols, a botanist with the Wisconsin Geological and Natural History Survey. Mr. Nichols is considered an expert in aquatic plant identification within the state. He determined that the species in question is northern water-milfoil; this was further confirmed by genetic analysis performed at the University of Connecticut on plant samples collected by NES Ecological Services . However, the hybrid has been found in lakes within Waushara County, and is suspected to be in others. For the time being, the WDNR is managing the plant as if it were Eurasian water-milfoil because it exhibits many of its competitive characteristics. Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 15). 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

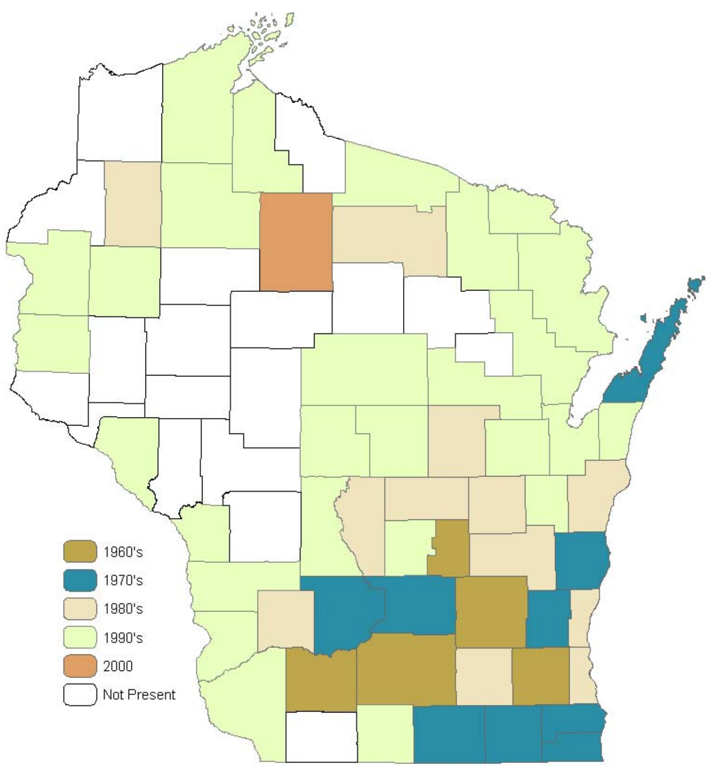

Figure 15. Eurasian water-milfoil spread in Wisconsin counties. Data from Wisconsin DNR.

reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and hampering recreational activities such as swimming, fishing, and boating.

NES identified the plant as Northern water-milfoil during 2002 vegetation survey. Nonetheless, it is recommended that samples of the plant be collected for genetic identification. This is the only means to truly discover which species it is or if it is the hybrid between the two. It is possible that Mr. Michael Moody, a researcher with the University of Connecticut, may be willing to analyze the samples free of charge. We recommend that sample specimens be sent to Mr. Moody for species determination. If the species is determined to be either the hybrid or Eurasian water-milfoil, the species should be monitored on an annual basis to determine if it is spreading. If spreading of either Eurasian water-milfoil or the hybrid occurs, the Marl Lake District should seriously consider completing a chemical treatment to reduce the occurrence of the plant. If the treatment is successful, remaining areas may be eliminated through hand removal and/or through the installation of sediment barriers. The likely chemical treatment would be a whole lake fluridone (Sonar®) treatment; however, it is recommended the WDNR be contacted for further, professional guidance on this subject should it become necessary.

Figure 16. Reed canary grass (*Phalaris arundinacea*). Stephen L. Solheim, photographer.

Reed canary grass (Figure 16) was found around the boat landing and on several shoreland properties around the lake. It likely occurs on most properties to some extent. The best method for controlling the small patches of this plant that were found around the lake would be to remove them by hand, root and all.

Watershed

As mentioned in the Results and Discussion section, the primary concern with the watershed rests with the areas that are currently being used for row cropping. Installation and maintenance of vegetated buffer strips around these areas and the water courses that drain them would minimize their affect on the lake. However, conversion of these areas to non-row cropping agriculture would be the best method of reducing phosphorus loads to the lake short of permanently vegetating them. For more information on this subject, Mr. Mark Schumacher, Waushara County Land Conservationist (920-787-0443) can be contacted.

The fact that the majority of the watershed is currently forested or in grassland/pasture helps to assure that excess runoff, carrying phosphorus and other pollutants to the lake, will be minimal. However, there should be some concern over present and future septic systems near the lake. With the exception of converting the forested areas to residential lots or agricultural use, an increased loading rate from septic systems will likely have the greatest impact on the health of Marl Lake. Increased loading from septic systems could occur in primarily two ways: 1) septic system failure and/or decreased efficiency, and 2) additional septic systems being installed around the lake.

Newer septic systems tend to function better than older systems, so the immediate concern should be with the existing, older systems on the lake. By state law, a septic system is considered to be failing if untreated wastewater is backed up into the building, seeps to the soil surface, enters surface or groundwater, or moves into the soil's saturated zone. With the exception of being backed up into the building, all of these failures could potentially increase nutrient loading to Marl Lake. The Wisconsin Department of Commerce estimates that nearly 1-in-5 septic systems are failing in Wisconsin.

Unfortunately, dealing with septic system issues on lakes is traditionally a very touchy subject because dealing with a failing system can result in a large expense for the property owner. However, if the protection of Marl Lake is truly the goal of the District and its members, these inhibitions towards septic system problems must be overcome to meet this goal.

Fortunately, newly installed systems in Waushara County are required to keep a regular maintenance schedule, including pumping and inspections every three years. A maintenance schedule such as this will do a great deal to protect the lake if the surrounding area is further developed. Unfortunately, neither the county nor the state requires similar maintenance schedules for older systems; therefore, the push for septic system inspections, maintenance, and even replacement needs to be from the District and its members.

It is recommended that the District pass a resolution to have all systems not covered by the county's regulations described above inspected within the next two years. Grants may be available to fund up to 75% of these efforts through the WDNR Lake Planning Grant Program. Furthermore, the District should require all properties to have their septic tanks pumped at least every three years, depending on the size of the tank and the amount the system is used. Determining the schedule for different classifications of systems based on their size and use could likely be determined by the company that would be contracted to complete the inspections. This plan should go as far as having reminder cards sent out to property owners that would require their return and the signature of a licensed plumber or sanitation service after the pumping is completed. Records would be maintained by the District. Penalties for non-compliance could be determined by the District, but it is likely that the possibility of a property being listed in the District's newsletter as not performing its maintenance pumping would be enough to keep most owners in compliance. The cost involved with the development of this program, including the cost of card printing, could also be partially funded through the grant mentioned above.

If systems are found to be failing, they may be required by county or state regulations to be restored or replaced. The Wisconsin Department of Commerce partially funds private sewage system replacements through their Wisconsin Fund, Private Sewage System Replacement and Rehabilitation Grant Program, but the requirements are stringent and include that the system must be serving the owner's principal residence and that the owners not make in excess of a specified annual income. More information about this grant program can be found on the Dept. of Commerce website or by calling (608) 267-7113.

Education

Education is an incredibly important aspect of any lake management plan. Informing District members about District activities is very important, but the education of its members is as important, if not more important. Educational topics should include:

- Lake Stewardship
  - A lake steward understands his or her affect on the lake ecosystem and takes measures to protect and enhance it. Lake stewards also understand that protecting the ecosystem as a natural resource and not just a recreational resource is important to all lake uses, including fishing, swimming, boating, and enjoying the aesthetics of the lake.
- Property Management
  - This topic can be tied to lake stewardship and should include information on the use of lawn fertilizers, the maintenance of septic systems, and methods of blending structures with the natural landscape. This topic should also include information on natural buffer strips that can be used to minimize soil erosion and nutrient loading to the lake from shoreland properties.
- Exotic and Invasive Plants
  - Education should stress the fact that prevention and early detection are paramount in the battle against these organisms. The District could take this even further by developing a *Volunteer Watercraft Inspection Program*. More information on the program can be obtained by contacting the UW-Extension Lakes Program at (715) 346-3366.
- Native Aquatic Plants
  - This topic should include discussions on the importance of aquatic plants to the health of the lake ecosystem, including fish and other wildlife.

METHODS

Lake Water Quality

Water Quality Monitoring

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

	Spring		**June**		**July**		**August**		**Fall**		**Winter**	
Parameter	**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	●	●			●	●					●	●
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 4.

Internal Phosphorus Load Estimation

The Wisconsin Internal Load Estimator Module of WiLMS was utilized to estimate possible internal loading rates of phosphorus within the lake based upon water quality data collected during 2002.

Aquatic Vegetation

Transect Surveys and Macrophyte Community Mapping

Quantitative aquatic vegetation surveys were conducted during August 1 and 5, 2002 by sampling 14 transects located along the shoreline of the lake (Figure 12). Sampling was completed via boating, wading, and snorkeling. In order to map the macrophyte communities and to assist in determining the frequency and location of transects, visual inspections were completed throughout the lake using a combination of sketches and notes created on hardcopy maps and position data recorded with a Trimble GeoExplorer 3 GPS/Data Collector. On each transect, a ten-foot diameter circle was sampled within each of five different depth ranges (Table 3). The maximum depth of sampling was determined through field observation of the approximate maximum depth of aquatic vegetation growth. At each sampling location, substrate type and species composition were recorded.

Table 3. Depth codes and ranges sampled during transect surveys.

Depth Code	Depth Range (feet)
1	0.0-1.5
2	1.5-3.0
3	3.0-5.0
4	5.0-10.0
5	>10.0

A visual estimate of percent foliage cover for each species was also recorded at the sampling locations. Coverage is determined as the perpendicular projection to the ground from the outline of the aerial parts of the plant species and is typically reported as the percent of total area (e.g., substrate or water surface) covered (Brower et al. 1990). For emergent and floating-leaf vegetation, the percent of water surface covered was used in the visual estimate, and for submergent vegetation the percent of substrate covered was used. After the collection of field data, the Daubenmire Classification Scheme (Mueller-Dumbois and Ellenberg 1974) was used to rank each species observed according to estimated foliage cover (Table 4). By providing a range of percent foliage cover for each rank, the Daubenmire Classification Scheme helps to minimize errors due to observer bias, visual estimation, etc.

Table 4. Daubenmire Classification Scheme cover ranking system.

Percent Foliage Cover	Rank
0-5	1
5-25	2
25-50	3
50-75	4
75-95	5
95-100	6

The collected transect data were used to estimate frequency of occurrence and relative frequency of occurrence for each species observed. The frequency of occurrence is defined as the number of times a given species occurred on the total plots of all transects sampled. The relative frequency of occurrence is the frequency of that species divided by the sum of the frequencies of all species in the community (Brower et al. 1990). Sum coverage is the total Daubenmire cover found for each plant.

Floristic Quality Assessment

A Florist Quality Assessment (FQA) was applied to the aquatic vegetation species lists generated for Marl Lake using the methodology of Nichols (1999). FQA is a rapid assessment metric used to assist in evaluating the floristic and natural significance of a given area. The assessment system is not intended to be a stand-alone tool, but is valuable as a complementary and corroborative method of evaluating the natural floristic quality of a lake ecosystem.

The primary concept in FQA is species conservatism. Each native species found in the lake was assigned a coefficient of conservatism (*C*) ranging from 0 to 10. The coefficient of conservatism estimates the probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-settlement condition. A *C* of 0 indicates little fidelity to a natural community, and a *C* of 10 is indicative of restriction to high quality, natural areas. The FQA was applied by calculating a mean coefficient of conservatism for all species observed in the lake. The mean *C* was then multiplied by the square root of the total number of species to yield a Floristic Quality Index (FQI). Examination of the floristic quality index within the context of statewide and regional trends was used to provide an overall evaluation of the floristic quality of Marl Lake.

Watershed Analysis

The watershed analysis began with an accurate delineation of Marl Lake's drainage area using U.S.G.S. topographic survey maps. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land use data supplied by Waushara County, were then combined to determine the preliminary watershed land use classifications. The watershed delineation and land use classifications were field verified during the fall of 2002.

The preliminary data were then corrected with the field verified data within the GIS and watershed area and acreages for each land use type were calculated. These data, along with historic and current water quality data were inputted into the Wisconsin Lake Modeling Suite (WiLMS) to determine potential phosphorus loads to the lake.

Education

Educational components were accomplished through a "Kick-off Meeting" held in May 2002, project updates created for inclusion in the District's newsletter, an article that appeared in the Oshkosh Northwestern, and a "Project Completion Meeting" at which the final report and recommendations were presented to the District. All of these materials are included in Appendix D.

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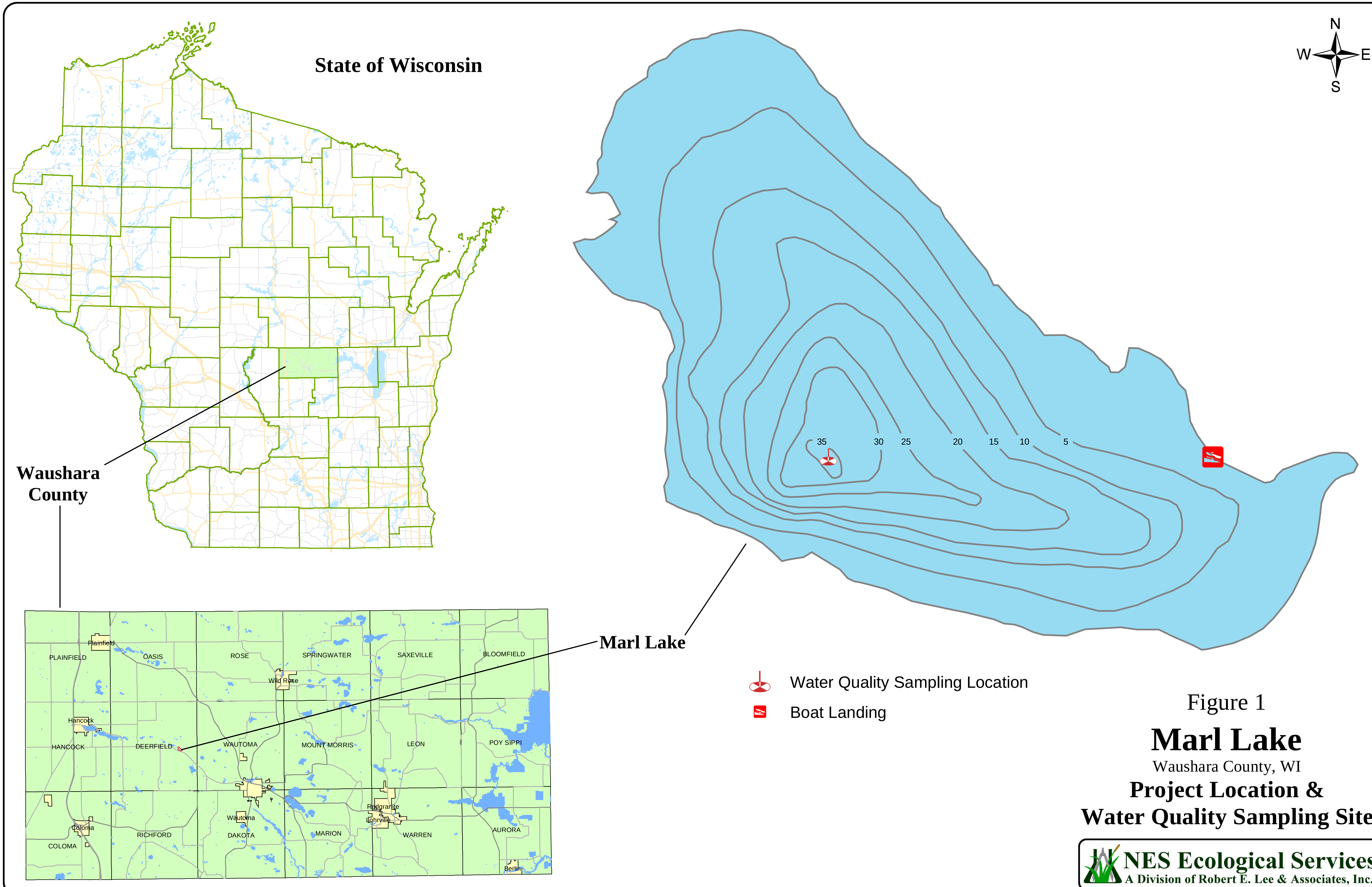
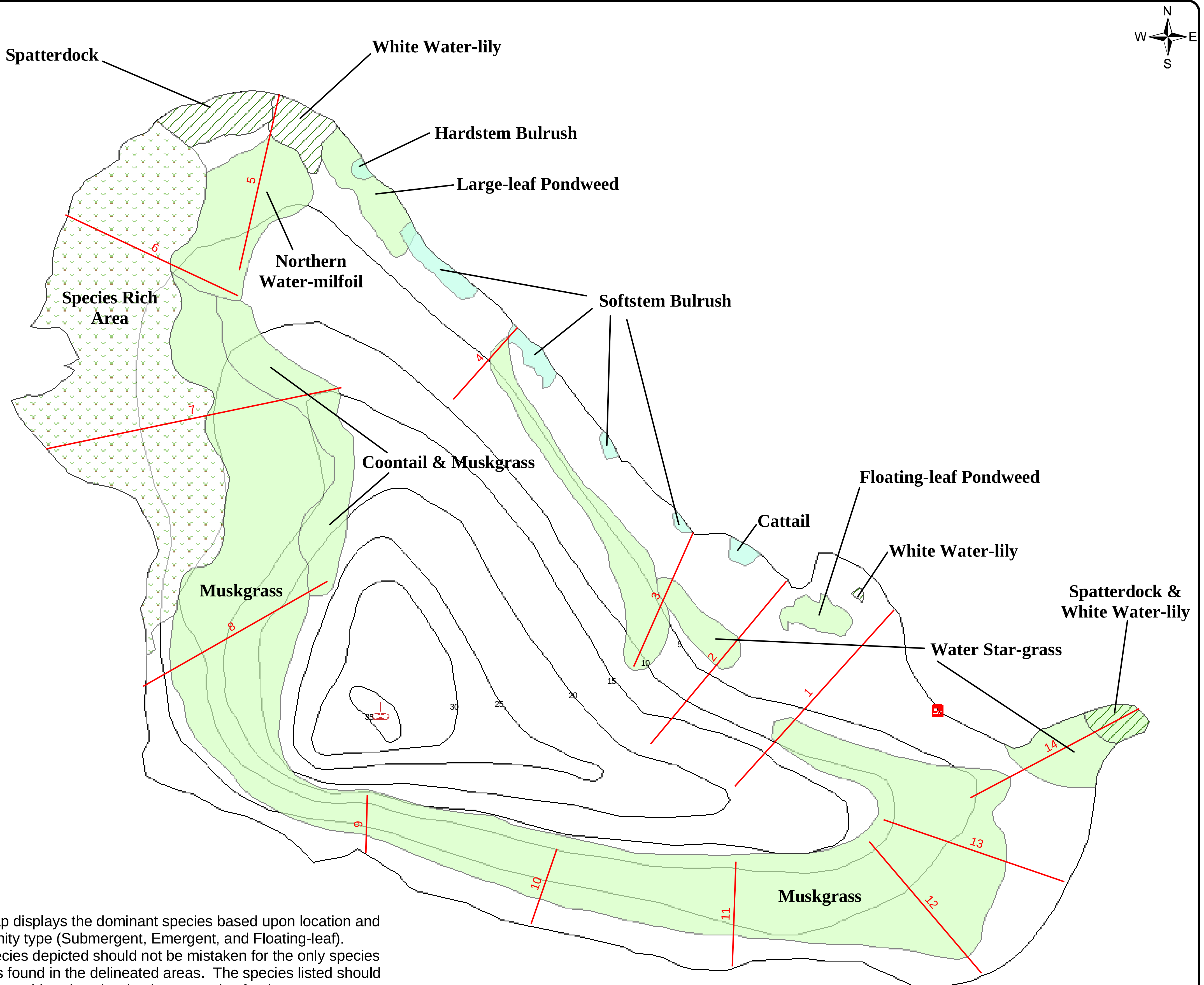


Figure 1

Marl Lake

Waushara County, WI

Project Location & Water Quality Sampling Site



NOTE: This map displays the dominant species based upon location and community type (Submergent, Emergent, and Floating-leaf). The species depicted should not be mistaken for the only species that was found in the delineated areas. The species listed should only be considered as the dominant species for the area. Areas that are not clearly dominated by a single species are classified as "Mixed" and the most dominant species are indicated. Furthermore, areas that do not have associated communities should not be interpreted as being devoid of plants. These areas usually contain many species mixed throughout a large area making clear mapping difficult.

Figure 11

Marl Lake

Waushara County, Wisconsin

Aquatic Plant Communities & Transect Locations

- Transects
- Species Rich Area*
- Floating-leaf Community
- Emergent Community**
- Submergent Community
- Water Quality Sample Site
- Boat Landing

* This area contained the most abundant and diverse plant assemblage in the lake. It contained nearly every species of submergent, floating-leaf, and emergent vegetation found throughout the rest of the lake. Please see Table 2 for a list of these plant species.

** Emergent species occurred frequently around the edge of the lake. The areas indicated on the map are larger areas clearly dominated by a single species.

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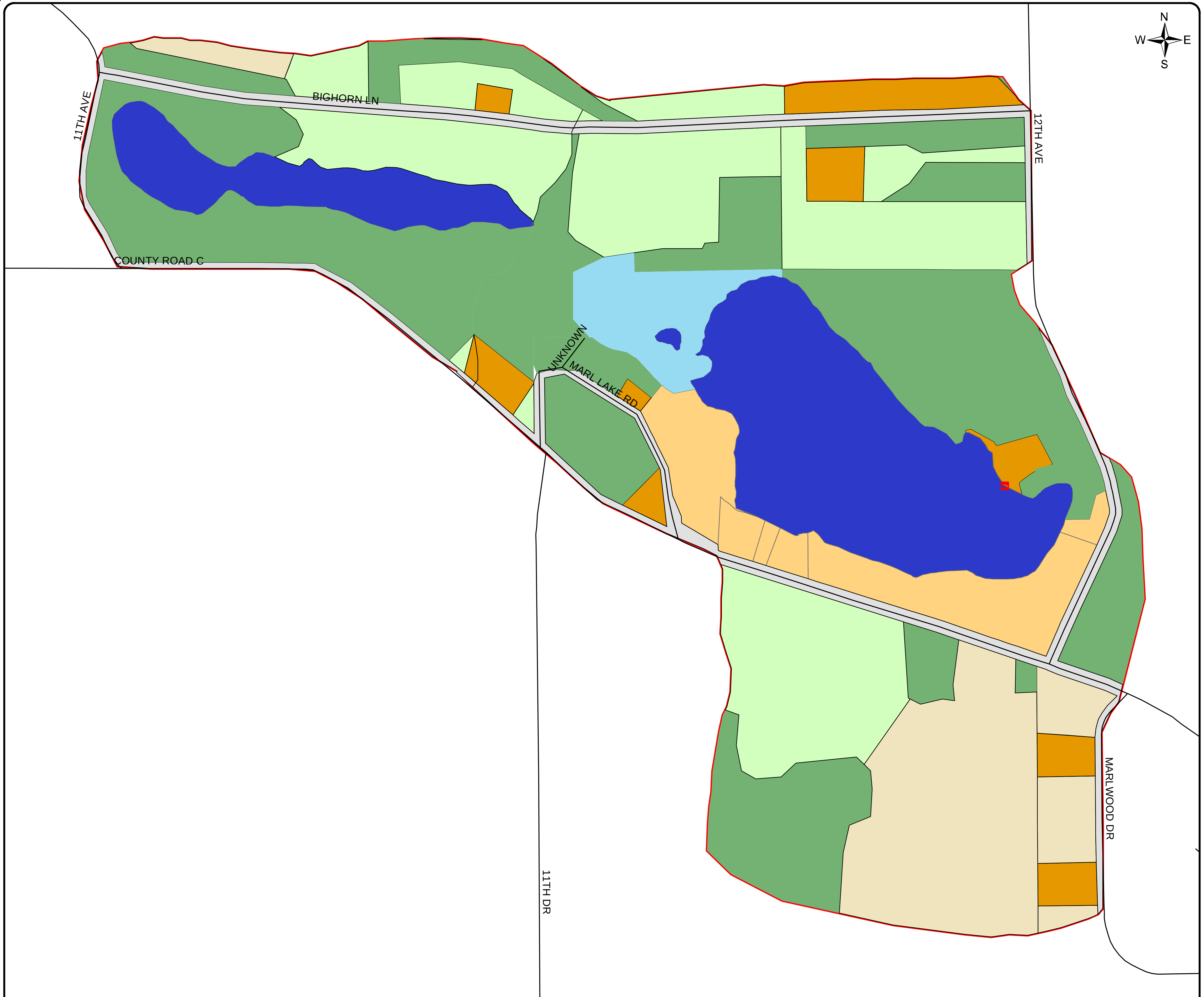

Figure 12

Marl Lake

Waushara County, Wisconsin

Watershed Land Use

- Forest
- Grassland/Pature
- Light Urban
- Row Crop
- Road Right-of-Way
- Rural Residential
- Surface Water
- Wetland
- Boat Landing

NES Ecological Services
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A

APPENDIX A

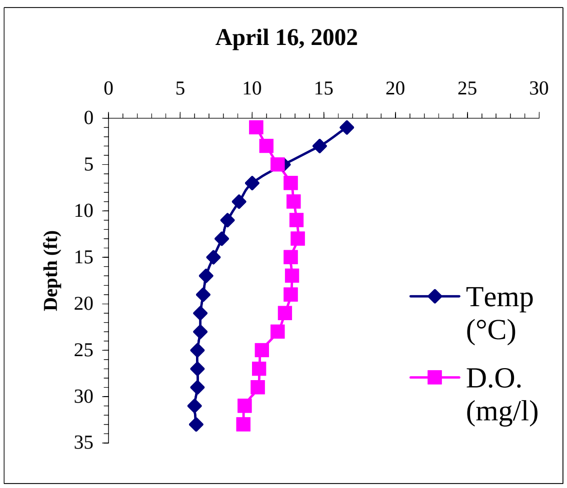
Water Quality Dataset Collected During 2002-2003

Marl Lake

Date: **04-16-02** **Max Depth (ft):** 33.8
Time: 14:30 **MARLS Depth (ft):** 3.0
Weather: **MARLB Depth (ft):** 30.0
Ent: BGN **Verf:** BN/JE **Secchi Depth (ft):** 33.8

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	16.6	10.3	8.4	294
3.0	14.7	11.0	8.4	293
5.0	12.2	11.8	8.4	292
7.0	10.0	12.7	8.4	291
9.0	9.1	12.9	8.4	291
11.0	8.3	13.1	8.4	293
13.0	7.9	13.2	8.4	296
15.0	7.3	12.7	8.4	302
17.0	6.8	12.8	8.3	306
19.0	6.6	12.7	8.3	322
21.0	6.4	12.3	8.1	336
23.0	6.4	11.8	8.0	344
25.0	6.2	10.7	7.9	367
27.0	6.2	10.5	7.9	375
29.0	6.2	10.4	7.8	376
31.0	6.0	9.5	7.8	387
33.0	6.1	9.4	7.7	393

Parameter	MARLS	MARLB
Total P (mg/l)	0.016	0.014
Dissolved P (mg/l)	0.000	0.000
Chl a (µg/l)	<1	<1
TKN (mg/l)	0.640	0.680
NO_4+NO_3-N (mg/l)	0.909	1.330
NH_3-N (mg/l)	0.058	0.182
Total N (mg/l)	1.549	2.010
Lab Cond. (µS/cm)	340	444
Lab pH	8.44	7.94
Alkal (mg/l $CaCO_3$)	161	212
Total Susp Sol (mg/l)		
Calcium (mg/l)	31.9	47.1



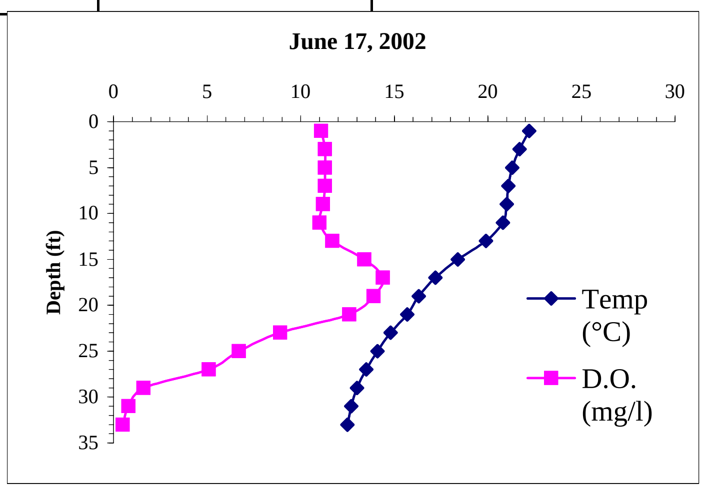
Notes:

Marl Lake

Date:	**06-17-02**		**Max Depth (ft):**	33.8
Time:	12:23		**MARLS Depth (ft):**	3.0
Weather:	clear 75		**MARLB Depth (ft):**	30.0
Ent:	BGN	**Verf:** BN/JE	**Secchi Depth (ft):**	21.9

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	22.2	11.1	9.0	283
3.0	21.7	11.3	9.1	282
5.0	21.3	11.3	9.1	281
7.0	21.1	11.3	9.1	282
9.0	21.0	11.2	9.1	281
11.0	20.8	11.0	9.1	283
13.0	19.9	11.7	8.9	302
15.0	18.4	13.4	8.8	309
17.0	17.2	14.4	8.9	313
19.0	16.3	13.9	8.9	317
21.0	15.7	12.6	8.8	322
23.0	14.8	8.9	8.5	333
25.0	14.1	6.7	8.3	338
27.0	13.5	5.1	8.1	344
29.0	13.0	1.6	7.9	352
31.0	12.7	0.8	7.9	359
33.0	12.5	0.5	7.8	364

Parameter	MARLS	MARLB
Total P (mg/l)	0.019	0.056
Dissolved P (mg/l)		
Chl a (µg/l)	<1	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		



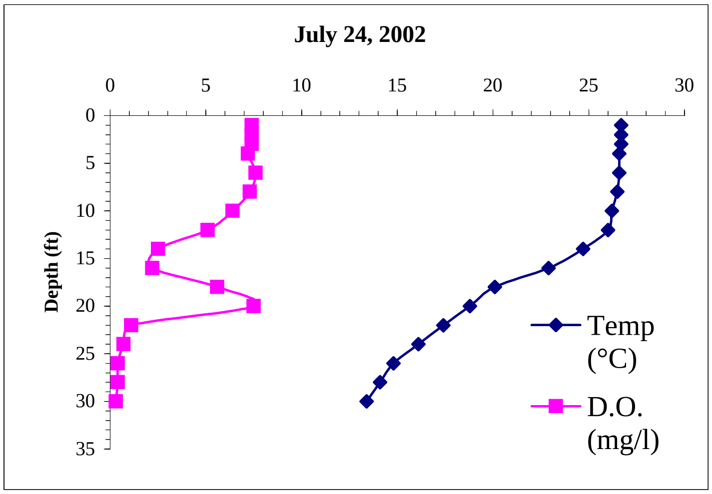
Notes:

Marl Lake

Date:	**07-24-02**	**Max Depth (ft):**	33.9
Time:	11:50	**MARLS Depth (ft):**	3.0
Weather:	73, partly cloudy	**MARLB Depth (ft):**	30.0
Ent:	BGN **Verf:** BN/JE	**Secchi Depth (ft):**	20.0

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	26.7	7.4	7.9	252
2.0	26.7	7.4	8.0	252
3.0	26.7	7.4	8.1	252
4.0	26.6	7.2	8.2	251
6.0	26.6	7.6	8.2	251
8.0	26.5	7.3	8.3	251
10.0	26.2	6.4	8.3	257
12.0	26.0	5.1	8.2	281
14.0	24.7	2.5	8.0	314
16.0	22.9	2.2	7.8	341
18.0	20.1	5.6	7.5	334
20.0	18.8	7.5	7.4	330
22.0	17.4	1.1	7.5	345
24.0	16.1	0.7	7.6	353
26.0	14.8	0.4	7.6	352
28.0	14.1	0.4	7.8	357
30.0	13.4	0.3	7.8	370

	MARLS	MARLB
Total P (mg/l)	0.020	0.042
Dissolved P (mg/l)	0.000	
Chl a (µg/l)	0.67	
TKN (mg/l)	0.640	1.180
NO_4+NO_3-N (mg/l)	0.147	0.019
NH_3-N (mg/l)	0.064	0.340
Total N (mg/l)	0.787	1.199
Lab Cond. (µS/cm)		
Lab pH	9.04	7.83
Alkal (mg/l $CaCO_3$)	125	180
Total Susp Sol (mg/l)	0	6
Calcium (mg/l)	18.9	



Notes:

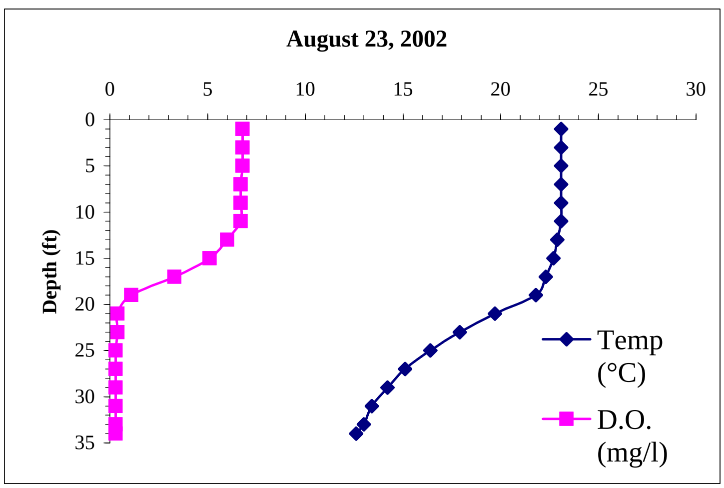
Marl Lake

Date: 08-23-02
Time: 11:50
Weather:
Ent: BGN **Verf:** TSN/TAH

Max Depth (ft): 35.2
MARLS Depth (ft): 3.0
MARLB Depth (ft): 32.0
Secchi Depth (ft): 13.8

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	23.1	6.8	8.8	300
3.0	23.1	6.8	9.0	300
5.0	23.1	6.8	9.0	300
7.0	23.1	6.7	9.0	300
9.0	23.1	6.7	8.9	300
11.0	23.1	6.7	8.8	300
13.0	22.9	6.0	8.6	306
15.0	22.7	5.1	8.4	321
17.0	22.3	3.3	8.1	339
19.0	21.8	1.1	7.8	356
21.0	19.7	0.4	7.8	376
23.0	17.9	0.4	7.5	384
25.0	16.4	0.3	7.4	378
27.0	15.1	0.3	7.5	379
29.0	14.2	0.3	7.5	394
31.0	13.4	0.3	7.3	421
33.0	13.0	0.3	7.2	450
34.0	12.6	0.3	7.1	468

Parameter	MARLS	MARLB
Total P (mg/l)	0.017	0.037
Dissolved P (mg/l)		
Chl a (µg/l)	5.13	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)	3	5
Calcium (mg/l)		



Notes:

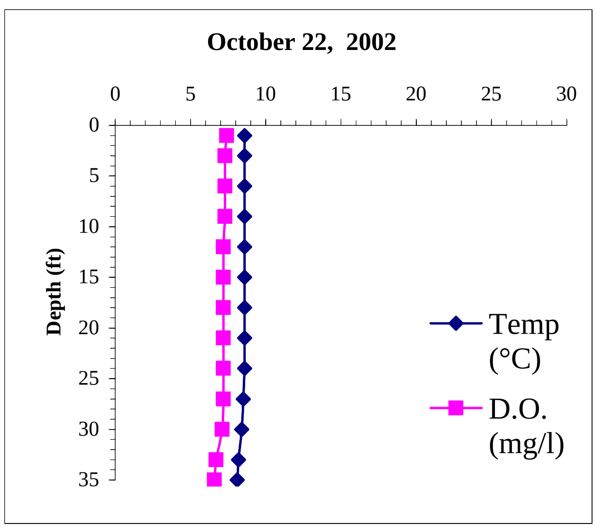
Marl Lake

Date: **10-22-02**
Time: 11:45
Weather: Overcast, 40, Breezy
Ent: tsn **Verf:** TSN/TAH

Max Depth (ft): 36.2
MARLS Depth (ft): 3.0
MARLB Depth (ft): 33.0
Secchi Depth (ft): 14.2

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	8.6	7.4	8.4	359
3.0	8.6	7.3	8.4	359
6.0	8.6	7.3	8.5	359
9.0	8.6	7.3	8.4	359
12.0	8.6	7.2	8.3	359
15.0	8.6	7.2	8.3	359
18.0	8.6	7.2	8.3	359
21.0	8.6	7.2	8.3	359
24.0	8.6	7.2	8.2	359
27.0	8.5	7.2	8.2	358
30.0	8.4	7.1	8.2	360
33.0	8.2	6.7	8.1	371
35.0	8.1	6.6	8.1	373

Parameter	MARLS	MARLB
Total P (mg/l)	0.019	0.013
Dissolved P (mg/l)		
Chl a (µg/l)	6.52	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)	0	0
Calcium (mg/l)		



Notes:

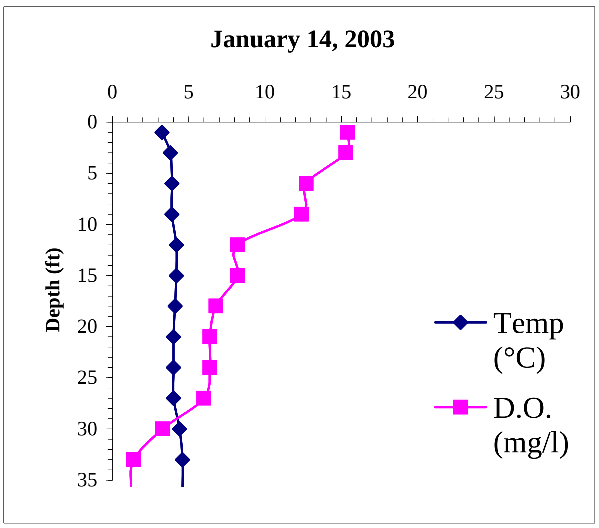
Marl Lake

Date: **01-14-03**
Time: 11:30
Weather: 7F, Sunny, Breezy
Ent: tsn **Verf:** TSN/TAH

Max Depth (ft): 37.9
MARLS Depth (ft): 3.0
MARLB Depth (ft): 33.0
Secchi Depth (ft): 14.2

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	3.3	15.4	8.6	392
3.0	3.8	15.3	8.6	393
6.0	3.9	12.7	8.7	393
9.0	3.9	12.4	8.7	393
12.0	4.2	8.2	8.3	403
15.0	4.2	8.2	8.0	416
18.0	4.1	6.8	7.8	436
21.0	4.0	6.4	7.7	452
24.0	4.0	6.4	7.6	461
27.0	4.0	6.0	7.6	472
30.0	4.4	3.3	7.5	481
33.0	4.6	1.4	7.4	484
36.0	4.6	1.2	7.4	484

Parameter	MARLS	MARLB
Total P (mg/l)	0.019	0.019
Dissolved P (mg/l)		
Chl a (µg/l)		
TKN (mg/l)	0.940	0.630
NO_4+NO_3-N (mg/l)	0.744	1.800
NH_3-N (mg/l)	0.202	0.257
Total N (mg/l)	1.684	2.430
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		



Notes: Ice thickness = 0.9'

B

APPENDIX B

Comprehensive Aquatic Vegetation Survey Data

Appendix B

Marl Lake
Vegetation Survey Data

Transect	Depth Range	Substrate	Acronym	Aerial Cover	Max Veg Z	Species	Common Name	Daubenmire Cover
1	1	silty sand	junef	20		Juncus effusus	Soft stemmed rush	2
1	1	silty sand	lemmi	10		Lemna minor	Small duckweed, water lentil, lesser duckweed	2
1	1	silty sand	phaar	10		Phalaris arundinacea	Reed canary grass	2
1	1	silty sand	sciva	10		Scirpus validus	Softstem bulrush	2
1	1	silty sand	cxcom	5		Carex comosa	Bristly sedge, bottle brush sedge	2
1	1	silty sand	nymod	1		Nymphaea odorata	White water lily, fragrant water lily	1
1	2	sandy	noveg			NO VEG	NO VEG	0
1	3	sandy	noveg			NO VEG	NO VEG	0
1	4	silty	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
1	4	silty	potzo	40		Potamogeton zosteriformis	Flat-stem pondweed	3
1	4	silty	potpe	10		Potamogeton pectinatus	Sago pondweed	2
1	4	silty	najfl	5		Najas flexilis	Slender naiad, bushy pondweed	2
1	4	silty	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
1	5	silty	cerde	1	22	Ceratophyllum demersum	Coontail, hornwort	1
2	1	silty sand	phaar	30		Phalaris arundinacea	Reed canary grass	3
2	1	silty sand	cxcom	10		Carex comosa	Bristly sedge, bottle brush sedge	2
2	1	silty sand	cxvul	5		Carex vulpinoidea	Sedge	2
2	1	silty sand	junef	5		Juncus effusus	Soft stemmed rush	2
2	1	silty sand	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
2	1	silty sand	plama	1		Plantago major	Common plantain	1
2	1	silty sand	sciva	1		Scirpus validus	Softstem bulrush	1
2	2	sandy	noveg			NO VEG	NO VEG	0
2	3	sandy silt	zosdu	80		Zosterella dubia	Water stargrass	5
2	3	sandy silt	potil	40		Potamogeton illinoensis	Illinois pondweed	3
2	3	sandy silt	potpe	10		Potamogeton pectinatus	Sago pondweed	2
2	3	sandy silt	najfl	5		Najas flexilis	Slender naiad, bushy pondweed	2
2	4	silty	zosdu	60		Zosterella dubia	Water stargrass	4
2	4	silty	potil	40		Potamogeton illinoensis	Illinois pondweed	3
2	4	silty	potpe	5		Potamogeton pectinatus	Sago pondweed	2
2	4	silty	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
2	4	silty	najfl	1		Najas flexilis	Slender naiad, bushy pondweed	1
2	5	silty	cerde	1		Ceratophyllum demersum	Coontail, hornwort	1
3	1	sandy silt	sciva	30		Scirpus validus	Softstem bulrush	3
3	1	sandy silt	euppe	10		Eupatorium perfoliatum	Common boneset	2
3	1	sandy silt	typla	10		Typha latifolia	Broad-leaved cattail	2
3	1	sandy silt	cxvul	5		Carex vulpinoidea	Sedge	2
3	1	sandy silt	polam	5		Polygonum amphibium	Water smartweed, water knotweed	2
3	1	sandy silt	junte	1		Juncus tenuis	Path rush	1
3	2	sandy silt	zosdu	20		Zosterella dubia	Water stargrass	2
3	2	sandy silt	potpe	5		Potamogeton pectinatus	Sago pondweed	2
3	2	sandy silt	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
3	2	sandy silt	najfl	1		Najas flexilis	Slender naiad, bushy pondweed	1
3	2	sandy silt	potzo	1		Potamogeton zosteriformis	Flat-stem pondweed	1
3	3	sandy silt	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
3	3	sandy silt	potil	1		Potamogeton illinoensis	Illinois pondweed	1
3	3	sandy silt	potpe	1		Potamogeton pectinatus	Sago pondweed	1
3	4	silty	zosdu	60		Zosterella dubia	Water stargrass	4
3	4	silty	chasp	40		Chara sp.	Muskgrasses, stoneworts	3
3	4	silty	potil	30		Potamogeton illinoensis	Illinois pondweed	3
3	4	silty	potpe	5		Potamogeton pectinatus	Sago pondweed	2
3	5	silty	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
3	5	silty	cerde	30		Ceratophyllum demersum	Coontail, hornwort	3
3	5	silty	myrsi	30		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	3
4	1	silty sand	cxcom	10		Carex comosa	Bristly sedge, bottle brush sedge	2
4	1	silty sand	lemmi	10		Lemna minor	Small duckweed, water lentil, lesser duckweed	2
4	1	silty sand	myrsi	10		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
4	1	silty sand	phaar	10		Phalaris arundinacea	Reed canary grass	2
4	1	silty sand	junte	5		Juncus tenuis	Path rush	2
4	1	silty sand	potpe	5		Potamogeton pectinatus	Sago pondweed	2
4	1	silty sand	polam	1		Polygonum amphibium	Water smartweed, water knotweed	1
4	1	silty sand	sciva	1		Scirpus validus	Softstem bulrush	1
4	2	silty	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
4	2	silty	potil	20		Potamogeton illinoensis	Illinois pondweed	2
4	2	silty	potno	20		Potamogeton nodosus	Long-leaf pondweed	2
4	2	silty	myrsi	15		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
4	2	silty	potpe	10		Potamogeton pectinatus	Sago pondweed	2
4	2	silty	potil	5		Potamogeton illinoensis	Illinois pondweed	2
4	3	silty	chasp	90		Chara sp.	Muskgrasses, stoneworts	5
4	3	silty	potil	25		Potamogeton illinoensis	Illinois pondweed	3
4	3	silty	cerde	5		Ceratophyllum demersum	Coontail, hornwort	2
4	3	silty	potpe	5		Potamogeton pectinatus	Sago pondweed	2
4	3	silty	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
5	1	silty	phaar	40		Phalaris arundinacea	Reed canary grass	3
5	1	silty	cxcom	30		Carex comosa	Bristly sedge, bottle brush sedge	3
5	1	silty	lemmi	30		Lemna minor	Small duckweed, water lentil, lesser duckweed	3

Transect	Depth Range	Substrate	Acronym	Aerial Cover	Max Veg Z	Species	Common Name	Daubenmire Cover
5	1	silty	eleac	10		Eleocharis acicularis	Needle spikerush, hairgrass	2
5	1	silty	polam	10		Polygonum amphibium	Water smartweed, water knotweed	2
5	1	silty	sciac	10		Scirpus acutus	Hardstem bulrush	2
5	1	silty	wolco	10		Wolffia columbiana	Common watermeal	2
5	2	mucky	lemmi	30		Lemna minor	Small duckweed, water lentil, lesser duckweed	3
5	2	mucky	nupva	30		Nuphar variegata	Spatterdock, bullhead pond lily	3
5	2	mucky	phaar	30		Phalaris arundinacea	Reed canary grass	3
5	2	mucky	sciac	20		Scirpus acutus	Hardstem bulrush	2
5	2	mucky	sciva	10		Scirpus validus	Softstem bulrush	2
5	2	mucky	wolco	5		Wolffia columbiana	Common watermeal	2
5	2	mucky	potno	1		Potamogeton nodosus	Long-leaf pondweed	1
5	2	mucky	typla	1		Typha latifolia	Broad-leaved cattail	1
5	3	silty	chasp	50		Chara sp.	Muskgrasses, stoneworts	4
5	3	silty	nupva	30		Nuphar variegata	Spatterdock, bullhead pond lily	3
5	3	silty	potil	30		Potamogeton illinoensis	Illinois pondweed	3
5	3	silty	myrsi	20		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
5	3	silty	potpe	5		Potamogeton pectinatus	Sago pondweed	2
5	3	silty	potzo	1		Potamogeton zosteriformis	Flat-stem pondweed	1
5	4	silty	myrsi	60		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	4
5	4	silty	potzo	10		Potamogeton zosteriformis	Flat-stem pondweed	2
5	4	silty	potpe	5		Potamogeton pectinatus	Sago pondweed	2
5	4	silty	chasp	1		Chara sp.	Muskgrasses, stoneworts	1
6	1	silty	sciva	60		Scirpus validus	Softstem bulrush	4
6	1	silty	potno	10		Potamogeton nodosus	Long-leaf pondweed	2
6	1	silty	potpe	10		Potamogeton pectinatus	Sago pondweed	2
6	1	silty	myrsi	5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
6	1	silty	nymod	1		Nymphaea odorata	White water lily, fragrant water lily	1
6	2	silty	sciva	20		Scirpus validus	Softstem bulrush	2
6	2	silty	nupva	10		Nuphar variegata	Spatterdock, bullhead pond lily	2
6	2	silty	nymod	10		Nymphaea odorata	White water lily, fragrant water lily	2
6	2	silty	potpe	1		Potamogeton pectinatus	Sago pondweed	1
6	2	silty	potzo	1		Potamogeton zosteriformis	Flat-stem pondweed	1
6	3	silty	nupva	80		Nuphar variegata	Spatterdock, bullhead pond lily	5
6	3	silty	lemmi	40		Lemna minor	Small duckweed, water lentil, lesser duckweed	3
6	3	silty	myrsi	10		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
6	3	silty	potzo	5		Potamogeton zosteriformis	Flat-stem pondweed	2
6	4	silty	myrsi	60		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	4
6	4	silty	potzo	10		Potamogeton zosteriformis	Flat-stem pondweed	2
6	4	silty	potpe	5		Potamogeton pectinatus	Sago pondweed	2
6	4	silty	chasp	1		Chara sp.	Muskgrasses, stoneworts	1
7	1	silty	leeor	30		Leersia oryzoides	Cut grass	3
7	1	silty	nymod	25		Nymphaea odorata	White water lily, fragrant water lily	3
7	1	silty	cxcom	20		Carex comosa	Bristly sedge, bottle brush sedge	2
7	1	silty	lemmi	20		Lemna minor	Small duckweed, water lentil, lesser duckweed	2
7	1	silty	sciva	20		Scirpus validus	Softstem bulrush	2
7	1	silty	typla	20		Typha latifolia	Broad-leaved cattail	2
7	1	silty	euppe	10		Eupatorium perfoliatum	Common boneset	2
7	1	silty	potzo	10		Potamogeton zosteriformis	Flat-stem pondweed	2
7	1	silty	wolco	5		Wolffia columbiana	Common watermeal	2
7	1	silty	potil	1		Potamogeton illinoensis	Illinois pondweed	1
7	2	silty	nupva	50		Nuphar variegata	Spatterdock, bullhead pond lily	4
7	2	silty	potpe	30		Potamogeton pectinatus	Sago pondweed	3
7	2	silty	lemmi	20		Lemna minor	Small duckweed, water lentil, lesser duckweed	2
7	2	silty	potzo	10		Potamogeton zosteriformis	Flat-stem pondweed	2
7	2	silty	sciva	10		Scirpus validus	Softstem bulrush	2
7	2	silty	sagla	1		Sagittaria latifolia	Common arrowhead, broad-leaf arrowhead, duck potato, wapato	1
7	3	silty	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
7	3	silty	potzo	30		Potamogeton zosteriformis	Flat-stem pondweed	3
7	3	silty	potil	20		Potamogeton illinoensis	Illinois pondweed	2
7	3	silty	polam	1		Polygonum amphibium	Water smartweed, water knotweed	1
7	3	silty	potpe	1		Potamogeton pectinatus	Sago pondweed	1
7	4	silty	chasp	60		Chara sp.	Muskgrasses, stoneworts	4
7	4	silty	myrsi	20		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
7	4	silty	zosdu	20		Zosterella dubia	Water stargrass	2
7	5	silty	chasp	30		Chara sp.	Muskgrasses, stoneworts	3
7	5	silty	cerde	20		Ceratophyllum demersum	Coontail, hornwort	2
7	5	silty	myrsi	10		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
7	5	silty	potzo	1		Potamogeton zosteriformis	Flat-stem pondweed	1
8	1	sandy	cxcom	30		Carex comosa	Bristly sedge, bottle brush sedge	3
8	1	sandy	leeor	30		Leersia oryzoides	Cut grass	3
8	1	sandy	phaar	15		Phalaris arundinacea	Reed canary grass	2
8	1	sandy	junsp	10		Juncus sp	Rushes	2
8	1	sandy	lycam	10		Lycopus americanus	Common water horehound	2
8	1	sandy	myrsi	5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
8	1	sandy	najfl	5		Najas flexilis	Slender naiad, bushy pondweed	2

Appendix B

Transect	Depth Range	Substrate	Acronym	Aerial Cover	Max Veg Z	Species	Common Name	Daubenmire Cover
8	1	sandy	nymod	5		Nymphaea odorata	White water lily, fragrant water lily	2
8	1	sandy	polam	5		Polygonum amphibium	Water smartweed, water knotweed	2
8	1	sandy	potpe	5		Potamogeton pectinatus	Sago pondweed	2
8	1	sandy	sciac	5		Scirpus acutus	Hardstem bulrush	2
8	1	sandy	cerde	1		Ceratophyllum demersum	Coontail, hornwort	1
8	2	sandy silt	potil	30		Potamogeton illinoensis	Illinois pondweed	3
8	2	sandy silt	potpe	20		Potamogeton pectinatus	Sago pondweed	2
8	2	sandy silt	myrsi	10		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
8	2	sandy silt	najfl	5		Najas flexilis	Slender naiad, bushy pondweed	2
8	2	sandy silt	potzo	1		Potamogeton zosteriformis	Flat-stem pondweed	1
8	3	silty	chasp	90		Chara sp.	Muskgrasses, stoneworts	5
8	3	silty	potil	20		Potamogeton illinoensis	Illinois pondweed	2
8	4	silty	myrsi	30		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	3
8	4	silty	chasp	20		Chara sp.	Muskgrasses, stoneworts	2
8	4	silty	potzo	20		Potamogeton zosteriformis	Flat-stem pondweed	2
8	5	silty	cerde	30		Ceratophyllum demersum	Coontail, hornwort	3
8	5	silty	chasp	20		Chara sp.	Muskgrasses, stoneworts	2
8	5	silty	myrsi	10		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
9	1	sandy	cxcom	30		Carex comosa	Bristly sedge, bottle brush sedge	3
9	1	sandy	phaar	20		Phalaris arundinacea	Reed canary grass	2
9	1	sandy	salex	10		Salix exigua	Sandbar willow	2
9	1	sandy	junsp	5		Juncus sp	Rushes	2
9	1	sandy	polam	5		Polygonum amphibium	Water smartweed, water knotweed	2
9	1	sandy	potil	5		Potamogeton illinoensis	Illinois pondweed	2
9	1	sandy	potpe	5		Potamogeton pectinatus	Sago pondweed	2
9	1	sandy	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
9	2	silty sand	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
9	2	silty sand	potil	30		Potamogeton illinoensis	Illinois pondweed	3
9	2	silty sand	najfl	10		Najas flexilis	Slender naiad, bushy pondweed	2
9	2	silty sand	potzo	10		Potamogeton zosteriformis	Flat-stem pondweed	2
9	3	silty sand	chasp	40		Chara sp.	Muskgrasses, stoneworts	3
9	3	silty sand	potil	20		Potamogeton illinoensis	Illinois pondweed	2
9	3	silty sand	potzo	20		Potamogeton zosteriformis	Flat-stem pondweed	2
9	3	silty sand	myrsi	5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
9	3	silty sand	cerde	1		Ceratophyllum demersum	Coontail, hornwort	1
9	4	sandy silt	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
9	4	sandy silt	potil	20		Potamogeton illinoensis	Illinois pondweed	2
9	4	sandy silt	myrsi	5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
9	5	silty	chasp	90		Chara sp.	Muskgrasses, stoneworts	5
9	5	silty	myrsi	30		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	3
9	5	silty	potil	1		Potamogeton illinoensis	Illinois pondweed	1
10	1	sandy	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
10	1	sandy	potil	1		Potamogeton illinoensis	Illinois pondweed	1
10	2	sandy	potil	20		Potamogeton illinoensis	Illinois pondweed	2
10	2	sandy	myrsi	10		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
10	2	sandy	najfl	10		Najas flexilis	Slender naiad, bushy pondweed	2
10	3	silty	chasp	100		Chara sp.	Muskgrasses, stoneworts	6
10	3	silty	potil	40		Potamogeton illinoensis	Illinois pondweed	3
10	3	silty	myrsi	30		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	3
10	4	silty	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
10	4	silty	myrsi	40		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	3
10	4	silty	potil	10		Potamogeton illinoensis	Illinois pondweed	2
10	5	silty	chasp	40		Chara sp.	Muskgrasses, stoneworts	3
10	5	silty	myrsi	5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
10	5	silty	potzo	1		Potamogeton zosteriformis	Flat-stem pondweed	1
11	1	sandy w/cobble	polam	5		Polygonum amphibium	Water smartweed, water knotweed	2
11	1	sandy w/cobble	phaar	1		Phalaris arundinacea	Reed canary grass	1
11	2	sandy w/cobble	potil	40		Potamogeton illinoensis	Illinois pondweed	3
11	2	sandy w/cobble	chasp	20		Chara sp.	Muskgrasses, stoneworts	2
11	2	sandy w/cobble	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
11	3	silty sand w/cobt	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
11	3	silty sand w/cobt	potil	30		Potamogeton illinoensis	Illinois pondweed	3
11	3	silty sand w/cobt	najfl	5		Najas flexilis	Slender naiad, bushy pondweed	2
11	3	silty sand w/cobt	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
11	4	silty	chasp	100		Chara sp.	Muskgrasses, stoneworts	6
11	4	silty	potil	30		Potamogeton illinoensis	Illinois pondweed	3
11	4	silty	myrsi	10		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
11	5	silty	chasp	60		Chara sp.	Muskgrasses, stoneworts	4
11	5	silty	cerde	30		Ceratophyllum demersum	Coontail, hornwort	3
11	5	silty	myrsi	30		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	3
12	1	sandy	zosdu	5		Zosterella dubia	Water stargrass	2
12	2	silty sand	chasp	60		Chara sp.	Muskgrasses, stoneworts	4
12	2	silty sand	potil	30		Potamogeton illinoensis	Illinois pondweed	3
12	2	silty sand	najfl	20		Najas flexilis	Slender naiad, bushy pondweed	2
12	2	silty sand	myrsi	5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2

Transcect	Depth Range	Substrate	Acronym	Aerial Cover	Max Veg Z	Species	Common Name	Daubenmire Cover
12	3	silty sand	chasp	30		Chara sp.	Muskgrasses, stoneworts	3
12	3	silty sand	najfl	30		Najas flexilis	Slender naiad, bushy pondweed	3
12	3	silty sand	potil	30		Potamogeton illinoensis	Illinois pondweed	3
12	3	silty sand	myrsi	1		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
12	4	silty	potpe	40		Potamogeton pectinatus	Sago pondweed	3
12	4	silty	chasp	30		Chara sp.	Muskgrasses, stoneworts	3
12	4	silty	myrsi	30		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	3
12	4	silty	potzo	5		Potamogeton zosteriformis	Flat-stem pondweed	2
12	5	silty	chasp	80		Chara sp.	Muskgrasses, stoneworts	5
12	5	silty	cerde	30		Ceratophyllum demersum	Coontail, hornwort	3
12	5	silty	myrsi	10		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
13	1	silty sand	lemmi	20		Lemna minor	Small duckweed, water lentil, lesser duckweed	2
13	1	silty sand	junef	10		Juncus effusus	Soft stemmed rush	2
13	1	silty sand	junte	10		Juncus tenuis	Path rush	2
13	1	silty sand	polam	10		Polygonum amphibium	Water smartweed, water knotweed	2
13	2	sandy	zosdu	30		Zosterella dubia	Water stargrass	3
13	2	sandy	potil	20		Potamogeton illinoensis	Illinois pondweed	2
13	2	sandy	cerde	5		Ceratophyllum demersum	Coontail, hornwort	2
13	2	sandy	myrsi	5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
13	2	sandy	polam	1		Polygonum amphibium	Water smartweed, water knotweed	1
13	2	sandy	potpe	1		Potamogeton pectinatus	Sago pondweed	1
13	3	silty	chasp	60		Chara sp.	Muskgrasses, stoneworts	4
13	3	silty	myrsi	20		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
13	3	silty	potil	10		Potamogeton illinoensis	Illinois pondweed	2
13	3	silty	cerde	1		Ceratophyllum demersum	Coontail, hornwort	1
13	3	silty	eloca	1		Elodea canadensis	Common waterweed	1
13	3	silty	najfl	1		Najas flexilis	Slender naiad, bushy pondweed	1
13	3	silty	nymod	1		Nymphaea odorata	White water lily, fragrant water lily	1
13	4	silty	potzo	60		Potamogeton zosteriformis	Flat-stem pondweed	4
13	4	silty	myrsi	40		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	3
13	4	silty	potpe	30		Potamogeton pectinatus	Sago pondweed	3
13	4	silty	chasp	20		Chara sp.	Muskgrasses, stoneworts	2
13	4	silty	potil	10		Potamogeton illinoensis	Illinois pondweed	2
13	5	silty	chasp	70		Chara sp.	Muskgrasses, stoneworts	4
13	5	silty	cerde	40		Ceratophyllum demersum	Coontail, hornwort	3
13	5	silty	myrsi	20		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
14	1	silty	zosdu	40		Zosterella dubia	Water stargrass	3
14	1	silty	leeor	30		Leersia oryzoides	Cut grass	3
14	1	silty	nymod	30		Nymphaea odorata	White water lily, fragrant water lily	3
14	1	silty	nupva	10		Nuphar variegata	Spatterdock, bullhead pond lily	2
14	1	silty	myrsi	5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
14	1	silty	potpe	5		Potamogeton pectinatus	Sago pondweed	2
14	2	silty	nymod	30		Nymphaea odorata	White water lily, fragrant water lily	3
14	2	silty	nupva	20		Nuphar variegata	Spatterdock, bullhead pond lily	2
14	2	silty	potna	20		Potamogeton natans	Floating-leaf pondweed	2
14	2	silty	zosdu	20		Zosterella dubia	Water stargrass	2
14	2	silty	myrsi	10		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
14	2	silty	potil	5		Potamogeton illinoensis	Illinois pondweed	2
14	2	silty	potzo	5		Potamogeton zosteriformis	Flat-stem pondweed	2
14	3	silty	chasp	40		Chara sp.	Muskgrasses, stoneworts	3
14	3	silty	myrsi	20		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
14	3	silty	potil	20		Potamogeton illinoensis	Illinois pondweed	2
14	3	silty	zosdu	20		Zosterella dubia	Water stargrass	2
14	3	silty	najfl	10		Najas flexilis	Slender naiad, bushy pondweed	2
14	4	silty	chasp	60		Chara sp.	Muskgrasses, stoneworts	4
14	4	silty	myrsi	20		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
14	4	silty	potzo	10		Potamogeton zosteriformis	Flat-stem pondweed	2

C

APPENDIX C

Lake Term Glossary

Algae	Microscopic plants that use sunlight as an energy source. Algae can be unicellular (Diatoms), filamentous (many green or blue-green species), colonies in a gelatinous mass (many blue-greens) or more complicated colonies like *Chara sp.*
Anthropogenic	An occurrence caused or produced by the action of humans.
Anoxic	Devoid of dissolved oxygen.
Benthic	Pertaining to a river bed or lake floor
Contact Herbicide	A plant specific pesticide which causes extensive cellular damage exclusively to the areas of the target which come in contact with the herbicide (Affects contacted area only)
Ecosystem	The interaction of a community of organisms with each other and with the characteristics that make up their environment (Aquatic ecosystem, Northern Boreal Forest)
Emergent	An aquatic plant having most of its vegetative parts above the water surface (Cattail, Common Arrowhead)
Epilimnion	The upper most layer of water within a stratified lake. During the summer, this layer holds the warmest water and during the winter it holds the coldest water. This layer continuously circulates.
Exotic	A non-native organism that has been introduced into an area (Purple Loosestrife, Eurasian Water Milfoil)
Floating-leaf	Plants rooted in the sediment or free-floating with leaves lying flat on the water surface (Duckweed, White Water Lilly)
Hypolimnion	The deepest layer of water within a stratified lake. In the winter it holds the warmest water and in the summer it holds the coldest water.
Interspecific	Between two or more distinct species.
Invasive	An organism which readily colonizes a disturbed area and tends to take it over by out-competing other plants. These can be native (Cattail) or exotic species (Purple Loosestrife).
Limiting Nutrient	The nutrient, usually phosphorus, which is in shortest supply and controls the growth rate of algae and macrophytes.
Littoral Zone	Pertaining to the shallow water zone of a lake that has sufficient light penetration to support macrophytes.
Macrophyte	A multicelled plant, usually with roots, stems, and leaves. A vascular plant (Cattail, Eurasian water-milfoil, pondweeds)
Median Value	A value in a set which has an equal number of observations above it and below it
Metalimnion	This is the layer between the epilimnion and the Hypolimnion that has the greatest range of temperature change with depth. The metalimnion contains the thermocline, but is not the same thing.
Native	An organism that is naturally occurring to an area (White Water Lilly, Northern Water-milfoil)

Nitrogen to Phosphorus Ratio	Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 16:1, the lake is considered phosphorus limited; if it is less than 16:1, it is considered nitrogen limited. The key ratio of 16:1 is related to the normal nitrogen to phosphorus ration found in most algae.
Non-Point Source Pollution	A source of pollution that comes from an indirect point of discharge (Overland flow)
Periphyton	A community of algae, and fragments of algae, which are attached to submerged objects such as plants and stones
Photosynthesis	The process in which chlorophyll producing organisms convert CO2 and water into sugar and oxygen, using sunlight as an energy source
Phytoplankton	Free-floating (not attached) algae.
Point Source Pollution	A source of pollution that comes from a direct point of discharge (Drain Tile Outfall)
Senesce	To complete a life cycle; to die off
Shoreland Buffer Zone	A buffer of native plants and habitat that occurs between the lake and developed property. The buffer zone serves to filter sediment and nutrients that wash off of a developed area before they reach the lake.
Species Diversity	An index that relates the number of species to their relative abundances. A community with many species with similar numbers (abundances) is more diverse than a community with the same number of species, but only a few of the species dominate the area with their abundances.
Species Richness	The total number of species occurring in a community
Submergent	An aquatic plant growing entirely under the water surface (Coontail, Large-leaf pondweed, Eurasian water-milfoil)
Systematic Herbicide	A plant specific pesticide which causes systematic cellular damage after coming in contact with the target. These herbicides spread through the entire plant.
Water Residence Time	The average amount of time water resides in a lake. Usually measured in years or days. A lake with a long residence time would have a slow flushing rate.
Zooplankton	Microscopic animals that are free-floating with in a water body. Many prey on algae and are an important food source for young fish.

D

APPENDIX D

Education Component Material

Marl Lake District

Comprehensive Lake Management Plan

May 26, 2003

Presentation Outline

Comprehensive Lake Management Plan Development Project
- Goals and Objectives
- Components
- Timeline

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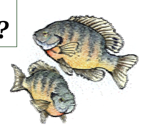
A Division of Robert E. Lee & Associates, Inc.

Project Goals & Objectives

Why should we develop a lake management plan?



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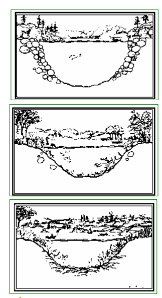
Eutrophication
-Lake Aging

Lake Trophic States



Oligotrophic

Mesotrophic

Eutrophic

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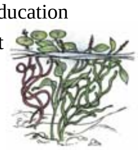
Protection of Marl Lake

•Sensitive Area Designation
•Exotic Species Education
  •Signs
  •Literature Handouts
•Baseline & Long-term Monitoring
•New Property Owner Education
•Watershed Management



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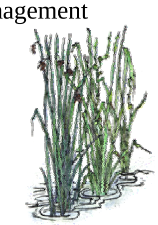
Enhancement of Marl Lake

•Habitat
•Shoreland Restoration
•Watershed Management



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Project Components

- Public Education
- Watershed Assessment
- Water Quality
- Aquatic Vegetation Survey

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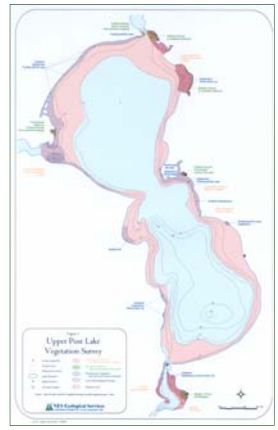

Project Timeline

Task	2002								2003					
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Prelim. Meeting														
Watershed Asses.														
Water Sample														
Plant Survey														
Progress Report														
Data Analysis														
Report Preparation														
Report Delivery														
Final Meeting														

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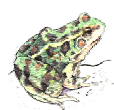
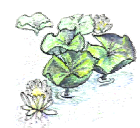
Your Participation is Important to the Success of this Project





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Lake management under way in Waushara

BY PATRICIA WOLFF
OF THE NORTHWESTERN

BERLIN – A little purple loosestrife here. A little Eurasian water-milfoil there. Some zebra mussels over here.

The spread of non-native, invasive plants and animal species are a threat to lakes all over Wisconsin, said Tim Hoyman, an aquatic ecologist with NES Ecological Services.

Many lake districts in the state are waging war against those threats.

Hoyman's Green Bay company is working with four lake districts in Waushara County to develop lake management plans aimed at correcting problems that are already there and avoiding new ones.

Managing a lake district is a lot like managing your health or your pocketbook, Hoyman said.

With all three, an ounce of prevention is worth a pound of cure.

"When it comes to health and finances, the person who starts early does better than the person who waits until he's 55. It's the same with lakes. It's better to keep them healthy," Hoyman said.

That was the idea that convinced the boards of directors of the Alpine Lake Protection and Rehabilitation District, the Little Hills Management District, the Marl Lake District and the Big Hills Lake Protection and Rehabilitation District to go after state grants to help with their planning.

The DNR's Lake Management Grant program pays up to 75 percent of the cost of planning projects. The average lake management plan costs roughly $10,000 and takes many months to complete, Hoyman said.

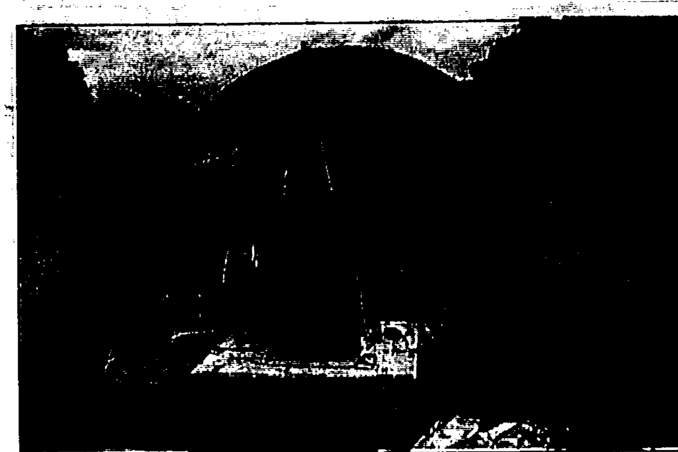
The people in the Marl-Lake District in the town of Deerfield got into planning to update a 1995 plant study.

"We wanted to see if we have Eurasian water-milfoil. So far, we have none. We have a healthy lake," Barry Wilson said.

He'd like to keep it that way. NES Ecological Services will help, Wilson said.

Wilson has been spending time on the 40-acre Marl Lake six miles west of Wautoma since 1946. Thirty-three prop-

LAKES, PAGE C2 ▶



SPECIAL TO THE NORTHWESTERN

JAMES HAVEL, an ecologist with NES Ecological Services of Green Bay, records aquatic plant survey data at Alpine Lake in Waushara County.

Lakes: DNR will prepare list of recommendations for lake districts once studies are complete

FROM PAGE C1

erty owners have homes on the lake, popular for swimming, boating and fishing. Fishermen and women ply the waters for bass, northern, bluegills, crappie and perch, Wilson said.

Wilson, who is retired, said he enjoys watching the wildlife that live around the lake. "Turkeys come down to drink. We see blue herons, ducks, everything you can think of," he said.

Each of the four lakes being studied is different and each requires a specific management plan to protect and improve it, Hoyman said.

"Lake Alpine has historically had aquatic plant problems, both in the form of rooted aquatic plants and algae," Hoyman said.

"Marl Lake and Little Hills Lake are not dealing with specific problems, but Big Hills Lake does support a healthy population and potentially problematic plant, Eurasian water-milfoil," he said.

Eurasian water-milfoil is a non-native plant that inhabits many of Wisconsin's lakes and occurs in lakes in most counties in the state. As of 2001, the plant had shown up in 15 of Waushara County's 100 lakes.

Eurasian water-milfoil is a problem because it grows earlier in the spring than other native plants, creating a canopy that blocks light from reaching other plants. At its worst, it can nearly take over a lake, causing navigation and swimming problems and upsetting the ecosystem to harm fish and other aquatic organisms, Hoyman said.

Once NES Ecological Services and the DNR have finished studying the four lakes, they will prepare a list of recommendations for the lake districts to implement.

In addition to the invasion of non-native species, people in lake districts are concerned about sediments, nutrients and other pollutants from watersheds getting into lakes. Development of homes around lakes contributes to the problem when property owners remove native vegetation and put in turf grass. This destroys habitat around the lake, Hoyman said.

"The best way for a lake to stay healthy is to let it function as a natural ecosystem," Hoyman said.

Patricia Wolff: (920) 361-0770 or pwolff@smgpo.gannett.com

Marl Lake Comprehensive Management Plan Project Update

Marl Lake District - August 2002

The Marl Lake project is moving along as planned. Many of the tasks the we discussed during the Kick-off meeting have been completed and the associated data awaits analysis this fall. Three lake water quality samples have been collected including one during the spring and two during this summer. Three additional samples will be collected including an August sample, and one during the fall and winter. The sample analyses that we have received back from the State Lab of Hygiene do not indicate anything out of the ordinary; however, the water clarity has been incredible considering the wet and hot weather the lake has received over the past months. Many of the lakes in the area are experiencing algal blooms, however, Marl Lake is still exhibiting excellent water clarity as indicated by the 20-foot Secchi disk depth that was recorded the fourth week of July.

The aquatic plant survey has also been completed with a long day's worth of work on July 30th. No exotic species were found during our survey, which is good news for the lake. Furthermore, we found one of the most diverse plant populations we have ever surveyed; an indication of Marl Lake's overall good health. We also found a large snapping turtle right before I was about to jump in the water near the northwest side of the lake. I guess the old adage of "look before you leap" holds true.

Look closely to see one of Marl Lake's year-round residents.

We have also received a great deal of data concerning the Marl Lake watershed through the much-appreciated cooperation of Waushara County and the East Central Regional Planning Commission. The data they supplied will help us determine the affects the watershed has on the lake and will be critical for the development of the lake management plan.

The importance of your participation was stressed during our discussions at the Kick-off meeting held in May. To date, we have not received any comments or questions from any of the lake residents (except for Barry). Please remember that your comments are important and greatly appreciated, so please do not hesitate to provide comments or ask questions.

Common arrowhead bloom near west shore.

For more information, please contact Tim Hoyman, NES Ecological Services. t.hoyman@releeinc.com
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Marl Lake District

Comprehensive Lake Management Plan

June 29, 2003

NES Ecological Services
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Presentation Outline

- Project Objectives
- Study Results
- Management Recommendations

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Project Goals & Objectives

- Data Collection and Analysis
  - Watershed
  - Aquatic Plants
  - Water Quality
- Develop Comprehensive Management Plan

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Water Quality

Phosphorus
(Limiting Plant Nutrient)

Chlorophyll-*a*
(Algal Abundance)

Water Clarity
(Secchi Disk)

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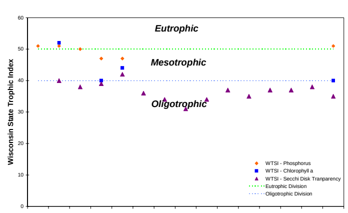
Water Quality



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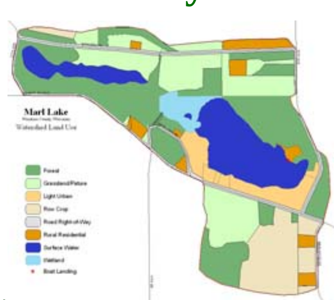
Watershed Analysis



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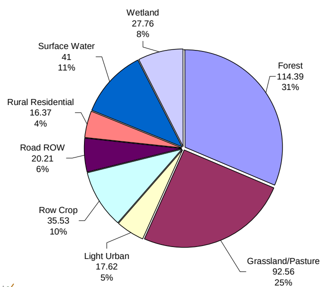

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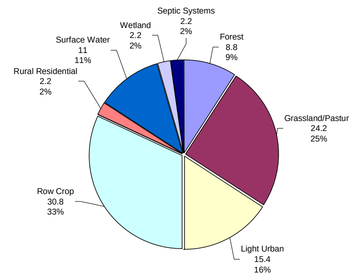
Watershed Analysis



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Aquatic Plants

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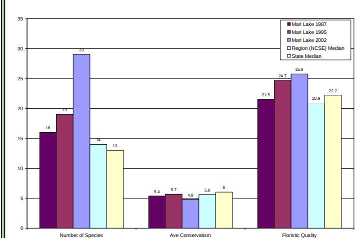
Aquatic Plants

Floristic Quality



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Water Quality Recommendations

"A lake is a mirror of its watershed."

Protect Water Quality by Minimizing Phosphorus Loads

Continue Lake Monitoring

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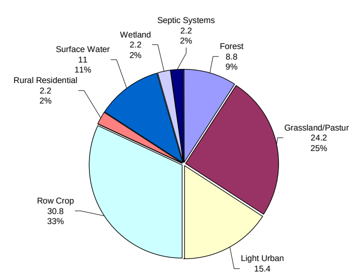
Watershed Recommendations



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Aquatic Plant Recommendations

- Protect Existing Community
- Milfoil Identification
- Continued Monitoring

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