Comprehensive Survey of Long Lake (Saxeville)
Waushara County, Wisconsin



Prepared by:

Cason & Associates, LLC

Professional Resources for Management of Lakes, Ponds, Rivers and Wetlands

P.O. Box 230
Berlin, WI 54923
920-361-4088

Prepared for:

The Long Lake Association
P.O. Box 9
Saxeville, WI 54976

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Summary

A thorough study of Long Lake, Waushara County, Wisconsin was conducted between in 2008. The primary goals of this project have been 1) to gather baseline information on the physical, chemical and biological aspects of Long Lake and the surrounding watershed, 2) to identify and prioritize management concerns including water quality and possible introduction of exotic species, and 3) to provide information needed to make informed decisions regarding the future management of the waters both ecologically and sociologically.

Project elements focused primarily on the aquatic plant community of Long Lake, water quality parameters, and an assessment of the lake's watershed. This project was funded in part by the Wisconsin DNR's Lake Planning grant program.

Results of this study include:

- The most abundant plant species encountered in Long Lake were muskgrass (*Chara* sp.), variable pondweed (*Potamogeton gramineus*) and bushy pondweed (*Najas flexilis*).

- No Eurasian watermilfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*) or zebra mussels (*Dreissena polymorpha*) were found in the lake during the timeframe of the study.

- Analysis of plant data indicated via the Simpson Diversity Index, the Coefficient of Conservatism and the Floristic Quality Index that Long Lake that the quality of Long Lake is above average in terms of the aquatic plant community.

- Long Lake has very good water quality and falls within the lower end of a classic mesotrophic lake.

- Dissolved oxygen measurements indicate high levels of oxygen throughout much of the lake during the entire study.

- Analysis found that the watershed of Long Lake is small (~450 acres) and predominantly forests.

- Modeling of land cover and water quality data indicated the water quality of Long Lake is better than expected and that the largest contributors of phosphorus include non-point sources within the watershed, precipitation, and septic systems.

Introduction

Long Lake is located in northern Waushara County, Wisconsin, near the village of Saxeville. The Long Lake Association is the principle management unit representing the interests of lakefront property owners. A second organization, the Friends of Long Lake serves as a financial arm of the Association. It is a non-profit organization that accepts tax deductible donations which are used help fund Association activities.

Lake Characteristics

Long Lake is a deep, clear lake of glacial origin surrounded by forested hills (**Figure 1**). The lake's 272 acres lie in an east-west axis comprised of two basins (**Figure 2**). The west basin has a maximum depth of 71 feet. The east basin has a maximum depth of 60 feet. The lake as a whole has an average depth of 22 feet and a volume of 5,984 acre-feet (approximately 2 billion gallons). The lake has no inlets or outlets, and is primarily fed by groundwater seepage. Hydraulic residence time has been calculated at 4.9 years. Long Lake experiences both thermal and oxygen stratification. In the past, mid-summer thermoclines were found beginning from 15 to 25 feet deep. Mid-summer oxyclines began at 25 to 35 feet, with anoxic conditions occurring below a depth of 40 to 45 feet.

Water quality indicators categorize Long Lake as early mesotrophic – a classification typical of natural lakes of this size found in Central Wisconsin. The good water quality, sandy shores and depth found in Long Lake make the lake very appealing for boaters and swimmers. Not-surprisingly, the lake is entirely surrounded by cottages and year-round homes. A well-maintained boat launch located on the south shore of the lake provides access to the public.

Management History

Aquatic plant community

As of 2008 no exotic aquatic plant species have been identified in Long Lake. In addition, the native aquatic plant community has not impeded recreational use of the lake. Consequently, to date, no aquatic plant management efforts (herbicide treatment, harvesting, etc.) have taken place on Long Lake.

Lake fishery

Lake assessment activities occurring in the last twenty years have included periodic fishery surveys conducted by the Wisconsin Department of Natural Resources (WDNR). Lake management activities have primarily involved periodic fish stocking to maintain a sport fishery. Since 1993 Long Lake has been used by the WDNR as a rearing facility for spotted musky (*Esox masquinongy*) brood stock.

In 2004, the Long Lake Association retained Aquatic Biologists, Inc. to conduct aquatic plant surveys of the lake. Specific project objectives were to assess the native aquatic plant communities, determine if any exotic aquatic plant species were present, develop

contingency plans for dealing with exotic species invasion, and research management options for lake habitat improvement.

Water quality

Water quality data have routinely been collected on Long Lake since 1976 although in 1987 data collection became more routine and consistent. Analysis since 1987 has primarily included measurements of nutrients, chlorophyll, and water clarity. Data sources have included spring and fall turnover sampling coordinated by the Water and Environmental Analysis Laboratory at UW – Stevens Point, Self Help monitoring by lake volunteers and sampling by the Wisconsin DNR as part of ongoing research into water quality trends in Wisconsin lakes.

Additional research

A comprehensive lake survey commissioned by the Long Lake Association was conducted by R.A. Smith and Associates, Inc. in 1993 and 1994. This study assessed lake water quality, aquatic plants, hydrology, and nutrient inputs. In 2004, Aquatic Biologists, Inc. conducted a survey of aquatic plants in Long Lake, producing results that included recommendations for management and improvement of the lake.

The current study of Long Lake was conducted with the following goals 1) to gather baseline information on the physical, chemical and biological aspects of Long Lake and the surrounding watershed, 2) to identify and prioritize management concerns, and 3) to provide information needed to make informed decisions regarding the future management of the waters both ecologically and sociologically.

Zebra mussels

The following information was provided by Jim Schiek, board member of the Long Lake Association regarding the history of zebra mussels (*Dreissena polymorpha*) in the lake.

History of Zebra Mussels, Long Lake, Saxeville, WI

In August of 2002, two zebra mussel shells were found on the north shore of Long Lake by a teenager who was snorkeling in about 4-5 feet of water. The shells were taken to the DNR office in Wautoma where Scott Provost identified them as zebra mussel shells. Also earlier that summer, Mary Gansberg of the DNR had taken water samples which were sent to the state lab for analysis. The results confirmed the existence of free swimming zebra mussel larvae (veligers).

The following spring (2003), with the help of several volunteers, eight (8) artificial substrate monitoring samplers were placed at strategic locations around each basin. The samplers were a piece of 4" PVC pipe cut in half, 24" in length. They were hung under either a dock or raft preferably in a shady location. Two additional DNR zebra mussel sampling stations were added to the program in 2004 and 2005.

At our annual meeting in July of 2003, Mary Gansberg of the DNR did an informal presentation to teach the lake association membership how to identify zebra mussels. She displayed samples of zebra Mussel shells at various stages of growth. This provided approximately 50-75 property owners an awareness of what to look for when inspecting docks, rafts, piers and monitoring stations.

At the end of each season, Labor Day weekend, there's a group of property owners that go around the lake assisting each other with the removal of the piers, rafts and boat lifts. In fact, in 2005 Dick Sachs of the DNR joined us and assisted with the inspection process. Not a single sighting of zebra mussels was reported as a result of this activity.

In 2004, Chad Cason completed an aquatic plant survey to determine if any exotic plant species (Eurasian water-milfoil, curly-leaf pondweed, and purple loosestrife) were present in Long Lake. No exotic species were found. Chad did note that they were not necessarily looking for zebra mussels but that none were encountered.

Tom Catlin, a long time lake resident, also reported that amateur divers inspected fish cribs and did not find any Zebra mussels.

The purpose of the monitoring was to determine if there is in-lake reproduction of Zebra mussels occurring and/or to monitor the growth and location of adult colonies within Long Lake. In Jan 2006 we submitted the results to Dick Sachs of the DNR and requested that Long Lake be de-listed. The request was granted and Long Lake was placed on the DNR watch list.

The old monitoring samplers were retired in 2008 but will be replaced with six (6) new, official DNR zebra mussel sampling stations this summer.

By Jim Schiek, April 13, 2009

The following page contains a letter by Dick Sachs, Wisconsin DNR regarding the delisting of Long Lake from the list of waterbodies within the State which contain zebra mussels.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary
Ronald W. Kazmierczak, Regional Director

Northeast Region Headquarters
2984 Shawano Ave., P.O. Box 10448
Green Bay, Wisconsin 54307-0448
Telephone 920-662-5100
FAX 920-662-5413
TTY Access via relay - 711

February 2, 2006

James Schiek
Long Lake Association
PO Box 9
Saxeville, WI 54976

Subject: Zebra Mussel De-Listing

Dear Mr. Schiek:

The department has received and reviewed the zebra mussel monitoring information recently submitted by the Long Lake Association, for the purpose of addressing the lake association's request to consider the removal of Long Lake from the List of Zebra Mussel Infested Water Bodies. Along with the information provided by the lake association, data collected through the department's zebra mussel monitoring activities were also reviewed. Together, these data sets exhibit:

- Two consecutive years of veliger (larval zebra mussel) monitoring without a positive result.
- Three consecutive years of sampler deployment in the lake without finding any zebra mussels.
- Three consecutive years of monitoring in-lake substrates (piers, boats, etc.) without finding any zebra mussels.

These findings meet the department's criteria for de-listing, and therefore it is our decision to remove Long Lake from the List of Zebra Mussel Infested Water Bodies.

Long Lake will be put on the Zebra Mussel Watch List with other water bodies where zebra mussels have been detected, but have not established sustaining populations. The department considers the water bodies on this list as priorities for zebra mussel monitoring, thus the department will continue to monitor Long Lake for veligers. Accordingly, the lake association should also continue its zebra mussel monitoring efforts, specifically the deployment of the substrate samplers (half-pipe and plate samplers) and the inspection of docks, boats, etc. by residents.

In conjunction with this decision to de-list Long Lake, we will be replacing the yellow *Aquatic Invasive Species Advisory* sign at the Long Lake boat landing with a *Help Prevent the Spread* sign. It's our understanding that the lake association feels that such action will enhance its efforts to prevent the introduction of aquatic invasive species (AIS) to Long Lake. In that spirit of prevention, we encourage the lake association's ongoing efforts and pledge our support and willingness to work in partnership with you to keep Long Lake AIS-free!

Sincerely,

Richard Sachs
Aquatic Invasive Species Coordinator, Northeast Region

Cc: Ron Martin, Scott Provost, Steve Galarneau

Figure 1. Area surrounding Long Lake in Waushara County, Wisconsin.

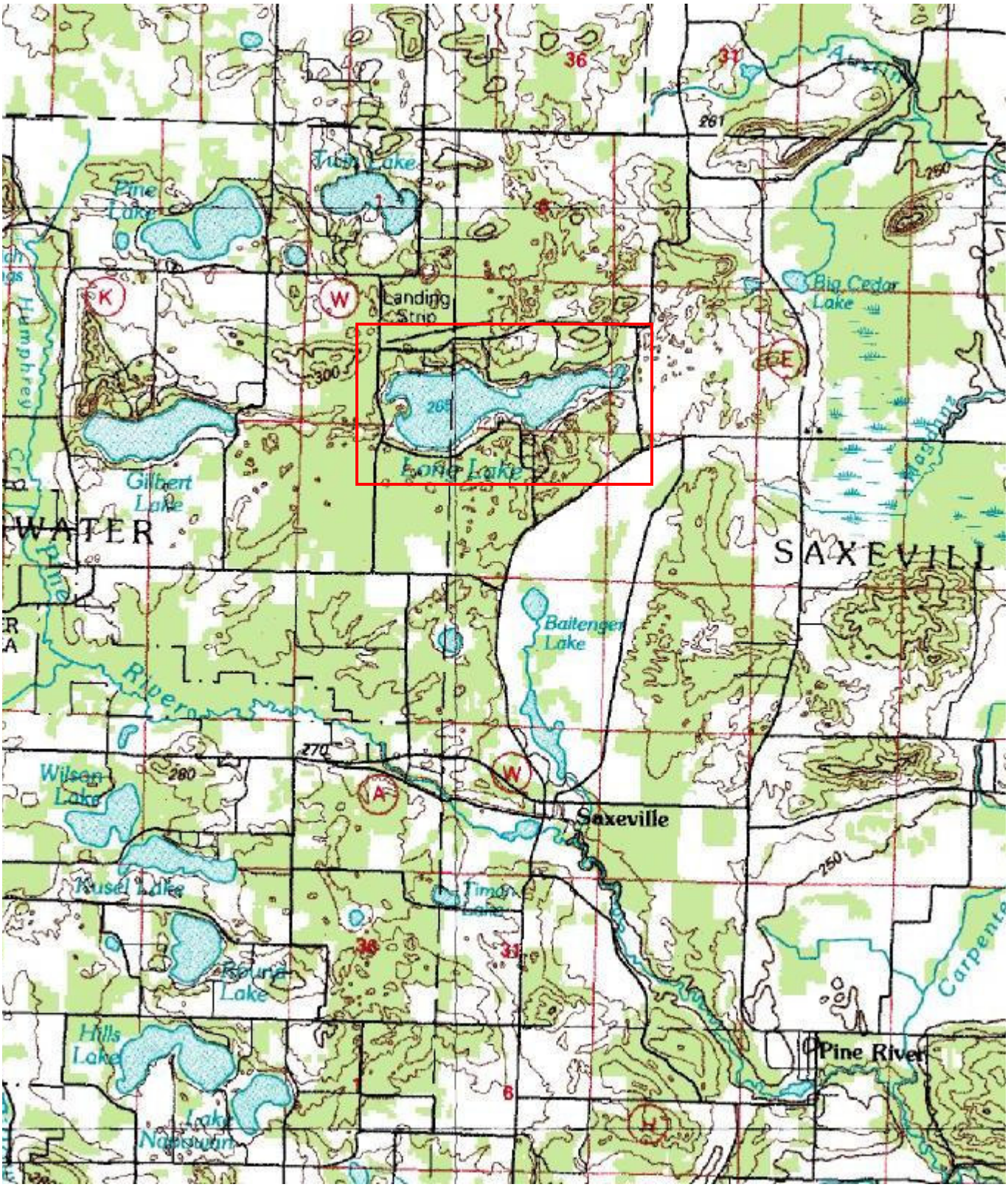
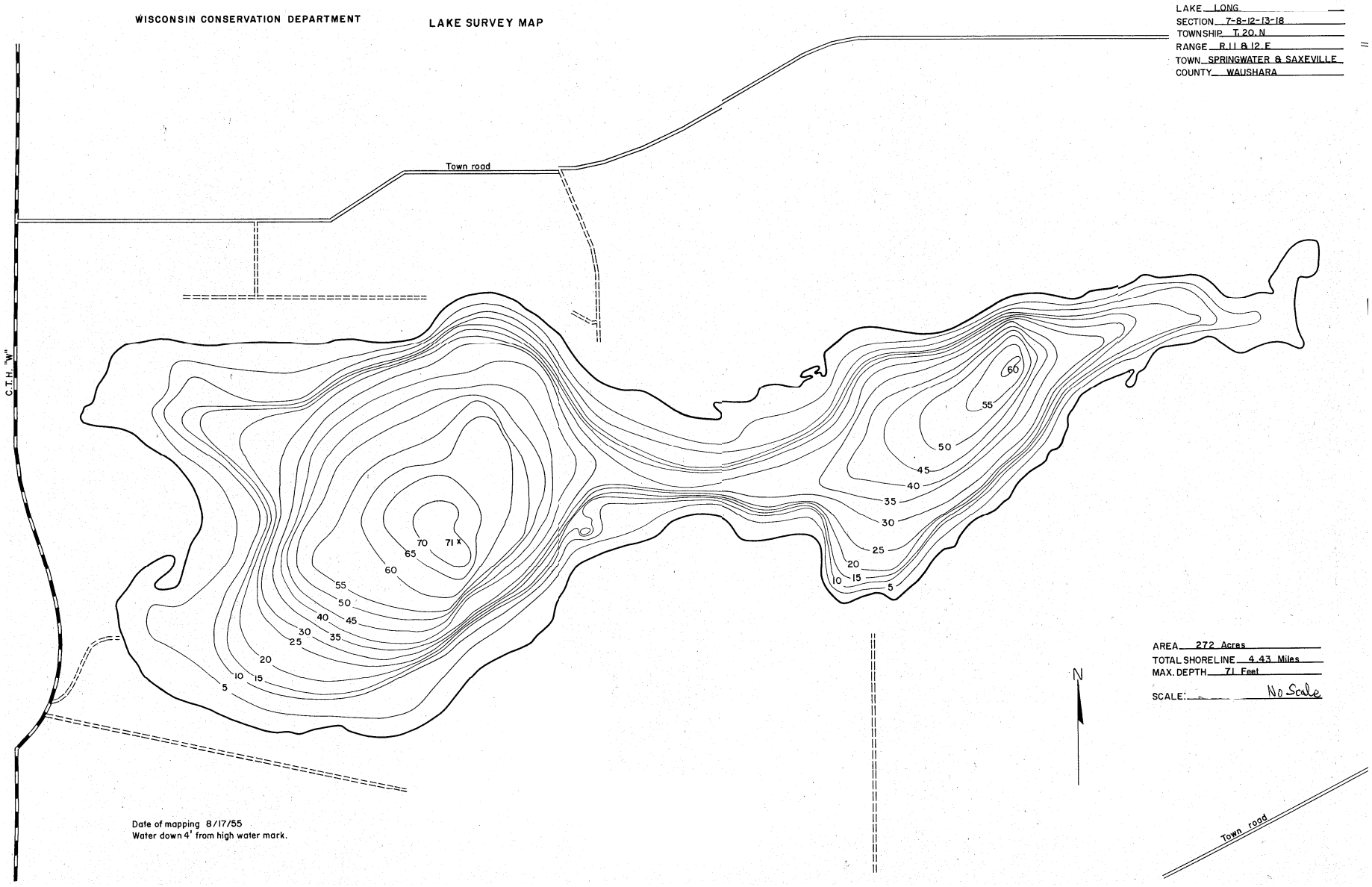


Figure 2. Long Lake in Waushara County, Wisconsin.



Methods

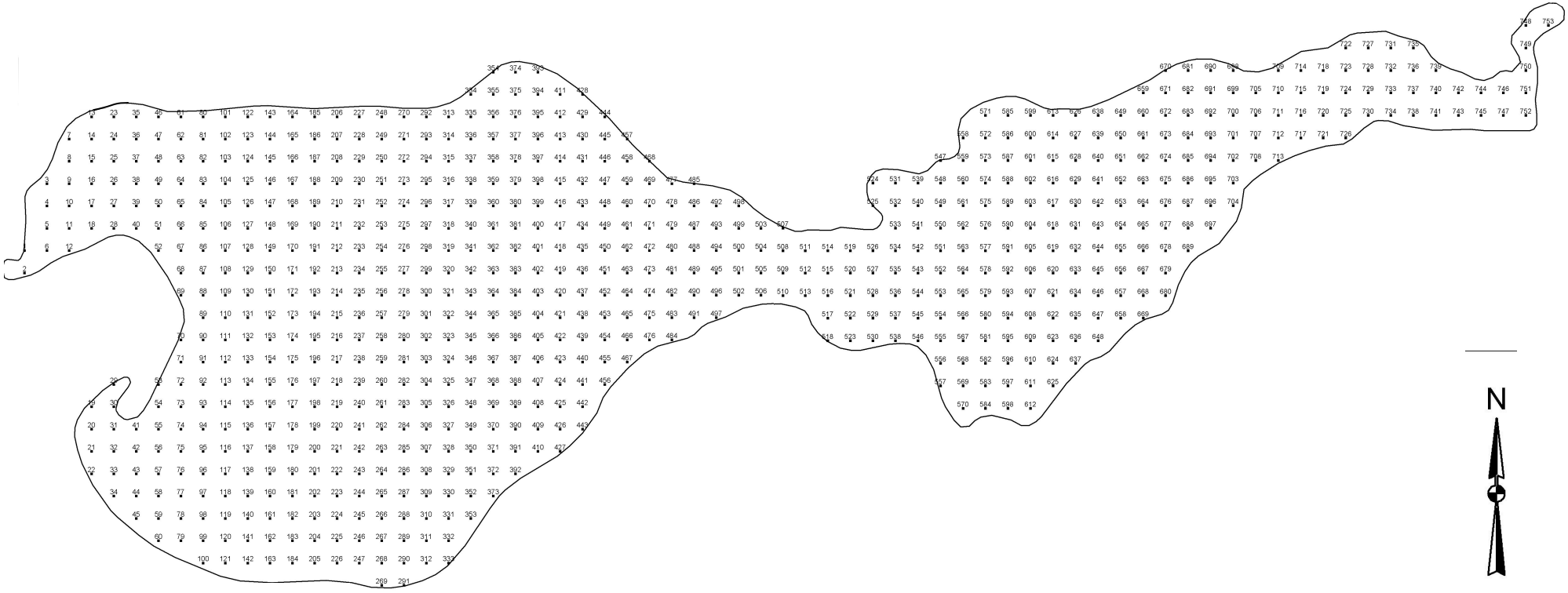
Submergent Aquatic Plant Survey

On August 28-29, 2008, a submergent aquatic plant survey was conducted. Within the past few years, DNR guidelines pertaining state-wide to the design and implementation of aquatic plant surveys have been established. These guidelines specifically require the use of a point-intercept method. Previous surveys in Long Lake have utilized a transect method. Under the guidance of Jennifer Hauxwell from the DNR, an approved plant survey map for Long Lake has been designed (**Figure 3**), in which a series of grid points were mapped across the lake. In total 753 points were mapped across the lake. At each location, aquatic plant samples were collected from a boat with a single rake tow. The rake used consisted of two short-toothed garden rake heads welded together and attached to a rope which was thrown from the boat. At each sample point, the rake was dragged along the bottom for approximately 2.5 feet to collect plants. All plant samples collected were identified to *genus* and *species* whenever possible, and the information was recorded. An abundance rating was given for exotic species collected using the criteria described in **Figure 4**. In addition to the plant data, depth and bottom substrate composition were recorded for each point intercept. Data collected has been be used to determine species composition, percent frequency and relative abundance. This data has also been used to develop distribution maps of the most abundant plant species.

Exotic Plant Distribution Mapping

On two occasions, surveys for exotic species namely Eurasian watermilfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*), and Zebra mussels were conducted on Long Lake. These surveys utilized surface observations and rake tows to determine the possible extent and locations of these species. The point intercept locations identified in **Figure 3** were used as a guide for these surveys as well. The first survey was conducted on June 11, 2008. This survey was conducted earlier in the season to best identify curly-leaf pondweed, which dies back later in the summer, when water temperature rises. A second exotic species mapping effort was made at the time of the point-intercept survey on August 28-29, 2008.

Figure 3. Long Lake aquatic plant survey map.



N

WISCONSIN
DEPT. OF NATURAL RESOURCES

0 0.4 Kilometers

Long Lake
Waushara County
WBIC 191100
T20N R11E S12
254 acres / 102.9 ha
753 Sampling Points
37m between Points
Site1: Lat. 44.21680255
Long. -89.13725555
Created: 2007

Figure 4. Plant abundance rating criteria used in submergent aquatic plant surveys.

Rating	Coverage	Description
1		A few plants on rake head
2		Rake head is about ½ full Can easily see top of rake head
3		Overflowing Cannot see top of rake head

Water Quality Assessment

Each spring, water samples are collected by Long Lake volunteers and sent to UW-Stevens Point for analysis. In 2008, the assessment of water quality was expanded to include summer sampling. Sampling took place in July, August, and September. Analyses included:

- pH
- Conductivity
- Alkalinity
- Total phosphorus
- Nitrate + nitrite as N
- Chlorophyll *a*
- Dissolved oxygen profile
- Temperature profile
- Secchi depth

Because of the two distinct basins within Long Lake, samples were collected at the deep points within the east and the west basins of the lake on each of the sampling dates. For all sampling dates, dissolved oxygen, temperature and Secchi depth were analyzed in the field. For the remaining parameters, samples were sent to the State Lab of Hygiene for analysis of nutrients and chlorophyll.

Historic water quality data for Long Lake has been collected from a number of sources including the DNR's Surface Water Integrated Monitoring System (SWIMS) and the EPA's Storet site. All available data has been collected and used to assess the chemical characteristics of Long Lake.

Chlorophyll *a*, total phosphorus and Secchi depth data collected during the summer months was used to quantify the productivity of the lake (Trophic State Index).
Software available from the WDNR entitled Wisconsin Lake Modeling Suite (WiLMS) was used to predict the trophic state of Long Lake given its size, watershed area, mean depth and ecoregion. Comparisons were made between the predicted TSI values and those calculated from the phosphorus, chlorophyll and Secchi data collected in 2008.
In addition, this software was used to predict the spring overturn, growing season mean, and annual average total phosphorus concentration in Long Lake. Comparisons were made between the predicted phosphorus and TSI values and those calculated from the phosphorus, chlorophyll and Secchi data for the August sampling. The WiLMS program was also used to estimate the internal nutrient loading occurring in Long Lake by incorporating nutrient and dissolved oxygen data.

Watershed Assessment

Because much of what happens in the watershed surrounding a lake can impact the overall water quality and health of a lake, it is important to investigate and document aspects of the watershed which can have such an impact.

The boundary of the watershed of Long Lake was delineated by using topographic maps and aerial photos. Data obtained from the Wisconsin DNR's Bureau of Technology

Services was used to determine the land-use and vegetative cover types within the watershed. The percent cover for each of these categories has been determined and presented. Land use patterns, vegetative cover, potential nutrient loading sources, and environmentally sensitive areas were further assessed visually. Information from the Wisconsin DNR and Waushara County was used to assess conditions within the watershed and areas within the County outside the watershed.

The WiLMS software was also used to estimate the external loading of runoff pollutants, namely phosphorus, into Long Lake. The software uses export coefficients for various land-use and cover types as well as precipitation, point sources and septic systems to represent phosphorus loading into the lake from external sources. This software also takes in account lake morphology, watershed drainage area and net precipitation.

The boundary of the watershed of Long Lake was delineated using topographic maps. ArcView GIS software was used to determine land- use patterns and vegetative cover. A ground survey of the watershed was conducted in an effort to identify potential nutrient loading sources and environmentally sensitive areas. The WiLMS software was used to estimate external and internal loading of phosphorus by assessing point and non-point sources of nutrients.

Data available from the Natural Resources Conservation Service (NRCS) was used to determine the soil types within the Long Lake watershed. This data includes percent cover for and the characteristics of each soil type.

Since a significant amount of nutrients and sediments can enter a lake from areas closest to the lake, it is important to also focus on the conditions nearest the lake and identify potential areas of concern. Possible areas of disturbance, high erosion, or generally poor riparian health were assessed. Suggestions for remediation or improvement of such areas have been included in this report.

Results

Aquatic Plant Community

Coordinates for the sampling points within the lake can be found in **Appendix A**.

Although 753 points were mapped across the Long Lake, vegetation was found at only 300 locations at the time of the survey. The remaining locations were predominantly too deep for aquatic plants to grow. Some locations (28 total) were either terrestrial or too shallow to navigate. A total of 19 aquatic plant species were found during the 2008 survey (**Table 1**). This is above the state-wide average of 13 species. Long Lake lies near the border of the Northern Central Hardwood Forests and Southeastern Wisconsin Till Plain regions of Wisconsin. The average number of species found in lakes in this region is 14 species (Nichols, 1999). The most abundant plant species encountered in Long Lake were muskgrass (*Chara* sp.), variable pondweed (*Potamogeton gramineus*) and bushy pondweed (*Najas flexilis*). Muskgrass was found at nearly 94% of the points sampled. Variable and bushy pondweeds were found at approximately 25% of these points. **Figures 5-7** show the distribution and density of these species across Long Lake at the time of the survey.

Percent frequency values reflect the relationship between the number of locations where a particular species was found versus the total number of locations sample. Relative frequency values reflect the abundance of a particular species in relation to all other species found.

In 2004 a similar submergent plant survey was conducted on Long Lake. This survey however, utilized a different survey methodology. This survey involved plotting a series of 23 transects approximately even distances around the lake shoreline. These transects extended at 90 degree angles from shore to a depth of twenty feet. Sampling plots were established along each transect at 2.5, 5, 10 and 20 foot depth contours. At each plot a 10-foot radius circle was estimated around the anchored boat. The circle was divided into four quarters, with each quarter representing a quadrant. Plants were collected in each quadrant with a rake. From each rake tow, all plants collected were identified to genus and species. Data was recorded separately for each quadrant. A total of 336 quadrants were sampled. The results of this survey are shown in **Table 2**. When compared to the results from 2008, as expected, many similarities exist. The most abundant species were found in each survey, albeit at different frequencies. Also, the 2008 survey identified more species than the 2004 survey. These differences are likely due to the methods used and the level of detail between the two surveys. Also, changes to the plant community of a lake are expected from year to year.

The raw data for the 2008 submergent aquatic plant survey can be found in **Appendix B**.

Figure 8 presents the relative abundance of submergent aquatic plant species found in Long Lake at the time of the 2008 survey.

Table 1. Results of the submergent aquatic plant survey conducted on Long Lake on August 28-29, 2008.

Species common name	scientific name	Percent Frequency	Relative Frequency
Muskgrass	*Chara* sp.	93.67	47.8
Variable pondweed	*Potamogeton gramineus*	25.33	12.9
Bushy pondweed	*Najas flexilis*	25.00	12.8
Wild celery	*Vallisneria americana*	11.33	5.8
Sago pondweed	*Stuckenia pectinata*	10.67	5.4
Northern water milfoil	*Myriophyllum sibiricum*	7.67	3.9
Illinois pondweed	*Potamogeton illinoensis*	5.67	2.9
Small pondweed	*Potamogeton pusillus*	3.67	1.9
Frie's pondweed	*Potamogeton friesii*	2.67	1.4
White water lily	*Nymphaea odorata*	2.33	1.2
White-stem pondweed	*Potamogeton praelongis*	1.67	0.9
Flat-stem pondweed	*Potamogeton zosteriformis*	1.67	0.9
Large-leaf pondweed	*Potamogeton amplifolius*	1.00	0.5
Floating-leaf pondweed	*Potamogeton natans*	1.00	0.5
Nitella	*Nitella* sp.	0.67	0.3
Clasping-leaf pondweed	*Potamogeton richardsonii*	0.67	0.3
Common bladderwort	*Utricularia vulgaris*	0.67	0.3
Common waterweed	*Elodea canadensis*	0.33	0.2
Robbins pondweed	*Potamogeton robbinsii*	0.33	0.2
Coontail	*Ceratophyllum demersum*	visual	--

Table 2. Results of the submergent aquatic plant survey conducted on Long Lake in 2004.

Species common name	scientific name	Percent Frequency	Relative Frequency
Muskgrass	*Chara* sp.	87.70	49.9
Variable pondweed	*Potamogeton gramineus*	19.90	11.3
Bushy pondweed	*Najas flexilis*	2.70	1.5
Wild celery	*Vallisneria americana*	8.70	5.0
Sago pondweed	*Stuckenia pectinata*	5.70	3.3
Northern water milfoil	*Myriophyllum sibiricum*	13.00	7.4
Illinois pondweed	*Potamogeton illinoensis*	24.40	13.9
Small pondweed	*Potamogeton pusillus*	--	--
Frie's pondweed	*Potamogeton friesii*	--	--
White water lily	*Nymphaea odorata*	0.30	0.2
White-stem pondweed	*Potamogeton praelongis*	1.20	0.7
Flat-stem pondweed	*Potamogeton zosteriformis*	3.90	2.2
Large-leaf pondweed	*Potamogeton amplifolius*	4.80	2.7
Floating-leaf pondweed	*Potamogeton natans*	3.00	1.7
Nitella	*Nitella* sp.	--	--
Clasping-leaf pondweed	*Potamogeton richardsonii*	--	--
Common bladderwort	*Utricularia vulgaris*	--	--
Common waterweed	*Elodea canadensis*	--	--
Robbins pondweed	*Potamogeton robbinsii*	--	--
Coontail	*Ceratophyllum demersum*	0.3	0.2

Figure 5. Distribution of muskgrass (*Chara* sp.) on August 28-29, 2008 in Long Lake, Waushara County, WI

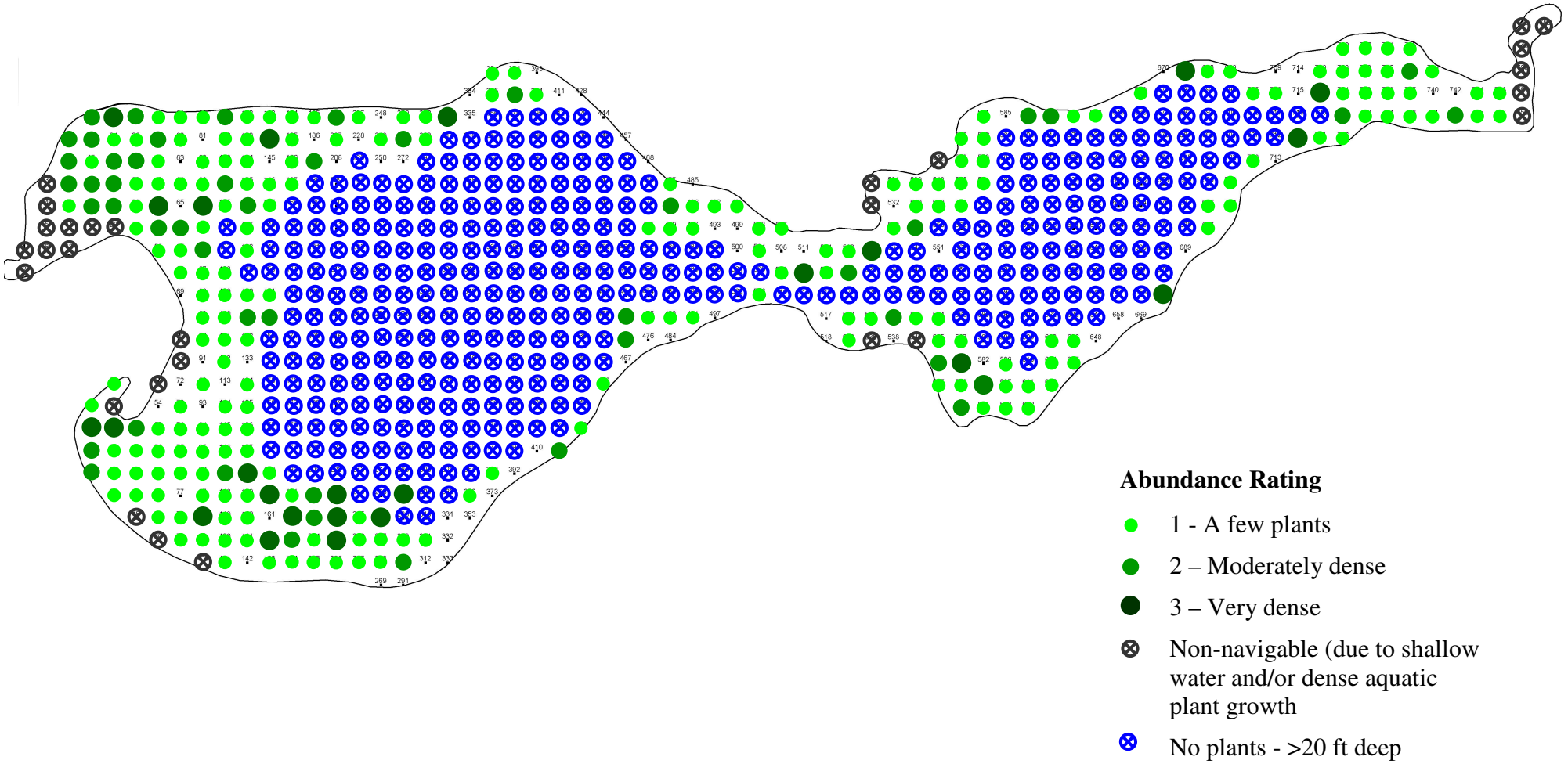


Figure 6. Distribution of variable pondweed (*Potamogeton gramineus*) on August 28-29, 2008 in Long Lake, Waushara County, WI

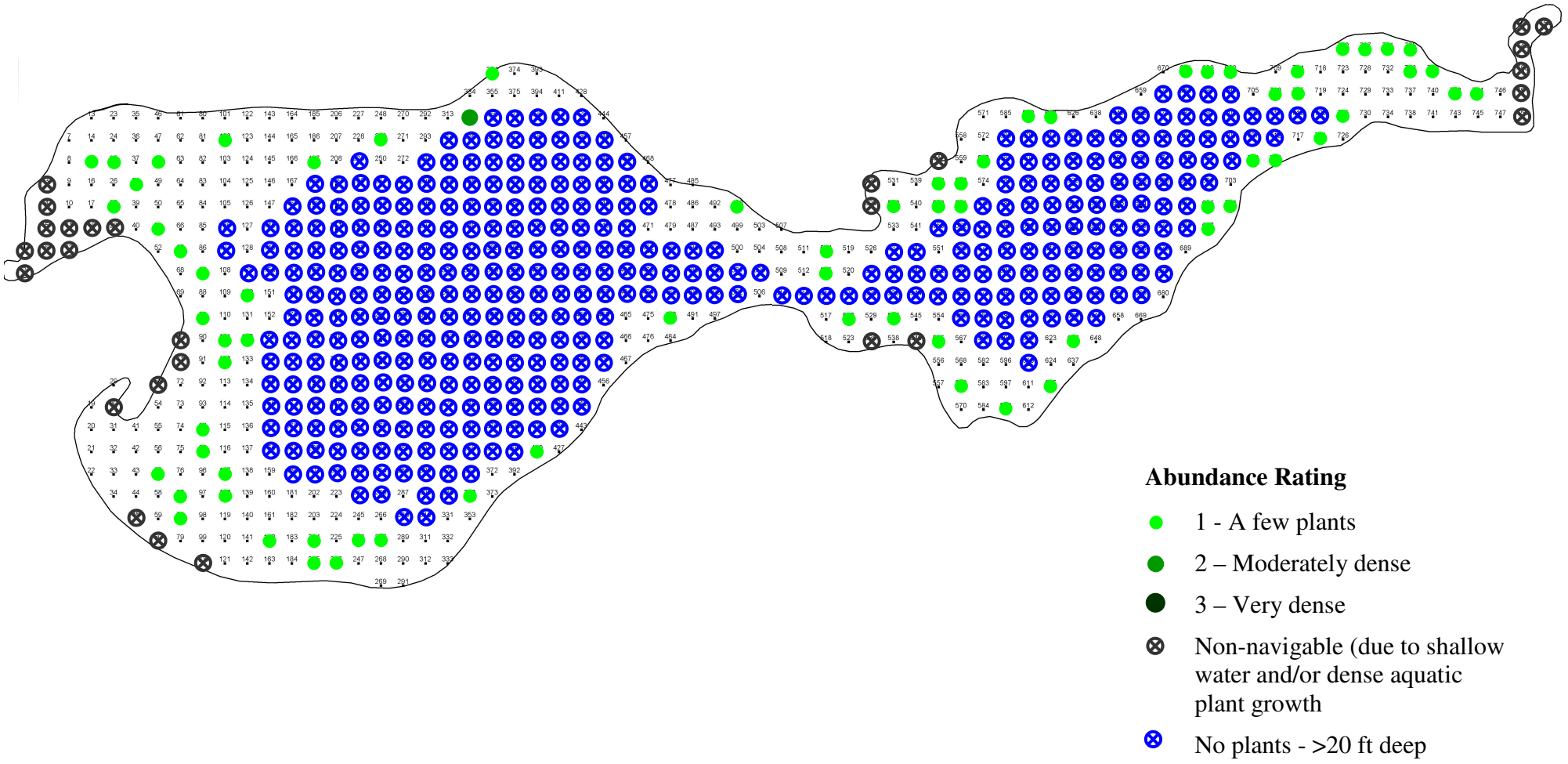


Figure 7. Distribution of bushy pondweed (*Najas flexilis*) on August 28-29, 2008 in Long Lake, Waushara County, WI

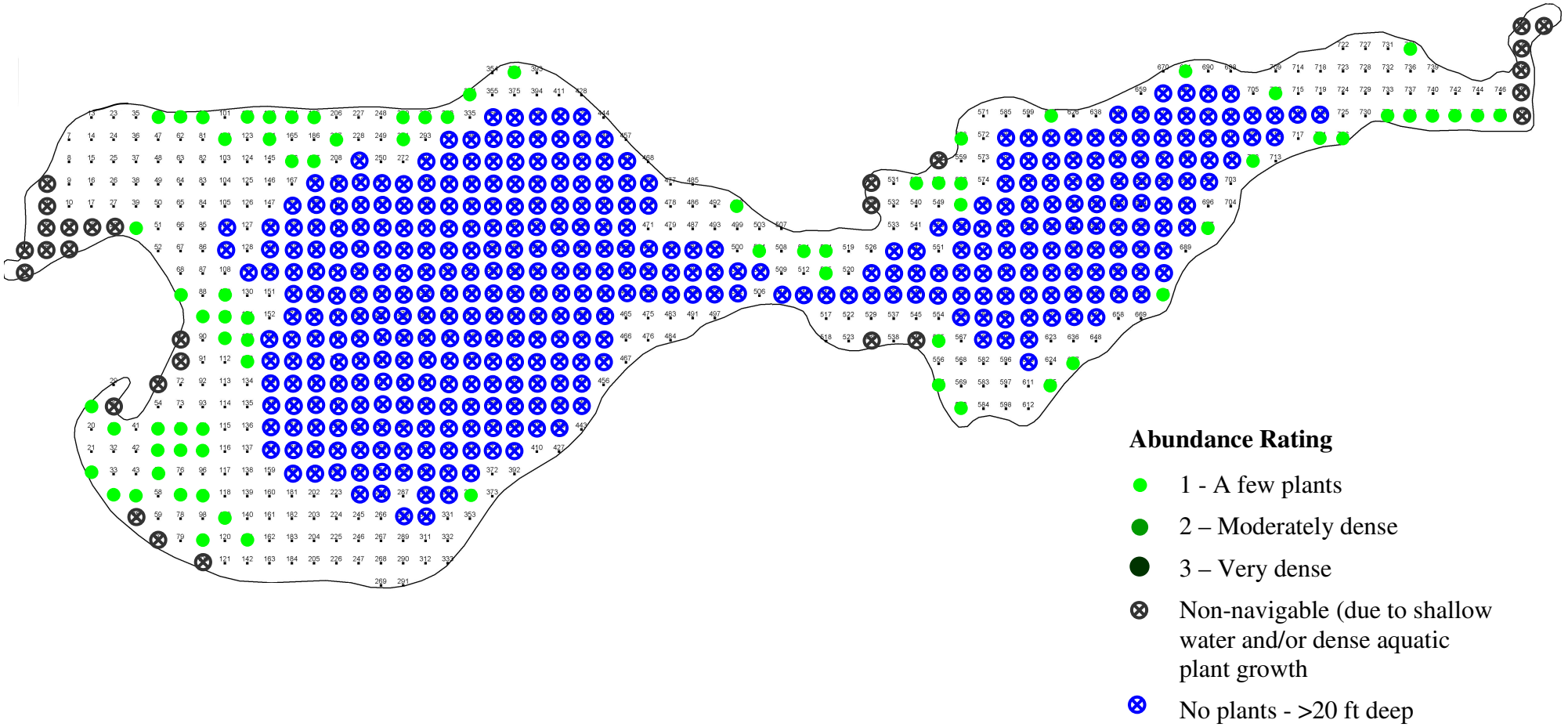
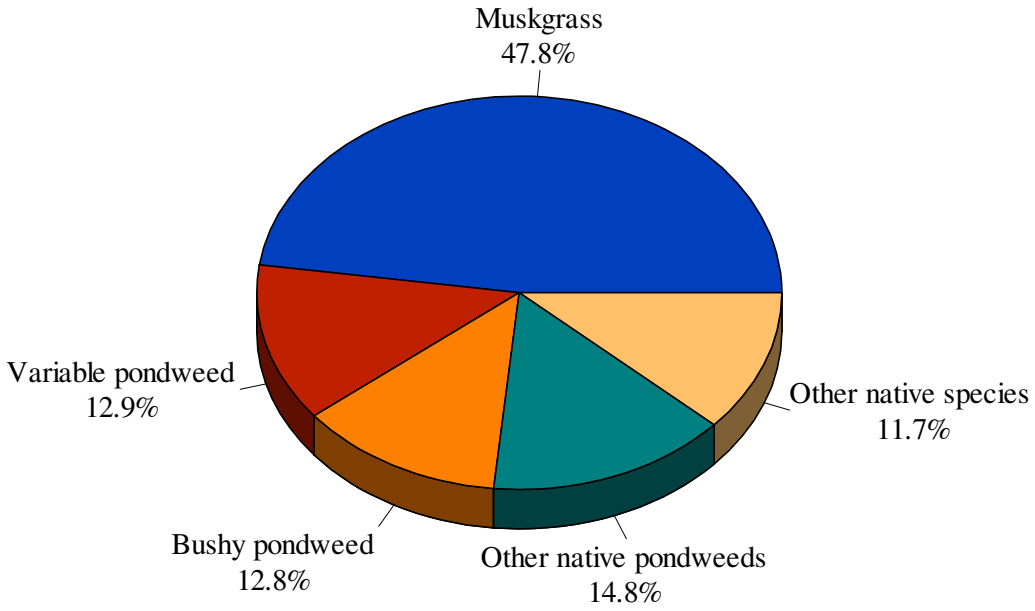


Figure 8. Submergent aquatic plant community composition for Long Lake, on August 28-29, 2008 in Long Lake, Waushara County, WI



Simpson Diversity Index

In order to estimate the diversity of the aquatic plant community, the Simpson Diversity Index takes in account both the number of species identified (richness) and the distribution or relative abundance of each species. As these parameters increase, so does the overall diversity. With the Simpson Diversity Index (D), 1 represents infinite diversity and 0, no diversity. That is, the bigger the value of D, the higher the diversity. The value of D calculated for Long Lake based on the 2008 data was 0.73.

Assessment of Floristic Quality

The plant data collect for Long Lake were used to assess the "floristic quality" of the lake. The method used assigns a value to each native plant species called a Coefficient of Conservatism. Coefficient values range from 0-10 and reflect a particular species' likelihood of occurring in a relatively undisturbed landscape. Species with low coefficient values, such as coontail, are likely to be found in a variety of habitat types and can tolerate high levels of human disturbance. On the other hand, species with higher coefficient values, such as wild rice, are much more likely to be restricted to high quality natural areas. By averaging the coefficient values available for the submergent and emergent species found in Long Lake, a lake-wide value of 6.26 was calculated (see **Table 3**). The average value for lakes in Wisconsin is 6.0 while the combined average for lakes in the Northern Central Hardwood Forests and Southeastern Wisconsin Till Plain regions of Wisconsin. is 5.6 (Nichols, 1999).

Table 3. Long Lake Floristic Quality Index (FQI) analysis table.

Species	Common Name	C
Chara spp.	Muskgrasses	7
Elodea canadensis	Common waterweed	3
Myriophyllum sibericum	Northern water-milfoil	7
Najas flexilis	Bushy pondweed	6
Nitella	Nitella	7
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton friesii	Frie's pondweed	8
Potamogeton gramineus	Variable pondweed	7
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton natans	Floating-leaf	5
Potamogeton praelongis	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Robbins pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Stuckenia pectinata	Sogo pondweed	3
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
	N	19
	mean C	6.26
	FQI	27.3

By utilizing the Coefficients of Conservatism for the plant species of Long Lake, further assessment of floristic quality can be made. By multiplying the average coefficient values for Long Lake by the square root of the number of plant species found, a Floristic Quality Index (FQI) was calculated at 27.3 (see **Table 3**). In general, higher FQI values reflect higher lake quality. The average for Wisconsin lakes is 22.2. The average for lakes in the Northern Central Hardwood Forests and Southeastern Wisconsin Till Plain regions is 20.9 (Nichols, 1999). Both Coefficient of Conservatism and the Floristic Quality Index values suggest the quality of Long Lake specifically in terms of the plant community, is above average.

Aquatic plants serve an important purpose in the aquatic environment. They play an instrumental role in maintaining ecological balance in ponds, lakes, wetlands, rivers, and streams. Native aquatic plants have many values. They serve as important buffers against nutrient loading and toxic chemicals, act as filters that capture runoff-borne sediments, stabilize lakebed sediments, protect shorelines from erosion, and provide critical fish and wildlife habitat. Therefore, it is essential that the native aquatic plant community in Long Lake be protected. **Appendix C** provides a list of the more abundant native aquatic plant species that were found in Long Lake. Ecological values and a description are given for each species.

Exotic Plant Distribution Mapping

No exotic species were identified during either the June 11 or August 28 surveys of Long Lake. Of particular interest was the lack of exotic species during the extensive point-intercept plant survey in August. This survey was particularly useful in identifying exotic plant species such as Eurasian watermilfoil and curly-leaf pondweed. Also, because zebra mussels often attach themselves to aquatic plants, this survey was additionally useful in monitoring for his species as well.

Water Quality Analysis

Dissolved oxygen and temperature

Dissolved oxygen, temperature, and percent saturation data collected for the east and west basins of Long Lake in 2008 are presented in **Appendix D**. These data were used to develop the profile graphs shown in **Figures 9 and 10**. Dissolved oxygen data show that surface levels of dissolved oxygen remained high throughout the season. The threshold level of oxygen needed for fish such as bass, perch, and sunfish to survive and grow is 5 mg/L. Even at the warmest times of the year, sufficient levels of oxygen were present at the surface of the lake. However, during the summer months, oxygen levels were significantly lower in the deeper portions of the south basin. The depths at which oxygen levels dropped off, referred to as the oxycline, was at depths between 30 and 35 feet during the summer months. In many lakes of Wisconsin, this change in oxygen concentrations is seen. These conditions are referred to as lake stratification. Below the oxycline there was insufficient oxygen to support many fish species.

To better understand this data, it is important to first understand the relationship between dissolved oxygen and temperature. As a rule, colder water can hold more oxygen than warmer water. **Table 4** illustrates this point. By utilizing this relationship, the level (or percent) of saturation of oxygen can be determined at a given temperature. Saturation levels from sampling at Long Lake can also be found in **Appendix D**. A number of the readings taken throughout the year appear to exceed the oxygen solubility given in **Table 4**. For these data the dissolved oxygen levels were higher than solubility levels at the corresponding temperatures. As a result, the percent saturation levels recorded in the field were above 100%. This is referred to as supersaturation and is due to factors such as wind and wave action and biological processes. This also commonly occurs under warm sunny conditions. Percent saturation values of 80-120% are considered to be excellent and values less than 60% or over 125% are considered to be poor. With a few exceptions the saturation levels in the upper portions of Long Lake were indicative of excellent water quality.

Table 4. Oxygen solubility in water at different temperatures.

Temperature		Oxygen solubility
ºC	ºF	(mg/L)
0	32	15
5	41	13
10	50	11
15	59	10
20	68	9
25	77	8

Figure 9. Profiles of dissolved oxygen, temperature, and percent saturation from 2008 for the east basin of Long Lake, Waushara County, WI.

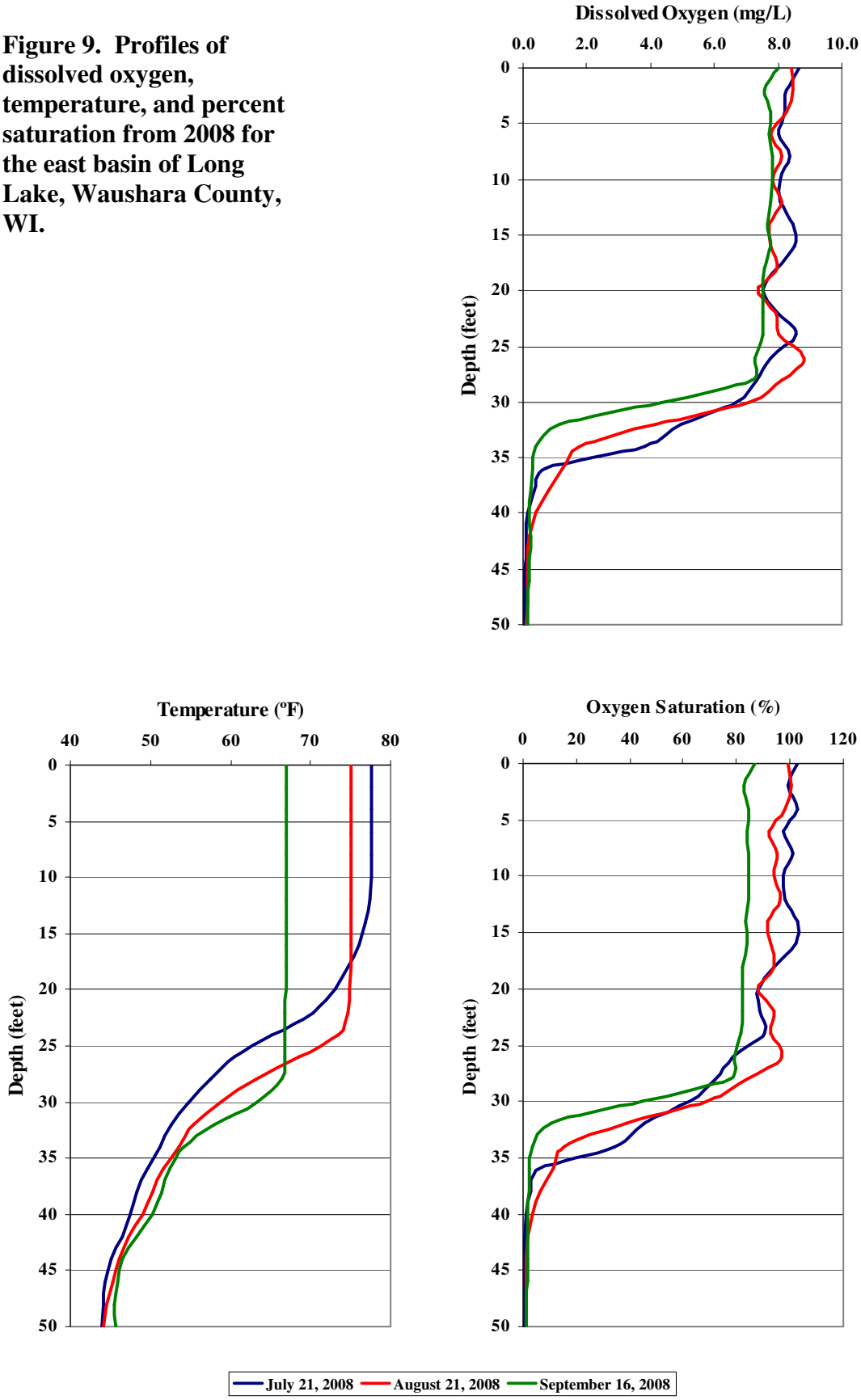
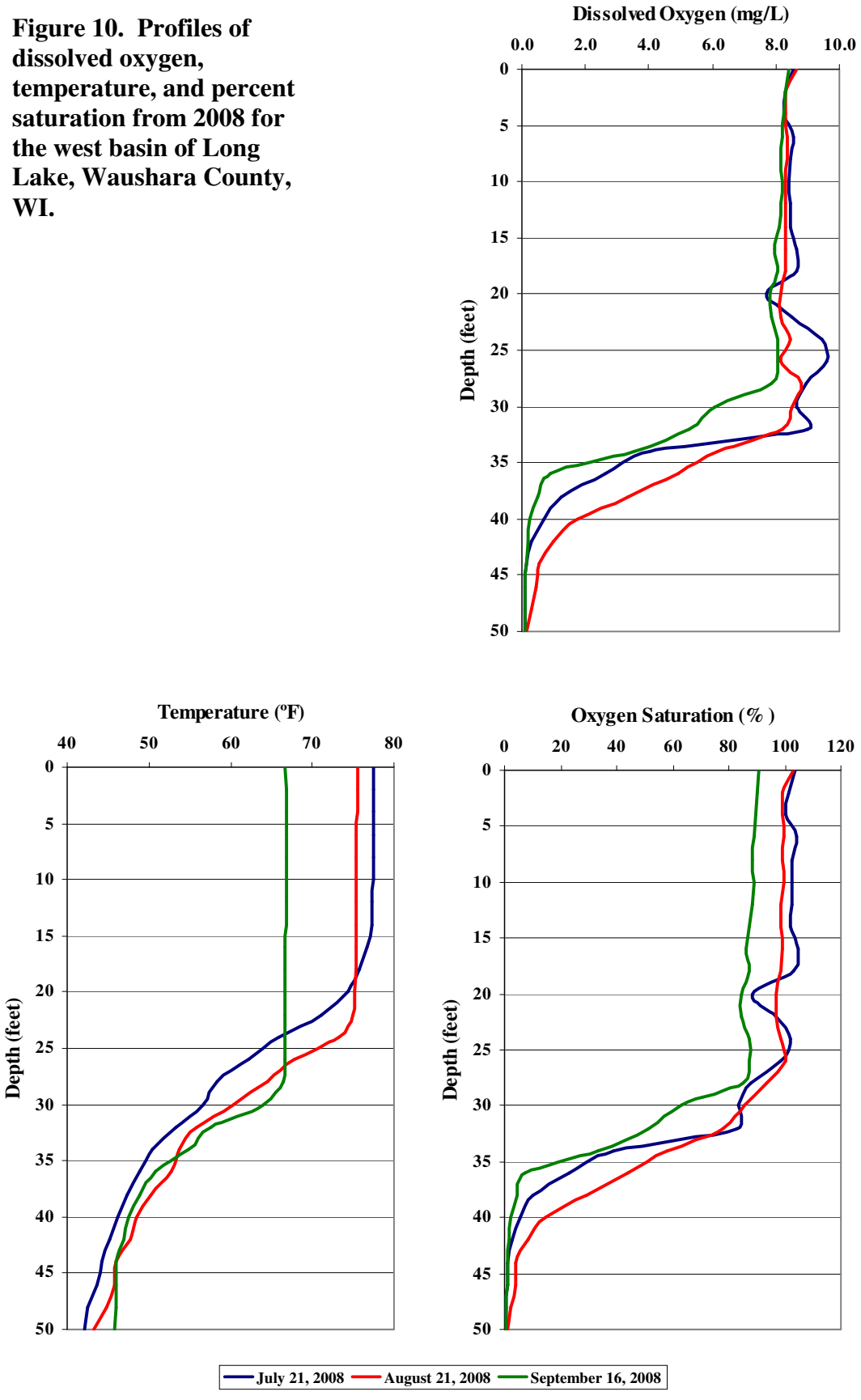


Figure 10. Profiles of dissolved oxygen, temperature, and percent saturation from 2008 for the west basin of Long Lake, Waushara County, WI.



Water Chemistry
Data available for multiple water chemistry parameters for Long Lake from 1976 to 2008 can be founding **Appendix D**. The results for parameters assessed in 2008 are discussed here.

pH
pH is a measure of a lake's acid level. It is the negative log of the hydrogen ion concentration in the water. Many factors influence pH including geology, productivity, pollution, etc. pH levels between 7 and 9.5 are not uncommon for hard water lakes in Wisconsin. pH data for Long Lake fall within this range and do not raise concern over water quality in the lake.

Conductivity
Conductivity is the measure of the inorganic compounds in a body of water as determined by how well an electrical current is carried through a water sample. Conductivity is dependant upon the concentration of inorganic compounds suspended in the water column. High conductivity values may indicate contamination from septic systems, fertilizers, animal wastes or road salts. As a result, conductivity can be used to determine if human activities are influencing water quality. The recommended value for conductivity in lake samples is below 300 µmhos/cm. The data from 2008 in both basin, were below 300 µmhos/cm.

Alkalinity
Alkalinity is a measure of the amount of carbonates, bicarbonates and hydroxide present in water. Alkalinity is predominantly determined by soil and bedrock characteristics. Lakes and ponds fed by groundwater from limestone aquifers tend to have high alkalinity. High alkalinity can also be a result of high algae and aquatic plant production. Low alkalinity (< 25 mg/L) waters are susceptible to acid rain. Alkalinity levels above 25 mg/L in Long Lake are indicative of a hard water system able to withstand acid rain conditions. These levels do not warrant concern.

Phosphorus
Total phosphorus is one of the most important water quality indicators. Because phosphorus is often the limiting factor in aquatic systems, phosphorus levels determine the amount of plant and algae growth in a lake. Phosphorus can come from external sources within the watershed (fertilizers, livestock, septic systems) or to a lesser extent, from groundwater. Phosphorus can also come from within the lake. Internal loading occurs when plants and chemical reactions release phosphorus from the lake sediments into the water column.

The average phosphorus concentration for natural lakes in Wisconsin is 0.025 mg/L (Shaw, et al, 2004). Values above 0.05 mg/L are indicative of poor water quality. With one exception in 1976, phosphorus levels have been consistently at or below 0.025 mg/L. Data in 2008 were all below 0.01 mg/L. These data indicate good water quality for Long Lake.

Chlorophyll
Chlorophyll is the pigment found in all green plants including algae that give them their green color. It is the site in plants where photosynthesis occurs. Chlorophyll absorbs sunlight to convert carbon dioxide and water to oxygen and sugars. Chlorophyll data is collected because this green pigment is found in algae and can be used to estimate how much phytoplankton (algae) there is in the lake. Generally speaking, the more nutrients there are in the water and the warmer the water, the higher the production of algae and consequently chlorophyll.

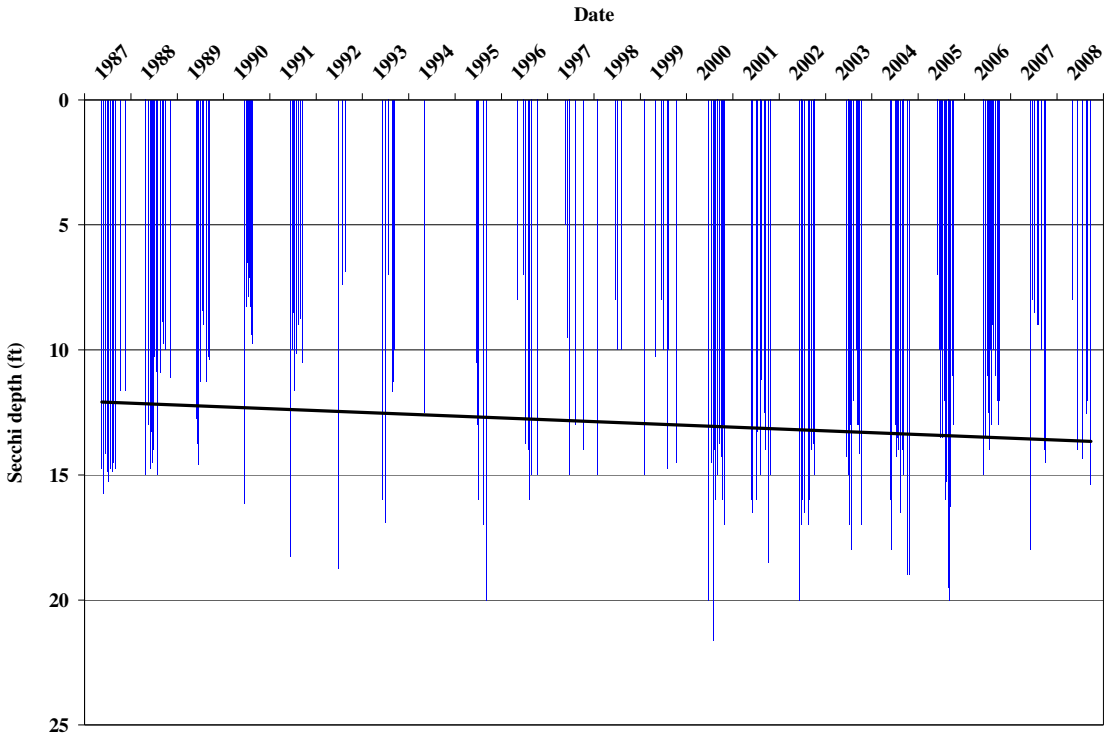
Chlorophyll concentrations below 10 ppb are most desirable for lakes. As with the phosphorus, the data collected for chlorophyll in the past 30 years were well below the level of concern. A majority of the chlorophyll were at or below 3.0 ppb.

Nitrogen
Excess nutrients (nitrates) entering groundwater in the watershed can be a significant threat to the overall water quality of Long Lake. Nitrogen is an important nutrient for plants and algae. It can enter lakes from groundwater, surface runoff (livestock manure and agricultural fertilizers) and precipitation. In addition, decomposing organic matter releases nitrogen.

Nitrogen can exist in a number of forms in aquatic systems. Samples collected from Long Lake in 2008 were tested for nitrates and nitrites. Nitrates and nitrites are inorganic forms of nitrogen which can be readily used by plants and algae. Water naturally contains less than 1 ppm of nitrogen. If the inorganic forms of nitrogen exceed 0.3 mg/l in spring, there is sufficient nitrogen to support summer algae blooms and negatively affect water quality. Nitrate and nitrite levels in Long Lake in 2008 were undetectable.

Secchi Transparency
Water clarity is often used as a quick and easy test for a lake's overall water quality, especially in relation to the amount of algae present. There is an inverse relationship between Secchi depth and the amount of suspended matter, including algae, in the water column. The less suspended matter, the deeper the Secchi disc is visible. Water clarity readings have been collected for over twenty years on Long Lake. These data can be found in **Appendix D**. **Figure 11** shows the Secchi depth data calculated for Long Lake since 1987. This figure also includes a black line showing the overall trend in water transparency over this timeframe. Secchi depths deeper than six feet are generally indicative of good water quality. Long Lake has consistently had transparencies greater than six feet over the past 20 years.

Figure 11. Water clarity data from 1988-1989, 1992-1994, and 2001 to present for Long Lake, Waushara County, Wisconsin.



Trophic State

There is a strong relationship between levels of phosphorus and chlorophyll and water clarity in lakes. As a response to rising levels of phosphorus, chlorophyll levels increase and transparency values often decrease. The effect of this is viewed as an increase in the productivity of a lake.

Lakes can be categorized by their productivity or trophic state. When productivity is discussed, it is normally a reflection of the amount of plant and animal biomass a lake produces or has the potential to produce. The most significant and often detrimental result is elevated levels of algae and nuisance aquatic plants. Lakes can be categorized into three trophic levels:

- oligotrophic - low productivity, high water quality
- mesotrophic - medium productivity and water quality
- eutrophic - high productivity, low water quality

These trophic levels form a spectrum of water quality conditions. Oligotrophic lakes are typically deep and clear with exposed rock bottoms and limited plant growth. Eutrophic lakes are often shallow and marsh-like, typically having heavy layers of organic silt and abundant plant growth. Mesotrophic lakes are typically deeper than eutrophic lakes with significant plant growth, and areas of exposed sand, gravel or cobble bottom substrates.

Lakes can naturally become more eutrophic with time, however the trophic state of a lake is more influenced by nutrient inputs than by time. When humans negatively influence the trophic state of a lake the process is called *cultural eutrophication*. A sudden influx of available nutrients may cause a rapid change in a lake's ecology. Opportunistic plants such as algae and nuisance plant species are able to out-compete other more desirable species of macrophytes. The resultant appearance is typical of poor water quality.

Total phosphorus, chlorophyll and Secchi depth are often used as indicators of the water quality and productivity (trophic state) in lakes. Values measured for these parameters can be used to calculate Trophic State Index (TSI) values (Carlson 1977). The formulas for calculating the TSI values for Secchi disk, chlorophyll, and total phosphorus are as follows:

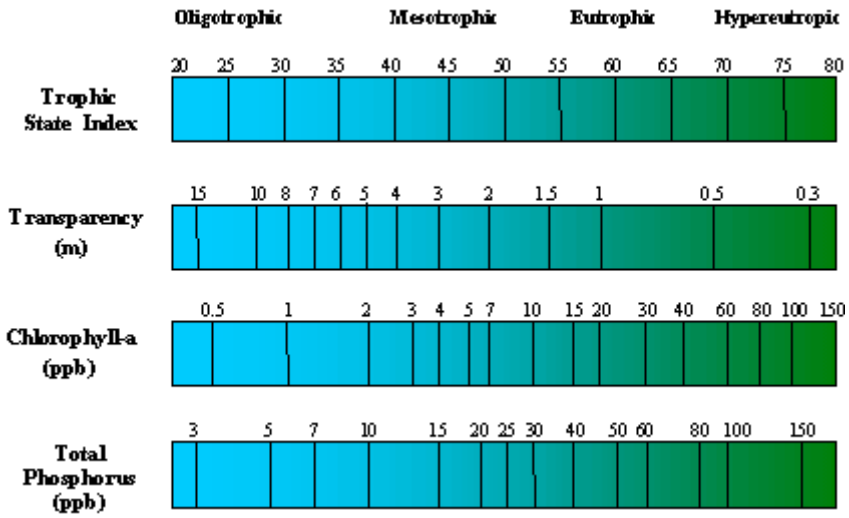
$$TSI = 60 - 14.41 \ln \text{Secchi disk (meters)}$$

$$TSI = 9.81 \ln \text{Chlorophyll } (\mu g/L) + 30.6$$

$$TSI = 14.42 \ln \text{Total phosphorus } (\mu g/L) + 4.15$$

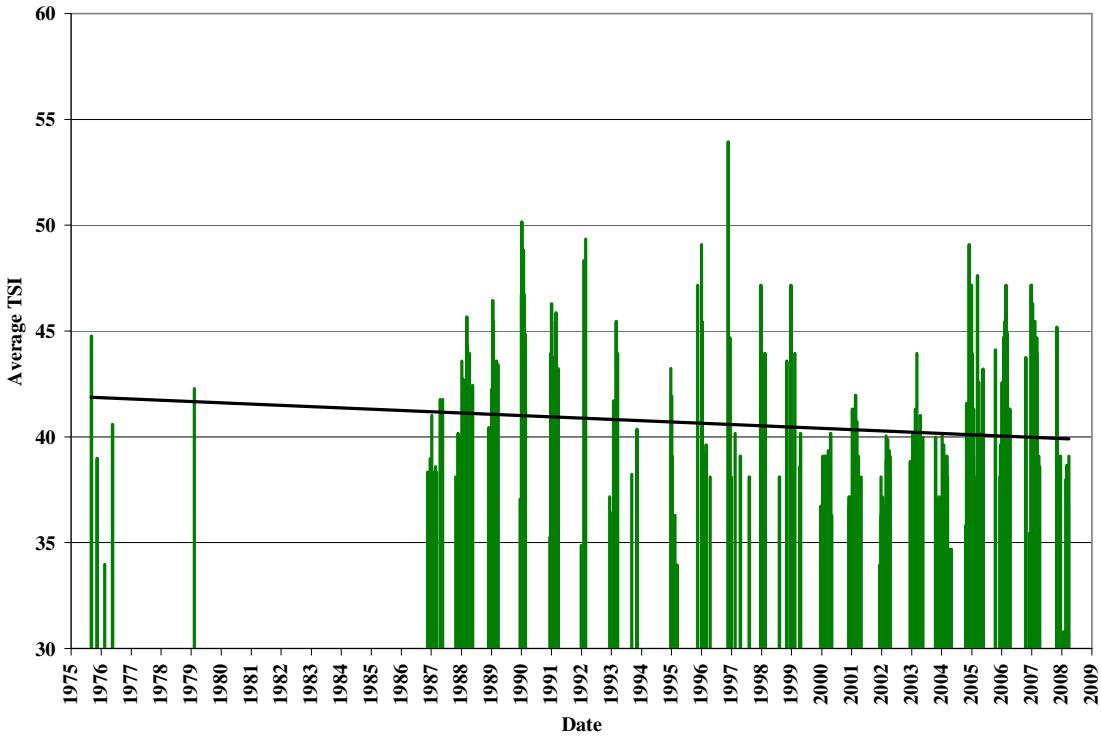
The higher the TSI calculated for a lake, the more eutrophic it is (**Figure 12**).

Figure 12. Relationship between trophic state in lakes and parameters including Secchi transparency, chlorophyll, and total phosphorus.



Classic eutrophic lakes have TSI values starting around 50. **Figure 13** shows the average TSI values dating back to 1976. In some cases the value of only one parameter was available. Other times the line on the graph represents the averaging of multiple parameters and in some cases the two basins. The TSI values fell below 50 nearly every time. In addition, the average TSI value since 1976 is 40.7. The average TSI value since 2000 is 39.7. This graph also has a black line indicating the overall trend in TSI values since 1976. The TSI data show that Long Lake falls within the lower end of a classic mesotrophic lake.

Figure 13. Average Trophic State Index values from 1976-2008 for Long Lake, Waushara County, WI.



Software available from the WDNR entitled Wisconsin Lake Modeling Suite (WiLMS) was used to predict the trophic state of Long Lake given its size, watershed area, mean depth and ecoregion. Comparisons were made between the predicted TSI values and those calculated from the phosphorus, chlorophyll and Secchi data for the July, August and September sampling events. In each category, the observed or measured values for these parameters were found to be lower than those predicted by the WiLMS software. In other words, water quality of Long Lake is greater than expected and above the average value for the North Central Hardwood Forests Ecoregion.

The WiLMS software was also used to estimate the internal and external loading of phosphorus into Long Lake. The software uses export coefficients for various land-use and cover types as well as precipitation, point sources and septic systems to represent phosphorus loading into the lake from external sources. This software also takes in account a number of other factors including lake morphology, watershed drainage area,

net precipitation, oxygen stratification, measured phosphorus concentrations during turnover and the growing season, and estimated area of anoxia. By inputting data for a number of these factors, the WiLMS software was able to predict the total annual phosphorus load into Long Lake. In total, the model estimated 1,433 kg (3,163 lbs) of phosphorus enter the lake annually from non point sources, aerial deposition, and septic systems. In addition, the annual internal loading of phosphorus was estimated at 109 kg (241 lbs). The internal loading value is low because only a small area of the lake becomes anoxic (areas greater than 30-35 feet) in the summer. It is under anoxic conditions that nutrients, namely phosphorus are released from the sediments in lakes.

Watershed Analysis

In August 2008, the watershed analysis was conducted. **Figures 14 and 15** show the delineation of the Long Lake watershed and the land use types present. The data for the land use map (**Figure 15**) was provided by the WDNR's Bureau of Technology Services.

The survey and resulting analysis found that the watershed of Long Lake is approximately 457.2 acres (0.71 mi^2). This is a small watershed relative to the size of the lake (272 acres). This is due to steep slopes around a majority of the lake; particularly along the south shore. In addition, areas just south of South Shore Drive and South Long Lake Road appeared to drain toward the lake. However, the elevated roads and lack of culverts cause rain water to be diverted away from the lake. This too limits the size of the watershed.

Information available online from the Wisconsin DNR indicates that areas within the Long Lake watershed have not been listed as environmentally sensitive areas.

Table 5 contains a breakdown of land use and cover types within the watershed of Long Lake. Not surprisingly, the watershed as a whole is dominated (over 90%) by coniferous and deciduous forests. In addition, 6.3% of the watershed is agricultural fields and 2.8% is wetland.

Table 5. Land use and cover types found within the watershed of Long Lake, Waushara County, Wisconsin.

Land Type	% cover	acres
Forest (deciduous)	69.6	318.2
Forest (coniferous)	21.3	97.4
Agriculture (general/row crops)	6.3	28.8
Wetland	2.8	12.8
		457.2

During the watershed assessment, no obvious signs of runoff or erosion were found. Lake residents noted that the area between Long Lake and Gilbert were once navigable by canoe. However these areas are now only small patches of wetlands. Property owners also indicated that in the past five years or more, the water level in Long Lake has been low. This is a sentiment shared by many lake residents in Wisconsin. The loss of navigability between the two lakes is certainly related to the low water levels. As is the fact that areas along the west end of the lake, which are now more wetland than lake were once navigable and the properties in this area once were waterfront lots.

While much of the shore of Long Lake has a high concentration of homes, areas of significant erosion were not evident near shore either. Human activity can contribute to shoreline erosion. An increase in development translates to increases in the number of lawns, driveways and other hard surfaces which are known to contribute nutrients and

Figure 14. Watershed of Long Lake, Waushara County, Wisconsin.

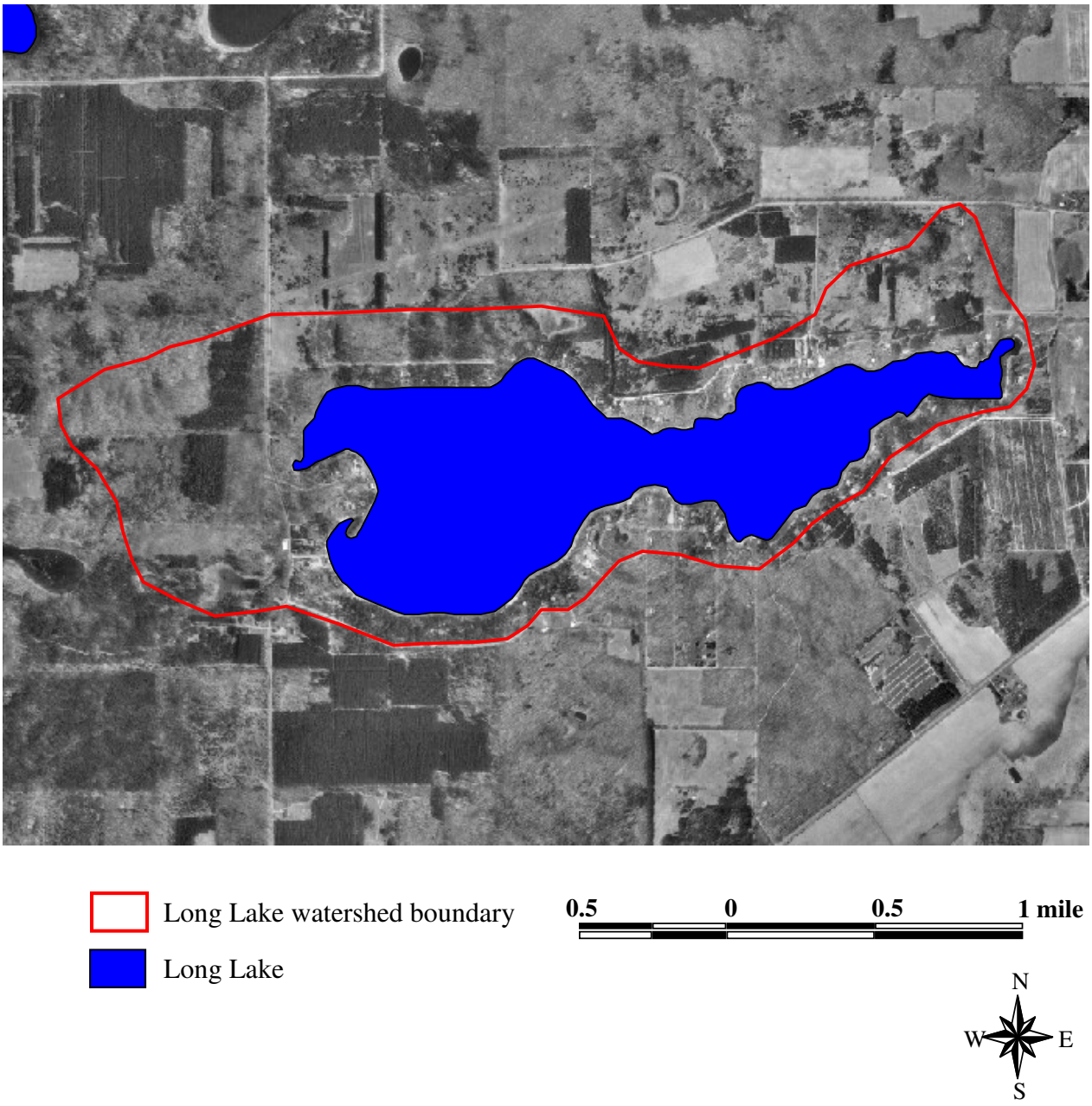
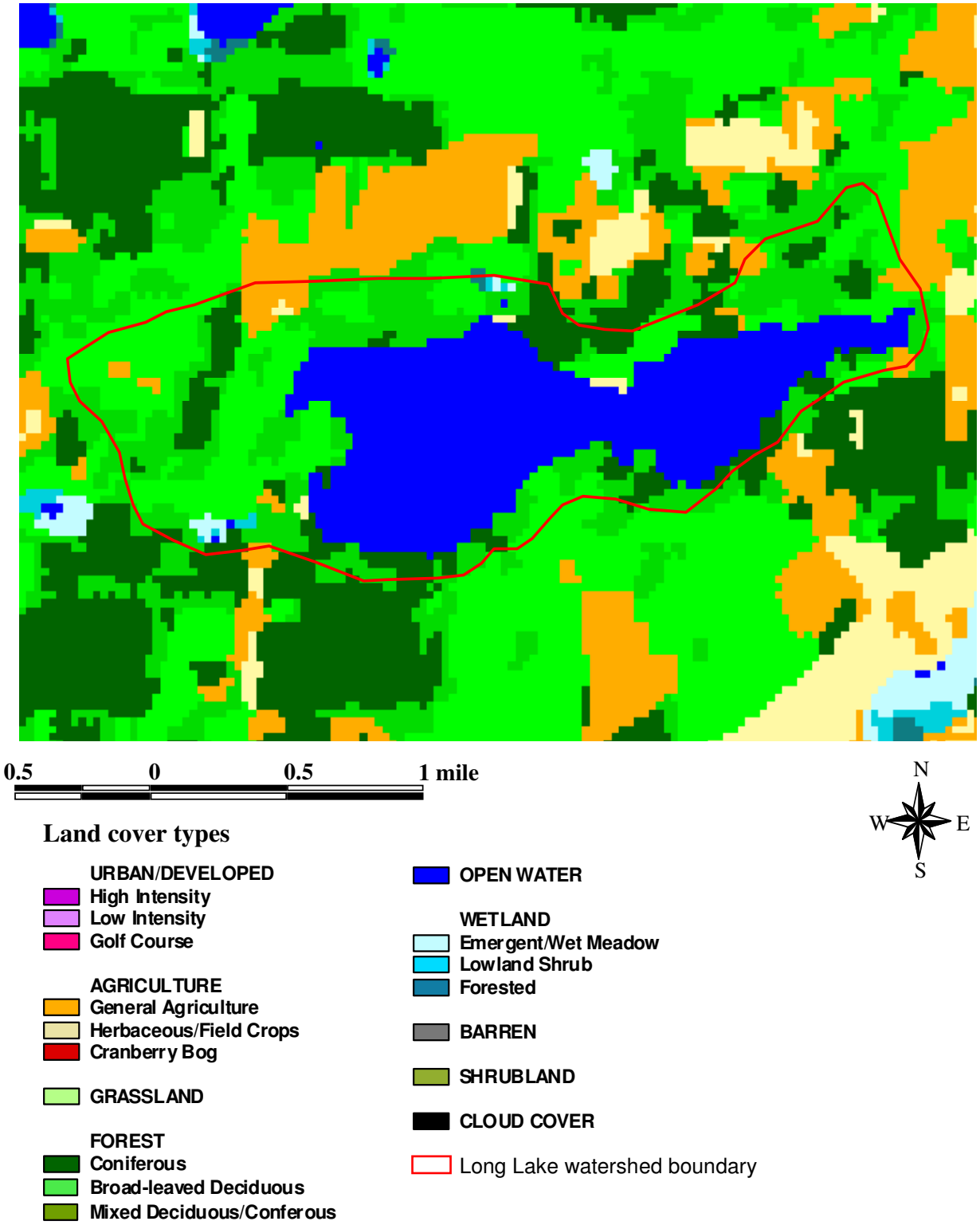


Figure 15. Land cover types and watershed delineation for Long Lake, Waushara County, Wisconsin.



sediments to a lake. Impacts from shoreline properties *can* have a negative impact on the water quality of a lake. This can be particularly significant for lakes like Long Lake with low agricultural cover and small watersheds.

Table 6 shows the percent of soil types within the watershed of Long Lake. A majority of the soils are well drained to excessively drained, and erodible. As a result, they are not prime farmland. This may account for the fact that only a small portion of the area surrounding Long Lake is actively farmed.

Table 6. Description of soil types within the watershed of Long Lake, Waushara County, WI

Soil type	Percent of Watershed	Description
Richford loamy sand, 12 to 20 percent slopes	24.00%	Somewhat excessively and well drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Highly erodible. Not prime farmland.
Plainfield sand, 12 to 30 percent slopes	19.64%	Excessively drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Highly erodible. Not prime farmland.
Plainfield sand, 6 to 12 percent slopes	14.76%	Excessively drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Potentially highly erodible. Not prime farmland.
Richford loamy sand, 6 to 12 percent slopes	12.94%	Somewhat excessively and well drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Potentially highly erodible. Not prime farmland.
Okee loamy sand, 6 to 12 percent slopes	10.10%	Somewhat excessively and well drained loamy soil. Moderate available water capacity. This soil is not hydric. The maximum allowable erosion rate is 4 tons/acre/year. Potentially highly erodible. Not prime farmland.
Richford loamy sand, 2 to 6 percent slopes	9.66%	Somewhat excessively and well drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Potentially highly erodible. Not prime farmland.
Okee loamy sand, 12 to 20 percent slopes	4.99%	Somewhat excessively and well drained loamy soil. Moderate available water capacity. This soil is not hydric. The maximum allowable erosion rate is 4 tons/acre/year. Highly erodible. Not prime farmland.
Plainfield sand, 2 to 6 percent slopes	2.96%	Excessively drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Not highly erodible. Not prime farmland.
Houghton muck, 0 to 1 percent slopes	0.94%	Very poorly drained organic soil. Frequently ponded. Very high available water capacity. This soil is hydric. The maximum allowable erosion rate is 3 tons/acre/year. Not highly erodible. Not prime farmland.

In the Waushara County Land and Water Resource Management Plan completed in February 2006, conditions within the Pine River and Willow Creek Watersheds, where Long Lake lies, are discussed. "The west half of the watershed has minimal impacts from non-point source pollution. All of the Class I and II streams and rivers are designated as Exceptional Resources Waters except for the Willow Creek which is an Outstanding Resource Water."

"There are 43 named lakes and 18 unnamed lakes in this watershed. Many of the seepage lakes have no inlet or outlet and are groundwater fed. At some point there will be an excess of phosphorus that the lakes will not precipitate, thus causing algae blooms. Many of the larger lakes have been developed since the 1890's. At that time summer cottages were built anywhere they could be fit in. Due to relatively low land prices and taxes, extensive redevelopment has been occurring during the 1990's. Surface runoff from large houses (over 1200 sq. ft.), impermeable surfaces, lawns, and in some cases septic systems, have increased the potential of non-point pollutants reaching the lake."

The Waushara County Land and Water Resource Management Plan does not specifically address Long Lake in terms of watershed or water quality concerns. It does include recommendations or action objectives which pertain to riparian owners, shoreline conditions and exotic species management. These objectives are incorporated into the Conclusions and Discussions portion of this report.

Additional information available was obtained from Waushara County regarding the groundwater near Long Lake. The data indicate nitrate concentrations in the groundwater near the lake are far below the level of concern for drinking water. In addition, the area of the County near Long Lake is moderately susceptible to groundwater contamination when considering a number of factors. These include thedepth to bedrock, bedrock type, soil characteristics, surficial deposits, and the depth to the water table.

Long Lake Fishery

Wisconsin DNR data of fish stocking efforts in Long Lake date back to 1972. These data (**Appendix D**) show that a number of fish species have been stocked in the past 25 years. These include largemouth bass (*Micropterus salmoides*), northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), smallmouth bass (*Micropterus dolomieui*), muskellunge (*Esox masquinongy*), white sucker (*Catostomas commersoni*), black crappie (*Pomoxsis nigromaculatus*), and yellow perch (*Perca flavescens*).

In addition, the following page displays a copy of a fishery summary written by the Wisconsin DNR. This summary contains boomshocking from 1990 to 2005 as well as information regarding the abundance and growth rates of a number of game fish species.

Additional information regarding the fishery of Long Lake and the habitat requirements of individual fish species can be found in the January 2005 report from Aquatic Biologist titled *A Survey of Aquatic Plants in Long Lake, Waushara County*.

Long Lake Summary

Boomshocking Catch Effort Comparisons (Number per Hour)

	Spring						Fall			
Lake	Long	Long	Long	Long	Long	Long	Long	Long	Long	Long
Date	04/25/2000	05/08/2000	04/23/2002	05/23/2002	04/20/2005	05/24/2005	10/15/1990	10/16/2002	10/18/2004	11/02/2005
Temp (F)	49	56	51	59	56	63	56	55	54	
Black Crappie	1	6	0	0				0		
Bluegill	191	444	580	594		512		794	474	731
Bluntnose Minnow	0		6					24		16
Bullhead spp.	1	2	0	10		2		0		
Cisco						1	16*	0		
Green Sunfish	0	0	4	0				0		
Largemouth Bass	64	184	122	80	67	75	26*	8	11	20
Northern Pike	8	4	2	6	3	17	21	2	7	19
Pumpkinseed	0	24	16	36		39		14		2
Rock Bass	49	64	104	78		108		62	84	153
Shiner spp.	0	0	2	0				2		
Smallmouth Bass	7	0	24	14	3	5	1	3	8	5
Walleye	20	0	12	0	15	6	4	2	2	6
White Sucker	31	32	38	18		88		0	24*	14
Yellow Perch	5	8	4	4		7		6	11	51

* many fish observed and were not captured
4/20/05 Gamefish only sampled.

Walleye Population Estimates

Lake	Long	Long	Long
Gear	Fyke	Fyke	Fyke
Date	1987	2002	2005
Number / Acre	1.1	0.9	1.2



Comments:

- **Cisco** During 1990 boomshocking survey approx. 49 cisco were captured and many more were observed. Past surveys using multiple gears (e.g. seine, fyke, and boomshock) captured numerous cisco. No cisco were captured in 2002 surveys. One captured in each 2004 and 2005 surveys. Numerous cisco were observed in deep water fall shocking run 2003 and 2004. Some late November anglers have reported splashing of spawning cisco in both 2003 and 2004.
- **White Sucker** fyke net catch has declined since the 1960s and 1970s surveys. In 2004 (1,385) and in 2005 (1,170) adult white suckers were stocked in Long Lake. Shocking run May 24, 2005 revealed good survival and spawning adults were abundant.
- **Bluegill** is dominant prey centrachid and appears to be in high abundance when compared to past surveys and other lakes with similar fisheries and physical characteristics. Growth rates are very slow with fish not reaching 6 inches until after 6 summers of growth.
- **Largemouth Bass** catch per effort decreased in the 2005 survey. In 2002 they had below average growth rates with fish not reaching 14 inches until after 7 complete summers of growth. Growth rates from 2005 survey were a mirror image of 2002 growth rates.
- **Walleye** population has remained relatively unchanged over the years holding fairly constant at ~ 1adult/acre. (Typical of walleye fisheries solely dependent on stocking). Some large fish were sampled spring of 2005 with 2 fish weighing over 13 pounds.
- **Spotted Musky** In 2004 fall shocking run, 2 adult musky were observed. In 2005 spring shocking runs, only 1 spotted musky was observed. No young of year or small spotted musky were sampled in our surveys. The hatchery removed 5 adult muskies in 2004 and 2 adults in 2005. Numerous reports of anglers targeting musky. Fall 2005 1 musky (41 inch) caught and removed.
- **Northern Pike** catch rates have increased slightly with fish from 11.5 - 35.4 inches being sampled. Only one fish sampled was legal (32 inch size limit). Most were in the 17-26 inch range. Growth rates of fish sampled in 2002 were below average. Growth rates were close to average in the 2005 survey. Because of lack of desirable shallow water spawning areas, the fish seem to be useing deeper water vegetation to spawn. Making them hard to sample.

Conclusions and Discussion

Aquatic Plant Management

Results of the aquatic plant survey conducted in 2008 reflect lake users comments that the aquatic plant community of Long Lake does not impact navigation or recreational use of the lake. In addition, survey results confirm that neither Eurasian watermilfoil nor curly-leaf pondweed currently infest the waters of Long Lake. There are about 25 lakes in Waushara County alone with Eurasian watermilfoil. This number increases when you include lakes with curly-leaf pondweed. Many of these lakes are a short distance from Long Lake. Due to the close proximity of these waters it is reasonable to assume that for the foreseeable future, Eurasian watermilfoil, in particular, will pose a risk of infesting the waters of Long Lake.

Exotic Species Contingency Plan

Because of the risk of infestation by exotic species, it is important that contingency plans be put in place to respond to the introduction of exotic species as quickly as possible. To this end, it would be wise to call upon the assistance of lake management consultants to annually survey Long Lake for exotic species. Lake residents should undertake an active monitoring program for the purpose of identifying and documenting possible exotics. This should be done through surveys similar to the one conducted on Long Lake in the spring 2008). However, by scheduling this type of survey in the spring and again in the late summer or early fall, the Association would be able to take advantage of the most opportune times to survey for curly-leaf pondweed and Eurasian watermilfoil, respectively.

The Long Lake Association has an active Clean Boats Clean Water (CBCW) program. The fact that there have been no exotics identified in Long Lake is a direct result of the efforts of the CBCW volunteers. Long Lake has the same level of public access and recreational use that many other area lakes have. Lake property owners should be highly encouraged to continue with the level of participation of recent years. It is the lake's best defense against introduction. If the level of volunteerism can be maintained, the spread of exotic species into Long Lake should be prevented or significantly delayed for the foreseeable future.

Education should play a big part in this program. All individuals willing to participate should be taught to identify exotic species. The Association should make it a priority to include such measures during all normally scheduled meetings whenever possible. In addition, special meetings should be considered to focus primarily on the identification of these species for riparian property owners and frequent lake users. The native plant, northern watermilfoil *(M. sibericum)*, grows in Long Lake. Because it superficially looks much like Eurasian watermilfoil, care should be taken to specifically learn to differentiate between the two species. In addition to Eurasian watermilfoil and curly-leaf pondweed, it would behoove members of the association to become familiar with the identification

of species such as purple loosestrife and zebra mussels. Each of these four species has been identified throughout Wisconsin and as was detailed prior, zebra mussels were at one time confirmed in Long Lake. **Appendix E** gives information regarding the identification and life history for these four species. Further information and education materials are available through the Wisconsin DNR and the local UW-Extension office.

If a lake user locates what he or she believes to be an exotic species, its location should be documented by recording GPS coordinates. In addition, a sample should be collected and taken to a member of the Association's Board or the coordinator of the monitoring program if one is appointed. Any suspicious material should be sent to the nearest Wisconsin DNR office for verification. If the identification is confirmed it will be important to initiate management measures as quickly as possible. The extent of an exotic species infestation often dictates which management option is most likely to result in successful control. As a result, **Appendix E** also contains information regarding management options for the four exotic species previously mentioned. As always, education should be a key component of any exotic species management effort.

Water Quality Management

Water quality is not a current problem for Long Lake. However it would be best for the Association to remain mindful and continue to keep the water quality of the lake a priority. It is recommended that the volunteer monitoring of the lake continue and be expanded. Currently spring and fall samples are collected for the ongoing study through UW - Stevens Point. This should continue. Also, summer monitoring of water quality should be expanded to not only include water clarity but also dissolved oxygen and temperature. The Association already owns a dissolved oxygen meter and Secchi disk. Therefore, it should not be difficult to expand the monitoring efforts. It is recommended oxygen and temperature be monitored monthly in April, July, August and September and water clarity be sampled either every month or every two weeks throughout the growing season (April through September)

Elevated nutrient inputs from human activities around Long Lake can adversely affect both water clarity and water quality. Although water quality in Long Lake is high, a number of practices can be carried out to ensure water quality is maintained. The most significant contributions of nutrients to Long Lake are from direct runoff from areas closest to the lake. The following are options for water quality enhancement which both the Association as a whole and individual lakefront property owners can undertake to maintain the water quality of Long Lake.

Nutrient management options

The first steps taken in managing nutrients in a lake should be to control external sources of nutrients. These can include: encouraging the use of phosphorus-free fertilizers; improving agricultural practices, reducing run-off, and restoring vegetation buffers around waterways.

Lawn care practices

Mowed grass up to the water's edge is a poor choice for the well being of the lake. Studies show that a mowed lawn can cause 7 times the amount of phosphorus and 18 times the amount of sediment to enter a water body than an area of land with naturally occurring vegetation (Korth and Dudiak, 2003). Lawn grasses also tend to have shallow root systems that cannot protect the shoreline as well as deeper-rooted native vegetation (Henderson et al., 1998).

Landowners living in close proximity to the water, in particular, those with shoreline property, should be discouraged from using lawn fertilizers. Fertilizers contain nutrients, including phosphorus and nitrogen which can wash directly into the lake. While elevated levels of phosphorus can cause unsightly algae blooms, nitrogen inputs have been shown to increase weed growth. Landowners are encouraged to perform a soil test before fertilizing. A soil test will help determine if there is even a need for fertilizer. The local UW-Extension office can assist in having soil tested. If there is a need to fertilize a lawn, a fertilizer that does not include phosphorus should be used. Most lawns in Wisconsin don't need additional phosphorus. The numbers on a bag of fertilizer are the percentages of available nitrogen, phosphorus and potassium found in the bag. Phosphorus free fertilizers will have a 0 for the middle number (e.g. 10-0-3).

To further reduce nutrient loading, avoid raking twigs, leaves, and grass clippings into the lake. They contain both nitrogen and phosphorus. The best disposal for organic matter, like leaves and grass clippings is to compost them. Composted material can then be used for gardening.

Vegetative buffer zones

There are beneficial alternatives to the traditional mowed lawn. The best alternative is to leave the natural shoreline undisturbed. If clearing is necessary to access and view the lake, consider very selective removal of vegetation.

Restoring a vegetative buffer zone is also an important alternative. A recommended buffer zone consists of native vegetation that may extend from 25 – 100 feet or more from the water's edge onto land, and 25 – 50 feet into the water. A buffer should cover between 50% and 75% of the shoreline frontage (Henderson et al., 1998). In most cases this still allows plenty of room for a dock, swimming area, and lawn. Buffer zones are made up of a mixture of native trees, shrubs, and other upland and aquatic plants.



Shoreline vegetation serves as an important filter against nutrient

loading and trapping loose sediment. A buffer provides excellent fish and wildlife habitat, including nesting sites for birds, and spawning habitat for fish. Properly vegetated shorelines also play a key role in bank stabilization. A number of resources are available to assist property owners in creating beneficial buffer zones. These include descriptions of native beneficial plant species and where they can be found locally.

Shoreline plant restoration



Shoreline vegetation can benefit lake ecology tremendously. A properly vegetated shoreline provides habitat for a variety of birds, furbearers, amphibians, and reptiles. Much of the emergent vegetation in Long Lake appears to have been replaced by lakefront development. Benefits to lake water quality, fishery and wildlife could be achieved by restoring shoreline plants in Long Lake. Lakefront habitat improvement is often done on a property-by-property basis. In recent years many new techniques have been developed for restoring lakefronts. This type of work often incorporates many attractive flowering plants and adds a great deal of aesthetic appeal to lakefronts as well. Studies have also shown that providing complex habitats through shoreline features such as plants and erosion control devices can result in significant increases in fish species richness (Jennings et al., 1999).

Erosion control

Erosion is a natural process, but it's for the benefit of the landowner and health of the lake that erosion control practices be carried out to slow the process as much as possible. Sedimentation into the lake causes nutrient pollution, turbid water conditions, eliminates fish spawning habitat, and increases eutrophication. Shoreline owners are encouraged to leave existing vegetation, which is a great shore stabilizer. The placement of logs, brush mats, and rock riprap are also options against erosion. When riprap is used it is recommended that desirable shrubs and aquatic plants be planted within the riprap. The plantings serve as nutrient filters and habitat. Before any shoreline stabilization project is initiated, it is recommended that property owners contact the local Wisconsin DNR office for project approval and to obtain any necessary permits.

Reduced impacts from boating

Boat traffic can cause an increase in suspended solids especially in shallow areas of lakes (Hill, 2004). Studies have shown that maximum increases in turbidity occur between 2 and 24 hours following boating activities. The full effects of heavy boating depend upon a number of factors including propeller size, boat speed, draft, and sediment characteristics (Asplund, 1996). Silty sediments tend to have the highest susceptibility to resuspension and the highest potential for the reintroduction of nutrients into the water column. Studies have also focused on algae (chlorophyll a) concentrations but found no significant changes following boating activity. This is due primarily to an indeterminate time lag which occurs between the release of nutrients and the subsequent increase in

algal growth. It has also been suggested that disturbances to the native plant communities due to watercraft use can accelerate the spread of opportunistic exotic plant species such as Eurasian watermilfoil and curly leaf pondweed (Asplund and Cook, 1997).

Wisconsin statutes require boaters to maintain no-wake speeds within 100 feet of shorelines, other boats, or fixed structures, including boat docks and swimming platforms. However, it is difficult to enforce such regulations and even slow boat traffic can have a negative impact on sediments and plant communities in shallow areas. This not only has a negative impact to the lake but can also damage boats. It is recommended that the Long Lake Association take the opportunity to educate members and lake users alike of the impacts boating can have on a lake.

Septic system maintenance

Septic systems are known to contribute nutrients to a lake. It is the responsibility of lakeshore property owners to ensure that septic systems are properly functioning. A failing septic system can contaminate both surface and ground water. Each home can contribute up to 2 lbs of phosphorus annually. If located in a groundwater discharge area, failing septic systems can be a particularly significant source of nutrient loading in a lake. Systems should be professionally inspected every 3 years, and pumped every 2-5 years depending on operating circumstances (EPA, 2002). Avoid flushing toxic chemicals and pharmaceuticals into the system. These can leach into the groundwater ad/or harm important bacteria that live in your tank and naturally break down wastes. Avoid planting trees, compacting soil, or directing additional surface runoff on top of the drain field.

Citizen Participation

In March 2009, hardcopies of the survey results from this study were provided to the Long Lake Association's board. Each board member was given the opportunity to review and provide feedback and questions regarding the study findings and clarifications were made to the report following that review. On March 28, 2009 the results of this study were presented to the Long Lake Association at a meeting held at the Saxeville Town Hall. This meeting was open to the public. A number of Association members as well as the members of the board were present. Results of the study were presented and a time was given for questions and answers. On May 23, 2009 Cason & Associates staff met with the Association board to discuss changes to the report. This meeting was followed by a brief presentation at the Clean Boats Clean Waters training session held at the Town Hall. Again an overview of the study and the results was given. On July 4, 2009, Jim Schiek and Larry Annen presented the findings of the study to the members of the Long Lake Association at their Annual Membership Meeting at the Saxeville Town Hall. A number of questions regarding the condition of the lake, results of the study and current lake management were answered and addressed. On July 18, 2009, Cason & Associates staff attended the Long Lake Association's annual Family Picnic. Although this was an informal setting, a number of questions regarding the condition of the lake and current management were addressed. Also, at the March 2009 Town of Saxeville Board Meeting, LLA board members reported on the study activity and again at a Town of Saxeville Land Use Planning Committee Meeting later in the summer. The discussions did not get into details but basic information was shared with non-lake residents as to the overall quality of Long Lake and the valuable asset this lake is to the community.

In addition to discussions at meetings, information regarding the results of this study has been included in Association newsletters. Also, hardcopies of the report have been made available to Association members. To date, all pertinent concerns have been addressed and the necessary changes were made to the report.

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Appendix A

- GPS coordinates for aquatic plant surveys conducted on Long Lake near Saxeville, Waushara County, WI.

GPS coordinates for aquatic plant surveys on Long Lake, Waushara County, WI.

Site	Latitude	Longitude	Site	Latitude	Longitude
1	44.2168	-89.1373	50	44.2174	-89.1345
2	44.2165	-89.1373	51	44.2171	-89.1345
3	44.2178	-89.1368	52	44.2168	-89.1345
4	44.2175	-89.1368	53	44.2148	-89.1345
5	44.2171	-89.1368	54	44.2144	-89.1345
6	44.2168	-89.1368	55	44.2141	-89.1345
7	44.2185	-89.1363	56	44.2138	-89.1345
8	44.2181	-89.1363	57	44.2135	-89.1345
9	44.2178	-89.1363	58	44.2131	-89.1345
10	44.2175	-89.1363	59	44.2128	-89.1345
11	44.2171	-89.1363	60	44.2125	-89.1345
12	44.2168	-89.1363	61	44.2188	-89.1340
13	44.2188	-89.1358	62	44.2184	-89.1340
14	44.2185	-89.1358	63	44.2181	-89.1340
15	44.2181	-89.1358	64	44.2178	-89.1340
16	44.2178	-89.1359	65	44.2174	-89.1340
17	44.2175	-89.1359	66	44.2171	-89.1340
18	44.2171	-89.1359	67	44.2168	-89.1340
19	44.2145	-89.1359	68	44.2164	-89.1340
20	44.2141	-89.1359	69	44.2161	-89.1340
21	44.2138	-89.1359	70	44.2154	-89.1340
22	44.2135	-89.1359	71	44.2151	-89.1340
23	44.2188	-89.1354	72	44.2148	-89.1340
24	44.2185	-89.1354	73	44.2144	-89.1340
25	44.2181	-89.1354	74	44.2141	-89.1341
26	44.2178	-89.1354	75	44.2138	-89.1341
27	44.2175	-89.1354	76	44.2134	-89.1341
28	44.2171	-89.1354	77	44.2131	-89.1341
29	44.2148	-89.1354	78	44.2128	-89.1341
30	44.2145	-89.1354	79	44.2124	-89.1341
31	44.2141	-89.1354	80	44.2188	-89.1335
32	44.2138	-89.1354	81	44.2184	-89.1335
33	44.2135	-89.1355	82	44.2181	-89.1335
34	44.2131	-89.1355	83	44.2178	-89.1335
35	44.2188	-89.1349	84	44.2174	-89.1335
36	44.2185	-89.1349	85	44.2171	-89.1335
37	44.2181	-89.1349	86	44.2168	-89.1336
38	44.2178	-89.1349	87	44.2164	-89.1336
39	44.2175	-89.1349	88	44.2161	-89.1336
40	44.2171	-89.1349	89	44.2158	-89.1336
41	44.2141	-89.1350	90	44.2154	-89.1336
42	44.2138	-89.1350	91	44.2151	-89.1336
43	44.2135	-89.1350	92	44.2148	-89.1336
44	44.2131	-89.1350	93	44.2144	-89.1336
45	44.2128	-89.1350	94	44.2141	-89.1336
46	44.2188	-89.1344	95	44.2138	-89.1336
47	44.2184	-89.1345	96	44.2134	-89.1336
48	44.2181	-89.1345	97	44.2131	-89.1336
49	44.2178	-89.1345	98	44.2128	-89.1336

GPS coordinates for aquatic plant surveys on Long Lake, Waushara County, WI.

Site	Latitude	Longitude	Site	Latitude	Longitude
99	44.2124	-89.1336	148	44.2171	-89.1322
100	44.2121	-89.1336	149	44.2168	-89.1322
101	44.2188	-89.1331	150	44.2164	-89.1322
102	44.2184	-89.1331	151	44.2161	-89.1322
103	44.2181	-89.1331	152	44.2158	-89.1322
104	44.2178	-89.1331	153	44.2154	-89.1322
105	44.2174	-89.1331	154	44.2151	-89.1322
106	44.2171	-89.1331	155	44.2148	-89.1322
107	44.2168	-89.1331	156	44.2144	-89.1322
108	44.2164	-89.1331	157	44.2141	-89.1322
109	44.2161	-89.1331	158	44.2138	-89.1322
110	44.2158	-89.1331	159	44.2134	-89.1322
111	44.2154	-89.1331	160	44.2131	-89.1322
112	44.2151	-89.1331	161	44.2128	-89.1322
113	44.2148	-89.1331	162	44.2124	-89.1322
114	44.2144	-89.1331	163	44.2121	-89.1322
115	44.2141	-89.1331	164	44.2188	-89.1317
116	44.2138	-89.1331	165	44.2184	-89.1317
117	44.2134	-89.1331	166	44.2181	-89.1317
118	44.2131	-89.1331	167	44.2178	-89.1317
119	44.2128	-89.1331	168	44.2174	-89.1317
120	44.2124	-89.1332	169	44.2171	-89.1317
121	44.2121	-89.1332	170	44.2168	-89.1317
122	44.2188	-89.1326	171	44.2164	-89.1317
123	44.2184	-89.1326	172	44.2161	-89.1317
124	44.2181	-89.1326	173	44.2158	-89.1317
125	44.2178	-89.1326	174	44.2154	-89.1317
126	44.2174	-89.1326	175	44.2151	-89.1317
127	44.2171	-89.1326	176	44.2148	-89.1317
128	44.2168	-89.1326	177	44.2144	-89.1317
129	44.2164	-89.1326	178	44.2141	-89.1317
130	44.2161	-89.1326	179	44.2138	-89.1317
131	44.2158	-89.1326	180	44.2134	-89.1317
132	44.2154	-89.1326	181	44.2131	-89.1318
133	44.2151	-89.1326	182	44.2128	-89.1318
134	44.2148	-89.1327	183	44.2124	-89.1318
135	44.2144	-89.1327	184	44.2121	-89.1318
136	44.2141	-89.1327	185	44.2188	-89.1312
137	44.2138	-89.1327	186	44.2184	-89.1312
138	44.2134	-89.1327	187	44.2181	-89.1312
139	44.2131	-89.1327	188	44.2178	-89.1312
140	44.2128	-89.1327	189	44.2174	-89.1312
141	44.2124	-89.1327	190	44.2171	-89.1312
142	44.2121	-89.1327	191	44.2168	-89.1312
143	44.2188	-89.1321	192	44.2164	-89.1312
144	44.2184	-89.1321	193	44.2161	-89.1312
145	44.2181	-89.1321	194	44.2158	-89.1312
146	44.2178	-89.1321	195	44.2154	-89.1313
147	44.2174	-89.1322	196	44.2151	-89.1313

GPS coordinates for aquatic plant surveys on Long Lake, Waushara County, WI.

Site	Latitude	Longitude	Site	Latitude	Longitude
197	44.2148	-89.1313	246	44.2124	-89.1304
198	44.2144	-89.1313	247	44.2121	-89.1304
199	44.2141	-89.1313	248	44.2187	-89.1298
200	44.2138	-89.1313	249	44.2184	-89.1298
201	44.2134	-89.1313	250	44.2181	-89.1298
202	44.2131	-89.1313	251	44.2177	-89.1298
203	44.2128	-89.1313	252	44.2174	-89.1298
204	44.2124	-89.1313	253	44.2171	-89.1298
205	44.2121	-89.1313	254	44.2167	-89.1298
206	44.2188	-89.1307	255	44.2164	-89.1299
207	44.2184	-89.1307	256	44.2161	-89.1299
208	44.2181	-89.1308	257	44.2157	-89.1299
209	44.2178	-89.1308	258	44.2154	-89.1299
210	44.2174	-89.1308	259	44.2151	-89.1299
211	44.2171	-89.1308	260	44.2147	-89.1299
212	44.2168	-89.1308	261	44.2144	-89.1299
213	44.2164	-89.1308	262	44.2141	-89.1299
214	44.2161	-89.1308	263	44.2137	-89.1299
215	44.2158	-89.1308	264	44.2134	-89.1299
216	44.2154	-89.1308	265	44.2131	-89.1299
217	44.2151	-89.1308	266	44.2127	-89.1299
218	44.2148	-89.1308	267	44.2124	-89.1299
219	44.2144	-89.1308	268	44.2121	-89.1299
220	44.2141	-89.1308	269	44.2118	-89.1299
221	44.2138	-89.1308	270	44.2187	-89.1294
222	44.2134	-89.1308	271	44.2184	-89.1294
223	44.2131	-89.1308	272	44.2181	-89.1294
224	44.2128	-89.1308	273	44.2177	-89.1294
225	44.2124	-89.1308	274	44.2174	-89.1294
226	44.2121	-89.1308	275	44.2171	-89.1294
227	44.2187	-89.1303	276	44.2167	-89.1294
228	44.2184	-89.1303	277	44.2164	-89.1294
229	44.2181	-89.1303	278	44.2161	-89.1294
230	44.2177	-89.1303	279	44.2157	-89.1294
231	44.2174	-89.1303	280	44.2154	-89.1294
232	44.2171	-89.1303	281	44.2151	-89.1294
233	44.2167	-89.1303	282	44.2147	-89.1294
234	44.2164	-89.1303	283	44.2144	-89.1294
235	44.2161	-89.1303	284	44.2141	-89.1294
236	44.2158	-89.1303	285	44.2137	-89.1294
237	44.2154	-89.1303	286	44.2134	-89.1294
238	44.2151	-89.1303	287	44.2131	-89.1294
239	44.2148	-89.1303	288	44.2127	-89.1294
240	44.2144	-89.1303	289	44.2124	-89.1294
241	44.2141	-89.1303	290	44.2121	-89.1295
242	44.2138	-89.1304	291	44.2117	-89.1295
243	44.2134	-89.1304	292	44.2187	-89.1289
244	44.2131	-89.1304	293	44.2184	-89.1289
245	44.2128	-89.1304	294	44.2181	-89.1289

GPS coordinates for aquatic plant surveys on Long Lake, Waushara County, WI.

Site	Latitude	Longitude	Site	Latitude	Longitude
295	44.2177	-89.1289	343	44.2161	-89.1280
296	44.2174	-89.1289	344	44.2157	-89.1280
297	44.2171	-89.1289	345	44.2154	-89.1280
298	44.2167	-89.1289	346	44.2151	-89.1280
299	44.2164	-89.1289	347	44.2147	-89.1280
300	44.2161	-89.1289	348	44.2144	-89.1280
301	44.2157	-89.1289	349	44.2141	-89.1280
302	44.2154	-89.1289	350	44.2137	-89.1280
303	44.2151	-89.1289	351	44.2134	-89.1280
304	44.2147	-89.1289	352	44.2131	-89.1280
305	44.2144	-89.1290	353	44.2127	-89.1281
306	44.2141	-89.1290	354	44.2194	-89.1275
307	44.2137	-89.1290	355	44.2191	-89.1275
308	44.2134	-89.1290	356	44.2187	-89.1275
309	44.2131	-89.1290	357	44.2184	-89.1275
310	44.2127	-89.1290	358	44.2181	-89.1275
311	44.2124	-89.1290	359	44.2177	-89.1275
312	44.2121	-89.1290	360	44.2174	-89.1275
313	44.2187	-89.1284	361	44.2171	-89.1275
314	44.2184	-89.1284	362	44.2167	-89.1275
315	44.2181	-89.1284	363	44.2164	-89.1275
316	44.2177	-89.1284	364	44.2161	-89.1275
317	44.2174	-89.1284	365	44.2157	-89.1275
318	44.2171	-89.1285	366	44.2154	-89.1275
319	44.2167	-89.1285	367	44.2151	-89.1276
320	44.2164	-89.1285	368	44.2147	-89.1276
321	44.2161	-89.1285	369	44.2144	-89.1276
322	44.2157	-89.1285	370	44.2141	-89.1276
323	44.2154	-89.1285	371	44.2137	-89.1276
324	44.2151	-89.1285	372	44.2134	-89.1276
325	44.2147	-89.1285	373	44.2131	-89.1276
326	44.2144	-89.1285	374	44.2194	-89.1270
327	44.2141	-89.1285	375	44.2191	-89.1270
328	44.2137	-89.1285	376	44.2187	-89.1270
329	44.2134	-89.1285	377	44.2184	-89.1270
330	44.2131	-89.1285	378	44.2181	-89.1270
331	44.2127	-89.1285	379	44.2177	-89.1271
332	44.2124	-89.1285	380	44.2174	-89.1271
333	44.2121	-89.1285	381	44.2171	-89.1271
334	44.2191	-89.1280	382	44.2167	-89.1271
335	44.2187	-89.1280	383	44.2164	-89.1271
336	44.2184	-89.1280	384	44.2161	-89.1271
337	44.2181	-89.1280	385	44.2157	-89.1271
338	44.2177	-89.1280	386	44.2154	-89.1271
339	44.2174	-89.1280	387	44.2151	-89.1271
340	44.2171	-89.1280	388	44.2147	-89.1271
341	44.2167	-89.1280	389	44.2144	-89.1271
342	44.2164	-89.1280	390	44.2141	-89.1271

GPS coordinates for aquatic plant surveys on Long Lake, Waushara County, WI.

Site	Latitude	Longitude
391	44.2137	-89.1271
392	44.2134	-89.1271
393	44.2194	-89.1266
394	44.2191	-89.1266
395	44.2187	-89.1266
396	44.2184	-89.1266
397	44.2181	-89.1266
398	44.2177	-89.1266
399	44.2174	-89.1266
400	44.2171	-89.1266
401	44.2167	-89.1266
402	44.2164	-89.1266
403	44.2161	-89.1266
404	44.2157	-89.1266
405	44.2154	-89.1266
406	44.2151	-89.1266
407	44.2147	-89.1266
408	44.2144	-89.1266
409	44.2141	-89.1266
410	44.2137	-89.1266
411	44.2190	-89.1261
412	44.2187	-89.1261
413	44.2184	-89.1261
414	44.2181	-89.1261
415	44.2177	-89.1261
416	44.2174	-89.1261
417	44.2171	-89.1261
418	44.2167	-89.1261
419	44.2164	-89.1261
420	44.2161	-89.1262
421	44.2157	-89.1262
422	44.2154	-89.1262
423	44.2151	-89.1262
424	44.2147	-89.1262
425	44.2144	-89.1262
426	44.2141	-89.1262
427	44.2137	-89.1262
428	44.2190	-89.1256
429	44.2187	-89.1256
430	44.2184	-89.1257
431	44.2180	-89.1257
432	44.2177	-89.1257
433	44.2174	-89.1257
434	44.2170	-89.1257
435	44.2167	-89.1257
436	44.2164	-89.1257
437	44.2160	-89.1257
438	44.2157	-89.1257
439	44.2154	-89.1257
440	44.2150	-89.1257
441	44.2147	-89.1257
442	44.2144	-89.1257
443	44.2140	-89.1257
444	44.2187	-89.1252
445	44.2184	-89.1252
446	44.2180	-89.1252
447	44.2177	-89.1252
448	44.2174	-89.1252
449	44.2170	-89.1252
450	44.2167	-89.1252
451	44.2164	-89.1252
452	44.2160	-89.1252
453	44.2157	-89.1252
454	44.2154	-89.1252
455	44.2150	-89.1252
456	44.2147	-89.1252
457	44.2184	-89.1247
458	44.2180	-89.1247
459	44.2177	-89.1247
460	44.2174	-89.1247
461	44.2170	-89.1247
462	44.2167	-89.1248
463	44.2164	-89.1248
464	44.2160	-89.1248
465	44.2157	-89.1248
466	44.2154	-89.1248
467	44.2150	-89.1248
468	44.2180	-89.1243
469	44.2177	-89.1243
470	44.2174	-89.1243
471	44.2170	-89.1243
472	44.2167	-89.1243
473	44.2164	-89.1243
474	44.2160	-89.1243
475	44.2157	-89.1243
476	44.2154	-89.1243
477	44.2177	-89.1238
478	44.2174	-89.1238
479	44.2170	-89.1238
480	44.2167	-89.1238
481	44.2164	-89.1238
482	44.2160	-89.1238
483	44.2157	-89.1238
484	44.2154	-89.1238
485	44.2177	-89.1233
486	44.2174	-89.1234
487	44.2170	-89.1234
488	44.2167	-89.1234

GPS coordinates for aquatic plant surveys on Long Lake, Waushara County, WI.

Site	Latitude	Longitude
489	44.2164	-89.1234
490	44.2160	-89.1234
491	44.2157	-89.1234
492	44.2174	-89.1229
493	44.2170	-89.1229
494	44.2167	-89.1229
495	44.2164	-89.1229
496	44.2160	-89.1229
497	44.2157	-89.1229
498	44.2174	-89.1224
499	44.2170	-89.1224
500	44.2167	-89.1224
501	44.2164	-89.1224
502	44.2160	-89.1224
503	44.2170	-89.1220
504	44.2167	-89.1220
505	44.2164	-89.1220
506	44.2160	-89.1220
507	44.2170	-89.1215
508	44.2167	-89.1215
509	44.2163	-89.1215
510	44.2160	-89.1215
511	44.2167	-89.1210
512	44.2163	-89.1211
513	44.2160	-89.1211
514	44.2167	-89.1206
515	44.2163	-89.1206
516	44.2160	-89.1206
517	44.2157	-89.1206
518	44.2153	-89.1206
519	44.2167	-89.1201
520	44.2163	-89.1201
521	44.2160	-89.1201
522	44.2157	-89.1201
523	44.2153	-89.1201
524	44.2177	-89.1196
525	44.2173	-89.1196
526	44.2167	-89.1197
527	44.2163	-89.1197
528	44.2160	-89.1197
529	44.2157	-89.1197
530	44.2153	-89.1197
531	44.2177	-89.1192
532	44.2173	-89.1192
533	44.2170	-89.1192
534	44.2167	-89.1192
535	44.2163	-89.1192
536	44.2160	-89.1192
537	44.2157	-89.1192
538	44.2153	-89.1192
539	44.2177	-89.1187
540	44.2173	-89.1187
541	44.2170	-89.1187
542	44.2167	-89.1187
543	44.2163	-89.1187
544	44.2160	-89.1187
545	44.2157	-89.1187
546	44.2153	-89.1188
547	44.2180	-89.1182
548	44.2177	-89.1183
549	44.2173	-89.1183
550	44.2170	-89.1183
551	44.2167	-89.1183
552	44.2163	-89.1183
553	44.2160	-89.1183
554	44.2157	-89.1183
555	44.2153	-89.1183
556	44.2150	-89.1183
557	44.2147	-89.1183
558	44.2183	-89.1178
559	44.2180	-89.1178
560	44.2177	-89.1178
561	44.2173	-89.1178
562	44.2170	-89.1178
563	44.2167	-89.1178
564	44.2163	-89.1178
565	44.2160	-89.1178
566	44.2157	-89.1178
567	44.2153	-89.1178
568	44.2150	-89.1178
569	44.2147	-89.1178
570	44.2143	-89.1178
571	44.2186	-89.1173
572	44.2183	-89.1173
573	44.2180	-89.1173
574	44.2176	-89.1173
575	44.2173	-89.1173
576	44.2170	-89.1173
577	44.2167	-89.1173
578	44.2163	-89.1173
579	44.2160	-89.1174
580	44.2157	-89.1174
581	44.2153	-89.1174
582	44.2150	-89.1174
583	44.2147	-89.1174
584	44.2143	-89.1174
585	44.2186	-89.1168
586	44.2183	-89.1169

GPS coordinates for aquatic plant surveys on Long Lake, Waushara County, WI.

Site	Latitude	Longitude
587	44.2180	-89.1169
588	44.2176	-89.1169
589	44.2173	-89.1169
590	44.2170	-89.1169
591	44.2166	-89.1169
592	44.2163	-89.1169
593	44.2160	-89.1169
594	44.2156	-89.1169
595	44.2153	-89.1169
596	44.2150	-89.1169
597	44.2146	-89.1169
598	44.2143	-89.1169
599	44.2186	-89.1164
600	44.2183	-89.1164
601	44.2180	-89.1164
602	44.2176	-89.1164
603	44.2173	-89.1164
604	44.2170	-89.1164
605	44.2166	-89.1164
606	44.2163	-89.1164
607	44.2160	-89.1164
608	44.2156	-89.1164
609	44.2153	-89.1164
610	44.2150	-89.1164
611	44.2146	-89.1164
612	44.2143	-89.1164
613	44.2186	-89.1159
614	44.2183	-89.1159
615	44.2180	-89.1159
616	44.2176	-89.1159
617	44.2173	-89.1159
618	44.2170	-89.1159
619	44.2166	-89.1160
620	44.2163	-89.1160
621	44.2160	-89.1160
622	44.2156	-89.1160
623	44.2153	-89.1160
624	44.2150	-89.1160
625	44.2146	-89.1160
626	44.2186	-89.1155
627	44.2183	-89.1155
628	44.2180	-89.1155
629	44.2176	-89.1155
630	44.2173	-89.1155
631	44.2170	-89.1155
632	44.2166	-89.1155
633	44.2163	-89.1155
634	44.2160	-89.1155
635	44.2156	-89.1155
636	44.2153	-89.1155
637	44.2150	-89.1155
638	44.2186	-89.1150
639	44.2183	-89.1150
640	44.2180	-89.1150
641	44.2176	-89.1150
642	44.2173	-89.1150
643	44.2170	-89.1150
644	44.2166	-89.1150
645	44.2163	-89.1150
646	44.2160	-89.1150
647	44.2156	-89.1150
648	44.2153	-89.1150
649	44.2186	-89.1145
650	44.2183	-89.1145
651	44.2180	-89.1145
652	44.2176	-89.1145
653	44.2173	-89.1146
654	44.2170	-89.1146
655	44.2166	-89.1146
656	44.2163	-89.1146
657	44.2160	-89.1146
658	44.2156	-89.1146
659	44.2190	-89.1141
660	44.2186	-89.1141
661	44.2183	-89.1141
662	44.2180	-89.1141
663	44.2176	-89.1141
664	44.2173	-89.1141
665	44.2170	-89.1141
666	44.2166	-89.1141
667	44.2163	-89.1141
668	44.2160	-89.1141
669	44.2156	-89.1141
670	44.2193	-89.1136
671	44.2190	-89.1136
672	44.2186	-89.1136
673	44.2183	-89.1136
674	44.2180	-89.1136
675	44.2176	-89.1136
676	44.2173	-89.1136
677	44.2170	-89.1136
678	44.2166	-89.1136
679	44.2163	-89.1136
680	44.2160	-89.1136
681	44.2193	-89.1131
682	44.2189	-89.1131
683	44.2186	-89.1131
684	44.2183	-89.1131

GPS coordinates for aquatic plant surveys on Long Lake, Waushara County, WI.

Site	Latitude	Longitude
685	44.2180	-89.1132
686	44.2176	-89.1132
687	44.2173	-89.1132
688	44.2170	-89.1132
689	44.2166	-89.1132
690	44.2193	-89.1127
691	44.2189	-89.1127
692	44.2186	-89.1127
693	44.2183	-89.1127
694	44.2179	-89.1127
695	44.2176	-89.1127
696	44.2173	-89.1127
697	44.2169	-89.1127
698	44.2193	-89.1122
699	44.2189	-89.1122
700	44.2186	-89.1122
701	44.2183	-89.1122
702	44.2179	-89.1122
703	44.2176	-89.1122
704	44.2173	-89.1122
705	44.2189	-89.1117
706	44.2186	-89.1118
707	44.2183	-89.1118
708	44.2179	-89.1118
709	44.2193	-89.1113
710	44.2189	-89.1113
711	44.2186	-89.1113
712	44.2183	-89.1113
713	44.2179	-89.1113
714	44.2193	-89.1108
715	44.2189	-89.1108
716	44.2186	-89.1108
717	44.2183	-89.1108
718	44.2193	-89.1104
719	44.2189	-89.1104
720	44.2186	-89.1104
721	44.2183	-89.1104
722	44.2196	-89.1099
723	44.2193	-89.1099
724	44.2189	-89.1099
725	44.2186	-89.1099
726	44.2183	-89.1099
727	44.2196	-89.1094
728	44.2193	-89.1094
729	44.2189	-89.1094
730	44.2186	-89.1094
731	44.2196	-89.1090
732	44.2193	-89.1090
733	44.2189	-89.1090
734	44.2186	-89.1090
735	44.2196	-89.1085
736	44.2192	-89.1085
737	44.2189	-89.1085
738	44.2186	-89.1085
739	44.2192	-89.1080
740	44.2189	-89.1080
741	44.2186	-89.1080
742	44.2189	-89.1076
743	44.2186	-89.1076
744	44.2189	-89.1071
745	44.2186	-89.1071
746	44.2189	-89.1067
747	44.2186	-89.1067
748	44.2199	-89.1062
749	44.2196	-89.1062
750	44.2192	-89.1062
751	44.2189	-89.1062
752	44.2186	-89.1062
753	44.2199	-89.1057

Appendix B

- Aquatic plant survey data from August 28 & 29, 2008 for Long Lake near Saxeville, Waushara County, WI.

Aquatic plant species key:

CEDE	*Ceratophyllum demersum*	Coontail
CHAR	*Chara* spp.	Muskgrasses
ELCA	*Elodea canadensis*	Common waterweed
MYSI	*Myriophyllum sibericum*	Northern water-milfoil
NAFL	*Najas flexilis*	Bushy pondweed
NITE	*Nitella* spp	Nitella
NYOD	*Nymphaea odorata*	White water lily
POAM	*Potamogeton amplifolius*	Large-leaf pondweed
POFR	*Potamogeton friesii*	Frie's pondweed
POGR	*Potamogeton gramineus*	Variable pondweed
POIL	*Potamogeton illinoensis*	Illinois pondweed
PONA	*Potamogeton natans*	Floating-leaf
POPR	*Potamogeton praelongis*	White-stem pondweed
POPU	*Potamogeton pusillus*	Small pondweed
PORI	*Potamogeton richardsonii*	Clasping-leaf pondweed
PORO	*Potamogeton robbinsii*	Robbins pondweed
POZO	*Potamogeton zosteriformis*	Flat-stem pondweed
STPE	*Stuckenia pectinata*	Sogo pondweed
UTVU	*Utricularia vulgaris*	Common bladderwort
VAAM	*Vallisneria americana*	Wild celery

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
1		not navigable																				
2		not navigable																				
3		not navigable																				
4		not navigable																				
5		not navigable																				
6		not navigable																				
7	1.0			2		1																
8	0.5			2																		
9	1.0			2		1																
10	1.0			1																		
11		terrestrial																				
12		terrestrial																				
13	1.0			2					1													
14	2.0			2																		
15	2.0			1								1										
16	2.0			2																		
17	1.0			2					1													
18		terrestrial																				
19	2.0			1			1													1	1	1
20	3.0			3																3		
21	3.0			2						1					1		1					1
22	3.0			2			1													1		
23	1.0			3		1													1			
24	3.5			1																		
25	4.4			2								1	1									
26	3.7			2																		
27	3.3			2								1	1									
28		terrestrial																				
29	3.0			1																	1	
30		terrestrial																				
31	0.5			2			1		1											1		1
31	2.5			3											1							1
32	4.0			1									1							1		1
33	2.5			1																		
34	2.0			1			1													1		
35	1.0			2		1			1				1									
36	5.6			1						1			1									
37	8.0			2		1																
38	13.5			1								1			1							
39	11.5			1																		
40	3.0			1			1															
41	0.5			2							1					1				1		
42	2.7			1																		
43	3.2			1																		
44	2.5			1			1															
45		terrestrial																				
46	1.5			1			1															

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
47	4.0			2																		
48	8.1			1								1				1				2		
49	13.1			1																		
50	19.1			3																		
51	8.0			2								1								1		
52	3.9			1																		
53		terrestrial																				
54	0.3																					
55	2.5			1			1															
56	3.0			1			1															
57	2.7			1			1					1										
58	2.6			1																		
59	0.8			1																		
60		terrestrial																				
61	1.0			1			1													1		
62	5.6			1																		
63	9.6					1									1	1				1		
64	17.0			1																		
65	21.1	no plants																				
66	18.7			2																		
67	4.9			1								1										
68	2.5			1																		
69	0.5						1										1					
70		terrestrial																				
71		terrestrial																				
72	0.3																					
73	3.0			1																		1
74	3.8			1			1															
75	3.7			1			1															
76	3.6			1																		
77	2.7						1					1										
78	1.3			1								1										
79	1.5			1																		
80	3.0			1			1															1
81	5.4															1						
82	11.4			1																		
83	16.3			1		1																
84	20.4			3																		
85	20.0			1																		
86	18.9			2																		
87	10.0			1								1										1
88	2.8			1																		
89	2.5			1			1					1										
90	2.0			1																		
91	2.6																					
92	0.5			1																		
93	1.0	no plants																				

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
94	4.0			1			1					1										
95	5.1			1			1					1										
96	4.5			1																		
97	3.3			1			1															
98	2.7			3																		
99	2.1			1			1															
100		terrestrial																				
101	2.5			2																		
102	10.8			1			1					1								1		
103	14.4			1																		
104	19.0			2																		
105	20.3			1																		
106	26.2	no plants																				
107	22.1	no plants																				
108	14.8			1																		
109	3.0			1			1															
110	3.1			1			1															
111	3.1	sponge		1			1					1										
112	8.0			1								1										1
113	16.9	no plants																				
114	13.9			1																		
115	9.0			1		1							1							1		
116	13.5			1		1																
117	4.4			2								1										
118	4.9			1								1										
119	3.7			1			1															
120	3.2			1																		
121	2.8			1																		
122	2.5			1			1									1						
123	14.0			1																		
124	14.8			1																		
125	18.0			1																		
126	20.4			2																		
127	21.1			1																		
128	27.7			1																		
129	21.4	no plants																				
130	10.5			1								1	1							1		
131	5.3			2			1															
132	3.7			1			1					1										
133	8.0						1						1									1
134	22.9			1																		
135	21.9			1																		
136	19.0			1																		
137	20.0			1																		
138	16.4			3		1																
139	7.3			1									1							1		
140	5.4			1																		

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
141	3.6			1			1															
142	2.5	no plants																				
143	2.5			1			1															
144	8.8			3			1													1		
145	17.0	no plants																				
146	19.3			1																		
147	21.0			1																		
148	26.5	no plants																				
149	30.0	no plants																				
150	28.7	no plants																				
151	21.7			1																		
152	19.0			2																		
153	23.7	no plants																				
154	33.0	no plants																				
155	35.9	no plants																				
156	33.6	no plants																				
157	29.4	no plants																				
158	28.7	no plants																				
159	19.2			1																		
160	14.4			3																		
161	8.8																			1		
162	3.8			3								1										
163	3.0			1																		
164	1.0			1			1															
165	3.2			1																1		
166	6.9			1			1															
167	19.3			1																		
168	26.2	no plants																				
169	28.5	no plants																				
170	30.9	no plants																				
171	33.9	no plants																				
172	33.9	no plants																				
173	36.0	no plants																				
174	36.0	no plants																				
175	38.0	no plants																				
176	40.1	no plants																				
177	37.8	no plants																				
178	35.0	no plants																				
179	32.2	no plants																				
180	28.0	no plants																				
181	19.2			1																		
182	14.4			3		1																
183	7.0			2																		
184	3.0			1																		
185	1.0			1			1															
186	3.3																			1		
187	11.5			2			1					1								1		

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
188	24.0	no plants																				
189	30.3	no plants																				
190	35.7	no plants																				
191	38.8	no plants																				
192	41.6	no plants																				
193	42.0	no plants																				
194	47.7	no plants																				
195	50.1	no plants																				
196	52.0	no plants																				
197	52.8	no plants																				
198	48.4	no plants																				
199	40.7	no plants																				
200	33.0	no plants																				
201	22.6	no plants																				
202	19.6			2																		
203	18.2			2																		
204	6.1			1								1										
205	3.2			1								1										1
206	2.4			2																		
207	3.5			1			1															
208	11.2	no plants																				
209	27.0	no plants																				
210	30.5	no plants																				
211	36.4	no plants																				
212	39.9	no plants																				
213	40.0	no plants																				
214	43.4	no plants																				
215	49.0	no plants																				
216	52.9	no plants																				
217	55.0	no plants																				
218	55.1	no plants																				
219	52.1	no plants																				
220	42.0	no plants																				
221	34.5	no plants																				
222	28.1	no plants																				
223	22.1			3																		
224	20.3			3																		
225	14.8			3																		
226	3.4			1								1										
227	3.0	no plants																				
228	18.0			1																		
229	24.6	no plants																				
230	29.0	no plants																				
231	34.0	no plants																				
232	42.4	no plants																				
233	50.9	no plants																				
234	53.5	no plants																				

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
235	55.2	no plants																				
236	56.1	no plants																				
237	57.3	no plants																				
238	57.8	no plants																				
239	56.1	no plants																				
240	49.9	no plants																				
241	41.6	no plants																				
242	32.6	no plants																				
243	30.4	no plants																				
244	27.8	no plants																				
245	20.1			1																		
246	6.1			1								1	1									
247	4.0			1																		
248	2.4	no plants																				
249	3.8			1								1								1		
250	17.8	no plants																				
251	30.2	no plants																				
252	33.2	no plants																				
253	38.6	no plants																				
254	55.4	no plants																				
255	60.1	no plants																				
256	61.4	no plants																				
257	61.1	no plants																				
258	57.8	no plants																				
259	55.3	no plants																				
260	56.2	no plants																				
261	52.0	no plants																				
262	46.2	no plants																				
263	39.6	no plants																				
264	37.5	no plants																				
265	31.4	no plants																				
266	22.1			3																		
267	6.4			1								1										
268	4.0			1																		
269	0.3	no plants																				
270	1.5			1			1															
271	4.6			2			1															1
272	18.8	no plants																				
273	34.4	no plants																				
274	39.6	no plants																				
275	48.8	no plants																				
276	57.4	no plants																				
277	61.0	no plants																				
278	63.0	no plants																				
279	63.6	no plants																				
280	64.1	no plants																				
281	62.9	no plants																				

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
282	61.4	no plants																				
283	56.4	no plants																				
284	50.2	no plants																				
285	47.2	no plants																				
286	39.2	no plants																				
287	20.8			3																		
288	28.1	no plants																				
289	4.7			1								1								1		
290	3.2			2								1										1
291		no plants																				
292	3.8			1			1															
293	17.9			1																		
294	28.8	no plants																				
295	35.8	no plants																				
296	41.9	no plants																				
297	50.2	no plants																				
298	55.8	no plants																				
299	60.0	no plants																				
300	63.4	no plants																				
301	65.3	no plants																				
302	67.0	no plants																				
303	67.9	no plants																				
304	68.1	no plants																				
305	65.4	no plants																				
306	56.6	no plants																				
307	51.7	no plants																				
308	39.8	no plants																				
309	35.8	no plants																				
310	25.8	no plants																				
311	4.5			1																		
312	2.7	no plants																				
313	11.8			3			1															
314	28.8	no plants																				
315	33.0	no plants																				
316	39.4	no plants																				
317	49.0	no plants																				
318	53.1	no plants																				
319	56.2	no plants																				
320	60.8	no plants																				
321	64.8	no plants																				
322	68.1	no plants																				
323	70.1	no plants																				
324	71.0	no plants																				
325	71.6	no plants																				
326	67.8	no plants																				
327	60.4	no plants																				
328	51.2	no plants																				

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
329	38.0	no plants																				
330	11.3	no plants																				
331	4.9			1																		
332	2.0	no plants																				
333		no plants																				
334	3.6						1							1								
335	19.0										1	2										1
336	24.2	no plants																				
337	37.0	no plants																				
338	48.0	no plants																				
339	49.5	no plants																				
340	50.0	no plants																				
341	55.5	no plants																				
342	59.0	no plants																				
343	63.5	no plants																				
344	67.0	no plants																				
345	69.4	no plants																				
346	71.1	no plants																				
347	71.8	no plants																				
348	67.0	no plants																				
349	57.6	no plants																				
350	46.0	no plants																				
351	28.1	no plants																				
352	9.4			1			1					1										
353	2.8	no plants																				
354	4.2			1								1										1
355	24.8			1																		
356	35.4	no plants																				
357	38.0	no plants																				
358	44.8	no plants																				
359	50.8	no plants																				
360	52.5	no plants																				
361	53.1	no plants																				
362	55.9	no plants																				
363	59.0	no plants																				
364	64.0	no plants																				
365	67.4	no plants																				
366	69.0	no plants																				
367	70.3	no plants																				
368	65.0	no plants																				
369	55.2	no plants																				
370	44.6	no plants																				
371	31.5	no plants																				
372	7.9			1																		
373	2.6	no plants																				
374	3.6			1			1															
375	20.6			2																		

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
376	34.8	no plants																				
377	38.2	no plants																				
378	43.2	no plants																				
379	48.5	no plants																				
380	52.6	no plants																				
381	55.8	no plants																				
382	56.8	no plants																				
383	58.4	no plants																				
384	61.0	no plants																				
385	64.6	no plants																				
386	66.4	no plants																				
387	68.2	no plants																				
388	67.0	no plants																				
389	55.0	no plants																				
390	38.0	no plants																				
391	25.1	no plants																				
392	4.4	no plants																				
393	3.8	no plants																				
394	20.2			1																		
395	36.2	no plants																				
396	39.0	no plants																				
397	45.6	no plants																				
398	48.0	no plants																				
399	52.0	no plants																				
400	56.4	no plants																				
401	58.2	no plants																				
402	58.9	no plants																				
403	59.8	no plants																				
404	60.8	no plants																				
405	63.3	no plants																				
406	61.2	no plants																				
407	53.6	no plants																				
408	44.0	no plants																				
409	35.3	no plants																				
410	15.8			1								1										
411	3.1	no plants																				
412	29.0	no plants																				
413	38.0	no plants																				
414	42.0	no plants																				
415	44.9	no plants																				
416	47.0	no plants																				
417	55.0	no plants																				
418	58.0	no plants																				
419	59.0	no plants																				
420	58.8	no plants																				
421	56.2	no plants																				
422	57.6	no plants																				

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
423	57.5	no plants																				
424	53.5	no plants																				
425	48.7	no plants																				
426	36.0	no plants																				
427	22.0			2																		
428	4.3	no plants																				
429	30.0	no plants																				
430	38.5	no plants																				
432	36.0	no plants																				
432	38.0	no plants																				
433	36.9	no plants																				
434	53.0	no plants																				
435	57.1	no plants																				
436	56.7	no plants																				
437	49.9	no plants																				
438	51.4	no plants																				
439	55.2	no plants																				
440	52.0	no plants																				
441	43.0	no plants																				
442	32.0	no plants																				
443	7.4			1								1										
444	1.5	no plants																				
445	32.5	no plants																				
446	36.8	no plants																				
447	36.8	no plants																				
448	36.4	no plants																				
449	37.8	no plants																				
450	46.5	no plants																				
451	49.0	no plants																				
452	45.8	no plants																				
453	41.6	no plants																				
454	37.8	no plants																				
455	34.4	no plants																				
456	25.8			1																		
457	2.7	no plants																				
458	31.3	no plants																				
459	34.3	no plants																				
460	31.6	no plants																				
461	22.9	no plants																				
462	45.5	no plants																				
463	36.1	no plants																				
464	34.8	no plants																				
465	15.4			2																		
466	20.5			2																		
467	5.8	no plants												1								
468	5.0	no plants																				
469	29.4	no plants																				

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
470	24.9	no plants																				
471	16.1			1																		
472	31.8	no plants																				
473	33.5	no plants																				
474	27.5	no plants																				
475	11.9			1																		
476	3.7	no plants																				
477	8.3			1																		
478	17.5			2																		
479	13.4			1																		
480	29.9	no plants																				
481	33.2	no plants																				
482	28.8	no plants																				
483	11.1			1								1										
484	1.0	no plants																				
485	2.9	no plants																				
486	14.2			1																		
487	12.2			1																		
488	28.6	no plants																				
489	33.9	no plants																				
490	29.5	no plants																				
491	9.9			1																		
492	14.0			1		1																
493	16.5	no plants																				
494	25.5	no plants																				
495	35.1	no plants																				
496	30.7	no plants																				
498	8.3			1			1															
498	14.2			1								1										
499	13.0			1																		
500	16.6	no plants																				
501	34.1	no plants																				
502	30.5	no plants																				
503	6.6			1																		
504	9.5			1			1															
505	22.8	no plants																				
506	21.8			1																		
507	1.5			1																		
508	9.5												1	1								
509	20.1			1																		
510	22.5	no plants																				
511	7.9						1													1		1
512	17.3			3																		
513	27.9	no plants																				
514	8.1			1			1					1										
515	13.2			1			1				1	1										
516	28.1	no plants																				

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
519	9.3			1																		
520	13.3			2																		
521	25.9	no plants																				
522	19.0			1								1										
523	3.5			1																		
524		terrestrial																				
525		terrestrial																				
526	19.4			3																		
527	21.7	no plants																				
528	28.5	no plants																				
529	12.3			1																		
530		terrestrial																				
531	1.0			1																		
532	2.0					1						1	1						1	1		1
533	19.1			1																		
534	25.9	no plants																				
535	31.3	no plants																				
536	32.7	no plants																				
537	5.9			2								1										
538	2.0	no plants																				
539	2.6			1			1															
540	5.2			1																		
541	21.6			2																		
542	29.9	no plants																				
543	32.5	no plants																				
544	30.5	no plants																				
545	2.0			1																		
546		terrestrial																				
547		terrestrial																				
548	3.5			1			1					1										
549	5.8			1								1							1			1
550	21.1	no plants																				
551	28.1																					
552	33.0	no plants																				
553	32.9	no plants																				
554	19.6			1																		
555	3.2			1			1					1										
556	4.5			2																		
557	0.5			1			1															
558	0.5			1			1															
559	1.5			1																		
560	4.5			1			1					1										
561	10.7			1			1					1										
562	21.3	no plants																				
563	30.1	no plants																				
564	32.7	no plants																				
565	31.8	no plants																				

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
566	27.3	no plants																				
567	20.9			1																		
568	20.1			3																		
569	10.0			1								1								1		
570	1.0			2			1									1						
571	4.5			1																		1
572	7.4			1																		
573	4.3			1								1										
574	10.6			1									1									
575	29.9	no plants																				
576	32.2	no plants																				
577	33.9	no plants																				
578	35.5	no plants																				
579	34.5	no plants																				
580	30.8	no plants																				
581	26.7	no plants																				
582	19.5	no plants																				
583	8.1			3		1							1							1		
584	1.0			1				1														1
585	14.4	no plants																				
586	28.0	no plants																				
587	31.8	no plants																				
588	32.8	no plants																				
589	34.8	no plants																				
590	37.3	no plants																				
591	39.3	no plants																				
592	38.2	no plants																				
593	36.4	no plants																				
594	34.0	no plants																				
595	28.2	no plants																				
596	19.0			1																		
597	8.2			1		1																
598	1.5			1				1				1										
599	4.5			2								1										1
600	28.0	no plants																				
601	35.0	no plants																				
602	35.7	no plants																				
603	39.9	no plants																				
604	45.4	no plants																				
605	43.2	no plants																				
606	39.7	no plants																				
607	36.9	no plants																				
608	32.7	no plants																				
609	26.9	no plants																				
610	22.9	no plants																				
611	19.7			1																		
612	3.1			1																		

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
613	7.8			2			1					1										1
614	29.7	no plants																				
615	35.3	no plants																				
616	39.7	no plants																				
617	46.7	no plants																				
618	47.1	no plants																				
619	43.7	no plants																				
620	38.6	no plants																				
621	33.5	no plants																				
622	28.4	no plants																				
623	19.1			1																		
624	18.8			1																		
625	8.1			1			1					1										1
626	8.1			1																		
627	32.1	no plants																				
628	38.4	no plants																				
629	45.7	no plants																				
630	51.8	no plants																				
631	51.5	no plants																				
632	49.0	no plants																				
633	42.4	no plants																				
634	33.1	no plants																				
635	22.7	no plants																				
636	8.5			1								1										
637	5.3			1			1													1		1
638	18.5			1																		1
639	36.5	no plants																				
640	48.2	no plants																				
641	49.3	no plants																				
642	52.8	no plants																				
643	51.4	no plants																				
644	50.3	no plants																				
645	39.4	no plants																				
646	30.8	no plants																				
647	24.2	no plants																				
648	4.9			1														1				
649	30.9	no plants																				
650	45.6	no plants																				
651	51.9	no plants																				
652	52.4	no plants																				
653	51.4	no plants																				
654	50.8	no plants																				
655	46.6	no plants																				
656	38.1	no plants																				
657	31.1	no plants																				
658	16.4					1				1												
659	18.0			1																		

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
660	47.2	no plants																				
661	54.6	no plants																				
662	54.6	no plants																				
663	49.4	no plants																				
664	49.8	no plants																				
665	50.1	no plants																				
666	45.6	no plants																				
667	34.6	no plants																				
668	28.0	no plants																				
669	3.0	no plants																				
670	0.5	no plants																				
671	39.0	no plants																				
672	55.0	no plants																				
673	57.3	no plants																				
674	54.5	no plants																				
675	43.4	no plants																				
676	42.7	no plants																				
677	38.0	no plants																				
678	36.2	no plants																				
679	29.7	no plants																				
680	15.4			3		v	1		1													
681	20.2			3			1					1										
682	45.0	no plants																				
683	57.1	no plants																				
684	57.9	no plants																				
685	52.9	no plants																				
686	38.2	no plants																				
687	34.8	no plants																				
688	31.2	no plants																				
689	19.6	no plants																				
690	6.6			1								1	1									1
691	41.4	no plants																				
692	55.6	no plants																				
693	57.4	no plants																				
694	42.8	no plants																				
695	21.0	no plants																				
696	8.2			1								1										
697	6.5			1			1					1										
698	7.3			1								1										
699	36.4	no plants																				
700	48.2	no plants																				
701	48.4	no plants																				
702	33.3	no plants																				
703	7.5			1																		
704	4.3			1								1										
705	9.2			1																		
706	33.6	no plants																				

sampling point	Depth (ft)	comments	CEDE	CHAR	ELCA	MYSI	NAFL	NITE	NYOD	POAM	POFR	POGR	POIL	PONA	POPR	POPU	PORI	PORO	POZO	STPE	UTVU	VAAM
707	35.4	no plants																				
708	11.0			1			1					1										
709	3.4	no plants																				
710	15.4			1			1					1										
711	28.0	no plants																				
712	21.2	no plants																				
713	4.5											1										
714	4.6											1										
715	18.6											1										
716	25.5	no plants																				
717	19.4			3																		
718	19.1			1																		
719	20.0			3																		
720	20.1	no plants																				
721	5.9			1		1	1					1			1					1		1
722	5.3			1		1						1										1
723	18.7			1																		
724	19.4			1																		
725	16.3			2		1						1										
726	1.0			1		1	1		1													1
727	9.2			1								1										1
728	17.7			1																		
729	20.6			1																		
730	3.5			1																		
731	5.5			1								1										1
732	13.9			1		1																
733	15.9			1																		
734	2.0			1			1				1											
735	4.8			1			1					1										
736	7.5			2								1										
737	8.2			1		1										1						
738	1.5			1			1				1											
739	3.9			1								1										
740	6.7										1								1	1		1
741	0.5			1			1									1				1		
742	6.6				1	1					1	1							1	1		1
743	0.5			2			1		1							1						
744	2.9			1								1	1									1
745	1.0			1			1									1						
746	2.0			1							1					1						
747	0.5			1			1						1							1		
748		not navigable																				
749		not navigable																				
750		not navigable																				
751		not navigable																				
752		not navigable																				
753		not navigable																				

Appendix C

- The Importance of Aquatic Plants

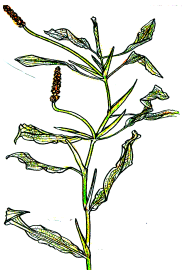
The Importance of Aquatic Plants

Plant information was gathered from Borman et al. (1997), Eggers and Reed (1997), Fasset (1940), Fink (1994), Nichols and Vennie (1991), and Whitley et al. (1999). Images obtained from Schmidt and Kannenberg (1998) and Borman et al. (1997).

Musk grass (*Chara* spp.) is a complex algae that resembles a higher plant. It's identified by its pungent, skunk-like odor and whorls of toothed branched leaves. Ecologically, musk grass provides shelter for juvenile fish and is associated with black crappie spawning sites. Waterfowl love to feast on musk grass when the plant bears its seed-like oogonia. This species serves an important role in stabilizing bottom sediments, tying up nutrients in the water column, and maintaining water clarity.



Variable Pondweed (*Potamogeton gramineus*) and **Illinois Pondweed** (*P. illinoiensis*) are very similar-looking perennial herbs that emerge from a rhizome. Their stout stems support lance-shaped leaves that come to a sharp point. Both of these pondweeds provide excellent cover for fish and invertebrates. Ducks, geese, muskrats, and beaver find most parts of these plants to be a tasty meal.



Bushy pondweed (*Najas flexilis*) also known as **slender naiad** has a finely branched stem that grows from a rootstock. Leaves are short (1-4 cm), pointed and grow in pairs. Bushy pondweed is an annual and must grow from seed each year. It tends to establish well in disturbed areas. Bushy pondweed is a one of waterfowl's favorite foods and considered very important. Waterfowl, marsh birds, and muskrats relish seeds, leaves and stems. Bushy pondweed stabilizes bottom sediment and offers cover for fish.



Wild Celery (*Vallisneria americana*) also known as **eelgrass** has long ribbon-like leaves that emerge in clusters. Leaves have a prominent central stripe and leaf tips tend to float gracefully at the water's surface. In the fall, a vegetative portion of the rhizome will break free and float to other locations. Wild celery is considered one of the best all natural waterfowl foods. The entire plant is relished by waterfowl, especially canvasbacks. Eelgrass beds serve as an important food source for sea ducks, marsh birds, and shore birds. Fish also find wild celery to be a popular hiding spot.

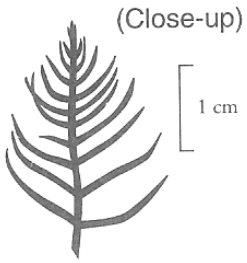


Sago Pondweed (*Potamogeton pectinatus*) is a perennial herb that emerges from a slender rhizome that contains many starchy tubers. Leaves are sharp, thin, and resemble a pine needle. Reddish nutlets (seeds) that resemble beads on a string rise to the water surface in mid-summer. Sago pondweed produces

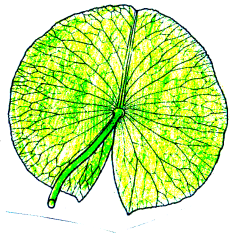


a large crop of seeds and tubers that are valued by waterfowl. Juvenile fish and invertebrates utilize sago pondweed for cover.

Northern Watermilfoil (*Myriophyllum sibiricum*) produces whorls of feather-like leaflets from a fairly stout stem. Northern watermilfoil is identified by its 5 to 12 pairs of leaflets that become progressively longer near the base of the leaf – giving the leaf a candelabra-like appearance. The leaves and fruit of this plant are eaten by a variety of waterfowl. Its finely divided leaves are habitat for numerous invertebrates that fish feed upon. Northern watermilfoil is an indicator of good water quality, as the plant seldom survives in more eutrophic environments.



White Water Lily (*Nymphaea odorata*) emerges from a buried rhizome. Durable round stalks grow up from the rhizome. This perennial herb supports large round leaves (4-10 inches) wide that float at the water's surface. Leaves appear waxy green on top and reddish-purple on their undersides. At mid-summer showy white flowers float at the waters surface. Lilies serve as important fish cover, especially for largemouth bass. White water lily seeds are eaten by waterfowl. Rhizomes, flowers, and leaves are consumed by muskrats, beaver, and deer. With large broad leaves, lilies also help prevent shoreline erosion by slowing wave action.



White-stem Pondweed (*Potamogeton praelongus*) has broad, wavy-edged leaves with stalkless leaf bases that wrap part way around the stem. The alternately arranged leaves have a distinctive boat-shaped tip. White-stem pondweed is often the first pondweed seen in early spring. No floating leaves are produced. White-stem pondweed provides good food and habitat for aquatic animals and waterfowl. It provides valuable food for trout and habitat for muskellunge in particular.



Flat-stem Pondweed (*Potamogeton zosteriformis*) emerges from a rhizome, which has strongly flattened stems. The leaves are narrow and grow 4-8 inches long. Leaves contain a prominent mid-vein and many fine parallel veins. Ecologically, flat-stem pondweed provides a home for fish and invertebrates, and is grazed by waterfowl and muskrats.

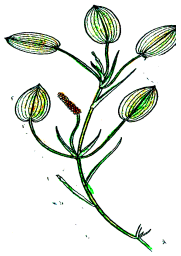


Large-Leaf Pondweed (*Potamogeton amplifolius*) also referred to by fisherman as **cabbage weed**, is a perennial herb that emerges from a ridged black rhizome. This pondweed is the largest of all pondweeds. The sturdy stem supports large broad leaves that are numerously veined (25-37). Growing upright throughout most of

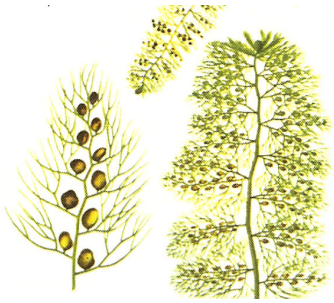


the water column, large-leaf pondweed provides excellent shade, shelter, and foraging habitat for fish. Producing a large number of nutlets, cabbage weed is also valued by waterfowl.

Floating Leaf Pondweed (*Potamogeton natans*) is a perennial that emerges from a red-spotted rhizome. Leaves that rest at the waters surface are heart shaped. Submerged leaves tend to be longer and skinnier than floating leaves. Fish find this pondweed to be useful for foraging opportunities and shelter. Growing upright in the water column, floating leaf pondweed attracts many aquatic invertebrates. Muskrats, ducks, and geese all graze on the plant.



Bladderwort (*Utricularia vulgaris*) is a carnivorous plant that can supplement its diet with insects or other small organisms. Bladderwort does not root to the ground. Instead, it is free-floating. Usually most of the plant hangs in the water near the bottom, but it floats to the top when it is ready to flower. Bladderwort has finely divided leaves. Scattered on these leaves are bladders that trap prey. When prey touches trigger hairs, the bladder expands, sucking in the animal. It is then dissolved within the bladder. Bladderwort stems provide food and cover for fish. This is particularly important in areas not readily colonized by rooted plants.



Elodea (*Elodea canadensis*) or **common waterweed** is made up of slender stems with small, lance-shaped leaves that attach directly to the stem. Leaves are found in whorls of two or three and are more crowded toward the stem tip. The branching stems of elodea provide valuable cover for fish and are home for many insects that fish feed upon. Elodea also provides food for muskrats and waterfowl.



Robbins Pondweed (*Potamogeton robbinsii*) also known as **Fern Pondweed** is a stiff, robust plant that produces only underwater leaves. It is usually dark-green with flat closely spaced leaves pointing away from the stem on two sides, thereby giving it the appearance of a fern. Leaf bases form a sheath around the stems and may have stipules present on new leaves. Fern pondweed is also able to stabilize bottom sediments. Fern pondweed is known to provide habitat for small aquatic animals used as food by predator fishes, especially northern pike. Seeds and vegetation provide food for aquatic animals and waterfowl.



Appendix D

- Additional raw data for Long Lake Comprehensive Survey

Dissolved oxygen and temperature data from 2008 for the east basin of Long Lake, Waushara County, WI.

Depth	July 21, 2008			August 21, 2008			September 16, 2008		
(ft)	Temp (ºF)	D.O. (mg/l)	% Sat.	Temp (ºF)	D.O. (mg/l)	% Sat.	Temp (ºF)	D.O. (mg/l)	% Sat.
0	77.6	8.66	103.1	75.1	8.44	99.2	66.9	8.04	87.1
2	77.7	8.25	99.5	75.1	8.47	100.4	66.9	7.58	83.0
4	77.7	8.24	102.8	75.1	8.27	98.4	66.9	7.77	84.5
6	77.6	8.00	97.6	75.1	7.78	92.0	66.9	7.74	84.1
8	77.6	8.38	101.2	75.1	8.11	95.4	66.9	7.80	84.4
10	77.6	8.08	97.6	75.0	7.82	93.7	66.9	7.80	84.3
12	77.5	8.07	98.0	75.0	8.12	96.2	66.9	7.79	84.4
14	76.8	8.48	102.7	75.0	7.72	91.4	66.9	7.66	83.5
16	76.1	8.52	102.4	75.0	7.77	92.6	66.9	7.75	84.1
18	74.6	7.98	94.2	75.0	7.95	94.1	66.9	7.58	82.1
20	73.1	7.50	88.3	74.9	7.38	88.0	66.9	7.54	82.2
22	70.4	7.96	88.8	74.6	7.93	93.7	66.8	7.53	81.9
24	65.3	8.54	90.6	73.5	8.04	92.8	66.8	7.54	81.7
26	60.5	7.79	78.8	68.5	8.80	97.1	66.8	7.28	79.3
28	57.5	7.35	71.9	63.2	8.11	83.9	66.4	7.19	77.7
30	54.8	6.69	62.8	58.7	7.10	69.1	63.2	4.34	44.8
32	52.6	4.93	45.3	55.3	4.18	38.9	58.0	1.15	10.8
34	51.2	3.79	34.0	53.6	1.77	15.6	54.2	0.38	3.5
36	49.7	0.69	6.0	51.7	1.23	11.1	52.4	0.29	2.6
38	48.3	0.33	2.9	50.2	0.77	6.6	51.4	0.24	2.2
40	47.4	0.14	1.1	49.0	0.42	3.6	50.3	0.21	1.9
42	46.6	0.09	0.8	47.3	0.20	1.6	48.2	0.23	2.0
44	45.1	0.08	0.7	46.1	0.17	1.3	46.6	0.21	1.7
46	44.4	0.07	0.6	45.3	0.15	1.3	46.0	0.18	1.5
48	44.2	0.07	0.5	44.5	0.14	1.1	45.6	0.16	1.3
50	43.9	0.07	0.5	44.1	0.11	1.0	45.7	0.14	1.1

Dissolved oxygen and temperature data from 2008 for the west basin of Long Lake, Waushara County, WI.

Depth	July 21, 2008			August 21, 2008			September 16, 2008		
(ft)	Temp (ºF)	D.O. (mg/l)	% Sat.	Temp (ºF)	D.O. (mg/l)	% Sat.	Temp (ºF)	D.O. (mg/l)	% Sat.
0	77.4	8.54	103.5	75.6	8.65	103.0	66.7	8.39	90.9
2	77.5	8.33	101.2	75.5	8.32	99	66.8	8.30	90.0
4	77.5	8.26	100.4	75.5	8.31	99	66.8	8.26	89.6
6	77.5	8.55	104.0	75.4	8.36	100	66.8	8.22	89.1
8	77.5	8.45	102.7	75.4	8.37	99	66.8	8.17	88.6
10	77.5	8.41	102.3	75.4	8.30	99.8	66.8	8.20	89.0
12	77.3	8.46	102.8	75.4	8.29	98.7	66.8	8.16	88.5
14	77.3	8.46	102.2	75.3	8.32	98.8	66.8	8.11	87.5
16	76.8	8.67	104.6	75.3	8.32	98.9	66.7	7.94	86.4
18	75.8	8.66	103.1	75.3	8.32	98.7	66.7	8.04	87.2
20	74.3	7.69	88.3	75.1	8.18	97.1	66.7	7.81	84.3
22	71.1	8.53	97.0	75.0	8.18	96.9	66.7	7.84	84.4
24	65.8	9.47	102.1	73.3	8.45	98.4	66.7	8.06	87.2
26	62.2	9.61	98.4	67.8	8.16	100.5	66.6	8.05	87.2
28	58.4	8.96	87.8	64.5	8.81	93.3	66.4	7.85	84.9
30	56.6	8.66	83.4	60.2	8.51	85.4	64.0	6.07	63.2
32	53.3	9.02	82.8	55.8	8.22	77.9	57.5	5.25	51.1
34	50.4	4.01	38.8	53.7	6.17	58	54.9	3.53	33.0
36	48.8	2.64	23.1	52.7	4.91	44	50.8	0.89	7.4
38	47.4	1.23	10.3	50.2	3.35	29.2	48.9	0.52	4.4
40	46.2	0.70	5.9	48.5	1.74	14.8	47.5	0.25	2.0
42	45.3	0.30	2.9	47.7	1.00	8.3	47.0	0.19	1.5
44	44.3	0.16	1.2	46.0	0.57	4.2	45.9	0.15	1.2
46	43.7	0.11	0.9	45.8	0.46	3.7	45.9	0.12	1.0
48	42.6	0.09	0.7	44.8	0.28	2.3	45.9	0.11	0.8
50	42.1	0.09	0.6	43.3	0.14	1.1	45.8	0.08	0.7

Historic fishery stocking data for Long Lake, Waushara County, WI.

Year	Species	Age Class	Number stocked	Avg Fish Length (in)	Source Type
1972	Walleye	Fingerling	12,000	3	DNR coop ponds
1972	Walleye	Yearling	2,120	11	Federal hatchery
1973	Walleye	Yearling	600	9	Federal hatchery
1974	Smallmouth bass	Fingerling	5,000	3	Private hatchery
1975	Smallmouth bass	Fingerling	10,000	3	DNR coop ponds
1975	Walleye	Adult	100	--	Federal hatchery
1976	Smallmouth bass	Yearling	3,600	--	--
1981	Northen pike	Yearling	218	--	Field transfer
1982	Northen pike	Fingerling	1,150	9	DNR coop ponds
1982	Northen pike	Yearling	1,070	--	Field transfer
1982	Walleye	Yearling	18	--	Field transfer
1983	Northen pike	Fingerling	1,350	9	DNR hatchery
1984	Largemouth bass	Fingerling	800	4	Field transfer
1984	Northen pike	Fingerling	1,060	9	DNR hatchery
1984	Walleye	Fingerling	2,300	4	Field transfer
1985	Northen pike	Fingerling	1,375	9	DNR hatchery
1987	Largemouth bass	Fingerling	3,600	6	Field transfer
1987	Northen pike	Fingerling	1,500	9	DNR hatchery
1987	Walleye	Fingerling	36,000	5	DNR hatchery
1991	Muskellunge	Fingerling	502	10	DNR hatchery
1991	Walleye	Fingerling	4,350	5	DNR coop ponds
1992	Muskellunge	Yearling	154	18	DNR hatchery
1992	Walleye	Fingerling	6,902	3	DNR coop ponds
1994	Walleye	Large fingerling	500	8	Private hatchery
1997	Muskellunge	Yearling	23	19	DNR ponds
1997	Walleye	Large fingerling	10,000	3	DNR ponds
1998	Walleye	Small fingerling	6,421	1	DNR hatchery
1999	Walleye	Small fingerling	6,800	2	DNR hatchery
1999	Walleye	Large fingerling	3,000	7	Private hatchery
1999	White sucker	Adult (broodstock)	1,284	9	Field transfer
1999	White sucker	Adult (broodstock)	1,500	8	Private hatchery
2000	Black crappie	Large fingerling	2,500	5	Private hatchery
2000	Walleye	Large fingerling	2,400	7	Private hatchery
2000	Walleye	Small fingerling	27,000	2	DNR hatchery
2000	White sucker	Adult	1,500	7	Private hatchery
2000	Yellow perch	Adult (field transfer)	3,750	5	Field transfer
2000	Yellow perch	Yearling	2,000	4	Field transfer
2001	Fathead minnow	Adult (broodstock)	--	--	Private hatchery
2001	Largemouth bass	Large fingerling	2,250	1	DNR ponds
2001	Northen pike	Adult (broodstock)	--	17	Private hatchery
2001	Walleye	Large fingerling	--	8	Private hatchery
2001	Walleye	Small fingerling	27,200	2	DNR ponds
2001	White sucker	Adult (broodstock)	--	10	Private hatchery
2002	Fathead minnow	Adult (broodstock)	10,000	2	Private hatchery
2002	White sucker	Yearling	1,500	5	Private hatchery

Historic fishery stocking data for Long Lake, Waushara County, WI.

Year	Species	Age Class	Number stocked	Avg Fish Length (in)	Source Type
2003	Black crappie	Fall yearling	1,875	--	Private hatchery
2003	Northen pike	Large fingerling	125	--	Private hatchery
2003	Walleye	Small fingerling	27,196	2	DNR hatchery
2003	Walleye	Fall yearling	3,000	--	Private hatchery
2003	White sucker	Fall yearling	250	--	Private hatchery
2003	Yellow perch	Adult (broodstock)	1,000	--	Private hatchery
2004	Black crappie	Fall yearling	800	4	Private hatchery
2004	Black crappie	Unknown	200	7	Private hatchery
2004	White sucker	Adult (field transfer)	1,385	19	Field transfer
2005	Fathead minnow	Adult	80,000	--	Private hatchery
2005	Walleye	Large fingerling	1,000	7	Private hatchery
2005	Walleye	Small fingerling	27,996	2	DNR ponds
2005	White sucker	Adult (field transfer)	1,170	20	Field transfer
2006	Brook trout	Adult (broodstock)	250	13	Private hatchery
2006	Fathead minnow	Adult	160,000	--	Private hatchery
2006	White sucker	Adult (field transfer)	1,175	24	Field transfer
2007	Black crappie	Adult	1,000	7	Private hatchery
2007	Brown trout	Large fingerling	5,575	6	DNR hatchery
2007	Fathead minnow	Yearling	80,000	--	Private hatchery
2007	Rainbow Trout	Adult	2,000	11	Private hatchery
2007	Walleye	Small fingerling	16,465	2	DNR hatchery
2007	Walleye	Yearling	2,000	7	Private hatchery
2008	Brown trout	Large fingerling	9,997	6	DNR hatchery
2008	Fathead minnow	Adult	80,000	2	Private hatchery
2008	Rainbow Trout	Adult	2,000	10	Private hatchery

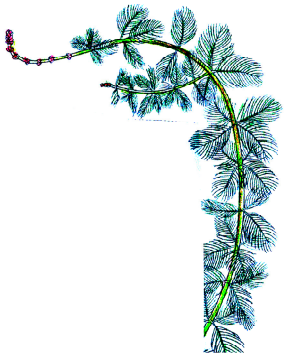
Appendix E

- Threat of exotic aquatic species to Long Lake

Exotic Species

Although no exotic species were found within the waters of Long Lake, it is important that members of the Long Lake Association familiarize themselves with some of the possible threats posed by invasive species. The following descriptions are given to promote awareness of exotic species.

Eurasian Watermilfoil



Eurasian watermilfoil (*Myriophyllum spicatum*) produces long spaghetti-like stems that often grow up to the water's surface. Leaves are feather-like and resemble bones on a fish. 3-5 leaves are arranged in whorls around the stem, and each leaf contains 12-21 pairs of leaflets. At mid-summer small reddish flower spikes may emerge above the water's surface. Perhaps the most distinguishing characteristic though, is the plant's ability to form dense, impenetrable beds that inhibit boating, swimming, fishing, and hunting.

Eurasian watermilfoil is native to Europe, Asia and Northern Africa. Of the eight milfoil (*Myriophyllum*) species found in Wisconsin, Eurasian watermilfoil is the only exotic. The plant was first introduced into U.S. waters in 1940. By 1960, it had reached Wisconsin's lakes. Since then, its expansion has been exponential (Brakken, 2000).

Eurasian watermilfoil begins growing earlier than native plants, giving it a competitive advantage. The dense surface mats formed by the plant block sunlight and have been found to displace nearly all native submergent plants. Over 200 studies link declines in native plants with increases in Eurasian watermilfoil (Madsen, 2001). The resultant loss of plant diversity degrades fishery habitat (Pullman, 1993), and reduces foraging opportunities for waterfowl and aquatic mammals. Eurasian watermilfoil has been found to reduce predatory success of fish such as largemouth bass (Engel, 1985), and spawning success for trout (*Salmonidae spp.*) (Newroth, 1985).

The continued spread of Eurasian watermilfoil can produce significant economic consequences. In the Truckee River Watershed below Lake Tahoe, located in western Nevada and northeastern California, economic damages caused by Eurasian watermilfoil to the recreation industry have been projected at $30 to $45 million annually (Eiswerth et al., 2003). In Tennessee Valley Authority Reservoirs, Eurasian watermilfoil was found to depress real estate values, stop recreational activities, clog municipal and industrial water intakes and increase mosquito breeding (Smith, 1971).

Eurasian watermilfoil has been found to reduce water quality in lakes by several means. Dense mats of Eurasian watermilfoil have been found to alter temperature and oxygen profiles – producing anoxic conditions in bottom water layers (Unmuth et al., 2000).

These anoxic conditions can cause localized die-offs of mollusks and other invertebrates. Eurasian watermilfoil has also been found to increase phosphorus concentration in lakes through accelerated internal nutrient cycling (Smith and Adams, 1986). Increased phosphorus concentrations released by dead and dying Eurasian watermilfoil have been linked to algae blooms and reduced water clarity.

Eurasian Watermilfoil Management Options

Historically, management of Eurasian watermilfoil has included mechanical, biological, and chemical means. It is important to consider each of these control measures before management efforts on any water body are undertaken. After weighing the pros and cons of each option, the wisest course of action should be chosen.

Hand pulling
Hand pulling of Eurasian watermilfoil is a useful tool when the extent of milfoil occurs at very low frequencies. For this method to be successful care must be taken to remove the entire root mass along with the plant or else it will quickly regenerate. If a pioneering population of Eurasian watermilfoil was found in a small location, this method may be a useful management tool. However, if it is unsuccessful at reducing or eliminating milfoil, other management options should be considered. This is still a viable option for riparian property owners. Without obtaining a permit, individuals can hand pull aquatic plants in a 30-foot strip along their property extending out as far as necessary. If *exotic* plants are singled out for hand removal, there are no restrictions on the extent of hand-pulling. If large amounts of milfoil are present, it will be labor intensive. If individuals choose to hand pull, care should be taken to properly identify Eurasian watermilfoil and minimize its fragmentation.

Mechanical harvesting
Mechanical control methods include hand cutters and boat-mounted mechanical weed harvesters (Nichols, 1974). While these methods provide temporary nuisance relief, they are rarely recommended as control methods for Eurasian watermilfoil. Eurasian watermilfoil can reproduce effectively through fragmentation (Borman et al. 1997). Free-floating plant matter left from cutting operations can spread quickly and encourage additional infestations within the lake or in neighboring lakes. Because a harvesting program is already in place on the Flowage, care should be taken if Eurasian watermilfoil is found in the near future. If possible, harvesting in areas of infestation should be suspended until additional control efforts are implemented to remove the milfoil. Although harvesting does remove plant matter, a source of nutrients to the lake, it is unlikely that harvesting will induce a shift back to a native plant-dominated community if milfoil were to be introduced to the Flowage. It is not recommended that Eurasian watermilfoil be controlled long-term through mechanical harvesting.

Milfoil weevils
There has been considerable research on biological vectors, such as insects, and their ability to affect a decline in Eurasian watermilfoil populations. Of these, the milfoil

weevil (*Euhrychiopsis lecontei*) has received the most attention. Native milfoil weevil populations have been associated with declines in Eurasian watermilfoil in natural lakes in Vermont (Creed and Sheldon, 1995), New York (Johnson et al., 2000) and Wisconsin (Lilie, 2000). While numerous lakes have attempted stocking milfoil weevils in hopes of controlling milfoil in a more natural manner, this method has not proven successful in Wisconsin. A twelve-lake study called "The Wisconsin Milfoil Weevil Project" (Jester et al. 1999) conducted by the University of Wisconsin, Stevens Point in conjunction with the Wisconsin DNR researched the efficacy of weevil stocking. This report concluded that milfoil weevil densities were not elevated, and that Eurasian watermilfoil was unaffected by weevil stocking in any of the study lakes. Recently, however, work carried out on a number of Portage County lakes has shown some promise at enhancing milfoil weevil populations. In order for weevils to be successful in reducing the extent of Eurasian watermilfoil, a number of environmental criteria are needed, including the availability of proper year-round habitat. In the event of milfoil infestation, a survey of existing weevils should be conducted to determine the likelihood of success if weevils were chosen as a management tool.

Until more evidence that suggests weevil stocking is an effective control agent for Eurasian watermilfoil, this method should be discouraged as a control option for most lakes.

Herbicides

Herbicides have been the most widely used and often most successful tools for controlling Eurasian watermilfoil. The two herbicide groups most commonly employed are fluridone (Avast®, Sonar®) and 2,4-D (Aquacide®, Aquakleen®, Navigate®, and Weedar 64®). Whole-lake fluridone treatments have been conducted on several Wisconsin Lakes. In addition, for fluridone to be most effective, a relatively long contact time is needed. 2,4-D herbicides, on the other hand, have been very effective at controlling Eurasian watermilfoil in hundreds of Wisconsin lakes. 2,4-D is a herbicide which rapidly breaks down and does not persist in the environment. When applied at labeled rates, 2,4-D has been shown to be an effective tool at selectively controlling Eurasian watermilfoil.

Curly-leaf Pondweed



Curly-leaf pondweed (*Potamogeton crispus*) has oblong leaves that are 2-4 inches long and attach to a slightly flattened stem in an alternate pattern. The most distinguishing characteristics are the curled appearance of the leaves, and the serrated leaf edges. Curly-leaf pondweed also produces a seed-like turion, which resembles a miniature pinecone. Curly-leaf pondweed produces turions in early summer allowing the plant to regenerate annually. Turion production begins when water temperatures reach into the 60's.

This exotic pondweed is a cold-water specialist. Curly-leaf pondweed can begin growing under the ice, giving it a competitive advantage over native plants, which are still lying dormant. By mid-summer when water temperatures reach the upper 70° F range, it begins to die off.

Curly-leaf pondweed has been found in the U.S. since at least 1910. A native of Europe, Asia, Africa and Australia, this plant is now found throughout much of U.S. (Baumann et al., 2000).

As with Eurasian watermilfoil, curly-leaf pondweeds aggressive early season growth allows it to out compete native species and grow to nuisance levels. Because the plant dies back during the peak of the growing season for other plants though, it is better able to coexist with native species than Eurasian watermilfoil. Perhaps the most significant problem associated with curly-leaf pondweed involves internal nutrient cycling. The die-off and decomposition of the plant during the warmest time of year often leads to a sudden nutrient release in the water. This often leads to nuisance algae blooms and poor water quality.

Curly-leaf Pondweed Management Options

Curly-leaf pondweed has primarily been managed through mechanical and chemical means. If curly-leaf pondweed were to be introduced, the following control options should be considered to determine the best course of action.

Hand pulling

As with Eurasian watermilfoil, this method may be appropriate for riparian property owners. Hand pulling is most effective when curly-leaf pondweed is discovered in its pioneering stage. If it has existed long enough to produce turions, hand pulling may become a long-term, labor-intensive process. To be most effective, as with other curly-leaf pondweed control options, early response is recommended. .

Mechanical harvesting and cutting
Both mechanical harvesting and hand cutting are commonly used to control curly-leaf pondweed. Cutting the plant provides temporary nuisance relief and may increase recreational opportunities on the lake. And although harvesting may not encourage dispersal of the plant, as it does with Eurasian watermilfoil, it is unlikely to provide any long-term control.

Herbicides
The herbicide most often used to control curly-leaf pondweed is Aquathol®. Aquathol® is an endothall salt-based herbicide which also rapidly breaks down. While endothall herbicides are effective on a broad range of aquatic monocots, early season applications made at low rates are highly species-selective for curly-leaf pondweed. While herbicides effectively kill the parent plant, the turions are resistant to herbicides, allowing curly-leaf pondweed to regenerate annually.

Studies conducted by the Army Corps of Engineers have found that conducting treatments of curly-leaf pondweed using Aquathol® when water temperatures are in the 50-60° F range will kill plants before turions form, thus providing long-term control. Researchers found that conducting two or more treatments over consecutive seasons for established curly-leaf pondweed populations will target both the standing crop of the pondweed as well as the resulting regrowth from the turions (Skogerboe and Poovey, 2002). These findings make Aquathol® the tool of choice for controlling curly-leaf pondweed in the lakes of Wisconsin.

Purple Loosestrife



Purple loosestrife (*Lythrum salicaria*) forms bright purple flowers in a spike atop stems that reach 2 to 7 feet in height. Lance-shaped leaves are arranged oppositely along the stem. Purple loosestrife can be found in a wide variety of habitats from shallow water to moist soils. Like Eurasian watermilfoil it is a very aggressive plant that can displace many native wetland plants including cattails (*Typha spp.*). Purple loosestrife plants produce hundreds of thousands of tiny seeds. When purple loosestrife is cut, seeds stick to mowing equipment and are spread to new locations. This invasive plant causes significant economic damage by clogging waterways and irrigation canals. Unlike cattails, purple loosestrife has little food or cover value for wildlife (Borman et. al. 1997).

Purple Loosestrife Management Options



Only one small patch of purple loosestrife was found growing along McCaslin Creek. Although it had not become a large nuisance, the Association and individual property owners should still be aware of control options to stop the spread of this exotic in the State. There are several methods that are commonly used for purple loosestrife control including digging or hand pulling, cutting, herbicide treatments and biological controls.

Manual removal

Digging and hand pulling are most effective for small infestations. Individual property owners are encouraged to use this method if they are able. Cutting involves removal and destruction of flowers and seed heads to inhibit plant propagation. Since cut plants tend to re-grow and since seeds present in the soils can sprout new plants, this method may need to be done for a number of years before desired control is achieved.

Herbicides

Herbicide treatments are the least labor intensive of methods. The preferred herbicide is glyphosate (Eagre®, Rodeo®). This compound rapidly biodegrades upon contact with soil or water. As a result, there are no water use restrictions following treatment. Because it is non-selective, each individual plant must be sprayed, as opposed to broadcast applications. Glyphosate is extremely effective in controlling purple loosestrife at a very low cost of treatment. The biggest disadvantage is that seeds in the soil will sprout new

plants, requiring annual treatments for a number of years before desired control is achieved. A DNR permit is required for treatment; however the fee is waived. This option should be considered if the distribution of purple loosestrife increases significantly.

Loosestrife beetles

Two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) are currently available from the Wisconsin DNR in an effort to control purple loosestrife by biological means. Research has shown that these insects are almost exclusively dependent upon purple loosestrife and do not threaten native plants. Although, as with most biological control agents, these insects will not eradicate loosestrife, but may significantly weaken the population and allow native species to reclaim infested areas. According to the WDNR, tests have shown significant declines in loosestrife as a result of biological control. The District should consider using biological control for loosestrife. The purple loosestrife control program established through the DNR provides a parent stock of beetles to individuals who are willing to raise the insects in a controlled environment until they are able to reproduce. Once the young have matured, they are released and are able to begin control of the purple loosestrife. As with other exotic plant control project, annual monitoring should be employed to assess the success of control measures. If significant progress is not made, alternative management options can be considered to control purple loosestrife.

Zebra Mussels



Zebra mussels (*Dreissena polymorpha*) are small (1/4" to 2") mollusks with elongated shells marked by alternating light and dark markings. They produce dense elastic strands, called byssal threads, by which they can securely attach to nearly any surface, often forming barnacle-like incrustations. Mussels spawn in the early spring when water temperatures reach 54º F. Fertilized eggs develop into microscopic free-swimming larvae called veligers. After three to four weeks, the surviving veligers settle onto firm objects where they quickly attach themselves. Within a year the young grow into adults that can live four to six years.

Zebra mussels were introduced to the Great Lakes region in the late 1980s through discharged ballast water of ships traveling the Saint Lawrence Seaway. These ships originated from European ports. Zebra mussels are native to the Ukraine and Russia near the Black and Caspian Seas. Since the 1700s zebra mussels have spread throughout European river systems.

Although zebra mussels do not cause much harm to the surrounding environment, they can negatively impact recreation and business by clogging water intake pipes, encrust boat hulls and piers, and wash up on beaches.

Zebra Mussel Management Options

Currently there is no lake-wide control option that isn't deadly to other aquatic life forms. In some areas of Europe and Lake Erie large populations of diving ducks have been shown to significantly decrease the population of zebra mussels each year. However, given the zebra mussel's high reproductive capacity, populations are able to recover each summer. In addition, diving duck populations in the Great Lakes region are low since they are only prevalent in the region during winter and summer migrations.

A number of fish species have been known to feed on zebra mussels. These include the freshwater drum, round goby, yellow perch, catfish, and carp. Certain fish species will feed on the adults while others eat the free-swimming juveniles. Although fish predation occurs, it is not significant enough to significantly decrease zebra mussel populations.

In recent years scientists have noted that native freshwater sponges in Lake Michigan appear to be increasing in number and attaching themselves to zebra mussels. In doing so, the sponges can kill the zebra mussels by cutting off the mussel's food and water supply.

Some success has been achieved by manually removing mussels from a lake. Although this method can dramatically reduce populations, it does not eradicate the mussels. In addition, it should be noted that this option is also very labor intensive.
Earlier this year a quarry in Virginia was able to eradicate zebra mussels from its waters. This was accomplished by applying a solution of potassium chloride over a three-week period in January. At the rate the solution was applied, it did not pose a risk to the environment or humans. This option would be most effective in small contained systems where cost does not prohibit control efforts.

Current research is focused on studying the environmental cues and physiological pathways that coordinate zebra mussel spawning. If the timing of male and female spawning can be disrupted, the numbers of fertilized eggs would be greatly reduced.