Aquatic Plant Management Plan
Long Lake
Polk County, Wisconsin

October 2017

Sponsored By
Long Lake Protection and Rehabilitation District

Aquatic Plant Management Advisory Committee

Prepared By

Harmony Environmental	Plan Writing and Facilitation
Endangered Resource Services, LLC	Aquatic Plant Survey and Mapping

Funded By
Long Lake Protection and Rehabilitation District
A Wisconsin Department of Natural Resources Grant

Table of Contents

Tables

Figures

Appendices

Executive Summary

This Aquatic Plant Management Plan updates the 2012 Long Lake Aquatic Plant Management Plan through 2022. The strategies for controlling curly leaf pondweed, protecting native plant populations, preventing establishment of invasive species, and allowing navigation through aquatic plant beds were updated. The plan includes data about the plant community, watershed, and water quality of the lake. It also reviews the history of aquatic plant management on Long Lake.

An aquatic plant point intercept survey was first completed for Long Lake in 2007. Subsequent surveys were completed in 2010, 2011, and 2016. The Department of Natural Resources required comprehensive surveys three times each year in 2010 and 2011 because of extensive treatment of curly leaf pondweed. The herbicide treatments resulted in nearly complete initial removal of curly leaf pondweed with some late season growth each year. Monitoring results showed increased native plant growth through the growing season following the herbicide treatments.

The aquatic plant surveys found that Long Lake has moderately low plant community diversity. Highest diversity is found in the shallow bays at either end of the lake. Native plants provide fish and wildlife habitat, stabilize bottom sediments, reduce the impact of waves against the shoreline, and prevent the spread of non-native invasive plants – all critical functions for the lake.

This Aquatic Plant Management Plan, updated with input from an advisory committee, will help the Long Lake Protection and Rehabilitation District carry out activities to meet plan aquatic plant management goals. The implementation plan describes the actions that will be taken toward achieving these goals.

A special thank you is extended to the aquatic plant management advisory committee for assistance with plan development.

Advisory Committee Members

Geno Braund
Keith Campbell (Board, Secretary)
Molly Condon
Mike Krieg
Michael Langer (Board, Chair)
Patti Langer
Joe Murray (Board, Treasurer)
Jerry Prokop
Steve Sherod
MarJean Sieberer
Lonny Thimjon
Anna Turk

Plan Goals

1) Improve water quality and clarity.

2) Protect and restore healthy rooted native aquatic plant communities.

3) Balance recreation and waterfront owner needs with protection of native plants and the fishery.

4) Prevent the introduction of Eurasian water milfoil, zebra mussels, and other aquatic invasive species.

5) Rapidly respond to eliminate any newly introduced aquatic invasive species.

Introduction

The Aquatic Plant Management Plan for Long Lake is sponsored by the Long Lake Protection and Rehabilitation District (LLPRD) with partial funding from a Wisconsin Department of Natural Resources Aquatic Invasive Species grant (AEPP-463-16).

This aquatic plant management plan updates the 2012 Long Lake Aquatic Plant Management Plan through 2022. The strategies for controlling curly leaf pondweed, protecting native plant populations, preventing establishment of invasive species, and allowing navigation through aquatic plant beds were updated. The plan includes data about the plant community, watershed, and water quality of the lake. It also reviews the history of aquatic plant management on Long Lake. This plan will guide the Long Lake Protection and Rehabilitation District and the Wisconsin Department of Natural Resources in aquatic plant management for Long Lake over the next five years (from 2017 through 2022). A plan update will begin with an updated plant survey in 2021.

Public Input for Plan Development

The LLPRD Aquatic Plant Management (APM) Advisory Committee provided input for the development of this plan. The APM Advisory Committee met three times. At the first meeting June 7, 2017, the committee reviewed aquatic plant management planning requirements, plant survey results, aquatic plant management efforts to date, existing plan goals, and discussed aquatic plant management concerns. At a second meeting on July 5, 2017, and a third meeting on August 9, 2017, the committee reviewed objectives, and updated action steps. The APM Advisory Committee concerns are reflected in the goals and objectives for aquatic plant management in this plan.

The LLPRD board announced the availability of the draft Aquatic Plant Management Plan for review with a public notice in the Polk County Ledger the weeks of August 28 and September 4, 2017. Copies of the plan were made available to the public on the Polk County web site www.co.polk.wi.us/landwater and at the Balsam Lake Public Library. Comments were accepted through September 30, 2017. No public comments were received.

Resident Concerns

The APM Committee expressed a variety of concerns that are reflected in the goals for aquatic plant management in this plan. Management concerns included addressing prevention of aquatic invasive species, and developing a response plan should they become introduced. Education was also very important to committee members.

Resident Survey
The LLPRD distributed a public opinion survey to Long Lake property owners on April 1, 2012. Responses received through May 21, 2012 are included in Appendix A. With 103 surveys returned out of the 169 mailed, the response rate was 61 percent. Results especially important to the aquatic plant management plan are summarized in Figures 1 through 3 below.

Invasive plants are viewed as having a negative impact on the lake, and residents support management efforts to prevent additional invasive species and control of curly leaf pondweed. Education is viewed as an important management effort as is protecting sensitive habitat areas in the lake.

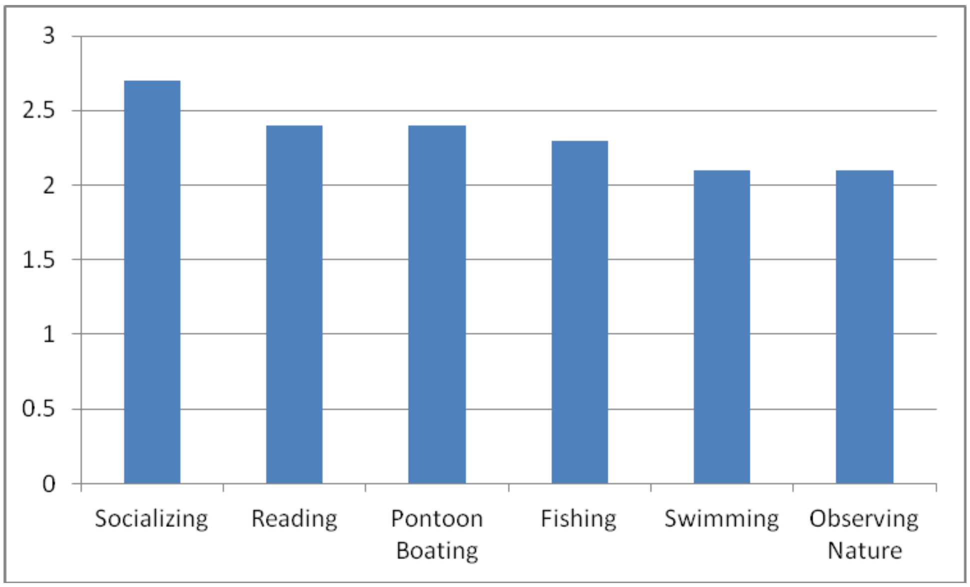


Figure 1. Lake Activities with the Highest Participation (Scale 0 to 4)

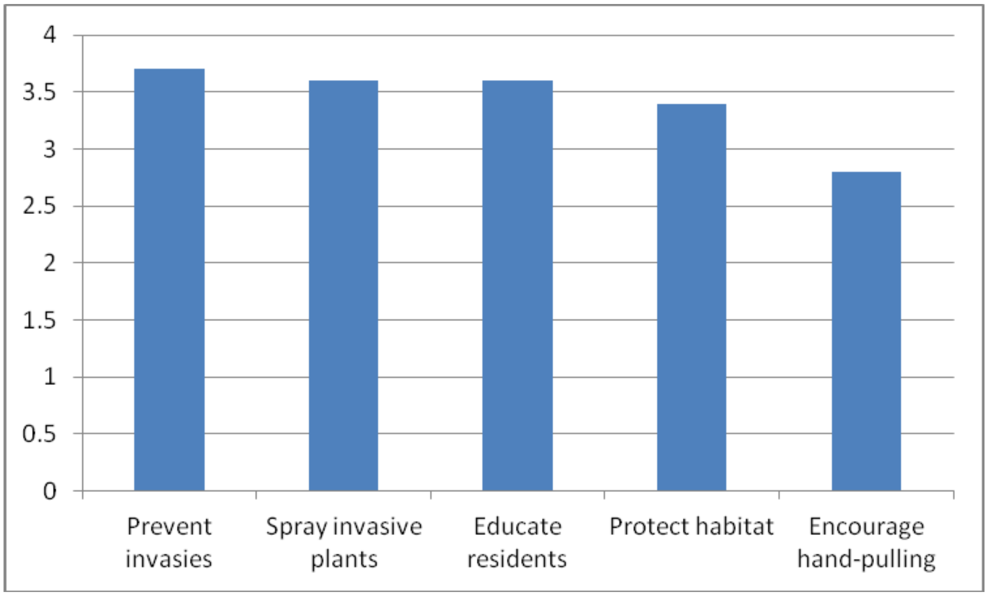


Figure 2. Management Activities Supported (Scale 0 to 4)

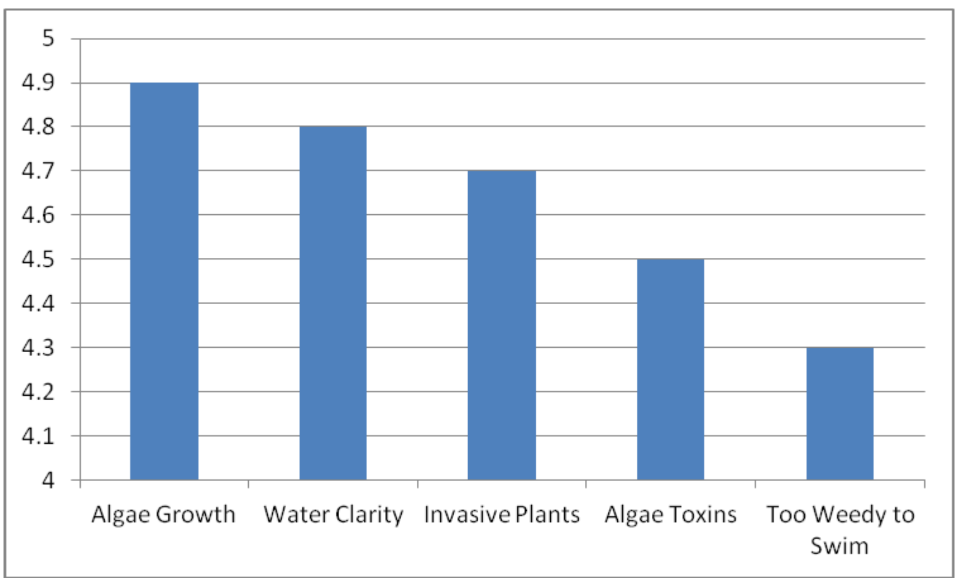


Figure 3. Greatest Negative Impact (Scale 0 to 6)

Lake Information

The Lake

Long Lake is a 272-acre lake located in Polk County, Wisconsin in the town of Balsam Lake (S6, S7, and S8, T34N, R17W). Its water body identification code is 2478200. The maximum depth of the lake is 17 feet, and the mean depth is 11 feet. The watershed area of Long Lake, including the lake, is approximately 2,343 acres (LWRD, 2013). A 2003 study estimated the direct watershed at about 1,279 acres (Barr, 2003). The lake is a seepage lake with no streams entering or leaving the lake. A ditch on the north end and another on the south end, flow to the lake during and after storm events.

Long Lake is a eutrophic to hypereutrophic lake with 2016 summer Secchi depths averaging 3 feet. The 2016 littoral zone (the depth to which plants grow) extended to 15 feet. The lake's substrate is 52.8 percent muck and sandy muck, 34.4 percent pure sand, and 12.8 percent rock as shown in Figure 4. Sediment Type. Nutrient-rich organic muck dominated the northwest, southeast and southern mid-lake bays while the central basin was a combination of sandy muck on the lake's western half that trended toward pure sand on the eastern half. Sand also dominated the shoreline around the central basin with areas of cobble and gravel primarily located around points, and north and west of the lake's eastern island. (Berg, 2016) A lake map is found as Figure 5.

Table 1. Long Lake Information

Size (acres)	272
Mean depth (feet)	11
Maximum depth (feet)	17
Littoral zone depth (feet)	15
Average summer Secchi depth (feet) 1992-2016	4.6

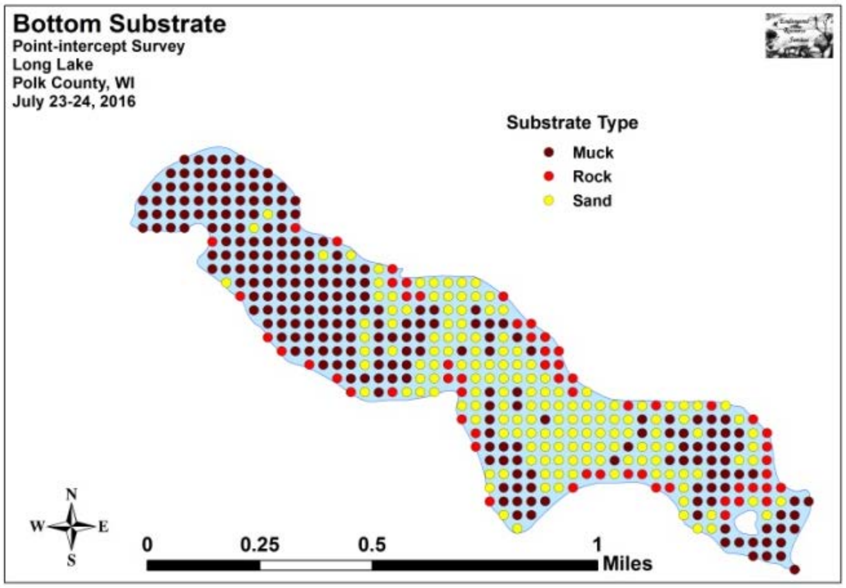


Figure 4. Sediment Type

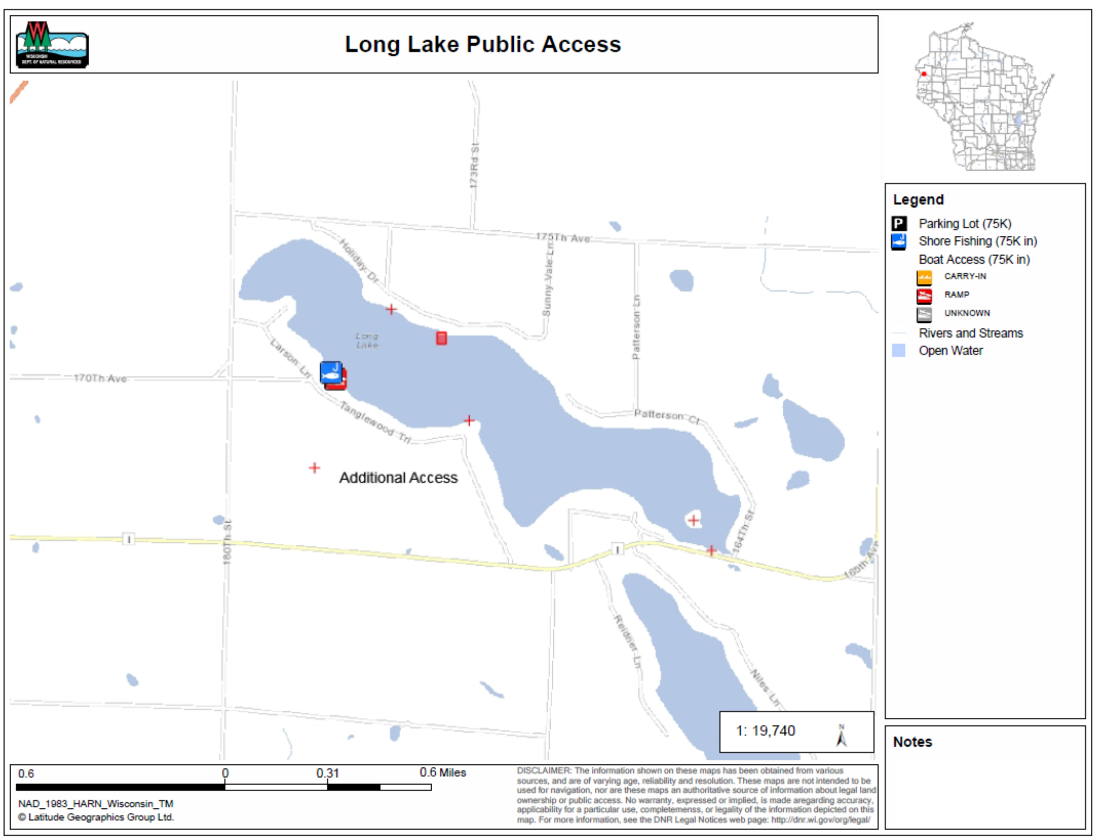


Figure 5. Long Lake Public Access

Water Quality

Water quality is frequently reported by the trophic state or nutrient level of the lake. Nutrient-rich lakes are classified as eutrophic. These lakes tend to have abundant aquatic plant growth and low water clarity due to algae blooms. At the high end of the eutrophic scale (hyper-eutrophic lakes) blue-green algae dominate and algae scums are present, sometimes throughout the summer. Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms. Oligotrophic lakes are nutrient-poor with little growth of plants and algae.

Secchi depth readings are one way to assess the trophic state of a lake. The Secchi depth is the depth at which the black and white Secchi disk is no longer visible when it is lowered into the water. Greater Secchi depths occur with greater water clarity. Secchi depth readings, phosphorus concentrations, and chlorophyll measurements can each be used to calculate a Trophic State Index (TSI) for lakes. TSI values range from 0 – 110. Lakes with TSI values greater than 50 are considered eutrophic. Those with values in the 40 to 50 range are mesotrophic. Lakes with TSI values below 40 are considered oligotrophic. Monitoring results place Long Lake in the eutrophic TSI range.

Citizen lake monitoring volunteers have collected data from the lake annually at the deep hole of Long Lake since 1992. The lake was sampled 5 times during July and August of 2016 with an average reported Secchi depth of 2.7. Results are available from the WDNR website.[1] For better comparison between lakes, only July and August results are summarized and reported in the figures that follow.

Figure 6 illustrates the annual summer Secchi depth averages for the lake. Figure 7 graphs the Trophic State Index (TSI) for Long Lake, based upon Secchi depth, chlorophyll, dissolved oxygen, and total phosphorus results. The TSI based on chlorophyll was 72 in 2016, a hyper-eutrophic value.

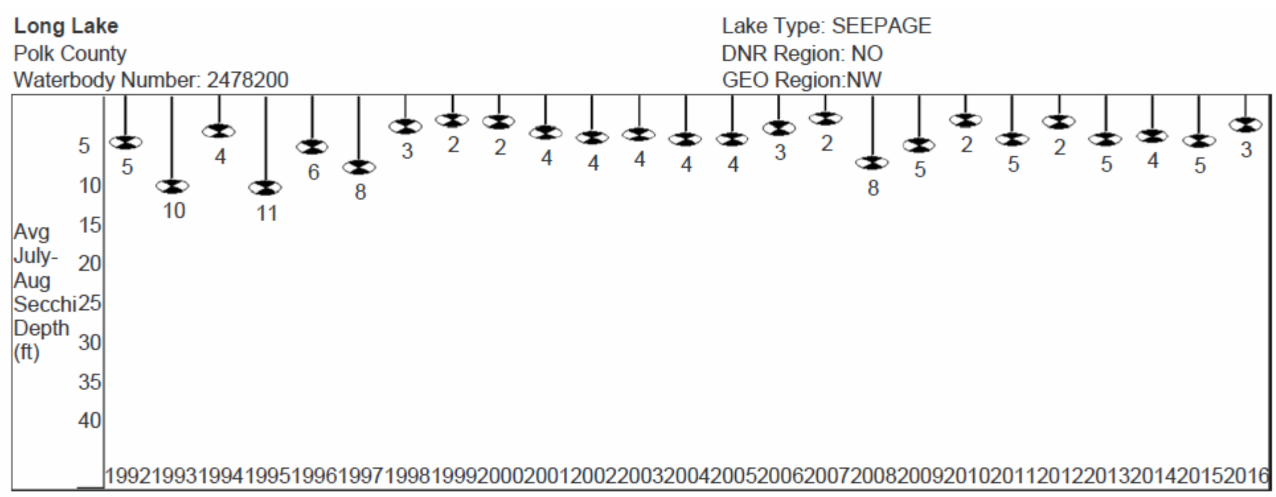
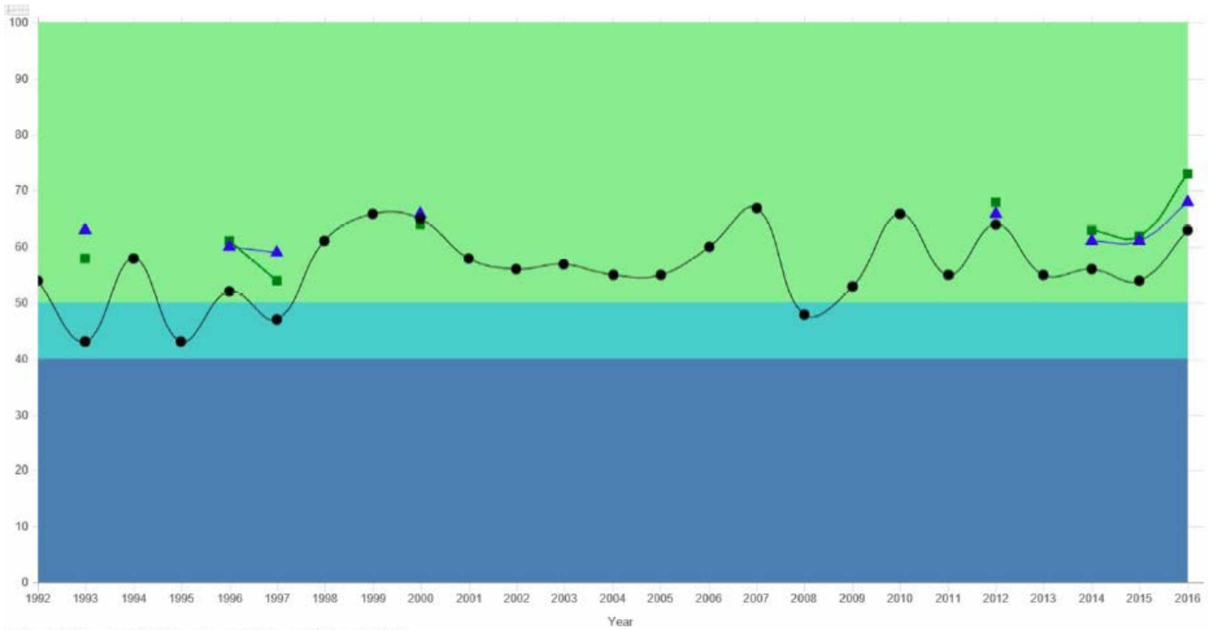


Figure 6. Long Lake Secchi Depths 1992-2016

[1] www.dnr.state.wi.us/lakes/clmn/



● = Secchi ■ = Chlorophyll ▲ = Total Phosphorus

Figure 7. Average Trophic State 1992-2016

Citizen monitoring results show good early summer water clarity with increasing algae growth and declining water clarity later in the summer. The trend of 2016 Secchi depth readings shown in Figure 8 below is typical.

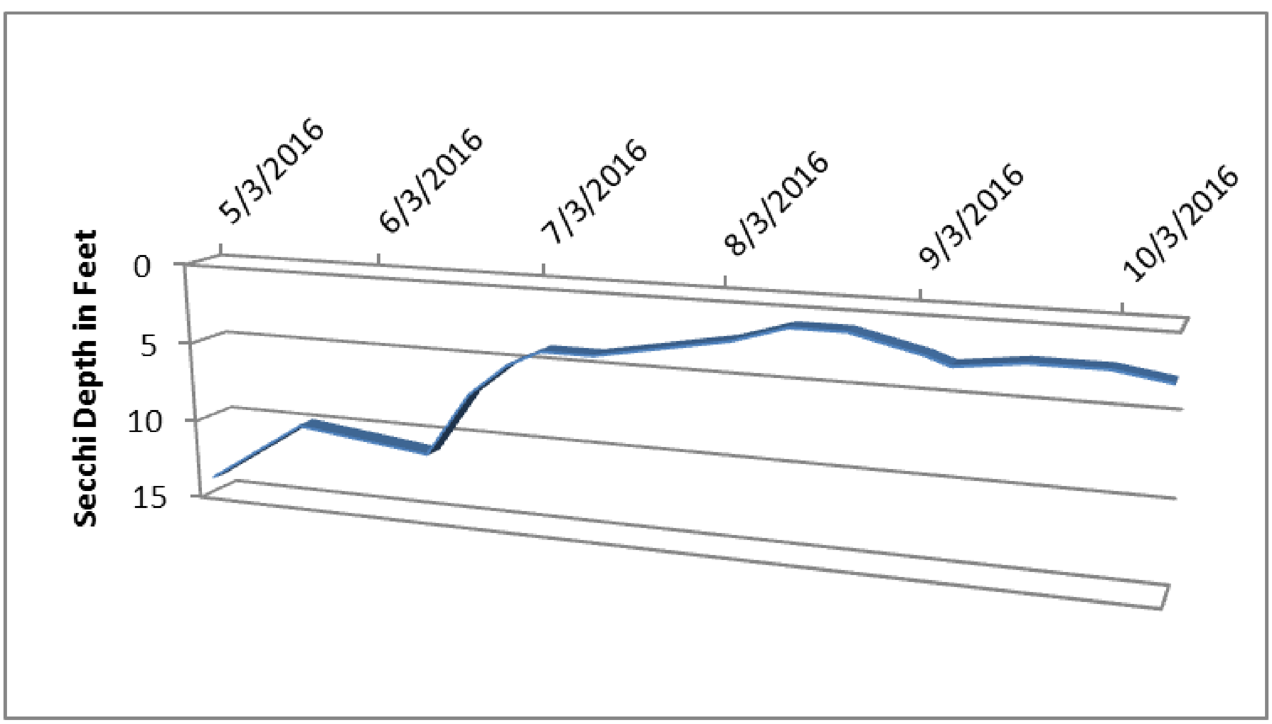


Figure 8. Long Lake 2016 Secchi Depth Trend

Long Lake Management Plan (2013)

The Polk County Land and Water Resources Department completed a water quality study in 2012. Results of this study were reported to an advisory committee and used to develop a lake management plan in 2013. The lake plan implementation focuses on supporting best management practice installation in agricultural and residential areas in the watershed and better understanding of internal loading.

Detailed water quality study results are reported in the lake management plan. The report divides the phosphorus load between external (watershed) sources and internal (in-lake and sediment sources). The total phosphorus load is estimated to be 2,413 pounds each year with about half contributed from each major source. Within the internal load, curly leaf pondweed is estimated to contribute 52 pounds each year (2 percent) when it covers 20 acres. Bill James from UW-Stout is re-examining the phosphorus budget in 2017 as a component of an investigation to reduce the lake's internal phosphorus load.

The plan established the following goals:

Water quality goal. Achieve and maintain a growing season mean total phosphorus concentration of .065 mg/L (65 ug/L) with plan implementation. *The summer total phosphorus average in 2016 was 165 µg/l. Total phosphorus goal will likely change with a 2017 plan addendum which will address internal loading with a proposed alum treatment.*

1. Minimize nutrients, sediment, and other pollutants that flow to the lake from its watershed.

2. Encourage lake processes which minimize the release of nutrients from within the lake.

3. Preserve and enhance lake and shoreline fish and wildlife habitat.

4. Lake residents and visitors understand the components of and the means to support a healthy lake.

5. Implement the goals of the Long Lake Aquatic Plant Management Plan.

Blue Green Algae Toxins

Blue green algae are of specific concern because they produce toxins at elevated concentrations. In 2009 high algae toxin levels were likely the cause of a human skin rash and a large dog becoming violently ill and were confirmed as the cause of the death of a small dog. These unfortunate events prompted the LLPRD to work with the Polk County Land and Water Resources Department to monitor algae toxins on Long Lake from 2010-2012. Blue green algae were the most abundant form of algae from 2010-2012. Toxin samples were only taken when algae scums were present. **Nearly 75 percent of the samples indicated a high probability of adverse health effects from the toxin microcystin LR, 17 percent had confirmed anatoxin-a present, and 75 percent of the 2012 samples tested positive for the toxin cylindrospermopsin.**

Watershed

A watershed map is included in Figure 9 below. The entire Long Lake watershed is over 2,000 acres. The area draining directed to the lake was reported to be about 1,279 acres in the Barr 2003 water quality study. The watershed is largely agricultural (57 percent) with significant amounts of residential land (13 percent) and open space (19 percent). The lake itself makes up 11 percent of the watershed (Figure 10) (LWRD, 2013).

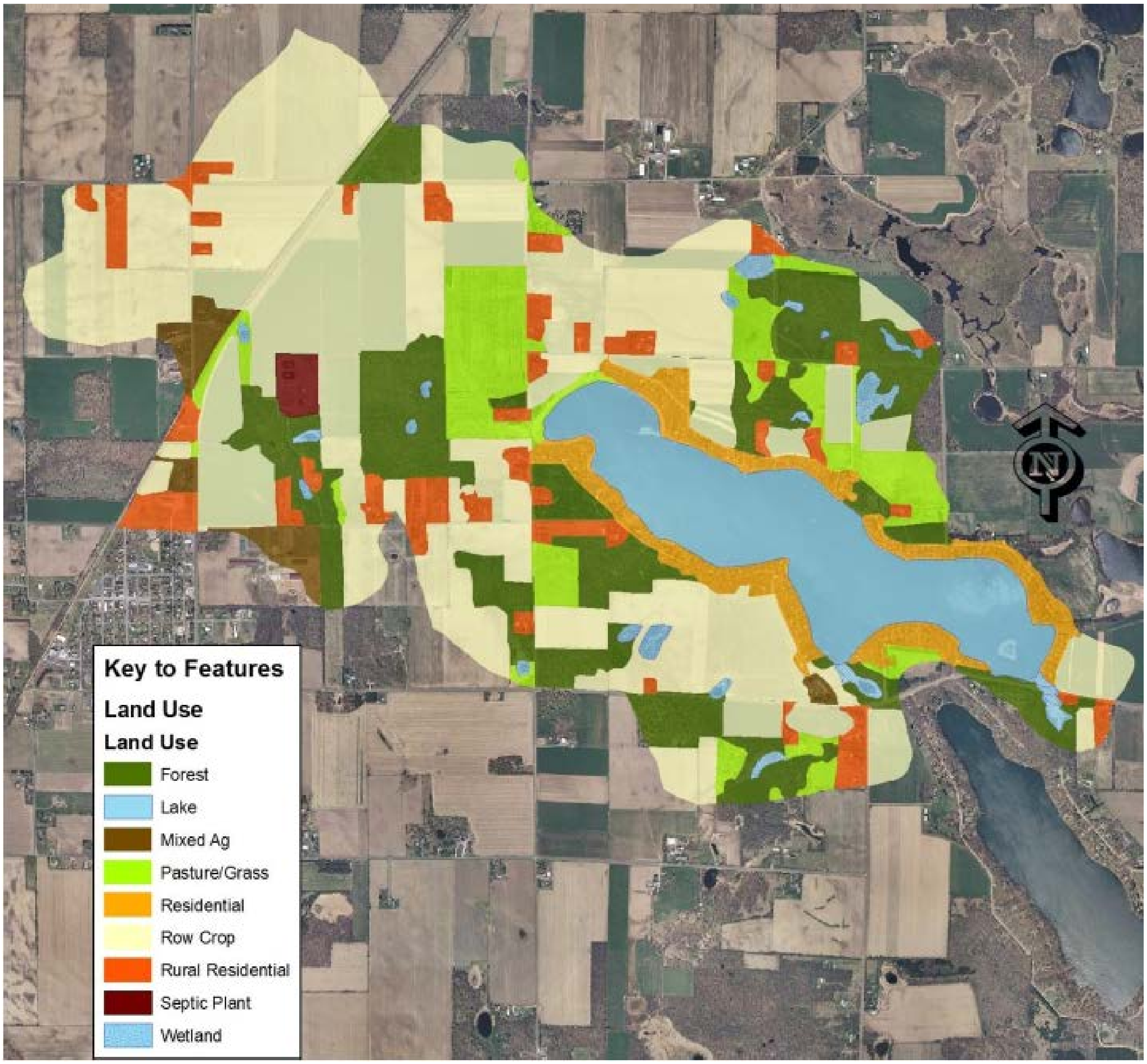


Figure 9. Long Lake Watershed Map

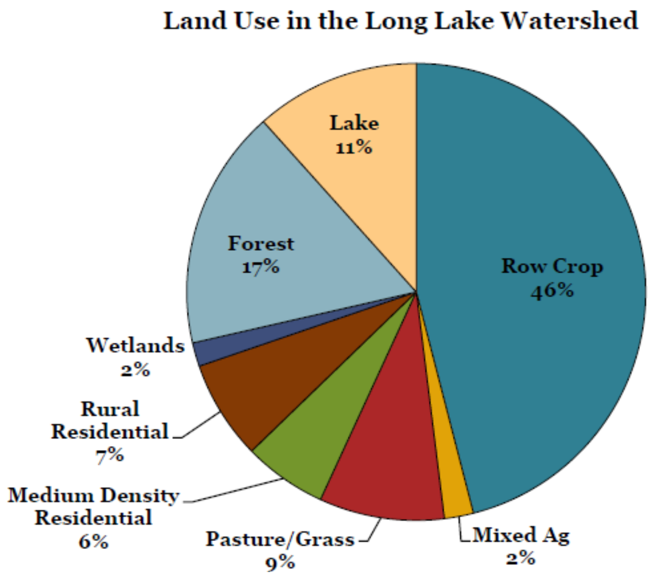


Figure 10. Watershed Land Use

2013 Plan Implementation

Significant work has been completed to implement the 2013 Long Lake Management Plan from 2014-2016. This work has been supported by a WDNR Lake Planning Grant (LPL-1536-14) and a Lake Protection Grant (LPT-466-14) along with LLPRD and landowner funds.

Residential Waterfront Projects

- 21 site visits and project designs completed
- 2 homeowner workshops and tours hosted
- Recognition signs posted at project sites
- 13 projects installed for 10 homeowners (about 6 percent of lake residences)

Agricultural Projects

One agricultural sediment basin was reconstructed. Polk County LWRD completed an inventory of crop fields to prioritize agricultural watershed work. The county also completed a design for a sedimentation basin for an agricultural property (Turner – North Ditch). Project installation is planned for 2017.

Internal Loading Investigation

Bill James with UW-Stout completed an alum study and executive summary (James, 2014). There were recommendations for additional study items in the report including updated lake modeling based on additional measurements of internal loading which will be completed in 2017.

Previous Study and Plan

Barr Engineering completed a water quality study and management plan from 2000 through 2003.[2] The six phase study included the following steps:

Phase I: Transect aquatic macrophyte survey (mid-June 2000)
Inflow monitoring from south side ditch
Phase II: Inflow monitoring from north side ditch
Phase III: In-lake water quality samples, lake levels and precipitation measurement
Membership survey (2000)
Phase IV: Watershed phosphorus and total phosphorus budgets
Phase V: Long-term water quality management goal (suggested)
Management scenarios to reach this goal (evaluated)
Sediment core experiments to determine appropriate alum/lime slurry doses.
Phase VI: Lake management plan report

<u>Water Quality Study Conclusions</u>

The 2003 water quality suggested a water quality goal of 45 ug/L average summer total phosphorus for upper surface water.

Recommended management actions to reach proposed management goal included: A lime slurry/alum treatment to control phosphorus loads from the lake sediments. A test of appropriate dosing was recommended as a first step because of a very soft lake bottom.
This recommendation was not adopted by the Long Lake District because cost would be high and Department of Natural Resources support was uncertain at the time. With updated information about alum treatments and initial support from the WDNR, the LLPRD unanimously approved pursuing an alum treatment and grant at the 2017 annual meeting.

Early season herbicide treatment of curly leaf pondweed.
This recommendation was formally adopted by the Long Lake District with the approval of Long Lake Aquatic Plant Management Plan in 2007.

Control of watershed sources through a county stormwater ordinance, shoreland gardens, a septic system ordinance, and watershed best management practices.
A stormwater ordinance that exceeds state minimum standards was adopted by Polk County in 2005. Best management practice including nutrient management planning for farmers were implemented in the watershed through the Balsam Branch Priority Watershed Project. This project was in place from 1995 through 2005.

[2] Barr. 2003.

Aquatic Habitats

Primary Human Use Areas

A public boat landing operated by the Village of Centuria is located on the south side of the lake. The boat landing includes space for parking nine vehicles and trailers. The landing is used heavily in the summer. Anglers frequently park along the road when the boat landing parking area is full. There is another public landing on the north side of lake that is used less frequently. The landing is paved, but there are no parking spaces.

The shoreline of Long Lake is largely developed for residential use with about 169 residences. There are 178 parcels in the lake district.[3] Lake residents' use focuses around their docks placed in the relatively shallow, littoral zone of the lake.

Habitat Areas

The littoral, or plant supporting, zone of the lake provides critical habitat for fish, waterfowl, and other wildlife. It is found in a narrow band around Long Lake at depths up to 10-15 feet. Extensive littoral zones are found in the northwest and southeast bays where the water is relatively shallow.

Sensitive Area Study

The Wisconsin Department of Natural Resources sensitive area study (1989) identified two areas that merit special protection of aquatic habitat. "These areas of aquatic vegetation on Long Lake offer critical or unique fish and wildlife habitat. This habitat provides the necessary seasonal or life stage requirements of the associated fisheries while offering water quality or erosion control benefits to the body of water." In the designated sensitive areas, aquatic vegetation removal is limited to navigational channels no greater than 25 feet wide. Chemical treatments are discouraged and if navigational channels must be cleared, pulling by hand is preferable.

Resource Value of Area A

This area consists of the northwestern bay. It provides important habitat for bass and panfish and northern pike spawning and nursery areas. The area also provides important habitat for forage species. Wildlife also are reliant upon this area for habitat. Eagles, loons, herons, waterfowl, songbirds, furbearers, turtles, and amphibians benefit from this valuable habitat.

Resource Value of Area B

This area consists of the southeastern bay.

Values are the same as those described above for Area A.

[3] Personal email communication Jeff Larson, LLPRD Treasurer. December 14, 2011.

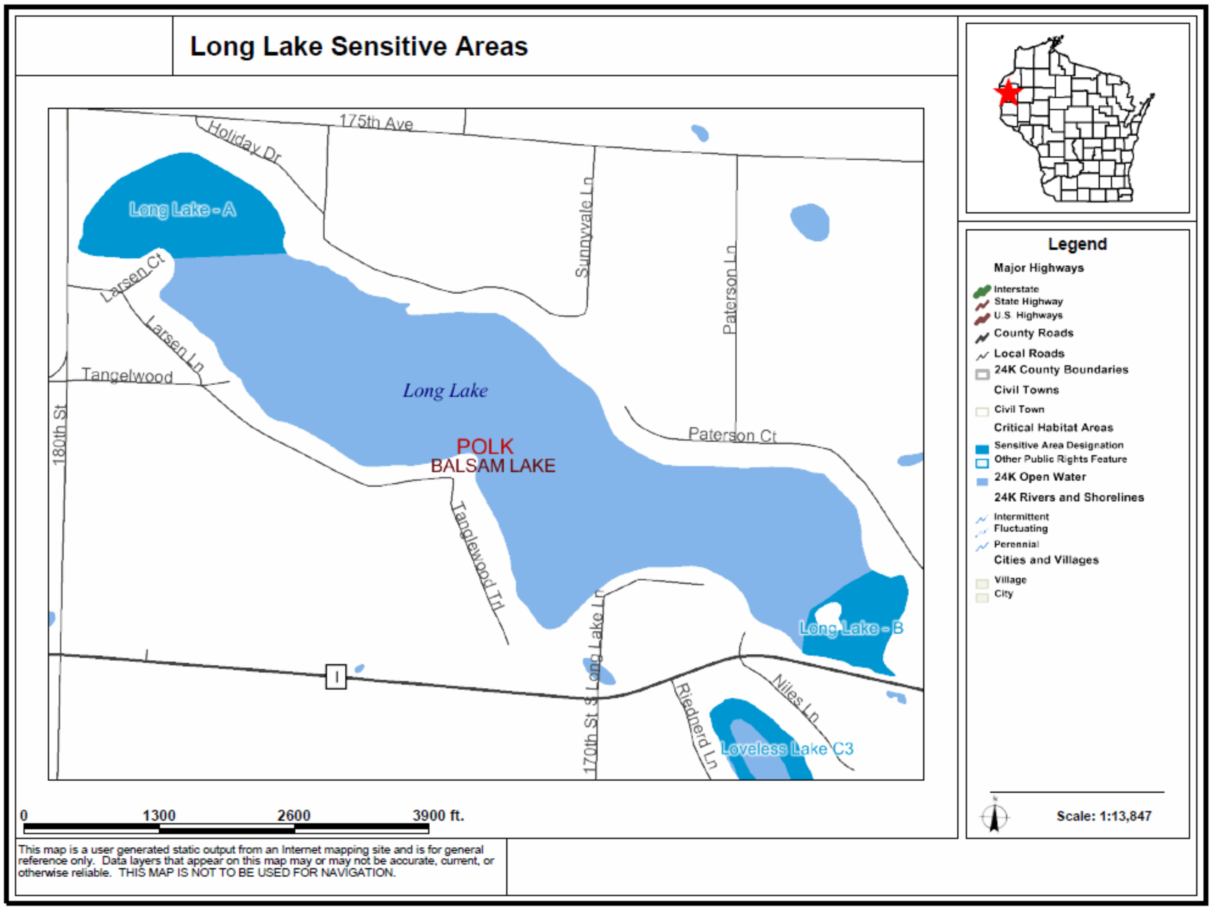


Figure 11. Long Lake Sensitive Areas

Long Lake Fishery

Long Lake's fish community consists of northern pike, largemouth bass, and panfish.[4] The Department of Natural Resources (DNR) stocked northern pike in the lake most years from 1980 through 2016. Stocking occurs in even numbered years in recent years. In some years from 250,000 to 500,000 inch fry were stocked. In other years from 475 to 3,000 fingerlings (4 to 11 inches) were stocked.

The DNR last completed a night electro-fishing survey in October of 2006. The survey captured 13 black crappie (5-10.5 inches), 122 blue gill (3-8.5 inches), 376 largemouth bass (6-8.5 inches), and 38 northern pike (12-27.5 inches).[5] The WDNR will complete a fisheries survey on Long Lake in 2017.

Fish spawning times are listed in Table 2 to consider for potential plant management activities.

---

[4] Wisconsin Lakes Book.

[5] Reviewed by Aaron Cole, WDNR Fisheries Biologist. February 2017.

Table 2. Fish Spawning Considerations

Fish Species	**Spawning Temp. (Degrees F)**	**Spawning Substrate / Location**	**Comments**
Northern Pike	Upper 30s – mid 40s (right after ice-out)	Emergent vegetation 6-10 inches of water	Eggs are broadcast
Black Crappie	Upper 50s to lower 60s	Nests are built in 1-6 feet of water	Nest builders
Largemouth Bass Bluegills	Mid 60s to lower 70s	Nests are built in water less than 3 feet deep	

Functions and Values of Native Aquatic Plants

Naturally occurring native plants are extremely beneficial to the lake. They provide a diversity of habitats, help maintain water quality, sustain fish populations, and support common lakeshore wildlife such as loons and frogs.

Water Quality

Aquatic plants can improve water quality by absorbing phosphorus, nitrogen, and other nutrients from the water that could otherwise fuel nuisance algae growth. Some plants can even filter and break down pollutants. Plant roots and underground stems help to prevent re-suspension of sediments from the lake bottom. This is especially important in shallow areas with mucky bottoms such as found in Long Lake as shown in Figure 12. Stands of emergent plants (with stems that protrude above the water surface) and floating plants help to blunt wave action and prevent erosion of the shoreline. Poor water clarity can limit aquatic plant growth by limiting light penetration.

Fishing

Habitat created by aquatic plants provides food and shelter for both young and adult fish. Invertebrates living on or beneath plants are a primary food source for many species of fish. Other fish, such as bluegills, graze directly on the plants themselves. Plant beds in shallow water provide important spawning habitat for many fish species.

Waterfowl

Plants offer food, shelter, and nesting material for waterfowl. Birds eat both the invertebrates that live on plants and the plants themselves.[6]

Invasive Species Protection

Non-native invasive aquatic species threaten native plants in Northern Wisconsin. The most common are Eurasian water milfoil (EWM) and curly leaf pondweed (CLP). These species are

[6] Above paragraphs summarized from *Through the Looking Glass*. Borman et al. 1997.

described as opportunistic invaders. This means that they take over openings in the lake bottom where native plants have been removed. Without competition from other plants, these invasive species may successfully become established and spread in the lake. This concept of opportunistic invasion can also be observed on land, in areas where bare soil is quickly taken over by weeds.

Removal of native vegetation not only diminishes the natural qualities of a lake, but it increases the risk of non-native species invasion and establishment. The presence of invasive species can change many of the natural features of a lake and often leads to expensive annual control plans. Allowing native plants to grow may not guarantee protection against invasive plants, but it can discourage their establishment. Native plants may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm. (WDNR 2007)

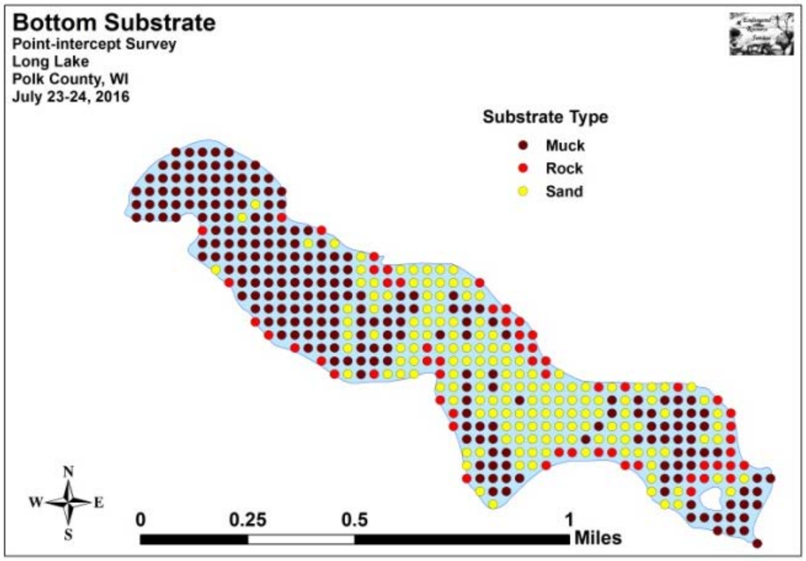


Figure 12. Lake Bottom Sediment

Plant Community

Aquatic Plant Survey Results

Endangered Resource Services completed aquatic plant surveys for Long Lake in 2007, 2010, 2011, 2012, and 2016 according to the WDNR-specified point intercept method. The survey results presented here summarize the results of the most recent survey completed in July 2016 and compare results between 2012 and 2016. Some comparisons are also included from 2010 and 2011. The 2007 survey occurred in June, so these results are not compared with the July warm water surveys.

The results discussed below are summarized or taken directly from the aquatic plant survey results. The survey and data analysis methods for the aquatic macrophyte survey are found in the following report prepared in 2016: Curly-leaf pondweed (*Potamogeton crispus*) Point-Intercept and Bed Mapping Surveys, and Warm-water Macrophyte Point-intercept Survey Long Lake - WBIC: 2478200 Polk County, Wisconsin conducted and prepared by Matt Berg, Endangered Resource Services, LLC. Extensive additional data and maps are included in these reports. Data is also taken from Berg's warm water point intercept survey reports from 2010 and 2011.

Using a standard formula based on a lake's shoreline shape and length, islands, water clarity, depth, and size, the Wisconsin Department of Natural Resources (WDNR) generated the sampling point grid of 453 points. Figure 13 shows the distribution of these sampling points. The 250 points on the base grid within or adjacent to the lake's known littoral area were sampled in 2016. No curly leaf pondweed was found during an early season June 11, 2016 sampling which followed a 35-acre early season CLP herbicide treatment.

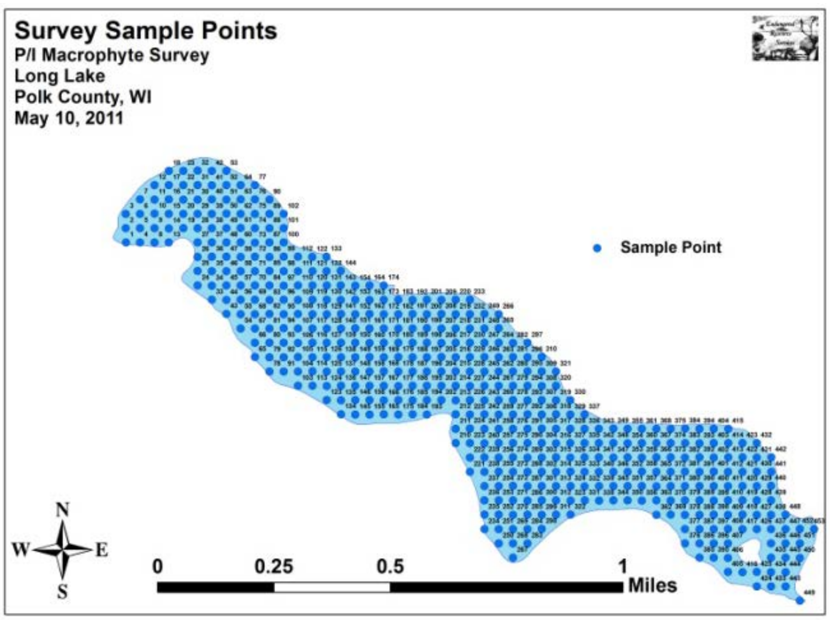


Figure 13. Sampling Point Grid

In July 2016 plants were found growing on approximately 61 percent of the littoral zone (the depth at which plants can grow). The littoral zones for 2012 and 2016 are shown in Figure 14 below. The depth of the littoral zone fluctuates seasonally and between years on Long Lake with plants growing deepest early in the growing season. The littoral zone has ranged from a low of 10 feet in previous years to a maximum of 15 feet in 2016. However, in 2016 most plant growth ended in 9 feet of water. The northwest and southeast bays are the largest littoral zone areas and have the highest density of plant growth.

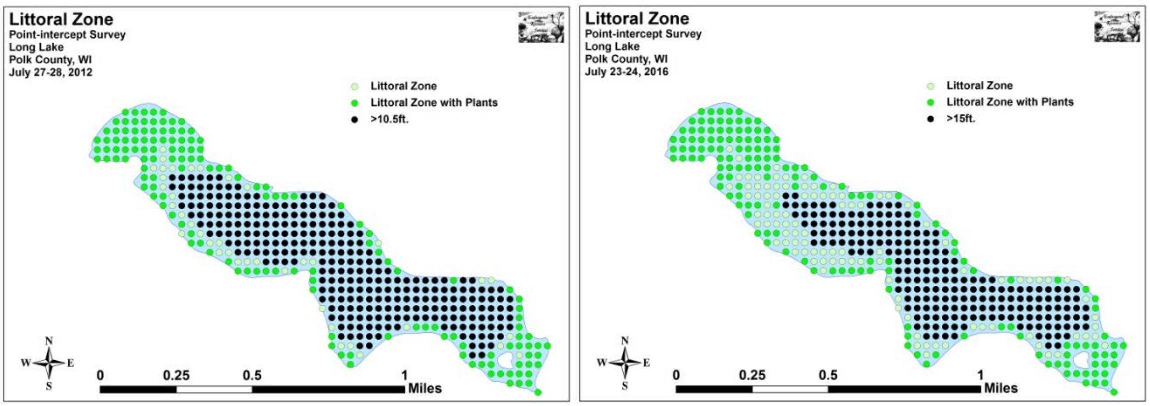


Figure 14. Long Lake Littoral Zone July 2012 and 2016

Species totals are low on Long Lake when compared with other lakes in the region. In 2016, only 23 species were found in the rake, although this total increased to 27 species when including visuals and plants seen during the boat survey. This number was up from the 18 total species documented in 2012 and 2011 and 22 species found in 2010. Mean native species richness at sites with vegetation was also low. In July 2016 there were 2.59 species per site, in 2012: 3.25, in 2011: 2.45, and in July 2010: 2.61. Native species richness was highest in the northwest bay (Figure 15). The lake exhibited moderate diversity with Simpson Index Values ranging from 0.87 in 2016 and 0.88 in 2012.[7]

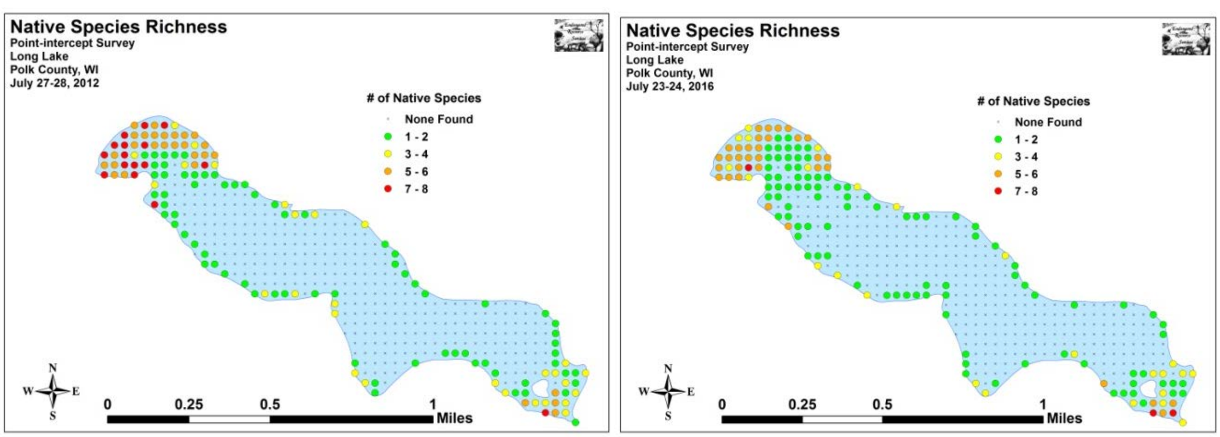


Figure 15. Native Species Richness July 2012 and 2016

[7] The Simpson Diversity Index is a measure of the likelihood that a different species of plant will be found each time a grab sample is taken. The highest Simpson Diversity Index is 1.0.

Figure 16 illustrates plant density based on fullness of the vegetation on the sample rake. The density rating of the rake sampled varied between one and three (from low to high density). Highest plant density occurs in the northwest and southeast bay.

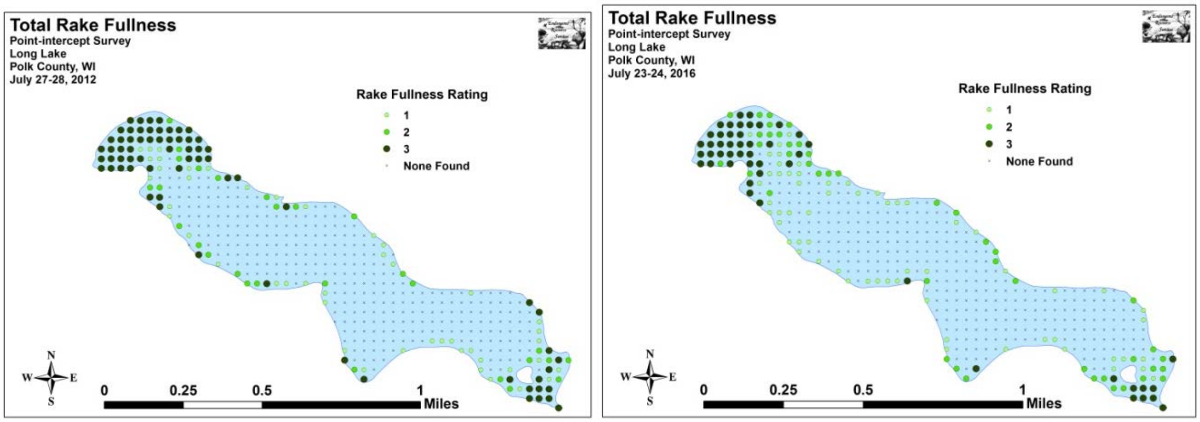


Figure 16. Total Rake Fullness July 2012 and 2016

Table 3. Aquatic Macrophyte Survey Comparison

	2012	2016
Total number of points sampled	453	453
Total number of sites with vegetation	142	152
Total number of sites shallower than the maximum depth of plants	181	250
Frequency of occurrence at sites shallower than maximum depth of plants	78.5	60.8
Simpson Diversity Index	0.88	0.87
Maximum depth of plants (ft)	10.5	15.0
Mean depth of plants (ft)	4.3	5.6
Median depth of plants (ft)	4.0	4.5
Average number of all species per site (shallower than max depth)	2.55	1.60
Average number of all species per site (veg. sites only)	3.25	2.63
Average number of native species per site (shallower than max depth)	2.55	1.58
Average number of native species per site (sites with native veg. only)	3.25	2.59
Species richness	17	23
Species richness (including visuals)	17	24
Species richness (including visuals and boat survey)	18	27
Mean rake fullness (veg. sites only)	2.15	1.93
Summer Secchi depth (July- August)	2.5	2.7

The most frequent aquatic macrophyte species have stayed relatively constant in recent years although their percent frequency has changed as reported in Table 4. Not shown below is the increase in frequency since 2011 of small duckweed (*Lemna minor*) and large duckweed (*Spirodela polyrhiza*). Both were in the top most frequent species in vegetation in 2012 and 2016. Curly leaf pondweed remains present (or regrows from turions) when sampled in July. The frequency of other top species fluctuates within the growing season and between years.

Table 4. Most Frequent Aquatic Macrophyte Species (late July percent frequency in vegetation)

	Curly leaf pondweed *(Potamogeton crispus)*	Coontail *(Ceratophyllum demersum)*	Star/forked duckweed *(Lemna trisulca)*	White water lily *(Nymphaea tuberosaa)*	Canada/common waterweed *(Elodea canadensis)*	Water star-grass *(Heteranthera dubia)*
2010	6.49	43.7	79.2	19.9	48.5	12.1
2011	19.5	27.7	34.8	21.7	63.3	10.5
2012	0.7	41.6	30.3	31.0	74.7	9.2
2016	3.3	74.3	14.5	30.9	18.4	6.7

Coontail, the most common species in 2016 after being the second most common in 2012, was abundant in the lake's organic muck bottom bays; especially in the northwest bay (Figure 17). Found at 59 sites in 2012, it demonstrated a highly significant increase in distribution to 113 sites in 2016. Its mean rake fullness value, however, was almost unchanged from 1.64 in 2012 to 1.59 in 2016.

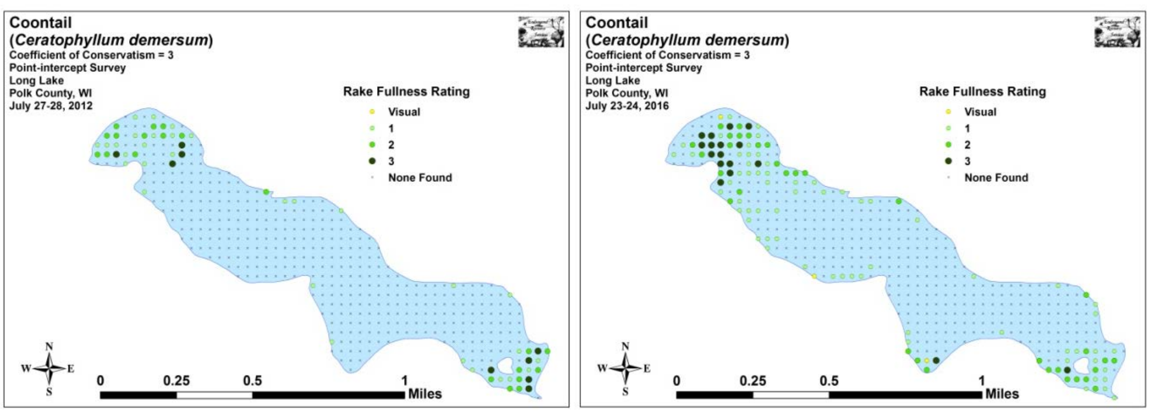


Figure 17. Coontail Density and Distribution (2012 and 2016)

White water lily was the second most common species in 2016 after being the fourth most common in 2012. Despite this jump in relative frequency, the species actually showed little change in distribution (44 sites in 2012 to 47 sites in 2016) and no change in density (mean rake fullness of 2.45 both years) (Figure 18).

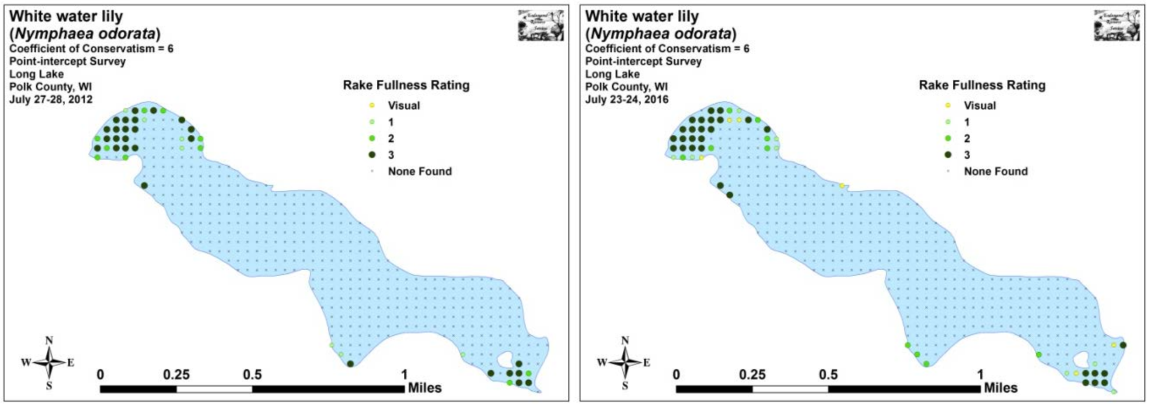


Figure 18. White Water Lily Density and Distribution (2012 and 2016)

Present at 106 sites in 2012, common waterweed was the most common macrophyte species in the lake. However, it declined significantly in distribution to just 28 sites in 2016. Although this overall decline might seem concerning, analysis of the maps for coontail show that these two species were essentially exchanged for one another. These two species seem to compete with each other to fill much of the void left by the elimination of curly leaf pondweed following the spring treatment.

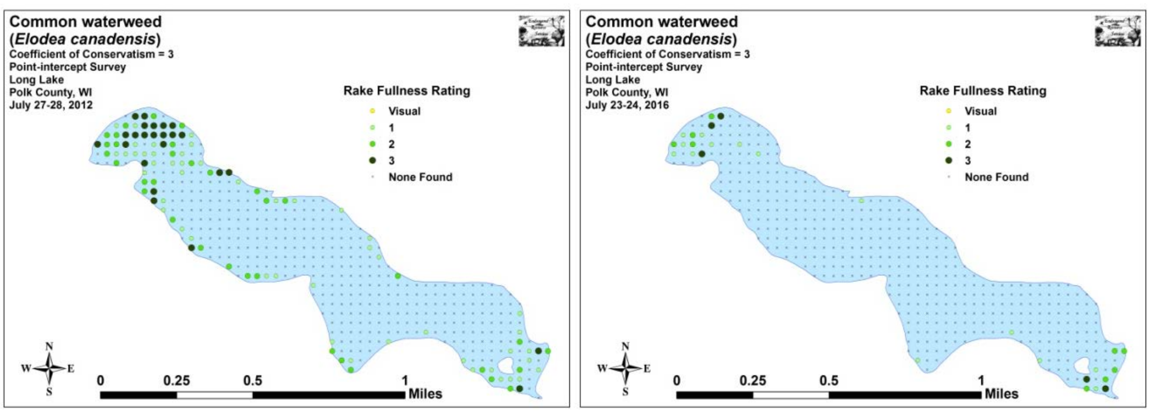


Figure 19. Common Waterweed Density and Distribution (2012 and 2016)

Floristic Quality Index
The Floristic Quality Index (FQI) is an index developed by Dr. Stanley Nichols of the University of Wisconsin-Extension. This index is a measure of the plant community response to development and human influence on the lake. It takes into account the species of aquatic plants present and their tolerance for changing water quality and habitat characteristics. A plant's tolerance is expressed as a coefficient of conservatism (C). Native plants in Wisconsin are assigned a conservatism value between 0 and 10. A plant with a high conservatism value has more specialized habitat requirements and is less tolerant of disturbance and/or water quality changes. Those with lower values are more able to adapt to disturbance or changing conditions, and can therefore be found in a wider range of habitats. The FQI is calculated using the number of species present and these plants' species conservatism values. A higher FQI generally indicates a healthier aquatic plant community.

The FQI for Long Lake was lower than the median 20.9 for similar lakes within the ecoregion as measured in 2012 (19.0) but slightly higher in July 2016 (23.3). The mean coefficient of conservatism also increased from 4.8 in 2012 to 5.1 in 2016 (both lower than the median for lakes within the ecoregion).

Although these increases could simply be capturing changes in annual growing conditions, plant surveyors believe they reflect a trend of generally improving conditions on the lake that have allowed the colonization of new species. Specifically, the 2016 Floristic Quality Index included four species (leafy pondweed, small pondweed, slender riccia, and grass-leaved arrowhead) that have not been seen on the lake during any of seven years of surveying on the lake. A fifth species, wild celery, was also seen for the first time in 2016. However, it was excluded from the index as it was found during the boat survey.

Northern Wild Rice
Wild rice (*Zizania palustris*) is an aquatic plant with special significance to Native American Tribes. It was not found in Long Lake in any of the aquatic plant surveys (2000, 2007, 2010, 2011, 2012, or 2016).

Aquatic Invasive Species

Three species of aquatic invasive plants not native to Wisconsin lakes were observed in the aquatic plant surveys. They are curly leaf pondweed (*Potamogeton crispus*), reed canary grass (*Phalaris arundinacea),* and narrow leaved cattail hybrid. More information about several common aquatic invasive species is included in Appendix B.

Curly leaf pondweed (CLP) grows extensively throughout the littoral zone of Long Lake. Curly leaf pondweed growth and recent management targeting CLP are summarized in subsequent pages.

Reed canary grass was observed in the July 2010, 2012, and 2016 surveys. It was also noted in the 1989 DNR sensitive area report. This plant is common and well-established adjacent to shorelines in northwest Wisconsin and is difficult to control.

Narrow-leaved cattail is native to southern but not northern Wisconsin. Narrow-leaved cattail (*Typha angustifolia*) and its hybrids with broad-leaved cattail are becoming increasingly common in northern Wisconsin where they also tend to be invasive. First noticed in 2011 in Long Lake, hybrid cattails have now crowded out most native cattails around the lake and in adjacent wetlands, and they are firmly and likely irrevocably established (Figure 20).

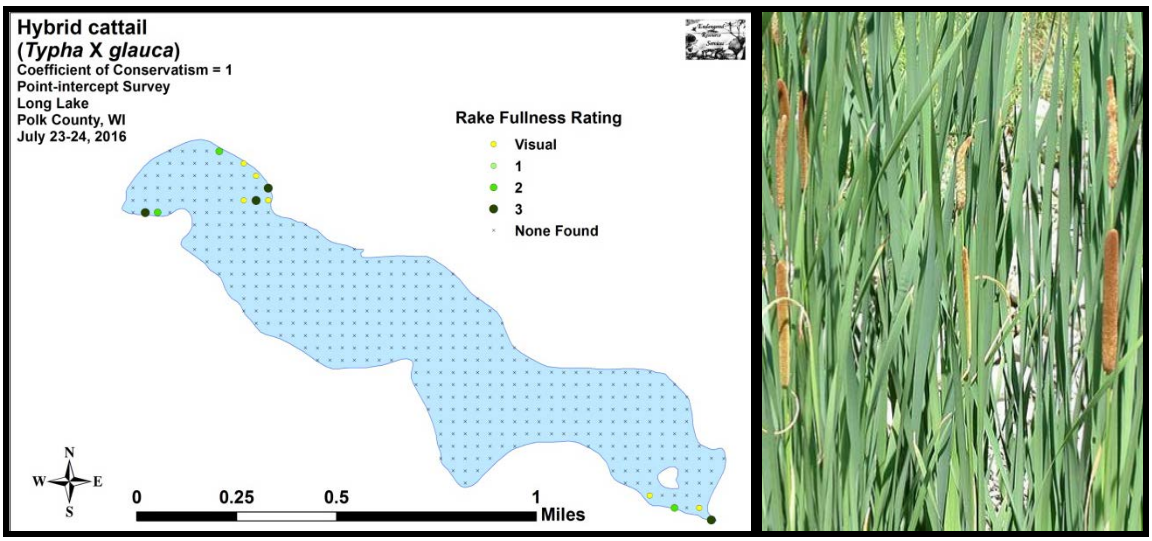


Figure 20. Hybrid Cattail Density and Distribution.

Japanese knotweed (*Polygonum cuspidatum*) and giant knotweed (*Polygonum sachalinense*) are potential concerns for riparian areas of Long Lake. The Polk County Land and Water Resources Department has documented several riparian locations of knotweed throughout Polk County.

There is a high risk that Eurasian water milfoil and other aquatic invasive species may become established in Long Lake. With Eurasian water milfoil present in many urban Twin Cities lakes, the danger of transporting plant fragments on boats and motors is very real. Department of Natural Resource scientists have also found Eurasian water milfoil in the nearby Wisconsin counties of Burnett (Ham, Little Trade, Shallow, and Round Lakes), Barron (Beaver Dam, Horseshoe, Sand, Kidney, Shallow, Duck, and Echo Lakes), and St. Croix (Bass Lake, Cedar, Goose Pond, Little Falls Lake, Lake Mallalieu, and Perch Lake). In Polk County, EWM is found in Long Trade, Horseshoe and Pike Lakes.

Curly Leaf Pondweed

Curly leaf pondweed is specifically designated as an invasive aquatic plant (along with Eurasian water milfoil and purple loosestrife) to be the focus of a statewide program to control invasive species in Wisconsin. Invasive species are defined as a "non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health (23.22(c))."

The Wisconsin Comprehensive Management Plan for Aquatic Invasive Species describes curly leaf pondweed impacts as follows:

> It is widely distributed throughout Wisconsin lakes, but the actual number of waters infested is not known. Curly-leaf pondweed is native to northern Europe and Asia where it is especially well adapted to surviving in low temperature waters. It can actively grow under the ice while most plants are dormant, giving it a competitive advantage over native aquatic plant species. By June, curly-leaf pondweed can form dense surface mats that interfere with aquatic recreation. By mid-summer, when other aquatic plants are just reaching their peak growth for the year, it dies off. Curly-leaf pondweed provides habitat for fish and invertebrates in the winter and spring when most other plants are reduced to rhizomes and buds, but the mid-summer decay creates a sudden loss of habitat. The die-off of curly-leaf pondweed also releases a surge of nutrients into the water column that can trigger algal blooms and create turbid water conditions. In lakes where curly-leaf pondweed is the dominant plant, the summer die-off can lead to habitat disturbance and degraded water quality. In other waters where there is a diversity of aquatic plants, the breakdown of curly-leaf may not cause a problem.[8]

[8] *Wisconsin's Comprehensive Management Plan to Prevent Further Introductions and Control Existing Populations of Aquatic Invasive Species.* Prepared by Wisconsin DNR. September 2003.

Aquatic Plant Management

This section reviews the potential management methods available and reports recent management activities on the lake.

Discussion of Management Methods

Permitting Requirements

The Department of Natural Resources regulates the removal of aquatic plants when chemicals are used, when plants are removed mechanically, and when plants are removed manually from an area greater than thirty feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107 – Aquatic Plant Management. **A permit is required for any aquatic chemical application in Wisconsin.** Additional requirements exist when a lake is considered an ASNRI (Area of Special Natural Resource Interest) due, in the case of Long Lake, to the designation of sensitive areas.

The requirements for manual and mechanical plant removal are described in *NR 109 – Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations*. A permit is required for manual and mechanical removal except for when a riparian (waterfront) landowner manually removes or gives permission to someone to manually remove plants, (with the exception of wild rice) from his/her shoreline up to a 30-foot corridor. For designated sensitive areas on Long Lake, that corridor is limited to 25 feet. A map of Long Lake sensitive areas is included as Figure 11. A riparian landowner may also manually remove the invasive plants Eurasian water milfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal refers to the control of aquatic plants by hand or hand–held devices without the use or aid of external or auxiliary power.[9]

The *Department of Natural Resources Northern Region Aquatic Plant Management Strategy* (May 2007) requires documentation of impaired navigation or nuisance conditions before native plants may be managed with herbicides. Severe impairment or nuisance will generally mean that vegetation grows thickly and forms mats on the water surface.

Techniques to control the growth and distribution of aquatic plants are discussed in the following text. The application, location, timing, and combination of techniques must be considered carefully. A summary table of Management Options for Aquatic Plants from the WDNR is found in Appendix F.

[9] More information regarding DNR permit requirements and aquatic plant management contacts is found on the DNR web site: www.dnr.state.wi.us.

Manual Removal[10]

Manual removal—hand pulling, cutting, or raking—will effectively remove plants from small areas. It is likely that plant removal will need to be repeated more than once during the growing season. The best timing for hand removal of herbaceous plant species is after flowering but before seed head production. For plants with rhizomatous (underground stem) growth, pulling roots is not generally recommended since this may stimulate new shoot production.
Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil establishment and for private landowners who wish to remove small areas of curly leaf pondweed growth. Care must be taken to ensure that all Eurasian water milfoil plant fragments are removed from the lake. Hand pulling may also be used in Long Lake for small areas of late season curly leaf pondweed growth to prevent formation and distribution of turions.

SCUBA divers may also manually remove invasive species. Manual removal with divers is recommended if sporadic EWM growth occurs and for late season removal of curly leaf pondweed. Care will be taken to avoid exposure to algae toxins with manual removal.

Raking is recommended to clear nuisance growth if needed in riparian area corridors up to thirty feet wide (twenty-five feet wide in sensitive areas). Permits for chemical removal in front of individual properties have not been issued since 2007.

Mechanical Control

Larger-scale control efforts require more mechanization. Mechanical cutting, mechanical harvesting, diver-operated suction harvesting, and rotovating (tilling) are the most common forms of mechanical control available. WDNR permits under Chapter NR 109 are required for mechanical plant removal.

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. The cutter head uses sickles similar to those found on farm equipment, and generally cuts to depths from one to six feet. A conveyor belt on the cutter head brings the clippings onboard the machine for storage. Once full, the harvester travels to shore to discharge the load of weeds off of the vessel.

The size, and consequently the harvesting capabilities, of these machines vary greatly. As they move, harvesters cut a swath of aquatic plants that is between 4 and 20 feet wide, and can be up to 10 feet deep. The on-board storage capacity of a harvester ranges from 100 to 1,000 cubic feet (by volume) or 1 to 8 tons (by weight).

In some cases, the plants are transported to shore by the harvester itself for disposal, while in other cases, a barge is used to store and transport the plants in order to increase the efficiency of the cutting process. The plants are deposited on shore, where they can be transported to a local farm to be used as compost (the nutrient content of composted aquatic plants is comparable to that of cow manure) or to an upland landfill for proper disposal. Most harvesters can cut

[10] Information from APIS (Aquatic Plant Information System). U.S. Army Corps of Engineers. 2005. and the *Wisconsin Aquatic Plant Management Guidelines*.

between 2 and 8 acres of aquatic vegetation per day, and the average lifetime of a mechanical harvester is 10 years.

Mechanical harvesting of aquatic plants presents both positive and negative consequences to any lake. Its results—open water and accessible boat lanes—are immediate, and can be enjoyed without the restrictions on lake use which follow herbicide treatments. In addition to the human use benefits, the clearing of thick aquatic plant beds may also increase the growth and survival of some fish. By eliminating the upper canopy, harvesting reduces the shading caused by aquatic plants. The nutrients stored in the plants are also removed from the lake, and the sedimentation that would normally occur as a result of the decaying of this plant matter is prevented. Additionally, repeated treatments may result in thinner, more scattered growth.

Aside from the obvious effort and expense of harvesting aquatic plants, there are many environmentally-detrimental consequences to consider. The removal of aquatic species during harvesting is non-selective. Native and invasive species alike are removed from the target area. This loss of plants results in a subsequent loss of the functions they perform, which include sediment stabilization and wave absorption. Shoreline erosion may therefore increase. Other organisms such as fish, reptiles, and insects are often displaced or removed from the lake in the harvesting process. This may have adverse effects on these organisms' populations as well as the lake ecosystem as a whole.

While the results of harvesting aquatic plants may be short term, the negative consequences are not so short lived. Much like mowing a lawn, harvesting must be conducted numerous times throughout the growing season. Although the harvester collects most of the plants that it cuts, some plant fragments inevitably persist in the water. This may allow the invasive plant species to propagate and colonize in new, previously unaffected areas of the lake. Harvesting may also result in re-suspension of contaminated sediments and the excess nutrients they contain.

Disposal sites are a key component when considering the mechanical harvesting of aquatic plants. The sites must be on shore and upland to make sure the plants and their reproductive structures don't make their way back into the lake or to other lakes. The number of available disposal sites and their distance from the targeted harvesting areas will determine the efficiency of the operation.

Timing is also important. The ideal time to harvest, in order to maximize the efficiency of the harvester, is just before the aquatic plants break the surface of the lake. For curly leaf pondweed, it should also be before the plants form turions (reproductive structures) to avoid spreading the turions within the lake. If the harvesting is conducted too early, the plants will not be close enough to the surface, and the cutting will not do much damage to them. If too late, turions may have formed and may be spread, and there may be too much plant matter on the surface of the lake for the harvester to cut effectively. Harvesting has been used to control curly leaf pondweed with some success on nearby lakes including Big Blake Lake.[11]

If the harvesting work is contracted, the equipment should be inspected before and after it enters the lake. If these machines travel from lake to lake, they may carry plant fragments with them,

[11] Jeremy Williamson. Personal communication. 2011.

and facilitate the spread of aquatic invasive species from one body of water to another. Harvesting contractors are not readily available in northwestern Wisconsin, so harvesting contracts are likely to be very expensive. One must also consider prevailing winds, since cut vegetation can be blown into open areas of the lake or along shorelines.

Diver dredging operations use pump systems to collect plant and root biomass. The pumps are mounted on a barge or pontoon boat. The dredge hoses are from 3 to 5 inches in diameter and are handled by one diver. The hoses normally extend about 50 feet in front of the vessel. Diver dredging is especially effective against the pioneering establishment of submersed invasive plant species. When a weed is discovered in a pioneering state, this methodology can be considered. To be effective, the entire plant, including the subsurface portions, should be removed.

Plant fragments can result from diver dredging, but fragmentation is not as great a problem when infestations are small. Diver dredging operations may need to be repeated more than once to be effective. When applied to a pioneering infestation, control can be complete. However, periodic inspections of the lake should be performed to ensure that all the plants have been found and collected.

Lake substrates play an important role in the effectiveness of a diver dredging operation. Soft substrates are very easy to work in. Divers can remove the plant and root crowns with little difficulty. Hard substrates, however, pose more of a problem. Divers may need hand tools to help dig the root crowns.

Diver Assisted Suction Harvesting (DASH)
With Diver Assisted Suction Harvesting (DASH) divers hand pull aquatic invasive plants from the lake-bed. A suction line transports removed plants to the surface. This method is probably most appropriate for relatively small and less dense areas of invasive plant growth. Poor water clarity will make it more difficult to use DASH.[12]

The Tomahawk Lake Association (TLA) developed and has used a DASH system for several years, although they call their system a hydraulic conveyor system (HCS). HCS is an automated system that removes, filters, and bags harvested EWM after it has been hand harvested from the lake bed by divers. The TLA HCS includes a floating chassis, a “jet pump” water system, a three tiered separation system, and a Hookah diver air supply system.[13] Use of the TLA HCS began in the summer of 2007. A second generation HCS began operation in 2011. Capital costs for the system are just over $25,000 and annual operating costs are about $31,000. The TLA harvested about 20,000 lbs. each year through 2014. Contracted DASH systems are available. Decontamination of the system is especially important with a contracted DASH system that moves between lakes. In 2017 DASH costs in nearby lakes have been about $2,500/day. Because of the mechanical elements of the system, a WDNR aquatic plant management harvesting permit is required.

[12] Wisconsin Lakes Convention Presentation. 2016.
[13] Wisconsin Lakes Convention presentation, TLA Hydraulic Conveyor System. Ned Greedy, 2014.

Figure 21. TLA Hydraulic Conveyor System (Greedy, 2014)

Rotovation involves using large underwater rototillers to remove plant roots and other plant tissue. Rotovators can reach bottom sediments to depths of 20 feet. Rotovating may significantly affect non-target organisms and water quality as bottom sediments are disturbed. However, the suspended sediments and resulting turbidity produced by rotovation settles fairly rapidly once the tiller has passed. Tilling contaminated sediments could possibly release toxins into the water column. If there is any potential of contaminated sediments in the area, further investigation should be performed to determine the potential impacts from this type of treatment. Tillers do not operate effectively in areas with many underwater obstructions such as trees and stumps. If operations are releasing large amounts of plant material, harvesting equipment should be on hand to collect this material and transport it to shore for disposal.

Biological Control[14]

Biological control is the purposeful introduction of parasites, predators, and/or pathogenic microorganisms to reduce or suppress populations of plant or animal pests. Biological control counteracts the problems that occur when a species is introduced into a new region of the world without a complex or assemblage of organisms that feed directly upon it, attack its seeds or progeny through predation or parasitism, or cause severe or debilitating diseases. With the introduction of pests to the target invasive organism, the exotic invasive species may be maintained at lower densities.

The effectiveness of biocontrol efforts varies widely (Madsen, 2000). Beetles are commonly and successfully used to control purple loosestrife populations in Wisconsin. Weevils are used as an experimental control for Eurasian water milfoil once the plant is established. Tilapia and carp are used to control the growth of filamentous algae in ponds. Grass carp, an herbivorous fish, is sometimes used to feed on pest plant populations, but grass carp introduction is not allowed in Wisconsin.

[14] Information from APIS (Aquatic Plant Information System). U.S. Army Corps of Engineers. 2005.

Weevils[15] have potential for use as a biological control agent against Eurasian water milfoil. There are several documented "natural" declines of EWM infestations with weevil present. In these cases, EWM was not eliminated but its abundance was reduced enough so that it did not achieve dominance. These declines are attributed to an ample population of native milfoil weevils (*Euhrychiopsis lecontei*). Weevils feed on native milfoils but will shift preference over to EWM when it is present. Lakes where weevils can become an effective control have an abundance of native northern water milfoil and fairly extensive natural shoreline where the weevils can live over winter. Any control strategy for EWM that would also harm native milfoil may hinder the ability of this natural bio-control agent. Lakes with large bluegill populations are not good candidates for weevils because bluegills feed on the weevils. The presence and efficacy of stocking weevils in EWM lakes is being evaluated in Wisconsin lakes. So far, stocking weevils has not been clearly shown to be effective.

There are advantages and disadvantages to the use of biological control as part of an overall aquatic plant management program. Advantages include longer-term control relative to other technologies, lower overall costs, and plant-specific control. On the other hand there are several disadvantages to consider, including very long control times (years instead of weeks), a lack of available biological control agents for particular target species, and relatively specific environmental conditions necessary for success. Biological control is not without risks; new non-native species introduced to control a pest population may cause problems of its own.

Purple Loosestrife Biocontrol[16]

Biocontrol may be the most viable long term control method for purple loosestrife control. The WDNR and University of Wisconsin-Extension (UWEX), along with hundreds of citizen cooperators, have been introducing natural insect enemies of purple loosestrife, from its home in Europe to infested wetlands in the state since 1994. Careful research has shown that these insects are dependent on purple loosestrife and are not a threat to other plants. Insect releases monitored in Wisconsin and elsewhere have shown that these insects can effectively decrease purple loosestrife size and seed output, thus letting native plants reduce its numbers naturally through enhanced competition.

A suite of four different insect species has been released as biological control organisms for purple loosestrife in North America and Wisconsin. Two leaf beetle species called "Cella" beetles that feed primarily on shoots and leaves were the first control insects to be released in Wisconsin, and are the insects available from WDNR for citizens to propagate and release into their local wetlands. A root-mining weevil species and a type of flower-eating weevil have also been released and are slowly spreading naturally. The Purple Loosestrife Biocontrol Program offers cooperative support, including free equipment and starter beetles from WDNR and UWEX, to all state citizens who wish to use these insects to reduce their local purple loosestrife.

The length of time required for effective biological control of purple loosestrife in any particular wetland ranges from one to several years depending on such factors as site size and loosestrife

---

[15] *Control of Eurasian Water Milfoil & Large-scale Aquatic Herbicide Use*. Wisconsin Department of Natural Resources. July 2006.

[16] http://dnr.wi.gov/topic/Invasives/loosestrife.html

densities. The process offers effective and environmentally sound control of the plant, not elimination, in most cases. It is also typically best done in some combination with occasional use of more traditional control methods such as digging and herbicide use. Biocontrol with beetles is may be appropriate at some point in time should purple loosestrife become establish around Long Lake.

Re-vegetation with Native Plants

Another aspect to biological control is native aquatic plant restoration. The rationale for re-vegetation is that restoring a native plant community should be the end goal of most aquatic plant management programs (Nichols 1991; Smart and Doyle 1995). However, in communities that have only recently been invaded by non-native species, a propagule (seed) bank probably exists that will restore the community after non-native plants are controlled (Madsen, Getsinger, and Turner, 1994). Re-vegetation following plant removal may be necessary on Long Lake because there is low native plant diversity. Replacement of declining pondweed species and northern water milfoil will be considered once curly leaf pondweed populations are controlled effectively.

A pilot project to establish submergent native aquatic plants such as northern water milfoil is recommended. However, few submergent native aquatic plant species are available commercially. Sources for water celery, sago pondweed, and coontail were found. However, coontail is already very abundant in Long Lake. It may also be possible to use nearby lakes as plant sources. Techniques for establishing these include mesh bags weighted with rocks and cages around planted aquatics. The threat of algae toxins may discourage involvement in planting, and on-going herbicide control of CLP may delay plant revegetation.

Physical Control[17]

In physical management, the environment of the plants is manipulated, which in turn acts upon the plants. Several physical techniques are commonly used: dredging, drawdown, benthic (lake bottom) barriers, and shading or light attenuation. Because each involves placing a structure on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 WDNR permit would be required. Such permits are not commonly granted.

Dredging removes accumulated bottom sediments that support plant growth. Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, need deepening, or require removal of toxic substances (Peterson 1982). Lakes that are very shallow due to sedimentation tend to have excess plant growth. Dredging can form an area of the lake too deep for plants to grow, thus creating an area for open water use (Nichols 1984). By opening more diverse habitats and creating depth gradients, dredging may also create more diversity in the plant community (Nichols 1984). Results of dredging can be very long term. However, due to the cost, environmental impacts, and the problem of disposal, dredging should not be performed for aquatic plant management alone. It is best used as a lake remediation technique. Dredging is not suggested for Long Lake as part of the aquatic plant management plan.

[17] Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

Drawdown, or significantly decreasing lake water levels can be used to control nuisance plant populations. With drawdown, the water body has water removed to a given depth. It is best if this depth includes the entire depth range of the target species. Drawdowns need to be at least one month long to ensure thorough drying and effective removal of target plants (Cooke 1980a). In northern areas, a drawdown in the winter that will ensure freezing of sediments is also effective. Although drawdown may be effective for control of hydrilla for one to two years (Ludlow 1995), it is most commonly applied to Eurasian water milfoil (Geiger 1983; Siver et al. 1986) and other milfoils or submersed evergreen perennials (Tarver 1980).

Although drawdown can be inexpensive and have long-term effects (2 or more years), it also has significant environmental effects and may interfere with use and intended function (e.g., power generation or drinking water supply) of the water body during the drawdown period. Lastly, species respond in very different manners to drawdown and individual species responses can be inconsistent (Cooke 1980a). Drawdowns may provide an opportunity for the spread of highly weedy species, particularly annuals. Drawdown requires a mechanism to significantly lower water levels which Long Lake does not have.

Benthic barriers or other bottom-covering approaches are another physical management technique. The basic idea is to cover the plants with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic, and synthetic materials; sediments such as dredge sediment, sand, silt or clay; fly ash; and various combinations of the above materials (Cooke 1980b; Nichols 1974; Perkins 1984; Truelson 1984). The problem with synthetic sheeting is that the gases evolved from plant and sediment decomposition collect underneath and lift the barrier (Gunnison and Barko 1992).
The problem with using sediments is that new plants establish on top of the added layer (Engel and Nichols 1984).

Benthic barriers will typically kill the plants under them within 1 to 2 months, after which time they may be removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed will be rapidly re-colonized (Eichler et al. 1995). Synthetic barriers, if left in place for multi-year control, will eventually become sediment-covered and will allow colonization by plants. Benthic barriers may be best suited to small, high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use over widespread areas, and heavily affect benthic communities by removing fish and invertebrate habitat. A WDNR permit would be required for a benthic barrier, and these barriers are not recommended.

Shading or light attenuation reduces the amount of light plants have available for growth. Shading has been achieved by fertilization to produce algae growth, application of natural or synthetic dyes, shading fabric, or covers, and establishing shade trees (Dawson 1981, 1986; Dawson and Hallows 1983; Dawson and Kern-Hansen 1978; Jorga et al. 1982; Martin and Martin 1992; Nichols 1974). During natural or cultural eutrophication, algae growth alone can shade aquatic plants (Jones et al. 1983). Although light manipulation techniques may be useful for narrow streams or small ponds, in general these techniques are only of limited applicability. Physical control is not currently proposed for management of aquatic plants in Long Lake.

Herbicide and Algaecide Treatments

Herbicides are chemicals used to kill plant tissue. Currently, no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability, or persistence in the environment (Joyce, 1991). Thus, there are a limited number of active ingredients that are assured to be safe for aquatic use (Madsen, 2000).

An important caveat is that these products are considered safe when used according to the label. The U.S. Environmental Protection Agency (EPA)-approved label gives guidelines protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. WDNR permits under Chapter NR 107 are required for herbicide application.

General descriptions of herbicide classes are included below.[18]

Contact herbicides

Contact herbicides act quickly and are generally lethal to all plant cells they contact. Because of this rapid action, or other physiological reasons, they do not move extensively within the plant and are effective only where they contact plants directly. They are generally more effective on annuals (plants that complete their life cycle in a single year). Perennial plants (plants that persist from year to year) can be defoliated by contact herbicides, but they quickly resprout from unaffected plant parts. Submersed aquatic plants that are in contact with sufficient concentrations of the herbicide in the water for long enough periods of time are affected, but regrowth occurs from unaffected plant parts, especially plant parts that are protected beneath the sediment. Because the entire plant is not killed by contact herbicides, retreatment is necessary, sometimes two or three times per year. **Endothall, diquat,** and **copper** are contact aquatic herbicides.

Systemic herbicides

Systemic herbicides are absorbed into the living portion of the plant and move within the plant. Different systemic herbicides are absorbed to varying degrees by different plant parts. Systemic herbicides that are absorbed by plant roots are referred to as soil active herbicides and those that are absorbed by leaves are referred to as foliar active herbicides. **2,4-D, dichlobenil, fluridone, and glyphosate** are systemic aquatic herbicides. When applied correctly, systemic herbicides act slowly in comparison to contact herbicides. They must move to the part of the plant where their site of action is. Systemic herbicides are generally more effective for controlling perennial and woody plants than contact herbicides. Systemic herbicides also generally have more selectivity than contact herbicides.

Broad spectrum herbicides

Broad spectrum (sometimes referred to as nonselective) herbicides are those that are used to control all or most species of vegetation. This type of herbicide is often used for total vegetation control in areas such as equipment yards and substations where bare ground is preferred. **Glyphosate** is an example of a broad spectrum aquatic herbicide. **Diquat, endothall, and**

[18] This discussion is taken from: *Managing Lakes and Reservoirs*. North American Lake Management Society.

fluridone are used as broad spectrum aquatic herbicides, but can also be used selectively under certain circumstances.

Selective herbicides

Selective herbicides are those that are used to control certain plants but not others. Herbicide selectivity is based upon the relative susceptibility or response of a plant to an herbicide. Many related physical and biological factors can contribute to a plant's susceptibility to an herbicide. Physical factors that contribute to selectivity include herbicide placement, formulation, timing, and rate of application. Biological factors that affect herbicide selectivity include physiological factors, morphological factors, and stage of plant growth.

Environmental considerations

Aquatic communities consist of aquatic plants including macrophytes (large plants) and phytoplankton (free floating algae), invertebrate animals (such as insects and clams), fish, birds, and mammals (such as muskrats and otters). All of these organisms are interrelated in the community. Organisms in the community require a certain set of physical and chemical conditions to exist such as nutrient requirements, oxygen, light, and space. Aquatic weed control operations can affect one or more of the organisms in the community, and in turn affect other organisms or weed control operations. These operations can also impact water chemistry which may result in further implications for aquatic organisms.

Table 5. Herbicides Used to Manage Aquatic Plants

Brand Name(s)	Chemical	Target Plants
Cutrine Plus, $CuSO_4$, Captain, Navigate, Komeen	Copper compounds	Filamentous algae, coontail, wild celery, elodea, and pondweeds
Reward	Diquat	Coontail, duckweed, elodea, water milfoil, and pondweeds
Aquathol, Aquathol K, Aquathol Super K, Hydrothol 191	Endothall	Coontail, water milfoil, pondweeds, and wild celery as well as other submersed weeds and algae
Rodeo	Glyphosate	Cattails, grasses, bulrushes, purple loosestrife, and water lilies
Navigate, Aqua-Kleen, DMA 4 IVM, Weed-Rhap	2, 4-D	Water milfoils, water lilies, and bladderwort

General descriptions of the breakdown of commonly used aquatic herbicides are included below.[19]

Copper

Copper-based compounds are generally used to treat filamentous algae. Common chemicals used are copper sulfate and Cutrine Plus, a chelated copper algaecide.

Copper is a naturally occurring element that is essential at low concentrations for plant growth. It does not break down in the environment, but it forms insoluble compounds with other elements and is bound to charged particles in the water. It rapidly disappears from water after application as an herbicide. Because it is not broken down, it can accumulate in bottom sediments after repeated or high rates of application.

Copper can be toxic to aquatic life at elevated concentrations (United States Environmental Protection Agency, June 2008). A study completed by MacDonald et al. (2000) developed consensus based numerical sediment quality guidelines for metals in freshwater ecosystems. This study provides guidelines for metals in freshwater ecosystems that reflect threshold effect concentrations (TECs, below which harmful effects are unlikely to be observed) and **probable effect concentrations (PECs, above which harmful effects are likely to be observed).** The consensus based TEC for copper is 31.6 mg/kg and the consensus based PEC for copper is 149 mg/kg.

The sediments of Long Lake exceed the PEC for copper at all five sampling sites. The sediments at site 4, located at the southeast end of the lake, are nearly twice the PEC for copper. The copper concentrations in the sediments of Long Lake are likely causing harmful effects to the ecosystem. Adverse biological effects can include decreased benthic invertebrate diversity, reduced abundance, increased mortality, and behavioral changes. (Polk LWRD, 2013)

[19] These descriptions are taken from Hoyer/Canfield: *Aquatic Plant Management*. North American Lake Management Society. 1997.

2,4-D
2,4-D photodegrades on leaf surfaces after being applied to leaves, and is broken down by microbial degradation in water and in sediments. Complete decomposition usually takes about 3 weeks in water but can be as short as 1 week. 2,4-D breaks down into naturally occurring compounds.

Recent WDNR studies contradict the above information. Under certain conditions, residual concentrations of 2,4-D above 100 ug/L may be present well past label irrigation restriction guidelines of 21 days. Degradation takes longer in some lakes:

- Oligotrophic (low-nutrient) lakes
- Low alkalinity lakes
- Lakes with no history of herbicide usage
- When water temperatures are cool. (WDNR 2011)

A study in Tomahawk Lake in Bayfield County, Wisconsin illustrated a very slow breakdown time of 2,4-D. Following a whole lake treatment of .5 mg/L 2,4-D, the chemical was still present 160 days after treatment. While there was successful removal of the target plant, Eurasian water milfoil, there were also significant declines in native plant biomass. A potential explanation was the low nutrient conditions in Lake Tomahawk which was described as an oligo-mesotrophic lake. (Nault 2010, Toshner 2010)

Granular formulations of 2,4-D and other herbicides dissipate at about the same rate as liquid formulations of herbicides (WDNR 2011)

Some recent studies indicate a need to consider the long-term effects of 2,4-D use. One is the effect on the endocrine system and reproduction of fat head minnows (DeQuattro, 2015). There is also some evidence that hybrid EWM can acquire resistance to 2,4-D (LaRue et al, 2013).

Diquat
When applied to enclosed ponds for submersed weed control, diquat is rarely found longer than 10 days after application and is often below detection levels 3 days after application. The most important reason for the rapid disappearance of diquat from water is that it is rapidly taken up by aquatic vegetation and bound tightly to particles in the water and bottom sediments. When bound to certain types of clay particles, diquat is not biologically available. When diquat is bound to organic matter, it can be slowly degraded by microorganisms. When diquat is applied foliarly, it is degraded to some extent on the leaf surfaces by photodegradation. Because it is bound in the plant tissue, a proportion is probably degraded by microorganisms as the plant tissue decays.

Endothall
Like 2,4-D, endothall is rapidly and completely broken down into naturally occurring compounds by microorganisms. The by-products of endothall dissipation are carbon dioxide and water. Complete breakdown usually occurs in about 2 weeks in water and 1 week in bottom sediments.

Fluridone
Dissipation of fluridone from water occurs mainly by photodegradation. Metabolism by tolerant organisms and microbial breakdown also occurs, and microbial breakdown is probably the most important method of breakdown in bottom sediments. The rate of breakdown of fluridone is variable and may be related to time of application. Applications made in the fall or winter, when the sun's rays are less direct and days are shorter, result in longer half-lives. Fluridone usually disappears from pondwater after about 3 months but can remain up to 9 months. It may remain in bottom sediment between 4 months and 1 year.

Glyphosate
Glyphosate is not applied directly to water for weed control, but when it does enter the water it is bound tightly to dissolved and suspended particles and to bottom sediments and becomes inactive. Glyphosate is broken down into carbon dioxide, water, nitrogen, and phosphorus over a period of several months.

Herbicide Used to Manage Invasive Species

Eurasian Water Milfoil
The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies the following herbicides for control of Eurasian water milfoil (EWM): 2,4-D, diquat, endothall, fluridone, and triclopyr.[20] All of these herbicides with the exception of diquat are available in both granular and liquid formulations. It is possible to target invasive species by using the appropriate herbicide and timing of application. Diquat is used infrequently in Wisconsin because it is nonspecific.[21]

The herbicide 2,4-D is most commonly used to treat EWM in Wisconsin. This herbicide kills dicots including native aquatic species such as northern water milfoil, coontail, water lilies, spatterdock, and watershield. A project in Bayfield County on Lake Tomahawk also found unexpected impacts on pondweeds which are monocots.[22] Early season (April to May) treatment of Eurasian water milfoil is recommended to limit the impact on native aquatic plant populations because EWM tends to grow before native aquatic plants.

Wisconsin DNR research indicates that larger scale treatments seem to have more consistent reduction from herbicide use than smaller treatments. These results are based upon data collection in many Wisconsin lakes where herbicides were used for EWM control. (Nault et al, 2015)

Herbicides can dissipate off of a small treatment site very rapidly. 2,4-D dissipated rapidly after it was applied to 98 small (0.1-10 acre) treatment areas across 22 study lakes with application rates of 2-4 ppm. The following results were found:

---

[20] Additional information provided by John Skogerboe, Army Corps of Engineers, personal communication. February 14, 2008.
[21] Frank Koshere. Wisconsin DNR. email communication. 3/03/10.
[22] Nault 2010.

- Initial 2,4-D concentrations detected in the water column were well below application targets.
- Herbicide moved quickly away from treatment sites within a few hours after treatment.
- The rapid dissipation of herbicide indicates that the concentrations in target areas may be lower than what is needed for effective EWM control. (Nault 2012)

Curly Leaf Pondweed

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies three herbicides for control of curly leaf pondweed: diquat, endothall, and fluridone. Fluridone requires exposure of 30 to 60 days making it infeasible to target a discreet area in a lake system. The other herbicides act more rapidly. Herbicide labels provide water use restriction following treatment. Diquat (Reward) has the following use restrictions: drinking water 1-3 days, swimming and fish consumption 0 days. Endothall (Aquathol K) has the following use restrictions: drinking water 7 – 25 days, swimming 0 days, fish consumption 3 days.

Studies have demonstrated that curly leaf pondweed can be controlled with Aquathol K (a formulation of endothall) in 50 to 60 degree F water, and that treatments of CLP this early in its life cycle can prevent turion formation.[23] Since curly leaf pondweed is actively growing at these low water temperatures and many native aquatic plants are still dormant, early season treatment selectively targets curly leaf pondweed. Staff from the Minnesota Department of Natural Resources and the U.S Army Engineer Research and Development Center have conducted trials of this method. These methods are accepted as standard operating procedures being approved in Wisconsin for aquatic invasive species control projects.[24]

Because the dosage is at lower rates than the dosage recommended on the label, a greater herbicide residence time is necessary. To prevent drift of herbicide and allow greater contact time, application in shallow bays is likely to be most effective. Herbicide applied to a narrow band of vegetation along the shoreline is likely to drift, rapidly decrease in concentration, and be rendered ineffective.[25] Steep drop-off, high winds, and other factors that increase herbicide dilution and contact time can decrease treatment effectiveness.[26] Early season treatment similar to that described above can be used to treat corridors for navigation purposes. Because of potential for drift, a higher concentration of endothall is generally used in navigation corridors.

Efforts are also made to treat as early in the season as possible and to absolutely not treat when temperatures reach 60 degrees F. Lake volunteers help to ensure that specified treatment conditions are followed. Because CLP is a monocot like many other aquatic plants, it is not possible to target its control later in the season when many other native plants are growing.

---

[23] *Research in Minnesota on Control of Curly Leaf Pondweed.* Wendy Crowell, Minnesota Department of Natural Resources. Spring 2002.

[24] Plan comments, Frank Koshere, September 16, 2010.

[25] Personal communication, Frank Koshere. March 2005.

[26] *Draft Report Following April 2008 Aquatic Herbicide Treatments of Three Bays on Lake Minnetonka*. Skogerboe, John. US Army Engineer Research and Development Center.

Long Lake Curly Leaf Pondweed Management

Curly leaf pondweed beds were estimated to cover 97 acres or 75 percent of the littoral zone and 35 percent of the lake in 2007. This coverage was estimated to contribute 32 percent of the annual total phosphorus budget (Barr 2007). However, the recently updated lake management plan (Polk County LWRD 2013) suggests the 2007 contribution would have been closer to 5 percent because not all of the phosphorus is available for algae growth. In any case, CLP dieback contributes phosphorus to the lake at a time when temperatures support algae growth.

The 2007 Long Lake Aquatic Plant Management Plan recommended an early season endothall treatment for curly leaf pondweed throughout the littoral zone using a low dose of 1 to 1.5 mg/L (Barr 2007). The ultimate goal was to reduce CLP coverage to less than 10 acres. Full scale treatments were delayed because of lack of sufficient grant or district funding in 2008 and 2009. In 2008 and 2009, the northwest and southeast bays were treated. Early season CLP endothall treatments also occurred prior to the 2007 plan approval. In 2004 and 2005 there was a total of 17 acres treated along shorelines of Long Lake.

A more comprehensive treatment program began in 2010. Treatment acreages and results are shown in Table 6. Because of the high percentage of the littoral zone to be treated, extensive monitoring was required: one survey prior to treatment and two whole-lake surveys following treatment each year. Monitoring requirements (required by WDNR permits) have decreased in subsequent years. Early season herbicide treatment of CLP was continued with more specific objectives in the 2012 APM Plan. Little or no decline in native plants has been found following CLP treatment.

Table 6. Long Lake CLP Treatment Results (2010-2015)[27]

Year	Acres [28]	Lake-wide CLP freq.	Pre-treat freq.[29]	Post/treat freq.	Turions /yd^2	Cost	Cost/acre (permit and herb.)[30]	Monitoring (pre/post, turions)
2010	65.0	19.9%			NA	$38,500	$592	$1,200
2011	56.5	14.6%	54.8%	1.4%	NA	$38,304	$678	$3,855
2012	58.0	13.7%	43%	1.7%	19.66	$39,905	$688	$5,555
2013	26.6	4.2% (est)[31]	31.9%	1.9%	13.44	$29,711	$1,117	$4,275
2014	**20.1**	1.4% (est)[32]	**7.9%**	7.2%	14.16	$24,466	$1,217	$3,800
2015	43	NA	45%	NA	40.08	NA	NA	$1,950
2016	35	7% (est.)	68.1%	0.9%	NA	$33,925	$944	NA

27 Data from Endangered Resource Services Monitoring Reports.
28 CLP treatment beds are delineated as any areas where significant CLP was present. (APM plan 2012).
29 Frequency is within treatment beds only.
30 Note that cost increases may be due to increased concentration of chemical and depth of treatment area.
31 Plus 7% of exploratory points.
32 Plus 5.2% of exploratory points.

The curly leaf pondweed early season treatment program has been successful on Long Lake. From 2010 – 2014, CLP beds have been delineated and treated where "any significant CLP is present." **Based on this definition, CLP beds had declined from 65 acres in 2010 to 20 acres in 2014. The frequency of CLP within the beds had also declined. This nearly reached the objective established in the 2012 plan – to less than 20 acres of CLP in beds.** Turion monitoring results indicated that CLP frequency was likely to continue to be low in 2015.

As a result of previous treatment success (measured by declining CLP beds and frequency) and an indication that 2015 growth would be low (low turion density), CLP treatment was suspended in 2015. Lack of herbicide effectiveness in 2014 was also noted. A preliminary hypothesis was that previous spot treatments were large enough to effectively provide a whole-lake effect. This was evidenced by control of CLP beyond the treatment area. The 20-acre treatment in 2014 did not have the same effect. There was no significant reduction of CLP frequency even with the treated CLP beds.

Treatment resumed in 2016 using the guidelines established late in 2014. With an established maximum of 35 acres, the board selected beds to be treated. There was a 68% frequency of CLP in selected beds prior to treatment and a 1% frequency post treatment. A lakewide effect was observed with the same low frequency in untreated areas. Further, the only native species that demonstrated any decline posttreatment was northern water-milfoil, and surprisingly, this decline was more pronounced in untreated areas. Based on these data that show the overall effectiveness of the treatment at controlling CLP while simultaneously having minimal impact on native species, 2016 appears to have been highly successful at meeting the LLPRD's stated goals for managing CLP. (Berg 2016)

CLP Treatment Guidelines: Results of December 2014 Advisory Committee/Board Meeting Affirmed, Board Meeting 8/25/15.

No CLP Treatment in 2015

Monitoring to be continued: CLP exploratory survey, sediment turion monitoring

Treatment to resume if certain thresholds are reached:

CLP Frequency: 30% or greater for each bed
Sediment Turion Density: >50 turions/yd^2 (per bed), >20 turions/yd^2 (mean over all beds)

<u>Treatment Area Guideline</u>
Based on past results, the target <u>minimum</u> treatment area for each bed will be 5 acres and target <u>minimum</u> total treatment area will be 25 acres. Treatment of individual, narrow beds smaller than 5 acres, especially near where depth drops off rapidly, will be avoided due to lack of past treatment success.

<u>Treatment Concentration Guideline</u>
<40 acre feet 2.5 ppm endothall as Aquathol K or equivalent
>40 acre feet 2.0 ppm endothall as Aquathol K or equivalent

Curly Leaf Pondweed 2017 Treatment

An early season CLP treatment was completed in 2017 with treatment areas based on 2016 areas. Treatment areas for 2016 are shown in Figure 22, and turions surveyed following the 2016 treatment are shown in Figure 23 and Table 7.

The LLPRD received an aquatic invasive species control grant to pay for 50 percent of the cost of the 2017 treatment and associated permitting and monitoring expenses. A long-term treatment strategy is part of this aquatic plant management plan.

Fall sediment turion monitoring began in 2012. Numbers of turions/yard in the sediment provides an indication of potential CLP growth in subsequent seasons.

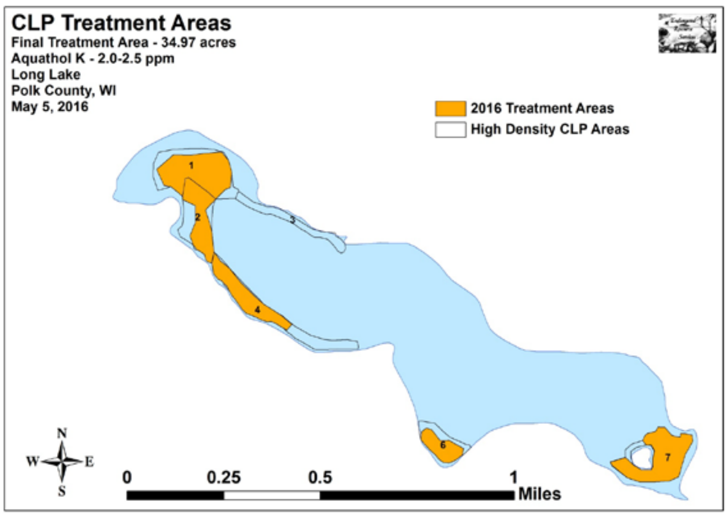


Figure 22. Curly Leaf Pondweed Treatment Areas 2016

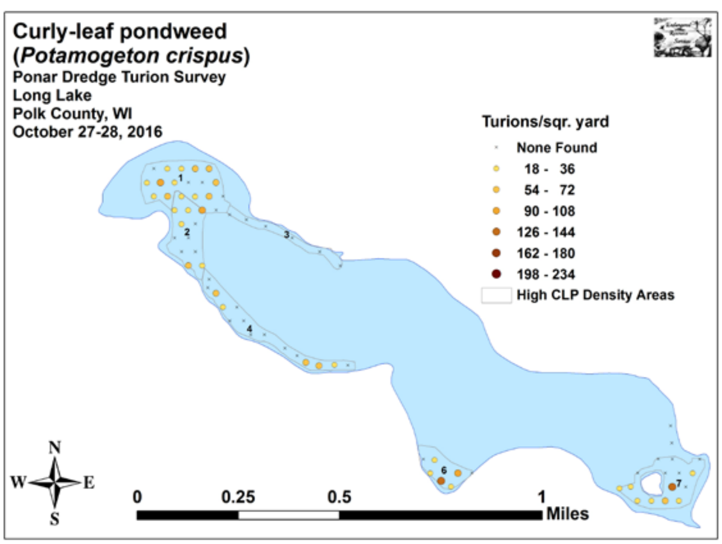


Figure 23. Sediment Turions in CLP Beds Fall 2016

Table 7. Sediment Turions in CLP Beds Fall 2016

Polygon Number	Points Surveyed	Points with Live Turions	Total Live Turions	Est. Mean Turions/yd^2
1	17	12	28	29.65
2	12	7	15	22.50
3	6	0	0	0.00
4	15	5	12	14.40
6	8	5	16	36.00
7	17	8	18	19.06
Total	**75**	**37**	**89**	**21.36**

Past Aquatic Plant Management[33]

The DNR reports that Long Lake has a history as one of the most chemically treated lakes in the state for aquatic plant management.[34] Algae and aquatic plant treatments occurred in channels from 50 to 150 feet wide along much of the lake shoreline. The northwest and southeast bays tended to have narrower, 25 foot wide channels. The overall acreage and frequency of algae treatments decreased over the years as shown in Table 8. From 1959 through 1981 chemical treatment for algae control included literally tons of sodium arsenite and copper sulfate generally used to treat about 80 acres of the lake. From 1983 to 2002 frequent algae treatments covered from 19 to 59 acres.

Herbicides were used to treat 5-13 acres of aquatic plants from 1959-1982. DNR treatment records reviewed from 1983-2002 also show regular herbicide treatments for aquatic plants (20-30 acres, 4 to 6 times per year). A wide variety of herbicides were used over the years including endothall, 2,4-D, glyphosate, and diquat (with various trade names).

Table 8. Algae Treatment along Lake Shoreline

Years	Chemicals Used	Area Generally Treated/Permitted	Frequency Annually (when known)
1959 - 1981	Sodium arsenite Copper sulfate	80 acres	Up to 9 times
1982 - 1987	Copper sulfate	53 – 58 acres	6 – 14 times
1988 - 2002	Copper sulfate	19 – 22 acres	5 – 10 times (8.6 ave.)
2003 - 2007	Copper sulfate Cutrine plus	3 – 9 acres	Up to 6 times

[33] Information from Wisconsin Department of Natural Resources Files. Spooner Office.
[34] Nonpoint Source Control Plan for the Balsam Branch Priority Watershed Project. DNR. 1995.

Table 9. Aquatic Plant Treatment in Navigation Channels

Year	Total Area Permitted	Frequency (when known)
1959 - 1981	5-13 acres	2-6 times
1982 - 1984	29.7 acres	4 times
1985 - 1988	20.7 acres (6,000 ft. by 150 ft.)	4 -5 times
1989 - 1993	19.15 acres	3-8 times
1994 - 2003	22 acres	1-10 times (5.5 ave.)
2004 - 2007	17-20 acres	1-7 times (4.25 ave.)

Table 10. Aquatic Plant Contractors

Names	Years (when known)
The Lake Biologist, Inc.	1977-1978
Lindberg Aquatic Services	1979-1981, 1985-1987
Aquatic Nuisance Control	1989, 1993-1994
Lake Management, Inc.	1998-2003
Aquatic Engineering	2004-2005
Northern Aquatic Service	2005-2011

The DNR Northern Region released an Aquatic Plant Management Strategy (Appendix C) in the summer of 2007 to protect the important functions of aquatic plants in lakes. As part of this strategy, the DNR prohibited management of native aquatic plants in front of individual lake properties after 2008 unless management is designated in an approved aquatic plant management plan.[35] Because of the importance of the native plant population for habitat, protection against erosion, and as a guard against invasive species infestation, plant removal with herbicides as an option for individual property owners must be carefully reviewed before permits are issued. The DNR will not allow removal after January 1, 2009 unless the "impairment of navigation" and/or "nuisance" conditions are clearly documented.

Common and Individual Corridor Management

The 2007 plan indicates that treatment of native species will be restricted to areas with impairment of navigation and nuisance conditions. It also indicates that owner requests for plant control would be coordinated with the district plan. No herbicide records for late season treatment of native plants for navigation channels were found after 2007. Plant surveyor, Matt Berg, noted that it was a nearly solid bed of coontail that made July navigation difficult southeast of the island in 2011.[36]

Common navigation channels will not be pursued for this plan update. Areas of the lake which are not navigable with heavy plant growth (NW and SE bays) are also very shallow and are designated sensitive areas. These sensitive areas are important brooding areas for fish. Plants hold sediments in place. The LLPRD does not want to encourage boating in shallow waters where sediments can be stirred up. Shallow water makes boating impractical.

[35] Aquatic Plant Management Strategy. DNR Northern Region. Summer 2007.
[36] Berg. 2011. Pg. 16.

The plan will allow for maintenance of individual corridors. This means that individuals will be able to pursue permits to maintain an opening of up to 30 feet around their docks (25 feet in sensitive areas). Aquatic herbicides can only be applied by licensed applicators, and a DNR permit is always required. Permits are issued only where navigation is severely impaired. The LLPRD will review navigation impairment to consider these permits on the lake. The LLPRD will not pay the cost of individual permits and herbicide applications. Instead, owners will cover the cost. Owners (or someone they hire) are allowed to clear up to a 30 foot opening in front of their property using hand methods. In designated sensitive areas this opening is limited to 25 feet. A map of sensitive areas is shown in Figure 11. This does not include use of any mechanical means such as boats, ATVs, or mowers. Mechanical control requires a DNR permit.

Preventing Invasive Species

There are five major elements the LLPRD and others can consider to prevent invasive species introduction: education to lake users, Clean Boats Clean Waters program, landing surveillance cameras, lake monitoring, and a rapid response strategy for any new invasive species.

Education to Lake Users

Education efforts focus on identification and prevention of new invasive species. Activities might include aquatic invasive species (AIS) information presented at annual meetings and workshops, signage at the public landings, lake maps and brochures with AIS messages, and web site and newsletter information.

The LLPRD currently distributes information through its website www.longlakepolk.com. This is a private website which requires a requested access. A LLPRD newsletter is usually distributed in early to mid-April each year.

Clean Boats Clean Waters (CBCW) Program

Clean Boats Clean Waters educators provide boaters with information on the threat posed by Eurasian Milfoil and other invasive species. They offer tips on how to keep boats, trailers, and equipment free of aquatic hitchhikers. They also collect information on boater behavior, concerns, and knowledge of existing local and state laws related to anti-AIS measures.

Long Lake has had a CBCW program since 2013. Hours of coverage at the main landing are shown in Figure 24. Polk County Land and Water Resources Department provides training for paid staff or volunteers to staff landings and educate boaters. A WDNR Clean Boats, Clean Waters grant can currently provide 75% funding up to $4,000 as long as a minimum of 200 hours are covered at the landings.

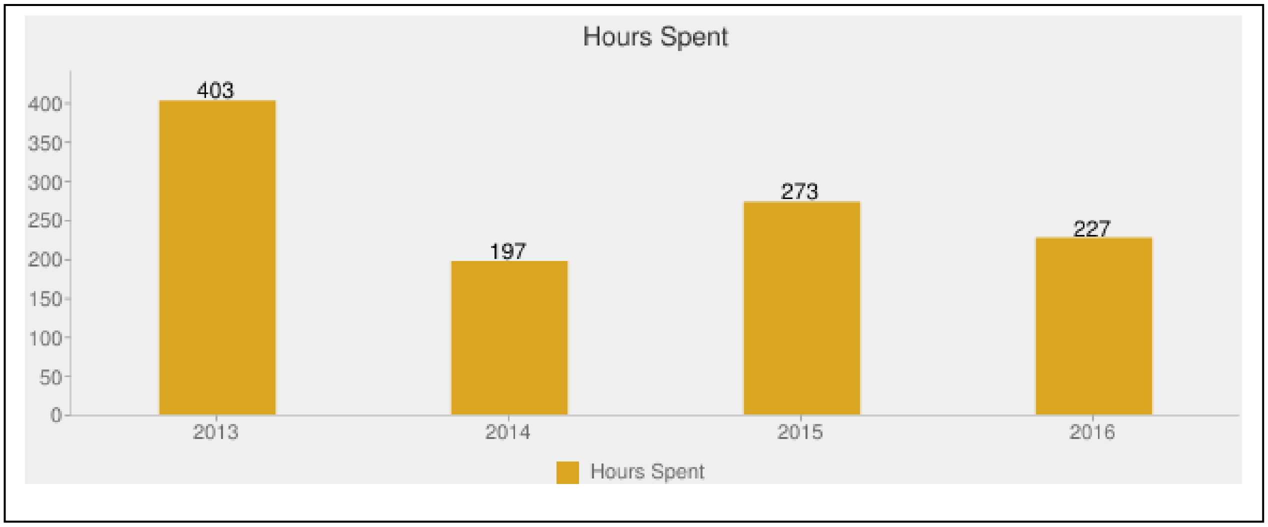


Figure 24. Clean Boats, Clean Waters Staffing on Long Lake 2013-2016

Landing Surveillance Cameras
Some lake organizations use video cameras at public landings to record landing activity. Videos are reviewed, and if watercraft are launched with vegetation attached, action is taken. Violations of the ordinance and state rule which prohibits transporting and launching boats and trailers with vegetation attached can be enforced by local law enforcement officers. The camera also serves as a reminder for boaters to check their equipment. Surveillance cameras are in place at Bone Lake and Church Pine Lake in Polk County. WDNR AIS Education, Prevention and Planning grants can be used to support camera installation (up to $4,000 in grant funds for each). Maintenance and video/photo review are not grant-eligible expenses.

Boat Washing/Decontamination
A boat decontamination unit is offered on a trial basis by the Wisconsin Department of Natural Resources Water Guard. Decontamination units are used for washing boats. The LLPRD could consider requesting the WDNR water guard decontamination unit or purchasing its own equipment for decontamination.

Lake Monitoring
The objective of lake monitoring is to look for new invasive species. Monitoring for invasive species is generally focused around boat landings and other areas of high public use. Trained volunteers or consultants may complete the monitoring. Divers may be used. It is critical to complete aquatic invasive species visual surveys when algae growth is low and visibility is good.

Rapid Response for New Invasive Species
The activity is intended to control any new invasive species that are found in the lake. Rapid response protocols include the following:

- monitoring for invasive species
- education of lake residents and visitors
- contacts to confirm invasive species identification
- procedures for notification
- plans for removal and control
- funding contingencies and grants.

Invasive species information is available on the DNR website http:/dnr.wi.gov/invasives.

A rapid response protocol is included as Appendix E.

Plan Goals and Strategies

This section of the plan lists goals and objectives for aquatic plant management for Long Lake. It also presents a strategy of actions that will be used to reach aquatic plant management plan goals.

Goals are broad statements of direction.

Objectives are measurable steps toward the goal.

Actions are the activities to accomplish objectives.

The **Implementation Plan** outlines a timeline, resources needed, partners, and funding sources for each action item.

Education of lake residents and anglers who visit the lake is important to each of the Aquatic Plant Management Plan goals. An education and information plan is also included in this section.

Plan Goals

1) Improve water quality and clarity.

2) Protect and restore healthy rooted native aquatic plant communities.

3) Balance recreation and waterfront owner needs with protection of native plants and the fishery.

4) Prevent the introduction of Eurasian water milfoil, zebra mussels, and other aquatic invasive species.

5) Rapidly respond to eliminate any newly introduced aquatic invasive species.

Responsible Parties for APM Implementation and Monitoring

Long Lake Protection and Rehabilitation (LLPRD) Board – elected representatives responsible for oversight of lake management district. Some actions such as hiring a contractor or consultant require a vote of the board.

APM Lead – directs contractors in herbicide treatments and related monitoring.

AIS Lead – leads and coordinates volunteer AIS education activities including Clean Boats, Clean Waters monitoring and education at the boat landings and lake monitoring.

Herbicide Contractor – the herbicide applicator hired by the LLPRD Board to complete herbicide treatment as permitted by the Wisconsin Department of Natural Resources.

APM Monitor– a consultant hired to complete monitoring under the direction of the APM Lead and the LLPRD Board.

Planning Consultant – facilitates discussion regarding aquatic plant management options and implementation and writes grants to assist with plan implementation.

WDNR – APM staff will review aquatic plant management permit applications and enforce permit conditions.

Polk County LWRD – Staff from the Polk County Land and Water Resources Department assist with education and plant identification.

Goal 1. Improve water quality and clarity.

Objectives

- Reduce phosphorus loading from curly leaf pondweed by reducing beds to less than 20 acres and preventing CLP spread.

- Increase native aquatic plant rooting depth.

RESULTS	2012	2016
Maximum depth of plants (ft)	10.5	15.0
Mean depth of plants (ft)	4.3	5.6
Median depth of plants (ft)	4.0	4.5

Discussion

An alum treatment is a key activity in the 2017 lake management plan addendum. Significantly improved water clarity is predicted to result from the alum treatment. Improved water clarity generally results in increased native plant rooting depth.

Actions

1. Continue early season curly leaf pondweed treatment using a low-dose endothall application according to treatment thresholds outlined below.
   - Apply for APM permit (APM Lead with assistance from Planning Consultant and APM Monitor)
   - Identify treatment areas with pre-monitoring in April or May. CLP treatment beds are delineated as any areas where CLP is present in frequency of occurrence >30%. (APM Monitor, Planning Consultant, and APM Lead)
   - Complete early season herbicide treatment

2. Complete CLP pre and post monitoring as required by the Department of Natural Resources.

3. Conduct annual monitoring of sediment CLP turions in the fall.

4. Consider removing late season (June – August) curly leaf pondweed growth by encouraging hand-pulling by residents or hiring SCUBA divers when water quality allows.

Curly Leaf Pondweed Treatment Thresholds*

25 - acre minimum overall treatment area, minimum 5-acres/bed

>30% Frequency of Occurrence within treatment beds

Suspend treatment until CLP in beds reaches 25 acres

Use sediment turions to forecast following year treatment. Guideline (may be updated): Sediment Turion Density: >50 turions/yd^2 (per bed), >20 turions/yd^2 (mean over all beds)

*Adaptive management will be employed; treatment thresholds may be modified with experience.

Goal 2. Protect and restore healthy rooted native aquatic plant communities.

Objectives

- Restore the lake's ecosystem by promoting the replacement of curly leaf pondweed with native aquatic plants.
- Maintain native aquatic plant functions including stabilizing sediments, reducing erosion, using nutrients, and providing habitat.

Discussion

Native plants play a critical role in the lake ecosystem, and removing native plants can lead to adverse effects on the lake. Rooted aquatic plants in the lake stabilize bottom sediments and prevent re-suspension of nutrients. This is especially important in mucky, shallow areas – characteristic of much of the area where plants grow in Long Lake. Emergent plants with stems reaching above the water level protect against shoreline erosion. All types of aquatic plants provide habitat for fish and other aquatic creatures. Healthy native plant populations prevent colonization by invasive plants such as Eurasian water milfoil. Erosion and runoff from waterfront property may alter sediment characteristics and encourage spread of invasive plants. Boating disturbance near the shoreline can remove aquatic plants and the valuable functions they provide.

Actions

1. Assess impacts of early season curly leaf pondweed herbicide treatments to native plants through extensive pre and post monitoring (covered in Goal 1).

2. Consider completing a small scale pilot project to re-introduce native plants to the lake. Wild celery and northern water milfoil are possibilities.

3. Educate lake residents about the values of native aquatic plants. (More information in Goal 5 discussion).

Goal 3. Balance recreation and waterfront owner needs with protection of native plants and the fishery.

Objectives

- Avoid disturbing shallow water spawning beds with chemical treatments.
- Avoid plant removal in areas of shallow water.
- Minimize curly leaf pondweed growth to allow for navigation (actions covered in Goal 1).
- Allow owners to maintain individual access corridors to their properties by manual or chemical means as permitted by state regulations.

Actions

1. Support individual corridor management through LLPRD verification of nuisance plant conditions and navigation impairment.

Discussion: Protecting Fish Habitat
Common navigation channels will not be pursued. Areas of the lake which are not navigable with heavy plant growth (NW and SE bays) are also very shallow and are designated sensitive areas. These sensitive areas are important brooding areas for fish. Plants hold sediments in place. The LLPRD does not want to encourage boating in shallow waters where sediments can be stirred up. Shallow water makes boating impractical.

Discussion: Individual Access Corridors
The only time a permit is not required to control aquatic plants is when a waterfront property owner manually removes (i.e., hand-pulls or hand rakes), or gives permission to someone to manually remove, plants (except wild rice) from his/her shoreline in an area that is 30 feet or less in width along the shore and is not within a designated sensitive area. In sensitive areas the opening is limited to 25 feet. The non-native invasive plants (Eurasian water milfoil, curly leaf pondweed, and purple loosestrife) may be manually removed beyond 30 feet without a permit, as long as native plants are not harmed. Wild rice removal always requires a permit. Raked plants must be removed from the lake.

> **Individual Access Corridors** are the openings from a waterfront property owner's shoreline out into the lake. These corridors may be a maximum of thirty feet wide and must remain in the same location from year to year. Herbicide treatment or harvesting may be authorized only with a permit from the Wisconsin Department of Natural Resources for individual corridors in front of waterfront property to control invasive or native plants.

<u>Invasive Plant Control for Individual Corridors</u>
Currently the only invasive aquatic plant prevalent in Long Lake is curly leaf pondweed. Curly leaf pondweed grows early in the summer, then dies back by early July. Nuisance conditions must be verified for herbicide treatment. Curly leaf pondweed beds in the lake are currently mapped and treated. In years when curly leaf pondweed beds are treated, there is no

need for individual corridor treatment of this plant. If lake-wide treatment is suspended for the year, the most recent curly leaf pondweed bed map (indicates >30% frequency of occurrence) may be used to verify nuisance conditions for the following year's treatment. An aquatic plant management permit is required each year.

The LLPRD will inform waterfront property owners of the process and limits of individual corridor access management options.

Procedure for Individual Corridor Permitting and Monitoring
A WDNR permit is required for any use of herbicides in the water.

<u>Document nuisance conditions (landowner/ herbicide contractor provide in permit application in February/March)</u>

- Indicate when plants cause problems and how long problems persist.
- Include dated photos of nuisance conditions from previous season (or location relative to curly leaf pondweed bed map).
- List depth at end of dock.
- Provide examples of specific activities that are limited because of presence of nuisance aquatic plants.
- Describe practical alternatives to herbicide use or harvesting that were considered. These might include:
  - Hand removal/hand raking of aquatic plants
  - Extending dock to greater depth
  - Altering the route to and from the dock
  - Use of another type of watercraft or motor, i.e., is the type of watercraft used common to other sites with similar conditions on this lake?
- Herbicide use in areas with wild rice will not be permitted. Wild rice is not known to be present in Long Lake.
- Aquatic Herbicide Contractor to provide this information in permit application based on information from the landowner.

<u>Verify/refute nuisance conditions and/or navigation impairment</u>

- Landowners will document conditions with photographs and submit request for review by the APM Lead or designee.
- Landowner requests LLPRD APM Lead review of their property prior to submitting a permit application to DNR.
- The APM Lead or designee visits site, reviews documentation and provides a written opinion of navigation impairment i.e., is herbicide treatment potentially warranted?
- Landowner/applicator applies for permit to WDNR including photographic documentation, identification of plants causing navigation problems, and LLPRD evaluation.
- For curly leaf pondweed treatment, verification must occur the year before treatment in May or June. Treatment for CLP must occur with water temperatures from 50 - 58 degrees F.
- WDNR will contact herbicide contractor and owner with a notice to proceed with treatment or denial of permit application.

Goal 4. Prevent the introduction of Eurasian water milfoil and other invasive, non-native aquatic species.

Objectives

- Provide invasive species education and monitoring at the boat landings.
- 100% enforcement of Polk County's Do Not Transport Ordinance.
- Raise awareness and encourage positive behavior change of lake residents and visiting anglers.
- Engage the community (including lake owners, visitors to the lake, and business owners) in lake management efforts

Actions

1. Continue the Clean Boats, Clean Waters program process and distribute materials at the Village of Centuria boat landing with volunteers and/or paid staff.

2. Work with the Polk County Sheriff's Department to encourage enforcement of the Do Not Transport Ordinance.

3. Investigate the use of a surveillance camera for AIS prevention at the Village of Centuria boat landing.

4. Investigate options for boat decontamination.

5. Educate lake residents and visiting anglers by conveying the messages with the methods described below.

   Audience
   Lake Residents (25% fulltime, 75% weekends, vacations, holidays – 2012 survey)
   Anglers (most frequent visitors to the lake)

   Messages
   PAY ATTENTION TO INVASIVE PLANT CONCERNS
   - Know how to identify Eurasian water milfoil (EWM), curly leaf pondweed, and Zebra mussels (ZM) and others
   - Impacts of invasive plants and animals
   - Proximity to lakes with EWM and ZM
   - Clean boats and trailers and drain live wells to prevent invasive plant and animal spread
   - It is illegal to transport aquatic plants on boats, trailers and equipment in WI

Methods – use more than one method to deliver messages

Aquatic Plant Management Plan summary

Eurasian Water Milfoil, Zebra Mussels other invasive photos for identification

LLPRD and Long Lake Association newsletters

Handouts/brochures

Presentations (annual meeting)

Website – upgrade with lake volunteer or contracted service

Signs

Kiosk at the landing

Host events for lake visitors

Distribute information through bait shops

Partner on projects with PCALR (Polk County Association of Lakes and Rivers)

Goal 5. Rapidly respond to eliminate any newly introduced invasive, non-native aquatic plant species.

Objectives

- Monitor to detect newly introduced invasive species.
- The LLPRD is ready to respond to invasive threats which are discovered.

Actions

Follow the Rapid Response Protocol in Appendix E.

- Train and support lake resident volunteers to identify Eurasian water milfoil and other aquatic invasive species.
- Continue consultant monitoring for invasive species at least on an annual basis.
- Establish a non-lapsing contingency fund of at least $15,000 for removal of invasive species.
- Designate board and resident responsibilities for the Rapid Response Protocol.

Additional Educational Plans

<u>Messages targeting lake residents.</u>

- Explain what, where, why, when, how much of Aquatic Plant Management plan including CLP treatment results to date
- What are the potential impacts of the CLP herbicide treatment
- Importance of aquatic plants to Long Lake – stabilize sediments, reduce erosion, take up nutrients, provide fish and wildlife habitat
- Distinguish between rooted and free-floating native aquatic plants
- Explain shallow lakes – no plants and algae dominated vs. native plants with clear water
- Shoreline restoration can improve water quality and habitat

<u>Methods</u>

Aquatic Plant Management plan summary
Eurasian Water Milfoil, Zebra Mussels other invasive photos for identification
Newsletters
Handouts/brochures
Presentation (annual meeting)
Treatment result maps
Website – upgrade with lake volunteer or contracted service
Promotion of conferences and training opportunities

Committees for Volunteer Engagement

Volunteer engagement will be critical for plan implementation. The advisory committee recommended the following as a starting point for committee structure, tasks, and process.

Monitoring:

- Establish contacts for aquatic invasive species identification
- Provide contacts for lake residents through newsletter, website, etc.
- Organize training

Communication:

Use new methods that will reach people directly such as door knocking, boat to boat, neighbor to neighbor. Provide easy to communicate information to back this up such as simple brochures, and talking points.

Aquatic Invasive Species Prevention:

- Clean Boats, Clean Waters Program
- Investigate surveillance cameras for the boat landing
- Investigate decontamination at landing

Committee Process

1. Discuss how the committees will interact with the board
2. Appoint committee leaders
3. Describe the purpose of each committee
4. Recruit volunteers (describe tasks and time required, ask volunteers to identify their own talents, tasks of interest to them, and time available) recruit at annual meeting, in newsletter and on web site
5. Committees each establish more specific plans using the Aquatic Plant Management Plan as a guide – set priorities and establish action steps with a schedule

Draft Implementation Plan for LLPRD[37]

The follow tables outline proposed actions and estimated budget for these actions. The actual annual budgets will be updated on the Long Lake website after approval by the Long Lake District at the fall meeting.

Goal 1. Improve water quality and clarity.				
Actions[38]	**Timeline**	**$ Estimate**	**Vol. Hours**	**Responsible Parties[39]**
Permit application	February	$525-$725		LLPRD APM Lead WDNR
Temperature monitoring	May		10	Lake Volunteer
CLP monitoring	May, June, July	$5,000		Endangered Resource Services, LLC
CLP turion monitoring	June	$750		Endangered Resource Services, LLC
CLP herbicide treatment	Late May	$26,000 - $40,000		Northern Aquatic Services

[37] Costs are annual costs estimated for initial implementation. These costs will be reviewed each year during the LLPRD budgeting process.
[38] See previous pages for action item detail.
[39]LLPRD = Long Lake Protection and Rehabilitation District Board
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources

Goal 2. Protect and restore healthy native aquatic plant communities.				
Actions[40]	**Timeline**	**$ Estimate**	**Vol. Hours**	**Responsible Parties**[41]
Small-scale native aquatic planting	?	$3,000	80	LLPRD (AIS or NAWCA grant)

Goal 3. Balance recreation and waterfront owner needs with protection of native plants and the fishery.				
Actions[42]	**Timeline**	**$ Estimate**	**Vol. Hours**	**Responsible Parties**
Review nuisance and navigation conditions for individual corridors	June – August		40	LLPRD

[40] See previous pages for action item detail.
[41] LLPRD = Long Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
[42] See previous pages for action item detail.

Goal 4. Prevent the introduction of Eurasian water milfoil and other invasive, non-native aquatic species.				
Actions[43]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours**	**Responsible Parties**[44]
Clean Boats, Clean Waters Program	May – Sept.	$5,000	40	LLPRD Polk County LWRD (training) Village of Centuria
Sheriff's department liaison	Ongoing	$0	20	LLPRD Polk County Sheriff
Handouts, brochures and invasive plant photos				LLPRD Polk County LWRD
Support volunteer committees	Ongoing		120	LLPRD

Goal 5. Rapidly respond to eliminate any newly introduced invasive, non-native aquatic plant species.				
Actions[45]	**Timeline**	**$ Estimate**	**Vol. Hours**	**Responsible Parties**[46]
Lake resident volunteer monitoring and training	Ongoing	$500	40	LLPRD Polk County LWRD

[43] See previous pages for action item detail.
[44]LLPRD = Long Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
[45] See previous pages for action item detail.
[46] LLPRD = Long Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources

Monitoring and Assessment

Aquatic Plant Surveys

Aquatic plant (macrophyte) surveys are the primary means for tracking achievement toward plan goals. The Long Lake Aquatic Plant Management Plan has used aquatic plant surveys to assess the impact of CLP treatment on native plants.

Action. Whole lake surveys are completed every five years in preparation for the aquatic plant management plan update. The next survey is planned for 2021.

The whole lake surveys will be conducted in accordance with the guidelines established by the Wisconsin DNR. Any new species sampled will be saved, pressed, and mounted for voucher specimens.

Aquatic Invasive Species Grants

Department of Natural Resources Aquatic Invasive Species (AIS) grants are available to assist in funding some of the action items in the implementation plan. Grants provide up to 75 percent funding.

AIS Education, Prevention, and Planning (AEPP) and Clean, Boats Clean Waters (CBCW) grants are due December 10 of each year. AIS Control (ACEI) grants are due February 1 of each year. Current LLPRD grants are shown in Table 11 below.

Table 11. Current LLPRD Grants

Grant Number	Dates Covered	Amount	% State Grant
AEPP-463-16	2/01/16 – 12/31/17	$6,921	75
CBCW-442-17	2/15/17 – 12/31/17	$4,000	75
ACEI-197-17	4/15/17 – 6/30/18	$19,237.50	50

Appendix A. Long Lake P&R District Residential Survey

Response rate: 103/169; 61%

1. Which of the following best describes when you use your Long Lake home/property? (Please consider the property you use most if you own more than one.) **102, 99%**
   Full-time residency: 26, 25%
   Seasonal – continued occupancy for months at a time: 14, 14%
   During weekends, vacations, and/or holidays: 62, 61%
   Rental to others: 0, 0%
   Land Only: 0, 0%

2. How long have you owned property on Long Lake? (Check one) **102, 99%**
   0 to 2 years: 4, 4%
   2+ to 5 years: 10, 10%
   5+ to 10 years: 12, 12%
   10+ to 20 years: 25, 25%
   More than 20 years: 51, 50%

3. Please indicate your degree of participation in the following activities on Long Lake? (Circle appropriate number for degree of participation for each item.) **101, 98%**

ACTIVITY	NONE	A LITTLE	SOME	QUITE A BIT	A GREAT DEAL	Total points, average
Power Boating	0	1	2	3	4	164, **1.8**
Canoeing	0	1	2	3	4	39, **0.4**
Hiking	0	1	2	3	4	85, **1.0**
Ice Fishing	0	1	2	3	4	72, **0.8**
Reading	0	1	2	3	4	210, **2.4**
Socializing	0	1	2	3	4	237, **2.7**
Water Skiing	0	1	2	3	4	96, **1.1**
Wake Boarding	0	1	2	3	4	54, **0.6**
Jet Skiing	0	1	2	3	4	52, **0.6**
Swimming	0	1	2	3	4	202, **2.1**
Scuba Diving	0	1	2	3	4	6, **0.1**
Snowmobiling	0	1	2	3	4	55, **0.6**
Fishing	0	1	2	3	4	221, **2.3**
Hunting	0	1	2	3	4	20, **0.2**
Sail boating	0	1	2	3	4	9, **0.1**
Pontoon Boating	0	1	2	3	4	228. **2.4**
Snow shoeing	0	1	2	3	4	11, **0.1**
Winter skiing	0	1	2	3	4	25, **0.3**
Kayaking	0	1	2	3	4	26, **0.3**
Hunting	0	1	2	3	4	16, **0.2**
Ice skating	0	1	2	3	4	23, **0.3**
Nature/Bird Watching	0	1	2	3	4	199, **2.1**

Running	0	1	2	3	4	51, **0.6**
Tubing	0	1	2	3	4	142, **1.6**
Other: Walking	0	1	2	3	4	15, 3.8
Other: Relaxing						3, 3
Other: Yard Work						11, 3.7
Other: Campfires						5, 2.5
Other: Fireworks						2, 2
Other: Yard games						3, 3
Other: Paddleboats						5, 2.5
Other: Gardening						4, 4
Other: Computers						4, 4

4. Please indicate how much each of the following **negatively** impacts your use of the lake. If you believe the concern is not present on the lake, circle "0".
(Circle appropriate level of negative impact for each item) **101, 98%**

Level of Negative Impact

	Not present	No impact	Unsure	A little	Some	Quite a bit	A great deal	
Algae growth	0	1	2	3	4	5	6	461, **4.9**
Algae Toxins	0	1	2	3	4	5	6	404, **4.5**
Not enough fish	0	1	2	3	4	5	6	241, **2.7**
Lake level too high	0	1	2	3	4	5	6	99, **1.1**
Lake level too low	0	1	2	3	4	5	6	347, **3.7**
Native aquatic plant* growth	0	1	2	3	4	5	6	324, **3.4**
Invasive aquatic plant** growth	0	1	2	3	4	5	6	441, **4.7**
Loss of wildlife habitat	0	1	2	3	4	5	6	243, **2.7**
Too small fish	0	1	2	3	4	5	6	239, **2.7**
Loss of natural scenery	0	1	2	3	4	5	6	225, **2.5**
Too many fishing tournaments	0	1	2	3	4	5	6	173, **1.9**
Fewer Loons	0	1	2	3	4	5	6	256, **2.8**
Water Clarity	0	1	2	3	4	5	6	457, **4.8**
Muck	0	1	2	3	4	5	6	364, **3.9**
Garbage in Lake	0	1	2	3	4	5	6	240, **2.8**
Too weedy to boat	0	1	2	3	4	5	6	360, **3.8**
Too weedy to swim	0	1	2	3	4	5	6	420, **4.3**
Other: Too many snails	0	1	2	3	4	5	6	12, 6.0
Other: Taking water from the lake	0	1	2	3	4	5	6	6, 3.0

***Native aquatic plants** – plants which grow submerged in water, floating on the water, or in shallow water. Native aquatic plants are naturally present in the lake. They provide food and cover for fish and wildlife and stabilize lake sediments and shorelines.

**** Invasive aquatic plants** - Invasive plants are "out of place." They are usually introduced by human action to a location where they did not previously occur naturally and then dominate their new location. Eurasian water milfoil and curly-leaf pondweed are examples of aquatic invasive species.

QUESTIONS RELATED TO AQUATIC PLANT MANAGEMENT FOLLOW

Note that aquatic plants are rooted in the lake bottom or floating on the lake surface. Particles of algae floating in the lake are not considered aquatic plants.

5. How would you describe the overall amount of aquatic plants in the lake? (Check one) **99, 96%**
   Not sure: 21, 21%
   Too few: 4, 4%
   Right amount: 16, 16%
   Too many: 59, 60%

6. Which best describes the amount of rooted aquatic plants near the shore (in the water)? **85, 98%** (Check one) **101, 98%**
   Not sure: 19, 19%
   Too few: 4, 4%
   Right amount: 18, 18%
   Too many: 60, 59%

7. At what time period during the year do you consider the aquatic plant growth in Long Lake to be excessive? (Check all that apply) **100, 97%**
   May – June: 13, 13%
   July – August: 74, 74%
   August – September: 50, 50%
   September – October: 13, 13%
   I don't know: 5, 5%
   Aquatic plant growth is always excessive: 8, 8%
   _Aquatic plant growth is never excessive: 1, 0%

8. During the past few years how much, if at all, have aquatic plants limited participation for you or your family in the following activities? (Circle the appropriate response for each item) **101, 98%**

	Do not participate	Not at all	A little	Somewhat	Quite a bit	A great deal	
Swimming	0	1	2	3	4	5	333, **3.3**
Fishing	0	1	2	3	4	5	211, 2.2
Motorized boating	0	1	2	3	4	5	246, 2.5
Non-motorized boating	0	1	2	3	4	5	102, 1.1
Enjoying the view	0	1	2	3	4	5	219, 2.3
Water skiing or tubing	0	1	2	3	4	5	182, 1.9
Jet skiing	0	1	2	3	4	5	79, 0.8

9. Curly leaf pondweed is an aquatic invasive plant that is found in many lakes in Wisconsin. Do you believe that you can identify this plant? (Check one) **102, 99%**
   Definitely no: 12, 12%
   Probably no: 18, 18%
   Not sure: 11, 11%
   Probably yes: 43, 42%
   Definitely yes: 18, 18%

10. How much of a problem, if at all, do you consider curly leaf pondweed growth in Long Lake? (Check one) **101, 98%**
   Large problem: 41, **41%**
   Moderate problem: 33, **33%**
   Unsure: 22, 22%
   Small problem: 4, 4%
   No problem: 0, 0%

11. Curly leaf pondweed has been found in Long Lake. The potential impacts of this invasive plant include overtaking native plants, impeding navigation in early summer, and increasing phosphorus levels in the water when the plant dies in June or July. The Lake District has previously used the herbicide Aquathol K to control the growth of curly leaf pondweed early in the season to avoid impacts to native plants. Should the Lake District continue control efforts for curly leaf pondweed? (Check one) **103, 100%**
   Definitely no: 1, 1%
   Probably no: 0, 0%
   Not sure: 9, 9%
   Probably yes: 13, **13%**
   Definitely yes: 80, **78%**
   No Response: 0, 0%

12. Below is a list of management activities that could be used to manage aquatic plants on Long Lake. Please tell us if you think each activity should be pursued by the Lake District.

(Circle a response for each item.) **101, 98%**

	Definitely no	Probably no	Unsure	Probably yes	Definitely yes	
Spray native aquatic plants	0	1	2	3	4	211, **2.3**
Harvest native aquatic plants	0	1	2	3	4	165, **1.8**
Spray invasive aquatic plants	0	1	2	3	4	359, **3.6**
Harvest invasive aquatic plants	0	1	2	3	4	213, **2.2**
Educate residents about lake issues	0	1	2	3	4	337, **3.6**
Prevent invasive species introduction	0	1	2	3	4	350, **3.7**
Protect sensitive habitat areas	0	1	2	3	4	315, **3.4**
Expand "slow no-wake" area	0	1	2	3	4	188, **2.0**
Encourage individuals to hand pull/rake invasive plants	0	1	2	3	4	271, **2.8**
Allow individuals to hire contractors to spray up to 30 ft. around docks	0	1	2	3	4	227, **2.4**
No management	0	1	2	3	4	43, **0.5**
Other: Allow man made limited sandy beaches	0	1	2	3	4	8, 4.0
Other: Increase lake water level	0	1	2	3	4	4, 4.0

13. Which of the following methods(s) have been used to control aquatic plants in the lake in front of your lakeshore property within the past 5 years? Please consider the property you use most if you own more than one**.** (Check all that apply) **95, 92%**
    Removal by hand-pulling or raking myself: 72, 76%
    Hired someone to hand pull or rake: 1, 1%
    Applied chemical myself: 4, 4%
    Physical removal aided by a boat, ATV, lawn-mower, or similar machine: 13, 14%
    I don't know: 5, 5%
    None: 14, 15%
    Other: District has sprayed for CLP on our shoreline and dock area: 3, 3%

QUESTIONS RELATED TO THE WATERFRONT RUNOFF PROGRAM FOLLOW

14. Below is a list of landscaping practices designed to protect and improve lake water quality. Please tell us which practices, if any, you use at your Long Lake property or whether or not you are familiar with the practice. (Check one for each line) **95, 92%**

	Already use	Familiar but not used	Not familiar
Rain gardens	3, 3%	43, 45%	34, 36%
Rain barrels	6, 6%	63, 66%	15, 16%
Shoreline buffer zones	44, 46%	29, 31%	12, 13%
Native plants anywhere on lake property	42, 44%	25, 26%	14, 15%
Infiltration pits or trenches	5, 5%	28, 29%	48, 51%
Water diversions	12, 13%	37, 39%	30, 32%
Not fertilizing or using zero phosphorus fertilizer	85, 89%	6, 6%	4, 4%
Other: Replaced blacktop driveway with crushed rock			

15. In the following list, please indicate which water quality landscaping practice, if any, you would consider putting in place on your Long Lake property. Please see the definitions below. If you already use the practice, please check . (Check all that are of interest) **85, 83%**
    Rain gardens: 23, 27%
    Rain barrels: 30, 35%
    Shoreline buffer zone: 40, 47%
    Native plants anywhere on lake property: 39, 46%
    Water diversions: 30, 35%
    Not fertilizing or using zero phosphorus fertilizer: 62, 73%

Other, please list
Would consider anything that helps the lake
Impact of sewer system for lake, addressing septic system on the lake (2 responses)

Rain gardens – Rain gardens are depressions in the landscape planted with flowers and grasses. A rain garden is positioned to capture runoff from rain events and absorb the water over several hours to a few days.
Rain barrels – Rain barrels capture water from a rain gutter downspout for watering gardens and potted plants.
Shoreline buffer zone – Areas of planted or naturally-growing native vegetation beginning at the water's edge and extending upland. Shoreline buffer zone minimum depths generally extend 35 feet back from the high water mark.
Water diversion – A practice that directs water flow to a place where it can soak into the ground rather than flow to the lake. Arranging gutters and downspouts to direct water so that it doesn't flow to the lake is an example. Berms (low ridges), drain tile, and channels are other means to divert water.

16. Would you take advantage of free information/visits offered by the Lake District to lake residents to address waterfront property runoff? **87, 84%**
    Yes: 65, 75%
    No: 22, 25%

17. The Long Lake District sends out information regarding its management activities and living on the lake. How do you prefer to receive information from the Long Lake District?
(Check all that apply) **96, 93%**
    I do not wish to receive information from the Lake District: 2, 2%
    Dockside Newsletter: 24, 25%
    Annual meeting: 40, 42%
    Special mailings: 52, 54%
    E-mail notices: 58, 60%
    Other, please specify: Kiosk at boat landing

Appendix B. Invasive Species Information

Curly Leaf Pondweed

Curly leaf pondweed is specifically designated as an invasive aquatic plant (along with Eurasian water milfoil and purple loosestrife) to be the focus of a statewide program to control invasive species in Wisconsin. Invasive species are defined as a "non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health (23.22(c)."

The Wisconsin Comprehensive Management Plan for Aquatic Invasive Species describes curly leaf pondweed impacts as follows:

> It is widely distributed throughout Wisconsin lakes, but the actual number of waters infested is not known. Curly-leaf pondweed is native to northern Europe and Asia where it is especially well adapted to surviving in low temperature waters. It can actively grow under the ice while most plants are dormant, giving it a competitive advantage over native aquatic plant species. By June, curly-leaf pondweed can form dense surface mats that interfere with aquatic recreation. By mid-summer, when other aquatic plants are just reaching their peak growth for the year, it dies off. Curly-leaf pondweed provides habitat for fish and invertebrates in the winter and spring when most other plants are reduced to rhizomes and buds, but the mid-summer decay creates a sudden loss of habitat. The die-off of curly-leaf pondweed also releases a surge of nutrients into the water column that can trigger algal blooms and create turbid water conditions. In lakes where curly-leaf pondweed is the dominant plant, the summer die-off can lead to habitat disturbance and degraded water quality. In other waters where there is a diversity of aquatic plants, the breakdown of curly-leaf may not cause a problem.[48]

The state of Minnesota DNR web site explains that curly leaf pondweed often causes problems due to excessive growth. At the same time, the plant provides some cover for fish, and some waterfowl species feed on the seeds and winter buds.[49]

---

[48] *Wisconsin's Comprehensive Management Plan to Prevent Further Introductions and Control Existing Populations of Aquatic Invasive Species*. Prepared by Wisconsin DNR. September 2003.

[49] Information from Minnesota DNR (www.dnr.state.mn.us/aquatic_plants).

The following description is taken from a Great Lakes Indian Fish and Wildlife Commission handout.

Curly Leaf Pondweed (Potamogeton crispus)[50]

Identification

Curly leaf pondweed is an invasive aquatic species found in a variety of aquatic habitats, including permanently flooded ditches and pools, rivers, ponds, inland lakes, and even the Great Lakes. Curly leaf pondweed prefers alkaline or high nutrient waters one to three meters deep. Its leaves are strap-shaped with rounded tips and undulating and finely toothed edges. Leaves are not modified for floating, and are generally alternate on the stem. Stems are somewhat flattened and grow to as long as two meters. The stems are dark reddish-green to reddish-brown, with the mid-vein typically tinged with red. Curly leaf pondweed is native to Eurasia, Africa, and Australia and is now spread throughout most of the United States and southern Canada.

Characteristics

New plants typically establish in the fall from freed turions (branch tips). The winter form is short, with narrow, flat, relatively limp, bluish-green leaves. This winter form can grow beneath the ice and is highly shade-tolerant. Rapid growth begins with warming water temperatures in early spring – well ahead of native aquatic plants.

Reproduction and Dispersal

Curly leaf pondweed reproduces primarily vegetatively. Numerous turions are produced in the spring. These turions consist of modified, hardened, thorny leaf bases interspersed with a few to several dormant buds. The turions are typically 1.0 – 1.7 cm long and 0.8 to 1.4 cm in diameter. Turions separate from the plant by midsummer, and may be carried in the water column supported by several leaves. Humans and waterfowl may also disperse turions. Stimulated by cooler water temperatures, turions germinate in the fall, over-wintering as a small plant. The next summer plants mature, producing reproductive tips of their own. Curly leaf pondweed rarely produces flowers.

Ecological Impacts

Rapid early season growth may form large, dense patches at the surface. This canopy overtops most native aquatic plants, shading them and significantly slowing their growth. The canopy lowers water temperature and restricts absorption of atmospheric oxygen into the water. The dense canopy formed often interferes with recreational activities such as swimming and boating.

In late spring, curly leaf pondweed dies back, releasing nutrients that may lead to algae blooms. Resulting high oxygen demand caused by decaying vegetation can adversely affect fish

---

[50] Information from GLIFWC Plant Information Center (http://www.glifwc.org/epicenter).

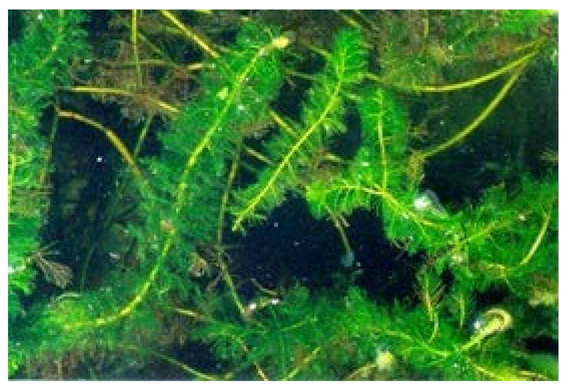
populations. The foliage of curly leaf pondweed is relatively high in alkaloid compounds possibly making it unpalatable to insects and other herbivores.

Control
Small populations of curly leaf pondweed in otherwise un-infested water bodies should be attacked aggressively. Hand pulling, suction dredging, or spot treatments with contact herbicides are recommended. Cutting should be avoided because fragmentation of plants may encourage their re-establishment. In all cases, care should be taken to remove all roots and plant fragments, to keep them from re-establishing.

Control of large populations requires a long-term commitment that may not be successful. A prudent strategy includes a multi-year effort aimed at killing the plant before it produces turions, thereby depleting the seed bank over time. It is also important to maintain, and perhaps augment, native populations to retard the spread of curly leaf and other invasive plants. Invasive plants may aggressively infest disturbed areas of the lake, such as those where native plant nuisances have been controlled through chemical applications.

Eurasian Water Milfoil (Myriophyllum spicatum)

Introduction
Eurasian water milfoil is a submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, Eurasian water milfoil is nearly impossible to distinguish from Northern water milfoil. Eurasian water milfoil has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.



Distribution and Habitat
Eurasian milfoil first arrived in Wisconsin in the 1960's. During the 1980's, it began to move from several counties in southern Wisconsin to lakes and waterways in the northern half of the state. As of 1993, Eurasian milfoil was common in 39 Wisconsin counties (54 percent) and at least 75 of its lakes, including shallow bays in Lakes Michigan and Superior and Mississippi River pools.

Eurasian water milfoil grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

Life History and Effects of Invasion

Unlike many other plants, Eurasian water milfoil does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces vegetatively by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. Milfoil is readily dispersed by boats, motors, trailers, bilges, live wells, or bait buckets, and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, Eurasian water milfoil is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of Eurasian milfoil provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of Eurasian water milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by Eurasian water milfoil may lead to deteriorating water quality and algae blooms of infested lakes. [51]

[51] Taken in its entirety from WDNR, 2008 (http://www.dnr.state.wi.us/invasives/fact/milfoil.htm).

Reed Canary Grass (*Phalaris arundinacea*)

Description

Reed canary grass is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades 3 1/2 to 10 inches long and 1/4 to 3/4 inch in width. Blades are flat and have a rough texture on both surfaces. The lead ligule is membranous and long. The compact panicles are erect or slightly spreading (depending on the plant's reproductive stage), and range from 3 to 16 inches long with branches 2 to 12 inches in length. Single flowers occur in dense clusters in May to mid-June. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Both Eurasian and native ecotypes of reed canary grass are thought to exist in the U.S. The Eurasian variety is considered more aggressive, but no reliable method exists to tell the ecotypes apart. It is believed that the vast majority of our reed canary grass is derived from the Eurasian ecotype. Agricultural cultivars of the grass are widely planted.

Reed canary grass also resembles non-native orchard grass (*Dactylis glomerata*), but can be distinguished by its wider blades, narrower, more pointed inflorescence, and the lack of hairs on glumes and lemmas (the spikelet scales). Additionally, bluejoint grass (*Calamagrostis canadensis*) may be mistaken for reed canary in areas where orchard grass is rare, especially in the spring. The highly transparent ligule on reed canary grass is helpful in distinguishing it from the others. Ensure positive identification before attempting control. The ligule is a transparent membrane found at the intersection of the leaf stem and leaf.

Distribution and Habitat

Reed canary grass is a cool-season, sod-forming, perennial wetland grass native to temperate regions of Europe, Asia, and North America. The Eurasian ecotype has been selected for its vigor and has been planted throughout the U.S. since the 1800's for forage and erosion control. It has become naturalized in much of the northern half of the U.S., and is still being planted on steep slopes and banks of ponds and created wetlands.

Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas.

Life History and Effects of Invasion

Reed canary grass reproduces by seed or creeping rhizomes. It spreads aggressively. The plant produces leaves and flower stalks for 5 to 7 weeks after germination in early spring, then spreads laterally. Growth peaks in mid-June and declines in mid-July. A second growth spurt occurs in the fall. The shoots collapse in mid to late summer, forming a dense, impenetrable mat of stems and leaves. The seeds ripen in late June and shatter when ripe. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.

This species prefers disturbed areas, but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in less than twelve years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, deforestation of swamp forests, sedimentation, and intentional planting. The difficulty of selective control makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites.[52]

Purple Loosestrife (Lythrum salicaria)[53]

Description

Purple loosestrife is a non-native plant common in Wisconsin. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

Purple loosestrife is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers vary from purple to magenta, possess 5-6 petals aggregated into numerous long spikes, and bloom from July to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes (underground stems) that form a dense mat.

Characteristics

Purple loosestrife is a wetland herb that was introduced as a garden perennial from Europe during the 1800's. It is still promoted by some horticulturists for its beauty as a landscape plant, and by beekeepers for its nectar-producing capability. Currently, about 24 states have laws prohibiting its importation or distribution because of its aggressively invasive characteristics. It has since extended its range to include most temperate parts of the United States and Canada. The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America.

---

[52] Taken from WDNR, 2008. (http://www.dnr.state.wi.us/invasives/fact/reed canary.htm).
[53] Wisconsin DNR invasive species factsheets.(http:/dnr.wi.gov/invasives).

Purple loosestrife was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the state, and has been recorded in 70 of Wisconsin's 72 counties. This plant's optimal habitat includes marshes, stream margins, river flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes, and rivers.

Reproduction and Dispersal

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70 percent, resulting in an extensive seed bank. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local disturbance is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland.

Ecological Impacts

Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways.

Mechanical Control

Purple loosestrife (PL) can be controlled by cutting, pulling, digging and drowning. Cutting is best done just before plants begin flowering. Cutting too early encourages more flower stems to grow than before. If done too late, seed may have already fallen. Since lower pods can drop seed while upper flowers are still blooming, check for seed. If none, simply bag all cuttings (to prevent them from rooting). If there is seed, cut off each top while carefully holding it upright, then bend it over into a bag to catch any dropping seeds. Dispose of plants/seeds in a capped landfill, or dry and burn them. Composting will not kill the seeds. Keep clothing and equipment seed-free to prevent its spread. Rinse all equipment used in infested areas before moving into uninfested areas, including boats, trailers, clothing, and footwear.

Pulling and digging can be effective, but can also create disturbed bare spots, which are good sites for PL seeds to germinate, or leave behind root fragments that grow into new plants. Use these methods primarily with small plants in loose soils, since they do not usually leave behind large gaps nor root tips, while large plants with multiple stems and brittle roots often do. Dispose of plants as described above.

Mowing has not been effective with loosestrife unless the plants can be mowed to a height where the remaining stems will be covered with water for a full twelve months. Burning has also proven largely ineffective. Mowing and flooding are not encouraged because they can contribute to further dispersal of the species by disseminating seeds and stems.

Follow-up treatments are recommended for at least three years after removal.

Chemical Control
This is usually the best way to eliminate PL quickly, especially with mature plants. The chemicals used have a short soil life. Timing is important. Treat in late July or August, but before flowering to prevent seed set. Always back away from sprayed areas as you go, to prevent getting herbicide on your clothes. The best method is to cut stems and paint the stump tops with herbicide. The herbicide can be applied with a small drip bottle or spray bottle, which can be adjusted to release only a small amount. Try to cover the entire cut portion of the stem, but not let the herbicide drip onto other plants since it is non-selective and can kill any plant it touches.

Glyphosate herbicides: Currently, glyphosate is the most commonly used chemical for killing loosestrife. Roundup and Glyfos are typically used, but if there is any open water in the area use Rodeo, a glyphosate formulated and listed for use over water. Glyphosate must be applied in late July or August to be most effective. Since you must treat at least some stems of each plant and they often grow together in a clump, all stems in the clump should be treated to be sure all plants are treated.

Another method is using very carefully targeted foliar applications of herbicide (NOT broadcast spraying). This may reduce costs for sites with very high densities of PL, since the work should be easier and there will be few other plant species to hit accidentally. Use a glyphosate formulated for use over water. A weak solution of around 1 percent active ingredient can be used and it is generally necessary to wet only 25 percent of the foliage to kill the plant.

You must obtain a permit from WDNR before applying any herbicide over water. The process has been streamlined for control of purple loosestrife and there is no cost. Contact your regional Aquatic Plant Management Coordinator for permit information.

Biological Control
Conventional control methods like hand pulling, cutting, flooding, herbicides, and plant competition have only been moderately effective in controlling purple loosestrife. Biocontrol is now considered the most viable option for more complete control for heavy infestations. The WDNR, in cooperation with the U.S. Fish and Wildlife Service, is introducing several natural insect enemies of purple loosestrife from Europe. A species of weevil (*Hylobius transversovittatus*) has been identified that lays eggs in the stem and upper root system of the plant; as larvae develop, they feed on root tissue. In addition, two species of leaf eating beetles (*Galerucella calmariensis* and *G. pusilla*) are being raised and released in the state, and another weevil that feeds on flowers (*Nanophyes marmoratus*) is being used to stress the plant in multiple ways. Research has shown that most of these insects are almost exclusively dependent upon purple loosestrife and do not threaten native plants, although one species showed some

cross-over to native loosestrife. These insects will not eradicate loosestrife, but may significantly reduce the population so cohabitation with native species becomes a possibility.

Appendix C. Aquatic Plant Management Strategy WDNR

AQUATIC PLANT MANAGEMENT STRATEGY

Northern Region WDNR
Summer, 2007

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

ISSUES

- Protect desirable native aquatic plants.
- Reduce the risk that invasive species replace desirable native aquatic plants.
- Promote "whole lake" management plans
- Limit the number of permits to control native aquatic plants.

BACKGROUND

As a general rule, the Northern Region has historically taken a protective approach to allow removal of native aquatic plants by harvesting or by chemical herbicide treatment. This approach has prevented lakes in the Northern Wisconsin from large-scale loss of native aquatic plants that represent naturally occurring high quality vegetation. Naturally occurring native plants provide a *diversity of habitat* that *helps maintain water quality*, helps *sustain the fishing* quality known for Northern Wisconsin, supports common lakeshore wildlife from loons to frogs, and helps to provide the *aesthetics* that collectively create the "up-north" appeal of the northwoods lake resources.

In Northern Wisconsin lakes, an inventory of aquatic plants may often find 30 different species or more, whereas a similar survey of a Southern Wisconsin lake may often discover less than half that many species. Historically, similar species diversity was present in Southern Wisconsin, but has been lost gradually over time from stresses brought on by cultural land use changes (such as increased development, and intensive agriculture). Another point to note is that while there may be a greater variety of aquatic vegetation in Northern Wisconsin lakes, the vegetation itself is often *less dense*. This is because northern lakes have not suffered as greatly from nutrients and runoff as have many waters in Southern Wisconsin.

The newest threat to native plants in Northern Wisconsin is from invasive species of aquatic plants. The most common include Eurasian Water Milfoil (EWM) and CurlyLeaf Pondweed (CLP). These species are described as *opportunistic invaders*. This means that these "invaders" benefit where an opening occurs from removal of plants, and without competition from other plants may successfully become established in a lake. Removal of native vegetation not only diminishes the natural qualities of a lake, it *may increase the risk that an invasive species can successfully invade onto the site where native plants have been removed*. There it may more easily establish itself without the native plants to compete against. This concept is easily observed on land where bared soil is quickly taken over by replacement species (often weeds) that crowd in and establish themselves as new occupants of the site. While not a providing a certain guarantee against invasive plants, protecting and allowing the native plants to remain may reduce the success of an invasive species becoming established on a lake. Once established, the invasive species cause far more inconvenience for all lake users, riparian and others included; can change many of the natural features of a lake; and often lead to *expensive annual control plans*. Native vegetation may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm.

To the extent we can maintain the normal growth of native vegetation, Northern Wisconsin lakes can continue to offer the water resource appeal and benefits they've historically provided. A regional position on removal of aquatic plants that carefully recognizes how native aquatic plants benefit lakes in Northern Region can help prevent a gradual decline in the overall quality and recreational benefits that make these lakes attractive to people and still provide abundant fish, wildlife, and northwoods appeal.

GOALS OF STRATEGY:

1. Preserve native species diversity which, in turn, fosters natural habitat for fish and other aquatic species, from frogs to birds.
2. Prevent openings for invasive species to become established in the absence of the native species.
3. Concentrate on a" whole-lake approach" for control of aquatic plants, thereby fostering systematic documentation of conditions and specific targeting of invasive species as they exist.
4. Prohibit removal of wild rice. WDNR – Northern Region will not issue permits to remove wild rice unless a request is subjected to the full consultation process via the Voigt Tribal Task Force. We intend to discourage applications for removal of this ecologically and culturally important native plant.
5. To be consistent with our WDNR Water Division Goals (work reduction/disinvestment), established in 2005, to "not issue permits for chemical or large scale mechanical control of native aquatic plants – develop general permits as appropriate or inform applicants of exempted activities." This process is similar to work done in other WDNR Regions, although not formalized as such.

BASIS OF STRATEGY IN STATE STATUTE AND ADMINISTRATIVE CODE

State Statute 23.24 (2)(c) states:

"The requirements promulgated under par. (a) 4. may specify any of the following:

1. The **quantity** of aquatic plants that may be managed under an aquatic plant management permit.
2. The **species** of aquatic plants that may be managed under an aquatic plant management permit.
3. The **areas** in which aquatic plants may be managed under an aquatic plant management permit.
4. The **methods** that may be used to manage aquatic plants under an aquatic plant management permit.
5. The **times** during which aquatic plants may be managed under an aquatic plant management permit.
6. The **allowable methods** for disposing or using aquatic

plants that are removed or controlled under an aquatic plant management permit.

7. The requirements for plans that the department may require under sub. (3) (b). "

State Statute 23.24(3)(b) states:
"The department may require that an application for an aquatic plant management permit contain a plan for the department's approval as to how the aquatic plants will be introduced, removed, or controlled."

Wisconsin Administrative Code NR 109.04(3)(a) states:
"The department may require that an application for an aquatic plant management permit contain an aquatic plant management plan that describes how the aquatic plants will be introduced, controlled, removed or disposed. Requirements for an aquatic plant management plan shall be made in writing stating the reason for the plan requirement. In deciding whether to require a plan, the department shall consider the potential for effects on protection and development of diverse and stable communities of native aquatic plants, for conflict with goals of other written ecological or lake management plans, for cumulative impacts and effect on the ecological values in the body of water, and the long-term sustainability of beneficial water use activities."

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

APPROACH

1. After January 1, 2009* no individual permits for control of native aquatic plants will be issued. Treatment of native species may be allowed under the auspices of an approved lake management plan, and only if the plan clearly documents "impairment of navigation" and/or "nuisance conditions". Until January 1, 2009, individual permits will be issued to previous permit holders, only with adequate documentation of "impairment of navigation" and/or "nuisance conditions". No new individual permits will be issued during the interim.

2. Control of aquatic plants (if allowed) in documented sensitive areas will follow the conditions specified in the report.

3. Invasive species must be controlled under an approved lake management plan, with two exceptions (these exceptions are designed to allow sufficient time for lake associations to form and subsequently submit an approved lake management plan):
   a. Newly-discovered infestations. If found on a lake with an approved lake management plan, the invasive species can be controlled via an amendment to the approved plan. If found on a lake without an approved management plan, the invasive species can be controlled under the WDNR's Rapid Response protocol (see definition), and the lake owners will be encouraged to form a lake association and subsequently submit a lake management plan for WNDR review and approval.
   b. Individuals holding past permits for control of *invasive* aquatic plants and/or "mixed stands" of native and invasive species will be allowed to treat via individual permit until January 1, 2009 if "impairment of navigation" and/or "nuisance conditions" is adequately documented, unless there is an approved lake management plan for the lake in question.

4. Control of invasive species or "mixed stands" of invasive and native plants will follow current best management practices approved by the Department and contain an explanation of the strategy to be used. Established stands of invasive plants will generally use a control strategy based on Spring treatment. (typically, a water temperature of less than 60 degrees Fahrenheit, or approximately May 31st, annually).

5. Manual removal (see attached definition) is allowed (Admin. Code NR 109.06).

---

* *Exceptions to the Jan. 1, 2009 deadline will be considered only on a very limited basis and will be intended to address unique situations that do not fall within the intent of this approach.*

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

DOCUMENTATION OF IMPAIRED NAVIGATION AND/OR NUISANCE CONDITIONS

Navigation channels can be of two types:

- Common use navigation channel. This is a common navigation route for the general lake user. It often is off shore and connects areas that boaters commonly would navigate to or across, and should be of public benefit.

- Individual riparian access lane. This is an access lane to shore that normally is used by an individual riparian shore owner.

Severe impairment or nuisance will generally mean vegetation grows thickly and forms mats on the water surface. Before issuance of a permit to use a regulated control method, a riparian will be asked to document the problem and show what efforts or adaptations have been made to use the site. (This is currently required in NR 107 and on the application form, but the following helps provide a specific description of what impairments exist from native plants).

Documentation of *impairment of navigation* by native plants must include:

a. Specific locations of navigation routes (preferably with GPS coordinates)
b. Specific dimensions in length, width, and depth
c. Specific times when plants cause the problem and how long the problem persists
d. Adaptations or alternatives that have been considered by the lake shore user to avoid or lessen the problem
e. The species of plant or plants creating the nuisance (documented with samples or a from a Site inspection)

Documentation of the *nuisance* must include:

a. Specific periods of time when plants cause the problem, e.g. when does the problem start and when does it go away.
b. Photos of the nuisance are encouraged to help show what uses are limited and to show the severity of the problem.
c. Examples of specific activities that would normally be done where native plants occur naturally on a site but can not occur because native plants have become a nuisance.

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

DEFINITIONS

Manual removal:	Removal by hand or hand-held devices without the use or aid of external or auxiliary power. Manual removal cannot exceed 30 ft. in width and can only be done where the shore is being used for a dock or swim raft. The 30 ft. wide removal zone cannot be moved, relocated, or expanded with the intent to gradually increase the area of plants removed. Wild rice may not be removed under this waiver.
Native aquatic plants:	Aquatic plants that are indigenous to the waters of this state.
Invasive aquatic plants:	Non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.
Sensitive area:	Defined under s. NR 107.05(3)(i) (sensitive areas are areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or lifestage requirements, or offering water quality or erosion control benefits to the body of water).
Rapid Response protocol:	This is an internal WDNR document designed to provide guidance for grants awarded under NR 198.30 (Early Detection and Rapid Response Projects). These projects are intended to control pioneer infestations of aquatic invasive species before they become established.

Appendix D. References

Aquatic Ecosystem Restoration Foundation. *Aquatic Plant Management: Best Management Practices in Support of Fish and Wildlife Habitat.* 2005. http://www.aquatics.org/aquatic_bmp.pdf

Barr Engineering. *Long Lake Management Plant Phases V and VI: Lake Management Plan*. Prepared for the Long Lake Protection and Rehabilitation District. Barr Engineering Company. May 2003.

Barr. *Long Lake Aquatic Plant Management Plan*. Prepared Long Lake Protection and Rehabilitation District. Barr Engineering Company. November 2007.

Borman, Susan, Robert Korth and Jo Tempte. *Through the Looking Glass*. University of Wisconsin-Extension. Stevens Point, Wisconsin. 1997.

Chorus, Ingird and Jamie Bartram. *Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management.* WHO. 1999.

Crow, Garrett E. and C. Barre Hellquist. *Aquatic and Wetland Plants of Northeastern North America*. The University of Wisconsin Press. Madison, Wisconsin. Volumes 1 and 2. 2000.

Harmony Environmental. *Balsam Lake Aquatic Plant Management Plan. Polk County, Wisconsin.* October 2010.

Madsen, John D. *Aquatic Plant Management Guidelines for Wisconsin Lakes.* March 22, 2003 Draft.

Nault, Michelle. *Effects of Whole Lake Early Season 2,4-D on Eurasian Watermilfoil (Myriophyllum spicatum).* Presentation at Minnesota-Wisconsin Invasive Species Conference. St. Paul, Minnesota. November 2010.

Nichols, Stanley A. *Distribution and Habitat Descriptions of Wisconsin Lake Plants*. Wisconsin Geological and Natural History Survey. Bulletin 96. Madison, Wisconsin. 1999.

Nichols, Stanley A. *Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications.* Journal of Lake and Reservoir Management 15 (2): 133-141. 1999.

North American Lake Management Society. *Managing Lakes and Reservoirs*. 2001.

Skogerboe, John. *Sampling of Herbicide Residuals Confirms Extended Exposure to Low Concentrations of 2,4-D and Triclopyr can Control Eurasian Watermilfoil.* Presentation at Minnesota-Wisconsin Invasive Species Conference. St. Paul, Minnesota. November 2010.

Skogerboe, John and Michael Netherland. *Draft Report Following April 2008 Aquatic Herbicide Treatments of Three Bays on Lake Minnetonka.* US Army Engineer Research and Development Center.

State of Wisconsin. Department of Health and Family Services. *Guidance for Local Health Departments. Cyanobacteria and Human Health.* June 2004.

University of Wisconsin-Extension. *Citizen Lake Monitoring Manual*. Revised 2006.

University of Wisconsin-Extension. *Aquatic Plant Management in Wisconsin*. April 2006 Draft.

University of Wisconsin – Madison. Wisconsin State Herbarium. *WISFLORA: Wisconsin Vascular Plant Species.* www.botany.wisc.edu/wisflora/

U.S. Army Corps of Engineers. *Aquatic Plant Information System (APIS).* 2005.

Vilas County Land and Water Conservation Department. *Aquatic Invasive Species: A Guide for Proactive & Reactive Management.* 2006.
http://wisconsinlakes.org/AboutLakes/PDFs/aisguidevc06.pdf

Williamson, Jeremy. *Cyanobacteria and Toxin Monitoring. Long Lake, Polk County Wisconsin 2010.* Polk County Land and Water Resources Department.

Wisconsin Department of Natural Resources. *Control of Eurasian Water Milfoil & Large-scale Aquatic Herbicide Use.* July 2006.

Wisconsin Department of Natural Resources and the Polk County Land Conservation Department. Nonpoint Source Control Plan for the Balsam Branch Priority Watershed Project. Publication WR-430-95. April 1995.

Wisconsin Department of Natural Resources. Eau Claire, WI. *Designation of Critical Habitat Areas. Bear Lake, Portage County.* March 2007.

Wisconsin Department of Natural Resources. *Fisheries in the Wisconsin Ceded Territory.* Last revised March 27, 2009.

Wisconsin Department of Natural Resources. *Natural Heritage Inventory County Data by Township: Polk County.* Last revised September 2010.

Wisconsin Department of Natural Resources. Northern Region. *Aquatic Plant Management Strategy.* Summer 2007.

Wisconsin Department of Natural Resources. *Reports and Data: Polk County*. December 2011. http://www.dnr.state.wi.us/lakes/CLMN/reportsanddata/.

Wisconsin Department of Natural Resources. Rick Cornelius, Jim Reimer, Frank Koshere, Mark Sundeen, and Kurt Roblek. *Long Lake (Polk Co.) Integrated Sensitive Area Survey Report and Management Guidelines.* August 1989.

Wisconsin Department of Natural Resources. *The State of the St. Croix River Basin.* 2002.

Wisconsin Department of Natural Resources. *Tomahawk and Sand Bar Lake Aquatic Plant Management Plans. Bayfield County, WI.* July 2010 Draft.

Wisconsin Department of Natural Resources. *Walleye Bag Limits Revised on 255 Northern Lakes.* May 19, 2009.

Wisconsin Department of Natural Resources. *Wisconsin Lakes*. PUB-FH-800. 2009.

Appendix E. Rapid Response for Early Detection of Aquatic Invasive Species

<u>Definition: Aquatic Invasive Species (AIS)</u> are non-native plant and animal species that can out-compete and overtake native species damaging native lake habitat and sometimes creating nuisance conditions. AIS currently in Long Lake include curly leaf pondweed (CLP), hybrid cattail, and Chinese mystery snail. Additional AIS threaten the lake and will be monitored throughout the lake by volunteers and consultants.

1. Maintain a non-lapsable contingency fund for rapid response to EWM or other invasive species[1] (LLPRD Board).

2. Conduct volunteer and professional monitoring (APM Monitor) at the public landing and other likely areas of AIS introduction. If a suspected plant is found, contact the AIS Identification Volunteer(s).

3. Direct lake residents and visitors to contact the AIS Identification Volunteer(s) if they see a plant or animal in the lake they suspect might be an AIS. Signs at the public boat landings, web pages, handouts at annual meetings, and newsletter articles will provide photos and descriptions of AIS that have a high likelihood of threatening Long Lake, contact information, and instructions.

4. If a volunteer locates a likely AIS, instructions will request that the volunteer record the location of suspected AIS using GPS, if available, or mark the location with a small float. *Provide instructions on marking with float.* Note that cell phone applications are available to identify GPS point.

   If a plant:

   a. Take a digital photo of the plant in the setting where it was found (if possible). Then collect 5 to 10 intact specimens. Try to get the root system, and all leaves as well as seed heads and flowers when present. Place in a zip lock bag with no water. Place on ice and transport to refrigerator.
   b. Inform LLPRD Board.

   If an animal other than a fish:

   a. Take a digital photo of the animal in the setting where it was found (if possible). Then collect up to five specimens. Place in a jar with water; put on ice and transport to refrigerator. Transfer specimen to a jar filled with rubbing alcohol (except for Jellyfish – leave in water).

   b. Inform LLPRD Board.

[1] A $15,000 contingency fund is currently maintained by the LLPRD. It is in place to cover costs related to aquatic invasive species rapid response and potential dam repair.

5. The AIS Identification Volunteer(s) will tentatively confirm identification of plant or animal AIS with Polk County LWRD or lake management consultant then,

   If a plant:

   a. Fill out plant incident form http://dnr.wi.gov/lakes/forms/3200-125-plantincident.pdf
   b. Contact WDNR staff, then deliver collected plants to the WDNR (810 W. Maple St., Spooner, WI 54801) as soon as possible (or to the location they specify).

   If an animal:

   a. Be sure the suspected invasive species has not been previously found on the waterbody
   b. If a zebra mussel report to WDNR and Polk County
   c. Fill out form 3200-126 – Aquatic Invasive Animal Incident Report

6. If identification is positive:
   a. Inform the person who reported the AIS and the board, who will then inform Polk County LWRD, and lake management consultant.

   b. Mark the location of AIS with a more permanent marker and GPS points. Special EWM buoys are available. (AIS Identification Volunteer(s)).

   c. Post a notice at the public landing (DNR has these signs available) and include a notice in the next newsletter. Notices will inform residents and visitors of the approximate location of AIS and provide appropriate means to avoid its spread (LLPRD Board).

7. Determine the extent of the AIS introduction (LLPRD in cooperation with Polk County LWRD and WDNR). Divers may be used. If small amounts of AIS are found during this assessment, divers may be directed to identify locations with GPS points and hand pull plants/remove animals found. All plant fragments will be removed from the lake when hand pulling.

8. Select a control plan in cooperation with the WDNR (LLPRD Board). The goal of the rapid response control plan will be eradication of the EWM. Additional guidance regarding EWM treatment is found in DNR's *Response for Early Detection of Eurasian Water Milfoil Field Protocol*.

   Control methods may include hand pulling, use of divers to manually or mechanically remove the AIS from the lake bottom, application of herbicides, and/or other effective and approved control methods.

9. Implement the selected control plan including applying for the necessary permits. Regardless of the control plan selected, it will be implemented by persons who are qualified and experienced in the technique(s) selected.

10. The LLPRD will work with the WDNR to apply for an Early Detection and Rapid Response AIS Control Grant.

11. Frequently inspect the area of the AIS to determine the effectiveness of the treatment and whether additional treatment is necessary (APM monitor, WNDR and/or other agency representatives).

12. Review the procedures and responsibilities of this rapid response plan on an annual basis. Changes may be made with approval of the LLPRD Board.

EXHIBIT A[2]

LONG LAKE PROTECTION AND REHABILITATION DISTRICT

Board Contacts:	Michael Langer: langerdistro@yahoo.com Keith Campbell: kcljcamp@centurytel.net Joe Murray: jmurray_87@msn.com

POLK COUNTY LAND AND WATER RESOURCES DEPARTMENT

AIS Coordinator	Jeremy Williamson: 715-485-8639 jeremyw@co.polk.wi.us
Director	Tim Ritten: 715-485-8631 TIMR@co.polk.wi.us

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Permits	Mark Sundeen: 715-635-4074 sundem@dnr.state.wi.us
Grants, EWM Identification and Notice	Alex Smith: 715-635-4124 Alex.Smith@wisconsin.gov

APM MONITOR

Endangered Resource Services	Matt Berg: 715-483-2847 saintcroixdfly@gmail.com

DIVERS

Ecological Integrity Services	Steve Schieffer: 715-554-1168 ecointegservice@gmail.com

ADDITIONAL REFERENCES

WDNR websites on AIS
http://dnr.wi.gov/lakes/invasives/GoalsNew.aspx?show=emerging
http://dnr.wi.gov/lakes/invasives/AISDiscoveryCommunicationProtocol.pdf

[2] This list is current as of 2017. Refer to the Long Lake web site www.longlakepolk.com for updated information.

Appendix F. Management Options for Aquatic Plants

Management Options for Aquatic Plants

Option	Permit Needed?	How it Works	PROS	CONS
No treatment	N	Do not treat plants	Protects native species that can prevent spread of invasive or exotic species, enhance water quality, and provide habitat for aquatic fauna	May allow small population of invasive plants to become larger, more difficult to control later
			No financial cost	
			No system disturbance	
			No harmful effects of chemicals	
			Permit not required	
Mechanical Control	Required under NR 109	Plants reduced by mechanical means	Flexible control	Must be repeated, often more than once per season
		Wide range of techniques, from manual to highly mechanized	Can balance habitat and recreational needs	Can suspend sediments and increase turbidity and nutrient release
a. Handpulling/Manual raking	Y/N	SCUBA divers or snorkelers remove plants by hand or plants are removed with a rake	Little to no damage done to lake or to native plant species	Very labor intensive
		Works best in soft sediments	Can be highly selective	Needs to be carefully monitored
			Can be done by shoreline property owners without permits within an area <30 ft wide OR where selectively removing EWM or CLP	Roots, runners, and even fragments of some species (including EWM) will start new plants, so all of plant must be removed
			Can be very effective at removing problem plants, particularly following early detection of an invasive exotic species	Small-scale control only

Management Options for Aquatic Plants

Option	Permit Needed?	How it Works	PROS	CONS
b. Harvesting	Y	Plants are "mowed" at depths of 2-5 ft, collected with a conveyor and off-loaded onto shore	Immediate results	Not selective in species removed
		Harvest invasives only if invasive is already present throughout the lake	EWM removed before it has the opportunity to autofragment, which may create more fragments than created by harvesting	Fragments of vegetation can re-root
			Usually minimal impact to the lake	Can remove some small fish and reptiles from lake
			Harvested lanes through dense weed beds can increase growth and survival of some fish	Initial cost of harvester expensive
			Can remove some nutrients from lake	
Biological Control	Y	Living organisms (e.g. insects or fungi) eat or infect plants	Self-sustaining; organism will over-winter, resume eating its host the next year	Effectiveness will vary as control agent's population fluctates
			Lowers density of problem plant to allow growth of natives	Provides moderate control - complete control unlikely
				Control response may be slow
				Must have enough control agent to be effective
a. Weevils on EWM*	Y	Native weevil prefers EWM to other native water-milfoil	Native to Wisconsin: weevil cannot "escape" and become a problem	Need to stock large numbers, even if some already present
			Selective control of target species	Need good habitat for overwintering on shore (leaf litter) associated with undeveloped shorelines
			Longer-term control with limited management	Bluegill populations decrease densities through predation

Management Options for Aquatic Plants

	Option	Permit Needed?	How it Works	PROS	CONS
b.	Pathogens	Y	Fungal/bacterial/viral pathogen introduced to target species to induce mortalitiy	May be species specific	Largely experimental; effectiveness and longevity unknown
				May provide long-term control	Possible side effects not understood
				Few dangers to humans or animals	
c.	Allelopathy	Y	Aquatic plants release chemical compounds that inhibit other plants from growing	May provide long-term, maintenance-free control	Initial transplanting slow and labor-intensive
				Spikerushes (*Eleocharis* spp.) appear to inhibit Eurasian watermilfoil growth	Spikerushes native to WI, and have not effectively limited EWM growth
					Wave action along shore makes it difficult to establish plants; plants will not grow in deep or turbid water
d.	Restoration of native plants	N; strongly recommend plan and consultation with DNR	Diverse native plant community established to repel invasive species	Native plants provide food and habitat for aquatic fauna	Initial transplanting slow and labor-intensive
				Diverse native community more repellant to invasive species	Nuisance invasive plants may outcompete plantings
				Supplements removal techniques	Largely experimental; few well-documented cases

Management Options for Aquatic Plants

Option	Permit Needed?	How it Works	PROS	CONS
Physical Control	Required under Ch. 30 / NR 107	Plants are reduced by altering variables that affect growth, such as water depth or light levels		
a. Drawdown	Y, May require Environmental Assessment	Lake water lowered; plants killed when sediment dries, compacts or freezes	Can be effective, especially when done in winter, provided drying and freezing occur. Sediment compaction is possible over winter	Plants with large seed bank or propagules that survive drawdown may become more abundant upon refilling
		Must have a water level control device or siphon	Summer drawdown can restore large portions of shoreline and shallow areas as well as provide sediment compaction	Species growing in deep water (e.g. EWM) that survive may increase, particularly if desirable native species are reduced
		Season or duration of drawdown can change effects	Emergent plant species often rebound near shore providing fish and wildlife habitat, sediment stabilization, and increased water quality	May impact attached wetlands and shallow wells near shore
			Success for EWM, variable success for CLP*	Can affect fish, particularly in shallow lakes if oxygen levels drop or if water levels are not restored before spring spawning
			Restores natural water fluctuation important for all aquatic ecosystems	Winter drawdawn must start in early fall or will kill hibernating reptiles and amphibians
				Controversial

Management Options for Aquatic Plants

	Option	Permit Needed?	How it Works	PROS	CONS
b.	Dredging	Y	Plants are removed along with sediment	Increases water depth	Expensive
			Most effective when soft sediments overlay harder substrate	Removes nutrient rich sediments	Increases turbidity and releases nutrients
			For extremely impacted systems	Removes soft bottom sediments that may have high oxygen demand	Exposed sediments may be recolonized by invasive species
			Extensive planning required		Sediment testing is expensive and may be necessary
					Removes benthic organisms
					Dredged materials must be disposed of
					Severe impact on lake ecosystem
c.	Dyes	Y	Colors water, reducing light and reducing plant and algal growth	Impairs plant growth without increasing turbidity	Appropriate for very small water bodies
				Usually non-toxic, degrades naturally over a few weeks.	Should not be used in pond or lake with outflow
					Impairs aesthetics
					Affects to microscopic organisms unknown

Management Options for Aquatic Plants

	Option	Permit Needed?	How it Works	PROS	CONS
d.	Mechanical circulation (Solarbees)	Y	Water is circulated and oxygenated	Reduces blue-green algae	Method is experimental; no published studies have been done
			Oxygenation of water decreases ammonium-nitrogen, which is a preferred nutrient source of EWM, theoretically limiting EWM growth (has not been demonstrated scientifically)	May reduce levels of ammonium-nitrogen in the water and at the sediment interface, which could reduce EWM growth	Although EWM prefers ammonium-nitrogen to nitrate, it will uptake nitrate efficiently, so EWM growth may not be affected
				Oxygenated water may reduce phosphorus release from sediments if mixing is complete	Units are aesthetically unpleasing
				Reduces chance of fish kills by aerating water	Units could be a navigational hazard
e.	Non-point source nutrient control	N	Runoff of nutrients from the watershed are reduced (e.g. by controlling construction erosion or reducing fertilizer use)	Attempts to correct source of problem, not treat symptoms	Results can take years to be evident due to internal recycling of already-present lake nutrients
				Could improve water clarity and reduce occurrences of algal blooms	Expensive
				Native plants may be able to compete invasive species better in low-nutrient conditions	Requires landowner cooperation and regulation
					Improved water clarity may increase plant growth

Management Options for Aquatic Plants

Option	Permit Needed?	How it Works	PROS	CONS
Chemical Control	Required under NR 107	Granules or liquid chemicals kill plants or cease plant growth; some chemicals used primarily for algae	Some flexibility for different situations	Possible toxicity to aquatic animals or humans, especially applicators
		Results usually within 10 days of treatment, but repeat treatments usually needed	Some can be selective if applied correctly	May kill desirable plant species, e.g. native water-milfoil or native pondweeds
			Can be used for restoration activities	Treatment set-back requirements from potable water sources and/or drinking water use restrictions after application, usually based on concentration
				May cause severe drop in dissolved oxygen causing fish kill, depends on plant biomass killed, temperatures and lake size and shape
				Controversial
a. 2,4-D (Weedar, Navigate)	Y	Systemic[1] herbicide selective to broadleaf[2] plants that inhibits cell division in new tissue	Moderately to highly effective, especially on EWM	May cause oxygen depletion after plants die and decompose
		Applied as liquid or granules during early growth phase	Monocots, such as pondweeds (e.g. CLP) and many other native species not affected.	Cannot be used in combination with copper herbicides (used for algae)
			Can be used in synergy with endotholl for early season CLP and EWM treatments	Toxic to fish
			Widely used aquatic herbicide	

Management Options for Aquatic Plants

Option	Permit Needed?	How it Works	PROS	CONS
b. Endothall (Aquathol)	Y	Broad-spectrum[3], contact[4] herbicide that inhibits protein synthesis	Especially effective on CLP and also effective on EWM	Kills many native pondweeds
		Applied as liquid or granules	May be effective in reducing reestablishment of CLP if reapplied several years in a row in early spring	Not as effective in dense plant beds
			Can be selective depending on concentration and seasonal timing	Not to be used in water supplies
			Can be combined with 2,4-D for early season CLP and EWM treatments, or with copper compounds	Toxic to aquatic fauna (to varying degrees)
			Limited off-site drift	3-day post-treatment restriction on fish consumption
c. Diquat (Reward)	Y	Broad-spectrum, contact herbicide that disrupts cellular functioning	Mostly used for water-milfoil and duckweed	May impact non-target plants, especially native pondweeds, coontail, elodea, naiads
		Applied as liquid, can be combined with copper treatment	Rapid action	Toxic to aquatic invertebrates
			Limited direct toxicity on fish and other animals	Needs to be reapplied several years in a row
				Ineffective in muddy or cold water (<50°F)

Management Options for Aquatic Plants

	Option	Permit Needed?	How it Works	PROS	CONS
d.	Fluridone (Sonar or Avast)	Y; special permit and Environmental Assessment may be required	Broad-spectrum, systemic herbicide that inhibits photosynthesis; some reduction in non-target effects can be achieved by lowering dosage	Effective on EWM for 1 to 4 years with aggressive follow-up treatments	Affects many non-target plants, particularly native milfoils, coontails, elodea, and naiads, even at low concentrations. These plants are important to combat invasive species
			Must be applied during early growth stage	Applied at very low concentration	Requires long contact time: 60-90 days
			Available with a special permit only; chemical applications beyond 150 ft from shore not allowed under NR 107	Slow decomposition of plants may limit decreases in dissolved oxygen	Demonstrated herbicide resistance in hydrilla subjected to repeat treatments, EWM has the potential to develop resistance
				Low toxicity to aquatic animals	Unknown effect of repeat whole-lake treatments on lake ecology
e.	Glyphosate (Rodeo)	Y	Broad-spectrum, systemic herbicide that disrupts enzyme formation and function	Effective on floating and emergent plants such as purple loosestrife	Effective control for 1-5 years
			Usually used for purple loosestrife stems or cattails	Selective if carefully applied to individual plants	Ineffective in muddy water
			Applied as liquid spray or painted on loosetrife stems	Non-toxic to most aquatic animals at recommended dosages	Cannot be used near potable water intakes
					RoundUp is often illegally substituted for Rodeo
					Associated surfactants of RoundUp believed to be toxic to reptiles and amphibians
					No control of submerged plants

Management Options for Aquatic Plants

	Option	Permit Needed?	How it Works	PROS	CONS
f.	Triclopyr (Renovate)	Y	Systemic herbicide selective to broadleaf plants that disrupts enzyme function	Effective on many emergent and floating plants	Impacts may occur to some native plants at higher doses (e.g. coontail)
			Applied as liquid spray or liquid	More effective on dicots, such as purple loosestrife; may be more effective than glyphosate	May be toxic to sensitive invertebrates at higher concentrations
				Results in 3-5 weeks	Retreatment opportunities may be limited due to maximum seasonal rate (2.5 ppm)
				Low toxicity to aquatic animals	Sensitive to UV light; sunlight can break herbicide down prematurely
				No recreational use restrictions following treatment	Relatively new management option for aquatic plants (since 2003)
g.	Copper compounds (Cutrine Plus)	Y	Broad-spectrum, systemic herbicide that prevents photosynthesis	Reduces algal growth and increases water clarity	Elemental copper accumulates and persists in sediments
			Used to control planktonic and filamentous algae	No recreational or agricultural restrictions on water use following treatment	Short-term results
				Herbicidal action on hydrilla, an invasive plant not yet present in Wisconsin	Precipitates rapidly in alkaline waters
					Small-scale control only, because algae are easily windblown
					Toxic to invertebrates, trout and other fish, depending on the hardness of the water
					Long-term effects of repeat treatments to benthic organisms unknown
					Clear water may increase plant growth

Management Options for Aquatic Plants

Option	Permit Needed?	How it Works	PROS	CONS
h. Lime slurry	Y	Applications of lime temporarily raise water pH, which limits the availablity of inorganic carbon to plants, preventing growth	Appears to be particularly effective against EWM and CLP	Relatively new technique, so effective dosage levels and exposure requirements are not yet known
			Prevents release of sediment phosphorus, which reduces algal growth	Short-term increase in turbidity due to suspended lime particles
			Increases growth of native plants beneficial as fish habitat	High pH detrimental to aquatic invertebrates
				May restrict growth of some native plants
i. Alum (aluminum sulfate)	Y	Removes phosphorus from water column and creates barrier on sediment to prevent internal loading of phosphorus	Most often used against algal problems	Must not eat fish for 30 days from treatment area
		Dosage must consider pH, hardness and water volume	Improves water clarity	Minimal effect on aquatic plants, or increased light penetration may increase aquatic plants
				Toxic to aquatic animals, including fish at some concentrations

***EWM - Eurasian water-milfoil** **Updated March 2006**
***CLP - Curly-leaf pondweed**
[1]**Systemic herbicide - Must be absorbed by the plant and moved to the site of action. Often slower-acting than contact herbicides.**
[2]**Broadleaf herbicide - Affects only dicots, one of two groups of plants. Aquatic dicots include waterlilies, bladderworts, watermilfoils, and coontails.**
[3]**Broad-spectrum herbicide - Affects both monocots and dicots.**
[4]**Contact herbicide - Unable to move within the plant; kills only plant tissue it contacts directly.**
References to registered products are for your convenience and not intended as an endorsement or criticism of that product versus other similar products.

Techniques for Aquatic Plant Control Not Allowed in Wisconsin

	Option	How it Works	PROS	CONS
Biological Control				
a.	Carp	Plants eaten by stocked carp	Effective at removing aquatic plants	Illegal to transport or stock carp in Wisconsin
			Involves species already present in Madison lakes	Carp cause resuspension of sediments, increased water temperature, lower dissolved oxygen levels, and reduction of light penetration
				Widespread plant removal deteriorates habitat for other fish and aquatic organisms
				Complete alteration of fish assemblage possible
				Dislodging of plants such as EWM or CLP turions can lead to accelerated spreading of plants
b.	Crayfish	Plants eaten by stocked crayfish	Reduces macrophyte biomass	Illegal to transport or stock crayfish in Wisconsin
				Control not selective and may decimate plant community
				Not successful in productive, soft-bottom lakes with many fish predators
				Complete alteration of fish assemblage possible
Mechanical Control				
a.	Cutting (no removal)	Plants are "mowed" with underwater cutter	Creates open water areas rapidly	Root system remains for regrowth
			Works in water up to 25 ft	Fragments of vegetation can re-root and spread infestation throughout the lake
				Nutrient release can cause increased algae and bacteria and be a nuisance to riparian property owners
				Not selective in species removed
				Small-scale control only
b.	Rototilling	Sediment is tilled to uproot plant roots and stems	Decreases stem density, can affect entire plant	Creates turbidity
		Works in deep water (17 ft)	Small-scale control	Not selective in species removed
			May provide long-term control	Fragments of vegetation can re-root
				Complete elimination of fish habitat
				Releases nutrients
				Increased likelihood of invasive species recolonization
c.	Hydroraking	Mechanical rake removes plants from lake	Creates open water areas rapidly	Fragments of vegetation can re-root
		Works in deep water (14 ft)		May impact lake fauna
				Creates turbidity
				Plants regrow quickly
				Requires plant disposal
Physical Control				
a.	Fabrics/ Bottom Barriers	Prevents light from getting to lake bottom	Reduces turbidity in soft-substrate areas	Eliminates all plants, including native plants important for a healthy lake ecosystem
			Useful for small areas	May inhibit spawning by some fish
				Need maintenance or will become covered in sediment and ineffective
				Gas accumulation under blankets can cause them to dislodge from the bottom
				Affects benthic invertebrates