

2013-17 Aquatic Plant Management Plan for Long and Mud Lakes

AIS Education, Prevention & Planning Project

Washburn County, Wisconsin

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2013-17 Aquatic Plant Management Plan for Long and Mud Lakes

AIS Education, Prevention & Planning Project

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Washburn County, Wisconsin

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Executive Summary

Long Lake and Mud Lake are located in southeast Washburn County, Wisconsin. Curly-leaf pondweed (CLP), an aquatic invasive species, has been present in the lakes for a number of years. Currently, CLP seldom occurs as monotypic beds and appears to be “just another plant” in the lakes. Curly-leaf pondweed growth did not reach nuisance or navigation impairment levels in most areas of the lakes. The CLP growth documented in 2011 may represent lower than normal densities due to a long, cool spring. Purple loosestrife and Japanese knotweed are also present around the lakes and management activities for control are included in this plan.

Eurasian watermilfoil (EWM) was not identified in Long or Mud Lake during the 2011 survey work. As such, vigilant watercraft inspection at lake access sites, in-lake aquatic invasive species (AIS) monitoring, and lake user education are essential to prevent the introduction of this and other AIS.

Historic aquatic plant management in Long Lake consisted primarily of chemical treatment of nuisance native aquatic plants. With Eurasian watermilfoil present in many surrounding lakes, the Long Lake Preservation Association decided to take proactive measures to prevent the introduction of this and other aquatic invasive species. Along with prevention, the Association also desired management options for the non-native plant species already present in the lakes. This Aquatic Plant Management Plan was developed to fulfill these needs by setting forth aquatic plant management goals and management activities for the next five years. The Long Lake Preservation Association is requesting WDNR approval for the activities included within this plan, which is anticipated to begin in 2013.

The goals of the Long Lake and Mud Lake Aquatic Plant Management Plan are to:

1. Protect, preserve, and enhance the native plant species community in and around the lakes while maintaining riparian access to open water for recreational use.
2. Maintain navigation for fishing and boating and riparian access to open water for recreational use in problem areas.
3. Monitor and manage curly-leaf pondweed, purple loosestrife, Japanese knotweed and other AIS in and around the lakes and adjacent wetlands.
4. Prevent the introduction of new aquatic invasive species and the spread of existing invasive species from the lakes to other lakes by implementing monitoring, inspection and education programs.
5. Educate and inform the lake community about the importance of aquatic plants in the lake ecosystem and about management alternatives and appropriate management actions.
6. Instill an appreciation for aquatic ecosystems and habitat in the Long and Mud Lake community.
7. Develop a better understanding of the lakes and the factors affecting lake water quality through continued and expanded monitoring efforts.
8. Coordinate water level management with other impoundments in the Red Cedar River watershed.

An outline of the aquatic plant management goals and activities can be found in Appendix A and a five-year timeline for completion of the activities is included in Appendix B. This plan is intended to be a living document which can be modified from time to time to ensure goals and community expectations are being met. Minor changes and adaptations are expected and may be made annually, but any major change in activities or management philosophy will be presented to the RCLA and the WDNR for approval.

Executive Summary (Continued)

Curly-leaf pondweed management will include annual spring bed mapping to help determine management activities that will most benefit the water quality and native plant communities Long and Mud Lake. For much of the lake, early-season (late spring through early summer) manual removal is the most appropriate method of CLP control at this time. The use of aquatic herbicides is appropriate only in a few locations of Long Lake where dense curly-leaf growth interfering with navigation has been documented—in the northern part of the Narrows (where CLP appears to be expanding downstream) and in the bay south of Holy Island. If the existing density or distribution of the CLP surveyed in 2011 changes substantially (for example, growth significantly reduces the native plant species diversity or causes navigational impairments) chemical application or mechanical harvesting may be used for control. Native plant control will be limited to common use navigation and access lanes for individual lake property owners which will be maintained via boat traffic and manual removal unless severely impaired navigation or nuisance conditions are documented. If impaired navigation or nuisance conditions are documented, chemical, biological, or mechanical control methods may be employed.

Table of Contents

Title Page
Distribution List
Executive Summary
Table of Contents

	Page
1.0 Introduction	1
2.0 Long Lake Preservation Association	3
3.0 Public Participation and Input	4
4.0 Aquatic Plant Management Strategy	5
5.0 Documentation of Problems and Need for Management	6
5.1 Aquatic Invasive Species.....	6
5.2 Native Plant Management for Navigation and Nuisance Relief.....	7
5.3 Dam Operation on the Upper Red Cedar River.....	10
6.0 Lake Information	11
6.1 Physical Characteristics	11
6.2 Lake Water Quality	13
6.2.1 Temperature and Dissolved Oxygen	14
6.2.2 Water Clarity	14
6.2.3 Phosphorus.....	15
6.2.4 Chlorophyll <i>a</i>	15
7.0 Aquatic Ecosystems	18
7.1 Aquatic Plants.....	18
7.2 Wetlands.....	19
7.3 Critical Habitat	20
7.4 Fisheries	23
7.5 Rare and Endangered Species Habitat.....	24
8.0 Management History	25
9.0 Aquatic Plant Communities	26
9.1 Aquatic Plant Surveys	26
9.1.1 Long Lake 2011 Cold Water CLP Survey.....	28
9.1.2 Long Lake 2011 Warm Water Point Intercept Survey	30
9.1.3 Mud Lake 2011 Cold Water CLP Survey.....	33
9.1.4 Mud Lake 2011 Warm Water Point Intercept Survey	34
10.0 Northern Wild Rice (<i>Zizania palustris</i>)	37
10.1 Wild Rice in Long Lake.....	38
10.2 Wild Rice in Mud Lake.....	40
11.0 Non-native Aquatic Invasive Species Present in Long and Mud Lakes	41
11.1 Curly-leaf Pondweed (<i>Potamogeton crispus</i>).....	41
11.2 Purple Loosestrife (<i>Lythrum salicaria</i>)	42
11.3 Japanese Knotweed (<i>Polygonum cuspidatum</i>)	43

Table of Contents (Continued)

12.0	Non-native Aquatic Invasive Species Threats to Long and Mud Lakes	44
12.1	Eurasian Watermilfoil (<i>Myriophyllum spicatum</i>).....	44
12.2	Rusty Crayfish and Chinese Mystery Snail	45
12.3	Zebra Mussel and Spiny Water Flea	45
13.0	WDNR Northern Region Aquatic Plant Management Strategy	46
14.0	Aquatic Plant Management Alternatives.....	47
14.1	No Manipulation.....	47
14.2	Manual Removal.....	48
14.2.1	Large-scale Physical Removal	48
14.3	Native Plant Restoration and Enhancement.....	50
14.4	Chemical Control and Management.....	50
14.4.1	How Chemical Control Works.....	50
14.4.2	Timing and Impacts	51
14.4.3	Pre and Post Treatment Aquatic Plant Surveying	51
14.4.4	Residual Testing.....	51
14.4.5	Liquid vs. Granular Formulations.....	52
14.4.6	Small-scale Herbicide Application	52
14.4.7	Large-scale Herbicide Application	52
14.4.8	Spot Treatments	53
14.4.9	EPA-approved Aquatic Herbicides in Wisconsin	53
14.4.9.1	Endothall.....	54
14.4.9.2	Diquat	54
14.4.9.3	Glyphosate	54
14.4.9.4	2,4-D.....	54
14.4.9.5	Triclopyr.....	54
14.4.9.6	Fluridone.....	55
14.4.9.7	Copper Complexes.....	55
14.5	Biological Control and Management.....	55
14.5.1	Biological Controls in Wisconsin.....	56
14.5.1.1	Milfoil Weevils.....	56
14.5.1.1.1	Purchasing Weevils	57
14.5.1.1.2	Rearing Weevils.....	57
14.5.1.1.3	Success of Weevils.....	57
14.5.1.2	Purple Loosestrife Beetles.....	58
14.6	Top-down Biomanipulation	59
15.0	Other Aquatic Plant Management Alternatives	60
15.1	Mechanical Control.....	60
15.1.1	Mechanical Harvesting	60
15.1.1.1	Harvesting Costs	61
15.1.2	Small-Scale Mechanical Management	61
15.1.3	Suction Dredging	62

Table of Contents (Continued)

15.1.4 Other Mechanical Management.....	62
15.2 Barley Straw	63
15.3 Aquatic Plant Habitat Disruption.....	63
15.3.1 Dredging	63
15.3.2 Benthic Barriers and Light Reduction	63
15.3.3 Water Level Manipulation	64
16.0 Aquatic Plant Management Discussion	65
16.1 Management of Curly-leaf Pondweed	65
16.2 Management of Purple Loosestrife.....	68
16.3 Other AIS.....	68
17.0 Aquatic Plant Management Goals, Objectives, and Actions	69
17.1 Goal One	70
17.1.1 Native Plant Protection, Preservation, and Enhancement.....	70
17.1.2 Aquatic Plant Management Impacts to the Fishery	70
17.1.3 Wild Rice Management.....	70
17.2 Goal Two	71
17.2.1 Identification and Monitoring.....	71
17.2.2 Evaluations and Recommendations	71
17.2.3 Aquatic Plant Management Permit Applications.....	71
17.3 Goal Three.....	72
17.3.1 Curly-leaf Pondweed Management	72
17.3.1.1 Bed Mapping and Density Monitoring.....	72
17.3.1.2 Physical Removal	72
17.3.1.3 Chemical Application	72
17.3.1.4 Pre- and Post-Chemical Treatment Aquatic Plant Surveying.....	73
17.3.2 Purple Loosestrife Monitoring and Management.....	73
17.3.3 Japanese Knotweed Monitoring and Management	74
17.3.4 Other Aquatic Invasive Species.....	74
17.4 Goal Four.....	75
17.4.1 AIS Education, Prevention and Planning.....	75
17.4.1.1 Watercraft Inspection and Signage	75
17.4.1.2 In-lake and Shoreline AIS Monitoring	75
17.4.1.3 Rapid Response Plan.....	75
17.4.1.4 AIS Coordinator	75
17.5 Goal Five	76
17.5.1 Lake Community Education.....	76
17.5.1.1 Education Events.....	76
17.5.1.2 Distribution of Information and Education Materials	76
17.6 Goal Six.....	77
17.6.1 Wildlife Appreciation	77

Table of Contents (Continued)

17.7 Goal Seven.....	78
17.7.1 Lake Community Understanding	78
17.7.1.1 Shoreland Restoration and Habitat Improvement	78
17.7.1.2 Riparian Owner Best Management Practices.....	78
17.7.1.3 CLMN Water Quality Monitoring Program	78
17.8 Goal Eight.....	80
17.8.1 Maintaining Open Lines of Communication	80
17.8.1.1 Spring, Rain Events, and Fall Withdrawals	80
17.8.1.2 Outflow Reductions	80
18.0 Aquatic Plant Management Plan Maintenance	81
18.1.1 Successful Reporting and Data Sharing.....	81
18.1.1.1 End of Year and Annual Management Proposals	81
18.1.1.2 Update of the Point Intercept Aquatic Plant Survey	81
18.1.1.3 End of Five-Year Project Evaluation and Assessment.....	81
19.0 Five-Year Timeline of Activities	82
20.0 References	83

List of Tables

Table 1	Physical Characteristics of Long and Mud Lakes	11
Table 2	The Trophic State Index and Description of Conditions.....	17
Table 3	Natural Heritage Inventory Listing for Long and Mud Lakes	24
Table 4	Summary Statics of the 2011 Long Lake Aquatic Plant Survey.....	32
Table 5	Summary Statics of the 2011 Mud Lake Aquatic Plant Survey.....	36

Table of Contents (Continued)

List of Figures

Figure 1	Long and Mud Lake Watersheds	2
Figure 2	Summer Aquatic Plant Density in Long Lake (red circles represent possible areas of navigation impairment and nuisance level native aquatic plant growth)	8
Figure 3	Summer Aquatic Plant Density in Mud Lake.....	9
Figure 4	Lake Map: Long and Mud Lakes.....	12
Figure 5	Mean Summer Water Clarity in Long Lake	14
Figure 6	Mean Summer Near-Surface Total Phosphorus in Long Lake	15
Figure 7	Mean Summer Chlorophyll-a Trophic State Index for Long Lake	16
Figure 8	Long and Mud Lake Sensitive Areas	22
Figure 9	WDNR Point Intercept Grid for Long Lake	27
Figure 10	WDNR Point Intercept Grid for Mud Lake	28
Figure 11	Curly-leaf Pondweed at Long Lake Sample Points, 2011 [3].....	29
Figure 12	Long Lake Littoral Zone [3]	30
Figure 13	Long Lake Substrate Type [3]	31
Figure 14	Mud Lake Littoral Zone [4]	34
Figure 15	Mud Lake Substrate Type [4]	35
Figure 16	Mature Wild Rice	37
Figure 17	Wild Rice in Long Lake West of Rice Island (top) and Long Lake-South (bottom).....	38
Figure 18	Wild Rice Distribution and Density in Long Lake, July 2011 [3]	39
Figure 19	Wild Rice in Mud Lake-North (left) and Mud Lake-South (right)	40
Figure 20	Wild Rice Distribution and Density in Mud Lake, July 2011 [4]	40
Figure 21	Curly-leaf Pondweed and Turions.....	41
Figure 22	Purple Loosestrife	42
Figure 23	Japanese Knotweed.....	43
Figure 24	Eurasian Watermilfoil	44
Figure 25	Rusty Crayfish (left) and Chinese Mystery Snail (right)	45
Figure 26	Aquatic Vegetation Manual Removal Zone.....	48
Figure 27	Diver Removal of Curly-leaf Pondweed in Red Cedar Lake, 2011	49
Figure 28	<i>Galerucella californiensis</i> (left), life cycle, and <i>G. pusilla</i> (right).....	58
Figure 29	Before (right) and After (left) Beetle Introduction at Prairie Lake Township Marsh, Barron County, Wisconsin.....	58
Figure 30	Curly-leaf Pondweed Beds in the Narrows	66
Figure 31	CLP Beds South and West of the Narrows Landing [3]	66
Figure 32	Curly-leaf Pondweed Beds near Holy Island	67
Figure 33	Small Scale (left) and Large Scale (right) Beetle Rearing Stations.....	73
Figure 34	Locations of Dams in the Red Cedar River Watershed	80

Table of Contents (Continued)

List of Appendices

Appendix A	Goals, Objectives, and Actions
Appendix B	Five-year Timeline of Events
Appendix C	Public Input Survey Results
Appendix D	WDNR Northern Region APM Strategy
Appendix E	Sensitive Areas Report for Long Lake
Appendix F	Guidelines for Protecting, Maintaining, and Understanding Lake Sensitive Areas
Appendix G	NR 109 - Aquatic Plants: Introduction, Manual Removal and Mechanical Control Regulations
Appendix H	Licensed Harvester Companies in MN, 2009
Appendix I	<i>Galerucella</i> Beetle Rearing Guide
Appendix J	EWM Rapid Response Plan for Long and Mud Lakes
Appendix K	Nuisance and Navigation Guidelines for Native Plant Management

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2013-17 Aquatic Plant Management Plan for Long and Mud Lakes

AIS Education, Prevention & Planning Project

Prepared for Long Lake Preservation Association

1.0 Introduction

Long Lake and Mud Lake are located in southeast Washburn County at the headwaters of the Brill River in northwest Wisconsin (Figure 1). Long Lake, the largest lake in Washburn County, covers 3,290 acres and has 44 miles of shoreline. Mud Lake, which drains into Long Lake, covers 126 acres and has 4.4 miles of shoreline. The lakes are a top-quality resource providing exceptional recreational opportunity and possessing outstanding fish, wildlife, and water quality resources. Long Lake is listed as an Outstanding Water Resource by the Wisconsin Department of Natural Resources (WDNR). The watershed, with 117 lakes of 5 acres or more, is also an ecological gem where land and water resources support a diverse wildlife community.

The Long Lake Preservation Association (LLPA) has been very active in protecting the resources provided by the lakes. Several lake and watershed planning projects have been completed, culminating in the *Long Lake Management Plan* in 1997 [1] and a *State of the Long Lake Watershed* report in 2004 [2]. The Lake Management Plan only briefly addressed aquatic plants and recommended curly-leaf pondweed (*Potamogeton crispus*) (CLP) bed mapping to identify any changes in its distribution and monitoring for the introduction of Eurasian watermilfoil (EWM). The State of the Watershed report recommended continued monitoring for aquatic invasive species (AIS) but did not address specific aquatic plant management activities.

Both lakes have an established curly-leaf pondweed population. Aquatic nuisance control records indicate CLP has been present in the lakes since at least 1990 and recent surveys show it currently presents a problem in only a few areas in Long Lake. The primary driving force behind the development of this plan is the threat of the introduction of other AIS into the lakes, particularly EWM. The LLPA partnered with a number of groups in the watershed to develop this plan. Aquatic plant surveys were completed in nearby lakes in the watershed (Slim, Slim Creek Flowage, Twin, Big Devil, and Little Devils Lakes), but Aquatic Plant Management Plans have not been developed.

The purpose of this plan is to guide the effective management and protection of aquatic plants in Long and Mud Lakes. The primary goal of this plan is to establish long-term and realistic objectives for managing nuisance non-native plant species while protecting valuable native species and their important habitat functions for each lake. This plan supports sustainable practices to protect, maintain and improve the native aquatic plant community, the fishery, and the recreational and aesthetic values of the lakes. This plan also lays out a strategy to prevent the introduction of other AIS not currently found in the lakes such as EWM.

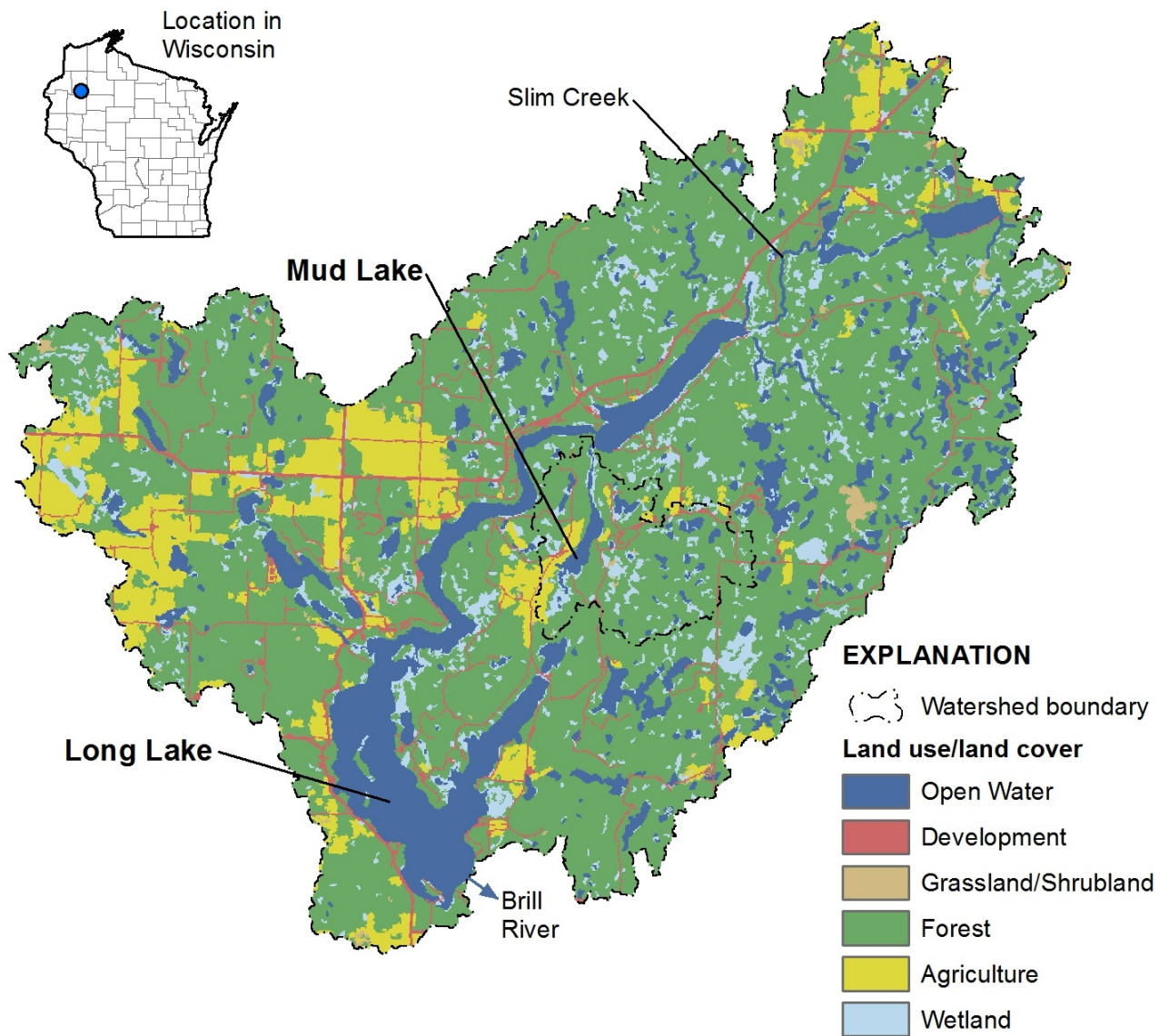


Figure 1 – Long and Mud Lake Watersheds

2.0 Long Lake Preservation Association

The mission of the LLPA is to maintain, protect, and enhance the quality of the lake and its surroundings for the collective interests of the members and the general public, to carry out educational programs, and to make representations on behalf of its members. The LLPA is an organization of standing committees structured around priorities and strategies intended to benefit the Long Lake and its watershed. Committees include the:

- [Executive Committee](#)
- [Watershed Environmental Monitoring Committee](#)
- [Education, Communication and Outreach \(ECO\) Committee](#)
- [Watershed Protection and Enhancement Committee](#)
- [Development and Capacity Building Committee](#)

Funding for LLPA activities, events and projects comes from membership dues and donations and from Lake Management Grants offered by the WDNR. These grant funds come from a pool of money set aside from gas taxes collected on fuel used for boats and other watercraft. Funds from dues, donations, and volunteer hours provide the required sponsor match for grants.

3.0 Public Participation and Input

The LLPA provided input, support, and review of draft documents during the development of this APM Plan. The LLPA has been and remains very active in protecting the resources of the Long Lake watershed. The LLPA posts lake- and watershed-related documents on its website at <http://www.longlakellpa.org/>.

Further public input was collected through a public input survey developed and distributed by the LLPA with the help of their consultant and the WDNR during the summer of 2011. Surveys were mailed to 400 randomly selected households around Long and Mud Lakes. One hundred fifty-five (155) completed surveys were returned (39% return rate), representing approximately 20% of the landowners. The public input survey provided a strong foundation for the development of this plan and identified a number of knowledge areas that could benefit from community education and outreach programs. The complete public input survey and results can be found in Appendix C.

The LLPA and the Hunt Hill Audubon Sanctuary sponsor “Cakes at the Lake” events for lake property owners and the surrounding community. One of these sessions focused specifically on aquatic invasive species, and several others provided updates to the public on efforts being undertaken by the LLPA and partners to protect the lake from AIS.

The LLPA also publishes a newsletter several times each year. Both a newsletter and calendar produced by the LLPA in 2011 focused on AIS education and information. This project was also discussed with the LLPA membership at the annual meeting held on Memorial Day weekend.

4.0 Aquatic Plant Management Strategy

The WDNR aquatic plant management guidelines and the Northern Region Aquatic Plant Management Strategy (Appendix D), and the Long Lake Sensitive Area Report (Appendix E) formed the framework for the development of this APM plan. All existing and new APM Plans and the associated management permits (chemical or harvesting) are reviewed by the WDNR. APM plans developed for northern Wisconsin lakes are evaluated according to the Northern Region APM Strategy goals that went into effect in 2007. Additional review may be completed by the Voigt Intertribal Task Force (VITF) in cooperation with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC).

The VITF is composed of nine Tribal members and a chairperson. The VITF recommends policy regarding inland harvest seasons, resource management issues, and budgetary matters to the Board of Commissioners. The VITF addresses matters that affect the treaty rights of the member tribes in the 1837 and 1842 Treaty ceded territories. The VITF recommends harvest seasons and regulations for each inland season. Those recommendations are then taken to the respective tribal councils for ratification prior to becoming an ordinance.

GLIFWC is an agency of eleven Ojibwe member tribes from Minnesota, Wisconsin, and Michigan, who retain off-reservation treaty rights to hunt, fish, and gather in treaty-ceded lands. GLIFWC exercises powers delegated by its member tribes and assists member bands in implementing off-reservation treaty seasons and in the protection of treaty rights and natural resources. GLIFWC provides natural resource management expertise, conservation enforcement, legal and policy analysis, and public information services. All member tribes retained hunting, fishing and gathering rights in treaties with the U.S. government, including the 1836, 1837, 1842 and 1854 Treaties.

This Aquatic Plant Management Plan supports sustainable practices to protect, maintain and improve the native aquatic plant community, the fishery, and the recreational and aesthetic values of the lake. This plan also lays out a strategy to prevent the introduction of new AIS not currently known to be in the lakes, which includes a monitoring program to aid in early detection of any new AIS. This five-year plan is intended to be a living document which will be evaluated on an annual basis and can be revised to ensure goals and community expectations are being met.

5.0 Documentation of Problems and Need for Management

This plan addresses concerns with aquatic invasive species, native plant growth, and dam operation. Curly-leaf pondweed, purple loosestrife (*Lythrum salicaria*), and Japanese knotweed (*Polygonum cuspidatum*) are non-native AIS present in and around Long and Mud Lakes. In addition, dense stands of native plant growth cause navigation issues and nuisance conditions in a few areas of Long Lake. The Red Cedar River Basin, in which the lakes are located, has a number of dams but no coordinated reservoir management strategy which has led to lake level issues in the past.

5.1 Aquatic Invasive Species

Curly-leaf pondweed was first noted in Long Lake in 1990 (WDNR APM treatment files) in a letter explaining the reasons for not issuing a chemical aquatic plant control permit. A field inspection performed by WDNR on June 6, 1990 described an established bed of curly-leaf in the bay south of Holy Island. The bed was found within 70 feet of shore and covered an area of less than one-tenth of an acre. Prior to the early 1990s curly-leaf was considered only a minor threat to waterbodies in Wisconsin and was therefore often not managed; however, with the development of management strategies for EWM, resource professionals started to look at CLP as a manageable AIS.

The first official documentation (voucher specimen submitted to herbarium) of curly-leaf in Long Lake was in 2005 and in Mud Lake in 2011 during the curly-leaf survey undertaken as part of this project. The 2011 survey described the growth of curly-leaf in both lakes as generally not invasive with plants interspersed among native vegetation [3, 4].

The spring 2011 distribution and bed mapping survey found CLP widely scattered throughout the lakes; however, growth at nuisance levels was found in less than 5 acres (0.1% of the entire littoral zone). The majority of the CLP plants were found in the northern portion of the Long Lake Narrows. Less dense beds of CLP were also found along the southern end of Holy Island in the south part of the lake, along the western shore near Kunz Island, and near along the eastern shore near the Sunset Bay Road boat launch.

Curly-leaf pondweed has been present for many years without presenting significant problems and the lakes provide a high ecological value to the area; therefore, the intent of curly-leaf management at this time is not eradication but closely monitoring distribution and focusing control efforts in areas where CLP impairs navigation. Monitoring is required because the distribution data available is from a year (2011) when lake managers in northern Wisconsin and Minnesota reported unusual curly-leaf growth in many infested lakes. Most reports suggested that early-spring curly-leaf growth in the region was delayed and that the overall peak density was lower than normal.

Purple loosestrife has a limited distribution in the Long Lake watershed, but it is present. Purple loosestrife can be found in the wetlands adjacent to the lake, and along the shorelines as single plants, small patches, or in large beds. Purple loosestrife management will entail close monitoring, physical removal, biological control (beetles) and foliar applications of herbicides.

Japanese knotweed is also present along the shores of Long Lake, most notably on the shoreline adjacent to Lincolnwood Resort. There is also a substantial patch within the grounds of the resort. Japanese knotweed management will entail close monitoring, physical removal, and application of herbicides.

In the survey distributed to property owners around the lakes in 2011, the majority of respondents (more than 86%) supported some form of aquatic plant management (primarily hand pulling (81%) and small- or large-scale mechanical harvesting (96%), but also requested more information on the various alternatives, particularly winter drawdown and chemical- and biological-based methods. The majority of respondents also believe aquatic plant management is the responsibility of the WDNR and the LLPA. Education and outreach are needed in order to implement community supported aquatic plant management alternatives.

As a popular destination lake, Long Lake is at high risk for the introduction of new AIS, particularly EWM which is present in many nearby lakes including the Minong Flowage, Nancy Lake, Gilmore Lake, and Beaver Dam Lake. This proximity makes the lakes a candidate for the introduction of EWM via boat traffic. Although EWM was not identified in Long and Mud Lakes during the survey work completed as a part of this project, it remains a concern because of its close presence in nearby lakes

Eurasian watermilfoil would likely thrive in Long Lake but may not do so well in Mud Lake. Northern watermilfoil (*Myriophyllum sibiricum*), a native macrophyte and close relative to EWM, is the 6th most abundant plant in Long Lake, was found at over 20% of the littoral zone sample sites in 2011 [3]. In Mud Lake, northern watermilfoil was only spotted from the boat once and never found on the rake at a sample point [4]. Continuing watercraft inspection, in-lake AIS monitoring, and education and outreach efforts are necessary to prevent the introduction and establishment of EWM and other AIS in the lakes.

5.2 Native Plant Management for Navigation and Nuisance Relief

An important aspect of this management plan is protecting the native aquatic and shoreland plants while maintaining recreational uses. Dense vegetation is common in Long and Mud Lakes (Figure 2 and Figure 3); however most of the dense growth is located such that it does not cause a significant nuisance to activities such as swimming and fishing, or navigation impairment. On Long Lake, areas near Holy Island on the south end of the lake, Grunhagen Bay on the southeast side of the lake, in the outlet channel to the dam, and up in the narrows may cause issues with riparian owners who have restricted access to open water due to aquatic plant growth. On Mud Lake, just about the entire lake has dense aquatic plant growth, which is inherent in a shallow lake system; in most cases, property owners living on Mud Lake expect and accept these conditions. In any given year, property owners in these areas may benefit from limited aquatic plant management. Guidelines for requesting and completing native aquatic plant management are provided in Appendix K.

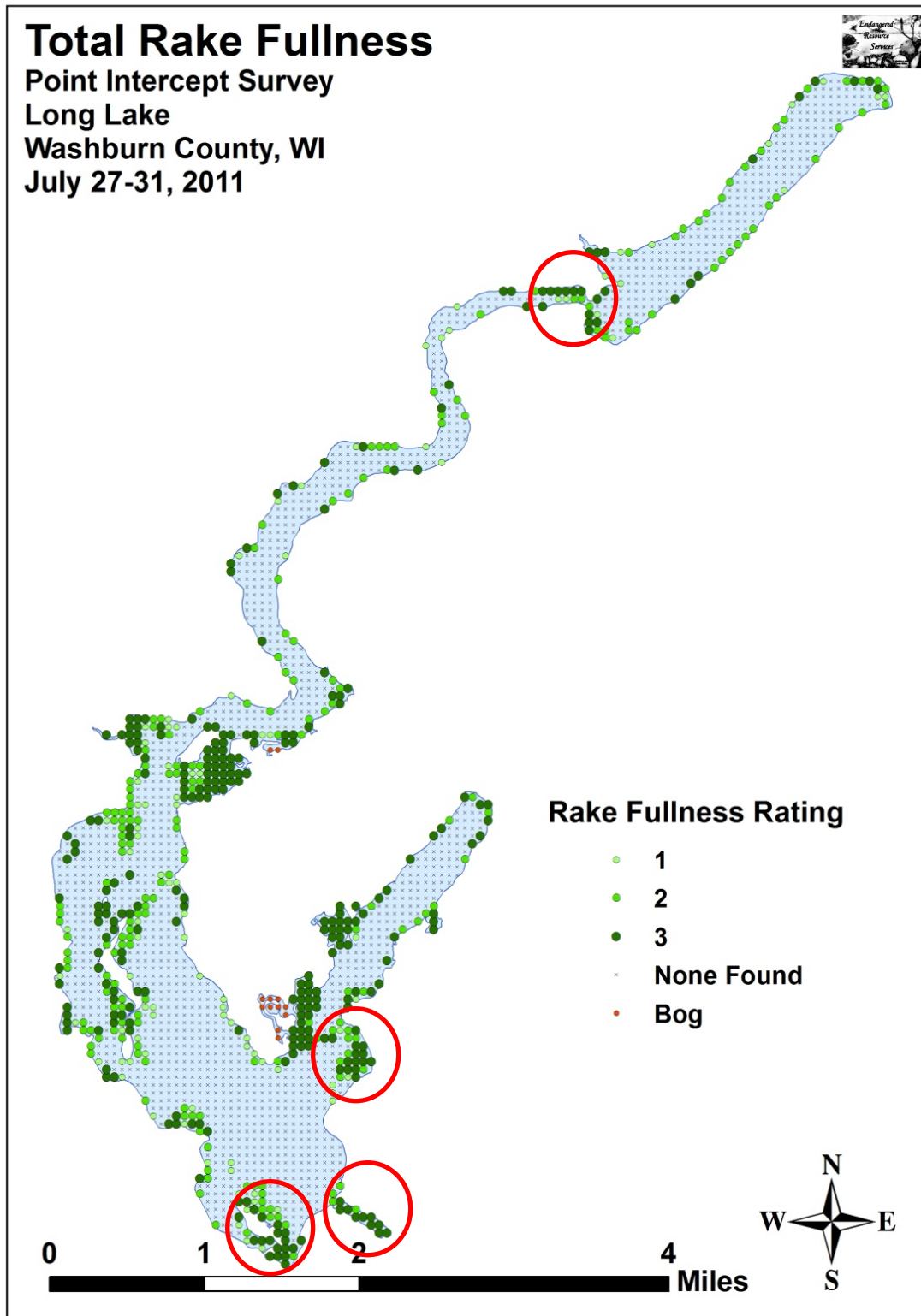


Figure 2 – Summer Aquatic Plant Density in Long Lake (red circles represent possible areas of navigation impairment and nuisance level native aquatic plant growth)

Total Rake Fullness

Point Intercept Survey

Mud Lake

Washburn County, WI

July 27, 2011

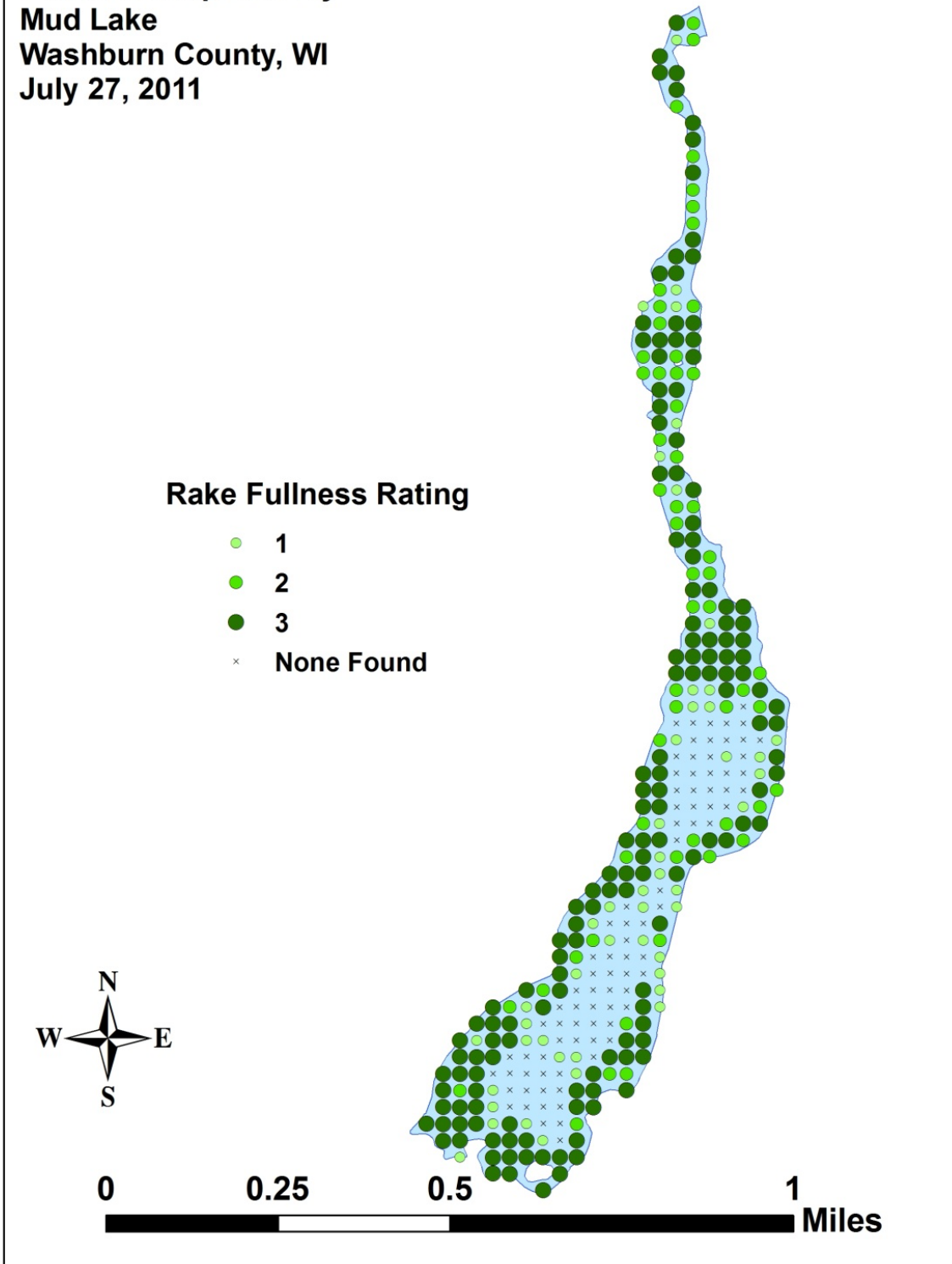


Figure 3 – Summer Aquatic Plant Density in Mud Lake

5.3 Dam Operation on the Upper Red Cedar River

A dam on the Brill River holds back the waters of Long Lake. There are several dams located on the upper reaches of the Red Cedar River and on its tributaries. Some of the larger dams include Big Chetac and Birch Lakes, the Red Cedar Lakes, Murphy Flowage, and Rice Lake. There is currently little to no coordination between the different dam operators, even though water level manipulations of one impoundment impacts the downstream waterbodies. For example, reductions in normal outflow from any one of these impoundments can substantially lower water levels in downstream impoundments if other dam operators are not informed of the change.

6.0 Lake Information

Identifying appropriate aquatic plant management recommendations for the Long and Mud Lake system requires a basic understanding of its physical characteristics, including its morphology (size, structure, and depth), critical habitat, and the fishery, as well as factors influencing water quality, such as soils and land use. All of these factors have the potential to influence aquatic plant growth. Aquatic plant management will impact certain aspects of a lake including water quality, fish and wildlife habitat, and both target and non-target aquatic plants. Water quality and plant survey data collected from the lakes during the development of this plan along with data collected in the past and future provide the information necessary to evaluate the effects of aquatic plant management (and other management activities) on the lakes and their ecosystem.

Much of the lake inventory information that follows is summarized from previous reports [1,2], some of which has been updated from more recent data (for example, lake areas were obtained from the 2010 WROC orthophotos and lake volumes were computed in ArcGIS using depths obtained from the 2011 aquatic plant surveys).

6.1 Physical Characteristics

Long Lake (WBIC 2106800) is a deep, linear lake that is somewhat U-shaped in that it has an arm extending to the northeast as well as the main lake body extending to the northwest (Figure 4). It has a surface area of 3,523 acres and a volume of approximately 93,113 acre-feet (Table 1). The average depth of the lake is 26.4 feet and the maximum depth is 81 feet. Several streams and other lakes contribute water flow to Long Lake including Slim Creek, a small unnamed tributary near Slim Creek, Twin Lake, the Devil Lakes, Little Mud Lake, and Mud Lake. This area is the headwaters region of the Brill River. Outflow over the Long Lake dam averages about 38 cubic feet per second (about 17,000 gallons per minute) [5]. The dam structure, located at the southern terminus of the lake near County Road D, is 15 feet high and it raises the water level 7 feet.

Mud Lake (WBIC 2107700) (Figure 4) is a shallow lake with a surface area of 132 acres and a volume of approximately 821 acre-feet (Table 1). Its maximum depth is 14 feet and average depth is 6.2 feet. Water enters Mud Lake via a small inlet stream to the south and from groundwater inflow (springs). The outlet of the lake flows north into Long Lake with an average discharge of about 3.5 cubic feet per second [5].

Table 1
Physical Characteristics of Long and Mud Lakes

Lake	Area ^a (acres)	Maximum Depth ^b (feet)	Mean Depth ^c (feet)	Volume ^c (acre-feet)	Residence time ^c (years)
Long	3,523	81	26.4	93,113	3.38
Mud	132	14	6.2	821	.32
All Lakes	3,655			93,934	
^a WROC (2010). ^b aquatic plant survey (ERS LLC, 2011). ^c computed by SEH.					

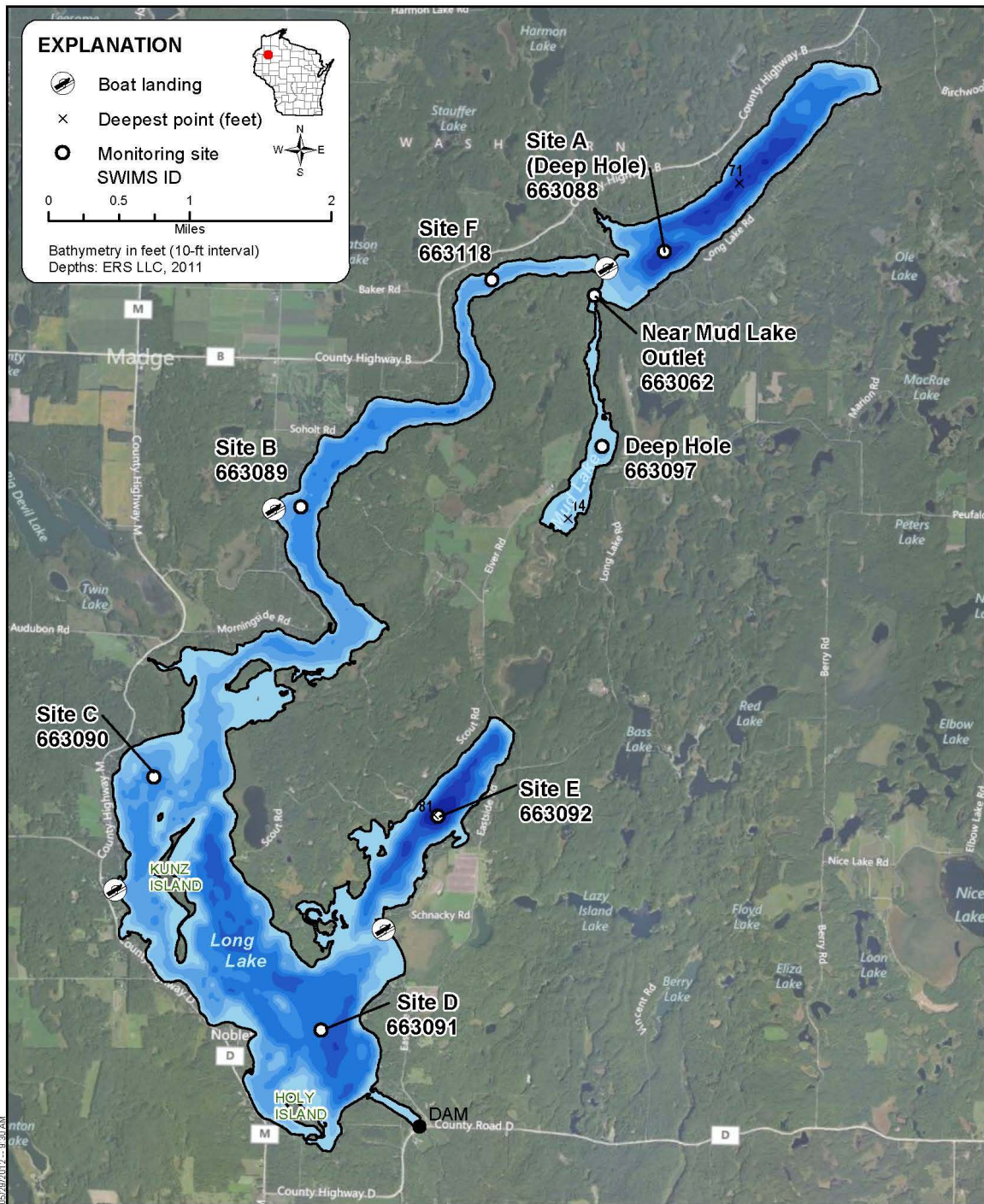


Figure 4 – Lake Map: Long and Mud Lakes

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Lake management requires consideration of the differences between deep and shallow lakes. Shallow lakes are those lakes with a maximum depth of less than 20 feet or with an average depth of less than 10 feet [6]. Mud Lake can be classified as a shallow lake and Long Lake as a deep lake. The water quality of a deep lake is generally driven by external nutrient sources whereas the water quality of a shallow lake is driven internal processes with aquatic plants playing an important role. Shallow lakes generally exist in one of two alternative states: the algae-dominated turbid water state and the plant-dominated clear water state. The turbid water state is characterized by dense algae populations, an undesirable bottom feeding fish community, and few aquatic plants whereas the clear water state is characterized by abundant aquatic plant growth, a greater number of zooplankton, and a diverse and productive game fish community.

A shallow lake that is free of both aquatic plants and algae is uncommon and it is unrealistic to expect such a lake to occur without a large investment in money and energy [6]. The chance of macrophyte-free, clear water is much higher with deep lakes. Shallow lakes are more susceptible to internal nutrient loading (for example, lake sediment phosphorus release) and strong biological manipulations (additions or removals of fish that affect the entire aquatic food web) than deep lakes, which are more responsive to changes in the external nutrient load [6].

A watershed is an area of land from which water drains to a common surface water feature, such as a lake, stream, or wetland. A lake is a reflection of its watershed, that is, a lake reflects its watershed's size, topography, soils, land use and vegetation. The Long Lake watershed covers 80+ square miles, including the 4.8 square mile Mud Lake watershed (Figure 1). The land cover in the watershed is predominantly forests which cover approximately 85% of the landscape, followed by agricultural lands covering less than 10% of the landscape. An extensive overview of the watershed can be found in the *State of the Long Lake Watershed* report [2].

The soils in the area generally consist of a mixture of sand, gravel and rocks deposited by the terminal moraine of the last glaciations. Well-sorted, sandy soils can be found in the northern part of the watershed. The soils in the watershed are rated Very Limited for septic tank absorption fields. A Very Limited rating indicates that the soil has one or more features that are unfavorable for the specified use and poor performance and high maintenance can be expected [7]. The limitations generally cannot be overcome without major soil reclamation, special design (for example, tertiary systems), or expensive installation procedures. Because of the soil characteristics, it is important to have regular septic system inspections to ensure the systems are functioning properly to prevent excessive nutrient loading to the lakes.

6.2 Lake Water Quality

The water quality of a lake influences the aquatic plant community, which in turn can influence the chemistry of a lake. Water clarity, total phosphorus, and chlorophyll *a* are measures of water quality that can be used to determine the productivity or trophic status of a lake. The Carlson trophic state index (TSI) is a frequently used biomass-related index. The trophic state of a lake is defined as the total weight of living biological material (or biomass) in a lake at a specific location and time. Eutrophication is the movement of a lake's trophic state in the direction of more plant biomass. Eutrophic lakes tend to have abundant aquatic plant growth, high nutrient concentrations, and low water clarity due to algae blooms. Oligotrophic lakes, on the other end of the spectrum, are nutrient poor and have little plant and algae growth. Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms.

Water quality data have been collected from Long Lake since 1991 and limited data (total phosphorus only) was collected from Mud Lake in 1994. Beginning in 1999, data considered representative of Mud Lake was collected near its outlet in Long Lake. Long Lake monitoring sites A, C, D, E, and F have the most recent long-term data so these sites are used in this analysis (Figure 2). Parameters that have been collected include temperature and dissolved oxygen profiles, nutrient concentrations, and Secchi depths. Water quality data are archived online in the WDNR Surface Water Integrated Monitoring System (SWIMS) database.

6.2.1 Temperature and Dissolved Oxygen

Long Lake is dimictic, meaning the lake thermally stratifies during the summer and under the ice in the winter and is fully mixed for short periods during the spring and fall. During the summer months, the thermocline develops at about 20 feet below the lake surface. Stratification isolates the lake bottom from interactions with the water column. Dissolved oxygen levels below the thermocline approach zero and above the thermocline dissolved oxygen levels are closer to saturation.

6.2.2 Water Clarity

The depth to which light can penetrate a lake is a factor that limits aquatic macrophyte growth. Water clarity is measured by lowering a black and white Secchi disk into the water and recording the depth of disappearance. The disk is then lowered further and slowly raised until it reappears. The Secchi depth is the mid-point between the depth of disappearance and the depth of reappearance. Because light penetration is usually associated with algae growth, a lake is considered eutrophic when Secchi depths are less than 6.5 feet. Secchi depths vary throughout the year, with shallower readings in summer when algae become dense and limit light penetration and deeper readings in spring and late fall when algae growth is limited.

Long Lake Secchi depths ranged from 5.5 to 12 feet in 2011. The average summer (June–August) Secchi depth of all sites was 8.7 feet, slightly less than the overall summer average (1991–2011) of 9 feet. Since 1991, summer averages have ranged from 6.4 to 11.1 feet. Annual variations of up to 10 feet were measured between the different sites in the lake. The northern and Narrows sites showed less between-year variation than the southern sites. Water clarity has been decreasing at a rate of about 0.05 feet per year over the past two decades (Figure 5). This small but significant trend amounts to a foot of lost clarity over the last 20 years.

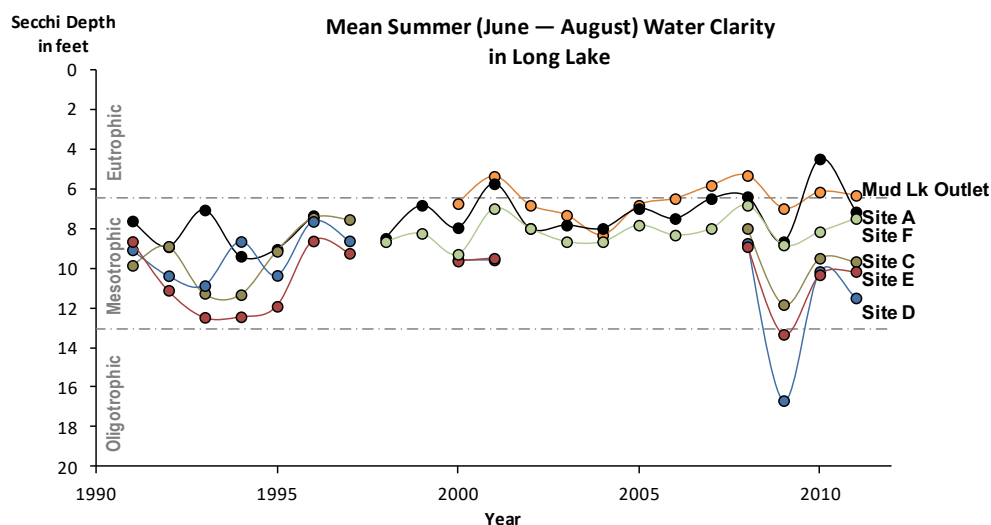


Figure 5 – Mean Summer Water Clarity in Long Lake

6.2.3 Phosphorus

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. When phosphorus is limiting production, small additions of the nutrient to a lake can cause dramatic increases in plant and algae growth and should therefore be the focus of management efforts to improve water quality. Deep lakes such as Long Lake are more responsive to the reduction of external phosphorus inputs, whereas shallow lakes such as Mud Lake are likely to be more responsive to biomanipulations [6].

Total phosphorus was only measured in Mud Lake in 1994, during which time it averaged 75.6 µg/L, which is indicative of near hypereutrophic conditions (very nutrient rich, supporting large amounts of plants, fish and other animals) (Table 2). Total phosphorus has been measured fairly consistently at two or more sites in Long Lake since 1993 (Figure 6). Site A and Site E were the only sites sampled in 2011 and the summer total phosphorus averaged 25 and 16.7 µg/L, respectively. The overall (1993-2011) lake-wide summer average total phosphorus of Long Lake is 21.6 µg/L. As with the Secchi measurements, Site A shows a trend of decreasing water quality (increasing phosphorus) over time, but no long-term trends are evident in at the other sites.

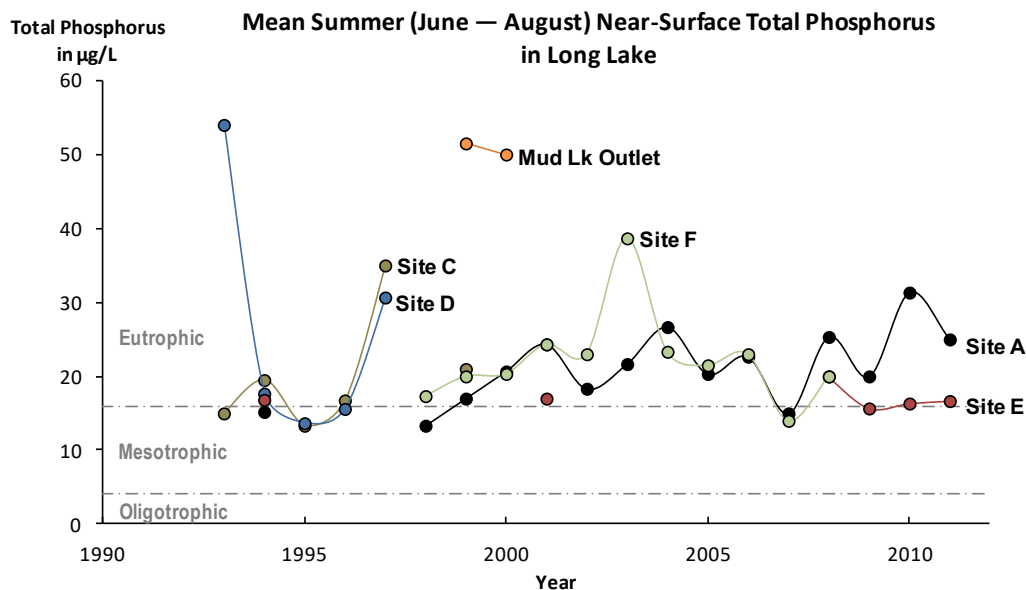


Figure 6 – Mean Summer Near-Surface Total Phosphorus in Long Lake

6.2.4 Chlorophyll *a*

Chlorophyll *a* is the green pigment found in plants and algae. The concentration of chlorophyll *a* is used as a measure of the algal population in a lake. Concentrations greater than about 10 µg/L are considered indicative of eutrophic conditions and concentrations 20 µg/L or higher are associated with algal blooms. For trophic state classification, preference is given to the chlorophyll *a* trophic state index (TSI_{CHL}) because it is the most accurate at predicting algal biomass.

Chlorophyll *a* has been measured throughout Long Lake since 1993. The most recent samples have been collected from Site A and Site E. At Site A, summer concentrations ranged from 8 to 14.5 µg/L in 2011 and averaged 11.4 µg/L, higher than the long-term site average of 8.8 µg/L. Site E fared better with summer concentrations ranging from 3.6 to 5.9 µg/L and a summer average concentration of 4.8 µg/L, which is lower than the site average of 5.7 µg/L. The overall (1993-2011) mean summer chlorophyll *a* concentration for all sites in Long Lake was 7.9 µg/L.

At Site A in 2011, the mean summer TSI_{CHL} ranged from 51 to 57 and averaged 54, which classifies Long Lake as eutrophic (Figure 7). At Site E, the values were in the mesotrophic range and averaged 46. The TSI_{CHL} at all sites on Long Lake historically vary from the upper 40s to lower 50s, putting the lake on mesotrophic-eutrophic boundary (Table 2).

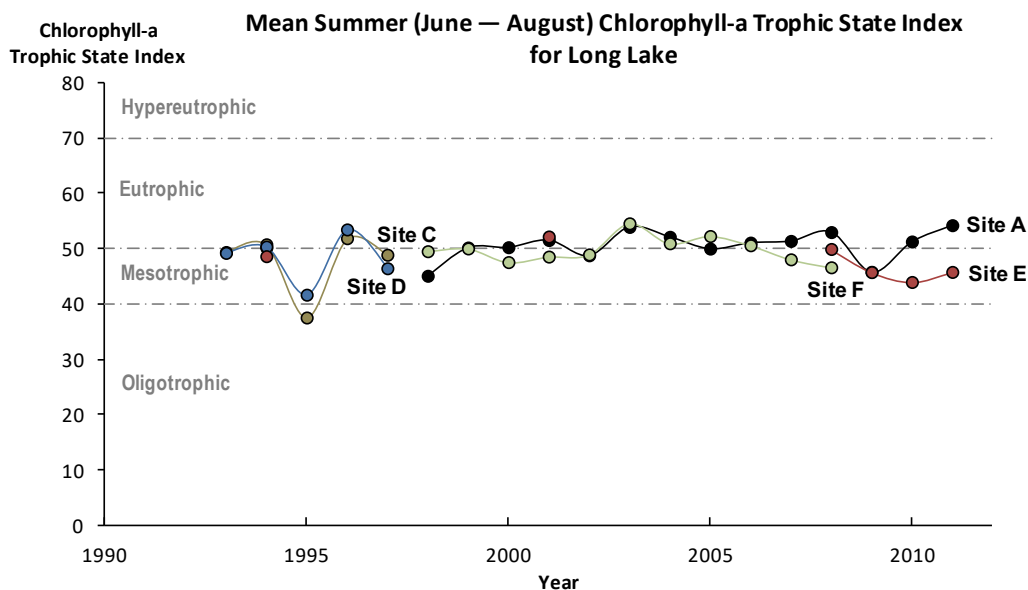


Figure 7 – Mean Summer Chlorophyll-a Trophic State Index for Long Lake

Table 2
The Trophic State Index and Description of Conditions

TSI	Description of Associated Conditions
< 30	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
30 - 40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
40 - 50	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
50 - 60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
60 - 70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
70 - 80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
> 80	Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

← **Long Lake**

← **Mud Lake**

7.0 Aquatic Ecosystems

A healthy lake is dependent on a healthy lake ecosystem. Native aquatic plants and animals (including fish), wetlands, rare and endangered species, and the habitat critical for the all of these entities help to maintain and protect a healthy overall lake ecosystem. When management is recommended for a body of water, care must be taken to protect, maintain, and enhance those parts of the overall ecosystem.

7.1 Aquatic Plants

Aquatic plants are a natural part of most lake communities and provide many benefits to fish, wildlife, and people. Native macrophytes have many important functions and values to a lake ecosystem. They are the primary producers in the aquatic food chain, converting the basic chemical nutrients in the water and soil into plant matter, which becomes food for all other life.

Aquatic plants provide valuable fish and wildlife habitat. More food for fish is produced in areas of aquatic vegetation than in areas where there are no plants. Insect larvae, snails, and freshwater shrimp thrive in plant beds. Panfish eat aquatic plants in addition to aquatic insects and crustaceans. Plants also provide shelter for young fish. Northern pike spawn in marshy and flooded areas in early spring and bass, sunfish, and yellow perch usually nest in areas where vegetation is growing.

Many submerged plants produce seeds and tubers (roots) which are eaten by waterfowl. Bulrushes, sago pondweed, wild celery, and wild rice are especially important duck foods. Submerged plants also provide habitat to a number of insect species and other invertebrates that are, in turn, important foods for brooding hens and migrating waterfowl.

Aquatic plants improve water clarity and water quality. Certain plants, like bulrushes, can absorb and break down polluting chemicals. Nutrients used by aquatic plants for growth are not available to algae, thus reducing algae abundance and improving water clarity. Algae, which thrive on dissolved nutrients, can become a nuisance when too many submerged water plants are destroyed. Aquatic plants also maintain water clarity by preventing the re-suspension of bottom sediments. Aquatic plants, especially rushes and cattails, dampen the force of waves and help prevent shoreline erosion. Submerged aquatic plants also weaken wave action and help stabilize bottom sediment.

Native aquatic plant communities also offer protection from non-native aquatic invasive species. Current scientific literature generally accepts the concept that invasions of exotic plants are encouraged, and in some cases induced, by the disruption of natural plant communities. Eurasian watermilfoil is an opportunistic plant. Much like lawn and agricultural weeds that germinate in newly disturbed soil, EWM is more likely to invade areas in which the native plant community has been disturbed or removed. Removing the natural competition from native plants may also open up the door to new invasive species and less desirable plant communities.

The lake aesthetic valued by so many is enhanced by the aquatic plant community. The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers and leaves that many people enjoy.

As a natural component of lakes, aquatic plants support the economic value of all lake activities. Wisconsin's \$13 billion tourism industry is anchored by 15,081 lakes and 12,600 rivers and streams which draw residents and tourists to hunt, fish, camp, and watch wildlife on and around lakes. According to the WDNR, Wisconsin's world class fishery lures more than 1.4 million licensed anglers each year, supports more than 30,000 jobs, generates a \$2.75 billion annual economic impact, and provides \$200 million in tax revenues for state and local governments.

Unfortunately, healthy aquatic plant communities are often degraded by poor water clarity, excessive plant control activities, and the invasion on non-native nuisance plants. These disruptive forces alter the diversity and abundance of aquatic plants in lakes and can lead to undesirable changes in many other aspects of a lake's ecology. Consequently, it is very important that lake managers find a balance between controlling nuisance plant growth and maintaining a healthy, diverse plant community.

7.2 Wetlands

In Wisconsin, a wetland is defined as an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions (Wisconsin Statue 23.32(1)). Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes. Wetlands are protected under the Clean Water Act and state law, and in some places, by local regulations or ordinances. Landowners and developers are required to avoid wetlands with their projects whenever possible; if the wetlands can't be avoided, they must seek the appropriate permits to allow them to impact wetlands (for example, fill, drain or disturb soils).

There are emergent, forested/shrub, and aquatic bed (lake and freshwater pond) wetlands present throughout the Long Lake watershed, covering over 4,500 acres [2]. About 675 acres of wetlands border Long Lake and over 130 acres bordering Mud Lake. There are also a number of wetlands in closed depressions throughout the watershed.

Emergent wetlands are wetlands with saturated soil and are dominated by grasses such as reedtop and reed canary grass, and by forbs such as giant goldenrod. Forested wetlands are wetlands dominated by mature conifers and lowland hardwood trees. Forested wetlands are important for stormwater and floodwater retention and provide habitat for various wildlife. Aquatic bed wetlands are wetlands characterized by plants growing entirely on or within a water body that is no more than six feet deep.

Wetlands serve many functions that benefit the ecosystem surrounding the lakes. Wetlands support a great variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl. Contrary to popular belief, healthy wetlands reduce mosquito populations; natural enemies of mosquitoes (for example, dragonflies, damselflies, backswimmers, and predacious diving beetles) need proper habitat, that is, healthy wetlands, to survive.

Wetlands provide flood protection within the landscape by retaining stormwater from rain and melting snow and capturing floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months.

Wetland plants and soils provide water quality protection by storing and filtering pollutants ranging from pesticides to animal wastes. Wetlands also provide shoreline protection by acting as buffers between the land and water. Wetland plants protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This is important in Long Lake where boat traffic and wave action may cause substantial damage to exposed sandy shores.

Although some small (two acres or less) wetlands may not appear to provide significant functional values when assessed individually, they may be very important components of a larger natural system. Not only do small wetlands provide habitat functions, they also store phosphorus and nitrogen and trap pollutants such as heavy metals and pesticides. Draining or filling these small wetlands, which often do not appear on maps, not only requires the proper permits, but can also release the once-stored pollutants and nutrients into lakes and streams and re-route runoff directly to the lake.

7.3 Critical Habitat

Every body of water has areas of aquatic vegetation or other features that offer critical or unique aquatic plant, fish and wildlife habitat. Such areas have been mapped by the WDNR and designated as Critical Habitat. Critical Habitat areas include important fish and wildlife habitat, natural shorelines, physical features important for water quality (for example, springs) and navigation thoroughfares. These areas, which can be located within or adjacent to the lake, are selected because they are particularly valuable to the ecosystem or would be significantly and negatively impacted by most human induced disturbances or development. Critical Habitat areas include both Sensitive Areas and Public Rights Features. Sensitive Areas offer critical or unique fish and wildlife habitat, are important for seasonal or life-stage requirements of various animals, or offer water quality or erosion control benefits.

The WDNR completed a Lake Sensitive Area Report on Long Lake in 1998 [8]. The sensitive areas survey identified 32 areas that merited special protection (Figure 8). The sensitive areas on Long Lake fall into two basic categories: aquatic plant communities providing important fish and wildlife habitat (27 in total), and gravel and coarse rock rubble substrate which provide important walleye spawning habitat (5 in total). Wild rice was documented in ten of the fish and wildlife habitat sensitive areas. The data and recommendations from the Sensitive Area Reports were reviewed and incorporated into this aquatic plant management plan. The Long Lake Sensitive Areas Report provides the following plant management recommendations:

- Limit aquatic vegetation removal to navigational channels no greater than 25 feet wide where necessary, the narrower the better.
- Prohibit littoral zone alterations covered by Wisconsin Statutes Chapter 30, unless there is clear evidence that such alterations would benefit the lake's ecosystem.
- Leave large woody debris, logs, trees, and stumps, in the littoral zone to provide habitat for fish, wildlife, and other aquatic organisms.

-
- Leave an adequate shoreline buffer of un-mowed natural vegetative cover and keep access corridors as narrow as possible (preferable less than 30 feet or 30% of any developed lot whichever is less).
 - Prevent erosion, especially at construction sites. Support the development of effective county erosion control ordinances.
 - Strictly enforce zoning ordinances and support development of new zoning regulations where needed.
 - Eliminate nutrient inputs to the lake caused by lawn fertilizers, failing septic systems, and other sources.
 - Control exotic species such as purple loosestrife.
 - Any chemical or mechanical harvesting used for vegetation removal should be limited to navigation channels and only when severely impaired navigation or nuisance conditions are documented. It is important to maintain vegetated shoreland buffers in sensitive areas and stumps and woody habitat, which provides fish cover, should not be removed from sensitive areas.

The full reports can be found in Appendix E of this plan. Also included is the companion document “Guidelines for Protecting, Maintaining, and Understanding Lake Sensitive Areas” (Appendix F). Although restrictions are in place to protect these areas during plant management operations, in some cases, short-term disruptions to habitat during the removal of monotypic stands of aquatic invasive species such as curly-leaf pondweed may lead to positive long-term improvements to the habitat of the lake. Temporary disruptions to the sensitive areas may be warranted when responding to the discovery of a new invasive species.

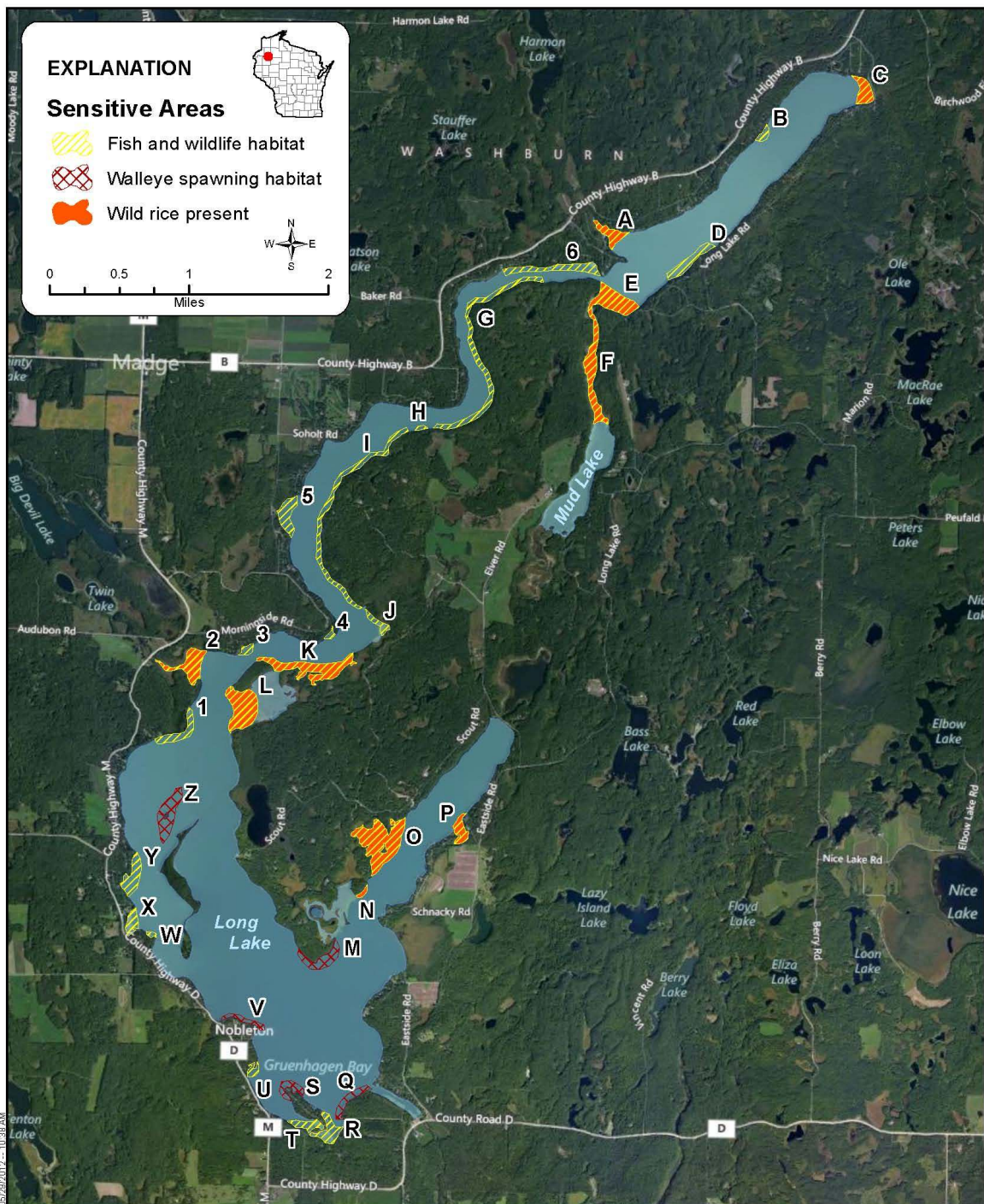


Figure 8 – Long and Mud Lake Sensitive Areas

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7.4 Fisheries

Long Lake has an excellent multi-species fishery that includes walleye, largemouth and smallmouth bass, northern pike, and panfish. Several fish and creel surveys were conducted between 1978 and 2004. The latest survey is not yet available to the public. The primary managed fish species on Long Lake is the walleye. Walleye are native to the lake, even though supplemental stocking from private and public sources has occurred since the 1930's. From 1993 through 2003 walleye fingerlings were stocked on an alternate year basis. Walleye fingerling counts during fall fish shocking completed by the WDNR in the 6 non-stocked years averaged 0.3 fish/mile (range 0 to 0.9). The same counts completed during the 6 stocked years averaged 3.0 fish/mile (range 1.1 to 9.1). Even though there is natural walleye production occurring in the lake, these results suggest that stocking walleyes in the lake shows a significant benefit.

Stocking in the lake has been sponsored by the Long Lake Chamber of Commerce, the LLPA, WDNR, Walleyes for Tomorrow, and the St. Croix Chippewa Tribe. Walleyes for Tomorrow sets up and manages a portable fish hatchery each spring. They release approximately 3 million fry back into the lake each spring. The eggs for the portable hatchery are collected from fish out of Long Lake, reared in the hatchery, and are released as fry. Water circulated through this portable hatchery system comes directly from Long Lake. This method of fish stocking exposes the fry to the same water temperature and water chemistry that they experience when released back into the lake.

Muskellunge were stocked between 1935 and 1942. Total numbers stocked were limited, and the program was discontinued due to its unpopularity with many of the resort owners and fisherman. Muskellunge were unable to sustain their population through natural reproduction and very few angler catches were reported through the 1960's.

Tribal walleye spearing does occur on Long Lake. Long Lake is in the ceded territory so spearing has been legal since 1985. Tribal exploitation rates on adult walleyes increased from just under 4.0% in 1994 to just under 7.0% in 2001. Combined total exploitation rates for angler and tribal harvest went from 26.4% in 1994, to 15.5% in 2001. These exploitation rates are above normal for an average walleye population in northwest Wisconsin.

The Northern pike population, size and growth rates in the lake have stayed relatively stable in recent years. Largemouth bass population, size and growth rate have increased dramatically since the 14 inch minimum size limit was set in 1989. A five-fold increase in bass population densities led to a no minimum length limit starting in 2005 on both bass species to cut back on the number of fish in the lake. It is thought that the increase in bass population is the reason for a drop in walleye populations, as largemouth bass predate heavily on walleye fry. Smallmouth bass are considered to be a non risk to the walleyes as they inhabit similar parts of the lake, and coincide with each other.

Long Lake fish regulations have generally followed statewide and/or regional fishing regulations set in any given year. Currently, there is an 18 inch minimum size limit on the walleyes, and with the bass still considered a problem, there is no minimum size limit at this point in time. Northern pike and panfish follow the statewide regulations.

Tournaments have and still do occur on Long Lake. Most tournaments are local bass and walleye tournaments. A local Thursday night bass league and a local Wednesday night walleye league fishes the lake. Both events encourage catch and release. Each spring in May, WITC, a local college in Rice Lake holds a fishing tournament as well. The tournament is bigger in size and boasts 40 or more boats each year. The tournament is open to all fish

species and catch and release is encouraged, although not mandatory. Some traveling bass tournaments stop at Long Lake each year. These generally have more boats participating as the winning purse is much greater than the local events. Some local winter ice fishing tournaments happen on the lake each year. The biggest one is the Long Lake Ice Fishing Contest. There is no data to show if the fish caught during this contest are harvested or released by anglers.

7.5 Rare and Endangered Species Habitat

The Natural Heritage Inventory database contains recent and historic observations of rare species and plant communities. Each species has a state status including Special Concern (SC), Threatened (THR) or Endangered (END). Species are listed by township; the lakes are located in the Townships Madge (T38N, R11W), the north part of Birchwood (T38N, R10W), and Long Lake (T37N, R11W).

No endangered species are listed for these townships, but threatened and special concern species are present (Table 3). Full descriptions of the plants and animals on the NHI list are on the WDNR website at <http://dnr.wi.gov/topic/EndangeredResources/biodiversity.html> (last accessed 2012-05-10). The 2011 aquatic plant survey of the lakes found no additional federally listed plant species. It is important for lake management to consider impacts to these valuable species, nearly all of which can be directly affected by aquatic plant management. Choosing the proper management techniques and the proper timing of management activities can greatly reduce or prevent negative impacts.

The Natural Heritage Inventory Program also tracks examples of all types of Wisconsin's natural communities that are deemed significant because of their undisturbed condition, size, what occurs around them, or for other reasons. Natural communities located around Long and Mud Lake can also be found in Table 3.

Table 3
Natural Heritage Inventory Listing for Long and Mud Lakes

Scientific Name	Common Name	State Status	Group Name	T37N R11W	T38N R10W	T38N R11W
<i>Buteo lineatus</i>	Red-shouldered hawk	THR	Bird	X		
<i>Haliaeetus leucocephalus</i>	Bald eagle	SC/P	Bird	X	X	X
<i>Lycaena dione</i>	Gray Copper	SC/N	Butterfly	X		
<i>Gomphus graslinellus</i>	Pronghorned clubtail	SC/N	Dragonfly	X		
<i>Etheostoma microperca</i>	Least darter	SC/N	Fish	X		
<i>Notropis anogenus</i>	Pugnose Shiner	THR	Fish	X		
<i>Notropis nubilus</i>	Ozark minnow	THR	Fish	X	X	
<i>Notropis texanus</i>	Weed shiner	SC/N	Fish	X		
<i>Canis lupis</i>	Gray Wolf	SC/FL	Mammal	X	X	X
<i>Arabis missouriensis</i>	Missouri rock-cress	SC	Plant		X	
<i>Crotalaria sagittalis</i>	Arrow-headed rattle-box	SC	Plant			X
<i>Emydoidea blandingii</i>	Blanding's turtle	THR	Turtle	X		
Lake—deep, hard, drainage			Community	X		
Lake—soft bog			Community	X	X	X
Southern dry-mesic forest			Community	X		
Lake—deep, soft, seepage			Community		X	
Northern mesic forest			Community		X	X
Northern wet forest			Community			X
Open bog			Community			X
THR, threatened; SC, special concern; /FL, federally protected as endangered or threatened /P, fully protected; /N, no laws regulating use, possession or harvest. Data current as of 2011-11-04						

8.0 Management History

Chemical aquatic plant control records trace back to the early 1980s for Long Lake (WDNR aquatic plant management files). Past aquatic plant management activity in the lake consisted primarily of chemical treatment of nuisance native aquatic plants. There has been much management activity near Holy Island with the intent to open up an area in front of the culvert to promote better water exchange in hopes of increasing water circulation and decreasing siltation and plant growth.

Herbicide treatments were often done by a collective of neighboring property owners rather than as individual treatments. Target species of chemical control often included high-value, relatively herbicide-resistant native Potamogetons (pondweeds), including large-leaf pondweed (*P. amplifolius*), whitestem pondweed (*P. praelongus*), and Richardson's pondweed (*P. richarsonii*). In the early to mid 1990s, herbicide applications became less common as both the WDNR and land owners began to realize the ecologic value of the relatively narrow littoral zone on the lake. Managers also posited that the proximity of many treatment areas to deep water likely rendered the treatments largely ineffective due to dilution of the herbicide.

9.0 Aquatic Plant Communities

Aquatic plant communities can be classified into three general categories: submergent, emergent, and floating-leaf. Submergent plants are usually, but not always, rooted to the bottom of a lake and completely under water except for certain parts, like flowers, at certain times during the year. Emergent plants include bulrush, cattail, grasses (such as wild rice), and sedges. Floating-leaf plants include water lilies, floating leaf pondweeds, and common elodea. These plants generally grow in shallow water down to about 15 feet. Floating leaf plants also include free-floating species such as duckweeds that are not rooted in the sediment.

Aquatic plants anchor sediments, buffer wave action, oxygenate water, and provide valuable habitat for aquatic animals. The amount and type of plants in a lake can greatly affect nutrient cycling, water clarity, and food web interactions. Aquatic plants are very important for fish reproduction, survival, and growth, and can greatly impact the type and size of fish in a lake. Eighty percent of the plants and animals on the Wisconsin endangered and threatened species list spend all or part of their life cycle within the near shore zone and as many as ninety percent of the living things in lakes and rivers are found along the shallow margins and shores. Allowing the re-growth of native plants in cleared areas can prevent CLP and other non-native invasive plant species from establishing in those sites.

9.1 Aquatic Plant Surveys

Endangered Resources Services, LLC (ERS) conducted early-season CLP bed mapping surveys and mid-season point intercept surveys on Long and Mud Lakes, along with Slim Lake, Slim Creek Flowage, Twin Lakes, Big Devils Lake, and Little Devils Lake. Data were collected on the other lakes as an inventory of aquatic plants found in the watershed; this plan includes a summary of the Long Lake and Mud Lake surveys, and aquatic plant management recommendations in this document only pertain to Long and Mud Lakes. Results for each survey completed are contained in individual lake reports assembled by ERS, which have been distributed to project partners.

The surveys were completed by ERS following standardized methods developed by the WDNR. These methods ensure that all aquatic plant sampling throughout the state is conducted in the same manner, which allows for data to be compared across time and space. Sample points for each lake were generated by the WDNR using a formula that takes into account the lake morphology and water clarity. Once generated, the sample grid remains the same for each individual lake regardless of the number of times a whole-lake plant survey is completed. A sample grid of 2,140 points was created for Long Lake (Figure 9) and a grid of 339 points for Mud Lake (Figure 10). Sample points are spaced 81 meters apart on Long Lake and 39 meters on Mud Lake. Because the distance between points makes it possible to miss individual plants and small isolated beds, AIS surveys also include a meandering survey (following a tight zigzag pattern) along the littoral zone of the lake. More detail about the methods used in each survey can be found in the ERS reports.

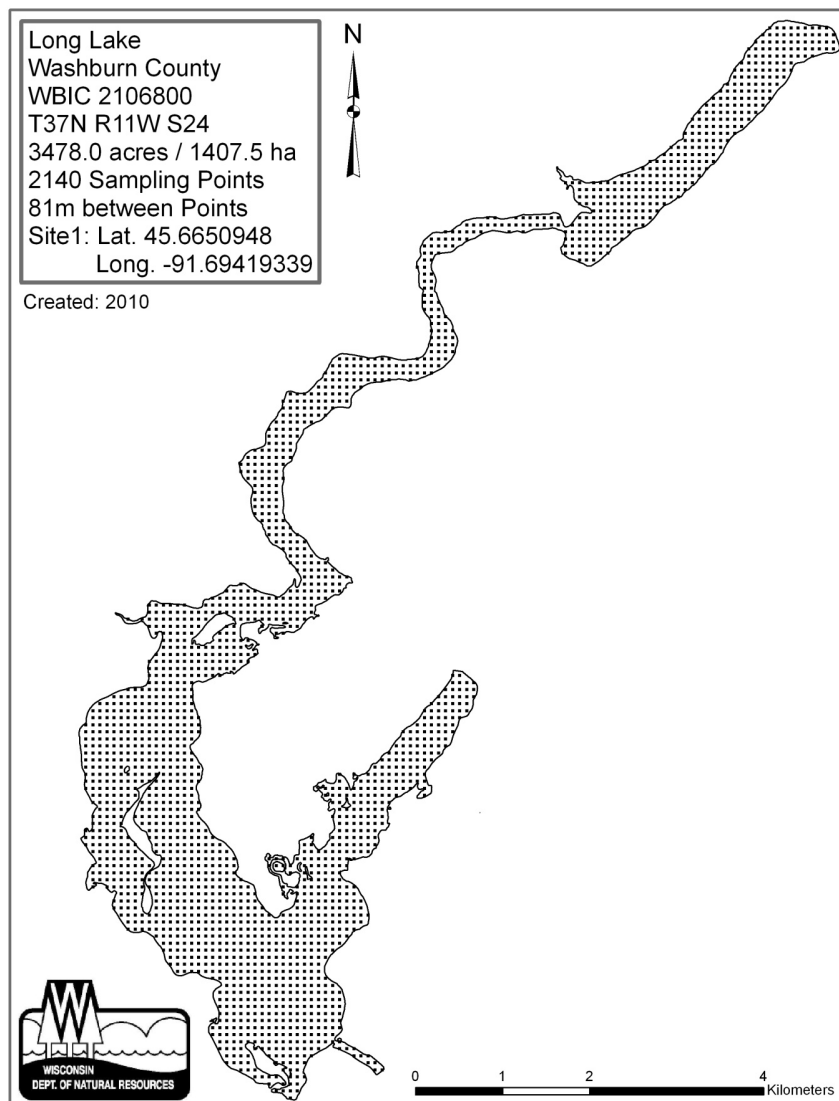


Figure 9 – WDNR Point Intercept Grid for Long Lake

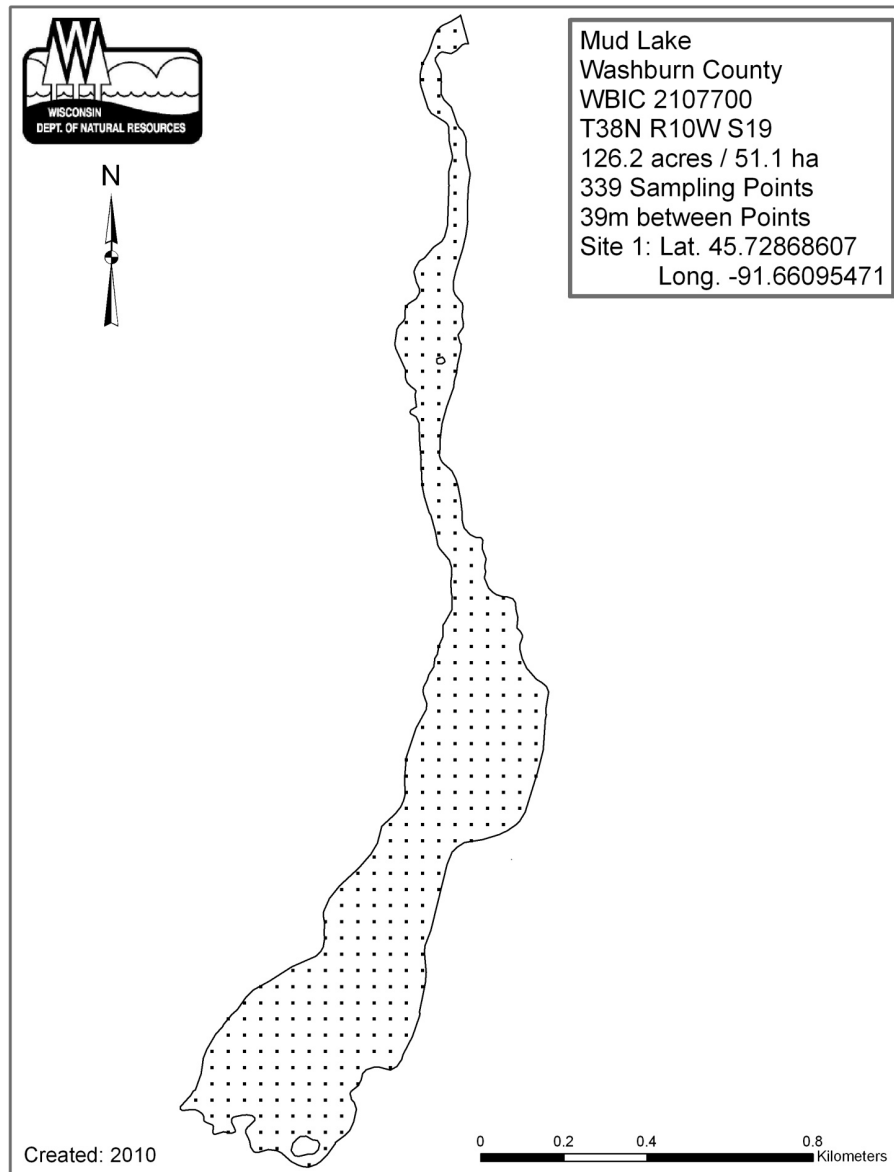


Figure 10 – WDNR Point Intercept Grid for Mud Lake

9.1.1 Long Lake 2011 Cold Water CLP Survey

Based on a littoral zone extending to approximately 14.5 feet of water, nearly 700 points were sampled for the presence of CLP (Figure 11). Curly-leaf was only identified at eight sample points or approximately 0.4% of the lake. Rake fullness values of 2 on a 1-3 scale were recorded at three of the eight points, and none had a rake fullness value of 3. This extrapolated to only 0.1% of the lake having a significant infestation. CLP was visually identified at two additional points. The points in the Long Lake sampling grid are 81 meters apart, making it possible to fail to spot CLP even if it was present. As a result, a bed mapping survey of the entire lake was also completed.

During the bed mapping survey, Curly-leaf pondweed was found to be widely scattered throughout the near shore littoral zone, but never in water more than 8.5 ft deep. Despite being an exotic species, CLP was generally not invasive in Long Lake, and, for the most part, was acting like “just another plant” interspersed among other native vegetation. Most CLP plants were found near boat landings or directly along docks. Nineteen small areas that met or were close to bed criteria were mapped. A bed determination is based on the following two criteria: (1) CLP plants make up greater than 50% of all aquatic plants in the area, and (2) the CLP has canopied at the surface or was close enough to the surface that it would likely interfere with normal boat traffic. All nineteen beds totaled only 4.82 acres, approximately 0.1% of the lake’s total surface area of 3,478 acres. The largest bed mapped was 1.74 acres and the smallest less than 0.01 acre.

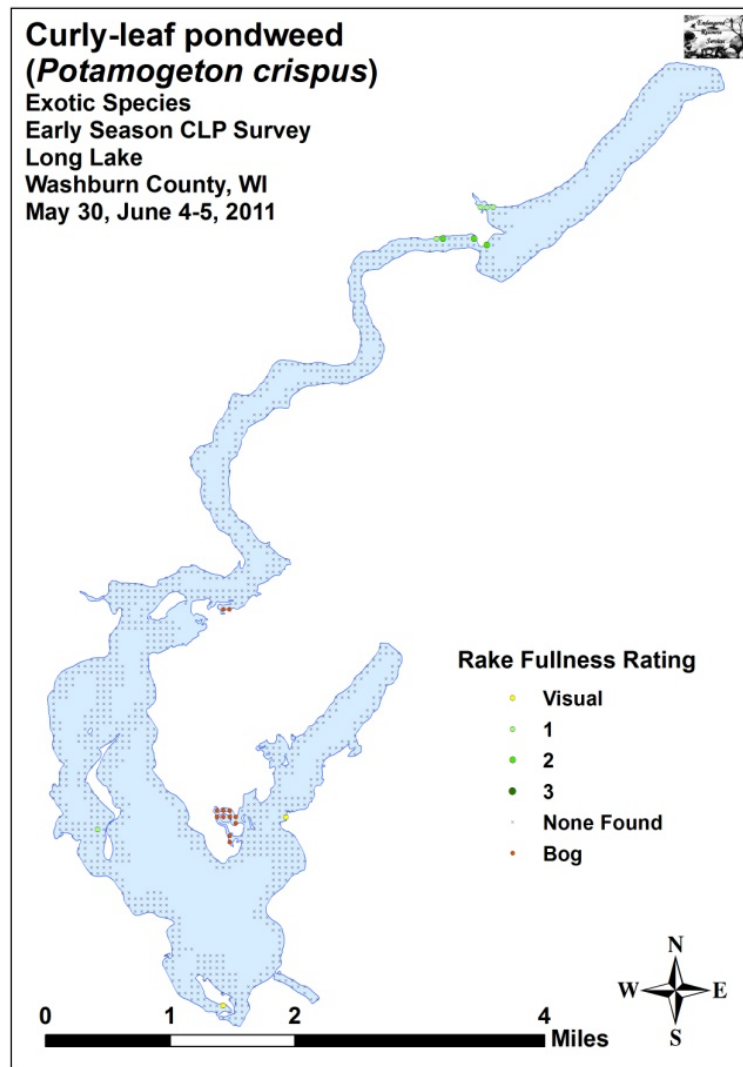


Figure 11 – Curly-leaf Pondweed at Long Lake Sample Points, 2011 [3]

9.1.2 Long Lake 2011 Warm Water Point Intercept Survey

All but 12 of the 2140 points established by the WDNR were sampled during this survey. The 12 points not samples were located on land or in bogs and therefore inaccessible by boat. A total of 59 different plant species were identified growing in or immediately adjacent to the lake. Plants were found growing at 584 of the 689 points considered to be in the littoral zone (Figure 12). This equates to approximately 27.4% of the entire lake bottom and in 84.8% of the littoral zone which extended to a depth of 17 feet. Despite this upper limit of littoral zone, most aquatic plant growth was limited to depth of 14 feet or less.

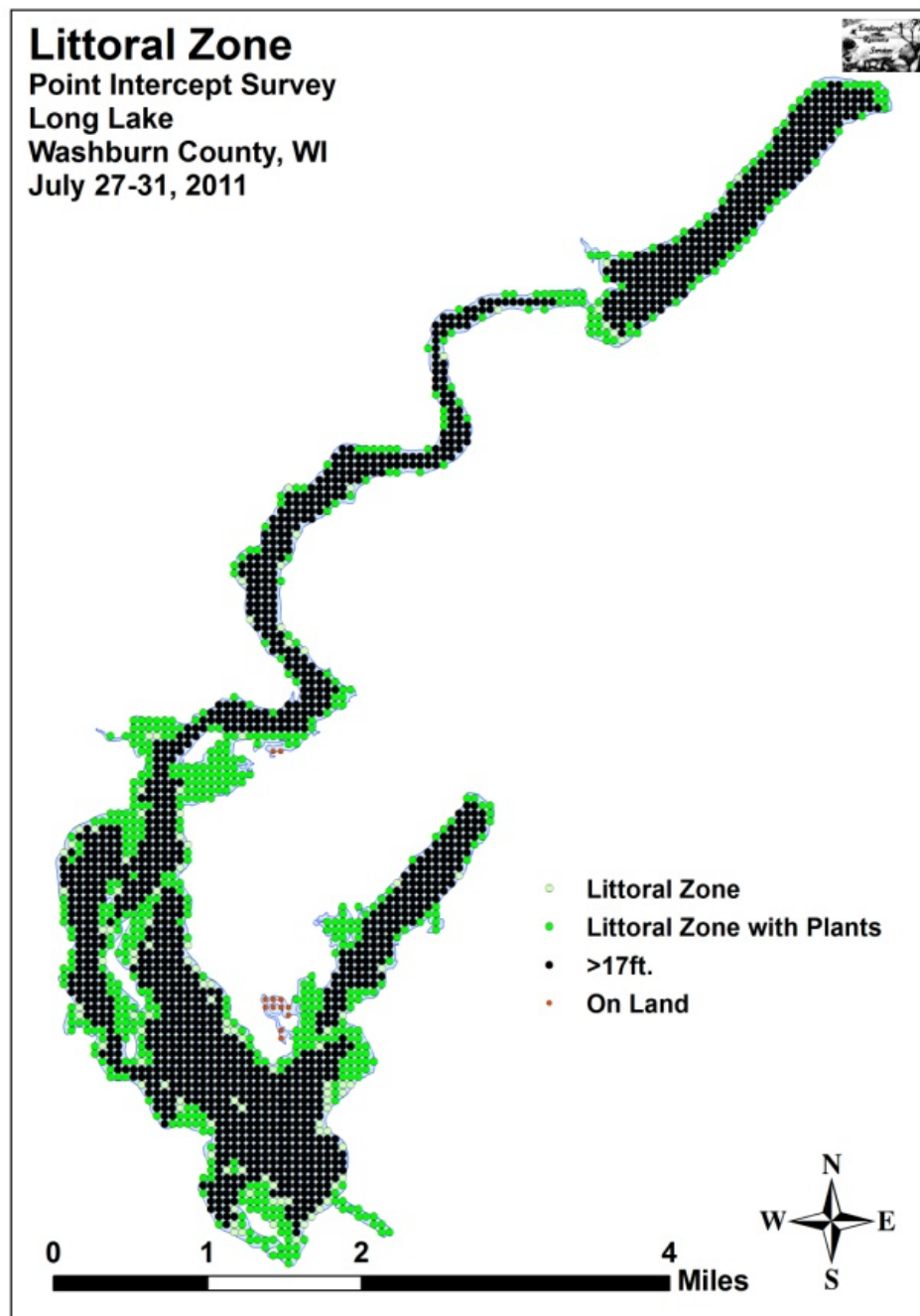


Figure 12 – Long Lake Littoral Zone [3]

The lake bed material, or substrate, could be determined at 698 survey points. Of these sites, 46% were muck, 27% were rock, and 27% were sand. Nutrient rich organic muck dominated the lake bottom in shallow side bays while sandy muck was common in deeper areas with limited plant growth. The lake shore was extremely variable, but most locations were some combination of sand and rock. In the main basin, most of the exposed points, bars, and islands were also sandy or rocky in nature (Figure 13).

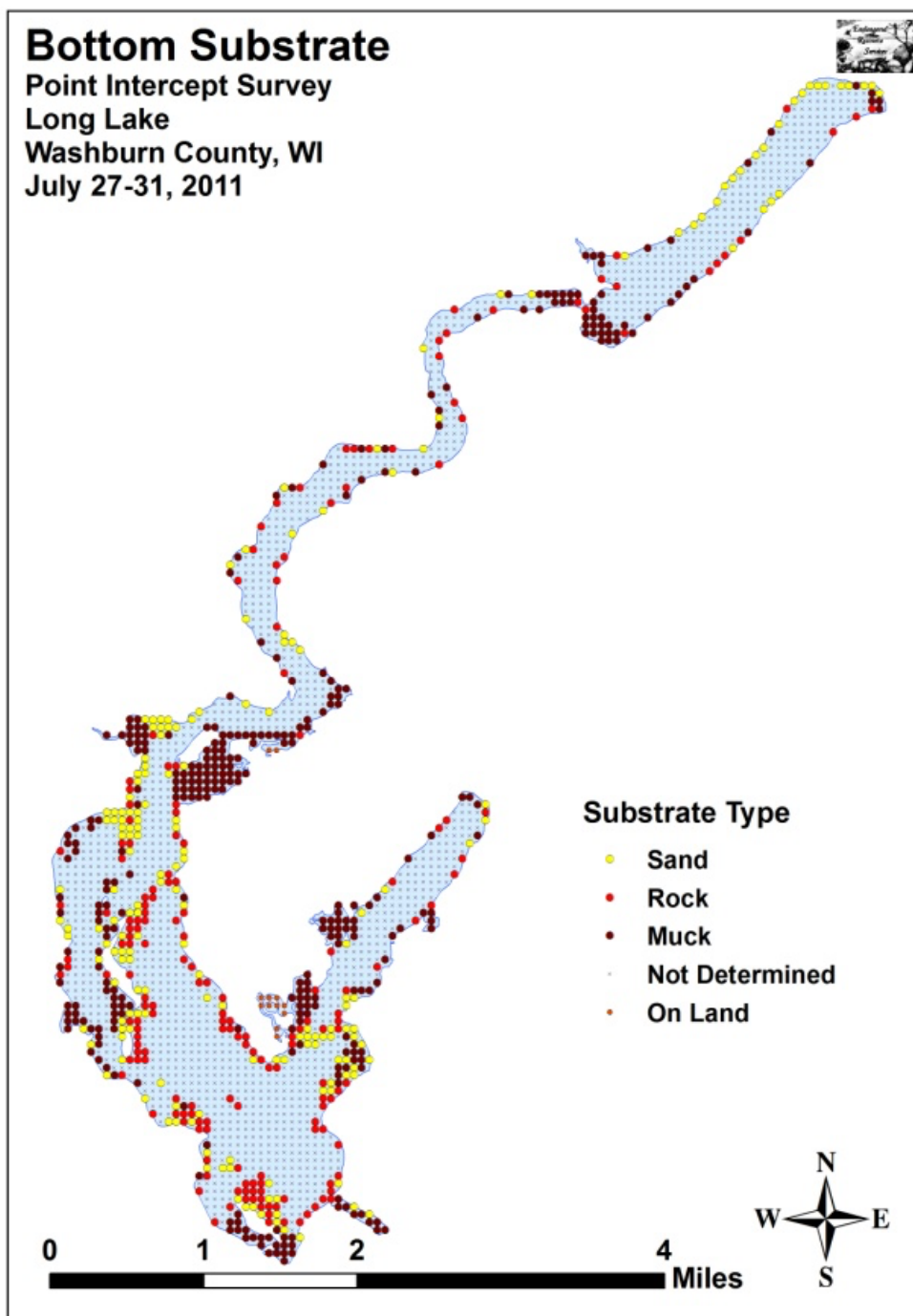


Figure 13 – Long Lake Substrate Type [3]

Summary statistics of the 2011 survey data are included in Table 4. For greater detail, see the 2011 Aquatic Plant Survey Report for Long Lake [3]. The Simpson's Diversity Index for Long Lake is 0.94. The Simpson's Diversity Index is used to quantify biodiversity where zero represents no probability that the two plants will be different and one guarantees that the two plants will be different. Lakes with high plant diversity are usually healthier with less human disturbance and are much more resistant to invasion by exotic species.

The mean Coefficient of Conservation (C) and the Floristic Quality Index (FQI), two measures of aquatic plant community health, determined from the survey results reveal that Long Lake is home to a rich and diverse aquatic plant community. C values range from 1-10, with higher values assigned to plant species that only thrive in pristine, undisturbed environments and are very susceptible to human disturbances that degrade water quality and overall lake health. These plants disappear from the community if disturbance is too great. Lower C-value species generally do well in a multitude of conditions including pristine and degraded environments. Many of these species remain in a lake even under severely degraded conditions and sometimes cause growth and density related issues themselves.

Long Lake ranks highly for this part of the state with an FQI more than double the median Northern Central Hardwood Forests Region FQI of 20.9 [9]. This exceptionally high value is likely a result of Long Lake's large size, variable substrate, large areas of undeveloped shoreline, and good water quality and clarity. All of these factors create a diversity of microhabitats which offer suitable growing conditions for a wide variety of plants. The lake supported six high value/sensitive species (C value of 9) including wild calla, blunt-leaf pondweed, crested arrowhead, creeping bladderwort (*Utricularia gibba*), flat-leaf bladderwort (*Utricularia intermedia*), and small bladderwort (*Utricularia minor*).

Table 4
Summary Statics of the 2011 Long Lake Aquatic Plant Survey

Total number of points sampled	2,128
Total number of sites with vegetation	584
Total number of sites shallower than the maximum depth of plants	689
Frequency of occurrence at sites shallower than maximum depth of plants	84.76
Simpson Diversity Index	0.94
Maximum depth of plants (ft)	17.0
Mean depth of plants (ft)	6.0
Median depth of plants (ft)	6.0
Number of sites sampled using rope rake (R)	35
Number of sites sampled using pole rake (P)	657
Average number of all species per site (shallower than max depth)	3.30
Average number of all species per site (veg. sites only)	3.89
Average number of native species per site (shallower than max depth)	3.29
Average number of native species per site (veg. sites only)	3.88
Species richness	52
Species richness (including visuals)	53
Species richness (including visuals and boat survey)	59
Floristic Quality Index	44.9
Mean Coefficient of Conservatism	6.3

Flat-stem pondweed, coontail, muskgrass, and wild celery were the most common macrophyte species, found at 42.64%, 40.24%, 33.22%, and 31.34% of survey points with vegetation, respectively. Together, they combined for a very low 37.91% of the total relative frequency which indicates a high level of evenness in the plant community (i.e., one species does not dominate). In most lakes, the top four species in a lake are usually >50% [3]. Fries' pondweed (7.35), Northern watermilfoil (6.25), Slender naiad (5.15), and Common waterweed (5.06) were the only other species with a relative frequency over 5.0.

Filamentous algae was identified at 107 sites throughout Long Lake. It was present at approximately 18% of sites with vegetation and had an average rake fullness value of 1.54. With the exception of the muck bottomed bay located at the Mud Lake channel outlet, almost all sites with filamentous algae were located in front of riparian residences.

Curly-leaf pondweed was widespread during the early season cold water survey, but had almost entirely senesced by the July warm water survey.

Hybrid cattail (*Typha* × *glauca*) and one of its parent species narrow-leave cattail (*T. angustifolia*) are native to southern but not northern Wisconsin. It is potentially invasive and appeared to be excluding the native broad-leaved cattail (*T. latifolia*) from many places on the lake where they were found together. There is some potential that it will continue to spread beyond the three bays where it was found to dominate the emergent plant community.

No evidence was found of Eurasian watermilfoil in Long Lake during the May/June curly-leaf pondweed survey or during the July whole-lake point intercept survey.

9.1.3 Mud Lake 2011 Cold Water CLP Survey

Based on a littoral zone extending to approximately 11.0 feet of water, all 339 points were sampled for the presence of CLP. CLP was only identified at six sample points or approximately 1.8% of the lake. Rake fullness values of 2 on a 1-3 scale were recorded at two of the six points, and none had a rake fullness value of 3. This equates to only 0.6% of the lake having a significant infestation. The points in the Mud Lake sampling grid are 39 meters apart, making it possible to miss CLP even if it was present. As a result, a bed mapping survey of the entire lake was also completed.

During the bed mapping survey, CLP was found to be widely scattered throughout the near-shore littoral zone, but never in water more than 7.5 feet deep. Despite being an exotic species, CLP was generally not invasive in Mud Lake, and, for the most part, was acting like “just another plant” interspersed among other native vegetation. Two small areas that met bed criteria or were at least close to it were mapped. A bed determination is based on the following two criteria: CLP plants make up greater than 50% of all aquatic plants in the area, and the CLP has canopied at the surface or was close enough to the surface that it would likely interfere with normal boat traffic. Both beds combined totaled less than 0.50 acres, the biggest bed being 0.47 acres, and the smallest 0.01 acre. This is approximately 0.4% of the lake's total surface area of 126 acres.

9.1.4 Mud Lake 2011 Warm Water Point Intercept Survey

All of the 339 points established by the WDNR were sampled during this survey. Plants were found growing at 253 of the 313 points considered to be in the littoral zone. This equates to approximately 74.6% of the entire lake bottom and in 80.8% of the littoral zone which extended to 11 ft of depth. Despite this upper limit of littoral zone, most aquatic plant growth ended in 9.5 ft of water (Figure 14). The substrate type was determined at all 339 points. Of these sites, 97% were organic muck, 2% were rock, and 1% were sand (Figure 15).

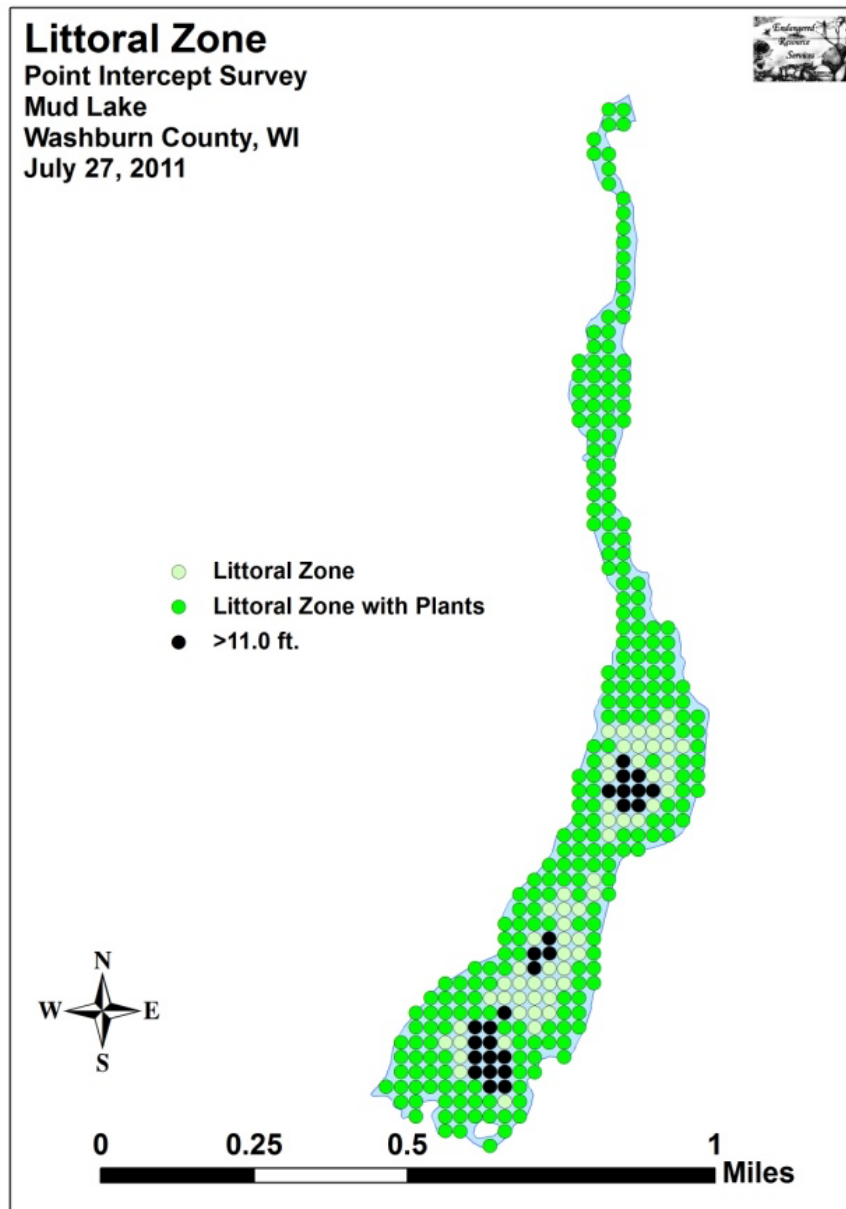


Figure 14 – Mud Lake Littoral Zone [4]

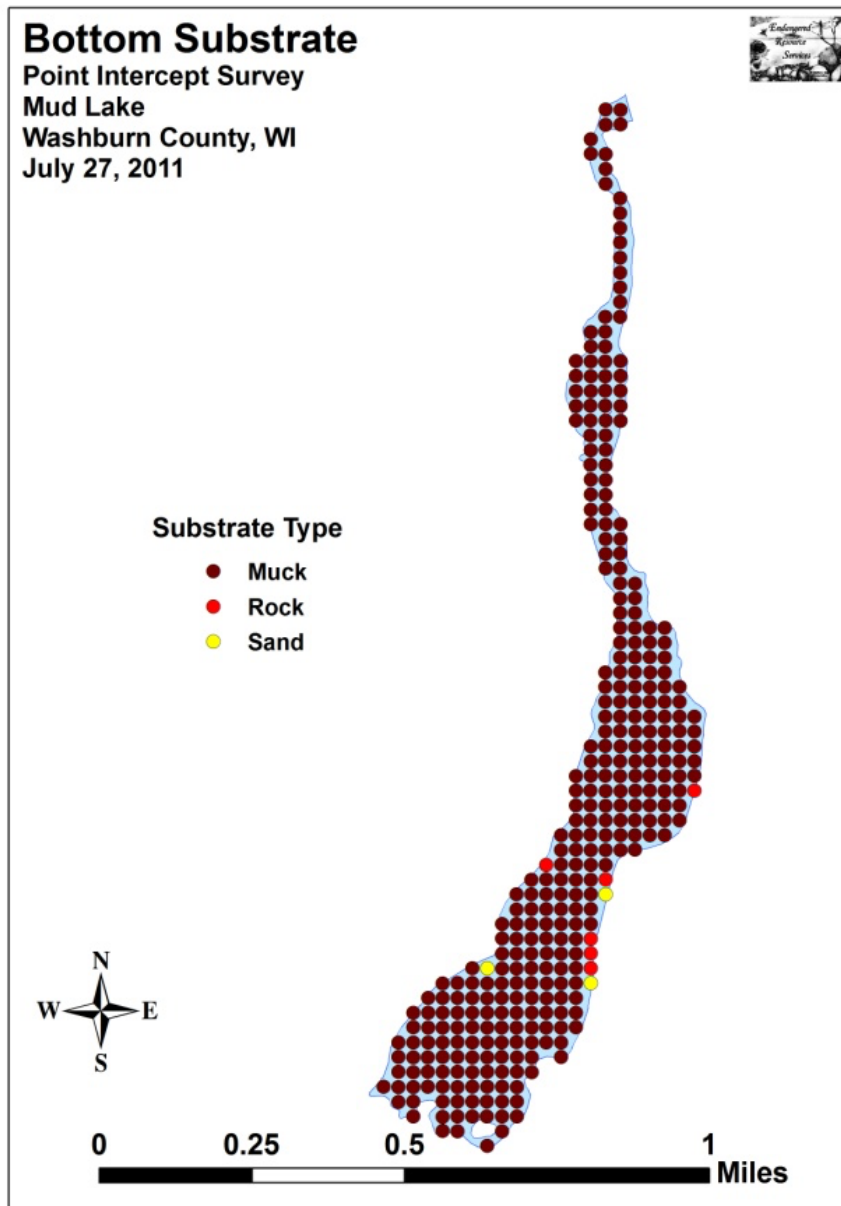


Figure 15 – Mud Lake Substrate Type [4]

A total of 29 different plant species were identified growing in or immediately adjacent to the lake providing a Simpson's Diversity Index of 0.89. The Simpson's Diversity Index represents the probability that two plant samples taken from the same point will be different. Zero represents no probability that the two plants will be different and one guarantees that the two plants will be different. Lakes with high plant diversity are usually healthier, with less human disturbance, and are much more resistant to invasion by exotic species.

The mean Coefficient of Conservation (C) and the Floristic Quality Index (FQI) computed from the 2011 survey results reveal that Mud Lake is about average for this part of the state. The FQI was slightly above the state average and the mean C slightly below average. While only a few high value species were identified during the survey (Fries pondweed, C = 8; small pondweed, C = 7; white-stem pondweed, C = 8; and northern wild rice, C = 8), these

plants were common to abundant which indicates that habitat to support these plants was widespread. Several high value species (panicked bog sedge (*Carex diandra*), C = 9; swamp loosestrife, C = 7; and wild calla, C = 9) were identified but are not included in the calculation of the FQI. Wild calla was not included because it was only documented during the boat survey (not on a rake sample) and panicked bog sedge and swamp loosestrife are not included as an index species for lake surveys. All summary statistics generated from the 2011 data are included in Table 5. For greater detail, see the 2011 Aquatic Plant Survey Report for Mud Lake [4].

Table 5
Summary Statics of the 2011 Mud Lake Aquatic Plant Survey

Total number of points sampled	339
Total number of sites with vegetation	253
Total number of sites shallower than the maximum depth of plants	313
Frequency of occurrence at sites shallower than maximum depth of plants	80.83
Simpson Diversity Index	0.89
Maximum depth of plants (ft)	11.0
Mean depth of plants (ft)	5.1
Median depth of plants (ft)	5.0
Number of sites sampled using rope rake (R)	0
Number of sites sampled using pole rake (P)	339
Average number of all species per site (shallower than max depth)	3.01
Average number of all species per site (veg. sites only)	3.72
Average number of native species per site (shallower than max depth)	3.00
Average number of native species per site (veg. sites only)	3.71
Species richness	24
Species richness (including visuals)	28
Species richness (including visuals and boat survey)	29
Average rake fullness (veg. sites only)	2.40
Floristic Quality Index	23.8
Mean Coefficient of Conservatism	5.2

Coontail, forked duckweed, flat-stem pondweed, and large duckweed were the most common macrophyte species being found at 80.24%, 49.01%, 33.99%, and 33.99% of survey points with vegetation, respectively [4]. Together, they combined for 53% of the total relative frequency. Common watermeal (9.13), small duckweed (9.02), Fries' pondweed (7.75), northern wild rice (5.41), and white water lily (5.10) were the only other species with a relative frequency over 5.0.

No evidence of EWM was found in Mud Lake during the May/June curly-leaf pondweed surveys or during the July whole-lake point intercept survey. By July, the limited amount of CLP seen in May had almost entirely senesced.

10.0 Northern Wild Rice (*Zizania palustris*)

Wild rice was found in both Long Lake and Mud Lake during the 2011 aquatic plant surveys. When present in a lake, wild rice is afforded numerous protections due to its ecological and cultural significance and management is therefore focused on harvest goals and protection of the resource rather than removal. Any activity included in a comprehensive lake or aquatic plant management plan that could potentially impact the growth of wild rice in any body of water that has in the past, currently has, or potentially could have wild rice in the future requires consultation with the Tribal Nations. This consultation is usually completed by the Department of Natural Resources in cooperation with GLIFWC during their review of lake management documents.

Wild rice is an annual aquatic grass that produces seed that is a nutritious source of food for wildlife and people (Figure 16). As a native food crop, it has a tremendous amount of cultural significance to the Wisconsin and Minnesota Native American Nations. Wild rice pulls large amounts of nutrients from the sediment in a single year and the stalks provide a place for filamentous algae and other small macrophytes to attach and grow. These small macrophytes pull phosphorous in its dissolved state directly from the water. Wild rice can benefit water quality, provide habitat for wildlife, and help minimize substrate re-suspension and shoreland erosion



Figure 16 – Mature Wild Rice

In Wisconsin, wild rice has historically ranged throughout the state. Declines in historic wild rice beds have occurred statewide due to many factors, including dams, pollution, large boat wakes, and invasive plant species. Renewed interest in the wild rice community has led to large-scale restoration efforts to reintroduce wild rice in Wisconsin's landscape. Extensive information is available on wild rice from GLIFWC and the WDNR.

10.1 Wild Rice in Long Lake

According to GLIFWC, Long Lake has supported rice beds for a very long time. The harvest of rice on the lake is date-regulated. Rice occurs in several locations, but the biggest bed is usually west of Rice Island (Figure 17). Although rice accounts for a fairly small portion of the surface area of the lake, these beds are quite important ecologically, and are frequently harvested. Peter David, GLIFWC Wildlife Biologist, would welcome more information on the annual abundance of the smaller beds on this lake.



Figure 17 – Wild Rice in Long Lake West of Rice Island (top) and Long Lake-South (bottom)

Northern wild rice was found widely scattered throughout Long Lake during the 2011 aquatic plant survey. Most rice plants were growing in creek and seep inlets as well as in sheltered muck bottomed bays; especially those that had stump fields (Figure 18). Lake wide, it was present at 20 points. Of these, none had a rake fullness value of 3, 8 points had a rakefullness of 2, and the remainder were a 1. Wild rice was also recorded as a visual at six additional points. With the possible exception of the bed that was established in the inlet of the unnamed creek that drains the Devils/Twin Lakes System, most rice was extremely patchy and probably not fit for harvest.

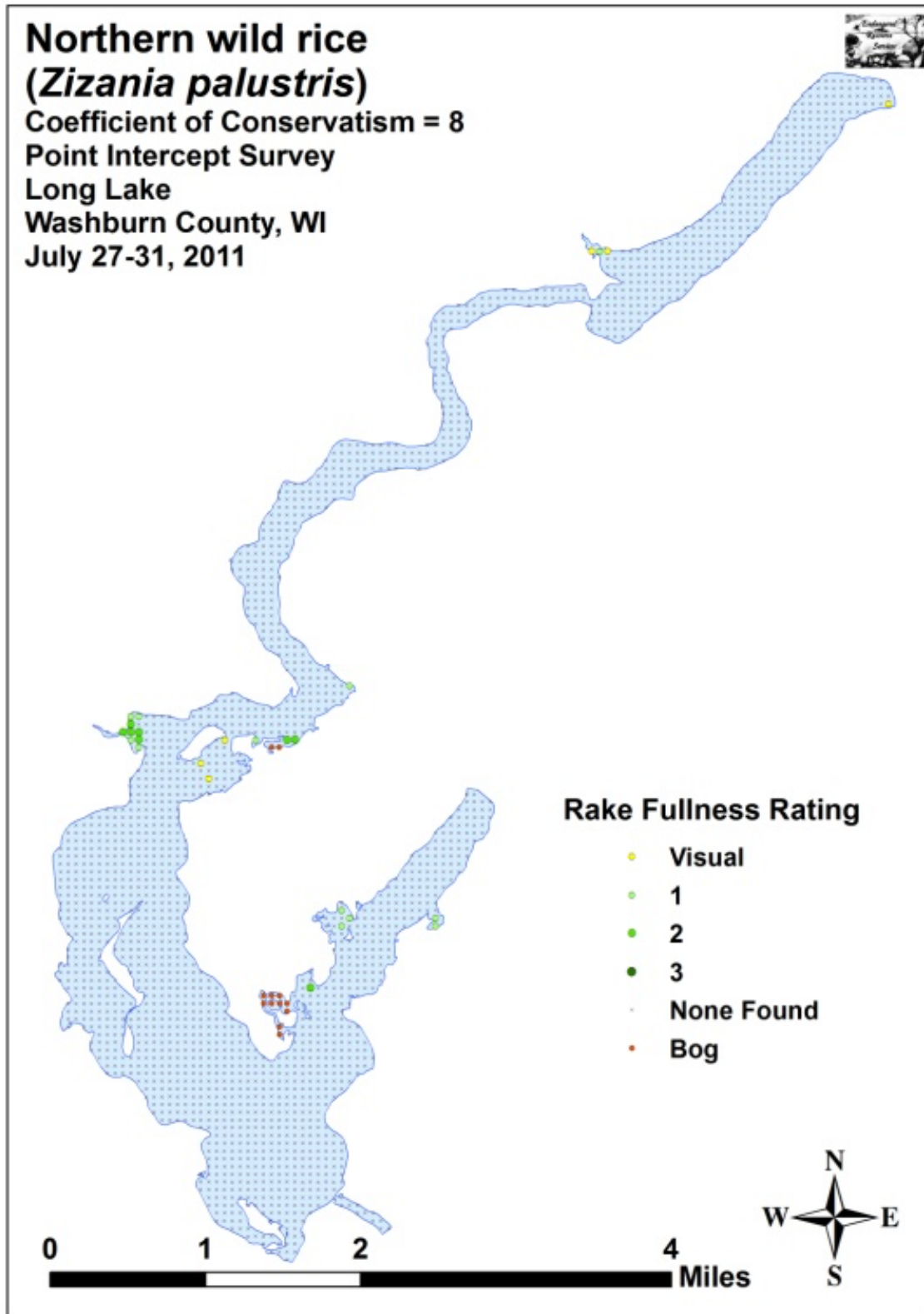


Figure 18 – Wild Rice Distribution and Density in Long Lake, July 2011 [3]

10.2 Wild Rice in Mud Lake

Mud Lake has a long history of supporting rice, and harvest on this lake is also date-regulated. According to GLIFWC, the rice harvest on Mud Lake seems to be under-reported. There are two primary beds, one on the northern narrows that connects Mud Lake to Long Lake, and the other at the south end shallows (Figure 19).

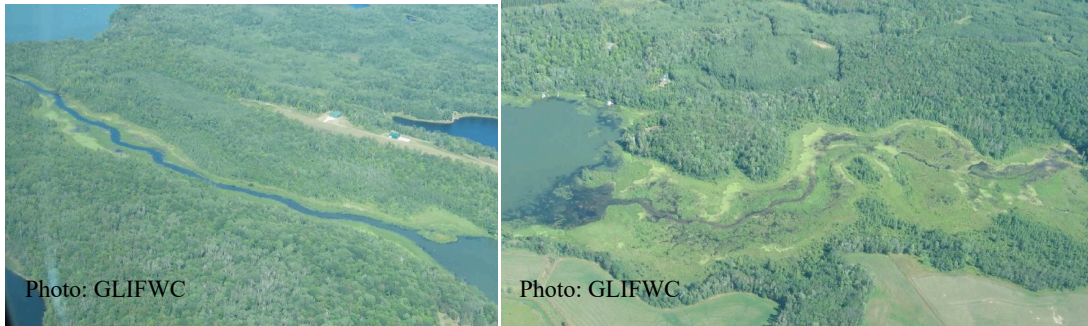


Figure 19 – Wild Rice in Mud Lake-North (left) and Mud Lake-South (right)

During the 2011 aquatic plant survey, northern wild rice was found scattered along the majority of the Mud Lake shoreline, with harvestable densities occurring throughout the channel area of the lake (Figure 20). Lake wide, it was present in the rake sampling at 51 points and was a visual at 19 additional points.

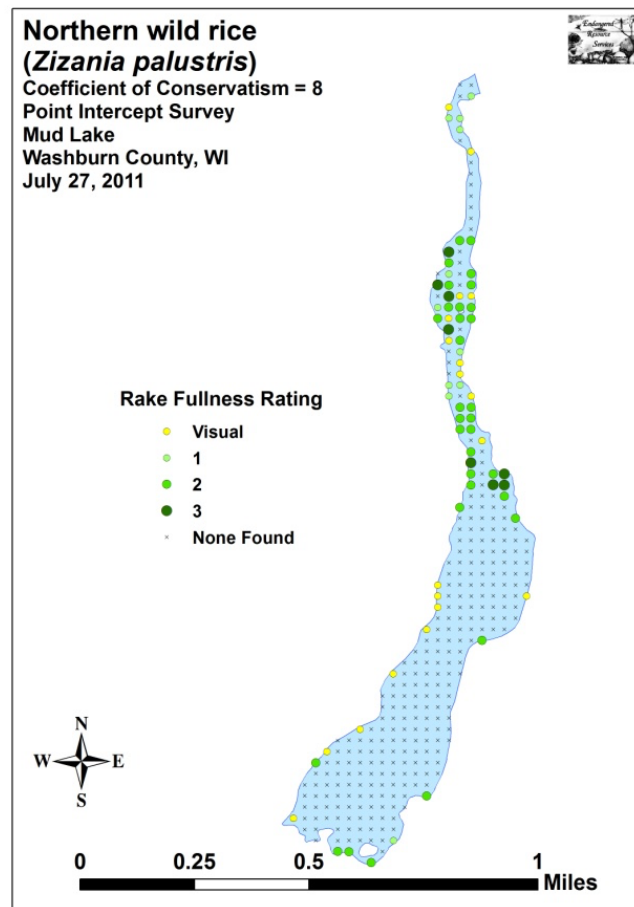


Figure 20 – Wild Rice Distribution and Density in Mud Lake, July 2011 [4]

11.0 Non-native Aquatic Invasive Species Present in Long and Mud Lakes

Curly-leaf pondweed, purple loosestrife, and Japanese knotweed are the only non-native aquatic invasive species documented in Long and Mud Lakes. At this time, curly-leaf pondweed is the most problematic of these aquatic invasive species, but there are several areas of substantial Japanese knotweed growth. Purple loosestrife distribution is limited. The LLPA is currently performing aquatic invasive species monitoring and water craft inspection in cooperation with the WDNR and UW-Extension Lakes programs. These programs will continue into the foreseeable future.

11.1 Curly-leaf Pondweed (*Potamogeton crispus*)

Curly-leaf pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant and has been documented throughout the U.S. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed (Figure 21). The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. CLP is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures.

CLP spreads through burr-like winter buds called turions (Figure 21). These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making CLP one of the first nuisance aquatic plants to emerge in the spring. Early summer senescence usually results in CLP dropping from the water column by early July.



Figure 21 – Curly-leaf Pondweed and Turions

Curly-leaf pondweed becomes invasive in some areas because of its tolerance for low light conditions and low water temperatures. These tolerances allow it to get a head start on and out-compete native plants in the spring. This fast, early growth of CLP can form dense surface mats that interfere with aquatic recreation. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. The decaying CLP can increase nutrients which contribute to algal blooms as well as create unpleasant conditions on shorelines and beaches. As dense mats of CLP decay, dissolved oxygen may be depleted. Because decay primarily occurs in waters that receive oxygen recharge via wave action and plant respiration, the loss of dissolved oxygen is generally unsubstantial and only occurs near the deep-water edges of the littoral zone.

11.2 Purple Loosestrife (*Lythrum salicaria*)

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 that form a dense mat (Figure 22).



Figure 22 – Purple Loosestrife

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. This plant's optimal habitat includes marshes, stream margins, alluvial 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 wetlands, lakes, and rivers. 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 distribution is limited in the Long Lake watershed, but present. It may be found in the wetlands adjacent to the lake, and distributed along the as single plants, small patches, or in large beds. It is easiest to distinguish in late July and August as it has a very distinctive flowering head.

11.3 Japanese Knotweed (*Polygonum cuspidatum*)

Knotweeds are robust, bamboo-like perennials introduced from Asia that are spreading throughout the Great Lakes states. The main species is Japanese knotweed. Knotweed grows in dense stands 6-12 feet tall. Its stems are hollow, green to reddish in color and bamboo-like. Its leaves are bright green, broad, egg or heart shaped, with a pointed tip. Small white flowers in branched spray appear July through August (Figure 23).



Figure 23 – Japanese Knotweed

Dormant in winter, the dead reddish brown stems often remain standing. It emerges from root crowns in April and reaches full height in June. The heaviest concentrations of knotweed are usually along rivers and roads, but are also found in parks, backyards, along lake shore, in forests and on farms. Japanese knotweed reproduces occasionally by seed, but spreads primarily by extensive networks of underground rhizomes, which can reach 6 feet deep, 60 feet long, and become strong enough to damage pavement and penetrate building foundations. Controlling Japanese knotweed is difficult and requires persistence and diligence. It can be dug, cut, covered, chemically sprayed, or have herbicide injected into individual stems.

12.0 Non-native Aquatic Invasive Species Threats to Long and Mud Lakes

Introduction of new AIS to a lake system is a constant threat to lakes and rivers. The non-native species of most concern are EWM, zebra and quagga mussels, spiny water flea, giant reed grass, New Zealand mudsnails, hydrilla, and Japanese knotweed. AIS monitoring recommended in this APM Plan and supported by the LLPA will be watching for the introduction of these and other AIS in hopes of early detection.

12.1 Eurasian Watermilfoil (*Myriophyllum spicatum*)

Eurasian watermilfoil is a submergent aquatic plant native to Europe, Asia, and northern Africa (Figure 24). Although EWM was not found in any of the lakes included in the Long Lake watershed, it remains a concern because of its presence in several nearby Barron, Washburn, and Sawyer County lakes. The proximity of these lakes makes Long Lake and other lakes in the watershed prime candidates for the introduction of EWM via boat traffic.



Figure 24 – Eurasian Watermilfoil

Eurasian watermilfoil first arrived in Wisconsin during the 1960s and is the only non-native milfoil in the state. During the 1980s, it began to move from several counties in southern Wisconsin to lakes and waterways in the northern half of the state. EWM grows best in alkaline systems with a high concentration of dissolved inorganic carbon and fertile, fine-textured, inorganic sediments. In less productive lakes EWM 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 nutrient-laden runoff, and heavy-use lakes.

Unlike many other plants, EWM is not dependant on seed for reproduction. In fact, its seeds germinate poorly under natural conditions. EWM reproduces by fragmentation, allowing it to disperse over long distances by currents and inadvertently by boats, motors, and trailers. The fragments, which are produced after the plant fruits once or twice during the summer and by destruction of the plant (for example by propellers), can stay alive for weeks if kept moist.

Once established in an aquatic community, EWM reproduces from shoot fragments and stolons (runners that creep along the lake bed). Stolons, lower stems, and roots persist over winter and store the carbohydrates that help EWM claim the water column early in spring. The rapid growth can form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block the sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of EWM 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 reduce the number of nutrient-rich native plants available for waterfowl.

Dense stands of EWM 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 EWM-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is “infested” or “dead”. The cycling of nutrients from sediments to the water column by EWM may lead to deteriorating water quality and algae blooms in infested lakes.

12.2 Rusty Crayfish and Chinese Mystery Snail

Rusty crayfish and Chinese mystery snails may be present in Long and Mud Lakes, but have not been documented. Very limited or no trapping or removal of these species has been undertaken by lake residents or the LLPA. Rusty crayfish (Figure 25) are present below the Long Lake outlet dam in the Brill River. Rusty crayfish are omnivores, meaning they forage on both plant and animal material. Originally from parts of the United States south of Indiana, they are larger and more aggressive than species of crayfish native to Wisconsin. Rusty crayfish prefer hard bottoms and tend to avoid soft sediment or mucky areas of lakes. When introduced they tend to replace native populations of crayfish, and then multiply rapidly. As omnivores they eat many things, including plant material, fish eggs, minnows, invertebrates and other crustaceans. In some lakes, they have devastated the aquatic plant community. Often, after reaching large populations, the number of rusty crayfish in the system declines rapidly. Some research suggests that this is because of a parasite infecting the crayfish.

Little is known about the impact of Chinese mystery snails (Figure 25), except that large die-offs are particularly offensive to the nose and impair lake aesthetics.



Figure 25 – Rusty Crayfish (left) and Chinese Mystery Snail (right)

12.3 Zebra Mussel and Spiny Water Flea

To date, no evidence of zebra mussels or spiny water fleas has been found in Long Lake or Mud Lake. According to the WDNR SWIMS database, zebra mussel veliger (free-swimming larvae) sampling was completed by the WDNR in Long Lake in 2005 and 2009. Spiny waterfleas were sampled for in 2005.

13.0 WDNR Northern Region Aquatic Plant Management Strategy

All existing Aquatic Plant Management (APM) Plans and the associated management permits (chemical or harvesting) are reviewed by the WDNR. It is important for APM Plans to include yearly monitoring and assessment to document impacts on water quality, fish and wildlife, native plants, and control results for the targeted species. It is equally important for APM Plans to evaluate the potential for restoring the natural plant community within a lake. If needed, shifting the plant community toward more native species through a reduction of targeted aquatic invasive species can prevent plant management from becoming endless, routine maintenance.

The WDNR has a Northern Region Aquatic Plant Management Strategy (Appendix D) that went into effect in 2007. All aquatic plant management plans developed for northern Wisconsin lakes are evaluated according to the following goals:

- Preserve native species diversity which, in turn, fosters natural habitat for fish and other aquatic species, from frogs to birds;
- Prevent openings for invasive species to become established in the absence of the native species;
- 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;
- 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. The WDNR discourages applications for removal of this ecologically and culturally important native plant.
- To be consistent with 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.

14.0 Aquatic Plant Management Alternatives

Problematic aquatic plants in a lake can be managed in a variety of ways. The eradication of non-native aquatic invasive plant species such as CLP is generally not feasible, but preventing them from becoming a more significant problem is an attainable goal. Aquatic invasive species can negatively impact the native plant species that are beneficial to the lake ecosystem. Targeted early- and mid-season removal or treatment can minimize some of these impacts by preventing the AIS from becoming the dominant plant species in the lake which allows for the growth of more desirable native aquatic plants.

Control methods for nuisance aquatic plants can be grouped into four broad categories:

- Manual and mechanical removal
- Chemical application
- Biological control
- Physical habitat alteration

Manual and mechanical removal methods include pulling, cutting, raking, harvesting and other means of removing the plants from the water. Chemical application is typified by the use of herbicides. Biological control methods include organisms that use the plants for a food source or parasitic organisms that use the plants as hosts. Biological control may also include the use of species that compete successfully with the nuisance species for resources. Physical habitat alteration includes dredging, flooding, and drawdown. In many cases, an integrated approach to aquatic plant management that utilizes a number of control methods is necessary.

Regardless of the target plant species, native or non-native, sometimes no manipulation of the aquatic plant community is the best management option. Plant management activities can be disruptive to areas identified as critical habitat for fish and wildlife and should not be done unless it can occur without ecological impacts.

Not all plant management alternatives can be used in a particular lake. What other states accept for aquatic plant management may not be acceptable in Wisconsin. What is acceptable and appropriate in southern Wisconsin lakes may not be acceptable and appropriate in northern Wisconsin lakes. Informed decision-making on aquatic plant management options requires an understanding of plant management alternatives and how appropriate and acceptable each alternative is for a given lake. Possible aquatic plant management alternatives are described below, beginning with the most appropriate options for Long and Mud Lakes.

14.1 No Manipulation

No manipulation of the aquatic plant community is often the easiest, cheapest, and in some cases most effective aquatic plant management alternative even for non-native invasive species like curly-leaf pondweed. Not actively managing plants should be considered a viable alternative in areas where excess aquatic plant growth does not impact lake uses, where the benefit of management is far out-weighted by the cost of management, where water quality or other lake characteristics limit nuisance growth conditions, and where highly valued native plants would be negatively impacted by treatment.

14.2 Manual Removal

Except for wild rice, manual removal of aquatic plants by means of a hand-held rake or by pulling the plants from the lake bottom by hand is allowed by the WDNR without a permit per NR 109 (Appendix G). The zone of manual removal cannot exceed 30 shoreland feet and all raked or pulled plant material must be taken completely out of the lake and removed from the shoreline (Figure 26). Plant fragments can be composted or added directly to a garden.

Although up to 30 feet of shoreland vegetation can be removed, removal should only be done to the extent necessary. Clearing large swaths of macrophytes not only disrupts lake habits, it also creates open areas for non-native species to establish. If an aquatic invasive species such as CLP is the target species, then removal by this means is unrestricted as long as native plants are not damaged or eliminated.

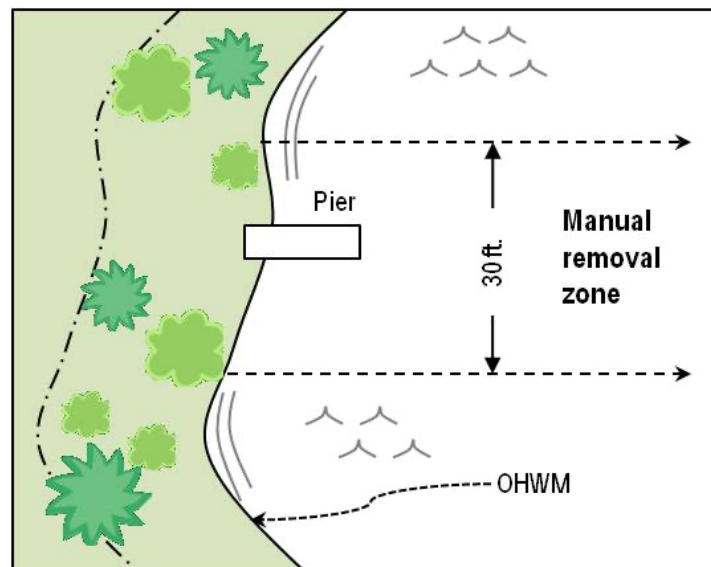


Figure 26 – Aquatic Vegetation Manual Removal Zone

Manual removal can be effective at controlling individual plants or small areas of plant growth. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. In shallow, hard bottom areas of a lake, or where impacts to fish spawning habitat need to be minimized, this is the best form of control. Pulling aquatic invasive species while snorkeling or scuba diving in deeper water is also allowable without a permit and can be effective at slowing the spread of a new aquatic invasive species infestation within a lake when done properly.

14.2.1 Large-scale Physical Removal

Larger scale hand or diver removal projects on other lakes have had positive impacts in temporarily reducing or controlling aquatic invasive species. Typically hand or diver removal is used when a new AIS has been identified and still exists as single plants or isolated small beds, but at least in one lake in New York State, it was used as a means to control a large-scale infestation of EWM. Kelting and Laxson [10] reported that from 2004 to 2006 an “intensive management effort” which involved “the selective removal of Eurasian watermilfoil using diver hand harvesting of the entire littoral zone of the lake at least twice each summer for three years” followed by three years of maintenance management successfully reduced the overall distribution of EWM in the lake. In 2004, EWM was found to be either common or abundant in 16% of the lakes littoral area. At the end of the intensive

harvesting period, EWM was common in only 3% of the littoral area, and nowhere was percent cover recorded as abundant [10].

Overall costs during the three years of intensive removal ranged from a high of \$796.00 per hectare of EWM to about \$300 per hectare [10]. In the first two years of e management effort, the cost per kg of EWM removed was relatively low. The cost per kilogram of EWM removed from the lake ranged from \$23 per kg in the first year \$752 per kg in the third year [10]. As the efforts proved to be successful at knocking down the distribution and density of the EWM, it took an equal amount of time and money to find and remove a much lower amount of EWM. The authors also commented that during the maintenance period the amount of EWM trended back up, indicating that limiting intensive management effort allowed for the EWM to make a comeback.

Several local lake groups have and continue to use large-scale physical removal to manage EWM. Horseshoe Lake in Barron County uses diver removal on small or isolated areas of EWM, and uses chemical herbicides on larger, more expansive sites. Early in the management phase, Sand Lake in Barron County attempted diver removal, but stopped using divers as the EWM expanded too rapidly for the divers to keep up with. For several years the St Croix Flowage in Douglas County attempted to control the spread of EWM by diver removal. While successful in the first couple of years, the use of small-scale herbicide application has been added to the control regime.

In 2011, the Red Cedar Lakes Association performed diver removal on a dense, isolated one acre bed of CLP in Red Cedar Lake. This large-scale effort was conducted by a group of about 10 local high school students (members of the Conservation Club) and an RCLA representative (Figure 27). Water depths and inexperience made removal difficult; however, the effort was fairly successful and the divers were able to remove a large boat load of CLP.



Figure 27 – Diver Removal of Curly-leaf Pondweed in Red Cedar Lake, 2011

14.3 Native Plant Restoration and Enhancement

Restoring native shoreland plant communities is undertaken on many lakes to reduce erosion, increase and improve native habitat, and improve water quality. Restoration not only improves the lake aesthetic enjoyed by so many, it also keeps invasive species at bay. An analysis of 55 lakes in west-central Wisconsin found the mean occurrence of non-native aquatic invasive species to be significantly greater at disturbed shoreline sites than at natural shorelines [11]. The study also found that the occurrence of non-native species and filamentous algae increased with the amount of disturbed shoreline on a lake.

There are many sources for more information regarding native aquatic plant restoration. One such resource is the Langlade County Land Records and Regulations Department, which maintains a Shoreland Restoration Web Site providing a great deal of information for re-establishing native plants: <http://lrrd.co.langlade.wi.us/shoreland/index.asp> (last accessed: June 2012). A review of this and other techniques should be done before undertaking a planting project.

Native plant restoration along the shoreline of Long and Mud Lakes should be pursued. Native emergent plant species should be planted along with shoreland buffers. Due to the diversity of native species within the lake, native aquatic plant reintroduction or expansion is not necessary except possibly in areas where the removal of dense curly-leaf pondweed beds leaves the littoral area devoid of vegetation.

14.4 Chemical Control and Management

Aquatic herbicides are chemicals specifically formulated for use in water to kill or control aquatic plants. Herbicides approved for aquatic use by the United States Environmental Protection Agency (EPA) have been reviewed and are considered compatible with the aquatic environment when used according to label directions. Some individual states, including Wisconsin, also impose additional constraints on their use.

14.4.1 How Chemical Control Works

Aquatic herbicides are sprayed directly onto floating or emergent aquatic plants or are applied to the water in either a liquid or pellet form. Herbicides affect plants through either systemic or direct contact action. Systemic herbicides are capable of killing the entire plant. Contact herbicides cause the parts of the plant in contact with the herbicide to die, which leaves the roots alive and able to re-grow.

Herbicides are classified as broad-spectrum (or non-selective) or selective. Broad-spectrum herbicides will generally affect (kill or injure) all plants contacted. Selective herbicides will affect only some plants. Often dicots (broad-leafed plants like EWM) will be affected by selective herbicides whereas monocots, such as common elodea (*Elodea canadensis*) may not be affected. The selectivity of an herbicide can be influenced by the method, timing, formulation, and concentration used.

Applying some systemic and contact herbicides together has a synergistic effect leading to increase selectivity and control [12]. Single applications of the two could result in reduced environmental loading of herbicides and monetary savings via a reduction in the overall amount of herbicide used and of the manpower required for application.

14.4.2 Timing and Impacts

When properly applied, herbicides can control aquatic vegetation without harming fish and wildlife. A WDNR permit is required for the use of aquatic herbicides and a certified pesticide applicator is required for application on most Wisconsin lakes. Full-season control can be achieved with herbicide application and control may extend into the following year. Because the plants remain in the lake and decay, treating too much plant matter can lead to a depletion of dissolved oxygen. Also, algal blooms may occur as nutrients are released into the water by the decaying plants. Spring and early summer are preferred for application because exotic species such as CLP and EWM are actively growing, whereas many native plants are not, fish spawning has ceased, and recreational use is generally low thereby limiting human contact.

14.4.3 Pre and Post Treatment Aquatic Plant Surveying

When introducing new chemical treatments to lakes where the treatment size is greater than ten acres or greater than 10% of the lake littoral area and more than 150 feet from shore, the WDNR requires pre and post chemical application aquatic plant surveying. The purpose of the pre and post surveys is to satisfy grant funded treatments conditions where restoration is a goal or where performance results are needed. The protocol for pre and post treatment survey is applicable for chemical treatment of CLP or EWM.

The WDNR protocol assumes that an Aquatic Plant Management Plan has identified specific goals for non-native invasive species and native plants species. Such goals could include reducing coverage by a certain percent, reducing treatments to below large-scale application designations, and/or reducing density from one level to a lower level. A native plant goal might be to see no significant negative change in native plant diversity, distribution, or density. Results from pre and post treatment surveying are used to improve consistency in analysis and reporting, and in making the next season's management recommendations.

The number of pre and post treatment sampling points required is based on the size of the treatment area. Ten to twenty acres generally requires at least 100 sample points. Thirty to forty acres requires at least 120 to 160 sampling points. Areas larger than 40 acres may require as many as 200 to 400 sampling points. Regardless of the number of points, each designated point is sampled by rake recording depth, substrate type, and the identity and density of each plant pulled out, native or invasive. More details related to pre- and post-chemical treatment survey protocol can be found at:

<http://www4.uwsp.edu/cnr/uwexlakes/ecology/APM/Appendix-D.pdf> (last accessed May 2012).

14.4.4 Residual Testing

Chemical residual testing is often done in conjunction with treatment to track the fate of the chemical herbicide used in a particular lake. Residual testing is completed to determine if target concentrations are met, to see if the chemical moved outside its expected zone, and to determine if the chemical breaks down in the system as expected. Water samples are collected prior to treatment and for a period of days following chemical application (for example, 1, 4, 7, 14, 21, and 28 days after application). Monitoring sites are located both within and outside of the treatment area, particularly in areas that may be sensitive to the herbicide used, where chemical drift may have adverse impacts, where movement of water or some other characteristic may impact the effect of the chemical, and where there may be impacts to drinking and irrigation water.

14.4.5 Liquid vs. Granular Formulations

Rapid dissipation of aquatic herbicides due to various water exchange processes can lead to poor submersed weed control in a variety of situations. The ability to target herbicide placement and maintain the desired concentration in the plant mass within the 3-dimensional aquatic environment can be critical to maximize efficacy of herbicides. Additional variables such as temperature and plant density can also alter herbicide distribution. Applications of liquid formulations in areas that are relatively deep with low growing vegetation, potential for rapid water exchange, and/or areas adjacent to or surrounded by a large percentage of untreated water could be impacted greatly by dilution [13]. Custom subsurface injection application systems with trailing hoses have been suggested for improved delivery of liquid herbicides in deeper water areas [14].

Granular formulations also have been developed to assist in delivering aquatic herbicides. The active ingredient is added to inert ingredients like clay particles that dissolve more slowly. Theoretically these formulations maintain placement of the herbicide longer or increase the exposure time of the target plant to the herbicide. These formulations often sink to the bottom in and around submersed aquatic plant communities (depending on plant density and frequency) and provide delayed release of the herbicide and are less vulnerable to dilution [13].

Granular formulations are generally more expensive than their liquid counterparts. Granular applications are usually based on a certain number amount of herbicide being applied to a designated surface area of a body of water. Depth of the treatment area and density of plant growth may also be considered when determining an appropriate treatment concentration. Liquid herbicides can be applied on the surface, but more recently, subsurface injection is more supported by the industry. Liquid application is based on the volume of water in the treatment area, and in general is used when flowing water or additional dilution is not a factor.

14.4.6 Small-scale Herbicide Application

Small-scale herbicide application involves treating small areas less than 10 acres combined on a given body of water. Small-scale chemical application is usually completed in the early season (April through May). It is also used as a follow up treatment to retreat areas missed or not impacted by large-scale applications. Pre and post treatment aquatic plant surveying is not required by the WDNR for small-scale treatments. Testing for herbicide residuals is also not required by the WDNR when completing small-scale treatments. Even though not required by the WDNR, participating in these activities is recommended as it helps to gain a better understanding of the impact and fate of the chemical used.

14.4.7 Large-scale Herbicide Application

Large-scale herbicide application involves chemical treatment of more than 10 acres combined on a given body of water. Like small-scale applications, this is usually completed in the early-season (April through May) for control of non-native invasive species like EWM and CLP while minimizing impacts on native species. Pre and post treatment aquatic plant surveying is required by the WDNR when completing large-scale chemical treatments. Residual testing is not required by the WDNR, but highly recommended, as is pre and post treatment aquatic plant surveying to gain a better understanding of the impact and fate of the chemical used.

14.4.8 Spot Treatments

Spot treatments are used in a similar manner to when small-scale herbicide application is used to follow up a large-scale herbicide application. More commonly used when treating EWM, a spot treatment is defined as treatment of a single plant or small cluster of plants that covers an area no greater than 25 square feet. It is administered by spreading approximately 1/4 cup (approximately 2.0 oz) of granular herbicide by hand from a boat in approximately 5 feet of water, based on a treatment rate of 200 lbs/acre. Target plants are visually located by trained inspectors on the day of treatment. Treatment occurs immediately upon locating a plant or cluster of plants. This treatment method depends on several things: 1) water clarity in a given lake needs to be sufficient enough to allow for trained inspectors to identify individual plants and small clusters in the water, even when they are not at or near the surface; 2) the spotters must know the difference between the target plant and native plants not only when they are side to side out of the water but also when they are in the water, potentially interspersed with other look-alikes; 3) since this treatment often involves many sites, herbicide application must be completed by a professional applicator; and 4) Weather conditions must be appropriate for treatment (mostly sunny, minimal waves).

While there is no specific WDNR protocol set up for spot treatments, the following guidelines are recommended:

- Chemical application must be completed by a commercial applicator
- At least one representative from the Lake Organization or a resource professional must accompany the commercial applicator during treatment
- Inspections and subsequent treatments should be completed from 10:00am to 4:00pm
- Inspections and treatment (if necessary) should be completed at least once a month June – September
- When the observer and applicator do not agree, a rake sample must be retrieved for positive ID
- An appropriate inspection and treatment path should be established prior to beginning inspection/ treatment
- GPS tracking of all movement on the lake should be completed and saved for future reference
- Record GPS coordinates and depth at each individual spot treatment site
- Record density of the target plant species (single, small cluster, or bed)
- Record the presence of other plants within 5 feet of the spot treatment
- Sites determined to be beds and that exceed an area larger than 20 ft x 20 ft must be recorded as small-scale treatment sites
 - A bed is defined as an area where at least 50% of existing aquatic plants are the target species and has a definable boundary
- Aquatic plant inspectors must wear polarized glasses
- Water clarity on the day of treatment (measured by a Secchi disk) should not be less than 75% of the mean depth of plant growth as established by previous plant surveys

14.4.9 EPA-approved Aquatic Herbicides in Wisconsin

There are a number of aquatic herbicides registered for use in Wisconsin. A brief summary of each is presented below. Factsheets for each can be found on the WDNR website at <http://dnr.wi.gov/lakes/plants/factsheets/> (last accessed May 2012).

14.4.9.1 Endothall

Trade names for endothall include Aquathol K or Super K, and Hydrothol 191. Endothall is a fast-acting non-selective contact herbicide which destroys the vegetative part of the plant but generally does not kill the roots. Endothall may be applied in a granular or liquid form. Typically endothall compounds are used primarily for short term (one season) control of a variety of aquatic plants. However, there has been some recent research that indicates that when used in low concentrations, endothall can be used to selectively remove exotic weeds; leaving some native species unaffected. Because it is fast acting, endothall can be used to treat smaller areas effectively. Endothall is not effective in controlling Canadian waterweed or Brazilian elodea. Endothall can impact early season wild rice growth so should not be used in areas where the target species and wild rice cohabitate.

14.4.9.2 Diquat

A trade name for diquat is Reward®. Diquat is a fast-acting non-selective contact herbicide which destroys the vegetative part of the plant but does not kill the roots. It is applied as a liquid. Typically diquat is used primarily for short term (one season) control of a variety of submersed aquatic plants. It is very fast-acting and is suitable for spot treatment. However, turbid water or dense algal blooms can interfere with its effectiveness. Diquat is strongly attracted to clay particles in the water and thus is not effective in lakes or ponds with muddy water or plants covered with silt. For this reason, care must be taken to not disturb bottom sediments during application.

14.4.9.3 Glyphosate

Trade names for aquatic products with glyphosate as the active ingredient include Rodeo®, AquaMaster®, and AquaPro®. This systemic broad spectrum herbicide is used to control floating-leaved plants like water lilies and shoreline plants like purple loosestrife. It is generally applied as a liquid to the leaves. Glyphosate does not work on underwater plants such as Eurasian watermilfoil. Although glyphosate is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed. Plants can take several weeks to die and a repeat application is often necessary to remove plants that were missed during the first application.

14.4.9.4 2,4-D

There are two formulations of 2,4-D approved for aquatic use. The granular formulation contains the low-volatile butoxy-ethyl-ester formulation of 2,4-D (2,4-D BEE; trade names include AquaKleen® and Navigate®). The liquid formulation contains the dimethylamine salt of 2,4-D (2,4-D DMA). Trade names include DMA*4. 2,4-D is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species. 2,4-D has been shown to be selective to Eurasian watermilfoil when used at the labeled rate, leaving native aquatic species relatively unaffected. It is not effective against elodea or hydrilla. 2,4-D can impact early season wild rice growth so should not be used in areas where the target species and wild rice cohabitate.

14.4.9.5 Triclopyr

Common trade names for triclopyr are Renovate 3 and Garlon 3A. There are two formulations of triclopyr. It is the TEA formation of triclopyr that is registered for use in aquatic or riparian environments. Triclopyr, applied as a liquid, is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species such as purple loosestrife. It is also available in a granular formulation under the trade name Renovate OTF. Triclopyr can be effective for spot treatment of Eurasian

watermilfoil and is relatively selective to Eurasian watermilfoil when used at the labeled rate. Desirable native species that may be affected include native milfoils, water shield, pickerelweed and lilies. Triclopyr is very useful for purple loosestrife control since native grasses and sedges are unaffected by this herbicide. Triclopyr degrades quickly in an aquatic environment making its use most effective in systems with low water-exchange where contact with target plants can be maintained for longer periods of time. .

14.4.9.6 Fluridone

Trade names for fluridone products include Sonar® and Whitecap®. Fluridone is a slow-acting systemic herbicide used to control Eurasian watermilfoil and other underwater plants. It may be applied as a pellet or as a liquid. Fluridone can show good control of submersed plants where there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not effective for spot treatments of areas less than five acres. It is slow-acting and may take six to twelve weeks before the dying plants fall to the sediment and decompose. When used to manage Eurasian watermilfoil, fluridone is applied several times during the spring/summer to maintain a low, but consistent concentration in the water. Granular formulations of fluridone are proving to be effective when treating areas of higher water exchange or when applicators need to maintain low levels over long time periods. Although fluridone is considered to be a broad spectrum herbicide, when used at very low concentrations, it can be used to selectively remove Eurasian watermilfoil. Some native aquatic plants, especially pondweeds, are minimally affected by low concentrations of fluridone.

14.4.9.7 Copper Complexes

Copper sulfate and chelated coppers have been widely used as non-selective, fast-acting, contact herbicides or algaecides. These chemicals have been used to control aquatic plants and algae, often in conjunction with endothall and diquat. Copper compounds are primarily used for algae control but can be effective against certain submerged plant species. Copper can build up in sediments, can be toxic to fish and invertebrates, and certain species of algae can build up a resistance [15]. The use of copper compounds to control algae was once widely accepted in Wisconsin, but in recent years it has not been supported as a viable control method because of the potential negative impacts inherent in its use.

14.5 Biological Control and Management

Biological control for aquatic plant management involves using animals, fungi, insects, or pathogens as a means to control nuisance plants. The goal of biocontrol is to weaken, reduce the spread, or eliminate the unwanted population so that native or more desirable populations can make a comeback. A special permit is required in Wisconsin before any biocontrol measure can be introduced into a new area.

Biological control of nuisance plants in aquatic systems has both positive and negative attributes. One positive is that control agents are often host specific, so effects to non-target species may be reduced. Control agents can also reproduce in response to increases in nuisance species density often without reapplication of the agent. Development and registration (where necessary) of biological control agents is generally less expensive than chemical agents.

Bio-control can have many potential disadvantages. A substantial risk is involved when new species are introduced as bio-control agents. To be considered successful, these species are expected to persist indefinitely in the environment where they are used, and may spread to new locations. Therefore, if there are any adverse effects resulting from the bio-control agent, these effects may be difficult or impossible to control. Other drawbacks include unpredictable success and rates of control that are slower than with chemical methods. Resistance in host species is unlikely to develop but can occur. Finally, agents that work in one area may not be suitable in all ecosystems. Climate, interference from herbicidal application, hydrological conditions, and eutrophication of the system can influence the effectiveness of bio-control agents. The growth of nuisance weeds can be suppressed with the use of bio-control agents, but not fully eliminated [16].

14.5.1 Biological Controls in Wisconsin

Many herbivorous insects have been and continue to be studied for their impacts on unwanted aquatic plant species. An herbivorous aquatic moth (*Acentria ephemerella*), two native herbivorous weevils (*Euhrychiopsis lecontei* and *Phytobius* spp.), and a midge species (*Cricotopus* spp.) have been associated with the decline of EWM in lakes. Several species of insect are being used to control purple loosestrife infestations very effectively, notably two *Galerucella* spp. The *Galerucella* beetles are easy to rear and can be extremely effective at reducing large populations of purple loosestrife. After nearly 20 years of use, *Galerucella* appear to have no negative effect on the areas in which they are introduced.

There are currently no biological controls for CLP, but research to identify and establish biological controls are on-going. Studying naturalized and native herbivores and pathogens that impact nuisance aquatic and wetland plants increases the number of potential biological control agents that could be incorporated into invasive plant management programs. The groundwork has been laid for conducting future biological control research and experimentation. Although not all of the native and naturalized organisms researched can be successful, the information and expertise is now available for potential insects and pathogens to be collected, analyzed, and studied. A continuation of the work that has been started is needed to make available for the future more successful native bio-control agents [17].

There are several forms of biological control that have been used in other states, but are not approved for use in Wisconsin. The grass carp (*Ctenopharyngodon idella*), also known as the white amur, feeds on aquatic plants and has been used as a biological tool to control nuisance aquatic plant growth in other states. In addition to grass carp, common carp and tilapia (a fish species) have been added to ecosystems to reduce aquatic vegetation. Wisconsin does not permit the use of these fish for aquatic plant control.

Plant fungi and pathogens are currently still in the research phase. Certain species for control of hydrilla and EWM have shown promise, but only laboratory tests in aquariums and small ponds have been conducted. Methods are not available for widespread application. Whether these agents will be successful in flowing waters or large-scale applications remains to be tested [16].

14.5.1.1 Milfoil Weevils

While many biological controls have been studied, only one has proven to be effective at controlling EWM under the right circumstances. The milfoil weevil (*Euhrychiopsis lecontei*) is a native aquatic weevil that feeds on aquatic milfoils. Their host plant is typically northern watermilfoil, but they prefer EWM when it is available. Milfoil weevils are typically present

in low numbers wherever northern or Eurasian watermilfoil is found. They often produce several generations in a given year and over winter in undisturbed shorelines around the lake. All aspects of the weevil's life cycle can affect the plant. Both adults and larva feed on the plant. As the larva mature they burrow into the stem of the plant. When they emerge as adults later, the hole left in the stem reduces buoyancy often causing the stem to collapse. The resulting interruption in the flow of carbohydrates to the root crowns, reduce the plants ability to store carbohydrates for over wintering reducing the health and vigor [18].

14.5.1.1.1. Purchasing Weevils

One company, EnviroScience, has taken a patent out on rearing and distributing the weevil. They call the program Middfoil, and it involves surveying, stocking, and monitoring of the success of the weevil. Recent information indicates they have successfully introduced weevils to more than 100 lakes in the United States and Canada in the last ten years. According to EnviroScience, costs for using the Middfoil program run about \$1.50 per weevil purchased, but includes the costs of mapping, stocking, and monitoring of effects.

14.5.1.1.2. Rearing Weevils

More recently, researchers in Wisconsin have been developing a protocol for layperson rearing of the EWM weevil. This process involves setting up large tanks with EWM, and then purchasing starter weevils from EnviroScience. With proper care and management, it is anticipated that this rearing method may be able to produce a 10 to 100 fold increase in weevils to be released into an affected area.

14.5.1.1.3. Success of Weevils

The weevil is not a silver bullet. They do not work in all situations. The extent to which weevils exist naturally in a lake, adequate shore land over wintering habitat, the population of bluegills and sunfish in a system, and water quality characteristics are all factors that have been shown to affect the success rate of the weevil. A study out of Washington State, suggests that weevils will do the best in water that has a total alkalinity of around 132.4, a water temperature around 21.5 C, a pH around 8.7, a EWM frequency of occurrence around 77.3, and in water around 1.5 meters deep [19].

In-lake weevil densities in Wisconsin have been found to be positively correlated with percent natural shoreline and negatively correlated to percent sandy shoreline [20]. Undisturbed grasses may be more important than forested areas for providing good over wintering habitat for weevils [21]. Dry sites available as opposed to areas that are affected by rising fall or winter lake levels are likely important for weevil habitat as well. While smaller populations of weevils in a lake may not be impacted by the amount of over wintering habitat, at a larger scale, such as would be created by artificial stocking, over wintering habitat could be a limiting factor.

Bluegill and sunfish populations can impact the success of milfoil weevils in a lake through predation [22]. If there is an over-abundant population of these fish species in a water body it is possible that introduced weevils could become fodder before ever having an impact on the EWM.

Should the need arise, it may be possible for EWM weevils to be used in Long Lake. However, before undertaking actions to introduce or supplement an existing population, more data should be collected, including a quantifiable estimation of current weevil densities, a better assessment of the bluegill and sunfish population, and a formal analysis of the over-wintering habitat available.

14.5.1.2 Purple Loosestrife Beetles

There are several insects that have been studied and approved for biological control purposes of purple loosestrife. However, only one of them has been proven to be extremely effective for control of purple loosestrife. Galerucella beetles (*G. californiensis* and *G. pusilla*) (Figure 28) have been used extensively across North America to help manage this aggressive wetland plant.

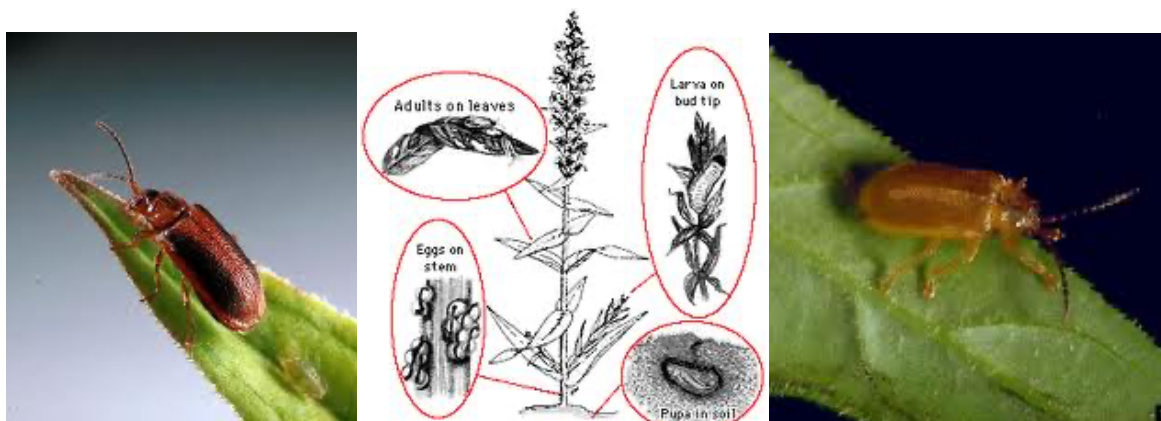


Figure 28 – *Galerucella californiensis* (left), life cycle, and *G. pusilla* (right)

These insects are prolific breeders, feed only on purple loosestrife, are easy to rear in captivity, can fly, and tolerate cold winters. Generally, after introducing even just a few insects into a new area, a self-sustaining population can be established. Once established, a balanced predator/prey relationship between the beetles and purple loosestrife develops. Once the beetles have reduced the plant population the beetle population declines but never disappears. Figure 29 shows a purple loosestrife infestation in Barron County, Wisconsin before (1999) and after (2003) beetle introduction. In just four years almost all the purple loosestrife in this location was reduced to small, non-flowering, unhealthy plants.



Figure 29 – Before (right) and After (left) Beetle Introduction at Prairie Lake Township Marsh, Barron County, Wisconsin

14.6 Top-down Biomanipulation

Biomanipulation involves techniques to manipulate the biological structure in the lake to improve water quality and centers around nutrient availability and the trophic structure or food web of the lake [23]. This approach has been used to lessen or eliminate nuisance blue-green algal populations, change the fisheries to a more desirable population, and alter the macrophyte community for fisheries or recreation. To successfully implement biological manipulations, it is important to understand the interaction between species traits and environmental conditions.

Usually one trophic level is manipulated and the effects of restructuring one level cascade to lower levels of the biological community. For example, small often microscopic critters called zooplankton feed on algae, like cows feed on grass. If there is a significant decline in zooplankton, perhaps because an over-abundance of small panfish eat them, then it is possible for the levels of algae to go up in a lake. It may be possible to reduce the number of small panfish by introducing larger predator fish. If panfish are reduced, then zooplankton can rebound again reducing the amount of algae in a system. The EWM weevil is another favorite food source for small panfish. Reducing the number of panfish may support greater survival of the weevils and other biological control agents.

Another trophic relationship was found between snails and EWM, suggesting the presence of snails can limit EWM growth [24]. EWM produces biochemicals that prevent epiphytic algae from growing around it, giving EWM a competitive advantage over native plants in eutrophic waters (where algae are common). Snails, which are algal consumers, may reduce the competitive advantage of EWM by reducing algal blooms that would otherwise shade and compete for nutrients with native plants. In the absence of snails, both EWM and algae (epiphytic and filamentous) achieved greater biomass [24].

15.0 Other Aquatic Plant Management Alternatives

Not all aquatic plant management alternatives available are effective and appropriate for every lake. It is important for a group considering aquatic plant management to be aware of other alternatives and why they are not appropriate. This awareness enables the group to make informed decisions and answer potential questions regarding the aquatic plant management strategy being implemented. The following management alternatives are not appropriate for Long or Mud Lake at this time, but some may be utilized in the future should the need arise.

15.1 Mechanical Control

Mechanical removal of aquatic plants involves the use of motorized accessories to assist in vegetation removal. Mechanical control can be used for both small- and large-scale control efforts. WDNR permits are required regardless of the size of the area to be managed with mechanical control.

When using mechanical control methods, plant fragments must be removed from the water to the extent practical. One benefit of this removal is some nutrients are removed from the water while the use of herbicides makes these nutrients available for renewed plant growth. Plants use nutrients from the water column and from the sediment when growing and often re-deposit nutrients back into the lake when they die. Early season or cool water plants like curly-leaf pondweed that senesce (die-off) in early summer can be a source of significant phosphorous loading which could promote algae blooms and low dissolved oxygen in severely infested lakes. Although in most cases plant parts are an insignificant amount of nutrients compared to annual runoff or groundwater inputs, removing as much of the cut plants as possible is best for the lakes. When harvesting CLP it is important that all material is removed as free-floating CLP fragments can remain viable and produce turions for up to two weeks.

15.1.1 Mechanical Harvesting

The most common form of mechanical control is the use of large-scale mechanical weed harvesters on the lake. The harvesters are generally driven by modified paddle wheels and include a cutter that can be raised and lowered, a conveyor system to capture and store the cut plants, and the ability to off-load the cut plants. The depth at which these harvesters cut generally ranges from skimming the surface to as much as five-feet deep.

Harvesters can remove thousands of pounds of vegetation in a relatively short period of time. They are not, however, species specific. Everything in the path of the harvester will be removed including the target species, other plants, macro-invertebrates, semi-aquatic vertebrates, forage fishes, young-of-the-year fishes, and even adult game fish found in the littoral zone [25].

Large-scale plant harvesting in a lake is similar to mowing the lawn. Plants are cut at a designated depth, but the root of the plant is often not disturbed. Cut plants will usually grow back after time, just like the lawn grass. Re-cutting several times a season is often required to provide adequate annual control [26]. Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds [26]. Some research indicates that after cutting, reduction in available plant cover causes declines in fish growth and zooplankton densities. Other research finds that creating deep lake channels by harvesting increases the growth rates of some age classes of bluegill and largemouth bass [27].

15.1.1.1 Harvesting Costs

Developing a harvesting program for a lake requires a cost analysis of the two primary implementation options, one being contracted harvesting services and the other purchasing the harvesting equipment and taking on the responsibilities of operation and maintenance. Cost estimates must take several factors into account including the cost to purchase equipment and the cost to operate, store, and maintain that equipment, the cost of transportation and disposal of harvested plant material, and the total acreage to be harvested annually. Contracting harvesting services removes the purchase, operation, storage, and maintenance costs, but does not necessarily remove the cost of plant disposal.

Once these estimates have been made, it is possible to calculate a critical acreage where the cost per acre associated with purchased equipment would be lower than for contracting harvesting services. If the acreage harvested is not expected to exceed the critical acreage, then contracting mechanical harvesting services is likely the best option. The costs supporting a harvesting program administered by a given lake group may be reduced by purchasing smaller or used equipment, determining a local, low cost disposal site, increasing the amount of acreage harvested, and through other cost analyses.

A recent comparison between the costs associated with each option based on case studies in Minnesota was completed by Freshwater Scientific Services [28]. Cost per acre for contracting harvesting services averaged \$410 per acre whereas costs for purchasing, operating, and maintaining a harvester averaged \$567 per acre. In general, the cost of harvesting decreased with increasing total acreage harvested, from about \$500 per acre at 40 acre sites to about 250 per acre at 160 acre sites [28]. Locally, the Rice Lake Protection and Rehabilitation District owns and operates a harvester at a cost of approximately \$420 per acre on approximately 220 acres.

When contracting harvesting, an equipment inspection program should be conducted to ensure that the unintentional spread of an invasive plant species does not occur. Often contractors are moving from lake to lake. Before a machine comes into a lake, it should be inspected and any plant material present removed. This will help protect the lake from the introduction of problematic aquatic plants and AIS. It also helps to know what lake the contractors have recently worked on and what problem plants might be present there. Upon leaving the lake, it is also a good idea to require that the equipment be cleaned before moving to the next project. These precautions help stop the spread of AIS to other lakes in the region.

The low density of CLP currently in the lakes does not support the use of large-scale harvesting for AIS control at this time. If harvesting is found to be an appropriate management alternative in the future, a list of firms that offer contracted harvesting is included in Appendix H to assist with any cost analysis.

15.1.2 **Small-Scale Mechanical Management**

There are a wide range of small-scale mechanical management techniques, most of which involve the use of boat mounted rakes, scythes, and electric cutters. As with large-scale mechanical harvesting, removing the cut plants is required and often accomplished with a rake. Commercial rakes and cutters range in prices from \$200 for rakes to around \$3,000 for electric cutters with a wide range of sizes and capacities. Such a harvester could be purchased and rented out to cover costs or its use offered as a service by the lake association.

A small harvester could be used to open up navigation channels and riparian access through dense native vegetation later in the season; however, active use of an area is often one of the best ways for riparian property owners to gain navigation relief near their docks. Although not truly considered mechanical management, plant disruption by normal boat traffic is a legal method of management. Most macrophytes do not grow well in an area actively used for boating and swimming. It should be noted that purposefully navigating a boat in circles to clear large areas is not only potentially illegal, but it can also re-suspend sediments, clear paths for aquatic invasive species growth and cause ecological disruptions.

15.1.3 Suction Dredging

Suction dredging is a form of mechanical harvesting where diver-operated suction tubes connected to a barge- or pontoon-mounted pumps and strainer devices with hoses, are used to vacuum plants uprooted by hand. This management technique is called harvesting because even though a specialized small-scale dredge is used, sediments are not removed from the system. Sediments can be re-suspended during the operation but use of a sediment curtain would mitigate these effects. Plants are removed directly from the sediments by divers operating this device. Suction dredging is mostly used for control of isolated, new infestations of AIS, and therefore not recommended for use in Long Lake or Mud Lake.

15.1.4 Other Mechanical Management

Cutting without plant removal, grinding and returning the vegetation to the water body, and rotovating (tilling) are also methods employed to control nuisance plant growth in some lakes. Cutting is just like harvesting except the plants are left in the waterbody. Grinding incorporates cutting and then grinding to minimize the biomass returned to the lake. Smaller particles disperse quicker and decay more rapidly. Rotovating works up bottom sediments dislodging and destroying plant root crowns and bottom growth. Cutting, grinding, and rotovating have major drawbacks and will not be used on the Long Lake or Mud Lake.

Bottom rollers and surface sweepers are devices usually attached to the end of a dock or pier and sweep through an area adjacent to the dock. Continued disruption of the bottom area causes plants to disappear and light sediments to be swept out. The use of rollers may disturb bottom dwelling organisms and spawning fish. Plant fragmentation of nuisance weeds may also occur. In soft bottom areas, sediment disturbance can be significant. These devices are generally not permitted in Wisconsin. A permit under Section 30.12(3) is required which governs the placement of structures in navigable waters.

Aquatic plant removal is sometimes done by riparian land owners using a bed spring, sickle mower blade, or other contraption attached to the back of a boat, lawn mower, or ATV which is dragged back and forth across the lake bottom. This type of management is considered mechanical and is generally not permitted by the WDNR.

The above mechanical aquatic plant management methods are not recommended for use on Long or Mud Lake.

15.2 Barley Straw

Organic materials, such as peat and barley straw, have been used for control of rooted aquatic plants and algae. There are several theories for why barley straw may work. One theory suggests that decomposing straw uses up nutrients in the water so they are not available for algae growth. Another suggests that decomposing straw gives off compounds toxic to algae [29]. Although mixed results have been reported, it is known that the decomposition of the straw requires oxygen, and the application of excessive amounts of straw could reduce the oxygen content of the water to levels that stress or kill fish.

Questions still remain as to whether barley straw is an algicide (kills existing algae) or an algistatic (inhibits algae growth). This designation is an important one for if it is considered an algicide it is also considered a pesticide. Because barley straw is not an EPA-registered pesticide, it cannot be sold as a pesticide or recommended for algae control; this would be the same as distributing an unregistered pesticide [30]. Although there is little evidence that barley acts like typical clarifiers such as alum (which causes the precipitation of phosphorus or removes particles from the water), this is one way in which the direct claim or implication of “algae control” can be avoided [30].

More research is required before any recommendations regarding barley straw can be made. Placement of any barley straw in waters of Wisconsin may require a permit from the WDNR.

15.3 Aquatic Plant Habitat Disruption

Aquatic plant habitat disruption involves management activities that alter the environment in which aquatic plants are growing. Several techniques are commonly used: drawdown or flooding, dredging, benthic barriers, shading or light attenuation, and nutrient inactivation. While not prohibited in Wisconsin, these plant management alternatives will undergo much greater scrutiny by the WDNR, and in most cases will not be permitted.

15.3.1 Dredging

Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, have inadequate pelagic and hypolimnetic zones, need deepening for navigation, or require removal of toxic substances. A WDNR permit is required to perform any dredging in a waterbody or wetland. In deep water, the plants do not receive enough light to survive. This method can be detrimental to desired plants, as all macrophytes would be prevented from growing for many years. This high level of disturbance may also create favorable conditions for the invasion of other invasive species.

At the present time, there is no reason to consider dredging in Long or Mud Lake.

15.3.2 Benthic Barriers and Light Reduction

Benthic barriers or other bottom-covering approaches are another physical management technique that has been in use for many years. The basic idea is that the plants are covered over 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 combinations of the above. WDNR approval is required and screens must be removed each fall and reinstalled in the spring to be effective over the long term.

15.3.3 Water Level Manipulation

Dropping the lake level to allow for the desiccation, aeration, and freezing of lake sediments has been shown to be an effective aquatic plant management technique. Repeated drawdowns lasting 4 to 6 months that include a freezing period are the most effective. Control of aquatic plants can last a number of years, however, the low lake levels may negatively affect native plants, provides an opportunity for adventitious annual species (such as reed canary grass), often reduces the recreational value of a waterbody, and can impact the fishery if spawning areas are affected. The cost of a drawdown is dependent on the outlet of the lake; if no control structure is present, pumping of the lake can be cost prohibitive whereas costs can be minimal if the lake can be lowered by opening a gate. Raising water levels to flood out aquatic plants is uncommon and has a number of negative effects including the potential for shoreland flooding, shoreland erosion, and nutrient loading.

While it may be possible to do a drawdown of Long Lake, there is currently no need for this management alternative.

16.0 Aquatic Plant Management Discussion

Although CLP is not causing wide-spread problems in Long Lake or Mud Lake, several areas of Long Lake do warrant management consideration. Physical removal of isolated CLP plants throughout the lakes by riparian owners and the LLPA should be considered the chief management alternative. Two areas described in the next section may warrant more than physical removal. Small-scale (less than 10 acres) herbicide application using liquid or granular formulations of endothall or diquat (both contact herbicides) could be used, however, removal of curly-leaf pondweed in these areas increases the risk of EWM being introduced and establishing itself. If management to remove CLP is done, riparian owners near the treatment areas, LLPA members, and other lake users will minimize the risk of a new AIS establishing by performing continuous AIS monitoring of the littoral zone, implementing an aggressive watercraft inspection program, and continuing education and information programs for LLPA members, riparian owners and general lake users.

Management of native aquatic plants that are causing navigation and nuisance conditions will be allowed, but only after appropriate identification, evaluation, and management recommendations have been made and approved by the LLPA and the WDNR.

16.1 Management of Curly-leaf Pondweed

Curly-leaf pondweed is widely scattered throughout much of the littoral zone of Long Lake and in two small isolated beds in Mud Lake. Despite being an exotic species, CLP is generally not invasive in Long Lake, and, for the most part, acts like “just another plant” interspersed among other native vegetation. Curly-leaf covers less than 0.1% of the entire Long Lake surface area. As previously mentions, in 2011 lake managers in northern Wisconsin and Minnesota reported unusual CLP growth in many infested lakes, with reports suggesting that early-spring CLP growth in the region was delayed and that the overall peak density was dramatically lower. This may be the case with Long and Mud Lakes and the data collected in 2011 may represent less extensive beds and lower plant densities than typically seen in previous years.

Many individual or isolated clusters of several CLP plants were found near boat landings or adjacent to docks. These plants should be physically removed by riparian owners trained in identification and removal methods, or through larger scale snorkel and scuba diver removal efforts led by the LLPA. Physical removal should occur before the plants begin setting turions. The WDNR does not limit the removal of CLP from a lake by physical means except for requiring that plants cut or pulled also be removed from the water and not left to drift away. Physical removal is the best management alternative for most of the CLP in the lakes.

Based on 2011 survey results several beds located in the lake are candidates for management other than physical removal. These beds are near the Narrows Landing (Beds 16-18 totaling 2.77 acres) (Figure 30 & 31), and near Holy Island (Beds 2-4 totaling 0.28 acres) (Figure 32). All other beds identified in the 2011 survey are less than 0.10 acre in size. These areas should have some level of physical removal completed and be monitored for expansion.

The worst areas of CLP growth in the entire system are beds 16-18 (Figure 30). CLP in this area stretches along the shoreline west and downstream of the narrows boat landing on the northern shore for more than 1,500 feet. The beds reach widths of up to nearly 200 feet in some areas along the shore. These beds are dense, monotypic stands of CLP with rake fullness ratings of 3 (Figure 31).

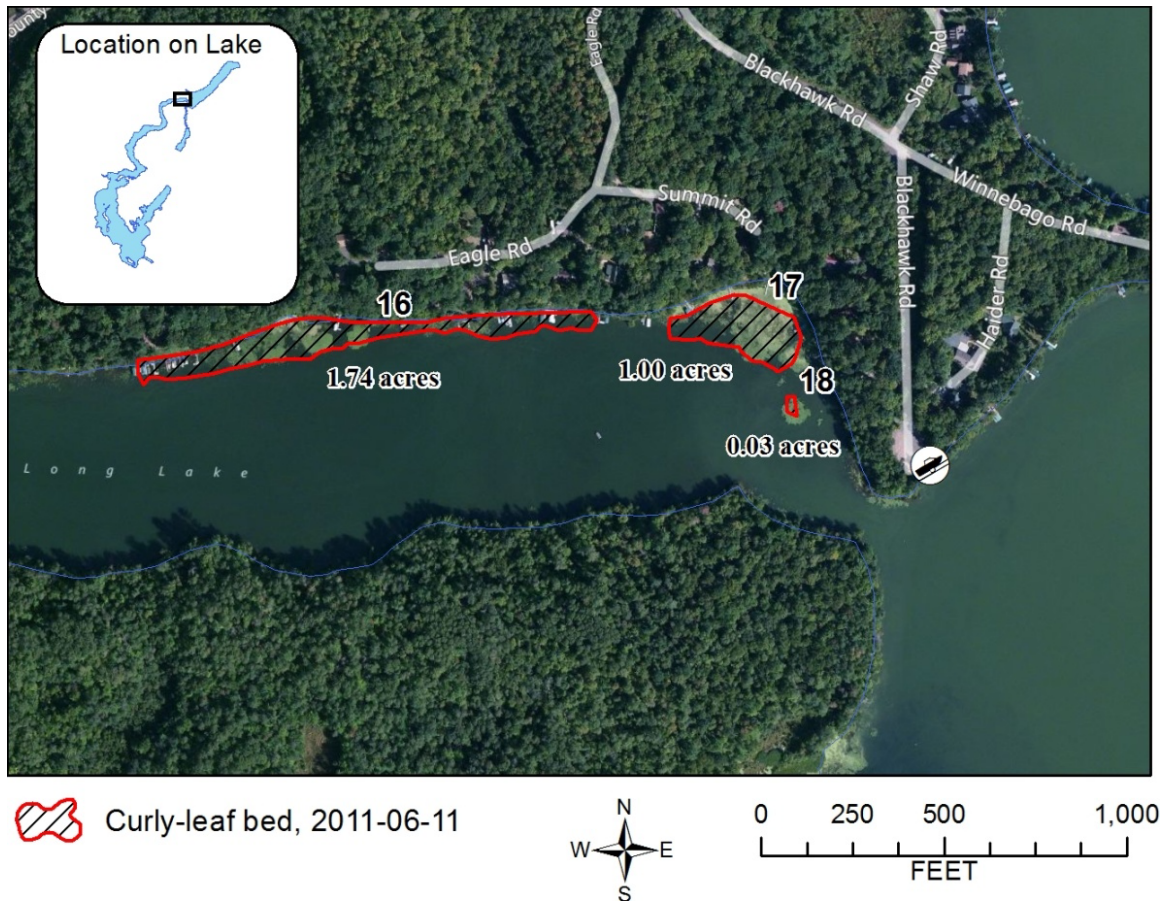


Figure 30 – Curly-leaf Pondweed Beds in the Narrows



Figure 31 – CLP Beds South and West of the Narrows Landing [3]

It appears that CLP growth has been expanding westward for some time because CLP growth the far western (downstream) edge of the beds is less dense and eventually trickles out. Curly-leaf habitat is still ideal past the western end, so it is very likely it will continue to spread if left untreated. This bed interferes with several land owners' access to open water, and appears to be shading out native early season aquatic plants found elsewhere in the lake. Other than CLP, white water lily and clumps of filamentous algae were the only other common plants documented in these areas during the 2011 survey.

Beds 2-4 are located in the bay south and west Holy Island (Figure 32). These beds had low to moderate growth densities with plants found in 3 to 5 feet of water. In 2011, the areas barely qualified as beds. However, local residents in the area expressed a great deal of concern that the CLP in this area usually forms dense canopies. Additional monitoring of this and other areas will be completed annually to determine if changes in the density and distribution of CLP warrant management beyond physical removal.

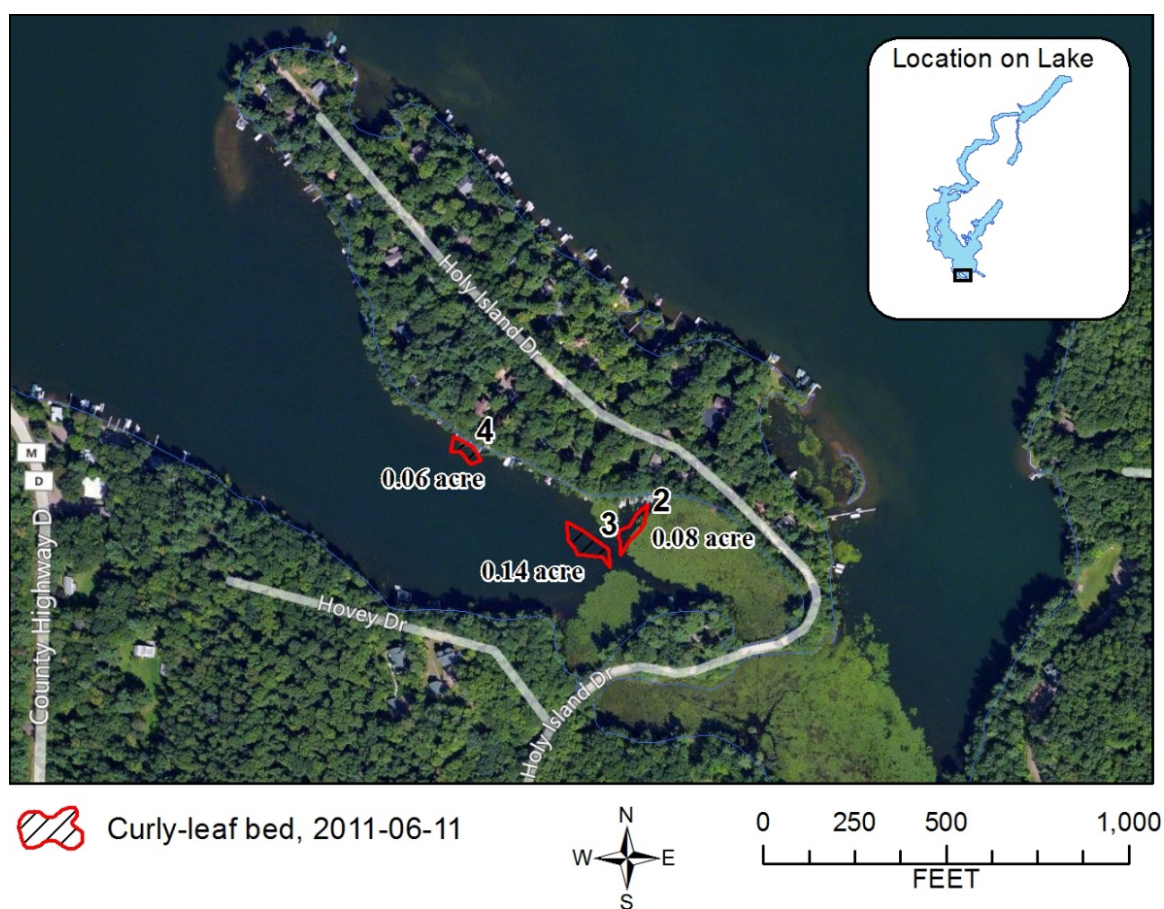


Figure 32 – Curl-leaf Pondweed Beds near Holy Island

16.2 Management of Purple Loosestrife

Purple loosestrife can be effectively controlled by physically removing new or isolated individual plants and small beds of plants. Pulling and digging are both effective but can leave root parts in the ground that will often grow new plants. AIS monitoring that includes purple loosestrife should be completed annually in July and August. Small-scale herbicide use can also be an effective management alternative. A foliar spray or dabbing of cut stems with glyphosate can be effective, but a permit is required for its use over, in, or near water.

Biological control using *Galerucella* beetles has been used in other areas of Washburn County by the WDNR and Washburn County Land and Water Conservation Department AIS Coordinator to control the spread of this plant. Hundreds of thousands of beetles have been distributed around Washburn County and neighboring counties since the mid 1990s resulting in documented established populations of the beetles throughout the county. If areas of purple loosestrife are identified where physical removal or the use of herbicides is impractical or difficult to implement, beetles could be collected and distributed in these areas.

16.3 Other AIS

Japanese knotweed is difficult to control. The LLPA should partner with Washburn County and the WDNR to undertake a fairly large-scale control project. An integrated approach to control Japanese knotweed is best. Incorporating early cutting with later herbicide application allows for more options and flexibility. Digging, pulling, or tilling before herbicide application may increase the effectiveness of herbicides. Herbicides can be applied by foliar spraying, dabbing of cut stems, and injecting stems with herbicide. Both glyphosate and triclopyr have been used in varying concentrations to treat Japanese knotweed. The best time to apply foliar sprays is when the plant is 3-6 feet tall either in the early summer or when new growth occurs shortly after cutting.

Biological controls for Japanese knotweed are being researched in Europe. Several insects and a leafspot fungus are currently undergoing safety and efficacy testing, but none have been approved for use in the United States at the present time.

Other AIS including EWM will continue to be monitored for, but no specific management is recommended at this time.

17.0 Aquatic Plant Management Goals, Objectives, and Actions

As previously established, aquatic plant management is necessary in Long and Mud Lakes. A combination of management alternatives including monitoring, education, physical removal, targeted use of herbicides, and biological control will be used to help minimize the negative impacts of AIS on native plants and water quality, and to provide navigation and nuisance relief.

Aquatic plant management in Long Lake and Mud Lake will follow eight broad goals which set context for objectives and actions to carry out over the course of the next five years. Appendix A is an outline of the aquatic plant management goals and activities, and Appendix B is a five-year timeline for completion of the activities included in this APM Plan. Any major change in activities or management philosophy will be presented to the LLPA, WDNR, and Tribal Resources for approval. The eight goals for this plan are as follows:

1. Protect, preserve, and enhance the native plant species community in and around the lakes.
2. Maintain navigation for fishing and boating and riparian access to open water for recreational use in problem areas.
3. Monitor and manage curly-leaf pondweed, purple loosestrife, Japanese knotweed and other AIS in and around the lakes and adjacent wetlands.
4. Prevent the introduction of new aquatic invasive species and the spread of existing invasive species from the lakes to other lakes by implementing monitoring, inspection and education programs.
5. Educate and inform the lake community about the importance of aquatic plants in the lake ecosystem and about management alternatives and appropriate management actions.
6. Instill an appreciation for aquatic ecosystems and habitat in the Long and Mud Lake community.
7. Develop a better understanding of the lakes and the factors affecting lake water quality through continued and expanded monitoring efforts.
8. Coordinate water level management with other impoundments in the Red Cedar River watershed.

This APM Plan will be implemented by the Long Lake Preservation Association, their consultants, and through partnerships formed with the WDNR, Washburn County, local towns, and other clubs and organizations. Annual reports and end of project assessments will be completed throughout the duration of this 5-year plan.

17.1 Goal One

Protect, preserve, and enhance the native plant species community in and around Long and Mud Lake

17.1.1 Native Plant Protection, Preservation, and Enhancement

The objective of any aquatic plant management is to protect and enhance diversity and distribution of native aquatic plants in the lake. Over the course of this management plan, the current diversity and distribution of native plants will not be reduced. An additional objective is to increase native plant diversity within areas designated for AIS management. Success will be measured by comparing annual pre- and post-treatment survey results (see 17.2.1.4 below). Any lake-wide gain or loss of diversity will be measured when a new whole-lake point intercept aquatic plant survey is completed in 2016.

The LLPA will educate riparian owners of the risk posed by removing native vegetation from around their docks — the removal of native vegetation opens up space for non-natives like CLP to inhabit or for new species like EWM to establish. If a riparian owner desires to remove native plants, the LLPA will encourage the use of physical removal as a preferred method. The LLPA will educate the riparian owner on EWM and other AIS identification and ask that monitoring for introduction be completed throughout the growing season.

17.1.2 Aquatic Plant Management Impacts to the Fishery

All lakes have habitat of critical importance to the lake ecosystem. The LLPA will manage AIS in a manner that will not negatively impact the lake ecosystem. To protect and maintain the current fishery, only physical removal methods will be implemented in waters less than 3 feet deep and in water designated as Sensitive Areas. Other management alternatives will be considered if it can be shown that the end result is an improvement to the native habitat.

The LLPA will promote the protection and enhancement of coarse woody habitat in Long and Mud Lake through the use of tree drops, “Fish sticks” projects (whole trees arranged together and anchored to shore where they look as if they have naturally fallen in the water), fish cribs or other acceptable fisheries management activities.

17.1.3 Wild Rice Management

The objective of wild rice management is to protect and enhance the waters where wild rice is currently present. Success will be measured by maintaining or increasing the amount of wild rice in the lakes.

The LLPA will partner with the WDNR, GLIFWC, and the Tribal Resources to provide education and information related to the value of wild rice as a resource found in the lakes. An example of such promotions would be to invite Tribal Resources to present on wild rice, or to set up a demonstration of wild rice harvesting techniques.

Wild rice distribution and expansion in Long and Mud Lakes will be monitored annually by trained LLPA volunteers or resource professionals retained by the LLPA through an annual littoral zone survey to be completed in August.

17.2 Goal Two

Maintain riparian access to open water for recreational use in problem areas

17.2.1 Identification and Monitoring

Several areas where growth of native aquatic plants that cause on-going concern for navigation and recreational purposes have already been identified. Additional areas may be identified annually by riparian owners and/or lake vegetation monitors retained by the LLPA. An individual or small group of riparian owners can ask the LLPA to evaluate possible areas of concern. Once asked, the LLPA or its retainers will complete an evaluation of the site and make recommendations for management if necessary.

17.2.2 Evaluations and Recommendations

All sites that currently have potential navigation and nuisance issues caused by excessive native plant growth will be evaluated by the LLPA or its retainers. Existing problem sites will be evaluated at least three times annually. New sites for evaluation may be requested by riparian owners at any time during the year. An impartial third party designated by the LLPA will conduct the evaluations, and base management recommendations on distribution, density, and diversity of the aquatic plants in the area of concern and on the level of impairment that is being caused. If management is recommended, documentation of the site including photos, size of site, GPS points, plant types present, the time and duration of problematic conditions that exist, and the management recommendations made. If sites are within area designated as critical habitat or sensitive area, or is close to existing wild rice beds management may be somewhat restricted. More detail can be found in Appendix A and in Appendix K.

Physical removal is and will be the first management alternative considered for these sites. If the level of inconvenience warrants, herbicide application will be considered. If the area of concern is in a designated critical habitat or sensitive area, additional restrictions on management may be considered. Other management options will be considered if they will be more economical, more effective, or possibly reduce the level of conflict and negative impacts to the resource.

17.2.3 Aquatic Plant Management Permit Applications

Individual or small groups of riparian owners will be allowed to apply for the necessary WDNR permits to treat areas of navigation and nuisance control provided these applications have been approved by the LLPA in advance. It is expected that the permits will be based on recommendations made in the previous section. Treatments may focus on invasive, non-native, or native plants and must follow appropriate guidelines accepted by the WDNR.

The LLPA will not pay for management of native aquatic plants. It may however consider covering the costs of the actual permit application as a good will gesture aimed at maintaining an open and candid dialogue with those riparian owners requesting native plant management.

17.3 Goal Three

Monitor and manage curly-leaf pondweed, purple loosestrife, Japanese knotweed and other AIS in and around Long and Mud Lakes and adjacent wetlands.

17.3.1 Curly-leaf Pondweed Management

The objective of CLP management is to prevent CLP from becoming the dominant early season plant in the areas it currently inhabits, and to reduce growth in areas designated for management to below “bed” status. For this APM Plan, a bed is defined as an area where CLP makes up greater than 50% of the area’s plant biomass and forms generally distinguishable beds with clearly defined borders and an average rake head density greater than 2 on a 0-3 scale based on annual early season monitoring. Success will be measured by keeping the distribution of CLP in the system at levels equal to or below the current level.

17.3.1.1 Bed Mapping and Density Monitoring

To determine if CLP is or has become the dominant plant in a particular area, bed mapping and density ratings will be completed in each year of this management plan. Density will be measured using rake sampling (0 to 3 rake head density measurement) in accordance with current aquatic plant monitoring guidelines. Areas with an average rake head density rating greater than 2 and covering more than one-eighth of an acre (about 75 ft × 75 ft) will be candidates for management.

17.3.1.2 Physical Removal

Physical removal (hand-pulling, raking, or diver removal) is the least invasive and destructive method of control for CLP. LLPA members and property owners around the lakes will be taught to remove individual plants and small clusters of CLP in shallow, easily accessible areas of the lakes. Instructional materials and training will be provided to aid riparian owners in the identification and removal of CLP.

It is also recommended that the LLPA sponsor an annual CLP Removal Day in mid to late June during which volunteers or paid participants will be assembled and a more vigorous physical removal program undertaken which could include diver removal.

17.3.1.3 Chemical Application

Because curly-leaf pondweed is established throughout Long Lake at sparse levels and intermingled with native macrophytes, chemical treatment is not warranted for most areas of the lake. Herbicide use will be evaluated as a treatment option only when CLP growth reaches bed status. Specifics for what herbicide to use when will be determined annually during the proposed treatment phase of planning. Granular or liquid herbicide could be used, as well as one or more different but approved herbicides in WI. Application of herbicides is required in the early season before water temperatures exceed 60° F for a prolonged period of time.

Once started in a designated area, herbicide applications will continue for at least three years in order to significantly reduce CLP density and increase the diversity and distribution of native plants in that area. All proposed annual herbicide treatment areas will be based on the previous year distribution survey results, with final current year treatments supported by a pre-treatment aquatic plant survey. A post-treatment survey will be completed to determine the impact of treatment on the target species (CLP) and non-target species (native macrophytes).

17.3.1.4 Pre- and Post-Chemical Treatment Aquatic Plant Surveying

Chemical herbicide application areas for CLP are determined in the previous year based on bed mapping and density monitoring. To be most effective, chemical herbicides must be applied before CLP reaches substantial biomass. Treatment in these areas often occurs before CLP plants are visible from the water surface. To determine final early season chemical application areas, a pre-treatment survey will be conducted. Multiple points will be established in areas designated for herbicide application. These points will be sampled by rake following point intercept guidelines to determine if the target plant is present and to what extent. The final early season treatment will be modified to account for pre-treatment survey results. Approximately 4 to 6 weeks after actual chemical treatment, a post treatment survey will be completed sampling the same points established in the pre treatment survey again. Comparisons will be made before and after treatment as to the impact of that treatment on target and non-target species. Success or failure of the treatment will also be assessed and modifications made in the following year.

17.3.2 **Purple Loosestrife Monitoring and Management**

The objective of purple loosestrife management on Long Lake and Mud Lake is to eliminate this invasive species from the shores of both lakes. There is currently limited purple loosestrife and management alternatives exist that make it possible to eliminate it from the lake. Success will be measured by eliminating existing plants from the shores and by not allowing new plants to become established.

Monitoring the entire system for new plants will be done at least monthly from July to September by the LLPA. Individual plants will be removed from the shoreline either by pulling or digging or the application of herbicides. If these measures fail to eliminate purple loosestrife from the shores, biological control agents (beetles) will be collected and transferred to the lake or raised by the LLPA in small or large-scale rearing stations (Figure 31). WDNR guidelines for establishing beetle rearing stations are included in Appendix I.



Figure 33 – Small Scale (left) and Large Scale (right) Beetle Rearing Stations

17.3.3 Japanese Knotweed Monitoring and Management

The objective of Japanese knotweed management is to prevent the further spread of this AIS, identify all areas in around Long and Mud Lakes where the plant currently exists, and then to reduce the size of infestation in those areas by at least half over the course of this five-year plan. To do this, the LLPA will partner with the Washburn County AIS program, WDNR, and other entities to support planning for and implementation of control measures. It is recommended that an integrated approach to control is used that includes diligent monitoring, physical removal, mechanical control, and chemical control.

17.3.4 Other Aquatic Invasive Species

The management objective for other AIS that may or may not be present in Long and Mud Lakes is to monitor for the introduction of new AIS, or the expansion of existing species within the lake. New threats may include EWM, zebra mussels, and spiny waterflea, existing species may include Chinese mystery snails and rusty crayfish, though at the present time these species have not been officially documented in the lake. The success of this objective will be measured by the level of knowledge and understanding gained in the management of these species.

17.4 Goal Four

Prevent the introduction of new aquatic invasive species and the spread of invasive species from the lakes to other lakes by implementing monitoring, inspection, and education programs.

17.4.1 AIS Education, Prevention and Planning

The objective of AIS education, prevention, and planning in this plan is to create a lake community that is aware of the problems associated with AIS, and that has enough knowledge about certain species to aid in detection, planning, and implementation of management alternatives. The success of this objective will be measured by the length of time other AIS can be kept out of the lakes.

17.4.1.1 Watercraft Inspection and Signage

The LLPA has and will continue an active water craft inspection program at the high traffic boat landings following UW-Extension Clean Boats, Clean Waters guidelines. All watercraft inspection data collected annually will be submitted to the WDNR SWIMS database. The LLPA will maintain and update AIS signage located at every public access on the lakes.

17.4.1.2 In-lake and Shoreline AIS Monitoring

The LLPA will continue an active in-lake and shoreline AIS monitoring program. Trained volunteers will patrol the shoreline and associated littoral zone looking for AIS including CLP, EWM, purple loosestrife, Japanese knotweed, giant reed grass, zebra mussels, and other AIS at least three times during the season as a part of the UW-Extension Lakes/WDNR CLMN AIS Monitoring Program. If a suspected AIS is found, it will be reported to the LLPA, County and(or) WDNR resource professionals. All data will be recorded and entered into the WDNR SWIMS database.

17.4.1.3 Rapid Response Plan

A EWM Rapid Response Plan for Long and Mud Lake can be found in Appendix J. The plan contains information on what to do if a suspect AIS is found, who to contact, and what should be done if a positive identification is made.

17.4.1.4 AIS Coordinator

The LLPA understands that organizing volunteer efforts, data entry, and providing education and training requires a great deal of time. To address this, it is recommended that the LLPA hire an AIS Coordinator for nearly full-time work from late spring to early fall. The Coordinator will be supported by the LLPA board and other partners and encouraged to work with professional resources to accomplish annual goals for AIS education, prevention, and planning.

17.5 Goal Five

Educate and inform the lake community about the importance of aquatic plants in the lake ecosystem and about management alternatives and appropriate management actions.

17.5.1 Lake Community Education

The objective of lake community education is to establish and maintain lake community participation in actions implemented to manage the lakes, give the lake community voice in management decisions, and to garner support and understanding for the management decisions made. Success will be measured by the level of satisfaction and involvement LLPA members have for the management efforts undertaken.

17.5.1.1 Education Events

In each year of this APM Plan, the LLPA will sponsor at least one education event focused on some aspect of AIS. This event could be a lake fair, a workshop targeting a specific topic (for example, watercraft inspection, shoreland restoration, aquatic plant identification, aquatic plant management, or wild rice awareness and education), or a special meeting. The event could be held by itself or in combination with some other regularly scheduled event.

17.5.1.2 Distribution of Information and Education Materials

The LLPA tries very hard to keep its membership informed of the events happening in and around the lakes. An annual newsletter is developed and distributed, a Lake Association webpage is maintained and updated on a regular basis, and AIS materials are either developed in house or obtained through the many AIS resource outlets that exist. Lake related documents like this APM Plan and the results of aquatic plant surveys are posted on the webpage. The LLPA Annual Meeting is well attended and people are genuinely interested in what occurs on the lakes.

17.6 Goal Six

Instill an appreciation for aquatic ecosystems and habitat in the Long and Mud Lake community.

17.6.1 Wildlife Appreciation

The objective is to improve the knowledge of the lake community of how management actions in and around the lakes affect the wildlife living there. Success will be measured in the amount of interest and participation LLPA members have in numerous monitoring programs.

The LLPA will provide education and informational materials related to wildlife and wildlife monitoring programs during events, in newsletters, on the webpage, and during meetings. LLPA volunteers are already participating in the Loon Watch program sponsored by the Sigurd Olson Institute. Other citizen-based monitoring programs in Wisconsin, for example, [Wisconsin NatureMapping](#), the [Frog and Toad Survey](#), and [Freshwater Sponges](#) abundance, will be promoted by the LLPA and riparian owner participation encouraged. A list of organizations can be found at the Wisconsin Citizen-based Monitoring Network site at <http://wiatri.net/cbm/> (last accessed June 2012). Web addresses for the above mentioned examples are provided below.

Wisconsin NatureMapping:	http://www.wisnatmap.org/
Wisconsin Frog and Toad Survey:	http://wiatri.net/inventory/FrogToadSurvey/
Freshwater Sponges:	http://dnr.wi.gov/org/es/science/citizen/index.htm

17.7 Goal Seven

Develop a better understanding of the lakes and the factors affecting lake water quality through continued and expanded monitoring efforts.

17.7.1 Lake Community Understanding

The objective of this goal is to educate the lake community about how their actions impact the aquatic plants and water quality in the lakes. Success will be measured in the number of projects LLPA members participate in and in the understanding the lake community gains in this endeavor. The completion of at least two or three projects annually and uninterrupted long-term trend monitoring via the CLMN water quality program will indicate successful implementation of this objective.

17.7.1.1 Shoreland Restoration and Habitat Improvement

It is recommended that the LLPA encourage riparian owner participation in shoreland restoration and habitat improvement programs sponsored by Washburn County, the WDNR, and other shoreland improvement programs. Information about these programs will be made available to all LLPA members through the newsletter, on the webpage, and during LLPA sponsored events.

17.7.1.2 Riparian Owner Best Management Practices

It is recommended in this plan that the LLPA encourage riparian owner participation in best management practices that may reduce shoreland runoff and nutrient loading into the lakes. Informational and educational materials will be made available to all LLPA members through the newsletter, on the webpage, and during LLPA sponsored events. Best management practices could include but are not limited to the establishment of buffer strips, runoff diversions, rain gardens, septic system maintenance, non-impervious surfaces, and no-mow areas.

17.7.1.3 CLMN Water Quality Monitoring Program

LLPA volunteers will continue to participate in the CLMN Water Quality Monitoring Program to further develop long-term trends in water quality. This APM Plan recommends completing CLMN expanded monitoring (Secchi, temperature, dissolved oxygen, total phosphorus, and chlorophyll *a*) at Site A and Site E and, if funding is available, Site D (Figure 2). October sampling should be added to the standard spring and June- August sampling to help identify changes that may be brought about late in the season by management actions. October sampling would only be completed if supported by grant funding.

Secchi measurements should be taken at the all monitoring sites at least once during each summer month (June – July), preferably twice a month at all sites. The Mud Lake Deep Hole site has very little data available and therefore little is known about its water quality — it would be beneficial to collect Secchi depths and temperature and dissolved oxygen profiles at the Mud Lake Deep Hole site during summer months to better characterize the water body and track any changes to its condition.

It is possible for aquatic plant management activities to impact water quality, either positively or negatively. Long-term trend monitoring completed as a part of the CLMN program already indicates a slight but significant trend toward poorer water quality with respect to water clarity readings taken throughout the system and with increasing phosphorus concentrations in certain parts of the lakes. Continued participation in basic, long-term trend water quality monitoring may help identify additional changes in water quality due to plant management activities.

The LLPA should revisit their existing comprehensive lake management plan to determine what recommendations in that plan have actually been implemented and evaluate the management strategies presented in the State of the Watershed Report.

17.8 Goal Eight

Coordinate water level management with other impoundments in the Red Cedar River watershed.

17.8.1 Maintaining Open Lines of Communication

The objective of this goal is to establish the importance of keeping open lines of communication between dam operators on the various impoundments in the Red Cedar River watershed. Benefits of coordinated water level management include enhanced recreation, flood control, low flow augmentation, and water quality improvement. Success will be measure by how successfully these lines are established and maintained, and by eliminating issues that have been problematic in the past.

17.8.1.1 Spring, Rain Events, and Fall Withdrawals

There are several dams in the Red Cedar River watershed including the Long Lake dam, the Red Cedar Lake dam at Mikana, the Big Chetac and Birch Lake dam in Birchwood, the Murphy Flowage dam in Rusk County, and the Rice Lake dam in Rice Lake (Figure 32). Dam operators for each of these systems must manipulate the water level to accommodate local community expectations and regulatory guidelines. Barron County personnel charged with overseeing the operation and maintenance of most of these dams indicate that more coordinated withdrawals throughout the upper reaches of the Red Cedar River may improve flushing and therefore reduce nutrient retention in these systems. This APM recommends establishing or re-establishing open lines of communication between all the dam operators and owners so withdrawals can be better coordinated to the benefit of all.

17.8.1.2 Outflow Reductions

Reducing outflow from the various impoundments on the Upper reaches of the Red Cedar River and its tributaries can impact impoundments downstream. For example, the Rice Lake Protection and Rehabilitation District has stated that they were not informed of outflow reductions upstream and as a result the outflow at the Rice Lake dam was not adjusted, causing several days of extremely low water in Rice Lake. The low water levels not only aggravated residents, but also complicated the Rice Lake aquatic plant harvesting program. Establishing open lines of communication between the various dam operators is crucial to the effective management of these impounded lake systems.

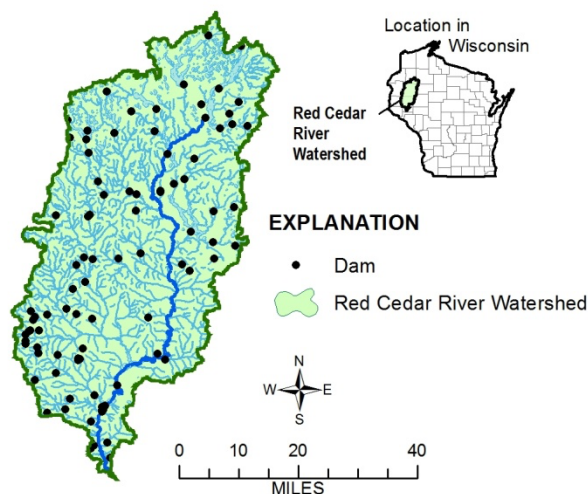


Figure 34 – Locations of Dams in the Red Cedar River Watershed

18.0 Aquatic Plant Management Plan Maintenance

This APM Plan is a working document guiding management actions on Long Lake and Mud Lake over the next five years. Annual and end of project assessment reports are necessary to monitor progress and justify changes to the management strategy. The following activities will support APM Plan maintenance.

18.1.1 Successful Reporting and Data Sharing

The objective here is to complete project reporting that meets the requirements of all stakeholders, gains proper approval, allows for timely reimbursement of expenses, and provides the appropriate data for continued management success. Success will be measured by the efficiency and ease in which these actions are completed.

18.1.1.1 End of Year and Annual Management Proposals

The LLPA and their retainers will compile, analyze, and summarize management operations, education and outreach efforts, and other pertinent data and report it in paper and digital formats to the members of the LLPA, Washburn County, local townships, and the WDNR. These reports will also serve as a vehicle to propose following year management recommendations. These reports will be completed by the LLPA and their retainers prior to implementing following year management actions by March 31st of each year.

18.1.1.2 Update of the Point Intercept Aquatic Plant Survey

It is recommended that the LLPA complete another whole-lake point intercept aquatic plant survey in 2016. Results will be compared to the 2011 survey to determine the impacts of management activities on both target and non-target aquatic plants.

18.1.1.3 End of Five-Year Project Evaluation and Assessment

At the end of this five-year project, all management efforts and related activities will be analyzed and summarized in a report. This document will discuss the successes and failures of the existing APM Plan and be the basis for making revisions to the APM Plan. The report will be compiled by the LLPA and their retainers and distributed to the LLPA membership, Washburn County, local townships, and the WDNR. The report will be completed June 30th of the year following the final year of this APM Plan.

19.0 Five-Year Timeline of Activities

The activities in this APM Plan are designed to be implemented over a five-year period with the majority of activities beginning in 2013. Appendix B provides a timeline for implementation of activities. As mentioned above, the plan is intended to be flexible to accommodate future changes in the needs of the lakes and their watershed, and those of the LLPA. Many activities in the timeline will require grant support to complete. If grant support is not acquired, then some activities will be modified or eliminated until more revenue can be arranged through the LLPA or state grant funding.

20.0 References

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Appendix A

Goals, Objectives, and Actions

Appendix B

Five-year Timeline of Events

Appendix C

Public Input Survey Results

Appendix D

WDNR Northern Region APM Strategy

Appendix E

Sensitive Areas Report for Long Lake

Appendix F

Guidelines for Protecting, Maintaining, and Understanding Lake Sensitive Areas

Appendix G

NR 109 - Aquatic Plants: Introduction, Manual Removal and Mechanical Control Regulations

Appendix H

Licensed Harvester Companies in MN, 2009

Appendix I

Galerucella Beetle Rearing Guide

Appendix J

EWM Rapid Response Plan for Long and Mud Lakes

Appendix K

Nuisance and Navigation Guidelines for Native Plant Management