Lower Turtle Lake Aquatic Plant Management Plan

Turtle Lakes Lake Protection Project

Barron County, Wisconsin

SEH No. TULMD 110870

January 3, 2011

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RE: Turtle Lakes Lake Protection Project
Lower Turtle Lake Aquatic Plant
Management Plan
Barron County, Wisconsin
SEH No. TULMD 110870

Mr. Ken Bonner
Lower Turtle Lake Management District
Route 1
Almena, WI 54805

Dear Ken:

The following document is to be considered a 5-year Aquatic Plant Management (APM) Plan for Lower Turtle Lake in Barron County. Enclosed are two copies of the APM Plan. Two additional copies have been sent to Pamela Toshner, Lakes Grant Coordinator with the Wisconsin Department of Natural Resources (WDNR) in Spooner, WI. Should the WDNR approve this APM Plan, you will be eligible for Aquatic Invasive Species Established Population Control Grant funding in February of 2011.

Sincerely,

Dave Blumer
Lake Scientist

dlb/jam
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Lower Turtle Lake Aquatic Plant Management Plan

Turtle Lakes Lake Protection Project
Barron County, Wisconsin

Prepared for:
Lower Turtle Lake Management District
Almena, WI

Prepared by:
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Jake Macholl Lake Scientist	Date
Dave Blumer Lake Scientist	Date

Distribution List

No. of Copies	Sent to
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2	Pamela Toshner Wisconsin Department of Natural Resources 810 W. Maple Street Spooner, WI 54801

Executive Summary

Lower Turtle Lake is a 276-acre lake located in west-central Barron County, Wisconsin. Curly-leaf pondweed (CLP), an aquatic invasive species, has been present in the lake for some time. Dense CLP beds in the northern and southern ends of the lake coupled with poor water quality conditions limits the native aquatic plant population. In recent years, plant management activity in the lake has been limited to lake property owners removing nuisance plants at a very small scale. The need for a coordinated strategy to manage aquatic invasive species and to prevent the introduction of new invasive species was recognized by the Lower Turtle Lake Management District (LTLMD) and is the impetus behind the development of this plan. This APM Plan covers aquatic plant management activities in Lower Turtle Lake for the next five years. WDNR approval is being sought for the activities included within this plan which is anticipated to begin in 2011.

There are six broad goals, each with a number of objectives and actions, which will guide plant management efforts on Lower Turtle Lake over the course of the next five years. Appendix C is an outline of the aquatic plant management goals and activities, and Appendix D is a five-year timeline for completion of the activities included in this APM Plan. This five-year plan is a living document; minor changes and adaptations are expected and will be made annually, but any major change in activities or management philosophy will be presented to the LTLMD and the WDNR for approval. The six goals for this plan are as follows:

1. Monitor, control, and manage aquatic invasive species;
2. Educate residents and users about and prevent the introduction of aquatic invasive species;
3. Monitor lake water quality;
4. Promote and implement shoreland best management practices;
5. Preserve, protect, and enhance native species;
6. Evaluate the APM plan each year and revise as necessary.

Curly-leaf pondweed management will entail annual monitoring, including spring bed mapping and fall turion density sampling, to determine the necessary CLP management activities that will help improve the native plant community and water quality of Lower Turtle Lake. If management action is necessary, early-season chemical application will be the method used.

All permits applications and necessary record keeping will be completed by the LTLMD, their consultant, and their commercial chemical applicator. Annual summaries and evaluations of the activities undertaken will be completed by the LTLMD and their consultant and submitted to the necessary partners for review. A final project summary will be completed by the LTLMD and their consultant in the final year of this project which will include a whole-lake aquatic plant survey to determine the overall impact of this 5-year plan.

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Lower Turtle Lake Aquatic Plant Management Plan

Turtle Lakes Lake Protection Project

Prepared for Lower Turtle Lake Management District

1.0 Introduction

Lower Turtle Lake is located in west-central Barron County. The Lower Turtle Lake Management District (LTLMD) has been actively working to improve water quality conditions in the lake since the 1990s. The LTLMD initiate lake studies in 1994 and 2004 out of concern for degraded water quality conditions. These studies were combined to create the Revised Comprehensive Lake Management Plan for the Turtle Lakes in early 2009. This plan was the basis for a 2010-2014 Lake Protection Project focused on agricultural and riparian owner incentives to incorporate Best Management Practices (BMPs) that could reduce phosphorous loading to the lake. Developing APM plans for both Upper and Lower Turtle Lake is a part of this five-year project. Project partners include the LTLMD, the LTLA, the UTLA, Barron County, local farmers and the Town of Almena.

Water quality in Lower Turtle Lake has not substantially deteriorated over the last fifteen years; however, recent negative trends, particularly reduced Secchi depth readings and increased chlorophyll *a* concentrations, suggest that further degradation has and continues to occur. Lower Turtle Lake experiences severe algal blooms throughout the summer season with chlorophyll *a* measurements at times exceeding 80 µg/L. The high level of phosphorous present in the system fuels algae growth which in turn limits beneficial plant growth. This causes a shift from a plant-dominated system to an algae-dominated system during the summer months.

Lower Turtle Lake needs to re-establish and enhance its native plant community. Native aquatic plants are not abundant in the lake and their diversity and distribution is poor (Berg, 2008). The native species with the largest populations include coontail, flat-stem pondweed, and northern water milfoil. The presence of dense beds of CLP is likely an important factor in the poor distribution and affects the diversity of the plant community. Early growing season removal of the densest areas of CLP in the north and south bays, which are also Sensitive Areas, may enable more of the desirable native plants species already present to flourish. The removal of CLP would also eliminate a source of phosphorous to the lake.

2.0 Lake Inventory

In order to make recommendations for aquatic plant management, basic information about the lake is necessary. A basic understanding of Turtle Lake's physical characteristics and factors influencing water quality, including size and depth, water quality, critical habitat, fisheries and wildlife, and soils, is needed to make appropriate recommendations for improvement. 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. Information, including water quality data and plant survey information, has and is currently being collected on Lower Turtle Lake and throughout its watershed. These data allow for an evaluation of the effects of aquatic plant management and other management activities on the lake and its ecosystem.

2.1 Physical Characteristics

Lower Turtle Lake (WBIC 2079700) is a hard-water drainage lake in west-central Barron County, Wisconsin about 2.5 miles east of the Village of Turtle Lake (Figure 1). According to the Wisconsin Lakes bulletin, the lake covers 276 acres, has a maximum depth of 24 feet and an average depth of 14 feet (WDNR, 2005). A LIDAR survey of Barron County completed in May 2005 indicates the lake covers 294 acres. Physical characteristics of the lake are provided in Table 1. Turtle Creek, which flows from Upper Turtle Lake, is the main tributary to Lower Turtle Lake. The stream enters at the north end of the lake and exits at the south end. The lake is also fed by three intermittant streams and wetland drainage.

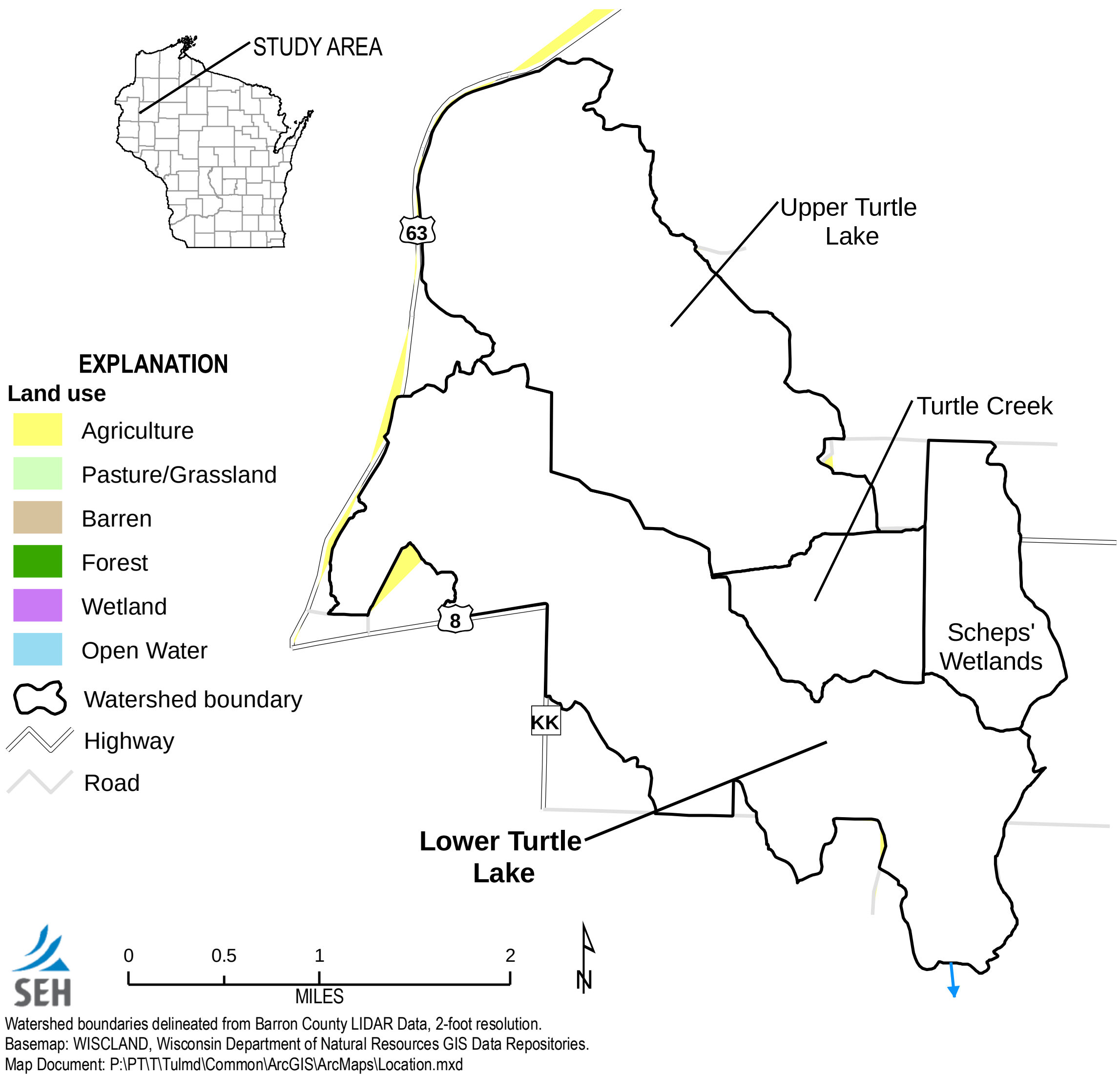


Figure 1 – Location of Lower Turtle Lake and Its Watershed

Table 1
Physical Characteristics of Lower Turtle Lake

Lake Area (acres)	294
Watershed Area (acres)	5,569
Watershed to Lake Ratio	18:1
Maximum Depth (feet)	24
Mean Depth (feet)	13.4
Volume (acre-feet)	3,933.7
Elevation (feet AMSL)	1,172
Maximum Fetch (miles)	1.5
Miles of Shoreline	4.42
Lake Type	Drainage

A watershed is an area of land from which water drains to a common surface water feature, such as a stream, lake, or wetland. The watershed boundaries were delineated by the Barron County Soil and Water Conservation Department and adjusted using 2-foot contour lines obtained from Barron County. The Lower Turtle Lake watershed is 5,569 acres including an internally drained area of 195 acres that drains to a wetland known locally as Scheps' Wetlands. Internally drained areas are closed depressions within the watershed that can only provide surface runoff to the drainage network during the extreme wet conditions. During normal conditions, the Scheps' Wetlands basin drains northward, away from the lake.

Land cover and land use management practices within a watershed have a strong influence on water quality. Increases in impervious surfaces, such as roads, rooftops and compacted soils, associated with residential and agricultural land uses can reduce or prevent the infiltration of runoff. This can lead to an increase in the amount of rainfall runoff that flows directly into Lower Turtle Lake and its tributary streams. The removal of riparian, i.e., nearshore, vegetation causes an increase in the amount of nutrient-rich soil particles transported directly to the lake during rain events.

The land use in the Lower Turtle Lake watershed is primarily classified as agricultural (row crops, pasture, etc.) and a mix of forests, wetlands, and barrens. The agricultural land use covers approximately 60% of the watershed and consists primarily of large-scale row cropping. Residential areas make up a relatively small portion of the land use; however, the majority of residential areas are concentrated around the lakes in the watershed leading to more immediate and likely greater impacts to water quality than areas located further away from the lakes.

2.2 Lake Water Quality

Citizen Lake Monitoring Network (CLMN) volunteers have collected water quality data from Lower Turtle Lake since 1987. Volunteers measured quantitative parameters such as temperature, dissolved oxygen, and Secchi depth, and collected water samples which were sent to the Wisconsin State Lab of Hygiene for analysis of total phosphorus, chlorophyll a, nitrogen, and other constituent concentrations. Qualitative observations such as lake level, color, and user perception of water quality were also recorded.

2.2.1 Water Clarity

The depth to which light can penetrate a lake is a factor that limits aquatic macrophyte growth. Water clarity was measured by CLMN volunteers using a Secchi disk. The Secchi disk measurement is the average of the depth that when lowered the disk just disappears from sight and the depth that when raised the disk is just visible. 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.

From 1987 through 2008, the average summer (July through August) Secchi depth in Lower Turtle Lake was 3.5 feet, with depths varying as much as 16.5 feet in a single year. The trend line shows there has been no appreciable change in the water clarity of the lake over time. There is a small decrease in water clarity from 2000 to 2008; however, it should be noted that the number of Secchi measurements taken during the summer months from 2000 through 2008 is less than the number taken in previous years, making a full trend analysis inappropriate.

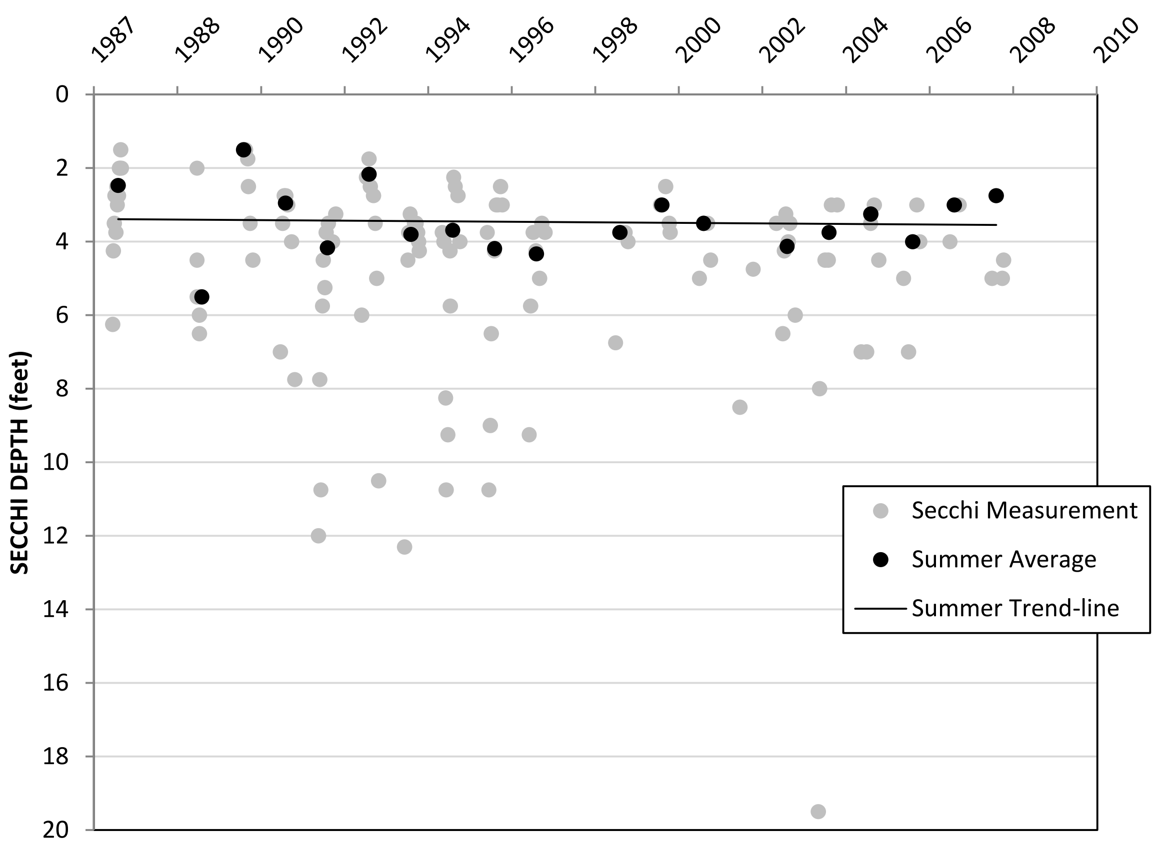


Figure 2 – Secchi Readings from 1987 through 2008 shown with Summer Average Trend.

2.2.2 Chlorophyll *a*

Chlorophyll *a* is a measurement of algae in the water. The concentration varies throughout the year, generally peaking in lake summer. The mean summer chlorophyll *a* concentration from 1993 through 2010 (32.6 µg/L) is nearly 3-times higher than the mean identified for northwest Wisconsin Lakes (12.4 µg/L) by Lillie and Mason (1983).

The preferred method of determining how productive a lake is, or its trophic status, is by converting the chlorophyll *a* concentration to a Wisconsin-specific Trophic Status Index (WTSI). Lower Turtle Lake is considered eutrophic based on an average summer $WTSI_{CHL}$ of 60, which has remained fairly steady since the early 1990s. As with Lower Turtle Lake, most eutrophic lakes generally have low clarity, poor water quality, and nuisance algal blooms affecting boating, swimming and other recreational activities (Table 2).

Table 2
The Wisconsin Trophic State Index and Description of Conditions for Lower Turtle Lake

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.

Lower Turtle Lake
$WTSI_{CHL}$ = 60

2.2.3 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. Total phosphorus levels indicate that Lower Turtle Lake is eutrophic, or highly productive. Average growing season (May to October) total phosphorous concentrations in Lower Turtle Lake have remained fairly steady since the early 1990s, but average summer (July through August) values have been variable (Figure 3). There is, however, a slight increase in phosphorus concentrations over the last decade. The summer mean phosphorus in Lower Turtle Lake from 2000 through 2010 (55.1 µg/L) is nearly double the mean reported for northwest Wisconsin lakes (28.0 µg/L) by Lillie and Mason (1983).

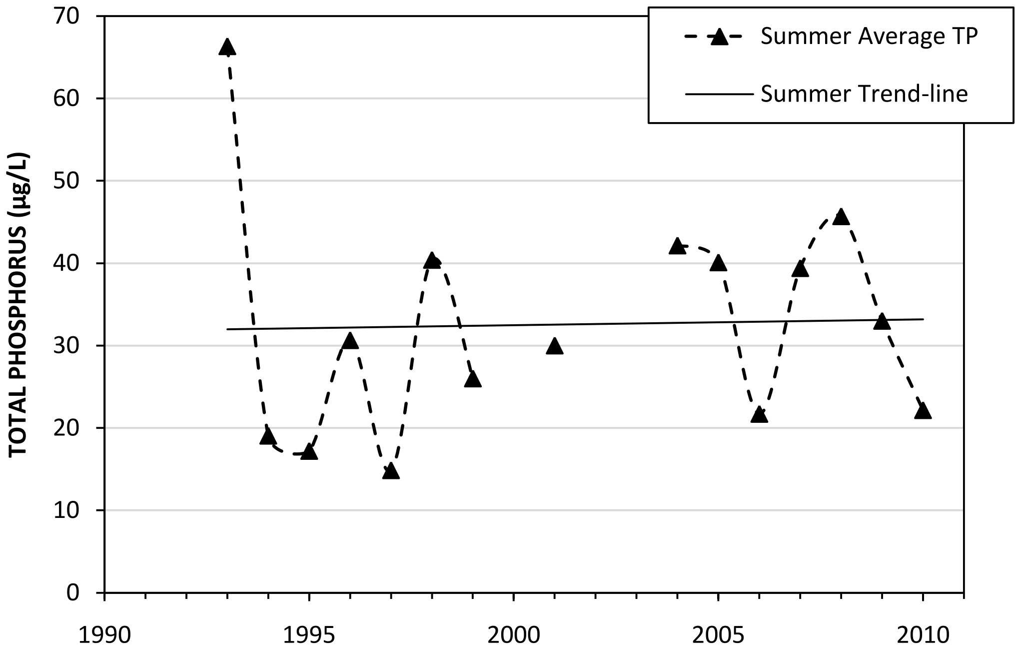


Figure 3 – Summer Average Total Phosphorus from 1993 through 2010

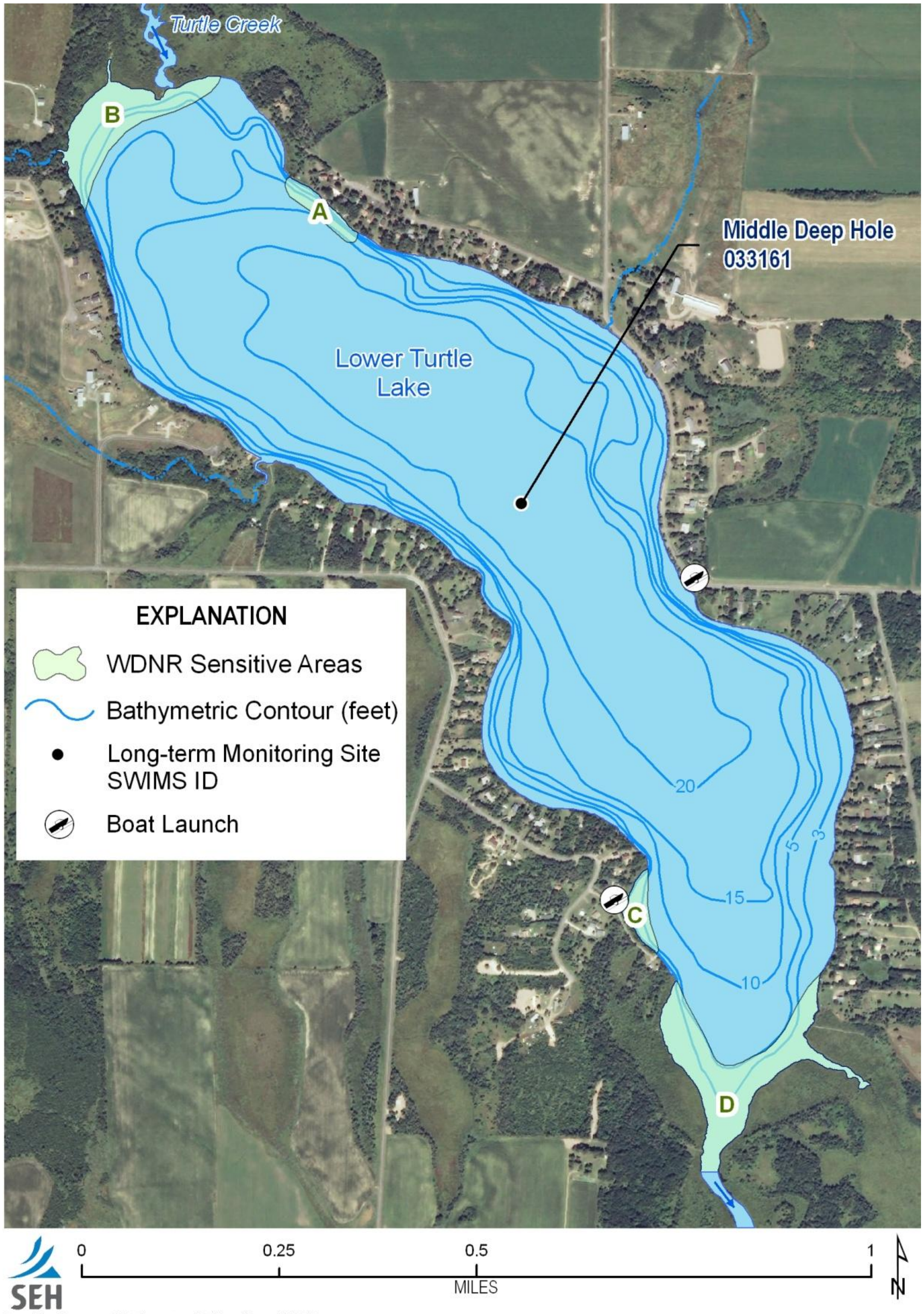
2.2.4 Nitrogen to Phosphorus Ratio

The ratio of the total nitrogen to total phosphorus (N:P) is used to determine the nutrient that likely limits aquatic plant growth in a lake. When N:P is greater than 16:1, phosphorus is interpreted as the limiting nutrient and when the ratio is less the 10:1, nitrogen is likely the limiting nutrient. In 1994 and 2010, the N:P ratios averaged 24:1 and 27:1, respectively, suggesting phosphorus is likely the limiting nutrient in Lower Turtle Lake.

2.3 Critical Habitat

Every body of water has areas of aquatic vegetation or other features that offer critical or unique fish and wildlife habitat. Such areas can be mapped by the WDNR and designated as Critical Habitat. Areas are designated as Critical Habitat when they include important fish and wildlife habitat, natural shorelines, physical features important for water quality (e.g., springs) and navigation thoroughfares. These areas, which can be located within or adjacent to the waterbody, are particularly valuable to the ecosystem or would be significantly impacted by most disturbances or development. In sensitive areas, the use of pesticides for plant control is generally not allowed, disturbances to the areas during mechanical harvesting should be avoided, and the removal of plants to improve navigation should be limited to the minimum amount practical.

A sensitive areas survey was conducted by the WDNR in August 1993. The full WDNR report can be found in Appendix A. Four areas of the lake were identified as Sensitive Areas because they provide important habitat and offer shoreline stabilization (Figure 4). The two large areas located at the northern and southern ends of the lake are the same areas that harbor the bulk of the CLP. A competitive advantage CLP has over native plants is its ability to grow rapidly shortly after ice-out. This rapid growth can lead to the development of dense, monotypic stands which provide a much less diverse habitat. Although restrictions are in place to protect these areas during plant management operations, short-term disruptions to habitat during the removal of CLP will likely lead to positive long-term improvements to the habitat of the lake.



Sensitive Areas and Bathymetry: Digitized from WDNR maps.
Orthophoto: 2008 NAIP.
Map Document: P:\PT\T\Tulmd\Common\ArcGIS\ArcMaps\Monitoring_SA

Figure 4 – WDNR Sensitive Area Designation and Lake Bathymetry

2.4 Fishery and Wildlife

Lower Turtle Lake has a diverse fishery consisting of walleye (*Sander vitreus*), northern pike (*Esox lucius*), musky (*Esox masquinongy*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), pumpkinseed (*Lepomis gibbosus*), warmouth (*Lepomis gulosus*), yellow perch (*Perca flavescens*), common carp (*Cyprinus carpio*), bullheads (*Ameiurus* spp.), and bowfin (*Amia calva*). Walleye stocking has occurred sporadically from 1933 to 1963 and during even years since 2000. Stocking was halted in 1969 and currently occurs every other year because there is not adequate natural reproduction to sustain the walleye fishery.

The WDNR performed a Treaty Assessment Survey on Lower Turtle Lake in 2004 – 2005. The full WDNR report can be found at http://www.dnr.state.wi.us/fish/reports/ (last accessed December 15, 2010). The survey found that number of largemouth bass in the lake has increased dramatically since 1974 while the number of walleye has decreased by 71% since 1993. The survey also found that angling pressure was directed towards panfish in the lake, but largemouth bass were the most common gamefish caught by anglers, followed by northern pike and walleye. Northern pike are the most common gamefish harvested by anglers on the lake.

The Natural Heritage Inventory (NHI) database contains recent and historic observations of rare species and plant communities. These observations are current as of October 6, 2009. Each species has a state status including Special Concern (SC), Threatened (THR) or Endangered (END). There are three plant species (Robbins' spikerush, *Eleocharis robbinsii*, SC; spotted pondweed, *Potamogeton pulcher*, END; Torrey's bulrush, *Scirpus torreyi*, SC), one bird species (bald eagle, *Haliaeetus leucocephalus*, SC) and four northern communities (dry-mesic forest, mesic forest, sedge medow, an wet forest) that have been documented in or near the Lower Turtle Lake watershed. The plant species are all aquatic plants, but were not identified during previous aquatic plant surveys.

2.5 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 serve many functions that benefit the ecosystem surrounding Lower Turtle Lake. Wetlands with a higher floral diversity of native species support a greater 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.

According to the National Wetland Inventory, emergent, forested and aquatic bed (lake and freshwater pond) wetlands are present in the Lower Turtle Lake watershed. The majority of the wetlands are located near or adjacent to the lake (Figure 1). Lower Turtle Lake has emergent and forested/shrub wetlands at its northern and southern ends that cover 43.3 acres and 102 acres, respectively.

Emergent wetlands are wetlands with saturated soil and are dominated by grasses such as redtop 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 provide flood protection within the landscape. The dense vegetation and lower location within the landscape allow wetlands to retain stormwater from rain and melting snow and capture floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide water quality protection because wetland plants and soils have the capacity to store and filter pollutants ranging from pesticides to animal wastes.

Wetlands also provide shoreline protection to Lower Turtle Lake 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 shoreline protection is important in waterways where boat traffic and water currents and wave action may cause substantial damage to the shore.

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. Aesthetics, recreation, education and science are also all services wetlands provide. Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes.

2.6 Soils

The soil in the Lower Turtle Lake watershed consists primarily of silt loams in the southern two-thirds of the watershed and sandy loams in the northern portion. Soils in the nearshore area of Lower Turtle Lake consist primarily of the Chetek sandy loam with 2 to 12 percent slopes. Soils are classified into hydrologic soil groups to indicate their potential for producing runoff. Much of the soil in the nearshore area is classified as group B (Figure 5). Group B soils have moderately low runoff potential when thoroughly wet and water movement through the soil is unimpeded. The large areas of group C soils, which have moderately high runoff potential, are primarily agricultural lands. Many of these lands drain directly to Lower Turtle Lake via intermittent streams. The Barron County Soil and Water Conservation Department has identified locations in these areas where the establishment of grassed waterways, an agricultural Best Management Practice, would likely be beneficial to the water quality in the lake.

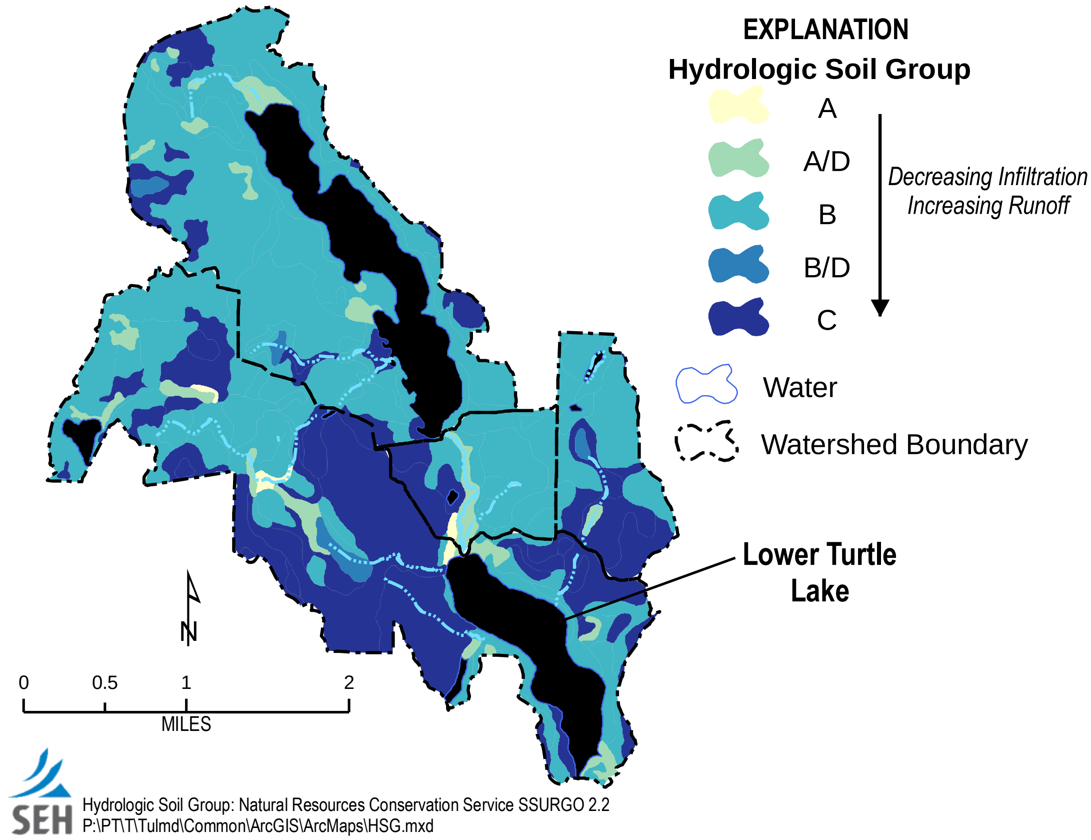


Figure 5 – Hydrologic Soil Group Classification in the Lower Turtle Lake Watershed

3.0 Aquatic Plant Surveys

Three official aquatic plant surveys have been completed in Lower Turtle Lake in the last 15 years. The Blue Water Science (BWS) consulting firm completed surveys in 1994 (McComas and Stuckert, 1995) and 2004 (McComas, 2005) using a transect method previously accepted by the WDNR. In 2008, Endangered Resource Services (ERS) completed an aquatic plant survey (Berg, 2008) using a point-intercept method, which is currently required by the WDNR. The 2008 survey, which is included on the accompanying CD, included both an early season cold water survey and a mid season warm water survey. A future whole-lake point intercept survey is scheduled for 2013. The 2013 survey is part of the 5-year Lake Protection Project that the LTLMD is participating in with other local groups, including the Upper Turtle Lake Association.

Aquatic plant management decisions in this document are based on the 2008 survey, the results of which are the most current and comprehensive. This document compares all three surveys; however because of differences in survey methods and in the amount of data reported, some comparisons are limited. The WDNR recommends that aquatic plant management plans extend no more than five years beyond the last plant survey; therefore, the plan presented in this document is for a three-year period.

Summary statistics from the 2008 point-intercept survey are presented in Table 3 along with those available from the 1994 and 2004 transect surveys. Species richness, when comparing rake samples, has not changed, nor has the maximum depth of plant growth. The average number of species identified per sample site decreased from 2004 to 2008. The frequency of occurrence for vegetation in the littoral zone, defined as the number of sample sites shallower than the maximum depth of plant growth, was consistently in the mid-80% range. The Simpson's Diversity Index, a measure that characterizes species diversity in a community, has not changed substantially since 1994 in Lower Turtle Lake.

Table 3
Aquatic Plant Survey Summary Statistics

Statistic	Survey Year		
	1994	**2004**	**2008**
Points sampled	66	75	479
Number of sites with vegetation	*46	60	112
Maximum depth of plants (ft)	8	8	8
Mean depth of plants (ft)	NA	NA	3.8
Median depth of plants (ft)	NA	NA	3.5
Percent of lake bottom coverage	31	NA	23.4
Sites shallower than maximum depth of plants	66	75	131
Frequency of occurrence at sites shallower than max depth of plants	88.5	80	85.5
Simpson Diversity Index	**0.88	**0.90	0.88
Sites sampled using rope rake (R)	0	0	0
Sites sampled using pole rake (P)	66	75	142
Average number of all species per site (shallower than max depth)	*2.4	3.32	2.95
Average number of all species per site (veg. sites only)	*2.72	4.15	3.46
Average number of native species per site (shallower than max depth)	*2.38	3.25	2.82
Average number of native species per site (veg. sites only)	*2.7	4.07	3.29
Species Richness	17	19	18
Species Richness (including visuals)	NA	NA	19
Species Richness (including visuals and boat survey)	NA	NA	27

*Does not include all transect data
**Calculated by ERS, 2010

The Floristic Quality Index (FQI), average Coefficient of Conservatism (C), and average rake density (ARD) for each survey is shown in Table 4. The apparent increase of the FQI in 2008 is likely due to the misidentification of Fries' pondweed as either small- or variable-leaved pondweed in the earlier surveys. Fries' pondweed was likely present in the earlier surveys; since C is the basis of the FQI calculation and Fries' pondweed has a higher C value than the other pondweeds, incorrectly indentifying Fries' pondweed as one of the other pondweeds would lead to a lower FQI.

The value of C ranges from 1 to 10 and Lower Turtle Lake's mean C of approximately 5, which remained relatively consistent over time, indicates that water quality conditions in the lake are limiting the type of aquatic plants able flourish to only those that do well under degraded water quality conditions. Average rake density, which ranges from 1 (low density) to 3 (high density) per species was higher in 2008 compared to both 1994 and 2004.

The FQI and C values for all three plant surveys indicate conditions have remained similar in the lake. The mean C for all three surveys falls below the regional (North Central Hardwood Forests) mean C of 5.6 (Nichols, 1999). The average FQI of the three plant surveys is 20.66, slightly below the mean FQI of 20.9 for the Northern Central Hardwood Forests Region (Nichols, 1999). These numbers indicate the lake has few species that can tolerate disturbance or pollution.

Table 4
Aquatic Plant Survey Information and Habitat Scores for Lower Turtle Lake

Survey Year	Survey Method	Surveyor	# of Plants Identified	*FQI	*Mean C	Average Rake Density all species (top five species)
1994	22 transects, 6 sample sites	BWS	15	19.11	4.09	*1.15 (1.2)
2004	25 transects, 75 sample sites	BWS	17	20.86	5.06	*0.75 (0.88)
2008	Point-intercept, 479 sample sites	ERS	16	22.00	5.50	1.6 (1.72)

*calculated by SEH, 2010
BWS = Blue Water Science
ERS = Endangered Resource Services

The most common aquatic plant species found in July and August 1994 (excluding curly-leaf pondweed) were flat-stem pondweed, water celery, clasping-leaf pondweed, northern water milfoil, and coontail. In July 2004, the most common species were flat-stem pondweed, water celery, coontail, northern water milfoil, and sago pondweed. In 2008, the most common species were flat-stem pondweed, water celery, coontail, Fries' pondweed, small pondweed, and clasping-leaf pondweed.

Several species were lost from 1994 to 2008, including fern-leaf pondweed and floating-leaf pondweed, and several were gained, including water stargrass, spatterdock, and duckweed. It is important to note that the 2008 survey identified 26 different aquatic plant species via rake, visual, and boat survey sightings. The 1994 and 2004 surveys did not record species that were found outside of the sample transects and the reports indicate that a few plant species were likely missed because of this. A comparison of the plant types found in each survey shows that the number of submerged plant species has remained fairly constant, but floating-leaf and emergent species have increased slightly since 1994. Table 5 shows the number of these species identified in each survey. The majority of the emergent plant species were located at the southern-most end of the lake during the 2008 survey.

Table 5
Plant Species by Aquatic Plant Type for Each Survey

	Number of Species			
Survey Year	**Emergent**	**Submerged**	**Floating-leaf**	**Total**
1994	3	12	1	15
2004	2	12	4	18
2008	7	13	5	25

The 2008 survey found that plant species in Lower Turtle Lake inhabit specific habitats defined primarily by sediment type and water depth. The following excerpt from Berg (2008) further defines this relationship:

> In general, we found bottom substrate to be the best predictor of the plant community at any given location in Lower Turtle Lake. Flat-stem pondweed and Small pondweed (*Potamogeton pusillus*) were true habitat generalists being found throughout the lake regardless of bottom type. Coontail, Curly-leaf pondweed, White water lily (*Nymphaea odorata*), Spatterdock (*Nuphar variegata*), Small duckweed (*Lemna minor*), Large duckweed (*Spirodela polyrhiza*) and Northern water milfoil (*Myriophyllum sibiricum*) dominated over organic muck areas. In sandy areas, we found Wild celery, Fries' pondweed, Clasping-leaf pondweed (*Potamogeton richardsonii*), Sago pondweed (*Stuckenia pectinata*), and Bushy pondweed (*Najas flexilis*) to be the dominant species.

The distribution of the substrates mentioned above is shown in Figure 6. Relative to surveys of other nearby lakes completed by ERS, Lower Turtle Lake had few aquatic plants (M. Berg, personal communication, 2009).

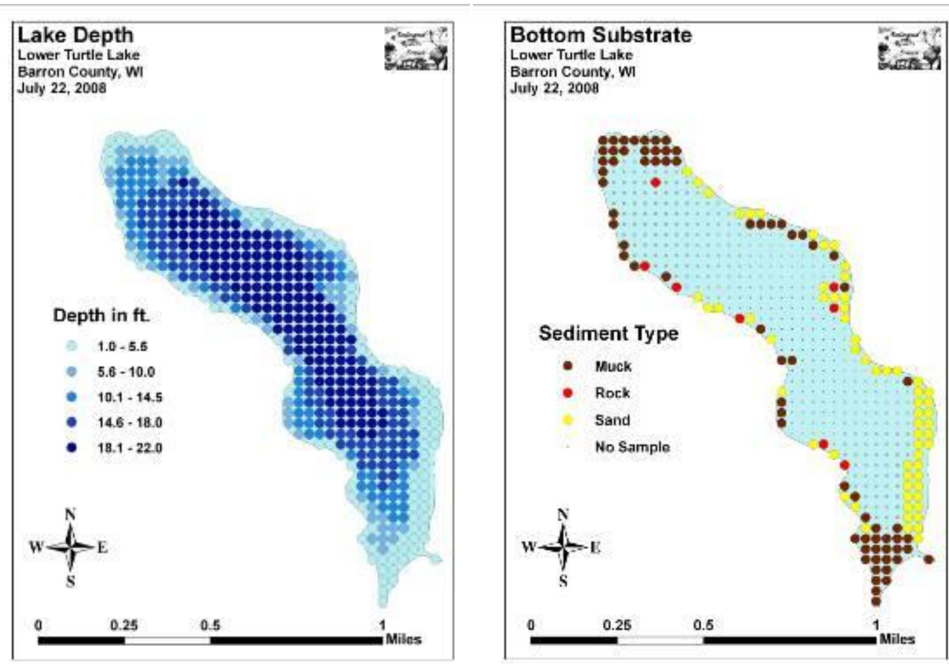


Figure 6 – Lake Depth and Substrate Type

A shoreline survey completed in 2004 classified approximately 57% of the riparian properties around the lake as disturbed (McComas, 2005). Plant survey work in 2008 noted that significant amounts of filamentous algae and other floating algae were especially common over organic muck in the north and south bays, in front of “managed” lawns where fertilizer application was evident, along shoreline areas where agricultural fields were immediately across the street, and in areas where property owners cut the native vegetation down to the lakeshore (Berg 2008).

In June 2009, Lower Turtle Lake was surveyed for the presence of AIS by the Beaver Creek Reserve as part of a multi-county AIS investigation. Although not a whole lake survey, observed aquatic plant species were documented and 17 different species were identified in Lower Turtle Lake. The seventeen plants identified produced an FQI of 20.65 (Mares and others, 2009), comparable to the values generated in the 1994, 2004, and 2008 surveys.

4.0 Wild Rice (*Zizania palustris*)

Wild rice is a prized and protected natural resource (Figure 7). It is a highly nutritional food source for wild life and humans alike. It has a tremendous amount of cultural significance to the Wisconsin and Minnesota Native American Nations. 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 during their review of lake management documents.

Figure 7 – Wild Rice

Wild rice is an annual grass species, which means it grows from seed to seed bearing mature plant in a single season. It pulls a tremendous amount of nutrients from the sediment in a single year. In addition to pulling a lot of available nutrients from the sediment, wild rice 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.

Wild rice was not found on Lower Turtle Lake but there are portions of the lake (specifically near the inlet and outlet of Turtle Creek) that, because of depth and sediment type, could potentially support its growth. Currently, most of these areas are dominated by monotypic beds of CLP during the spring. If CLP is controlled in these areas, it may be possible to establish wild rice beds. These areas have little shoreland development, so the presence of wild rice would likely not cause additional problems for land owners.

5.0 Non-native Aquatic Invasive Species

The only non-native aquatic invasive species documented in Lower Turtle Lake is CLP. The Chinese mystery snail is known to be present in Upper Turtle Lake and therefore potentially inhabits Lower Turtle Lake. CLP is the more problematic of these two aquatic invasive species. Not much is known about the environmental impacts of Chinese mystery snails, other than periodic die offs that can be very aesthetically displeasing. The LTLMD and the LTLA are currently involved in aquatic invasive species monitoring and water craft inspection in cooperation with WDNR and UW-Extension Lakes programs. These programs will continue.

5.1 Curly-leaf Pondweed (*Potamogeton crispus*)

Curly-leaf pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia (Figure 8).

Figure 8 – Curly-leaf Pondweed and Turions

It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. The plant usually drops to the lake bottom by early July. 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. It has been reported in all states but Maine. CLP spreads through burr-like winter buds called turions (Figure 8). 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.

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. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant conditions on shoreland and beaches.

CLP was documented in Lower Turtle Lake in all of the plant surveys completed, including the 2009 Beaver Creek Reserve survey. In 1994 and 2004, the surveys were completed in July and August when CLP has pretty much completed its life cycle and dropped out of the water column. Despite this, it was found in 27% of the sites sampled in 1994, and in 7% of the sites sampled in 2004. An early season, cold water survey to specifically document the presence of CLP was completed as a part of the 2008 survey. Curly-leaf pondweed was identified at 51 of 479 points or 10.7% (31.3 acres) of the lake's total surface area of 294 acres (Figure 9). This equates to 38.9% of the lake's 75 acre littoral zone (Figure 9). About half of these points had a rake density rating of 2 or more on a 1-3 scale and were considered monotypic and bed forming. A mid season warm water survey in July 2008 found CLP at 18 points in the littoral zone equating to 13.7% of the littoral zone.

The 2009 Beaver Creek Reserve survey completed in late June found CLP in 11 of 14 transects placed at 1500-ft intervals around the lake (Figure 10). In some areas, the presence of both CLP and a native pondweed (*Potamogeton pusillus*) made navigation difficult (Mares and others, 2009).

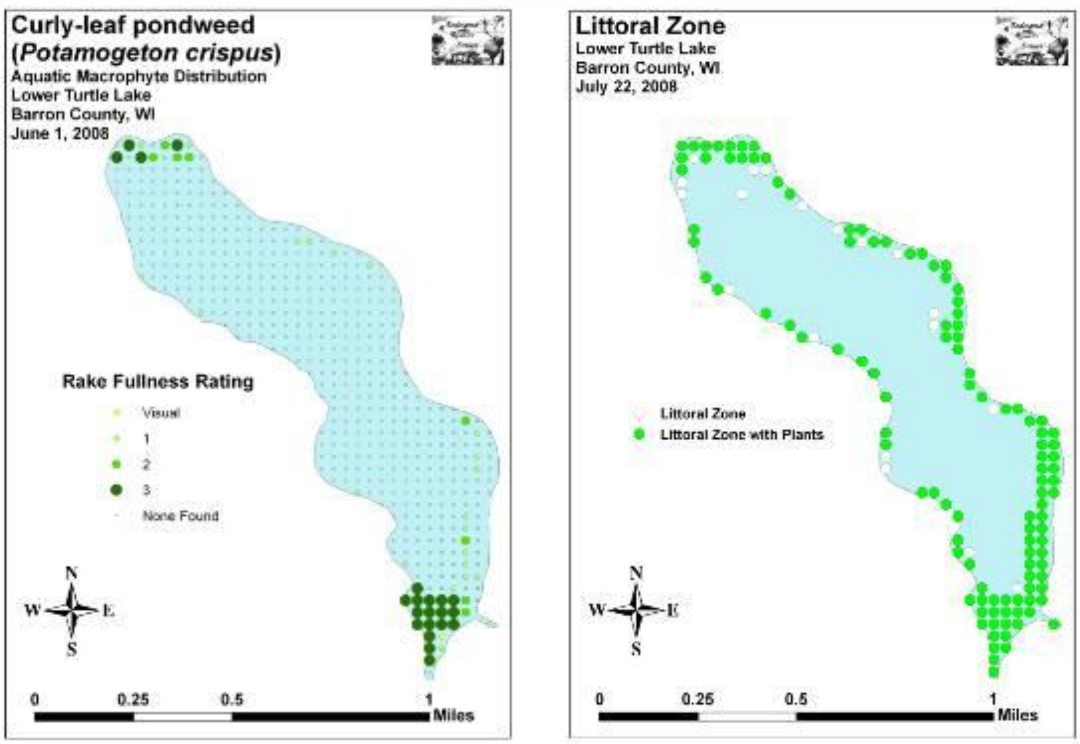


Figure 9 – June 2008 CLP Distribution and July 2008 Littoral Zone

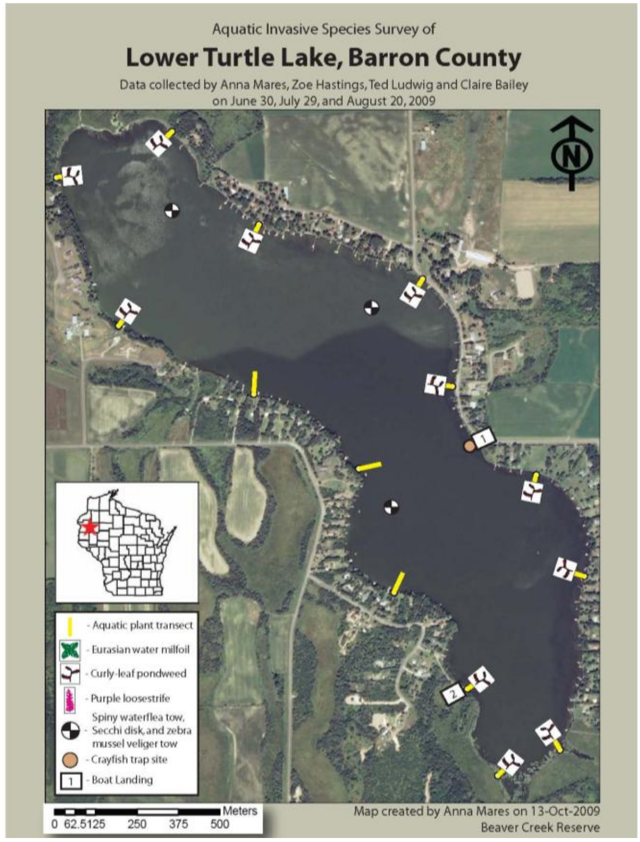


Figure 10 – June 30, 2009 CLP locations on Lower Turtle Lake

There appears to be a correlation between areas of dense monotypic stands of CLP early in the season, and dense areas of filamentous algae growth later. The densest areas of filamentous algae were located in the same areas as the earlier CLP beds (Figure 11). The substrate in these areas consists primarily of muck (Figure 6).

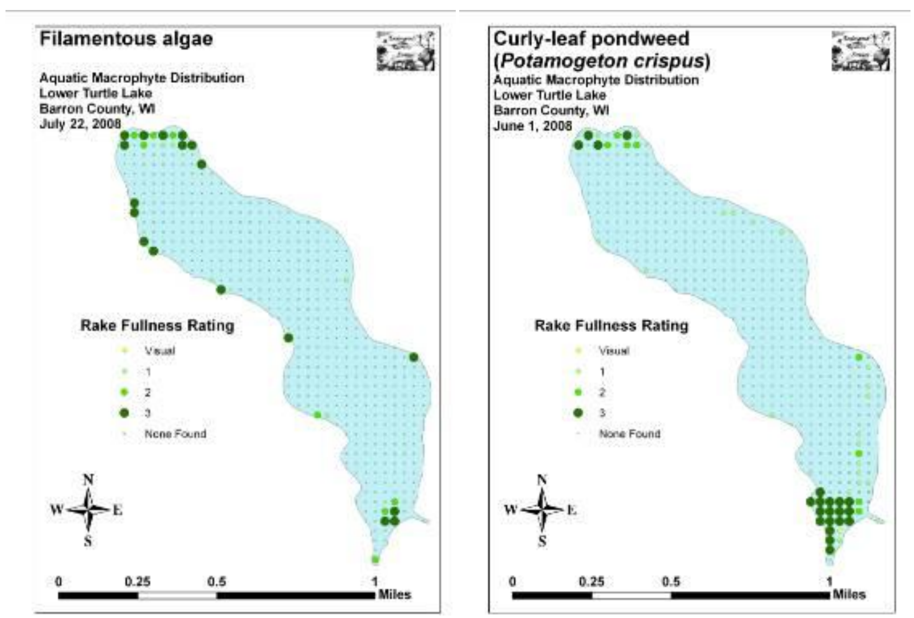


Figure 11 – Filamentous algae beds and early season CLP beds

Decay of CLP and other vegetation will release phosphorous into the lake water. The reported phosphorous content of CLP varies widely and is likely dependent on a variety of existing conditions in any given lake. Roesler (2008) found the phosphorous content of the CLP from nearby Big Chetac Lake to be 0.26% of the plant biomass. Assuming that the biomass of CLP in Lower Turtle Lake is similar to that of Big Chetac Lake (245 g/m^2), the potential phosphorus released by the 29 acres of CLP in Lower Turtle Lake (identified during the 2008 early season survey) is approximately 164.5 pounds. Because some of the phosphorus released by decaying CLP is captured by sediment or utilized by filamentous algae and other plants, it is likely that only 50% of the this phosphorus (82 pounds) makes it into the water column where it can be utilized by algae.

The 82 pounds of phosphorus potentially released by CLP into the water column each year is immediately available for use by algae. Based on phosphorous loading calculations done in 2005 and 2009, this is approximately 5.5% of the 1500-pound annual phosphorus load to the lake. Agricultural land use is the largest source of phosphorus, contributing more than 65% of the total load. Other sources, including nearshore development and septic systems, groundwater, and internal loading via sediment release, make up the remainder of the load.

There is some concern over the impacts decaying CLP has on dissolved oxygen levels in a lake. While decaying CLP may slightly reduce dissolved oxygen levels near the deep water edges of the littoral zone, decay generally occurs in waters that receive oxygen recharge via wave action and plant respiration. A more likely impact of curly-leaf pondweed, other than the phosphorous released from the plant itself, is an increase in pH which usually accompanies extensive plant and algal growth due to the removal of carbon dioxide from the water column during plant respiration. Phosphorus can be released from sediments in contact with high pH waters even when dissolved oxygen is present.

5.2 Eurasian Water Milfoil (*Myriophyllum spicatum*)

Eurasian water milfoil (EWM) is a submersed aquatic plant native to Europe, Asia, and northern Africa (Figure 12). Although EWM was not found in Lower Turtle Lake, it remains a concern because of its presence in nearby Barron County lakes including Lower Vermillion Lake, Echo Lake, Horseshoe Lake, Shallow Lake, Beaver Dam Lake, and Duck Lake. This proximity makes Lower Turtle Lake a candidate for the introduction of EWM via boat traffic.

Figure 12 – Eurasian Water Milfoil

EWM is the only non-native milfoil in Wisconsin, first arriving in the 1960s. 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 fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen- and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon.

Unlike many other plants, Eurasian water milfoil does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These fragments may be carried downstream by water currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, and trailers and 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). As an opportunistic species, EWM is adapted for rapid growth early in spring. 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 out 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 of infested lakes (WDNR, 2010).

Information about what to do if monitoring for EWM were to pick up a suspect plant and if that plant were to actually be identified as EWM is provided in a EWM Rapid Response Plan included as a part of the overall Aquatic Plant Management Plan. This document lists who to contact and the steps necessary to move forward with official vouchering of the suspect plant and the steps to follow to carry out management or removal.

5.3 Other Aquatic Invasive Species (AIS)

At the present time there are no other AIS known to be in Lower Turtle Lake. Purple loosestrife, rusty crayfish, zebra mussels, giant reed grass, spiny water-flea, hydrilla, and others could threaten the lake in the future. Continued AIS monitoring and water craft inspection should continue.

6.0 Public Participation

The Lower Turtle Lake Management District has been actively working to improve water quality conditions in the lake since the 1990s. Both the 1994 and 2004 lake studies were conducted out of concern for degraded water quality conditions. The 2008 plant survey work was in response to changes in the WDNR aquatic plant surveying protocol from a transect-based method to a point-intercept method, and was paid for out of LTLMD coffers with no assistance from state grant programs. The two past lake studies were combined to create the Revised Comprehensive Lake Management Plan in early 2009. This plan was the basis for a 2010-2014 Lake Protection Project focused on agricultural and riparian owner incentives to incorporate Best Management Practices (BMPs) that could reduce phosphorous loading to the lake. Developing APM plans for both Upper and Lower Turtle Lake is a part of this five-year project. Project partners include the LTLMD, the LTLA, the UTLA, Barron County, local farmers and the Town of Almena. Representatives from each group form a Stakeholders Board that meets once every two months to update the project and discuss current and future activities.

7.0 Past Management Activities

The LTLMD has not completed any major aquatic plant control in the lake. Copper sulfate was used many years ago to help control algae, but exactly when and how much is not known. Individual land owners have participated in aquatic plant control, mostly by physical removal, with some individual chemical treatment via WDNR permits. For several years in the 1990s, the LTLMD was making small payments to local farmers to encourage them to incorporate certain BMPs to improve the lake water quality. Riparian landowners have been approached by the Lake District and provided with education and informational materials to incorporate better shoreland practices to improve the lake. The UW-Extension Lakes Adopt-a-Lake program was also brought in at one point in the early 2000s to involve students from the Turtle Lake Area School District in projects to improve lake conditions. At one point, a large wetland restoration project was instigated west of Lower Turtle Lake that may have helped reduce phosphorous loading to the system.

These above mentioned activities met with limited success and were discontinued. The wetland project did not get implemented when a local farmer raised objections against it. The Adopt-a-Lake program ended after single year, very few land owners got involved in shoreland protection and improvement projects, and payments to local farmers were discontinued when the benefits received were not enough to continue the payments. At the end of 2008, the LTLMD, while still concerned over the poor water quality of the lake, was unsure of what to do next and felt little support from Barron County and the WDNR. At this point, the Revised Comprehensive Lake Management Plan was created to provide direction and eligibility for funding for a five-year lake protection project. Currently, this five-year project is in its second year and all parties are communicating with each other. Small strides forward have been made in getting agricultural and riparian partners motivated to make improvements and implement BMPs. Management of CLP is a logical next step in making forward progress.

8.0 Documentation of Plant Problems and Need for Management

Lower Turtle Lake needs to re-establish and enhance its native plant community. As was mentioned in the 2008 plant survey work, native aquatic plants are not abundant in the lake and their diversity and distribution is poor. The native species with the largest populations include coontail, flat-stem pondweed, and northern water milfoil. The presence of dense beds of CLP is likely an important factor in the poor distribution and affects the diversity of the plant community. Early growing season removal of the densest areas of CLP in the north and south bays, which are also Sensitive Areas, may enable more of the desirable native plants species already present to flourish. The removal of CLP would also eliminate a source of phosphorous to the lake.

Efforts should be made to protect existing native plants. Restoring and enhancing native plant communities could further improve conditions. Emergent species may be the easiest to restore. Wild rice could be introduced into those areas of the lake that are isolated from developed land. Restoring rushes, arrowhead, pickerel weed, and similar plants along shoreland currently devoid of any emergent vegetation could reduce erosion, and help to hold sediment in place. As water clarity improves over the course of the next 3-5 years other native plants may begin to return. There remains a threat of non-native invasive species being introduced (EWM) or becoming more dominant (CLP). Water craft inspection should be continued, as should in-lake and shoreline invasive species monitoring to prevent the introduction of new AIS.

9.0 Management Alternatives

Problematic aquatic plants in a lake can be managed in a variety of ways. The eradication of non-native invasive plants 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 treatment or removal can minimize some of these impacts by preventing the AIS from becoming the dominant plant species in the lake and encouraging the growth of more desirable native aquatic plants.

Protecting native plants should be a primary focus of plant management in the Turtle Lakes due to the benefits they offer including providing fish and wildlife habitat, keeping aquatic invasive plant species at bay, maintaining water quality, protecting the shoreline from erosion, improving lake aesthetics, and increasing land owner privacy. Management efforts to improve water quality in the lake will help increase both aquatic plant diversity and quality.

A diverse plant community will prevent certain native plants from becoming a nuisance. For example, submersed aquatic plants like coontail, northern watermilfoil, and common waterweed may be beneficial native plants, but can become an issue they are the predominant species in a lake. These plants do well in the presence of man-made disturbances, often increasing when other plants more sensitive to human disturbances are disappearing.

Emergent plants like pickerel weed, arrowhead, various bulrushes, and wild rice may be considered a nuisance by some riparian owners, but in general are extremely beneficial to a lake and their removal should be minimized. Wild rice is afforded numerous protections due to its ecological and cultural significance and its management is therefore focused on protection and establishment rather than removal.

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

- Mechanical/physical control;
- Chemical control;
- Biological control; and
- Aquatic plant habitat manipulation.

Mechanical and physical control methods include pulling, cutting, raking and harvesting. Chemical control 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. Examples of plant habitat manipulation include dredging, flooding and drawdown. In many cases, an integrated approach to aquatic plant management is necessary.

Regardless of the target plant species, native or non-native, sometimes no management 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

All existing APM Plans and the management permits (chemical or harvesting) that accompany them are reviewed by the WDNR. It has become increasingly important for new and existing APM Plans to at a minimum 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 new APM Plans to evaluate the potential for restoring the lake's natural plant community. Shifting the plant community toward more native species through a reduction of targeted aquatic invasive species prevents plant management from becoming endless, routine maintenance.

9.1 WDNR Northern Region Aquatic Plant Management Strategy

The WDNR has a Northern Region Aquatic Plant Management Strategy (Appendix B) 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.

The management options discussed below have been arranged in order of appropriateness and acceptability in consideration to Lower Turtle Lake, beginning with Manual Removal, the most appropriate and acceptable management option.

9.2 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 provided the area of removal does not exceed 30 shoreland feet and all raked or pulled plant material is taken completely out of the lake (NR 109). If an aquatic invasive species like EWM or CLP is the target species, then removal by this means is unrestricted. 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 may be 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 waterbody when done properly.

9.3 Chemical Control and Management

Chemical management techniques have changed dramatically in the past 20 years. Increased concern about the safety of pesticide use in the 1960s and 1970s changed the review process for all pesticides, particularly for products used in water. Currently, no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of bio-magnification, bioavailability, or persistence in the environment (Madsen, 2000). In 1976, 20 active ingredients were available for aquatic use. As of 1995, only six are available with one additional compound (Triclopyr) undergoing the registration process. The six compounds have undergone rigorous testing to enable them to be approved by the U.S. Environmental Protection Agency (EPA) for use in aquatic settings.

The six families of aquatic herbicides that have been approved for use in Wisconsin not only have been ensured safe for aquatic use, but also have manufacturers committed to the aquatic market supporting them. These products are only considered safe when used according to the label accompanying the product. The EPA-approved label provides guidelines for protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. In most states, additional permitting or regulatory restrictions exist for the use of these herbicides. A typical state restriction requires that these herbicides be applied only by licensed applicators. Before developing or implementing any plans for applying herbicides, annual updates from state regulatory and environmental agencies are necessary to check for changes in label restrictions and application policies or permit requirements (Madsen, 2000).

Herbicides labeled for aquatic use can be classified as either contact or systemic. Contact herbicides act immediately on the tissues they contact. Typically, these herbicides are faster acting, but they do not have a sustained effect and in many cases do not kill root crowns, roots, or rhizomes. In contrast, systemic herbicides are translocated through the plant. They are slower acting but often result in mortality of the entire plant (Madsen, 2000).

Herbicides are applied in either liquid or granular form directly to the water overlying the problem area. Most granular herbicides are activated through the photo-degradation of the granular structure which releases the active chemical. These chemicals either elicit direct toxicity reactions or affect the photosynthetic ability of the target plant. The plants die and degrade within the lake. Some herbicide residuals sink to the lake sediment, providing some additional temporary control of vegetation (NYSDEC, 2005).

When properly applied, certain herbicides can control aquatic vegetation without harming fish and other wildlife. In some instances, herbicides can be used selectively to control certain plant species without killing others. Aquatic herbicides can be part of an integrated management plan where some areas are treated and others are left with vegetation or treated with another method. They can be particularly effective for controlling aggressive weed species such as CLP. Aquatic herbicides offer temporary solutions. None of the EPA approved products when properly used will eliminate plants from a body of water permanently. Plants will reappear, and re-treatment or application of another control method will usually be necessary.

Correct timing of the chemical application is important, since seeds can germinate and roots can sprout even when the parent plants are killed off. The specific time for the application will depend on the specific target weed, required dosage rate, water temperature, water chemistry characteristics of the lake, weather conditions, water movement and retention time, and recreational use of the lake. Herbicide applications must consider the timing of the growing season relative to the algae levels (since photo degradation of herbicides may be slower when algae reduces lake clarity), ice cover, and the effect the chemical application will have on the recreational use of the lake. Most herbicides have use restrictions immediately after treatment, sometimes lasting up to 30 days (NYSDEC, 2005).

Successful use of aquatic herbicides for selective control of submersed weeds can vary depending on composition of native plant communities, and unintended consequences may result when the wrong herbicide is selected for a particular situation. In some cases several different aquatic herbicides can be combined to improve efficacy of control.

Herbicides applied in combination are frequently used in agriculture to improve efficacy on target plants to provide more cost-effective control. Diquat applied in combination with copper has been shown to significantly increased plant uptake of both herbicides compared to either herbicide applied alone. Endothall combined with 2,4-D at low concentrations was shown to improve control of EWM and CLP under aquarium scale evaluations. This combination may therefore provide improved selective control of two exotic species, including a monocot (curly-leaf pondweed) and a dicot (Eurasian water milfoil), in a single treatment event. Such single applications could result in reduced environmental loading of herbicides to aquatic sites, and savings in manpower and costs. Improved selectivity, particularly with respect to native dicots, could allow the herbicide combination to be used in plant communities where species of environmental concern, such as water lilies or native milfoils, occur (Skogerboe and Getsinger, 2006).

Chemically treated lakes may experience significant side effects. Non-target plants may not be resistant to the herbicide. Furthermore, if a wide variety of plant species are eradicated by herbicide treatment, the fast-growing (“opportunistic”) exotic species that were the original target plants may re-colonize the treatment area and grow to levels greater than before treatment (NYSDEC, 2005).

Short-term impacts of aquatic herbicides have been fairly well studied for most of the inhabitants of lakes and the surrounding environment, and have been deemed to pose acceptable risk if applied in the appropriate manner. In general, humans and most animals have high tolerance to the toxic effects of herbicides presently approved for use in lakes. This is especially true of the newer generation herbicides that have been formulated to impact metabolic processes specific to chlorophyll-producing plants. However, the long-term impact of herbicides on humans and other plants and animals in the environment continues to be studied (NYSDEC, 2005).

When herbicides are applied in a lake environment, the affected plants drop to the bottom of the lake, die, and decompose. The resulting depletion of dissolved oxygen and release of nutrients could have detrimental effects on the health or survival of fish and other aquatic life as well as stimulating new plant growth (NYSDEC, 2005). This could also impact water quality in a given body of water.

Herbicide costs will vary with the chemical brand and form (liquid or granular), required dose rate, applicator fees, frequency of application, and the amount of pre and post treatment monitoring and assessment that is done. Typical costs for using herbicide range from $400-700 per acre of treated area (more if extensive post treatment monitoring is completed) with the majority of these costs associated with the raw materials.

Full disclosure of any negative impacts, good education, and making sure application is done properly by experienced people will help to reduce negative public opinion related to herbicide use. While there is some concern that target plants may develop a resistance to some herbicides, and that chemical residues may remain in the aquatic environment longer than is reported, there is little evidence of any build-up of herbicide residues or chronic toxicity in natural aquatic systems and fish populations appear not to be adversely affected (Murphy and Barrett, 1990).

A study by the Michigan Department of Environmental Quality (Lovato and others, 1998) found that 2,4-D and endothall can migrate from lake water to groundwater. In this study, the migration of 2,4-D was more of a concern than that of endothall. Once in groundwater, a lack of oxygen may allow the compounds that make up 2,4-D to persist for longer periods of time and 2,4-D was found to persist in measureable quantities in the study wells for 8 months. The migration of herbicides from lake water to groundwater is dependent on hydrogeologic conditions and more study in this area is needed.

9.3.1 Small-scale Herbicide Application

Small-scale herbicide application involves treating smaller areas, usually less than 10 acres combined on a given body of water. Small-scale chemical application is most often completed in the early season, but not always. It may be used to follow up a large-scale treatment to retreat areas missed or not impacted by the first application. While not required by the WDNR at this time, chemical residual testing is suggested to track the fate of the chemical herbicide used. Water samples are taken prior to treatment, and then 1, 4, 7, 14, 21, and 28 days after chemical application. Sampling sites are within the treatment area, outside of the treatment area, in areas that may be sensitive to the herbicide used, in areas where chemical drift may have adverse impacts, and in areas where movement of water or some other characteristic may impact the effect of the chemical. Residual testing is completed to determine if target concentrations are met, to see if the chemical moved outside its expected zone, and if it breaks down in the system as expected.

Small-scale herbicide application to control CLP in select areas is recommended for use in Lower Turtle Lake. However, at this time, residual testing is not. If herbicide application pushes levels considered large-scale, is repeated more than once in any given year, or is in an area where there may be question as to its effectiveness on target species or its impacts on non-target species, residual testing for the chemical used will be recommended. Pre and post treatment aquatic plant surveying is recommended, regardless of the size and type of treatment used.

9.3.2 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 for control of non-native invasive species like EWM and CLP while minimizing impacts on native species. If used, residual testing is recommended, as is pre and post treatment aquatic plant surveying to determine the impacts.

Large-scale chemical application has not been used on Lower Turtle Lake as of yet, but is recommended in this APM Plan if small-scale herbicide application prove to be inadequate to control CLP.

9.3.3 EPA-Approved Aquatic Herbicides in Wisconsin

9.3.3.1 <u>Endothall</u>

Endothall is considered primarily a contact herbicide. Its common trade name is Aquathall K or Super K, or Hydrothall. Endothall is a broad spectrum herbicide most commonly used to kill pondweeds like curly-leaf. Because CLP is an annual plant not dependant on existing root structure to grow, a contact herbicide like endothall can be very effective. Endothall can effectively control of a wide range of aquatic plants, including monocotyledons (monocots) and dicotyledons (dicots). It is not effective on roots, rhizomes, or tubers. Unlike Diquat, another contact herbicide, it is not affected by particulates or dissolved organic material. It should not be used in tank mixtures with copper, as it can have an antagonistic reaction with chelated copper compounds.

Endothall has been described as a broad spectrum contact-type, membrane-active herbicide. Some have shown that endothall may be slowly taken up by submersed weeds while others have reported that endothall may cause rapid membrane disruption in plant cells, while inhibiting oxygen consumption. This herbicide is effective at controlling Eurasian water milfoil at 2 to 3 mg/L where exposure times of 18 to 72 hr are maintained. Native aquatic plant sensitivity varies greatly among species. Eurasian water milfoil and pondweeds such as curly-leaf pondweed, Illinois pondweed, southern naiad, and sago pondweed are very sensitive to endothall, while coontail is moderately sensitive. Other plants such as common waterweed, wild celery, water stargrass, and many floating-leaf and emergent species are more tolerant of endothall. Endothall, therefore, has the potential to selectively control Eurasian water milfoil and/or curly-leaf pondweed in sites where pondweeds do not dominate the plant community (Skogerboe and Getsinger, 2006).

9.3.3.2 <u>Diquat</u>

Diquat is a non-selective, contact herbicide that will kill or injure a wide variety of plants by damaging cell tissues when absorbed by the foliage. It will not kill parts of the plant it does not come into direct contact with. Its common trade name is Reward. Diquat is not effective in lakes or ponds with muddy water or plants covered with silt because it is strongly attracted to clay particles in the water. Bottom sediments must not be disturbed when this herbicide is used. At approved application rates Diquat does not appear to have any long or short term effects on most aquatic organisms.

9.3.3.3 2,4-D

2,4-D is one of the most common systemic herbicides in use today. It is a relatively selective herbicide commonly used for treatment of EWM. A few of its most common trade names for use in an aquatic environment are Aqua-kleen, Aquacide or Navigate. In its liquid form it is known as Weedar 64. The product is a systemic growth regulator with hormone-like activity. It readily stimulates cell division, resulting in death of apical growth and eventually total cell disruption and plant death. Generally, dicots such as Eurasian watermilfoil are sensitive to 2,4-D and are controlled with applications of 2 to 4 mg/L while monocots such as curly-leaf pondweed are not (Skogerboe and Getsinger, 2006). It effectively controls broadleaf plants (dicots) like EWM, coontail, and northern watermilfoil with a relatively short contact time, but does not generally harm pondweeds or water celery. 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.

9.3.3.4 Triclopyr

Triclopyr is a systemic herbicide, similar to 2,4-D used for control of aquatic dicots. It common trade name is Garlon 3A or Renovate. 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, though not as long as Fluridone. Low concentrations of this herbicide can be effective for EWM control when exposure time reaches 48 to 72 hours (Netherland and Getsinger, 1992). It does not appear to significantly affect pondweeds and coontail (Clayton & Clayton, 2001). To date, Triclopyr has not been approved for general use in WI.

9.3.3.5 Glyphosate

Glyphosate is a systemic herbicide not effective on submersed plants. It is used for control of emergent or floating leaf plants like purple loosestrife, cattails, phragmites, and lily pads. Glysophate is the herbicide found in Round-Up (trade name) that is available over the counter for terrestrial weed control. A water-safe version of it called Rodeo is commercially available, but not from the average retail store. The Rodeo form of glysophate must be used when on or near water. It is not legal to use Round-Up on or near water. A surfactant and dye are usually added to it to make it stick to the target vegetation better and to make it more visible after application. Glysophate can be applied in a foliar spray or painted or dabbed onto cut stems. It is a systemic herbicide drawn into the plant and to the roots, so it will kill all parts of the target plant if applied correctly.

9.3.3.6 Fluridone

Fluridone is a non-selective systemic herbicide. It requires very long exposure times often three months or more, but may be effective at very low concentrations. Its common trade name is SONAR. Fluridone is gaining acceptance for control of EWM. It was just recently approved for use in Wisconsin lakes. It works best where the entire lake or flowage system can be managed, but not in spot treatments or high water exchange areas. Fluridone does not appear to have any long or short term adverse effects on fish or other aquatic invertebrates if label directions are followed. USEPA tolerance for fluridone residues in fish is 0.5 ppm.

9.3.4 Chemical Algaecides

Copper sulfate and chelated coppers have been widely used as non-selective, fast-acting, contact herbicides or algaecides. Copper compounds are widely used for algae control but certain groups of phytoplanktonic algae are more tolerant to copper. Copper can build up in sediments, can be toxic to fish and invertebrates, and certain species of algae can build up a resistance (Charudattan 2001).

Several forms of copper in solution have been used to control algae and some aquatic plants in lakes however, even though copper has been used in Lower Turtle Lake in the past, it is not part of this APM Plan.

9.3.4.1 Copper Sulfate

Hanson and Stefan (1984) summarized the effects 58 years of copper sulfate treatments had to the Fairmont Lakes in Minnesota. They conclude that some of the intended algae were killed, but several short-term effects, including dissolved oxygen depletion caused by decomposing algae, resulted in fish kills and the recycling of phosphorous from the lake bed. In general, these treatments were only effective for a period of 7 to 21 days before algae concentrations returned to their pre-treatment levels. Several long-term effects resulted as well. Toxic levels of copper accumulated in the sediments, resistance in several plant species led to even greater dosages of copper, algae species present shifted from less problematic green algae to highly problematic blue-green algae, the fish population shifted from abundant game fish to rough fish, and aquatic macrophytes and benthic macro-invertebrates all but disappeared.

9.3.4.2 Chelated Copper

Chelated copper formulations tend to stay in solution longer, give better control, and are generally less toxic to fish species than traditional copper sulfate (Watson 1989). In some cases, chelated copper compounds have been combined with other herbicides including endothall to control certain aquatic plants and reduce algae concentrations (Pennington and others, 2001). 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.

9.4 Mechanical Control and Management

There are several mechanical means for controlling aquatic vegetation. The following summarizes what is available, but not necessarily applicable in Lower Turtle Lake.

9.4.1 Large-scale Harvesting

Harvesting assumes that vegetation is cut and removed from the system after cutting. Harvesters are 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 time period. 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 (Booms, 1999). 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 (Madsen, 2000). Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds (Madsen, 2000). 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 (Greenfield et al., 2004).

One benefit of large-scale aquatic plant harvesting is the removal of large amounts of plant biomass from a water body. Plants use up nutrients including phosphorous in the water and sediment. However, they often re-deposit that phosphorous back into the lake water and sediment when they die. Early season or cool water plants like CLP, that complete their life cycle, die, and senesce (decay) in early summer can be a source of significant phosphorous loading and may negatively affect dissolved oxygen levels.

Large scale harvesting as an alternative to the use of herbicides is not currently being considered for Lower Turtle Lake, but will be re-evaluated at a later date.

9.4.2 Alternative Small-scale Mechanical Management

Cutting without plant removal, grinding and returning the vegetation to the water body, and rotovating 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. All three of these alternatives have major drawbacks and will not be used on Lower Turtle Lake.

On a smaller scale, bottom rollers and surface sweepers exist that are usually attached to the end of a dock or pier and sweep through an area adjacent to the dock. Bottom rollers are usually driven by electric motors and run at least once a week. Continued disruption of the bottom area usually 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. Concern has also been expressed about the use of weed rollers on sediments high in organic matter (Greenfield et al., 2004).

The Lake Sweeper or Lake Maid is an automatic weed control device that is used in similar areas to the weed roller. Like weed rollers, the Lake Sweeper is attached at one end to a dock or other fixed location and consists of a 24’-42’ metal pole that moves forward and reverse in a 270-degree arc. A pump provides the force to move the floating pole back and forth. Instead of rolling along the sediment, the Lake Sweeper floats along the lake surface, with a series of lightweight rakes dragging behind it. According to the manufacturer, these rakes can kill a variety of submerged aquatic plants within three to five days by gradually weakening the plants. Purchase costs for a Lake Sweeper is approximately $2,000. Installation is said to be simple and operating costs are reported by the manufacturer to be very low. The potential for the Lake Sweeper to increase the rate of release of viable plant fragments has not been independently evaluated (Greenfield et al., 2004).

Automated untended aquatic plant control devices as the Minnesota Department of Natural Resources (MDNR) has taken to calling these devices, have the potential to remove larger swaths of vegetation, displace more sediment, and eliminate plants for a longer period of time than many other devices used by homeowners to control aquatic plants. For these reasons, it is important to ensure that the device is used appropriately.

Weed Rollers and similar devices have been permitted by the MN DNR, assuming certain requirements have been met. Minnesota regulations state that:

- A permit is required to use Crary Weed Rollers, and similar devices, for aquatic plant control regardless of the size of the area. A permit will likely not be issued where operating this device is expected to "dredge" or excavate the lake bottom.
- A permit valid for three years may be obtained if the device is operated in an area of submerged vegetation that is no larger than 2,500 square feet, and extends no more than 50 feet along the shore or one-half the property owner's frontage, whichever is less. An annual permit is required for larger areas.

These devices are generally not permitted in Wisconsin as is demonstrated by the following paragraph taken from the Crary Weed Roller webpage at www.weedroller.com.

> The state has no specific statute which governs mechanical weed control for Wisconsin riparians. They have however declared jurisdiction over the Weed Roller under statute #30.12 - 3 which governs the placement of certain "structures" in navigable waters. Form 3500-53 must be submitted with a $25 filing fee. The Wisconsin Dept. of Natural Resources has demonstrated to be adverse to the Weed Roller and the issuance of permits for its use.

Other states including Florida, Illinois, Indiana, Iowa, Michigan, New York, North Dakota, and Washington allow their use. In most states a permit is required.

Another common, less sophisticated method for removing aquatic plants from a beach or dock area is for riparian owners to hook a bed spring, sickle mower blade, or other contraption to the back of a boat, lawn mower, or ATV and drag it back and forth across the bottom. This type of management is considered mechanical and is generally not permitted by the WDNR. Plant disruption by normal boat traffic is not considered illegal. One of the best ways for land owners to gain navigation relief near their docks is to use their watercraft on a regular basis.

9.4.3 Suction Harvesting and Suction Dredging

Another form of mechanical harvesting is using diver operated suction harvesting to remove aquatic plants. Diver-operated suction harvesting entails the use of barge-mounted pumps and strainer devices with hoses used by divers to “vacuum up” 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 are re-suspended during the operation but use of a sediment curtain can mitigates these effects. Plants are removed directly from the sediments by divers operating this device.

9.5 Biological Control and Management

Biological control (bio-control) involves using animals, fish, fungi, insects, other plants, or pathogens as a means to control another in the same environment. The goal of bio-control is to weaken, reduce the spread, or eliminate the unwanted population so that native or more desirable populations can make a comeback. Care must be taken to insure that the control species does not become as big a problem as the one that is being controlled. A special permit is required in Wisconsin before any bio-control measure can be introduced into a new area.

9.5.1 Native Plant Restoration and Enhancement

Restoring a native plant community is almost always the end goal of an aquatic plant management program. Lakes currently lacking a native plant community can have these communities reestablished. In communities that have only recently been invaded by non-native species, propagule and seed banks probably exist that will restore the native plant community after successful management of the non-native plant. However, in communities that have had monotypic, non-native plant dominance for a long period of time (e.g., greater than 10 years), native plants may have to be reintroduced after a successful management program has been instituted. A healthy native plant community might slow invasion or reinvasion by non-native species and will provide the environmental and habitat needs of an aquatic littoral zone. However, even healthy, well-developed native plant communities may eventually be invaded and dominated by non-native species (Madsen, 2000).

It may be beneficial to work toward some level of native plant restoration in Lower Turtle Lake, particularly in light of the fact that a large watershed project is currently being implemented to reduce the amount of phosphorous loading in the lake. With a decrease in phosphorous, water clarity may improve enough to allow re-establishment of some species of native plants.

9.5.2 Insects, Animals, or Pathogens

Bio-control using other animals, insects, pathogens, or fungi for reduction 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 bio-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 (Greenfield et al., 2004).

9.5.2.1 Biological Controls Approved for use 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 a waterbody. Several species of insect are being used to control purple loosestrife infestations very effectively. Two *Galerucella* spp. are easy to rear, can be extremely effective at reducing large populations of purple loosestrife, and after nearly 20 years of use appear to have no negative effect on the areas in which they are introduced.

To date, this researcher is not aware of any insect controls being studied specifically for the control of CLP. However, research into establishing bio-controls is on-going. Studying naturalized and native herbivores and pathogens that impact nuisance aquatic and wetland plants increases the number of potential bio-control agents that could be incorporated into invasive plant management programs. The groundwork has been laid for conducting future bio-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 (Freedman et al., 2007).

There are several forms of biological control that have been used in other states, but are generally not approved for use in Wisconsin. The grass carp, also known as the white amur (*Ctenopharyngodon idella*), 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 (Greenfield et al., 2004).

9.5.3 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, at least in small scale applications may work. One 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 (Scheffer, 1998). In general, research done to determine the effect of barley straw has not been consistent or very positive.

Questions still remain as to whether barley straw should be considered an algicidal (kills existing algae) or an algistatic (prevents new algae growth). This designation is an important one for if it is considered an algicidal agent then it is also considered a pesticide. As a pesticide, the EPA requires rigorous testing and a registration number before being approved for use in a public water body. No company has ever registered barley for use as a pesticide. It has not gone through the testing required for registration. Therefore, barley cannot be sold as a pesticide to control algae. This ruling has serious implications for certified commercial applicators (individuals who have been state certified to apply aquatic pesticides for hire) and lake management specialists. These individuals cannot recommend or apply barley for algae control; this application would be the same as distributing an unregistered pesticide (Lembi, 2002).

However, EPA acknowledges that some products have multiple uses and that it is legal to advertise, sell, and apply a product based on its non-pesticidal uses, even if the product also has pesticidal uses. In this case, as long as someone does not claim algae control per se, they could sell or apply barley straw. The obvious alternative reason for the application of barley is that it might act as a water clarifier. 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 (Lembi, 2002).

9.6 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. It is unlikely that any of these management alternatives will be completed in Lower Turtle Lake.

9.6.1 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, and have inadequate pelagic and hypolimnetic zones, need deepening, or require removal of toxic substances. Dredging typically creates an area of the lake too deep for plants to grow, thus opening an area for riparian use. By opening more diverse habitats and creating depth gradients, dredging may also create more diversity in the plant community. Results of dredging can be very long term. Biomass of curly-leaf pondweed in Collins Lake, New York remained significantly lower than pre-dredging levels 10 years after dredging. However, due to the cost, environmental impacts, and the problem of disposal, dredging should not be performed for aquatic plant management alone. It is best used as a multi-purpose lake remediation technique (Madsen, 2000).

9.6.2 Benthic Barriers and Light Reduction

Benthic barriers or other bottom-covering approaches are another physical management technique that has been in use for a substantial period of time. 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.

Benthic barriers will typically kill plants under them within one to two months, after which they may be removed. Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively. Sites from which barriers are removed will be rapidly re-colonized. In addition, synthetic barriers may be left in place for multi-year control but will eventually become sediment-covered and allow re-colonization by plants. Benthic barriers, effective and fairly low-cost control techniques for limited areas (e.g., <1 acre), may be best suited to high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use over widespread areas, and heavily affect benthic communities (Madsen, 2000).

A basic environmental manipulation for plant control is light reduction or attenuation. Shading has been achieved by fertilization to produce algal growth, application of natural or synthetic dyes, shading fabric, or covers, and establishing shade trees. During natural or cultural eutrophication, phytoplankton growth alone can shade macrophytes. Although light manipulation techniques may be useful for narrow streams or small ponds, in general these techniques are of only limited applicability in lakes (Madsen, 2000).

9.6.3 Water Level Manipulation

Drawdown is an effective aquatic plant management technique that alters the plant's environment. Essentially, the water body has all of the water removed to a given depth. It is best if this depth includes the entire depth range of the target species. Drawdown, to be effective, needs to be at least one month long to ensure thorough drying. In northern areas, a drawdown in the winter that will ensure freezing of sediments is also effective. Drawdown requires that there be a mechanism to lower water levels. Although it is inexpensive and has long-term effects (2 or more years), it also has significant environmental effects and may interfere with use and intended function (e.g., power generation or drinking water supply) of the water body during the drawdown period. Lastly, species respond in very different manners to drawdown and often not in a consistent fashion. Drawdown may provide an opportunity for the spread of highly weedy or adventitious species, particularly annuals (Madsen, 2000). Raising the water level, although not very common, can have a similar effect to dredging as the water depth can be made too great for aquatic plants to grow. Drawdown is not feasible on Lower Turtle Lake as there is no outlet structure on the lake that can be manipulated.

9.7 No Management

No management is often the easiest, cheapest, and sometimes most effective aquatic plant management even for non-native invasive species like CLP. No management 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-weighed by the cost of management, where water quality or other lake characteristics limit nuisance growth conditions, and where highly valued native plants like wild rice would be negatively impacted by treatment.

10.0 Aquatic Plant Management Discussion

Aquatic plant species diversity and distribution is not good in Lower Turtle Lake due to limited light penetration caused by algae dominated water. Plant species that do well in degraded water are the most abundant, and even these are limited. Promoting the expansion of more desirable native plant growth is an important management goal, and is tied to improving water quality and clarity by reducing phosphorous and chlorophyll *a* concentrations in the lake. There are several significant non-point sources of nutrients to the system including agricultural runoff from the watershed, near shore runoff (including septic systems) from riparian properties, and internal recycling of nutrients already present in the system. CLP is also a source of phosphorous.

10.1 Agricultural Runoff

The primarily agricultural watershed of Lower Turtle Lake is a major source of nutrients to the system. Efforts to make changes in agricultural activities in the watershed and to make changes along the shoreline of the lake are already being implemented through a five-year lake protection project. Because phosphorus is the nutrient that limits plant growth in the lake, the reduction of phosphorus loading to the lake will likely reduce the frequency and magnitude of algal blooms.

10.2 Curly-leaf Pondweed

Dense beds of CLP that prevent native plant species from becoming established and impact water quality need to be removed. Harvesting is not target plant specific and would have to occur later in the spring to accommodate maximum CLP growth and removal. Furthermore, there is not really enough CLP in the system to justify buying harvesting equipment or purchasing harvesting services. Native plant removal later in the season is not recommended, as native plants are limited to begin with, so other than the short window of time where a harvester would be most effective there is no established need.

Early season application of the chemical endothall would provide the most benefit to the lake. Eliminating CLP early in the season prevents it from producing turions for later growth and may allow other plants that previously had been out-competed by CLP to grow more vigorously. Early growth of CLP likely provides some cover for fish fry once bluegill and bass spawning has been completed. Harvesting can negatively impact this nursery. Early season chemical application would not necessarily eliminate this nursery, but rather make it possible for more desirable plants to form it.

The areas that should be the focus of chemical treatments, where dense beds of CLP exist, in Lower Turtle Lake are outlined in Figure 13. These potential treatment areas cover approximately 5 acres at the northern end of the lake and 12 acres at the southern end. As discussed below, spring bed mapping should be completed before carrying out chemical treatments.

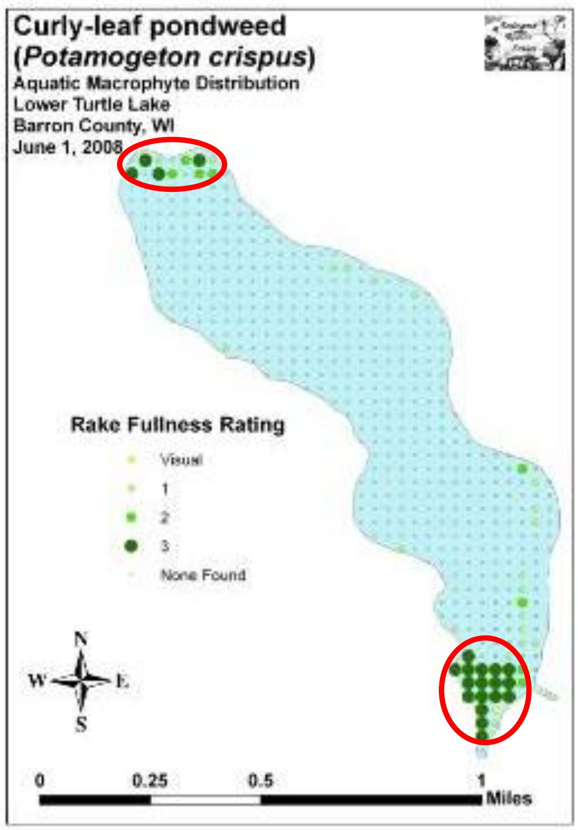


Figure 13 – Proposed Areas for Chemical Treatment of CLP Treatment on Lower Turtle Lake

The areas with the most CLP are also Sensitive Areas B and D where chemical treatments are strongly discouraged; however, an early season treatment will potentially allow native species to flourish in these areas. The goals of plant management at this time are to improve the distribution and diversity of native species and improve water quality. To reach these goals, management activities need to prevent monotypic CLP beds from developing, which, when they die of in mid-summer, release nutrients that fuel algae growth.

As CLP management progresses over the course of several years, the area treated should be adjusted to reflect changes in the distribution and density of CLP. There is some evidence to suggest that repeated annual herbicide treatments can reduce the amount of CLP growth in a lake. If CLP growth is limited, native plants whose growth had been prevented by the dense monotypic CLP growth may start coming back. If chemical treatment of CLP is undertaken, pre and post chemical treatment plant surveying should be implemented

Establishing an annual spring CLP bed mapping and fall CLP turion density sampling program based on a minimal number of predetermined sites will help to determine the extent of CLP to treat each year. CLP control strategies need to focus on both reducing growth and promoting the re-establishment of native aquatic plants. Establishing a baseline condition before beginning a CLP control program is vital for guiding decisions on the level of management required, prioritizing areas of the lake for treatments, and selecting the specific tools and strategies to be implemented. In addition, pre and post management monitoring is needed to evaluate the effectiveness of any actions. One measure of CLP treatment success is a reduction in the number of turions in the treatment area.

10.3 Re-establishing Native Plant Communities by Planting and Restoration

Establishing or re-establishing native plants, with a focus first on emergent species, will benefit Lower Turtle Lake now and in the future. It is also another way to keep AIS like CLP in check. Native plants may re-establish naturally once invasive species are removed if seeds and other propagules are still present. Artificially reintroducing native plants is often difficult and costly. Reintroduction requires a fairly large source of new plants, protection from fish and birds may be needed, temporary stabilization and protection of sediment in the planting area from wind and waves is generally needed (Figure 14), and substantial short-term labor needs for collecting stock, planting, and maintenance is often required.

There are essentially three types of aquatic plants: emergent, floating leaf, and submergent. Emergent plants include reed, bulrush, cattail, grasses (like wild rice), sedges, and tall herbs. Floating leaf plants include water lilies, floating leaf pondweeds, and common waterweed. These plants generally grow in shallow water down to 2 or 3 meters. Submerged 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.

Figure 14 – Buffer Blocker System, Langlade County, Wisconsin

If desirable native plants to not come back by themselves, it may be possible to collect plant stock from other areas of the lake. It may be necessary to collect plants from other lakes or to purchase then from commercial vendors. Collecting plants from the same or other water bodies may require a permit. If commercial plants are purchased, care should be taken to not introduce unwanted vegetation at the same time.

A good rule of thumb to follow is to plant as many submerged or floating leaf plants as possible given resource constraints, as these plants are likely the most susceptible to failure. Emergent plant species are not as susceptible to failure (Moss and others, 1996). There are many sources for more information. Smart and others (1998) discuss many techniques for establishing native aquatic plants in reservoirs with an absence of vegetation or low species diversity. The Langlade County, Wisconsin Land Records and Regulations Department has a Shoreland Restoration Web Site which provides a great deal of information for re-establishing native plants (http://lrrd.co.langlade.wi.us/shoreland/index.asp, last accessed: December 2010). A complete review of these techniques and others should be completed before undertaking a planting project.

Planting projects on Lower Turtle Lake should start small. Working with a few willing land owners to restore emergent plant species first, and introducing wild rice to the northern and southern bays is the extent of restoration recommended in this plan. It proven successful, restoration projects can be expanded. Improving water clarity over the next few years should also enhance the growth of more desirable aquatic plants.

11.0 Aquatic Plant Management Goals, Objectives, and Actions

There are six broad goals, each with a number of objectives and actions, which will guide plant management efforts on Lower Turtle Lake over the course of the next five years. Appendix C is an outline of the aquatic plant management goals and activities, and Appendix D is a five-year timeline for completion of the activities included in this APM Plan. This five-year plan is not intended to be a static document; rather, it is a living document which can be revised to ensure goals are being met. Minor changes and adaptations are expected and will be made annually, but any major change in activities or management philosophy will be presented to the LTLMD and the WDNR for approval. The six goals for this plan are as follows:

1. Monitor, control, and manage aquatic invasive species;
2. Educate residents and users about and prevent the introduction of aquatic invasive species;
3. Monitor lake water quality;
4. Promote and implement shoreland best management practices;
5. Preserve, protect, and enhance native species;
6. Evaluate the APM plan yearly and revise as necessary.

This APM Plan will be completed by the LTLMD, their consultants, and through partnerships formed with the WDNR, the Barron County Soil and Water Conservation Department, and other local clubs and organizations.

11.1 Monitor, control, and manage aquatic invasive species

Curly-leaf pondweed control will initially consist of early season small-scale herbicide application in designated areas of the lake to reduce CLP beds by 50%. Early season CLP bed mapping, pre and post treatment aquatic plant surveys, and fall CLP turion density monitoring will be used to support the small-scale treatment program. Large-scale management may be completed on the lake if small-scale management is shown to be ineffective. Land owners will be taught to distinguish CLP from other beneficial native plants and encouraged to remove as much as they can. The expected outcome of this management is new native aquatic plant growth and a detectable reduction in turion density in those areas chemically treated in the next five years.

11.2 Educate residents and users about and prevent the introduction of aquatic invasive species

Volunteers will continue watercraft inspection at the public access site on Lower Turtle Lake following guidelines established by the UW-Extension Lakes Clean Boats Clean Waters program. The majority of this time will come on holidays and weekends during the fishing season. At least one volunteer will attend Clean Boats Clean Waters training in order to be eligible to train other watercraft inspectors. At least one team (minimum of two people) of volunteers will be trained according to CLMN AIS monitoring guidelines and complete AIS monitoring at least once a month from April through October. This team will be expected to put in a predetermined amount of time and may be compensated for a portion of that time.

The LTLMD will promote AIS education and distribute information to lake property owners and lake users through its newsletter, webpage, and public meetings. The LTLMD will sponsor or participate in an annual Lake Fair which will address pertinent lake issues. The Lake Fair could be held during another regularly scheduled event (e.g., the annual meeting or annual picnic), held with another entity such as a neighboring lake, or as a part of a larger public event.

11.3 Monitor lake water quality

CLP management and comprehensive management activities will have an effect on current water quality conditions in the lake. Without a complete water quality monitoring program there will be no way to determine what these changes are. Water quality monitoring, including CLMN and expanded parameters, will help characterize current conditions for future comparisons.

Nutrient testing will be completed periodically during the open water season and once during the winter. All pertinent water quality data will be submitted to the WDNR SWIMS database. All water samples will be processed by the Wisconsin State Lab of Hygiene or by another WDNR approved lab.

11.4 Promote and implement shoreland best management practices

Much of the shoreland on Lower Turtle Lake is developed to some extent. The promotion and implementation of shoreland BMPs is currently underway as part of the Lake Protection Project. New and existing property owners will be encouraged to implement best management practices that may help to improve the lake. Educational and informational materials will be provided to property owners by the LTLMD and its partners.

11.5 Preserve, protect, and enhance native species

It is important to promote the protection and expansion of native plants and animals in and around Lower Turtle Lake. The LTLMD will promote the value of the native plants and other wildlife that are found in and around Lower Turtle Lake through its educational and informational activities. Land owners and lake users will be encouraged to become involved in monitoring programs such as LoonWatch (http://www.loonwatch.org). Wild rice is currently not present in Lower Turtle Lake. The LTLMD will work with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) to evaluate if wild rice could be introduced in the lake. If it is determined that Lower Turtle Lake could support wild rice growth, the

LTLMD will work with partners to introduce it, and encourage land owners and lake users to support its introduction.

11.6 Evaluate the APM plan yearly and revise as necessary

Annual summaries and evaluations of the activities undertaken in all of these goals will be completed by the LTLMD and their consultant and submitted to the necessary partners for review. A final project summary will be completed by the LTLMD and their consultant in the final year of this project. A whole-lake aquatic plant survey and assessment will also be completed in the final year of this project to help determine the affect of aquatic plant management on Lower Turtle Lake.

12.0 Five-Year Timeline of Activities

The activities in this APM Plan are designed to be implemented over a 5-year period beginning in 2011. Appendix D 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 lake and its watershed, and those of the LTLMD. 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 LTLMD or state grant funding.

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dlb/jam

Appendix A

Lake Sensitive Areas Report

Appendix B

WNDR Northern Region Aquatic Plant Management Strategy

Appendix C

Aquatic Plant Management Goals, Objectives, and Actions

Appendix D

Five-Year Timeline of Activities

Appendix E

Eurasian Watermilfoil Rapid Response Plan