# Aquatic Plant Management Plan

## Little Elkhart Lake

## Little Elkhart Lake

## Rehabilitation District

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Stantec

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# 1.0 EXECUTIVE SUMMARY

The Little Elkhart Lake Rehabilitation District (LELRD or the District) is a group with a strong tradition in conservation and resource management within Little Elkhart Lake (the Lake). The District has been active in a number of lake management activities on Little Elkhart Lake including: aquatic plant management, water quality sampling and management, invasive species sampling and fisheries management through stocking. The LELRD contracted Stantec Consulting Services Inc. (Stantec) to help develop an Aquatic Plant Management (APM) Plan for the Lake.

The Little Elkhart Lake APM Plan includes a review of available lake information, an aquatic plant survey, watershed assessment and water quality evaluation to determine the most appropriate plant management alternatives (physical, mechanical, biological or chemical) for the Lake. The APM Plan also recommends specific management activities for aquatic invasive species (AIS) in the Lake system, which is discussed below.

Stantec completed an aquatic plant survey of the Lake on July 23 & 27, 2012. The most abundant aquatic plants identified were muskgrass (*Chara sp.*), large-leaf pondweed (*Potamogeton amplifolius*) and coontail (*Ceratophyllum demersum*). A follow up, post-treatment survey was conducted on August 28, 2013 that mapped current Eurasian water-milfoil (*Myriophyllum spicatum* – EWM) and curly-leaf pondweed (*Potamogeton crispus* – CLP) infestation at around 6 acres and less than 0.5 acres respectively (Figure 2). Floristic Quality Index (FQI) values (an index that uses the aquatic plant community as an indicator of lake health) was 25.31 for the Lake with an average Coefficient of Conservatism (C) of 5.52. The FQI is higher than average value for lakes in the state's Southeast Till Plain Eco-region, 20.9 and higher still than the upper quartile, 24.4 indicating a higher quality aquatic plant community than comparable lakes while the average C is slightly below the average for this Eco-region (5.6).

In conjunction with issues posed by AIS, dense native plant growth causes navigational problems within portions of the Lake. Much of the problem is caused by floating-leaf species, mainly white water lily (Nymphaea odorata). Past practice has focused on maintaining common navigational lanes within problem areas through herbicide management.

## 1.1 RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

One aquatic invasive plant, Eurasian water-milfoil (EWM), was found to be infested in Little Elkhart Lake with another invasive species, curly-leaf pondweed (CLP), scattered. The infestation of EWM within the Lake currently exceeds 5 acres and has become prevalent within the aquatic plant community of the Lake over the last decade; though it is lower than historic levels in 2010 of over 15 acres. A second aquatic invasive plant, curly-leaf pondweed (CLP) (*Potamogeton crispus*) was found scattered at low in the Lake.

Since EWM is present on a large scale basis (greater than 10% of the littoral zone) within the Lake, ongoing management, monitoring and educational efforts are highly recommended. This will help prevent spread of this AIS, along with CLP, to other waters. Due to the presence of these two exotic, invasive species, the following Recommended Action Plan focuses on AIS control and public education. Navigational access issues throughout the Lake should be assessed annually and managed only when necessary.

The following Active Goals form the structure of the Little Elkhart Lake Aquatic Plant Management Plan:

**Active Goal**: Manage AIS to improve recreation, increase recreational opportunities and rehabilitate native plants.

**Task**: Reduce EWM abundance to less than 5.0% frequency of occurrence within the littoral zone, or approximately 2.5 acres to be documented through annual surveys. Treatment regime for 2014-2018 management of EWM to reduce coverage in the lake is displayed below. Stantec recommends an initial application rate at a concentration at or near maximum label rates within areas of EWM growth. Currently, spot treatments should take place in subsequent years with either liquid or granular herbicides depending on the size of the beds being targeted. Consideration should be given to liquid should be used when beds are over 2.5 ac in individual size with granular formulations used on smaller areas. Annual goals for EWM control are displayed below.

***Task:*** Continue monitoring presence of CLP within the Lake. If the population of CLP expands beyond 1.0 acres and/or approximately 2.5 % frequency of occurrence, management should be conducted using an early season application of endothall or imazamox at or near maximum label rates; and/or hand pulling.

**Active Goal**: Provide LELRD members and Lake users with educational information related to potential impacts their activities could have on introduction of aquatic invasive species within the Lake and likely modes of transport as well precautionary measures that should be taken.

***Task:*** Install an information kiosk at the boat launches and/or materials sent annually to each member with information on AIS identification as well as any new species to aware of that may impact the Lake and appropriate precautionary measures.

**Active Goal**: Increase participation with the Clean Boats, Clean Waters (CB/CW) program

***Task:*** Train 2-4 additional volunteers from the District to help with the CB/CW program

***Task:*** Commit to a minimum of 50 annual volunteer hours of monitoring for Little Elkhart Lake's boat landing with a set schedule to supplement Glacierland RC & D's efforts.

**Active Goal:** To implement and maintain an aquatic invasive species monitoring program that will survey for invasive species, and if found, monitor their locations and extent of population spread.

***Task:*** Each year AIS treatment is to take place, continue to complete pre and post-treatment point-intercept aquatic plant surveys to monitor AIS and native plant responses to the management and plan for the future. AIS should be surveyed and mapped before and after treatment, according to DNR protocol, to evaluate effectiveness of treatment.

**Active Goal:** To resume the comprehensive water quality monitoring within on Little Elkhart Lake through the WDNR Citizen Lake Monitoring Network.

**Task:** Continuing in 2014 and beyond, have the trained citizen volunteers monitor water quality through secchi readings, temperature and dissolved oxygen profiles, with special emphasis on chlorophyll *a* and phosphorus water samples, given historic increases. Samples will be taken once monthly from May – September.

**Active Goal:** Maintain a common navigational corridor in from the southeast bay leading to the main lake, if necessary based on each year's aquatic plant growth (Figure 3).

**Task:** Monitor plant growth within this bay and, only if necessary, acquire a permit to create and maintain a common, 30' – 50' wide navigational access from the bay to the main lake by herbicide treatment or harvesting. This task may not be required annually and should be re-evaluated each year.

# 2.0 INTRODUCTION

Little Elkhart Lake Rehabilitation District was formed in 1975 to manage and improve the quality of the Lake and includes all property owners along the shores of Little Elkhart Lake. The District has a strong tradition of conservation and resource management within the Lake and has been active in a number of lake management activities including: aquatic plant management, water quality sampling and management, invasive species sampling and fisheries stocking.

This document is the APM Plan the Lake and discusses the following:

- Lake morphology and lake watershed characteristics
- Historical aquatic plant management activities
- Stakeholder's goals and objectives
- Aquatic plant ecology
- 2012 baseline aquatic plant survey
- Feasible aquatic plant management alternatives
- Selected suite of aquatic plant management options

# 3.0 BASELINE INFORMATION

## 3.1 LAKE HISTORY AND MORPHOLOGY

Little Elkhart Lake is located in the Town of Rhine, Sheboygan County, Wisconsin. The Lake is a natural seepage lake with fluctuating water levels and lies within the Sheboygan River watershed, which empties into Lake Michigan. The following summarizes the Lake's physical attributes:

| | |
|---|---|
| **Lake Name** | Little Elkhart Lake |
| **Lake Type** | Seepage |
| **Surface Area (acres)** | 56.3 |
| **Maximum depth (feet)** | 25 |
| **Mean depth (feet)** | 8 |
| **Shoreline Length (miles)** | 2.24 |
| **Public Landing** | 1 |

Source: Wisconsin Lakes, WDNR PUB-FH-800, 2009

The Project Area probably formed about 10,000 years ago by glacial activity. A large piece of glacial ice left behind during glacial degradation likely formed the depressional landscape in which the Lake is located. Such lakes are typically called "kettle lakes".

## 3.2 WATERSHED OVERVIEW

With no waterways flowing into Little Elkhart Lake, it has a relatively small watershed (approximately 749 acres) with drainage into the Lake being primarily overland flow. Little Elkhart Lake has a watershed-to-lake ratio of approximately 13.3:1. The larger the watershed to lake ratio, the more affect the watershed has on the Lake. Typically, lakes or impoundments with large ratios are more likely to be eutrophic. Lakes with large watersheds have more surface area, yielding more surface water runoff to the lake. Surface water from larger watersheds typically contains higher levels of nutrients and sediments. Nutrient and sediment loading is likely offset in the Lake by a moderate ratio and lower retention time for water within the impoundment. The watershed's impact on water quality and nutrient loading within Little Elkhart Lake is found in section 5.6.

Land use in the Project Area's watershed is predominantly forest land followed by rural residential, and then mixed agricultural with by five other minor types of land use: commercial/industrial, grassland/shrubland, road, wetlands and open water. Land use groups by acreage are presented in the table below.

**PROJECT AREA WATERSHED ANALYSIS**

| Land Use | Acres | Percent of Watershed |
|---|---|---|
| Mixed Agricultural | 121.53 | 16.22% |
| Commercial / Industrial | 47.58 | 6.35% |
| Coniferous Forest | 3.16 | 0.42% |
| Deciduous Forest | 241.13 | 32.18% |
| Grassland / Shrubland | 95.52 | 12.75% |
| Open Water | 56.3 | 7.51% |
| Rural Residentail | 155.1 | 20.70% |
| Road | 10.77 | 1.44% |
| Wetlands | 18.33 | 2.45% |
| **TOTAL** | **749.42** | **100.00%** |

Soil characteristics within a watershed are related to water quality attributes. Little Elkhart Lake's watershed consists of two primary soil associations as described below:

Casco loam: These soils are found on slopes of outwash plains and are nearly level to very steep, well drained, loamy alluvium overlying calcareous, stratified sandy and gravel outwash. Permeability of these is high, helping to reduce overland flow within the watershed.

Hochheim silt loam: These soils were formed by glaciation and are found typically on till plains and drumlins and are found on moderately to very steep slope. Hochheim soils are well drained and consist mainly of thin loess over loamy till. Permeability of these soils is moderately high, helping to reduce overland flow within the watershed.

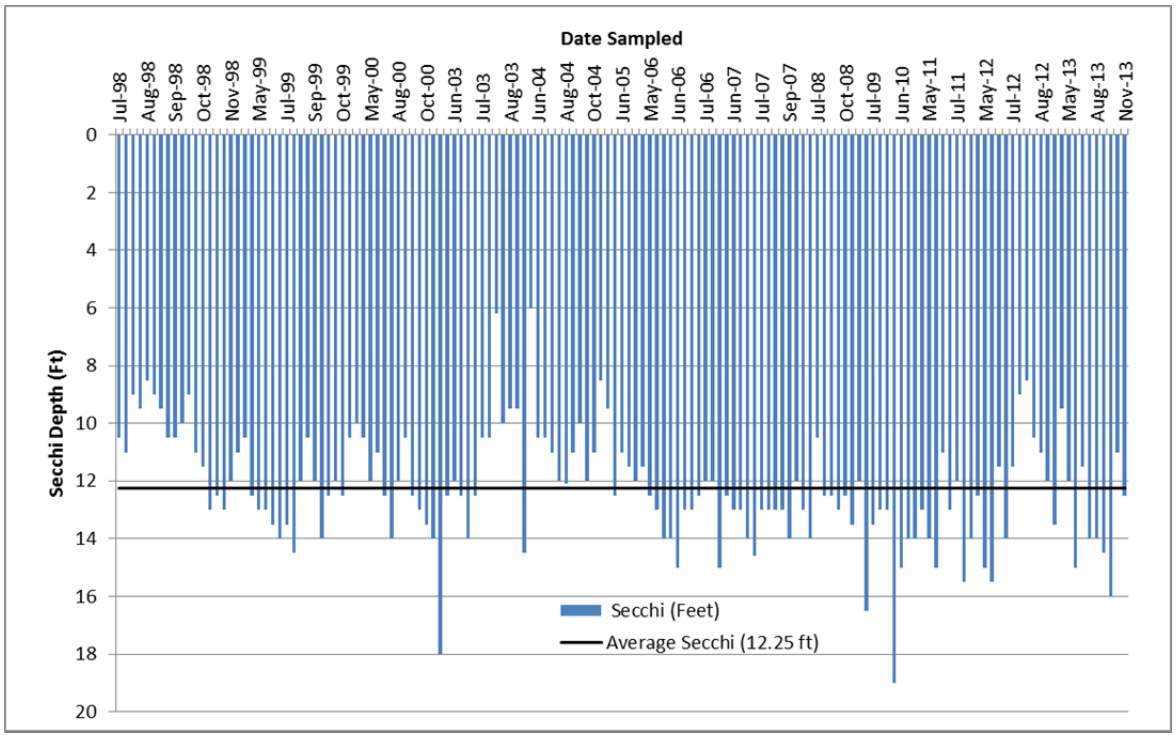
### 3.3 WATER QUALITY

LELRD volunteers have collected water quality data since 1979. Parameters examined include total phosphorous, water clarity and Chlorophyll-a. These data were incorporated during development of the Little Elkhart Lake APM Plan.

- Water clarity (Secchi depth) - 1998-2000 & 2003 - 2013 (Citizen Lake Monitoring)
- Total phosphorus – 1979, 2000, 2003-2004, 2007 & 2014 (Citizen Lake Monitoring)
- Chlorophyll a – 1979, 2000, 2003, 2007 & 2014 (Citizen Lake Monitoring)

#### 3.3.1 WATER CLARITY

Higher Secchi depth readings indicate clearer water and deeper light penetration, allowing plants to grow in deeper areas of the Lake. Historical water clarity based on Secchi Disk readings at Little Elkhart Lake is 12.25 feet (3.73 meters), indicating good water clarity. Average Wisconsin Secchi Disk readings are approximately 10 feet (Larry Bresina, *The Secchi Disk and Our Eyes - Working Together to Measure Clarity of Our Lakes*; internet document).



### 3.3.2 Total Phosphorus and Chlorophyll *a*

Phosphorus is the limiting nutrient affecting aquatic plant growth in more than 80% of Wisconsin lakes and is often the cause of excessive aquatic plant growth. Phosphorus input to lakes can occur naturally, but often times are linked to human activities. Major sources of Phosphorus include human and animal wastes, soil erosion, stormwater runoff (associated with impervious land cover, i.e. solid areas like roofs and driveways), detergents, septic systems and fertilizer runoff from farmland or lawns.

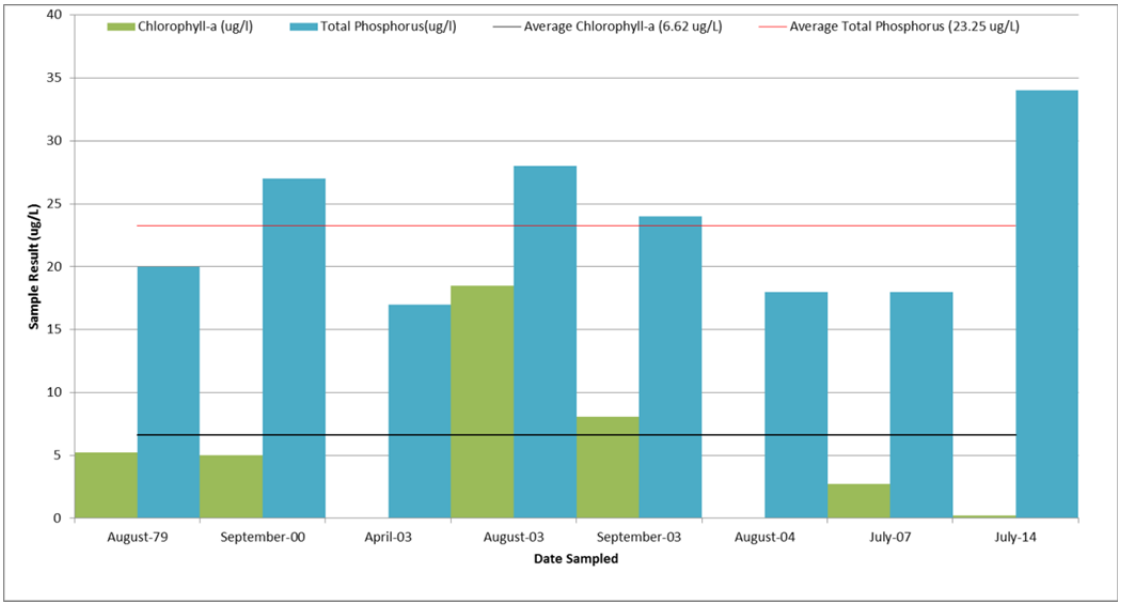
Phosphorus levels can be analyzed in a variety of ways. Soluble reactive phosphorus (SRP) is the amount of phosphorus in solution that is available to and directly taken up by plants. Total phosphorus includes the amount of phosphorus in solution and particulate form. Most water quality studies analyze total phosphorous levels. For natural lakes, the average total phosphorus should be between 16 and 30 micrograms per liter (µg/L) while levels of 20 µg/L are considered average for natural lakes. The following table relates average phosphorus readings to water quality (Shaw et al., 2004) as a useful analysis tool.

| Water Quality Index | Total Phosphorus (ug/L) |
|---|---|
| Very Poor | 150+ |
| Poor | 53 - 149 |
| Fair | 31 - 52 |
| Good | 16 - 30 |
| Very Good | 2 - 15 |
| Excellent | 1 or less |

Source: Shaw et al., 2004.

Chlorophyll *a* is a green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae, and is used as a common indicator of water quality (Shaw et al, 2004). Higher chlorophyll *a* values indicate lower water clarity. Values of 10 ug/L and higher are associated with algal blooms while values below 10 ug/L indicate good water quality.

Average historic total phosphorus and chlorophyll *a* concentrations, though limited, at Little Elkhart Lake are 23.25 ug/L and 6.62 µg/L, respectively indicating good water quality.



### 3.3.3 TROPHIC STATE INDEX

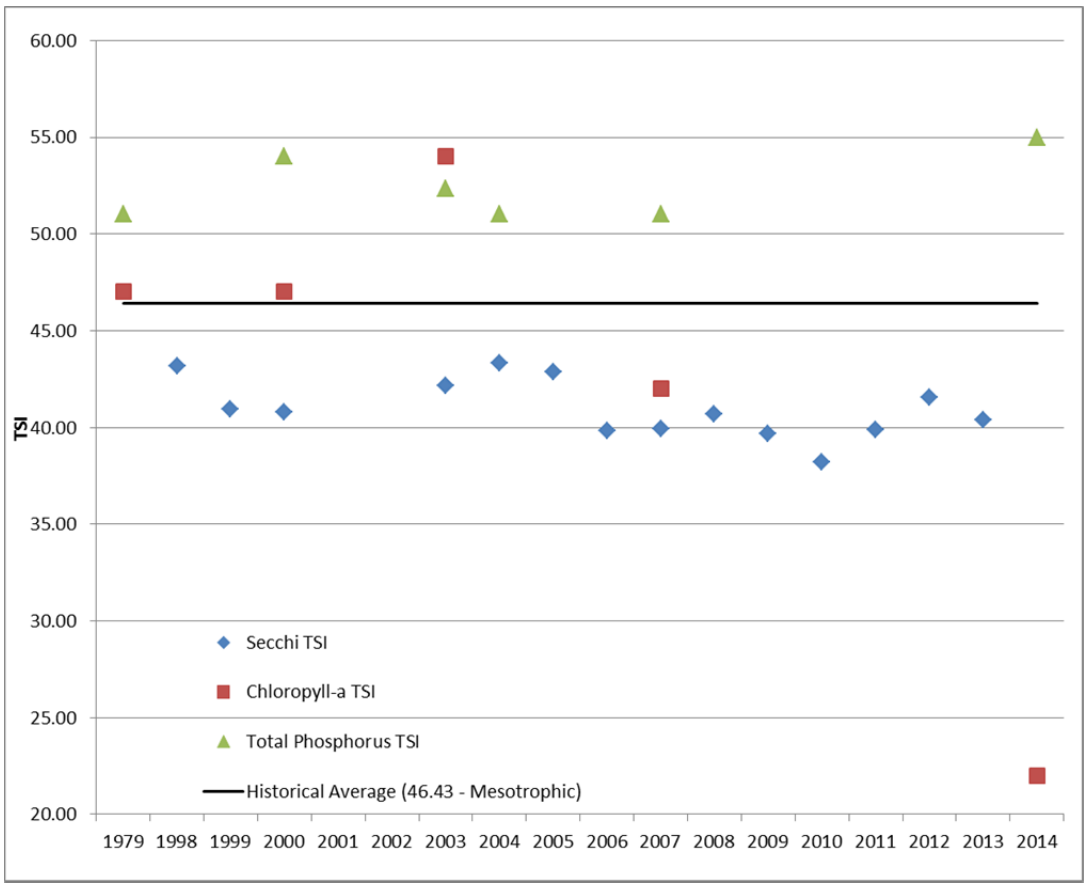
Trophic State Index (TSI) values are assigned to a lake based on total phosphorus, chlorophyll *a*, and water clarity values. The TSI is a measure of a lake's biological productivity. Lakes with a higher TSI value are highly ecologically productive, but in association have lower water clarity, increased nutrient input, and the potential for frequent algae blooms. Conversely, lakes with low nutrient input and very clear water are typically less productive and have lower TSI values. Little Elkhart Lake has a TSI value of 47.34, ranking it as mesotrophic or moderately productive. The TSI used for Wisconsin lakes is described below:

| Category | TSI | Lake Characteristics | Total P *(ug/l)* | Chlorophyll a *(ug/l)* | Water Clarity *(feet)* |
|---|---|---|---|---|---|
| Oligotrophic | 1-40 | Clear water; oxygen rich at all depths, except if close to mesotrophic border; then may have low or no oxygen; cold-water fish likely in deeper lakes. | < 12 | <2.6 | >13 |
| Mesotrophic | 41-50 | Moderately clear; increasing probability of low to no oxygen in bottom waters. | 12 to 24 | 2.6 to 7.3 | 13 to 6.5 |
| Eutrophic | 51-70 | Decreased water clarity; probably no oxygen in bottom waters during summer; warm-water fisheries only; blue-green algae likely in summer in upper range; plants also excessive. | > 24 | >7.3 | <6.5 |
| **Little Elkhart Lake** | **46.43** | **Mesotrophic** | **23.25** | **6.62** | **12.25** |

Adopted from Carlson 1977, Lillie and Mason, 1983, and Shaw 1994 et al

Little Elkhart Lake is a natural, seepage lake relying on groundwater input and precipitation or runoff to maintain water levels. Seepage lakes do not have an inlet or outlet and, as such, can have potentially longer term impacts from watershed input. Water quality within the Lake depends on annual rainfall and amount of nutrient runoff. In years of high rainfall, water quality is expected to decrease and may take a year or longer to return to normal due to residence time; while years of drought show an increase in water quality parameters due to less runoff. This is shown on the chart below from 2008, a wet year, to 2010.

2008 was a historically wet year which increased the nutrient loading into the lake due to increased runoff. The increase in nutrient loading led to higher phosphorus levels and occasional algae blooms, leading to higher chlorophyll *a* levels and lower secchi levels, increasing TSI values for all three parameters. From 2009-2010, the Lake slowly returned to normal and experienced increased water quality.




Historical water clarity, total phosphorus, and chlorophyll *a* data show no reliable trends or patterns in annual variances of individual TSI averages for any of the three parameters (see chart above). Secchi values are consistently lower than total phosphorus and chlorophyll a results, most likely due to a healthy aquatic plant community using a majority of available nutrients. Keeping additional input of phosphorus and sediments from entering the lake will be helpful for maintenance of current water quality. Overall, the TSI average indicates that Little Elkhart Lake is a mesotrophic lake with an average TSI rating of 46.43.

### 3.4 SUMMARY OF LAKE FISHERY

The fishery within the Lake is similar to most Wisconsin lakes with an assortment of panfish, including bluegill, pumpkinseed, black crappie and perch. Largemouth bass comprise most of the predatory population and a smaller component of northern pike. All regulations for the Lake are concurrent with statewide general minimum size and bag limits for all species. The following table identifies relative fish species abundance within Little Elkhart Lake.

| Fish Species | Present | Common | Abundant |
|---|---|---|---|
| Northern Pike | X | | |
| Largemouth Bass | | | X |
| Panfish | X | | |

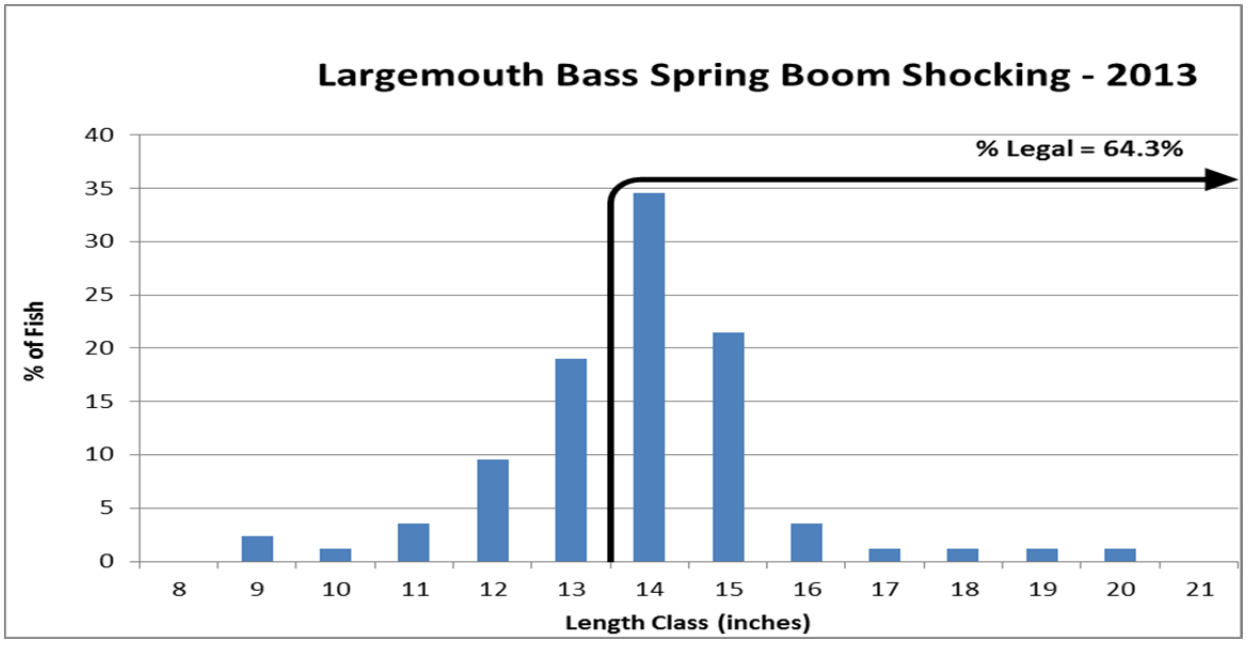
Source: Wisconsin Lakes, WDNR PUB-FH-800, 2009

All species present within the Lake are sustained through natural reproduction with no fish stocking taking place since 1984. Rainbow trout were stocked periodically from 1979-1984. Rainbow trout require cool waters and the water temperature regime in the Lake is not conducive for long term survival of this species for natural reproduction. The winter of 2013-2014 had an extended ice cover period, which attributed towards a near complete fish die-off due to lack of oxygen. Stocking was completed in early 2014 to re-populate the lake with additional stocking scheduled to take place yet in fall, 2014. Stocking amounts and age-class stocked by year are included below.

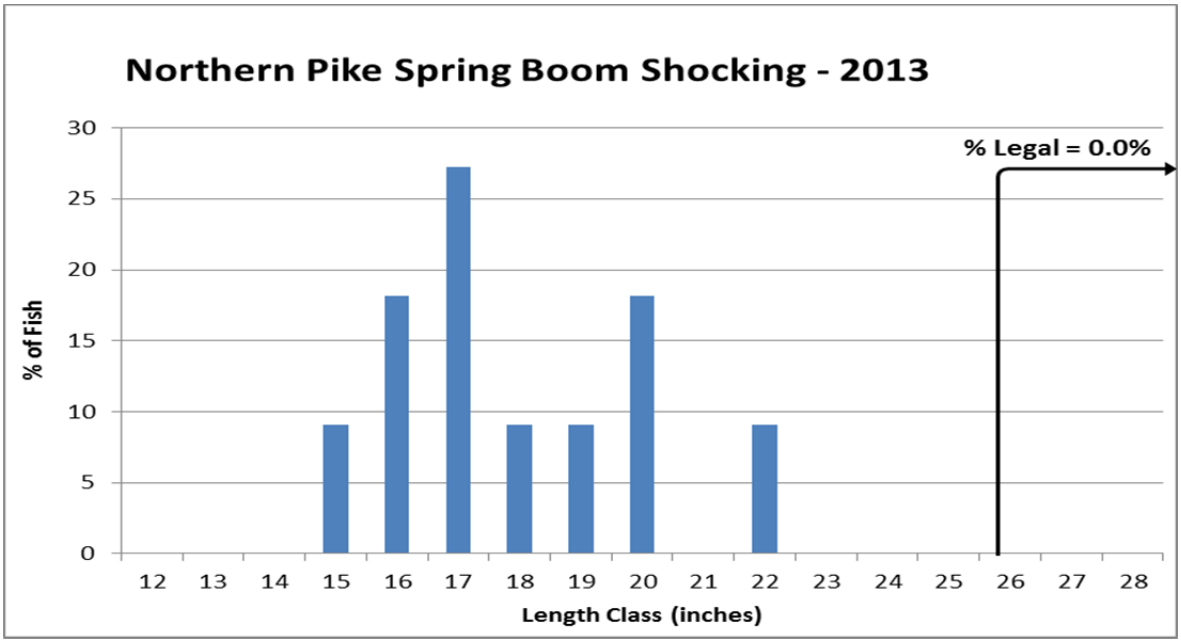
| | Walleye | | Northern Pike | | Largemouth Bass | | Rainbow Trout | | Bluegill | | Yellow Perch | | Black Crappie | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Amount | Age class | Amount | Age class | Amount | Age class | Amount | Age class | Amount | Age class | Amount | Age class | Amount | Age class |
| 1975 | 250,000 | fry | 100,000 | fry | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | 8,000 | fingerling | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1976 | 25,000 | fry | --- | --- | 10,000 | fingerling | --- | --- | --- | --- | --- | --- | --- | --- |
| 1979 | --- | --- | --- | --- | --- | --- | 23,700 | fingerling | --- | --- | --- | --- | --- | --- |
| 1982 | --- | --- | --- | --- | 10,000 | fingerling | 3,000 | yearling | --- | --- | --- | --- | --- | --- |
| 1983 | --- | --- | --- | --- | --- | --- | 1,000 | yearling | --- | --- | --- | --- | --- | --- |
| 1984 | --- | --- | --- | --- | --- | --- | 1,000 | yearling | --- | --- | --- | --- | --- | --- |
| 2014 | --- | --- | --- | --- | 500 | Yearling | --- | --- | 1,360 | adult | 1,200 | adult | --- | --- |
| 2014 -additional | --- | --- | 2,700 | fingerling | --- | --- | --- | --- | --- | --- | 2,500 | yearling | 2,500 | yearling |

Little Elkhart Lake's fish were last surveyed by the WDNR in 2013 with a spring electrofishing survey. From the data, a rough estimation of the fishery can be concluded when comparing raw data to the current minimum size limits for Little Elkhart Lake. Though walleye were historically sampled, lastly in 2006, none were present in 2013 while those present in 2006 were likely present due to angler introduction. The focus of the spring electrofishing was for gamefish species, including largemouth bass and northern pike.

During the 2013 electrofishing survey, 64.3% of the 84 largemouth bass sampled were above the legal minimum size (14 inches or greater) for harvest with few younger fish surveyed. However, few fish over 15 inches were sampled, likely attributed to angler harvest.



Northern pike sampled during showed poor overall size, with only no fish reaching legal minimum size (26 inches or greater) sampled out of 11. Gear selectivity and angler harvest may be the cause of poor size structure of northern pike. Large specimens are reportedly caught, especially by ice anglers.




Panfish species were numerous during the 2013 surveys and mostly comprised of bluegill (105 sampled). Pumpkinseed were the next most abundant species present (26 sampled) with only two yellow perch and one black crappie sampled. Though bluegill growth in the Lake has shown the ability to grow larger fish, they average 3.7 inches in length with few over 6" sampled, possibly showing high angler harvest due to preference for larger fish. Pumkinseed showed a similar trend.

Prior to the 2014 winter kill, the fishery in the Lake appeared healthy and stable. Winter kill has happened occasionally in past seasons within the Lake and the fishery has rebounded each time. Stocking has already been initiated in 2014 with funding already in place to further augment the population in 2015 for restoration. Current goals for fishery restoration are to re-establish historical panfish populations of perch, bluegill and black crappie along with gamefish populations of northern pike and largemouth bass. Prior to winter kill, largemouth bass provided excellent sport fishing opportunities with many fish over legal size present with some trophy quality specimens. At this time, harvest of newly-stocked fish is not recommended and historical data shows past management and regulations have been acceptable.

### 3.5 LAKE MANAGEMENT HISTORY

LELRD has been very active in managing the waters, specifically aquatic plants, within the Lake. Projects undertaken include the following:

- 1975 and 1983 Pumping of the lake to lower water levels due to resident complaints
- 1977, 2002, 2009, & 2012 Full aquatic plant surveys
- 1986 Installation of high water level outlet
- 2003 Limnological Study and Aquatic Plant Management Plan
- 2010-2013 Herbicide management for AIS
- 2007-2013 Semi-Annual surveys to monitor AIS
- Sporadically prior to 1998 Herbicide & mechanical harvesting for aquatic plant control

CLP and EWM were first documented in the lake in 2004 and 1977, respectively. Since then, there has been various management activities focused solely on EWM, mainly herbicide treatments. Though CLP is present, it has not been sampled at high enough densities to warrant management, though annual monitoring for it has continued. The most recent treatments are displayed below.

| Year | Treatment Date | EWM Treated (ac) | CLP Treated (ac) | Other Treated (ac) |
|---|---|---|---|---|
| 2010 | May 17 | 15.35 | 0 | 0 |
| 2010 | June 27 | 0 | 0 | 1.0 |
| 2011 | June 3 | 6.00 | 0 | 0 |
| 2012 | May 12 | 5.15 | 0 | 0 |
| 2012 | June 20 | 0 | 0 | 1.75 |
| 2013 | June 19 | 3.5 | 0 | 0 |
| 2013 | July 8 | 0 | 0 | 1.9 |
| 2013 | August 12 | 0 | 0 | 1.2 |

Treatments have focused on AIS control in recent years with nuisance relieve for navigation limited to shallow areas by piers and common navigational channels with nuisance primarily cause floating-leaf species such as white water lily. All AIS treatments have been early-season, cool water applications designed to target only AIS. Eurasian water-milfoil management techniques began as large scale techniques (>10.0 ac) with either liquid or granular 2,4-D applied at 2.5 – 3.0 ppm. Since 2010, acreage of EWM treated annually has decreased by 63%. The "other" acres treated have been for navigational relief of excessive topped out native plants impeding navigation.

### 3.6 GOALS AND OBJECTIVES

LELRD identified the following goals for aquatic plant management in the Lake.

- Effectively manage all AIS; currently EWM and CLP
- Conduct pre and post evaluation monitoring of APM management activities, if any
- Maintain and improve recreational/navigational opportunities
- Protect and improve fish and wildlife habitat
- Preserve native aquatic plants
- Prevent the spread of existing AIS and prevent the introductions of new of AIS
- Identify and protect sensitive areas
- Educate the Little Elkhart Lake community on proper AIS identification and prevention efforts
- Gather Little Elkhart Lake users input

# 4.0 PROJECT METHODS

To accomplish the project goals, the LELRD needs to make informed decisions regarding aquatic plant management on Little Elkhart Lake. To make informed decisions, LELRD proposed to:

- Analyze and interpret basic aquatic plant community data
- Recommend practical, scientifically-sound aquatic plant management strategies

Offsite and onsite research methods were used during this study. Offsite methods included a thorough review of available background information on the Lake, its watershed and water quality. An aquatic plant community survey was completed onsite to provide the data needed to evaluate aquatic plant management alternatives.

## 4.1 EXISTING DATA REVIEW

Stantec researched a variety of resources to develop a thorough understanding of the ecology of the Lake. Information sources included:

- Local and regional geologic, limnologic, hydrologic and hydrogeologic research
- Discussions with club members
- Available topographic maps and aerial photographs
- Data from WDNR files

These sources were essential to understanding the historic, present and potential future conditions of the Lake, as well as to ensure that previously completed studies were not unintentionally duplicated. Specific references are listed in Section 8.0 of this report.

## 4.2 AQUATIC PLANT SURVEY AND ANALYSIS

The aquatic plant community of the Lake was surveyed on July 23 & 27, 2012 by Stantec. The survey was completed according to the point intercept sampling method described by Madsen (1999) and as outlined in the WDNR Point Intercept Survey Methodology (Hauxwell et al., 2010).

WDNR research staff determined the sampling point resolution in accordance with the WDNR guidance and provided a base map with the specified sample point locations. The sample resolution was a 30 meter grid with 232 pre-determined intercept points. Latitude and longitude coordinates and sample identifications were assigned to each intercept point on the grid. Geographic coordinates were uploaded into a global positioning system (GPS) receiver. The GPS unit was then used to navigate to intercept points. At each intercept point, plants were collected by lowering a double-headed rake on an adjustable pole to the bottom, rotating it twice, and pulling it straight up in water less than 12 ft of depth and by tossing a specialized rake on a rope and dragging the rake along the bottom sediments.

All collected plants were identified to the lowest practicable taxonomic level (e.g., typically genus or species) and recorded on field data sheets. Visual observations of aquatic plants were also recorded when plants detached from the rake and floated to the surface. Water depth and, when detectable, sediment types at each intercept point were also recorded on field data sheets.

The point intercept method was used to evaluate the existing emergent, submergent, floating-leaf and free-floating aquatic plants. If a species was not collected at a specific point, the space on the datasheet was left blank. For the survey, the data for each sample point was entered into the WDNR "Worksheets" (i.e., a data-processing spreadsheet) to calculate the following statistics:

**Taxonomic richness** (the total number of taxa detected)

- **Maximum depth of plant growth**

- **Community frequency of occurrence** (number of intercept points where aquatic plants were detected divided by the number of intercept points shallower than the maximum depth of plant growth)
- **Mean intercept point taxonomic richness** (the average number of taxa per intercept point)
- **Mean intercept point native taxonomic richness** (the average number of native taxa per intercept point)
- **Taxonomic frequency of occurrence within vegetated areas** (the number of intercept points where a particular taxon [e.g., genus, species, etc.] was detected divided by the total number of intercept points where vegetation was present)
- **Taxonomic frequency of occurrence at sites within the photic zone** (the number of intercept points where a particular taxon [e.g., genus, species, etc.] was detected divided by the total number of intercept points which are equal to or shallower than the maximum depth of plant growth)
- **Relative taxonomic frequency of occurrence** (the number of intercept points where a particular taxon [e.g., genus, species, etc.] was detected divided by the sum of all species' occurrences)
- **Mean density** (the sum of the density values for a particular species divided by the number of sampling sites)
- **Simpson Diversity Index (SDI)** (is an indicator of aquatic plant community diversity. SDI is calculated by taking one minus the sum of the relative frequencies squared for each species present. Based upon the index of community diversity, the closer the SDI is to one, the greater the diversity within the population.)
- **Floristic Quality Index (FQI)** (This method uses a predetermined Coefficient of Conservatism [C], that has been assigned to each native plant species in Wisconsin, based on that species' tolerance for disturbance. Non-native plants are not assigned conservatism coefficients. The aggregate conservatism of all the plants inhabiting a site determines its floristic quality. The mean C value for a given lake is the arithmetic mean of the coefficients of all native vascular plant species occurring on the entire site, without regard to dominance or frequency. The FQI value is the mean C times the square root of the total number of native species. This formula combines the conservatism of the species present with a measure of the species richness of the site. )

### 4.3 PUBLIC INVOLVEMENT, QUESTIONNAIRE AND PLAN REVIEW

A public questionnaire was developed by Stantec and the LELRD and reviewed by the WDNR. This questionnaire was designed to gauge lake users' opinions on a number of important topics related to APM Plan options and implementation strategies. The survey inquired about the users' perception of aquatic invasive plant problems and other lake issues. The survey was also developed to determine what lake users consider an appropriate plant management strategy and cost. The public questionnaire and results can be found in Appendix A.

In addition, a public meeting was conducted to present the current condition of the Lake, data for this APM Plan update, and directly gauge the public's input on the Lake and goals for aquatic plant management. This meeting was held on Saturday, April 6, 2013. Approximately 13 citizens were in attendance.

### 4.4 WATER QUALITY EVALUATION METHODS

Water quality sampling within the Lake has been sampled from periodically over time with the main focus on water clarity, which has been sampled 1998-2000 and again 2003-present. 2014 sampling was conducted in accordance with WDNR protocol by Stantec.

Water samples were analyzed for concentrations of chlorophyll *a* and total phosphorus. These data, along with historic water quality data, were used to help determine the trophic state index (TSI) for Little Elkhart Lake, which is discussed further in Section 3.3.

### 4.5 WATERSHED EVALUATION METHODS

Watershed and land use evaluation is a necessary component of a management plan. The land use within the watershed is one of the primary sources of nutrient release into the ecosystem. Slight changes in land use in the watershed can create major impacts on the receiving water body. For instance, if a large land area is disturbed runoff will have a greater sediment and nutrient load. The opposite can occur if major areas that were disturbed are now vegetated with trees or native plants.

Watershed evaluation includes a presentation of the data gathered as part of this project and modeling programs used to predict land use changes and watershed impacts. The Wisconsin Lake Modeling Suite (WiLMS), a screening level and water quality evaluation toll, was used to model the Lake's watershed. Using this model, estimates of nutrient and sediment runoff from various land cover types was analyzed for potential impact to the Lake. In conjunction with WiLMS, the Lake Eutrophication Analysis Procedure (LEAP) was used to model internal phosphorus loading and eutrophication indices of the Lake based on watershed land cover, creating a nutrient budget.

# 5.0 DISCUSSION OF PROJECT RESULTS

## 5.1 AQUATIC PLANT ECOLOGY

Aquatic plants are vital to the health of a water body. Unfortunately, people all too often refer to rooted aquatic plants as "weeds" and ultimately wish to eradicate them. This type of attitude, and the misconceptions it breeds, must be overcome in order to properly manage a lake ecosystem. Rooted aquatic plants (macrophytes) are extremely important for the well-being of a lake community and possess many positive attributes. Despite their importance, aquatic macrophytes sometimes grow to nuisance levels that hamper recreational activities. This is especially prevalent in degraded ecosystems. The introduction of certain aquatic invasive species (AIS), such as EWM, often can exacerbate nuisance conditions, particularly when they compete successfully with native vegetation and occupy large portions of a lake.

When "managing" aquatic plants, it is important to maintain a well-balanced, stable and diverse aquatic plant community that contains high percentages of desirable native species. To be effective, aquatic plant management in most lakes must maintain a plant community that is robust, species rich and diverse. Appendix B includes a discussion about aquatic plant ecology, habitat types and relationships with water quality.

## 5.2 AQUATIC INVASIVE SPECIES

AIS are aquatic plants and animals that have been introduced by human action to a location, area or region where they did not previously exist. AIS often lack natural control mechanisms. They may have had in their native ecosystem, and may interfere with the native plant and animal interactions in their new "home". Some AIS have aggressive reproductive potential and contribute to a decline of a lake's ecology and interfere with recreational use of a lake. Common Wisconsin AIS include:

- Eurasian Watermilfoil
- Curly Leaf Pondweed
- Flowering Rush
- Zebra Mussels
- Rusty Crayfish
- Spiny Water Flea
- Purple Loosestrife

Appendix C provides additional information on these AIS.

## 5.3 2012 AQUATIC PLANT SURVEY

The survey was carried out July 23 and 27, 2012, and included sampling at 232 intercept points. The aquatic macrophyte community of the Lake included 23 free floating, floating leaf, emergent and submerged aquatic plant species during 2012. Table 1 lists the taxa identified during the 2012 aquatic plant survey. Figures 1.1-1.4 illustrate the locations of each species identified.

**Table 1: Taxa Detected During 2012 Aquatic Plant Survey, Little Elkhart Lake, Sheboygan County, WI**

| Genus | Species | Common Name | Category |
|---|---|---|---|
| ***Myriophyllum*** | ***spicatum*** | **Eurasian water-milfoil** | **Invasive** |
| *Algae* | *sp.* | Filamentous algae | Submersed |
| *Bidens* | *beckii* | Water marigold | Submersed |
| *Brasenia* | *schreberi* | Watershield | Floating-leaf |
| *Ceratophyllum* | *demersum* | Coontail | Submersed |
| *Chara* | *sp.* | Muskgrass | Submersed |
| *Eleocharis* | *acicularis* | Needle spikerush | Submersed |
| *Elodea* | *canadensis* | Common waterweed | Submersed |
| *Iris* | *versicolor* | Northern blue flag | Emergent |
| *Lemna* | *trisulca* | Forked duckweed | Free-floating |
| *Myriophyllum* | *sibiricum* | Northern water-milfoil | Submersed |
| *Najas* | *flexilis* | Bushy pondweed | Submersed |
| *Nitella* | *sp.* | Nitella | Submersed |
| *Nuphar* | *variegata* | Spatterdock | Floating-leaf |
| *Nymphaea* | *odorata* | White water lily | Floating-leaf |
| *Polygonum* | *amphibium* | Water smartweed | Emergent |
| *Potamogeton* | *amplifolius* | Large-leaf pondweed | Submersed |
| *Potamogeton* | *gramineus* | Variable pondweed | Submersed |
| *Potamogeton* | *zosteriformis* | Flat-stem pondweed | Submersed |
| *Schoenoplectus* | *acutus* | Hard-stem bulrush | Emergent |
| *Stuckenia* | *pectinata* | Sago pondweed | Submersed |
| *Typha* | *latifollia* | Broad-leaved cattail | Emergent |
| *Utricularia* | *vulgaris* | Common bladderwort | Submersed |

A diverse plant community was present during 2012. The Simpson Diversity Index value of the community was 0.89, taxonomic richness was 23 species, there was an average of 2.91 species identified at points that were within the photic zone and an average of 2.94 species present at points with vegetation present. Two AIS were identified in Little Elkhart Lake: Eurasian water-milfoil and curly-leaf pondweed (2013 post-treatment). Table 2 summarizes overall aquatic plant community statistics.

**Table 2: 2012 Aquatic Plant Community Statistics, Little Elkhart Lake, Sheboygan County, WI.**

| | |
|---|---|
| Date Sampled | 07/23 & 07/27/2012 |
| Points Sampled | 220 |
| Points with vegetation | 199 |
| Points shallower than maximum depth of plants | 201 |
| Frequency of occurrence | 99.00% |
| Simpson Diversity Index | 0.89 |
| Maximum depth of plants (ft) | 18 |
| Average number of species per site (shallower than max depth) | 2.91 |
| Average number of species per site (veg. sites only) | 2.94 |
| Average number of native species per sire (shallower than max depth) | 2.83 |
| Average number of native species per site (veg. sites only) | 2.88 |
| Species Richness | 23 |

The most abundant aquatic plant identified during the aquatic plant survey was muskgrass (*Chara sp.*). It exhibited a 59.7% frequency of occurrence and was present at 60.3% of the sites with vegetation. Large-leaf pondweed (*Potamogeton amplifolius*) was the second most abundant species occurring at 40.8% of the photic zone and was present at 41.2% of the sites with vegetation. The third most abundant species, coontail (*Ceratophyllum demersum*), was present at 34.8% of photic zone sites and 35.2% of sites with vegetation. Table 3 includes the abundance statistics for each species.

Eurasian water-milfoil was sampled during the 2012 at 12 locations. This equates to a 5.97% frequency of occurrence and presence at 6.03% of the sites with vegetation and approximately 4.35 acres. EWM coverage within the lake has increased over the most recent seasons (2012 to 2013 post-treatment) from 4.35 acres to the current 5.71 acres as surveyed by Stantec in 2013. However, these conditions are much improved from pre large-scale management acreage of 15.35 acres in 2010, down 63% from 2010 to 2013.

**Table 3: 2012 Aquatic Plant Taxa-Specific Statistics, Little Elkhart Lake, Sheboygan County, WI**

| Common Name | Percent Frequency of Occurrence within vegetated areas | Percent Frequency of Occurrence at sites shallower than max depth of plants | Percent Relative Frequency of Occurrence | Number of Intercept Points Where Detected | Average Density |
|---|---|---|---|---|---|
| Eurasian water-milfoil | 6.03 | 5.97 | 2.05 | 12 | 1.00 |
| Filamentous algae | 2.01 | 1.99 | 0.68 | 4 | 1.00 |
| Water marigold | 1.51 | 1.49 | 0.51 | 3 | 1.00 |
| Watershield | 10.55 | 10.45 | 3.59 | 21 | 1.19 |
| Coontail | 35.18 | 34.83 | 11.97 | 70 | 1.29 |
| Muskgrass | 60.30 | 59.70 | 20.51 | 120 | 1.48 |
| Needle spikerush | 0.50 | 0.50 | 0.17 | 1 | 1.00 |
| Common waterweed | 9.05 | 8.96 | 3.08 | 18 | 1.00 |
| Northern blue flag | 0.50 | 0.50 | 0.17 | 1 | 1.00 |
| Forked duckweed | 20.60 | 20.40 | 7.01 | 41 | 1.00 |
| Northern water-milfoil | 5.53 | 5.47 | 1.88 | 11 | 1.00 |
| Bushy pondweed | 14.57 | 14.43 | 4.96 | 29 | 1.10 |
| Nitella | 8.04 | 7.96 | 2.74 | 16 | 1.25 |
| Spatterdock | 4.02 | 3.98 | 1.37 | 8 | 1.00 |
| White water lily | 34.17 | 33.83 | 11.62 | 68 | 1.07 |
| Water smartweed | 1.01 | 1.00 | 0.34 | 2 | 1.00 |
| Large-leaf pondweed | 41.21 | 40.80 | 14.02 | 82 | 1.10 |
| Variable pondweed | 4.02 | 3.98 | 1.37 | 8 | 1.00 |
| Flat-stem pondweed | 24.62 | 24.38 | 8.38 | 49 | 1.18 |
| Hard-stem bulrush | 2.51 | 2.49 | 0.85 | 5 | 1.00 |
| Sago pondweed | 0.50 | 0.50 | 0.17 | 1 | 1.00 |
| Broad-leaved cattail | 0.50 | 0.50 | 0.17 | 1 | 1.00 |
| Common bladderwort | 7.04 | 6.97 | 2.39 | 14 | 1.14 |

EWM is a submersed aquatic plant native to Europe, Asia and northern Africa. It was introduced to the United States by early European settlers. EWM was first detected in Wisconsin lakes during the 1960's. In the past three decades, AIS has significantly expanded its known range to 69 of Wisconsin's 72 counties, and continues to infest new water bodies every year. Because of its potential for explosive growth and its incredible ability to regenerate, EWM can successfully out-compete most native aquatic plants, especially in disturbed areas.

EWM shows no substrate preference in most instances and can grow in water depths greater than 4 meters (Nichols, 1999). Dense beds of EWM are usually identified in soft/organic rich sediments in many lakes. It can reproduce by seeds, but its main form of reproduction is vegetative by fragmentation, which allows it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried by water currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, trailers, bilges, live wells or bait buckets, and can stay alive for weeks if kept moist. Once established in an aquatic

community, EWM reproduces from shoot fragments and stolons (runners that creep along the substrate).

EWM is an opportunistic species and is adapted for rapid growth early in spring which 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 that reduce habitat diversity and threaten the integrity of aquatic communities. For example, dense stands disrupt predator-prey relationships by fencing out larger fish and reducing the number of nutrient-rich native plants available for waterfowl (DNR, 2002).

Curly-leaf pondweed, also an invasive species, is also present within the Lake. CLP occurred at only one location covering approximately 0.16 acres during the 2013 post-treatment survey and none during the 2012 full point-intercept survey. Due to CLP's life cycle, the best time to gauge distribution of the plant is in spring before it dies off in mid-summer and the 2012 and 2013 surveys may not be a true representation of AIS within the Lake due to timing. However, in previous early season surveys to identify treatment areas, it has not been present in dense colonies. Curly-leaf pondweed does not appear to be problematic at this time. Because of its limited distribution within the Lake, control of this species is not recommended; however, further monitoring is recommended to ensure that it does not become problematic in the future.

CLP spreads through burr-like winter buds (turions), which are moved among waterways. This plant also reproduces by seed, but vegetative reproduction through turions is much more common. New plants form under the ice in winter, making CLP one of the first nuisance aquatic plants to emerge in the spring. The leaves of CLP 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 dies and drops to the lake bottom anywhere from early July to mid-August, depending on water temperatures and that particular growing season.

CLP becomes invasive in some areas because of its tolerance for low light and water temperatures. These tolerances allow it to out-compete native plants in the spring. CLP forms surface mats that interfere with aquatic recreation in mid-summer. CLP dies off prior to the end of the growing season, when most aquatic plants are growing. These die-offs potentially result in a reduction of dissolved oxygen, and increased nutrients levels which can contribute to algal blooms that create unpleasant smelling messes on beaches and shores (WDNR website, 2006).

### 5.3.1 Free-Floating Plants

The following is a list of the free floating aquatic plant species identified within the Lake during the 2012 aquatic plant survey. Descriptions of all species sampled can be found in Appendix C.

- *Lemna trisulca* - forked duckweed

### 5.3.2 Submergent Plants

The following is a list of submergent aquatic plant species identified within the Project Area during the 2012 aquatic plant survey.

- *Algae sp.* - filamentous algae [algal]
- *Bidens beckii* – water marigold
- *Ceratophyllum demersum* - coontail
- *Chara sp.* - chara or muskgrass [algal]
- *Eleocharis acicularis* – needles spikerush
- *Elodea canadensis* - elodea or common waterweed
- *Myriophyllum sibiricum* – northern water-milfoil
- ***Myriophyllum spicatum* - Eurasian water-milfoil**
- *Najas felxilis* - slender naiad

- *Nitella sp.* - nitella or stonewort [algal]
- *Potamogeton amplifolius* - large-leaf pondweed
- *Potamogeton gramineus* – variable pondweed
- *Potamogeton zosteriformis* - flat-stem pondweed
- *Stuckenia pectinata* – sago pondweed
- *Utricularia vulgaris* – common bladderwort

#### 5.3.3 FLOATING-LEAF PLANTS

The following is a list of floating-leaf aquatic plant species identified within the Project Area during the 2012 aquatic plant survey.

- *Brasenia schreberi* - watershield
- *Nuphar variegata* – spatterdock
- *Nymphaea odorata* – white water lily

#### 5.3.4 EMERGENT PLANTS

The following is a list of emergent aquatic plant species identified within the Project Area during the 2011 aquatic plant survey.

- *Iris versicolor* – northern blue flag
- *Polygonum amphibium* – water smartweed
- *Schoenoplectus acutus* - hardstem bulrush
- *Typha latifolia* – broad-leaved cattail

### 5.4 FLORISTIC QUALITY INDEX

Higher FQI numbers indicate higher floristic quality and biological integrity and a lower level of disturbance impacts. FQI varies around the State of Wisconsin and ranges from 3.0 to 44.6 with an average FQI of 22.2 (WDNR, 2005). Coefficient of Conservatism values (C values) relate to a plant species' ability to tolerate disturbance. Low C values (0-3) indicate that a species is very tolerant of disturbance, while high C values (7-10) indicate species with a low tolerance of disturbance. Intermediate C values (4-6) indicate plant species that can tolerate moderate disturbance. The following provides the calculated FQI and mean C values for each water body surveyed within the Lake during the 2012 aquatic plant survey. It should be noted that filamentous algae, EWM and CLP do not have assigned C values, and therefore were not included in the FQI. A summary of C values by species sampled and each year's FQI is found in Table 4. Data from the 2013 post-treatment survey is included.

**Table 4: Historic and 2012 Floristic Quality Indicies, Little Elkhart Lake, Sheboygan County, WI**

| Common Name | 2002 | 2009 | 2012 | 2013* |
|---|---|---|---|---|
| Watershield | 6 | 6 | 6 | 6 |
| Coontail | 3 | 3 | 3 | 3 |
| Muskgrass | 7 | 7 | 7 | 7 |
| Needle spikerush | --- | 5 | 5 | --- |
| Common waterweed | 3 | 3 | 3 | 3 |
| Water star-grass | 6 | --- | --- | --- |
| Northern blue flag | --- | --- | 5 | --- |
| Forked duckweed | 6 | 6 | 6 | 6 |
| Small duckweed | 4 | --- | --- | 4 |
| Water marigold | 8 | 8 | 8 | --- |
| Northern water-milfoil | 6 | 6 | 6 | 6 |
| Whorled water-milfoil | --- | 8 | --- | --- |
| Bushy pondweed | 6 | 6 | 6 | 6 |
| Nitella | 7 | 7 | 7 | 7 |
| Yellow pond lily | --- | 8 | --- | --- |
| Spatterdock | 6 | 6 | 6 | 6 |
| White water lily | 6 | 6 | 6 | 6 |
| Water smartweed | --- | --- | 5 | 5 |
| Large-leaf pondweed | 7 | 7 | 7 | 7 |
| Variable pondweed | --- | --- | 7 | --- |
| Illinois pondweed | 6 | 6 | --- | 6 |
| Floating-leaf pondweed | 5 | 5 | --- | 5 |
| Small pondweed | 7 | 7 | --- | --- |
| Flat-stem pondweed | 6 | 6 | 6 | 6 |
| Stiff water crowfoot | --- | 8 | --- | --- |
| Hardstem bulrush | --- | 6 | 6 | 6 |
| Softstem bulrush | --- | 4 | --- | --- |
| Sago pondweed | 3 | 3 | 3 | --- |
| Broad-leaved cattail | --- | 1 | 1 | --- |
| Flat-leaf bladderwort | --- | 9 | --- | --- |
| Small bladderwort | --- | 10 | --- | --- |
| Common bladderwort | 7 | 7 | 7 | 7 |
| Total Species | 20 | 27 | 21 | 18 |
| Mean C | 5.75 | 6.07 | 5.52 | 5.67 |
| **Floristic Quality Index (FQI)** | **25.71** | **31.56** | **25.31** | **24.04** |

* - Based on 2013 post-treatment survey, not a full point-intercept survey

The FQI calculated from the 2012 aquatic plant survey data was 25.31 with an average C of 5.52. These values, when compared to the Southeastern Till Plains Eco-region means of 14.3 and 5.0 respectively, are above average with the FQI being in the upper quartile of lakes for the regions (Table 5).

**Table 5: FQI and Average Coefficient of Little Elkhart Lake Compared to Wisconsin and Southeastern Till Plain lakes.**

| | Average Coefficient of Conservatism | | | Floristic Quality | | |
|---|---|---|---|---|---|---|
| Quartile* | Lower | Mean | Upper | Lower | Mean | Upper |
| Wisconsin Lakes | 5.5 | 6 | 6.9 | 16.9 | 22.2 | 27.5 |
| Southeastern Till Plains | 5.2 | 5.6 | 5.8 | 17 | 20.9 | 24.4 |
| Little Elkahrt Lake - 2012 | 5.52 | | | 25.31 | | |

* - Values indicate highest value of the lowest quartile, mean, and lowest value of the upper quartile

Lakes within the Southeastern Till Plains are typically natural lakes that, due to higher population density in this area of the State, have developed shoreline. Increased development around a lake and overall use of these lakes leads to more disturbance form an expected natural condition, which leads to lower plant community metrics like FQI and coefficient of conservatism. Both of these are

below the average for all Wisconsin lakes due to this. For Little Elkhart Lake, however, the FQI indicates a plant community typically associated with lower disturbance levels and of high quality, especially for this region.

This is, in part, due to fairly high diversity within Little Elkhart Lake. Though EWM is present, there is a diverse native plant community still present. 22 native species were found during the 2012 survey with an average of 2.91 native species per sample point with vegetation present with many sample points having more than this and up to eight native species present. This diverse native plant community is important should any AIS management continue as they are already established and present to populate areas vacated by EWM due to potential management. Many lakes with EWM growth, especially within this region, lack a native community to do so.

### 5.5 HISTORICAL AQUATIC PLANT DATA COMPARISON

The aquatic plant community of Little Elkhart Lake has been sampled numerous times throughout its history providing a unique opportunity to gauge changes over the years. Beginning with line transect surveys in 1977 and 2002, protocol was changed to be more repeatable with point intercept surveys. Full point intercept surveys have been completed in 2009 and 2012 with limited surveys associated with treatments occurring semi-annually since 2009. Data from the original, 1977 line-transect survey is not available.

Though the survey methods have changed, the relative plant community within the lake has remained stable in abundance and diversity throughout all surveys. As this happens, species diversity, average coefficient of conservatism and FQI are relatively stable over time as the lake ecosystem ages. These trends play out and are shown to be stable for all metrics over time when comparing historical survey data (Table 4, section 5.4).

From the three most recent, full lake aquatic plant surveys a few changes are evident. The five most common species in the three most recent surveys are variable, as expected for a waterbody with a diverse aquatic plant community. Notably, however, is the absence of Eurasian water-milfoil from the most dominant species. EWM was present in much higher numbers in 2002, but due to continued management has decreased substantially. This decrease in EWM has allowed more desirable, native plants to flourish, as noted by the increase in two pondweed species from 2002 to 2012 (Table 6).

**Table 6: Historical Aquatic Plant Community Statistics, Little Elkhat Lake, Sheboygan County, WI**

| | 2002 | 2009 | 2012 |
|---|---|---|---|
| **F.o.o. at sites shallower than maximum depth of plants** | 0.9259 | 0.9231 | 0.99 |
| **Simpson Diversity Index** | NA | 0.92 | 0.89 |
| **Most Dominant Species** | Northern water-milfoil | Muskgrass | Muskgrass |
| | Eurasian water-milfoil | Coontail | Large-leaf pondweed |
| | Bushy pondweed | Forked duckweed | Coontail |
| | Small pondweed | Common waterweed | White water lily |
| | Forked duckweed | Bushy pondweed | Flat-stem pondweed |
| **Species Richness** | 21 | 30 | 23 |
| **Community FQI** | 25.71 | 31.56 | 25.31 |
| **Average Coeffecient of Conservatism** | 5.75 | 6.07 | 5.52 |

**Table 7: Historical Aquatic Plant Occurrences, Little Elkhart Lake, Sheboygan County, WI.**

| Common Name | Year | | |
|---|---|---|---|
| | 2002 | 2009 | 2012 |
| Eurasian water-milfoil | 59.26 | 23.98 | 5.96 |
| Filamentous algae | --- | 3.17 | 1.99 |
| Watershield | 3.70 | 5.43 | 10.45 |
| Coontail | 22.22 | 35.29 | 34.83 |
| Muskgrass | 22.22 | 44.80 | 59.70 |
| Needle spikerush | --- | 1.36 | 0.50 |
| Common waterweed | 14.81 | 29.41 | 8.96 |
| Water star-grass | 3.57 | --- | --- |
| Northern blue flag | --- | --- | 0.50 |
| Forked duckweed | 37.04 | 34.84 | 20.40 |
| Small duckweed | 3.57 | --- | --- |
| Water marigold | 21.43 | 0.90 | 1.49 |
| Watermoss | --- | 0.90 | --- |
| Northern water-milfoil | 70.37 | 23.98 | 5.47 |
| Whorled water-milfoil | --- | V | --- |
| Bushy pondweed | 40.74 | 29.41 | 14.43 |
| Nitella | 29.63 | 17.19 | 7.96 |
| Yellow pond lily | --- | V | --- |
| Spatterdock | 7.41 | 2.26 | 3.98 |
| White water lily | 29.63 | 15.38 | 33.83 |
| Water smartweed | --- | --- | 1.00 |
| Large-leaf pondweed | 25.93 | 12.57 | 40.80 |
| Variable pondweed | --- | --- | 3.98 |
| Illinois pondweed | 25.93 | 9.50 | --- |
| Floating-leaf pondweed | 7.14 | V | --- |
| Small pondweed | 37.04 | 1.81 | --- |
| Flat-stem pondweed | 11.11 | 23.08 | 24.38 |
| Stiff water crowfoot | --- | 0.45 | --- |
| Hardstem bulrush | --- | V | 2.49 |
| Softstem bulrush | --- | 0.45 | --- |
| Sago pondweed | 3.70 | 6.33 | 0.50 |
| Broad-leaved cattail | --- | 1.36 | 0.50 |
| Flat-leaf bladderwort | --- | 0.45 | --- |
| Small bladderwort | --- | 4.07 | --- |
| Common bladderwort | 18.52 | 9.95 | 6.97 |

V - species was visually recorded only with no statistics calculated

Over the two most recent surveys (2009 and 2012), the aquatic plant community has seen some minor changes, most notably a sampled decrease in diversity from 30 to 23 species. Species sampled in 2009 but not present in 2012 include watermoss, whorled water-milfoil, yellow pond lily (likely spatterdock), Illinois pondweed, floating-leaf pondweed, small pondweed, stiff water crowfoot, softstem bulrush, flat-leaf bladderwort and small bladderwort. Though 10 species appear to have dropped out from 2009 to 2012, two of them, Illinois pondweed and floating-leaf pondweed, were sampled during the 2013 post-treatment survey.

Data comparison between years on the Lake shows that the Lake exhibits a healthy, dynamic aquatic plant community. Dominant species will vary year to year depending on many factors including weather patterns, community composition in year's prior, water levels and more. Some conditions may be favorable for certain species during one growing year but not others and vice versa. This is common and indicative of a healthy lake. For example, past surveys may have been under favorable conditions. This is illustrated in the variance of Illinois pondweed; 25.9% relative

frequency of occurrence in 2002, 9.50% in 2009, not sampled in 2012, but sample again during 2013. Variance is normal and that noted within Little Elkhart Lake is currently not a cause for concern.

Even though as the macrophyte community of the lake matures, AIS are an ever increasing threat. Eurasian water-milfoil is the most prevalent AIS present though it has decreased dramatically from the 2002 survey, 59.3% frequency, to 2012 survey findings of 5.96%. This species was found growing in dense, often monotypic colonies matting on the water's surface within the Lake and has dominated shallow, soft-sediment areas.

Though drastically reduced in recent years, locally dense growth of EWM and sometimes seasonally heavy native aquatic plant growth, in near-shore areas and bays can cause increasingly difficult navigation and lake use for lake users, as shown by 85.7% of questionnaire responds indicating AIS growth has negatively affected their use of the lake. If EWM is continued to be left unchecked it will outcompete native plant communities and alter species composition in a high quality waterbody.

### 5.6 WATERSHED EVALUATION

The Wisconsin Lake Modeling Suite (WiLMS) is a WDNR computer software program that is used to model lake water quality based on watershed land use and current water quality data. WiLMS can be used as a planning tool to assist in management recommendations or procedures within a watershed to ensure stable or increased water quality. Using WiLMS developed by the WDNR a lake total phosphorous prediction model and a lake eutrophication analysis procedure model was developed for the combined lakes in the watershed.

LEAP is a program within WiLMS that predicts lake trophic status indices based on watershed area, lake depth and lake ecoregion. For Little Elkhart Lake, the watershed without the Lake itself is 693.1 acres while the Lake has a mean depth of 7.9 feet and total surface area of 56.3 acres within the watershed and it belongs in the Southeast Wisconsin Till Plain ecoregion.

The LEAP program then takes into account the current, collected water quality data of phosphorus, chlorophyll *a* and secchi depth and statistically compares these values against predicted values to screen for any potential issues.

After running LEAP for the Little Elkhart Lake watershed, the difference between the actual and predicted trophic state values for total phosphorus and chlorophyll *a* were found to be insignificant using a scientific T-test with a 90% confidence interval. However, the difference between the actual and predicted value for secchi depth was found to be significantly lower than predicted, meaning the water in Little Elkhart Lake is exceptionally clear for a lake in its ecoregion. Overall, the data shows that the water quality within the Lake is within the predicted range based on its watershed for the Ecoregion.

LEAP was also used to predict the possibility of nuisance algal blooms within the Lake. This occurs when excess nutrients are available for planktonic algae, resulting in increased amounts and leading to soupy, green colored water and reduced water clarity and recreational value and are associated with chlorophyll a readings of > 20.0 ug/L. Based on current conditions of the Lake and its watershed, the chance that these levels meet or exceed the nuisance threshold at any one time annually are low, approximately 36%, and remain low when extrapolated out to multiple years at 39%, further re-enforcing the excellent water quality within the lake.

Using WiLMS, a Lake Total Phosphorous Prediction (LTPP) model was used to predict the amount of phosphorus loading into the Lake from within its watershed boundaries through non-point sources. This is important because in many lakes, phosphorus is the limiting nutrient for plant growth. An increase in phosphorus levels will allow for increased plant growth and possibly cause problematic algae blooms if phosphorus loading becomes too high.

The LTPP predicted a total phosphorous amount of 110 kg per year being added to the waterbody through non-point sources. The predicted amount of phosphorous contributed into the watershed

through each land use is different. A breakdown of phosphorus loading by land cover with the Little Elkhart Lake Watershed is shown below. Agricultural land inputs the most annually, at approximately 39 kg/year while internal loading or recycling, of phosphorus already in the lake accounts for 7 kg of the Lake's budget per year. Commercial land listed below includes portions of Road America property within the watershed and was listed as such due to high amounts of impervious surfaces. There are no direct, point sources for phosphorus loading into the Lake. Direct model outputs are found in Appendix G.

| | | Phosphorus Loading | |
|---|---|---|---|
| **Land Use** | **Acres** | **kg / year** | **Average kg / acre / year** |
| Mixed Agricultural | 121.53 | 39 | 0.32 |
| Commercial / Industrial | 47.58 | 29 | 0.61 |
| Coniferous Forest | 3.16 | 0.12 | 0.04 |
| Deciduous Forest | 241.13 | 8.88 | 0.04 |
| Grassland / Shrubland | 95.52 | 12 | 0.13 |
| Open Water | 56.3 | 7 | 0.12 |
| Rural Residentail | 155.1 | 6 | 0.04 |
| Road | 10.77 | 7 | 0.65 |
| Wetlands | 18.33 | 1 | 0.05 |
| **TOTAL** | **749.42** | **110** | **2.00** |

Areas of natural land cover, such as forests and wetlands, have reduced runoff and release lower rates of phosphorus into the lakes compared to developed areas with higher amounts of impervious surfaces, such as roads and buildings. Meaning, though forests may occupy the largest percent of land cover, they do not contribute the largest percent of phosphorus loading into the Lake. Agricultural land, though only 16.2% of the total watershed area attributes 35.4% of the annual phosphorus load into the Lake.

| Land Use | Acres | Percent of Watershed | Percent of Phosphorus Loading |
|---|---|---|---|
| Mixed Agricultural | 121.53 | 16.22% | 35.45% |
| Commercial / Industrial | 47.58 | 6.35% | 26.36% |
| Coniferous Forest | 3.16 | 0.42% | 0.11% |
| Deciduous Forest | 241.13 | 32.18% | 8.07% |
| Grassland / Shrubland | 95.52 | 12.75% | 10.91% |
| Open Water | 56.3 | 7.51% | 6.36% |
| Rural Residentail | 155.1 | 20.70% | 5.45% |
| Road | 10.77 | 1.44% | 6.36% |
| Wetlands | 18.33 | 2.45% | 0.91% |
| **TOTAL** | **749.42** | **100.00%** | **100.00%** |

Currently, water quality is excellent within the Lake when comparing model data. All three trophic status indices are below predicted values for its ecoregion with exceptional water clarity. Though agricultural land is the third highest percent of land cover and highest contributor of phosphorus into the Lake, there is none that directly abuts the Lake and modeled input may be slightly high though there is reason for concern as indicated below, which is reprinted from the County's current Land and Water Resource Plan, for this watershed;

"*Unfortunately, there are indications that overall [agriculture] soil erosion rates are going back up. Several factors that point to this are:*

*1. Changes in dairy feeding operations have seen an increase in corn grown for silage.*
*2. A number of dairy farms have been expanding and are putting greater emphasis on corn silage. Growing corn silage on a given field results in more erosion than corn for grain according to NRCS "C" factors. Also growing corn for silage practically eliminates the potential for conservation tillage to leave at least 30% residue after planting.*
*3. Over the last five years, landowners have been dropping out of the FPP due to income restrictions resulting in little or no tax credit. Without the T-value requirement associated with the FPP to contend with, these farms are prone to more erosive cropping practices."*

Given these increases and as agriculture is the largest potential contributor of nutrient loading into the Lake/watershed, management options can be taken to reduce input. Sheboygan County's Land and Water Resource Plan outlines best management practices to reduce nutrient runoff including grass waterways. This plan is available online at http://www.sheboygancounty.com/home/showdocument?id=468 Participation in any activities outlined within this plan by property owners within the watershed would be optional. Furthermore the Town of Rhine has opted out of County comprehensive zoning, and has adopted Village powers and administrates their own Town zoning code. While there is an agricultural land use/zoning designation there are no specific requirements for compliance with any runoff or buffer standards. However, it is recommended the District, Township and County Conversation Department work with agricultural landowners to enact watershed controls as appropriate to ensure continued water quality, where feasible.

One area of substantial impervious surface within the watershed is the Road America race track. While the entire track and all building are impervious surfaces, currently most of the spectator parking is on grass surfaces. If there are plans for expansion or improvements in the future, thought should be given for impervious pavers and/or grass buffer strips and drainage swales to minimize any adverse impacts within the watershed when permits are sought from the WDNR for land disturbances over 1 acre.

### 5.7 MEMBERSHIP QUESTIONNAIRE AND PUBLIC INPUT

A membership questionnaire was sent out to all members of the Little Elkhart Lake Rehabilitation District and made available to the general public and any interested lake user. This survey was also made available online. Results are included in Appendix A.

In total, 23 responses (22 which were District members) to the survey were completed with all but one residing within District boundaries. Respondents have a great personal history with the Lake with 70% of respondents having recreationally enjoyed the Lake for at least 10 years with most (43.5%) rating their experiences on the Lake as "Very enjoyable". Little Elkhart Lake can be a highly recreated waterbody during summer months with by low-impact activities which, at times, can be increased by extensive use from Camp Anokijig residents. Results among users favorite activities from the survey reflected this and are, in order, based on average ranking; canoeing or kayaking, pontoon boating, open water fishing and pleasure boating. Pontoon boating garnered the most votes as their #1 favorite.

Though responses indicate experiences on the Lake are highly enjoyed, they have not been without impact from aquatic invasive species growth. Nearly half (47.8%) of users that responded replied that there enjoyment overtime have lessened to a degree with 64.3% of these respondents attributing it directly to excessive aquatic plant growth. In conjunction, 85.7% of users indicated that excessive AIS growth negatively impacted their use of the Lake at least some of the time.

Because of the impact of EWM and sometimes dense, native growth of aquatic plants on their recreation and enjoyment of Little Elkhart Lake, 100% of respondents believe aquatic plant management is needed. To control AIS within the Lake, respondents ranked herbicide control as their top option for followed by relying on DNR guidance. Mechanical harvesting for AIS control was the third choice among survey respondents.

Based on the respondent's goals for the APM plan questionnaire, the main focus should be on reducing the extent and density of existing AIS with a plan in place to obtain grant funding assistance for AIS management efforts (number 1 and 2 overall ranked goals). AIS management cannot be a single pronged approach. An important part of this process is monitoring to ensure AIS do not spread out of/or into Little Elkhart Lake. Respondents indicated a strong desire to have a secondary potential option for AIS management. Preventing the spread of existing AIS was the top choice for 2nd most important management options.

Navigational impact due to native plant growth is also a concern among District residents with active management for impedance taking place within the past three years. For 85.7% of District members who responded to the survey, aquatic plant growth has impacted their navigation within portions of the Lake. Much of this has been caused by a combination of both floating-leaf and submersed aquatic plant species (71.4%).

Currently, Town of Rhine municipal code limits periods on lakes within the Township for boating in relation to speed and operation of gasoline motors as follows:

- Slow, No-wake from 7:30 pm until 10:00 am – Year round
- 35-mph speed limit – Open water only
- Slow, no-wake and electric motors only on Sundays from the second Sunday in June through the third Sunday in September.

Due to the Lake's small size and increasing use, District members have recently proposed increasing regulations on the Lake. To begin the process, several questions were included within the questionnaire.

To begin, the majority (68.2%) would like to see a speed limit continue to be enforced on the Lake. However, a change in timing of a speed limit is sought. Only 26.7% want the limit to be enforced during the open water season only (status quo). Conversely, 66.7% want the enforcement to apply year long, including during iced-over periods with most (40%) requesting a change to an all year, all hours limit.

A 35-mph speed limit is currently in place during open-water periods only (applied to watercraft only). 100% of respondents chose proposed limits less than the current municipal code. 85.7% want the speed limit to be dropped to 25 mph or less, with the highest choice of dropping it to 10 mph or less (35.7%). The District is also in the process of working with the Town and WDNR wardens in evaluating a reduction in the lake speed limits.

# 6.0 MANAGEMENT ALTERNATIVES AND RECOMMENDATIONS

Based on the goals of the stakeholders as mentioned in section 3.6, several management alternatives are available for this APM plan. Some general alternatives are discussed below. More information on management alternatives are included in Appendix F. The following management alternatives are based on historical, aquatic plant management approaches and incorporate needs established by the questionnaire and recommendations of Stantec.

## 6.1 AQUATIC PLANT MAINTENANCE ALTERNATIVES

Maintenance alternatives may be used at a lake in which a healthy aquatic plant community exists and invasive and non-native plant species are generally not present. Maintenance alternatives are a protection-oriented because no significant plant problems exist or no active manipulation is required. These alternatives can include an educational plan to inform lake shore owners of the value of a natural shoreline and encourage the protection of the lake water quality and the native aquatic plant community.

### 6.1.1 AQUATIC INVASIVE SPECIES MONITORING

Two AIS were identified within the Project Area during the 2012 full point-intercept survey and 2013 pre-treatment survey. In order to monitor existing populations of current AIS and for new AIS in the future, a strong Lake monitoring program that surveys for AIS is highly recommended. In some lake systems native aquatic plants "hold their own" and AIS never grow to nuisance levels; however, in others active management is required. The spread of AIS can be caused by several factors, including water quality.

Stantec recommends completing pre and post treatment aquatic plant monitoring in any areas that are actively managed for AIS control to evaluate management effectiveness. Aquatic plant communities may undergo changes for a variety of reasons, including varying water levels, water clarity, nutrient levels and aquatic plant management actions. In general, lake-wide aquatic plant surveys are recommended every year to monitor changes in the overall aquatic plant community during large-scale treatments and then again every 5 years once small scale, maintenance treatments take place to monitor and the effects of the aquatic plant management activities.

### 6.1.2 CLEAN BOATS/CLEAN WATERS CAMPAIGN

Prevention of the introduction of new AIS to the Lake and spread of existing AIS from the Lake should be a priority. To prevent the spread of AIS from Little Elkhart Lake, a monitoring program such as CB/CW is an excellent choice. This program is carried out by trained volunteers who inspect incoming and outgoing boats at launches. Signage also accompanies the use of CB/CW to inform lake users of proper identification of AIS and boat inspection procedures. Education of club members about inspecting watercraft for AIS before launching a boat or leaving access sites on other lakes could help prevent new AIS infestations.

CB/CW is currently sporadic on Little Elkhart Lake through a joint effort between the Glacierland RC&D, which hires the Sheboygan County invasive species coordinator, and District residents. However, use of the program on Little Elkhart Lake is low, only 14.25 hours in 2012 and 11 hours in 2013. Increased joint participation of this program is recommended and should be promoted within the District and the County.

### 6.1.3 AQUATIC PLANT PROTECTION AND SHORELINE MANAGEMENT

Protection of the native aquatic plant community is needed to slow the spread of AIS from lake to lake and within a lake once established. Therefore, riparian landowners should refrain from removing

native vegetation. Additionally, EWM and CLP can thrive in nutrient (phosphorus and nitrogen) enriched waters or where nutrient rich sediments occur. Two relatively simple actions can prevent excessive nutrients and sediments from reaching the lake.

The first activity is the restoration of natural shorelines, which act as a buffer for runoff containing nutrients and sediments. This can be a potential issue within Little Elkhart Lake, as much of the watershed is agricultural use. Good candidates for shoreland restorations include areas that are mowed to the lake's edge, or that have structures directly adjacent to the lake edge. Establishing natural shoreline vegetation can sometimes be as easy as not mowing to the water's edge. Native plants can also be purchased from nurseries for restoration efforts. Shoreline restoration has the added benefits of providing wildlife habitat and erosion prevention. Or many times a simple "no mow" buffer strip 35' – 50' back from the water's edge can provide an effective and economical restoration for shoreland property owners. A vegetated buffer area can also prevent surface water runoff from roads, parking areas and lawns from carrying nutrients to the Lake. Currently, much of the Lake's shoreline is in a natural condition, providing an important buffer from runoff impacts.

The second easy nutrient prevention effort is to use lawn fertilizers only when a soil test shows a lack of nutrients. Importantly, fertilizers containing phosphorus, though readily available to the consumer, are illegal for use in Wisconsin, unless a soil test shows a deficiency in phosphorus. The fertilizers commonly used for lawns and gardens have three major plant macronutrients: Nitrogen, Phosphorus and Potassium. These are summarized on the fertilizer package by three numbers. The middle number represents the amount of phosphorus. Since most Wisconsin lakes are "Phosphorus limited", meaning additions of phosphorus can cause increased aquatic plant or algae growth, preventing phosphorus from reaching the lake is a good practice. Local retailers and lawn care companies can provide soil test kits to determine a lawn's nutrient needs. Of course, properties with an intact natural buffer require very little maintenance, and no fertilizers.

Another possible source of nutrients to a lake is the septic systems surrounding it. Septic systems should be properly installed and maintained in order to prevent nutrient laden wastewater from reaching the lake. A professional inspector can assess septic systems to determine if they are adding undue nutrients to the lake. Many times the age and type of septic system is a likely indication as to the current functionality of the system and does not require an on-site visit, which can many times be controversial. The local County Zoning Department or Health Department can many times assist in this regard.

The Sheboygan County Land Conservation Department (LCD) may be able to offer assistance with shoreland restoration projects and soil testing to determine nutrients needs for lawns and gardens. Interested landowners can contact the Sheboygan County Land Conservation Department at (920) 459-1370 to request additional information.

### 6.1.4 Public Education and Involvement

The LELRD should continue to keep abreast of current AIS issues throughout the County. The County Land Conservation Department, WDNR Lakes Coordinator and the UW Extension are good sources of information. Many important materials can be ordered at the following website: http://www.uwsp.edu/cnr/uwexlakes/publications/

Appendix F includes resources for further information about public education opportunities.

If the above hyperlink to web address becomes inactive, please contact Stantec for appropriate program and contact information.

## 6.2 Aquatic Plant Management Alternatives

The management alternatives may be used when aquatic plants present a problem(s) that must be dealt with or manipulated by human action. EWM and CLP have proven to create navigation and

recreational nuisance on the Lake. Management of these AIS is required to improve the recreational quality of the Lake. The following alternatives may be used to manage AIS such as EWM and CLP.

### 6.2.1 MANUAL REMOVAL

Native plants may be found at nuisance levels in scattered locales throughout the waterway. Manual removal efforts, including hand raking or hand pulling unwanted native plants (except wild rice in the northern region), is allowed under Wisconsin law, to a maximum width of 30 feet (recreational zone) per riparian property. The intent is to provide pier, boatlift or swimming raft access in the recreation zone. A permit is not required for hand pulling or raking if the maximum width cleared does not exceed this 30-foot recreation zone (manual removal of any native aquatic vegetation beyond the 30-foot area would require a permit from the WDNR that satisfies the requirements of Chapter NR 109, Wisconsin Administrative Code, see Appendix E). However, manual removal is **not** recommended because it could open a niche for non-native invasive aquatic plants to occupy. Removal of native plants also destroys habitat for fish and wildlife.

If a small isolated stand of AIS is present, hand pulling may be a viable option. No permit is required to remove non-native invasive aquatic vegetation, as long as the removal is conducted completely by hand with no mechanical assistance of any kind. All aquatic plant material must be removed from the water to minimize dispersion and re-germination of unwanted aquatic plants. Portions of the roots may remain in the sediments, so removal may need to be repeated periodically throughout the growing season. This can be a very effective control mechanism for EWM.

Manual removal of aquatic plants can be quite labor intensive and time consuming. This technique is well suited for small areas in shallow water. Hiring laborers to remove aquatic vegetation is an option, but also increases cost. Scuba divers can be contracted to remove unwanted vegetation in deeper areas. Benefits of manual removal by property owners include low cost compared to chemical control methods, quick containment of pioneering (new) populations of invasive aquatic plants, and the ability for a property owner to slowly and consistently work on active management. The drawback of this alternative is that pulling aquatic plants includes the challenge of working in the water, especially deep water, the threat of letting fragments escape and colonize a new area and the fact that control of any significant sized population is quite labor intensive, and therefore very costly.

### 6.2.2 AQUATIC INVASIVE PLANT SPECIES HERBICIDE TREATMENT

An herbicide treatment may be an appropriate way treat larger areas of AIS to conduct restoration of native plants. When using chemicals to control AIS, it is a good idea to reevaluate the lake's plant community and the extent of the AIS conditions before, during and after chemical treatment as the chosen herbicide may impact native plant communities including coontail, common waterweed, naiad species and others, especially during whole-lake applications and/or extended periods of herbicide exposure. The WDNR may require another whole-lake plant survey and will likely require a pre-treatment AIS survey. Along with the above mentioned surveys, pre and post treatment monitoring should be included for all aquatic plant treatments and is typically a WDNR requirement.

The science regarding what chemicals are most effective, dosages, timing and how they should be applied is constantly being updated. Currently EWM is the most common aquatic invasive plant species targeted for chemical treatment in Wisconsin. At present, 2,4-D is the most common active ingredient for selective systemic herbicides used for EWM management in Wisconsin, although triclopyr use is increasing, and has been commonly used in Minnesota for well over a decade. Typically granular based formulations are more costly and are used for smaller spot type treatments, while liquid formulations are less costly and used for larger contiguous treatment areas or whole lake type treatments. In order to decrease any potential impact to native plants and be as selective as possible for EWM, treatments are completed in the spring when native plant growth is minimal, typically prior to 70˚ water temperatures.

Current WDNR and Army Corps of Engineer research has shown that herbicide applied to water diffuses off site due to a variety of environmental and physical conditions, including wind, waves, water depth and treatment area relative to lake volume. Due to these actions, as treatment areas decrease, herbicide retention time needed for impact is lessened due to diffusion off site because of the small amount of area treated and amount of herbicide applied relative to the entire water volume. To combat this, it is recommended to apply at higher rates when compared to a whole-lake rate and typically with a granular herbicide, a combination of active ingredients in hopes to extend contact time. As EWM abundance lessens within Little Elkhart Lake and smaller treatment areas (>2.0 ac) are mapped, it is recommended to use either 2,4-D or a 2,4-D / triclopyr combination herbicide applied between 3.0 – 4.0 parts per million (ppm), depending on water depth and volume of the treatment area. This approach has shown to be an effective management tool in various lakes throughout Wisconsin and is continuing to be researched for efficacy and long term control.

It is worth noting there are various hybrid strains of EWM that are being genetically confirmed throughout the State and many of these are showing resistance to typical systemic herbicides, there are research projects currently underway with the WDNR and herbicide manufacturers' testing in the field as well as in the lab various combination herbicides (systemic & contact) as well other modes of action like pigment bleaching herbicides (fluridone) that may be more effective on these strains of hybrid EWM, in particular on a whole lake basis.

The size of the infestation tends to dictate the type of the treatment. Small treatment areas or beds under 5 acres are many times considered spot treatments and are usually targeted with granular type herbicides, but when you have multiple "spot" treatments it many times makes more sense from an economic standpoint as well as efficacy to target the "whole" lake for treatment. What this typically entails is calculating the entire volume of water within the lake, in acre/feet and then using a low dose of a liquid herbicide, such as 2,4-D at a lake wide rate of typically between 250 – 350 parts per billion (PPB). Many times the amount of herbicide in this type of whole lake treatment can be further reduced but timing the treatment as close as possible to lake stratification. After the thermocline develops in the lake, typically between 60 – 70 degrees, this may effectively eliminate the area of the water column below the thermocline from the treatment, reducing the amount of herbicide needed for a whole lake treatment by 30- 40%. Where this technique can be utilized it should be to reduce the amount of herbicide used within the lake and to more effectively target the whole lake treatment.

Currently CLP is considered the second most prevalent aquatic invasive plant species targeted for chemical treatment in the State. At present, endothall, a contact herbicide is the most common active ingredient in herbicides used for CLP management in Wisconsin, although imazamox has been used periodically in the last several years. This product has shown promise in that it is a systemic herbicide for CLP control and can potentially have a much lower impact to the native plant community, than a contact herbicide, and appears to show increased year after treatment control of turions. Similar to EWM treatments, granular based formulations are more costly and are used for smaller spot type treatments, while liquid formulations are less costly and used for larger contiguous treatment areas or whole lake type treatments. In order to decrease any potential impact to native plants and be as selective as possible for CLP, treatments are completed in the spring when native plant growth is minimal, typically prior to 60˚ water temperatures. CLP seems to prefer and flourish in mucky or in a highly flocculent substrate, which is generally not present in most of Little Elkhart Lake. Given the lack of appropriate substrate and the limited expansion of this invasive within Little Elkhart Lake, monitoring may be the best option for management.

Chemical treatment is usually a long term commitment and requires a specific plan with a goal set for "tolerable" levels of the relevant AIS. One such landmark might be 10% or less of the littoral area being occupied by aquatic invasive plants. WDNR recommends conducting a whole-lake point-intercept survey on a five year bases (for Little Elkhart Lake the next would be 2016). Such a survey

may reveal new AIS and at the very least would provide good trend data to see how the aquatic plant community is evolving.

Herbicides provide the opportunity for broader control than hand pulling and unlike harvesters, allow for a true restoration effort (this is why harvesters are not discussed in this document). Disadvantages include negative public perception of chemicals in natural lakes, the potential to affect non-target plant species (if not applied at an appropriate application rate and/or time of year), and the fact that water use restrictions may be necessary after application.

#### 6.2.3 MAINTAIN NAVIGATIONAL ACCESS TO THE LAKE

As AIS levels are decreased, it is possible for native plants to grow dense enough in their place to cause a nuisance and impede navigation, especially in shallow, soft-sediment bays. Currently, this impedance exists in various locations of the lake. Most of his impedance is currently caused by floating-leaf species within this area and options to maintain a common, navigational access channel within problem areas has been permitted in the past.

If such a problem were to continue to arise in the future, herbicide application of a contact herbicide such as diquat for submergent species or imazapyr with a surfactant or sticking agent for floating-leaf species to a narrow, corridor up to 30-50' wide will maintain access to the lake for the public (Figure 3). This action should assessed annually and only be completed if necessary and may not be needed year to year.

#### 6.2.4 WATER LEVEL DRAWDOWN

Drawdown of water level can be a very effective tool in managing EWM if an available option. During a drawdown the water level is lowered to expose the lake bed where EWM is present, allowing winter temperatures to fatally freeze and dry plants and their associated root systems. Drawdowns have drastically reduced EWM frequencies in some lakes, but populations typically rebound after several years. Drawdowns impact native plants but not to the extent that it does EWM. Many native plants respond well to fluctuating water levels, and there is usually an increase in diversity and density of native aquatic plants following the first summer after refilling the reservoir. Certain emergent plants that need lowered water levels to germinate and reproduce, such as bulrush, benefit from drawdowns. However, Little Elkhart Lake does not have a water control structure; therefore this option is not viable.

#### 6.2.5 BIOLOGICAL EWM CONTROL THROUGH MILFOIL WEEVILS

The milfoil weevil (*Euhrychiopsis lecontei)* has shown promise as an eco-friendly solution with potential for long-term sustainable control of lake-wide Eurasian watermilfoil infestations. Typically adult weevils are naturally occurring within localized lakes and are collected from those nearby lakes to rear them to produce offspring in a laboratory facility. The offspring (in the form of eggs and larvae) are then re-introduced into dense milfoil stands often over 2-3 seasons and are monitored throughout the stocking programs.

The goal of biological control is to build a sustainable population that is capable of maintaining the milfoil at low levels. As the natural predator of this invasive species, the weevil spends its entire life cycle feeding on the leaves and tunneling through the main stem of the plant, damaging the vascular system which slowly kills the plant. This process takes three-five+ years, depending on the extent of the infestation and how aggressive the stocking program is.

**BENEFITS:**

1. The beetles simply utilizing a nature-based predator-prey relationship already found occurring in North American lakes. The benefit is using an environmentally-safe and eco-friendly approach for milfoil control.

2. Because weevil populations naturally exist in the Wisconsin lakes, they sustain their own population and can continue to control the milfoil year after year.

3. Weevils are highly selective – All of the peer-reviewed scientific literature confirms that weevils only live on certain types of milfoils: Eurasian, Northern and/or a hybrid of the two. Little possibility of negative impacts to other plants, animals or humans.

**Costs:**
Weevils are sold in units of 1,000 and 1 unit = $1,000 or $1.00/weevil. Because it is live organism, weevils are not stocked on a per acre basis but rather on the size of the milfoil infestation, and to some extent how rapidly control is desired. Each water body is different, but once a self-sustaining population is achieved, management costs can drop sometimes only requiring occasional monitoring and enhancement of weevil populations if milfoil levels warrant it. Long-term monitoring is an important component for any milfoil management program and should be considered when deciding on a management strategy.

There is a surveying component expense in addition to the weevil cost. This is dependent on the size of the program and can typically range from $1,500 to $5,000 in most cases. A typical three year project for a 200 acre lake with approximately 50 acres of milfoil could be $45,000 - $55,000 ($15,000 - $18,000 per year average). Larger lakes or higher infestations could implement a longer program at that same rate. The purpose is to treat high problem areas while allowing the weevils to get established with the idea that less and less (or no) herbicide will be used as the weevils move throughout the Lake.

**Potential disadvantages:**
1. The cost of the program is high at least initially, several times higher than herbicide and/or harvesting.
2. For the best results lakes with good naturally occurring native weevil populations seem to be best suited and experience the best results.
3. Weather and potential climate change issues affect the effectiveness of the weevils. Early long, hot and dry summers can negatively affect weevil populations and more so their ability to "eat through" the bumper crop of EWM that accompanies these types of increasingly more common growing seasons. Also dramatic water level fluctuations can negatively affect weevil populations.
4. High populations of stunted panfish without adequate food supplies can prey on the weevils, while not a preferred food source it can become one as other sources are diminished, typically present where stunted panfish population exists.
5. Length of time to see results, most times it takes a minimum of 3 years to see any results, sometimes 5 to 10 years is not uncommon with a possible commitment to stocking each year, and some lakes they never really seem to establish themselves without constant stocking.
6. The success of weevil control projects has been very unpredictability; it is difficult to determine where they are going to work well and where they may not, what lake types, water quality, near shore and shoreland habitats. It has been very difficult to pinpoint which lakes make the best candidates and have the highest likelihood of success. This risk factor alone is too much for many groups.

***Please Note:*** *Unfortunately, milfoil weevils are no longer commercially available and, as such, are not a current option. It is possible that if they again become available in the future this option be further explored if desired and current milfoil abundance warrants. At the time of this report the company that previously produced the weevils, has been in discussions with the State of Wisconsin and other non-profits at potentially taking over this discontinued portion of their business.*

# 7.0 CONCLUSION AND RECOMMENDED ACTION PLAN

Two aquatic invasive plants were found within the Project Area during the 2012 aquatic plant survey: EWM and CLP. Neither species was identified during earlier plant surveys. EWM is present on a large scale basis and ongoing management and control efforts are highly recommended. This will help prevent spread of AIS, along with CLP, to other water bodies. The following Recommended Action Plan focuses on AIS control and public education.

## 7.1 RECOMMENDED ACTIVE GOALS

The recommended action plan includes actions for the LELRD based on results from the public questionnaire and the Manipulation Alternatives listed in Section 6. The LELRD has approved the following active goals. It will be up to members of LELRD to determine the actions, find the funding and gather the individuals needed to implement the active goals.

**Active Goal**: Manage AIS to improve recreation, increase recreational opportunities and rehabilitate native plants.

**Task**: Reduce EWM abundance to less than 5.0% frequency of occurrence within the littoral zone, or approximately 2.5 acres to be documented through annual surveys. Treatment regime for 2014-2018 management of EWM to reduce coverage in the lake is displayed below. Stantec recommends an initial application rate at a concentration at or near maximum label rates within areas of EWM growth. Currently, spot treatments should take place in subsequent years with either liquid or granular herbicides depending on the size of the beds being targeted. Consideration should be given to liquid should be used when beds are over 2.5 ac in individual size with granular formulations used on smaller areas. Annual goals for EWM control are displayed below.

***Task:*** Continue monitoring presence of CLP within Little Elkhart Lake. If the population of CLP expands beyond 1.0 acres and/or approximately 2.5 % frequency of occurrence, management should be conducted using an early season application of endothall or imazamox at or near maximum label rates; and/or hand pulling.

**Active Goal**: Provide LELRD members and lake users with educational information related to potential impacts their activities could have on introduction of aquatic invasive species within the lake and likely modes of transport as well precautionary measures that should be taken.

***Task:*** Install an information kiosk at the boat launches and/or materials sent annually to each member with information on AIS identification as well as any new species to aware of that may impact the lake and appropriate precautionary measures.

**Active Goal**: Increase participation with the Clean Boats, Clean Waters program

***Task:*** Train additional 2-4 volunteers from the District to help with the CB / CW program

***Task:*** Commit to a minimum of 50 annual volunteer hours of monitoring for Little Elkhart Lake's boat landing with a set schedule to supplement Glacierland RC & D's efforts.

**Active Goal:** To implement and maintain an aquatic invasive species monitoring program that will survey for invasive species, and if found, monitor their locations and extent of population spread.

***Task:*** Each year AIS treatment is to take place, continue to complete pre and post-treatment point-intercept aquatic plant surveys to monitor AIS and native plant

responses to the management and plan for the future. AIS should be surveyed and mapped before and after treatment, according to DNR protocol, to evaluate effectiveness of treatment.

**Active Goal:** To resume the comprehensive water quality monitoring within on Little Elkhart Lake through the WDNR Citizen Lake Monitoring Network.

**Task:** Continuing in 2014 and beyond, have the trained citizen volunteers monitor water quality through secchi readings, temperature and dissolved oxygen profiles, with special emphasis on chlorophyll *a* and phosphorus water samples, given historic increases. Samples will be taken once monthly from May – September.

**Active Goal:** Maintain a common navigational corridor in from the southeast bay leading to the main lake, if necessary based on each year's aquatic plant growth (Figure 3).

**Task:** Monitor plant growth within this bay and, only if necessary, acquire a permit to create and maintain a common, 30' – 50' wide navigational access from the bay to the main lake by herbicide treatment or harvesting. This task may not be required annually and should be re-evaluated each year.

### 7.2 CLOSING

This APM Plan was prepared in cooperation with the District and subsequently was reviewed and approved by the WDNR. It includes the major components outlined in the WDNR Aquatic Plant Management guidance. The "Recommended Action Plan" section of this report can be used as a stand-alone document to facilitate EWM management activities for the Lake. This section outlines important monitoring and management activities. The greater APM Plan document and appendices provides a central source of information for the Lake's aquatic plant community information, the overall lake ecology, and sources of additional information. If there are any questions about how to use this APM Plan or its contents please contact Stantec.

This APM Plan should receive a "minor" update at 5 years to reflect current issues and potentially an updated plant survey. Then at 10 years a complete plan revision would be recommended with the most recent data and lake management methods. Information regarding aquatic plant management and protection is available from the WDNR website: http://dnr.wi.gov/org/water/fhp/lakes/aquaplan.htm, or from Stantec, upon request.

# 8.0 REFERENCES

While not all references are specifically cited or some maybe referenced in the report itself, the following resources were used in preparation of this report.

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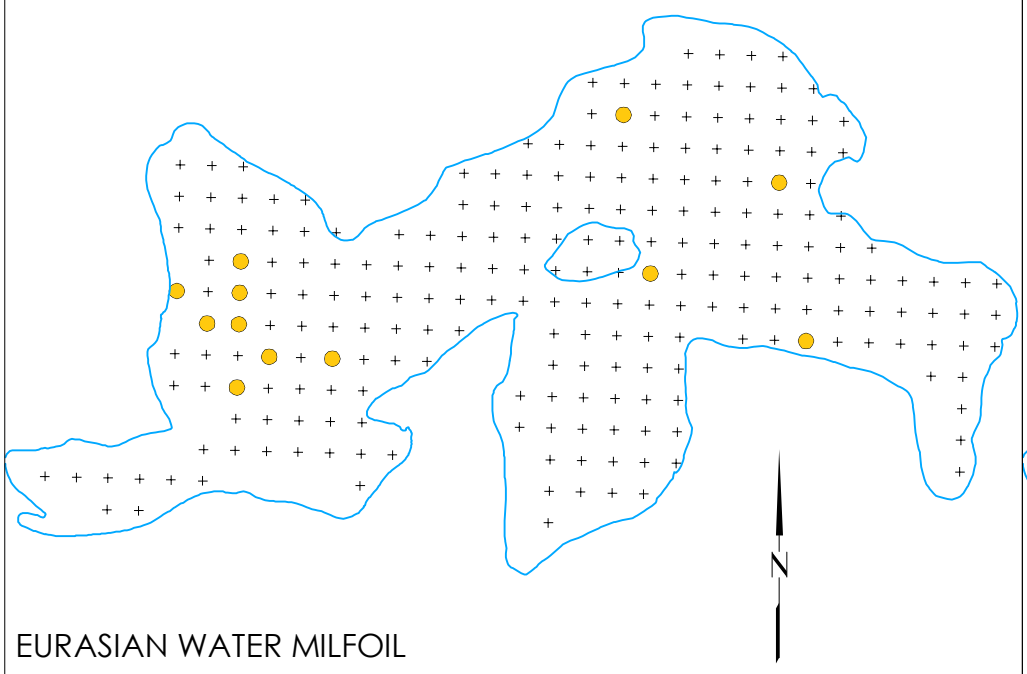
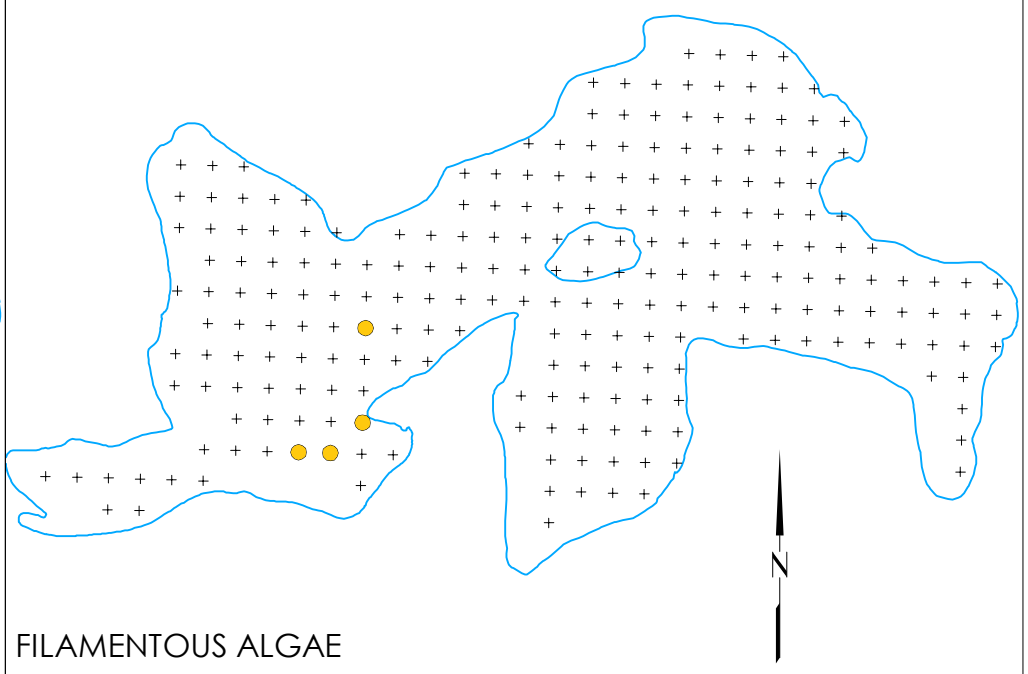
Wisconsin Department of Natural Resources, *Wisconsin Lakes,* Publication # PUB-FH-800, 2005

# Figures




EURASIAN WATER MILFOIL

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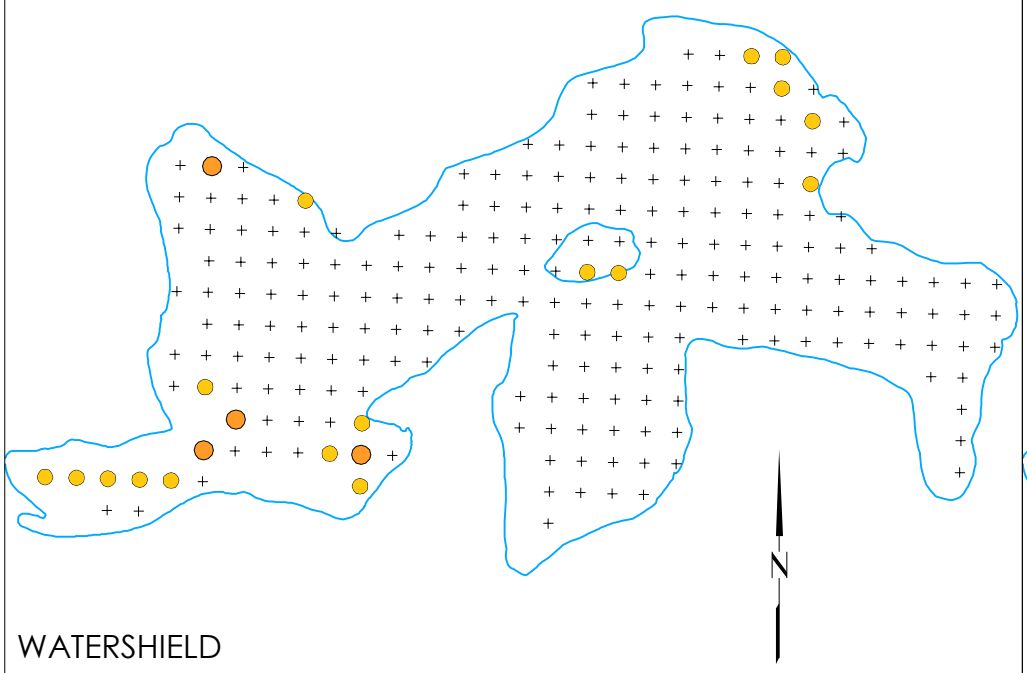


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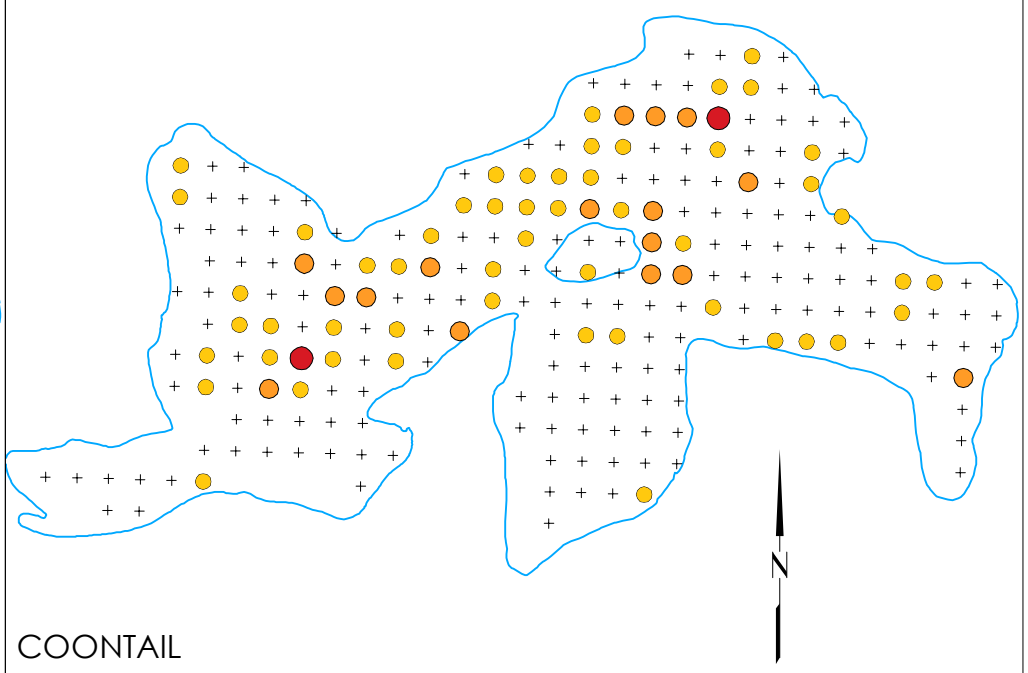


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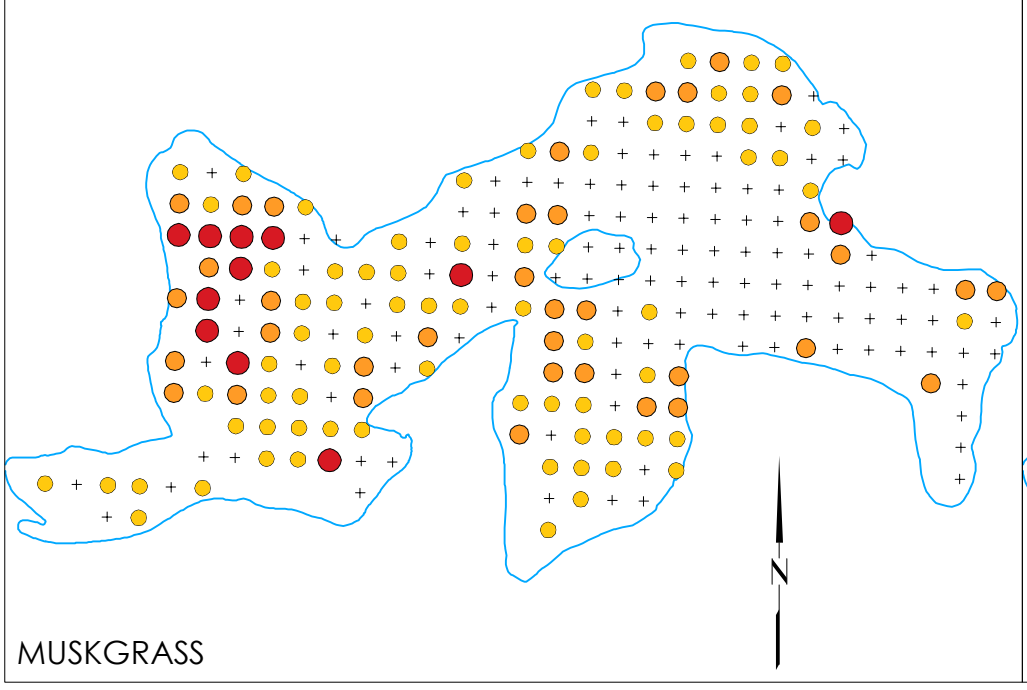


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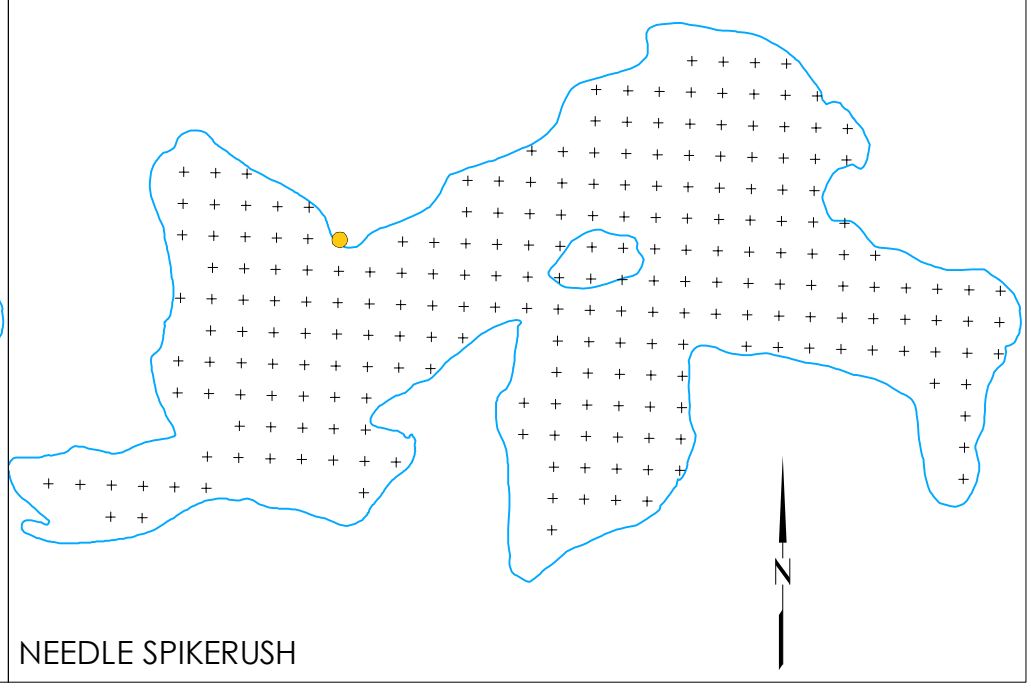



NEEDLE SPIKERUSH

LEGEND

- A few plants on rake
- Rake head is about ½ full
- Overflowing - cannot see rake head
- Point Intercept GPS Sample Points - 2013

Maps generated utilizing data collected by Stantec.

A few plants on rake head

Rake head is about 1/2 full Can easily see top of rake head

Overflowing Cannot see top of rake head

Stantec

Design with community in mind

12075 Corporate Parkway Suite 200
Mequon, WI
53092
Tel. (262) 241-4466
Fax. (262) 241-4901
www.stantec.com

Project Information
Project Number: 193701611

V:\1937\ACTIVE\193701611\CAD\DWG\LITTLE ELKHART PI SURVEY 2013 FIG 1.1.DWG
9/24/2013 4:03 PM

| | | |
|---|---|---|
| Prepared by | EJM | 09/24/13 |
| Peer Review by | JTS | 09/24/13 |
| Final Review by | MEK | 09/24/13 |

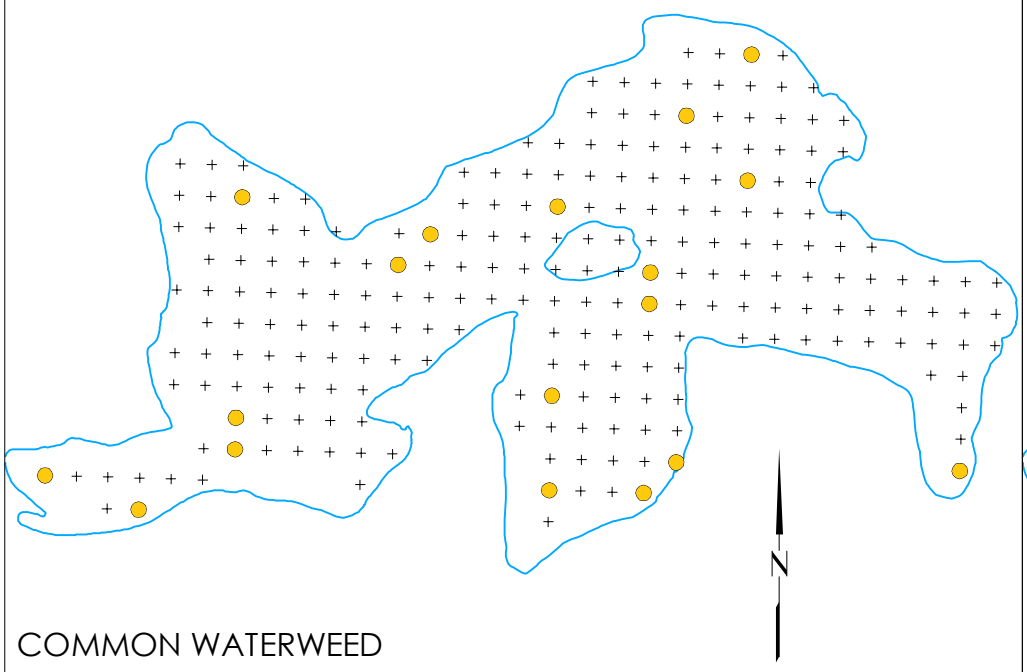
Data Sources include: ESRI and Stantec
Image: NAIP 2010

The information on this map has been completed by Stantec staff from a variety of sources and is subject to change without notice. Stantec makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information.

Client/Project
LITTLE ELKHART LAKE
REHABILITATION DISTRICT
SHEBOYGAN COUNTY, WISCONSIN

Figure No.
1.1

Title
# 2013 FULL POINT INTERCEPT LITTLE ELKHART LAKE

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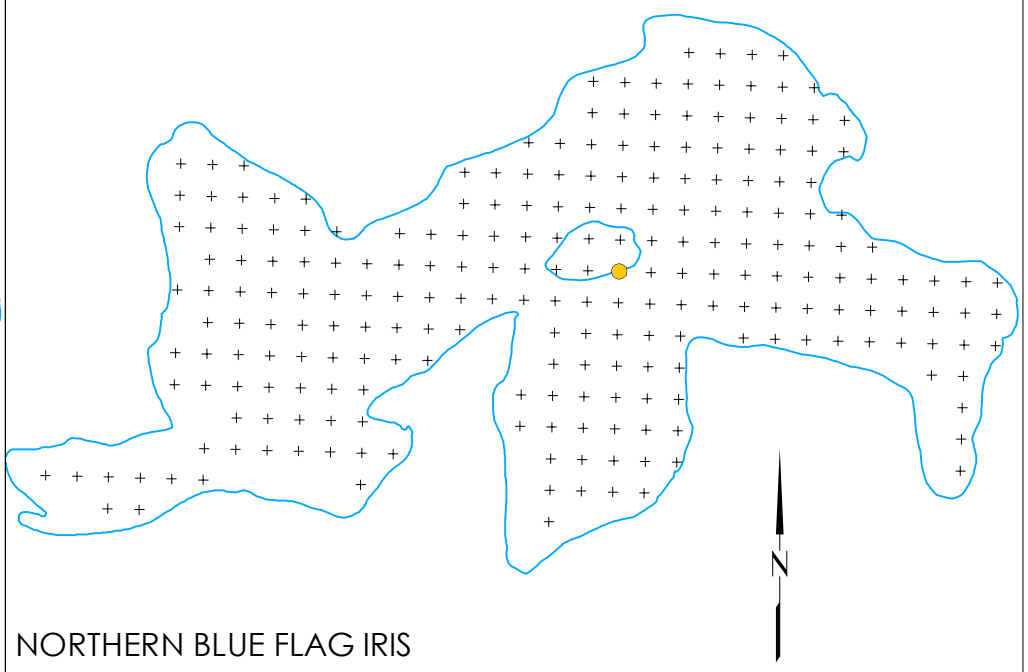


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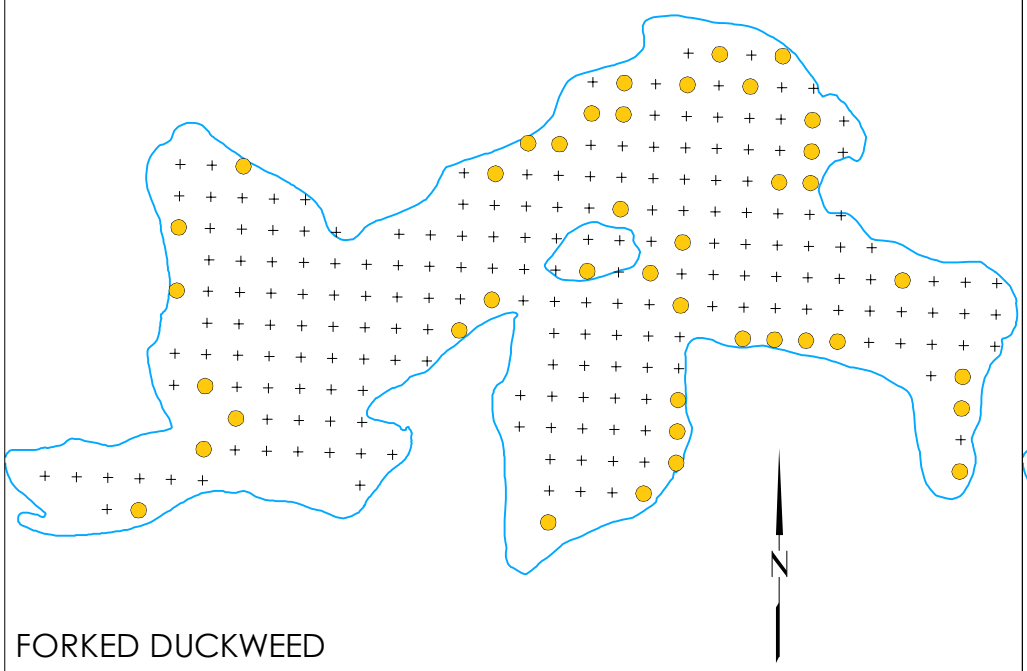


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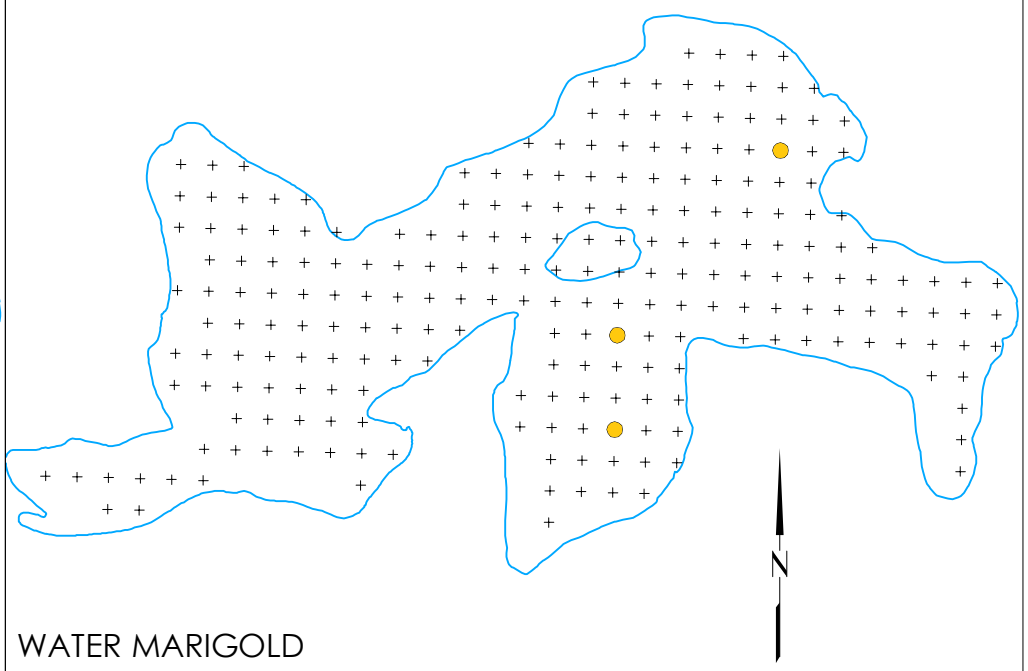
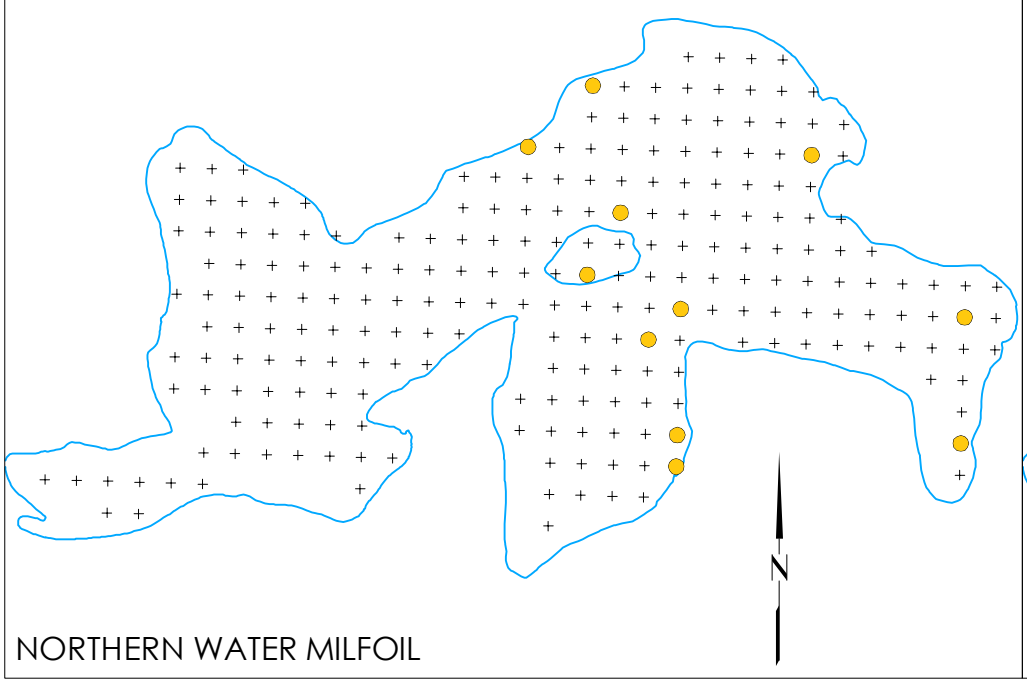
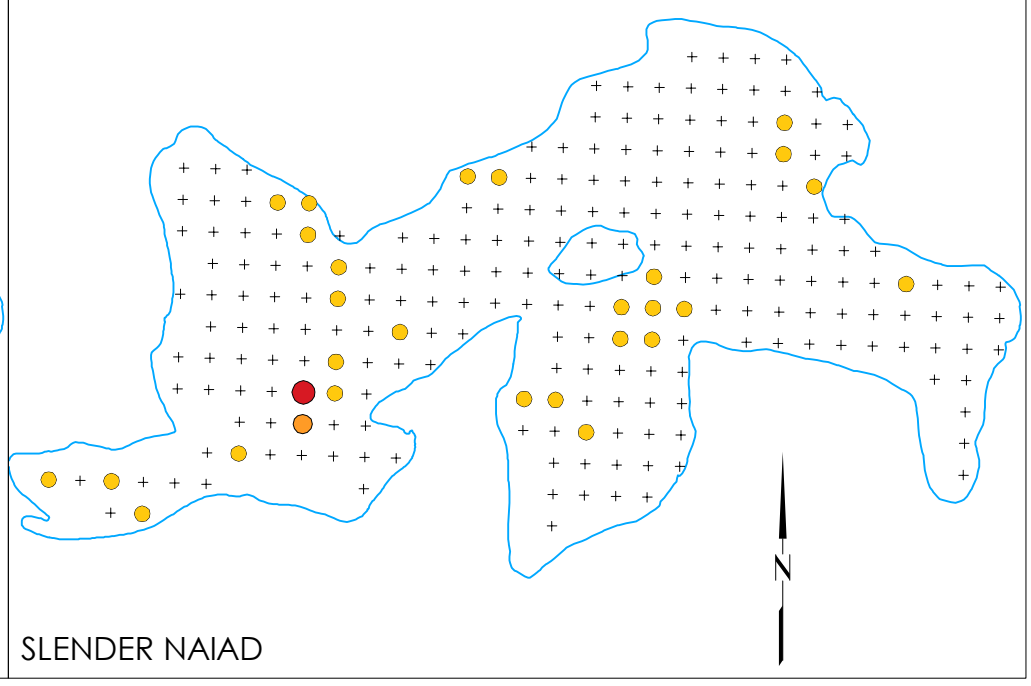



WATER MARIGOLD




NORTHERN WATER MILFOIL




SLENDER NAIAD

LEGEND

- A few plants on rake
- Rake head is about ½ full
- Overflowing - cannot see rake head
- Point Intercept GPS Sample Points - 2013

Maps generated utilizing data collected by Stantec.

A few plants on rake head

Rake head is about 1/2 full Can easily see top of rake head

Overflowing Cannot see top of rake head

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Project Number: 193701611

V:\1937\ACTIVE\193701611\CAD\DWG\LITTLE ELKHART PI SURVEY 2013 FIG 1.2.DWG
9/25/2013 11:34 AM

| | | |
|---|---|---|
| Prepared by | EJM | 09/24/13 |
| Peer Review by | JTS | 09/24/13 |
| Final Review by | MEK | 09/24/13 |

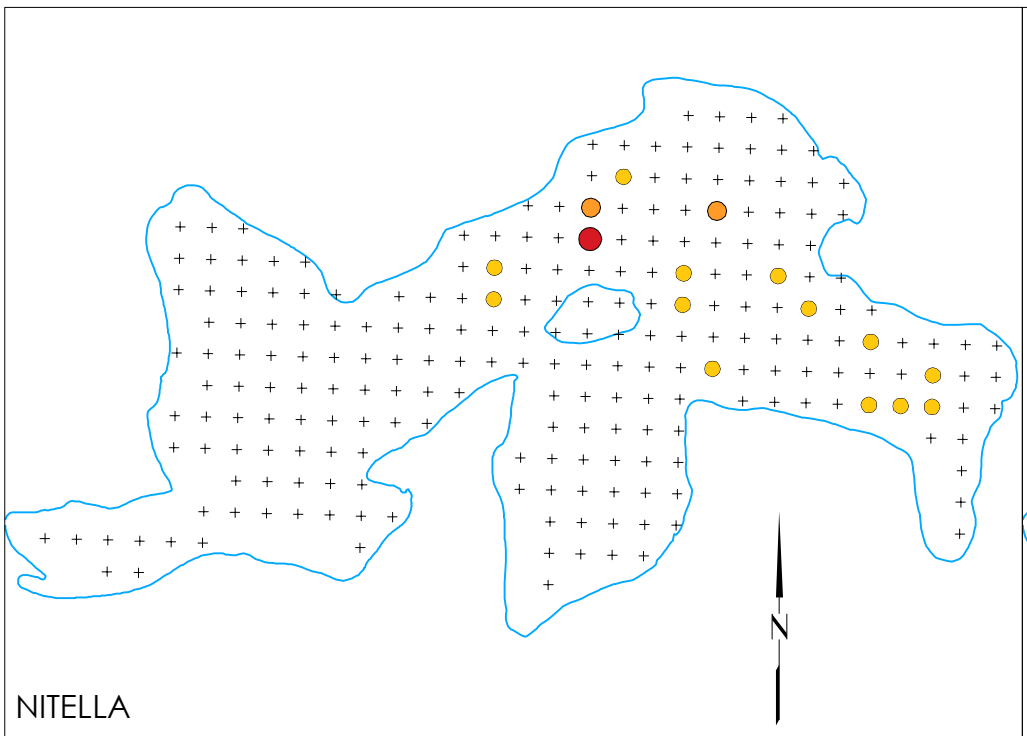
Data Sources include: ESRI and Stantec
Image: NAIP 2010



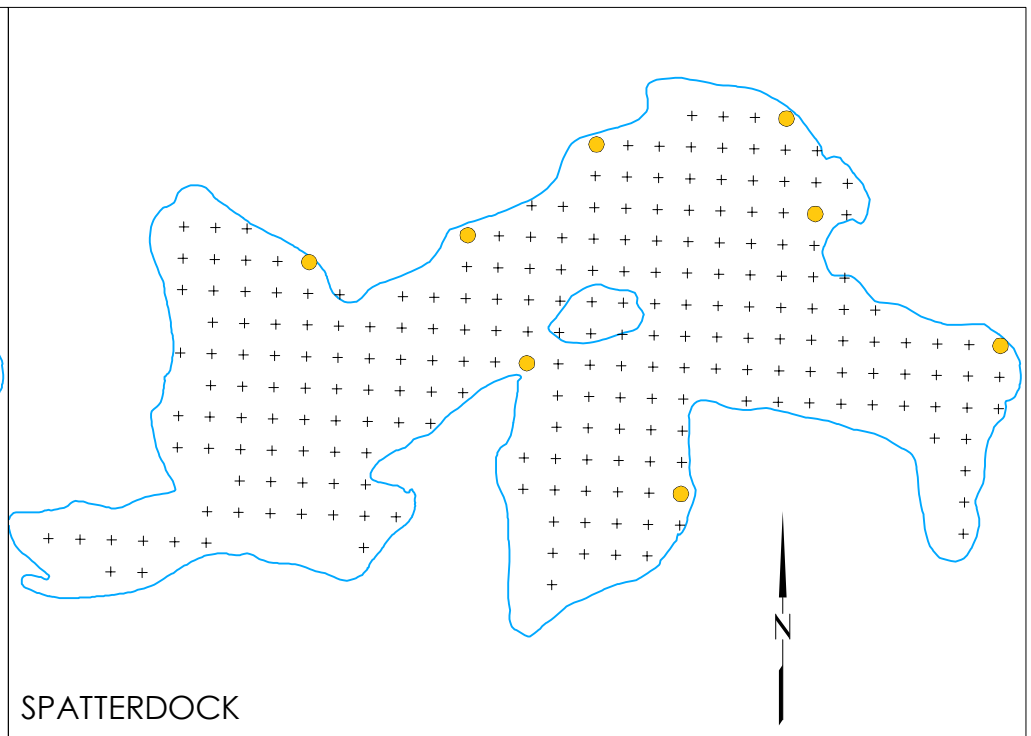
Client/Project
LITTLE ELKHART LAKE
REHABILITATION DISTRICT
SHEBOYGAN COUNTY, WISCONSIN

Figure No.
1.2

Title
# 2013 FULL POINT INTERCEPT LITTLE ELKHART LAKE




NITELLA

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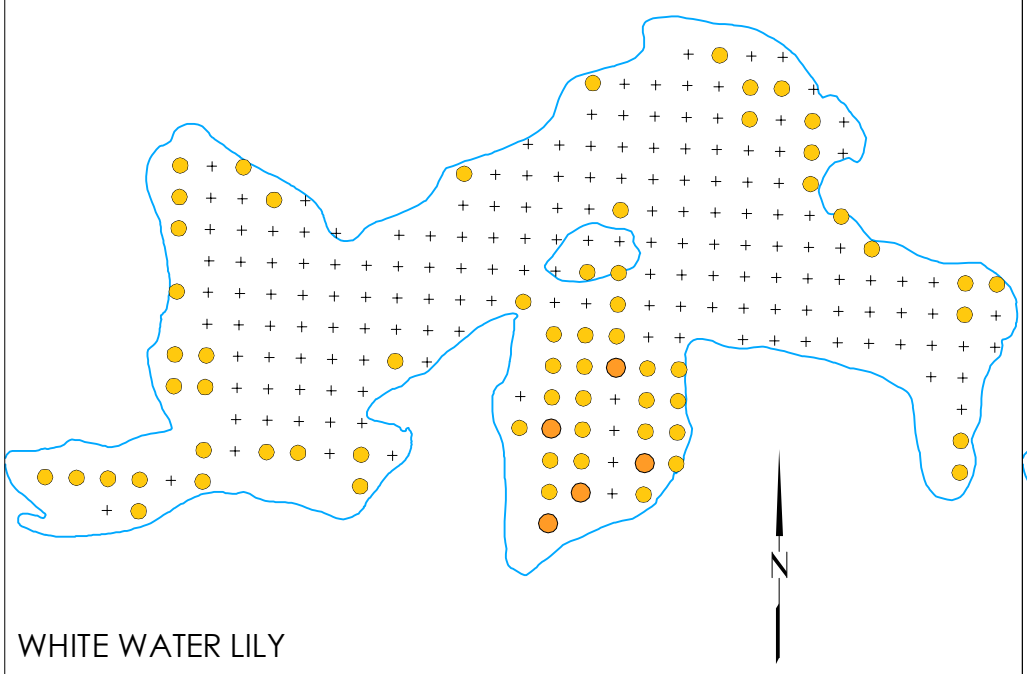
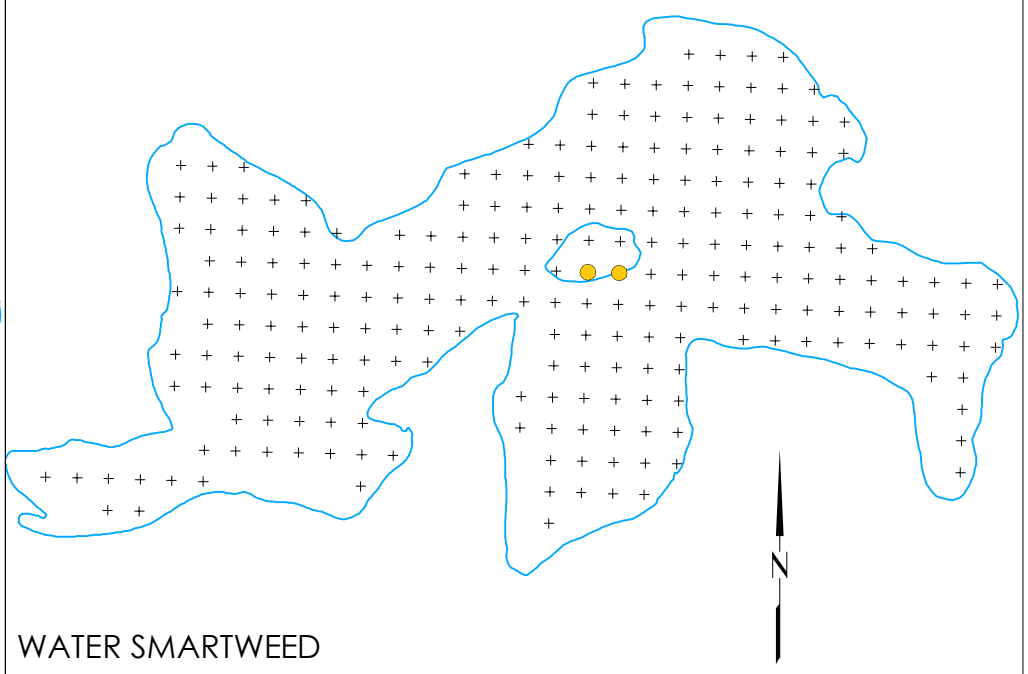



WHITE WATER LILY

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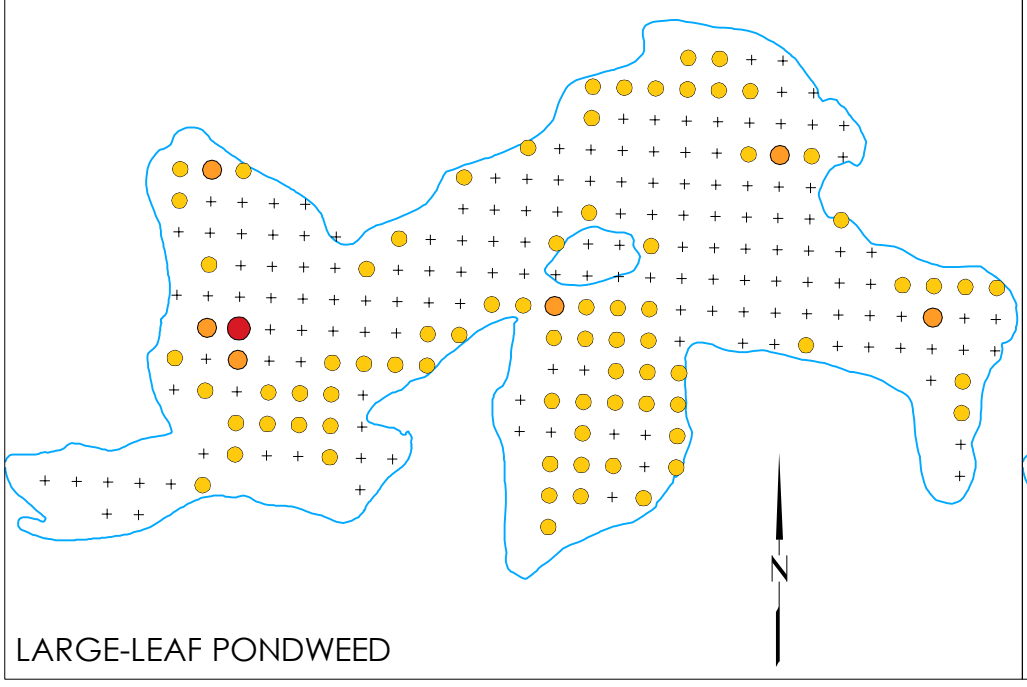
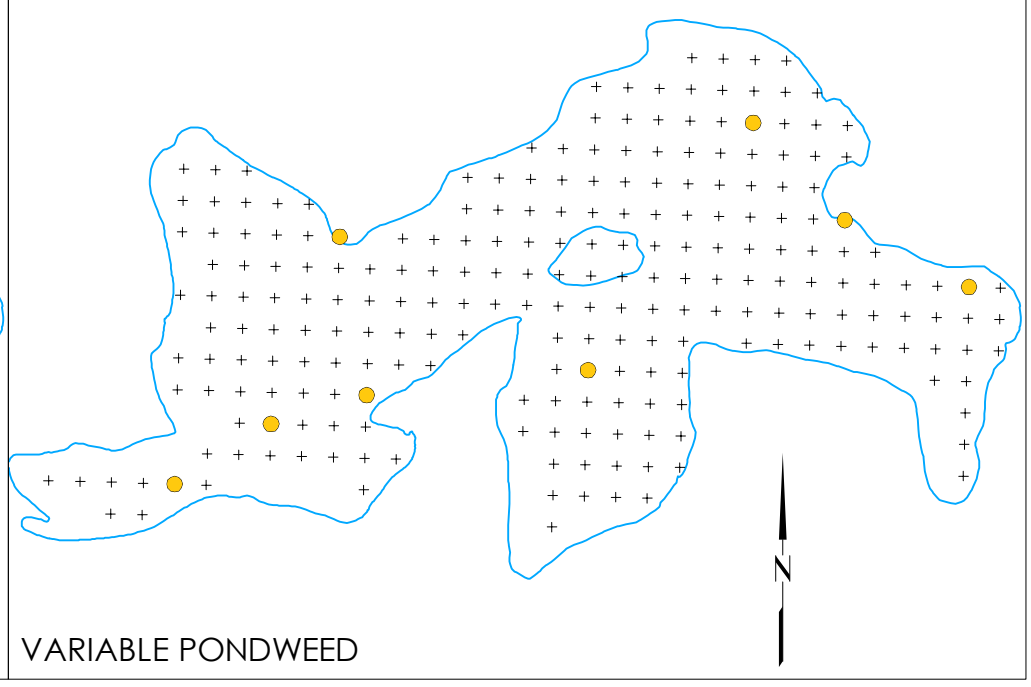



LARGE-LEAF PONDWEED




VARIABLE PONDWEED

LEGEND

- A few plants on rake
- Rake head is about ½ full
- Overflowing - cannot see rake head
- Point Intercept GPS Sample Points - 2013

Maps generated utilizing data collected by Stantec.

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Overflowing Cannot see top of rake head

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V:\1937\ACTIVE\193701611\CAD\DWG\LITTLE ELKHART PI SURVEY 2013 FIG 1.3.DWG
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|---|---|---|
| Prepared by | EJM | 09/25/13 |
| Peer Review by | JTS | 09/25/13 |
| Final Review by | MEK | 09/25/13 |

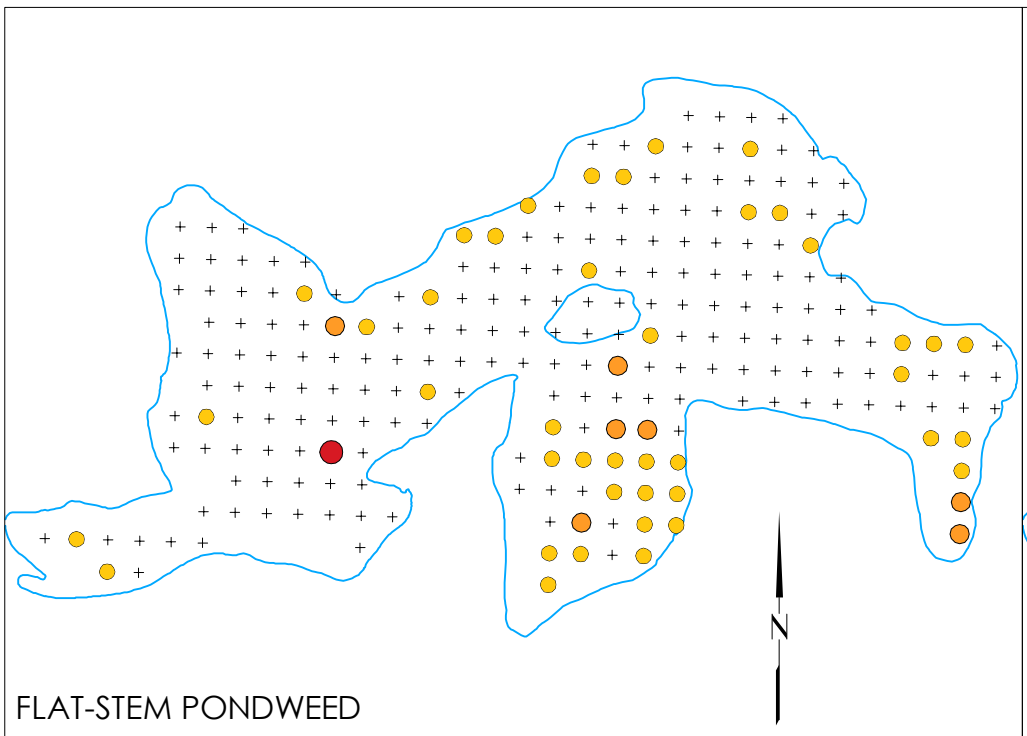
Data Sources include: ESRI and Stantec
Image: NAIP 2010



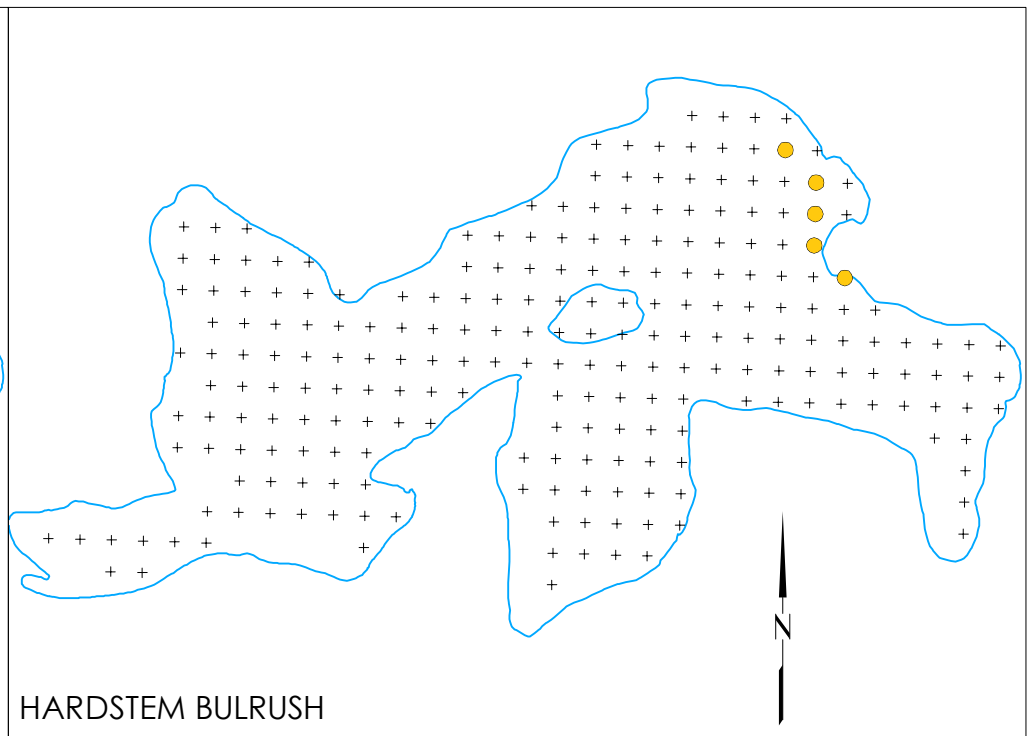
Client/Project
LITTLE ELKHART LAKE
REHABILITATION DISTRICT
SHEBOYGAN COUNTY, WISCONSIN

Figure No.
1.3

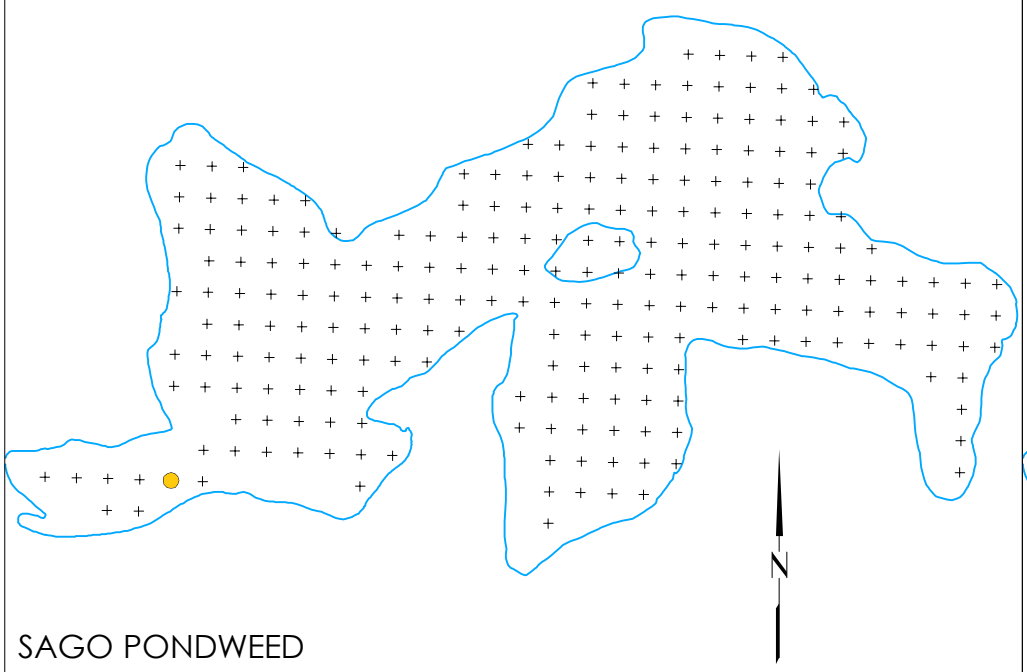
Title
# 2013 FULL POINT INTERCEPT LITTLE ELKHART LAKE



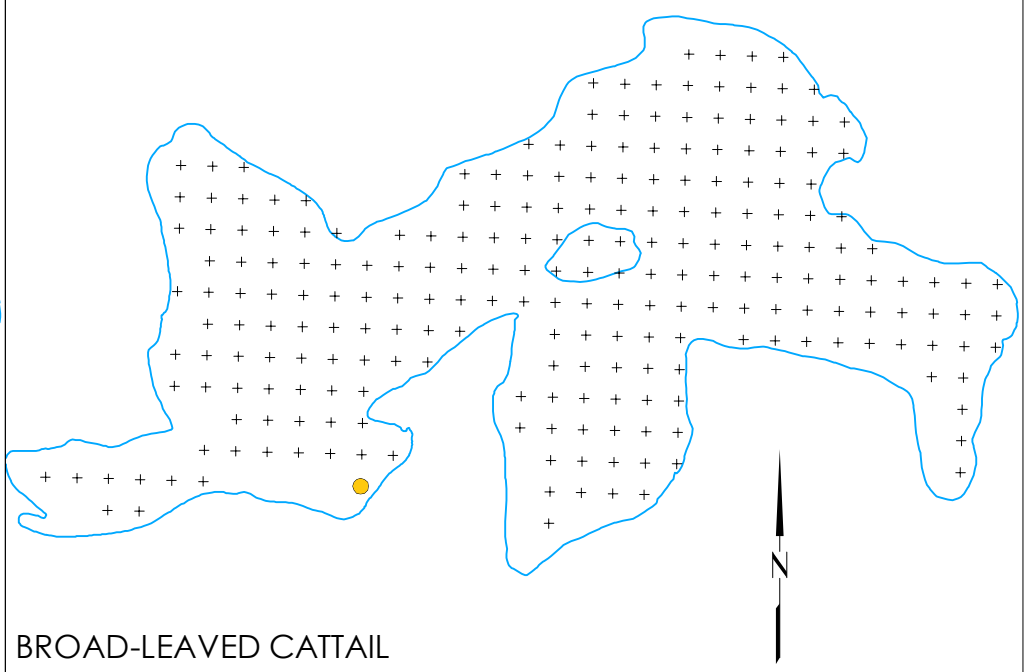

FLAT-STEM PONDWEED



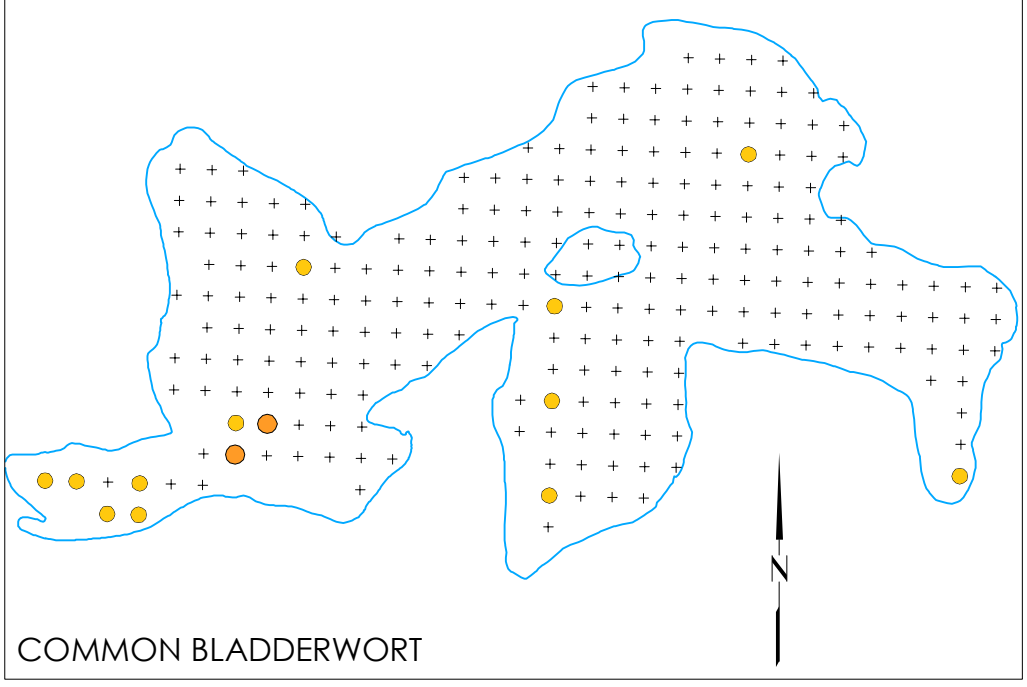

HARDSTEM BULRUSH




SAGO PONDWEED




BROAD-LEAVED CATTAIL




COMMON BLADDERWORT

LEGEND

- A few plants on rake
- Rake head is about ½ full
- Overflowing - cannot see rake head
- Point Intercept GPS Sample Points - 2013

Maps generated utilizing data collected by Stantec.

A few plants on rake head

Rake head is about 1/2 full Can easily see top of rake head

Overflowing Cannot see top of rake head

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Project Number: 193701611

V:\1937\ACTIVE\193701611\CAD\DWG\LITTLE ELKHART PI SURVEY 2013 FIG 1.4.DWG
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|---|---|---|
| Prepared by | EJM | 09/25/13 |
| Peer Review by | JTS | 09/25/13 |
| Final Review by | MEK | 09/25/13 |

Data Sources include: ESRI and Stantec
Image: NAIP 2010

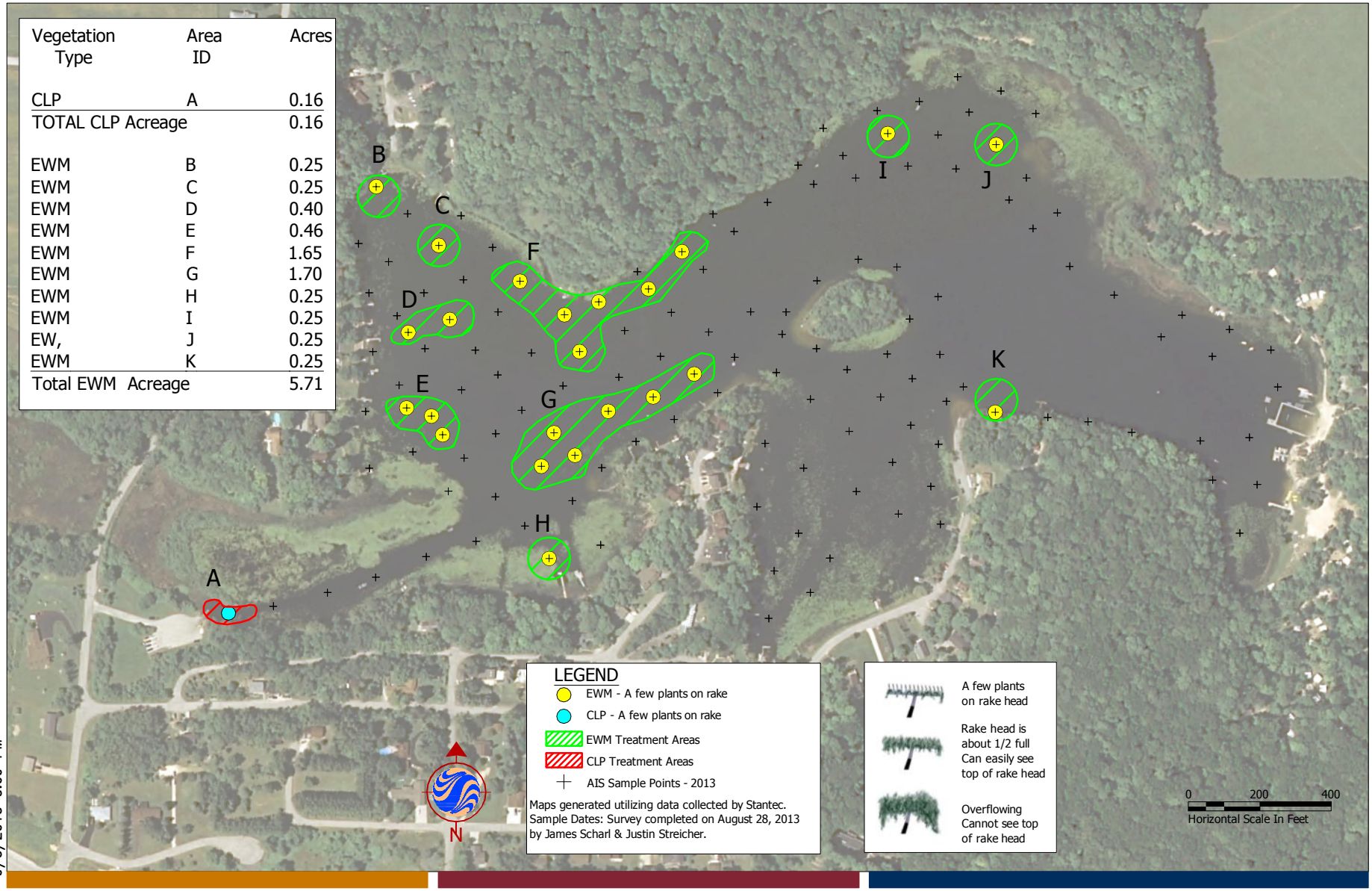


Client/Project
LITTLE ELKHART LAKE
REHABILITATION DISTRICT
SHEBOYGAN COUNTY, WISCONSIN

Figure No.
1.4

Title
# 2013 FULL POINT INTERCEPT LITTLE ELKHART LAKE

| Vegetation Type | Area ID | Acres |
|---|---|---|
| CLP | A | 0.16 |
| TOTAL CLP Acreage | | 0.16 |
| EWM | B | 0.25 |
| EWM | C | 0.25 |
| EWM | D | 0.40 |
| EWM | E | 0.46 |
| EWM | F | 1.65 |
| EWM | G | 1.70 |
| EWM | H | 0.25 |
| EWM | I | 0.25 |
| EW, | J | 0.25 |
| EWM | K | 0.25 |
| Total EWM Acreage | | 5.71 |

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Project Information

Project Number: 193702385

| | | |
|---|---|---|
| Prepared by | EJM | 09/04/13 |
| Peer Review by | JTS | 09/04/13 |
| Final Review by | MEK | 09/04/13 |

Data Sources include: ESRI and Stantec
Image: NAIP 2010



Client/Project

LITTLE ELKHART LAKE REHABILITATION DISTRICT
SHEBOYGAN COUNTY, WISCONSIN

Figure No.

1.0

Title

# 2013 AIS TREATMENT LITTLE ELKHART LAKE

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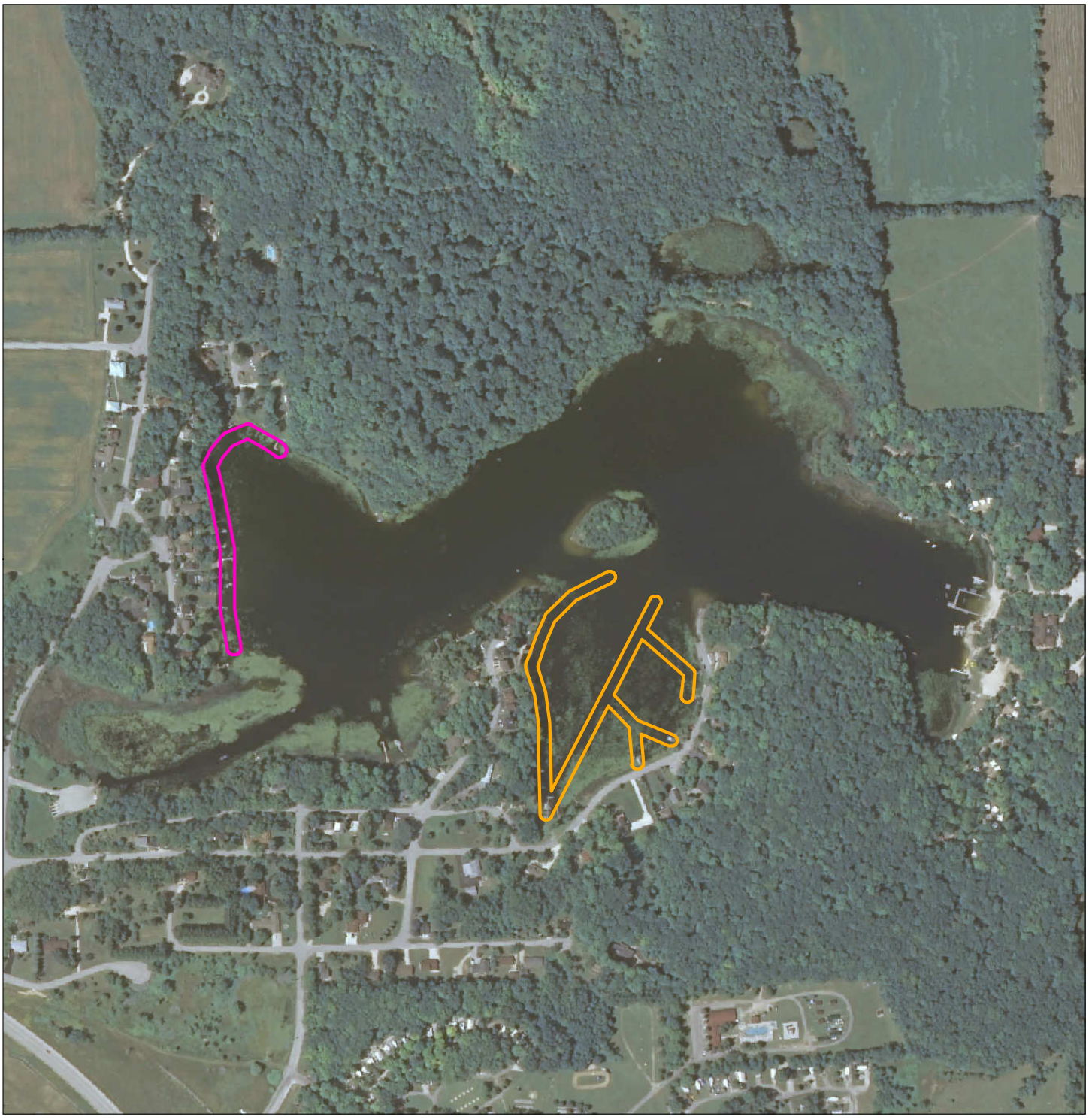

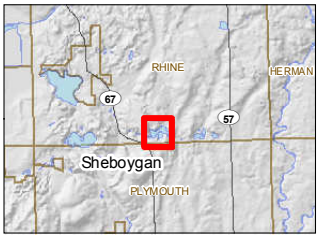


Legend

- Submersed & Floating Leaf (2.28 ac)
- Landowner Access as Needed and Approved by WDNR (Individual Access Treatment - 30ft Wide)

**Notes**

1. Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet
2. Data Sources Include: Stantec, WDNR, and WisDOT
3. Orthophotography: NAIP 2010



*All areas for floating-leaf and/or submersed nuisance vegetation for navigational access, as needed, and are to be verified and approved annually prior to treatment

Figure No.
**3**

**DRAFT**

Title
**Potential Navigational Access Management Areas**

Client/Project
Little Elkhart Lake Rehabiliation District

Project Location
T16N, R21E, S33 & S34
T. of Rhine,
Sheboygan Co., WI

193701611
Prepared by KAS on 2014-11-04
Technical Review by PM on 2014-11-04
Independent Review by JS on 2014-11-05

0 250 500 Feet
1:6,000 (at original document size of 8.5x11)

N

Stantec

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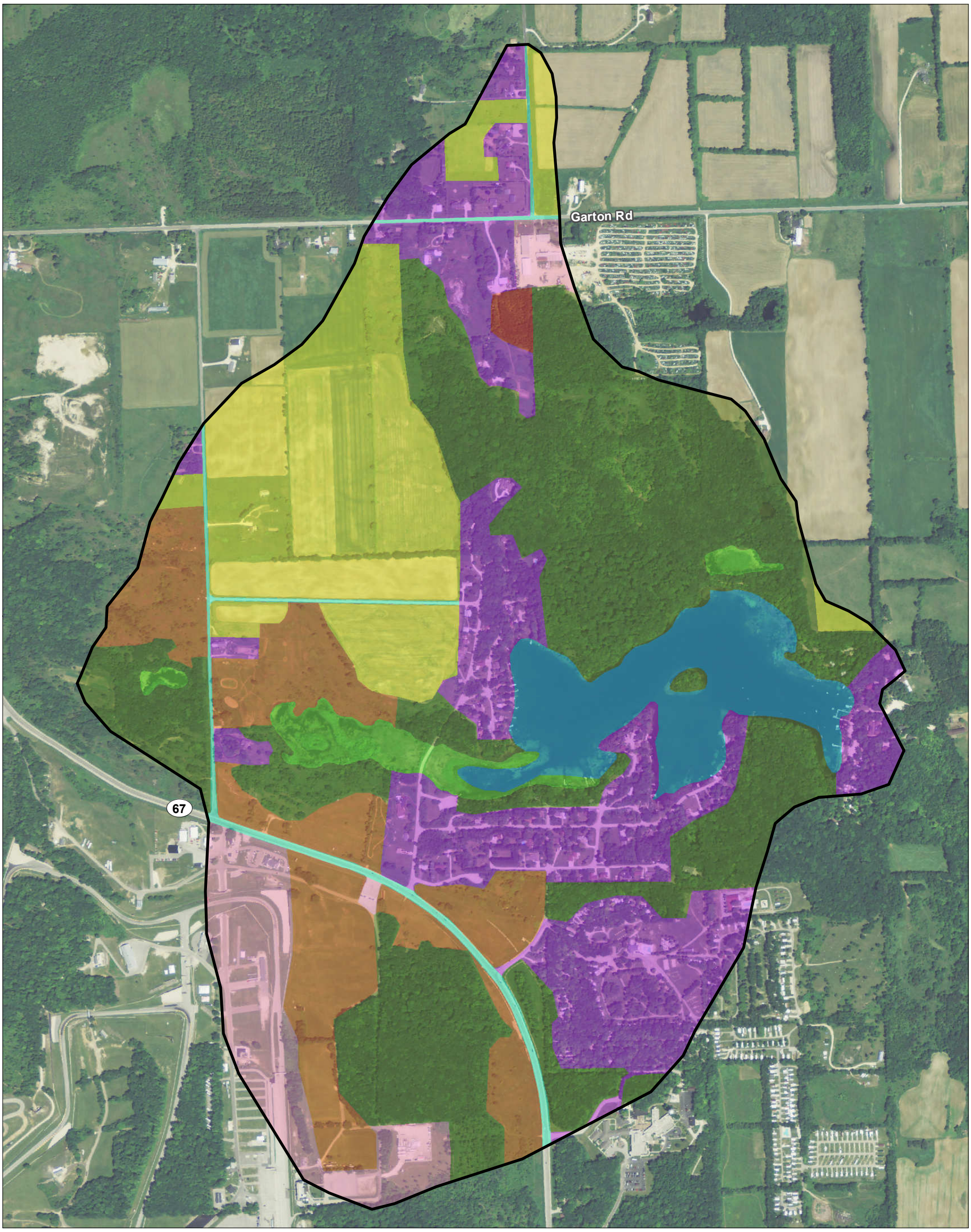
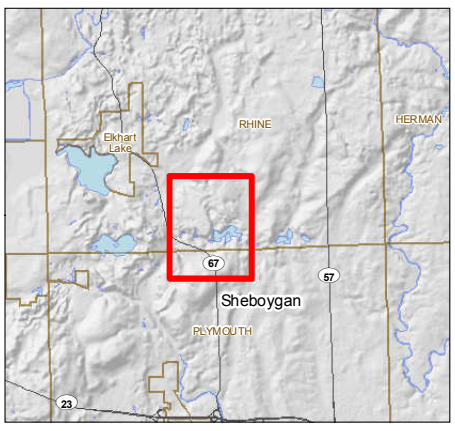



**Notes**

1. Coordinate System: NAD 1983 StatePlane Wisconsin South FIPS 4803 Feet
2. Data Sources Include: Stantec, WDNR, and WisDOT
3. Orthophotography: NAIP 2013



Legend

- Little Elkhart Lake Watershed

Land Cover

- Agricultural (121.53 ac)
- Commercial / Industrial (47.58 ac)
- Coniferous Forest (3.16 ac)
- Deciduous Forest (241.13 ac)
- Grassland / Shrubland (95.52)
- Open Water (56.3 ac)
- Residential (155.10 ac)
- Road (10.77 ac)
- Wetland (18.33 ac)

Figure No.

**4**

**DRAFT**

Title

# Land Cover
# Little Elkhart Lake Watershed

Client/Project

Little Elkhart Lake
Rehabiliation District

Project Location
T16N, R21E, S33 & S34
T. of Rhine,
Sheboygan Co., WI

193701611
Prepared by KAS on 2014-11-06
Technical Review by AB on 2014-11-06
Independent Review by XXX on 2014-XX-XX

0 400 800 Feet

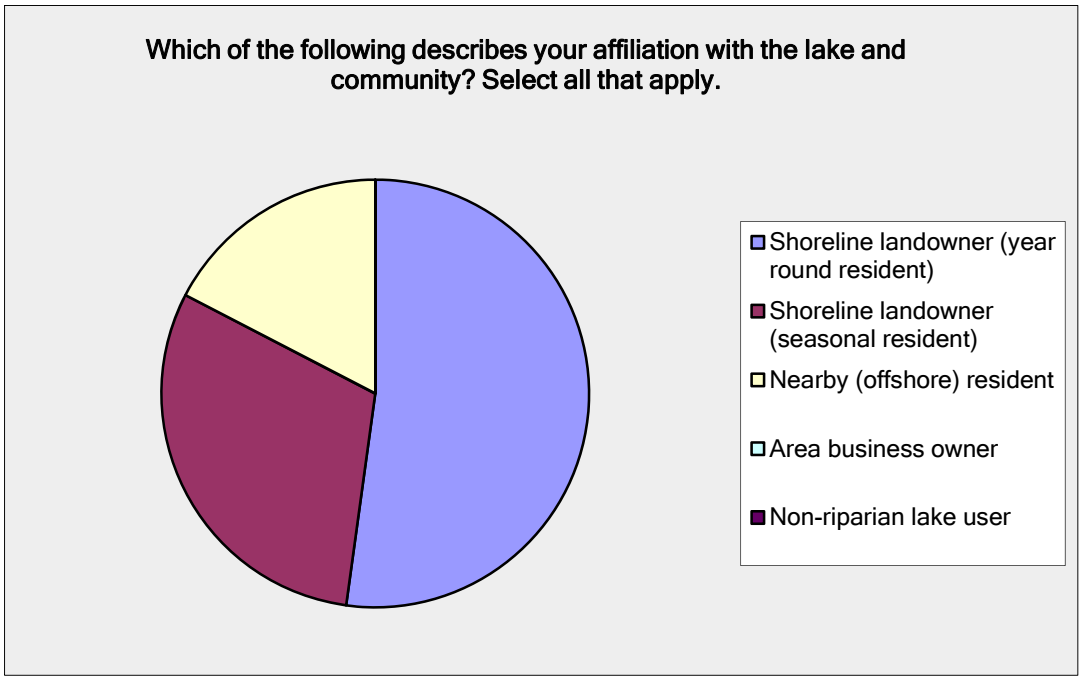
1:9,600 (At Original document size of 11x17)

N

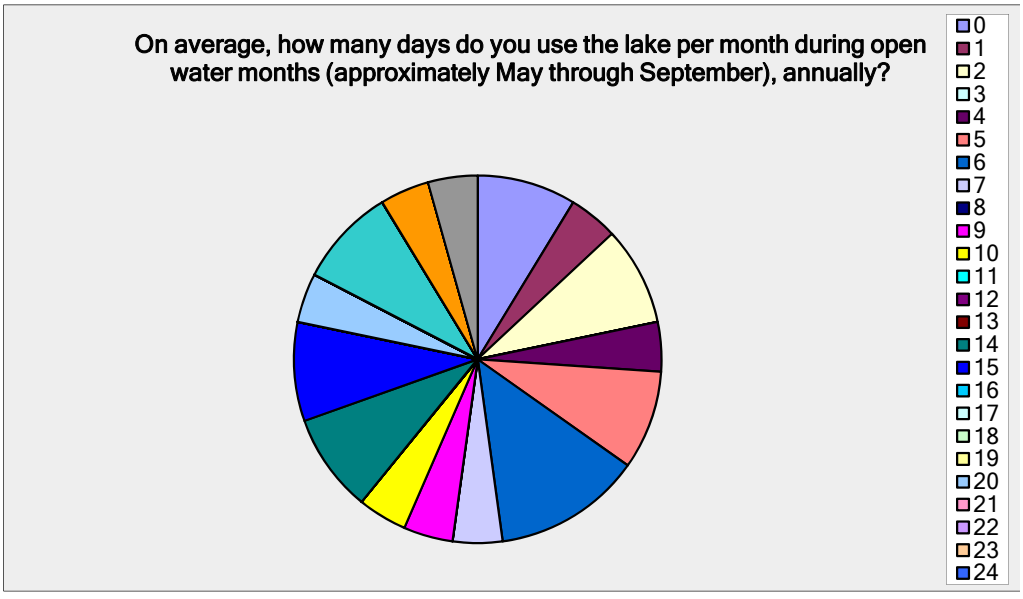
Stantec

# Appendix A – Summary of Public Survey

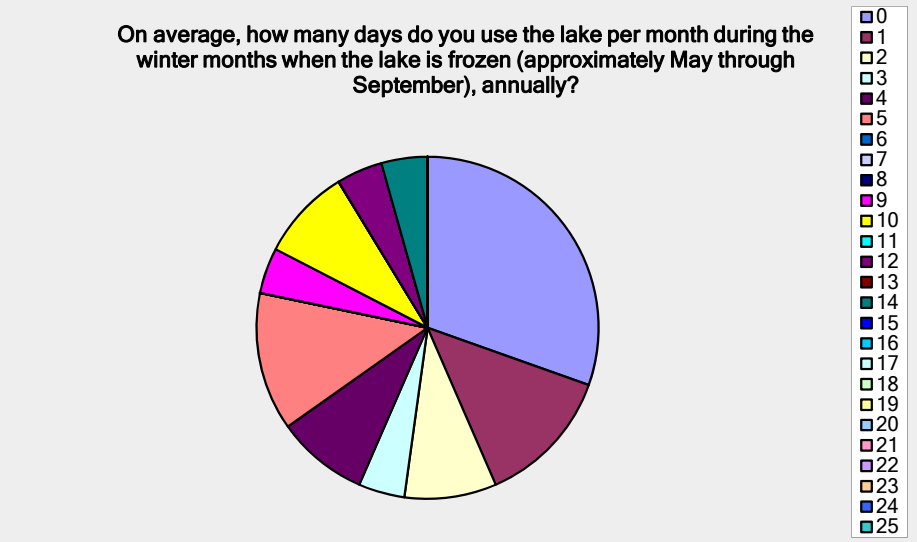
| Which of the following describes your affiliation with the lake and community? Select all that apply. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Shoreline landowner (year round resident) | 52.2% | 12 |
| Shoreline landowner (seasonal resident) | 30.4% | 7 |
| Nearby (offshore) resident | 17.4% | 4 |
| Area business owner | 0.0% | 0 |
| Non-riparian lake user | 0.0% | 0 |
| Other (please specify) | 0.0% | 0 |
| | *answered question* | 23 |
| | *skipped question* | 0 |



| On average, how many days do you use the lake per month during open water months (approximately May through September), annually? | | |
|---|---|---|
| Answer Options | Response Percent | Response Count |
| 0 | 8.7% | 2 |
| 1 | 4.3% | 1 |
| 2 | 8.7% | 2 |
| 3 | 0.0% | 0 |
| 4 | 4.3% | 1 |
| 5 | 8.7% | 2 |
| 6 | 13.0% | 3 |
| 7 | 4.3% | 1 |
| 8 | 0.0% | 0 |
| 9 | 4.3% | 1 |
| 10 | 4.3% | 1 |
| 11 | 0.0% | 0 |
| 12 | 0.0% | 0 |
| 13 | 0.0% | 0 |
| 14 | 8.7% | 2 |
| 15 | 8.7% | 2 |
| 16 | 0.0% | 0 |
| 17 | 0.0% | 0 |
| 18 | 0.0% | 0 |
| 19 | 0.0% | 0 |
| 20 | 4.3% | 1 |
| 21 | 0.0% | 0 |
| 22 | 0.0% | 0 |
| 23 | 0.0% | 0 |
| 24 | 0.0% | 0 |
| 25 | 8.7% | 2 |
| 26 | 0.0% | 0 |
| 27 | 0.0% | 0 |
| 28 | 4.3% | 1 |
| 29 | 0.0% | 0 |
| 30 | 0.0% | 0 |
| 31 | 4.3% | 1 |
| *answered question* | | 23 |
| *skipped question* | | 0 |



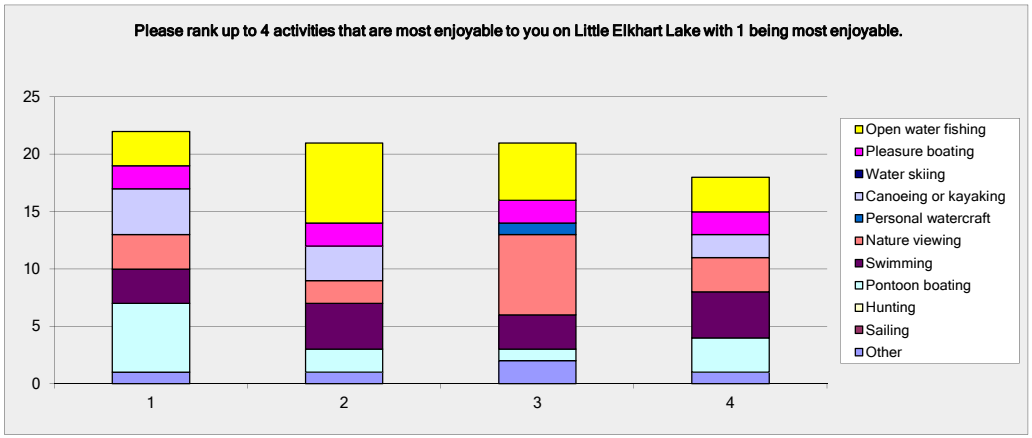
| On average, how many days do you use the lake per month during the winter months when the lake is frozen (approximately May through September), annually? | | |
|---|---|---|
| Answer Options | Response Percent | Response Count |
| 0 | 30.4% | 7 |
| 1 | 13.0% | 3 |
| 2 | 8.7% | 2 |
| 3 | 4.3% | 1 |
| 4 | 8.7% | 2 |
| 5 | 13.0% | 3 |
| 6 | 0.0% | 0 |
| 7 | 0.0% | 0 |
| 8 | 0.0% | 0 |
| 9 | 4.3% | 1 |
| 10 | 8.7% | 2 |
| 11 | 0.0% | 0 |
| 12 | 4.3% | 1 |
| 13 | 0.0% | 0 |
| 14 | 4.3% | 1 |
| 15 | 0.0% | 0 |
| 16 | 0.0% | 0 |
| 17 | 0.0% | 0 |
| 18 | 0.0% | 0 |
| 19 | 0.0% | 0 |
| 20 | 0.0% | 0 |
| 21 | 0.0% | 0 |
| 22 | 0.0% | 0 |
| 23 | 0.0% | 0 |
| 24 | 0.0% | 0 |
| 25 | 0.0% | 0 |
| 26 | 0.0% | 0 |
| 27 | 0.0% | 0 |
| 28 | 0.0% | 0 |
| 29 | 0.0% | 0 |
| 30 | 0.0% | 0 |
| 31 | 0.0% | 0 |
| *answered question* | | 23 |
| *skipped question* | | 0 |



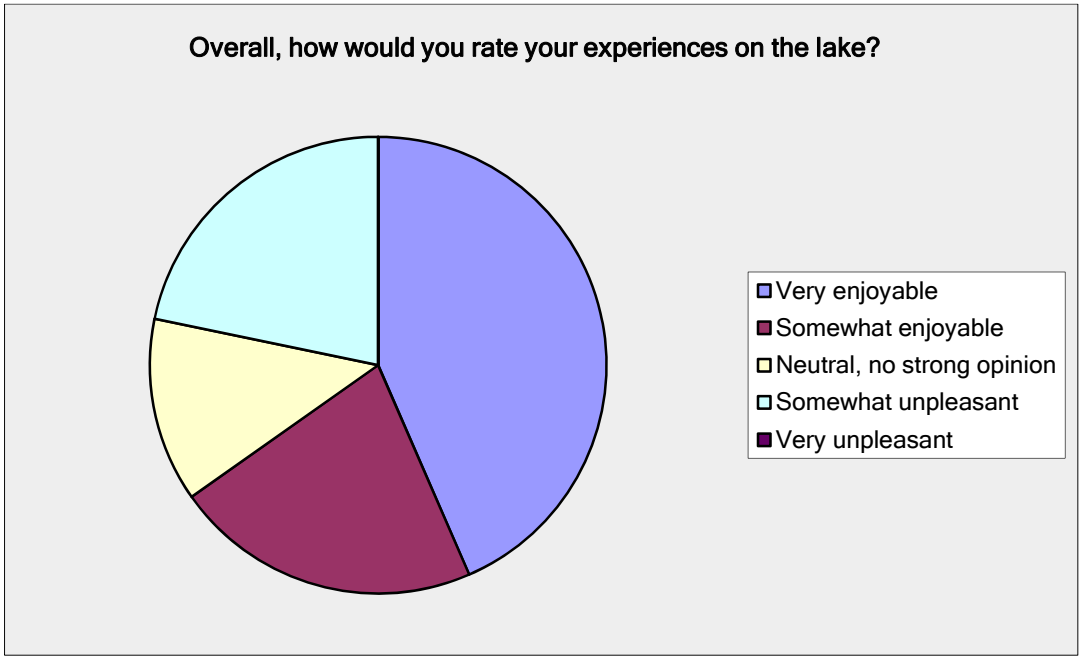
**Please rank up to 4 activities that are most enjoyable to you on Little Elkhart Lake with 1 being most enjoyable.**

| Answer Options | Open water fishing | Pleasure boating | Water skiing | Canoeing or kayaking | Personal watercraft | Nature viewing | Swimming | Pontoon boating | Hunting | Sailing | Other | Response Count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 2 | 0 | 4 | 0 | 3 | 3 | 6 | 0 | 0 | 1 | 22 |
| 2 | 7 | 2 | 0 | 3 | 0 | 2 | 4 | 2 | 0 | 0 | 1 | 21 |
| 3 | 5 | 2 | 0 | 0 | 1 | 7 | 3 | 1 | 0 | 0 | 2 | 21 |
| 4 | 3 | 2 | 0 | 2 | 0 | 3 | 4 | 3 | 0 | 0 | 1 | 18 |
| Other (please specify) | | | | | | | | | | | | 4 |
| *average rank* | *2.44* | *2.50* | *0.00* | *2.00* | *3.00* | *2.67* | *2.57* | *2.08* | *0.00* | *0.00* | *2.60* | |

| Number | Other (please specify) |
|---|---|
| 1 | paddle boat |
| 2 | use pedal boat frequently along with flotation devices. |
| 3 | enjoy the quietness of sitting in a boat and letting the world float by |
| 4 | watching/listening to Anokijig campers/kids enjoying the lake |
| 5 | Ice fishing |

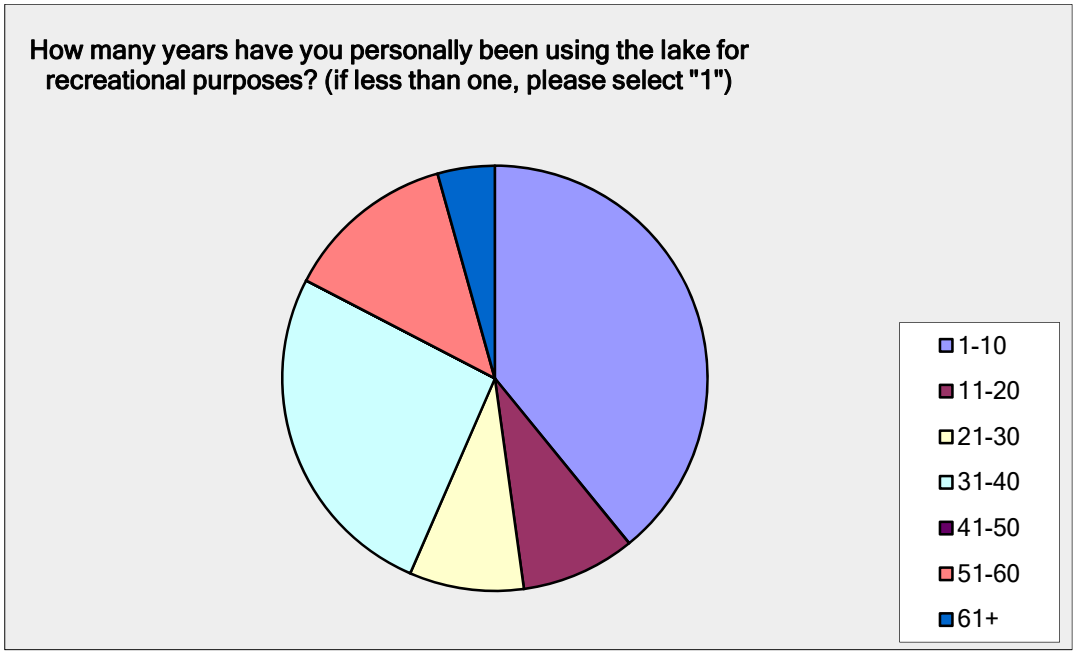


| Overall, how would you rate your experiences on the lake? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Very enjoyable | 43.5% | 10 |
| Somewhat enjoyable | 21.7% | 5 |
| Neutral, no strong opinion | 13.0% | 3 |
| Somewhat unpleasant | 21.7% | 5 |
| Very unpleasant | 0.0% | 0 |
| | *answered question* | 23 |
| | *skipped question* | 0 |

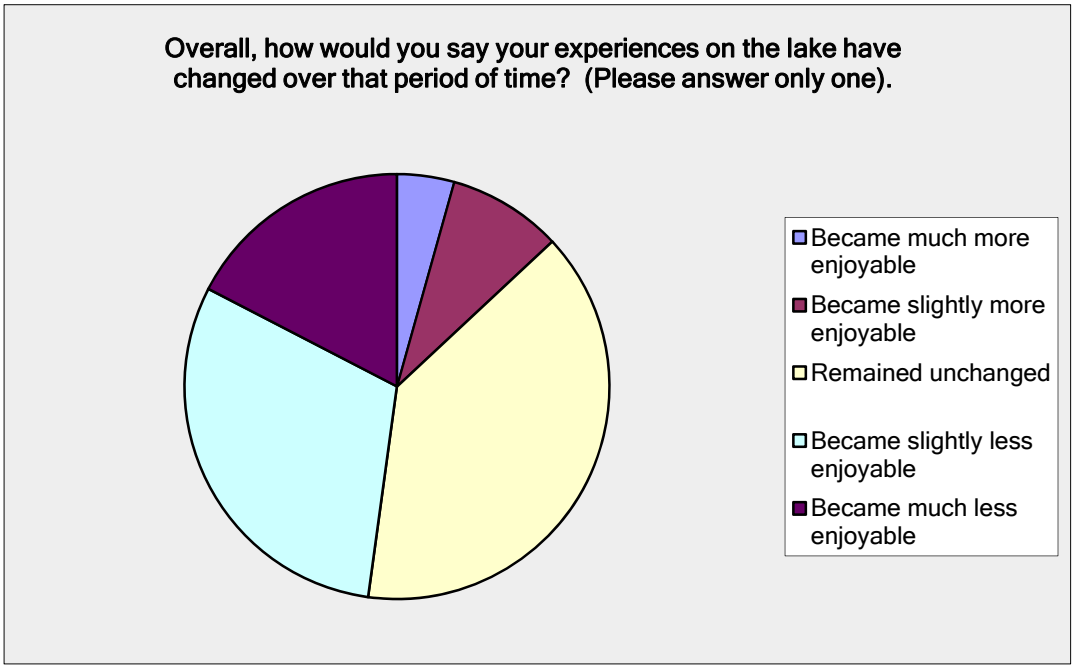


| How many years have you personally been using the lake for recreational purposes? (if less than one, please select "1") | | |
|---|---|---|
| Answer Options | Response Percent | Response Count |
| 1 | 17.4% | 4 |
| 2 | 8.7% | 2 |
| 3 | 0.0% | 0 |
| 4 | 0.0% | 0 |
| 5 | 0.0% | 0 |
| 6 | 4.3% | 1 |
| 7 | 0.0% | 0 |
| 8 | 0.0% | 0 |
| 9 | 0.0% | 0 |
| 10 | 8.7% | 2 |
| 11 | 4.3% | 1 |
| 12 | 0.0% | 0 |
| 13 | 0.0% | 0 |
| 14 | 0.0% | 0 |
| 15 | 0.0% | 0 |
| 16 | 0.0% | 0 |
| 17 | 0.0% | 0 |
| 18 | 0.0% | 0 |
| 19 | 0.0% | 0 |
| 20 | 4.3% | 1 |
| 21 | 0.0% | 0 |
| 22 | 0.0% | 0 |
| 23 | 0.0% | 0 |
| 24 | 0.0% | 0 |
| 25 | 0.0% | 0 |
| 26 | 0.0% | 0 |
| 27 | 4.3% | 1 |
| 28 | 0.0% | 0 |
| 29 | 0.0% | 0 |
| 30 | 4.3% | 1 |
| 31 | 0.0% | 0 |
| 32 | 0.0% | 0 |
| 33 | 8.7% | 2 |
| 34 | 8.7% | 2 |
| 35 | 0.0% | 0 |
| 36 | 0.0% | 0 |
| 37 | 0.0% | 0 |
| 38 | 0.0% | 0 |
| 39 | 4.3% | 1 |
| 40 | 4.3% | 1 |
| 41 | 0.0% | 0 |
| 42 | 0.0% | 0 |
| 43 | 0.0% | 0 |
| 44 | 0.0% | 0 |
| 45 | 0.0% | 0 |
| 46 | 0.0% | 0 |
| 47 | 0.0% | 0 |
| 48 | 0.0% | 0 |

| | | |
|---|---|---|
| 49 | 0.0% | 0 |
| 50 | 0.0% | 0 |
| 51 | 0.0% | 0 |
| 52 | 0.0% | 0 |
| 53 | 0.0% | 0 |
| 54 | 0.0% | 0 |
| 55 | 4.3% | 1 |
| 56 | 0.0% | 0 |
| 57 | 0.0% | 0 |
| 58 | 0.0% | 0 |
| 59 | 4.3% | 1 |
| 60 | 4.3% | 1 |
| 61 | 0.0% | 0 |
| 62 | 0.0% | 0 |
| 63 | 0.0% | 0 |
| 64 | 0.0% | 0 |
| 65 | 4.3% | 1 |
| | *answered question* | 23 |
| | *skipped question* | 0 |

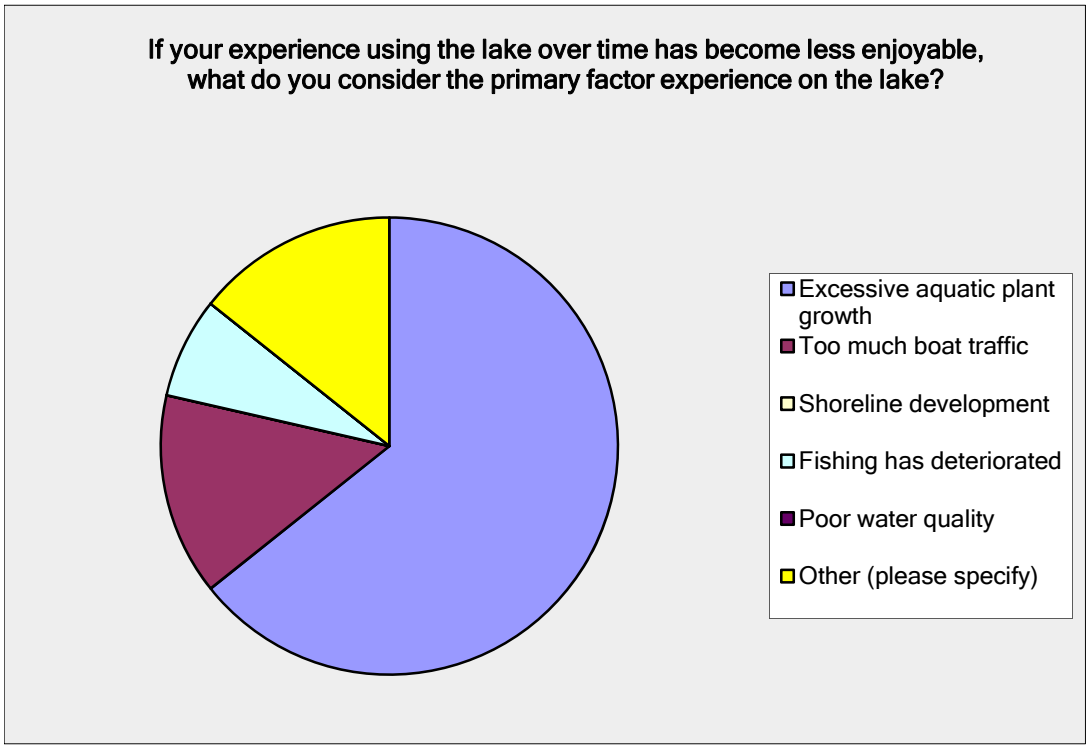


| Overall, how would you say your experiences on the lake have changed over that period of time? (Please answer only one). | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Became much more enjoyable | 4.3% | 1 |
| Became slightly more enjoyable | 8.7% | 2 |
| Remained unchanged | 39.1% | 9 |
| Became slightly less enjoyable | 30.4% | 7 |
| Became much less enjoyable | 17.4% | 4 |
| *answered question* | | 23 |
| *skipped question* | | 0 |



| If your experience using the lake over time has become less enjoyable, what do you consider the primary factor experience on the lake? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Excessive aquatic plant growth | 64.3% | 9 |
| Too much boat traffic | 14.3% | 2 |
| Shoreline development | 0.0% | 0 |
| Fishing has deteriorated | 7.1% | 1 |
| Poor water quality | 0.0% | 0 |
| Other (please specify) | 14.3% | 2 |
| | *answered question* | 14 |
| | *skipped question* | 12 |

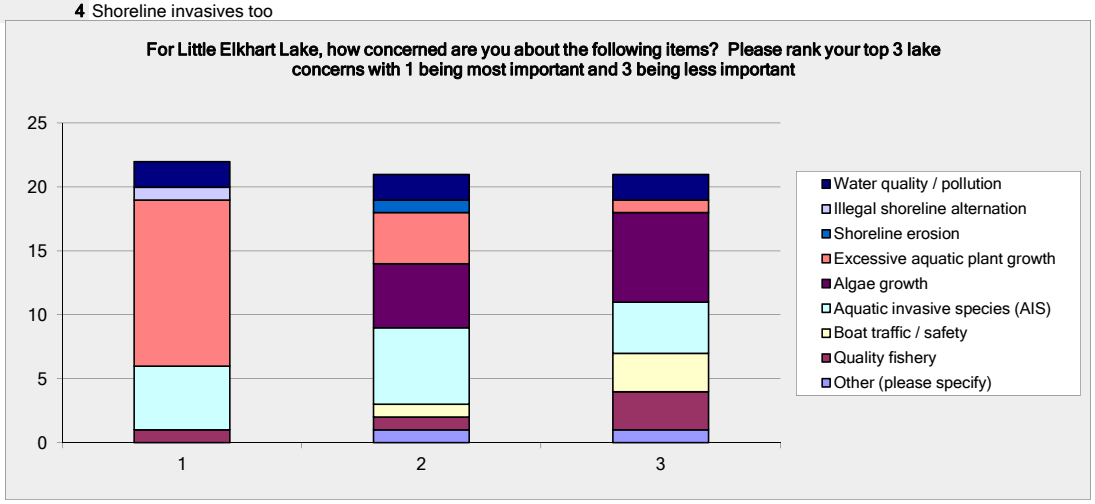
| Number | Other (please specify) |
|---|---|
| 1 | If I knew this weed problem was here prior to buy and my house I would've never bought it. I am willing to pay for the weed control in front of my property myself. |
| 2 | User behavior |
| 3 | Comment - Would select A (excessive aquatic plant growth) twice |



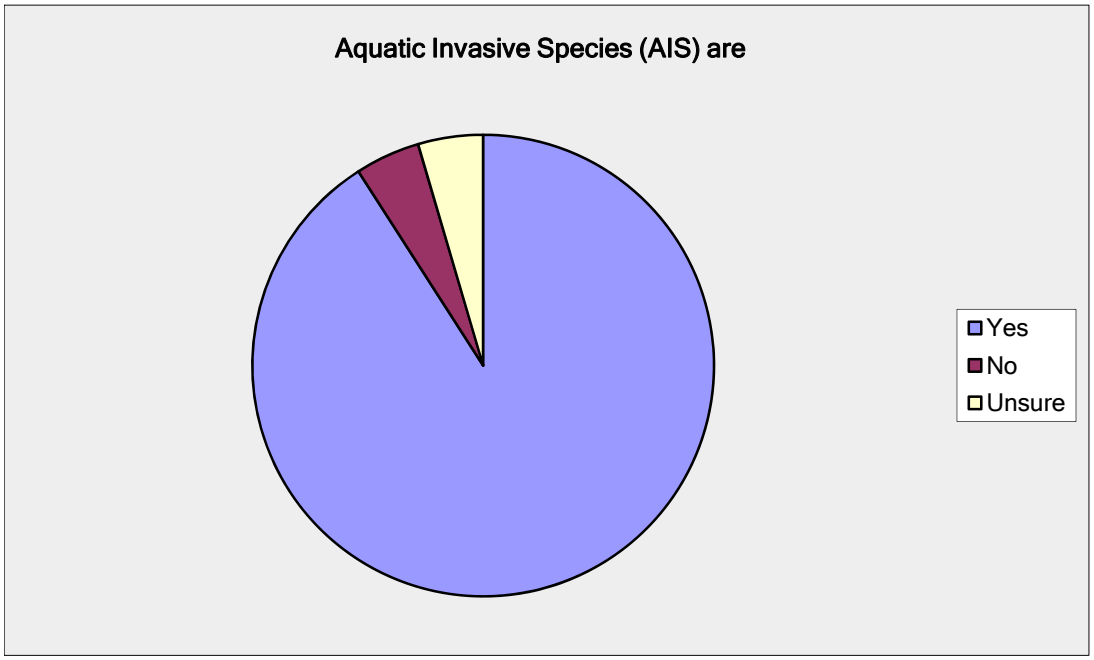
**For Little Elkhart Lake, how concerned are you about the following items? Please rank your top 3 lake concerns with 1 being most important and 3 being less important**

| Answer Options | Water quality / pollution | Illegal shoreline alternation | Shoreline erosion | Excessive aquatic plant growth | Algae growth | Aquatic invasive species (AIS) | Boat traffic / safety | Quality fishery | Other (please specify) | Response Count |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 1 | 0 | 13 | 0 | 5 | 0 | 1 | 0 | 22 |
| 2 | 2 | 0 | 1 | 4 | 5 | 6 | 1 | 1 | 1 | 21 |
| 3 | 2 | 0 | 0 | 1 | 7 | 4 | 3 | 3 | 1 | 21 |
| Other (please specify) | | | | | | | | | | 2 |
| Average Rank | 2.00 | 1.00 | 2.00 | 1.33 | 2.58 | 1.93 | 2.75 | 2.40 | 2.50 | |
| | | | | | | | | | *Answered question* | 22 |
| | | | | | | | | | *skipped question* | 1 |

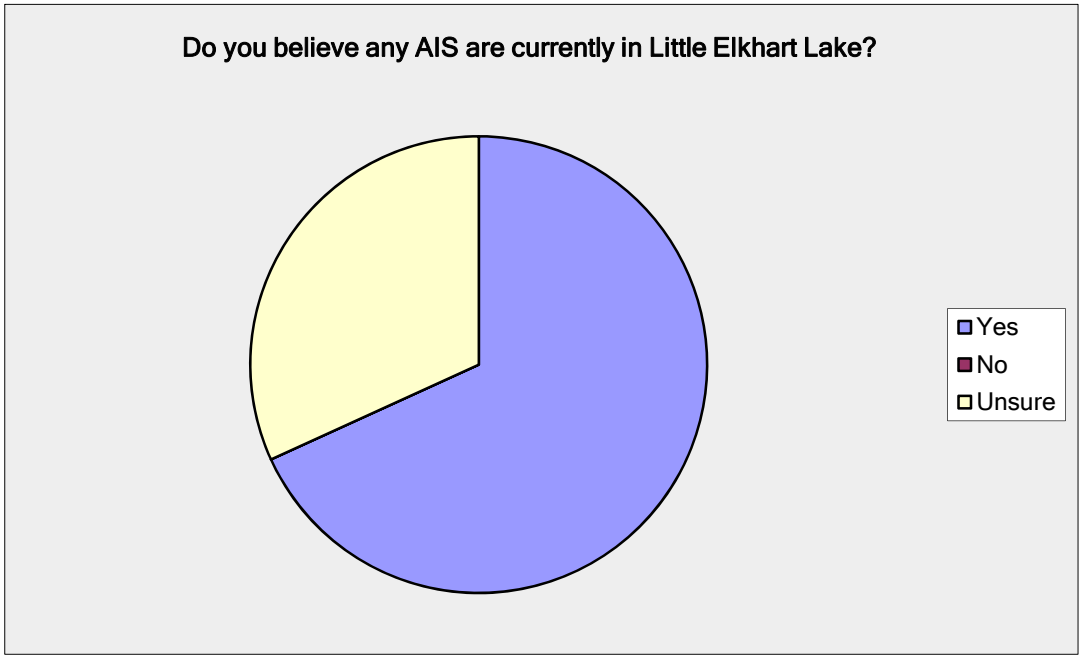
| Number | Other (please specify) |
|---|---|
| 1 | all the plant clippings from the motor traffic drift/blow into our shoreline area blocking access and encouraging algae |
| 2 | excess noise; jet skis, loud boats, ice motorcycles and snowmobiles with modified exhaust |
| 3 | The aquatic growth has overgrown so swimming is difficult |
| 4 | Shoreline invasives too |



| Aquatic Invasive Species (AIS) are non-native plants or animals that can out-compete their native counterparts and potentially cause a myriad of problems within the lake | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Yes | 90.9% | 20 |
| No | 4.5% | 1 |
| Unsure | 4.5% | 1 |
| | *answered question* | 22 |
| | *skipped question* | 1 |

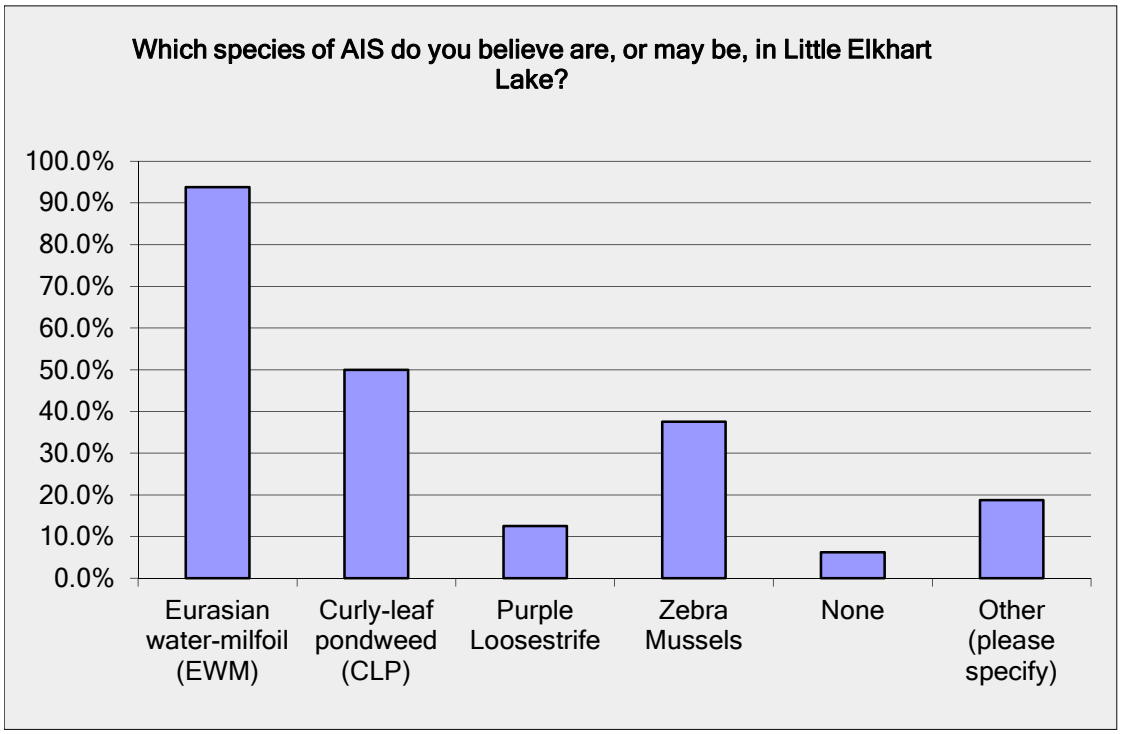


| Do you believe any AIS are currently in Little Elkhart Lake? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Yes | 68.2% | 15 |
| No | 0.0% | 0 |
| Unsure | 31.8% | 7 |
| | *answered question* | 22 |
| | *skipped question* | 1 |



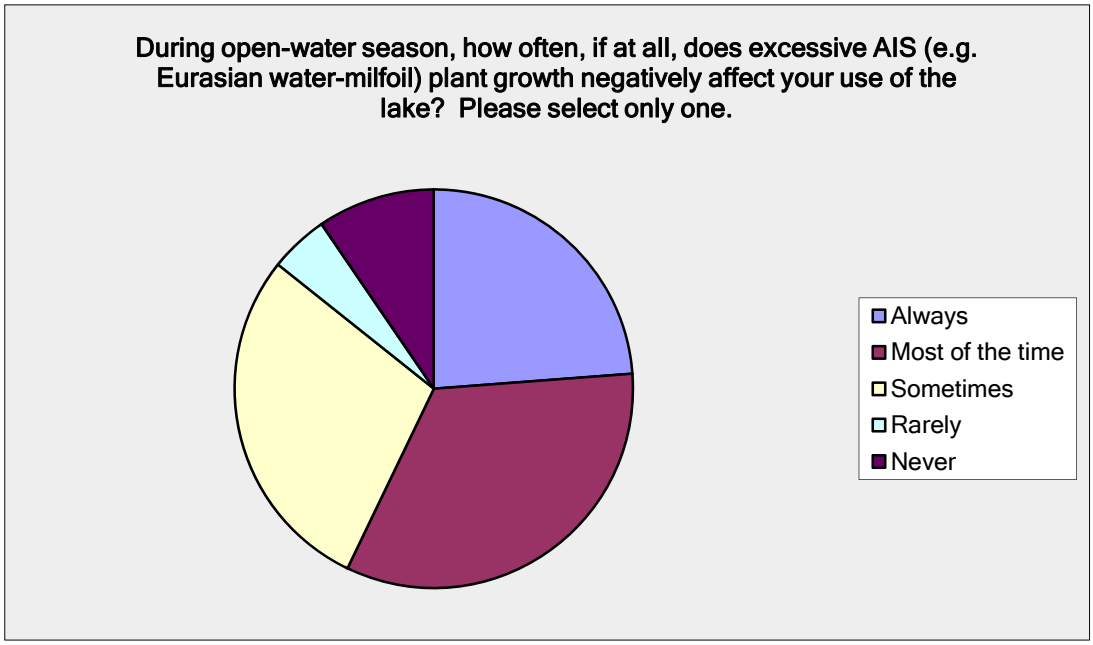
| Which species of AIS do you believe are, or may be, in Little Elkhart Lake? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Eurasian water-milfoil (EWM) | 93.8% | 15 |
| Curly-leaf pondweed (CLP) | 50.0% | 8 |
| Purple Loosestrife | 12.5% | 2 |
| Zebra Mussels | 37.5% | 6 |
| None | 6.3% | 1 |
| Other (please specify) | 18.8% | 3 |
| | *answered question* | 16 |
| | *skipped question* | 5 |

| Number | Other (please specify) |
|---|---|
| 1 | I know these three are in the lake I'm not sure of any other ones. I do not study weeds. But I can't say for a fact they are overwhelming on the west shore. Please take the time this summer to come and investigate for yourself bring your swimsuit |
| 2 | chinese snails |
| 3 | Phragmites |

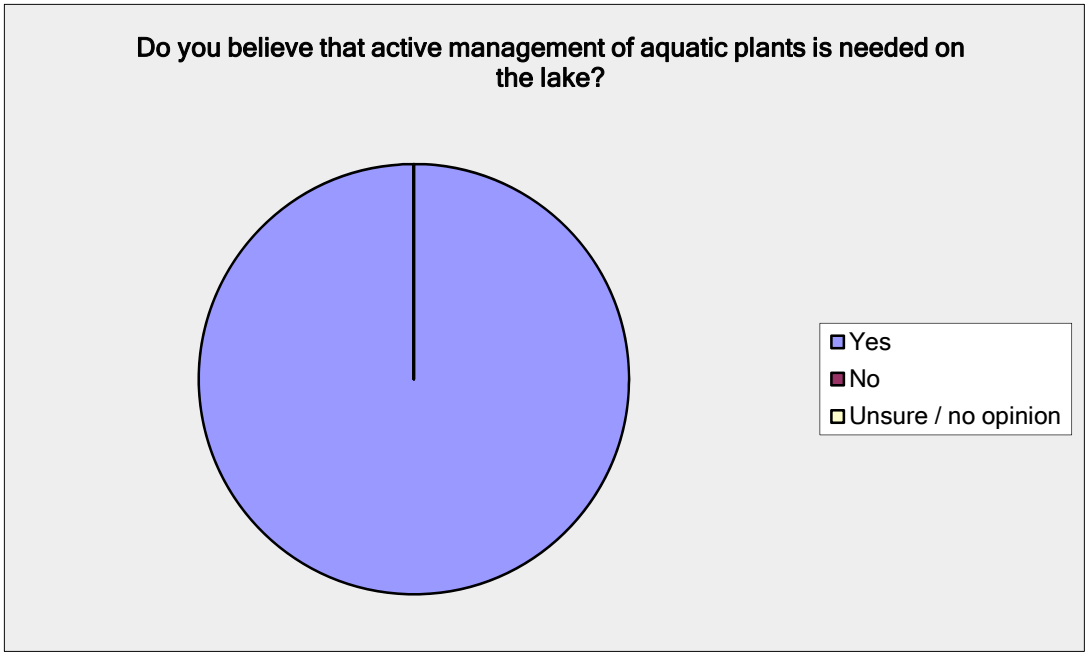


| During open-water season, how often, if at all, does excessive AIS (e.g. Eurasian water-milfoil) plant growth negatively affect your use of the lake? Please select only one. | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Always | 23.8% | 5 |
| Most of the time | 33.3% | 7 |
| Sometimes | 28.6% | 6 |
| Rarely | 4.8% | 1 |
| Never | 9.5% | 2 |
| Comments | | 2 |
| | *answered question* | 21 |
| | *skipped question* | 2 |

| Number | Comments |
|---|---|
| 1 | Most of the time if not always during the growth of these weeds. |
| 2 | You have to do the Little Elkhart Lake reverse drop to remove the mass of weeds from the prop as soon as you reach open water.This is mostly caused by lilly pads, but AIS don't help! |



| Do you believe that active management of aquatic plants is needed on the lake? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Yes | 100.0% | 22 |
| No | 0.0% | 0 |
| Unsure / no opinion | 0.0% | 0 |
| *answered question* | | 22 |
| *skipped question* | | 1 |



**Which of the following AIS management options would you support? Please rank your top 4 preferences with 1 being the most preferred and 4 being the least preferred option.**

| Ranking | Manual removal or hand pulling | Mechanical harvesting or cutting | Herbicide control | Diver/hydraulic dredging | Continue to monitor the infestation through annual AIS surveys | No action: wait and see what happens over the long term | Not sure, would rely on a professional consulting firm | Not sure, would rely on the WDNR for guidance | Response Count |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 11 | 1 | 0 | 0 | 3 | 2 | 22 |
| 2 | 3 | 6 | 4 | 1 | 3 | 0 | 2 | 2 | 21 |
| 3 | 4 | 2 | 2 | 4 | 4 | 0 | 2 | 1 | 19 |
| 4 | 2 | 2 | 6 | 2 | 1 | 0 | 2 | 1 | 16 |
| AVERAGE | 2.55 | 2.23 | 2.13 | 2.88 | 2.75 | 0.00 | 2.33 | 2.17 | |

| | Question Totals |
|---|---|
| *answered question* | 22 |
| *skipped question* | 1 |

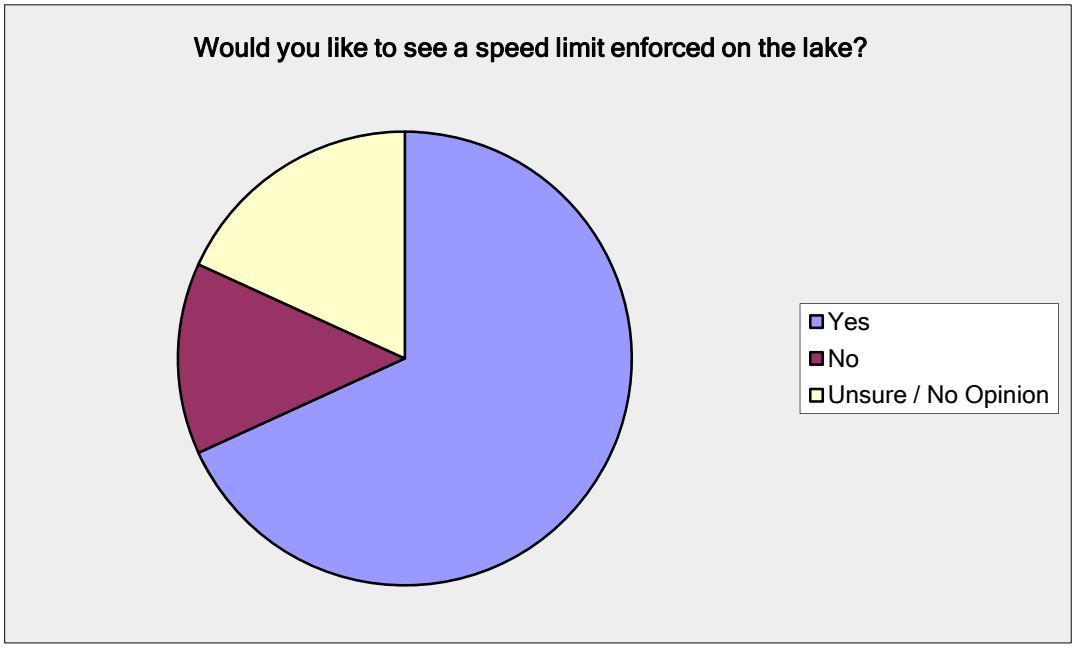
**Please rank up the importance of the following elements of the Aquatic Plant Management Plan update with 1 being most important and 4 being least important.**

| Ranking | Study and understand current aquatic plant problems | Protect native plant species | Reduce extent and density of existing AIS infestations | Prevent the spread of existing AIS | Prevent the introduction of new AIS | Identify and explore new aquatic plant management strategies | Seek grant funding for AIS management efforts | Ability to obtain a large scale permit to manage 10+ acres of AIS | Indentify areas in need on annual management for navigational purposes | Other - please specify | Response Count |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 1 | 7 | 0 | 0 | 0 | 6 | 3 | 1 | 0 | 22 |
| 2 | 0 | 2 | 5 | 6 | 2 | 1 | 4 | 1 | 1 | 0 | 22 |
| 3 | 3 | 0 | 4 | 3 | 5 | 1 | 2 | 2 | 1 | 0 | 21 |
| 4 | 2 | 3 | 0 | 1 | 3 | 7 | 2 | 1 | 1 | 0 | 20 |
| AVERAGE | 2.33 | 2.83 | 1.81 | 2.50 | 3.10 | 3.67 | 2.00 | 2.14 | 2.50 | 0 | |

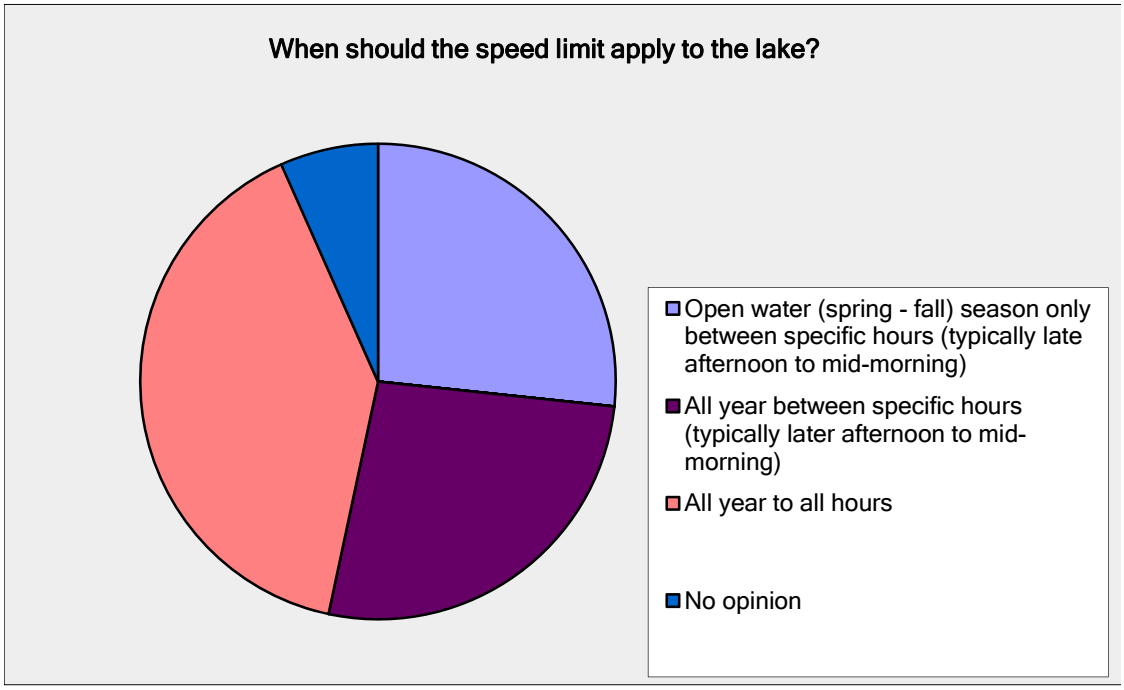
| | Question Totals |
|---|---|
| Other (please specify) | 1 |
| *answered question* | 22 |
| *skipped question* | 1 |

| Number | Other (please specify) |
|---|---|
| 1 | My neighbors and I need help. Hand pulling this crap is a backbreaker. In this time and age there's got to be something you can do to maintain a nice looking lake. What we have to look at day after day is absolutely nasty. |

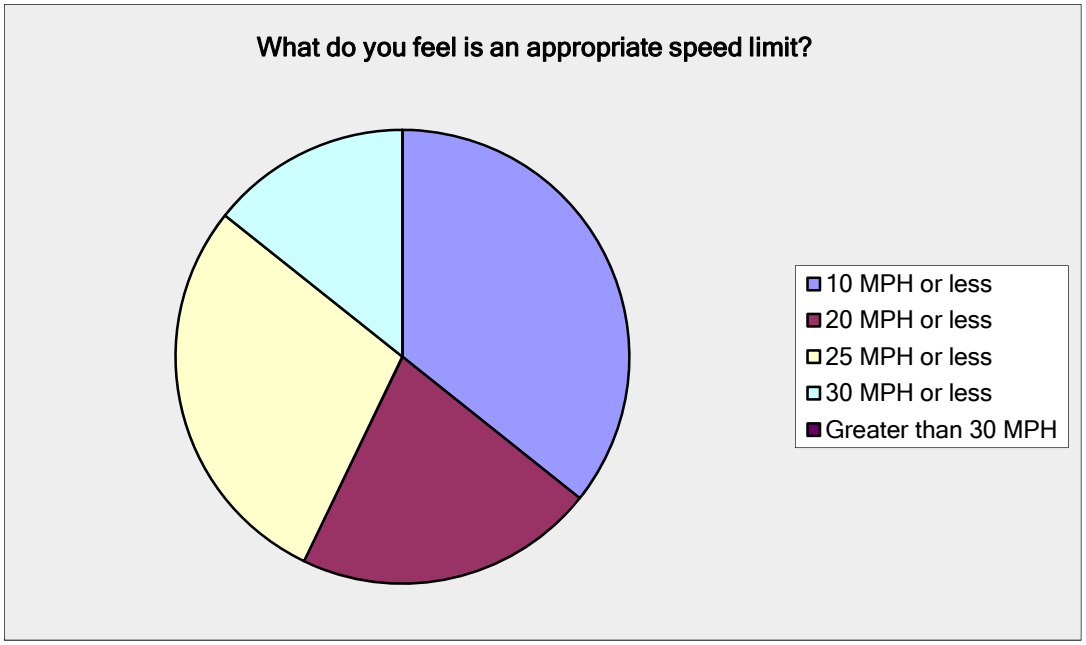
| Would you like to see a speed limit enforced on the lake? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Yes | 68.2% | 15 |
| No | 13.6% | 3 |
| Unsure / No Opinion | 18.2% | 4 |
| | *answered question* | 22 |
| | *skipped question* | 1 |



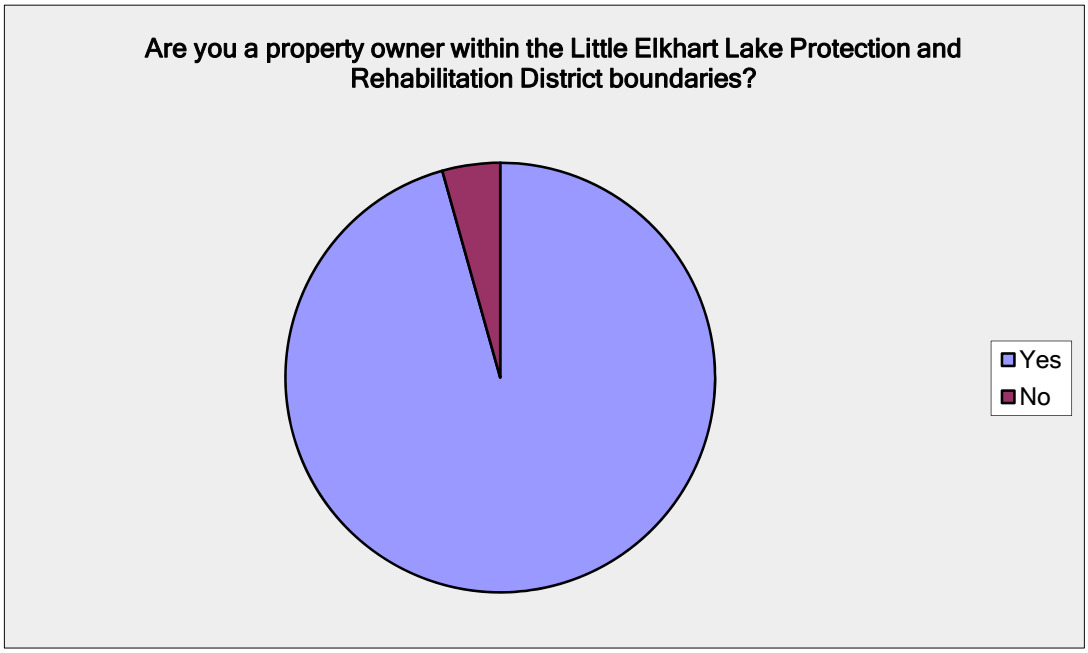
| When should the speed limit apply to the lake? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Open water (spring - fall) season only between specific hours (typically late afternoon to mid-morning) | 26.7% | 4 |
| Open water season only to all hours | 0.0% | 0 |
| Frozen water (winter) season only between certain hours (typically later afternoon to mid-morning) | 0.0% | 0 |
| Frozen water season only to all hours | 0.0% | 0 |
| All year between specific hours (typically later afternoon to mid-morning) | 26.7% | 4 |
| All year to all hours | 40.0% | 6 |
| No opinion | 6.7% | 1 |
| | *answered question* | 15 |
| | *skipped question* | 7 |



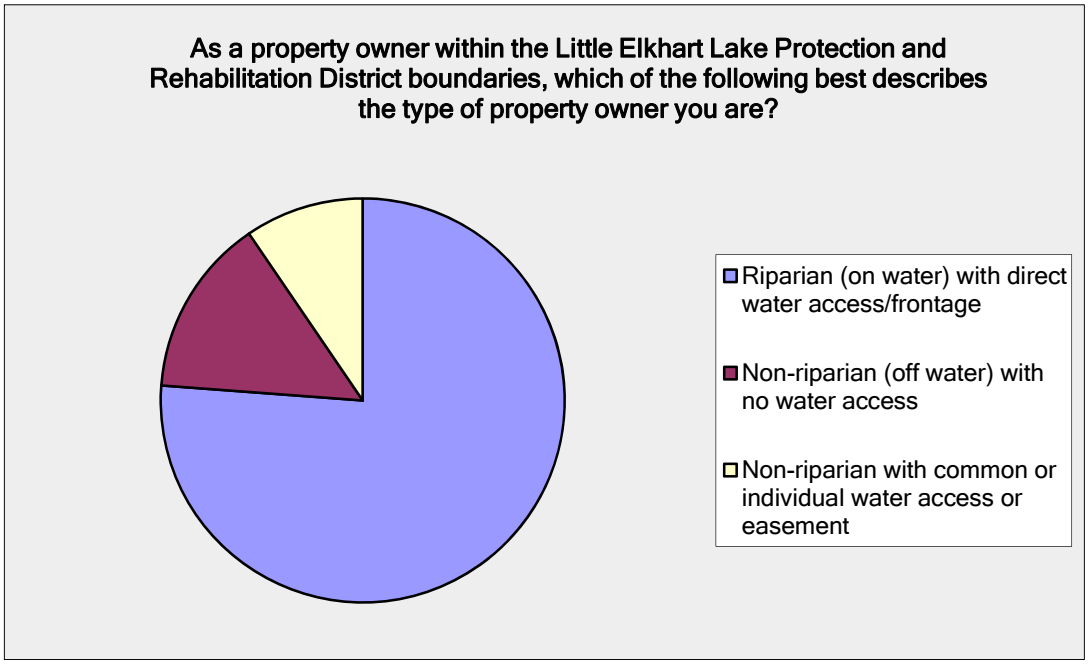
| What do you feel is an appropriate speed limit? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| 10 MPH or less | 35.7% | 5 |
| 20 MPH or less | 21.4% | 3 |
| 25 MPH or less | 28.6% | 4 |
| 30 MPH or less | 14.3% | 2 |
| Greater than 30 MPH | 0.0% | 0 |
| | *answered question* | 14 |
| | *skipped question* | 7 |



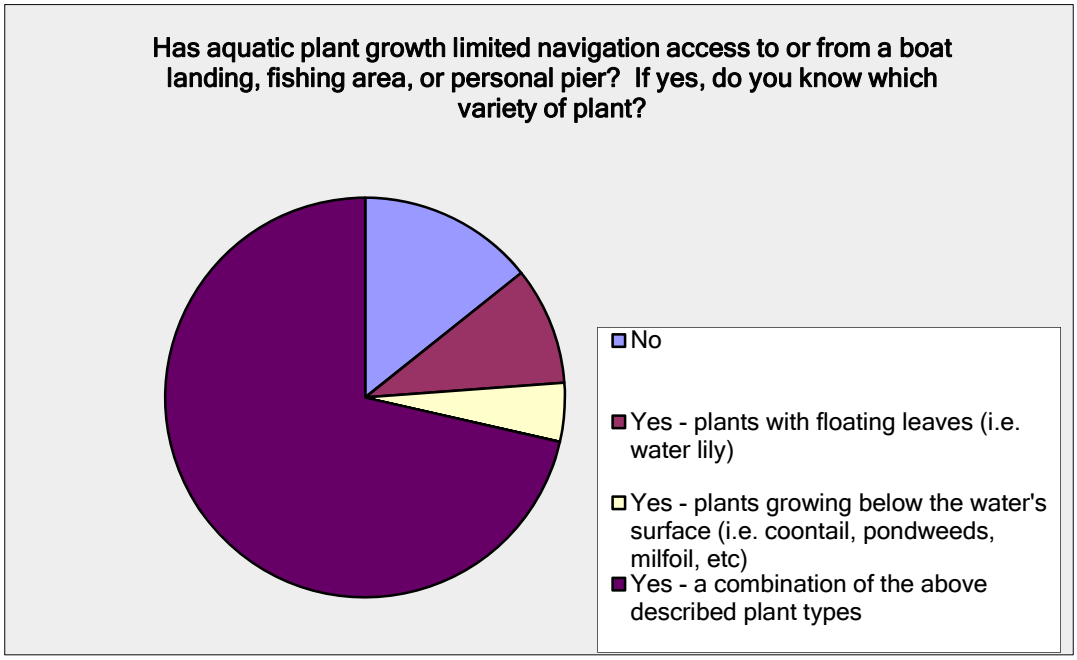
| Are you a property owner within the Little Elkhart Lake Protection and Rehabilitation District boundaries? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Yes | 95.7% | 22 |
| No | 4.3% | 1 |
| *answered question* | | 23 |
| *skipped question* | | 0 |



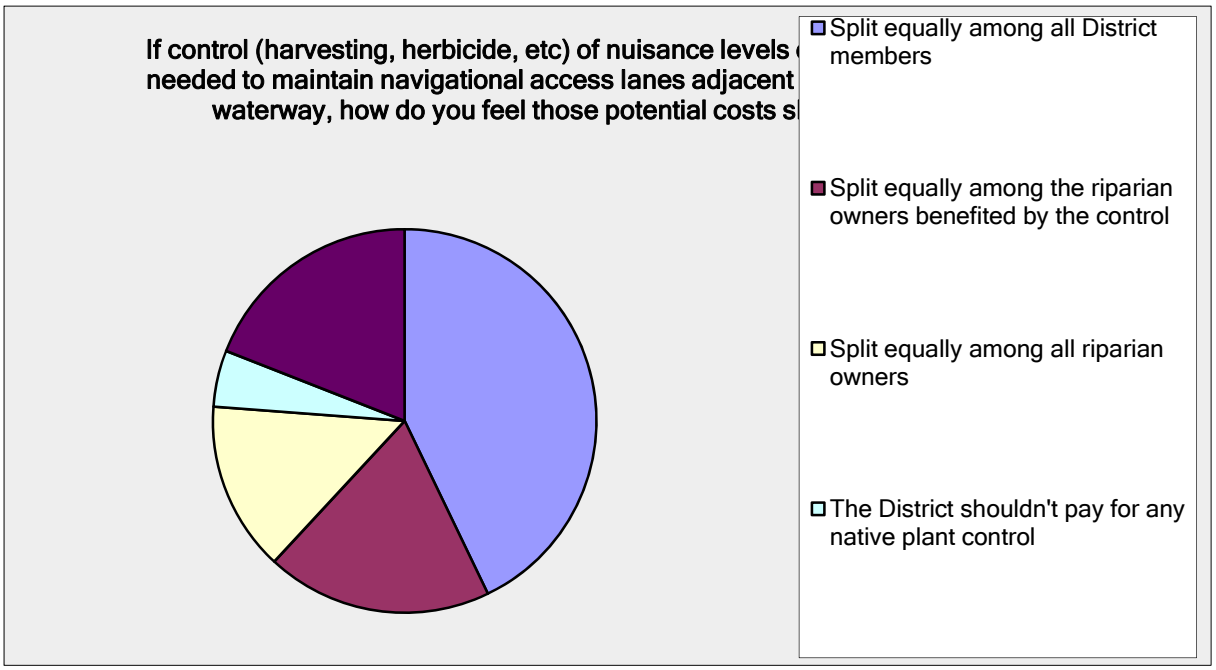
| As a property owner within the Little Elkhart Lake Protection and Rehabilitation District boundaries, which of the following best describes the type of property owner you are? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Riparian (on water) with direct water access/frontage | 76.2% | 16 |
| Non-riparian (off water) with no water access | 14.3% | 3 |
| Non-riparian with common or individual water access or | 9.5% | 2 |
| *answered question* | | 21 |
| *skipped question* | | 1 |



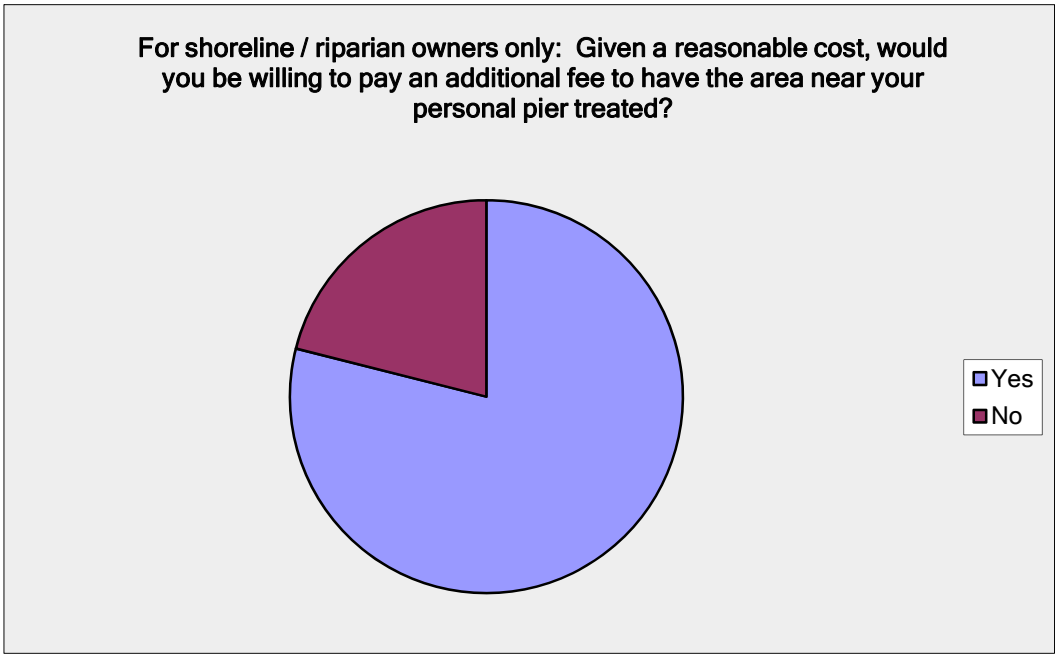
| Has aquatic plant growth limited navigation access to or from a boat landing, fishing area, or personal pier? If yes, do you know which variety of plant? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| No | 14.3% | 3 |
| Yes - plants with floating leaves (i.e. water lily) | 9.5% | 2 |
| Yes - plants growing below the water's surface (i.e. | 4.8% | 1 |
| Yes - plants growing above the surface (i.e. cattail) | 0.0% | 0 |
| Yes - a combination of the above described plant types | 71.4% | 15 |
| *answered question* | | 21 |
| *skipped question* | | 1 |



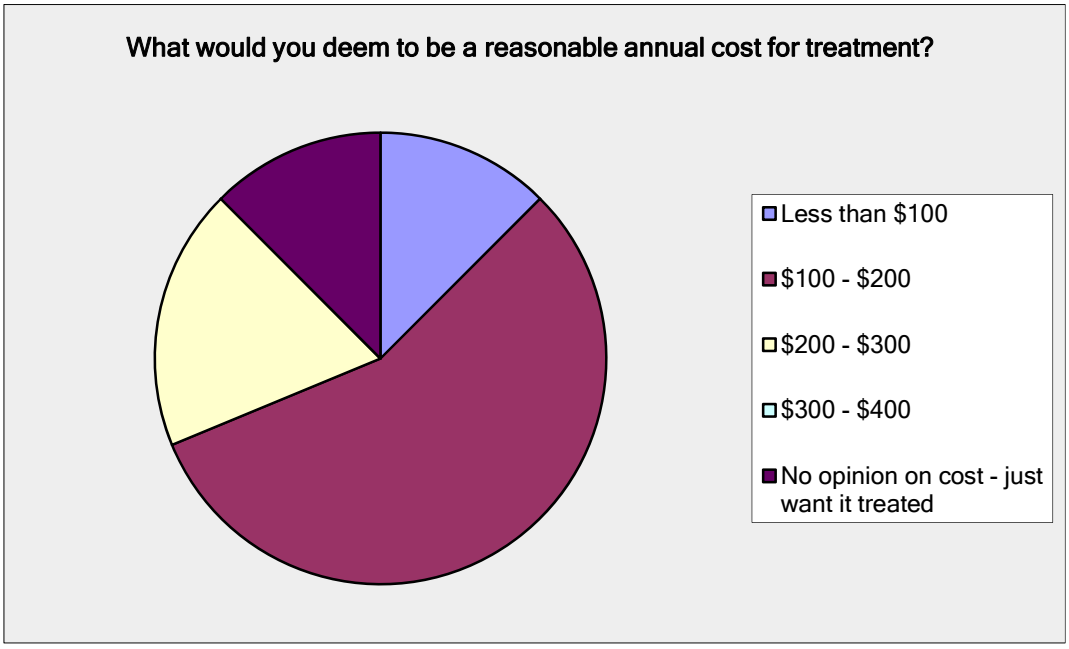
| If control (harvesting, herbicide, etc) of nuisance levels of native aquatic plants is needed to maintain navigational access lanes adjacent to private piers within the waterway, how do you feel those | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Split equally among all District members | 42.9% | 9 |
| Split equally among the riparian owners benefited by the control | 19.0% | 4 |
| Split equally among all riparian owners | 14.3% | 3 |
| The District shouldn't pay for any native plant control | 4.8% | 1 |
| The District should only par for common navigational areas benefiting | 19.0% | 4 |
| *answered question* | | 21 |
| *skipped question* | | 1 |



| For shoreline / riparian owners only: Given a reasonable cost, would you be willing to pay an additional fee to have the area near your personal pier treated? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Yes | 78.9% | 15 |
| No | 21.1% | 4 |
| | *answered question* | 19 |
| | *skipped question* | 3 |



| What would you deem to be a reasonable annual cost for treatment? | | |
|---|---|---|
| **Answer Options** | **Response Percent** | **Response Count** |
| Less than $100 | 12.5% | 2 |
| $100 - $200 | 56.3% | 9 |
| $200 - $300 | 18.8% | 3 |
| $300 - $400 | 0.0% | 0 |
| No opinion on cost - just want it treated | 12.5% | 2 |
| | *answered question* | 16 |
| | *skipped question* | 6 |



| Any additional comments or concerns? | |
|---|---|
| **Answer Options** | **Response Count** |
| | 10 |
| *answered question* | 10 |
| *skipped question* | 12 |

| Number | Response Text |
|---|---|
| 1 | 53073 and go for a swim. I would sure like to have someone's opinion on how they would enjoy swimming in weeds. I am willing to pay for weed control in front of my property. As long as it works. I am sick of going to meetings hearing about someone coming out and spring and |
| 2 | Overall the Lake has been rapidly evolving over last 4 decades. Much more collective weed growth. Was deeper in some areas, nicer swimming conditions, plentiful perch and walleye in addition to bass, northern and pan fish. |
| 3 | Winter/snowmobiles & ATV's should have a different speed limit than summer/boats |
| 4 | need to maintain our water clarity..... |
| 5 | I hate the weeds, but they shelter fish, and keep jet skis out of Wehmeyer bay. |
| 6 | allow motors on Sundays but at no wake speed |
| 7 | Evasive species, Lillie's, are a major concern. I believe herbicide is needed to contain. |
| 8 | We already pay $150 a year extra and don't get weed treatment |
| 9 | Lake is too small for personnel water craft by law |
| 10 | If our common water access required additional funding, initially, to control plants, we would open to increased funding levels. |

# Appendix B1 – Importance of Aquatic Plants to Lake Ecosystem

## AQUATIC PLANT TYPES AND HABITAT

Aquatic plants can be divided into two major groups: microphytes (phytoplankton and epiphytes) composed mostly of single-celled algae and macrophytes that include macro algae, flowering vascular plants and aquatic mosses and ferns. Wide varieties of microphytes co-inhabit all habitable areas of a lake. Their abundance depends on light, nutrient availability, and other ecological factors.

In contrast, macrophytes are predominantly found in distinct habitats located in the littoral (i.e., shallow near shore) zone where light sufficient for photosynthesis can penetrate to the lake bottom. The littoral zone is subdivided into four distinct transitional zones: the eulittoral, upper littoral, middle littoral and lower littoral (Wetzel, 1983).

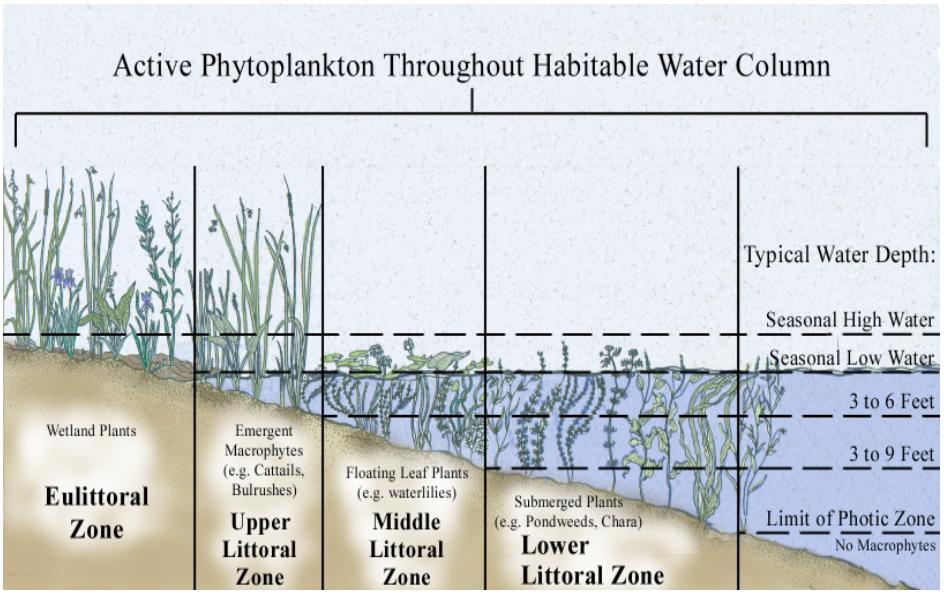
**Eulittoral Zone**: Includes the area between the highest and lowest seasonal water levels and often contains many wetland plants.

**Upper Littoral Zone**: Dominated by emergent macrophytes and extends from the shoreline edge to water depths between 3 and 6 feet.

**Middle Littoral Zone**: Occupies water depths of 3 to 9 feet, extending deeper from the upper littoral zone. The middle littoral zone is often dominated by floating-leaf plants.

**Lower Littoral Zone:** Extends to a depth equivalent to the limit of the photic zone, which is the maximum depth that sufficient light can support photosynthesis. This area is dominated by submergent aquatic plant types.

The following illustration depicts these particular zones and aquatic plant communities.




Aquatic Plant Communities Schematic

The abundance and distribution of aquatic macrophytes are controlled by light availability, lake trophic status as it relates to nutrients and water chemistry, sediment characteristics and wind energy. Lake morphology and watershed characteristics relate to these factors independently and in combination (NALMS, 1997).

## AQUATIC PLANTS AND WATER QUALITY

In many instances aquatic plants serve as indicators of water quality due to the sensitive nature of plants to water quality parameters such as water clarity and nutrient levels. To grow, aquatic plants

must have adequate supplies of nutrients. Microphytes and free-floating macrophytes (e.g., duckweed) derive all their nutrients directly from the water. Rooted macrophytes can absorb nutrients from water and/or sediment. Therefore, the growth of phytoplankton and free-floating aquatic plants is regulated by the supply of critical available nutrients in the water column. In contrast, rooted aquatic plants can normally continue to grow in nutrient-poor water if lake sediment contains adequate nutrient concentrations. Nutrients removed by rooted macrophytes from the lake bottom may be returned to the water column when the plants die. Consequently, killing too many aquatic macrophytes may increase nutrients available for algal growth.

In general, an inverse relationship exists between water clarity and macrophyte growth. That is, water clarity is usually improved with increasing abundance of aquatic macrophytes. Two possible explanations are postulated. The first is that the macrophytes and epiphytes out-compete phytoplankton for available nutrients. Epiphytes derive essentially all of their nutrient needs from the water column. The other explanation is that aquatic macrophytes stabilize bottom sediment and limit water circulation, preventing re-suspension of solids and nutrients (NALMS, 1997).

If aquatic macrophyte abundance is reduced, then water clarity may suffer. Water clarity reductions can further reduce the vigor of macrophytes by restricting light penetration. Studies have shown that if 30 percent or less of a lake areas occupied by aquatic plants is controlled, water clarity will generally not be affected. However, lake water clarity will likely be reduced if 50 percent or more of the macrophytes are controlled (NALMS, 1997).

Aquatic plants also play a key role in the ecology of a lake system. Aquatic plants provide food and shelter for fish, wildlife and invertebrates. Plants also improve water quality by protecting shorelines and the lake bottom, improving water quality, adding to the aesthetic quality of the lake and impacting recreational activities.

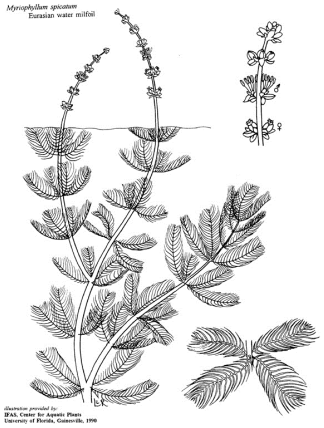
# Appendix B2 – Aquatic Invasive Species

## INVASIVE AQUATIC PLANTS

Invasive species have invaded our backyards, forests, prairies, wetlands and waters. Invasive species are often transplanted from other regions, even from across the globe. "A species is regarded as invasive if it has been introduced by human action to a location, area or region where it did not previously occur naturally (i.e., is not native), becomes capable of establishing a breeding population in the new location without further intervention by humans, and spreads widely throughout the new location " (Source: WDNR website, Invasive Species, 2007). AIS include plants and animals that affect our lakes, rivers and wetlands in negative ways. Once in their new environment, AIS often lack natural control mechanisms they may have had in their native ecosystem and may interfere with the native plant and animal interactions in their new "home". Some AIS have aggressive reproductive potential and contribute to ecological declines and problems for water based recreation and local economies. AIS often quickly become a problem in already disturbed lake ecosystems (i.e. one with relatively few native plant species). While native plants provide numerous benefits, AIS can contribute to ecological decline and financial constraints to manage problem infestations.

### Eurasian Watermilfoil *(Myriophyllum spicatum)*

EWM is the most common AIS found in Wisconsin lakes. EWM was first discovered in southeast Wisconsin in the 1960's. During the 1980's, EWM began to spread to other lakes in southern Wisconsin and by 1993 it was common in 39 Wisconsin counties. EWM continues to spread across Wisconsin and is now found in the far northern portion of the state including Vilas County.




Unlike many other plants, EWM does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces vegetative by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, trailers, bilges, live wells or bait buckets, and can stay alive for weeks if kept moist (WDNR website, 2007).

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 milfoil claim the water column early in spring, photosynthesize, divide and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of 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 reducing the number of nutrient-rich native plants available for waterfowl (WDNR website, 2007).

Dense stands of EWM also inhibit recreational uses like swimming, boating and fishing. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by EWM may lead to deteriorating water quality and algae blooms of infested lakes (WDNR website, 2007).

### Curly leaf pondweed *(Potamogeton crispus)*

Curly-leaf pondweed (CLP) spreads through burr-like winter buds (turions), which are moved among waterways. 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.

The leaves of curly-leaf pondweed 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 becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out-compete native plants in the spring. CLP forms 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 stinking messes on beaches (WDNR website, 2007).

**Purple Loosestrife (Lythrum salicaria)**

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

Purple loosestrife was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the State, and has been recorded in 70 of Wisconsin's 72 counties. Low densities in most areas of the state suggest that the plant is still in the pioneering stage of establishment. Areas of heaviest infestation are sections of the Wisconsin River, the extreme southeastern part of the state, and the Wolf and Fox River drainage systems.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes and rivers. Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months (WDNR website, 2007).

**OTHER AQUATIC INVASIVE SPECIES**

The following AIS are not plants, but are mentioned here because they also can significantly disrupt healthy aquatic ecosystems.

**Rusty Crayfish *(Orconectes rusticus)***

Rusty Crayfish are large crustaceans that feed aggressively on aquatic plants, small invertebrates, small fish and fish eggs. They can remove nearly all the aquatic vegetation from a lake, offsetting the balance of a lake ecosystem. More information about this invader can be found at http://dnr.wi.gov/invasives/fact/rusty.htm.

**Zebra Mussels *(Dreissena polymorpha)***

Zebra Mussels are small freshwater clams that can attach to hard substrates in water bodies, often forming large of thousands of individual mussels. They are prolific filter feeders, removing valuable

phytoplankton from the water, which is the base of the food chain in an aquatic ecosystem. More information about this invader can be found at http://dnr.wi.gov/invasives/fact/zebra.htm.

**Spiny Water Fleas (*Bythotrephes cederstoemi*)**

Spiny Water Fleas are predatory zooplanktons (tiny aquatic animals) that have a barbed tail making up most of their body length (one centimeter average). They compete with small fish for food supplies (zooplankton) and small fish cannot swallow the spiny water flea due to the long spiny appendage. More research is being completed to determine the potential impacts of the spiny water flea. More information about this invader can be found at http://dnr.wi.gov/invasives/fact/spiny.htm.

# Appendix C – Descriptions of Aquatic Plants

## Free-Floating Plants

*Lemna trisulca* (Forked duckweed) has a simple, flattened leaf with a single root. This variety of duckweed is easily distinguished from the others by its "rowboat and oars" shape. Like other duckweeds, forked duckweed is free floating and gets its nutrients directly from the water. These angular duckweeds are often tangled together and form a mass. As with other duckweeds, forked duckweed is a good food source for waterfowl while the masses provide cover for fish and invertebrates (Borman, et al., 1997).

Forked Duckweed
Source: UW Herbarium Website

## Submergent Plants

*Algae sp.* (Filamentous algae) are single cell algae that form long, visible chains or filaments that can intertwine and for a mat. A filamentous alga begins by growing on lake bottoms, but commonly floats to the surface and is often called "pond scum". Many different species of algae may be present at the same time to form filamentous algae.

Filaentous algae
Source: AquaPlant Website

Water marigold
Source: UW Herbarium Website

*Bidens beckii* (Watermarigold) has submersed leaves that are finely divided into thread-like divisions. This plant also produces aerial leaves that are lance-shaped and toothed. When blooming, the yellow flower is similar in appearance to a daisy. Water marigold is found mainly in shallower water, but can be found up to 10 feet deep in soft-sediment areas. The submerged leaves provide shade and shelter for fish (Borman, et al., 1997).

Coontail
Source: UW Herbarium Website

*Ceratophyllum demersum* (Coontail) is one of the most widely distributed aquatic plants within Wisconsin. The plant lacks true roots and can be found in water up to 16 feet deep. The leaves are arranged in a whorled fashion and are stiff and located closer together at the tip of the plant, giving it the appearance of a raccoon tail. Coontail is excellent habitat for invertebrates, especially in the winter when most other plants have died. The plant itself is food for waterfowl and provides shelter and foraging opportunities for fish (Borman, et al., 1997). Coontail may be mistaken for EWM.

Chara sp.
Source: UW Herbarium Website

*Chara, sp.* (Muskgrass / Chara) looks like a vascular plant; it actually is a multi-celled alga (macroalgae). Muskgrass is usually found in hard waters and prefers muddy or sandy substrate and can often be found in deeper water than other submergent plants. Muskgrass beds provide valuable habitat for small fish and invertebrates. Muskgrass is also a favorite waterfowl food. Its rhizoids slow the movement and suspension of sediments and benefit water quality in the ability to stabilize the lake bottom (Borman, et al., 1997). It can easily be identified by its characteristic "musty" odor.

*Eleocharis acicularis* (Needle spikerush) has slender and short stems that emerge in tufts from fine rhizomes. Stems are topped with an oval spikelet that is wider than the stem. (Borman, et al, 1997). It prefers hard substrates and is found more frequently in northern Wisconsin (Nichols, 1999). This species provides food for a variety of waterfowl and muskrats.

Needle spikerush
Source: UW Herbarium Website

Elodea
Source: UW Herbarium Website

*Elodea canadensis* (Elodea or common waterweed) is an abundant native plant species that is distributed statewide. It prefers soft substrate and water depths to 15 feet (Nichols, 1999). Elodea reproduces by seed and sprigs (USDA, 2002). The stems of elodea offer shelter and grazing to fish, but very dense elodea can interfere with fish movement. Elodea can be considered invasive at times and out-competes other more desirable plants.

*Myriophyllum sibiricum* (Northern water-milfoil) is usually found growing in soft sediment in fairly clear-water lakes. Leaves are divided like a feather, with five to twelve pairs of thread-like leaflets. Leaves are arranged in whorls. Northern water-milfoil is more desirable than its invasive cousin, Eurasian water-milfoil. Waterfowl eat the foliage and fruit, while beds of this plant provide cover and foraging opportunities for fish and invertebrates (Borman, et al., 1997).

Northern watermilfoil
Source: UW Herbarium Website

Eurasian water-milfoil
Source: UW Herbarium Website

*Myriophyllum spicatum* (Eurasian water-milfoil or EWM) is a submersed aquatic plant native to Europe, Asia and northern Africa. It was introduced to the United States by early European settlers. EWM was first detected in Wisconsin lakes during the 1960's. In the past three decades, this AIS has significantly expanded its range to about 61 of Wisconsin's 72 counties and continues to infest new water bodies every year. Because of its explosive growth and its iability to regenerate, EWM can successfully out-compete most native aquatic plants, especially in disturbed areas.

Eurasian water-milfoil shows no substrate preference in most instances and can grow in water depths greater than 4 meters (Nichols, 1999). Dense beds of EWM are usually identified in soft/organic rich sediments in many lakes. Eurasian water-milfoil can reproduce by seeds, but its main form of reproduction is vegetatively by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried by currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, trailers, bilges, live wells, or bait buckets and can stay alive for weeks if kept moist. Once established in an aquatic community, EWM reproduces from shoot fragments and stolons.

EWM is an opportunistic species and is adapted for rapid growth early in spring which can form a dense canopy that shades out native plants. Its ability to spread rapidly by fragmentation and effectively block 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 reducing the number of nutrient-rich native plants available for waterfowl (DNR, 2002).

Slender Naiad
Source: UW Herbarium Website

*Najas flexilis* (Slender Naiad) is sometimes called bushy pondweed and has fine branched stems that emerge from a slight rootstalk. Slender Naiad can grow in both shallow and deep water. Waterfowl, marsh birds, and muskrats consume the stems, leaves, and seeds of naiad. The foliage produces forage and shelter opportunities for fish and invertebrates (Borman, et al., 1997).

Nitella sp.
Source: UW Herbarium Website

*Nitella sp.* (Nitella) is another type of macroalgae that looks like a vascular plant. Nitella is similar in appearance to muskgrass and is often found in similar habitats. However, Nitella can be distinguished from muskgrass by its smooth stems and branches, which are smooth (Borman, et al., 1997).

Large-leaf Pondweed
Source: UW Herbarium Website

*Potamogeton amplifolius* (Large-leaf Pondweed) is also often referred to as musky weed or cabbage by anglers. Large leaf pondweed has robust stems and broad submersed leaves, which are slightly folded and lined with many veins. Floating leaves are oval and on long stalks. It is found mainly in soft sediments in water one to several feet deep and is sensitive to increased turbidity. The plant is commonly grazed by waterfowl, offers habitat for invertebrates, and foraging opportunities for fish (Borman, e al., 1997).

*Potamogeton crispus* (Curly leaf pondweed) spreads through burr-like winter buds (turions), which are moved among waterways. 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. The leaves of curly-leaf pondweed 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.

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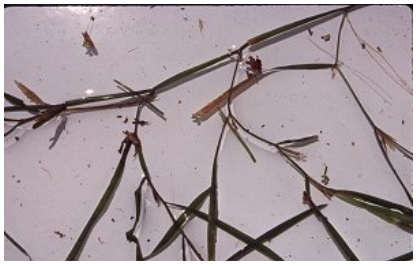
*Pomatogeton gramineus* (Variable Pondweed) is usually found in more firm sediment in water that is about 3 feet deep. Variable pondweed overwinters by hardy rhizomes and winter buds. Flowering usually occurs early in the growing season and fruit is produced during mid-summer. The fruits and tubers are grazed by waterfowl and the extensive network of leafy branches offers invertebrate habitat and foraging opportunities for fish (Borman, et al., 1997).

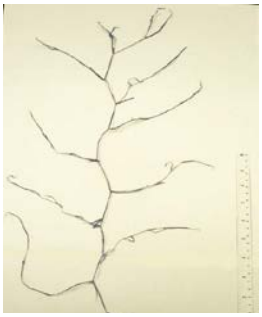
Variable Pondweed
Source: UW Herbarium Website



Flat- Stem Pondweed
Source: UW Herbarium Website

*Potamogeton zosteriformis* (Flat-Stem Pondweed) is a submergent pondweed with freely-branched flattened stems. Flat stem pondweed is commonly confused with water stargrass (*Zosterella dubia*) but Flat-stem Pondweed can be distinguished by its prominent mid-vein and many fine, parallel veins.

*Stuckenia pectinata* (Sago Pondweed) resembles two other pondweeds with needle-like leaves, but sago pondweed tends to be much more common. The fruit and tubers of sago pondweed are very important food sources for waterfowl, while leaves and stems provide shelter for small fish and invertebrates (Borman, et al., 1997).



Sago Pondweed
Source: UW Herbarium Website

Common bladderwort
Source: UW-Herbarium Website

*Utricularia vulgaris* (Common bladderwort) has floating stems that can reach 2-3 meters in length. Along the stem are leaf-like branches. On these branches are the bladders that trap prey. The branches also have fine spines (spicules) scattered along their margins. Yellow, two-lipped flowers are produced on stalks that protrude above the water surface. Common bladderwort is free-floating and can be found in water ranging from a few inches to several meters deep. The trailing stems of common bladderwort provide food and cover for fish. Because they are free-floating, they can grow in areas of very loosely consolidated sediment. This provides needed fish habitat in areas that are not readily colonized by rooted plants (Borman, et al., 1997).

## Emergent Plants

*Iris virginica* (blue flag) has leaves and flower stalks that emerge from a stout rhizome that is very shallow and sometimes exposed above the sediment. It is found in wetlands, stream banks and shallow water of ponds and lakes. The flowers range from indigo blue to lavender. Blue flag is grazed by muskrats and a variety of waterfowl including canvasback. It also provides cover for waterfowl and wildlife.

Blue flag
Source: UW Herbarium Website

Water Smartweed
Source: CT Botanical Society

Polygonum amphibium (water smartweed) can live across a diverse range of habitats and in water up to 6 feet deep. Specimens growing in water from floating leaves and can sometimes be confused with some pondweed species. Water smartweed is tolerant of a wide range of water conditions and is found throughout Wisconsin.

*Schoenoplectus acutus* (Hardstem bulrush) has tall cyllindricxal olive-green sturdy stems. The firm stems are hard when pressed between ones fingers, while softstem bulrush can easily be crushed with the fingers. This plant is mainly found growing in water less than 2 meters and is an important food and habitat plant for investaebrats, northern pike, and marsh birds (Borman et al., 1997).

Hardstem Bulrush
Source: UW Herbarium Website

Broad-leaf Cattail
Source: UW Herbarium Website

*Typha latifolia* (Broad-leaf Cattail) has pale green, sword-like leaves that are sheathed around one another at the base. Broad-leaved cattail can be distinguished from narrow-leaved cattail by somewhat wider and flatter leaves and the presence of male and female flower spikes immediately adjacent to each other,. Cattails can grow to nuisance levels, but do provide nesting habitat for many marsh birds and cover for small fish (Borman, et al., 1997).

## Floating-leaf Plants

Spatterdock
Source: UW Herbarium Website

*Nuphar variegata* (Spatterdock) has a flexible stalk and an oval shaped leaf. It grows in water less than 6 feet deep and prefers soft sediment. Yellow flowers occur throughout the summer. Floating leaves provide cover and shade for fish as well as habitat for invertebrates (Borman, et al., 1997).

*Nymphaea odorata* (White Water Lily) has a flexible stalk with a round floating leaf. White Water Lily can be found growing in a variety of sediment types in less than 6 feet of water. Fragrant white flowers occur throughout the summer. The floating leaves provide shelter and shade for fish as well as habitat for invertebrates (Borman, et al., 1997).

White Water Lily
Source: UW Herbarium Website

# Appendix D – Summary of Aquatic Plant Management Alternatives

# Management Options for Aquatic Plants

| Option | Permit Needed | How it Works | Pros | Cons |
|---|---|---|---|---|
| **No Management** | No | No active plant management | Possible protects native species that can enhance water quality and provide habitat for aquatic fauna:<br>• No financial cost<br>• No system disturbance<br>• No harmful effects of chemicals<br>• Permit not required | May allow small populations of invasive plants to become larger and more difficult to control later<br>• Requires intensive monitoring |
| **Mechanical Control** | Required under NR 109 | Plants reduced by mechanical means | Flexible control | Must be repeated, often more than once per season, sometimes weekly |
| | | Wide range of techniques from manual to mechanized | Can balance habitat and recreational needs | Can suspend sediments and increase highly turbidity and nutrient release |
| **a. Handpulling/ Manual raking** | Yes/No | Scuba divers or snorkelers remove plants are removed with a rake | Little to no damage done to lake or to native plant species | Very labor intensive and costly by hand or plants |
| | | Works best in soft sediments | Can be highly selective<br><br>Can be done by shoreline property owners within an area <30 ft wide or removing EWM or CLP<br><br>Can be very effective at removing problems particularly following early detection of an invasive specie | Needs to be carefully monitored<br><br>Roots, runners and even fragments of some without permits species (including EWM) will start new where selectively planted, so all of plant must be removed<br><br>Small scale control only plants<br><br>Can be very costly if subcontracted |
| **b. Harvesting** | Yes | Plants are “mowed” at depths of 2-5 ft., collected with a conveyor and off loaded onto shore | Immediate results | Not selective in species removed |
| | | Harvest invasives only if invasive is already present throughout the lake | Good for CLP management if cut prior to turion production and is then cut to be kept in check through its growth cycle<br><br>Usually minimal impact to the lake<br><br>Harvested lanes through dense weed beds can increase growth and forage ability of some fish<br><br>Can remove some nutrients from the lake | Fragments of EWM can re-root<br><br>Difficulty in finding disposal sites<br><br>Can remove some small fish and reptiles from lake<br><br>Initial cost of harvester expensive<br><br>High transport, maintenance and operational costs<br><br>Liability if owned |
| **Biological Control** | Yes | Living organisms (e.g. insects or fungi) eat or infect plants | Self sustaining organism will over winter resume eating its host the next year<br><br>Lowers density of problem plant to allow growth of natives | Effectiveness will vary as control agent’s population fluctuates<br><br>Provides moderate control – complete control unlikely<br><br>Control response may be slow. Must have enough control agent to be effective |

# Management Options for Aquatic Plants

| | | | | |
|---|---|---|---|---|
| **a. Weevils on EWM** | Yes | Native weevil prefers EWM to other native water milfoil | Native to Wisconsin: Weevil cannot "escape" and become a problem<br><br>Selective control of target species<br><br>Longer term control with limited management | Excessive cost need to stock large numbers, even if some already present and are costly **$1.00/each**<br><br>Need good habitat for over wintering on shore (leaf litter) associated with undeveloped shorelines<br><br>High Panfish populations decrease densities through predation |
| **b. Pathogens** | Yes | Fungal/bacterial/viral pathogen introduced to target species to induce mortality | May be species specific<br><br>May provide long term control<br><br>Few dangers to humans or animals | Largely experimental; effectiveness and longevity unknown<br><br>Possible side effects not understood |
| **c. Allelopathy** | Yes | Aquatic plants release chemical compounds that inhibit other plants from growing | May provide long term, maintenance free control<br><br>Spikerushes (*Eleocharis* spp.) appear to inhibit Eurasian watermill foil growth | Initial transplanting slow and labor intensive<br><br>Spikerushes native to Wisconsin and have not effectively limited EWM growth<br><br>Wave action along shore makes it difficult to establish plants; plants will not grow in deep or turbid water |
| **d. Restoration of native plants** | Possibly, strongly recommend plan and consultation with DNR | Diverse native plant community established to help repel invasive species | Native plants provide food and habitat for aquatic fauna<br><br>Diverse native community more repellant to invasive species<br><br>Supplements removal techniques | Initial transplanting slow and labor intensive<br><br>Nuisance invasive plants may outcompete plantings<br><br>Largely experimental; few well documented successful cases and very costly |
| **Physical Control** | Required under Ch. 30/NR 107 | Plants are reduced by altering variables that affect growth, such as water depth or light levels | | |
| **a. Drawdown** | Yes, may require Environmental Assessment | Lake water lowered; plants killed when sediment dries, compacts or freezes | Can be effective for EWM, especially when done over winter, provided drying and freezing occur. Sediment compaction is possible over winter. | Plants with large seed bank or propagules that survive drawdown may become more abundant upon refilling |
| | | Must have a water level control or device or siphon | Summer drawdown can restore large portions of shoreline and shallow areas as well as provide sediment compaction | Species growing in deep water (e.g. EWM) that survive may increase, particularly if desired native species are reduced |
| | | Season or duration of drawdown can change effects | Emergent plant species often rebound near shore providing fish and wildlife habitat, sediment stabilization and increased water quality<br><br>Successful for EWM | May impact attached wetlands and shallow wells near shore<br><br>Not a good control measure for CLP |

# Management Options for Aquatic Plants

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| | | | Low cost if not a hydroelectric dam<br><br>Restores natural water fluctuation important for all aquatic ecosystems | Can affect fish, particularly in shallow lakes if oxygen levels drop or if water levels are not restored before spring spawning<br><br>Winter drawdown must start in early fall or will kill hibernating reptiles and amphibians<br><br>Controversial |
| **b. Dredging** | Yes | Plants are removed along with sediment | Increases water depth | Expensive |
| | | Most effective when soft sediments overlay harder substrate | Removes nutrient rich sediments | Increases turbidity and releases nutrients |
| | | For extremely impacted systems | Removes soft bottom sediments that may have high oxygen demand | Exposed sediments may be recolonized by invasive species |
| | | Extensive planning and permitting required | | Sediment testing is expensive<br><br>Removes benthic organisms<br><br>Dredged materials must be disposed if<br><br>Severe impact on lake ecosystem |
| **c. Dyes** | Yes | Colors water, reducing light and reducing plant and algal growth | Impairs plant growth without increasing turbidity<br><br>Usually non-toxic, degrades naturally over a few weeks | Appropriate for very slam water bodies<br><br>Should not be used in pond or lake with outflow<br><br>Impairs aesthetics<br><br>Affects to microscopic organisms unknown |
| **d. Mechanical circulation (Solarbees)** | Yes | Water is circulated and oxygenated | Reduces blue green algae | Method is experimental; no published studies have been done |
| | | Oxygenation of water decreases ammonium-nitrogen, which is a preferred nutrient source of EWM, theoretically limiting EWM growth (has not been demonstrated scientifically) | May reduce levels of ammonium-nitrogen in the water and at the sediment interface, which could reduce EWM growth<br><br>Oxygenated water may reduce phosphorus release from sediments if mixing is complete<br>Reduces chance of fish kills by aerating water | Although EWM prefers ammonium-nitrogen to nitrate, it will uptake nitrate efficiently, so EWM growth may not be affected<br><br>Units are aesthetically unpleasing<br><br>Units could be a navigational hazard |
| **e. Non-point source nutrient control** | No | Runoff of nutrients from the watershed are reduced (e.g. by controlling construction erosion or reducing fertilizer use) | Attempts to correct source of problem, not treat symptoms<br><br>Could improve water clarity and reduce occurrences of algal blooms | Results can take years to be evident due to internal recycling of already resent lake nutrients<br><br>Expensive |

# Management Options for Aquatic Plants

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| | | | Native plants may be able to compete invasive species better in low nutrient conditions | Requires landowner cooperation and regulation<br><br>Improved water clarity may increase plant growth |
| **Chemical Control** | Required under NR 107 | Granules or liquid chemicals kill plants or cease plant growth; some chemicals used primarily for algae | Some flexibility for different situations | Possible toxicity to aquatic animals or humans, especially applicators |
| | | Results usually within 10 days of treatment, but repeat treatments usually needed | Some can be selective if applied correctly<br><br>Can be used for restoration activities | May kill desirable plant species, e.g. native water milfoil or native pondweeds<br><br>Treatment set back requirements from potable water sources and/or drinking water use restrictions after application, usually based on concentration<br><br>May cause severe drop in dissolved oxygen causing fish kill, depends on plant biomass killed, temperatures and lake size and shape<br><br>Controversial |
| **a. 2,4-D (DMA-4; Sculpin** | Yes | Systemic[1] herbicide selective to broadleaf[2] plants that inhibit cell division in new tissue | Moderately to highly effective; especially on EWM | May cause oxygen depletion after plants die and decompose |
| | | Applied as liquid or granules during early growth phase | Monocots, such as pondweeds (e.g. CLP) and many other native species not affected<br><br>Can be used in synergy with endotholl for early season CLP and EWM treatments<br><br>Widely used aquatic herbicides | Cannot be used in combination with copper herbicides (used for algae)<br><br>Toxic to fish |
| **b. Endothall (Aquathol)** | Yes | Broad-spectrum[3], contact [4] herbicide that inhibits protein synthesis | Especially effective on CLP and also effective on EWM | Kills many native pondweeks |
| | | Applied as liquid or granules | May be effective in reducing reestablishment of CLP if reapplied several years in a row in early spring<br><br>Can be selective depending on concentration and seasonal timing<br><br>Can be combined with 2,4-D for early season CLP and EWM treatments, or with copper compounds | Not as effective in dense plant beds<br><br>Not to be used in water supplies<br><br>Toxic to aquatic fauna (to varying degrees) |
| **c. Diquat (Reward)** | Yes | Broad-spectrum, contact herbicide that disrupts cellular functioning | Mostly used for water-milfoil and duckweed | May impact non-target plants, especially native pondweeds, coontail, elodea, naiads |
| | | Applied as liquid, can be combined with copper treatment | Rapid action<br><br>Limited direct toxicity on fish and other animals | Toxic to aquatic invertebrates<br><br>Needs to be reapplied several years in a row |

# Management Options for Aquatic Plants

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| | | | | Ineffective in muddy or cold water (<50°F) |
| **d. Fluridone (Sonar)** | Yes | Broad-spectrum, systemic pigment bleaching herbicide that inhibits photosynthesis, some reduction in non target effects can be achieved by lowering dosage | Effective on EWM for 2 to 4+ years<br><br>Applied at very low concentration typically on lake wide basis of less than 8 PPB<br><br>Specific granular formulation release over extended periods of time 30 – 60 days eliminating peaks and lessening impacts to non targets (natives) | Affects some non-target plants, particularly native milfoils, coontails, elodea and naiads, even at low concentrations. These plants are important to combat invasive species<br><br>Requires long contact time: 60-90 + days<br><br>Requires residual monitoring |
| | | | Slow decomposition of plants may limit decreases in dissolved oxygen<br><br>Low toxicity to aquatic animals | Demonstrated herbicide resistance in hydrilla subjected to repeat treatments<br><br>Unknown effect of repeat whole lake treatments on lake ecology |
| **e. Glyphosate (Rodeo)** | Yes | Broad spectrum, systemic herbicide that disrupts enzyme formation and function | Effective on floating and emergent plants such as purple loosestrife | Effective control for 1-5 years |
| | | Usually used for purple loosestrife stems or cattails | Selective if carefully applied to individual plants | Ineffective in muddy water |
| | | Applied as liquid spray or painted on loosestrife stems | Non-toxic to most aquatic animals at recommended dosages | Cannot be used near potable water intakes<br><br>No control of submerged plants |
| **f. Triclopyr (Renovate)** | Yes | Systemic herbicide selective to broadleaf plants that disrupts enzyme function | Effective on many emergent and floating plants | Impacts may occur to some native plants at higher does (e.g. coontail) |
| | | Applied as liquid spray or liquid | More effective on dicots, such as purple loosestrife; may be more effective than glyphosate<br><br>Results in 3-5 weeks<br><br>Low toxicity to aquatic animals<br><br>No recreational use restrictions following treatment | May be toxic to sensitive invertebrates at higher concentrations<br><br>Retreatment opportunities may be limited due to maximum seasonal rate (2.5 ppm)<br><br>Sensitive to UV light; sunlight can break herbicide down prematurely<br><br>Relatively new management option for aquatic plants (since 2003) |
| **g. Copper compounds (Cutrine, Captain)** | Yes | Broad-spectrum, systemic herbicide that prevents photosynthesis | Reduces algal growth and increases water clarity | Elemental copper accumulates and persists in sediments |
| | | Used to control planktonic and filamentous algae | No recreational or agricultural restrictions on water use following treatment<br><br>Herbicidal action on hydrilla, an invasive plant not yet present in Wisconsin | Short term results<br><br>Small-scale control only, because algae are easily windblown |

# Management Options for Aquatic Plants

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| | | | | | Toxic to invertebrates, trout and other fish, depending on the hardness of the water<br><br>Long-term effects of repeat treatments to benthic organism unknown<br><br>Clear water may increase plant growth |
| **h.** | **Lime slurry** | Yes | Applications of lime temporarily raise water pH, which limits the availability of inorganic carbon to plants, preventing growth | Appears to be particularly effective against EWM and CLP<br><br>Prevents release of sediment phosphorus, which reduces algal growth<br><br>Increases growth of native plants beneficial as fish habitat | Relatively new technique, so effective dosage levels and exposure requirements are not yet known<br><br>Short-term increase in turbidity due to suspended lime particles<br><br>High pH detrimental to aquatic invertebrates<br><br>May restrict growth of some native plants |
| **i.** | **Alum (aluminum sulfate)** | Yes | Remove phosphorus from water column and creates barrier on sediment to prevent internal loading of phosphorus | Most often used against algal problems<br><br>Lasts up to 5 years | Most not eat fish for 30 days from treatment area |
| | | | Dosage must consider pH, hardness and water volume | Improves water clarity | Minimal effect on aquatic plants, or increased light penetration may increase aquatic plants<br><br>Potential ecosystem toxicity issues for aquatic animals, including fish at some concentrations |
| **j.** | **Phoslock** | yes | Remove/sequesters phosphorus from water column and creates barrier on sediment to prevent internal loading of phosphorus | Most often used against algal problems/blooms<br><br>Improves water quality | Higher cost than Alum |
| | | | Dosing based on water quality parameters and volumes | Lasts up to 5 years<br><br>Made from natural materials/carriers and tends to be more environmentally friendly than alum | |

***EWM** - Eurasian water-milfoil
***CLP** - Curly-leaf pondweed

[1]**Systemic herbicide -** Must be absorbed by the plant and moved to the site of action. Often slower-acting than contact herbicides.

[2]**Broadleaf herbicide -** Affects only dicots, one of two groups of plants. Aquatic dicots include waterlilies, bladderworts, watermilfoils, and coontails.

[3]**Broad-spectrum herbicide -** Affects both monocots and dicots.

[4]**Contact herbicide -** Unable to move within the plant; kills only plant tissue it contacts directly

# Techniques for Aquatic Plant Control Not Allowed in Wisconsin

| Option | How it Works | Pros | Cons |
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| **Biological Control** | | | |
| **a. Carp** | Plants eaten by stocked carp | Effective at removing aquatic plants<br><br>Involves species already present in Madison lakes | Illegal to transport or stock carp in Wisconsin<br><br>Carp cause resuspension of sediments, increased water temperature, lower dissolved oxygen levels and reduction of light penetration<br><br>Widespread plant removal deteriorates habitat for other fish and aquatic organisms<br><br>Complete alteration of fish assemblage possible<br><br>Dislodging of plants such as EWM or CLP turions can lead to accelerated spreading of plants |
| **b. Crayfish** | Plants eaten by stocked crayfish | Reduces macrophyte biomass | Illegal to transport or stock crayfish in Wisconsin<br><br>Control not selective and may decimate plant community<br><br>Not successful in productive, soft-bottom lakes with many fish predators<br><br>Complete alteration of fish assemblage possible |
| **Mechanical Control** | | | |
| **a. Cutting (no removal)** | Plants are “mowed” with underwater cutter | Creates open water areas rapidly<br><br>Works in water up to 25 ft | Root system remains for regrowth<br><br>Fragments of vegetation can re-root and spread infestation throughout the lake<br><br>Nutrient release can cause increased algae and bacteria and be a nuisance to riparian property owners<br><br>Not selective in species removed small-scale control only |
| **b. Rototilling** | Sediment is tilled to uproot plant roots and stems | Decreases stem density, can affect entire plant | Creates turbidity |
| | Works in deep water (up to 17 ft) | Small scale control<br><br>May provide long-term control | Not selective in species removed<br><br>Fragments of vegetation can re-root<br><br>Complete elimination of fish habitat |

# Techniques for Aquatic Plant Control Not Allowed in Wisconsin

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| | | | Releases nutrients<br><br>Increased likelihood of invasive species recolonization |
| **c. Hydroraking** | Mechanical rake removes plants from lake<br><br>Works in deep water (14 ft) | Creates open water areas rapidly | Fragments of vegetation can re-root<br><br>May impact lake fauna<br><br>Creates turbidity<br><br>Plants regrown quickly<br><br>Requires plant disposal |
| **Physical Control** | | | |
| **a. Fabrics/Bottom Barriers** | Prevents light from getting to lake bottom | Reduces turbidity in soft substrate areas<br><br>Useful for small areas | Eliminates all plants, including native plants important for a healthy lake ecosystem<br><br>May inhibit spawning by some fish<br><br>Need maintenance or will become covered in sediment and ineffective<br><br>Gas accumulation under blankets can cause them to dislodge from the bottom<br><br>Affects benthic invertebrates<br><br>Anaerobic environment forms that can release excessive nutrients from sediment |

# Appendix E – NR107 and NR 109 Wisconsin Administrative Code

# Chapter NR 107

## AQUATIC PLANT MANAGEMENT



**Note:** Chapter NR 107 as it existed on February 28, 1989 was repealed and a new Chapter NR 107 was created effective March 1, 1989.

**NR 107.01 Purpose.** The purpose of this chapter is to establish procedures for the management of aquatic plants and control of other aquatic organisms pursuant to s. 227.11 (2) (a), Stats., and interpreting s. 281.17 (2), Stats. A balanced aquatic plant community is recognized to be a vital and necessary component of a healthy aquatic ecosystem. The department may allow the management of nuisance–causing aquatic plants with chemicals registered and labeled by the U.S. environmental protection agency and labeled and registered by firms licensed as pesticide manufacturers and labelers with the Wisconsin department of agriculture, trade and consumer protection. Chemical management shall be allowed in a manner consistent with sound ecosystem management and shall minimize the loss of ecological values in the water body.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89; **correction made under s. 13.93 (2m) (b) 7., Stats., Register, December, 2000, No. 540.**

**NR 107.02 Applicability.** Any person sponsoring or conducting chemical treatment for the management of aquatic plants or control of other aquatic organisms in waters of the state shall obtain a permit from the department. Waters of the state include those portions of Lake Michigan and Lake Superior, and all lakes, bays, rivers, streams, springs, ponds, wells, impounding reservoirs, marshes, watercourses, drainage systems and other ground or surface water, natural or artificial, public or private, within the state or its jurisdiction as specified in s. 281.01 (18), Stats.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89; **correction made under s. 13.93 (2m) (b) 7., Stats., Register, December, 2000, No. 540.**

**NR 107.03 Definitions. (1)** "Applicator" means the person physically applying the chemicals to the treatment site.

**(2)** "Chemical fact sheet" means a summary of information on a specific chemical written by the department including general aquatic community and human safety considerations applicable to Wisconsin sites.

**(3)** "Department" means the department of natural resources.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89.

**NR 107.04 Application for permit. (1)** Permit applications shall be made on forms provided by the department and shall be submitted to the district director for the district in which the project is located. Any amendment or revision to an application shall be treated by the department as a new application, except as provided in s. NR 107.04 (3) (g).

**Note:** The DNR district headquarters are located at:

1. Southern — 3911 Fish Hatchery Road, Fitchburg 53711
2. Southeast — 2300 N. Dr. Martin Luther King Jr. Dr., Box 12436, Milwaukee 53212
3. Lake Michigan — 1125 N. Military Ave., Box 10448, Green Bay 54307
4. North Central — 107 Sutliff Ave., Box 818, Rhinelander 54501
5. Western — 1300 W. Clairemont Ave., Call Box 4001, Eau Claire 54702
6. Northwest — Hwy 70 West, Box 309, Spooner 54801

**(2)** The application shall be accompanied by:

(a) A nonrefundable permit application fee of $20, and, for proposed treatments larger than 0.25 acres, an additional refundable acreage fee of $25.00 per acre, rounded up to the nearest whole acre, applied to a maximum of 50.0 acres.

1. The acreage fee shall be refunded in whole if the entire permit is denied or if no treatment occurs on any part of the permitted treatment area. Refunds will not be prorated for partial treatments.

2. If the permit is issued with the proposed treatment area partially denied, a refund of acreage fees shall be given for the area denied.

(b) A legal description of the body of water proposed for treatment including township, range and section number;

(c) One copy of a detailed map or sketch of the body of water with the proposed treatment area dimensions clearly shown and with pertinent information necessary to locate those properties, by name of owner, riparian to the treatment area, which may include street address, local telephone number, block, lot and fire number where available. If a local address is not available, the home address and phone number of the property owner may be included;

(d) A description of the uses being impaired by plants or aquatic organisms and reason for treatment;

(e) A description of the plant community or other aquatic organisms causing the use impairment;

(f) The product names of chemicals proposed for use and the method of application;

(g) The name of the person or commercial applicator, and applicator certification number, when required by s. NR 107.08 (5), of the person conducting the treatment;

(h) A comparison of alternative control methods and their feasibility for use on the proposed treatment site.

**(3)** In addition to the information required under sub. (2), when the proposed treatment is a large–scale treatment exceeding 10.0 acres in size or 10% of the area of the water body that is 10 feet or less in depth, the application shall be accompanied by:

(a) A map showing the size and boundaries of the water body and its watershed.

(b) A map and list identifying known or suspected land use practices contributing to plant–related water quality problems in the watershed.

(c) A summary of conditions contributing to undesirable plant growth on the water body.

(d) A general description of the fish and wildlife uses occurring within the proposed treatment site.

(e) A summary of recreational uses of the proposed treatment site.

(f) Evidence that a public notice of the proposed application has been made, and that a public informational meeting, if required, has been conducted.

1. Notice shall be given in 2 inch x 4 inch advertising format in the newspaper which has the largest circulation in the area affected by the application.

2. The notice shall state the size of the proposed treatment, the approximate treatment dates, and that the public may request within 5 days of the notice that the applicant hold a public informational meeting on the proposed application.

a. The applicant will conduct a public informational meeting in a location near the water body when a combination of 5 or more individuals, organizations, special units of government, or local units of government request the meeting in writing to the applicant

with a copy to the department within 5 days after the notice is made. The person or entity requesting the meeting shall state a specific agenda of topics including problems and alternatives to be discussed.

b. The meeting shall be given a minimum of one week advance notice, both in writing to the requestors, and advertised in the format of subd. 1.

(g) The provisions of pars. (a) to (e) shall be repeated once every 5 years and shall include new information. Annual modifications of the proposed treatment within the 5–year period which do not expand the treatment area more than 10% and cover a similar location and target organisms may be accepted as an amendment to the original application. The acreage fee submitted under sub. (2) (a) shall be adjusted in accordance with any proposed amendments.

**(4)** The applicant shall certify to the department that a copy of the application has been provided to any affected property owners' association, inland lake district, and, in the case of chemical applications for rooted aquatic plants, to any riparian property owners adjacent to and within the treatment area.

**(5)** A notice of the proposed treatment shall be provided by the department to any person or organization indicating annually in writing a desire to receive such notification.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89.

**NR 107.05 Issuance of permit. (1)** The department shall issue or deny issuance of the requested permit between 10 and 15 working days after receipt of an acceptable application, unless:

(a) An environmental impact report or statement is required under s. 1.11, Stats. Notification to the applicant shall be in writing within 10 working days of receipt of the application and no action may be taken until the report or statement has been completed; or

(b) A public hearing has been granted under s. 227.42, Stats.

**(2)** If a request for a public hearing is received after the permit is issued but prior to the actual treatment allowed by the permit, the department is not required to, but may, suspend the permit because of the request for public hearing.

**(3)** The department may deny issuance of the requested permit if:

(a) The proposed chemical is not labeled and registered for the intended use by the United States environmental protection agency and both labeled and registered by a firm licensed as a pesticide manufacturer and labeler with the Wisconsin department of agriculture, trade and consumer protection;

(b) The proposed chemical does not have a current department aquatic chemical fact sheet;

(c) The department determines the proposed treatment will not provide nuisance relief, or will place unreasonable restrictions on existing water uses;

(d) The department determines the proposed treatment will result in a hazard to humans, animals or other nontarget organisms;

(e) The department determines the proposed treatment will result in a significant adverse effect on the body of water;

(f) The proposed chemical application is for waters beyond 150 feet from shore except where approval is given by the department to maintain navigation channels, piers or other facilities used by organizations or the public including commercial facilities;

(g) The proposed chemical applications, other than those conducted by the department pursuant to ss. 29.421 and 29.424, Stats., will significantly injure fish, fish eggs, fish larvae, essential fish food organisms or wildlife, either directly or through habitat destruction;

(h) The proposed chemical application is in a location known to have endangered or threatened species as specified pursuant to s. 29.604, Stats., and as determined by the department;

(i) The proposed chemical application is in locations identified by the department as sensitive areas, except when the applicant demonstrates to the satisfaction of the department that treatments can be conducted in a manner that will not alter the ecological character or reduce the ecological value of the area.

1. Sensitive areas are areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or lifestage requirements, or offering water quality or erosion control benefits to the body of water.

2. The department shall notify any affected property owners' association, inland lake district, and riparian property owner of locations identified as sensitive areas.

**(4)** New applications will be reviewed with consideration given to the cumulative effect of applications already approved for the body of water.

**(5)** The department may approve the application in whole or in part consistent with the provisions of subs. (3) (a) through (i) and (4). Denials shall be in writing stating reasons for the denial.

**(6)** Permits may be issued for one treatment season only.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89; **corrections in (3) (g) and (h) made under s. 13.93 (2m) (b) 7., Stats., Register, December, 2000, No. 540.**

**NR 107.06 Chemical fact sheets. (1)** The department shall develop a chemical fact sheet for each of the chemicals in present use for aquatic nuisance control in Wisconsin.

**(1m)** Chemical fact sheets for chemicals not previously used in Wisconsin shall be developed within 180 days after the department has received notice of intended use of the chemical.

**(2)** The applicant or permit holder shall provide copies of the applicable chemical fact sheets to any affected property owners' association and inland lake district.

**(3)** The department shall make chemical fact sheets available upon request.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89.

**NR 107.07 Supervision. (1)** The permit holder shall notify the district office 4 working days in advance of each anticipated treatment with the date, time, location, and proposed size of treatment. At the discretion of the department, the advance notification requirement may be waived.

**(2)** Supervision by a department representative may be required for any aquatic nuisance control project involving chemicals. Supervision may include inspection of the proposed treatment area, chemicals, and application equipment before, during or after treatment. The inspection may result in the determination that treatment is unnecessary or unwarranted in all or part of the proposed area, or that the equipment will not control the proper dosage.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89.

**NR 107.08 Conditions of the permit. (1)** The department may stop or limit the application of chemicals to a body of water if at any time it determines that chemical treatment will be ineffective, or will result in unreasonable restrictions on current water uses, or will produce unnecessary adverse side effects on nontarget organisms. Upon request, the department shall state the reason for such action in writing to the applicant.

**(2)** Chemical treatments shall be performed in accordance with label directions, existing pesticide use laws, and permit conditions.

**(3)** Chemical applications on lakes and impoundments are limited to waters along developed shoreline including public parks except where approval is given by the department for projects of public benefit.

**(4)** Treatment of areas containing high value species of aquatic plants shall be done in a manner which will not result in adverse long–term or permanent changes to a plant community in a specific aquatic ecosystem. High value species are individual species of aquatic plants known to offer important values in spe-

cific aquatic ecosystems, including *Potamogeton amplifolius, Potamogeton Richardsonii, Potamogeton praelongus, Potamogeton pectinatus, Potamogeton illinoensis, Potamogeton robbinsii, Eleocharis spp., Scirpus spp., Valisneria spp., Zizania aquatica, Zannichellia palustris* and *Brasenia schreberi.*

**(5)** Treatment shall be performed by an applicator currently certified by the Wisconsin department of agriculture, trade and consumer protection in the aquatic nuisance control category whenever:

(a) Treatment is to be performed for compensation by an applicator acting as an independent contractor for hire;

(b) The area to be treated is greater than 0.25 acres;

(c) The product to be used is classified as a "restricted use pesticide"; or

(d) Liquid chemicals are to be used.

**(6)** Power equipment used to apply liquid chemicals shall include the following:

(a) Containers used to mix and hold chemicals shall be constructed of watertight materials and be of sufficient size and strength to safely contain the chemical. Measuring containers and scales for the purpose of measuring solids and liquids shall be provided by the applicator;

(b) Suction hose used to deliver the chemical to the pump venturi assembly shall be fitted with an on–off ball–type valve. The system shall also be designed to prevent clogging from chemicals and aquatic vegetation;

(c) Suction hose used to deliver surface water to the pump shall be fitted with a check valve to prevent back siphoning into the surface water should the pump stop;

(d) Suction hose used to deliver a premixed solution shall be fitted with an on–off ball–type valve to regulate the discharge rate;

(e) Pressure hose used to discharge chemicals to the surface water shall be provided with an on–off ball–type valve. This valve will be fitted at the base of the hose nozzle or as part of the nozzle assembly;

(f) All pressure and suction hoses and mechanical fittings shall be watertight;

(g) Equipment shall be calibrated by the applicator. Evidence of calibration shall be provided at the request of the department supervisor.

(h) Other equipment designs may be acceptable if capable of equivalent performance.

**(7)** The permit holder shall be responsible for posting those areas of use in accordance with water use restrictions stated on the chemical label, but in all cases for a minimum of one day, and with the following conditions:

(a) Posting signs shall be brilliant yellow and conspicuous to the nonriparian public intending to use the treated water from both the water and shore, and shall state applicable label water use restrictions of the chemical being used, the name of the chemical and date of treatment. For tank mixes, the label requirements of the most restrictive chemical will be posted;

(b) Minimum sign dimensions used for posting shall be 11 inches by 11 inches or consistent with s. ATCP 29.15. The department will provide up to 6 signs to meet posting requirements. Additional signs may be purchased from the department;

(c) Signs shall be posted at the beginning of each treatment by the permit holder or representing agent. Posting prior to treatment may be required as a permit condition when the department determines that such posting is in the best interest of the public;

(d) Posting signs shall be placed along contiguous treated shoreline and at strategic locations to adequately inform the public. Posting of untreated shoreline located adjacent to treated shoreline and noncontiguous shoreline shall be at the discretion of the department;

(e) Posting signs shall be made of durable material to remain up and legible for the time period stated on the pesticide label for water use restrictions, after which the permit holder or representing agent is responsible for sign removal.

**(8)** After conducting a treatment, the permit holder shall complete and submit within 30 days an aquatic nuisance control report on a form supplied by the department. Required information will include the quantity and type of chemical, and the specific size and location of each treatment area. In the event of any unusual circumstances associated with a treatment, or at the request of the department, the report shall be provided immediately. If treatment did not occur, the form shall be submitted with appropriate comment by October 1.

**(9)** Failure to comply with the conditions of the permit may result in cancellation of the permit and loss of permit privileges for the subsequent treatment season. A notice of cancellation or loss of permit privileges shall be provided by the department to the permit holder accompanied by a statement of appeal rights.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89**;** correction in (7) (b) made under s. 13.93 (2m) (b) 7., Stats., Register, September, 1995, No. 477.

**NR 107.09 Special limitation.** Due to the significant risk of environmental damage from copper accumulation in sediments, swimmer's itch treatments performed with copper sulfate products at a rate greater than 10 pounds of copper sulfate per acre are prohibited.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89.

**NR 107.10 Field evaluation use permits.** When a chemical product is considered for aquatic nuisance control and does not have a federal label for such use, the applicant shall apply to the administrator of the United States environmental protection agency for an experimental use permit under section 5 of the federal insecticide, fungicide and rodenticide act as amended (7 USC 136 et seq.). Upon receiving a permit, the permit holder shall obtain a field evaluation use permit from the department and be subject to the requirements of this chapter. Department field evaluation use permits shall be issued for the purpose of evaluating product effectiveness and safety under field conditions and will require in addition to the conditions of the permit specified in s. NR 107.08 (1) through (9), the following:

**(1)** Treatment shall be limited to an area specified by the department.

**(2)** The permit holder shall submit to the department a summary of treatment results at the end of the treatment season. The summary shall include:

(a) Total chemical used and distribution pattern, including chemical trade name, formulation, percent active ingredient, and dosage rate in the treated water in parts per million of active ingredient;

(b) Description of treatment areas including the character and the extent of the nuisance present;

(c) Effectiveness of the application and when applicable, a summary comparison of the results obtained from past experiments using the same chemical formulation;

(d) Other pertinent information required by the department; and

(e) Conclusions and recommendations for future use.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89.

**NR 107.11 Exemptions. (1)** Under any of the following conditions, the permit application fee in s. NR 107.04 (2) (a) will be limited to the basic application fee:

(a) The treatment is made for the control of bacteria on swimming beaches with chlorine or chlorinated lime;

(b) The treatment is intended to control algae or other aquatic nuisances that interfere with the use of the water for potable purposes;

(c) The treatment is necessary for the protection of public health, such as the control of disease carrying organisms in sanitary sewers, storm sewers, or marshes, and the treatment is sponsored by a governmental agency.

**(2)** The treatment of purple loosestrife is exempt from ss. NR 107.04 (2) (a) and (3), and 107.08 (5).

**(3)** The use of chemicals in private ponds is exempt from the provisions of this chapter except for ss. NR 107.04 (1), (2), (4) and (5), 107.05, 107.07, 107.08 (1), (2), (8) and (9), and 107.10.

(a) A private pond is a body of water located entirely on the land of an applicant, with no surface water discharge or a discharge that can be controlled to prevent chemical loss, and without access by the public.

(b) The permit application fee will be limited to the non–refundable $20 application fee.

**(4)** The use of chemicals in accordance with label instructions is exempt from the provisions of this chapter, when used in:

(a) Water tanks used for potable water supplies;

(b) Swimming pools;

(c) Treatment of public or private wells;

(d) Private fish hatcheries licensed under s. 95.60, Stats.;

(e) Treatment of emergent vegetation in drainage ditches or rights–of–way where the department determines that fish and wildlife resources are insignificant; or

(f) Waste treatment facilities which have received s. 281.41, Stats., plan approval or are utilized to meet effluent limitations set forth in permits issued under s. 283.31, Stats.

**History:** Cr. Register, February, 1989, No. 398, eff. 3–1–89; **corrections in (4) (d) and (f) made under s. 13.93 (2m) (b) 7., Stats., Register, December, 2000, No. 540.**

# Chapter NR 109

## AQUATIC PLANTS: INTRODUCTION, MANUAL REMOVAL and MECHANICAL CONTROL REGULATIONS



**NR 109.01 Purpose.** The purpose of this chapter is to establish procedures and requirements for the protection and regulation of aquatic plants pursuant to ss. 23.24 and 30.715, Stats. Diverse and stable communities of native aquatic plants are recognized to be a vital and necessary component of a healthy aquatic ecosystem. This chapter establishes procedures and requirements for issuing aquatic plant management permits for introduction of aquatic plants or control of aquatic plants by manual removal, burning, use of mechanical means or plant inhibitors. This chapter identifies other permits issued by the department for aquatic plant management that contain the appropriate conditions as required under this chapter for aquatic plant management, and for which no separate permit is required under this chapter**.** Introduction and control of aquatic plants shall be allowed in a manner consistent with sound ecosystem management, shall consider cumulative impacts, and shall minimize the loss of ecological values in the body of water. The purpose of this chapter is also to prevent the spread of invasive and non–native aquatic organisms by prohibiting the launching of watercraft or equipment that has any aquatic plants or zebra mussels attached.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

**NR 109.02 Applicability.** A person sponsoring or conducting manual removal, burning or using mechanical means or aquatic plant inhibitors to control aquatic plants in navigable waters, or introducing non–native aquatic plants to waters of this state shall obtain an aquatic plant management permit from the department under this chapter.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

**NR 109.03 Definitions.** In this chapter:

**(1)** "Aquatic community" means lake or river biological resources.

**(2)** "Beneficial water use activities" mean angling, boating, swimming or other navigational or recreational water use activity.

**(3)** "Body of water" means any lake, river or wetland that is a water of this state.

**(4)** "Complete application" means a completed and signed application form, the information specified in s. NR 109.04 and any other information which may reasonably be required from an applicant and which the department needs to make a decision under applicable provisions of law.

**(5)** "Department" means the Wisconsin department of natural resources.

**(6)** "Manual removal" means the control of aquatic plants by hand or hand–held devices without the use or aid of external or auxiliary power.

**(7)** "Navigable waters" means those waters defined as navigable under s. 30.10, Stats.

**(8)** "Permit" means aquatic plant management permit.

**(9)** "Plan" means aquatic plant management plan.

**(10)** "Wetlands" means 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.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

**NR 109.04 Application requirements and fees.** **(1)** Permit applications shall be made on forms provided by the department and shall be submitted to the regional director or designee for the region in which the project is located. Permit applications for licensed aquatic nursery growers may be submitted to the department of agriculture, trade and consumer protection.

**Note:** Applications may be obtained from the department's regional headquarters or service centers. DATCP has agreed to send application forms and instructions provided by the department to aquatic nursery growers along with license renewal forms. DATCP will forward all applications to the department for processing.

**(2)** The application shall be accompanied by all of the following unless the application is made by licensed aquatic nursery growers for selective harvesting of aquatic plants for nursery stock. Applications made by licensed aquatic nursery growers for harvest of nursery stock do not have to include the information required by par. (d), (e), (h), (i) or (j).

(a) A nonrefundable application fee. The application fee for an aquatic plant management permit is:

1. $30 for a proposed project to manage aquatic plants on less than one acre.

2. $30 per acre to a maximum of $300 for a proposed project to manage aquatic plants on one acre or larger. Partial acres shall be rounded up to the next full acre for fee determination. An annual renewal of this permit may be requested with an additional application fee of one–half the original application fee, but not less than $30.

(b) A legal description of the body of water including township, range and section number.

(c) One copy of a detailed map of the body of water with the proposed introduction or control area dimensions clearly shown. Private individuals doing plant introduction or control shall provide the name of the owner riparian to the management area, which includes the street address or block, lot and fire number where available and local telephone number or other pertinent information necessary to locate the property.

(d) One copy of any existing aquatic management plan for the body of water, or detailed reference to the plan, citing the plan references to the proposed introduction or control area, and a description of how the proposed introduction or control of aquatic plants is compatible with any existing plan.

(e) A description of the impairments to water use caused by the aquatic plants to be managed.

(f) A description of the aquatic plants to be controlled or removed.

(g) The type of equipment and methods to be used for introduction, control or removal.

(h) A description of other introduction or control methods considered and the justification for the method selected.

(i) A description of any other method being used or intended for use for plant management by the applicant or on the area abutting the proposed management area.

(j) The area used for removal, reuse or disposal of aquatic plants.

(k) The name of any person or commercial provider of control or removal services.

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

(b) Within 30 days of receipt of the plan, the department shall notify the applicant of any additional information or modifications to the plan that are required. If the applicant does not submit the additional information or modify the plan as requested by the department, the department may dismiss the aquatic plant management permit application.

(c) The department shall approve the aquatic plant management plan before an application may be considered complete.

**(4)** The permit sponsor may request an annual renewal in writing from the department under s. NR 109.05 if there is no change proposed in the conditions of the original permit issued.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

**NR 109.05 Permit issuance. (1)** The department shall issue or deny issuance of the requested permit within 15 working days after receipt of a completed application and approved plan as required under s. NR 109.04 (3).

**(2)** The department may specify any of the following as conditions of the permit:

(a) The quantity of aquatic plants that may be introduced or controlled.

(b) The species of aquatic plants that may be introduced or controlled.

(c) The areas in which aquatic plants may be introduced or controlled.

(d) The methods that may be used to introduce or control aquatic plants.

(e) The times during which aquatic plants may be introduced or controlled.

(f) The allowable methods used for disposing of or using aquatic plants that are removed or controlled.

(g) Annual or other reporting requirements to the department that may include information related to pars. (a) to (f).

**(3)** The department may deny issuance of the requested permit if the department determines any of the following:

(a) Aquatic plants are not causing significant impairment of beneficial water use activities.

(b) The proposed introduction or control will not remedy the water use impairments caused by aquatic plants as identified as a part of the application in s. NR 109.04 (2) (e).

(c) The proposed introduction or control will result in a hazard to humans.

(d) The proposed introduction or control will cause significant adverse impacts to threatened or endangered resources.

(e) The proposed introduction or control will result in a significant adverse effect on water quality, aquatic habitat or the aquatic community including the native aquatic plant community.

(f) The proposed introduction or control is in locations identified by the department as sensitive areas, under s. NR 107.05 (3) (i) 1., except when the applicant demonstrates to the satisfaction of the department that the project can be conducted in a manner that will not alter the ecological character or reduce the ecological value of the area.

(g) The proposed management will result in significant adverse long–term or permanent changes to a plant community or a high value species in a specific aquatic ecosystem. High value species are individual species of aquatic plants known to offer important values in specific aquatic ecosystems, including Potamogeton amplifolius, Potamogeton Richardsonii, Potamogeton praelongus, Stuckenia pectinata (Potamogeton pectinatus), Potamogeton illinoensis, Potamogeton robbinsii, Eleocharis spp., Scirpus spp., Valisneria spp., Zizania spp., Zannichellia palustris and Brasenia schreberi.

(h) If wild rice is involved, the stipulations incorporated by *Lac Courte Oreilles v. Wisconsin*, 775 F. Supp. 321 (W.D. Wis. 1991) shall be complied with.

(i) The proposed introduction or control will interfere with the rights of riparian owners.

(j) The proposed management is inconsistent with a department approved aquatic plant management plan for the body of water.

**(4)** The department may approve the application in whole or in part consistent with the provisions of sub. (3). A denial shall be in writing stating the reasons for the denial.

**(5)** (a) The department may issue an aquatic plant management permit on less than one acre in a single riparian area for a 3–year term.

(b) The department may issue an aquatic plant management permit for a one–year term for more than one acre or more than one riparian area. The permit may be renewed annually for up to a total of 3 years in succession at the written request of the permit holder, provided no modifications or changes are made from the original permit.

(c) The department may issue an aquatic plant management permit containing a department–approved plan for a 3 to 5 year term.

(d) The department may issue an aquatic plant management permit to a licensed nursery grower for a 3–year term for the harvesting of aquatic plants from a publicly owned lake bed or for a 5–year term for harvesting of aquatic plants from privately owned beds with the permission of the property owner.

**(6)** The approval of an aquatic plant management permit does not represent an endorsement of the permitted activity, but represents that the applicant has complied with all criteria of this chapter.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03**; reprinted to restore dropped language from rule order, Register October 2003 No. 574.**

**NR 109.06 Waivers.** The department waives the permit requirements under this chapter for any of the following:

**(1)** Manual removal or use of mechanical devices to control or remove aquatic plants from a body of water 10 acres or less that is entirely confined on the property of one person with the permission of that property owner.

**Note:** A person who introduces native aquatic plants or removes aquatic plants by manual or mechanical means in the course of operating an aquatic nursery as authorized under s. 94.10, Stats., on privately owned non–navigable waters of the state is not required to obtain a permit for the activities.

**(2)** A riparian owner who manually removes aquatic plants from a body of water or uses mechanical devices designed for cutting or mowing vegetation to control plants on an exposed lake bed that abuts the owner's property provided that the removal meets all of the following:

(a) 1. Removal of native plants is limited to a single area with a maximum width of no more than 30 feet measured along the

shoreline provided that any piers, boatlifts, swimrafts and other recreational and water use devices are located within that 30–foot wide zone and may not be in a new area or additional to an area where plants are controlled by another method; or

2. Removal of nonnative or invasive aquatic plants as designated under s. NR 109.07 when performed in a manner that does not harm the native aquatic plant community; or

3. Removal of dislodged aquatic plants that drift on–shore and accumulate along the waterfront.

(b) Is not located in a sensitive area as defined by the department under s. NR 107.05 (3) (i) 1., or in an area known to contain threatened or endangered resources or floating bogs.

(c) Does not interfere with the rights of other riparian owners.

(d) If wild rice is involved, the procedures of s. NR 19.09 (1) shall be followed.

**(4)** Control of purple loosestrife by manual removal or use of mechanical devices when performed in a manner that does not harm the native aquatic plant community or result in or encourage re–growth of purple loosestrife or other nonnative vegetation.

**(5)** Any aquatic plant management activity that is conducted by the department and is consistent with the purposes of this chapter.

**(6)** Manual removal and collection of native aquatic plants for lake study or scientific research when performed in a manner that does not harm the native aquatic plant community.

**Note:** Scientific collectors permit requirements are still applicable.

**(7)** Incidental cutting, removal or destroying of aquatic plants when engaged in beneficial water use activities.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

**NR 109.07 Invasive and nonnative aquatic plants. (1)** The department may designate any aquatic plant as an invasive aquatic plant for a water body or a group of water bodies if it has the ability to cause significant adverse change to desirable aquatic habitat, to significantly displace desirable aquatic vegetation, or to reduce the yield of products produced by aquaculture.

**(2)** The following aquatic plants are designated as invasive aquatic plants statewide: Eurasian water milfoil, curly leaf pondweed and purple loosestrife.

**(3)** Native and nonnative aquatic plants of Wisconsin shall be determined by using scientifically valid publications and findings by the department.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

**NR 109.08 Prohibitions. (1)** No person may distribute an invasive aquatic plant, under s. NR 109.07.

**(2)** No person may intentionally introduce Eurasian water milfoil, curly leaf pondweed or purple loosestrife into waters of this state without the permission of the department.

**(3)** No person may intentionally cut aquatic plants in public/navigable waters without removing cut vegetation from the body of water.

**(4)** (a) No person may place equipment used in aquatic plant management in a navigable water if the person has reason to believe that the equipment has any aquatic plants or zebra mussels attached.

(b) This subsection does not apply to equipment used in aquatic plant management when re–launched on the same body of water without having visited different waters, provided the re–launching will not introduce or encourage the spread of existing aquatic species within that body of water.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

**NR 109.09 Plan specifications and approval. (1)** Applicants required to submit an aquatic plant management plan, under s. NR 109.04 (3), shall develop and submit the plan in a format specified by the department.

**(2)** The plan shall present and discuss each of the following items:

(a) The goals and objectives of the aquatic plant management and protection activities.

(b) A physical, chemical and biological description of the waterbody.

(c) The intensity of water use.

(d) The location of aquatic plant management activities.

(e) An evaluation of chemical, mechanical, biological and physical aquatic plant control methods.

(f) Recommendations for an integrated aquatic plant management strategy utilizing some or all of the methods evaluated in par. (e).

(g) An education and information strategy.

(h) A strategy for evaluating the efficacy and environmental impacts of the aquatic plant management activities.

(i) The involvement of local units of government and any lake organizations in the development of the plan.

**(3)** The approval of an aquatic plant management plan does not represent an endorsement for plant management, but represents that adequate considerations in planning the actions have been made.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

**NR 109.10 Other permits.** Permits issued under s. 30.12, 30.20, 31.02 or 281.36, Stats., or under ch. NR 107 may contain provisions which provide for aquatic plant management. If a permit issued under one of these authorities contains the appropriate conditions as required under this chapter for aquatic plant management, a separate permit is not required under this chapter. The permit shall explicitly state that it is intended to comply with the substantive requirements of this chapter.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

**NR 109.11 Enforcement. (1)** Violations of this chapter may be prosecuted by the department under chs. 23, 30 and 31, Stats.

**(2)** Failure to comply with the conditions of a permit issued under or in accordance with this chapter may result in cancellation of the permit and loss of permit privileges for the subsequent year. Notice of cancellation or loss of permit privileges shall be provided by the department to the permit holder.

**History:** CR 02–061: cr. Register May 2003 No. 569, eff. 6–1–03.

# Appendix F – Resource for Additional Information

## Online References for More Information

### General Information

http://www.dnr.state.wi.us/org/water/fhp/lakes/aquaplan.htm
Wisconsin Department of Natural Resources - Aquatic Plant Management

http://www.uwsp.edu/cnr/uwexlakes/ecology/APMguide.asp
UW Extension Lakes Program – Aquatic Plant Management in Wisconsin

http://www.wisconsinlakes.org/
Wisconsin Association of Lakes

http://www.uwsp.edu/cnr/uwexlakes/
UW Extension Lakes Program – Homepage

http://datcp.state.wi.us/index.jsp
Wisconsin Department of Agriculture, Trade and Consumer Protection

http://el.erdc.usace.army.mil/aqua/
Army Corps of Engineers – Aquatic Plant Control Research Program

http://www.nalms.org/
North American Lake Management Society

http://www.apms.org/
Aquatic Plant Management Society

http://www.fapms.org/
Florida Aquatic Plant Management Society

http://www.mapms.org/
Midwest Aquatic Plant Management Society

http://www.epa.gov/
Environmental Protection Agency

http://web.fisheries.org/main/
American Fisheries Society

http://www.botany.wisc.edu/herbarium/
Wisconsin State Herbarium – Aquatic Plant Indenfication

http://www.uwsp.edu/cnr/uwexlakes/CBCW/default.asp
UW Extension Lakes Program – Clean Boats Clean Waters

**Aquatic Invasive Species**

http://www.dnr.state.wi.us/invasives/aquatic/
Wisconsin Department of Natural Resources – Aquatic Invasive Species

http://www.uwex.edu/erc/invasives.html
UW Extension- Environmental Resources Center

http://www.ipaw.org/
Invasive Plants Association of Wisconsin

http://www.seagrant.wisc.edu/ais/
University of Wisconsin Sea Grant Institute– Aquatic Invasive Species

http://www.anstaskforce.gov/default.php
Aquatic Nuisance Species Task Force

http://www.invasivespeciesinfo.gov/aquatics/databases.shtml
United States Department of Agriculture – Invasive Species Information Center

http://aquat1.ifas.ufl.edu/welcome.html
University of Florida - Center for Aquatic and Invasive Plants

**Grants**

http://www.dnr.state.wi.us/org/caer/cfa/Grants/Lakes/Largelake.html
Lake Management Planning – Large Scale Grants

http://www.dnr.state.wi.us/org/caer/cfa/Grants/Lakes/smalllake.html
Lake Management Planning – Small Scale Grants

http://www.dnr.state.wi.us/org/caer/cfa/Grants/Lakes/invasivespecies.html
Aquatic Invasive Species

http://www.dnr.state.wi.us/org/caer/cfa/Grants/Lakes/lakeprotection.html
Lake Protection and Classification Grants

http://www.dnr.state.wi.us/org/caer/cfa/Grants/recboat.html
Recreation Boating Facilities

http://www.dnr.state.wi.us/org/caer/cfa/Grants/Rivers/riverplanning.html
River Protection Planning

http://www.dnr.state.wi.us/org/caer/cfa/Grants/Rivers/riverprotection.html
River Protection Management

# Appendix G – WiLMS Data

**Date: 11/7/2014 Scenario: 1**

Lake Id: Little Elkhart Lake
Watershed Id: 0

**Hydrologic and Morphometric Data**

Tributary Drainage Area: 693.1 acre
Total Unit Runoff: 7.00 in.
Annual Runoff Volume: 404.3 acre-ft
Lake Surface Area <As>: 56.3 acre
Lake Volume <V>: 445 acre-ft
Lake Mean Depth <z>: 7.9 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 419.8 acre-ft/year
Areal Water Load <qs>: 7.5 ft/year
Lake Flushing Rate <p>: 0.94 1/year
Water Residence Time: 1.06 year
Observed spring overturn total phosphorus (SPO): 17.0 mg/m^3
Observed growing season mean phosphorus (GSM): 24.1 mg/m^3
% NPS Change: 0%
% PS Change: 0%

**NON-POINT SOURCE DATA**

| Land Use | Acre (ac) | Low | Most Likely | High | Loading % | Low | Most Likely | High |
|---|---|---|---|---|---|---|---|---|
| | | Loading (kg/ha-year) | | | | Loading (kg/year) | | |
| Row Crop AG | 0.0 | 0.50 | 1.00 | 3.00 | 0.0 | 0 | 0 | 0 |
| Mixed AG | 121.53 | 0.30 | 0.80 | 1.40 | 36.1 | 15 | 39 | 69 |
| Pasture/Grass | 95.52 | 0.10 | 0.30 | 0.50 | 10.6 | 4 | 12 | 19 |
| HD Urban (1/8 Ac) | 0.0 | 1.00 | 1.50 | 2.00 | 0.0 | 0 | 0 | 0 |
| MD Urban (1/4 Ac) | 0.0 | 0.30 | 0.50 | 0.80 | 0.0 | 0 | 0 | 0 |
| Rural Res (>1 Ac) | 155.10 | 0.05 | 0.10 | 0.25 | 5.8 | 3 | 6 | 16 |
| Wetlands | 18.33 | 0.10 | 0.10 | 0.10 | 0.7 | 1 | 1 | 1 |
| Forest | 244.29 | 0.05 | 0.09 | 0.18 | 8.2 | 5 | 9 | 18 |
| Open Water | 0 | 0.1 | 0.3 | 1.0 | 0.0 | 0 | 0 | 0 |
| Commercial/Indust. | 47.58 | 1 | 1.5 | 2.00 | 26.5 | 19 | 29 | 39 |
| Road | 10.77 | 1 | 1.5 | 2 | 6.0 | 4 | 7 | 9 |
| Lake Surface | 56.3 | 0.10 | 0.30 | 1.00 | 6.3 | 2 | 7 | 23 |

**POINT SOURCE DATA**

| Point Sources | Water Load (m^3/year) | Low (kg/year) | Most Likely (kg/year) | High (kg/year) | Loading % |
|---|---|---|---|---|---|

**SEPTIC TANK DATA**

| Description | | Low | Most Likely | High | Loading % |
|---|---|---|---|---|---|
| Septic Tank Output (kg/capita-year) | | 0.30 | 0.50 | 0.80 | |
| # capita-years | 0.0 | | | | |
| % Phosphorus Retained by Soil | | 98.0 | 90.0 | 80.0 | |
| Septic Tank Loading (kg/year) | | 0.00 | 0.00 | 0.00 | 0.0 |

**TOTALS DATA**

| Description | Low | Most Likely | High | Loading % |
|---|---|---|---|---|
| Total Loading (lb) | 117.6 | 240.6 | 424.2 | 100.0 |
| Total Loading (kg) | 53.3 | 109.1 | 192.4 | 100.0 |
| Areal Loading (lb/ac-year) | 2.09 | 4.27 | 7.54 | |
| Areal Loading (mg/m^2-year) | 234.10 | 478.92 | 844.58 | |
| Total PS Loading (lb) | 0.0 | 0.0 | 0.0 | 0.0 |
| Total PS Loading (kg) | 0.0 | 0.0 | 0.0 | 0.0 |
| Total NPS Loading (lb) | 112.6 | 225.5 | 374.0 | 100.0 |
| Total NPS Loading (kg) | 51.1 | 102.3 | 169.6 | 100.0 |

# LEAP - Lake Eutrophication Analysis Procedure

| | | | |
|---|---|---|---|
| **Lake Name:** | Little Elkhart | **Ecoregion:** | Southeast Wisconsin Till Plain |
| **Watershed Area:** | 693.1 Acres | **Surface Area:** | 56.3 Acres |
| **Mean Depth:** | 7.9 ft | **TP Load:** | 65 kg/yr |
| **Lake Outflow:** | 1 AF/yr | **Avg TP Inflow:** | 99 ug/L |
| **Residence Time:** | 0.8 years | | |
| **Areal Water Load:** | 2.89 m/yr | **P Retention Coef:** | 0.55 |

| Variable | Observed | Predicted | Std Error | Residual | T-test |
|---|---|---|---|---|---|
| TP (ug/L) | 23 | 45 | 13 | -0.29 | -2.01 |
| Chlr a (ug/L) | 6.6 | 17.0 | 9.4 | -0.41 | -1.55 |
| Secchi (m) | 3.7 | 1.5 | 0.6 | 0.40 | 2.31 |

*Note: Residual = Log10(Observed/Predicted)*

*T-test for signifigant difference between observed & predicted*

## Chlrophyll A Interval Frequencies (%)

| ppb | Observed | Case A | Case B | Case C |
|---|---|---|---|---|
| 10 | 13% | 81% | 79% | 71% |
| 20 | 1% | 28% | 30% | 36% |
| 30 | 0% | 8% | 9% | 18% |
| 60 | 0% | 0% | 0% | 3% |

**Case A = within year variation considered**

**Case B = within year + year-to-year variation**

**Case C = Case B + Model Error**

## Carlson's Trophic Status Index

**Avg TSI = 47**

**TP TSI = 49**

**Chlr a TSI = 49**

**Secchi TSI = 41**