Report

Aquatic Plant Management Plan

Big Lake

Presque Isle Town Lakes Committee

September 30, 2011

WDNR GRANT: LPL-1131-07
Project Number 004010-09001-0

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BIG LAKE

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1.0 Executive Summary

The Presque Isle Town Lakes Committee (PITLC) was formed in 2005 to address resource management concerns in lakes within the Town of Presque Isle. The Committee has been active in a number of lake management activities on Big Lake including: aquatic plant management, water quality sampling, invasive species sampling, and community education activities. The Committee contracted Northern Environmental (now Bonestroo, Inc.) to help develop an aquatic plant management (APM) plan for Big Lake. The Big Lake APM Plan includes a review of available lake information, an aquatic plant survey, and an evaluation of feasible physical, mechanical, biological, and chemical management alternatives if deemed appropriate. The APM plan also recommends specific prevention activities for aquatic invasive species (AIS) in the lake system; which are discussed below.

Northern Environmental completed an aquatic plant survey on Big Lake in 2007, which identified 28 aquatic plant species. The most abundant aquatic plants identified during the survey coontail (*Ceratophyllum demersum*), bushy pondweed (*Najas flexilis*), wild celery (*Vallisneria americana*), and fern pondweed (*Potamogeton robbinsii*). The Floristic Quality Index (FQI) is an index that uses the aquatic plant community as an indicator of lake health. Big Lake exhibited an FQI of 33.14, higher than the state northern ecoregion average (24.3).

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

No aquatic invasive plants were found during the aquatic plant survey in 2007. If an invasive plant were found the Wisconsin Department of Natural Resources (WDNR) recommends that Big Lake residents work with WDNR and aquatic plant professionals to determine extent of AIS after discovery and to then determine appropriate management (per WDNR Water Resource Management Specialist's, Kyle McLaughlin, comments dated November 24, 2008). The fact that the native plant community is intact with no AIS illustrates that there is a unique and diverse plant community in Big Lake. Such a plant community is worthy of protection from human disturbance and from the impact aquatic invasive species would have if introduced to this system. Because of that, the following Recommended Action Plan focuses on conservation and plant protection.

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

Active Goal: To initiate the WDNR Clean Boats, Clean Waters program on Big Lake.

Active Goal: To provide visitors with educational information concerning the potential impact their activities could have on introduction of aquatic invasive species, wildlife, habitats and Big Lake water quality.

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.

Active Goal: To work in concert with the WDNR staff and representatives of fishing related businesses to evaluate Big Lake fish management practices and develop goals in order to maintain and enhance a quality family sport fishery.

Active Goal: To enforce the Town of Presque Isle's 200 foot no-wake areas (from shoreline and islands) ordinances in order to minimize recreational impacts on the plant community, shoreline habitats, and to promote safe boating.

Active Goal: To support the identification and preservation of critical species and critical habitat lands, and wetlands within the watershed. (These are areas with rare vegetation, important habitat for wildlife, or important spawning and nursery areas for fish. Preservation of these lands has a direct impact on the water quality of the lake).

Active Goal: To provide education and information to shoreline property owners regarding how native aquatic plant protection and shoreline management can slow the spread of aquatic invasive plants (if they become introduced), improve the lake fishery, improve wildlife habitat and affect the quality of the water in the lake (including development of a *shoreline restoration packet* that could be given to landowners who's property has development categorized as Moderate or Major).

Active Goal: To encourage the incorporation of water quality protection measures in the design, construction and maintenance of all lake access sites on Big Lake (e.g. storm water control, site drainage control, appropriate plant matter disposal, and watercraft wash down facilities if found to be needed).

Active Goal: To meet on a regular basis with local government agencies and representatives of lakes located within the Town of Presque Isle, to identify essential and new lake management issues and determine collaborative solutions.

2.0 Introduction

Big Lake is an 835 acre drainage lake located in northern Vilas County. The lake has a 22.61 square mile watershed. Big Lake exhibits good water clarity and according to the Wisconsin Trophic State Index, is an Oligotrophic lake.

Lake residents have become concerned about the possibility of the introduction of Eurasian watermilfoil (*Myriophyllum spicatum* - EWM), curly-leaf pondweed (*Potamogeton crispus* - CLP) and other AIS into the aquatic plant community of Big Lake. Although no AIS were recorded during the aquatic plant survey in 2007, this APM Plan includes strategies for detection, monitoring, and management/removal of EWM and CLP from Big Lake if ever established.

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

- Lake morphology and lake watershed characteristics
- Historical aquatic plant management activities
- Stakeholder's goals and objectives
- Aquatic plant ecology
- 2007 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

Big Lake is located in the Towns of Boulder Junction and Presque Isle in northwestern Vilas County, Wisconsin. The lake is part of the Wisconsin Manitowish River Watershed. Surface water in this area drains to the southwest into the Upper Chippewa River Watershed. Rice Creek connects Big Lake to Round Lake to the northeast and Island Lake to the south. Figure 1 depicts the lake location. The following summarizes the lake's physical attributes:

Lake Name	Big
Lake Type	Drainage
Surface Area (acres)	835
Maximum depth (feet)	61
Shoreline Length (miles)	9.04
Public Landings	2

Source: Wisconsin Lakes, WDNR 2005

Figure 2 illustrates the lake bathymetries. Big Lake provides year-round recreation activities ranging from, fishing, swimming, waterskiing, pleasure boating, snowmobiling, and more.

3.2 WATERSHED OVERVIEW

The Big Lake watershed encompasses approximately 14,470 acres or 22.61 square miles. The majority of the watershed is forested and within the Northern Highland – American Legion State Forest. There are fifteen other named lakes, including Wildcat Lake, within the watershed.

Big Lake is designated as a Priority Navigable Water (PNW). Priority Navigable Waters include waters with self-sustaining walleye populations in ceded territories and waters with self sustaining musky populations. Big Lake contains both a self-sustaining muskellunge and walleye population within the Ceded Territories.

The Big Lake area consists of mainly Rubicon, Pence and Seelyeville soil types. Rubicon and Pence soil types are sandy soils that are well to excessively drained, which occur at moderate slopes of 5 to 30 percent, mostly occurring between 6 and 15 percent. They are formed in glacial outwash plains with stratified sand and gravel layers. Seelyeville are mucky soils that are very poorly drained. Seelyeville soils are formed in herbaceous organic material more than 51 inches thick, with a slope of 0 to 1 percent and can be found in lowland or marshy areas (USDA, 1988).

3.3 WATER QUALITY

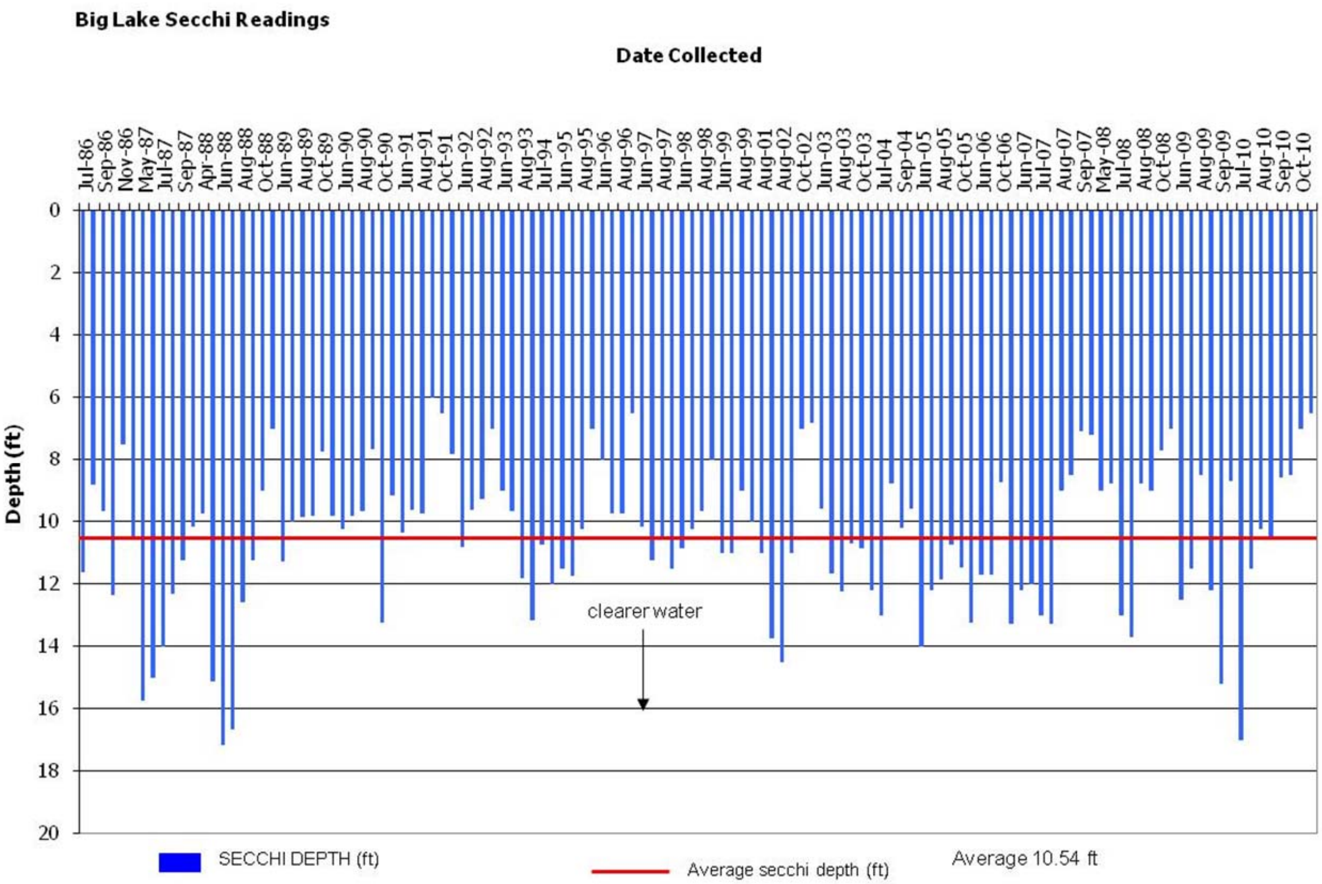
WDNR Lake Water Quality Database indicates that the following water quality information is available

- Water clarity (Secchi depth) - 1986 - present (Citizen Lake Monitoring)
- Dissolved oxygen and temperature - 2003 (Citizen Lake Monitoring)

The above referenced data was used in creating the Big Lake APM Plan. Higher Secchi depth readings indicate clearer water and deeper light penetration. Water clarity is measured by lowering an 8-inch disk (Secchi disk) with alternating black and white quadrants into the water until it is no longer visible. The disk is raised until it is again visible. The two readings are averaged providing the secchi depth or water clarity measurement.

3.3.1 WATER CLARITY

The historical water clarity average based on Secchi Disk readings is 10.54 feet and ranges from 6.0 to 17.2 feet. The Wisconsin average Secchi Disk reading in 2005 was 10 feet (Larry Bresina, The Secchi Disk and Our Eyes - Working Together To Measure Clarity of Our Lakes; internet document). The following graph illustrates the historical water clarity measurements on Big Lake. Data up to 2010 is included



3.3.2 DISSOLVED OXYGEN AND TEMPERATURE

Along with water clarity, dissolved oxygen and temperature profiles were recorded at three foot intervals to a depth of 61 feet over the deepest portion of the lake (Table 1). As lakes warm throughout the summer uneven heating of water occurs. This causes warmer water to “separate”, or stratify, from cooler, denser water. Between layers of stratified water a thermocline may establish. A thermocline is a thin layer of water layers in which the temperature changes more rapidly with depth than in the layers above and below it. The area below the thermocline may become low in oxygen concentration and limit the depth to which organisms can survive. At approximately 5.00 ppm of dissolved oxygen (DO), fish become stressed and at 2.00 ppm DO, most fish cannot survive. On Big Lake, the thermocline occurred at 15 feet of depth during the August, 2003 profile. Stratification had not yet begun during the May, 2003 profile and a thermocline was not yet present.

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. 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	<6.5
Big Lake	**40.29**	**mesotrophic**	**10.0**	**2.7**	**10.54**

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

Data indicate that Big Lake is a slightly mesotrophic lake. Data collected during 2007 aquatic plant survey is included.

3.4 SUMMARY OF LAKE FISHERY

The following table identifies the fish species the WDNR lists as being present in Big Lake.

Fish Species	Present	Common	Abundant
Muskellunge		X	
Northern Pike	X		
Walleye		X	
Largemouth Bass	X		
Smallmouth Bass		X	
Panfish		X	

Source: WDNR Wisconsin Lakes Publication # PUB-FH-800, 2005

The WDNR shows records of muskellunge being stocked in Big Lake. All fish were stocked to supplement natural reproduction and as fingerlings, except for 2000 and 2001 when they were stocked as fry (WDNR Fish stocking website, 2007).

Year	Muskellunge
1976	600
1977	1,005
1980	1,712
1983	1,700
1986	1,700
1988	1,700
1990	1,700
1991	800
2000	103,350
2001	172,800

All fisheries in Big Lake are currently sustained through natural reproduction. Big Lake is located in the "Ceded Territories" of Wisconsin. The Ceded Territories was ceded to the United States by the Lake Superior Chippewa Tribes in 1837 and 1842. The WDNR describes Native American fishing in the Ceded Territories this way: "The six Chippewa tribes of Wisconsin are legally able to harvest walleyes using a variety of high efficiency methods, but spring spearing is the most frequently used method. In spring each tribe declares how many walleyes and muskellunge they intend to harvest from each lake. Harvest begins shortly after ice-out, with nightly fishing permits issued to individual tribal spearers. Each permit allows a specific number of fish to be harvested, including one walleye between 20 and 24 inches and one additional walleye of any size. All fish that are taken are documented each night with a tribal clerk or warden present at each boat landing used in a given lake. Once the declared harvest is reached in a given lake, no more permits are issued for that lake and spearfishing ceases (http://dnr.wi.gov/fish/ceded/tribalharvest.html)."

All fishing regulations and bag limits for Big Lake are concurrent with standard WDNR regulations in the Ceded Territories except for muskellunge, walleye, and bass (largemouth & smallmouth). For non-Chippewa anglers there is no minimum size limit for walleye with a two (2) fish daily bag limit, but only one may be over 15". For muskellunge, the minimum size limit is 40" while bass are catch and release only. In the Ceded Territories the WDNR works to establish "safe harvest limits" set so there is less than a 1-in-40 chance that more than 35% of the adult walleye population will be harvested in any given lake by either tribal or recreational fishermen, or both combined.

3.5 LAKE MANAGEMENT HISTORY

There is no record of past management activities on Big Lake. Overall, the Town of Presque Isle has adopted several ordinances that help protect lakes and shorelines. Town of Presque Isle ordinances 500, 902, 908, and 909 all protect lakes in one way or another. Ordinance 501.03(2) mandates no wake on lakes less than 50 acres. 501.03(3),(a) requires no wake within 200 feet of any shoreline. 501.03(4) limits waterskiing and other like activities to the hours between 10 AM and 5 PM. The above mentioned ordinances in the 900 category, zoning, all limit minimum lot frontage to 200 feet, and 300 feet minimum on lots created after March 25th, 2001. Other watershed related ordinances are included in the zoning ordinances.

3.6 GOALS AND OBJECTIVES

PITLC identified the following goals for aquatic plant management on Big Lake.

- Maintain and improve recreational opportunities
- Protect and improve fish and wildlife habitat
- Preserve native aquatic plants
- Prevent the introductions of AIS
- Identify and Protect sensitive areas
- Identify sources of financial assistance for aquatic plant management activities
- Coordinate sound aquatic plant management practices where needed within Big Lake
- Educate the Big Lake community on proper AIS identification and prevention efforts
- Gather citizen input
- Increase citizen participation in lake management

4.0 Project Methods

To accomplish the project goals, the PITLC needs to make informed decisions regarding APM on the lake. To make informed decisions, PITLC proposed to:

- Collect, 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

Bonestroo researched a variety of information 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 lake 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 August 7 and 8, 2007 by Northern Environmental. The survey was completed according to the point intercept sampling method described by Madsen (1999) and as outlined in the WDNR draft guidance entitled “Aquatic Plant Management in Wisconsin” (WDNR, 2005).

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 70 meter grid with 685 pre-determined intercept points (Figure 3). Latitude and longitude coordinates and sample identifications were assigned to each intercept point on the grid (Appendix A). 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 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. 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 SHORELINE CHARACTERIZATION

The point intercept method described above may not accurately identify emergent and floating leaved aquatic plants in near shore areas. Therefore, a boat tour was completed traveling the entire perimeter of the lake's shoreline. During the boat tour, visual observations of the emergent and floating leaved plant communities were located and recorded. The boat tour also included a shoreline characterization, which provides an evaluation of shoreline development on the Lake. The following scale was used to rate the level of shoreline development.

1: Undeveloped (i.e. Forested or wetland)

2: Minor development (i.e. Properties may have mostly natural shoreline, sparse structures set further away from the lake, one pier, and little or no clearing of natural vegetation).

3: Moderate development (i.e. Properties may exhibit clearing and/or manipulation to the shore and lawn areas but not to waters edge. More elaborate piers or boathouses may be present).

4: Major development (i.e. Properties may include large lawn areas extending to the shoreline, which contains little or no natural shoreline vegetation. Increased building density, possibly close to the shore, multiple docks or boathouses, and significant shoreline alteration such as seawalls or rip rap may be present).

4.4 PUBLIC INVOLVEMENT, QUESTIONNAIRE, AND PLAN REVIEW

A public questionnaire was developed by Northern Environmental, the PITLC and the WDNR. This questionnaire was designed to gauge lake users' opinions on a number of important topics related to APM Plan implementation. The survey inquired about the users' perception of aquatic plant problems and other lake issues. The survey was also developed to determine what lake users consider an appropriate plant management intensity and cost. The public questionnaire was sent out to lake residents within the total PITLC project study area with their 2007 taxes in early 2008 and can be found in Appendix I.

Public involvement and education efforts included a presentation by Northern Environmental with the PITLC members on June 26, 2007 to discuss and kick off the APM Plan project. In November of 2007, draft copies of the APM Plan for Big Lake, and other Presque Isle Town lakes, were submitted to the WDNR and the PITLC for distribution to, and comments from, lake residents. Comments from PITLC and the Vilas County Land and Water Conservation Department were received in December 2007. Edits to the documents were completed base on the comments received. Final preparation of the APM plan was on hold waiting WDNR review of the draft documents. Hearing no comments for the WDRN by April 8th, 2008, edited copies were bound and sent to the WDNR.

On May 3, 2008 a Northern Environmental project manger met with the PITLC, two members of the Vilas County Land and Water Department and the WDNR Lake Management Coordinator to discuss the findings of the APM Plans for the Presque Isle Town lakes. WDNR Lake Management Coordinator announced at that meeting that the WDNR review had not been completed and the group should anticipate comment yet to come. On November 24 of 2008, WDNR submitted 45 comments on the draft Big Lake APM plan. Northern Environmental Project Manager met with the PITLC, a representative of the Town of Presque Isle, Vilas County Land and Water Department Invasive Species Coordinator and the WDNR Lake Management Coordinator on January 21, 2009 to discuss the WDNR's comments.

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

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
- Zebra Mussels
- Rusty Crayfish
- Spiny Water Flea
- Purple Loosestrife

Appendix C provides additional information on these AIS. Populations of rusty crayfish (*Orconectes rusticus*) have been identified within Big Lake since 1972. Rusty crayfish are large crustaceans that feed aggressively on aquatic plants, small invertebrates & fish, and fish eggs.

5.3 2007 AQUATIC PLANT SURVEY

The survey was carried out August 7 and 8, 2007, and included sampling at 685 intercept points. The aquatic macrophyte community of the Lake included 28 floating leaved, emergent, and submerged aquatic vascular plant species during 2007. Table 2 lists the taxa identified during the 2007 aquatic plant survey. Figures 4a through Figure 4g illustrate the locations of each species identified.

Vegetation was sampled at a maximum depth of 20 feet. Aquatic vegetation was detected at 31.7 percent (%) of photic zone intercept points. The Simpson Diversity Index value of the community was 0.91, taxonomic richness was 28 species, and there was an average of 0.79 species identified at points that were within the photic zone. There was an average of 2.52 species present at points with vegetation present. Table 3 summarizes these overall aquatic plant community statistics.

The most abundant aquatic plant identified during the aquatic plant survey was nitella *(Nitella sp.)*. It exhibited a 26.7% frequency of occurrence (percent of photic zone intercept points at which the taxa was detected). It was present at 38.6% of the sites with vegetation, and had a 22.8% relative frequency of occurrence. Table 4 includes the abundance statistics for each species.

The most abundant aquatic plant identified during the aquatic plant survey was coontail (*Ceratophyllum demersum*). It exhibited a 15.1% frequency of occurrence (percent of photic zone intercept points at which the taxa was detected). It was present at 47.6% of the sites with vegetation, and had an 18.9% relative frequency of occurrence. Table 4 includes the abundance statistics for each species.

Coontail
Source: UW Herbarium Website

Coontail (*Ceratophyllum demersum*) 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.

Wild Celery
Source: UW Herbarium Website

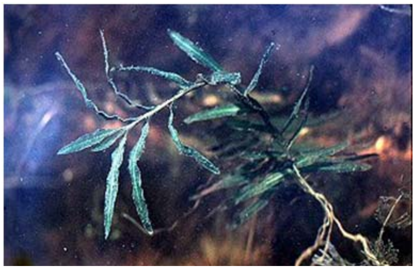
Wild celery (*Vallisneria americana*) and slender naiad or bushy pondweed (*Najas flexilis*) were the second most abundant vascular plant species occurring at 8.5% of the photic zone. They were present at 26.7% of the sites with vegetation and had a 10.6% relative frequency of occurrence.

Wild celery (*Vallisneria americana*) also known as eel-grass or tape-grass, and has ribbon-like leaves that tend to grow until they emerge in clusters along the waters surface. Wild celery is a premiere source of food for waterfowl. All portions of the plant are consumed. Beds of wild celery are also considered good fish habitat providing shade, shelter and feeding opportunities (Borman, et al., 1997).

Bushy pondweed or slender naiad (*Najas flexilis*) 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).

Bushy Pondweed
Source: UW Herbarium Website

Fern or Robbins' pondweed *(Potamogeton robbinsii)* was the third most abundant vascular plant species occurring at 8.2% of the photic zone. It was present at 25.7% of the sites with vegetation and had a 10.2% relative frequency of occurrence.



Fern Pondweed
Source: UW Herbarium Website

Fern or Robbins' pondweed *(Potamogeton robbinsii)* is a submergent pondweed with robust stems and strongly two-ranked leaves, creating a feather or fern-like appearance while in the water. Fern pondweed sprouts in the spring and thrive in deeper water. Fern pondweed provides habitat for invertebrates that are grazed by waterfowl and also offers good cover for fish, particularly northern pike (Borman, et al., 1997).

5.3.1 FLOATING-LEAF PLANTS

The following two floating-leaf aquatic plant species were identified during the 2007 aquatic plant survey.

- *Nuphar variegata* (spaterdock)
- *Nymphaea odorata* (white water lily)

5.3.2 SUBMERGENT PLANTS

The following 20 submergent aquatic plant species were identified during the 2007 aquatic plant survey.

- *Algae sp.* (filamentous algae)
- *Ceratophyllum demersum* (coontail)
- *Chara sp.* (muskgrass) [algal]
- *Eleocharis acicularis* (needle spikerush)
- *Elodea canadensis* (common waterweed)
- *Heteranthera dubia* (water stargrass)
- *Megalodonta beckii* (water marigold)
- *Myriophyllum sibiricum* (northern watermilfoil)
- *Myriophyllum tenellum* (dwarf watermilfoil)
- *Najas flexilis* (bushy pondweed)
- *Nitella sp.* (nitella) [algal]
- *Potamogeton amplifolius* (large-leaf pondweed)
- *Potamogeton gramenius* (variable pondweed)
- *Potamogeton illinoensis* (Illinois pondweed)
- *Potamogeton praelongus* (white-stem pondweed)
- *Potamogeton pusillus* (small pondweed)
- *Potamogeton richardsonii* (clasping-leaf pondweed)
- *Potamogeton robbinsii* (fern pondweed)
- *Potamogeton zosteriformis* (flat-stem pondweed)
- *Vallisneria americana* (wild celery)

5.3.3 EMERGENT PLANTS

The following six emergent aquatic plant species were identified during the 2007 aquatic plant survey.

- *Eleocharis palustris* (creeping spikerush)
- *Equisetum fluviatile* (water horsetail)
- *Pontederia chordata* (pickerelweed)
- *Sagittaria cristata* (crested arrowhead)
- *Schoenoplectus acutus* (hardstem bulrush)
- *Sparganium sp.* (Bur-reed species)

Table 2 lists the species identified. Appendix D includes brief descriptions of all aquatic plants identified.

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 the average FQI of 22.2 (WDNR, 2005). The FQI calculated from the 2007 aquatic plant survey data was 33.14. This FQI value is higher than Wisconsin's northern region mean of 24.3 and suggests that Big Lake exhibits slightly above average water quality when using aquatic plants as an indicator. Table 5 summarizes the FQI values.

5.5 SHORELINE CHARACTERIZATION

Emergent and floating leaved plants identified along the shoreline outside of formal grid sample points included: *Nymphaea odorata* (white water lily), *Carex sp.* (sedges), *Pontederia cordata* (pickerelweed), *Sagittaria sp*. (arrowhead), *Sparganium sp*. (bur-reed species), *Nuphar variegata* (spatterdock), *Eleocharis acicularis* (creeping spikerush), *Decodon verticillatus* (swamp loosestrife), *Typha sp.* (cattail), *Lobelia dortmanna* (water lobelia), *Schoenoplectus acutus* (hardstem bulrush), *Brasenia schreberi* (watershield), and *Zizania palustris* (northern wild rice). Refer to Appendix D for descriptions of some of these plants. Floating and emergent plants were identified around the entire shoreline during the boat survey. Figure 5 shows a representation of the shoreline. Plants identified during the shoreline survey but not during the point-intercept method were not included in the community statistics or calculation of the FQI.

Also, the level of shoreline development was noted and recorded around the lake. The shoreline was largely undeveloped and minorly developed. Figure 5 illustrates the level of shoreline development.

5.6 PUBLIC QUESTIONNAIRE

There were 13 responses to the public survey questionnaire; 64% were Big Lake shoreline landowners, 28% were nearby landowners, and 8% were area business owners. Fishing, swimming, nature viewing, and pleasure boating were top activities reportedly enjoyed by the respondents with a majority using the lake greater than ten days a year. Aquatic plant growth was reported to be a nuisance by the respondents at the following rate; "sometimes" (23%), "rarely" (46%) and "never" (31%). The major concerns of the respondents were water quality, aquatic invasive species, and algae growth. Most listed study and understand the current situation and prevent the introduction of AIS as important APM goals.

The majority of the respondents are well informed on AIS and reported having at least some awareness on all aspects AIS to presentence within Town lakes, how to prevent its spread and introduction, how AIS spread, and their impact on recreation and the lake's ecosystem.

46% of respondents believe that aquatic plant management is needed, 15% don't believe APM is needed and, 38% are unsure. The majority of respondents (85%) thought that the level of appropriate aquatic invasive plant management would be to manage problem areas, 8% thought aggressive lake-wide management would be needed, while the reminder did not see a need for action. None of the respondents were willing to make individual contributions to APM but most thought that state and federal assistance should be sought, while user fees and room tax funding options should be explored.

5.7 WATER QUALITY SAMPLING

2007 collected water samples were tested and showed a phosphorus reading of 10 ug/L and a chlorophyll *a* reading of 2.7 ug/L. A Secchi reading was taken at the same time and was visible to 12 feet. All chlorophyll a and clarity results are concurrent with the mesotrophic status of the lake while the phosphorus results indicate an oligotrophic state. However, there is water chemistry data from the aquatic plant survey. More sampling is required to accurately deem the trophic status of Big Lake.

Along with water quality sampling, a dissolved oxygen and temperature profile was recorded at one foot intervals to a depth of 25 feet over the deepest portion of the lake (Table 1). As lakes warm throughout the summer uneven heating of water occurs. This causes warmer water to “separate”, or stratify, from cooler, denser water. Between layers of stratified water a thermocline may establish. A thermocline is a thin layer of water layers in which the temperature changes more rapidly with depth than in the layers above and below it. The area below the thermocline may become low in oxygen concentration and limit the depth to which organisms can survive. At approximately 5.00 ppm of dissolved oxygen (DO), fish become stressed and at 2.00 ppm DO, most fish cannot survive. On Big Lake, the thermocline occurred at 18 feet of depth at the time of the DO and temperature profile.

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 is included in Appendix E. Currently, the Northern Region of the WDNR is working under an aquatic plant management strategy that is officially titiled Aquatic Plant Management Strategy, Northern Region WDNR, Summer, 2007 (working draft), or commonly referred to the NOR Region APM Strategy (Appendix H). This strategy lays out an approach for acceptable aquatic plant management in Northern Region lakes. The strategy protects native aquatic plant communities in northern Wisconsin and does not allow permits to control native plants unless documented circumstances of nuisance levels exist. The following management alternatives are based on the approaches described in the NOR Region APM Strategy, and incorporate recommendations of Bonestroo.

6.1 AQUATIC PLANT MAINTENANCE ALTERNATIVES

The maintaenance alternative 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. The maintenance alternative is a protection-oriented management alternative because no significant plant problems exist or no active manipulation is required. This alternative 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

Aquatic plant growth on Big Lake is dense in some shallow locations. However, no AIS were identified during the 2007 survey in Big Lake and management activities to impact native species are not recommended. Any management alternatives at this time should focus on AIS monitoring and prevention. In order to monitor for AIS in the future a strong Citizen 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, in others however, vigilant and active management is required. This can be based on several things including water quality. Data provided on the WDNR Citizen Lake Monitoring website indicates monitoring of water clarity was last completed in 2006. Big Lake residents should also consider becoming active Citizen Lake Monitors for water quality (Secchi depth, total phosphorus and chlorophyll *a*).

Assuming an AIS were to become established in the next several years, the most likely species would be EWM or CLP. If these or other AIS are found a sample should be collected and taken to the DNR for proper confirmation. The University of Wisconsin-Extension Lake's Program provides training and coordinates the Citizen Lake Monitoring Program. More information about the program is available by contacting Laura Herman, Citizen Lake Monitoring Network Education Specialist, (715) 346-3989, email: lherman@uwsp.edu, website: http://www.uwsp.edu/cnr/uwexlakes/clmn/.

Bonestroo also recommends completing lake-wide aquatic plant surveys every 5 years (essentially repeating the 2007 point intercept aquatic plant survey) to monitor changes in the overall aquatic plant community and the effects of the APM activities. Aquatic plant communities may change with varying water levels, water clarity, nutrient levels, and aquatic plant management actions.

6.1.2 CLEAN BOATS/CLEAN WATERS CAMPAIGN

There are two public landings on Big Lake and the Clean Boats / Clean Waters (CB / CW) program is not currently in use. Therefore, it is recommended that the CB/CW program be put into action on Big Lake and the connecting waterbodies. This program is carried out by trained volunteers who inspect the incoming boats at public launches. Signage also accompanies the use of CB / CW to inform lake users of proper identification of AIS and boat inspection procedures. Education of the public, property and resort owners about inspecting watercraft for AIS before launching the boat or leaving access sites on other lakes could help prevent new AIS infestations. Installation of this program is recommended.

6.1.3 AQUATIC PLANT PROTECTION AND SHORELINE MANAGEMENT

Protection of the native aquatic plant community is needed to slow the spread of EWM from lake to lake and within a lake once established. Therefore, riparian landowners should refrain from removing native vegetation. Additionally, EWM can thrive in nutrient (phosphorus and nitrogen) enriched waters or where nutrient rich sediments occur. Two 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. Properties classified in the shoreland survey as having a level 3: Moderate Development or level 4: Major Development, would be good candidates for shoreland restorations. Establishing natural shoreline vegetation can sometimes be as easy as not mowing to the waters 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. A vegetated buffer area can also prevent surface water runoff from roads, parking areas and lawns from carrying nutrients to the lake.

The Vilas County Land and Water Conservation Department offers a cost-share program for county landowners. The primary emphasis of the program continues to be to restore native vegetation to shoreland property. For shoreline restoration projects and other conservation practices involving revegetation activities, landowners are reimbursed up to 70% of the costs of planting and purchasing native trees, shrubs, and wildflowers. Interested landowners can contact the Vilas County Land & Water Conservation Department at (715) 479-3648 to request an application form for the program. Another avenue to fund shoreland restoration is the WDNR Lake Protection Grant program. This program offers 75% of the project cost covered by the state up to $200,000. For more information on the Lake Protection Grant program contact the Lake Management Coordinator at the WDNR Rhinelander Service Center by calling (715) 365-8937.

The second easy nutrient prevention effort is to use lawn fertilizers only when a soil test shows a lack of nutrients. Phosphorus free fertilizers should be used when possible. 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. Landowners should be encouraged to use phosphorus free fertilizers on lakeshore lawns. 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 the lake. Septic systems should be properly installed and maintained in order to prevent improperly treated wastewater, which carries a lot of nutrients, from reaching the lake. Property owners who are not sure if their septic system is adding nutrients to the lake should contact a professional inspector and have their system assessed.

6.1.4 PUBLIC EDUCATION AND INVOLVEMENT

The PITLC should continue to keep abreast of current AIS issues throughout the County. The County Land and Water Resource Conservation Department and the 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 G includes resources for further information about public education opportunities.

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

6.2 AQUATIC PLANT MANIPULATION ALTERNATIVES

The management alternative may be used when aquatic plants present some sort of problem that must be dealt with or manipulated by human action. The WDNR NOR Region APM Strategy states "Newly-discovered infestations, if found on a lake with an approved lake management plan, the invasive species can be controlled via an amendment to the approved plan." The following alternatives are based on the assumption that the PITLC will meet in consultation with the WDNR before pursuing manipulation of AIS populations.

6.2.1 MANUAL REMOVAL

Native plants may be found at nuisance levels at individual properties. Manual removal efforts, including hand raking or hand pulling unwanted plants, is allowed under Wisconsin law, to a maximum width of 30 feet (recreational zone). 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 F). 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 an Aquatic invasive plant is found in a small population hand pulling is a good first line of defense. If EWM or CLP ever becomes established within Big Lake, manual (hand) removal of these plants in small, isolated populations, particularly in shallow water would be appropriate. 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. Before significant plant removal is undertaken, a sample of the species assumed to be EWM or CLP should be brought to and confirmed by the WDNR.

Manual removal of aquatic plants can be quite labor intensive and time consuming. This technique is well suited for small areas in shallow water where property owners can weed the aquatic garden. 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 include 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. Again, hiring laborers to remove aquatic vegetation is an option, but also increases cost.

Landowners removing plants manually should learn to identify the aquatic plant species. If an individual has questions about a particular aquatic plant or what level of manual removal is allowed, they should talk to the Vilas County Land & Water Conservation Department at (715) 479-3648, or the Kevin Gauthier, Lakes Management Coordinator, Wisconsin Department of Natural Resources, 107 Sutliff Ave, Rhinelander, (715) 365-8937. Appendix F includes additional resources for plant identification.

6.2.2 Aquatic Invasive Plant Species Chemical Herbicide Treatment

If Big Lake becomes infested with EWM or CLP of areas of approximately ¼ acre or greater, a chemical herbicide treatment may be an appropriate way to conduct restoration of native plants. Before any specific course of action is undertaken the WDNR must be consulted. As of the time this report is written the consultation would begin with Kevin Gauthier, Lakes Management Coordinator in Rhinelander, (715) 365-8937. All herbicide treatments must be undertaken with a WDNR issued permit (NR 107 Wisconsin Administrative Code). A WDNR AIS Early Detection and Rapid Response Grant is usually the best place for a lake group to receive financial assistance for chemical treatment of a newly discovered AIS population.

When using chemicals to control AIS it is a good idea to reevaluate the lake and the extent of the AIS conditions before, during and after chemical treatment. The WDNR may require another whole-lake plant survey and will certainly require a proposed treatment area survey. Along with the above mentioned survey, pre and post treatment monitoring should be included for all aquatic plant treatments and is typically a WDNR requirement in their Northern Region.

The science regarding what chemicals are most effective and how they can be used is constantly being updated. Currently EWM is the most common aquatic invasive plant species targeted for chemical treatment in the Northwoods. At present, granular 2,4-D is the most common herbicide used on EWM in the Northwood's area. In order to decrease damage to native plants and be as selective as possible for EWM, treatments are completed in the spring when native plant growth is minimal.

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 Big Lake the next would be 2012). Such a survey may reveal a new AIS and at the very least would provide good trend data to see how the aquatic plant community is evolving.

Advantages of herbicides include broader control than hand pulling, and represents a true restoration effort, which harvesters do not (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 water use restrictions after application may be necessary.

7.0 Conclusion and Recommended Action Plan

No aquatic invasive plants were found during the aquatic plant survey in 2007. The fact that the native plant community had an above average plant FQI illustrates that there is a unique and diverse plant community in Big Lake. Such a plant community is worthy of protection for human disturbance and the potential impact aquatic invasive species would have if introduced to this system. Because of that, the following recommended action plan focuses on maintenance of the current plant community and conservation of native plants.

7.1 RECOMMENDED ACTIVE GOALS

The recommended action plan includes actions for Big Lake based on the Maintenance Alternative listed above in Section 6. The PITLC president has approved the following active goals. It will be up to residents of Big Lake and the PITLC to determine the actions, find the funding, and gather the individuals needed to implement the active goals.

Active Goal: To initiate the WDNR Clean Boats, Clean Waters program on Big Lake.

Active Goal: To provide visitors with educational information concerning the potential impact their activities could have on introduction of aquatic invasive species, wildlife, habitats and Big Lake water quality.

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.

Active Goal: To work in concert with the WDNR staff and representatives of fishing related businesses to evaluate Big Lake fish management practices and develop goals in order to maintain and enhance a quality family sport fishery.

Active Goal: To enforce the Town of Presque Isle's 200 foot no-wake areas (from shoreline and islands) ordinances in order to minimize recreational impacts on the plant community, shoreline habitats, and to promote safe boating.

Active Goal: To support the identification and preservation of critical species and critical habitat lands, and wetlands within the watershed. (These are areas with rare vegetation, important habitat for wildlife, or important spawning and nursery areas for fish. Preservation of these lands has a direct impact on the water quality of the lake).

Active Goal: To provide education and information to shoreline property owners regarding how native aquatic plant protection and shoreline management can slow the spread of aquatic invasive plants (if they become introduced), improve the lake fishery, improve wildlife habitat and affect the quality of the water in the lake (including development of a *shoreline restoration packet* that could be given to landowners who's property has development categorized as Moderate or Major).

Active Goal: To encourage the incorporation of water quality protection measures in the design, construction and maintenance of all lake access sites on Big Lake (e.g. storm water control, site drainage control, appropriate plant matter disposal, and watercraft wash down facilities if found to be needed).

Active Goal: To meet on a regular basis with local government agencies and representatives of lakes located within the Town of Presque Isle, to identify essential and new lake management issues and determine collaborative solutions.

7.2 CLOSING

This APM Plan was prepared in cooperation with the Presque Isle Town Lakes Committee. 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 B.

This APM Plan should be updated periodically to reflect current aquatic plant problems, and the most recent acceptable APM 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 Bonestroo upon request.

8.0 References

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Figures

Tables

Appendix A - Point Intercept Sample Coordinates

Appendix B – 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).

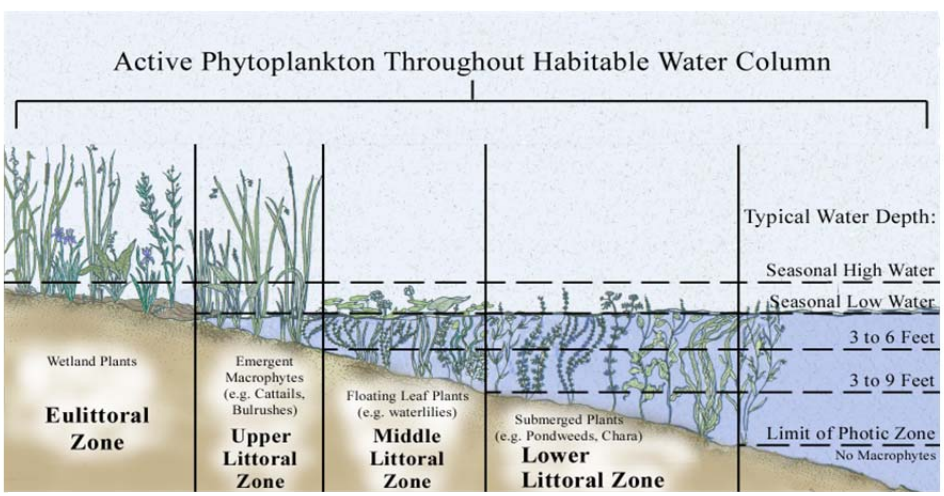
Eulittoral Zone: Includes the area between the highest and lowest seasonal water levels, and often contains many wetland plants.

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, a direct 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 C – 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 vegetatively by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. 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)* 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)* are small freshwater clams that can attach to hard substrates in water bodies, often forming large masses 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)* are predatory zooplankton (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 D – Descriptions of Aquatic Plants

Appendix E – Summary of Aquatic Plant Management Alternatives

Appendix F – NR 107 and NR 109 Wisconsin Administrative Code

Appendix G – Resource for Additional Information

Appendix H – Aquatic Plant Management Strategy, Northern Region WDNR, Summer, 2007 (working draft)

Appendix I – Summary of Public Survey