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AQUATIC PLANT MANAGEMENT PLAN

BIG SAND LAKE
VILAS COUNTY, WISCONSIN

July 5, 2007
Revised August 3, 2007

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DNR Grant # AEPP-056-07

Northern Environmental Project Number: PAL 08-5500-0781

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1.0 EXECUTIVE SUMMARY

The Big Sand Lake Property Owners Association, with the Town of Phelps acting as grant sponsor pursued a Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant to develop an Aquatic Plant Management (APM) Plan for Big Sand Lake. Big Sand Lake is located in Eastern Vilas County and has an 11,810 acre watershed which is primarily forested. Big Sand Lake exhibits good water clarity and is an oligotrophic to mesotrophic lake using the Trophic State Index.

The WDNR completed an aquatic plant survey on Big Sand Lake in August 2006, which identified 45 aquatic plant species. The most abundant aquatic plants identified during the survey were Robbins or Fern pondweed and Elodea (common waterweed). The Floristic Quality Index (FQI) is an index that uses the aquatic plant community as an indicator of lake health. Plants sensitive to disturbances in the lake ecosystem are assigned a higher value than plants which can tolerate disturbances. The values of all species present are used in a formula to determine the plant community's FQI. Big Sand Lake exhibited an FQI much higher than the state average.

Eurasian watermilfoil (EWM) is an aquatic invasive species (AIS) that was confirmed to be present on Big Sand Lake in 1990. EWM was found at approximately 257 acres of Big Sand Lake using the 2006 lake wide aquatic plant survey data.

Curly-leaf pondweed (CLP) is another AIS that was identified on Big Sand Lake in 2006. CLP was identified at only 3 sampling points. Monitoring for the presence and expansion of known locations of CLP should be completed. CLP can exhibit aggressive growth habits, therefore CLP distribution and density may potentially increase on Big Sand Lake. Left unchecked, CLP poses a threat to the diverse aquatic plant community on Big Sand Lake.

The overall aquatic plant management objective is to reduce the acreage and frequency of occurrence within vegetated areas of EWM on Big Sand Lake and to restore the native plant community. Management efforts such focus on the EWM reduction and allow the natural restoration of the native aquatic plant community as the EWM is minimized. An achievable and quantitative goal for EWM reduction is to minimize the total acreage within 5 years by 80 percent. Wisconsin Administrative Code NR 107.04(3) defines a large-scale treatment as anything over ten acres or more than 10% of the water body that is less than ten feet deep. This overall goal correlates to a reduction of EWM acres by 80 percent over the next five years. An 80 percent reduction of EWM in Big Sand Lake correlates to annual reduction of 41 acres per year with a remaining population of 52 acres of EWM in 2012. EWM was found at 149 sample sites out of the 607 vegetated sites, a frequency of occurrence within vegetated areas of 24.5 percent. With a decline of EWM of 80 percent over five years the relative frequency will decline 3.92 percent each year. By 2012 EWM should have a frequency of occurrence within vegetative areas of 4.9 percent, down from 24.5 percent in 2006. The following table depicts this reduction by year and acreage. The table also assumes no major re-growth or expansion of EWM on a yearly basis. Highly used recreational areas and public boat launches or access points should be give priority when considered treatment locations due to a greater potential for EWM spread coming from these areas. The APM plan should be updated in 2011-2012 to evaluate the aquatic plant community and to assess the current management strategies.

Year	Acreage	Frequency of Occurrence Within Vegetative Areas
2008	216	20.55
2009	175	16.63
2010	134	12.71
2011	93	8.79
2012	52	4.87

Information gathered from the public questionnaire indicated most enjoyed using the lake for fishing, swimming, and boating. Most people have experienced problems with aquatic plant growth affecting their recreation and believe that AIS is a concern that justifies active management.

The APM Plan involved evaluating physical, mechanical, biological, and chemical management alternatives and outlines specific management activities for the EWM and CLP on Big Sand Lake.

Recommended APM Plan

Proposed management of EWM includes manual removal in isolated shallow locations. No permit is required to remove EWM along a landowner's shoreline property, but removal of native plants is restricted to a 30 foot wide recreation zone (for pier, boatlift, or swim raft access). Additional native plant removal is not recommended and would require a permit from the WDNR. Larger EWM areas will be treated with a selective herbicide containing 2,4-D in accordance with a WDNR issued permit under NR 107 Wisconsin Administrative Code. EWM treatments will be completed in the spring when native plant growth is minimal to increase the selectivity of the herbicide. Pre and post treatment monitoring is required for all EWM treatments. CLP should be closely monitored in spring and early summer to document its growth and expansion in Big Sand Lake. Isolated stands of CLP should be manually removed prior to June 1st to prevent the spread by turions. If CLP stands are beyond control by manual means, an endothall-based herbicide should be used to treat these areas in early spring. The APM Plan also: includes prevention components such as the Wisconsin Clean Boats Clean Waters Program; assigns responsibilities for APM activities; and outlines a monitoring protocol to evaluate the EWM treatment effectiveness, changes in the lake's aquatic plant community, water quality, and public opinion.

2.0 INTRODUCTION

Recognizing the importance of Vilas County lakes to both residents and visitors, local government units and lake associations are working together to protect these important water resources. One of the latest lake protection efforts is the formation of the Vilas County Aquatic Invasive Species (AIS) Planning Partnership aimed at preventing and controlling AIS infestations within Vilas County. The Planning Partnership promotes organization at the township level for local communities to prioritize and manage AIS problems on area waters. The Long Lake Association of Vilas County and the Big Sand Lake Property Owners Association wanted to address Eurasian Watermilfoil (EWM), an AIS present on Long Lake and Big Sand Lake within the Town of Phelps. The Long Lake Association of Vilas County, with the Town of Phelps acting as grant sponsor, applied for a Wisconsin Department of Natural Resources (WDNR) grant to complete an Aquatic Plant Management (APM) Plan for Long Lake and Big Sand Lake. An APM Plan is a prerequisite for funding many APM activities and large scale WDNR permits. WDNR completed an aquatic plant survey on Big Sand and Long Lakes, and awarded an AIS Control Grant to fund development of the APM Plans. This document is the APM Plan for Big Sand Lake and discusses the following:

- Lake morphology and lake watershed characteristics
- Historical aquatic plant management activities
- Stakeholder's goals and objectives
- Aquatic plant ecology
- 2006 baseline aquatic plant survey
- Feasible aquatic plant management alternatives
- Selected suite of aquatic plant management options

3.0 BACKGROUND INFORMATION

3.1 Lake History and Morphology

Big Sand Lake is located in the Town of Phelps in eastern Vilas County, Wisconsin. Figure 1 depicts the lake location. The following summarizes the lake's physical attributes:

Lake Type	Drainage
Surface Area (acres)	1,408
Maximum depth (feet)	65
Average depth (feet)	16
Shoreline Length (miles)	8.5

Source Wisconsin Lakes, WDNR 2005

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

Big Sand Lake is the headwaters to Long Lake and the Deerskin River. Big Sand Lake is connected to Long Lake via Thoroughfare Creek (Figure 1). A water level control structure was originally built in 1907 at the Deerskin River outlet on Long Lake. This dam is currently operated by the Wisconsin Valley Improvement Company who maintains the water level on Long Lake and Big Sand Lake between 1698.43 (maximum) and 1695.84 (minimum) feet above mean sea level (msl).

3.2 Watershed Overview

The Big Sand Lake watershed encompasses 11,810 acres. Land cover within the overall watershed includes the following:

- Forested (62%)
- Wetland (9%)
- Agriculture (9%)
- Open Water (19%)

Source: WDNR Land Sat Imagery and WISCLAND database

Figure 3 illustrates the watershed and land uses. The watershed is in the Northern Highland physiographic region of Wisconsin (United States Department of Agriculture [USDA], 1988). The region includes drumlins and ground moraines deposited after the last glacial advance. The topography of this area is characterized by low, rounded, and oval ridges bisected by long narrow drainages (USGS, 1981). Outside of the moraine areas are outwash plains that formed from glacial melt water deposits). Some outwash areas are pitted with many depressions, wetlands, and small lakes with no outlets (USDA, 1988). The unconsolidated sediments are underlain by Precambrian aged igneous rocks.

3.3 Water Quality

Available information from the on-line WDNR Lake Water Quality Database indicates a volunteer citizen monitor measured the following parameters on Big Sand Lake in 1992, 1994, 1999 and 2000.

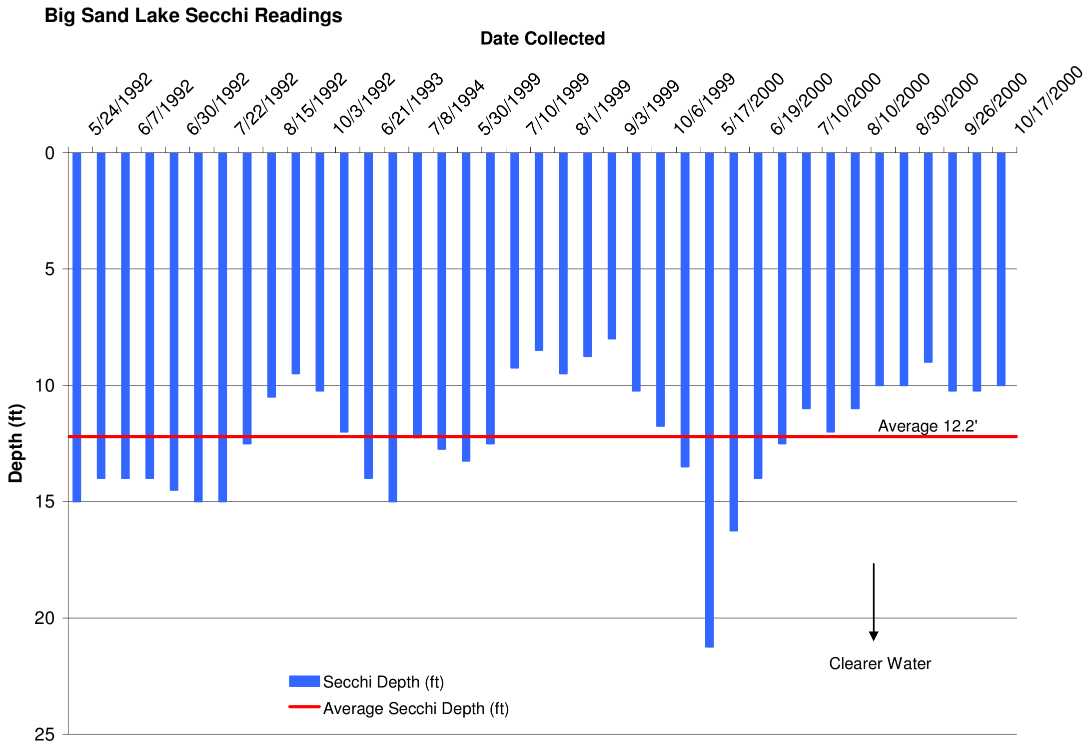
- Water clarity (secchi depth) - [1992, 1994, 1999 and 2000]
- Total Phosphorus – [1992 to 1994]
- Chlorophyll a – [1992 to 1994]

Water clarity is measured by lowering an 8-inch 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. Total Phosphorus is a measure of nutrients available for plant growth and chlorophyll a is a measure of pigment in the water that is within algae.

A review of WDNR files determined that one or more of the following: Total Phosphorus and Chlorophyll a; were also measured by WDNR in 1989 and 2001-2002.

3.3.1 Water Clarity

The historical water clarity average is 12.1 feet (3.7 meters). The following graph illustrates the historical and current water clarity measurements on Big Sand Lake.



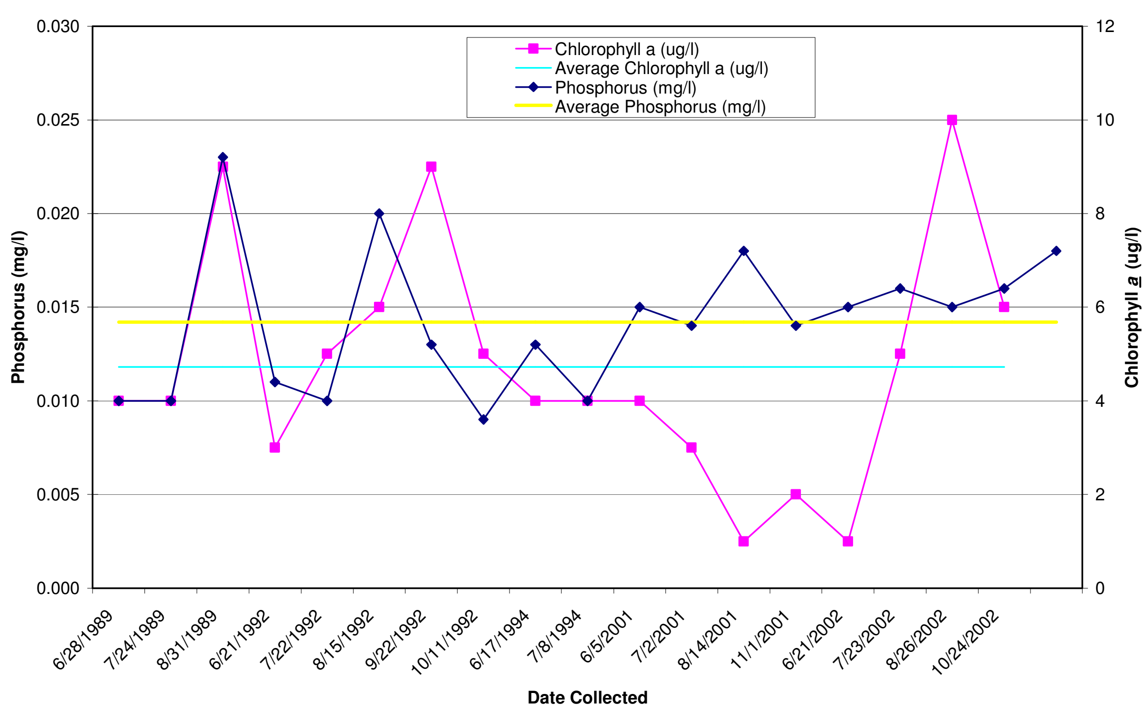
3.3.2 Total Phosphorus and Chlorophyll *a*

The following table illustrates the historical water quality parameters measured on Big Sand Lake.

Date	Total P (*mg/l*)	Chlorophyll *a* (*µg/l*)
June 28, 1989	0.010	4
July 24, 1989	0.010	4
August 31, 1989	0.023	9
November 13, 1989	0.011	---
June 21, 1992	0.009	3
July 22, 1992	0.013	5
August 15, 1992	0.010	6
September 22, 1992	0.020	9
October 11, 1992	0.013	5
June 17, 1994	0.010	4
July 18, 1994	0.015	4
June 5, 2001	0.014	4
July 2, 2001	0.018*	3*
August 14, 2001	0.014*	1*
November 01, 2001	0.015	2*
June 21, 2002	0.016	1
July 23, 2002	0.015	5
August 26, 2002	0.016	10
October 24, 2002	0.018	6
AVERAGE	**0.014**	**4.7**

Notes: *mg/l= milligrams per liter, (parts per million)*
ug/l = micrograms per liter, (parts per billion)[1000 ppb = 1 ppm]
** = Result Approximate (WDNR)*

Big Sand Lake Chemisty Data



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 *(mg/l)*	Chlorophyll a *(ug/l)*	Water Clarity *(meters)*
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.	0.003 to 0.01	2 to 5	3.7 to 2.4
Mesotrophic	41-50	Moderately clear; increasing probability of low to no oxygen in bottom waters.	0.018 to 0.027	8 to 10	1.8
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.	0.03 to 0.05	11 to 15	1.5 to 1.2 (less is hyper-eutrophic)

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

The historical water clarity and chlorophyll a data indicate that Big Sand Lake is an oligotrophic lake. The total phosphorus data collected indicate an oligotrophic to mesotrophic lake system, according to the Wisconsin TSI.

3.4 Summary of Lake Fishery

The following table identifies the fish species that are present in Big Sand 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

Available information indicates that walleyes were stocked in 1974, 1976, 1985, 1987, 1989, 1991-1992, 1994-1995, 1999, 2001, 2003 and 2005. Muskellunge were stocked in 1974, 1977, 1984-1985, 1990-1993, 1996, 1998, and 2000. (WDNR Fish stocking website, 2006).

3.5 Aquatic Plant Management History

According to WDNR records, Eurasian Watermilfoil (EWM) was confirmed in Big Sand Lake in 1990.

3.6 Goals and Objectives

During the grant application process, discussions with the Big Sand Lake Property Owners Association identified the following important APM Plan goals and objectives:

- Evaluate feasible aquatic plant management alternatives specific to Long Lake and Big Sand Lake
- Manage AIS and nuisance plants in accordance with the best available technologies
- Maintain and improve recreational opportunities
- Protect and improve fish and wildlife habitat
- Preserve native aquatic plants
- Identify and protect sensitive areas
- Prevent the introductions of new AIS
- Prevent the spread of AIS
- Raise awareness and promote education about aquatic plant problems within the town
- Identify and discuss various sources of financial assistance for APM activities

4.0 PROJECT METHODS

To accomplish the project goals, the Big Sand Lake Property Owners Association needs to make informed decisions regarding APM on the Lake. To make informed decisions, the Association 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 data needed to evaluate aquatic plant management alternatives.

4.1 Existing Data Review

A variety of background information resources were researched 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 PALP members
- Available topographic maps and aerial photographs
- Data from WDNR files
- Past lake study reports (if available)

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 1 through August 3, 2006 by WDNR and UW Extension staff. The survey was completed according to the point intercept sampling method described by Madsen (1999), 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 80 meter grid with 1427 pre-determined intercept points (Figure 4). 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. At each intercept point, a value of 1-3 was assigned to the species collected based on densities observed on the rake, or rake fullness ratings. 1 being a few plants on the rake head, 2 when the rake head is approximately ½ full, and three being full of aquatic plants with the rake head not visible. If a species was not collected at that point, the space 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 site)

- **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 Questionnaire

A public questionnaire was prepared and solicited by the Lake Association to gauge lake user's perception of aquatic plant concerns on the lake and gather opinions to categorize project goals.

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 AIS, such as EWM and CLP, 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.

5.1.1 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).

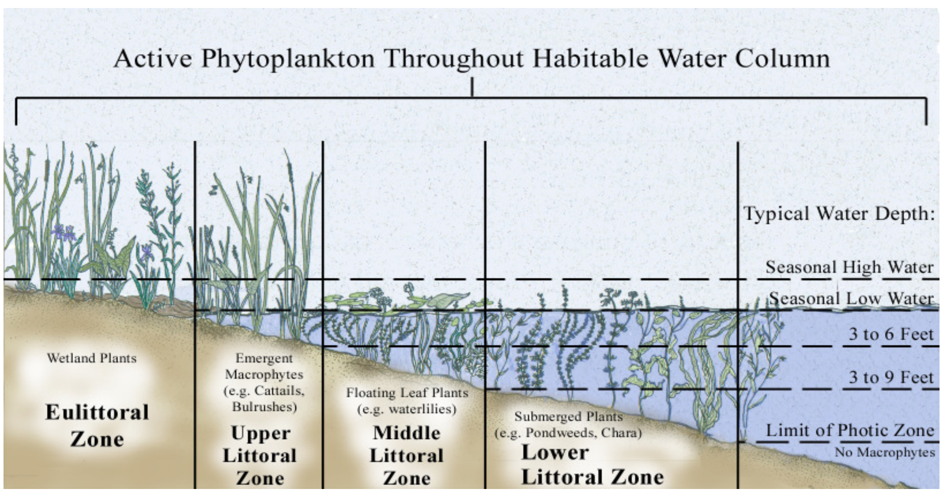
Eulittoral Zone: Includes the area between the highest and lowest seasonal water levels, and often contains many wetland plants.

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).

5.1.2 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).

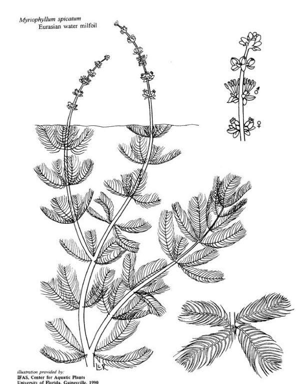
If aquatic macrophyte abundance is reduced, then water clarity may suffer. Water clarity reductions can further reduce the vigor of macrophytes by restricting light penetration. Studies have shown that if 30 percent or less of a lake areas occupied by aquatic plants is controlled, water clarity will 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.

5.1.3 Aquatic Invasive Plant Species

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, 2006). 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 and Oneida Counties.

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, 2006).

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, 2006).

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, 2006).

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, 2006).

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, 2006).

5.1.4 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 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 Flea (*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.

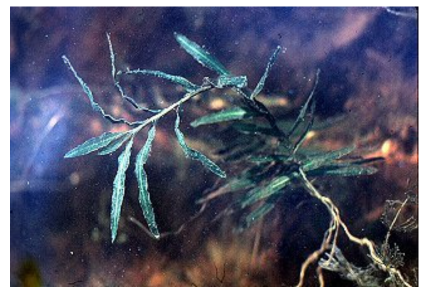
5.2 Aquatic Plant Survey

The survey included sampling at 607 intercept points. Many of the pre-determined points were not sampled because they were actually located on land or beyond the maximum depth of aquatic plant growth. The aquatic macrophyte community of the Lake included 42 floating leaved, emergent, and submerged aquatic vascular plant species and 3 algal genera during 2006. Table 1 lists the taxa identified during the August 2006 aquatic plant survey. Figures 5a through Figure 5f illustrate the locations of each species identified.

Vegetation was identified to a maximum depth of 19.5 feet (photic zone). Aquatic vegetation was detected at 89 percent (%) of photic zone intercept points. A diverse plant community inhabited the Lake during 2006. During the August survey, the Simpson Diversity Index value of the community was 0.88. With the taxonomic richness at 45 species, including algal genera, there was an averages of 2.34 species identified at points that were within the photic zone. There was an average of 2.64 species present at points with vegetation present. Table 2 summarizes these overall aquatic plant community statistics.

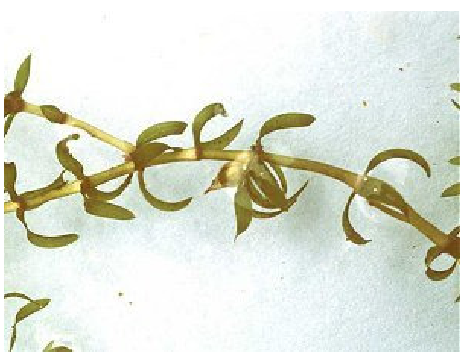
The most abundant aquatic plant identified during the July survey was Robbins pondweed, also known as Fern pondweed (*Potamogeton robinnsii*). It exhibited a 49% frequency of occurrence (percent of photic zone intercept points at which the taxa was detected). It was present at 56% of the sites with vegetation, and had a 21% relative frequency of occurrence. Table 3 includes the abundance statistics for each species.

Potamogeton robbinsii (Fern Pondweed) 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).



Fern Pondweed
Source: UW Herbarium Website

Elodea (*Elodea canadensis*) was the second most abundant vascular plant species occurring at 46% of the photic zone. It was present at 52% of the sites with vegetation and had a 20% relative frequency of occurrence. Table 3 includes the abundance statistics for each species.



Elodea
Source: UW Herbarium Website

Elodea canadensis (Elodea or common waterweed) is an abundant submergent 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.

Eurasian watermilfoil [EWM] (*Myriophyllum spicatum*) was the third most common plant found on Big Sand Lake, found at 25% of the photic zone points and at 29% of vegetated sampling sites. Table 3 includes the abundance statistics for each species.

EWM
Source: UW Herbarium Website

Myriophyllum spicatum (Eurasian watermilfoil or EWM) is a submersed aquatic plant native to Europe, Asia and northern Africa. This AIS was introduced to the United States by early European settlers. Eurasian watermilfoil can reproduce by seeds, but its main form of reproduction is vegetatively by fragmentation, allowing it to disperse over long distances. Because of its incredible ability to regenerate, EWM can successfully out-compete most native aquatic plants, especially in disturbed lake ecosystems. The fragments may be transported by boats and trailers to other lakes.

5.2.1 Free-Floating Plants

The following 2 free-floating aquatic plant species were identified during the 2006 aquatic plant survey.

- *Lemna minor* (Small Duckweed)
- *Spirodela polyrhiza* (Large duckweed)

Table 1 lists the species identified. Appendix B includes descriptions of the floating-leaf plants identified.

5.2.2 Floating-Leaf Plants

The following 3 floating-leaf aquatic plant species were identified during the 2006 aquatic plant survey.

- *Brasenia schreberi* (Watershield)
- *Nuphar variegata* (Spatterdock)
- *Nymphaea odorata* (White water lily)

Table 1 lists the species identified. Appendix B includes descriptions of the floating-leaf plants identified.

5.2.3 Submergent Plants

The following 32 submergent aquatic plant species were identified during the 2006 aquatic plant survey.

- *Ceratophyllum demersum* (Coontail)
- *Chara* (Chara/Muskgrass) [algal]
- *Elatine minima* (Waterwort)
- *Elodea canadensis* (Elodea)
- *Elodea nuttallii* (Slender waterweed)
- *Heteranthera dubia* (Water stargrass)
- *Isoetes sp.* (Quillwort)
- *Lobelia dortmanna* (Water lobelia)
- *Megalodonta beckii* (Water marigold)
- *Myriophyllum sibiricum* (Northern watermilfoil)
- *Myriophyllum spicatum* (Eurasian watermilfoil)
- *Myriophyllum tenellum* (Dwarf watermilfoil)
- *Najas flexis* (Slender naid / Bushy pondweed)
- *Nitella sp.* (Nitella) [algal]
- *Potamogeton alpinus* (Alpine pondweed)
- *Potamogeton amplifolius* (Large-leaf pondweed)
- *Potamogeton crispus* (Curly-leaf pondweed)
- *Potamogeton foliosus* (Leafy pondweed)
- *Potamogeton gramineus* (Variable pondweed)
- *Potamogeton illinoensis* (Illinois pondweed)
- *Potamogeton praelongus* (White-stem pondweed)

- *Potamogeton pusillus* (Small pondweed)
- *Potamogeton richardsonii* (Clasping-leaf pondweed)
- *Potamogeton robinnsii* (Robbins or Fern pondweed)
- *Potamogeton strictifolius* (Stiff pondweed)
- *Potamogeton zosteriformis* (Flat-stem pondweed)
- *Ranunculus aquatilis* (Stiff water crowfoot)
- *Stuckenia pectinata* (Sago pondweed)
- *Utricularia intermedia* (Flat-leaf bladderwort)
- *Utricularia vulgari* (Common bladderwort)
- *Valisneria americana* (Wild celery)
- Filamentous algae [algal]

Table 1 lists the species identified. Appendix B includes brief descriptions of the submergent plants identified.

5.2.4 Emergent Plants

The following 7 emergent aquatic plant species were identified during the 2006 aquatic plant survey.

- *Eleocharis acicularis* (Needle spikerush)
- *Eleocharis palustris* (Creeping spikerush)
- *Juncus paleocarpus f. submersus* (Brown-fruited Rush)
- *Sagittaria sp. (Arrowhead)*
- *Schoenoplectus actus* (Hardstem bulrush)
- *Schoenoplectus tabernaemontani* (Softstem bulrush)
- *Sparganium angustifolium.* (Narrowleaved bur-reed)

Table 1 lists the species identified. Appendix B includes brief descriptions of the emergent plants identified.

5.3 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 2006 aquatic plant survey data was 42.0. This FQI value is much higher than Wisconsin's median of 22.2 and suggests that Big Sand Lake exhibits very good water quality when using aquatic plants as an indicator of water quality. Table 4 summarizes the FQI for Big Sand Lake.

5.4 Shoreline Characterization

Most of the lake's shoreline is forested and includes platted lots which are developed into residential properties. Some wetland areas along the south and west shores of the lake are undeveloped.

5.5 Public Questionnaire

Sixty questionnaires were completed for Big Sand Lake. Eighty-five percent of respondents were shoreline landowners. Respondents ranked fishing, swimming, and pontoon boating as the most enjoyable activities on Big Sand Lake. Eighty-nine percent of the surveyed people rated their experiences on Big Sand Lake as enjoyable or very enjoyable. Seventy percent of the respondents listed AIS as their primary lake concern, followed by excessive aquatic plant growth (39 %) and AIS (21 %) as second concerns.

Thirty percent of the people polled reported that aquatic plant growth always negatively affected their use of the lake, twenty-seven percent reported most of the time, and thirty-four percent stated aquatic plant negatively affecting use sometimes. Eighty-one percent of the lake users believed that aquatic plant management is needed on Big Sand Lake. Sixty-nine percent responded that they supported aquatic herbicide use for AIS management. Most respondents would be willing to pay for some aquatic plant management but fifty-seven listed state grant assistance as the top choice from a list of funding options. Appendix C includes additional information gathered from the public questionnaire.

6.0 CONCLUSIONS AND MANAGEMENT ALTERNATIVES

6.1 Conclusions

Big Sand Lake is an 1,418 acre drainage lake. The lake has an 11,810 acre watershed which is primarily forested. The shoreline was mostly developed with homes and includes some scattered undeveloped areas**.** The historical water quality information suggests that the lake is an oligotrophic to mesotrophic lake. According to WDNR records, EWM was confirmed in Big Sand Lake in 1990.

Information gathered from the public questionnaire indicated most enjoyed using the lake for fishing, swimming, and boating. Most people have experienced problems with aquatic plant growth affecting their recreation and believe that AIS is a concern that justifies active management.

During the August 2006 aquatic plant survey, 45 aquatic plant species were found (including algal genera). The most abundant aquatic plants identified during the August survey were Robbins pondweed (*Potamogeton robinsii*) and Elodea (*Elodea canadensis*), which were found at 49% and 46% of the photic zone, respectively. Eurasian watermilfoil [EWM] (*Myriophyllum spicatum*) was the third most abundant plant, found at 25% of the photic zone. EWM was estimated to be present at 257 acres during August 2006 (Figure 6). The FQI for Big Sand Lake (42.0) is significantly higher than the state average and indicates excellent water quality when using aquatic plants as an indicator of lake health.

The overall aquatic plant management objective is to reduce the acreage and frequency of occurrence of EWM on Big Sand Lake and to restore the native plant community. Management efforts such focus on the EWM reduction and allow the natural restoration of the native aquatic plant community as the EWM is minimized. An achievable and quantitative goal for EWM reduction is to minimize the total acreage within 5 years by 80 percent. Wisconsin Administrative Code NR 107.04(3) defines a large-scale treatment as anything over ten acres or more than 10% of the water body that is less than ten feet deep. This overall goal correlates to a reduction of EWM acres by 80 percent over the next five years. An 80 percent reduction of EWM in Big Sand Lake correlates to annual reduction of 41 acres per year with a remaining population of 52 acres of EWM in 2012. EWM was found at 149 sample sites out of the 607 vegetated sites, a frequency of occurrence within vegetated areas of 28.54 percent. With a decline of EWM of 80 percent over five years the frequency of occurrence within vegetated areas will decline 4.5 percent each year. By 2012 EWM should have a frequency of occurrence within vegetated areas of 5.78 percent, down from 28.54 percent in 2006. The following table depicts this reduction by year, acreage and frequency of occurrence in vegetated areas. The table also assumes no major re-growth or expansion of EWM on a yearly basis. Highly used recreational areas and public boat launches or access points should be give priority when considered treatment locations due to a greater potential for EWM spread coming from these areas. The APM plan should be updated in 2011-2012 to evaluate the aquatic plant community and to assess the current management strategies.

Year	Acreage	Frequency of Occurrence within Vegetated Areas
2008	216	24.04
2009	175	19.54
2010	134	15.04
2011	93	10.54
2012	52	6.04

Information gathered from the public questionnaire indicated most enjoyed using the lake for fishing, swimming, and boating. Most people have experienced problems with aquatic plant growth affecting their recreation and believe that AIS is a concern that justifies active management.

The APM Plan involved evaluating physical, mechanical, biological, and chemical management alternatives and outlines specific management activities for the EWM and CLP on Big Sand Lake.

6.2 Management Alternatives for EWM

The discovery of EWM prompted APM efforts on Big Sand Lake. WDNR requires development of an APM Plan for certain large scale management activities and for AIS control grant cost sharing. A necessary component of an APM Plan is an evaluation of chemical, mechanical, biological, and physical aquatic plant control methods. While there may be additional AIS control measures used elsewhere (e.g. grass carp, or alternative herbicides), only those options approved for use in Wisconsin are discussed here. Appendix D includes a comprehensive description of available APM techniques, including descriptions about the technology, benefits, drawbacks, and estimated cost.

6.2.1 Manual Removal

Manual removal efforts include hand raking or hand pulling individual unwanted plants from the water. Specialized rakes are available for this purpose. All aquatic plant material must be removed from the water. Portions of roots may remain in the sediments, so removal may need to be repeated periodically. This technique is well suited for small areas in shallow water. Scuba divers can be contracted to remove unwanted vegetation in deeper areas. Benefits of manual removal include low cost compared to other control methods. The drawback of this alternative is that raking or pulling aquatic plants can be quite labor intensive. Hiring laborers to remove aquatic vegetation is an option, but also increases cost.

Manual removal of aquatic vegetation by individual landowners can be completed to a maximum width of 30 feet to provide pier, boatlift or swimming raft access (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. Removal of EWM only beyond the 30 foot recreation zone does not require a permit. 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 (NR 109). Appendix E includes a copy of NR 109.

This technique could be used on Big Sand Lake for nuisance vegetation along riparian landowners shorelines within a 30 foot recreation zone (i.e. containing swim raft, boatlift or pier). Only EWM can be removed beyond the 30 foot recreation zone manually without a NR 109 permit.

6.2.2 Mechanical Harvesting

Mechanical harvesting is the removal of aquatic plants from a lake using a harvester machine that cuts the plants and collects them on the harvester for transport to the shoreline for off-site disposal. Harvesters have a cutting head that can be raised or lowered to a desired depth up to 5 feet. Large scale harvesting operations may involve additional equipment including a transport barge and shore conveyor. Harvesting is often used for large areas with dense monotypic AIS plant growth that significantly impedes boating or recreation on the lake. Advantages of this technology include: immediate results; removal of plant material and nutrients; and the flexibility to move to problem areas and at multiple times of the year "as needed". Disadvantages of this method include the limited depth of operation in shallow areas; possible need to repeat harvest an area throughout the summer; high initial equipment costs; maintenance, labor, and insurance costs; disposal site requirements; and a need for trained staff. A WDNR permit is required by NR 109 for aquatic plant harvesting.

Mechanical harvesting on Big Sand Lake would not be advised. EWM occupies only approximately one quarter of the lake's photic zone. Harvesting is not selective and stressing native aquatic plants through harvesting could facilitate expansion of EWM. Most of the lake is too deep for aquatic plant growth, therefore "opening up" large recreation areas or boat navigation lanes is not needed.

6.2.3 Drawdown

Lowering the water level to expose near shore lake bed can be an effective management tool for EWM control, although results are variable. By lowering the lake level, the lake bed could be exposed and subject to freezing conditions. Benefits of a water level drawdown include the relative inexpense of the proposed action. Drawdowns have the capability to significantly impact populations of aquatic plants and are sometimes used during lake wide restoration efforts, inlcuding multiple year or periodic drawdowns to simulate drought and promote emergent plant growth. Disadvantages include adverse affects on other aquatic plants, the controversy associated with shoreline landowners, and temporary destruction of habitat for invertebrates and herptiles. The drawdown may be largely successful if there is a cold winter with relatively little snow cover. Conversely, mild winters and increased snow limit their effectiveness.

The Wisconsin Valley Improvement Company operates a dam at the Long Lake outlet. This dam has a water level control structure, which could presumably lower the water level of Long Lake and Big Sand Lake (maximum level of drawdown capability is unknown). This physical alternative has many variables and careful consideration should be given throughout planning a water level drawdown. Cordination with Long Lake would be necessary for Big Sand Lake to undertake any type of drawdown project since Long Lake also would be impacted.

Drawdown is not recommended as a management alternative at the current time. Drawdown may be considered in the future as a possible alternative if the current recommendations of hand pulling and herbicide treatments are determined to not be successful

6.2.4 Native Vegetation

Native plants are an important natural biological AIS control measure. A healthy native plant population can inhibit or slow an invasion of EWM by competing for space and nutrients, although in some lakes, even healthy native plant populations may eventually become infested with EWM. Damaging or stressing native plant communities may increase the potential for an AIS infestation. Any management of a low to mid level infestation should consider the benefits of native vegetation as an EWM deterrent, and plan for their protection.

The high FQI value (42.0) and species richness (45) indicate that native plant communities on Big Sand Lake are healthy. These native plant communities could be slowing the spread of EWM in some areas.

6.2.5 Milfoil Weevils

The use of aquatic weevils (*Euhrychiopsis lecontei*) is a biological control option that has shown effective EWM control in some Wisconsin lakes. The aquatic weevil is native to Wisconsin and normally is present in healthy stands of northern watermilfoil. The weevils however, prefer to feed on EWM plants. The weevil burrows into the plant's stem, destroying plant tissue. Increasing a natural population of weevils can be a costly endeavor but EWM reductions can be observed if the weevil population is maintained. This management alternative is best suited for lakes with limited shoreline development because the insects need to over-winter on a shoreline with vegetation and adequate leaf litter.

A weevil study on Big Sand Lake was completed in the summers of 1996 and 1997. The study focused on, 1) determining milfoil weevil distribution across lakes, 2) assessing limnological characteristics associated with their abundance, and 3) evaluating milfoil weevil augmentation as a practical management tool for controlling EWM. The study showed that no whole-lake characteristics and only some milfoil bed characteristics such as the percentage of natural shoreline, the depth and distance of the EWM bed from shore, the number of apical tips and the percentage of broken apical tips per stem of EWM, were significantly correlated with milfoil weevil abundance.

Big Sand Lake demonstrated a mean abundance of 0.3 $\pm$0.15 milfoil weevils per apical stem on the June 25, 1996 survey. Ten percent of the collected specimens were adults, 40% were larvae, 17.5% were pupae and 32.5% were eggs. Observed weevil abundance among treated plots pre-augmentation was 1.2 weevils per stem in summer 1996. The treated plot was augmented with 4 milfoil weevils per stem. In summer 1997 0.85 weevils per stem were observed post-augmentation. EWM biomass saw a 49% reduction and a 39% decrease in EWM stem density.

This study suggests that augmenting milfoil weevil populations to 4 weevils per stem of EWM may cause a decline in the EWM in the immediate area of stocking, but how far these effects extend in the immediate area of stocking, how far these effects extend beyond the augmentation plots is unknown. If successful, it would be critical to determine the number of weevils necessary for EWM control within a specific size of macrophyte bed so that the lake resource managers and property owners can effectively implement this method or use it in conjunction with other control methods the study concluded.

Supplemental stocking of weevils is not recommended at this time due to the high cost and variable factors necessary for EWM control. Shoreline property owners have the potential to assist in weevil reproduction by maintaining undeveloped shoreline.

6.2.6 Selective Aquatic Herbicides

Chemical herbicides or pesticides designed for aquatic use can be used to eliminate or significantly reduce the abundance of unwanted aquatic plant species. The United States Environmental Protection Agency (EPA) researches aquatic pesticides and determines what product can be registered for aquatic use. Aquatic pesticides that are registered for use in Wisconsin requires a strict registration process and most demonstrate that they are safe for the environment and do not pose a risk to human health when used according to label requirements. Numerous aquatic herbicides are registered for aquatic use and are designed to target specific plant types. Herbicides can be grouped into two general categories, contact and systemic. A contact herbicide will kill any part of the plant it contacts. Plant tissue not exposed to the chemical may survive. A systemic herbicide is one that is taken up within the plant tissue, translocated throughout the plant, and destroys the entire plant. Herbicides are also categorized as broad based, ones that can kill many different plant species, and selective, ones that can kill a targeted plant species if applied correctly. The WDNR requires a permit (Chapter NR 107. Wis. Adm. Code) for aquatic herbicide applications in public waters. Appendix E includes a copy of NR 107. The product must be approved for aquatic use in Wisconsin and the applicator must be certified with the Wisconsin Department of Agriculture, Trade, and Consumer Protection (WDATCP) and licensed by WDNR. Advantages of herbicides include better control in confined areas (e.g. around docks) than harvesters can achieve. Disadvantages include negative public perception of chemicals, 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.

A few herbicides have demonstrated EWM control (USACoE website, 2007). The most successful, WDNR-approved herbicide is one containing 2,4, D (*2,4-dichlorophenoxyacetic acid*). 2,4-D is a systemic herbicide that simulates a plant growth hormone and interferes with division of the plant cells, resulting in plant death. 2,4-D is relatively selective for EWM control when applied at a suitable application rate. Trade names of 2,4-D products include Navigate®, Aqua Kleen®, and Weeder 64®. Selective control can be enhanced by applying the product when EWM is actively growing, but native plant growth is minimal. There is a 24 hour swimming and water use restriction following the application in some areas. Also, water from a treatment area should not be used to irrigate ornamental plants until the herbicide concentration is less than 100 parts per billion (ppb) [0.1 parts per million (ppm)]. An industry guidance for this limitation is a 14 day watering use restriction.
Also, water treated areas should not be used for potable water sources until the herbicide concentration is less then 70 ppb (0.07 ppm).

7.0 RECOMMENDED ACTION PLAN

To accomplish the APM Plan goals, the Big Sand Lake Property Owners Association has developed an action plan. This plan selects appropriate aquatic plant management techniques for EWM growth on Big Sand Lake based on the evaluations completed in Section 6.2. The specific implementation of the management recommendations, including monitoring, responsibilities, and funding are discussed in the following sections. The APM Plan also addresses protection of native aquatic plants, education and prevention efforts.

This APM Plan should be updated periodically to reflect current aquatic plant problems, and the most recent acceptable APM methods. Information is available from the WDNR website: http://dnr.wi.gov/org/water/fhp/lakes/aquaplan.htm or from Northern Environmental upon request.

7.1 Manual EWM Removal

Individual property owners can manually remove nuisance aquatic plants in the lake offshore from their property. Manual removal can be completed to a maximum 30 foot width (measured along the shoreline) to provide pier, swim raft, or boat hoist access (recreation zone). A permit is not required for hand pulling or raking aquatic plants within the 30 foot recreation zone. Manual removal beyond the 30 foot zone is only allowed for EWM. Individuals removing EWM must remove all of the plant material and fragments from the water. Removal of any native vegetation beyond 30 feet would require a permit under NR 109, Wis. Adm. Code. Native plant removal is not recommended because it could actually facilitate the spread of EWM.

Landowners removing plants manually should learn to identify EWM and other look-alike native species. If an individual has questions about a particular aquatic plant or what level of manual removal is allowed , they should talk to a Lake Association representative. Appendix F includes additional resources for plant identification.

7.2 Selective EWM Herbicide Treatment

Nuisance EWM beds present beyond the 30 foot manual removal zone or too dense for effective hand removal efforts should be treated with an aquatic herbicide containing 2,4-D that is registered with the State of Wisconsin for use on public waters. 2,4-D products have demonstrated selective control of EWM if applied correctly. At this time, application rates should not exceed 150 pounds per surface acre. All treatments will need to be completed in accordance with a permit issued under NR 107, Wis. Adm. Code. No nuisance levels of native plants should be treated on a large scale. A commercial aquatic pesticide applicator, certified with the Wisconsin Department of Agriculture and Consumer Protection (DATCP) and licensed by the WDNR should be hired to treat nuisance EWM beds as local funding allows. The applicator shall specify in the NR 107 permit application the chemical application size, rate, and location of proposed treatment areas. A list of licensed applicators may be available from DATCP or on the "Lake List" located at UW Extension Lakes Program website at http://www.uwsp.edu/cnr/uwexlakes/lakelist/ where people can search for companies offering select APM services by company name or area of expertise.

Eradication of EWM is not feasible on Big Sand Lake. Aggressive management may prevent the spread of EWM and get the infestation "under control", where subsequent year's treatments could be reduced in size. Figure 6 illustrates the August 2006 aquatic plant distribution. Note that this EWM distribution map was created from aquatic plant survey data collected during August 2006. This effort involved sampling points on a 80 meter grid. This sampling resolution is designed to characterize the entire aquatic plant community on a particular lake, and can be formally repeated in the future. The intent of this survey is not to map the full distribution of one particular species. Many areas of the lake between sample points may contain EWM. Reported EWM bed locations should be noted on a base map such as Figure 6 and recorded with a GPS if possible, preferably one with sub-meter accuracy. Reported EWM beds can then be verified by a WDNR or a hired professional if necessary prior to applying for permits or funding.

The above mentioned verification of EWM beds should preferably occur in late summer or early fall, when EWM would be at its maximum growth. A permit application process should begin in the fall prior to the year of the proposed treatment. This mapping effort will be used to determine potential treatment acreages. Next , priority treatment areas should be selected from these areas. For example, high use areas and boat landings may be a first priority. A permit application should be completed by December of each year to allow for full utilization of WDNR AIS grant funds. Application for WDNR AIS grants are due February 1st and August 1st of each year. WDNR personnel prefer to see a draft grant application at least one month prior to the application deadline. Since grant preference is given to local units of government, the Big Sand Lake Property Owners Association should work closely with the Town and the WDNR throughout the permitting process. A spring EWM Assessment or "Pre-Treatment survey" should be completed each year to modify the permit application prior to the actual EWM treatment. This pre-treatment survey allows the permit application to be modified to accurately reflect proposed treatment areas and current EWM locations/acreages. This modification request should be submitted in writing to WDNR along with a map of proposed treatment areas.

One major EWM treatment per season should be completed. This treatment should occur once water temperatures reach approximately 60°F. However, one potential follow up "spot treatment" may also be needed which will be determined by completing a post-treatment aquatic plant survey one month after the initial treatment. All NR 107 public notice and water use restriction posting requirements should be followed. A public notice must be filed in the Vilas County News Review, if the treatment is > 10 acres or the treatment area is >10 % of the lakes area that is 10 feet deep or less, and a public informational meeting held if requested. All property owners within or adjacent to treatment areas should be notified with a copy of the permit application and map indicating the proposed treatment areas. A yellow sign describing the treatment must be posted by the dock or shoreline of any properties being treated. Post-EWM treatment assessments should be completed annually to apply for subsequent permits and funds. Figure 6 will be updated annually.

7.2.1 Schedule of Events

The following table describes a schedule of required activities for the EWM treatment program on Big Sand Lake.

Activity	Frequency	Date
Mapping of EWM or post-treatment survey	Annually	No later than September 30th
Establish Priority Treatment Areas	Annually	October 30th
Prepare NR 107 Permit Application (*for grant purposes*)	Annually	December 1st
Prepare DRAFT WDNR AIS Control Grant Application	Annually	January 1st
Submit WNDR AIS Control Grant Application*	Annually	February 1st
Pre-treatment Survey	Annually	Approximately 2 weeks after ice-our of when EWM is about 6" tall
Submit *Amended* NR 107 Permit Application	Annually	Within 2 weeks of Pre-treatment survey completion
EWM treatment**	Annually	May 31st
Lake Association Budget Voting	Annually	??
Lake wide Aquatic Plant Survey	Every 5 years	July 30th 2011
Update APM Plan	Every 5 years	December 1, 2011

* = August 1st is a second AIS Control grant deadline.
** = Activity will not be completed until water temperature reaches approximately 60 degrees Fahrenheit.

7.2.2 Designation of Responsibility

The following table assigns responsibility for the EWM treatment program events listed above. When the Town or Association is identified as a responsible party, these entities should identify which individual, or committee should complete the specified activity.

Activity	Responsible Party
Mapping of EWM or post-treatment EWM survey	Trained Volunteer or Aquatic Plant Professional
Establish Priority Treatment Areas	Big Sand Lake Property Owners Association, WDNR, and Aquatic Plant Professional
Prepare NR 107 Permit Application (*for grant purposes*)	Licensed Applicator or Big Sand Lake Property Owners Association
Prepare DRAFT WDNR AIS Control Grant Application	Big Sand Lake Property Owners Association
Submit WDNR AIS Control Grant Application	Town of Phelps* (acts as grant sponsor)

Pre-treatment EWM Survey	Aquatic Plant Professional
Submit EWM pre-treatment survey results	Aquatic Plant Professional or Lake Association
EWM treatment	Licensed Applicator
Lake Association Budget Voting	Big Sand Lake Property Owners Association
Lake wide Aquatic Plant Survey	Aquatic Plant Professional hired by Big Sand Lake Property Owners Association or Town
Update APM Plan	Aquatic Plant Professional hired by Big Sand Lake Property Owners Association

* Local units of government receive preference in AIS Control grant projects and should act as project sponsor

7.3 Management of Curly-leaf Pondweed

Curly-leaf pondweed (CLP) was identified at three locations during the August 2006 aquatic plant survey (Figure 5b). The extent of CLP should be more fully characterized during the spring months since this plant usually dies back by mid-July. A CLP mapping effort should be undertaken to determine if CLP is at "pioneer" levels. An AIS pioneer level is defined as being present for less than 5 years and is less than 5 acres in size or less than 5% of the lake area whichever is greater. Pioneer level infestations qualify for a "rapid response" type of AIS grant. If the CLP mapping effort determines infestations levels are beyond the level in which manual removal is feasible, herbicide treatments with an endothall-based herbicide should be conducted. These treatments should occur in early spring prior to the development of turions.

7.4 Prevention Efforts

The following sections discuss recommended activities to prevent the spread of new AIS into Big Sand Lake. Prevention efforts can also prevent the spread of EWM and CLP from Big Sand Lake into other area lakes.

7.4.1 Watercraft Inspection

A watercraft inspection program should be developed for Big Sand Lake in accordance with the Clean Boat/ Clean Waters (CB/CW) Program developed by the University of Wisconsin Extension Lakes Program. CB/CW is a highly regarded volunteer watercraft inspection program developed by the WDNR and UWEX Lakes Program. The CB/CW efforts in Wisconsin involves providing information to lake users about what invasive species look like and what precautions they should take to avoid spreading them. It also involves visual inspection of boats to make sure they are "clean" and demonstration to the public of how to take the proper steps to clean their boats and trailers. Watercraft inspectors also install signs at boat landings informing boaters of infestation status, state law, and steps to prevent spreading AIS. The **Clean Boats Clean Waters** Program is sponsored by the DNR, UW Extension, and the Wisconsin Association of Lakes and offers training to volunteers on how to organize a watercraft inspection program. For more information see the following website:

http://www.uwsp.edu/cnr/uwexlakes/CBCW/default.asp

Training materials, a list of workshop dates, publications, supplies, and links to other important information are all provided on the CB/CW web page. Volunteers may also contact Erin Henegar, Volunteer Coordinator for the Invasive Species Program, UW Extension-Lakes Program at (715) 346-4978 for details. Please note if any of the above hyperlinks to web addresses become inactive, please contact the WDNR, UW Extension Lakes Program, or Northern Environmental for appropriate program and contact information. At a minimum, AIS and CB/CW signs at public boat launches should be maintained.

7.4.2 Aquatic Plant Protection and Shoreline Management

Protection of the native aquatic plant community is needed to slow the spread of EWM and CLP. 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 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. 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. The Vilas County Land and Water Conservation Department offers a cost-share program for county landowners to be to restore native vegetation to shoreland property. Landowners can be reimbursed up to 70% of the costs of restoration activities. Interested shoreline property owners can contact the Vilas County LWCD at (715) 479-3648 to request additional information.

The second easy nutrient prevention effort is the use of phosphorus free fertilizers. 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.

Nutrients from old or failing septic systems may also contribute nutrients to the lake. Septic systems should be inspected and maintained in accordance with the Vilas County Sanitary Ordinance #75.

Appendix F includes resources for further information about these AIS Prevention efforts.

7.5 Public Education and Involvement

Public involvement and education efforts include a presentation by Northern Environmental at a Lake Association meeting on July 21, 2007 to discuss the APM Plan project. This meeting was open to the public and questions were answered after the presentation.

The Long Lake District, Town of Phelps and the Big Sand Lake Property Owners Association should stay involved with the Vilas County AIS Planning Partnership to keep abreast of current AIS issues throughout the County. These organizations should collectively continue to educate lake users about the importance of aquatic plants to the lake ecosystem and EWM management efforts. Vilas County Lakes Association (VCLA), Vilas County AIS Planning Partnership, WDNR, UW Extension Lakes Program are superb sources of public education materials and programs. 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 Northern Environmental for appropriate program and contact information.

7.6 Monitoring

To evaluate the effectiveness of the APM Program, monitoring of multiple components should be completed. Some of these are discussed in the section(s) above related to a specific management activity, but are re-iterated here in the context of overall monitoring efforts.

7.6.1 Aquatic Plant Monitoring

In some lake systems, native aquatic plants "hold their own" and AIS never grow to nuisance levels, in others, however vigilant management is required. Areas that have not been treated or were treated in previous years should also be monitored to see if native plant communities have inhibited further spread of AIS. Additionally, the lake should be monitored for new or expanding AIS infestations. At a minimum the public boat launch area should be inspected at least once per year for new AIS infestations. Grants may be available to help fund hiring professionals to complete these monitoring efforts or local lake enthusiasts can become trained AIS monitors. The Wisconsin Citizen Monitoring Network offers training of volunteers for AIS monitoring and other citizen monitoring opportunities such as water quality monitoring. Additional information about this program can be obtained at

http://www.dnr.state.wi.us/org/water/fhp/lakes/selfhelp/shlmhowto.htm

If the above hyperlink to web address becomes inactive, please contact Northern Environmental for appropriate program and contact information. Appendix F includes resources for further information about volunteer monitoring opportunities.

Big Sand Lake should complete pre-treatment and post-treatment EWM monitoring to gauge the effectiveness of EWM treatments. See section 7.2 for monitoring dates and assignment of responsibility for EWM treatment monitoring.

Monitoring for the presence and expansion of known locations of CLP should be completed. CLP can exhibit aggressive growth habits, therefore CLP distribution and density may potentially increase on Big Sand Lake. Monitoring for CLP should occur in spring or early summer (before July).

Northern Environmental also recommends completing lakewide aquatic plant surveys every 5 to 10 years (essentially repeating the 2006 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.

7.6.2 APM Technologies

The APM technologies listed in Appendix D should be re-visited periodically to evaluate if new or improved alternatives are available. The professional environmental science community includes universities, state natural resource agencies (e.g. WDNR), and federal agencies (e.g. EPA, United States Army Corps of Engineers [USACE]) are excellent sources for information. Appendix F includes resources for further information about APM alternatives and current research. This activity should be completed in conjunction with an overall APM Plan update effort, which includes a lake wide aquatic plant survey.

7.6.3 Public

Periodically, the lake users should be polled to evaluate the public's perception of APM activities on the lake. A questionnaire similar to the one solicited during this project could be used. Other methods of soliciting public opinion include telephone interviews, face to face interviews, web-based online surveys, and focus groups.

7.6.4 Water Quality

The WDNR citizen monitoring website did not identify any current water quality data. Members of the lake should consider becoming an active Citizen Lake Monitor for water quality (secchi depth, total phosphorus and chlorophyll *a*). At a minimum, water clarity (secchi depth) monitoring is recommended. Secchi depth monitoring is an easy volunteer activity that yields useful information about lake health over the long term. For more information, please visit:

http://dnr.wi.gov/org/water/fhp/lakes/selfhelp/shlmhowto.htm

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

7.7 Funding

The Lake Association and Town should work together to fund the activities listed in this Recommended Action Plan. First, all available volunteer roles should be filled if possible. Then, cost estimates or professional bids should be solicited for the remaining activities (e.g. monitoring and EWM treatments) from professional firms. These cost estimates can be used to budget for needed activities.

Available funds can be used as local matching funds to apply for cost sharing assistance from the WDNR AIS Control grant program. Qualified lake associations and local governments are both eligible applicants, but funding preference goes to local units of government. Eligible projects include monitoring, permit fees, and EWM treatment. The application deadline is February 1st and August 1st annually. A proposed schedule and assignment of responsibility are provided in Section 7.2. For more detailed information about AIS Control grants, please visit:

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

A second source for EWM control projects is the WDNR Recreational Boating Facilities (RBF) grant program. Projects are presented to the Wisconsin Waterways Commission (WWC) which meets approximately 4 times per year to review project presentations. This program funds 50 % of eligible activities. For more detailed information about the RBF program, please visit:

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

If the above hyperlink to web address becomes inactive, please contact Northern Environmental for appropriate program and contact information. If the above funding combinations appear woefully inadequate to fund the management activities, then additional sources should be considered. Other funding alternatives may include:

- Additional State grant assistance
- Private (landowner) funding
- Countywide sales or room tax
- Resource user fee (e.g. AIS boat sticker)
- Property tax or special assessment
- Federal invasive species management partnerships

These sources would require government action at the State and/or County levels.

7.8 Closing

This APM Plan was prepared in cooperation with the PALP and the Big Sand Lake Property Owners Association. 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 roles and responsibilities for local governments and lake associations. The greater APM Plan document provides a central source of information for the lake's aquatic plant community information and the overall lake ecology. If there are any questions about how to use this APM Plan or its contents, Please contact Northern Environmental.

8.0 REFERENCES

While not all references are specifically cited, the following resources were used in preparation of this report.

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FIGURES

TABLES

APPENDIX A

POINT INTERCEPT SAMPLE COORDINATES

APPENDIX B

DESCRIPTONS OF AQUATIC PLANTS

APPENDIX C

PUBLIC SURVEY INFORMATION

APPENDIX D

SUMMARY OF AQUATIC PLANT MANAGEMENT ALTERNATIVES

APPENDIX E

NR 107 AND NR 109 WISCONSIN ADMINISTRATIVE CODE

APPENDIX F

RESOURCE FOR ADDITIONAL INFORMATION

AQUATIC PLANT MANAGEMENT PLAN

BIG SAND LAKE
VILAS COUNTY, WISCONSIN

DNR LAKE PLANNING
GRANT NO: AEPP–056-07

July 5, 2007