FOX LAKE LONG-RANGE (2007-2010/12) AQUATIC PLANT MANAGEMENT PLAN

PREPARED FOR:

THE FOX LAKE INLAND LAKE PROTECTION AND REHABILITATION DISTRICT AND THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES

NOVEMBER 8, 2006

Hey and Associates, Inc.
Water Resources, Wetlands and Ecology

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CHAPTER 1 – GOALS

INTRODUCTION

Fox Lake is a 2,625-acre lake located within the municipal boundaries of the Town of Fox Lake and City of Fox Lake. Fox Lake is a natural glacial drainage lake that was enlarged in 1845 by the construction of a dam on the lake outlet named Mill Creek. Fox Lake has a history of alternating between clear water and turbid water states. Currently, Fox Lake is in a clear water state and contains abundant macrophyte growth. Evidence also suggests the fishery is improving relative to recent years. Both the improved water clarity and condition of the fishery are attributed to the macrophyte growth; however, the abundant plant growth is also causing navigation problems in the lake.

Recent aquatic plant surveys have shown that the aquatic plant community in Fox Lake is expanding. The aquatic plant community is composed of both native and an exotic aquatic invasive species. Curly-leaf pondweed and Eurasian water-milfoil (EWM) are both present in the lake. A management strategy to limit EWM on a lake-wide basis is needed to prevent it from further expanding in Fox Lake.

A lake-wide comprehensive survey in 2006 revealed dense plant growth in shallow, protected areas with silty bottom sediment. Contrary to prior surveys, Coontail was the most abundant plant encountered in these areas. Management is required to maintain navigation in affected areas.

PURPOSE STATEMENT

The Fox Lake Long-Range (2007-2010/12) Aquatic Plant Management Plan is a long-term plan which will guide aquatic plant management activities. The purposes of plan are to promote a healthy and diverse aquatic plant community, facilitate recreational lake use, and educate local residents on the benefits of maintaining a healthy aquatic plant community. This includes the challenges of managing a shallow eutrophic lake and maintaining a clear water macrophyte dominated state (versus turbid algal dominated state), maintaining habitat areas for fish, wildlife, and zooplankton, and developing strategies to address the management of Coontail and EWM. Recreational use concerns must address an overabundance of plants in many shallow areas of the lake, algae blooms, and weeds being washed to shorelines that may require management to facilitate access for many lake residents.

GOAL STATEMENT

The purpose of the Fox Lake Long-Range (2007-2010/12) Aquatic Plant Management Plan focuses on balancing the ecological needs of the lake and the recreational uses of the district residents. This requires careful maintenance of existing aquatic plants and carefully planned selective aquatic plant management.

The goals of the interim aquatic plant management plan are:

- Maintain and promote the clear water state
- Protect and promote the existing native aquatic plant community, fish, and wildlife
- Educate district residents about the importance of aquatic plants
- Receive public input and opinions for acceptable plant management options
- Facilitate access to deep water areas and recreational uses.

CHAPTER 2 – BACKGROUND

MANAGEMENT HISTORY

Fox Lake has a long management history of fish stocking, rough fish removal, various in-lake and watershed surveys, water quality monitoring, aquatic plant management, dredging, and sediment sampling. Much of the history of the lake has been documented in local newspapers by comments made by local residents. Examples of the management history and lake conditions are documented below:

- Fish stocking 1949-2006 including bluegill, walleye, Northern pike, bass, and muskellunge
- Aquatic plants killed with copper sulfate in 150 foot wide band around lake in 1961
- Fisherman's Club requests survey of lake by State Conversation Department due to soil erosion, weed conditions, lake level, pollution, and game feeding
- Rainbow trout caught near Drew Creek inlet
- Fisherman's Club posts signs around lake to deter refuse dumping; water levels causing navigation problems; considering buying a weed cutter
- Bluegill fishkill in winter 1959; bullheads die in spring 1959
- Conservation Department encourage lake residents to shovel ice to prevent fishkill in winter 1962
- Abundant fish reported by Conservation Department in 1962
- Dredging considered by City of Fox Lake in 1962 on Cambra Creek
- In 1963 residents reported weed spraying ruined fishing
- In 1964 local paper reported the lake reeks of pollution smell and lake was a "haven" for algae
- Quarterly water quality monitoring by Wisconsin Department of Natural Resources (WDNR) Bureau of Research in 1970s.
- One-year water quality monitoring by Aqua-Tech in 1982-83.
- Fox Lake: Water Quality and Management Study, by the Water Resource Management Workshop, University of Wisconsin - Madison (1984).
- WDNR Long Term Trend Program monitoring from 1986 to the present.
- Aquatic Macrophyte Surveys by WDNR and others in 1954, 1986, 1994, 1998, 2004, 2005, and 2006.
- Various fishery surveys by WDNR most recently in 2003-2005, including a carp capture and recovery survey.
- Carp exclusion study in 1993 and 1994.
- A priority watershed inventory of barnyard runoff and upland, streambank and lake shoreline erosion sources as part of the Beaver Dam Lakes Priority Watershed Project.
- Water quality appraisal report for the priority watershed project.
- Bottom sediment core sampling by WDNR Bureau of Research.
- Expanded Self-Help Monitoring by the Fox Lake Protection and Rehabilitation District.
- Lake and watershed monitoring 2004-2006.
- WDNR Self-help volunteer monitoring 1990-2006.

LAKE MAP

Fox Lake is a 2,625-acre lake located within the municipal boundaries of the Town of Fox Lake and City of Fox Lake T13N, R13 S13-16, 21-23, 26, and 27 in Dodge County, WI. Table 2-1 summarizes the lake's physical characteristics. Appendix A contains a 1:24,000 USGS topographic map, aerial orthophotographs, a lake bathymetric map, a map of lake sediment characteristics, locations of historic aquatic plant survey transects, and the comprehensive survey site locations.

Table 2-1
Physical Characteristics of Fox Lake, Fox Lake, Wisconsin

Parameter	Size
Surface Area (open water)	2,525 acres
Surface Area (with fringe wetlands)	4,690 acres
Maximum Depth	19 feet
Mean Depth	5 feet
Volume	19,307 acre-feet
Shoreline Length	17.9 miles

Source: WDNR

AQUATIC PLANT COMMUNITY

Historically, the plant community on Fox Lake was surveyed using a transect-based technique. In 2006, a comprehensive point-intercept survey was conducted on the lake to provide a better overall picture of the aquatic plant community. Point-intercept surveys contain many more survey points than transect-based surveys. The historic transects were recreated from the 2006 data from sampling locations from the point-intercept survey that roughly correspond to historic sampling locations; however, methodological differences do exist between the survey types. As a result, comparisons between 2006 and prior years are likely not as precise as comparisons between years where the transect method was solely applied. In applicable cases, the 2006 data for the estimated historic transects and the comprehensive survey is included. The comprehensive data is labeled as "total" where it is included. Data presented without comparisons to prior years is for the 2006 comprehensive survey unless otherwise noted. Maps of the 2006 survey results are included in Appendix B. Appendix C contains the survey data sheets.

Aquatic plant data was available for Fox Lake from 1950 to the present. A brief explanation of each calculation follows:

1) Frequency of Occurrence: the number of sites a plant species was collected divided by the total number of sites. The abundance of plants is not taken into account with this calculation. Only the presence/absence is noted. This value is also used to calculate the total percentage of littoral zone supporting aquatic plant growth.

2) Maximum Rooting Depth: the deepest sampling point that contained rooted aquatic plants. This measure is an important estimate of water clarity. Aquatic plants usually grow at 2-3 times the Secchi depth.

3) Floristic Quality Index (FQI, Nichols 1999): a biological index value based on the presence/absence of species and the ability of plants to tolerate disturbed conditions.

FQI is calculated by multiplying the average C value for all native plant species by the square root of the number of native plant species collected. "C" is the coefficient of conservatism which is a value assigned to native aquatic plants estimating a plant's likelihood to occur in an undisturbed lake. The values range from 0-10, with 10 representing an undisturbed condition and 0 representing severely degraded conditions.

4) Simpson's Diversity Index (SDI, Simpson 1949): the index represents the probability that two individuals randomly selected from a sample will belong to different species. There are two components important to diversity – richness and evenness. Richness is the number of species per sample. Evenness is a measure of how species are distributed across samples. High evenness means that most species have a moderately high relative abundance while low evenness means that one or two species dominate and the rest are rare.

Fox Lake supports a plant community typical of a shallow lake in southern Wisconsin. This is evident by the frequency of occurrence of aquatic plants (Figure 2-1), the Floristic Quality Index scores, Simpson's Diversity Index Scores, and the presence of exotic invasive species (Tables 2-2 and 2-3). The recent trends indicate Fox Lake's aquatic plant community expanded in the littoral zone and maintained an adequate level of diversity. This is in contrast to initial reports in 1998 that the lake drawdown and Carp removal program was a failure in terms of restoring the aquatic plant community. Since 1998, the percentage of plant cover has more than doubled in the littoral zone and plants are growing at greater depths.

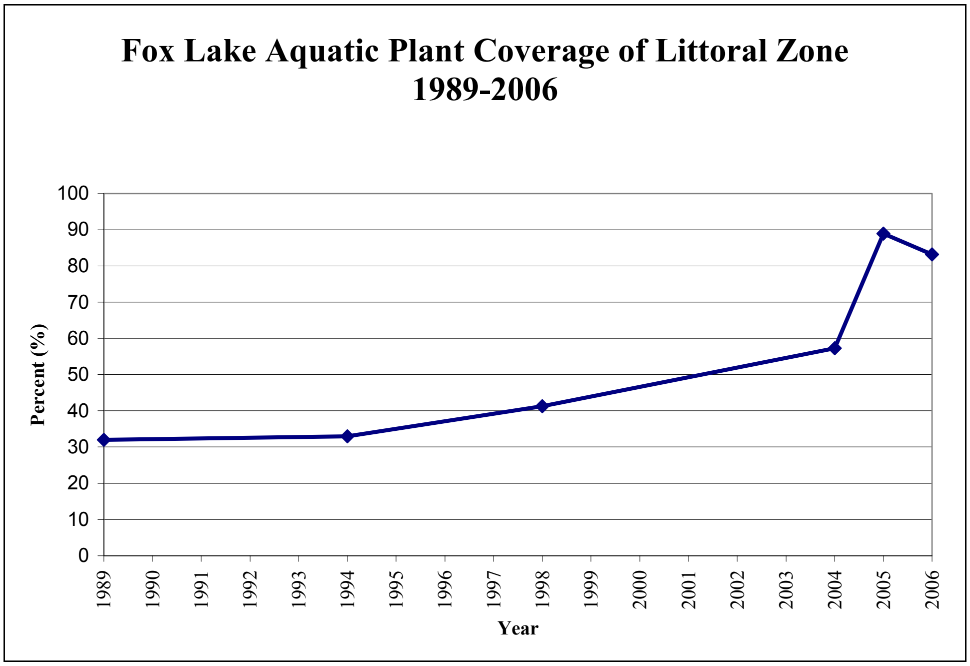

Figure 2-1
Percent Plant Cover in Littoral Zone
Source: WDNR and Hey and Associates, Inc.

The native plant community is competing well with the non-native invasive species present in the lake. Typically, exotic invasive species will occupy most, if not the entire, littoral zone and push out native aquatic plants. A monotypic or low diversity aquatic plant community is the result. The frequency of occurrence and relative frequency statistics indicate EWM may be starting to gain more dominance in the aquatic plant community relative to previous years (Figures 2-2 and 2-3). Other significant trends in the aquatic plant community are summarized in Figure 2-4.

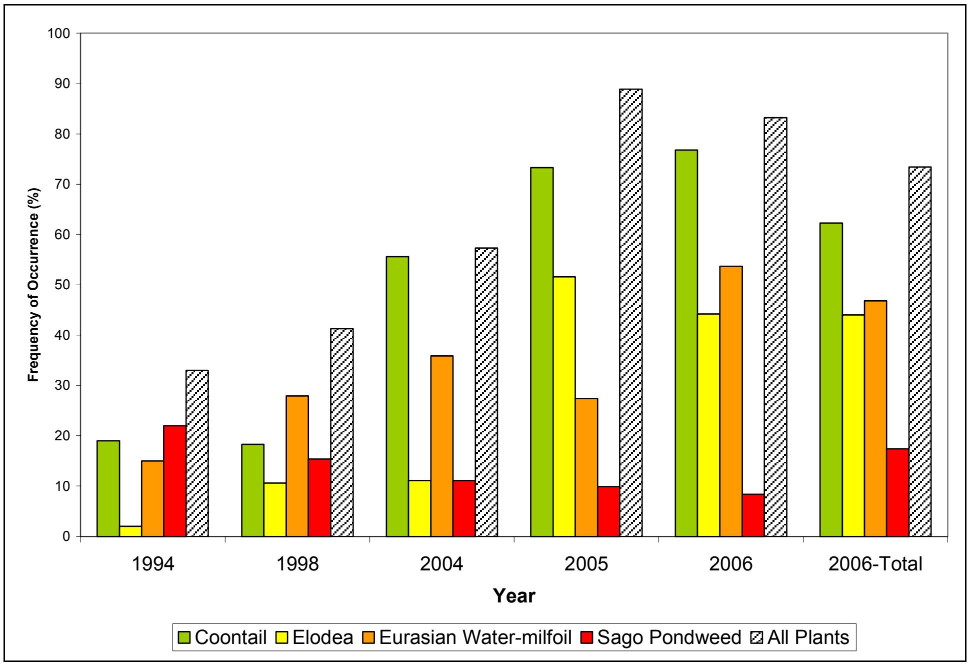

Figure 2-2
Frequency of Occurrence of Dominant Aquatic Plants
Source: WDNR and Hey and Associates, Inc

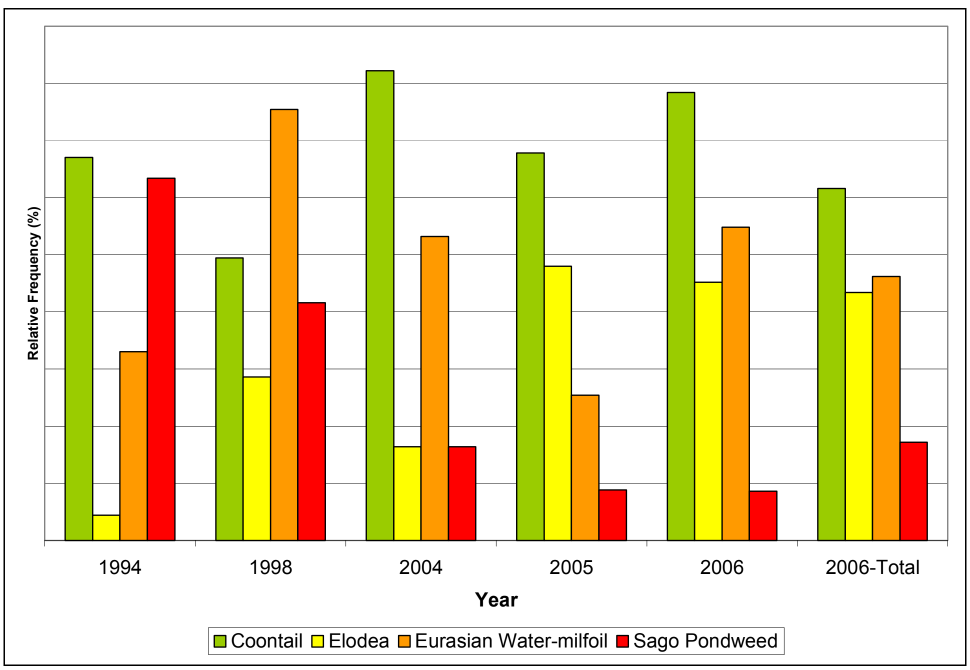

Figure 2-3
Relative Frequency of Dominant Aquatic Plants
Source: WDNR and Hey and Associates, Inc

Table 2-2

Aquatic Plant Community Summary Statistics

Source: WDNR and Hey and Associates, Inc

Scientific Name	Common Name	C	Frequency of Occurrence					
			1994	1998	2004	2005	2006	2006-Total
C. demersum	Coontail	3	19.0	18.3	55.6	73.3	76.8	62.3
Chara spp.	Muskgrass	7	-	-	5.1	8.9	11.6	9.4
E. canadensis	Elodea	3	2.0	10.6	11.1	51.6	44.2	44.0
H. dubia	Water Stargrass	6	3.0	-	4.3	10.4	-	-
L. minor	Small Duckweed	5	-	2.6	18.8	20.5	15.8	4.3
L. trisulca	Star Duckweed	6	-	-	1.0	2.6	1.1	0.3
M. spicatum	Eurasian Water-milfoil	NA	15.0	27.9	35.9	27.4	53.7	46.8
N. flexilis	Slender Naiad	6	1.0	-	-	-	-	*
N. lutea	American lotus	8	-	-	-	-	-	-
N. marina	Spiny Naiad	NA	-	-	1.0	-	-	-
Nuphar spp.	Yellow Water Lily	8	1.0	-	1.7	6.8	-	0.3
Nymphaea spp.	White Water Lily	6	5.0	5.1	5.1	4.3	1.1	1.2
P. crispus	Curly-leaf Pondweed	NA	5.0	1.9	8.5	18.5	-	1.0
P. sp. #1	Unknown Pondweed	6	1.0	-	1.7	-	1.1	0.5
P. zosteriformis	Flat-stem Pondweed	6	-	-	-	14.1	-	-
S. pectinatus	Sago Pondweed	3	22.0	15.4	11.1	9.9	8.4	17.4
S. polyriza	Large Duckweed	5	-	-	2.6	-	-	-
Sparganium (fluctuans)	Floating-leaf Bur-reed	10	-	-	-	1.5	-	-
V. americana	Water Celery	6	1.0	-	1.0	-	-	*
W. columbiana	Watermeal	5	-	-	-	4.3	-	-
Z. palustris	Horned Pondweed	7	1	-	-	1	-	-
-	**All Species**	=>	33.0	41.3	57.3	88.9	83.2	73.4
-	**Average C**	=>	5.4	4.0	5.6	5.8	5.0	5.5
-	**FQI**	=>	17.1	8.9	19.3	20.9	14.1	18.1
-	**Maximum Rooting Depth (ft)**	=>	5	6	6	8	8	14
-	**Total # Plant Species**	=>	12	7	15	15	9	14

* indicates the plant was identified visually but not collected in the survey

1994. Winkeman, J. Results of the 1994 Macrophyte in Fox Lake. WDNR Bureau of Research

1998 Values tabulated from data provided from P. Garrison WDNR Bureau of Research

2006-Total are results for comprehensive point-intercept survey

Table 2-3
Aquatic Plant Community Summary Statistics
Source: WDNR and Hey and Associates, Inc

Scientific Name	Common Name	Relative Frequency					
		1994	**1998**	**2004**	**2005**	**2006**	**2006-Total**
C. demersum	Coontail	33.5	24.7	41.1	33.9	39.2	30.8
Chara	Muskgrass	-	-	3.8	4.1	5.9	4.7
E. canadensis	Elodea	2.2	14.3	8.2	24.0	22.6	21.7
H. dubia	Water Stargrass	2.9	-	3.2	4.8	-	-
M. spicatum	Eurasian Water-milfoil	16.5	37.7	26.6	12.7	27.4	23.1
N. flexilis	Slender Naiad	1.4	-	-	-	-	-
N. lutea	American lotus	-	-	-	-	-	-
N. marina	Spiny Naiad	-	-	0.6	-	-	-
Nuphar spp.	Yellow Water Lily	-	-	-	-	-	-
Nymphaea spp.	White Water Lily	-	-	-	-	-	-
P. crispus	Curly-leaf Pondweed	6.5	2.6	6.3	8.6		0.5
P. foliosus	Leafy Pondweed	2.1	-	1.3	-	0.5	0.3
P. pectinatus	Sago Pondweed	31.7	20.8	8.2	4.4	4.3	8.6
P. zosteriformis	Flat-stem Pondweed	-	-	-	6.5	-	-
Sparganium (fluctuans)	Floating-leaf Bur-reed	-	-	-	0.7	-	-
V. americana	Water Celery	1.8	-	0.6	-	-	-
W. columbiana	Watermeal	-	-	-	-	-	-
Z. palustris	Horned Pondweed	1.4	-	-	0.3	-	-
-	**Total**	**100**	**100**	**100**	**100**	**100**	**90**
-	**Simpson's Diversity Index**	**0.75**	**0.75**	**0.74**	**0.79**	**0.71**	**0.84**

1994. Winkeman, J. Results of the 1994 Macrophyte in Fox Lake. WDNR Bureau of Research
1998 Values tabulated from data provided from P. Garrison WDNR Bureau of Research

The dominant aquatic plants in Fox Lake in 2006 were Common waterweed (*Elodea canadensis*), Coontail, EWM. Each of these species may cause navigation and recreational nuisances in high densities. Appendix D contains maps of significant natural resource areas and lake use areas.

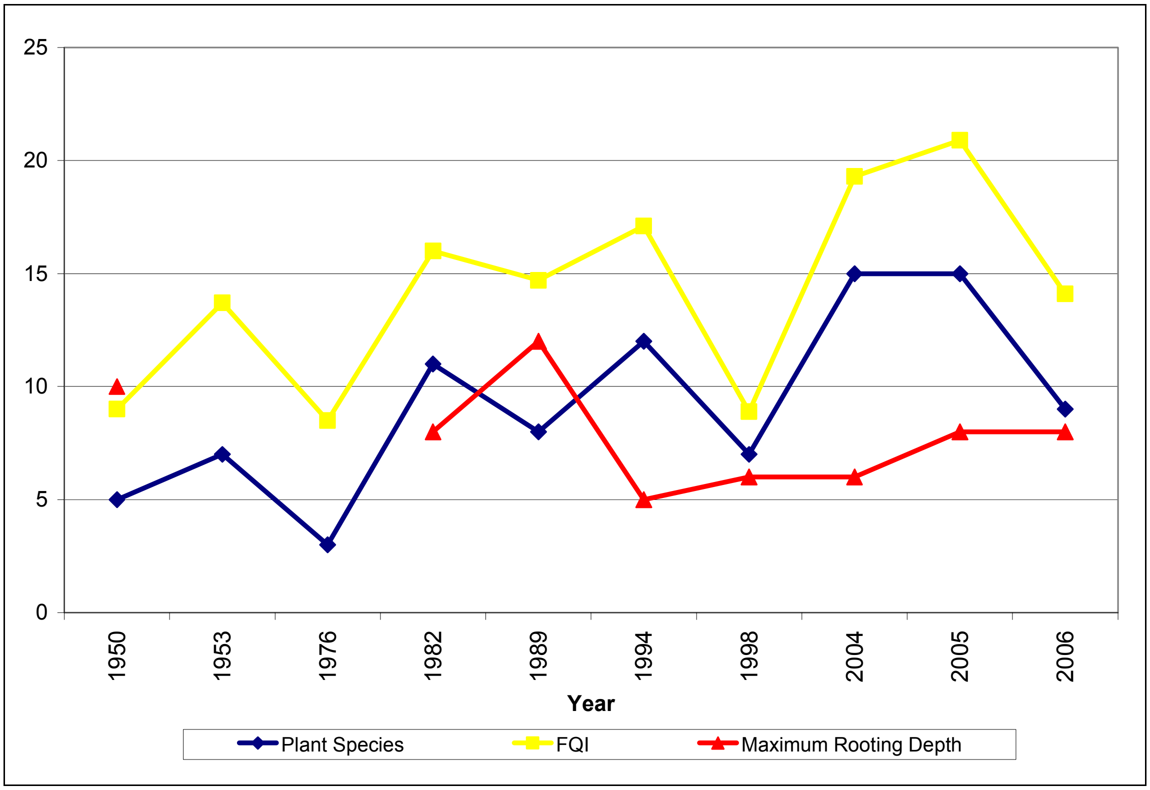

Figure 2-4
Plant Community Trends
Source: WDNR and Hey and Associates, Inc.

Non-Native and/or Invasive Species

There are a total of 4 invasive species in Fox Lake. They are Coontail, Elodea, Curly-leaf pondweed, and Eurasian water-milfoil. Filamentous algae were also found in Fox Lake, which can also pose a recreational nuisance.

1) Eurasian water-milfoil (*Myriophyllum spicatum*), a non-native invasive species. Eurasian water-milfoil forms dense mats at the water surface that shade out native plants, deposits large amounts of dead plant material as it dies back in the fall that may cause local shifts in water chemistry and dissolved oxygen, and supports fewer invertebrates than native plants (Cheruvelli et al. 2001). Eurasian water-milfoil was found at a relatively high number of sites in 2006 (~50%) relative to 2005 (27.4%) and 2004 (35.9%). Increased frequency of EWM is a negative trend especially if it is detected in future surveys.

2) Curly-leaf pondweed (*Potamogeton crispus*, CLP) is another non-native invasive species found in Fox Lake. Mid to late summer surveys are inconsistent at detecting the actual extent of CLP in lakes because their life cycle is atypical. CLP begins to grow in the fall, continues to grow throughout the winter, and dies off in late June or early July. As a result, surveys to detect CLP should occur in late May or early June to provide more accurate information. CLP does not appear to be a problem in Fox Lake during mid to late summer. Curly-leaf pondweed provides minimal value for fish and wildlife.

3) Coontail (*Ceratophyllum demersum*) is a native plant that may form dense beds and impede recreation. Coontail is the primary nuisance plant in Fox Lake and occupied 62.3% of the sampling sites lake-wide. The transect-based survey indicated the frequency was comparable to 2005 and generally higher than historic measurements.

4) Elodea (*Elodea canadensis*) was the third most dominant aquatic plant in 2005 and 2006 but appears to have decreased slightly in 2006. Elodea provides habitat for invertebrates that are a food source for fish and waterfowl and produces more oxygen than most aquatic plants. Elodea can grow abundantly in some lakes and cause recreational and navigational nuisances. It appears that Elodea is one plant in Fox Lake that is competing well with Eurasian water-milfoil.

5) Filamentous algae were found at 65.0% of sites in 2005 and 23.9% of sites in 2004. No data was available from previous surveys regarding its presence in Fox Lake. Excessive algae growth usually indicates excessive nutrients are present and causes recreational use and navigation problems. Filamentous algae were a problem in Fox Lake in 2005, but did not appear to be as severe a problem in 2006 at the time of the aquatic plant survey (13.2%).

WATER QUALITY

The steady decline of Fox Lake's water quality has been the focus of a number of studies. The studies indicate that Fox Lake is eutrophic to hyper-eutrophic and capable of a rapid transition from a clear water macrophyte dominated ecosystem into a turbid algal dominated system. Typical goals to manage a shallow eutrophic lake in the clear water state require total phosphorus <100ug/l (Scheffer et al. 1993 and Hosper and Meijer 1992). In-lake phosphorus concentrations range from 100 ug/l to greater than 200 ug/l during the summer months from 1990-2005 (Figure 2-3) were measured on Fox Lake. Mean chlorophyll-a concentrations increased almost tenfold since 1982 illustrating the general trend of increasing algal populations (Figure 2-4).

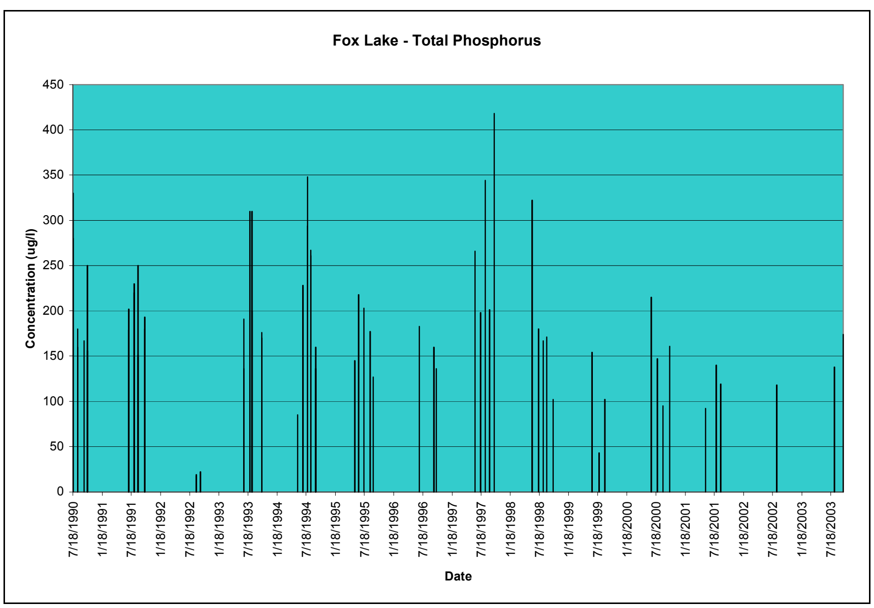

Figure 2-5
Fox Lake Total Phosphorus
Source: WDNR

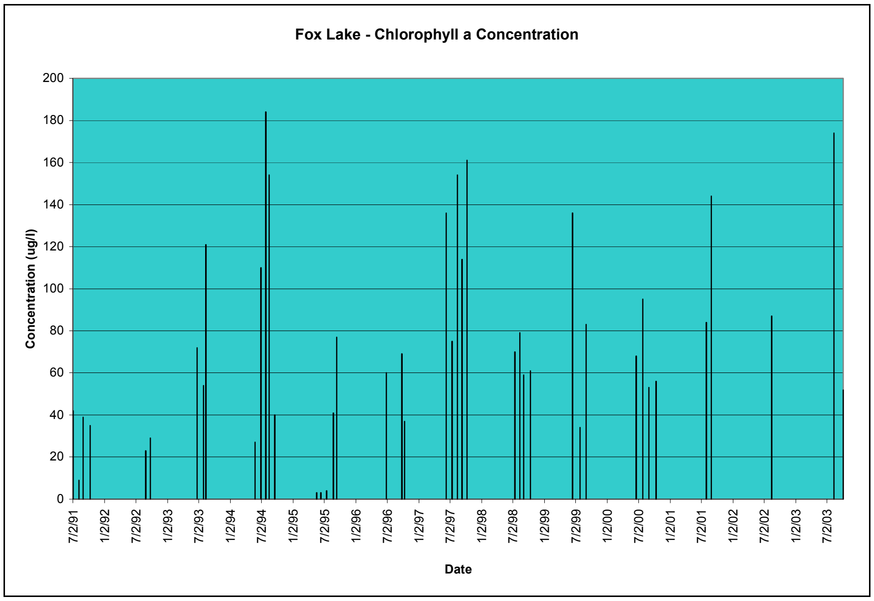

Figure 2-6
Fox Lake Chlorophyll-a
Source: WDNR

Secchi disk readings from 1991 - 2005 were generally poor, less than two feet, except in the two years (1995 and 2005) with abundant plant growth (Figure 2-5).

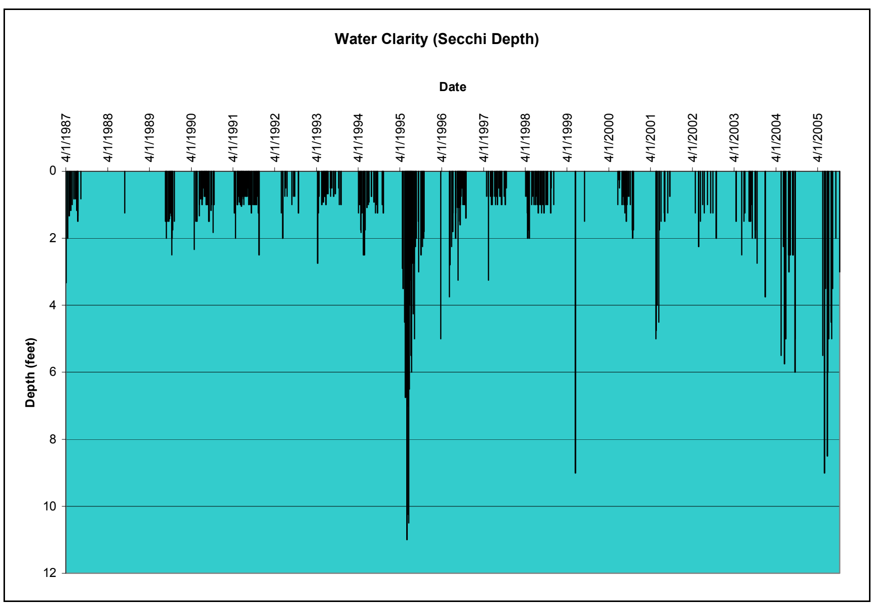

Figure 2-7
Fox Lake Secchi Depth
Source: WDNR

Analysis of Trophic State Index values for chlorophyll-a, Secchi disk, and total phosphorus indicate that Fox Lake is eutrophic and that lake turbidity may be due to more than just high algal populations, but may be augmented by suspended sediment from nonpoint source pollution and re-suspension of bottom sediment by wind and bottom feeding fish activity. Since these characteristics all act as forward switches, actions that reduce their effects should help maintain the clear water state in Fox Lake.

Water column profile monitoring in 2005 indicated that Fox Lake does not stratify (Figure 2-6). Dissolved oxygen remained above 5 mg/l even in the deep areas of the lake. Dissolved oxygen levels below 5 mg/l can be harmful to aquatic life. One drawback to a lack of stratification is that one potential refuge for pelagic grazing zooplankton is removed. Pelagic zooplankton seeks refuge in deep areas with low oxygen to avoid fish predation. This effect may be balanced by reducing internal nutrient loading that occurs as lakes stratify. No internal loading via sediment release was detected in 2005 (Table 2-3) probably due to the lake aeration.

Table 2-4
Fox Lake Phosphorus at Deep Hole 2005

Depth (ft)	Number of Samples	Dissolved Phosphorus (mg/l)	Total Phosphorus (mg/l)
3	10	0.0829	0.1566
15	11	0.0833	0.1529

Source: WDNR

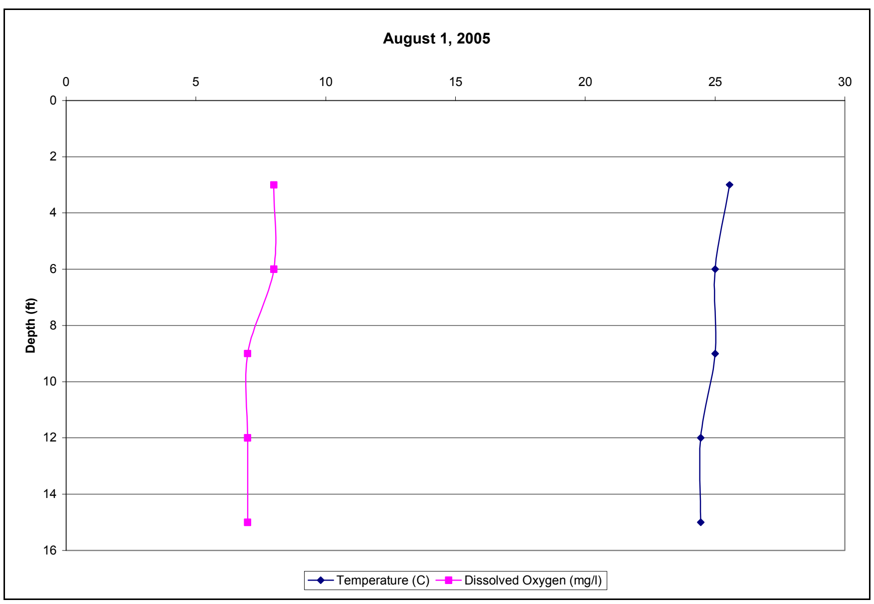

Figure 2-8
Fox Lake Depth Profile
Source: WDNR

WATERSHED DESCRIPTION

The Fox Lake watershed is approximately 35,600 acres in size, draining areas of Dodge, Fond du Lac, Green Lake and Columbia Counties. The Fox Lake watershed was recently studied in depth as part of *Beaver Dam River Priority Watershed Project* sponsored by the Wisconsin Department of Natural Resources Nonpoint Source Pollutant Abatement Program. The watershed project focuses on the control of upland pollutant sources of crop erosion, streambank and shoreline erosion, and barnyard waste runoff. The watershed is made up of four sub-watersheds outlined in Table 2-4.

Table 2-5
Fox Lake Sub-watersheds

Sub-watershed	Acres	Percent of Total
Alto Creek	13,693	38%
Cambra Creek	14,900	42%
Drew Creek	3,894	11%
Fox Lake Direct Drainage	3,087	9%
Total	**35,574**	**100%**

Source: A Nonpoint Source Control Plan for the Beaver Dam River Priority Watershed Project (WDNR, 1993).

The watershed is comprised of rolling hills and plains interspersed with wetlands. While the original vegetation consisted of prairie grasses, marshland, and shrubs, today greater than 70% of the watershed is in agricultural land use. The geology of the area consists of bedrock of sandstone and dolomite formations overlain by glacial deposits of clay, silt, sand, and gravel. The major soil types are silty loams on the uplands and muck soils adjacent to stream courses and along the marsh areas of Fox Lake.

Alto Creek is a polluted tributary to Fox Lake that passes through large tracts of wetlands which buffer the creek from direct surface runoff. Monitoring indicates this stream could support a coldwater fishery if polluted runoff were controlled. Problems in Alto Creek include sediment loading and possibly pesticides. Watershed based sediment controls are being used to improve conditions in the creek (Wisconsin Department of Natural Resources, 2002).

Cambra Creek is another tributary to Fox Lake. It is relatively clear due to extensive filtering and buffering by adjacent cattail-dominated wetlands. Extensive farming within the subwatershed is likely delivering nutrients and sediment to Fox Lake. Carp use the shallow and extensive fringe wetlands adjacent to the stream and lake.

Drew Creek is a small stream tributary to Fox Lake that appears to carry a significant sediment load after storm events (Wisconsin Department of Natural Resources, 1993). Livestock access, animal waste runoff and silage leachate are other concerns. Sediment at the stream's mouth is creating undesirable near-shore conditions by building up a small delta at the confluence with Fox Lake. Nutrient and sediment loadings from each subwatershed are summarized in Table 2-5. Sources of total phosphorus reported as annual loads within the watershed are located in Table 2-6.

Table 2-6
Fox Lake Sediment and Nutrient Loads by Subwatershed

Sub-watershed	Land Area (acres)	Sediment Load (tons/yr)	Phosphorus Load (lbs/yr)	% total Phosphorus Load	% of Total Load Due to Cropland
Alto Creek	13,693	6,477	23,859	45%	98
Cambra Creek	14,900	4,156	18,530	35%	96
Drew Creek	3,894	1,861	6,834	13%	96
Fox Lake	3,087	1,000	3,845	7%	97
Total	**35,573**	**13,494**	**53,068**	**100%**	

Source: WDNR

Table 2-7
Estimated Annual Total Phosphorus Load to Fox Lake

Phosphorus Source	Present Total phosphorus load [lbs/yr]	Priority Watershed Project goal of total phosphorus load [lbs/yr]
Upland sediment erosion	53,068	32,581
Barnyard runoff	2,433	657
Winter manure spreading	1,795	1,041
Shoreline sediment erosion	1,237	618
Groundwater	6,041	6,041
Precipitation	383	383
Wetland reduction	(13,290)	(9,200)
Total	**51,668**	**38,728**

Source: Hey and Associates, Inc.

A trophic model was developed for Fox Lake to determine the relationship between watershed loading and in-lake measurements of total phosphorus. The model is shown in Figure 2-7. The watershed loadings for total phosphorus should be below 30,000 pounds per year to maintain the clear water state (TP<0.1 mg/l).

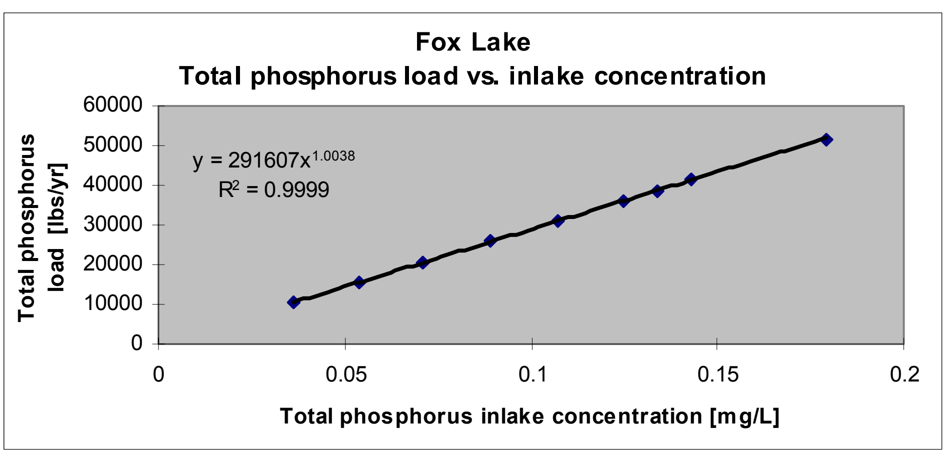

Figure 2-9
Trophic Model for Fox Lake

WATER USE

Fox Lake supports recreational uses typical of many lakes in Wisconsin including: fishing, swimming, pleasure boating, personal watercraft, waterfowl hunting, and water skiing. Currently there are approximately 1000 acres of Slow No Wake on Fox Lake. Appendix D contains maps of the public use areas on the lake, areas typically used for waterskiing, and current "Slow No Wake" zones defined by Town of Fox Lake ordinance.

FISHERIES AND WILDLIFE

Fox Lake supports diverse fish, wildlife, and waterfowl including state species of concern, state threatened species, and state endangered species. Their state and global element ranks are also included (Table 2-7). A Wisconsin endangered species designation means that its continued existence is in jeopardy based on scientific evidence. A Wisconsin threatened species appears likely--in the near future--to become endangered based on scientific evidence. According to State Statute 29.415 and NR27, it is illegal to take, transport, possess, or sell any threatened or endangered species without a permit. Special Concern species are suspected to have limited abundance or distribution, but no scientific proof has documented their status. State and Global Element Ranks portray the overall species' status at the statewide and global scales.

Other waterfowl and wildlife known to inhabit the area are: Bald Eagles, otter, Cormorants, many types of ducks, geese, Mute Swan, Loons. The fish community includes Walleye, Largemouth Bass, Northern Pike, and a few Muskie. The panfish community in Fox Lake is dominated by a large Black Crappie population, as well as smaller populations of White Crappie, Bluegill, and Yellow Perch. Other panfish species present in the lake include Pumpkinseed and Green Sunfish. Other species in Fox Lake include Golden Shiner, Common Carp, and Yellow and Black Bullhead. Detailed fall electro-fishing reports are contained in Appendix E.

Many of the species on Fox Lake depend on aquatic plants for their survival. Most waterfowl use aquatic plants as a food source. Many fish species use aquatic plants as habitat over some portion of their life history. Invertebrates eaten by small fish live on aquatic plants while the top predatory gamefish use aquatic plants to ambush their prey. Aquatic plants also provide spawning opportunities for many fish species. Figure 2-8 shows areas of the lake that are important fish nurseries and/or utilized by wildlife.

Table 2-8
Species or Natural Communities of Significance near Fox Lake

Species/Natural Community	WI Status	Special Concern Protection Status	State Element Rank	Global Element Rank	Date Identified
Wet-Mesic Prairie	NA	-	Imperiled	Imperiled	1985
Western Harvest Mouse	Special Concern	None	Imperiled	Secure	1966
Great Egret	Threatened	-	Critically Imperiled	Secure	1997
Black-Crowned Night Heron	Special Concern	Migratory Bird Act	Imperiled	Secure	1974
Southern Dry-Mesic Forest	NA	-	Rare or Uncommon	Apparently Secure	1977

Species/Natural Community	WI Status	Special Concern Protection Status	State Element Rank	Global Element Rank	Date Identified
Southern Mesic Forest	NA	-	Rare or Uncommon	Very Rare	1978
Emergent Marsh	NA	-	Secure	Apparently Secure	1979
Shrub-Carr	NA	-	Secure	Secure	1979
Banded Killifish	Special of Concern	None	Rare or Uncommon	Apparently Secure	1995
Blanchard's Cricket Frog	Endangered	-	Imperiled	Secure	1919
Red-Necked Grebe	Endangered	-	Critically Imperiled	Secure	-

Source: WDNR

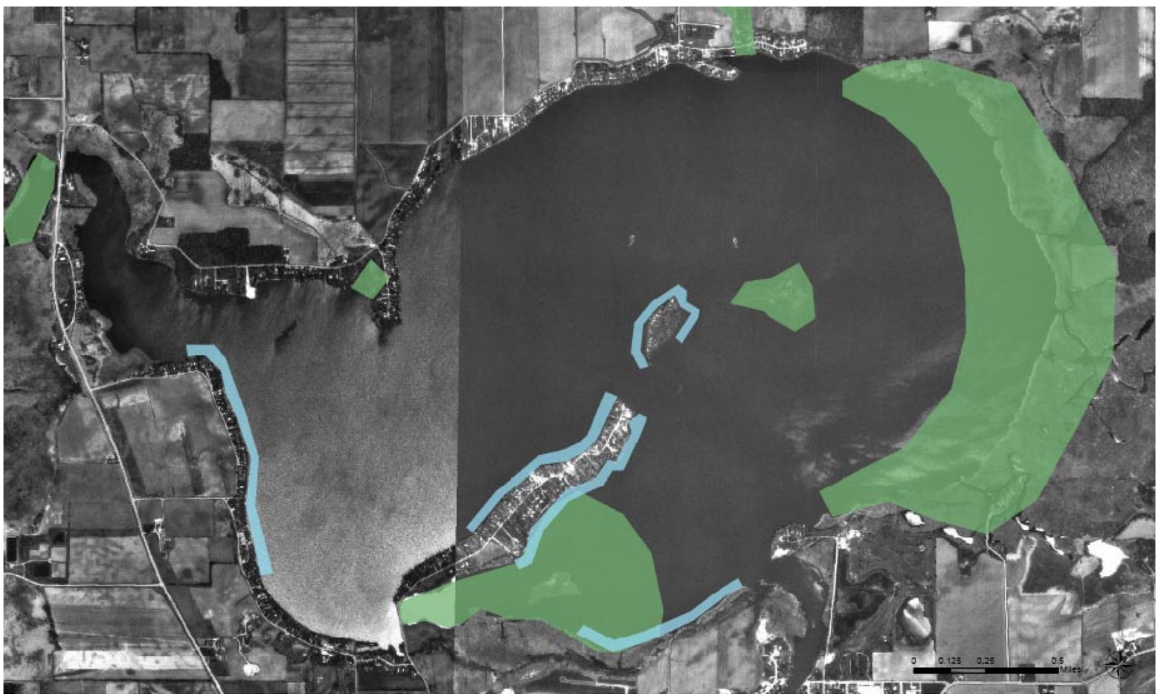

Figure 2-10
Wildlife Areas (green) and Fish Nurseries (blue)
Source: Hey and Associates, Inc. and WDNR

CHAPTER 3 – ANALYSIS AND ALTERNATIVES

INTRODUCTION

The purpose of this section is to analyze Fox Lake's plant community's ecological characteristics and provide alternatives for plant management activities for the next 3 to 5 years. The analysis will identify management objectives, review the current status of the aquatic plant community, provide background on alternate stable states and shallow lake ecology, and identify the potential impacts of different levels of management intensity. The three levels of plant management intensity are: maintenance, low manipulation, and high manipulation. A review of plant management alternatives, their feasibility for use on Fox Lake, and an estimate of cost, is also included.

Analysis

The management objectives are to provide lake access and nearshore recreational opportunities for lake residents while maintaining the beneficial ecological functions of the aquatic plant community. For Fox Lake, the primary beneficial ecological function of the plant community is to maintain the clear water state. Other secondary benefits provided by the aquatic plant community include enhanced fish and wildlife and shoreline protection.

Aquatic Plant Community

A thorough review of the status of the aquatic plant community was included in Chapter 2 of this report. A planning level summary of the aquatic plant community characteristics follows.

Currently Fox Lake is in a clear water macrophyte dominant state. Previous survey data suggests that as recently as 1998, Fox Lake was in a turbid water state. Since no data was available from 1998 to 2004, the shift to the clear water state was not entirely documented. Significant increases in the abundance and frequency of aquatic plants was documented from 2004 to 2005. Relatively high levels of aquatic plants were also found in 2006. The areas of the lake supporting dense plant growth are shallow littoral areas with a silty bottom. Since much of the littoral zone in Fox Lake is shallow (<6 feet deep) and silty, it should be expected that nuisance conditions will develop in those areas. Figure 3-1 shows the locations of nuisance plant areas in 2006. Nuisance conditions are defined as areas of the lake where recreational uses such as swimming, boating, and fishing are impeded.

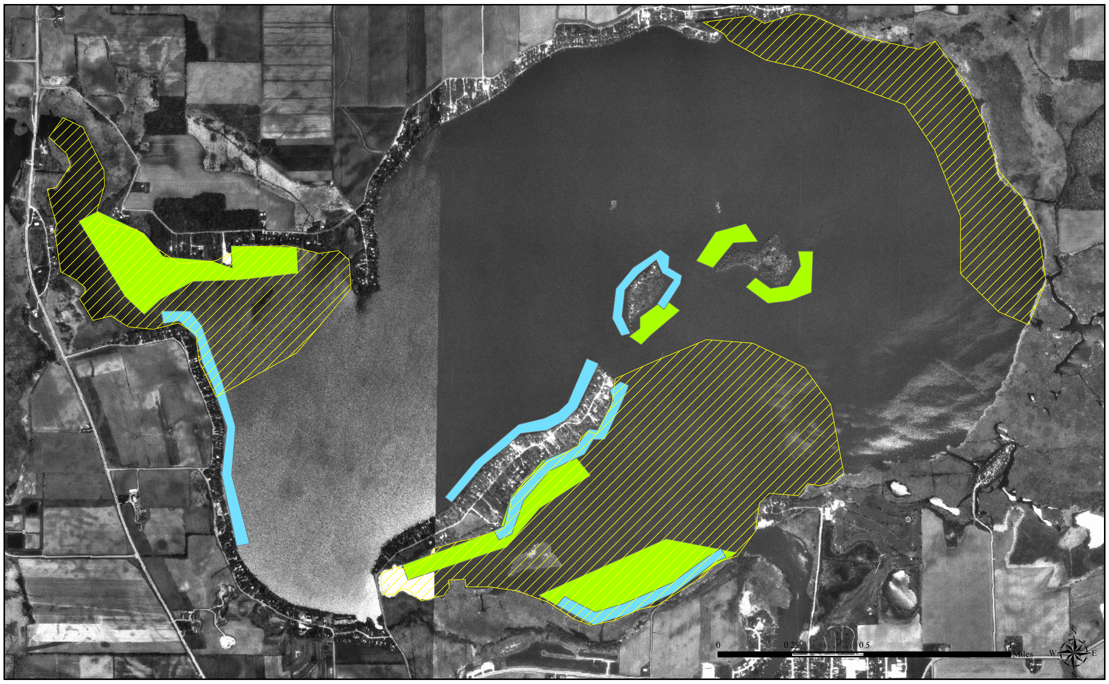

Figure 3-1
Nuisance Plant Areas (yellow hatched), Fish Nursery Areas (blue), and High Quality Native Plants (green)
Source: Hey and Associates, Inc.

Figure 3-1 also shows ecologically significant areas containing habitats important for fish or valuable native plants. Any management in areas with high quality plants or fish nurseries should carefully balance the ecological impacts of removing vegetation versus supporting recreational use.

Alternate Stable States

"Alternate Stable States" refers to a model used to explain the often rapid shift that occurs in shallow eutrophic lakes from the clear water macrophyte dominant state to a turbid water algal dominant state (Figure 3-2). Eutrophic refers to a nutrient rich condition that is very biologically productive with many plants, algae, and fish. The eutrophic condition is usually caused by watershed development or degradation associated with land use changes, but do occur naturally if lakes have very large watershed areas. Oligotrophic lakes are nutrient poor and very unproductive. They are usually found in more pristine landscapes. Mesotrophic lakes are intermediate in terms of productivity. They lie between eutrophic and oligotrophic lakes.

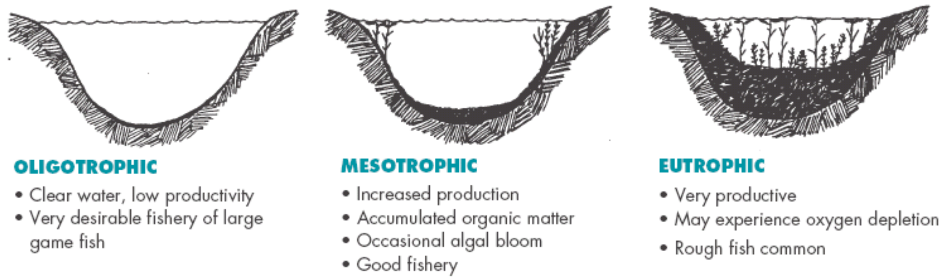

Figure 3-2
Aging Stages of Lakes and their Attributes
Source: University of WI-Extension and SEWRPC

A highly eutrophic lake or hyper-eutrophic lake may contain abundant plant growth, but is more likely to develop nuisance algal blooms than support aquatic plants. Hyper-eutrophic lakes have total phosphorus concentrations in excess of 100 ug/l. The excess phosphorus is readily absorbed by algae. As the algae grow the water becomes more turbid. As lake water becomes less transparent, the amount of light reaching the lake bottom decreases. Less light on the lake bottom results in fewer aquatic plants. Plants first become absent from deeper areas of the lake and gradually are lost in shallower areas if water clarity is further decreased. Unfortunately, this cycle operates as a positive feedback loop because plants compete with algae for nutrients and light. When the algae are released from competition with plants, their growth usually increases and may further deplete the aquatic plant community. In some cases hyper-eutrophic lakes reach a clear water state.

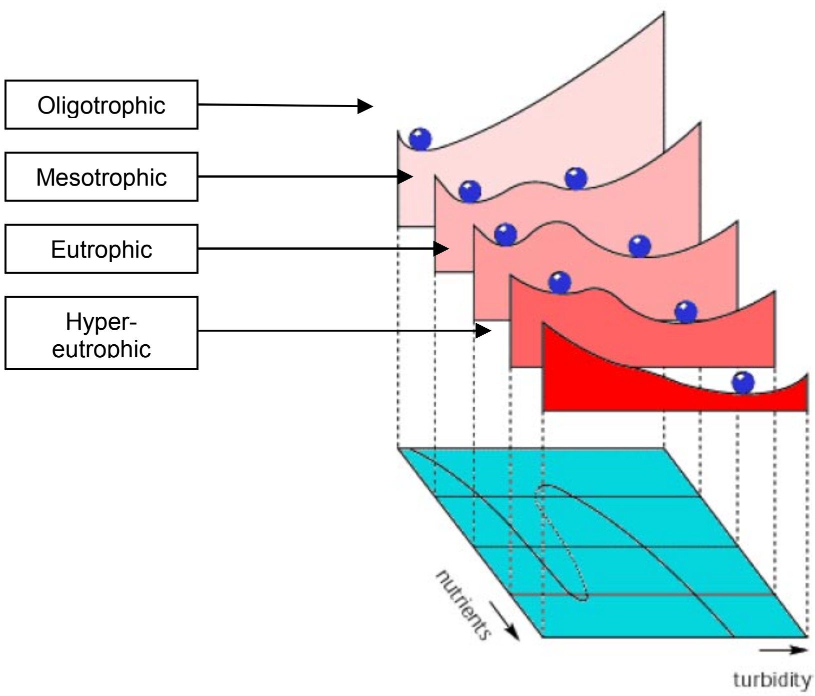

Figure 3-3
"Ball and Cup" model of alternate stable states (left side of model is clear water state)
Modified from Sheffer 2001

As Figure 3-3 shows, the clear or turbid water state depends on the amount of nutrients and turbidity. The location of the ball in the model represents the probability that a given state will occur with a combination of nutrient and turbidity conditions. The vertical height of the ball location represents the preferred state of the system at any given time where the lower position is more likely to occur. The humps in the model represent the amount of energy or management required to switch to the alternate stable state. It is clear from this graphical representation that it is unlikely for a hyper-eutrophic lake to persist in the clear water state without management.

Characteristics of the clear water state include abundant aquatic plant growth, a diverse and productive gamefish community, and numerous zooplanktons while the turbid state is free of aquatic plants, produces dense algae populations, and supports an undesirable, bottom feeding fish population (Jeppesen et al. 1990, Hasler and Jones 1949, Wetzel 1996, Van Donk et al. 1993, Kufel and Ozimek 1994, Timms and Moss1984, Schriver et al. 1995). One of these states *will* occur in shallow hyper-eutrophic lakes. An alternate version of the alternate stable states model is depicted in Figure 3-4.

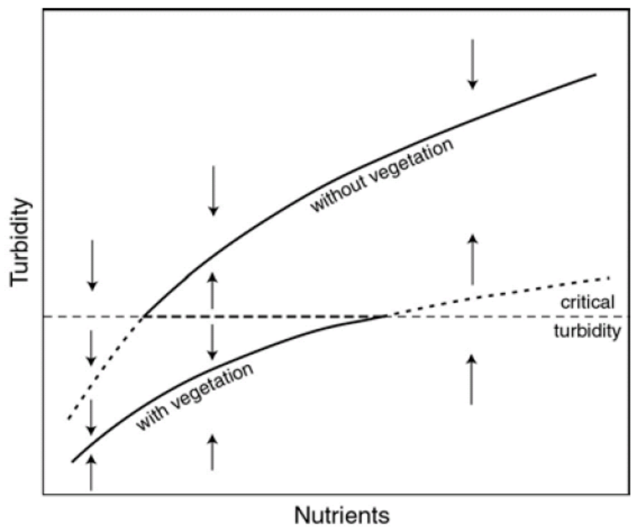

Figure 3-4
Graphical model of interaction for turbidity and nutrients for lakes between alternate stable states
Source: Sheffer 2001

The precise factors causing a lake to switch between stable states vary from lake to lake and are not clearly understood. It is known that certain circumstances, termed buffers, tend to keep a lake in one of the two stable states.

Buffers that maintain a turbid water state include:

1) Re-suspension of bottom sediment through wind action or boating activities may lead to increased turbidity that shades out aquatic plants and/or adding nutrients directly to the water column benefiting algae (Van den Berg et al. 1997, James and Barko 1990, Hamilton and Mitchell 1997).

2) Fish communities with a large number of Common Carp that typically uproot vegetation and re-suspend sediment and/or large numbers of zooplanktivorous fish. Common Carp can have the same effect as wind or boating on bottom sediment (Whillans 1996). Too many zooplanktivorous fish reduces the capacity for algae grazing and is usually caused by a lack of top predatory fish to regulate lower trophic levels (Ozimek et al. 1990, Van Donk et al. 1990, Hanson and Butler 1994).

3) A lack of structure can reduce top predators since many fish use ambush techniques to catch their prey. A lack of structure also allows increased predation on grazing zooplankton. Both of these factors can contribute to increased algae density (Timms and Moss 1984 and Shriver et al. 1995).

4) Algae growth early in the growing season due to high nutrient availability. Since algae populations can expand rapidly under favorable conditions, aquatic plants never get established in the spring. This is in part due to the susceptibility of shallow lakes with large watershed to the impacts of nutrient laden surface runoff (Crosbie and Chow-Fraser 1999).

5) Decaying algae also provide a poor substrate for future plant growth.

Buffers that tend to maintain a clear water state are derived from the benefits of aquatic plants and are the opposite of turbid water buffers:

1) Plants minimize the impacts of wave energy on the lake bottom to minimize sediment re-suspension and protect existing plant beds.

2) Plants compete with algae for light and some nutrients.

3) Plants provide refuges for zooplankton from fish predation. This facilitates grazing on algae.

4) Plants provide spawning habitat and ambush sites for Northern pike. Pike are efficient littoral predators on planktivorous fish.

5) Plants provide their growing material for next year when they die back in the fall. Tightly packed or loosely packed sediment is a difficult medium for plants to grow on, but decaying plants from the previous year provide ideal growing conditions for many aquatic plants.

A trophic cascade is the name for complex biological interactions occurring across a food chain. The presence/absence of aquatic plants plays an important role in trophic cascades. Trophic cascades occur in the following manner with respect to algal abundance in lakes. Top predators such as Northern pike are lost from a lake through over fishing, lack of reproduction, or reduced stocking efforts. Pike no longer feed on panfish populations so they become very large numerically yet the average panfish size decreases or becomes stunted. The overabundant small panfish feed on zooplankton and deplete the zooplankton population. Since zooplankton graze on algae suspended in the water column, reduced populations of zooplankton usually result in lower water clarity. Two of the important ecological services provided by aquatic plants are cover for predatory fish that allow them to ambush their prey (panfish) and refuges for zooplankton to avoid predation by panfish. Sustaining or enhancing the aquatic plant community alters trophic interactions to promote the clear water state. Biomanipulations are management activities that intentionally alter the existing trophic structure to enhance buffers that promote the clear water state (Figure 3-5; Moss et al. 1996 and Sheffer 1998).

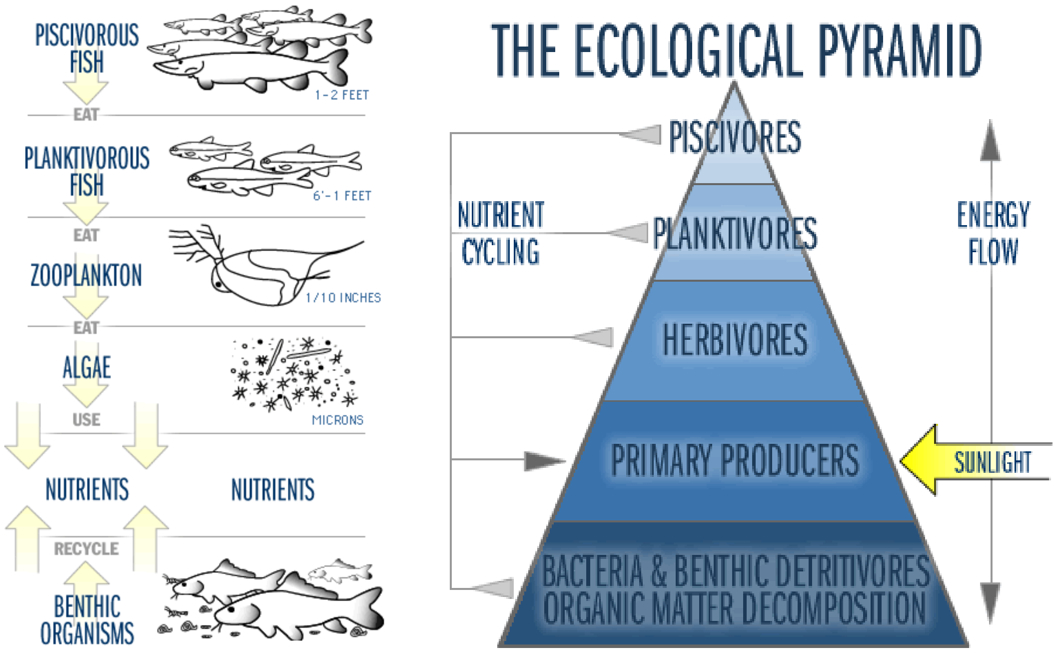

Figure 3-5
Trophic Cascade Interactions in Lakes
Source: Water on the Web

Aquatic plant management on Fox Lake must consider the delicate balance of maintaining the clear water state in a hyper-eutrophic lake. Small changes to the lake ecosystem, including the aquatic plant community, may result in a rapid shift back to the turbid water state. The alternate stable states model predicts there is a threshold for ecosystem changes that cause the shift, but there is no way to know what the threshold limit is. Simulation models have shown that even a small amount of plant management may cause the plant community to collapse or become more vulnerable to shifting to the turbid water state due to weather conditions (van Nes et. al 2002). As a result, aquatic plant management on Fox Lake must take a conservative approach.

Management Intensity

There are three levels of plant management identified by the Wisconsin Department of Natural Resources *Aquatic Plant Management in Wisconsin* (2005). The level of plant management required depends on the goals of the plant management plan and the characteristics of the lake ecosystem. The three levels of control are: maintenance, low manipulation, and high manipulation. Figure 3-6 shows the proposed plant management areas in Fox Lake for navigation channels and Figure 3-7 shows areas where large-scale management of EWM would be beneficial. All riparian owners are also eligible under Wisconsin NR 107 to apply for nearshore aquatic plant management permits.

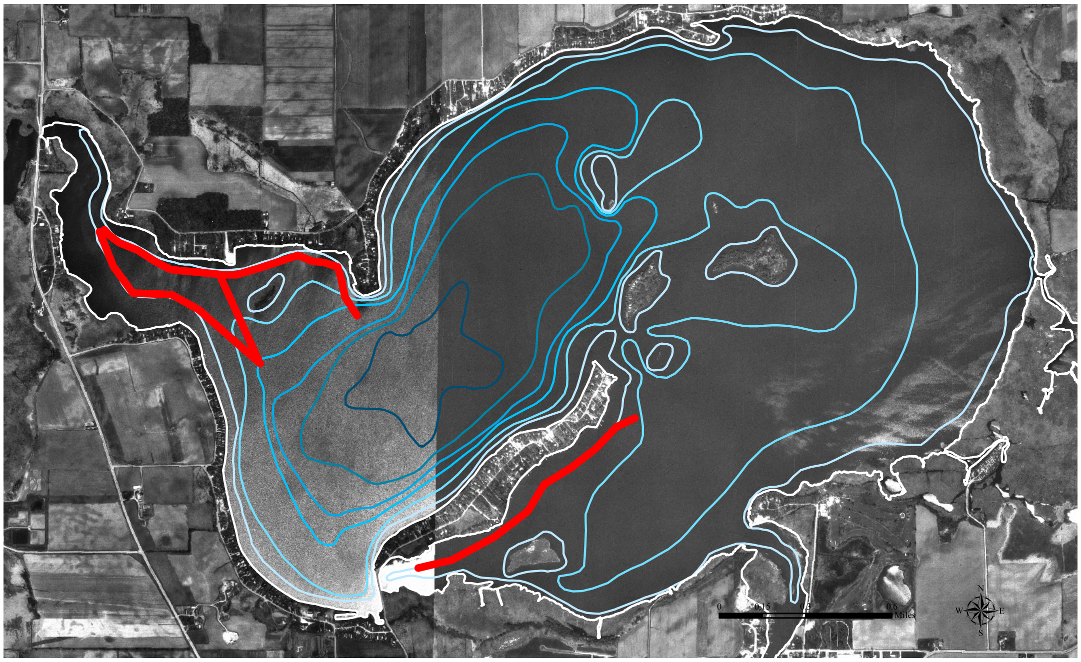

Figure 3-6
Proposed Navigation Channel Locations
Source: Hey and Associates, Inc.

Maintenance control is used as part of a protection orientated plan for lakes with no invasive species or nuisance conditions occur. Since Fox Lake contains abundant plant growth with nuisance conditions and invasive species, maintenance level management will not meet the aquatic plant management plan goal of providing lake access and facilitating recreational uses. Maintenance control would meet the plan goal of maintaining a clear water state. If the Eurasian water-milfoil population continues to increase, maintenance control may not be sufficient to protect the fish and wildlife. Research suggests that dense Eurasian water-milfoil beds do not provide the same benefits to fish and wildlife as more diverse native plant beds. Maintenance is currently not a feasible option for Fox Lake.

Low manipulation is an intermediate level of control. This level of control is appropriate for lakes with moderate plant problems but protection is the main goal. A plant management strategy using a low manipulation level of control could meet the needs of lake users and facilitate lake access if local areas of plant control were allowed in nearshore areas. The goal of protecting and promoting the existing native plant community could be met if control methods were selective to remove only invasive plant species. Fish and wildlife may or may not benefit from a low level of plant control depending on how well the native plant community competes with Eurasian water-milfoil. Low manipulation will not facilitate navigation outside of nearshore areas.

High manipulation is the control option with the most intense plant management. It is appropriate for lakes with moderate to severe problems. This type of program might include large-scale plant management such as harvesting or attempts to minimize the effects of exotic plant species. This level of control would meet the goal of the aquatic plant management plan to provide lake access and facilitate recreational uses, but could also cause Fox Lake to return to the turbid water state if too many plants are removed. High manipulation might also remove too many plants and reduce the habitat and food resources available for fish and wildlife. High manipulation is an acceptable level of control for Fox Lake as long as the focus is to meet minimum navigation requirements or to selectively manage EWM.

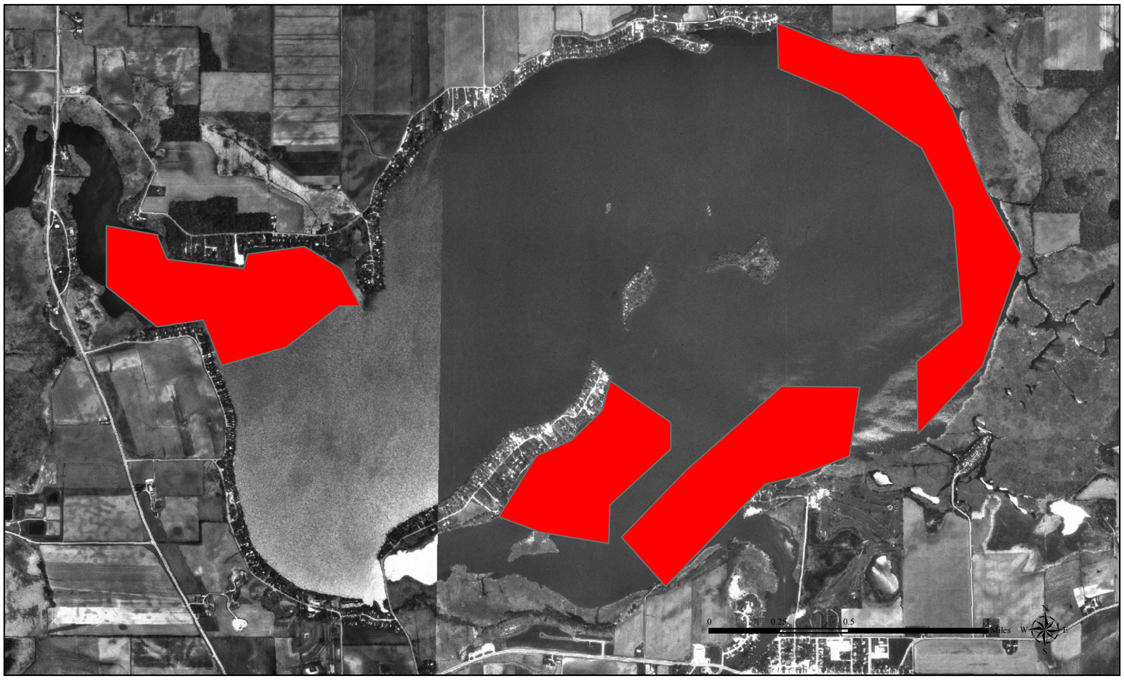

Figure 3-7
Priority Eurasian water-milfoil Management Areas
Source: Hey and Associates, Inc.

Management Alternatives, Feasibility, and Cost

There are a number of aquatic plant management options available. Management options can be broken down into the following categories: do nothing, manual removal, mechanical removal, chemical control, physical control, and biological control. Each method can be effective depending on lake conditions. Conversely each method also carries its own set of drawbacks and limitations. As a result, some options may not be appropriate for Fox Lake.

Do Nothing

Do nothing is an option where aquatic plants are not managed in any way, but monitoring typically occurs to track the changes in plant community structure. Programs to monitor for invasive species introduction or expansion are also common. In lakes containing both a healthy aquatic plant community and aquatic invasive or exotic species, allowing the native plant community to function in its natural state may prevent invasive species from spreading extensively through the lake. Other advantages include no financial cost, no harmful effects of chemicals, and no permits are required. The major drawback is that small populations of invasive species may expand and require more extensive management in future years.

No management of the aquatic plants in Fox Lake will meet the goal of maintaining a clear water state, but it will not meet the goals of promoting the native plant community, fish, and wildlife or facilitate lake access and recreational uses. Plant survey data from 2005 and 2006 suggest that aquatic plants will continue to present navigation and recreation nuisances. To meet the use and access goals of Fox Lake District residents, management will be required to create navigation channels and in nearshore areas.

Manual Removal

As the name suggests, manual removal is using a mechanized or non-mechanized implement to physically remove plants from the lake bottom. There are a number of methods in practice to manually remove plants.

Hand-pulling: Hand-pulling is removing plants from the lake bottom with your hands and a shovel or rake. This can be a very selective method of plant removal, but it is also very time and labor intensive. The duration of control varies based on the type of plants removed and whether or not entire root systems or just stems are pulled. This method is preferred for small areas and to control nuisance plants with a patchy distribution such as around docks and piers. No permit is required if plants are removed from areas less than 30 feet wide or if the only plant being removed is Eurasian water-milfoil or other aquatic invasive species. A lake rake can be purchased for $80 – $115 on the internet or contractors may be hired from aquatic plant management companies. Care must be taken to minimize removal of native plants or Eurasian water-milfoil may colonize managed areas. This option would be very effective for residents on Fox Lake.

Hand-cutting: Hand-cutting is a similar technique to hand-pulling with the exception that the plant roots are not removed. The amount of control provided by hand-cutting is limited. The advantage of hand-cutting is that it provides immediate relief and is low cost. Disadvantages include the short period of relief and the potential for repeated cuttings. Hand-cutting may also spread Eurasian water-milfoil fragments unless the entire cut plant is removed. Hand-cutting would be an acceptable alternative for removing nuisance native vegetation.

Mechanical Removal

Mechanical Harvesting: Mechanical harvesting is using a large machine to cut and remove aquatic vegetation to create navigation channels or improve fish habitat by creating edge. The vegetation is removed by using a conveyance system at the shoreline to unload plant material. The plant material is then disposed of. Harvester cutting depths are adjustable on newer machines. Widths of cuts can vary from 4 to 20 feet while depths may vary from 5 to 10 feet. Benefits of harvesting include immediate relief from nuisance conditions and the removal of plant material from the lake that may reduce biological oxygen demand and release of nutrients during the decay process. Drawbacks to harvesting are considerable start up and maintenance costs, they are not selective, and cutting multiple times a season may be necessary. Even though harvesters are equipped with plant collection devices, some fragments may drift into other sections of the lake and alter the plant community composition. This is especially a concern for Eurasian water-milfoil. Harvesters are also difficult to use around piers and in shallow water. Leasing and contracting services are available. Costs are approximately $150 – $800 per acre for contracted services. Mechanical harvesting is an excellent option for Fox Lake to create navigation channels. Mechanical harvesting options also exist to incorporate into a lake-wide Eurasian water-milfoil control strategy.

Mechanical Cutting: Cutters function identically to harvesters with the exception that plant material is not collected by the machinery. This technique carries enormous risk in lakes with invasive plants and is not recommended for Fox Lake.

Chemical Control

Herbicides: Herbicides are the lone type of chemical control available for aquatic plant management. They are chemical substances that disrupt the growth cycle of plants. There are different types of herbicides. Systemic herbicides are absorbed and transported throughout the plant effectively killing the entire plant. Contact herbicides only kill the exposed portion of the plant so plants may re-grow from the remaining roots. Another distinction between different types of pesticides is the range of plants they affect. Selective herbicides will only damage the target plants versus broad spectrum herbicides which effect most if not all plants they come in contact with. Herbicide selectivity depends on the chemical mode of action, the dose, how it is applied, and the timing of the application (Table 3-1).

Table 3-1
Herbicides Used to Manage Eurasian water-milfoil

Herbicide Name	Trade Name	Formulation	Mode of Action
2,4-D Butoxyethlester (BEE)	Aqua-kleen, Navigate	Granular	Selective, systemic growth regulator
2,4-D Dimethylamine (DMA)	DMA 4 IVM	Liquid	Selective, systemic growth regulator
Diquat	Reward, Weedtrine-D	Liquid	Nonselective, contact
Endothall Dipotassium salt	Aquathol K, Aquathol Super K	Liquid Granular	Rate and timing dependent selectivity, contact
Endothall Dimethylalkylamine salt	Hydrothol 191	Liquid or Granular	Nonselective, contact
Fluridone	Avast!, Sonar	Liquid or Granular	*Rate dependent selectivity, systemic*
Triclopyr	Renovate 3	Liquid	Selective, growth regulator

Italics indicate best suited for large-scale or whole lake treatments; remaining chemical may be used for spot treatments

Source: Aquatic Ecosystem Restoration Foundation (2005)

Many systemic herbicides will provide longer control of target plants often extending into the following growing season. Contact herbicides tend to produce shorter periods of control. Concerns related to herbicide include potential toxic effects on aquatic invertebrates, adding additional decaying plant material to the lake bed that may reduce oxygen levels and increase nutrients, and water use restrictions. Each chemical has its own limitations and it is important to determine whether or not an application will cause use conflicts between lake users (Table 3-2).

Table 3-2
Water Use Restrictions for Herbicides Used to Manage Eurasian water-milfoil

Herbicide Name	Trade Name	Water Use Restrictions
2,4-D Butoxyethlester (BEE)	Aqua-kleen, Navigate	Drinking until below 70 ppb Irrigation until below 100 ppb
2,4-D Dimethylamine (DMA)	DMA 4 IVM	Same as Navigate May be toxic to invertebrates
Diquat	Reward, Weedtrine-D	Drinking 1-3 days Recommended 1 day recreational use (reduces effectiveness)
Endothall Dipotassium salt	Aquathol K, Aquathol Super K	Fish consumption 3 days Irrigation 7-25 days May be toxic to fish
Endothall Dimethylalkylamine salt	Hydrothol 191	Same as Aquathol K
Fluridone	Avast!, Sonar	Recommended irrigation tress 7 days, crops 14-30 days
Triclopyr*	Renovate 3	Irrigation 120 days or until below detection Fish 30 days

Chemical control is an effective management option along shorelines and around piers. Another advantage to chemical control is that it is affordable to many riparian homeowners. Treament of small areas (50 feet by 150 feet) cost ranges from $200 – $400 depending on the number of treatments and chemicals used. Large-scale treatments usually have a lower cost per acre and range from $100 – $1,200 per acre depending on the chemical used. A permit is required for all chemical controls under NR 107. It is highly recommended that riparian homeowners wanting to use chemicals to treat aquatic plants hire a licensed, certified professional applicator. Applying chemicals in a manner inconsistent with label instructions is prohibited by law. Chemical controls used around piers to facilitate navigation would be beneficial for lake residents. Selective chemical controls are also on option to develop a lake-wide plan to manage Eurasian water-milfoil.

Physical Control

A number of options for physical control of aquatic plants are available depending on the characteristics of your lake and the management site.

Dredging: Dredging the removal of lake sediments using mechanical or hydraulic equipment. It is a non-selective technique that removes all plant material and lake bottom material. Dredging will also increase the depth of management sites and will expose the original lake bed. In many lakes, cultural eutrophication and increased sediment loads have covered the lake bottom with decaying plant material and silt. Removing this material may improve the spawning habitat for some species and decrease it for others. The disadvantages of dredging include high costs ($5 – $30 per cubic yard) and general disruption of the aquatic habitat. This technique is not recommended for Fox Lake unless it is conducted as part of a lake-wide plant management strategy.

Water Level Drawdown: Drawdowns are a common method of aquatic plant control in lakes with water level manipulation capacity. Winter drawdowns are the most common as many plants species cannot tolerate freezing conditions. Drawdowns in the summer months rely on heat and desiccation to reduce plant abundance. Once the lake level is brought up, some species may show a positive response to the drawdown; however, responses from Eurasian water-milfoil are unpredictable. Other potential effects of a drawdown are: reduced oxygen levels in winter due to reduced water volume, benthic organisms may be impacted, and affects to shorelines and wetlands. Water level drawdown during the summer months is likely prohibitive for the residents on Fox Lake due to limited lake access. A drawdown on Fox Lake of 6 feet would be required to limit plant growth in nuisance areas. The feasibility of a lake-wide drawdown would require an extended planning process and public support.

Dyes: Dyes are water soluble compounds mixed in lake water that limit light penetration and reduce plant growth. Dyes favor species tolerant to low light conditions and may be used to create open water conditions where they might not otherwise occur. The disadvantages to using dye are that they are generally not effective in depths less than 4 feet and require repeated applications as they degrade or flush from the application area. Due to the large water volume, this technique is not applicable to Fox Lake.

Biological Controls

Biological control in lakes is currently in the experimental phases of development. As with many biological interactions, the effects of releasing organisms into a lake are only predictable to a certain degree. In addition, biological controls tend to operate in a cyclical nature so the effectiveness as a management tool may vary from year to year.

Grass Carp (Ctenopharyngodon idella): Grass Carp are an exotic carp species native to Eastern Europe and Asia. It is known as an aggressive consumer of aquatic plants, especially elodea and pondweeds. Grass Carp may completely eliminate aquatic plants once introduced. Grass Carp are illegal to introduce in Wisconsin waters.

Milfoil Weevil (Euhrychiopsis lecontei): The Milfoil Weevil has been documented in isolated circumstances to control Eurasian water-milfoil populations in Wisconsin, Illinois, and Vermont. Adult females lay eggs on the tips of the plant. The larval weevils emerge and attack milfoil at its growth points and stems. Most evidence to date suggests that the feasibility of long-term control is unknown and that intensive stocking is required for lake-wide control (3,000 adults per acre) for a cost of $15,000 per acre. Evidence also suggests that Milfoil Weevils are most effective on dense stands of milfoil and tend to avoid other plants. This technique is relatively unreliable and results are unpredictable and best applied on a whole-lake scale. At this time the Milfoil Weevil is not an attractive management alternative for Fox Lake.

Native Plants: Native plants may compete with Eurasian water-milfoil if there is a healthy, diverse community present. Eurasian water-milfoil thrives in disturbed conditions whether natural or human induced. Even in cases where herbicide treatments have been highly effective, the most likely plant to re-colonize a treated area is an invasive plant. Two strategies to prevent re-colonization are spreading seeds of native species or transplanting adult plants. Spreading the seeds over a treatment area must occur early in the growing season so plants may complete their life cycle. If annuals go to seed, control may be effective the following year. This technique requires planning and the acquisition of seeds from in-lake sources or reputable nurseries. Transplanting adult plants to treatment areas should occur after plants reach full-size and before seeds are dropped. Both of these techniques are effective at enhancing the native plant community and prevent re-infestations of invasive plants. Costs for plant relocation are approximately $150 per hour. Large-scale native plant relocation is an important consideration to complement large-scale lake management of Eurasian water-milfoil.

Summary

Fox Lake is currently in a clear water macrophyte dominant state. Clear water states are difficult to maintain in hyper-eutrophic lakes. Plant management activities should be minimized to promote the clear water state while facilitating lake access and recreational uses. Beneficial plant management in the lake would include strategies that reduce the impact of Eurasian water-milfoil and promote native plants.

Aquatic plant management on Fox Lake will require a combination of low and high manipulation to accomplish this plan's stated goals. Suggested activities include mechanical harvesting to improve navigation in off-shore areas, a mixture of hand-pulling and chemical treatments around lake residents' shoreline and piers, and selective herbicide treatments to manage Eurasian water-milfoil on a lake-wide scale.

CHAPTER 4 – RECOMMENDATIONS, IMPLEMENTATION, MONITORING, AND EVALUATION

INTRODUCTION

The following sections will provide a set of recommendations for aquatic plant management for the 3- to 5-year period beginning in the summer of 2007, implementation of key activities, and strategies for monitoring and evaluation. These recommendations should be reviewed at the end of the 3- to 5-year period and adjusted accordingly. There are a number of main components to the following recommendations. They are: facilitate recreational lake uses in nearshore areas for lake residents, improve navigation in offshore areas affected by aquatic plant growth, approve and implement a lake-wide Eurasian water-milfoil control strategy, continue to educate the local community on the benefits of aquatic plants and promote ecologically sound management strategies, and establish a long-term monitoring strategy.

Recommendations

The general recommendations for the Fox Lake Inland Lake Protection and Rehabilitation District are:

- Develop an integrated plant management strategy to facilitate lake access and recreational use in nearshore areas and navigation channels that minimizes impacts to the overall aquatic plant community and protects ecologically significant areas of the lake
- Develop and implement a lake-wide Eurasian water-milfoil strategy
- Establish a long-term monitoring strategy
- Educate the public on the value of a healthy native aquatic plant community and shallow lake ecology

Integrated Plant Management Strategy

An integrated aquatic plant management strategy (Figure 4-1) applies a number of different methods to effectively allow recreation while maintaining ecological benefits. For Fox Lake, this management strategy will require a combination of low and high level manipulation including herbicides and mechanical harvesting. This strategy should focus on minimizing impacts to native plants, reducing EWM whenever possible, and promoting lake access and recreational use.

Nearshore Areas

Control techniques will be limited to hand-pulling or raking, selective chemical treatments targeting Eurasian water-milfoil and Coontail, or relatively small treatments with contact herbicides to control native aquatic plants (other than Coontail). All financial obligations for plant management in nearshore areas are the responsibility of the local riparian homeowner[1]. Whenever possible, treatments that affect non-nuisance native plants should be avoided. Fox Lake is a highly productive lake so it is unrealistic to expect shallow areas of the lake to be plant free. Normal levels of native aquatic plants do not restrict navigation

[1] Other local landowners such as the District, the Town, and City of Fox Lake may also sponsor nearshore applications near boat launches, fishing piers, or swimming areas as needed.

or recreation and should not be managed in any way. It is essential that beneficial native plants such as Elodea or pondweeds are not removed or minimally removed because they may restrict the spread of Eurasian water-milfoil. Visual evidence suggests Elodea is competing well with Eurasian water-milfoil. Sago pondweed is a high value aquatic plant for fish and wildlife and should not be removed. Plants also provide the added benefits of reducing shoreline erosion and improving water clarity.

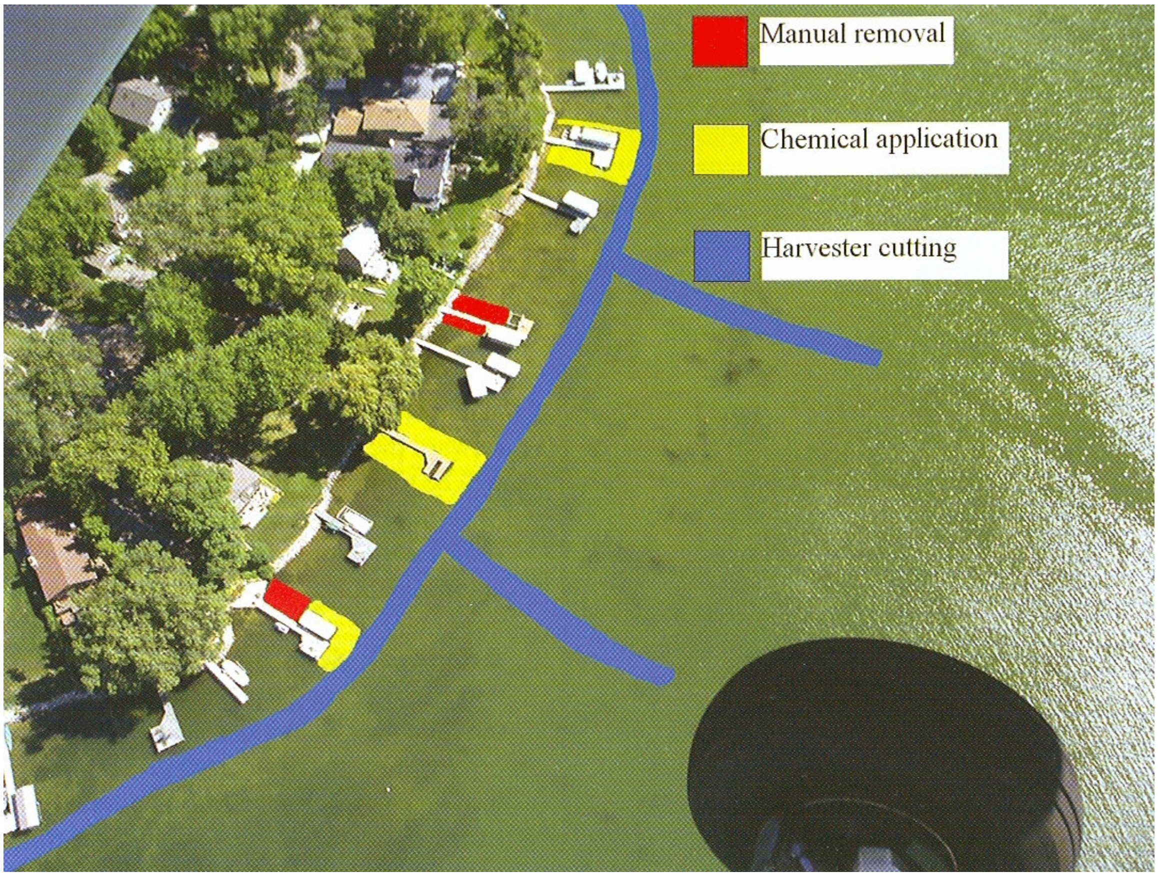

Figure 4-1
Integrated Aquatic Plant Management Strategy
Source: NALMS and WDNR

To ensure adequate protection of native plants, all properties that request aquatic plant management by chemical methods should be inspected prior to chemical treatment to determine the optimal management strategy. The inspection will include using a rake type sampler to determine the types and density of plants present at each management site. Results of the inspection should be recorded to ensure the chemical application reports are accurate to the track aquatic plants at each property from year to year. If inspections cannot be conducted by the WDNR, an independent third party will be hired by the Fox Lake Inland Lake Protection and Rehabilitation District to supervise the chemical treatments.

Manual removal methods, such as hand-pulling or raking, that focus on selective removal of Eurasian water-milfoil and Coontail are preferred. Residents are allowed to remove native and non-native plants without a permit in a 30-foot wide area around their piers to allow for navigation and recreation. Eurasian water-milfoil may be selectively removed (hand-pulled or raked) outside of the 30-foot area without a permit, but other plants are limited to a 30-foot wide area. All removed plants must be disposed of on dry land in a manner that will not allow the plants to wash back into the lake and infest other areas. Composting is one way to dispose of plant material.

Chemical treatments will be allowed for property owners affected by Eurasian water-milfoil or Coontail as a secondary option. All chemical treatments require a permit from the Wisconsin Department of Natural Resources. The selective herbicide 2,4-D will be used to treat Eurasian water-milfoil and Coontail dominated sites while contact herbicides may be used to treat sites where non-nuisance plants are causing recreational nuisances.

Eurasian water-milfoil or Coontail will be treated using a 2,4-D so beneficial native plants will be largely unaffected. The 2,4-D treatments should occur early in the growing season to minimize competition between EWM and native plants. EWM grows much earlier than many native plants, so its removal early in the growing season should facilitate growth of native plants. Follow-up treatments may occur as necessary to remove EWM or Coontail. Granular formulations should be used to promote longer relief and extended contact time with target plants. Residents may treat the least of 1) their entire frontage or 2) a 50-foot wide by 150-foot long channel with 2,4-D. Permits may be issued with more restrictive areas allowed as per the discretion of the Wisconsin Department of Natural Resources.

Contact herbicides that may also affect native plants should be avoided, but may be used as a tertiary option in areas where aquatic plants other than Eurasian water-milfoil and Coontail are a nuisance. No contact herbicides should be used when the primary management target plants are either Eurasian water-milfoil or Coontail. Contact herbicides create disturbed areas on the lake bottom where the fast growing Eurasian water-milfoil may gain a competitive advantage. Treatment areas using contact herbicides should be limited to a 30-foot wide by 150-foot long area. Contact herbicide treatments should not occur until early summer to provide temporary relief from native plants impeding recreation.

Typically chemical treatments are centered on piers, but an alternate strategy that may provide more relief would be to center the treatment on the property boundary between parcels (Figure 4-1A). This would increase the average size of the remaining plant beds. If an adjacent property owner does not need or want a chemical treatment, then piers may be used as the treatment centerline (Figure 4-1B). It is the responsibility of the homeowner to determine where the center of their treatment area should be located and accurately represent its location on their permit application.

It is important to note that treatment strategies are NOT additive. Riparian property owners may NOT treat 50-feet of frontage with herbicides and hand-pull plants from an additional 30-foot wide area. Plant management is only allowed in either 1) a 30-foot wide area for contact herbicide treatment or manual removal or 2) a 50-foot area for selective herbicide application. Situations creating a total management area in excess of the above specifications are illegal. The only exception to this rule is that Eurasian water-milfoil may be selectively removed by hand-pulling anywhere along a property's frontage. Plant removal using multiple methods is allowed if it is confined to a single 30-foot wide area where plants closest to shore are manually removed and plants in deeper water are chemically treated (Figure 4-1).

Finally, it would be in the best interest of the lake residents for a central entity such as the District to oversee all plant management permit applications. This would allow all plant management to be negotiated under a single contract with a reputable applicator and efficient inspection of proposed management sites. Multiple permit applications and herbicide applicators would make it more difficult to schedule the suggested site monitoring activities and result in higher costs to residents.

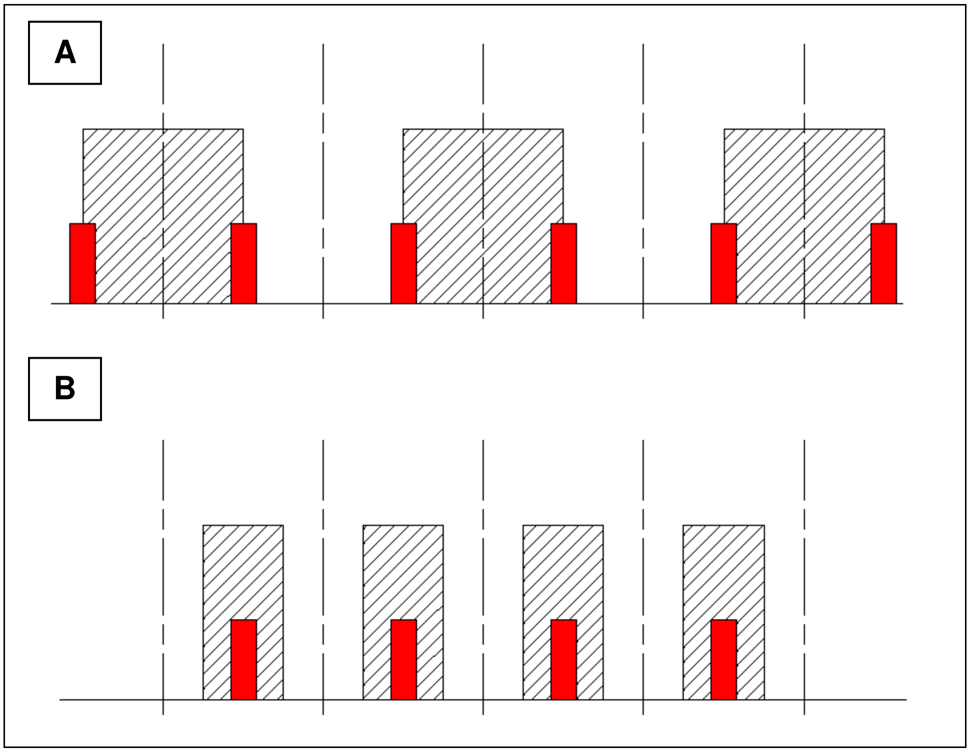

Figure 4-2
Alternate Contact Herbicide Application Strategy (not to scale)
Source: Hey and Associates, Inc.

Navigation Channels

Due to the dominance of aquatic plants in shallow littoral areas in Fox Lake, actions to facilitate navigation to deep water areas will be required. The proposed location of navigation channels on the lake correspond to the areas of highest plant density, population density, and minimal depth requirements for operation. Areas with dense plants, numerous residents, and areas of at least 3-foot depth are the highest priority (Figure 4-3). These areas were determined during planning meetings open to the public. An additional channel may be cut through the Mill Creek outlet (not pictured) to facilitate boat traffic from the City of Fox Lake boat launch if funding is available.

Harvesting should be conducted by a contractor and no plans should be made to purchase equipment over the duration of this plan. It is uncertain whether Fox Lake will remain in the clear water state and a large capital investment is premature. The District will need to develop loading and unloading sites for harvesting equipment and disposal sites for harvested materials prior to implementing the program. Due to the large size of the lake, at least two loading and unloading locations will be needed to correspond with the Cambra

Creek area and the Jug. In addition, a large-scale permit[2] including application fee will be required under NR 109 prior to commencement of any harvesting activities.

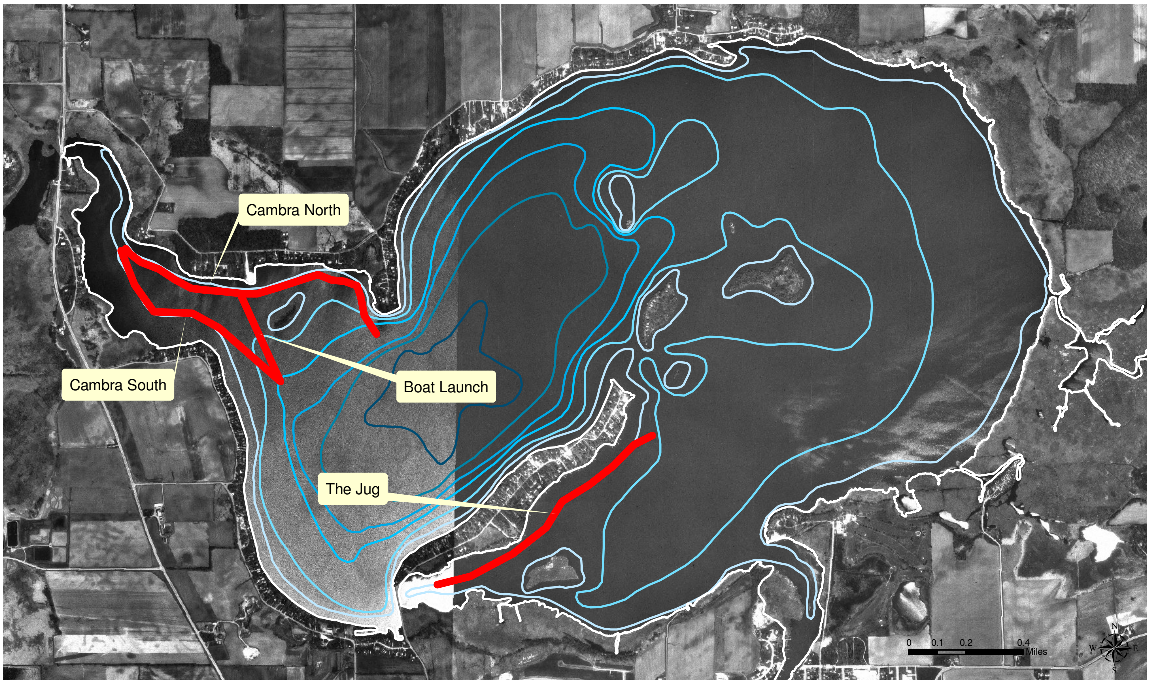

Figure 4-3
Proposed Navigation Channel Locations
Source: Hey and Associates, Inc.

The financial obligation of creating and maintaining navigation channels is the responsibility of the Fox Lake Inland Lake Protection and Rehabilitation District. A summary of the total acreage and costs for a single harvest of the desired channels is located in Table 4-1. Estimates assume a 25-foot wide channel at a rate of $300 per acre. Typically, harvesting is repeated on an as-needed basis 2 to 5 times over the growing season. Areas experiencing regular boat traffic such as the boat launch channel may not require harvesting. Use of cut channels by boaters should be encouraged to reduce the number of cuttings (and cost) required to maintain the channels.

Table 4-1
Proposed Navigation Channel Acreage and Cost Estimates
Source: Hey and Associates, Inc.

Site	Acres	Cost
Cambra North	3.2	$959
Cambra South	2.2	$661
Boat Launch	1.0	$298
The Jug	2.8	$835
Totals	**9.2**	**$2,752**

[2] Large-scale permits are required for areas larger than 10-acres. Since the area on Fox Lake approaches 10-acres for the primary channels, it is recommended that a large-scale permit is acquired to facilitate cutting in any secondary areas.

It is recommended that additional side channels be cut into areas of dense plant growth to facilitate feeding by predatory fish and angler navigation (Figure 4-4). The best location of side channels is to the southeast of the proposed channel in the Jug and would consist of a single pass of the harvester. The width of an angler channel would only be ~10 feet. These side channels would be located at the discretion of the Fox Lake Inland Lake Protection and Rehabilitation District and are of the lowest priority of any harvesting activities.

Figure 4-4
Potential Secondary Angler Navigation Channel Locations
Source: Hey and Associates, Inc.

Lake-wide Eurasian water-milfoil Strategy

Due to the expansion of Eurasian water-milfoil in Fox Lake, a lake-wide management strategy should be implemented to limit the ecological impacts of this exotic invasive species. Eurasian water-milfoil has spread to most of the lake (Figure 4-5). Priority areas for a lake-wide management strategy should focus on areas with the densest infestation (Figure 4-6) and progress to areas of lesser density. A total of 635 acres would benefit from immediate EWM management. Due to the large costs associated with large-scale plant management, Fox Lake Inland Lake Protection and Rehabilitation District should conduct a pilot study to determine the best management alternative to control EWM in the lake. The two best strategies to control EWM are fall herbicide applications and fall harvesting. A comparative study comparing multiple plots including controls would allow the District to further develop a lake-wide control strategy. Funding through the Aquatic Invasive Species Grants from the Wisconsin Department of Natural Resources is available. Limited funding is also available through the Army Corps of Engineers. Initial cost estimates range from ~$100,000 - $500,000 to treat the initial 625-acres identified as containing EWM in 2006.

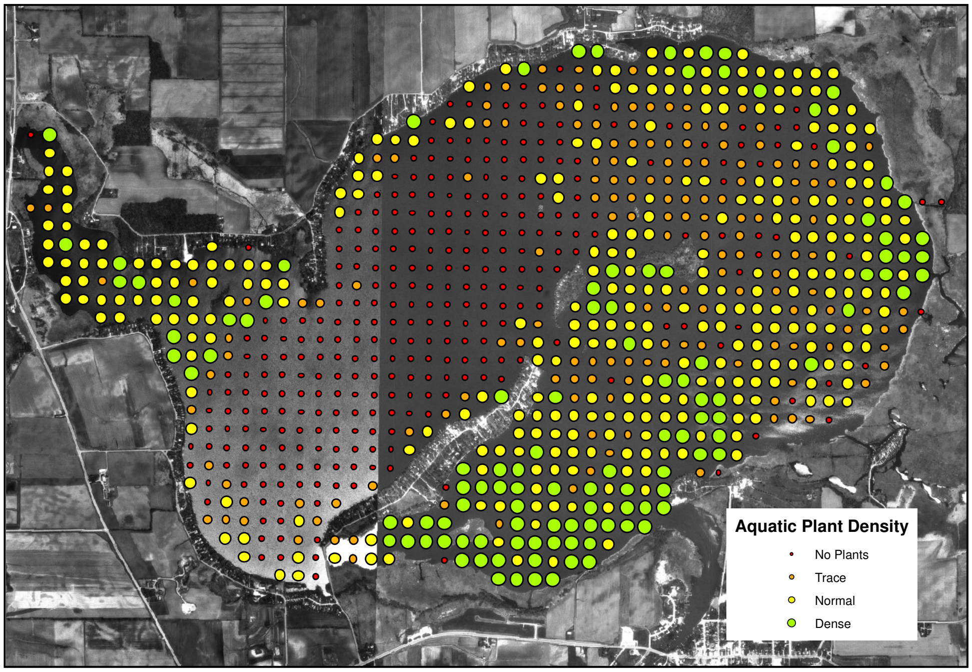

Figure 4-5
Lake-wide Eurasian water-milfoil Distribution 2006
Source: Hey and Associates, Inc.

Figure 4-6
Priority Lake-wide Eurasian water-milfoil Management Areas
Source: Hey and Associates, Inc.

Monitoring Strategy

Due to the sensitive nature of the aquatic plant community in Fox Lake exhibited by its tendency to alternate between the turbid and clear water states, a comprehensive aquatic plant survey should occur on an annual basis during initial phases of aquatic plant management activities. If the lake remains in the clear water state over the plan's duration (3 to 5 years), the frequency of monitoring should be scaled back to once each time the plan is renewed or concurrent with any lake-wide management activities. Due to the past intensity of monitoring activities, it is unlikely that cost-sharing funds will be available for future plant community monitoring. As a result the District should assume an additional $10,000 per year will be required for a comprehensive survey.

Public Education

A public meeting will be held to introduce the final plan to the district residents. A number of education and planning meetings were held that were open to the public during plan development. Topics covered include: shallow lake ecology and alternate stable states, aquatic plant identification, and aquatic plant management options.

The Fox Lake Inland Protection and Rehabilitation District should consider implementing a "Clean Boats, Clean Waters" program; update the existing watershed and water quality plan; encourage public involvement in promoting overall lake health in addition to the activities outlined in the current aquatic plant management plan.

The "Clean Boats, Clean Waters" watercraft inspection program is a volunteer-based effort to minimize the spread of aquatic invasive species. Volunteers are trained to organize and conduct a boater education program in their community. Adults and youth teams educate boaters on how and where invasive species are most likely to hitch a ride into water bodies. Volunteers perform boat and trailer checks for invasive species, distribute informational brochures, and collect and report any new water body infestations.

Implementation

A public meeting will help to present the long-term aquatic plant management plan to the public that will include educational information related to the value of a healthy aquatic plant community and the benefits of selective plant management.

Aquatic plant management in nearshore areas is the responsibility of each individual homeowner and should follow the recommendations outlined in the "Integrated Plant Management Strategies" at the beginning of this chapter. Selective manual removal of Eurasian water-milfoil and Coontail should be the primary management option. 2,4-D may be used to manage EWM and Coontail as a secondary management option. Under special circumstances contact herbicides may be used to provide navigation relief due to abundant native plants other than Coontail. All chemical treatments require a permit and should be performed by a certified licensed applicator. Permit applications should begin in the late winter or early spring so an early season 2,4-D treatment may occur at sites affected by EWM. The District should apply for the NR 107 permit on behalf of the homeowners desiring treatment. The District should also submit a request for proposal to a number of chemical applicators with the desired treatment schedule and permit stipulations to ensure the recommendations of the aquatic plant management plan are met.

A harvesting program should begin in the summer of 2007 to remove aquatic vegetation from off-shore navigation areas. Planning should begin in the winter of 2006-7 to find suitable disposal sites and a reputable contractor. All activities should follow the recommendations outlined in the "Navigation Channels" section earlier in this chapter. A permit will be required under NR 109 prior to management activities.

A lake-wide Eurasian water-milfoil management strategy should be developed that will reduce the ecological impacts of this exotic invasive species. Large-scale chemical treatments using 2,4-D or selective mechanical harvesting are the two primary options. Due to the large financial burden associated with lake-wide management, the District should sponsor a pilot study to determine which method will be successful on Fox Lake. Planning for the pilot study should begin in the winter of 2006-7 and commence in 2007-2008. Potential funding sources for a pilot study are the WDNR Aquatic Invasive Species Grant Program and the U.S. Army Corps of Engineers.

Due to Fox Lake's tendency to shift between clear and turbid water states, an annual comprehensive aquatic plant survey should occur over the duration of this plan. Assuming there are no major changes in the aquatic plant community, this criteria could be relaxed with the next aquatic plant management plan update in 3 to 5 years.

Evaluation

The Fox Lake Long-term Aquatic Plant Management Plan should be revised in 3 to 5 years utilizing a planning effort similar to the initial plan development. Benchmarks to gauge the success of the current plan include data from aquatic plant surveys, feedback from the public regarding navigation and recreation, and maintaining water clarity.

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