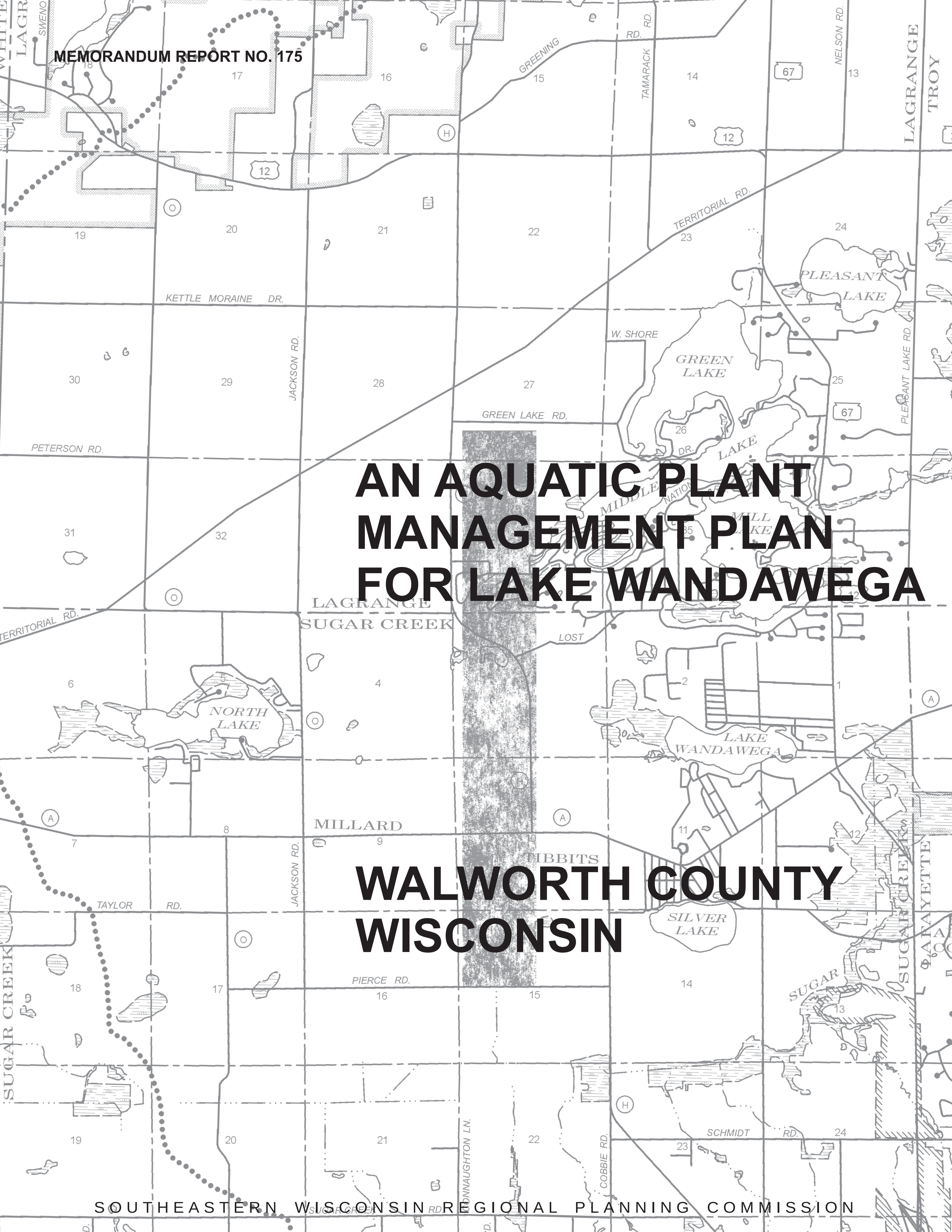
MEMORANDUM REPORT NO. 175



AN AQUATIC PLANT MANAGEMENT PLAN FOR LAKE WANDAWEGA

WALWORTH COUNTY WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due to Dr. Jeffrey A. Thornton, CLM, PH, and Dr. Thomas M. Slawski, SEWRPC Principal Planners; Ms. Sara W. Teske, SEWRPC Research Analyst; Mr. Edward J. Schmidt, SEWRPC GIS Planning Specialist; and Mr. Michael A. Borst, SEWRPC Research Aide, for their contributions to the conduct of this study and the preparation of this report.

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WALWORTH COUNTY, WISCONSIN

Prepared by the

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The preparation of this publication was financed in part through a grant from the Wisconsin Department of Natural Resources Lake Management Planning Grant Program.

April 2009

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Chapter I

INTRODUCTION

Lake Wandawega is a 119-acre seepage lake located entirely within U.S. Public Land Survey Township 3 North, Range 16 East, Sections 1, 2, 11, and 12, Town of Sugar Creek, in Walworth County, Wisconsin. The Lake is a valuable natural resource offering a variety of recreational and related opportunities to the resident community and its visitors. In recent years, however, the recreational and aesthetic values of Lake Wandawega have been perceived by residents and their visitors to be adversely affected by excessive aquatic plant growths within portions of the Lake. Seeking to improve the usability and to prevent the deterioration of its natural assets and recreational potential, the Lake Wandawega community created the Lake Wandawega Improvement Association, Inc. (LWIA), as a vehicle through which to undertake lake management actions to protect and rehabilitate the Lake. The LWIA, in cooperation with the Town of Sugar Creek, continues to undertake annual programs of lake and aquatic plant management in the basin.

Lake Wandawega has been the subject of earlier lake management-related investigations, including a special inland lake study program conducted cooperatively by the Wisconsin Department of Natural Resources (WDNR) and the Southeastern Wisconsin Regional Planning Commission (SEWRPC), documented in a WDNR *Lake Use Report* published in 1969;[1] and, a nonpoint source pollution abatement planning program, documented in a WDNR Priority Watershed Plan.[2] This report provides information on the condition of the aquatic plant communities in Lake Wandawega during 2007, including relevant tributary area and waterbody data, and provides recommendations for management of aquatic plants within Lake Wandawega.

BACKGROUND

Specifically, this report represents part of the ongoing commitment of the Lake Wandawega community, through the LWIA and the Town of Sugar Creek, to sound planning with respect to the Lake. The report sets forth inventories of the aquatic plant communities present within Lake Wandawega. Those inventories were prepared by SEWRPC in cooperation with the LWIA, and include the results of field surveys conducted by the Commission staff during July and August of 2007. The aquatic plant surveys were conducted by Commission

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[1]*Wisconsin Department of Natural Resources Publication Lake Use Report No. FX-30,* Wandawega Lake, Walworth County, Wisconsin, *1969.*

[2]*Wisconsin Department of Natural Resources Publication No. WT-478-97,* Nonpoint Source Control Plan for the Sugar/Honey Creek Priority Watershed Project, *February 1997.*

staff using the modified Jesson and Lound[3] transect method developed by the WDNR. The planning program was funded, in part, through a Chapter NR 190 Lake Management Planning Grant awarded to the LWIA and administered by the WDNR.

The scope of this report is limited to a consideration of the current water quality conditions and aquatic plant communities present within Lake Wandawega, the documentation of historical changes in the plant communities based upon currently existing data and information, and the refinement of those management measures which can be effective in the control of aquatic plant growth in the Lake. Recommendations are made with respect to the potential management measures proposed to be implemented by the LWIA and the Town of Sugar Creek.

AQUATIC PLANT MANAGEMENT PROGRAM GOALS AND OBJECTIVES

The aquatic plant management goals and objectives for Lake Wandawega were developed in consultation with the LWIA and the Town of Sugar Creek. The agreed-upon goals and objectives are to:

1. Protect and maintain public health, and promote public comfort, convenience, necessity, and welfare, in concert with the natural resource, through the environmentally sound management of native vegetation, fishes, and wildlife populations in and around Lake Wandawega;

2. Effectively control the quantity and density of aquatic plant growths in portions of the Lake Wandawega basin to better facilitate the conduct of water-related recreation, improve the aesthetic value of the resource to the community, and enhance the natural resource value of the waterbody;

3. Effectively maintain the water quality of Lake Wandawega to better facilitate the conduct of water-related recreation, improve the aesthetic value of the resource to the community, and enhance the resource value of the waterbody; and,

4. Promote a quality, water-based experience for residents and visitors to Lake Wandawega consistent with the policies and objectives of the WDNR as set forth in the regional water quality management plan, SEWRPC Planning Report No. 30, *A Regional Water Quality Management Plan for Southeastern Wisconsin—2000*, adopted by the Regional Planning Commission on July 12, 1979.

The inventory and aquatic plant management plan elements presented in this report conform to the requirements and standards set forth in the relevant *Wisconsin Administrative Codes.*[4] Implementation of the recommended actions set forth herein should continue to serve as an important step in achieving the stated lake use objectives over time.

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[3]*R. Jesson, and R. Lound, Minnesota Department of Conservation Game Investigational Report No. 6,* An Evaluation of a Survey Technique for Submerged Aquatic Plants, *1962.*

[4]*This plan has been prepared pursuant to the standards and requirements set forth in the following chapters of the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 103, "Water Quality Standards for Wetlands;" Chapter NR 107, "Aquatic Plant Management;" and Chapter NR 109, "Aquatic Plants Introduction, Manual removal and Mechanical Control Regulations."*

Chapter II

INVENTORY FINDINGS

INTRODUCTION

Lake Wandawega is located in the Town of Sugar Creek, Walworth County, Wisconsin, as shown on Map 1. Lake Wandawega is a natural lake comprised of two shallow basins. The Lake is a seepage lake and, as such, depends principally on precipitation falling directly onto the Lake's surface, runoff from the tributary area, and groundwater flowing into the Lake for its sources of water; it has no defined inlet or outflow. The level of the Lake is largely sustained through local groundwater inflows and precipitation.

WATERBODY CHARACTERISTICS

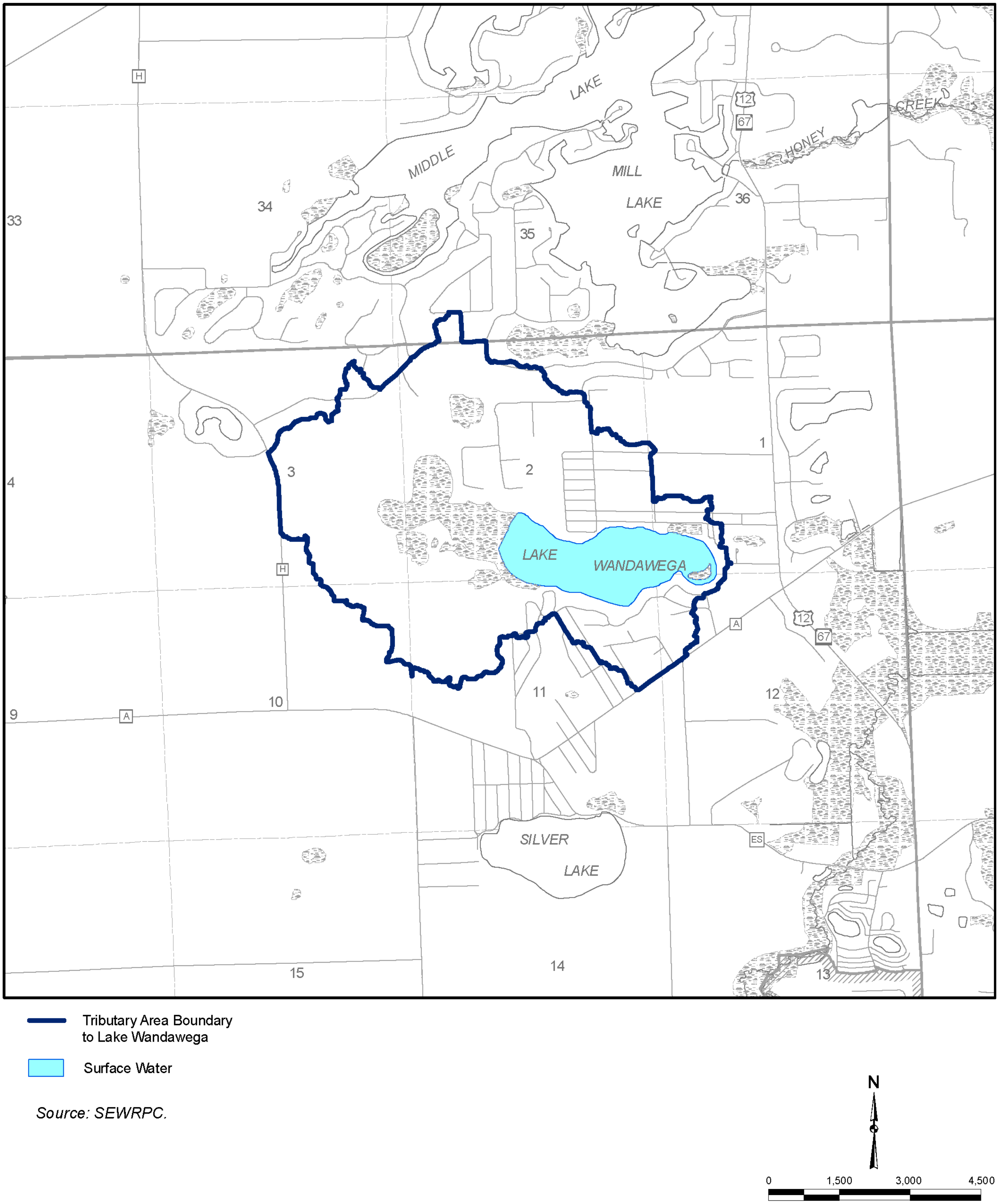
Lake Wandawega is a 119-acre waterbody, the hydrographical characteristics of which are set forth in Table 1. As aforementioned, the Lake is a shallow, seepage lake, oriented in approximately an east-west orientation. Lake Wandawega has a maximum depth of approximately eight feet, a mean depth of four feet, and a volume of about 480 acre-feet. The bottom contours of the Lake reveal a generally uniform basin. The bathymetry of the Lake is shown on Map 2.

The lake shoreline is 2.3 miles in length, with a shoreline development factor of 1.5, indicating that, due to its naturally elongate shape, the shoreline is about one and one-half times longer than that of a perfectly circular lake of the same area. The shoreline development factor is important because it is often related to the amount of littoral zone (the shallower, nearshore area of a lake usually rich in plant and animal life) in a lake. The greater a lake's shoreline development factor, the more irregular its shoreline and, therefore, the greater the likelihood of the lake containing an extensive littoral zone area with habitat suitable for plant and animal life. By comparison, the shoreline development factor of 1.5 suggests that the shoreline geography of Lake Wandawega has a greater similarity to that of the nearby Silver Lake to the south, with a factor of 1.2—indicating that Silver Lake is nearly circular shape—than to that of the neighboring Lauderdale Lakes to the north, which have a shoreline development factor of 3.9—reflecting that waterbody's highly irregular shoreline.

Other physical factors, such as bottom sediment composition and basin contours, also impact the amount of biological activity in a lake. Lake bottom sediment types in the nearshore areas of Lake Wandawega consist of soft sediments along about 80 percent of the shoreline, with gravel and rubble comprising about 18 percent of the shoreline, and sand comprising only about 2 percent of the shoreline. Additionally, the lake bottom has a shallow, relatively low pitch. A preponderance of soft bottom sediments and flatness of bottom contour are conditions consistent with lakes of higher productivity.

Map 1

LOCATION OF LAKE WANDAWEGA



Source: SEWRPC.

Table 1

HYDROLOGY AND MORPHOMETRY OF LAKE WANDAWEGA: 2007

Parameter	Wandawega Lake
Size	
Surface Area of Lake	119 acres
Total Tributary Area[a]	1,066 acres
Lake Volume	480 acre-feet
Residence Time[b]	2.0 years
Shape	
Length of Lake	0.7 mile
Width of Lake	0.3 mile
Length of Shoreline	2.3 miles
Shoreline Development Factor[c]	1.5
General Lake Orientation	East-west
Depth	
Mean Depth	4 feet
Maximum Depth	8 feet
Percentage of Lake Area	
Less than Three Feet	32 percent
Greater than 20 Feet	0 percent

[a]The total tributary area for Lake Wandawega has been variously recorded in earlier reports to be between 989 to 1,203 acres. The current measurement is based on elevation refinements made possible through Commission digital terrain modeling analysis.

[b]Residence time is estimated as the time period required for a volume of water equivalent to the volume of the lake to enter the lake during years of normal precipitation.

[c]Shoreline development factor is the ratio of the shoreline length to the circumference of a circular lake of the same area.

Source: Wisconsin Department of Natural Resources, U.S. Geological Survey, and SEWRPC.

TRIBUTARY AREA AND LAND USE CHARACTERISTICS

As shown on Map 3, the area tributary to Lake Wandawega is situated mostly within the Town of Sugar Creek, with a small portion of the extreme northern edge of the tributary area being situated in the Town of LaGrange, both in Walworth County. This area, which drains directly to Lake Wandawega, is approximately 1,066 acres, or about 1.7 square miles, in areal extent. The Lake and its tributary area are situated in the north-central portion of Walworth County.

Population

Population and the number of housing units within the Lake Wandawega tributary area have generally shown a relatively steady increase since 1960, as documented in Table 2. After a large increase in population between 1970 and 1980, the population of the Lake Wandawega community remained fairly static during the decade between 1980 and 1990, prior to another population increase at the end of the 20th Century. The greatest increase in population occurred between 1990 and 2000 when the number of people increased by nearly 40 percent, from 536 persons to 749 persons. The number of housing units increased steadily during the period of 1960 to 2000, and increased most rapidly between 1990 and 2000, when the number of housing units increased from 189 units to 269 units, an increase of over 42 percent.

Land Uses

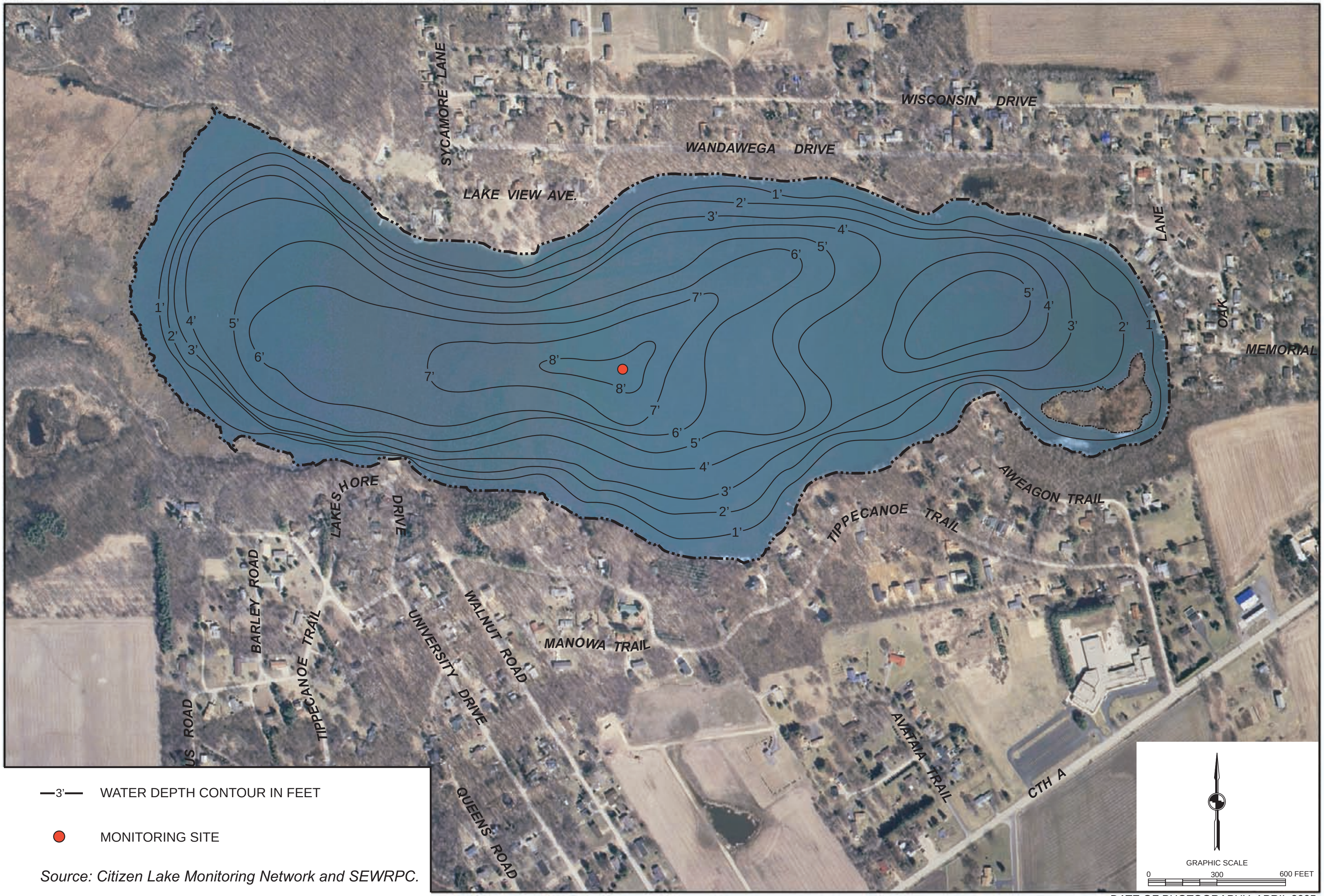
The land uses within the area tributary to Lake Wandawega are primarily rural, with agricultural uses being the dominant rural land use. The shoreline of the Lake, however, is largely developed for residential uses. Extensive wetland areas are located at the western and southeastern ends of the Lake, with a woodland area being located along the northern shore of the Lake.

Map 4 shows the existing land uses within the tributary area as of 2000; those uses also are summarized in Table 3. Future changes in land use within the area tributary to the Lake may include limited further urban development, infilling of already platted lots, and possible redevelopment of existing properties.

Under proposed year 2035 conditions, as shown on Map 5 and summarized in Table 3, urban land uses are expected to further increase, from about 25 percent of the land coverage in 2000 to about 46 percent of the land coverage in 2035. Agricultural uses are anticipated to decrease from about 75 percent of the land coverage in the year 2000, to about 54 percent of the land coverage under planned year 2035 conditions. These land use changes have the potential to modify the nature and delivery of nonpoint source contaminants to the Lake, with concomitant impacts on the aquatic plant communities within the waterbody.

Map 2

BATHYMETRIC MAP OF LAKE WANDAWEGA



DATE OF PHOTOGRAPHY: APRIL 2005

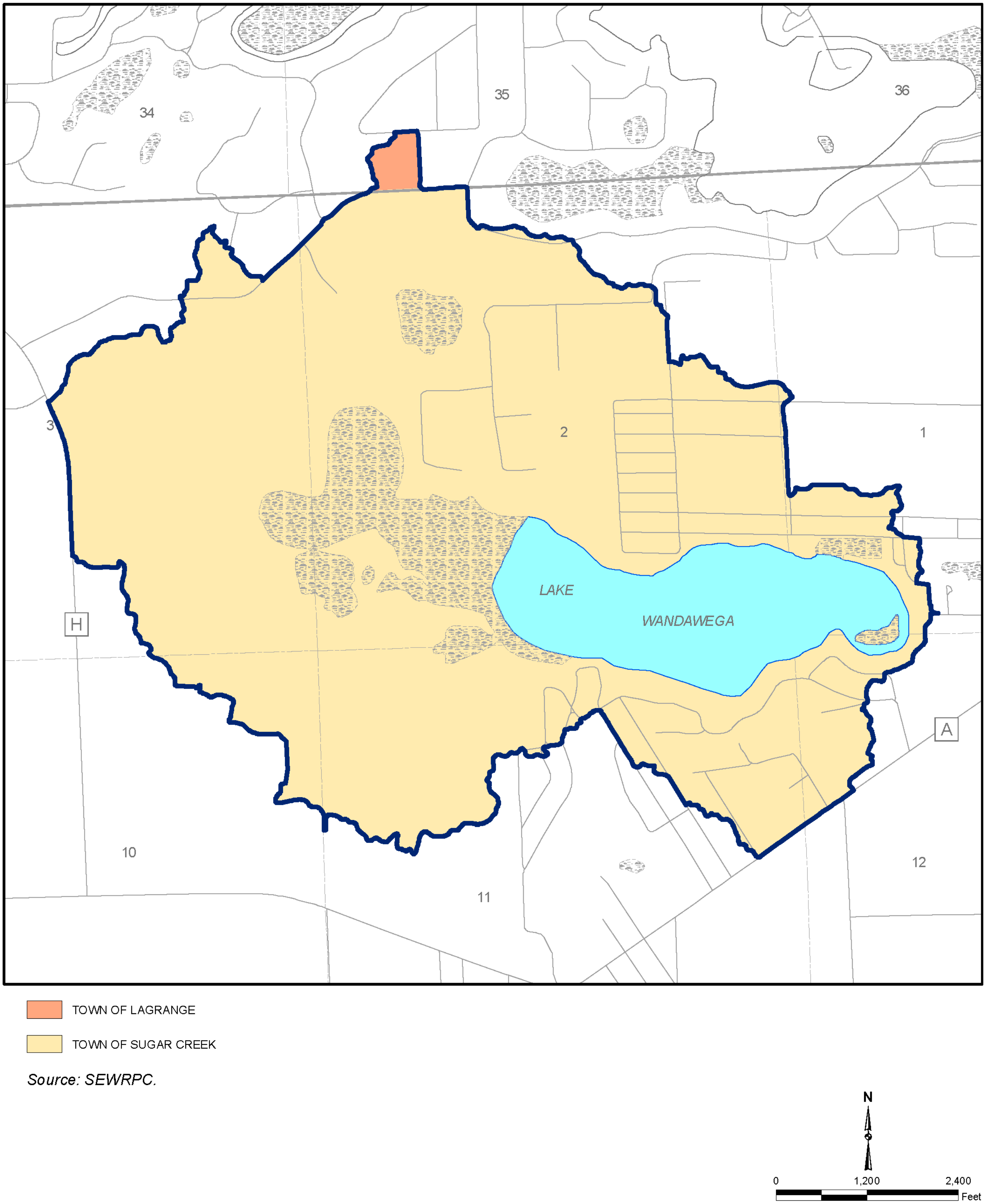
—3'— WATER DEPTH CONTOUR IN FEET

● MONITORING SITE

Source: Citizen Lake Monitoring Network and SEWRPC.

Map 3

CIVIL DIVISION BOUNDARIES WITHIN THE LAKE WANDAWEGA TRIBUTARY AREA



Source: SEWRPC.

Table 2

POPULATION AND HOUSEHOLDS WITHIN THE AREA TRIBUTARY TO LAKE WANDAWEGA: 1960-2000[a]

Year	Direct Tributary Area	
	Population	Households
1960	319	80
1970	383	116
1980	557	183
1990	536	189
2000	749	269

Source: U.S. Bureau of the Census and SEWRPC.

SHORELINE PROTECTION STRUCTURES

Erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with lake access and use. Wind-wave erosion, ice movement, and motorized boat traffic usually cause such erosion. A survey of the shoreline of Lake Wandawega, conducted by Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff during 2007, indicated that, at that time, nearly all of the shoreline was vegetated, with the exception of several small beach areas and a few small isolated sections of riprap or bulkheads, as shown on Map 6. There were no severe erosion-related problems observed along the Lake shoreline during this survey, although some upland erosion associated with stormwater conveyances was observed in the vicinity of the Lake at Evergreen Lane, near Sycamore Lane, and adjacent to Aweagon Trail.

WATER QUALITY

Water quality data on Lake Wandawega have been collected intermittently since 1966. Data have been acquired under the auspices of the Wisconsin Department of Natural Resources (WDNR) Baseline Monitoring Program and the UWEX Citizen Lake Monitoring Network (CLMN), formerly known as the WDNR Self-Help Monitoring Program. Water quality data currently available are summarized below, and presented in Appendix A.

Water Clarity

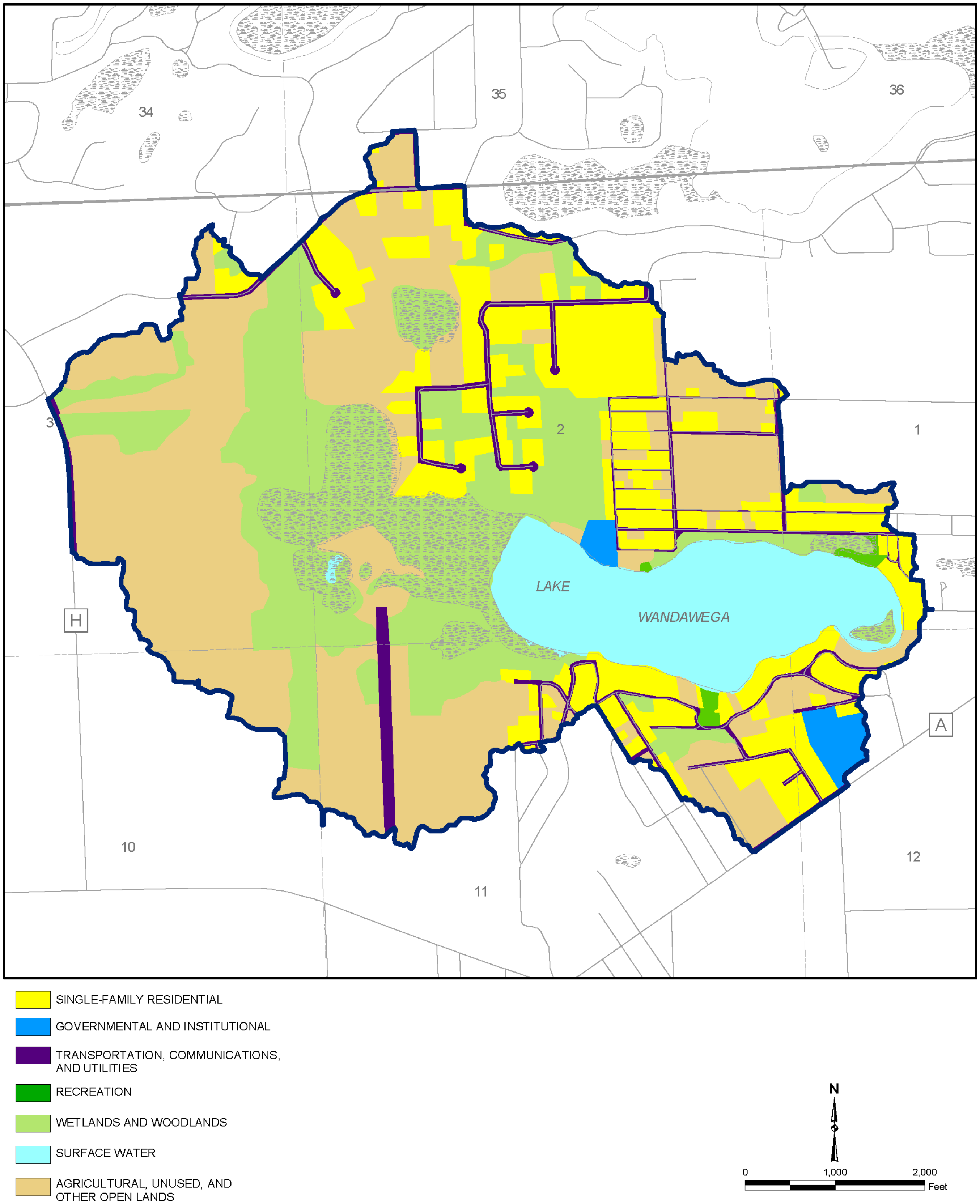
Water clarity, or transparency, is often used as an indication of water quality. Transparency can be affected by physical factors, such as water color and suspended particles, and by various biologic factors, including seasonal variations in planktonic algal populations living in the lake. Water clarity is measured typically with a Secchi disk: a black-and-white, eight-inch-diameter disk, which is lowered into the water until a depth is reached at which the disk is no longer visible. This depth is known as the "Secchi-disk reading." Such measurements comprise an important part of the aforementioned CLMN program in which citizen volunteers assist in lake water quality monitoring efforts.

Since 1966, transparency measurements for Lake Wandawega have varied from about 1.5 feet to 7.0 feet, generally indicating poor to fair water quality. The data seem to indicate a slight overall improvement in water clarity during the period from 1999 through 2006, although due to the overall scarcity of data, it is difficult to accurately assess whether there is a general trend toward improving water clarity in Lake Wandawega. Further, records of Secchi disk transparency measurements reported from the Lake frequently indicate that the Secchi disk had hit the lake bottom, resulting in an underestimate of water clarity. This, in turn, has resulted in an overestimate of lake trophic state, as noted below.

As of January 2007, Lake Wandawega was not listed by the WDNR as having an established population of zebra mussels (*Dreissena polymorpha*). Zebra mussels, a nonnative species of shellfish with known negative impacts on native benthic organism populations, are having a varied impact on the inland lakes of the Upper Midwest, disrupting the food chain by removing significant amounts of bacteria and smaller phytoplankton which serve as food for a variety of other aquatic organisms, including larval and juvenile fishes and many forms of zooplankton. As a result of the filter feeding proclivities of these animals, many lakes have experienced improved water clarity. This improved water clarity, in turn, has led to increased growths of rooted aquatic plants, including Eurasian water milfoil. Curiously, within the Southeastern Wisconsin Region, zebra mussels have been observed attaching themselves to the stalks of the Eurasian water milfoil plants, dragging the stems out of the zone of light penetration due to the weight of the zebra mussel shells, and interfering with the competitive strategy of the

Map 4

EXISTING LAND USE WITHIN THE LAKE WANDAWEGA TRIBUTARY AREA: 2000



Source: SEWRPC.

Table 3

EXISTING AND PLANNED LAND USE WITHIN THE TOTAL AREA TRIBUTARY TO LAKE WANDAWEGA: 2000 AND 2035

Land Use Categories[a]	2000 Acres	2000 Percent of Tributary Area	2035 Acres	2035 Percent of Tributary Area
Urban				
Residential	192	18.0	366	34.3
Commercial	- -	- -	2	0.2
Industrial	- -	- -	- -	- -
Governmental and Institutional	13	1.2	13	1.2
Transportation, Communication, and Utilities	56	5.3	100	9.4
Recreational	4	0.4	6	0.6
Subtotal	265	24.9	487	45.7
Rural				
Agricultural and Other Open Lands	395	37.0	179	16.8
Wetlands	91	8.5	91	8.5
Woodlands	194	18.2	188	17.6
Surface Water	121	11.4	121	11.4
Extractive	- -	- -	- -	- -
Landfill	- -	- -	- -	- -
Subtotal	801	75.1	579	54.3
Total	1,066	100.0	1,066	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

Eurasian water milfoil plants. This has contributed to improved growths of native aquatic plants in some cases, and to the growths of filamentous algae too large to be ingested by the zebra mussels in others. Should zebra mussels become established in Lake Wandawega, their populations should be carefully monitored. Regardless as to the seemingly beneficial impacts of these animals, the overall effect is that, as zebra mussels and other invasive species spread to inland lakes and rivers, so do the environmental, aesthetic, and economic costs to water users.

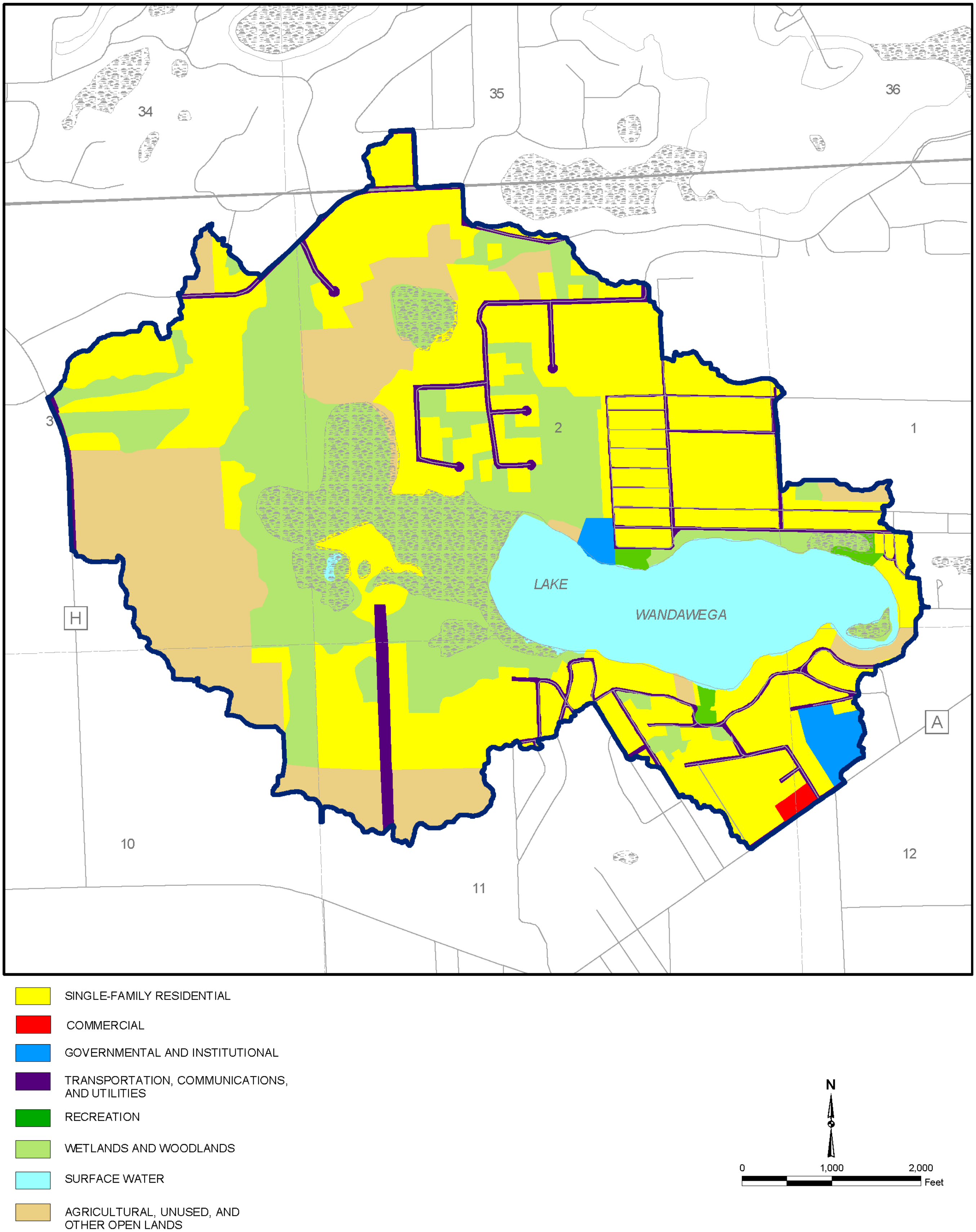
In addition to in-lake direct measurements of water clarity using a Secchi disk, transparency of many Wisconsin lakes has been measured using remote sensing technology. The Environmental Remote Sensing Center (ERSC), established in 1970 at the University of Wisconsin-Madison campus, was one of the first remote sensing facilities in the United States. Using data gathered by satellite remote sensing over a three-year period, the ERSC generated a map based on a mosaic of satellite images showing the estimated water clarity of the largest 8,000 lakes in Wisconsin. The WDNR, through its volunteer Self-Help Monitoring Program (now the CLMN) was able to gather water clarity measurements from about 800 lakes, or about 10 percent of Wisconsin's largest lakes. Of these, the satellite remote sensing technology utilized by ERSC was able to accurately estimate clarity, providing a basis for extrapolating water clarity estimates to the remaining 90 percent of lakes. Measurements collected through ERSC remote sensing program estimated the average water clarity of Lake Wandawega to be about 6.1 feet, a value indicative of generally poor to fair water quality. Such data are essentially consistent with the abovementioned Self-Help Monitoring Program and CLMN Secchi-disk measurements.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. Generally, dissolved oxygen levels are higher at the surface of a lake, where there is an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved

Map 5

PLANNED LAND USE WITHIN THE LAKE WANDAWEGA TRIBUTARY AREA: 2035



Source: SEWRPC.

Map 6

SHORELINE PROTECTION STRUCTURES ON LAKE WANDAWEGA: 2007

Source: SEWRPC.

DATE OF PHOTOGRAPHY: APRIL 2005

oxygen levels are usually lowest near the bottom of a lake, where decomposer organisms and chemical oxidation processes utilize oxygen in the decay process.

Early data on dissolved oxygen levels in Lake Wandawega showed very low levels of oxygen near both the surface and bottom of the Lake during the winter months of 1978 and 1979. This condition, common to many shallow lakes in Wisconsin, can lead to winter fish kills if oxygen stores are not sufficient to meet the total demand. Frequent winterkills and partial winterkills in Lake Wandawega were noted in the WDNR lake use report of 1969.[1] The 1979 regional water quality management plan also noted a severe winter fish kill as having occurred during the 1976 to 1977 study period.[2]

Current and past data for Lake Wandawega indicate oxygen levels at all depths during open water periods were likely to be adequate to support fish and other aquatic animal life, although due to the overall scarcity of data, it is difficult to determine this with certainty. Because Lake Wandawega is shallow, wind turbulence during these open water periods, along with plant photosynthesis, would be expected to keep dissolved oxygen concentrations at acceptable levels at all water depths throughout the open water periods. It is likely also that this wind-induced mixing would prevent the Lake from thermally stratifying during these periods.

Notwithstanding, when a lake becomes stratified—that is, when a thermal or chemical gradient of sufficient intensity produces a barrier separating upper waters, called the epilimnion, from lower waters, known as the hypolimnion, the surface supply of oxygen to the hypolimnion is cut off. Eventually, if there is not enough dissolved oxygen to meet the demands from the bottom dwelling aquatic life and decaying organic material, the dissolved oxygen levels in the bottom waters may be reduced to zero, a condition known as anoxia or anaerobiasis. Data for Lake Wandawega do not indicate anoxia during open-water periods, due, no doubt, to the fact that the Lake does not appear to stratify during summer.

Where oxygen levels are depleted in the hypolimnion, fish tend to move upward, nearer to the surface of the lake, where higher dissolved oxygen concentrations exist. This migration, when combined with temperature, can select against some fish species that prefer the cooler water temperatures that generally prevail in the lower portions of the lakes. When there is insufficient oxygen at these depths, these fish are susceptible to summer-kills, or, alternatively, are driven into the warmer water portions of the lake where their condition and competitive success may be severely impaired.

In addition to these biological consequences, the lack of dissolved oxygen at depth can enhance the development of chemoclines, or chemical gradients, with an inverse relationship to the dissolved oxygen concentration. For example, the sediment-water exchange of elements, such as phosphorus, iron, and manganese, is increased under anaerobic conditions, resulting in increased hypolimnetic concentrations of these elements. Under anaerobic conditions, changes in iron and manganese oxidation states enable the release of phosphorus from the iron and manganese complexes to which they were bound under aerobic conditions. This "internal loading" can affect water quality significantly if these nutrients and salts are mixed into the epilimnion, especially during early summer, when these nutrients can become available for algal and rooted aquatic plant growth. Water quality data currently available suggest that internal loading is not likely in Lake Wandawega, due to the apparent lack of stratification in the Lake, although more data need to be collected to accurately determine this.

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[1]*Wisconsin Department of Natural Resources Publication Lake Use Report No. FX-30,* Lake Wandawega, Walworth County, Wisconsin, *1969.*

[2]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, *Volume Two*, Alternative Plans, *February 1979.*

Chlorophyll-*a*

Chlorophyll-*a* is the major photosynthetic ("green") pigment in algae. The amount of chlorophyll-*a* present in the water is an indication of the biomass or amount of algae in the water. The mean chlorophyll-*a* concentration for lakes in southeastern Wisconsin is about 43.3 micrograms per liter (μg/l), with a median concentration of about 9.9 μg/l.[3] Chlorophyll-*a* levels above about 10 μg/l result in a green coloration of the water that may be severe enough to impair recreational activities, such as swimming or waterskiing.[4] As reported in the initial regional water quality management plan, water samples collected from Lake Wandawega during late July and late August of 1976 had chlorophyll-*a* values above 15 milligrams per cubic meter (mg/m^3 = μg/l). During the period from 1980 through 1999, chlorophyll-*a* concentrations in Lake Wandawega ranged from 0.37 μg/l to 5.0 μg/l, with mean chlorophyll-*a* concentrations averaging about 1.9 μg/l. These more recent data suggest that Lake Wandawega may not be experiencing regular problem levels of chlorophyll-*a*, although more data are needed to assess this with any degree of certainty.

Nutrient Characteristics

Aquatic plants and algae require such nutrients as phosphorus and nitrogen for growth. In hard-water alkaline lakes, most of these nutrients are generally found in concentrations that exceed the needs of growing plants. However, in lakes where the supply of one or more of these nutrients is limited, plant growth is limited by the amount of the nutrient that is available in the least quantity relative to all of the others. The ratio (N:P) of total nitrogen (N) to total phosphorus (P) in lake water indicates which nutrient is the factor most likely to be limiting aquatic plant growth in a lake.[5] Where the N:P ratio is greater than 14:1, phosphorus is most likely to be the limiting nutrient. If the ratio is less than 10:1, nitrogen is most likely to be the limiting nutrient. During the period from 1976 through 1979, the N:P ratio was always 16:1 or greater, indicating plant growth at that time was consistently limited by phosphorus, which is common in most inland lakes in Wisconsin. There are no current data available to determine N:P ratios for Lake Wandawega, although it is unlikely that the phosphorus-limited condition of the Lake has changed since the late-1970s.

Total phosphorus concentrations were measured for Lake Wandawega intermittently during the period from 1978 through 2004. Total phosphorus concentrations include the phosphorus contained in plant and animal fragments suspended in the lake water, phosphorus bound to sediment particles, and phosphorus dissolved in the water column, and is, therefore, usually considered a good indicator of nutrient status in a lake.

For lakes, the guideline value set forth in the adopted regional water quality management plan is 20 μg/l of total phosphorus or less during spring turnover. This is the level considered as necessary to limit algal and aquatic plant growths to levels consistent with recreational water use objectives, as well as water use objectives for maintaining a warmwater fishery and other aquatic life. In Lake Wandawega, as described in the aforereferenced Priority Watershed Plan,[6] the 1995 spring total phosphorus concentration was 10 μg/l; the summer phosphorus concentrations averaged 15 μg/l. Total phosphorus concentrations since that time have been about the same as the 1995 summer average. These levels were found to be below the levels necessary to support nuisance algae

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[3]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *1983*.

[4]*J.R. Vallentyne, 1969 "The Process of Eutrophication and Criteria for Trophic State Determination." in* Modeling the Eutrophication Process—Proceedings of a Workshop at St. Petersburg, Florida, *November 19-21, 1969, pp. 57-67.*

[5]*M.0. Allum, R.E. Gessner, and T.H. Gakstatter, U.S. Environmental Protection Agency Working Paper No. 900,* An Evaluation of the National Eutrophication Data, *1976.*

[6]*Wisconsin Department of Natural Resources Publication No. WT-478-97,* Nonpoint Source Control Plan for the Sugar/Honey Creek Priority Watershed Project, *February 1997.*

blooms. As recommended in the aforereferenced Priority Watershed Plan, water resource objectives and management recommendations for Lake Wandawega were compiled so as to reduce the overall phosphorus loading by 18 percent from conditions prevailing at the time of the project. Achievement of such a reduction would reflect the best managed conditions possible in the Lake.

Seasonal gradients of phosphorus concentrations between the epilimnion and hypolimnion of a lake reflect the biogeochemistry of this growth element. When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed. Phosphorus from these organisms is then either stored in the bottom sediments or rereleased into the water column. Because phosphorus is not highly soluble in water, it readily forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions and accumulates, predominantly, in the lake sediments. If the bottom waters become depleted of oxygen during stratification, however, certain chemical changes occur, including the change in the oxidation state of iron from the insoluble Fe^{3+} state to the more soluble Fe^{2+} state. The effect of these chemical changes is that phosphorus becomes soluble and is more readily released from the sediments – in a process known as *internal loading*. This process also occurs under aerobic conditions, but generally at a slower rate than under anaerobic conditions. As the waters mix, this phosphorus may be widely dispersed throughout the lake waterbody and become available for algal growth.

Phosphorus concentration and related physic-chemical data for Lake Wandawega for the period 1978 to 1979, as tabulated in Appendix A, indicate that significant internal loading of phosphorus in Lake Wandawega was not likely to have occurred given the shallow, well-mixed nature of the Lake. While there are no current comprehensive water quality data available to determine the likelihood of such loading occurring since that time, the shallow depth of the Lake would suggest that internal loading of phosphorus into the Lake from the lake sediments is likely to be minimal.

Should any such loading occur, the magnitude of the release and its subsequent effects in contributing to algal growth in the surface waters of the Lake may be moderated by a number of circumstances, including the rates of mixing during the spring and fall overturn events. Slow mixing generally results in any phosphorus released into the bottom waters of the Lake being reprecipitated and unavailable to aquatic plants.[7]

POLLUTION LOADINGS AND SOURCES

Pollutant loads to a lake are generated by various natural processes and human activities that take place in the area tributary to a lake. These loads are transported to the lake through the atmosphere, across the land surface, and by way of inflowing streams. Pollutants transported by the atmosphere are deposited onto the surface of the lake as dry fallout and direct precipitation. Pollutants transported across the land surface enter the lake directly as surface runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Pollutants transported by streams also enter a lake as surface water inflows.

In seepage lakes, like Lake Wandawega, pollutant loadings transported by way of precipitation falling directly onto the lakes' surfaces, runoff from the tributary areas immediately surrounding the lakes, and groundwater flowing into the lakes comprise the principal routes by which contaminants enter the waterbodies.[8] Currently, there are no significant point source discharges of pollutants into Lake Wandawega. For this reason, the discussion that follows is based upon nonpoint source pollutant loadings to the Lake.

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[7]*See, for example, R.D. Robarts, P.J. Ashton, J.A. Thornton, H.J. Taussig, and L.M. Sephton, "Overturn in a hypertrophic, warm, monomictic impoundment (Hartbeespoort Dam, South Africa),"* Hydrobiologia*, Volume 97, 1982, pp. 209-224.*

[8]*Sven-Olof Ryding and Walter Rast,* The Control of Eutrophication of Lakes and Reservoirs*, Unesco Man and the Biosphere Series, Volume 1, Parthenon Press, Carnforth, 1989; Jeffrey A. Thornton, Walter Rast, Marjorie M. Holland, Geza Jolankai, and Sven-Olof Ryding,* The Assessment and Control of Nonpoint Source Pollution of Aquatic Ecosystems*, Unesco Man and the Biosphere Series, Volume 23, Parthenon Press, Carnforth, 1999.*

Nonpoint sources of water pollution include urban sources, such as runoff from residential, commercial, transportation, construction, and recreational activities; and rural sources, such as runoff from agricultural lands and onsite sewage disposal systems.

Nonpoint source phosphorus, suspended solids, and urban-derived metals inputs to Lake Wandawega were estimated using the Wisconsin Lake Model Spreadsheet (WILMS version 3.0),[9] and the unit area load-based models developed for use within the Southeastern Wisconsin Region.[10]

Phosphorus Loadings

During the current study, as shown in Table 4, existing year 2000 phosphorus loads to Lake Wandawega were identified and quantified using Commission land use inventory data.[11] It was estimated that, under year 2000 conditions, the total phosphorus load to Lake Wandawega was about 430 pounds. Of the annual total phosphorus load, it was estimated that approximately 367 pounds per year, or about 85 percent of the total loading, were contributed by runoff from rural lands, mostly agricultural, and 63 pounds per year, or about 15 percent, were contributed by runoff from urban lands, mostly from residential sources. About 16 pounds, or about 4 percent, were contributed by direct precipitation onto the lake surface.

Phosphorus release from the lake bottom sediments, or internal loading, as discussed above, does not appear to have been a contributing factor to the total phosphorus loading to the Lake.

Under forecast year 2035 conditions, as set forth in the adopted regional land use plan,[12] the annual total phosphorus load to the Lake is anticipated to diminish as agricultural activities within the area tributary to Lake Wandawega are replaced by urban residential land uses. Table 5 shows the estimated phosphorus loads to Lake Wandawega under planned year 2035 conditions. The most likely annual total phosphorus load to the Lake under the planned conditions is estimated to be about 287 pounds. Of the total annual forecast phosphorus load of 287 pounds of phosphorus to Lake Wandawega, approximately 181 pounds per year, or about 63 percent of the total loading, are estimated to be contributed by runoff from rural land, and 106 pounds per year, or about 37 percent, from urban land. About 16 pounds, or about 6 percent, are expected to be contributed by direct precipitation onto the lake surface. Thus, it may be anticipated that not only will the amount of the phosphorus load decrease, but that the distribution of the sources of the phosphorus load to the Lake may change, with the amount of phosphorus being contributed from urban sources experiencing an increase from 15 percent of the total in 2000 to about 37 percent of the total in 2035, while the amount of phosphorus from rural sources will decrease from 85 percent of the total in 2000 to about 63 percent of the total in 2035.

However, this trend may be offset by the increasing utilization of agro-chemicals in urban landscaping.[13] Studies within the Southeastern Wisconsin Region indicate that urban residential lands fertilized with a phosphorus-based

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[9]*John C. Panuska and Jeff C. Kreider, Wisconsin Department of Natural Resources Publication No. PUBL-WR-363-94,* Wisconsin Lake Modeling Suite Program Documentation and User's Manual, Version 3.3 for Windows, *August 2002.*

[10]*SEWRPC Planning Report No. 30,* op. cit.

[11]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

[12]Ibid.

[13]*U.S. Geological Survey Water-Resources Investigations Report No. 02-4130,* Effects of Lawn Fertilizer on Nutrient Concentration in Runoff from Lakeshore Lawns, Lauderdale Lakes, Wisconsin, *July 2002.*

Table 4

ESTIMATED ANNUAL POLLUTANT LOADINGS TO LAKE WANDAWEGA BY LAND USE CATEGORY: 2000

Land Use Category	Pollutant Loads			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential[a]	1.9	38.4	0.0	1.6
Commercial	- -	- -	0.0	3.0
Industrial	- -	- -	0.0	1.5
Governmental	3.3	17.6	0.9	24.8
Transportation	0.3	6.2	0.0	0.0
Recreational	0.1	1.0	0.0	0.0
Subtotal	5.6	63.2	0.9	31.0
Rural				
Agricultural	88.9	339.7	0.0	0.0
Wetlands	0.2	3.6	0.0	0.0
Woodlands	0.4	7.8	0.0	0.0
Water	11.4	15.7	0.0	0.0
Extractive	- -	- -	- -	- -
Subtotal	100.9	366.8	0.0	0.0
Total	106.5	430.0	0.9	31.0

[a]*Includes the contribution from onsite sewage disposal systems. The contribution from onsite sewage disposal systems, based upon the* per capita *phosphorus contribution contained within wastewater estimated within the WILMS model, could range from approximately 20.5 pounds per year to as much as about 370.5 pounds per year, depending upon soil type, system condition, and system locations. For purposes of this analysis, 114.5 pounds per year were used as that value provided the loading that was best correlated to the measured in-lake phosphorus concentration.*

Source: SEWRPC.

fertilizer can contribute up to two times more dissolved phosphorus to a lake than lawns fertilized with a phosphorus-free fertilizer or not fertilized at all.[14]

Sediment Loadings

For the current study period, the estimated sediment loadings to Lake Wandawega under existing year 2000 are shown in Table 4. A total annual sediment loading of about 107 tons was estimated to be contributed to Lake Wandawega, as shown in Table 4. Of the likely annual sediment load, it was estimated that 101 tons per year, or about 94 percent of the total loading, were contributed by runoff from rural lands, mostly from agricultural sources, and six tons, or about 6 percent, contributed by urban lands. Approximately 11 tons, or about 10 percent of the annual sediment load, were contributed by atmospheric deposition onto the lake surface.

Under planned year 2035 conditions, as set forth in the adopted regional land use plan and as shown in Table 5, the annual sediment load to the Lake is anticipated to diminish. The most likely annual sediment load to the Lake under buildout conditions is estimated to be about 61 tons. Of the forecast sediment load anticipated for Lake Wandawega, about 52 tons of sediment are estimated to be contributed to the Lake from rural sources and eight tons from urban sources. Approximately 11 tons of sediment per year are estimated to continue to be contributed by direct precipitation onto the lake surface.

[14]Ibid.

Table 5

ESTIMATED ANNUAL POLLUTANT LOADINGS TO LAKE WANDAWEGA BY LAND USE CATEGORY: 2035

Land Use Category	Pollutant Loads			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential[a]	3.6	73.2	0.0	1.6
Commercial	0.8	2.4	0.4	3.0
Industrial	- -	- -	0.0	1.5
Governmental	3.3	17.6	0.9	24.8
Transportation	0.5	11.0	0.0	0.0
Recreational	0.1	1.6	0.0	0.0
Subtotal	8.3	105.8	1.3	30.9
Rural				
Agricultural	40.3	153.9	0.0	0.0
Wetlands	0.2	3.6	0.0	0.0
Woodlands	0.3	7.5	0.0	0.0
Water	11.4	15.7	0.0	0.0
Extractive	- -	- -	- -	- -
Subtotal	52.2	180.7	0.0	0.0
Total	60.5	286.5	1.3	30.9

[a]*Includes the contribution from onsite sewage disposal systems. The contribution from onsite sewage disposal systems, based upon the* per capita *phosphorus contribution contained within wastewater estimated within the WILMS model, could range from approximately 20.5 pounds per year to as much as about 370.5 pounds per year, depending upon soil type, system condition, and system locations. For purposes of this analysis, 114.5 pounds per year were used as that value provided the loading that was best correlated to the measured in-lake phosphorus concentration.*

Source: SEWRPC.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[15] The majority of these metals become associated with sediment particles[16] and, consequently, are likely to be encapsulated into the bottom sediments of a lake.

The estimated loadings of copper and zinc likely to be contributed to Lake Wandawega under existing year 2000 and forecast year 2035 land use conditions are shown in Tables 4 and 5, respectively. In 2000, about one pound of copper and 31 pounds of zinc were estimated to be contributed annually to Lake Wandawega, all from urban lands. Under planned year 2035 conditions, as set forth in the adopted regional land use plan,[17] the annual heavy metal loads to the Lake are anticipated to remain at about the same as those estimated under existing year 2000 conditions.

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[15]*Jeffrey A. Thornton, et al.*, op. cit.

[16]*Werner Stumm and James J. Morgan,* Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters, *Wiley-Interscience, New York, 1970.*

[17]*SEWRPC Planning Report No. 48,* op. cit.

TROPHIC STATUS

Lakes are commonly classified according to their degree of nutrient enrichment, or trophic status. The ability of lakes to support a variety of recreational activities and healthy fish and other aquatic life communities is often correlated to the degree of nutrient enrichment that has occurred. There are three terms generally used to describe the trophic status of a lake: oligotrophic, mesotrophic, and eutrophic.

Oligotrophic lakes are nutrient-poor lakes. These lakes characteristically support relatively few aquatic plants and often do not contain very productive fisheries. Oligotrophic lakes may provide excellent opportunities for swimming, boating, and waterskiing. Because of the naturally fertile soils and the intensive land use activities, there are relatively few oligotrophic lakes in southeastern Wisconsin.

Mesotrophic lakes are moderately fertile lakes which may support abundant aquatic plant growths and productive fisheries. However, nuisance growths of algae and macrophytes are usually not exhibited by mesotrophic lakes. These lakes may provide opportunities for all types of recreational activities, including boating, swimming, fishing, and waterskiing. Many lakes in southeastern Wisconsin are mesotrophic.

Eutrophic lakes are nutrient-rich lakes. These lakes often exhibit excessive aquatic macrophyte growths and/or experience frequent algae blooms. If the lakes are shallow, fish winterkills may be common. While portions of such lakes are not ideal for swimming and boating, eutrophic lakes may support very productive fisheries. Although some eutrophic lakes are present in the Region, severely eutrophic lakes are rare, especially since the regionwide implementation of recommendations put forth in the regional water quality management plan. Severely enriched lakes are sometimes referred to as being hypertrophic.

Several numeric "scales," based on one or more water quality indicators, have been developed to define the trophic condition of a lake. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numeric scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scale used is appropriate for the lake to which it is applies. In this case, two indices appropriate for Wisconsin lakes have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[18] and the Carlson Trophic State Index (TSI),[19] with a variation known as the Wisconsin Trophic State Index value (WTSI).[20] The WTSI is a refinement of the Carlson TSI and is designed to account for the greater humic acid content—brown water color—present in Wisconsin lakes; it has been adopted by the WDNR for use in lake management investigations.

Based on the Secchi-disk measurements recorded over the time period from 1966 to 2006, WTSI values for Lake Wandawega averaged about 56. Based upon data gathered during the aforementioned ERSC satellite remote sensing study, Lake Wandawega was estimated to have a TSI value of 51. A value above 50 is generally indicative of the enriched conditions associated with eutrophic lakes. While such a determination is consistent with the aforementioned physical factors of Lake Wandawega—to wit, lake bottom sediment composition and shallow lake bottom contours—and with the available water quality data obtained from the Lake, it is likely that the Lake is eutrophic, given that the Secchi disk used to measure water clarity, as mentioned above, frequently hit the bottom of the Lake while still visible. This, together with the total phosphorus concentrations of generally less

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[18]*H. Olem and G. Flock, U.S. Environmental Protection Agency Report EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition*, Walworth, D.C., August 1990.*

[19]*R.E. Carlson, "A Trophic State Index for Lakes,"* Limnology and Oceanography*, Vol. 22, No. 2, 1977.*

[20]*See R.A. Lillie, S. Graham, and P. Rasmussen, "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes,"* Research and Management Findings*, Wisconsin Department of Natural Resources Publication No. PUBL-RS-735 93, May 1993.*

than 0.02 mg/l and chlorophyll-*a* concentrations of less than 5 µg/l—as reported in Appendix A, would suggest that the Lake should be classified as oligo-mesotrophic, or relatively nutrient-poor.

AQUATIC PLANTS: DISTRIBUTION AND MANAGEMENT AREAS

Previous surveys and inventories of the aquatic macrophyte communities in Lake Wandawega were conducted by WDNR staff during in 1967, 1976, and 2005. For the current study, Commission staff conducted an aquatic plant survey on Lake Wandawega during August of 2007. A comparison of the submergent aquatic plant species reported from these surveys is set forth in Table 6, while the data from the August 2007 survey are set forth in greater detail in Table 7. The ecological significance of each submergent aquatic plant, compiled from the results of the 2007 Commission aquatic plant survey in Lake Wandawega, is set forth in Table 8. Representative illustrations of these aquatic plants can be found in Appendix B. Map 7 shows the distribution of aquatic plants in Lake Wandawega at the time of the 2007 aquatic plant survey.

The dominant submergent aquatic plant species during the July 1967 study were water milfoil (*Myriophyllum* sp.) and large-leaf pondweed (*Potamogeton amplifolius*).[21] Other species reported to be present in the Lake included muskgrass (*Chara vulgaris*), floating-leaf pondweed (*Potamogeton natans*), and Sago pondweed (*Potamogeton pectinatus*). It also was noted that vegetation was observed to be growing over the entire extent of the Lake basin, with milfoil being dominant in the nearshore areas and large-leaf pondweed being dominant in the deeper water areas. Floating-leaved aquatic plants reported during the 1967 survey included yellow and white water lilies (*Nuphar* sp. and *Nymphaea* sp.), duckweed (*Lemna* sp.) and watershield (*Brasenia schreberi*). Pickerel weed (*Pontederia* sp.) arrowhead (*Sagittaria* sp.), soft-stem bulrush (*Scirpus validus*) and cattail (*Typha* sp.) were noted as emergent macrophytes present in and around the Lake during 1967.

During the August 1976 survey, the dominant submergent aquatic species was bushy pondweed (*Najas flexilis*), and the second most abundant species was large-leaf pondweed.[22] Other submergent species reported during the 1976 survey included coontail (*Ceratophyllum demersum*), muskgrass, water milfoil, variable pondweed (*Potamogeton gramineus*), floating-leaf pondweed, Sago pondweed, white-stem pondweed (*Potamogeton praelongus*), clasping-leaf pondweed (*Potamogeton richardsonii*), and flat-stem pondweed (*Potamogeton zosteriformis*). Floating-leaved aquatic plants reported during the 1976 survey included yellow and white water lilies and watershield, with water smartweed (*Polygonum coccineum*) being noted as an emergent macrophyte present in and around the Lake during 1976.

As shown in Table 7, during the current study, the dominant submergent aquatic species were northern water milfoil (*Myriophyllum sibiricum*) and bushy pondweed. Also present in significant numbers were Illinois pondweed (*Potamogeton illinoensis*), waterweed (*Elodea canadensis*), Eurasian water milfoil (*Myriophyllum spicatum*), and muskgrass. Other submergent aquatic plants reported as present, but in lesser numbers, were coontail, large-leaf pondweed, variable pondweed, leafy pondweed (*Potamogeton foliosis*), floating-leaf pondweed, Sago pondweed, small pondweed (*Potamogeton pusillus*), clasping-leaf pondweed, flat-stem pondweed, white-water crowfoot (*Ranunculus longirostris*), bladderwort (*Utricularia* spp.), eel-grass (*Vallisneria Americana*), and water stargrass (*Zosterella dubia*). Floating-leaved aquatic plants observed on Lake Wandawega—shown on Map 7, but not included in the lists of submergent aquatic plants set forth in Tables 6 and 7—included yellow and white water lilies and watershield.

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[21] *Wisconsin Department of Natural Resources Publication Lake Use Report No. FX-30*, op. cit.

[22] *Unpublished manuscript: Wisconsin Department of Natural Resources and Southeastern Wisconsin Regional Planning Commission,* Lake Wandawega*, 1978.*

Table 6

SUBMERGENT AQUATIC PLANT SPECIES OBSERVED IN LAKE WANDAWEGA: 1967-2007

Aquatic Plant Species	July 1967	August 1976	May 2005[a]	August 2007[b]
Ceratophyllum demersum (coontail)	- -	X	X	X
Chara vulgaris (muskgrass)	X	- -	X	X
Elodea canadensis (waterweed)	- -	- -	X	X
Myriophyllum sibiricum (northern water milfoil)	X	X	X	X
Myriophyllum spicatum (Eurasian water milfoil)	- -	X	X	X
Najas flexilis (bushy pondweed)	X	X	X	X
Potamogeton amplifolius (large-leaf pondweed)	X	X	X	X
Potamogeton gramineus (variable pondweed)	X	- -	X	X
Potamogeton foliosis (leafy pondweed)	- -	- -	- -	X
Potamogeton illinoensis (Illinois pondweed)	- -	- -	X	X
Potamogeton natans (floating-leaf pondweed)	X	X	X	X
Potamogeton pectinatus (Sago pondweed)	X	X	- -	X
Potamogeton pusillus (small pondweed)	- -	- -	X	X
Potamogeton praelongis (white-stem pondweed)	X	- -	X	- -
Potamogeton richardsonii (clasping-leaf pondweed)	- -	X	- -	X
Potamogeton zosteriformis (flat-stem pondweed)	X	- -	- -	X
Ranunculus longirostris (white-water crowfoot)	- -	- -	- -	X
Utricularia spp. (bladderwort)	- -	- -	X	X
Vallisneria americana (water celery/eel-grass)	- -	- -	- -	X
Zosterella dubia (water stargrass)	- -	- -	- -	X

[a]*The 2005 survey was conducted by WDNR staff utilizing a grid-based sampling protocol.*

[b]*The 2007 survey was conducted by SEWRPC staff utilizing a transect-based sampling protocol.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

The presence of the numerous species of pondweed is generally considered to be indicative of a healthy lake and good habitat for fishes and aquatic life. It should be noted that the specific species of pondweed observed is highly dependent on the seasonality of these plants, with individual species having well-defined growing periods that reflect water temperature, insolation, and other factors.

Of greater concern is the presence of the nonnative submergent aquatic plant species, Eurasian water milfoil, reported during the 2007 survey. Eurasian water milfoil is an invasive plant species capable of explosive growth, resulting in an ability to outcompete important native aquatic plant species, leading to significant ecological disruptions in the aquatic plant community of a lake and degrading water quality and habitat for fish, invertebrates and other wildlife. Eurasian water milfoil and curly-leaf pondweed (*Potamogeton crispus*) are declared nuisance species identified in Chapter NR 109 of the *Wisconsin Administrative Code*. Eurasian water milfoil was first reported as being present in the Lake during the 1976 aquatic plant survey, but the growth was limited to only two areas and the amount was sparse in both areas; by 2007, Eurasian water milfoil was found in more than half the sites sampled.

Aquatic plant communities do undergo cyclical and periodic changes, which reflect, in part, changing climatic conditions on an interannual scale and, as well in part, the evolution of the aquatic plant community in response to changing hydroclimate conditions in the Lake—these latter including factors, such as changes in long term nutrient loading, sedimentation rates, and recreational use patterns. The former, interannual, changes occur over a period of three to seven years and may be temporary; the latter, evolutionary, occur over a decadal period or longer and are longer-lasting.

The current data set, even though it represents a 40-year period of record, does not lend itself to statistical comparisons of species abundance or assessment as to the type of changes, interannual or longer, occurring due to

Table 7

AQUATIC PLANT SPECIES OBSERVED IN LAKE WANDAWEGA: AUGUST 2007

Aquatic Plant Species	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Ceratophyllum demersum (coontail)	32	41.6	2.0	83.1
Chara vulgaris (muskgrass)	37	48.1	2.2	106.5
Elodea canadensis (waterweed)	44	57.1	2.3	129.9
Myriophyllum sibiricum (northern water milfoil)	62	80.5	2.5	200.0
Myriophyllum spicatum (Eurasian water milfoil)	43	55.8	2.1	119.5
Najas flexilis (bushy pondweed)	59	76.6	2.8	213.0
Potamogeton amplifolius (large-leaf pondweed)	22	28.6	2.7	76.6
Potamogeton gramineus (variable pondweed)	1	1.3	1.0	1.3
Potamogeton foliosis (leafy pondweed)	8	10.4	1.4	14.3
Potamogeton illinoensis (Illinois pondweed)	59	76.6	2.2	166.2
Potamogeton natans (floating-leaf pondweed)	2	2.6	2.5	6.5
Potamogeton pectinatus (Sago pondweed)	1	1.3	2.0	2.6
Potamogeton pusillus (small pondweed)	29	37.7	2.4	92.2
Potamogeton richardsonii (clasping-leaf pondweed)	1	1.3	1.0	1.3
Potamogeton zosteriformis (flat-stem pondweed)	6	7.8	1.2	9.1
Ranunculus longirostris (white-water crowfoot)	8	10.4	1.9	19.5
Utricularia spp. (bladderwort)	8	10.4	1.3	13.0
Vallisneria americana (water celery/eel-grass)	3	3.9	1.3	5.2
Zosterella dubia (water stargrass)	1	1.3	1.0	1.3

NOTE: Sampling occurred at 77 sampling sites along 15 transects.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

[b]*The average density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

[c]*The importance value is the product of the relative frequency of occurrence and the average density, expressed as a percentage. This number provides an indication of the dominance of a species within a community.*

Source: SEWRPC.

differences in sampling methods and data compilation techniques employed over that time-span. During 2007, the aquatic plant survey of Lake Wandawega was conducted using the modified Jesson and Lound transect method as promulgated by the WDNR. This methodology, when utilized in successive aquatic plant surveys, will allow the statistical evaluation of changes in the aquatic plant community within the Lake.[23]

A key to the ability of an ecosystem, such as a lake, to maintain its ecological integrity is biological diversity. Conserving the biological diversity, or biodiversity, of an ecosystem helps not only to sustain the system, but preserves a spectrum of options for future decisions regarding the management of that system. During 2007, the aquatic plant community of Lake Wandawega demonstrated significant biodiversity, being comprised of at least 16 different submergent aquatic plant species. This highly diverse community was prevalent throughout the western half of the Lake. In contrast, some areas of the Lake contained plant communities with very little

[23]*Memo from Stan Nichols, to J. Bode, J. Leverence, S. Borman, S. Engel, D., Helsel, entitled "Analysis of Macrophyte Data for Ambient Lakes-Dutch Hollow and Redstone Lakes example," Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, February 4, 1994.*

Table 8

POSITIVE ECOLOGICAL SIGNIFICANCE OF AQUATIC PLANT SPECIES PRESENT IN LAKE WANDAWEGA: 2007

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	Excellent producer of fish food, especially for young trout, bluegills, small and largemouth bass, stabilizes bottom sediments, and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed)	Provides shelter and support for insects which are valuable as fish food
Myriophyllum sibiricum (northern water milfoil)	Provides food for waterfowl, insect habitat and foraging opportunities for fish
Myriophyllum spicatum (Eurasian water milfoil)	None known
Najas flexilis (bushy pondweed)	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Potamogeton amplifolius (large-leaf pondweed)	Offers shade, shelter and foraging for fish; valuable food for waterfowl
Potamogeton foliosis (leafy pondweed)	Provides food for geese and ducks; food for muskrat, beaver and deer; good surface area for insects and cover for juvenile fish
Potamogeton gramineus (variable pondweed)	Provides habitat for fish and food for waterfowl, muskrat, beaver and deer
Potamogeton illinoensis (Illinois pondweed)	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl
Potamogeton natans (floating-leaf pondweed)	Provides food for waterfowl, muskrat, beaver and deer; good fish habitat
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton pusillus (small pondweed)	Provides food for ducks, geese, muskrat, beaver, and deer, and provides food and shelter for fish
Potamogeton richardsonii (clasping-leaf pondweed)	Provides food, shelter and shade for some fish, food for some wildfowl, and food for muskrat. Provides shelter and support for insects, which are valuable as fish food
Potamogeton zosteriformis (flat-stem pondweed)	Provides some food for ducks
Ranunculus longirostris (white-water crowfoot)	Provides food for trout, upland game birds, and wildfowl
Utricularia spp. (bladderwort)	Provides cover and foraging for fish
Vallisneria americana (water celery/eel-grass)	Provides good shade and shelter, supports insects, and is valuable fish food
Zosterella dubia (water stargrass)	Provides food and shelter for fish, locally important food for waterfowl

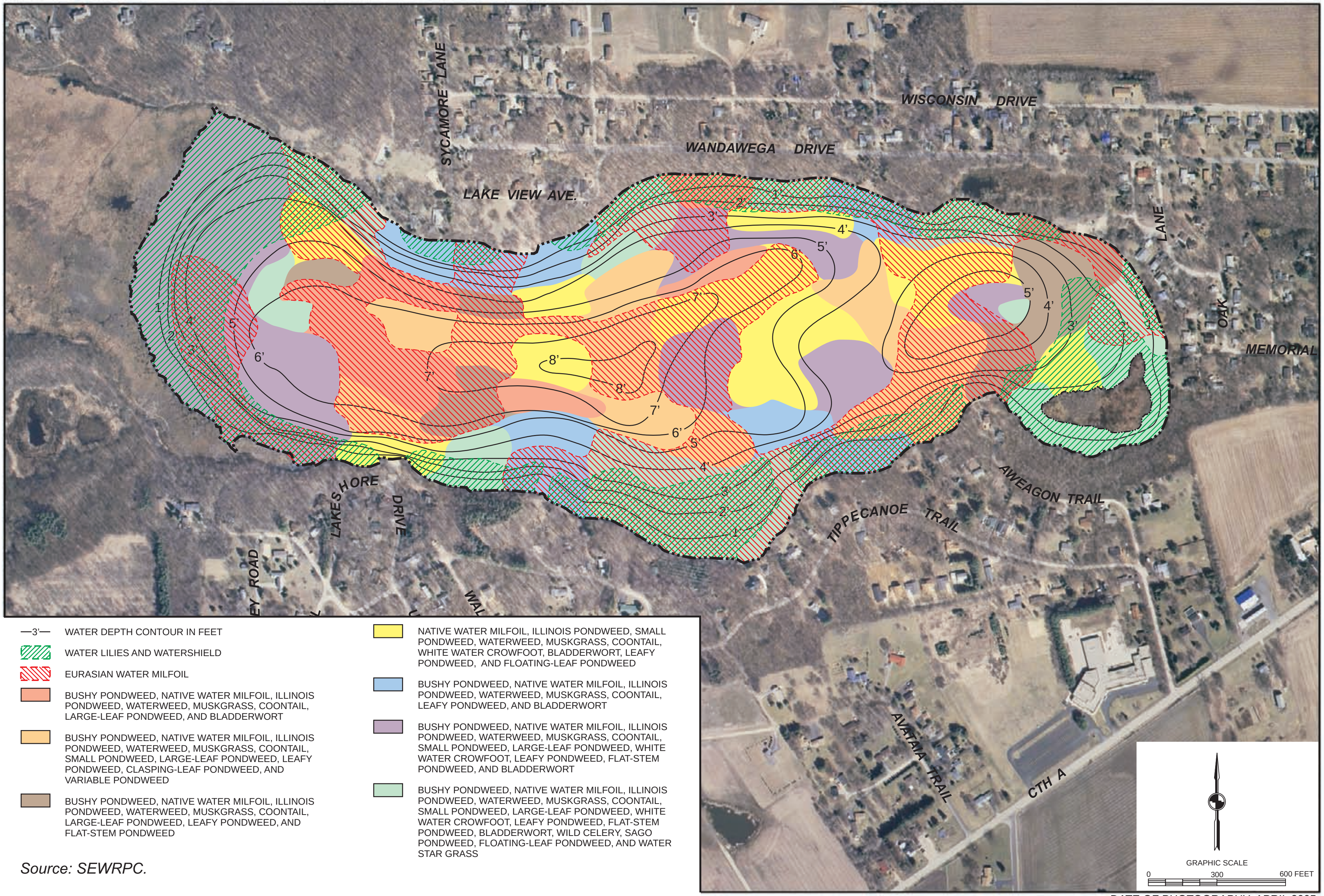
NOTE: Information obtained from *A Manual of Aquatic Plants* by Norman C. Fassett, University of Wisconsin Press; *Guide to Wisconsin Aquatic Plants*, Wisconsin Department of Natural Resources; and, *Through the Looking Glass...A Field Guide to Aquatic Plants*, Wisconsin Lakes Partnership, University of Wisconsin-Extension.

Source: SEWRPC.

diversity, communities with five or fewer species. Such areas were found mostly in the mid-depth areas of the eastern half of the Lake. Most areas of the Lake contained plant communities of moderate diversity, with between five and 11 species being present. Such moderate diversity communities were found uniformly scattered over the eastern three-fourths of the lake basin.

Map 7

AQUATIC PLANT COMMUNITY DISTRIBUTION IN LAKE WANDAWEGA: 2007



Source: SEWRPC.

DATE OF PHOTOGRAPHY: APRIL 2005

Aquatic Plant Species of Special Significance

During the 2007 and earlier aquatic plant surveys on Lake Wandawega, several aquatic plant species of special significance were observed: Eurasian water milfoil, an exotic species considered detrimental to the ecological health of the Lake; and, muskgrass, large-leaf pondweed, and white-stem pondweed, all of which are native species considered to have especially positive impacts on the ecological health of the Lake.

Eurasian water milfoil is one of eight milfoil species found in Wisconsin and the only one known to be exotic or nonnative. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can inhibit its growth, which can be explosive under suitable conditions. The plant exhibits this characteristic growth pattern in lakes with organic-rich sediments, or where the lake bottom has been disturbed. It frequently has been reported as a colonizing species following dredging, unless its growth is anticipated and controlled. Eurasian water milfoil populations can displace native plant species and interfere with the aesthetic and recreational use of the waterbodies. This plant has been known to cause severe recreational use problems in lakes within the Southeastern Wisconsin Region.

Eurasian water milfoil reproduces by the rooting of plant fragments. Consequently, some recreational uses of lakes can result in the expansion of Eurasian water milfoil communities, especially when boat propellers fragment Eurasian water milfoil plants. These fragments, as well as fragments that occur for other reasons, such as wind-induced turbulence or fragmentation of the plant by fishes, are able to generate new root systems, allowing the plant to colonize new sites. The fragments also can cling to boats, trailers, motors, and/or bait buckets, and can stay alive for weeks contributing to the transfer of milfoil to other lakes. For this reason, it is very important to remove all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies.

As previously mentioned, there were several native plant species observed in the 2007 and earlier surveys of the Lake that have especially positive ecological value: muskgrass, large-leaf pondweed, and white-stem pondweed. Muskgrass is a favorite waterfowl food source and, as an effective bottom sediment stabilizer, benefits water quality. Its prevalence in the plant communities of a lake may be a significant contributing factor to establishing and maintaining good water quality of a lake and, consequently, in establishing water quality conditions that assist native plant species to successfully compete with nonnative species. Large-leaf pondweed, also known as musky weed or bass weed, enjoys a reputation as a highly valuable provider of fish habitat. Additionally, this plant has achieved some measure of success as an introduced aquatic plant in transplanting efforts in Lac La Belle and Okauchee Lake, in Waukesha County, Wisconsin, making it a potentially valuable partner in littoral zone restoration projects.[24] White-stem pondweed, because of its sensitivity to changes in water quality and intolerance of turbidity, is considered an excellent indicator species; its disappearance from water systems is an indication of declining water quality in disturbed systems. Conversely, its presence in a lake is usually an indicator of very-good water quality. Observed during the 1976 survey, white-stem pondweed was not observed in the most recent survey of Lake Wandawega, although this may be an artifact of the high degree of seasonality observed among these plants.

Past and Present Aquatic Plant Management Practices

An aquatic plant management program has been carried out on Lake Wandawega in a documented manner since 1950. Records of aquatic plant management efforts were first maintained by the WDNR beginning in 1950. Prior to 1950, aquatic plant management interventions are likely, but were not recorded. Currently, all forms of aquatic plant management are subject to permitting by the WDNR pursuant to authorities granted the Department under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*.

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[24]*Wisconsin Lakes Partnership*, Through the Looking Glass…A Field Guide to Aquatic Plants, *Wisconsin Lakes Partnership, University of Wisconsin-Extension, 1999.*

Aquatic plant management activities in Lake Wandawega have been limited. Recorded chemical herbicide treatments that have been applied to Lake Wandawega are shown in Table 9, with such treatments being relatively few in number. As shown in Table 9, between 1950 and 1967, a total of 6,148 pounds of sodium arsenite were applied to Lake Wandawega to control perceived nuisance growths of aquatic plants. Since 2004, the primary chemical herbicide used to manage aquatic plants in Lake Wandawega has been 2,4-D.

Sodium arsenite was typically sprayed onto the surface of a lake within an area of up to 200 feet from the shoreline. Treatment typically occurred between mid-June and mid-July. The amount of sodium arsenite used was calculated to result in a concentration of about 10 milligrams per liter (mg/l) sodium arsenite (about five mg/l arsenic) in the treated lake water. The sodium arsenite typically remained in the water column for less than 120 days. Although the arsenic residue was naturally converted from a highly toxic form to a less toxic and less biologically active form, much of the arsenic residue was deposited in the lake sediments.

When it became apparent that arsenic was accumulating in the sediments of treated lakes, the use of sodium arsenite was discontinued in the State in 1969. The applications and accumulations of arsenic were found to present potential health hazards to both humans and aquatic life. In drinking water supplies, arsenic was suspected of being carcinogenic and, under certain conditions, arsenic has leached into and contaminated groundwater, especially in sandy soils that serve as a source of drinking water in some communities. The U.S. Environmental Protection Agency-recommended drinking water standard for arsenic is a maximum level of 0.05 mg/l.

Since anaerobic conditions rarely occur in the hypolimnion of Lake Wandawega, arsenic is unlikely to be released from the bottom sediments into the water column. In addition, the sediments contaminated with arsenic are continually being covered by new sediments; thus, the concentrations of arsenic in the sediments may be expected to decrease with passage of time as a result of this dilution.

FISHERIES AND WILDLIFE

The WDNR reports that, in Lake Wandawega, largemouth bass and northern pike are considered to be common while panfish are considered to be abundant.[25] Currently, the Lake is managed for largemouth bass, northern pike, and panfish. A fisheries survey was conducted by the WDNR in 2004, although the extreme amount of aquatic plant growth in the Lake interfered with the sampling process. The most common fish found during this survey were black, brown, and yellow bullheads. Other species sampled included bluegill, largemouth bass, pumpkinseed, black crappie, warmouth, and yellow perch.[26] Stocking of the Lake with largemouth bass and northern pike has been intermittent since 1980, with known stockings being documented in Table 10.

With respect to wildlife, and given the land uses present around the shorelands of the Lake, only smaller animals and waterfowl would be expected to inhabit the Lakeshore areas. Muskrats, raccoons, Eastern red fox, Virginia opossum, grey and Southern flying squirrels, mink, and cottontail rabbits are likely the most abundant and widely distributed fur-bearing mammals in the immediate riparian areas. Larger mammals, such as the whitetail deer, are likely to be confined to the larger wooded areas and the open meadows found within the tributary area of the Lake.

The Lake Wandawega tributary area supports a significant population of waterfowl including mallards, wood duck, and blue-winged teal. A pair of sandhill cranes has been observed nesting on the island at the eastern end of Lake Wandawega. During the migration seasons a greater variety of waterfowl may be present and in greater numbers.

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[25] *Wisconsin Department of Natural Resources Publication No. PUB-FH-800 2005,* Wisconsin Lakes, *2005.*

[26] *Electronic mail communication to Mr. Michael Borst of the Commission staff from Mr. Douglas E. Welch of the WDNR staff, dated October 8, 2007.*

Table 9

CHEMICAL CONTROL OF AQUATIC PLANTS IN LAKE WANDAWEGA: 1950-2007

Year	Total Acres Treated	Algae Control			Macrophyte Control				
		Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine Plus (pounds)	Sodium Arsenite (pounds)	2,4-D (pounds)	Diquat (gallons)	Glyphosate (gallons)	Endothall/ Aquathol (gallons)
1950-1969	- -	- -	- -	- -	6,148	- -	- -	- -	- -
1970	- -	- -	- -	- -	- -	- -	- -	- -	- -
1971	0.9	- -	- -	- -	- -	- -	- -	- -	5.0
1972	0.9	- -	- -	- -	- -	- -	- -	- -	1.0
1973-2003	- -	- -	- -	- -	- -	- -	- -	- -	- -
2004	- -	- -	- -	- -	- -	20	- -	- -	- -
2005	- -	- -	- -	- -	- -	30	- -	- -	- -
2006	- -	- -	- -	- -	- -	- -	- -	- -	- -
2007	- -	- -	- -	- -	- -	170	- -	- -	- -
Total	- -	- -	- -	- -	6,148	220	- -	- -	6.0

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 10

FISH STOCKED INTO LAKE WANDAWEGA

Year	Species Stocked	Number	Average Fish Length (inches)
1980	Largemouth bass	10,000	2.50
1981	Northern pike	100,000	Fry
1982	Northern pike	200	Yearling
1982	Largemouth bass	5,000	1.00
1983	Northern pike	400	9.00
1983	Largemouth bass	3,000	5.00
2001	Northern pike	119,000	Fry
2002	Largemouth bass	3,000	5.00
2003	Largemouth bass	2,975	2.00

Source: Wisconsin Department of Natural Resources and SEWRPC.

Amphibians and reptiles are vital components of the Lake Wandawega ecosystem, and include frogs, toads, and salamanders, and turtles and snakes, respectively. About 14 species of amphibians and 16 species of reptiles would normally be expected to be present in the Lake Wandawega area.

WDNR-Designated Sensitive Areas and Critical Species Habitat

Within or around lakes, the WDNR identifies sites that have special importance biologically, historically, geologically, ecologically, or even archaeologically. Areas are identified as Sensitive Areas pursuant to Chapter NR 107 of the *Wisconsin Administrative Code* after comprehensive examination and study is completed by WDNR staff from many different disciplines and fields of study. Currently, Lake Wandawega is indicated as lacking any such WDNR-designated Sensitive Areas.

SEWRPC also has identified natural areas and critical species habitat areas within the Southeastern Wisconsin Region.[27] In the Lake Wandawega tributary area, the lakeshores located within the environmental corridors

[27]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997.*

should be candidates for immediate protection through proper zoning or through public ownership. Of the areas not already publicly owned, the remaining areas of natural shoreline, and riparian wetland areas are perhaps the most sensitive areas in need of greatest protection. In this regard, two natural areas that contain intact native plant and animal communities of local significance have been identified, and are shown on Map 8. These natural areas of local significance, designated as NA-3 and AQ-3, respectively, include:

1. Lake Wandawega Marsh: A privately owned, 82-acre, deep and shallow marsh located at the west end of Lake Wandawega; and,

2. Lake Wandawega itself.

RECREATIONAL USES AND FACILITIES

As set forth in the regional water quality management plan, Lake Wandawega is a multi-purpose waterbody serving a variety of recreational uses.[28] Active recreational uses include boating, swimming and snorkeling, and fishing during the summer months, and cross-country skiing, snowmobiling, and ice-fishing during the winter. Public access to Lake Wandawega is provided by a Town-owned, single, paved launch located adjacent to the privately owned park-beach facility at the eastern end of the Lake. Lake Wandawega currently is deemed to have adequate public access as defined in Chapter NR 1 of the *Wisconsin Administrative Code*, which establishes quantitative standards for determining the adequacy of public recreation boating access, setting maximum and minimum standards based upon available parking facilities for car-top and car-trailer units.

The Lake is used year-round as a visual amenity. Walking, bird watching, and picnicking are popular passive recreational uses of this waterbody, and it experiences moderate use during open-water periods. During the current study, a boat survey conducted on Lake Wandawega in 2007 indicated that about 70 boats were either moored in the water or stored on land in the shoreland areas around the Lake, as shown in Table 11. Recreational high-speed boating is likely not a major active recreational use of the Lake, since only about 15 percent of all watercraft moored in the water or stored on land in the shoreline areas on the Lake were capable of high-speed operation. Of the motorized watercraft observed moored or stored, pontoon boats represented the largest group, with fishing boats and personal watercraft the next most common categories. Of the nonmotorized watercraft observed, rowboats and paddleboats represented the most common types on the Lake, with canoes also observed in good numbers. The types of watercraft found on the Lake included fishing boats, pontoon boats, paddleboats, canoes, sailboats, rowboats, and personal watercraft (“jetskis”®).

The types of motorized watercraft docked or moored on a lake, as well as the relative proportion of nonmotorized to motorized watercraft, reflect the attitudes of the primary users of the lake, the lake residents. Only about 15 percent of the watercraft on Lake Wandawega were motorized, compared to about 80 percent of the watercraft on Pewaukee Lake in Waukesha County, Wisconsin, for example. Additionally, of the watercraft on Pewaukee Lake, powerboats made up the largest proportion, comprising almost 40 percent. On Lake Wandawega, the largest proportion of all watercraft was comprised of rowboats, which represented about 46 percent of all watercraft on the Lake.

To assess the degree of recreational boat use on a lake, it has been estimated that, in southeastern Wisconsin, the number of watercraft operating on a lake at any given time is between about 2 percent and 5 percent of the total number of watercraft docked and moored. On Lake Wandawega, this would amount to somewhere between one and four boats of all kinds, only about 15 percent of which would be motorized. There is a range of opinions on the issue of what constitutes optimal boating density, or the numbers of acres of open water available in which to operate a boat on a lake, but, regardless of the measure, recreational boating densities on Lake Wandawega can be assessed as relatively low.

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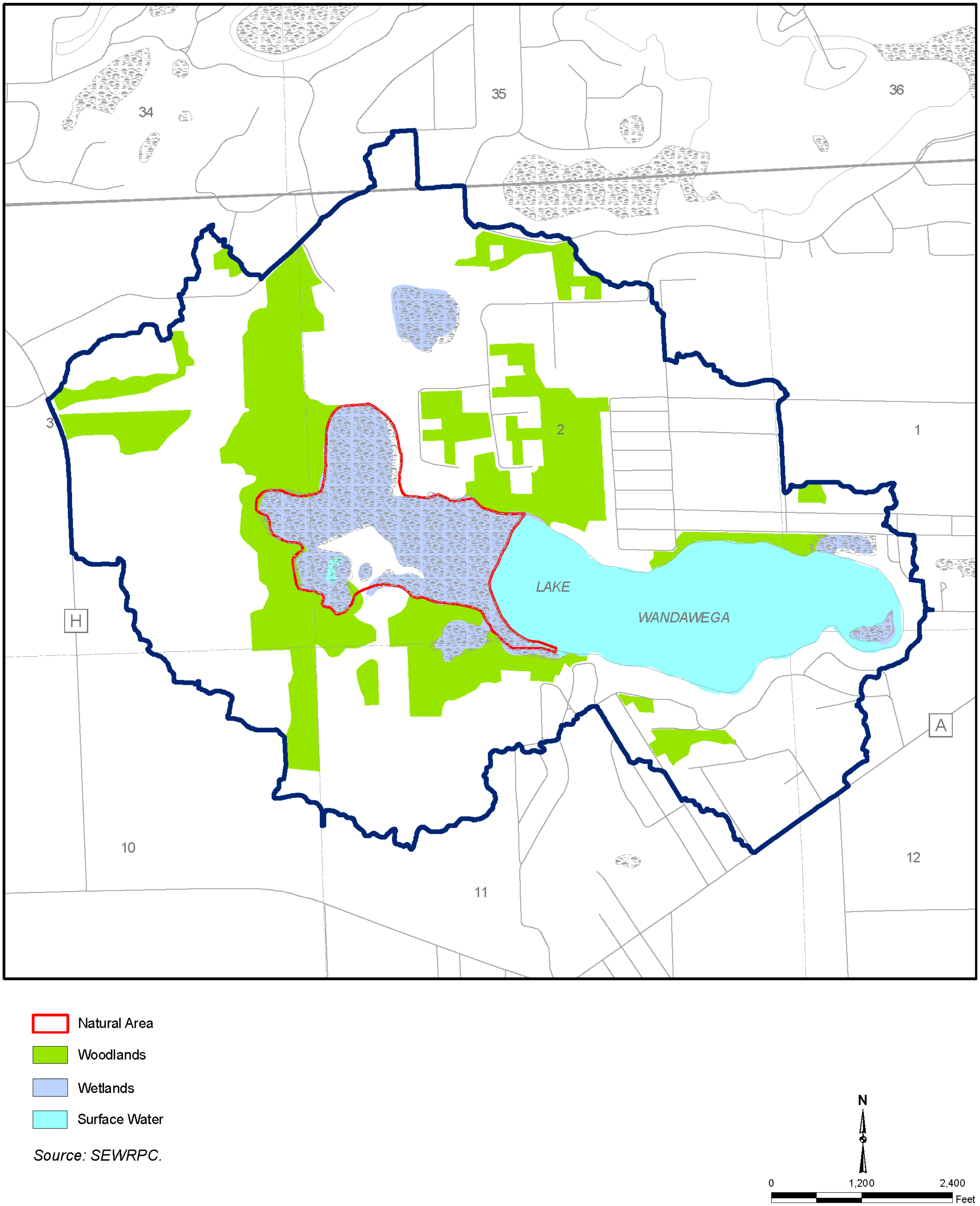
[28]*SEWRPC Planning Report No. 30,* op.cit. *See also SEWRPC Memorandum Report No. 93,* op.cit.

Map 8

WETLANDS, WOODLANDS, AND NATURAL AREAS WITHIN THE LAKE WANDAWEGA TRIBUTARY AREA: 2000



Source: SEWRPC.

Table 11

WATERCRAFT DOCKED OR MOORED ON LAKE WANDAWEGA: 2007[a]

Type of Watercraft									
Powerboat	Fishing Boat	Pontoon Boat	Personal Watercraft	Canoe	Sailboat	Kayak	Paddleboat	Rowboat	Total
0	2	6	3	9	1	0	17	32	70

[a]*Including trailered watercraft and watercraft on land observed during survey.*

Source: SEWRPC.

In this regard, during the mid-1980s, an average area of about 16 acres per powerboat or sailboat was, at that time, considered suitable for the safe and enjoyable use of a boat on a lake. Over time, motorized watercraft of all kinds have steadily increased in power and speed. For safe waterskiing and fast boating, the regional park and open space plan suggested an area of 40 acres per boat as the minimum area necessary for safe operations.[29] Using these guidelines, estimates of the density of boats capable of high speeds on Lake Wandawega, based on the counts of watercraft docked or moored around the Lake, would produce boating densities well within the one-boat-per-40-acres guideline suggested for safe conduct of high-speed boats on Lake Wandawega.

Another way to assess the degree of recreational boat use on a lake is through direct counts of boats actually in use on a lake at a given time. During 2007, surveys to assess the types of watercraft in use on a typical summer weekday and a typical summer weekend day were conducted by Commission staff. The results of these surveys are shown in Table 12. As shown in the table, fishing boats were the most popular watercraft in use on Lake Wandawega, during weekdays and weekends. Based on counts of boats actually in use during weekdays and weekends, the density of high-speed watercraft on Lake Wandawega was not more than one boat per 119 acres. These densities observed on Lake Wandawega are generally well within those considered appropriate for the conduct of safe high-speed boating activities. It is noted, however, that the higher degree of boating activity that often occurs on regional lakes during holiday weekends may produce high-speed boating densities that temporarily exceed the guideline values.

Table 13 shows how people were using Lake Wandawega recreationally during a typical summer weekday and a typical summer weekend in 2007. The most popular weekday recreational activities on Lake Wandawega included visiting the park—people were using the small beach and picnic area at the privately owned boat launch site at the eastern end of the Lake, as well as the three other private beaches/parks located around the Lake; swimming; fishing from boats; and, waterskiing/tubing. The most popular weekend recreational activities observed were visiting the park, fishing from boats, and swimming.

In the absence of specific Town ordinances, recreational boating activities on Lake Wandawega are subject to State of Wisconsin boating and water safety laws as set forth in Chapter 30, *Wisconsin Statutes*.

LOCAL ORDINANCES

The Towns of LaGrange and Sugar Creek have adopted the Walworth County ordinances in regard to general zoning and subdivision control ordinances, floodland zoning, shoreland or shoreland-wetland zoning, and construction site erosion control/stormwater management controls, as shown in Table 14.

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[29]*See SEWRPC Planning Report No. 27,* A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000*, November 1977.*

Table 12

WATERCRAFT IN USE ON LAKE WANDAWEGA: JULY 2007

Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddleboat	Total
Saturday, July 7									
10:00 a.m. to 11:00 a.m.	0	0	2	0	0	0	0	0	2
2:00 p.m. to 3:00 p.m.	0	0	0	0	0	0	0	0	0
Thursday, July 10									
10:00 a.m. to 11:00 a.m.	0	0	1	0	0	0	0	0	1
2:00 p.m. to 3:00 p.m.	1	0	0	0	0	0	0	0	1

Source: SEWRPC.

Table 13

RECREATIONAL USE IN/ON LAKE WANDAWEGA: JULY 2007

	Weekend Participants									
Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Saturday, July 7										
10:00 a.m. to 11:00 a.m.	0	0	0	0	0	0	3	0	5	8
2:00 p.m. to 3:00 p.m.	0	0	0	0	0	11	0	0	18	29
Total for the Day	0	0	0	0	0	11	3	0	23	37
Percent	0	0	0	0	0	30	8	0	62	100

	Weekday Participants									
Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Thursday, July 10										
10:00 a.m. to 11:00 a.m.	0	0	0	0	0	0	1	0	2	3
2:00 p.m. to 3:00 p.m.	0	0	3	0	0	13	1	0	15	31
Total for the Day	0	0	3	0	0	13	1	0	17	34
Percent	0	0	9	0	0	38	3	0	50	100

Source: SEWRPC.

Table 14

LAND USE REGULATIONS WITHIN THE AREA TRIBUTARY TO LAKE WANDAWEGA IN WALWORTH COUNTY BY CIVIL DIVISION: 2003

	Type of Ordinance				
Community	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
Walworth County................	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Floodland and shoreland only	Adopted
Town of LaGrange..........	County ordinance	County	County	County	County
Town of Sugar Creek......	County ordinance	County	County	County	County

Source: SEWRPC.

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Chapter III

ALTERNATIVE AND RECOMMENDED AQUATIC PLANT MANAGEMENT PRACTICES

INTRODUCTION

Lake Wandawega generally contains a robust and fairly diverse aquatic plant community capable of supporting a warmwater fishery, albeit with some areas that suffer impairment of recreational boating opportunities and other lake-oriented activities due to an overabundance of aquatic macrophytes, such as bushy pondweed and milfoil. For example, in those areas of the Lake where Eurasian water milfoil (*Myriophyllum spicatum*) is abundant, certain recreational uses are limited, the aesthetic quality of the Lake is impaired, and in-lake habitat degraded. The plant primarily interferes with recreational boating activities by encumbering propellers, clogging cooling water intakes, snagging paddles, and slowing sailboats by wrapping around keels and control surfaces. The plant also causes concern among swimmers who can become entangled within the plant stalks. Thus, without control measures, these areas can become problematic to navigation, fishing, and swimming. Native aquatic plants, generally found at slightly deeper depths, pose fewer potential problems for navigation, swimming, and fisheries, and generally have attributes that sustain a healthy fishery. Many native aquatic plants provide fish habitat and food resources, and offer shelter for juvenile fishes and young-of-the-year fish.

In this Chapter, alternative and recommended actions for the management of aquatic plants in Lake Wandawega are presented. These measures are focused primarily on those measures which can be implemented by the Lake Wandawega Improvement Association (LWIA), with lesser emphasis given to those measures which are applicable to other agencies having jurisdiction within the area tributary to the Lake.

AQUATIC PLANT MANAGEMENT MEASURES

As stated in Chapter II of this report, aquatic plant management activities in Lake Wandawega can be categorized as limited, with harvesting being used in concert with an annual herbicide treatment to control aquatic plant growth in the Lake. This dual control approach allows for herbicide use to be minimized and, when synchronized with mechanical harvesting, provides for maximum impact of the harvesting operations. In addition, individual householders on Lake Wandawega are known to have engaged in manual harvesting in the vicinities of their piers and docks.

The shoreland and aquatic macrophyte management elements of this plan consider alternative management measures consistent with the provisions of Chapters NR 103, NR 107, and NR 109 of the *Wisconsin Administrative Code*. Further, the alternative aquatic plant management measures are consistent with the requirements of Chapter NR 7 of the *Wisconsin Administrative Code*, and with the public recreational boating access requirements relating to the eligibility under the State cost-share grant programs, set forth under Chapter NR 1 of the *Wisconsin Administrative Code*.

Array of Management Measures

Aquatic plant management measures can be classed into four groups: ***physical measures***, which include lake bottom coverings and water level management; ***biological measures***, which include the use of various organisms, including herbivorous insects and plantings of aquatic plants; ***manual*** and ***mechanical measures***, which include harvesting and removal of aquatic plants; and, ***chemical measures***, which include the use of aquatic herbicides. All control measures are stringently regulated and require a State of Wisconsin permit; chemical controls are regulated under Chapter NR 107 of the *Wisconsin Administrative Code,* and all other aquatic plant management practices are regulated under Chapter NR 109 of the *Wisconsin Administrative Code*. Placement of bottom covers, a physical measure, also requires a Wisconsin Department of Natural Resources (WDNR) permit under Chapter 30 of the *Wisconsin Statutes*. Costs range from minimal for manual removal of plants using rakes and hand-pulling, to upwards of $75,000 for the purchase of a mechanical plant harvester, for which the operational costs can approach $2,500 to $25,000 per year depending on staffing and operation policies.

Physical Measures

Lake bottom covers and light screens provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. They have been used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motorboating. Sand and gravel are usually widely available and relatively inexpensive to use as cover materials, but plants readily recolonize areas so covered in about a year. Synthetic materials, such as polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years. However, such materials, known as bottom screens or barriers, generally have to be placed and removed annually. Such barriers also are susceptible to disturbance by watercraft propellers or the build-up of gasses from decaying plant biomass trapped under the barriers. In the case of Lake Wandawega, the need to encourage native aquatic plant growth while simultaneously controlling the growth of Eurasian water milfoil, suggests that the placement of lake bottom covers as a method to control aquatic plant growth does not appear to be warranted. Thus, such measures are not considered viable for Lake Wandawega.

Biological Measures

Biological controls offer an alternative approach to controlling nuisance plants, particularly purple loosestrife (*Lythrum salicaria*), an invasive shoreland wetland plant, and Eurasian water milfoil. Classical biological control techniques have been successfully used to control both nuisance plants with herbivorous insects.[1] Recent evidence shows that *Galerucella pucilla* and *Galerucella calmariensis*, beetle species, and *Hylobius transversovittatus* and *Nanophyes brevis*, weevil species, have potential as biological control agents for purple loosestrife.[2] Extensive field trials conducted by the WDNR in the Southeastern Wisconsin Region since 1999 have indicated that these insects can provide effective management of large infestations of purple loosestrife. In contrast, the few studies of Eurasian water milfoil control utilizing *Eurhychiopsis lecontei*, an aquatic weevil species, have resulted in variable levels of control, with little control being achieved on those lakes having extensive motorized boating traffic. Thus, while the use of insects as a means of shoreland wetland plant management is considered to be viable, the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control, is not considered a viable option for use on Lake Wandawega at this time. Notwithstanding, there is some evidence that *Eurhychiopsis lecontei* may be a naturally occurring organism in the Lake, which contributes to the periodic declines observed in the populations of Eurasian water milfoil.

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[1]*B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control,"* LakeLine*, Vol. 17, No. 3, September 1997, pp. 20-21, 34-3; see also, C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities*, 1984, pp. 659-696; and C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology*, John Wiley, New York, New York, USA.*

[2]*Sally P. Sheldon, "The Potential for Biological Control of Eurasian Water Milfoil (*Myriophyllum spicatum*) 1990-1995 Final Report," Department of Biology Middlebury College, February 1995.*

The use of grass carp, *Ctenopharyngodon idella*, an alternative biological control used elsewhere in the United States, is not permitted in Wisconsin. Grass carp are proposed to be a designated invasive species pursuant to Chapter NR 40 of the *Wisconsin Administrative Code*, currently being promulgated by the Wisconsin Natural Resources Board.[3]

A variation on the theme of biological control is the introduction of aquatic plants into a waterbody as a means of encouraging or stimulating the growth of desirable native aquatic plant species in a lake. While few projects of this nature have been undertaken in the Southeastern Wisconsin Region, the Lac La Belle Management District, in partnership with the WDNR and University of Wisconsin-Milwaukee, did attempt to supplement the aquatic plant community of that Lake by selectively planting pondweeds (*Potamogeton* spp.).[4] Several hundred pondweeds were transplanted into Lac La Belle, and, while there is some evidence that a few of these transplants were successful, the net outcome of the project was disappointing. Few of the introduced plants were observed in subsequent years.[5] Given the extensive and diverse aquatic plant community present in Lake Wandawega, supplemental plantings are not considered to be a viable aquatic plant management option.

Manual and Mechanical Measures

The physical removal of specific types of vegetation by selective harvesting of plants provides a highly selective means of controlling the growths of nuisance aquatic plant species, including purple loosestrife and Eurasian water milfoil. Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, manual harvesting of aquatic plants within a 30-foot-wide corridor along a 100-foot length of shoreline would be allowed without a WDNR permit, provided the plant material is removed from the Lake. Any other manual harvesting would require a State permit, unless employed in the control of designated nonnative invasive species, such as Eurasian water milfoil, curly-leaf pondweed, or purple loosestrife. These designated species may be controlled at any time using manual or mechanical means provided that no harm is caused to native aquatic plants, pursuant to Section NR107.06(4) of the *Wisconsin Administrative Code*.

Aquatic macrophytes also may be harvested mechanically with specialized equipment consisting of a cutting apparatus, which cuts up to about five feet below the water surface, and a conveyor system that picks up the cut plants. Mechanical harvesting can be a practical and efficient means of controlling plant growth as it removes the plant biomass and nutrients from a lake. Mechanical harvesting is particularly effective as a measure to control large-scale growths of aquatic plants. Narrow channels can be harvested to provide navigational access and “cruising lanes” for predator fish to migrate into the macrophyte beds to feed on smaller fish. The harvesting of water lilies and other emergent native plants should be minimized to the extent practicable.

“Clear cutting” aquatic plants and denuding the lake bottom of flora, using either manual or mechanical harvesting, should be avoided. However, top cutting of plants, such as Eurasian water milfoil, using mechanical

[3]*See Order of the State of Wisconsin Natural Resources Board creating Chapter NR 40 relating to the identification, classification and control of invasive species, IS-34-06, 2008.*

[4]*Donald H. Les and Glenn Guntenpergen, “Laboratory Growth Experiments for Selected Aquatic Plants, Final Report, July 1989 – June 1990 (Year 1),” Report to the Wisconsin Department of Natural Resources, June 1990;Wisconsin Department of Natural Resources, Environmental Assessment: Improvement of the Water Quality and Fisheries Habitat of LacLaBelle [sic] and the Lower Oconomowoc River, s.d.*

[5]*At the 2003 annual meeting of the Lac La Belle Management District, a citizen reported observing a herbicide application in the vicinity of the planted area of the Lake. Such an application might explain the observed lack of success of this management measure. See SEWRPC Community Assistance Planning Report No. 47, 2nd Edition,* A Water Quality Management Plan for Lac La Belle, Waukesha County, Wisconsin, *May 2007.*

harvesters, as shown in Figure 1, has proven to be beneficial in some lakes as a means of minimizing the competitive advantage of the Eurasian water milfoil plant and encouraging native aquatic plant growths.[6]

In the shoreland area, where purple loosestrife may be expected to occur, bagging and cutting loosestrife plants prior to the application of chemical herbicides to the cut ends of the stems, can be an effective control measure for small infestations of this plant. Loosestrife management programs, however, should be followed by an annual monitoring and control program for up to 10 years following the initial control program to manage the regrowth of the plant from seeds. Manual removal of such plants is recommended for isolated stands of purple loosestrife when and where they occur.

In the nearshore area, specially designed rakes are available to assist in the manual removal of nuisance aquatic plants, such as Eurasian water milfoil. The use of such rakes also provides a safe and convenient method of controlling aquatic plants in deeper nearshore waters around piers and docks. The advantage of the rakes is that they are relatively inexpensive, easy and quick to use, and immediately remove the plant material from the lake, without a waiting period. Removal of the plants from the lake avoids the accumulation of organic matter on the lake bottom, which adds to the nutrient pool that favors further plant growth. State permitting requirements for manual aquatic plant harvesting mandate that the harvested material be removed from the lake. Should the LWIA acquire a number of these specially designed rakes, they could be made available for the riparian owners to use on a trial basis to test their operability before purchasing them.

Hand-pulling of stems, where they occur in isolated stands, provides an alternative means of controlling plants, such as Eurasian water milfoil, in the Lake, and purple loosestrife, on the lakeshore. Because this is a more selective measure, the rakes being nonselective in their harvesting, manual removal of Eurasian water milfoil is considered a viable option in Lake Wandawega, where practicable and feasible.

An advantage of mechanical aquatic plant harvesting is that the harvester typically leaves enough plant material in the lake to provide shelter for fish and other aquatic organisms, and to stabilize the lake bottom sediments. Aquatic plant harvesting also has been shown to facilitate the growth of native aquatic plants in harvested areas by allowing light penetration to the lakebed. Many native aquatic plants are low-growing species that are less likely to interfere with human recreational and aesthetic uses of a lake. A disadvantage of mechanical harvesting is that the harvesting operation may cause fragmentation of plants and, thus, unintentionally facilitate the spread of some plants that utilize fragmentation as a means of propagation, namely Eurasian water milfoil. Harvesting may also disturb bottom sediments in shallower areas where such sediments are only loosely consolidated, thereby increasing turbidity and resulting in deleterious effects, including the smothering of fish breeding habitat and nesting sites. Disrupting the bottom sediments also could increase the risk that an exotic species, such as Eurasian water milfoil, may colonize the disturbed area since this is a species that tends to thrive under disturbed bottom conditions. To this end, most WDNR-issued permits do not allow harvesting in areas having a water depth of less than three feet. Nevertheless, if done correctly and carefully, harvesting has been shown to be of benefit in ultimately reducing the regrowth of nuisance plants when used under conditions suitable for this method of control. Both manual and mechanical harvesting techniques are considered to be viable options for control of aquatic plants in Lake Wandawega.

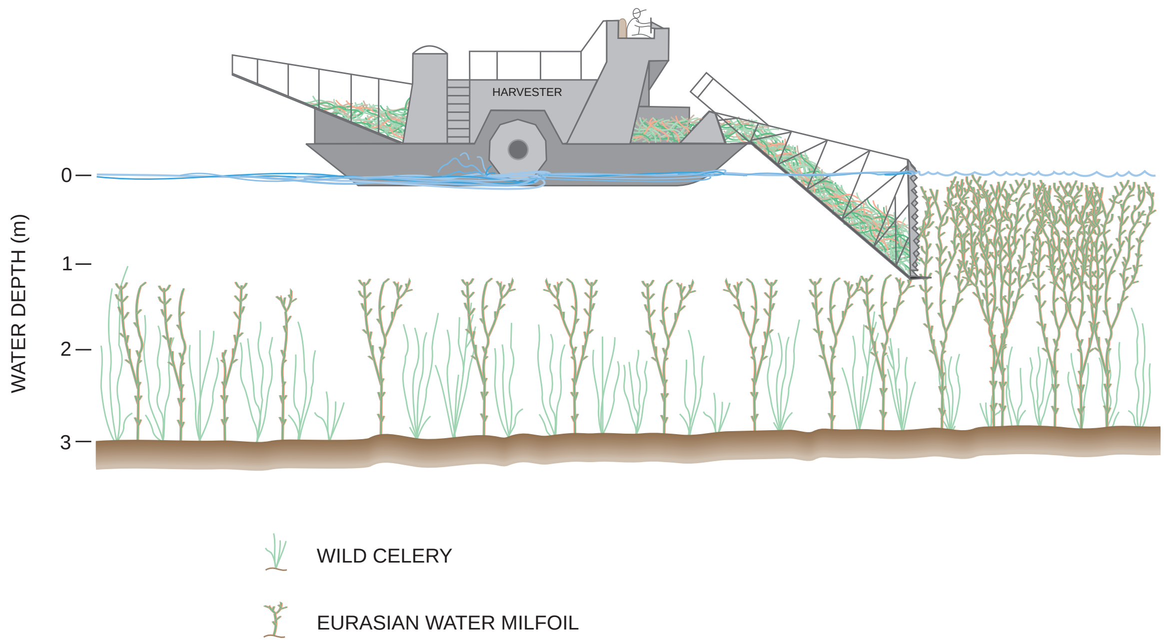
Chemical Measures

Chemical treatment with herbicides is a short-term method of controlling heavy growths of nuisance aquatic plants. Chemicals are generally applied to the growing plants in either a liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophytes growth are the relatively low-cost and the ease, speed, and convenience of application. Depending upon the specific herbicide considered for use, chemical herbicide applications also can target specific aquatic plants fairly closely, although there are currently no

[6]*See SEWRPC Memorandum Report No. 143,* An Aquatic Plant Management Plan for the Lauderdale Lakes, Walworth County, Wisconsin*, August 2001.*

Figure 1

PLANT CANOPY REMOVAL WITH AN AQUATIC PLANT HARVESTER



NOTE: Selective cutting or seasonal harvesting can be done by aquatic plant harvesters. Removing the canopy of Eurasian water milfoil may allow native species to reemerge.

Source: Wisconsin Department of Natural Resources and SEWRPC.

chemical herbicides that are species-specific. The disadvantages associated with chemical control include unknown long-term effects on fish, fish food sources, and humans; a risk of increased algal blooms due to the eradication of macrophyte competitors; an increase in organic matter in the sediments, possibly leading to increased plant growth, as well as anoxic conditions which can cause fish kills; adverse effects on desirable aquatic organisms; loss of desirable fish habitat and food sources; and, finally, a need to repeat the treatment the following summer due to existing seed banks and/or plant fragments. Widespread chemical treatments can also provide an advantage to less desirable, invasive, introduced plant species to the extent that such treatments may produce conditions in which nonnative species can outcompete the more beneficial, native aquatic plant species. Hence, this is seldom a feasible management option to be used on a large scale. Widespread chemical treatment, therefore, is not considered a viable option for Lake Wandawega, although limited chemical control is often a viable technique for the control of the relatively small-scale infestations of aquatic plants, such as Eurasian water milfoil, or shoreland plants, such as purple loosestrife.

To minimize the possible impacts of deoxygenation, loss of desirable plant species, and contribution of organic matter to the sediments, early spring or late fall applications should be considered. Such applications also minimize the concentration and amount of chemicals used due to the facts that colder water temperatures enhance the herbicidal effects, while the application of chemical herbicides during periods when most native aquatic plants species are dormant limit the potential for collateral damage. Use of chemical herbicides in aquatic environments is stringently regulated and requires a WDNR permit and WDNR staff oversight during applications.

Use of early spring or (currently experimental) late fall chemical controls, especially in those shoreline areas where mechanical harvesting would not be deemed viable, targeting growths of Eurasian water milfoil and purple loosestrife in and around the Lake, is considered a viable option for Lake Wandawega.

Recommended Management Measures

The most-effective plans for managing aquatic plants rely on a combination of methods and techniques, such as those described above. Therefore, to enhance the recreational uses of Lake Wandawega, while maintaining the quality and diversity of the biological communities, the following recommendations are made:

- Manual harvesting around piers and docks is the recommended means of controlling nonnative nuisance species of plants in those areas. In this regard, the LWIA could consider purchasing several specialty rakes designed for the removal of vegetation from shoreline property and make these available to riparian owners. This would allow the riparian owners to use the rakes on a trial basis before purchasing their own. Although the rakes do not require a permit for use along a 30-foot-wide length of shoreline, State requirements for manual aquatic plant harvesting mandate that the harvested material be removed from the lake. Where feasible and practicable, hand-pulling of stems, where they occur in isolated stands, is also recommended as an alternative means of controlling Eurasian water milfoil and purple loosestrife. Manual control should target nonnative species.

- It is recommended that the use of chemical herbicides be limited to controlling nuisance growths of exotic species, particularly Eurasian water milfoil and purple loosestrife. It is recommended that chemical applications, if required, be made by licensed applicators in early spring or late fall, subject to State permitting requirements to maximize their effectiveness on nonnative plant species while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions. Such use should be evaluated annually and the herbicide applied only on an as-needed basis. Only herbicides that selectively control milfoil, such as 2,4-D and endothall, should be used; for the control of purple loosestrife, the use of glyphosate could be considered for application to the cut stems of the plants after the seed heads have been bagged and cut.

- The use of algicides, such as Cutrine Plus, is not recommended because there are few significant, recurring filamentous algal or planktonic algal problems in Lake Wandawega and valuable macroscopic algae, such as *Chara* and *Nitella,* are killed by this product. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners.

- Manual harvesting, supplemented as necessary by mechanical harvesting, used in concert with an annual herbicide treatment, should be considered as the primary method of aquatic plant management in Lake Wandawega, especially targeting nonnative invasive species of aquatic plants. Due to the nature of the dual approach to aquatic plant control employed on the Lake, specific control measures are recommended to be applied in various areas of the Lake, as summarized below.

- Few lakes in southeastern Wisconsin lack aquatic plant growth, and Lake Wandawega is no exception. However, some areas of the Lake, such as the mid-depth areas in the eastern half of the Lake basin, could benefit from a greater diversity of native aquatic plants, especially where low-growing plants, such as muskgrass, which provide food and shelter for fish and waterfowl occur. Because of their low-growing height, these species are often outcompeted by the nonnative Eurasian water milfoil. Eurasian water milfoil grows rapidly to the lake surface, capturing the available sunlight and shading out the native species. Thus, control of the Eurasian water milfoil, using manual and chemical means as noted above, is one means of promoting the growth of native plants, and is recommended for Lake Wandawega.

- Through informational programming, riparian owners should be encouraged to monitor their shoreline areas, as well as open-water areas of the Lake, for new growths of nonnative nuisance plants and report such growths immediately to the LWIA so that a timely and effective response can be executed.

- It also is recommended that the LWIA consider the conduct of in-lake aquatic plant surveys at about three- to five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of major areas of nuisance plant growth and areas chemically treated.

- Additional periodic monitoring of the aquatic plant community is recommended for the early detection and control of future-designated nonnative species that may occur. Such control could be effected with the assistance of funds provided under the Chapter NR 198, aquatic invasive species control grant program, and should be undertaken as soon as possible once the presence of a nonnative, invasive species is observed and confirmed, reducing the risk of spread from waters where they are present and restoring native aquatic communities. Control of currently designated invasive species, designated pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, using appropriate control measures,[7] is recommended throughout the Lake.

ANCILLARY PLAN RECOMMENDATIONS

Shoreline Protection

Shoreline protection measures refer to a group of management measures designed to reduce and minimize shoreline loss due to erosion by waves, ice, or related action of the water. Currently, much of the shoreline of Lake Wandawega is in a natural state. To the extent practicable, continued use of vegetative shoreline protection is recommended. Where structural management measures were installed, most of the observed shoreline protection measures were in a good state of repair and no severe erosion-related problems were observed. Some upland erosion in areas draining to the Lake, however, were observed and corrective actions indicated. Monitoring of shoreline vegetation for early detection and control of purple loosestrife, for example, and ongoing maintenance of shoreline protection structures is recommended.

Array of Management Measures

Four shoreline erosion control techniques are commonly used: vegetative buffer strips, rock revetments, wooden and concrete bulkheads, and beach. Maintenance of a vegetated buffer strip immediately adjacent to the Lake is the simplest, least costly, and most natural method of reducing shoreline erosion. This technique employs natural vegetation, rather than maintained lawns, in the first five to 10 feet back from the waterline and the establishment of emergent aquatic vegetation from the waterline out to two to six feet lakeward. The use of such natural shorescaping techniques is generally required pursuant to Chapter NR 328 of the *Wisconsin Administrative Code*, except in moderate- to high-energy shorelines where more-robust structural approaches may be required. A worksheet is provided within Section NR 328.08 Table 1 as a means of assisting property owners who wish to install or modify existing shoreline protection structures.

Desirable plant species that may be expected and encouraged to form an effective buffer strip, or which could be planted, include arrowhead (*Sagittaria latifolia*) and cattail (*Typha* spp.)—both of which have been reported as occurring along the shoreline of Lake Wandawega, as well as common reed (*Phragmites communis*), water plantain (*Alisma plantago-aquatica*), bur-reed (*Sparganium eurycarpum*), and blue flag (*Iris versicolor*) in the wetter areas; and jewelweed (*Impatiens biflora*), elderberry (*Sambucus canadensis*), giant goldenrod (*Solidago gigantea*), marsh aster (*Aster simplex*), red-stem aster (*Aster puniceus*), and white cedar (*Thuja occidentalis*) in the drier areas. In addition, trees and shrubs, such as silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), black willow (*Salix nigra*), and red-osier dogwood (*Cornus stolonifera*) could become established. These plants will develop a more extensive root system than lawn grass and the aboveground portion of the plants will protect the soil against the erosive forces of rainfall and wave action. A narrow path to the Lake could be

[7]*Appropriate control measures include, but are not limited to, any permitted aquatic plant management measure, placement of signage, and use of buoys to isolate affected areas of the Lake. Such measures as may be appropriate should be determined in consultation with WDNR staff and conducted in accordance with required permits under Chapters NR 107, NR 109, and NR 198, among others, of the* Wisconsin Administrative Code.

maintained as lake access for boating, swimming, fishing, and other activities. A vegetative buffer strip would also serve to trap nutrients and sediments washing into the Lake via direct overland flow. This alternative would involve only minimal cost.

Rock revetments, or riprap, are a highly effective method of shoreline erosion control applicable to many types of erosion problems, especially in areas of low banks and shallow water. These structures are already in place along a few isolated portions of the shoreline of Lake Wandawega. The technique involves the shaping of the shoreline slope, the placement of a porous filter material, such as sand, gravel, or pebbles, on the slope and the placement of rocks on top of the filter material to protect the slope against the actions of waves and ice. The advantages of rock revetments are that they are highly flexible and not readily weakened by movements caused by settling or ice expansion, they can be constructed in stages, and they require little or no maintenance. The disadvantages of rock revetments are that they limit some uses of the immediate shoreline. The rough, irregular rock surfaces are unsuitable for walking; require a relatively large amount of filter material and rocks to be transported to the lakeshore; and can cause temporary disruptions and contribute sediment to the lake. If improperly constructed, revetments may fail because of washout of the filter material.

Vertical bulkheads, which form barriers to wildlife and amphibians, are not recommended. Beaches, and the use of sand blankets for the control of aquatic plants within the shoreland zone, also are not recommended, although maintenance of existing beach areas is warranted, given the current intensity of use of these areas by the community.

Recommended Management Measures

The use of vegetative buffer strips and riprap, as shown in Figure 2, is recommended. These alternatives were selected because they can be constructed, at least partially, by local residents; because most of the construction materials involved are readily available; because the measures would, in most cases, enable the continued use of the immediate shoreline; and because the measures are visually “natural” or “semi-natural” and should not significantly affect the aesthetic qualities of the lake shoreline. In those portions of the Lake subject to direct action of wind waves and ice scour, the use of riprap would provide a more robust means of stabilizing shorelines, while elsewhere along the lakeshore creation of vegetated buffer strips would provide, not only shoreline erosion protection, but also enhanced shoreland habitat for fish and wildlife. In this regard, it should be noted that the selection of appropriate shoreland protection structures is subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*.

Water Quality Management

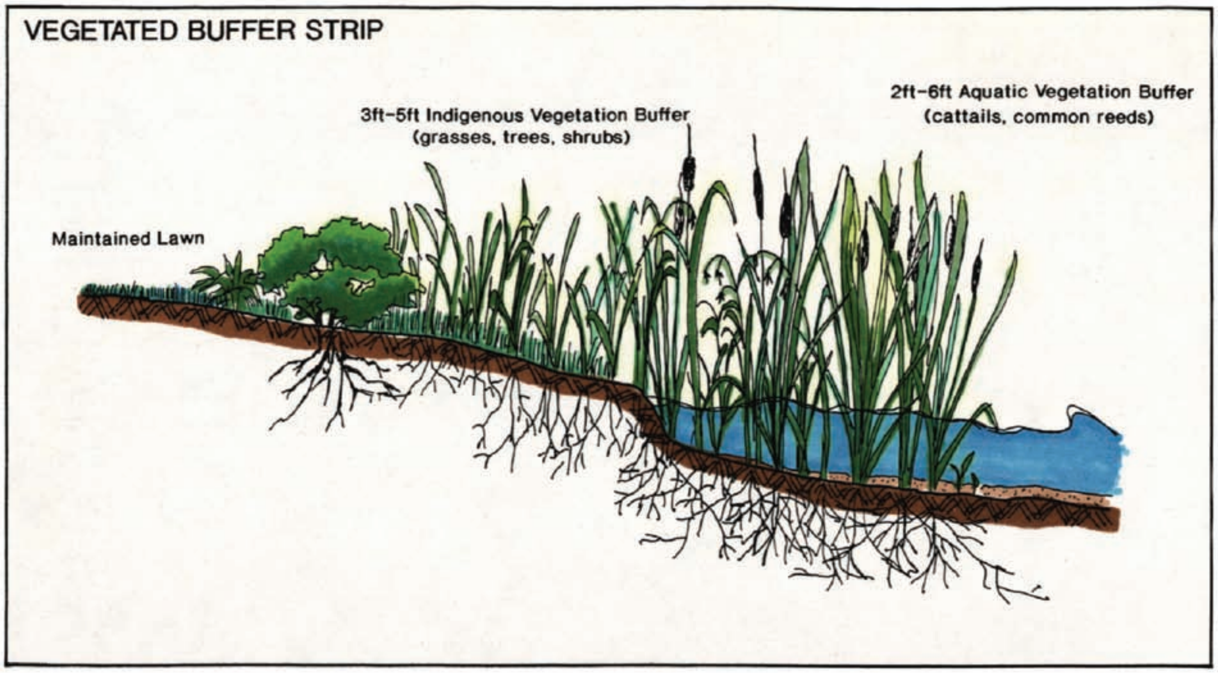
Water quality is one of the key parameters used to determine the overall health of a waterbody. The importance of good water quality can hardly be underestimated, as it impacts nearly every facet of the natural balances and relationships that exist in a lake between the myriad of abiotic and biotic elements present. Because of the importance water quality plays in the functioning of a lake ecosystem, careful monitoring of this lake element represents a fundamental management tool.

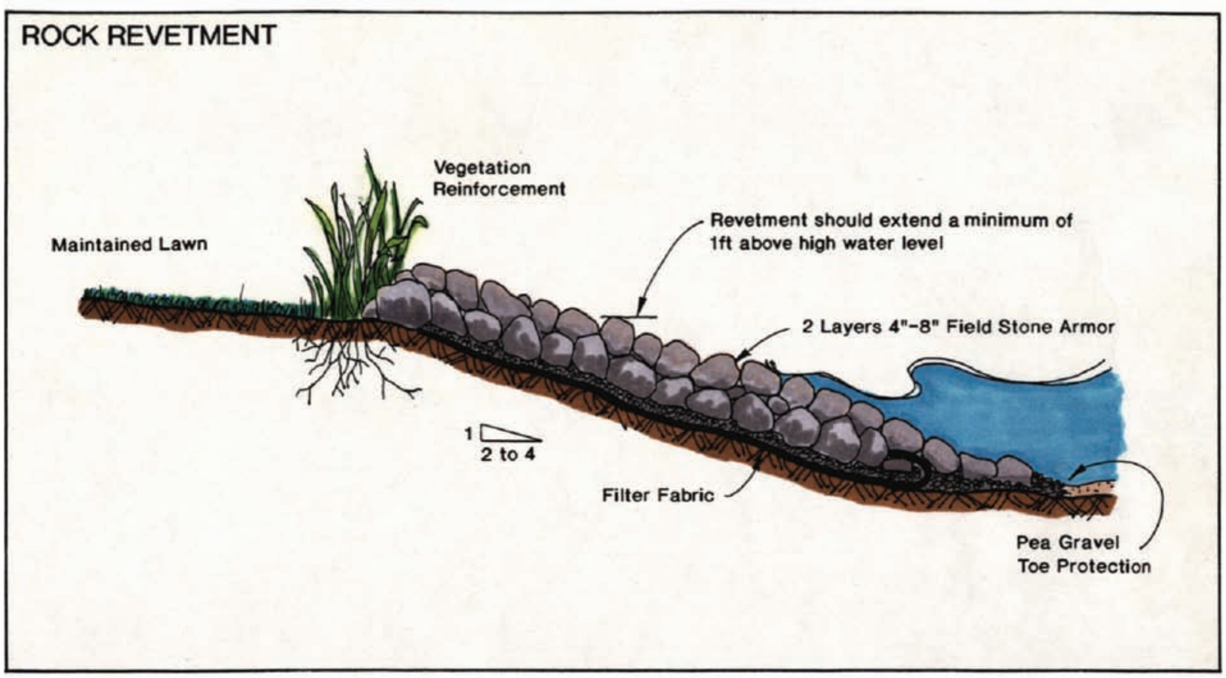
Array of Management Measures

The University of Wisconsin-Extension (UWEX) operates the Citizen Lake Monitoring Network (CLMN), formerly the WDNR Self-Help Monitoring Program. Volunteers enrolled in this program gather data at regular intervals on water clarity through the use of a Secchi disk. Because pollution tends to reduce water clarity, Secchi-disk measurements are generally considered one of the key parameters in determining the overall quality of a lake’s water, as well as a lake’s trophic status. Secchi-disk measurement data are added to the WDNR-sponsored data base containing lake water quality information for most of the lakes in Wisconsin and is accessible on-line through the WDNR website. The UWEX also offers an Expanded Self-Help Monitoring Program that involves collecting data on several key physical and chemical parameters in addition to the Secchi-disk measurements. Under this program, samples of lake water are collected by volunteers at regular intervals and analyzed by the State Laboratory of Hygiene (SLOH). Data collection is more extensive and, consequently, places more of a burden on volunteers. In the past, members of the LWIA have taken part in the abovedescribed programs, collecting water quality data on an intermittent basis.

Figure 2

RECOMMENDED ALTERNATIVES FOR SHORELINE EROSION CONTROL





NOTE: Design specifications shown herein are for typical structures. The detailed design of shoreline protection structures must be based upon analysis of local conditions.

Source: SEWRPC.

In addition to the UWEX volunteer-based CLMN program, the University of Wisconsin-Stevens Point (UW-SP) also offers several volunteer-conducted water quality sampling programs. Under these latter programs, volunteers collect water samples and send them to the UW-SP Water and Environmental Analysis Laboratory (WEAL) for analysis. The U.S. Geological Survey (USGS) also offers an extensive water quality monitoring program under their Trophic State Index monitoring program. USGS field personnel conduct a series of approximately five monthly samplings beginning with the spring turnover. Samples are analyzed by the SLOH for an extensive array of physical and chemical parameters.

The basic UWEX CLMN program is available at no charge, but does require volunteers to be committed to taking Secchi disk measurements at regular intervals throughout the spring, summer, and fall. The Expanded Self-Help Program requires additional commitment by volunteers to take a more-extensive array of measurements and samples for analysis, also on a regular basis. As with any volunteer-collected data, despite the implementation of standardized field protocols, individual variations in levels of expertise due to background and experiential differences, can lead to variations in data and measurements from lake-to-lake and from year-to-year for the same lake, especially when volunteer participation changes. The UW-SP turnover sampling program requires only a once-a-year sampling, thereby requiring a smaller time commitment by the volunteers, but, there is a modest charge for the laboratory analysis, and, because sampling is performed by volunteers, is subject to those variations identified above. Additionally, since samples need to be taken as closely as possible to the actual turnover period, which occurs only during a relatively short window of time, volunteers need to monitor lake conditions as closely as possible to be able to determine when the turnover period is occurring. The USGS program does not require volunteer sampling. All sampling and analysis is provided by USGS personnel using standardized field techniques and protocols. As a result, a more standardized set of data and measurements may be expected. However, the cost of the USGS program is significantly higher than the UW-SP program, even with State cost-share availability.

Recommended Management Measures

The WDNR offer Small Grant cost-share funding within the Chapter NR 190 Lake Management Planning Grant Program that can be applied for to defray the costs of laboratory analysis and sampling equipment. It is recommended that the LWIA resume regular participation in the CLMN program sponsored by the UWEX. Data gathered as part of this program should be presented annually by the volunteers at meetings of the LWIA, where the citizen monitors could be given some recognition for their work. The Lake Coordinator of the WDNR, Southeast Region, could assist in enlisting more volunteers in this program. The information gained at first-hand by the public from participation in this program can increase the credibility of the proposed changes in the nature and intensity of use to which the Lake is subjected.

It is further recommended that the LWIA consider participating in one of the other more comprehensive water quality programs: the UWEX Expanded Self-Help Program on an annual basis, or, either the UW-SP WEAL lake sampling program or USGS program on a periodic basis every three to five years. The use of either the UW-SP or USGS programs would be especially valuable as a means to attain a comprehensive water quality determination on a periodic basis while maintaining yearly CLMN data.

Recreational Use Management

Current public recreational boating standards as set forth in Sections NR 1.91(4) and NR 1.91(5) of the *Wisconsin Administrative Code*, establish minimum and maximum standards for public boating access development, respectively, to qualify waters for resource enhancement services provided by the WDNR. As noted in Chapter II, there is currently one public boating access on Lake Wandawega. This site, located at the eastern end of the Lake, is owned by the Town of Sugar Creek. The site provides a single, paved launch with a gravel parking area and is deemed to provide adequate public access. The site should continue to be periodically monitored to ensure consistency with public recreational boating access standards.

Recommended Management Measures

In addition to periodically inspecting and maintaining the existing public recreational boating access, it is recommended that the Town of Sugar Creek place appropriate signage at the public recreational boating access site be provided to alert users of Eurasian water milfoil, zebra mussels, and other nonnative invasive species. Such information should also be included in the Lake Wandawega Improvement Association's informational programming, consistent with the aquatic plant management measures set forth in this plan. The Association should consider participating in the WDNR Clean Boats-Clean Waters Program.

Public Informational and Educational Programming

As part of the overall citizen informational and educational programming to be conducted in the Lake Wandawega community, residents and visitors in the vicinity of the Lake should be made aware of the value of the ecologically significant areas in the overall structure and functioning of the ecosystems of the Lake. Specifically, informational programming related to the protection of ecologically valuable areas in and around the Lake should focus on the need to minimize the spread of nuisance aquatic invasive species, such as purple loosestrife and Eurasian water milfoil.

With respect to aquatic plants, distribution of posters and pamphlets, available from the UWEX and the WDNR, that provide information and illustrations of aquatic plants, their importance in providing habitat and food resources in aquatic environments, and the need to control the spread of undesirable and nuisance plant species is recommended. Currently, many lake residents seem to view all aquatic plants as "weeds" and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impact. Inclusion of specific public informational and educational programming within the activities of the Town of Sugar Creek and the LWIA is recommended. These programs should focus on the value and impacts of these plants on water quality, fish, and on wildlife, and on alternative methods for controlling existing nuisance plants, including the positive and negative aspects of each method. These programs can be incorporated into the comprehensive informational and educational programs that also would include information on related topics, such as water quality, recreational use, fisheries, and onsite sewage disposal systems.

Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the lake management program, are available from the UWEX, the WDNR, the Walworth County Offices, and many Federal government agencies. These brochures could be provided to homeowners through local media, direct distribution, or targeted library/civic center displays. Alternately, they could be incorporated into the newsletters produced and distributed by the LWIA. Many of the ideas contained in these publications can be integrated into ongoing, larger-scale activities, such as anti-littering campaigns, recycling drives, and similar pro-environment activities.

Other informational programming offered by the WDNR, Walworth County, and the UWEX Lakes Program, such as the Adopt-A-Lake program and Project WET (Water Education Training) curriculum, can contribute to an informed public, actively involved in the protection of ecologically valuable areas within the area tributary to Lake Wandawega. Citizen monitoring and awareness of the positive value of native aquatic plant communities are important opportunities for public informational programming and participation that are recommended for the Lake.

Lake Association Board Continuing Education

As part of their commitment to the effective managing of Lake Wandawega, the LWIA board members should avail themselves of opportunities to learn about current developments and issues involving lake management. There are numerous publications, writings, newsletters, seminars and conventions available through governmental, educational and other organizations and agencies dealing with the subject of lake management. The University of Wisconsin-Stevens Point, Walworth County, UWEX, Wisconsin Association of Lakes (WAL), the North American Lake Management Society (NALMS), and WDNR, all produce written material and conduct meetings and seminars dealing with lake management issues. Publications, such as *Lake Tides*, published by the Wisconsin Lakes Partnership and available from UWEX, are also readily available and deal with a wide range of lake-related topics. Additionally, the statewide Lakes Convention, held annually (in Green Bay, Wisconsin), provides valuable opportunities to learn about important and timely developments in lake management and learn about lake issues from experts in their fields. Participation in activities that will further understanding of lake management issues is deemed an important part of the lake management experience.

SUMMARY

This plan documents the findings and recommendations of a study of the aquatic plant community of Lake Wandawega requested by the Town of Sugar Creek and the LWIA, and examines existing and anticipated conditions, potential aquatic plant management problems, and recreational use problems on Lake Wandawega. The plan sets forth recommended actions and management measures for the resolution of those problems. The recommended plan is summarized in Table 15 and shown on Map 9.

Lake Wandawega was found to be an oligo-mesotrophic lake of good water quality. Preservation of environmental corridor lands, and especially within the shoreland areas situated immediately adjacent to the Lake, is recommended. Walworth County and the Town of Sugar Creek, together with the LWIA, should support appropriate land management practices designed to reduce nonpoint source pollutant discharges in stormwater runoff into the Lake. Further, the Town and LWIA should promote appropriate shoreline management practices, including the use of riprap and vegetative buffer strips, where applicable.

The shoreland protection and aquatic plant management elements of this plan recommend actions be taken that would reduce human impacts on ecologically valuable areas in and adjacent to the Lake, encourage a biologically diverse community of native aquatic plants, and limit the spread of nonnative invasive plant species. The plan recommends the use of mechanical harvesting of nuisance plants in those areas where depth of water and bottom substrate are sufficient to support such activity, limited use of chemical herbicides mainly in areas where nuisance levels of nonnative invasive species are present, manual harvesting aquatic plants around piers and docks with subsequent removal of cut material from the Lakes, and monitoring of invasive species populations. The plan further recommends periodic in-lake aquatic plant surveys every three to five years to monitor changes in the aquatic plant community and assess effectiveness of aquatic plant management techniques.

The plan recommends regular participation in the UWEX CLMN volunteer water quality monitoring program with consideration of participation in the Expanded Self-Help Program, and periodic conduct of USGS, or equivalent, comprehensive water quality surveys. With regard to recreational uses of Lake Wandawega, the plan recommends maintaining the public access site in a manner consistent with Chapter NR 1 standards and Chapter NR 7 guidelines, as well as maintaining signage regarding aquatic and other invasive species.

Finally, the recommended plan includes continuation of an ongoing program of public information and education, focusing on providing riparian residents and lake users with an improved understanding of the lake ecosystem. For example, additional options regarding household chemical use, lawn and garden care, onsite sewage disposal system operation and maintenance, shoreland protection and maintenance, and recreational use of the Lake should be made available to riparian property owners, thereby providing riparian residents with alternatives to traditional activities. Additionally, LWIA Board members are encouraged to maintain and broaden their awareness of current developments in the area of lake management through participation in meetings, seminars, conventions and other lake management-related events, and educational opportunities.

Adherence to the recommendations contained in this plan should provide the basis for a set of management actions that are: aligned with the goals and objectives set forth in Chapter I of this report; reflective of the ongoing commitment by the Lake Wandawega community, through the LWIA and the Town of Sugar Creek, to sound planning with respect to the Lake; and, sensitive to current needs, as well as those in the immediate future.

Table 15

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR LAKE WANDAWEGA

Plan Element	Subelement	Management Measures	Management Responsibility
Aquatic Plant Management Measures	Aquatic Plant Management	Conduct periodic in-lake reconnaissance surveys of aquatic plant communities and update aquatic plant management plan every three to five years	LWIA
		Mechanically harvest nuisance plants to maintain boating access, promote public safety, enhance angling opportunities, and encourage growth of native plants Limited use of aquatic herbicides for control of nuisance nonnative aquatic plant growth where necessary; specifically target Eurasian water milfoil[a] (EWM) Encourage growth of native plants in Lake Wandawega through use of vegetated buffer strips and control of EWM	WDNR and LWIA
		Additional periodic monitoring of the aquatic plant community for the early detection and control of future-designated nonnative species that may occur	WDNR, LWIA and private landowners
		Manually harvest around piers and docks as necessary[b] Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and deposition of organic materials in Lake	Private landowners
		Monitor invasive species populations; where they occur, remove isolated stands of purple loosestrife through bagging, cutting, herbicide application to cut stems	WDNR, LWIA and private landowners
Ancillary Management Measures	Shoreline Protection Management	Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Walworth County, Town of Sugar Creek, WDNR, and private landowners
	Water Quality Management	Continue participation in WDNR CLMN program and consider participation in WDNR Expanded Self-Help Program, periodic participation in U.S. Geological Survey TSI or similar programs	WDNR, USGS, LWIA
	Recreational Use Management	Maintain recreational boating access from the public access site pursuant to Chapter NR 7 guidelines Maintain signage at public access sites regarding invasive species and WDNR Clean Boats-Clean Waters Program; provide disposal containers for disposal of plant material removed from watercraft	WDNR, Town of Sugar Creek
	Public informational and educational programming	Continue to provide informational material and pamphlets on lake-related topics, especially the importance of aquatic plants and the protection of ecologically significant areas; consider offering public informational programming on topics of lake-oriented interest and education	Town of Sugar Creek, LWIA, WDNR, and UWEX
		Encourage inclusion of lake studies in environmental curricula (e.g., Pontoon Classroom, Project WET, Adopt-A-Lake)	Area school districts, UWEX, WDNR, Town of Sugar Creek, and LWIA
		Encourage riparian owners to monitor their shoreline areas as well as open-water areas of the Lake for new growths of nonnative plants and report same immediately to LWIA	LWIA
	Lake district board continuing education	Maintain awareness of current developments in the area of lake management through informative publications such as "Lake Tides" (available free through the Wisconsin Lakes Partnership) and attendance at lake education conventions, workshops, and seminars	LWIA

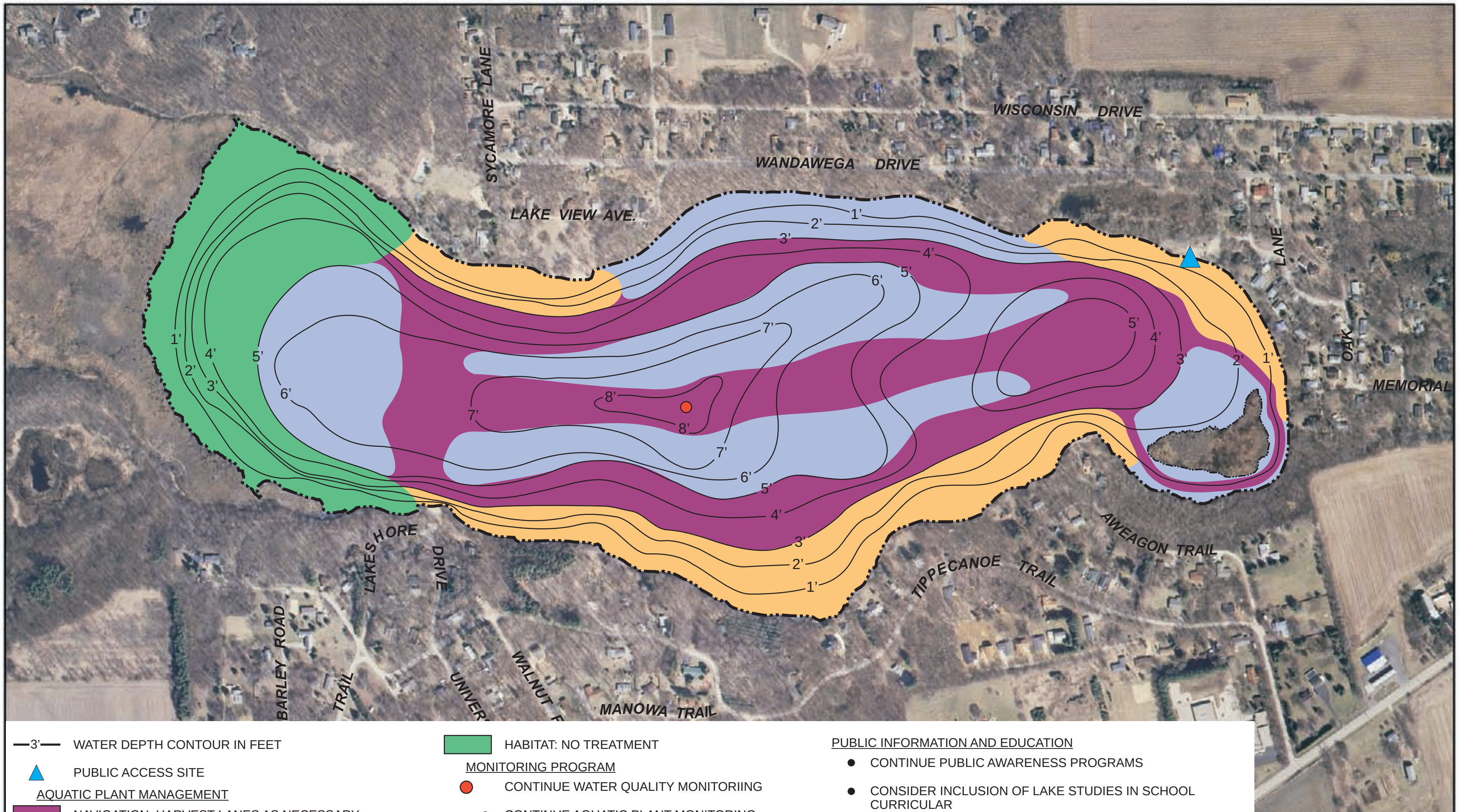
[a] *Use of aquatic herbicides requires a WDNR permit pursuant to Chapter NR 107 of the* Wisconsin Administrative Code.

[b] *Manual harvesting beyond a 30-linear-foot width of shoreline is subject to WDNR individual permitting pursuant to Chapter NR 109 of the* Wisconsin Administrative Code.

Source: SEWRPC.

Map 9

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR LAKE WANDAWEGA



—3'— WATER DEPTH CONTOUR IN FEET

PUBLIC ACCESS SITE

AQUATIC PLANT MANAGEMENT

NAVIGATION: HARVEST LANES AS NECESSARY
HIGH PRIORITY

SHORELAND/LITTORAL: LIMITED HERBICIDES, TARGET
EURASIAN WATER MILFOIL
HIGH PRIORITY

MIXED USED: CONTROL NONNATIVE SPECIES AS
NECESSARY
LOW PRIORITY

HABITAT: NO TREATMENT

MONITORING PROGRAM

- CONTINUE WATER QUALITY MONITORIING
- CONTINUE AQUATIC PLANT MONITORING
- MONITOR INVASIVE SPECIES POPULATIONS AS NECESSARY

SHORELINE MANAGEMENT

- MAINTAIN EXISTING STRUCTURES
- MONITOR INVASIVE SPECIES POPULATIONS AS NECESSARY

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAMS
- CONSIDER INCLUSION OF LAKE STUDIES IN SCHOOL CURRICULAR
- ENCOURAGE BOARD MEMBERS AND OTHERS TO ATTEND SEMINARS ON LAKE ISSUES

GRAPHIC SCALE
0 300 600 FEET

Source: SEWRPC.

DATE OF PHOTOGRAPHY: APRIL 2005

APPENDICES

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Appendix A

SEASONAL WATER QUALITY CONDITIONS IN LAKE WANDAWEGA: 1966-2006

Sample Date	Sample Depth (feet)	Secchi Depth (feet)	pH (std. units)	Dissolved Oxygen (mg/l)	Chlorophyll-*a* (µg/l)	Phosphorus (mg/l)
Summer						
08/25/1966	3	- -	8.3	- -	- -	- -
09/09/1980	1	8.0	- -	- -	2.00	- -
09/14/1981	1	2.5	- -	- -	5.00	- -
06/21/1995	1	- -	- -	7.5	2.08	0.023
06/21/1995	5	- -	- -	6.9	- -	0.036
07/25/1995	1	- -	- -	9.0	0.37	0.016
08/22/1995	1	- -	- -	7.3	0.73	0.014
08/18/1999	1	4.9	9.7	9.5	1.06	0.014
08/03/2004	1	4.6	8.7	9.6	- -	0.015
09/07/2006	- -	6.0	- -	- -	- -	- -
06/28/2007	- -	9.5	- -	- -	- -	- -
07/09/2007	- -	10.0	- -	- -	- -	- -
07/20/2007	- -	10.0	- -	- -	- -	- -
08/04/2007	- -	10.0	- -	- -	- -	- -
08/18/2007	- -	10.0	- -	- -	- -	- -
Fall						
11/16/1978	0	7.0	7.9	12.7	- -	0.030
11/16/1978	6	7.0	7.8	12.6	- -	0.020
09/21/1995	1	- -	8.9	9.4	1.75	0.011
10/17/1995	1	- -	8.1	10.6	1.84	0.013
09/21/2006	- -	6.0	- -	- -	- -	- -
09/23/2006	- -	5.0	- -	- -	- -	- -
10/07/2006	- -	7.0	- -	- -	- -	- -
09/11/2007	- -	10.0	- -	- -	- -	- -
09/22/2007	- -	10.5	- -	- -	- -	- -
10/05/2007	- -	10.5	- -	- -	- -	- -
09/21/2008	- -	11.3	- -	- -	- -	- -
Winter						
02/03/1978	0	3.3	7.5	0.4	- -	0.070
02/03/1978	6	3.3	7.6	0.9	- -	0.050
03/09/1979	2	2.9	7.8	1.9	- -	0.020
03/09/1979	7	2.9	7.6	1.1	- -	0.010
Spring						
04/12/1978	0	5.0	7.7	10.4	- -	0.050
04/12/1978	6	- -	7.7	10.3	- -	0.070
04/26/1979	0	6.0	7.1	8.7	- -	0.010
04/26/1979	7	- -	- -	- -	- -	0.045
04/17/1995	1	- -	- -	- -	2.34	0.010
05/05/2004	1	4.3	9.0	10.9	- -	0.017
05/01/2007	- -	9.0	- -	- -	- -	- -
05/31/2007	- -	9.0	- -	- -	- -	- -
06/10/2006	- -	9.0	- -	- -	- -	- -

Source: SEWRPC.

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Appendix B

AQUATIC PLANT ILLUSTRATIONS FOR LAKE WANDAWEGA

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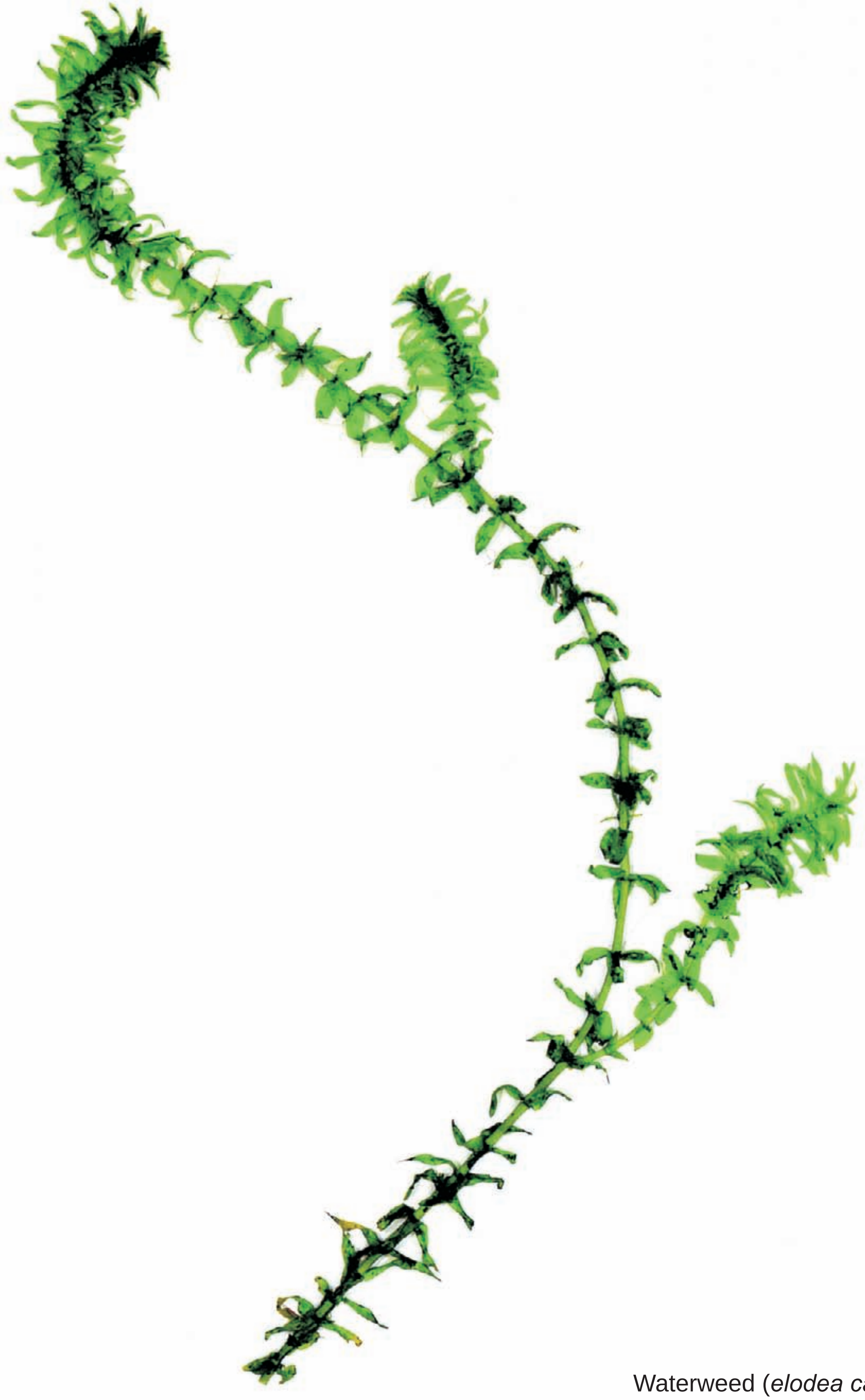
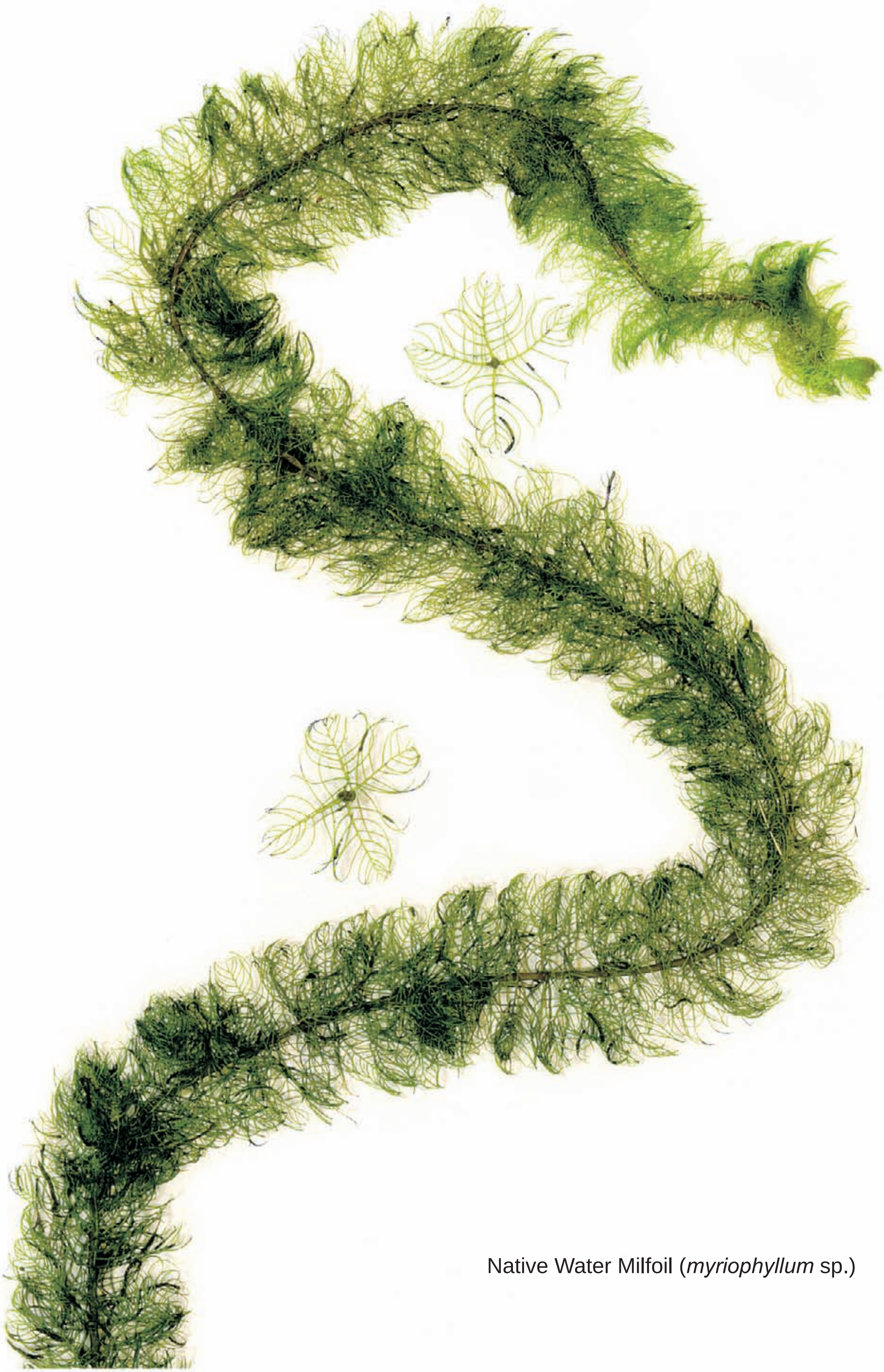
Coontail (*ceratophyllum demersum*)

Muskgrass (*chara vulgaris*)



Waterweed (*elodea canadensis*)



Native Water Milfoil (*myriophyllum* sp.)

Eurasian Water Milfoil (*myriophyllum spicatum*)
Exotic Species (nonnative)

Bushy Pondweed (*najas flexilis*)

Large-Leaf Pondweed (*potamogeton amplifolius*)

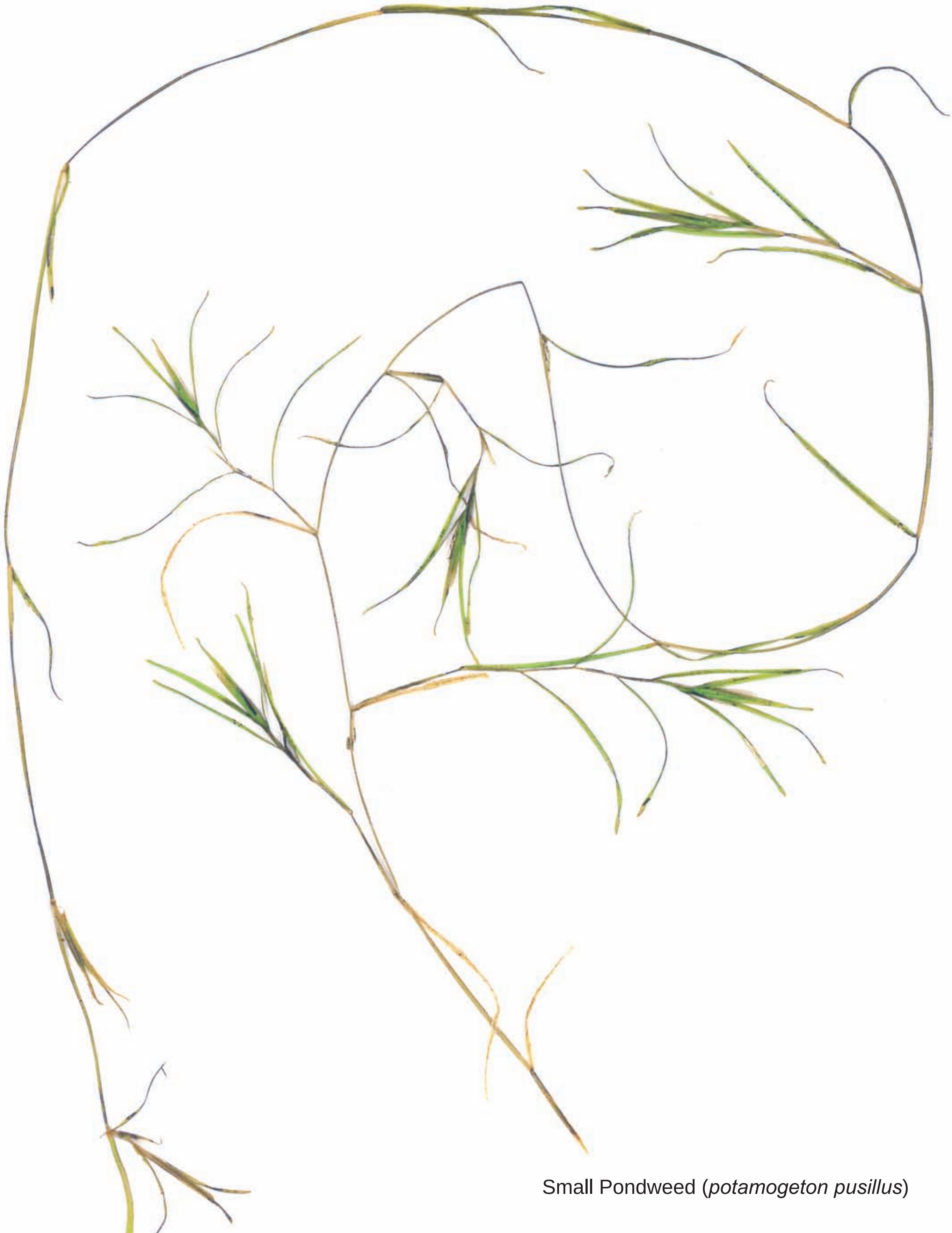
Leafy Pondweed (*potamofeton foliosus*)

Variable Pondweed (*potamogeton gramineus*)

Illinois Pondweed (*potamogeton illinoensis*)

Floating-Leaf Pondweed (*potamogeton natans*)

Sago Pondweed (*potamogeton pectinatus*)



Small Pondweed (*potamogeton pusillus*)

Clasping-Leaf Pondweed
(*potamogeton richardsonii*)

Flat-Stem Pondweed (*potamogeton zosteriformis*)

White Water Crowfoot (*ranunculus longirostris*)

Bladderwort (*utricularia* sp.)

Eel-Grass / Wild Celery (*valisneria americana*)

Water Stargrass (*zosterella dubia*)