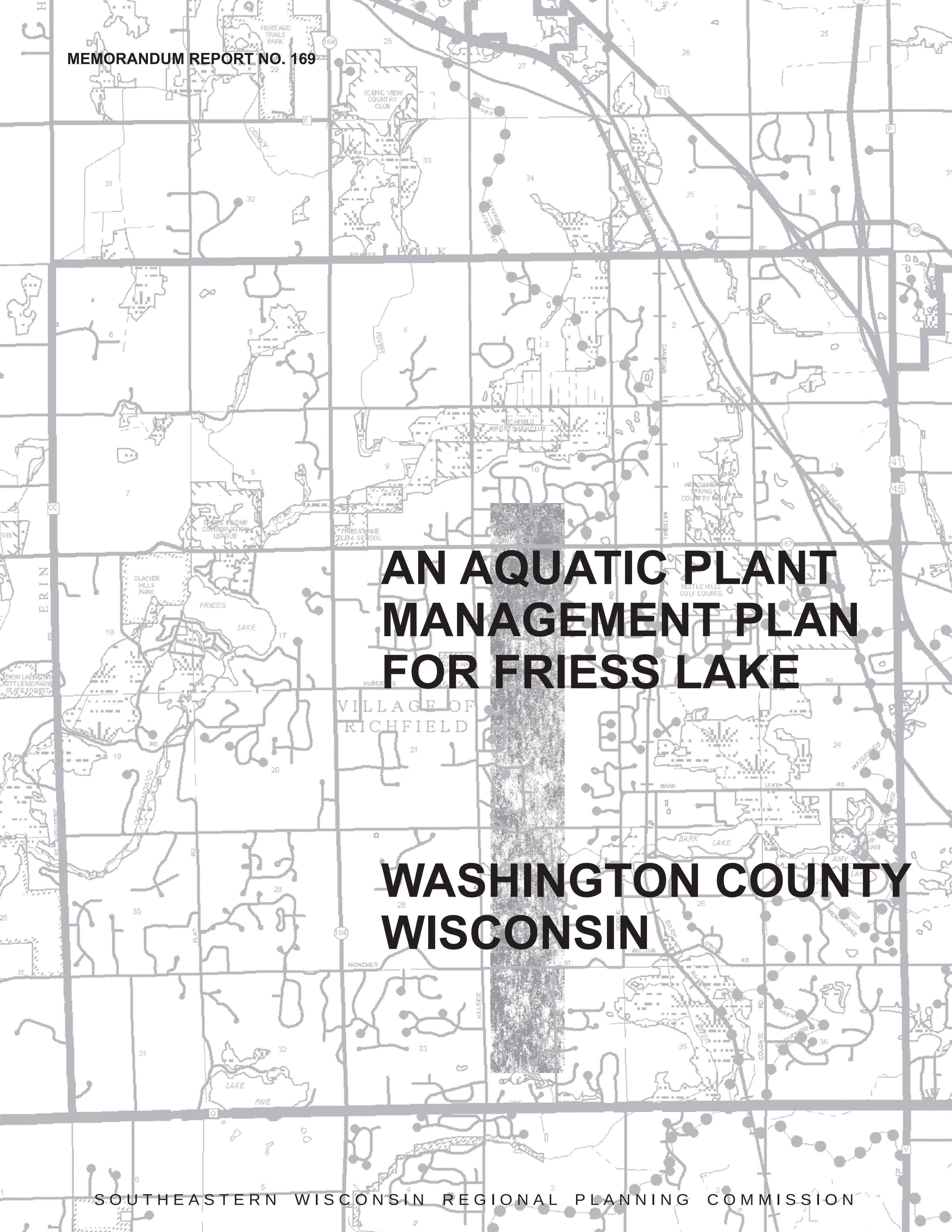


MEMORANDUM REPORT NO. 169

AN AQUATIC PLANT MANAGEMENT PLAN FOR FRIESS LAKE

WASHINGTON COUNTY WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

**SOUTHEASTERN WISCONSIN REGIONAL
PLANNING COMMISSION STAFF**

Philip C. Evenson, AICP .... Executive Director

Kenneth R. Yunker, PE .... Deputy Director

Nancy M. Anderson, AICP .... Chief Community Assistance Planner

Christopher T. Hiebert .... Chief Transportation Engineer

Michael G. Hahn, PE, PH .... Chief Environmental Engineer

Elizabeth A. Larsen .... Business Manager

John G. McDougall .... Geographic Information Systems Manager

John R. Meland .... Chief Economic Development Planner

Dr. Donald M. Reed .... Chief Biologist

Kenneth J. Schlager, PE .... Chief Telecommunications Engineer

Donald P. Simon, RLS .... Chief Planning Illustrator

William J. Stauber, AICP .... Chief Land Use Planner

Special acknowledgement is due to Dr. Jeffrey A. Thornton, CLM, PH, and Dr. Thomas M. Slawski, SEWRPC Principal Planners; Mr. Aaron W. Owens and Ms. Sara Wilder Teske, SEWRPC Research Analysts; 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.

MEMORANDUM REPORT NUMBER 169

AN AQUATIC PLANT MANAGEMENT PLAN FOR FRIESS LAKE

WASHINGTON COUNTY, WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin 53187-1607
www.sewrpc.org

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

June 2008

$10.00

(This page intentionally left blank)

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

(This page intentionally left blank)

Chapter I

INTRODUCTION

Friess Lake, located in the Village of Richfield,[1] Washington County, Wisconsin, is a 119-acre through-flow lake. Friess Lake is a valuable natural resource and offers a variety of recreational and related opportunities to the resident community and its visitors. The Lake is located on the Oconomowoc River entirely within U.S. Public Land Survey Township 9 North, Range 19 East, Sections 17 and 18, in the Village of Richfield, in Washington County.

In recent years, the recreational and aesthetic values of Friess Lake have been perceived to be adversely affected by excessive aquatic plant growth within portions of the Lake. Seeking to improve the usability and to prevent the deterioration of the natural assets and recreational potential of the Lake, the Friess Lake community has worked to coordinate and undertake various lake management activities for the protection of Friess Lake, including the creation of an appropriate citizen-based organization and the conduct of aquatic plant management measures.[2]

With the active participation of the citizen-based lake organizations, the Friess Lake community, in cooperation with the Village of Richfield, requested a further review and update of the aquatic plant management element of the comprehensive lake management plan for the Lake.[3] This plan review and update is a continuation of the program of lake management planning that has been undertaken on the Lake over the preceding 20-year period. This planning program has included not only the production and publication of the two editions of the comprehensive lake management plan for Friess Lake but also included lake management investigations

---

[1]*During November 2007, the electors of the Town of Richfield voted to approve the incorporation of the Town as the Village of Richfield, which became effective as of February 13, 2008.*

[2]*The Friess Lake community is currently served by the Friess Lake Advancement Association, and has been served by both this organization and the Friess Lake Action Group (FLAG). The latter organization actively assisted with the development and publication of a second edition of the comprehensive lake management plan for the Lake, published as SEWRPC Community Assistance Planning Report No. 98, 2nd Edition,* A Lake Management Plan for Friess Lake, Washington County, Wisconsin, *during November 1997. FLAG has since been subsumed into the FLAA, which continues to represent the interests of the Friess Lake community, in partnership with the Village of Richfield, with respect to lake management activities.*

[3]*SEWRPC Community Assistance Planning Report No. 98, 2nd Edition,* op. cit. *See also SEWRPC Community Assistance Planning Report No. 98,* A Water Quality Management Plan for Friess Lake, Washington County, Wisconsin, *August 1983.*

completed as an element of the Oconomowoc River Priority Watershed Project.[4] The Friess Lake community undertakes an ongoing program of lake and aquatic plant management.

The present report refines the aquatic plant management element of the comprehensive lake management plan. It reports on the condition and status of the aquatic plant community in Friess Lake during 2005, including the results of an aquatic plant reconnaissance conducted during 2007, and reviews relevant data on the drainage area tributary to the Lake and the waterbody. This plan presents refined recommendations for the management of aquatic plants within Friess Lake.

BACKGROUND

This report represents part of the ongoing commitment of the Friess Lake community, through the Friess Lake Advancement Association (FLAA) and the Village of Richfield, to sound planning with respect to the Lake. The report sets forth inventories of the aquatic plant communities present within Friess Lake. Those inventories were prepared by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) in cooperation with the FLAA, and include the results of field surveys conducted by the Commission in July 2005 and a subsequent aquatic plant reconnaissance in June 2007. The aquatic plant surveys were conducted by Commission staff using the modified Jesson and Lound transect method employed by the Wisconsin Department of Natural Resources (WDNR).[5] The planning program was funded under a Chapter NR 191 Lake Protection Grant administered by the WDNR and awarded to the Village of Richfield.

As noted above, this report is intended to refine the aquatic plant management elements of the comprehensive lake management plans for Friess Lake. The scope of this report is limited to a consideration of the aquatic plant communities present within Friess Lake, the documentation of historic changes in the plant communities based upon currently existing data and information, and refinement of those management measures which can be effective in the control of aquatic plant growth. Recommendations are made with respect to those actions to be considered and undertaken by the FLAA and the Village of Richfield, in cooperation with other governmental and nongovernmental entities as appropriate.

AQUATIC PLANT MANAGEMENT PROGRAM GOALS AND OBJECTIVES

The lake use goals and objectives for Friess Lake were developed in consultation with the FLAA and the Village of Richfield. The agreed 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 Friess Lake;

2. Effectively control the quantity and density of aquatic plant growths in portions of the Friess Lake basin 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;

3. Effectively maintain the water quality of Friess Lake 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] *Wisconsin Department of Natural Resources Publication No. PUBL-WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986.*

[5] *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. Promote a quality, water-based experience for residents and visitors to Friess Lake consistent with the policies and objectives of the WDNR as set forth in, amongst other documents, the adopted regional water quality management plan,[6] the County land and water resources management plan,[7] and, the County surface water inventory.[8]

This inventory and aquatic plant management plan elements conform to the requirements and standards set forth in the relevant *Wisconsin Administrative Codes.*[9] 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.

---

[6]*SEWRPC Planning Report No. 30*, A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, *as refined by SEWRPC Memorandum Report No. 93*, A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *published in March 1995.*

[7]*Washington County Land and Water Conservation Division, Planning and Parks Department,* Land & Water Resource Management Plan (1'st [*sic*] Revision 2006-2010), *December 2005.*

[8]*SEWRPC Memorandum Report No. 139,* Surface Water Resources of Washington County, Wisconsin, Lake and Stream Classification Project: 2000, *September 2001.*

[9]*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."*

(This page intentionally left blank)

Chapter II

INVENTORY FINDINGS

INTRODUCTION

Friess Lake is located in the Village of Richfield, Washington County, Wisconsin, as shown on Map 1. As set forth in the comprehensive lake management plan for Friess Lake,[1] As previously mentioned in Chapter I of this report, this information within this chapter supplements the comprehensive lake management plan for Friess Lake completed in 1997 and is primarily focused on refining the aquatic plant management element of the comprehensive lake management plan. Friess Lake is a natural lake comprised of two deep basins. The Lake is a flow-through lake, and is the first of a chain of lakes fed by the Oconomowoc River. The Lake receives water principally from the Oconomowoc River and an unnamed creek that enters the Lake on its eastern shore; it is drained by the Oconomowoc River, a tributary of the Rock River in the Mississippi River drainage basin. The level of the Lake is largely controlled through natural inflow and outflow of the Oconomowoc River, without the aid of artificial dams or similar structures, although a small control structure was placed about one mile downstream of the Lake outlet between about 1960 and 1982. Little Friess Lake, a 16-acre embayment, is located immediately south of the main basin of Friess Lake.

WATERBODY CHARACTERISTICS

Friess Lake is a 119-acre waterbody, the hydrographical characteristics of which are set forth in Table 1. As aforementioned, the Lake is a flow-thorough lake with two basins. Friess Lake has a maximum depth of approximately 48 feet, a mean depth of 26 feet, and a volume of 3,102 acre-feet. The general orientation of Friess Lake is northwest-southeast. The bottom contours of the Lake are steeply sloped along most of the southern and western shorelines, as shown on Map 2. Lake bottom substrates in the near shore areas of Friess Lake consist largely of sand with some soft sediments in the areas adjacent to the Oconomowoc River inflow and outflow.

TRIBUTARY AREA AND LAND USE CHARACTERISTICS

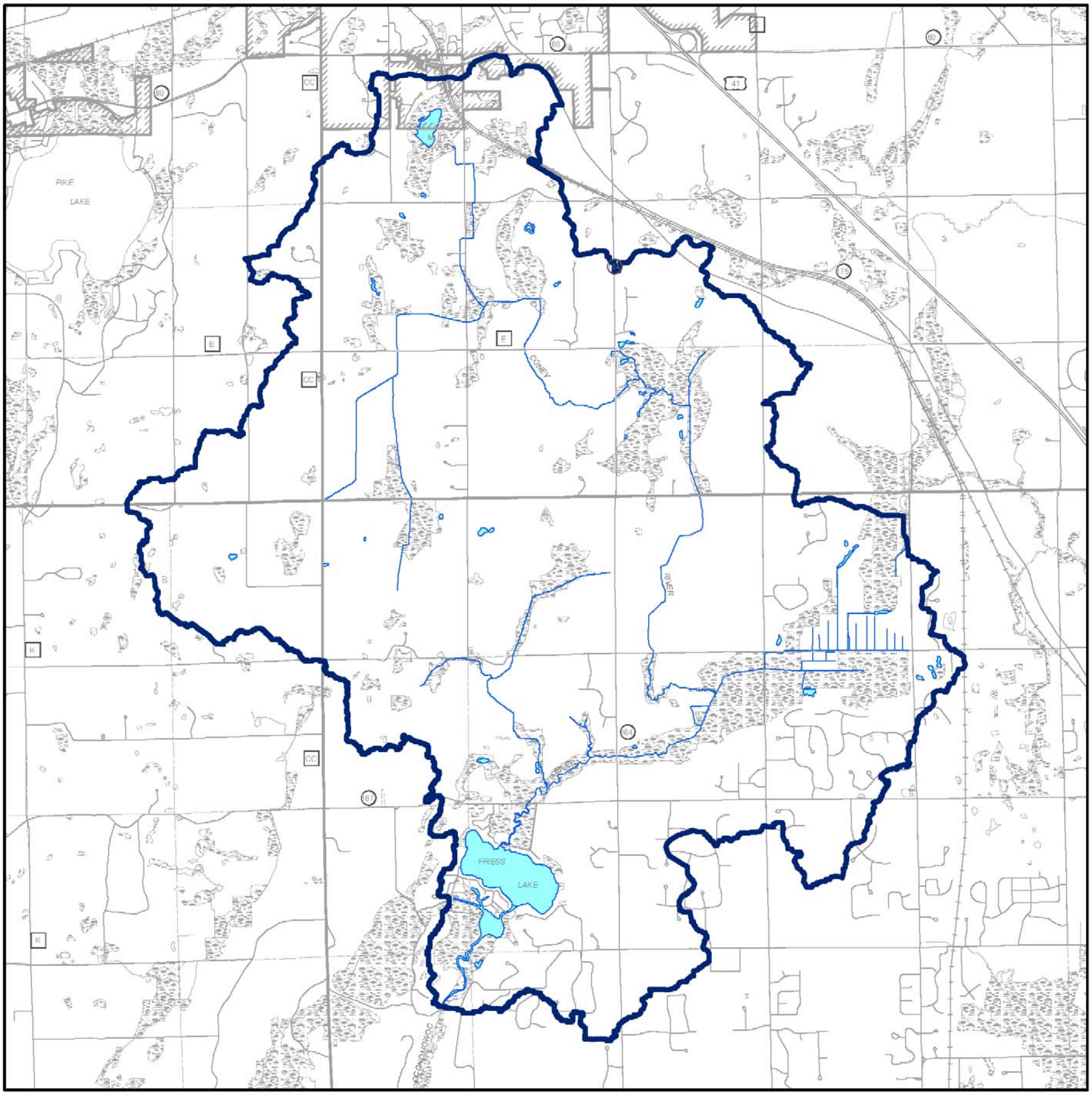
The area directly tributary to Friess Lake is situated entirely within the Village of Richfield in Washington County. This area, which drains directly to Friess Lake without passing through any upstream waterbody, is approximately 1.5 square miles (953 acres) in areal extent. As shown on Map 3, the total area tributary to Friess Lake is approximately 19.4 square miles (12,413 acres) and includes portions of: the Villages of Slinger and Richfield and the Towns of Erin, Hartford, and Polk, all in Washington County. The tributary areas of Friess Lake are situated in the south central portion of Washington County.

---

[1] *SEWRPC Community Assistance Planning Report No. 98, 2nd Edition,* A Lake Management Plan for Friess Lake, Washington County, Wisconsin, *November 1997.*

Map 1

LOCATION OF FRIESS LAKE



Total Drainage Area Boundary for Friess Lake

Surface Water

Source: SEWRPC.

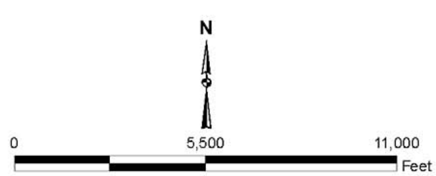


Table 1

HYDROLOGY AND MORPHOMETRY OF FRIESS LAKE: 2007

Parameter	Friess Lake
Size	
Surface Area of Lake	119 acres
Direct Tributary Area	953 acres
Total Tributary Area	12,413 acres[a]
Lake Volume	3,102 acre-feet
Residence Time[b]	0.3 years
Shape	
Length of Lake	0.64 miles
Width of Lake	0.23 mile
Length of Shoreline	2.3 miles
Shoreline Development Factor[c]	1.5
General Lake Orientation	NW-SE
Depth	
Mean Depth	26 feet
Maximum Depth	48 feet
Percentage of Lake Area	
Less than 10 feet	22 percent
10 to 30 feet	28 percent
Greater than 30 feet	50 percent

[a]*The total tributary area of Friess Lake was reported as 12,374 acres in Southeastern Wisconsin Regional Planning Commission CAPR Report No. 98 (2nd Edition),* A Lake Management Plan for Friess Lake, *1997. Since that time, advances in cartographical techniques have led to a refinement of tributary area boundaries and a more precise measurement of the tributary area.*

[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.

Population

The population and number of housing units within the Friess Lake direct tributary area have generally shown a steady increase, as shown in Table 2. After a large population increase between 1963 and 1970, there was a slight decrease in population from 1970 to 1980. From 1980 to 2000, increases in population were fairly steady with an increase each decade of about 30 to 34 percent over the previous decade. The greatest increase in population occurred from 1963 to 1970 when the number of people increased more than two and one-half times, from 186 to 502 individuals. The number of housing units increased most rapidly during the period from 1990 to 2000 when the number increased from 215 to 314 units, an increase of over 45 percent.

Over the total tributary area of Friess Lake, increases in population and number of households were fairly steady, as shown in Table 2. The largest increase in population occurred during the 1990 to 2000 period when the population increased by about 43 percent, from 2,571 to 3,670 individuals. The greatest increase in the numbers of housing units occurred during the same time period.

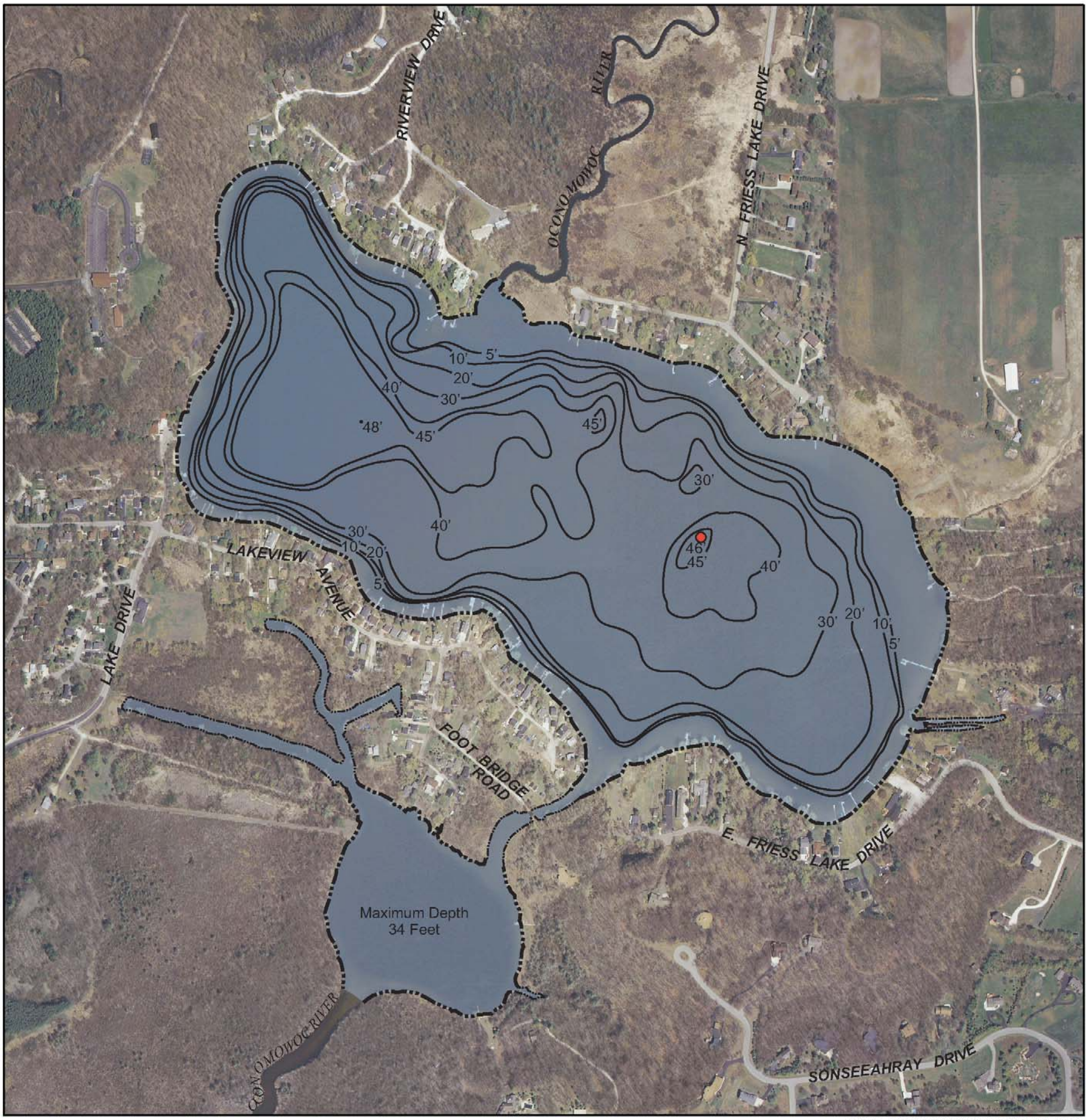
Land Uses

Land uses within the portion of the area directly tributary to Friess Lake are primarily urban, with single-family medium-density residential use being the dominant urban land use. The shoreline of the Lake is almost entirely developed for residential uses, although there are wetland areas located adjacent to the Oconomowoc River inflow and outflow as well as at the northeastern and northwestern corners of the Lake, and a woodland area located at the eastern end of the Lake.

Map 4 shows existing land uses as of 2000 in the total area tributary to Friess Lake; the areal extent of those uses is summarized in Table 3. Future changes in land use within the area tributary to the Lake may include limited further urban-density development, infilling of already platted lots, and possible redevelopment of existing properties. Under proposed year 2035 conditions, as shown on Map 5, urban land uses are expected to increase from about 19 percent of the land coverage in 2000, to about 26 percent of the land in 2035. Agricultural uses are anticipated to decrease from about 54 percent of the land coverage as of 2000 to about 47 percent of the land coverage under 2035 conditions. As shown on Map 5, these changes are predicted to occur mostly in the central portion of the tributary area. These land use changes have the potential to modify the nature and delivery of nonpoint sourced contaminants to the Lake, including both plant nutrients and sediments, with concomitant impacts on the aquatic plant community within the waterbody.

Map 2

BATHYMETRIC MAP OF FRIESS LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

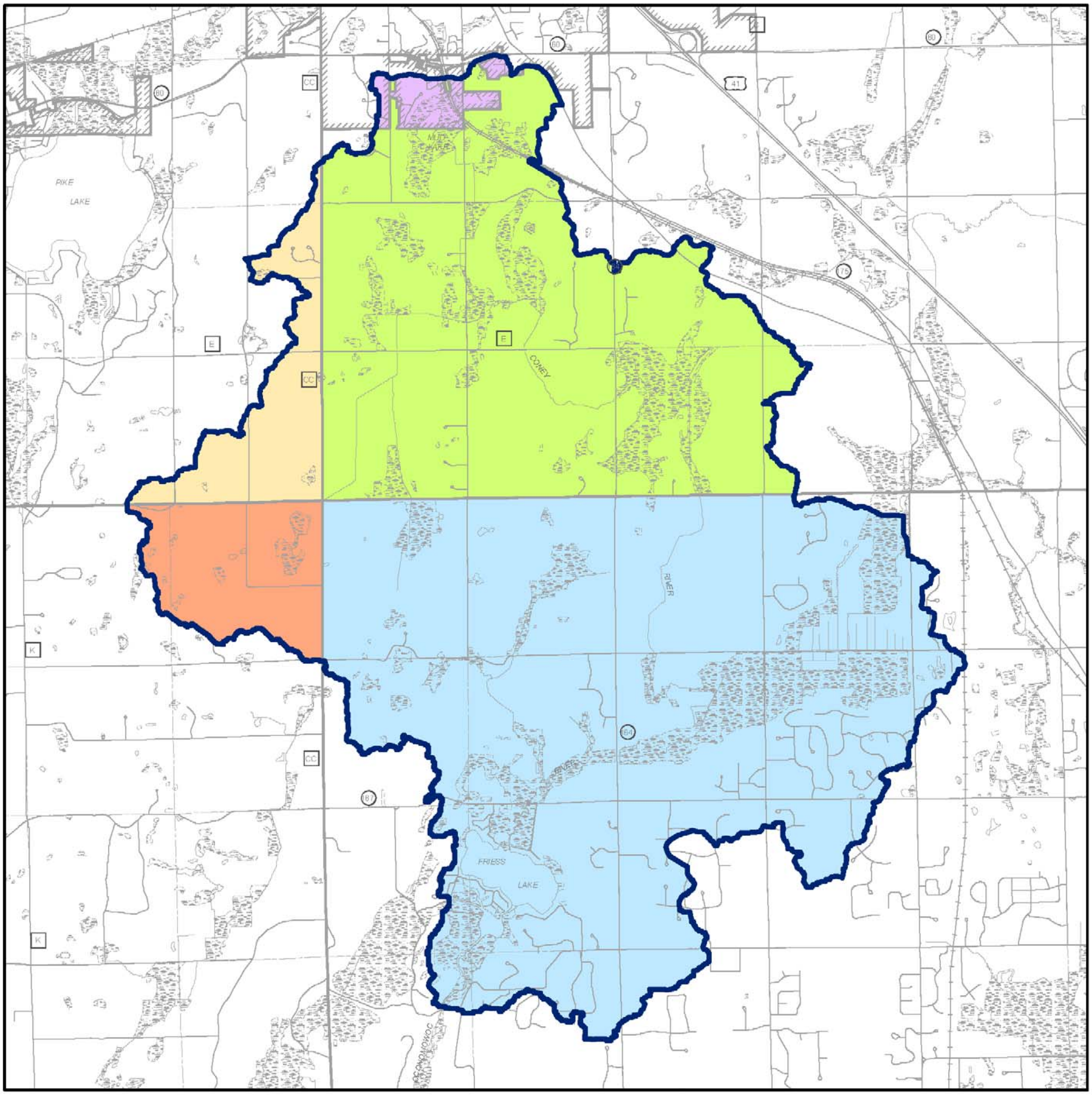
● MONITORING SITE

Source: U.S. Geological Survey and SEWRPC.

GRAPHIC SCALE 0 350 700 FEET

Map 3

CIVIL DIVISION BOUNDARIES WITHIN THE TOTAL TRIBUTARY AREA TO FRIESS LAKE



TOWN OF ERIN

TOWN OF HARTFORD

TOWN OF POLK

VILLAGE OF RICHFIELD

VILLAGE OF SLINGER

N

0 5,500 11,000 Feet

Source: SEWRPC.

Table 2

POPULATION AND HOUSEHOLDS WITHIN THE DIRECT AND TOTAL AREAS TRIBUTARY TO FRIESS LAKE: 1963-2000[a]

Year	Direct Tributary Area		Total Tributary Area	
	Population	Households	Population	Households
1963	186	61	796	211
1970	502	119	1,522	414
1980	493	155	2,032	633
1990	661	215	2,571	840
2000	861	314	3,670	1,267

[a]*These data differ slightly from those reported in the 1997 SEWRPC study on Friess Lake due to refinements of the Friess Lake tributary area boundaries through the use of more accurate topographical surveying techniques developed since the time of the earlier report.*

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 Friess Lake, conducted by SEWRPC staff for the previous 1997 planning study, indicated that, at that time, most of the shoreline was vegetated with erosion-related problems observed in only a few isolated locations. A similar survey of the shoreline of the Lake was conducted during the summer of 2005. The 2005 survey showed an increase in the use of riprap as shoreline protection structures, especially along the southwestern and northeastern shorelines, as shown on Map 6. No significant erosion-related problems were observed.

WATER QUALITY

Water quality data on Friess Lake have been collected intermittently since 1976, when data were collected by the Wisconsin Department of Natural Resources (WDNR) and SEWRPC as part of the aforereferenced water quality management plan inventory process.[2] From 1986 through 1995, water quality data for Friess Lake were recorded by the WDNR as part of its Long-Term Trend Monitoring Program; these data were included and analyzed as part of the lake management plan development process.[3] At that time, based on measurements of Secchi disk water transparency, and chlorophyll-*a* and total phosphorus concentrations, the Lake was considered to have fair to poor water quality. Subsequently, water quality data for Friess Lake and Little Friess Lake have been gathered primarily in the form of Secchi disk water clarity measurements, collected under the auspices of the WDNR Self-Help Monitoring Program since 2001, now titled the Citizen Lake Monitoring Network (CLMN) and administered by the University of Wisconsin-Extension (UWEX).

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 algae populations and activities of fish and other organisms living in the lake.

During the previous study period, it was reported that Secchi disk measurements in Friess Lake ranged from a minimum of about one foot in early March 1991, to a maximum of about 16 feet in early July 1994; spring overturn measurements during the period 1986 to 1994 averaged about five feet, indicating poor to fair water quality.

During the current study period, as shown in Figure 1, water clarity measurements for Friess Lake seemed to indicate an improvement in water clarity over the period from 1997 through 2007, with measurements indicating poor to very poor water quality during the late 1990s, but improving during the 2000s to measurements indicative of fair to good water quality conditions. Generally, Secchi disk measurements in Friess Lake indicated fair water quality. In Little Friess Lake, as shown in Figure 2, Secchi disk measurements generally indicated good water quality.

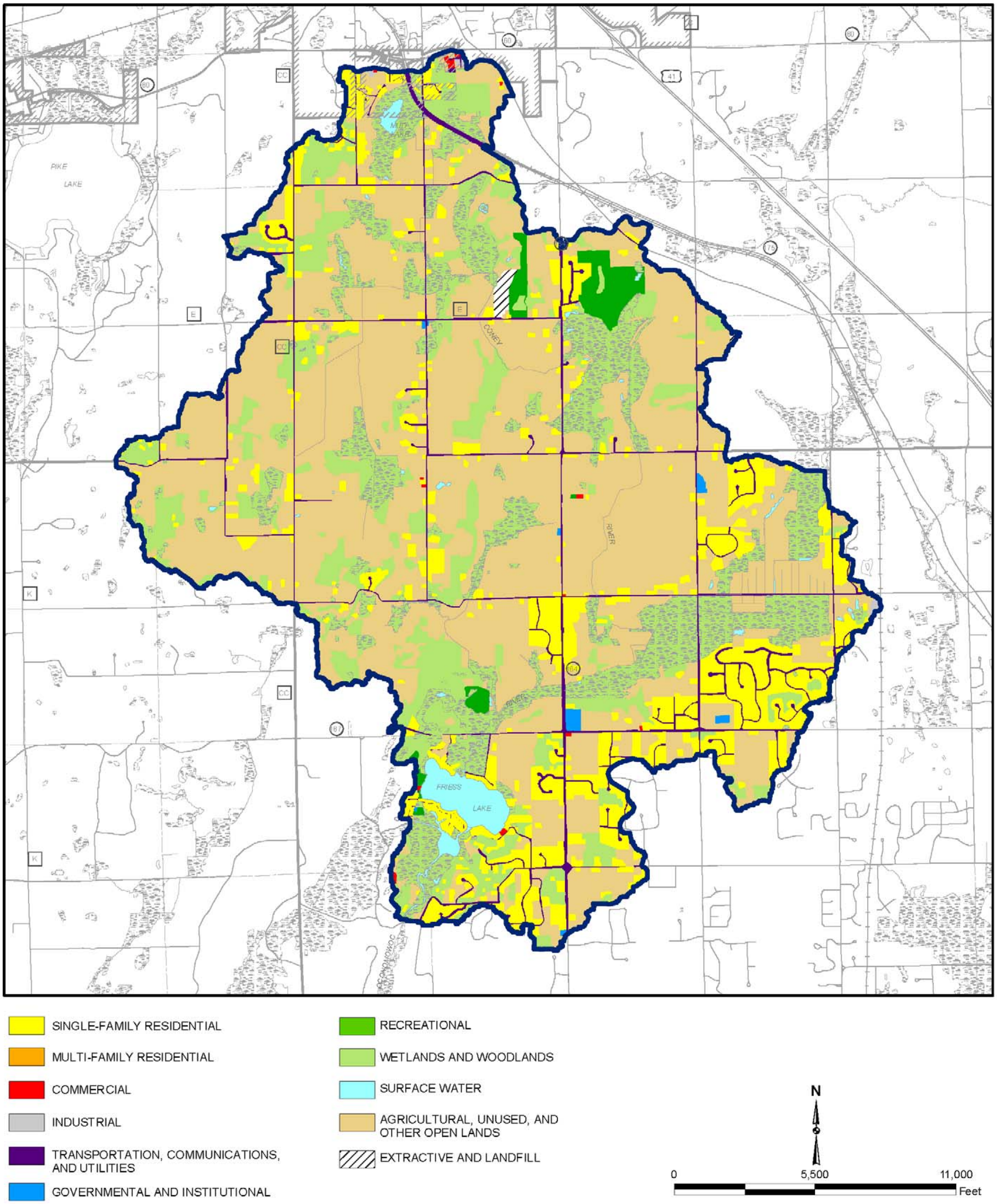
---

[2]*SEWRPC Community Assistance Planning Report No. 98,* A Water Quality Management Plan for Friess Lake, Washington County, Wisconsin, *August 1983.*

[3]*SEWRPC Community Assistance Planning Report No. 98 (2nd Edition),* op. cit.

Map 4

EXISTING LAND USE WITHIN THE TOTAL TRIBUTARY AREA TO FRIESS LAKE: 2000



Source: SEWRPC.

Table 3

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

Land Use Categories[a]	2000 Acres	2000 Percent of Tributary Area	2035 Acres	2035 Percent of Tributary Area
Urban				
Residential	1,599	12.9	2,244	18.1
Commercial	11	0.1	12	0.1
Industrial	8	0.1	41	0.3
Governmental and Institutional	24	0.2	65	0.5
Transportation, Communication, and Utilities	519	4.2	684	5.5
Recreational	171	1.4	190	1.5
Subtotal	2,332	18.9	3,236	26.0
Rural				
Agricultural and Other Open Lands	6,686	53.8	5,795	46.8
Wetlands	1,668	13.4	1,668	13.4
Woodlands	1,513	12.2	1,499	12.1
Surface Water	188	1.5	188	1.5
Extractive	27	0.2	27	0.2
Landfill	- -	- -	1	<1.0
Subtotal	10,082	81.1	9,178	74.0
Total	12,414	100.0	12,414	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

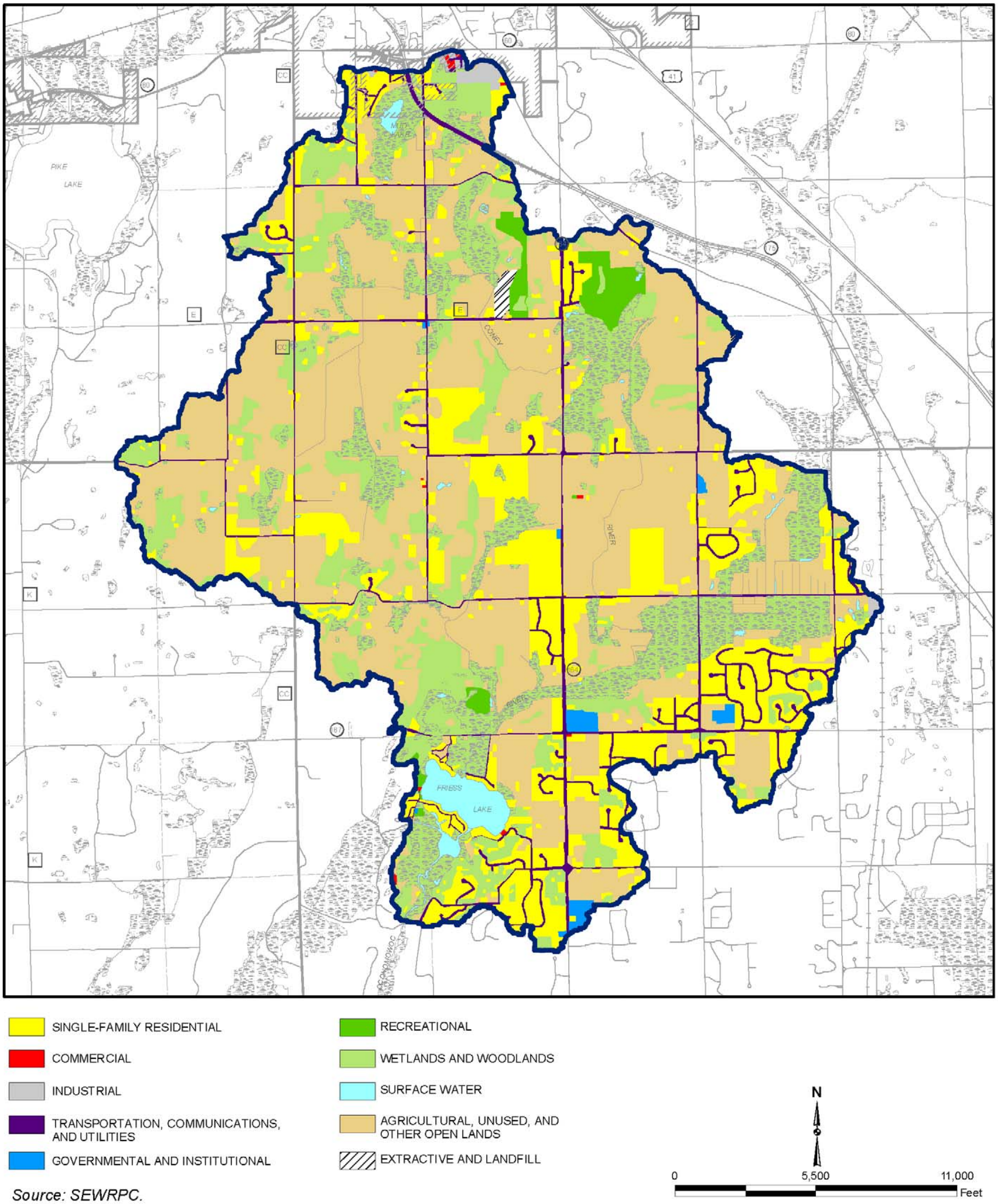
Neither Friess Lake nor Little Friess Lake are listed by the WDNR as having established populations of Zebra mussels (*Dreissena polymorpha*), a nonnative species of shellfish with known negative impacts on native benthic invertebrate populations. Volunteers from both of these Lakes have participated in the zebra mussel monitoring program since 2002. The zebra mussel monitoring program consists of the lake volunteer and a WDNR staff member conducting sampling on each Lake three times a summer. Friess Lake has three sample locations and a total of nine samples are taken each year and Little Friess Lake has two sample locations for a total of six samples taken each year. All samples collected have been examined and no zebra mussel larvae have been observed to date.

Zebra mussels are having a varied impact on inland lakes in the Upper Midwest. While they disrupt the food chain by removing significant amounts of phytoplankton which serve as food not only for the mussels but also for larval and juvenile fish and many forms of zooplankton, many lakes experience improved water clarity as a result of the filter feeding proclivities of these animals. This improved clarity 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 these 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 Eurasian water milfoil plants. This, in turn, 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. Efforts to inform lake users and area residents of the threats posed by zebra mussels should be continued to minimize the spread of such nonnative species amongst inland lakes and rivers.

In addition to direct in-lake measurements of water clarity using a Secchi disk, transparency in 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 as one of the first remote sensing facilities in the United States, uses data gathered by satellite remote sensing over a three year period to map the estimated water

Map 5

PLANNED LAND USE WITHIN THE TOTAL TRIBUTARY AREA TO FRIESS LAKE: 2035



Source: SEWRPC.

Map 6

SHORELINE PROTECTION STRUCTURES ON FRIESS LAKE: 2005

Source: SEWRPC.

Figure 1

PRIMARY WATER QUALITY INDICATORS FOR FRIESS LAKE: 1977-2007

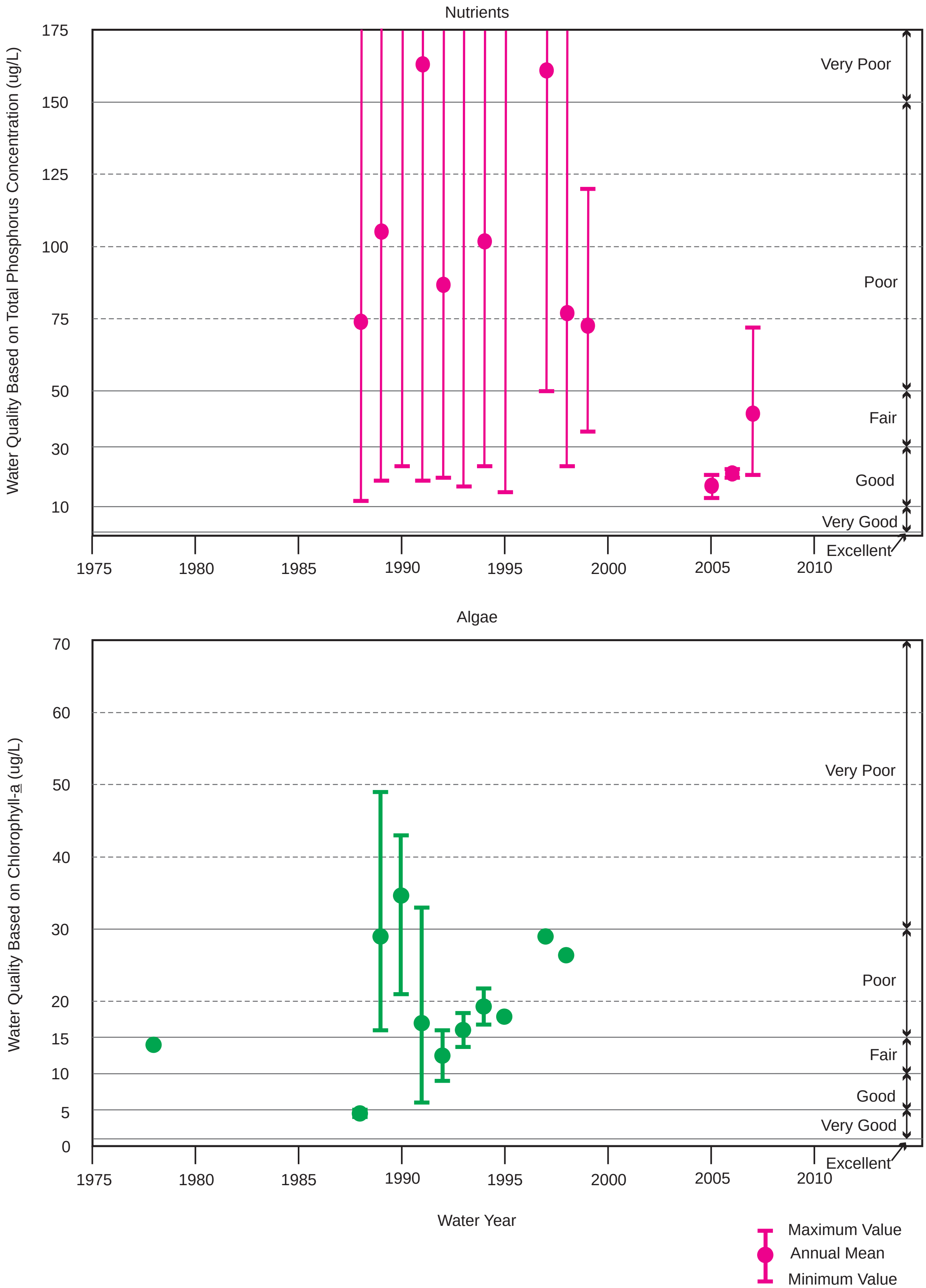
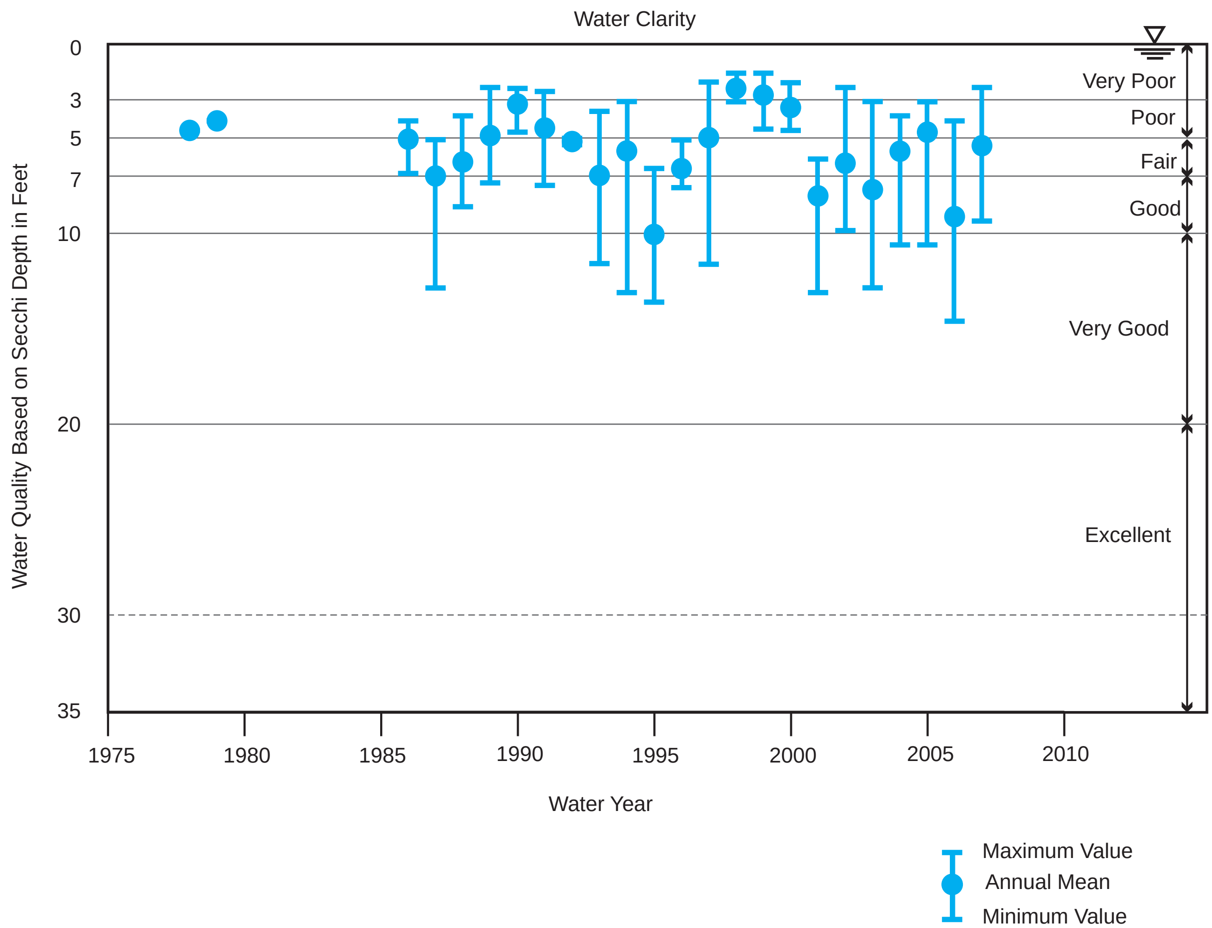


Figure 1 (continued)



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

clarity of the largest 8,000 lakes in Wisconsin. The WDNR, through its Self-Help Monitoring Program, was able to gather water clarity measurements in the form of Secchi disk transparency readings from about 800 lakes, or about 10 percent of these lakes. Estimates of water clarity in Friess Lake and Little Friess Lake, developed utilizing the ERSC remote sensing data, suggest that average water clarity in Friess Lake was 4.5 feet and 7.2 feet in Little Friess Lake. These values are indicative of generally poor to fair water quality in Friess Lake and fair to good water quality in Little Friess Lake. Such data are consistent with the abovementioned Self-Help/CLMN Secchi disk data.

Anecdotal observations of water clarity in Friess Lake made by volunteers at the time of collection of the Self-Help/CLMN data indicate that perceptions of water clarity have varied from murky to clear and perceptions of water color have varied from green to brown. To quantify these perceptions, the Self-Help/CLMN program utilizes descriptions of water conditions that are assigned numerical values, as follows:

1 = conditions are beautiful, and could not be any nicer;

2 = very minor aesthetic problems, but excellent for swimming and boating enjoyment;

3 = swimming and aesthetic enjoyment of the lake is slightly impaired because of high algae levels;

4 = desire to swim and level of enjoyment of the lake is reduced substantially because of algae;

5 = swimming and aesthetic enjoyment of the lake is significantly reduced because of algae.

Figure 2

PRIMARY WATER QUALITY INDICATORS FOR LITTLE FRIESS LAKE: 2000-2006

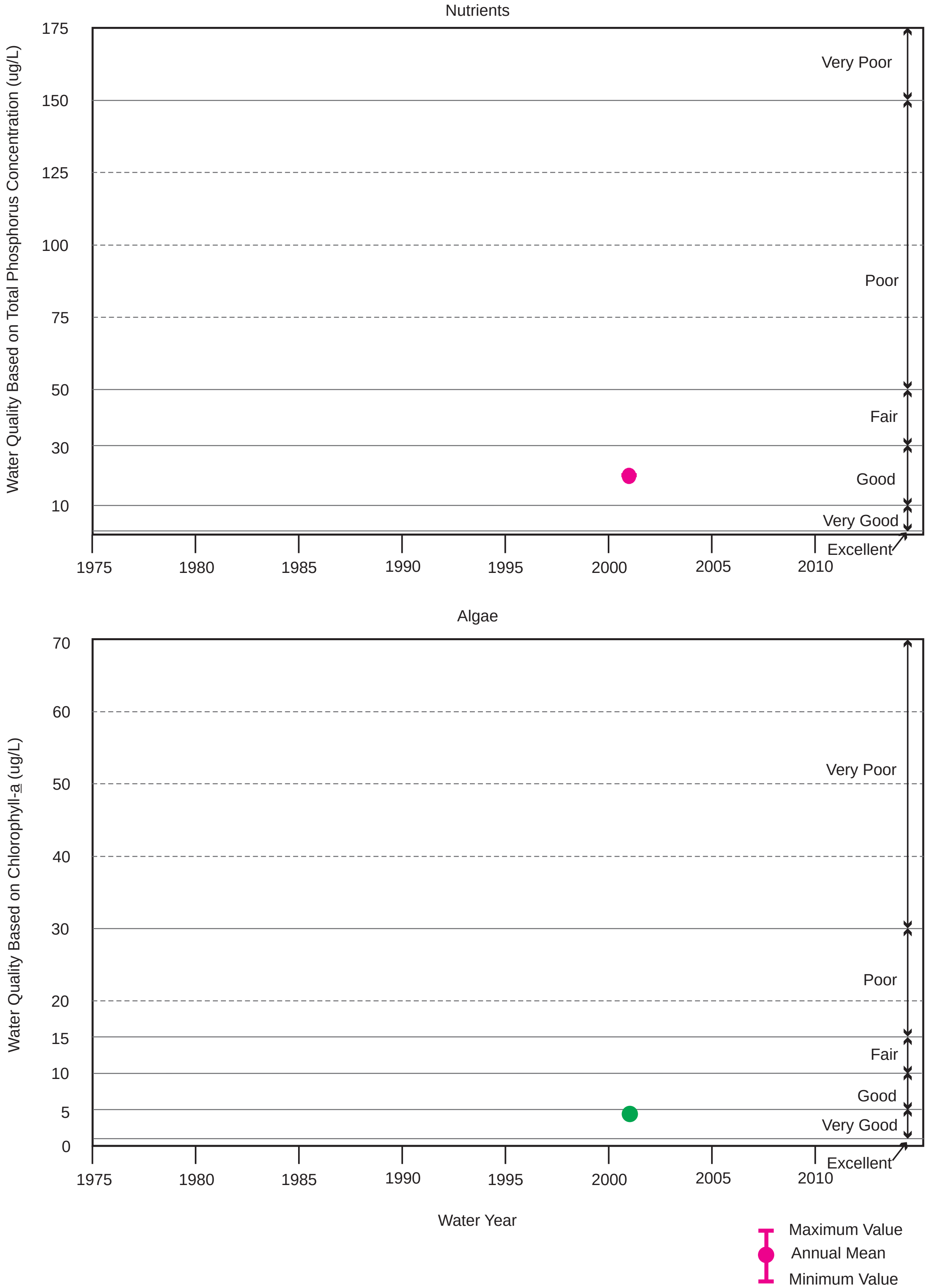
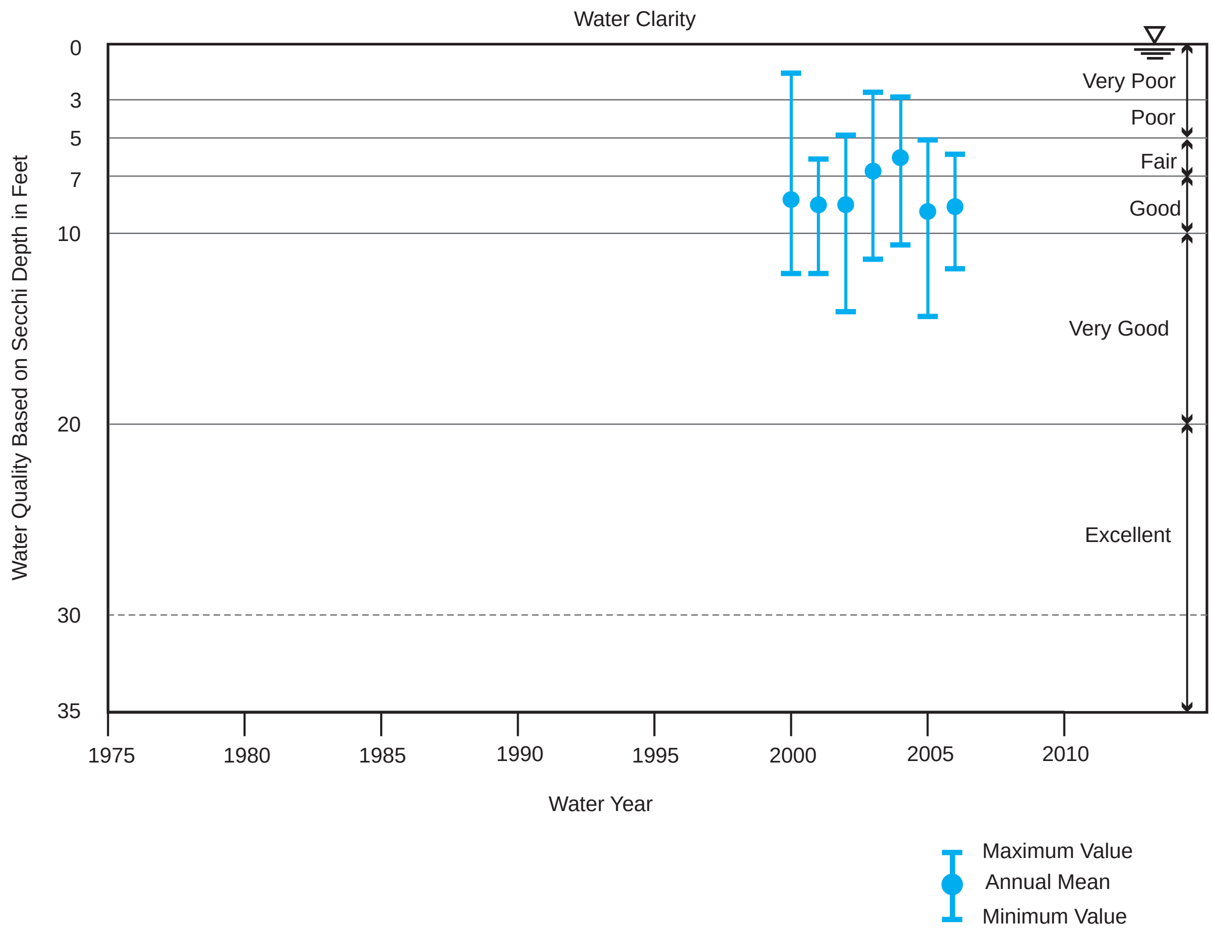


Figure 2 (continued)



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

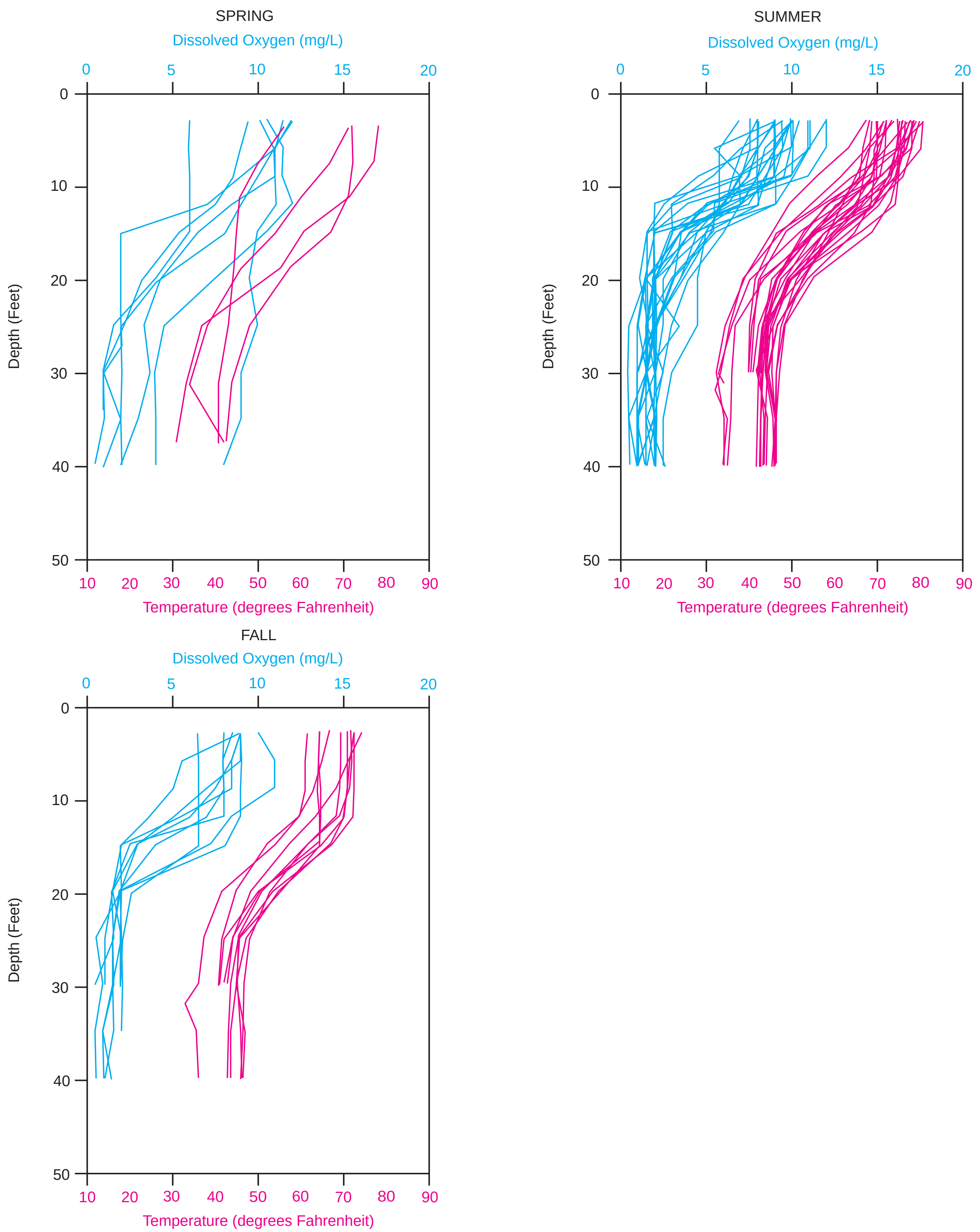
Using these numerical values, the perception ratings for Friess Lake generally ranged between 2 and 3 for the period from 1987 to 2006.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting living organisms in a lake ecosystem. As shown in Figure 3, dissolved oxygen levels were generally higher at the surface of Friess Lake, where there is an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels were lower near the bottom of the Lake, where decomposer organisms and chemical oxidation processes utilize oxygen in the decay process. When any lake becomes stratified, that is, when a thermal or chemical gradient of sufficient intensity produces a barrier separating the upper waters, called the epilimnion, from the 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 of 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. During the current study period, as shown in Figure 3, by mid- to late-summer, Friess Lake thermally stratifies at depths of about 15 to 25 feet. Nevertheless, except for one measurement during 2002, the Lake did not appear to become anoxic in the bottom waters. Data from Little Friess Lake for the current study period, shown in Figure 4, indicate that that Lake thermally stratifies in mid- to late-summer at depths of about 10 to 20 feet; however, Little Friess Lake also did not become anoxic in the bottom waters. During the previous study, it was reported that Friess Lake had become anoxic during both the 1976 through 1977 and the 1986 through 1995 monitoring periods.

Figure 3

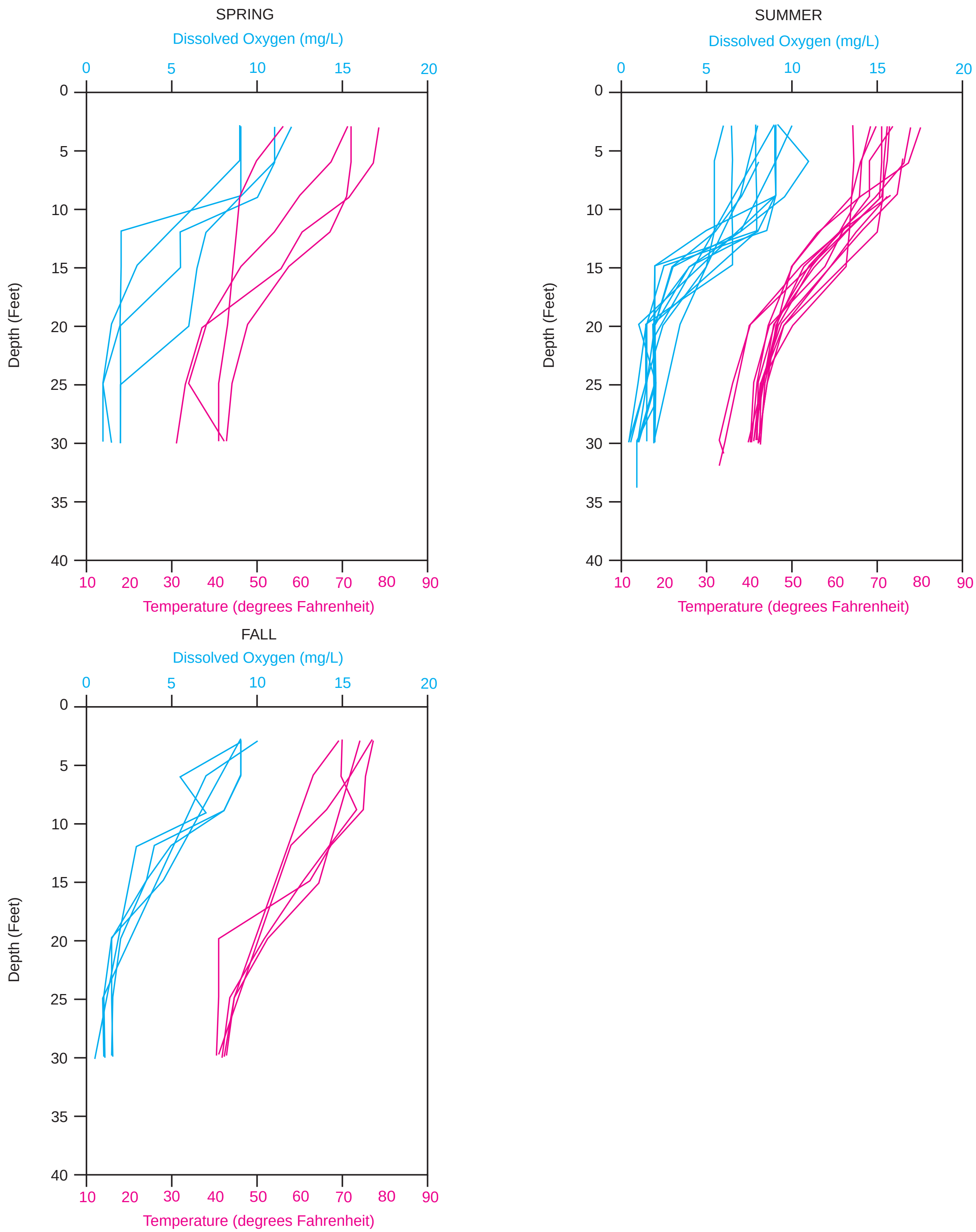
DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR FRIESS LAKE: 2001-2006



Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 4

DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR LITTLE FRIESS LAKE: 2001-2006



Source: Wisconsin Department of Natural Resources and SEWRPC.

Hypolimnetic anoxia is common in many of the lakes in southeastern Wisconsin during summer stratification. The depleted oxygen levels in the hypolimnion cause fish to move upward, nearer to the surface of the lakes, 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 like manner, the fishes may be subject to winter-kill during periods of ice cover as the ice seals the lake waters from atmospheric exchange of oxygen with the water column.

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 higher hypolimnetic concentrations in these elements. Under anaerobic conditions, iron and manganese change oxidation states enabling the release of phosphorus from the iron and manganese complexes to which they are 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. During the previous study, it was noted that high concentrations of phosphorus in the bottom waters of Friess Lake were consistent with release of phosphorus from the lake sediments. However, this release of phosphorus remained largely trapped in the hypolimnion and did not contribute significantly to the phosphorus pool in the epilimnion. In fact, there appeared to be a net loss of phosphorus to the bottom sediments between spring and summer, with little internal loading of phosphorus from the bottom sediments of Friess Lake during the period of lake water column mixing. The likely import of internal loading to the nutrient budgets of Friess Lake or Little Friess Lake is difficult to assess due to the lack of total phosphorus measurements in the hypolimnion of either Lake, but is assumed to be minimal.

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 the 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 as direct runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Pollutants transported by streams enter a lake as surface water inflows. In flow-through lakes, like Friess Lake, pollutant loadings transported by the inflowing streams and across the land surface comprise the principal routes by which contaminants enter a waterbody.[4] Currently, there are no significant point source discharges of pollutants to Friess Lake or to the surface waters tributary to Friess Lake. For this reason, the discussion that follows is based upon nonpoint or diffuse source pollutant loadings to the Lake.

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. In the comprehensive lake management plan, phosphorus and sediment budgets for Friess Lake were computed using Washington County Land Conservation Department modeling augmented by SEWRPC computer modeling. For the current study, nonpoint source phosphorus, suspended solids, and urban-derived metals inputs to and outputs from Friess Lake were estimated using the Wisconsin Lake Model Spreadsheet (WILMS version 3.0) and unit area load-based models developed for use within the Southeastern Wisconsin Region.

---

[4]*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.*

Phosphorus Loadings

In the previous report, phosphorus was identified as the factor generally limiting aquatic plant growth in Friess Lake. Thus, excessive levels of phosphorus in the lake are likely to result in conditions that interfere with the desired use of the lake.

During the aforementioned 1997 SEWRPC study, it was estimated that, based upon 1990 land use conditions, the total phosphorus load to Friess Lake was 2,800 pounds. Of this total, about 1,980 pounds, or 70 percent, were contributed by inflows from the Oconomowoc River; direct precipitation and groundwater combined contributed about 195 pounds, or 7 percent of the total annual phosphorus load; and direct surface runoff and onsite sewage disposal systems combined contributed about 23 percent.

During the current study, as shown in Table 4, existing year 2000 phosphorus loads to Friess Lake were identified and quantified using Commission land use inventory data. It was estimated that, under year 2000 conditions, the total phosphorus load to Friess Lake was 2,600 pounds. Of the annual total phosphorus load, it was estimated that 2,000 pounds per year, or 78 percent of the total loading, was contributed by runoff from rural land; 564 pounds per year, or 21 percent, was contributed by runoff from urban land; and 11 pounds, or 1 percent, 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 during the previous study period.

Under year 2035 conditions, as set forth in the adopted regional land use plan, the annual total phosphorus load to the Lake is anticipated to diminish slightly as agricultural activities within the area tributary to Friess Lake are replaced by urban residential land uses. The most likely annual total phosphorus load to the Lake under buildout conditions is estimated to be largely unchanged at 2,600 pounds, even though agricultural sources of phosphorus are expected to continue to decline in this watershed. It should be noted, however, that the increasing utilization of agro-chemicals in urban landscaping may offset the projected decrease in agricultural nonpoint source phosphorus loadings.[5] Table 5 shows the estimated phosphorus loads to Friess Lake under 2035 conditions. Of the total annual forecast phosphorus load of about 2,600 pounds of phosphorus to Friess Lake, 1,800 pounds per year, or 69 percent of the total loading, are estimated to be contributed by runoff from rural land; 780 pounds per year, or 30 percent, contributed by runoff from urban land; and 11 pounds, or 1 percent, by direct precipitation onto the lake surface.

These modeled pollutant loads for year 2000 and 2035 land use conditions do not account for the extent of riparian buffer protection adjacent to the Oconomowoc River upstream of the Friess Lake inlet and the shoreline of Friess Lake. Riparian buffers adjacent to waterways can significantly reduce anthropogenic sources of contaminants from agricultural and/or urban land uses including phosphorus, with even the smallest buffer strip (e.g. less than five feet) providing environmental benefit (see Riparian Buffer Effectiveness Analysis in Appendix A). Increased buffer widths adjacent to the shoreline of Friess Lake and upstream of Friess Lake adjacent to the Oconomowoc River and its associated tributaries could greatly reduce the amount of pollutants currently entering Friess Lake as well as future loads. Increased buffer widths have also been associated with significant increases in aquatic and terrestrial abundance and diversity, therefore, increased riparian buffer widths constitutes an effective management strategy to maintain and protect the biological communities within and adjacent to Friess Lake.

---

[5]*Studies within the Southeastern Wisconsin Region indicate that urban residential lands fertilized with a phosphorus-based 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. See 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 FRIESS LAKE BY LAND USE CATEGORY: 2000

Land Use Category	Pollutant Loads			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential[a]	3.4	70.5	0.0	3.5
Commercial	1.3	4.0	0.7	4.9
Industrial	2.2	7.2	1.3	9.1
Governmental	1.0	4.8	0.2	2.8
Transportation	0.3	462.3	0.0	0.0
Recreational	0.6	15.4	0.0	0.0
Subtotal	8.8	564.2	2.2	20.3
Rural				
Agricultural	468.5	1,790.5	- -	- -
Wetlands	0.4	154.4	- -	- -
Woodlands	2.4	68.4	- -	- -
Water	8.0	11.0	- -	- -
Extractive	2.8	11.0	- -	- -
Subtotal	482.1	2,035.3	- -	- -
Total	490.9	2,599.5	2.2	20.3

[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 five pounds per year to as much as about 140 pounds per year, depending upon soil type, system condition, and system locations. For purposes of this analysis, 43 pounds per year were used as that value provided the loading that was best correlated to the measured in-lake phosphorus concentration.*

Source: SEWRPC.

Sediment Loadings

During the previous study period, estimated sediment loadings to Friess Lake indicated that 516 tons of sediment is delivered to the Lake each year with 402 tons, or 76 percent, of this sediment loading being attributed to the load carried into the Lake by the Oconomowoc River.

For the current study period, the estimated sediment loadings to Friess Lake for existing year 2000 are shown in Table 4. A total annual sediment loading of 490 tons was estimated to be contributed to Friess Lake under existing year 2000 conditions, as shown in Table 4. Of the likely annual sediment load, it was estimated that 474 tons per year, or 97 percent of the total loading, was contributed by runoff from rural land, with nine tons, or about 2 percent, contributed by urban lands, and eight tons, or about 1 percent, contributed by atmospheric deposition to the lake surface.

Under 2035 conditions, as set forth in the adopted regional land use plan, the annual sediment load to the Lake is anticipated to diminish slightly. The most likely annual sediment load to the Lake under buildout conditions is estimated to be 450 tons. However, the distribution of the sources of the sediment load to the Lake may be expected to change, with an increased mass of sediment being contributed from urban land use sources, estimated to be 30 tons of sediment per year, and a decreased mass of sediment from rural land use sources, estimated to be 410 tons of sediment per year. An estimated 10 tons of sediment per year are estimated to be contributed by direct precipitation onto the lake surface.

As previously mentioned in the Phosphorus Loadings section above, increased buffer widths adjacent to the shoreline of Friess Lake and upstream of Friess Lake adjacent to the Oconomowoc River and its associated

Table 5

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

Land Use Category	Pollutant Loads			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential[a]	4.8	99.2	0.0	4.9
Commercial	1.8	3.6	0.6	4.5
Industrial	12.4	38.7	7.2	49.3
Governmental	3.0	16.1	0.8	9.5
Transportation	3.2	607.3	0.0	0.0
Recreational	2.3	17.6	0.0	0.0
Subtotal	27.5	782.5	8.6	68.2
Rural				
Agricultural	406.1	1,552.3	- -	- -
Wetlands	1.3	154.4	- -	- -
Woodlands	2.5	66.2	- -	- -
Water	7.9	11.0	- -	- -
Extractive	2.8	11.0	- -	- -
Subtotal	420.6	1,794.9	- -	- -
Total	448.1	2,577.4	8.6	68.2

[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 five pounds per year to as much as about 140 pounds per year, depending upon soil type, system condition, and system locations. For purposes of this analysis, 43 pounds per year were used as that value provided the loading that was best correlated to the measured in-lake phosphorus concentration.*

Source: SEWRPC.

tributaries could greatly reduce the amount of pollutants currently entering Friess Lake, as well as future loads (see Appendix A).

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[6] The majority of these metals become associated with sediment particles[7] and are likely to be encapsulated into the bottom sediments of the Lake.

Heavy metal loadings were not determined for the previous report. For the current study, the estimated loadings of copper and zinc likely to be contributed to Friess Lake for existing year 2000 and forecast year 2035 are shown in Tables 4 and 5, respectively. In 2000, about two pounds of copper and 20 pounds of zinc were estimated to be contributed annually to Friess Lake from urban lands.

Under 2035 conditions, as set forth in the adopted regional land use plan, the annual heavy metal loads to the Lake are anticipated to increase by approximately three- to four-fold. The most likely annual loads to the Lake under buildout conditions are estimated to be eight pounds of copper and 70 pounds of zinc.

---

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

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

As previously mentioned in the Phosphorus Loadings section above increased buffer widths adjacent to the shoreline of Friess Lake and upstream of Friess Lake adjacent to the Oconomowoc River and its associated tributaries could greatly reduce the amount of pollutants currently entering Friess Lake as well as future loads (see Appendix A).

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 which 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.

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 applied. In this case, two indices appropriate for Wisconsin lakes have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[8] and the Carlson Trophic State Index (TSI),[9] with a variation known as the Wisconsin Trophic State Index value (WTSI).[10] The WTSI is a refinement of the Carlson TSI designed to account for the greater humic acid content, brown water color, present in Wisconsin lakes, and has been adopted by the WDNR for use in lake management investigations.

WTSI readings calculated during the previous report indicated that Friess Lake was a eutrophic waterbody. Based on Secchi-disk measurements over the current study period, Friess Lake had an average TSI value of 56 and a WTSI value of 57. Based upon data gathered by the aforementioned ERSC, Friess Lake had a Trophic State Index (TSI) value of 56; Little Friess Lake had a value of 49. A value above 50 is generally indicative of the enriched conditions associated with eutrophic lakes.

---

[8]*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*, Washington, D.C., August 1990.*

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

[10]*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.*

Lakes in southeastern Wisconsin are generally naturally mesotrophic, with WTSI values of between 40 and 50, with most lakes being at the higher end of this range. This borderline eutrophic condition reflects the relatively high background levels of soil phosphorus in the glacially deposited soils of this portion of the State.

AQUATIC PLANTS: DISTRIBUTION AND MANAGEMENT AREAS

Previous surveys and inventories of the aquatic macrophyte communities in Friess Lake were conducted in 1976, 1986, 1992, 1994, and 1995 and were detailed in the previous SEWRPC study.[11] For the current study, Commission staff conducted an aquatic plant survey on Friess Lake during July of 2005, using the modified Jesson and Lound transect method as adopted 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.[12] The 2005 aquatic plant survey conducted by Commission staff also included Little Friess Lake. The results of these surveys are shown in Tables 6 and 7, respectively. The 2005 aquatic plant surveys of Friess Lake and Little Friess Lake were supplemented by an aquatic plant reconnaissance conducted on the Lakes during June 2007, as documented in Table 8.

Map 7 shows the distribution of aquatic plants in Friess Lake at the time of the 2005 aquatic plant survey. The extent and distribution of aquatic plant growth during 2005 is similar to that reported during 1994. A species list, along with comments on the ecological significance of each plant on the list, compiled from the results of the Commission aquatic plant surveys in Friess and Little Friess Lakes, is set forth in Table 9. Representative illustrations of these aquatic plants can be found in Appendix B.

The dominant species observed in Friess Lake during the 2005 survey was Eurasian water milfoil (*Myriophyllum spicatum*). As shown in Table 6, muskgrass (*Chara vulgaris*), Sago pondweed (*Potamogeton pectinatus*), eelgrass (*Valisneria americana*), bushy pondweed (*Najas flexilis*), and coontail (*Ceratophyllum demersum*) also were observed to be present in significant numbers. Other major species present included, leafy pondweed (*Potamogeton foliosis*), northern water milfoil (*Myriophyllum sibiricum*), waterweed (*Elodea canadensis*), and Illinois pondweed (*Potamogeton illinoensis*).

The dominant aquatic plant in Little Friess Lake at the time of the 2005 survey was coontail, as shown in Table 7. Eurasian water milfoil and eelgrass also were recorded as being present in significant numbers. Other species present included: bushy pondweed, stonewart (*Nitella* spp.), leafy pondweed, Sago pondweed, large-leaf pond-weed (*Potamogeton amplifolius*), spiny naiad (*Najas marina*), Illinois pondweed, waterweed, muskgrass, northern water milfoil, white-stem pondweed (*Potamogeton praelongus*), and clasping-leaf pondweed (*Potamogeton richardsonii*). The appearance of large-leaf pondweed and white-stem pondweed, in particular, are encouraging signs since these species generally are associated with good water clarity and good water quality.

A reconnaissance survey of the aquatic plant communities in Friess Lake and Little Friess Lake was conducted by Commission staff during June of 2007. The results of this reconnaissance indicated no significant changes in the aquatic plant populations since the 2005 survey.

Changes in Aquatic Plant Abundances and Community Composition

Table 8 compares the relative densities of the major aquatic plant species observed in Friess Lake since 1976. These data would seem to indicate that the aquatic plant community in Friess Lake has undergone significant change since that time, but, in general, has remained relatively stable in recent years.

---

[11] *SEWRPC Community Assistance Planning Report No. 98, 2nd Edition,* op. cit.

[12] *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 6

AQUATIC PLANT SPECIES OBSERVED IN FRIESS LAKE: JULY 2005

Aquatic Plant Species	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Ceratophyllum demersum (coontail)	13	21.3	2.5	52.5
Chara vulgaris (muskgrass)	17	27.9	2.5	70.5
Elodea canadensis (waterweed)	10	16.4	1.2	19.7
Myriophyllum sibiricum (northern water milfoil)	9	14.8	1.4	21.3
Myriophyllum spicatum (Eurasian water milfoil)	36	59.0	2.7	157.4
Najas flexilis (bushy pondweed)	16	26.2	2.1	55.7
Potamogeton foliosis (leafy pondweed)	12	19.7	1.7	32.8
Potamogeton illinoensis (Illinois pondweed)	3	4.9	2.0	9.8
Potamogeton pectinatus (Sago pondweed)	18	29.5	2.0	59.0
Vallisneria americana (water celery/eelgrass)	16	26.2	2.2	57.4

NOTE: Sampling occurred at 61 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.

Between 1976 and 1986, the Lake experienced an increase in both the abundance and diversity of aquatic plants, with nine additional species, including the nonnative Eurasian water milfoil and curly-leaf pondweed, being observed in the Lake for the first time during the 1986 survey. Two other pondweed species, previously present during the 1976 survey, were not recorded during 1986. Some of this change, shown in Table 8, may reflect the timing of the surveys, with certain pondweeds, for example, favoring the cooler waters of spring and autumn rather than the warmer waters of the summer period. Notwithstanding, the presence of Eurasian water milfoil and curly-leaf pondweed in the Lake is cause for concern. Both of these latter species are declared nuisance species in Wisconsin, as identified in Chapter NR 109 of the *Wisconsin Administrative Code*. Eurasian water milfoil, in particular, is an invasive plant species capable of explosive growth, resulting in an ability to outcompete important native aquatic plant species. This ability can lead to significant ecological disruptions in the aquatic plant community of a lake, degrading water quality and habitat for fish, invertebrates and other wildlife. Concomitant with the increase in abundance of these nonnative species, for example, was the decrease in abundance and/or disappearance of certain native species common to lakes with better water quality, such as large-leaf pondweed. The increase in abundance of species such as the Eurasian water milfoil was attributed, in part at that time, to the deposition of silt and sediment along the shoreline adjacent to the Lake inlet. These areas of deposition were consistent with the areas of "muck" identified by Commission staff during the 1994 survey.

Subsequent aquatic plant surveys carried out on Friess Lake during the 1990s have documented a relatively stable aquatic plant community, as shown in Table 8. The few changes in pondweed species most likely reflect the timing of the various surveys. Eurasian water milfoil has remained common to abundant in the Lake since it was first reported in 1986, while curly-leaf pondweed has been sparse to absent during this same period.

The increased diversity of aquatic plants in Friess Lake has continued into the 21st Century, with few significant changes in the aquatic plant flora being recorded during the 2005 survey and 2007 reconnaissance. Nevertheless, the abundances of the aquatic plant populations observed at the time of the 2005 survey, for all species sampled,

Table 7

AQUATIC PLANT SPECIES OBSERVED IN LITTLE FRIESS LAKE: JULY 2005

Aquatic Plant Species	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Ceratophyllum demersum (coontail)	14	87.5	3.0	262.5
Chara vulgaris (muskgrass)	1	6.3	1.0	6.3
Elodea canadensis (waterweed)	2	12.5	1.0	12.5
Myriophyllum sibiricum (northern water milfoil)	1	6.3	1.0	6.3
Myriophyllum spicatum (Eurasian water milfoil)	10	62.5	1.9	118.8
Najas flexilis (bushy pondweed)	3	18.8	2.0	37.5
Najas marina (spiny naiad)	2	12.5	1.5	18.8
Nitella spp. (stonewarts)	3	18.8	2.0	37.5
Potamogeton amplifolius (large-leaf pondweed)	2	12.5	2.0	25.0
Potamogeton foliosis (leafy pondweed)	3	18.8	1.7	31.3
Potamogeton illinoensis (Illinois pondweed)	2	12.5	1.5	18.8
Potamogeton pectinatus (Sago pondweed)	3	18.8	1.7	31.3
Potamogeton praelongus (white-stem pondweed)	1	6.3	1.0	6.3
Potamogeton richardsonii (clasping-leaf pondweed)	1	6.3	1.0	6.3
Vallisneria americana (water celery/eelgrass)	6	37.5	3.0	112.5

NOTE: Sampling occurred at 16 sampling sites along four 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.

were generally less than they had been during the earlier surveys, with the relative abundance of many species being similar to those observed during 1976. As noted, the differences in specific species of pondweeds (*Potamogeton* spp.) are most likely an artifact of the timing of the surveys rather than reflecting any real change in the species composition in the Lake. Coontail and muskgrass, together with Eurasian water milfoil have continued to remain common to abundant in the Lake during this period.

Regional Perspective

In 1976, aquatic plant densities in Friess Lake were very low compared to those recorded in the majority of inland lakes in southeastern Wisconsin. By 1995, the aquatic plant communities were considered to be at levels considered to be more normal for the Region. The noted changes in species composition and increases in abundance led to localized recreational use problems, especially in shallow water areas around piers and docks and in the shallow water areas of the northern lake shore. Changes in the aquatic plant communities also were believed to be contributing to the deterioration of fish and wildlife habitat in the Lake.

Aquatic plant communities do undergo cyclical and periodic changes, which reflect, in part, changing climatic conditions on the interannual scale, as well as, 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 usage patterns. Interannual changes occur over a period of three to seven years and may be temporary, while the aquatic plant community changes occur over a decadal period or longer and are longer-lasting. In reviewing the current 30-year data set, it is likely that the variations observed in bushy pondweed and eel grass abundances, for example, may reflect interannual variability, with these species

Table 8

ABUNDANCE OF AQUATIC PLANTS FROM FRIESS LAKE MACROPHYTE SURVEYS

Aquatic Plant Species	1976 Survey	1986 Survey[a]	1992 Survey[a]	1995 Survey[a]	2005 Survey	2007 Survey
Ceratophyllum demersum (coontail)	- -	Sparse	Common	Abundant	Common	Sparse
Chara sp. (muskgrass)	- -	Common	Abundant	Common	Common	Sparse
Elodea canadensis (waterweed)	- -	Sparse	Sparse	Common	Very sparse	Very sparse
Lemna minor (duckweed)	Very sparse	- -	Common	- -	N/A	N/A
Myriophyllum spicatum (Eurasian water milfoil)	- -	Common	Common	Abundant	Common	Sparse
Najas flexilis (bushy pondweed)	Very sparse	Abundant	Common	Common	Sparse	Very sparse
Nuphar variegatum (yellow water lily)	Very sparse	Common	Sparse	Common	N/A	N/A
Nymphaea sp. (white water lily)	- -	Common	- -	- -	N/A	N/A
Potamogeton amplifolius (large-leaf pondweed)	Sparse	- -	- -	- -	- -	- -
Potamogeton crispus (curly-leaf pondweed)	- -	Sparse	- -	Sparse	- -	- -
Potamogeton illinoensis (Illinois pondweed)	- -	- -	Common	- -	Sparse	Very sparse
Potamogeton pectinatus (Sago pondweed)	Sparse	Sparse	Common	Common	Sparse	Very sparse
Potamogeton pusillus (variable pondweed)	- -	Abundant	- -	- -	- -	- -
Potamogeton richardsonii (Richardson's pondweed)	Very sparse	- -	- -	Common	- -	- -
Potamogeton robbinsii (Robbins' pondweed)	- -	- -	Sparse	- -	- -	- -
Potamogeton zosteri formis (flat-stemmed pondweed)	- -	Sparse	- -	Sparse	- -	- -
Utricularia vulgaris (bladderwort)	- -	Sparse	Sparse	- -	- -	- -
Vallisneria americana (eel grass-wild celery)	Very sparse	Common	Common	Common	Sparse	Sparse

[a]*Survey conducted by Wisconsin Department of Natural Resources as part of the Long-Term Trend Monitoring Program.*

[b]*Descriptors for the 2005 survey are based on numeric values for Average Density where the maximum density possible is 4.0; "Abundant" = 3.5-4.0; "Common" = 2.5-3.4; "Sparse" = 1.5-2.4; "Very Sparse" = 0.5-1.4;" - -" = 0.0-0.4. The Average Density is the sum of the 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. "N/A" = did not sample.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

being reported as sparse in 1976, common in the 1980s and 1990s, and sparse in 2005. Sago pondweed abundances exhibited a similar cyclical pattern.

In addition to these interannual variations, some of the variation in reported abundance may reflect intra-annual or seasonal variability associated with the timing of the various surveys, as previously noted. The pondweeds, in particular, are subject to greater seasonality than some of the other species. In other words, the actual community composition may reflect water temperature rather than actual changes in aquatic plant community composition. Various pondweed species were always present at low levels of abundance during the 30-year period of record, although the actual varietals have differed over this period.

In contrast, the introduction of Eurasian water milfoil to the Lake has led to a permanent alteration in the aquatic plant community composition. The variations in the abundance of Eurasian water milfoil, however, from common to abundant to common, most likely reflect interannual periodicity in this species and is likely to be driven by a combination of predator-prey cycles that include the plant and milfoil weevil (*Eurhychiopsis lecontei*) and the relative severity of the winters during the intervening years.

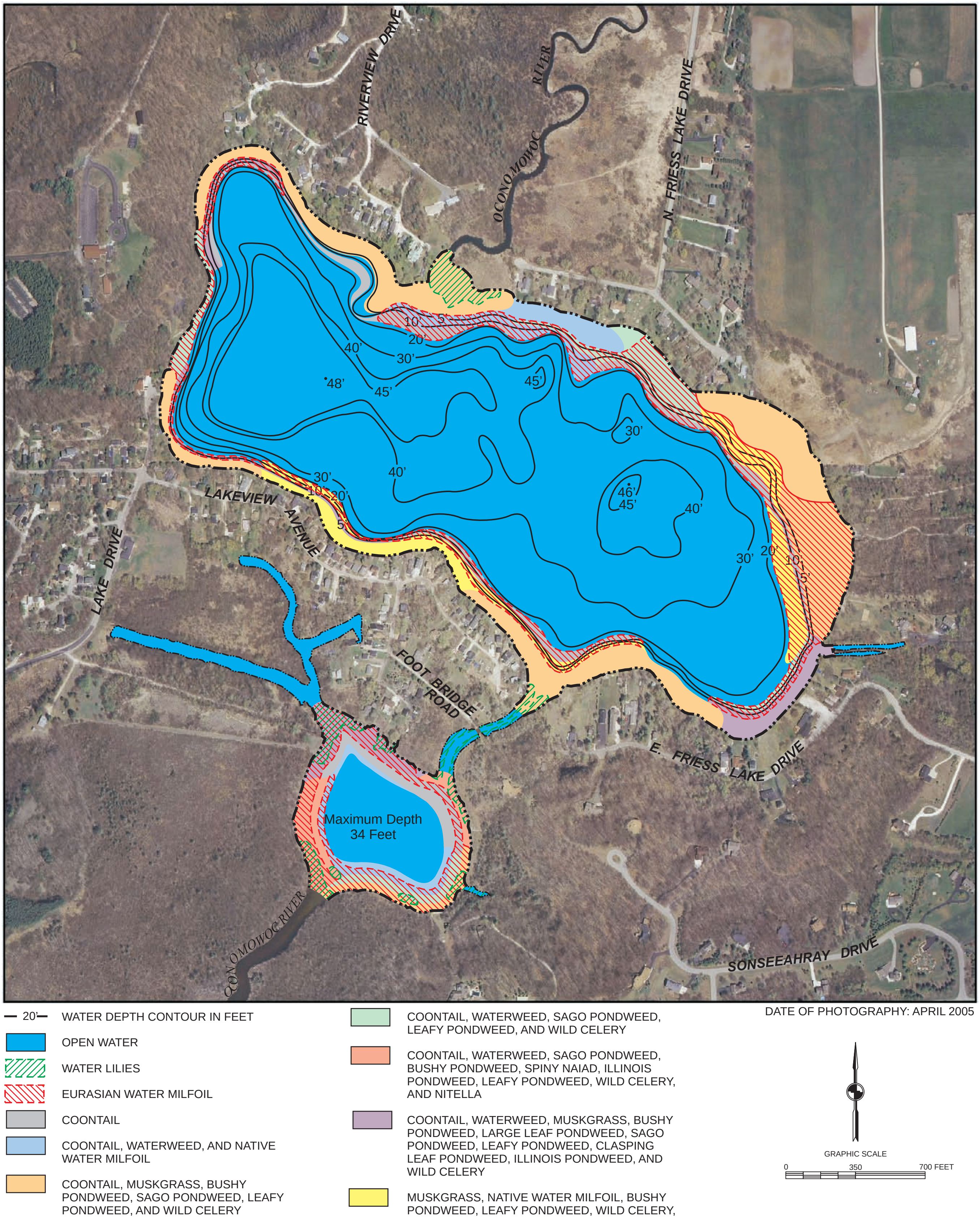
Implications for Aquatic Plant Management

A critical key to the ability of an ecosystem, such as a lake, to maintain its ecological integrity is through 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 the 2005 aquatic plant surveys of Friess Lake and Little Friess Lake, several aquatic plant communities in the Lakes showed significant biodiversity, being comprised of at least nine different species. These highly diverse communities were most prevalent in the near shore areas at the eastern end of Friess Lake adjacent to the inlet from the unnamed tributary stream, as well as in the 5 to 10 foot depth range along the southeastern corner of Friess Lake. In Little Friess Lake, these highly diverse communities were most prevalent in the near shore areas at the northeastern and southeastern corners of the Lake.

Map 7

AQUATIC PLANT COMMUNITY DISTRIBUTION IN FRIESS LAKE: 2005



Source: SEWRPC.

Table 9

POSITIVE ECOLOGICAL SIGNIFICANCE OF AQUATIC PLANT SPECIES PRESENT IN FRIESS LAKE AND LITTLE FRIESS LAKE: 2005

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
Najas marina (spiny naiad)	Important food source for ducks
Nitella spp. (stonewarts)	Sometimes eaten by waterfowl; provides foraging 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 illinoensis (Illinois pondweed)	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton praelongus (white-stem pondweed)	Good food provider for waterfowl, muskrat, and some fish species; valuable habitat for musky. Considered an indicator species for water quality due to its intolerance of turbid water conditions
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
Vallisneria americana (water celery/eelgrass)	Provides good shade and shelter, supports insects, and is valuable fish food

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.

By contrast, some areas of the Lakes contained plant communities with limited diversity, communities with three or fewer species. Such areas included the near shore areas on the northern side of Friess Lake just east of the Oconomowoc River inlet and the northeastern corner of Little Friess Lake. Between the highly diverse areas and areas of limited diversity, there were numerous areas of both Lakes that contained plant communities of moderate diversity, with between five and seven species being observed.

In general, in Friess Lake, aquatic plant communities of high diversity were found mostly in the near shore area at the eastern end of the Lake, while moderately diverse communities populated nearly all of the remainder of the shoreline areas of the Lake. In Little Friess Lake, high-diversity communities were found in the nearshore areas in the southwestern and northwestern corners of the Lake, moderately diverse communities in the southeastern corner of the Lake, and low diversity communities in the northeastern corner of the Lake.

Aquatic Plant Species of Special Significance

As aforementioned, during the 2005 and earlier aquatic plant surveys on Friess and Little Friess Lakes, several species of significance were observed. Two of these species, Eurasian water milfoil and curly-leaf pondweed (*Potamogeton crispus*), are invasive nonnative species and are considered detrimental to the ecological health of the Lakes.

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 explosive growth 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.

Curly-leaf pondweed is a plant that thrives in cool water and exhibits a peculiar split-season growth cycle that helps give it a competitive advantage over native plants. In late summer, the plant produces specialized over-wintering structures, or “turions.” In late summer, the main body of the plant dies off and drops to the bottom where the turions lie dormant until the cooler fall water temperatures trigger the turions to germinate. Over the winter, the turions produce winter foliage that thrives under the ice. In spring, when water temperatures begin to rise again, the plant has a head start on the growth of native plants and quickly grows to full size, producing flowers and fruit earlier than its native competitors. Because it can grow in more turbid waters than many native plants, protecting or improving water quality is an effective method of control of this species; clearer waters in a Lake can help native plants compete more effectively with curly-leaf pondweed.

There also were several native plant species of exceptionally high ecological value observed in the 2005 survey of the Lakes. These plants include: 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, subsequently, in establishing water quality conditions that assist native plant species to successfully compete with curly-leaf pondweed, as described above. Large-leaf pondweed, also known as musky weed or bass weed, enjoys a reputation as a highly valuable provider of fish habitat. White-stem pondweed, because of its sensitivity to changes in water quality and intolerance of turbidity, is considered an excellent indicator species, with its disappearance from water systems frequently being an indication of declining water quality in disturbed systems. Conversely, its presence in a lake is usually an indicator of very good water quality. White-stem pondweed and large-leaf pondweed, albeit in small numbers, were observed in the more highly diverse plant communities found in Little Friess Lake.

Past and Present Aquatic Plant Management Practices

As shown in Table 10, between 1950 and 1967, a total of 400 pounds of sodium arsenite and 1,730 pounds of copper sulfate were applied to Friess Lake to control perceived nuisance growths of aquatic plants and algae.

Table 10

CHEMICAL CONTROL OF AQUATIC PLANTS IN FRIESS LAKE: 1950-2003

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 (gallons)	Diquat (gallons)	Glyphosate (gallons)	Endothall / Aquathol (gallons)
1950-1953	- -	- -	- -	- -	- -	- -	- -	- -	- -
1954	- -	- -	- -	- -	400	- -	- -	- -	- -
1955-1971	- -	- -	- -	- -	- -	- -	- -	- -	- -
1972	28.00	160	- -	- -	- -	- -	- -	- -	- -
1973	28.50	200	- -	- -	- -	- -	- -	- -	- -
1974	28.00	190	- -	- -	- -	- -	- -	- -	- -
1975	N/A	210	- -	- -	- -	- -	- -	- -	- -
1976	N/A	200	- -	- -	- -	- -	- -	- -	- -
1977	28.30	200	- -	- -	- -	- -	- -	- -	- -
1978	- -	- -	- -	- -	- -	- -	- -	- -	- -
1979	17.00	100	- -	- -	- -	- -	- -	- -	- -
1980	24.50	190	- -	- -	- -	- -	- -	- -	- -
1981	17.20	130	- -	- -	- -	- -	- -	- -	- -
1982	2.98	150	- -	- -	- -	- -	- -	- -	- -
1983	- -	- -	- -	- -	- -	- -	- -	- -	- -
1984	N/A	- -	- -	75	- -	0.5	- -	- -	- -
1985	- -	- -	- -	- -	- -	- -	- -	- -	- -
1986	0.69	- -	- -	- -	- -	0.5	- -	- -	- -
1987	0.71	- -	- -	29.6 + 225 gallons	- -	0.5 + 4 lbs	- -	- -	195 lbs
1988	0.56	- -	- -	0.50 gal	- -	1.0 + 54 lbs	- -	- -	0.50
1989	- -	- -	- -	- -	- -	- -	- -	- -	- -
1990	8.05	- -	- -	- -	- -	26.0	- -	- -	- -
1991	8.40	- -	- -	6.00 gal	- -	41.0	6.00	- -	- -
1992	- -	- -	- -	- -	- -	- -	- -	- -	- -
1993	6.72	- -	- -	27.50 gal	- -	30.0	- -	- -	- -
1994	3.49	- -	- -	0.40 gal	- -	- -	2.00	- -	2.50
1995	6.50	- -	- -	7.50 gal	- -	- -	7.50	- -	7.50
1996	4.25	- -	- -	2.50 gal	- -	5.5	2.50	- -	2.50
1997	3.25	- -	- -	3.25 gal	- -	- -	3.25	- -	3.25
1998	- -	- -	- -	- -	- -	- -	- -	- -	- -
1999	3.25	3.0 gal	- -	- -	- -	- -	3.50	- -	- -
2000	- -	- -	- -	- -	- -	- -	- -	- -	- -
2001	2.50	- -	- -	2.75 gal	- -	- -	3.50	- -	2.75
2002	2.94	- -	- -	2.00 gal	- -	- -	3.00	- -	3.25
2003	2.05	- -	- -	2.25 gal	- -	- -	2.25	- -	2.25
Total	- -	1,730 + 3.0 gallons	- -	104.6 + 279.65 gal	400	105 + 58 lbs	33.50	- -	24.5 + 195 lbs

NOTE: N/A = Records are not available for this time period.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Aquatic plant management interventions prior to 1950, while known to have occurred on many lakes in the Region, were not recorded by the WDNR.

In 1969, when it became apparent that arsenic, which presents potential health risks to both humans and aquatic life, was accumulating in the sediments of treated lakes, the use of sodium arsenite was discontinued in the State. In contrast, copper compounds, including copper sulfate, AV-70, and Cutrine Plus, continue to be applied to Friess Lake. Copper is a nutrient required by plants in very low amounts, although, at higher concentrations, it is toxic to most species of planktonic and filamentous algae. Blue-green algae are especially susceptible to copper toxicity. Like arsenic, copper can accumulate in the bottom sediments, and excessive levels of copper have been found to be toxic to fish and benthic organisms. However, copper is typically not harmful to humans,[13] and this element continues to be used periodically as an algicide in Friess Lake.

Current aquatic plant management activities in Friess Lake can be categorized as primarily chemical control. An aquatic plant management program utilizing a range of aquatic herbicides has been carried out on Friess Lake in a documented manner since 1972. As shown in Table 10, the aquatic herbicides diquat, endothall, and 2,4-D have been applied to Friess Lake in recent years to control aquatic macrophyte growth. Diquat and endothall are contact herbicides and kill plant parts exposed to the active ingredient. Diquat use is restricted to the control of duckweed (*Lemna* sp.), milfoil (*Myriophyllum* spp.), and waterweed (*Elodea* sp.). However, this herbicide is nonselective and will kill many other aquatic plants, such as pondweeds (*Potamogeton* spp.), bladderwort (*Utricularia* sp.), and naiads (*Najas* spp.). Endothall kills primarily pondweeds, but does not control such nuisance species as Eurasian water milfoil (*Myriophyllum spicatum)*; 2,4-D is a systemic herbicide that is absorbed by the leaves and translocated to other parts of the plant. It is considered to be more selective than the other herbicides listed above, and is generally used to control Eurasian water milfoil, although it also will kill more valuable species such as water lilies (*Nymphaea* spp. and *Nuphar* spp.). 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*.

FISHERIES AND WILDLIFE

Being a drainage lake, Friess Lake is far more productive than many of the other lakes in the Southeastern Wisconsin Region that are largely spring fed. Growth appears to be much faster, the fish are generally larger, and fishing is better. Historically, a 1976 lake inventory of Friess Lake conducted by the WDNR indicated that the fish community at that time was comprised of 22 different fish species, including bluegill, pumpkinseed, yellow perch, green sunfish, bluntnose minnow, black crappie, lake chubsucker, common carp, brook silverside, northern pike, and largemouth bass. In the 1976 survey, Friess Lake contained a State-listed Species of Concern, the lake chubsucker (*Erimyzon sucetta*); during the current study period, a State-designated endangered fish species, the slender madtom, (*Noturus exilis*), also was reported as being present in Friess Lake.[14]

A more recent fish survey was conducted by the WDNR using a combination of fyke nets and boat electrofishing gear during the spring of 2007 in anticipation of the proposed development of public access, which subject will be discussed below. During this survey the WDNR found a healthy fish population, with northern pike being fairly abundant and a good size structure. A number of pike, mostly females, over 26 inches were caught and WDNR recommend that anglers be careful not to over-fish that population. WDNR also caught a fair number of walleye in the 17 to 23 inch range. As summarized below, the Richfield Sportsmen's Club has provided all of the walleye stocking in the past on Friess Lake, but WDNR is scheduled to begin walleye stocking in the Lake on alternate years starting in 2008. The largemouth bass population is perhaps the highlight of gamefish in the Lake with a high percentage of fish over 14 inches long as shown in Figure 5.[15] Bluegills and crappies have a decent size structure compared to other lakes in the Region with the largest reaching about 8.5 inches and more than 10 inches in length, respectively (Figure 6). Perch, pumpkinseed, rock bass, white sucker, yellow bullhead, brown bullhead, golden shiner, longnose gar, and carp were also present.

---

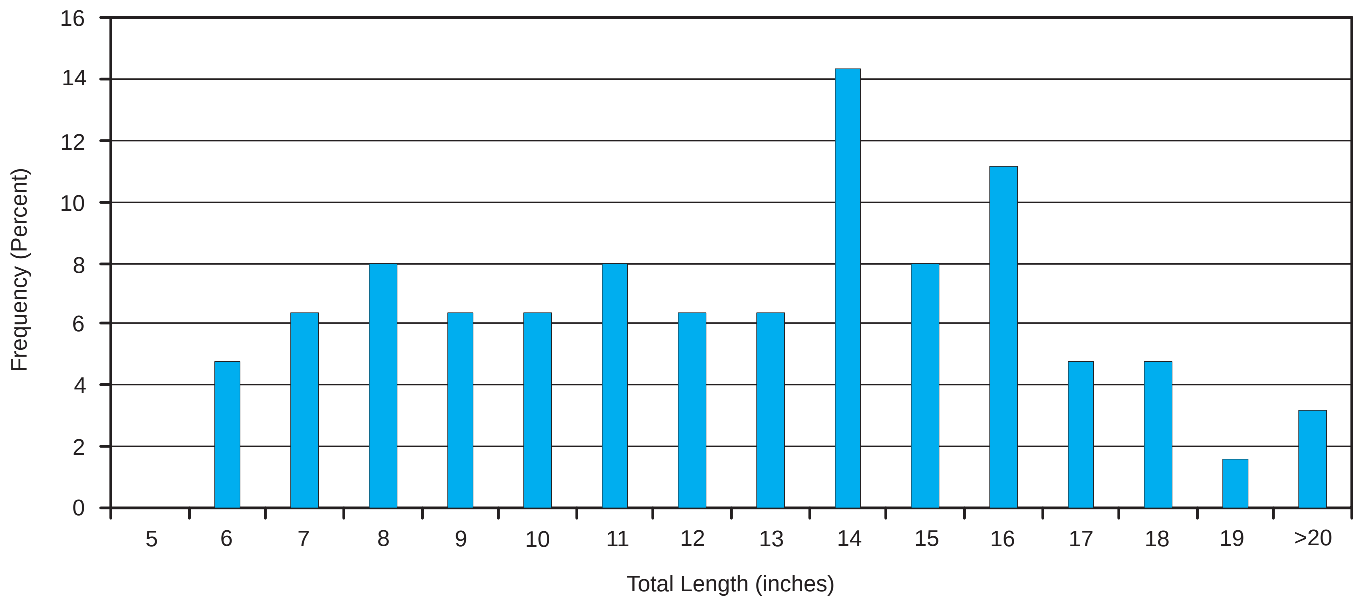
[13]*A small number of humans are unable to excrete copper from their bodies, and, hence, are susceptible to copper toxicity. However, these cases are so rare as to not warrant discontinuation of the use of copper as an algicide: see J.A. Thornton and W. Rast, "The Use of Copper and Copper Compounds as Algicides," in H. Wayne Richardson,* Handbook of Copper Compounds and Applications, *Marcel Dekker, New York, 1997, pp. 123-142.*

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

[15]*Personal communication, John E. Nelson, WDNR, February 2008.*

Figure 5

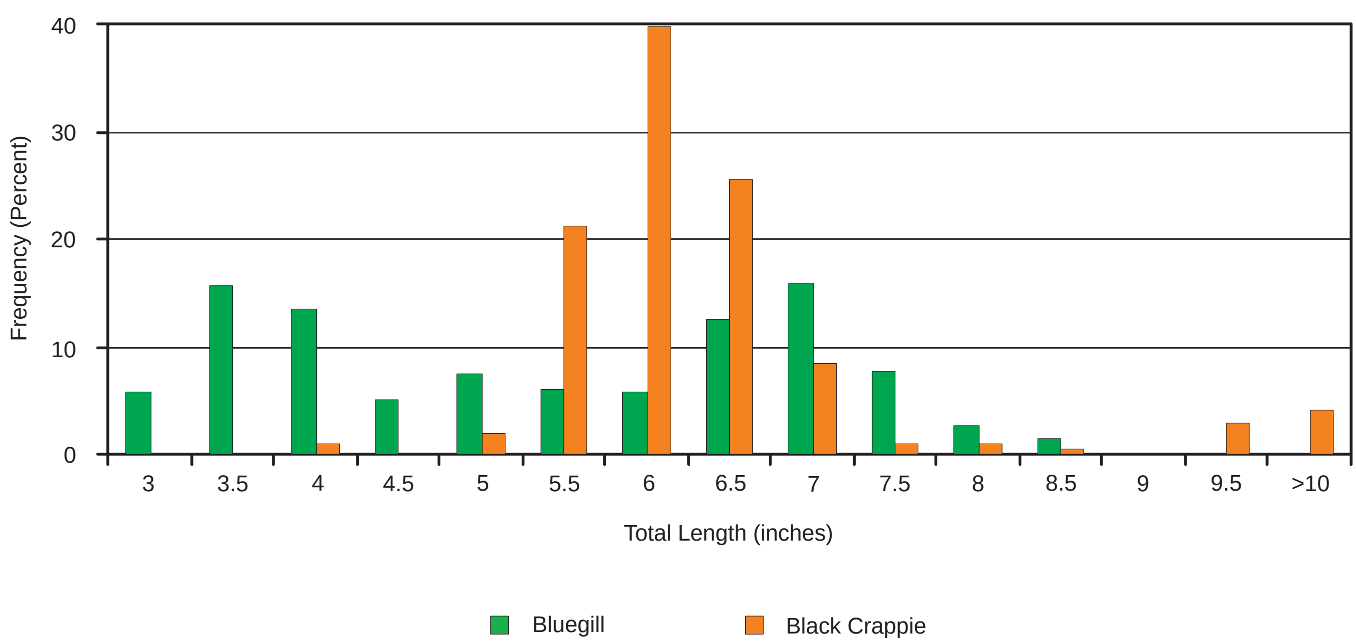
LARGEMOUTH BASS LENGTH DISTRIBUTION IN FRIESS LAKE: 2007



Source: SEWRPC.

Figure 6

BLUEGILL AND BLACK CRAPPIE LENGTH DISTRIBUTION IN FRIESS LAKE: 2007



Source: SEWRPC.

Since carp are present in Friess Lake there is always the concern and possibility that they will become a problem and greatly diminish the fishery, however, WDNR staff does not consider carp a problem population. Recruitment on such waters can be more consistent since the carp have access to good spawning habitat in years of high runoff during late May/early June. WDNR did identify a fair number of carp near the inlet to Friess Lake. However, WDNR does not regard this population as a "problem" due to the presence of a high quality submerged aquatic vegetation, an overall healthy fish community, and general good water quality within Friess Lake. In addition, small carp (e.g. less than 15 inches in length) are generally abundant in problem waters, but Friess Lake contains carp that are much larger, indicating that recruitment is more occasional. Therefore, WDNR is not recommending any significant management action such as a large scale chemical control for the lake to reduce carp numbers. However, any local efforts to remove carp via spearing contests, such as a carp derby, is recommended by WDNR staff.

In general, the most significant fish management issue that we face in the Southeastern Wisconsin Region, is that of over harvest of panfish. Many anglers do not realize or recognize that they are having a negative impact on fishing quality by taking too many fish, especially while these species are spawning (e.g. bluegill spawning beds). Although there is a decent panfish population in Friess Lake, the panfish populations throughout the Region are usually over-harvested to the point of mediocrity. Therefore, in an effort to protect the panfish populations in Friess Lake, WDNR favors a general regulation of 10 sunfish, 10 crappie and 10 perch as a way to reduce harvest. This still may not address the issue of anglers coming back to a lake for a second or third trip when the panfish are biting hard, but this would be a positive strategy to reduce overall harvest.

As shown in Table 11, stocking records for Friess Lake show that the Richfield Sportman's Club has been annually stocking about 750 to 1,500 walleye into Friess Lake since 1988 and the WDNR recently stocked approximately 4,500 walleye in 2006. The WDNR currently plans to begin stocking the Lake with walleye every other year at a rate of 35 fingerling per acre.[16] The timing of this program is subject to modification as a result of the discovery of viral hemorrhagic septicemia (VHS) in the State and the subsequent imposition of restrictions on stocking fishes. WDNR staff anticipate resumption of the stocking programs once the State fish hatcheries have been tested and cleared as free of this disease.

Amphibians and reptiles are vital components of the Friess Lake 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 Friess Lake area; at least one of which, Blanchard's cricket frog, (*Acris crepitans blanchardi*), is a State-designated Endangered Species.

Given the land uses present around the shorelands of the Lake, only smaller animals and waterfowl generally inhabit the Lakeshore. Muskrat, beaver, grey and fox squirrels, and cottontail rabbits are probably the most abundant and widely distributed fur-bearing mammals in the immediate riparian areas. Larger mammals, such as the whitetail deer, are generally confined to the larger wooded areas and the open meadows found in the park and open space lands within the tributary areas of the Lake. The Friess Lake tributary areas support a significant population of waterfowl including mallards, wood duck, and blue-winged teal. During the migration seasons a greater variety of waterfowl may be present and in greater numbers.

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* and related authorities granted under Chapter 30 of the *Wisconsin Statutes*, after a comprehensive examination and study is completed by WDNR staff from many different disciplines and fields of study. Currently, Friess Lake does not contain WDNR-designated Sensitive Areas.

[16]Ibid.

Table 11

FISH STOCKED INTO FRIESS LAKE

Year	Source	Species Stocked	Number	Average Fish Length (inches)
1988-2007[a]	Richfield Sportsman's Club	Walleye	750 to 1,500 annually	5 to 7
2006	WDNR	Walleye	4,500	1.30

[a]*Within this time period there were only two years when fish were not stocked.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

In the Southeastern Wisconsin Region, the Regional Planning Commission has undertaken a comprehensive planning effort aimed at identifying key areas of environmental and ecological importance, as a complement to the Commission's efforts to delineate environmental corridors and isolated natural resource features within the Region.[17] The total tributary area of Friess Lake contains numerous natural areas that contain intact native plant and animal communities of local, countywide, statewide or greater significance. In addition to those sites identified in the previous report, there are several natural areas within the vicinity of Friess Lake whose locations are shown on Map 8.[18] These local natural areas include:

1. County J Swamp: A 100-acre moderate- to good- quality complex of shrub-carr, lowland hardwoods, and mesic hardwoods located along the Oconomowoc River upstream of Friess Lake, this area has received an NA-3 rating, designating it as an area of local significance.

2. Daniel Boone Bogs: This 21-acre site, owned by the Daniel Boone Conservation Club, contains a pair of good-quality, relatively undisturbed sphagnum bogs with a number of uncommon species present, including the common bog arrow-grass (*Triglochin maritimum*), a State-designated special concern species. The Bogs have been given an NA-2 rating, identifying the area as a site of countywide or regional significance.

3. Glacier Hills Park Bogs and Upland Woods: This 60-acre site owned partly by Washington County and partly by private parties, is rated as an NA-2 site of countywide or regional significance. It contains steep, kettle moraine topography supporting two good-quality bogs in kettle depressions. It also contains areas of dry-mesic hardwood forest with small stands of dry hill prairie containing the State-designated threatened plant, kittentail (*Besseya bullii*), a type of wildflower restricted to high-quality natural habitats. This site also provides habitat for State-designated threatened species, the Red-shouldered hawk (*Buteo lineatus*).

4. Friess Lake Tamarack Swamp: This 228-acre, privately owned site has received a rating of NA-2, designating it as a site of countywide or regional significance. It is a large, mostly wooded, wetland complex, consisting of young to medium-aged tamarack swamp, shrub-carr, and shallow marsh.

5. Hubertus Road Sedge Meadow: This good-quality southern sedge meadow bordering the Oconomowoc River is a seven-acre site, privately owned, that has been ranked as NA-3, qualifying it as a site of local significance.

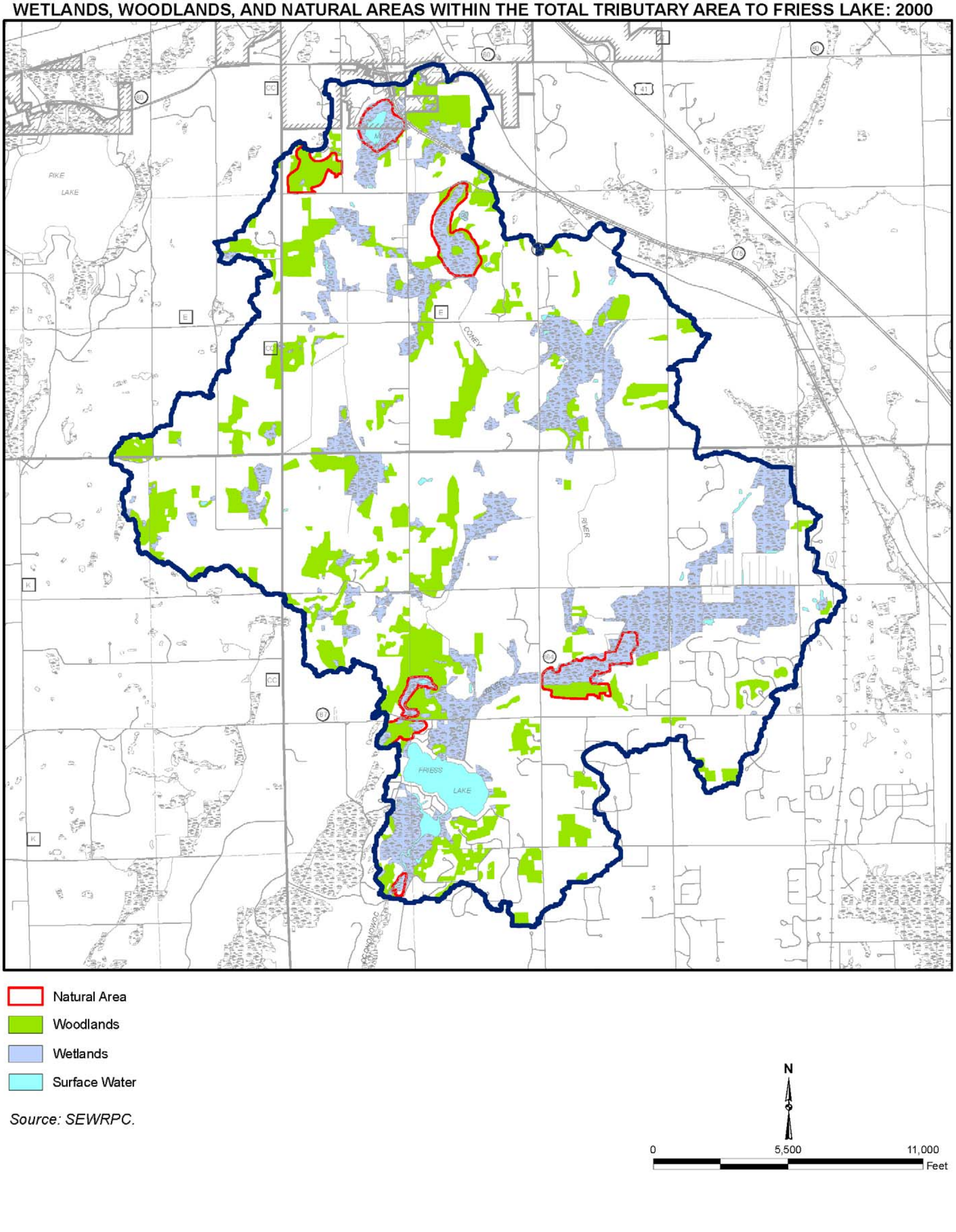
---

[17]*SEWRPC, "Refining the Delineation of the Environmental Corridors in Southeastern Wisconsin,"* Technical Record, *Vol. 4, No. 2, March 1981; see also, SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997.*

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

Map 8

WETLANDS, WOODLANDS, AND NATURAL AREAS WITHIN THE TOTAL TRIBUTARY AREA TO FRIESS LAKE: 2000



Source: SEWRPC.

6. St. Augustine Road Sedge Meadow: This 11-acre, privately owned site consists of good-quality southern sedge meadow and is ranked as NA-3, designating it as a site of local significance.

7. Donegal Road Woods: This 137-acre site is partly privately owned and partly owned by the WDNR. It has a ranking of NA-3, identifying it as a site of local significance, and consists primarily of large, irregularly shaped dry-mesic woods on steep, southeast-facing slopes.

Friess Lake is listed as a Critical Lake of Southeast Wisconsin and has been given a designation of AQ-3, identifying it as a lake of local significance.

RECREATIONAL USES AND FACILITIES

As set forth in the regional water quality management plan, [19] Friess Lake is a multi-purpose waterbody serving a variety of recreational uses. The Lake is used year-round as a visual amenity. Walking, bird watching and picnicking are popular passive recreational uses of this waterbody. Active recreational uses include boating, waterskiing, swimming, and fishing during the summer months, and cross-country skiing, snowmobiling, and ice-fishing during the winter. The Washington County Glacier Hill Park is located on the northwestern shoreline of the Lake.[20]

Friess Lake is heavily utilized during open water periods. During 2007, a boat count conducted on Friess Lake indicated that about 264 boats were either moored in the water or stored on land in the shoreland areas around the Lake. More than half of all watercraft, as shown in Table 12, were capable of high speed operation. Of the motorized watercraft observed to be moored or stored on or in the vicinity of the Lake, pontoon boats represented the largest group, with power boats and personal watercraft (PWCs or “jetskis®”) the next most common categories. Of the nonmotorized watercraft observed, rowboats and paddleboats represented the most common types on the Lake, with kayaks also observed in good numbers.

At the time of this writing, the Village of Richfield is pursuing an agreement with the WDNR to provide public recreational boating access to Friess Lake. Under the proposed terms of this partnership, the Village of Richfield will manage the site owned by the WDNR. The proposed site is to be located at the northwest corner of Little Friess Lake, providing access to Friess Lake through a navigable portion of the Oconomowoc River. Upon completion, this site will provide adequate public access to Friess Lake, as set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. Chapter NR 1 of the *Wisconsin Administrative Code* establishes quantitative standards for determining the adequacy of public recreational boating access, setting maximum and minimum standards based upon available parking facilities for car-top and car-trailer units. Recreational boating access to Friess Lake currently is provided through a privately owned tavern-resort facility located at the western end of the Lake, which does not meet the standards for adequate public access.

To assess the degree of recreational boat use on a lake, it has been estimated that, in southeastern Wisconsin, the number of watercraft operating at any given time is approximately 2 to 5 percent of the total number of watercraft docked and moored. On Friess Lake, this would amount to somewhere between 5 and 13 boats of all kinds, about half 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. In the mid-1980s, an average area of about 16 acres per power or sail boat was, at that time, considered suitable for the safe and

---

[19]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One,* Inventory Findings, *September 1978; Volume Two,* Alternative Plans, *February 1979; and Volume Three,* Recommended Plan, *June 1979. See also SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[20]*The Glacier Hills County Park does not provide recreational boating access to Friess Lake.*

Table 12

WATERCRAFT DOCKED OR MOORED ON FRIESS LAKE: 2005[a]

Type of Watercraft									
Powerboat	Fishing Boat	Pontoon Boat	Personal Water Craft	Canoe	Sailboat	Kayak	Paddleboat	Rowboat	Total
47	20	55	29	23	7	11	35	37	264

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

Source: SEWRPC.

enjoyable use of a boat on a lake. Over time, motor power, and the maximum speeds of watercraft, has steadily increased. For safe waterskiing and fast boating, an area of 40 acres per boat was suggested in the aforementioned Regional guidelines as the minimum area necessary for safe operations. Based upon these guidelines, and applying a typical number of operational high speed watercraft in southeastern Wisconsin, boating densities on Friess Lake could be expected to be between 17 and 43 acres per high-speed boat.

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 13. As shown in the Table 13, on Friess Lake, fishing boats were the most popular watercraft in use on weekday mornings, while fishing boats and powerboats were the most common watercraft in use on weekday and weekend day afternoons. Based on these actual counts, the densities of high-speed watercraft on Friess Lake ranged from about 59 acres per high-speed boat on a weekday afternoon to about 79 acres per high-speed boat on a weekday morning, and from 19 acres per high-speed boat on a weekend afternoon to about 40 acres per high-speed boat on a weekend morning. The densities observed on Friess Lake as described above are generally consistent with those considered appropriate for the conduct of safe high-speed boating activities pursuant to the adopted Regional guidelines, although the higher degree of boating activity on weekend afternoons may produce high-speed boating densities that exceed those guidelines. This survey was completed on a Saturday afternoon, however, Sunday afternoon traffic was reported to be approximately twice the amount of Saturday boat traffic.[21] Based upon this information high-speed boating densities on Sundays would likely routinely exceed the Regional guidelines.

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 residents. On Pewaukee Lake, for example,[22] nearly 80 percent of all watercraft on the Lake are motorized compared to about 57 percent of the watercraft on Friess Lake. Additionally, of all of the watercraft on Pewaukee Lake, power boats made up the largest portion, almost 40 percent, while, on Friess Lake, the largest portion of the watercraft is comprised of pontoon boats, which represent about 21 percent of all watercraft on the Lake.

Table 14 shows the number of people using Friess Lake for recreational purposes during a typical summer weekday and a typical summer weekend in 2007. The most popular weekday recreational activities on Friess Lake included using the County park (these were people using the small beach and picnic area at the privately owned launch site at the west end of the Lake), swimming, fishing from boats, and waterskiing/tubing. The most popular

---

[21]*Friess Lake Planning Meeting, January 30, 2008.*

[22]*See SEWRPC Community Assistance Planning Report No. 58, 2nd Edition,* A Lake Management Plan for Pewaukee Lake, Waukesha County, Wisconsin, *May 2003.*

Table 13

WATERCRAFT IN USE ON FRIESS LAKE: JULY 2007

Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Water Craft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Wednesday, July 18									
10:00 a.m. to 11:00 a.m.	0	0	3	0	0	0	0	0	3
2:00 p.m. to 3:00 p.m.	1	0	1	0	0	0	0	0	2
Saturday, July 21									
10:00 a.m. to 11:00 a.m.	1	0	4	0	0	0	0	0	5
2:00 p.m. to 3:00 p.m.	2	1	4	1	0	0	0	0	8

Source: SEWRPC.

Table 14

RECREATIONAL USE IN/ON FRIESS LAKE: JULY 2007

Date and Time	Weekday Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Users	Total
Wednesday, July 18										
10:00 a.m. to 11:00 a.m.	0	0	0	0	0	4	5	0	9	18
2:00 p.m. to 3:00 p.m.	0	0	4	0	0	9	2	0	9	24
Total for the Day	0	0	4	0	0	13	7	0	18	42
Percent	0	0	10	0	0	31	17	0	42	100

Date and Time	Weekend Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Users	Total
Saturday, July 21										
10:00 a.m. to 11:00 a.m.	0	0	2	0	0	0	5	0	0	7
2:00 p.m. to 3:00 p.m.	0	11	2	0	3	3	10	0	0	29
Total for the Day	0	11	4	0	3	3	15	0	0	36
Percent	0	31	11	0	8	8	42	0	0	100

Source: SEWRPC.

weekend recreational activities observed were fishing from boats, pleasure boating, skiing/tubing, operating personal watercraft, and swimming.

Recreational boating activities on Friess Lake are subject to State of Wisconsin boating and water safety laws as set forth in Chapter 30, *Wisconsin Statutes*. Additionally, the Lake is subject to the boating ordinances promulgated by the Village of Richfield, included herein as Appendix C.

LOCAL ORDINANCES

The Village of Richfield has adopted its own general zoning and subdivision control ordinances, and effective as of February 13, 2008, has adopted Washington County ordinances with minor revisions in regards to floodland zoning, shoreland or shoreland-wetland zoning, and construction site erosion control/stormwater management controls, as shown in Table 15. The Village of Richfield planning and zoning administrator currently enforces these ordinances.

Table 15

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

Community	Type of Ordinance				
	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
Washington County........	- -[a]	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Floodland and shoreland only	Adopted
Village of Richfield	Adopted	County ordinance with minor revisions	County ordinance with minor revisions	Adopted	County ordinance with minor revisions
Village of Slinger.........	Adopted	Adopted	Adopted	Adopted	None
Town of Erin................	Adopted	County ordinance	County ordinance	Adopted	County ordinance
Town of Hartford	Adopted	County ordinance	County ordinance	County ordinance	County ordinance
Town of Polk	Adopted	County ordinance	County ordinance	Adopted	County ordinance

[a]*In 1986, Washington County rescinded its general zoning ordinance, and all nine towns which were subject to the general County zoning ordinance have since adopted a town zoning ordinance*.

Source: SEWRPC.

Chapter III

ALTERNATIVE AND RECOMMENDED AQUATIC PLANT MANAGEMENT PRACTICES

INTRODUCTION

There are a number of aquatic plant management-related issues of concern that impact the recreational use and protection of the Friess Lake ecosystem. It is important to note that the recommendations summarized within this chapter supplements the comprehensive lake management plan for Friess Lake completed in 1997 and is primarily focused on refining the aquatic plant management element of the comprehensive lake management plan. These issues were identified in Chapter II and include: continuing urban-density residential development in the area tributary to the Lake; the provision of adequate public recreational boating access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*; the presence of nuisance growths of Eurasian water milfoil and other aquatic plants within Friess Lake; the potential negative ecological impacts posed by invasive species such as Eurasian water milfoil, curly-leaf pondweed, zebra mussel, and purple loosestrife; and, improvement of in-lake habitat and water quality.

In some ways, these issues of concern are interrelated. For example, in those areas of the Lake where Eurasian water milfoil 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 clogging propellers and cooling water intakes, snagging paddles, and slowing sailboats by wrapping around keels and control surfaces. The plant also causes concern amongst swimmers who can become entangled within the plant stalks. Thus, without control measures, these areas can become problematic to boat navigation, fishing, and swimming. Native aquatic plants, generally found at slightly deeper depths, pose fewer potential problems for navigation, swimming, and fisheries. In addition, many native aquatic plants provide fish habitat and food resources and offer shelter for juvenile fishes and young-of-the-year.

Despite areas in Friess Lake where nuisance growths of Eurasian water milfoil occur, the 2005 aquatic plant survey and 2007 reconnaissance seem to indicate a possible reversal in the trend of aquatic plant population increases evident in the earlier surveys. The Lake generally contains a robust and fairly diverse aquatic plant community capable of supporting a warmwater fishery, although some areas of the Lake suffer impairments of recreational boating opportunities and other lake-oriented activities due to an overabundance of aquatic macrophytes and algae.

In this Chapter, alternative and recommended management measures to address the identified issues of concern are presented. These measures include:

1. Aquatic plant and shoreland protection management measures designed to encourage native plant communities and limit the spread of nonnative, invasive species;

2. Water quality management measures designed to monitor water quality conditions within the Lakes;

3. Fisheries management measures designed to mitigate the habitat-related impacts of a changing aquatic flora and maintain an ecologically viable system;

4. Recreational management measures designed to promote safe recreational use, curtail the spread of invasive species, and provide the potential for the community to gain access to outside funding sources and lake enhancement services; and,

5. Land use management measures designed to limit the inputs of contaminants, especially nutrients, to the Lakes from their tributary areas.

Alternative and recommended management measures to address these concerns are described briefly below. The alternatives and recommendations set forth herein focus on those measures which are applicable to the Friess Lake Advancement Association (FLAA) and the Village of Richfield and, with lesser emphasis given to those measures which are applicable to other agencies with jurisdiction within the area tributary to the Lakes. These measures refine the recommended lake management actions set forth in the adopted lake management plan for Friess Lake.[1]

IN-LAKE AQUATIC PLANT AND RELATED MANAGEMENT MEASURES

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, 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 set forth under Chapter NR 1 of the *Wisconsin Administrative Code*. All aquatic plant management activities are subject to permitting by the Wisconsin Department of Natural Resources (WDNR) pursuant to the authorities set forth in Chapter NR 107 and NR 109 of the *Wisconsin Administrative Code*.

Aquatic Plant Management

As stated in Chapter II of this report, aquatic plant management activities in Friess Lake can be categorized as being based primarily on chemical controls. From 1950 through 1967, a total of 400 pounds of sodium arsenite and 1,730 pounds of copper sulfate were applied to Friess Lake to manage aquatic plants. The use of arsenic-based herbicides was discontinued in the State of Wisconsin in 1969. Since 1984, the aquatic herbicides diquat, endothall, and 2,4-D have been applied to Friess Lake to control aquatic macrophyte growth, with copper compounds—including copper sulfate, AV-70, and Cutrine Plus—continuing to be used since 1972 for the control of algal growth. In addition, individual householders on Friess Lake are known to engage in manual harvesting in the vicinities of their piers and docks.

Array of Management Measures

Aquatic plant management measures are classed into five groups: 1) physical measures, which include lake bottom coverings and water level management; 2) mechanical measures, which include harvesting; 3) manual removal; 4) chemical measures, which include the use of aquatic herbicides; and 5) biological control measures, which include the use of various organisms, including insects. 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 also requires a WDNR permit under Chapter 30 of the *Wisconsin Statutes*. Use of grass carp as a biological control agent is not permitted in Wisconsin. Costs range

---

[1]*SEWRPC Community Assistance Planning Report No. 98, 2nd Edition,* A Lake Management Plan for Friess Lake, Washington County, Wisconsin, *November 1997.*

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, improve the appearance of lakefront properties, and open channels for boating access. Sand and gravel are usually readily available and relatively inexpensive to use as cover materials, but plants readily recolonize areas so covered in a few years, depending on the rates of sediment deposition in a lake. While synthetic materials, such as polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years, the need to remove these structures annually limits the utility of these materials as a method to control aquatic plant growth. Consequently, the use of physical aquatic plant control measures is not considered to be a viable alternative for use in Friess Lake.

Mechanical Measures

Aquatic macrophytes may be mechanically harvested with specialized equipment consisting of a cutting apparatus, which cuts up to five feet below the water surface, and a conveyor system that picks up the cut plants and hauls them to the shore. Mechanical harvesting can be a practical and efficient means of controlling plant growth as it removes the plant biomass, and associated 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. “Clear cutting” aquatic plants and denuding the lake bottom of flora should be avoided, although “top cutting” of plants, such as Eurasian water milfoil, as shown in Figure 7, can be effective in allowing the resurgence of native aquatic plants. The harvesting of water lilies and other emergent native plants should be avoided.

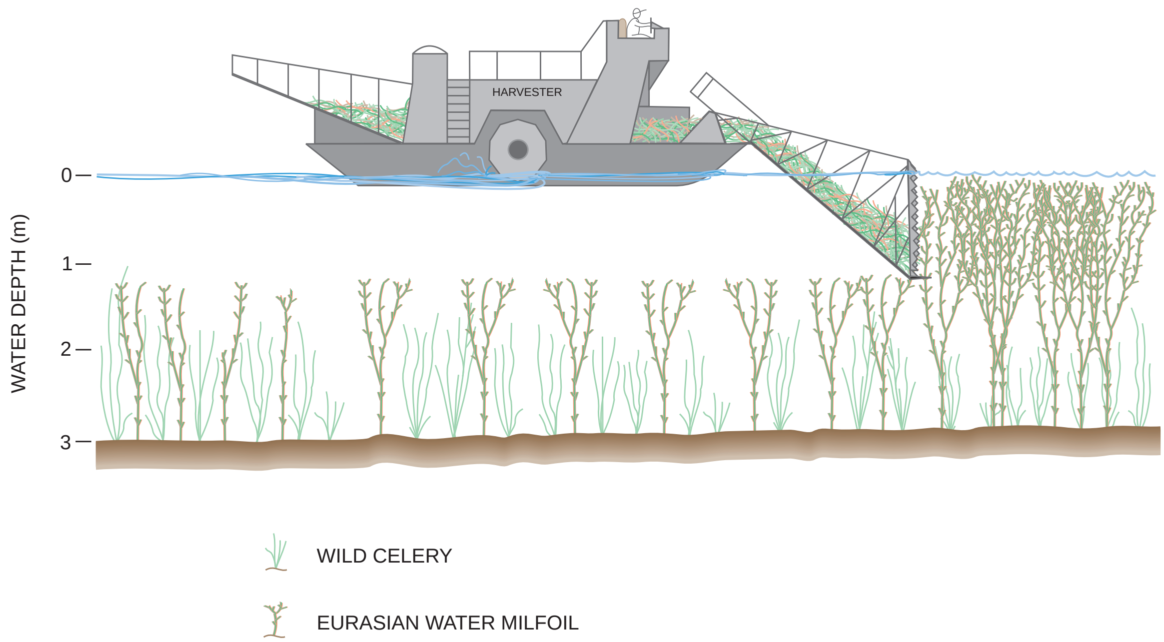
Aquatic plant harvesting typically leaves enough plant material in the lake to provide shelter for fish and other aquatic organisms, and to stabilize the lake bottom sediments. A disadvantage of mechanical harvesting is that the harvesting operation may cause fragmentation of plants and, thus, unintentionally facilitate the spread of some plants that utilize fragmentation as a means of propagation, such as 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 a nonnative 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-permitted harvesting plans do not allow harvesting in areas having a water depth of less than three feet. If done correctly and carefully, however, harvesting has been shown to be of benefit in ultimately reducing the regrowth of nuisance plants. 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. Notwithstanding, mechanical harvesting is not considered a viable option for control of aquatic plants in the Lake.

Manual Measures

The physical removal of specific types of vegetation by manual harvesting of aquatic plants provides a highly selective means of controlling the growths of nuisance 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 given 100-foot length of shoreline would be allowed without a specific 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 or curly-leaf pondweed. In such applications, the removal of the harvested plants remains an important criterion.

Figure 7

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.

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 stems can be an effective control measure for small-scale 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 near shore area, specially designed rakes are available to assist in the 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 near shore 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 FLAA 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 Lakes and purple loosestrife on the lakeshore. Because this is a more selective measure, hand pulling of nuisance aquatic plants during the early spring is considered a viable option in Friess Lake and its shoreland areas. Manual removal of Eurasian water milfoil using other devices such as rakes also is considered a viable option in Friess Lake, where practicable and feasible.

Chemical Measures

Chemical treatment with herbicides is a short-term method of controlling heavy growths of nuisance plants. Chemicals are generally applied to the growing plants in either 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. 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 growths 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 they may outcompete the more beneficial, native species. Hence, this is seldom a feasible management option to be used on a large scale. Nevertheless, limited and targeted 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. Widespread chemical treatment is not considered a viable option for Friess Lake.

To minimize the collateral impacts of de-oxygenation, 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 concentrations and amounts of chemicals used due to the colder water temperatures that enhance the herbicidal effects. Use of early spring chemical controls, especially in shoreline areas and targeting growths of Eurasian water milfoil and purple loosestrife in and around the Lake, is considered a viable option for Friess Lake.

Biological Measures

Biological controls provide an alternative approach to controlling nuisance plants, particularly Eurasian water milfoil and purple loosestrife. Classical biological control techniques have been successfully used to control nuisance plants.[2] 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, while *Eurhychiopsis lecontei*, an aquatic weevil species, has potential as a biological control agent for Eurasian water milfoil.[3] Extensive field trials conducted by the WDNR in the Southeastern Wisconsin Region during 1999 and 2000 have indicated that the former insects can provide effective management of large infestations of purple loosestrife. In contrast, very few studies have been completed using *Eurhychiopsis lecontei* as a means of aquatic plant management control. These studies have suggested that the Eurasian water milfoil weevils have limited utility in most lakes in the Region, especially those having significant recreational boating traffic. Nevertheless, their presence as a natural component of the aquatic fauna of lakes having populations of Eurasian water milfoil is most likely responsible for the periodic declines or "crashes" in the population densities of Eurasian water milfoil observed in southeastern Wisconsin lakes. Thus, while the use of insects as a means of wetland plant management is considered to be viable, the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control, given the intensity of recreational boating traffic in Friess Lake, is not considered a viable option for use on Friess Lake at this time. In contrast, the use of biological control agents to manage purple loosestrife is recommended. The use of grass carp, *Ctenopharyngodon idella*, an alternative biological control used elsewhere in the United States, is not permitted in Wisconsin.

---

[2]*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.*

[3]*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.*

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 use of Friess Lake 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 invasive species of plants in those areas. In this regard, the FLAA could consider purchasing several specialty rakes designed for the removal of vegetation from shoreline properties 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 if used to manage aquatic vegetation within a 30-foot-wide corridor along a 100-foot length of shoreline, State permitting requirements for manual aquatic plant harvesting mandate that the harvested material be removed from the lake. A State permit would be required should greater lengths of shoreline be considered for aquatic plant management. Where feasible and practicable, hand pulling of stems, where they occur in isolated stands, is also recommended as a 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 nonnative species, particularly Eurasian water milfoil, purple loosestrife, and curly-leaf pondweed. It is recommended that chemical applications, if required, be made by licensed applicators in early spring subject to State permitting requirements to maximize their effectiveness on nonnative plant species. Early spring or late fall treatments minimize potential impacts on nontarget native plant species and act as preventative measures to reduce the development of nuisance conditions during the summer months. Such an aquatic plant management program 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 should be used. Algicides, such as Cutrine Plus, are not recommended because there are few significant, recurring filamentous algal or planktonic algal problems in Friess Lake and valuable macroscopic algae, such as *Chara* and *Nitella* may be killed by this product. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners.

- Few lakes in southeastern Wisconsin lack aquatic plant growth, and Friess Lake is no exception. However, the Lake would benefit from a greater diversity of native aquatic plants. Low-growing plants, such as spiny naiad and muskgrass, which provide food and shelter for fish and waterfowl, do occur in the Lake. However, because of their low 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 the manual and chemical means as noted above, would be one means of promoting the growths of these native plants, and is recommended for Friess Lake.

- 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 invasive plants and report such growths immediately to the FLAA so that a timely and effective response can be executed.

- In-lake aquatic plant surveys should be conducted at about 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. This information base should include descriptions of the 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, identified pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, using appropriate control measures,[4] is recommended throughout the Lake.

Shoreline Protection Management

Shoreline protection measures refer to a group of 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 is protected by some type of structural measure, mainly riprap, to stabilize the shoreline. Most of the observed shoreline protection measures were in a good state of repair. Use of structural shoreline protection measures is subject to State of Wisconsin permitting, subject to the conduct of a site-specific evaluation utilizing the worksheets provided in Chapter NR 328 of the *Wisconsin Administrative Code*.

Array of Management Measures

Four shoreline erosion control techniques are commonly used: vegetative buffer strips, rock revetments, wooden and concrete bulkheads, and beaches created by placement of sand or gravel “blankets” along the shoreline. 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, within five to 10 feet of the lakeshore and the establishment of emergent aquatic vegetation from two to six feet lakeward of the shoreline. 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 in a buffer strip, or which could be planted, include arrowhead (*Sagittaria latifolia*), cattail (*Typha* spp.), 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 the 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 can be maintained as lake access for boating, swimming, fishing, and other activities. A vegetative buffer strip also would 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 (i.e. banks approximately less than two feet in height) and shallow water. These structures are already in place along much of the shoreline of Friess Lake. 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

[4]*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, amongst others, of the* Wisconsin Administrative Code.

sediment to the lake. If improperly constructed, revetments may fail because of washout of the filter material. A rock revetment is estimated to cost $25 to $35 per linear foot.

However, it is important to note that these low bank areas also may be good candidates for "soft" engineering or bioengineering techniques or an integrated bank treatment (i.e. combination of armoring and vegetation), which can also be very effective in controlling shoreline erosion. Riprap permits are not as easy to obtain from the WDNR as bioengineering or integrated bank treatment permits, but riprap may not be necessary. The WDNR have extensive information on lakeshore and streambank erosion control that is highly recommended prior to any erosion control project is implemented.[5] For example, there is a Bank Erosion Potential Index (BEPI) worksheet available to help determine the correct type of erosion control necessary for a particular lake shoreline project.

Recommended Management Measures

The use of vegetative buffer strips, riprap (as shown in Figure 8), and/or bioengineering 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 Wisconsin Self-Help Monitoring Program, now titled the Citizen Lake Monitoring Network (CLMN). 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 data base containing lake water quality information for most of the lakes in Wisconsin and are accessible on-line through the WDNR website. The Expanded Self-Help Monitoring Program involves the collection of 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. Data collection is more extensive and, consequently, places more of a burden on volunteers. Currently, members of the FLAA take part in the above described programs, collecting water quality data on a regular basis throughout the summer months.

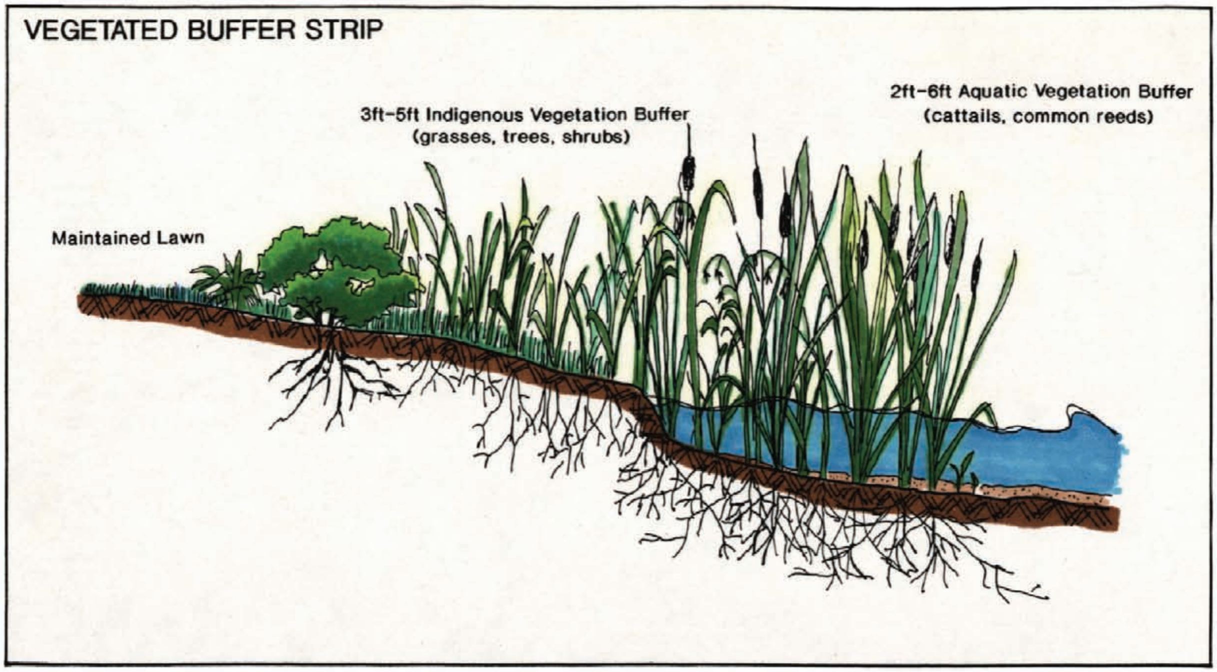
In addition to the volunteer-based monitoring, the U.S. Geological Survey (USGS) also offers an extensive water quality monitoring program. USGS field personnel conduct a series of approximately four monthly samplings beginning with the spring turnover. Samples are analyzed for an extensive array of physical and chemical parameters. The University of Wisconsin-Stevens Point (UWSP) also offers several water quality sampling programs. Under these latter programs, volunteers collect water samples and send them to the UWSP Water and

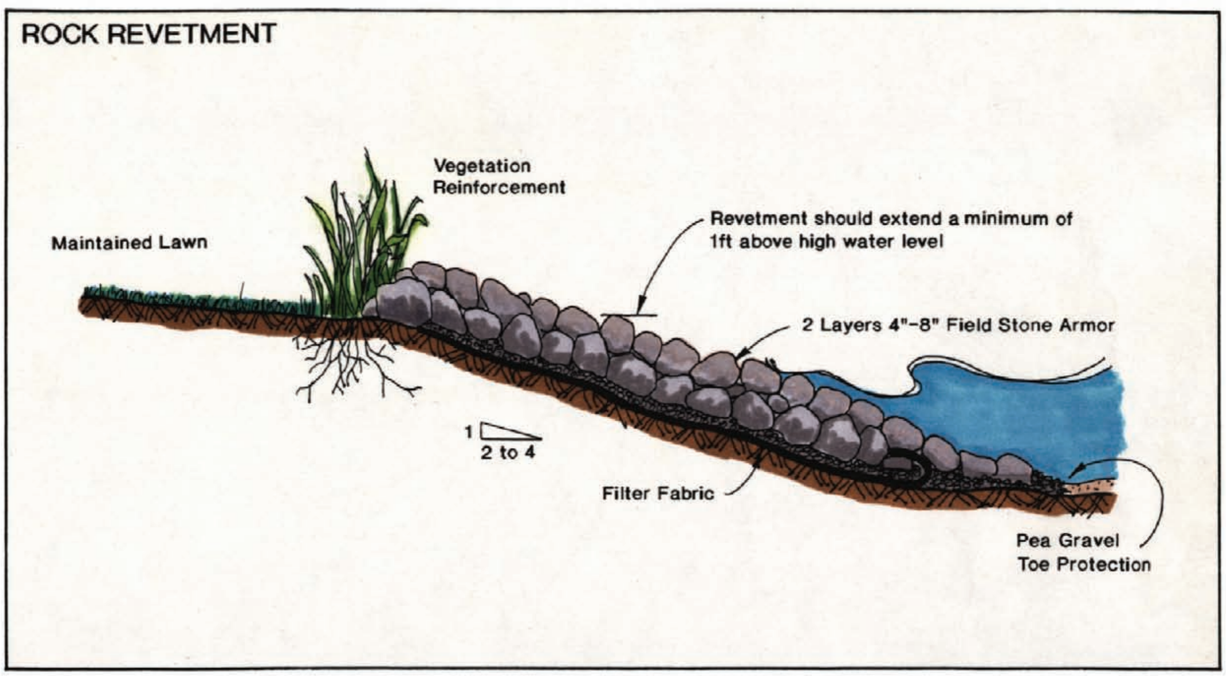
---

[5]*WDNR, Shoreline Erosion Control – Lakes, http://dnr.wi.gov/org/water/fhp/waterway/erosioncontrol.html*

Figure 8

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.

Environmental Analysis Laboratory (WEAL) for analysis. These data also are entered into the statewide data base maintained by the WDNR.

The basic Self-Help Monitoring/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 Monitoring Program requires additional commitment by volunteers to take a more extensive array of measurements and samples for analysis, also on a regular basis. Standardized field protocols and individual volunteer training sessions associated with these programs help to minimize individual variations in the data set arising from individual expertise due to differences in background and experience. Volunteer participation changes are a concern. The UWSP turnover sampling programs require once-a-year sampling, thereby requiring a smaller time commitment by the volunteers. There is a modest charge for the laboratory analysis associated with the UWSP programs. Because sampling is performed by volunteers, this program also is subject to the potential 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 UWSP program, even with state cost-share availability.

Recommended Management Measures

The WDNR offers 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. Currently, Friess Lake may not qualify for such a grant due to the lack of adequate public recreational boating access site as defined in Chapter NR 1 of the *Wisconsin Administrative Code*. In this regard, the agreement between the Village of Richfield and the WDNR with respect to the pending development of a public recreational boating access site, as described in Chapter II of this report, should alter the eligibility of the Lake for such funding as Friess Lake will be in compliance with the minimum requirements for public recreational boating access upon construction of this access site. Having a proposed launch where the land is bought and set aside allows the WDNR, at the time of ranking grants, to state that the lake has "adequate access". However, no points are given in the ranking questions regarding public access until the access is open and operational. Consequently, it is recommended that the FLAA continue to participate in the Self-Help Monitoring/CLMN Program and the Expanded Self-Help Monitoring Program as well as the WDNR’s zebra mussel monitoring program. Data gathered as part of these programs should be presented annually by the volunteers at meetings of the FLAA, where the citizen monitors could be recognized for their work, and the community informed regularly as to the state of the lake. The information gained at first hand by the public from participation in programs such as these can increase the credibility of the proposed changes in the nature and intensity of use to which the Lake is subjected.

The UWSP and the USGS programs are worthy of consideration. The USGS program would be especially valuable as a means to attain a comprehensive water quality determination on a periodic basis, e.g., every three to five years, while maintaining an ongoing data set through the Self-Help Monitoring/CLMN Program.

Fisheries Management

Based upon fisheries surveys described in Chapter II of this report, Friess Lake appeared to have a fairly diverse and healthy fishery. As a result of the provision of adequate public recreational boating access to the Lake, Friess Lake will be eligible for WDNR fisheries enhancement services such as periodic fish surveys and stocking. The fisheries management recommendations summarized below are based on the results of the 2007 WDNR fisheries survey and comments from John Nelson, WDNR fisheries biologist.

Array of Management Measures

Friess Lake provides a suitable habitat for a warmwater fishery with adequate water quality and dissolved oxygen levels that can contribute to the maintenance of a fish population that is dominated by desirable sport fish. To this end, a rigorous fisheries survey should be undertaken periodically in order to better identify fish population composition, length-weight distribution, community age structure, and related life history information, such as proportion of available spawning habitat, spawning success, and juvenile recruitment. These data are important for making stocking-related decisions. Potential alternatives for improving the fishery include protecting existing fish spawning sites and establishing additional habitat sites through the development of a more desirable aquatic plant community, especially in the shallow water habitat areas of the Lake. These alternatives can be supplemented by regulatory provisions relating to the removal of fishes from the Lake and the addition of fishes to the Lake by stocking. For example, implementation and enforcement of a general regulation of 10 sunfish, 10 crappie and 10 perch as a way to reduce harvest could also be effective tool in protecting the fishery. In addition, although carp are not considered a problem at this time, the FLAA should consider implementing an annual carp fishing derby to help reduce the population of carp within the Lakes as a preventative measure to protect the fishery. All of these measures appear to be appropriate for use in Friess Lake.

Habitat Protection

Habitat protection refers to a range of conservation measures designed to maintain existing fish spawning habitat. These measures include restricting recreational and other intrusions into gravel-bottomed shoreline areas during the spawning season (for bass this is spring, typically between mid-April to mid-June), use of natural vegetation in shoreland management zones, and other "soft" shoreline protection options that aid in habitat protection.

In lakes where vegetation is lacking or where plant species diversity is low, artificial habitat may need to be developed. This situation does not apply in Friess Lake, given the results of the aquatic plant surveys that indicate a strong likelihood of sufficient habitat to sustain a fairly healthy fish community. Nevertheless, the use of natural shoreline landscaping techniques provides one alternative to enhance available fish and wildlife habitat around the Lake.

Species Composition

Species composition management refers to a group of conservation and restoration measures that include the stocking of desirable species designed to enhance the angling resource value of a lake. The mixture of species is determined by the stocking objectives. These are usually to: supplement an existing population, maintain a population that cannot reproduce itself, add a new species to a vacant niche in the food web, replace species lost to a natural or man-made disaster, or establish a fish population in a depopulated lake. Assistance in stocking programs and fisheries management, as stated above, will be available through the WDNR upon completion of the public recreational boating access site. Fish stocking requires a WDNR permit.

Recommended Management Measures

The following fisheries management measures, designed to improve and enhance the fishery in Friess Lake, are recommended to be considered:

- Encourage the use of natural vegetation and other "soft" shoreline protection options in shoreland management zones to aid in habitat protection;

- Monitor fish populations periodically through the conduct of periodic fisheries surveys and utilization of these fisheries surveys to formulate stocking recommendations to promote a more robust and diverse fishery in the Lake;

- Continue the stocking of fishes in Friess Lake as per WDNR recommendations; and,

- Utilize fishing regulations to protect stocked fishes and to improve opportunities for the populations of targeted species to become self-sustaining.

- Support WDNR efforts to implement and enforce a general regulation of 10 sunfish, 10 crappie and 10 perch as a way to reduce harvest and protect the fishery.

- Consider implementing an annual carp fishing derby to help reduce the population of carp within the Lakes as a preventative measure to protect the fishery.

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 recreational 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 site on Friess Lake. This site, located at the western end of the Lake, is privately owned and operated by a tavern/restaurant. The site provides a single paved launch, several car and trailer combination parking spaces, and a small swimming beach with several picnic tables. There is a daily use fee for these facilities. It is considered to be a private access site pursuant to Chapter NR 1 with no private provider agreement in place. Therefore, Friess Lake currently lacks adequate public recreational boating access. A public recreational boating access site is currently under development through a cooperative agreement between the WDNR and the Village of Richfield. This public access site is located in the northwestern corner of Little Friess Lake and will provide access to Friess Lake by way of a navigable portion of the Oconomowoc River connecting Friess Lake and Little Friess Lake. The site, to be owned by the WDNR and operated by the Village of Richfield, will provide adequate public recreational boating access to Friess Lake, pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*; at the time of this writing, completion of the site is anticipated for 2008.

Array of Management Measures

Pending completion of the proposed public recreational boating access site on Little Friess Lake that meets current WDNR standards, no further development is deemed necessary. Completion of a private provider agreement between the owner of the tavern/restaurant site and the WDNR could augment the access available through the proposed public recreational boating access site; however, such an agreement remained unlikely to be signed at the time of writing.

Recommended Management Measures

In addition to the provision of adequate public recreational boating access as a result of the completion of the Little Friess Lake access site development, it is recommended that appropriate signage be provided at the site, with information on, amongst other issues, Eurasian water milfoil, zebra mussel, and other potentially invasive nonnative species.

TRIBUTARY AREA MEASURES RELATED TO AQUATIC PLANT MANAGEMENT

Land Use Management

A basic element of lake management programs is the promotion of sound land use development and management in the tributary area to a lake. The type and location of future urban and rural land uses in the area tributary to Friess Lake will determine, to a large degree, the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, various land management measures; and, to some considerable degree, the water quality of the Lake itself.

The recommended future land use conditions for the area tributary to Friess Lake are set forth in the adopted regional land use plan.[6] This plan presents alternatives for the preservation of primary environmental corridor lands in essentially natural, open space use. The delineated environmental corridors contain most of the ecologically valuable lands in the vicinity and adjacent to the Lake. Hence, the protection and preservation of the environmental corridor lands is to be recommended. Where appropriate, wetlands, and woodlands are

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

recommended to be placed in conservancy protection districts, especially those features identified in the adopted regional natural areas and critical species habitat protection and management plan.[7]

With respect to the recommended future land use pattern, as reported in the previous report, the adopted regional land use plan in effect at that time[8] set forth estimates for increases in urban land use in the area tributary to Friess Lake at about 350 acres, resulting in urban land comprising about 23 percent of the total watershed area. As observed in the previous report, there were indications at that time that urban growth within the area tributary to the Lake would probably exceed the predicted level primarily as a result of large-lot residential development. Current estimates for future urban land use development, as set forth in Chapter II, project 2035 urban land use to comprise 26 percent of the tributary area as lands currently in agricultural use are developed into urban residential lands, these changes occurring primarily in the central section of the Friess Lake total tributary area. Some limited infilling of existing, platted lots would be expected to occur, and, in addition, the redevelopment and reconstruction of existing single-family homes on lakefront properties may be expected. Increases in urban land uses and associated impervious surfaces will increase runoff into the Lake and waterways tributary to the Lake, and may increase some nonpoint source pollutant loadings that represent a potentially significant threat to the Lake's water quality. Sources of nonpoint source pollutants include both rural and urban land uses, including land disturbing activities associated with construction and redevelopment within the tributary area.

Control of Nonpoint Source Pollution

Friess Lake is a eutrophic waterbody. As such, it may be considered, by definition, to be in need of protection to maintain and rehabilitation to enhance its current aesthetic and recreational uses. The anticipated urbanization of the watershed under buildout conditions, as set forth in the aforereferenced regional land use plan, when viewed in light of the recent USGS findings regarding the potential impacts of suburban lawn care practices on stormwater runoff in urbanized watersheds in Wisconsin,[9] has heightened concern among Lakeshore residents that the water quality of the Lake could deteriorate. As described in Chapter II, the primary sources of pollutant loadings to Friess Lake are nonpoint sources, generated from within the area tributary to the Lake. Watershed management measures may be used to reduce nonpoint source pollutant loadings from such rural sources as runoff from cropland and pastureland; from such urban sources as runoff from residential, commercial, transportation, and recreational land uses; and from construction activities. The alternative, nonpoint source pollution control measures considered in this report are based upon the recommendations set forth in the regional water quality management plan[10] and adopted lake management plan,[11] and information presented by the U.S. Environmental Protection Agency.[12]

---

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

[8]*SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin: 2010, *January 2002.*

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

[10]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One,* Inventory Findings, *September 1978, Volume Two,* Alternative Plans, *February 1979, Volume Three,* Recommended Plan, *June 1979; and SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[11]*SEWRPC Community Assistance Planning Report No. 98, 2nd Edition,* op. cit.

[12]*U.S. Environmental Protection Agency, Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, *2nd Edition, August 1990; and its technical supplement, U.S. Environmental Protection Agency, Report No. EPA-841/ R-93-002,* Fish and Fisheries Management in Lake and Reservoirs: Technical
(Footnote Continued on Next Page)

Array of Protection Measures
To control nonpoint source pollution to Friess Lake and its tributary area, application of both urban and rural nonpoint source controls is recommended. In addition, measures to control nonpoint source pollution loading during land development activities also are recommended.

Urban Nonpoint Source Controls
Nonpoint Source Pollution Control in Developed Urban Areas
Potentially applicable urban nonpoint source control measures include wet detention basins, stormwater infiltration basins, grassed swales, and good urban housekeeping practices. Public informational programs can be developed to encourage good urban housekeeping practices, to promote the selection of building and construction materials which reduce the runoff contribution of metals and other toxic pollutants, and to promote the acceptance and understanding of the proposed pollution abatement measures and the importance of lake water quality protection. Good urban housekeeping practices and source controls include restricted use of fertilizers and pesticides; improved pet waste and litter control; the substitution of plastic for galvanized steel and copper roofing materials and gutters; proper disposal of motor vehicle fluids; increased leaf collection; street sweeping; and reduced use of street deicing salt. Generally, the application of low-cost urban housekeeping practices may be expected to reduce nonpoint source loadings from urban lands by about 25 percent.

Proper design and application of urban nonpoint source control measures such as grassed swales, detention basins, and infiltration basins requires the preparation of a detailed stormwater management system plan that addresses stormwater drainage problems and controls nonpoint sources of pollution. Based upon preliminary evaluation, however, it is estimated that few practices would be effective in the areas within the immediate vicinity of Friess Lake. Management measures that can be applied within the Village of Richfield in the immediate vicinity of Friess Lake are limited largely to good urban housekeeping practices, grassed swales, and vegetative lakeshore buffers. However, structural measures could be considered for installation as part of the development process in urbanizing areas within those currently undeveloped portions of the tributary area, and in those portions of the watershed along roadways where provision of measures to reduce runoff velocities from the impervious surfaces may be desirable.

Nonpoint Source Pollution Control in Developing Urban Areas
Developing areas can generate significantly higher pollutant loadings than established areas of similar size. These areas include a wide array of activities, including individual site development within the existing urban area, and new land subdivision development. Additional urban development is presently occurring and/or planned within the drainage area tributary to Friess Lake. These construction sites may be expected to produce suspended solids and phosphorus loadings at rates several times higher than established urban lands, and control of sediment loss from construction sites is recommended.

Construction erosion controls are important pollution control measures that can minimize localized loadings of phosphorus and sediment from the drainage area, and minimize the cumulative impacts of such loadings. The control measures include such revegetation practices as temporary seeding, mulching, and sodding; such runoff control measures as placement of filter fabric fences, straw bale barriers, storm sewer inlet protection devices, diversion swales, sediment traps, and sedimentation basins; and such site management practices as placement of tracking pads to limit the movement of soils from work sites. Construction site erosion controls may be expected to reduce pollutant loadings from construction sites by about 75 percent.

(Footnote Continued from Previous Page)
Supplement to the Lake and Reservoirs Restoration Guidance Manual, *May 1993; and R.J. Hunt, Y. Lin, J.T. Krohelski, and P.F. Juckem, U.S. Geological Survey Water-Resources Investigations Report 00-4136,* Simulation of the Shallow Hydrologic System in the Vicinity of Voltz Lake, Wisconsin, Using Analytic Elements and Parameter Estimation, *2000.*

Rural Nonpoint Source Controls
Upland erosion from agricultural and other rural lands currently is a contributor of sediment and other contaminants within the area tributary to Friess Lake. Estimated phosphorus and sediment loadings from croplands, woodlots, pastures, and grasslands in the area tributary to Friess Lake were presented in Chapter II. As set forth, portions of the remaining agricultural lands within the area tributary to Friess Lake will be replaced, over time, with urban density residential, commercial, and industrial development. While such development could potentially reduce the agro-chemical loadings to Friess Lake, this benefit maybe offset by the fact that urban lands contribute a wider range of contaminants to surface waters and generally increased rates of surface runoff.

Recommended Management Measures
Insofar as future land usage reflects these latter recommendations, it is recommended that development proceed with due regard for the management of stormwater and other urban runoff so as not to impair the water quality of the Lake. To wit, it is recommended that:

- Development within the area tributary to Friess Lake should occur at densities consistent with those set forth in the adopted land use plans;
- Land use development, or redevelopment, proposals around the shoreline of the Lake be carefully reviewed for potential impacts on the Lake;
- Residential developments be placed in conservation subdivisions utilizing smaller lots to preserve open space and preserve natural and cultural resources to the extent practicable;[13]
- A regular program of inspection and maintenance, as necessary, be implemented with respect to onsite sewage disposal systems to ensure their continued capacity and functioning, until such time as public sanitary sewerage service is provided;
- Urban pollution control measures, including wet detention-infiltration basins, grassed swales, and good urban “housekeeping” practices, be encouraged to minimize pollutant loadings while maintaining water loadings to the Lake;
- Where new development or redevelopment is proposed, the provisions of the relevant Village of Richfield land division and construction site erosion control ordinances be strictly enforced within the area tributary to Friess Lake; and,
- Sound rural land management practices be implemented to reduce soil loss and contaminant loadings through preparation of farm conservation plans and other practices in accordance with the regional land use plan.

ANCILLARY PLAN RECOMMENDATIONS

Public Informational and Educational Programming
As part of the overall citizen informational and educational programming to be conducted in the Friess Lake 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 Lakes. 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 species, such as purple loosestrife and Eurasian water milfoil.

[13]*See SEWRPC Planning Guide No. 7*, Rural Cluster Development Guide, *December 1996.*

With respect to aquatic plants, distribution of posters and pamphlets, available from the UWEX and 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 Village of Richfield and the FLAA is recommended. These programs should focus on the value of and the 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, WDNR, Washington County, 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 FLAA. 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, Washington County, and UWEX, such as the 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 Friess Lake. 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.

SUMMARY

This plan, which documents the findings and recommendations of a study requested by the Village of Richfield and the FLAA, examines existing and anticipated drainage area conditions, potential aquatic plant management problems, and recreational use concerns on Friess Lake. The plan sets forth recommended actions and management measures for the resolution of those concerns. The recommended plan is summarized in Table 16 and shown on Map 9.

Friess Lake was found to be a eutrophic lake of slightly below average water quality. Preservation of environmental corridor lands, and especially within the shoreland and nearshore areas situated immediately adjacent to the Lake, is recommended. Washington County and the Village of Richfield, together with the FLAA, should support appropriate land management practices designed to reduce nonpoint source pollutant discharges in stormwater runoff into the Lake. Further, the Village and FLAA should promote appropriate shoreline management practices, including the use of riprap and vegetative buffer strips, where applicable.

The shoreland and aquatic plant management elements of this plan recommend actions be taken to reduce human impacts on ecologically valuable areas in and adjacent to the Lake, and to limit the spread of nonnative invasive plant species. The plan recommends periodic in-lake aquatic plant surveys, limited use of chemical herbicides mainly in areas where nuisance levels of nonnative invasive species are present, manual harvesting of aquatic plants around piers and docks with subsequent removal of cut material from the Lakes, and monitoring of invasive aquatic species populations.

The plan recommends continued participation in the Expanded Self-Help Monitoring/CLMN volunteer water quality monitoring program with consideration of periodic USGS, or similar, comprehensive water quality surveys. With regard to fisheries, the plan recommends periodic WDNR-conducted fish surveys to determine management and stocking needs and recommends the use of natural vegetation in shoreland areas to aid in habitat protection.

Table 16

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR FRIESS LAKE

Plan Element	Subelement	Management Measures	Management Responsibility
In-Lake 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	WDNR, FLAA, Village of Richfield
		Limited use of aquatic herbicides for control of nuisance nonnative aquatic plant growth where necessary; specifically target Eurasian water milfoil[a]	
		Additional periodic monitoring of the aquatic plant community for the early detection and control of future-designated nonnative species that may occur	
		Manually harvest around piers and docks as necessary[b]	Private landowners
		Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and deposition of organic materials in Lake	
		Continue to participate in WDNR's zebra mussel monitoring program	WDNR, FLAA, Village of Richfield, individuals
		Monitor invasive species populations; where they occur, remove isolated stands of purple loosestrife through bagging, cutting, herbicide application to cut stems	WDNR, FLAA, Village of Richfield, private landowners
	Shoreline Protection Management	Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Washington County, Village of Richfield, WDNR, and private landowners
	Water Quality Management	Continue participation in WDNR Self-Help monitoring program and periodic participation in U.S. Geological Survey TSI or similar programs	WDNR, USGS, Village of Richfield, FLAA
		Encourage growth of native plants through maintenance and/or establishment of riparian buffer widths adjacent to Friess Lake and Little Friess Lake as well as upstream of the Lake on the Oconomowoc River and its associated tributaries.	Washington County, Village of Richfield, FLAA, WDNR, and private landowners
	Fisheries management	Conduct periodic fish surveys to determine management and stocking needs; continue stocking; enforce size and catch limit regulations	WDNR
		Support WDNR efforts to implement and enforce a general regulation of 10 sunfish, 10 crappie and 10 perch as a way to reduce harvest and protect the fishery	Village of Richfield, FLAA, WDNR, and individuals
		Consider implementing an annual carp fishing derby to help reduce the population of carp	Village of Richfield, FLAA, WDNR, and individuals
		Protect fish habitat, including environmentally sensitive lands such as wetlands; encourage use of natural vegetation in shoreland areas to aid in habitat protection	Village of Richfield, FLAA, WDNR, individuals
	Recreational Use Management	Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines; enforce and periodically review boating regulations	WDNR, Village of Richfield
		Maintain signage at public access sites regarding invasive species; provide disposal containers for disposal of plant material removed from watercraft	
		Complete development of public access site for Friess Lake in order to secure fisheries management services and state cost-share funding opportunities for qualified lake management and protection projects	WDNR, Village of Richfield

Table 16 (continued)

Plan Element	Subelement	Management Measures	Management Responsibility
Tributary Area Management Measures	Land Use	Observe development area guidelines set forth in the regional land use plan; consider conservation development principles	Washington County and Village of Richfield
		Establish adequate protection of wetlands and shorelands, and other environmental corridor lands and isolated natural features	Washington County, Village of Richfield, and WDNR
		Maintain historic lake front residential dwelling densities to extent practicable	Washington County, Village of Richfield
		Promote sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans in accordance with regional land use plan	USDA, WDATCP, and Washington County
		Promote sound urban housekeeping and yard care practices through informational programming; implement stormwater management measures	FLAA, Washington County, Village of Richfield
		Strictly enforce construction site erosion control and stormwater management ordinances	Washington County, Village of Richfield
		Implement onsite sewage disposal system management, including inspection and maintenance, in those portions of the watershed not served by public sanitary sewerage systems	Washington County and private landowners
Ancillary Measures	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	Village of Richfield, FLAA, 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, Village of Richfield, and FLAA
		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 FLAA	FLAA

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

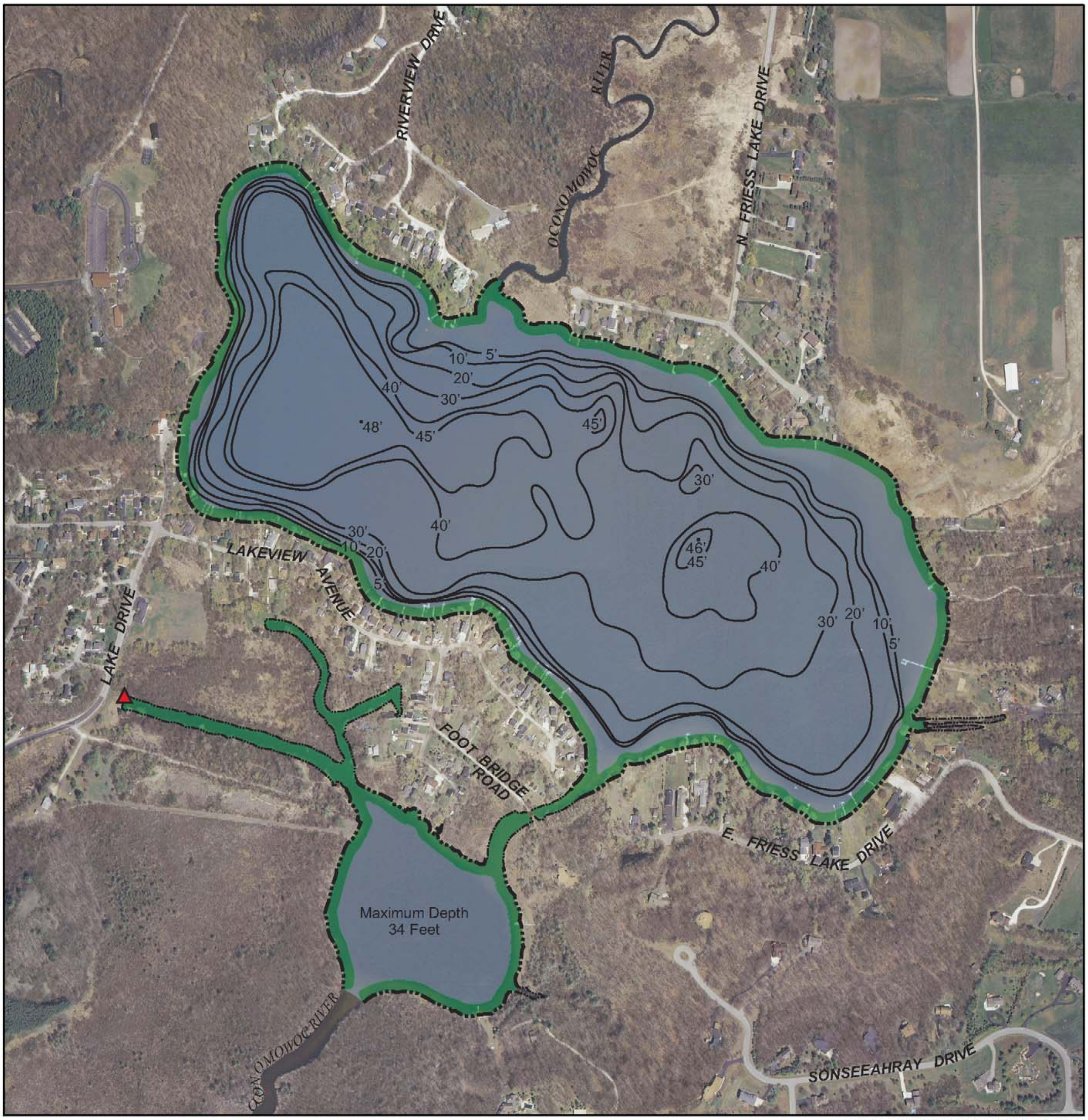
[b] *Manual harvesting beyond a 30 linear foot width of shoreline is subject to WDNR permitting pursuant to Chapter NR 109 of the* Wisconsin Administrative Code*.*

Source: SEWRPC.

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 usage, lawn and garden care, onsite sewage disposal system operation and maintenance, shoreland protection and maintenance, and recreational usage of the Lake should be made available to riparian property owners, thereby providing riparian residents with alternatives to traditional activities.

Map 9

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR FRIESS LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

AQUATIC PLANT MANAGEMENT

- CONDUCT PERIODIC AQUATIC PLANT SURVEYS
- LIMIT AQUATIC HERBICIDE USE TO CONTROL OF NONNATIVE INVASIVE SPECIES

MANUALLY HARVEST AROUND PIERS AND DOCKS

RECREATIONAL USE MANAGEMENT

CREATE AND MAINTAIN PUBLIC RECREATIONAL BOATING ACCESS SITE

LAND USE MANAGEMENT

- OBSERVE DEVELOPMENT GUILDELINES SET FORTH IN REGIONAL LAND USE PLAN
- PROMOTE SOUND LAND MANAGEMENT PRACTICES
- MAINTAIN ONSITE SEWAGE DISPOSAL SYSTEMS

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN CITIZEN LAKE MONITORING NETWORK
- CONTINUE INFORMATIONAL PROGRAMMING

GRAPHIC SCALE
0 350 700 FEET

Source: SEWRPC.

(This page intentionally left blank)

APPENDICES

(This page intentionally left blank)

Appendix A

RIPARIAN BUFFER EFFECTIVENESS ANALYSIS

INTRODUCTION

The scientific literature on the effectiveness of riparian buffers in improving water quality through processing and removing anthropogenic contaminants from surface and ground waters is extensive. Added to this literature is legal practice that has established the principle of shoreline setbacks, especially with respect to both the shoreland management of lakes and flowages and to flood control. Recently, riparian buffers have been employed as an environmental management tool. Despite significant research efforts, there remains no consensus for what constitutes optimal riparian buffer design or proper buffer width to achieve maximum pollutant removal effectiveness, water quality protection, and biological protection. The Wisconsin Buffer Initiative (WBI) further developed two key concepts that are relevant to this plan: 1) riparian buffers are very effective in protecting water resources, and 2) riparian buffers need to be a part of a larger conservation system to be most effective.[1] However, it is important to note that the WBI limited its assessment and recommendations solely to the protection of water quality, and did not consider the additional values and benefits of riparian buffers such as flood control, prevention of channel erosion, provision of fish and wildlife habitat, enhancement of environmental corridors, and water temperature moderation, among others.

This analysis seeks to identify documented scientific information extracted from published literature, which allowed the derivation of the recommended 75-foot-wide riparian buffer width for lakes and streams in the regional water quality management plan update study area, and by extension, the Southeastern Wisconsin Region. This will aid managers and planners in making decisions about establishing, maintaining, or restoring riparian buffers adjacent to all waterbodies. Although, buffer width stands out as one factor influencing the capacity for buffers to remove potential contaminants, numerous other factors described herein play significant roles in the establishment of 75-foot-wide riparian buffers as part of this comprehensive water quality management plan update.

More than 65 peer-reviewed scientific publications dating from 1975 through 2005 were examined for data on the effectiveness of riparian buffers for total suspended solids (TSS), nitrogen, and phosphorus removal around streams and lakes. These data form the basis for defining the relationship between buffer width and percent removal efficiencies for those contaminants. When introduced into the natural environment in quantities or

---

[1]*University of Wisconsin-Madison, College of Agricultural and Life Sciences,* The Wisconsin Buffer Initiative, *December 2005.*

concentrations exceeding the absorption capacity of shoreland buffers, these potential pollutants have the ability to negatively impact waterways and waterbodies, diminishing their utility as recreational and aesthetic resources and reducing their value as essential elements of aquatic ecosystems.

As part of this analysis, three key elements were incorporated into the general 75-foot buffer width recommendation set forth in the regional water quality management plan update. These elements are:

- The value of riparian buffers as vegetated zones adjacent to streams, lakes, and wetlands and their use as a best management practice (BMP) for **controlling contaminants** such as nutrients and TSS entering waterbodies.

- The value of riparian buffers as habitat areas adjacent to streams, lakes, and wetlands and their use as a BMP for **protecting and maintaining species** habitat and diversity, especially amongst species of economic concern.

- The role of riparian buffers as a **component of comprehensive watershed management plans**, which must also include point source and nonpoint source control of nutrients and TSS loadings.

CONTROL OF CONTAMINANTS

Riparian buffers are one of the most effective best management practices to protect water resources in terms of water quality, riverbank stability, wildlife habitat, and aesthetics. These strips of grass, shrubs, and/or trees along the banks of rivers, streams, and lake shorelines filter polluted runoff and provide a transition zone between the land and water and associated human uses. These buffers work in various ways and with varying degrees of effectiveness. Effectiveness depends upon a number of factors including the nature of the specific contaminant, its environmental reactivity, the mass of contaminant being conveyed across the land surface, and the distance and slope across which the contaminant is being carried. The role of buffers in controlling and managing the transfer of several major contaminants through the land-water ecotone, or interface, is briefly reviewed below.

Sediment Filter
Riparian buffers help catch and filter out sediment and debris from surface runoff. Depending upon the width and complexity of the buffer, generally 50 percent to 100 percent of the sediment particles—as well as the nutrients and other contaminants attached to them—can settle out and be retained within the buffer strip as plants slow sediment-laden runoff waters. These buffers act as physical filters, retaining particulates within the mass of plant materials, roots, and stalks. For this purpose, wider forested buffers are even more effective than narrow grassed buffers.

Nutrient Filter, Transformer, and Sink
Riparian buffers “trap” pollutants that could otherwise wash into surface and ground water. Such buffers act both as a physical filter, retaining contaminants that adhere to sediment particles through the settling processes described above, and as biological filters. The plants that comprise the buffer strips can utilize a portion of the nutrient load being processed through the buffer strip for nutrition and growth. Phosphorus and nitrogen from sources such as fertilizer application and animal waste can become pollutants if more is applied to the land than upland plants can use. These “excess” nutrients can be transported by runoff of rainfall or snowmelt to aquatic systems, such as streams and lakes where the nutrients are then available to support and sustain the growth and reproduction of shoreland and aquatic plants. In large quantities, these plants commonly limit recreational use of the waters and shorelands, and interfere with the aesthetic enjoyment of these areas.

Phosphorus stimulates growth (i.e. it is a growth limiting element) of both terrestrial and aquatic plants in the Southeastern Wisconsin Region, and is largely responsible for the eutrophication of our waterbodies. The affinity of this element to soil particles results in approximately 80 percent or more of the available phosphorus being captured when sediment is filtered out of surface runoff by passing through the buffer.

In the case of nitrogen, another important element for plant growth, the chemical and biological activity in the soil, particularly in the soils of streamside forests, can capture and transform nitrogen and other pollutants into less biologically-available forms. Nitrogen-fixing bacteria are especially useful in capturing "excessive" nitrogen and transforming the elemental nitrogen into biologically available and/or gaseous forms.

It should be noted that, with respect to aquatic systems, the vegetation within the buffers acts as a temporary sink as the nutrients and excess water are taken up by root systems and stored in the biomass of trees during the growing season. A large portion of these nutrients are then re-released into the environment during the autumn as the plants senesce or die; however, nutrients entering the aquatic environment during the fall are less likely to create or contribute to conditions that interfere with human recreational use and aesthetic enjoyment of the downstream water resources.

Stream Flow Regulator
Riparian buffers slow the passage of water across the land surface and allow water to infiltrate into the soil. This recharge contributes to the maintenance of the groundwater supply. Groundwater reaches streams and rivers at a much slower rate, and over longer periods of time, than surface runoff. Thus, increasing recharge helps maintain stream flow during the driest times of the year.

Bed and Bank Stabilizer
Riparian buffer vegetation helps to stabilize streambanks and shorelines and reduce erosion. The roots of the plants hold bank soils together, and the stems protect banks by deflecting the erosive action of waves, ice, boat wakes, and storm runoff. In like manner, riparian buffers also can reduce the amount of streambed scour by absorbing surface water runoff and slowing water velocities. When plant cover is removed, more surface water reaches a stream, causing the water to crest higher during storms or snowmelt, and subjecting the shorelands to higher flow velocities that can scour shorelines and streambeds.

Effectiveness of Shoreland Buffers
The following range of buffer widths can be gleaned from the literature:

- To Stabilize Eroding Banks: On smaller streams, good erosion control may only require covering the banks with shrubs and trees, and a 35-foot-wide managed grass buffer. If there is active bank erosion, or on larger streams, at least a 50-foot width is necessary. Severe bank erosion on larger streams may require engineering actions to stabilize and protect the bank; however, once completed, bank protection can be done with plants. For better stabilization, more of the buffer should be planted in shrubs and trees.

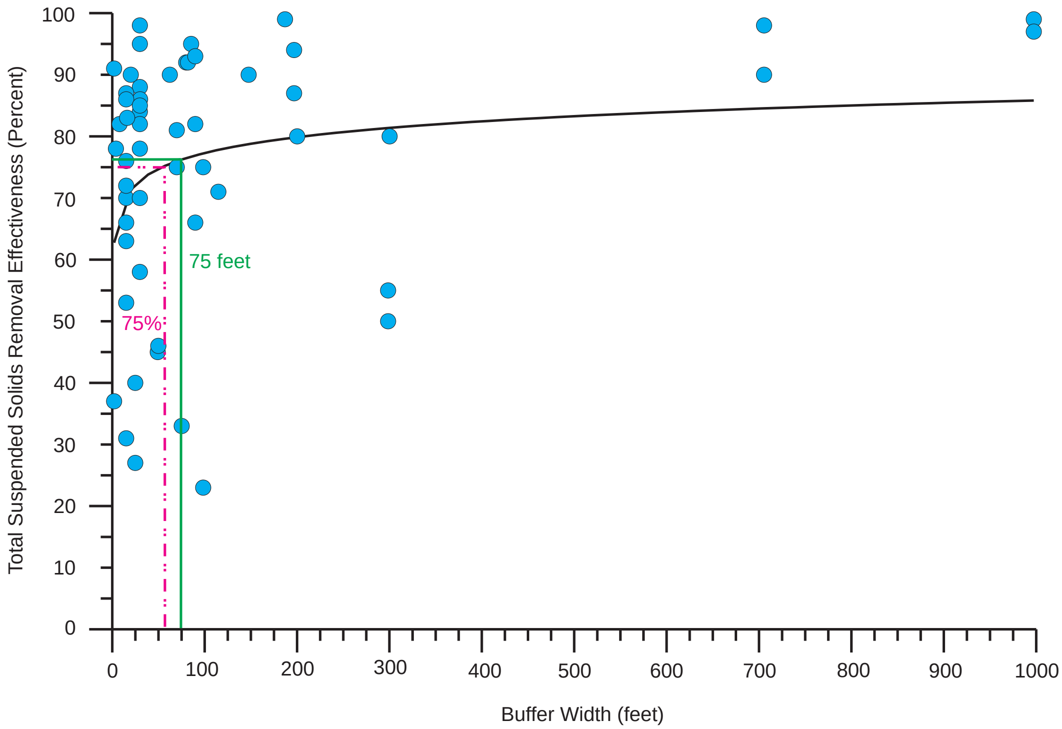
- To Filter Sediment and Attached Contaminants from Runoff: For slopes of less than 15 percent, most sediment settling occurs within a 35-foot-wide buffer of grass. Greater width is needed on steeper slopes, for shrubs and trees, or where sediment loads are particularly high.

- To Filter Dissolved Nutrients and Pesticides from Runoff: A width of up to 100 feet or more may be necessary on steeper slopes and on less permeable soils to allow runoff to soak in sufficiently, and for vegetation and microbes to work on nutrients and pesticides. Most pollutants are removed within 75 feet.

Based upon the literature review, for the purposes of contaminant management, a buffer width of 75 feet represents the most appropriate width for water quality protection. As shown in Figures A-1 through A-4, and consistent with the water quality modeling assumptions applied in the regional water quality management plan update, a 75-foot buffer width provides a high level of effectiveness in reducing TSS loads delivered to the buffer by about 75 percent, delivered total nitrogen loads by about 65 percent, delivered nitrate loads by about 75 percent, and delivered total phosphorus loads by about 70 percent. There are increased benefits of reduction beyond the 75-foot width for each of these parameters. For example, about 90 percent removal effectiveness would be expected for both nitrate and total phosphorus at approximately a 300-foot buffer width. Coincidently,

Figure A-1

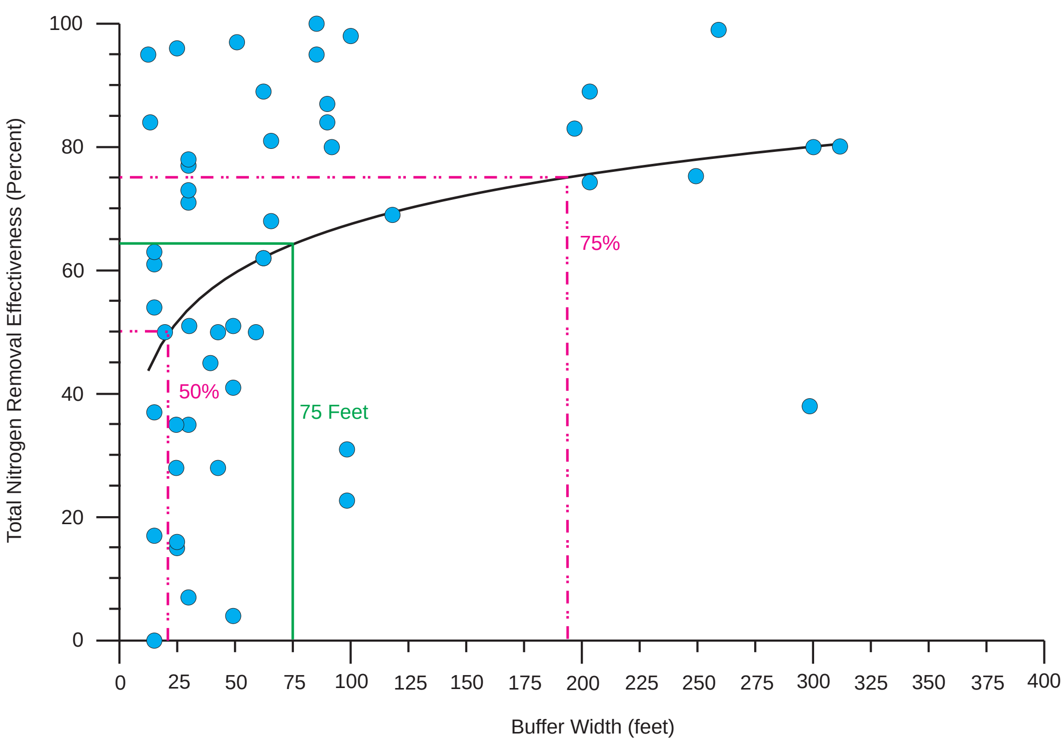
RELATIONSHIP OF TOTAL SUSPENDED SOLIDS REMOVAL EFFECTIVENESS TO RIPARIAN BUFFER WIDTH



Source: SEWRPC.

Figure A-2

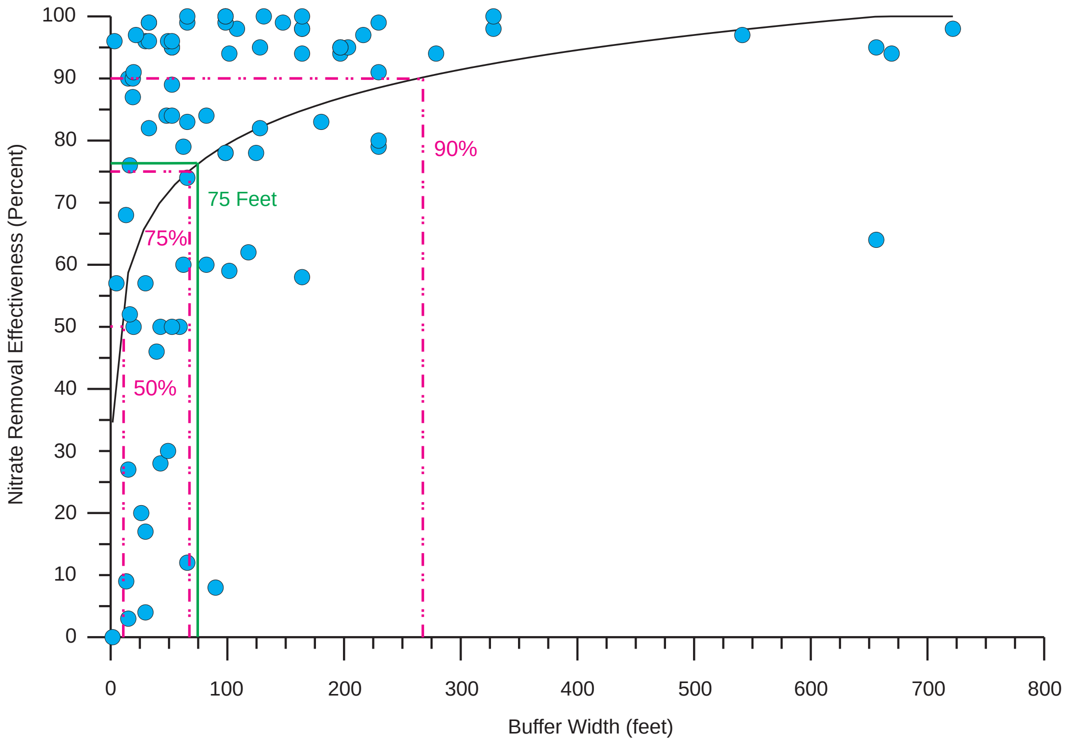
RELATIONSHIP OF TOTAL NITROGEN REMOVAL EFFECTIVENESS TO RIPARIAN BUFFER WIDTH



Source: SEWRPC.

Figure A-3

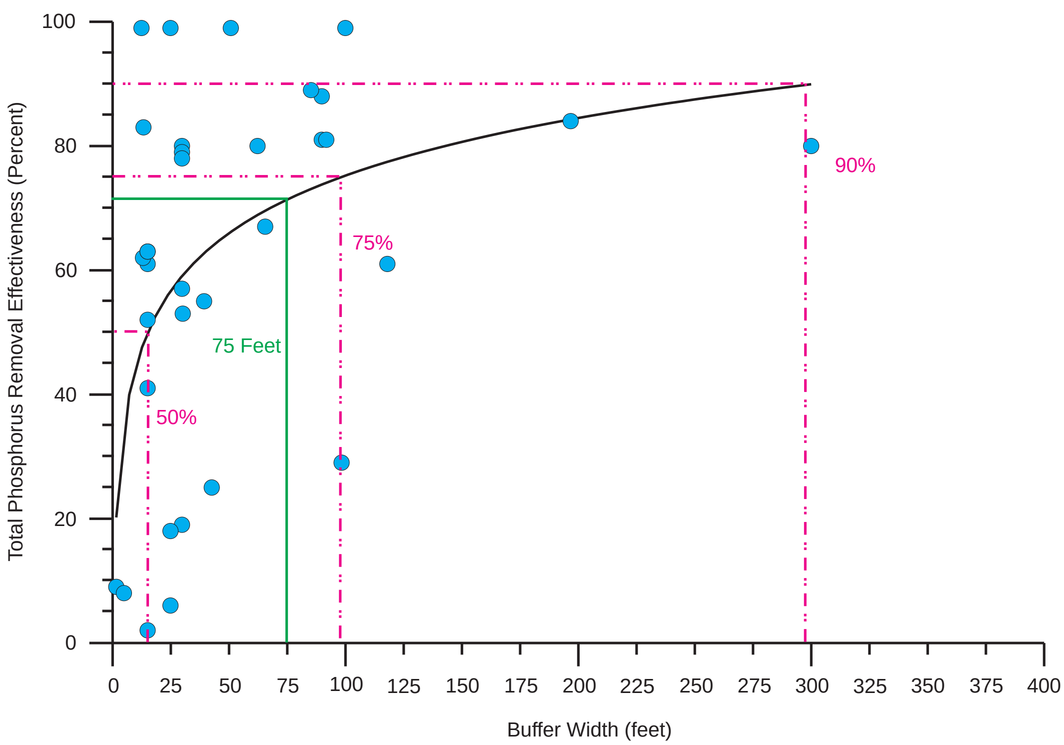
RELATIONSHIP OF NITRATE REMOVAL EFFECTIVENESS TO RIPARIAN BUFFER WIDTH



Source: SEWRPC.

Figure A-4

RELATIONSHIP OF TOTAL PHOSPHORUS REMOVAL EFFECTIVENESS TO RIPARIAN BUFFER WIDTH



Source: SEWRPC.

this 300-foot buffer width is well within the range for added biological community benefits as described below. However, examination of Figures A-1 through A-4 indicates that for a relatively high cost, as indicated by the incremental buffer width beyond 75 feet, a relatively small improvement in water quality would be achieved, as indicated by the incremental increase in pollutant removal effectiveness beyond that for the 75-foot buffer.

It should also be noted that buffer effectiveness is determined by slope, soil permeability, and nature of vegetative cover. Steep slopes and soils of low permeability have less capacity to provide water quality benefits and therefore, require greater buffer widths than less steeply sloped and more permeable soils. Steeply sloped lands promote rapid runoff of water and associated contaminants, while less permeable soils limit infiltration and interflow. Studies show that subsurface flows provide more effective pollutant removal capacity than surface runoff flows.[2] However, the effectiveness and efficiency of all buffers can be limited by the extent of contaminant loading, with even the largest buffers having reduced effectiveness under conditions of extremely high loadings. Thus, a system of riparian buffers along with agricultural nutrient management plans and urban stormwater management plans is recommended under the regional water quality management plan update to provide effective control of nonpoint source pollution.

The nature of vegetated cover within the buffer also will determine in part the magnitude of nutrient removal based upon: the requirements of specific plants primarily for nitrogen and phosphorus necessary for growth; the season, with the majority of removal occurring during the growing season; and the degree of physical filtration, with more densely packed stems typically slowing runoff and retaining a greater percentage of soil bound pollutants. Seasonality in terms of both plant growth cycles and freeze thaw cycles can influence the net effectiveness of pollutant removal, with plants actively taking up or removing nutrients in the spring and summer and releasing those nutrients during the fall when plants senesce, while frozen ground limits the ability of water to infiltrate during the winter months reducing the percentage of uptake of nutrients.[3] Modifying the timing and rate of delivery of contaminants to aquatic systems can significantly modify undesirable biological responses in receiving waters such as lakes and streams.

BIOLOGICAL PROTECTION

Riparian buffers can be complex ecosystems that provide habitat and improve the stream and lake communities that they shelter. Habitat and riparian corridor conditions are strongly influenced by the width and nature of the buffers adjacent to a waterbody and are an important BMP with regard to protecting water from contamination by nonpoint source pollutants, as previously noted. There are many different kinds of buffers. While these buffers may be applied to a variety of situations and may be called by different names, their functions are much the same—the improvement and protection of surface water and groundwater quality; reduction of erosion on croplands, streambanks, and lakeshores; and, provision of protection and cover for insects, fish, birds, amphibians, reptiles, and mammals. The types of riparian buffers include, but are not limited to: streamside or lakeshore plantings of trees, shrubs, and grasses; filter strips or grassed waterways; and undisturbed shoreland vegetation.

---

[2]*Paul M. Mayer, Steven K. Reynolds, and Timothy J. Canfield*, Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations*, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, EPA/600/R-05/118, October 2005.*

[3]*D.M. Robertson, S.J. Field, J.F. Elder, G.L. Goddard, and W.F. James,* Phosphorus Dynamics in Delavan Lake Inlet, Southeastern Wisconsin, 1994*, U.S. Geological Survey Water Resources Report 96-4160, 1996; W.F. James, C.S. Smith, J.W Barko, and S.J. Field, "Direct and Indirect Influences on Aquatic Macrophyte Communities on Phosphorus Mobilization from Littoral Sediments of an Inlet Region in Lake Delavan, Wisconsin," U.S. Army Corps of Engineers,* Technical Report W-95-2*, September 1995.*

Wildlife Habitat
The distinctive habitat offered by riparian buffers is home to a multitude of plant and animal species, including those rarely found outside of this band of land influenced by a river or lake. Continuous stretches of riparian buffer serve as wildlife travel corridors. Consequently, streambanks and lakeshores form integral elements of the environmental corridor concept developed and implemented within the Region in accordance with the regional land use and natural areas and critical species habitat protection and management plans.

Aquatic Habitat
Riparian buffers benefit aquatic habitat by improving the quality of nearby waters through shading, filtering, and moderating stream flow. Trees and shrubs provide shade during the summer months, maintaining cooler and more even water temperatures, especially along small streams. Cooler water holds more oxygen and reduces stress on fish and other aquatic creatures. A few degrees difference in temperature can have a major effect on their survival. High value species, such as trout, for example, require cooler water temperatures for survival and reproduction.

The woody debris generated from within the riparian buffer supports the aquatic food web by providing food and cover for fish and their food organisms. By slowing water velocities, providing substrate for insects, among other benefits the woody debris encourages a range of organisms within a system that would be less diversely populated if it did not contain woody debris.

Recreation and Aesthetics
Riparian buffers are especially valuable in providing a green screen along waterways, blocking views of nearby development, and allowing privacy for riverfront landowners. Buffers also provide such recreational opportunities as hiking trails. For many humans, it is these attributes of riparian buffers that are most obvious and most enjoyable.

To Protect Fisheries
Research has shown that a minimum 100-foot buffer width is required to protect the quality and health of the aquatic food web.[4] However, the highest quality fishery communities were associated with the widest riparian buffers that ranged from approximately 650 to 3,000 feet in width, which indicates that buffer widths greater than 100 feet continue to provide additional protection benefits to the fishery community. Regardless of the type of fishery, the 100-foot minimum is a relevant buffer width standard to protect and maintain a coldwater, coolwater, or warmwater fishery and associated aquatic community. The quality of these communities improves with increases beyond the minimum buffer width. In addition, research also has shown that impacts to the continuity and fragmentation of the riparian corridor buffer width are equally as important in protecting aquatic communities. Similarly, both width and continuity of undisturbed buffer strips were related positively to stream health as indicated by aquatic insect IBI, aquatic insect species richness, fisheries Index of Biotic Integrity (IBI), and trout presence.[5] These researchers found that stream health was generally well protected with riparian buffers that ranged from about 110 to 130 feet in width, contained less than 13 fragments per kilometer (e.g., number of road crossings or some equivalent per length of buffer), and at least 31 percent of the buffer was comprised of 100 feet or more in width. As shown in Figure A-5, stream health (i.e. aquatic insect IBI) and buffer characteristics were linearly related where stream health improves with buffer width from about 50 to 160 feet in width. Narrow buffers having some fragmentation had modest effects on reducing stresses to stream health, whereas wide buffers

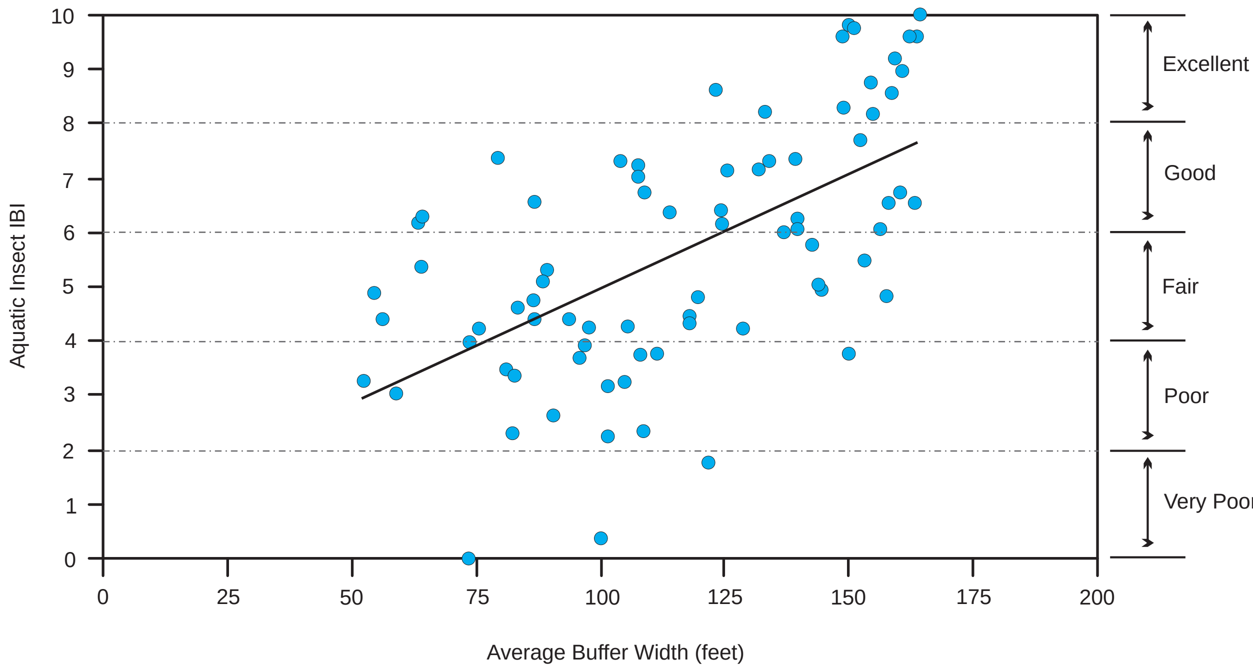
---

[4]*Jana S. Stewart, Lizhu Wang, John Lyons, Judy A. Horwatich, Roger Bannerman, "Influences of watershed, riparian-corridor, and reach-scale characteristics on aquatic biota in agricultural watersheds,"* Journal of the American Water Resources Association, *Vol. 37, No. 6, 1475-1487, 2001; Wisconsin Department of Natural Resources Bureau of Integrated Science Services,* Buffer Width and Continuity for Preserving Stream Health in Agricultural Landscapes, *Issue Fifty-six, December 2005.*

[5]*Wisconsin Department of Natural Resources Bureau of Integrated Science Services,* Buffer Width and Continuity for Preserving Stream Health in Agricultural Landscapes, *Issue Fifty-six, December 2005.*

Figure A-5

MACROINVERTEBRATE INDEX OF BIOTIC INTEGRITY SCORES AND AVERAGE BUFFER WIDTH



Source: Adapted from B.M. Weigel and others, "Buffer Width and Continuity for Preserving Stream Health in Agricultural Landscapes," Bureau of Integrated Science Services, Wisconsin Department of Natural Resources, Issue 56, 2005.

without fragmentation had substantial effects. Consistent with these findings related to stream health, the regional water quality management plan update includes a recommendation that opportunities to expand riparian buffers beyond the recommended 75-foot width be pursued along high-quality stream systems including those designated as outstanding or exceptional resource waters of the State, trout streams, or other waterways that support and sustain the life cycles of economically important species such as salmon, walleye, and northern pike.

Land use within the watershed also is an important variable influencing fish and macroinvertebrate abundance and diversity, which is why riparian buffers alone cannot address the stresses of excessive nutrient loading, stormwater runoff, or other nonpoint source pollution. For example, researchers found that combined upland (barnyard runoff controls, manure storage, and contour plowing and reduced tillage) and riparian (streambank fencing, streambank sloping, limited streambank riprapping) Best Management Practices (BMPs) treatments significantly improved overall stream habitat quality, bank stability, instream cover for fishes, and fish abundance and diversity.[6] Specifically, improvements were most pronounced at sites with riparian BMPs; however, in sites with limited upland BMPs installed in the watershed there were no improvements in water temperature or the quality of fish community. The regional water quality management plan update recommends buffers as part of an overall system of agricultural controls such as those listed above.

To Protect Wildlife Habitat

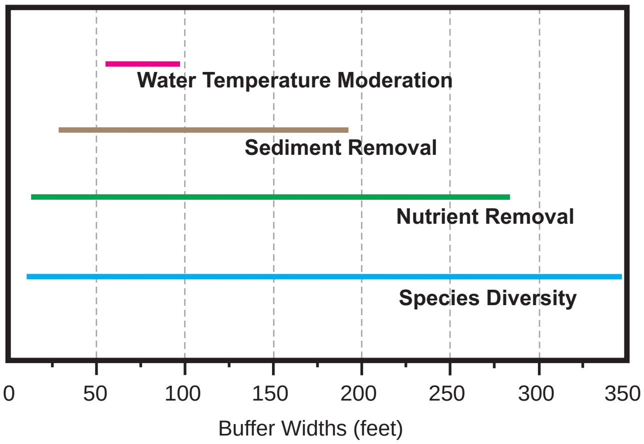
Buffer widths for wildlife depend upon the desired species to be protected. As shown in Figure A-6, large streamside forest buffer widths of up to 350 feet are needed for wildlife habitat purposes in contrast to those required for protection of water quality. The larger the buffer zone, the more valuable it is as wildlife habitat.

---

[6]*Lizhu Wang, John Lyons, and Paul Kanehl, "Effects of watershed best management practices on habitat and fish in Wisconsin streams,"* Journal of the American Water Resources Association, *Vol. 38, No. 3, 663-680, June 2002.*

Figure A-6

RANGE OF BUFFER WIDTHS FOR PROVIDING SPECIFIC BUFFER FUNCTIONS



NOTE: Site-specific evaluations are required to determine the need for buffers and specific buffer characteristics.

Source: Adapted from A.J. Castelle and others, "Wetland and Stream Buffer Size Requirements–A Review," Journal of Environmental Quality*, Vol. 23.*

Larger animals—such as fox, deer, raccoon, and large birds of prey—and interior forest species—especially forest dwelling birds that require deep forest habitat—generally require more room. Additionally, the diversity of various sedges, grasses, forbs, shrubs, and trees may be dependent upon the area available for seed dispersal, germination, and growth. Nevertheless, a narrow width and reduced diversity of vegetation may be acceptable as a travel corridor if connected to larger diverse areas of habitat. Even small patches of trees are better for migrating birds than no buffer or monotypical stands such as lawns or crops. These wildlife buffer concepts underlie the primary environmental corridor specifications of a 200-foot minimum width and two mile length.[7]

SYNTHESIS

Buffers can be used for a variety of purposes from enhancing aquatic species diversity through reducing water temperature entering streams to enhancing terrestrial species diversity through the provision of safe passages with adequate food and shelter. For these reasons, buffer size may vary widely, depending on the specific functions required for a particular buffer or for the protection of a particular species as shown in Figure A-6. Buffers that have widths in the 15- to 35-foot range generally provide limited water quality benefit and minimal protection of aquatic resources under most conditions. Under most circumstances, a minimum buffer width of about 50 to 100 feet is necessary to protect wetlands and streams. In general, minimum buffer widths in the 50- to 65-foot range would be expected to provide for the maintenance of the natural physical and chemical characteristics of aquatic resources. Buffer widths at the upper end of the 50- to 100-foot range seem to be necessary for the maintenance of the biological components of many wetland and stream systems, although it is important to note that site-specific conditions, such as slope, vegetation, and soil characteristics, can greatly influence the need for either wider or narrower buffers. Based upon the literature review, for the purposes of habitat management, a buffer width of 75 feet represents the minimum width necessary for provision of protection of aquatic organisms and habitat. However, a buffer of only 75 feet is not adequate to protect all aquatic and terrestrial plant and animal species.

It is clear that "one size does not fit all" with regard to riparian buffers. Buffer width depends on the purpose which the buffer is meant to serve. There is no single generic buffer which will keep the water clean, stabilize the bank, protect the fish and wildlife, and satisfy human demands. The minimum acceptable width is one that will provide acceptable levels of all of these beneficial uses at an acceptable cost. Consequently, a basic buffer should be about 75 feet from the top of the bank at the water's edge.

In practice, the size and vegetation of the buffer should match the land use and topography of the site.

- Topography: A buffer is more important for water quality in areas that collect runoff and deliver it to streams, and less critical on lands that drain away from the water. Steeper slopes call for a wider riparian buffer to allow more opportunity for the buffer to capture pollutants from faster moving runoff.

---

[7]*Paul Beier and Reed F. Noss, "Do Habitat Corridors Provide Connectivity?,"* Conservation Biology, Review, *Vol. 12, No. 6, 1241-1252, December 1998.*

- Hydrology and Soils: The ability of the soil to remove pollutants and nutrients from surface and ground water depends upon the type of soil, its depth, and relation to the water table. On wetter soils, a wider buffer is needed to achieve the same benefit.

- Vegetation: The purposes of the buffer will influence the type of vegetation to plant or encourage. In urban and residential areas, trees and shrubs do a better job at capturing pollutants from parking lots and lawn runoff and providing visual screening and wildlife habitat. Between croplands and waterways, a buffer of shrubs and grasses can provide many of the benefits of a forested buffer without shading crops, although trees can be used on the north side of fields. Trees have several advantages over other plants in improving water quality and offering habitat. Trees are not easily smothered by sediment and have greater root mass to resist erosion. Above ground, they provide better cover for birds and other wildlife using waterways as migratory routes. Trees can especially benefit aquatic habitat on smaller streams. In general, native vegetation is preferable to nonnative plants.

CONCLUDING REMARKS

While it is clear from the literature that wider buffers can provide a greater range of values for aquatic systems, the need to balance human access and use with the environmental benefits to be achieved suggests that a 75-foot-wide riparian buffer provides a minimum width necessary to contribute to good water quality and a healthy aquatic ecosystem. In general, most pollutants are removed within a 75-foot buffer width. While water quality benefits increase somewhat when buffers exceed the 75-foot width, such increases in width are increasingly less cost effective as a smaller portion of the total pollutant load is removed at a significantly higher cost. From an ecological point of view, buffers beyond a 75-foot width provide greater benefits.

These findings form the basis for the Washington County shoreland protection program, for example, and underlie many of the other shoreland ordinances adopted elsewhere in Wisconsin. A 75-foot buffer width is consistent with the required shoreland setbacks set forth in Chapter NR 115 of the *Wisconsin Administrative Code*, and with other recommended setbacks currently included within legal definitions of the shoreland area. Thus, a 75-foot wide buffer appears to be the best and most practical compromise between human use of the landscape and the needs of the environment that sustain such human uses. However, the quality and continuity of these corridors play important roles in their effectiveness, with greater levels of fragmentation by roadways and other structures limiting the effectiveness of those buffers that are put into place.

REFERENCES

M. Borin, and E. Bigon. *Abatement of NO3-N concentration in agricultural waters by narrow buffer strips.* Environmental Pollution 117:165-168, 2002.

W. Brusch, and B. Nilsson. *Nitrate transformation and water movement in a wetland area*. Hydrobiologia 251:103-111, 1993.

D.A. Burns, and L. Nguyen. *Nitrate movement and removal along a shallow groundwater flow path in a riparian wetland within a sheep-grazed pastoral catchment: results of a tracer study.* New Zealand Journal of Marine and Freshwater Research 36: 371-385.

A.J. Castelle, A.W. Johnson, and C. Conolly. *Wetland and stream buffer size requirements – a review*. Journal of Environmental Quality 23:878-882, 1994.

E.E. Cey, D.L. Rudolph, R. Aravena, and G. Parkin. *Role of the riparian zone in controlling the distribution and fate of agricultural nitrogen near a small stream in southern Ontario.* Journal of Contaminant Hydrology 37:45-67, 1999.

J.C. Clausen, K. Guillard, C.M. Sigmund, and K.M. Dors. *Water quality changes from riparian buffer restoration in Connecticut.* Journal of Environmental Quality 29:1751-1761, 2000.

T.A. Dillaha, J.H. Sherrard, D. Lee, S. Mostaghimi, and V.O. Shanholtz. *Evaluation of vegetative filter strips as a best management practice for feed lots*. Journal of the Water Pollution Control Federation 60:1231-1238, 1988.

T.A. Dillaha, R.B. Reneau, S. Mostaghimi, and D. Lee. *Vegetative filter strips for agricultural nonpoint source pollution control.* Transactions of the American Society of Agricultural Engineers 32:513-519, 1989.

R.C. Doyle, G.C. Stanton, and D.C. Wolf. *Effectiveness of forest and grass buffer strips in improving the water quality of manure polluted runoff.* American Society of Agricultural Engineers Paper, 77-2501, 1977.

M. Ghaffarzadeh, C.A. Robinson, R.M. Cruse. *Vegetative filter strip effects on sediment deposition from overland flow.* Agronomy Abstracts, 324, 1992.

G.C. Hanson, P.M. Groffman, and A.J. Gold. *Symptoms of nitrogen saturation in a riparian wetland.* Ecological Applications 4:750-756, 1994.

N.E. Haycock, P.M. Groffman, and A.J. Gold. *Role of floodplain sediments in reducing the nitrate concentration of subsurface run-off: a case study in the Cotswolds, UK.* Hydrological Processes 7:287-295, 1993.

N.E. Haycock, G. Pinay. *Groundwater nitrate dynamics in grass and poplar vegetated riparian buffer strips during the winter.* Journal of Environmental Quality 22:273-278, 1993.

M.M. Hefting and J.M. de Klein. *Nitrogen removal in buffer strips along a lowland stream in the Netherlands: a pilot study.* Environmental Pollution 102: S1:521-526, 1998.

A.R. Hill, K.J. Devito, S. Campagnolo, and K. Sanmugadas. *Subsurface denitrification in a forest riparian zone: Interactions between hydrology and supplies of nitrate and organic carbon.* Biogeochemistry 51:193-223, 2000.

R.R. Horner, and B.W. Mar. *Guide for water quality impact assessment of highway operations and maintenance.* Washington Department of Transportation, 1982.

R.K. Hubbard, and R. Lowrance. *Assessment of forest management effects on nitrate removal by riparian buffer systems.* Transactions of the American Society of Agricultural Engineers 40:383-391, 1997.

R.K. Hubbard, and J.M. Sheridan. *Nitrate movement to groundwater in the southeastern Coastal Plain.* Journal of Soil and Water Conservation 44: 20-27, 1989.

T.C. Jacobs, and J.W. Gilliam. *Riparian losses of nitrate from agricultural drainage waters.* Journal of Environmental Quality 14:472-478, 1985.

T.E. Jordan, D.L. Correll, and D.E. Weller. *Nutrient interception by a riparian forest receiving inputs from adjacent cropland.* Journal of Environmental Quality 14:472-473, 1993.

R. Lowrance. *Groundwater nitrate and denitrification in a coastal plain riparian forest.* Journal of Environmental Quality 21:401-405, 1992.

R. Lowrance, L.S. Altier, J.D. Newbold, R.R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correll, J.W. Gilliam, J.L. Robinson, R.B. Brinsfield, K.W. Staver, W. Lucas, and A.H. Todd. *Water quality functions of riparian forest buffer systems in Chesapeake Bay Watersheds.* Environmental Management 21:687-712, 1997.

R.R. Lowrance, R.L. Todd, and L.E. Asmussen. Nutrient *cycling in an agricultural watershed – 1:phreatic movement.* Journal of Environmental Quality 13:22-27, 1984.

J. Lynch, E. Corbett, and K. Mussaliem. *Best management practices for controlling nonpoint source pollution of forested watersheds.* Journal of Soil and Water Conservation 1:164-167.

C.E. Madison, R.L. Blevins, W.W. Frye, and B.J. Barfield. *Tillage and grass filter strip effects upon sediment and chemical losses.* Agronomy Abstracts, 331. 1992.

W.L. Magette, R.B. Brinsfield, R.E. Palmer, and J.D. Wood. *Nutrient and sediment removal by vegetated filter strips.* Transactions of the American Society of Agricultural Engineers 32:663-667, 1989.

J.V. Mannering, and C.B. Jonson. *A comparison of nitrogen losses from urea and ammonium nitrate in surface runoff water*. Soil Science 105(6), 428-433, 1968.

T.L. Martin, N.K. Kaushik, H.R. Whiteley, S. Cook, and J.W. Nduhiu. *Groundwater nitrate concentrations in the riparian zones of two southern Ontario streams.* Canadian Water Resources Journal 24:125-138, 1999.

P.M. Mayer, S.K. Reynolds Jr., T.J. Canfield. *Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness:A Review of Current Science and Regulations.* U.S. Environmental Protection Agency Office of Research and Development National Risk Management Research Laboratory, 2005.

W.H. Neibling, and E.E. Alberts. *Composition and yield of soil particles transported through sod strips.* American Society of Agricultural Engineers Paper, 1979.

L.L. Osbourne, and D.A. Kovacic, 1993. *Riparian vegetated buffer strips in water quality restoration and stream management.* Freshwater Biology 29:243-258, 1993.

W.T. Peterjohn, and D.L. Correll. *Nutrient dynamics in an agricultural watershed observations on the role of a riparian forest.* Ecology 65:1466-1475, 1984.

G. Pinay, and H. Decamps. *The role of riparian woods in regulating nitrogen fluxes between alluvial aquifer and surface water: a conceptual model.* Regulated Rivers: Research and Management 2:507-516, 1988.

G. Pinay, L. Roques, and A. Fabre. *Spatial and temporal patterns of denitrification in riparian forest.* Journal of Applied Ecology 30:581-591, 1993.

K. Prach, and O. Rauch. *On filter effects of ecotones.* Ekologia 11:293-298, 1992.

L.J. Puckett, T.K. Cowdery, P.B. McMahon, L.H. Tornes, and J.D. Stoner. *Using chemical hydrologic, and age dating analysis to delineate redox processes and flow paths in the riparian zone of a glacial outwash aquifer-stream system.* Water Resources Research 38:10.1029, 2002.

G.R. Schellinger, and J.C. Clausen. *Vegetative filter treatment of dairy barnyard runoff in cold regions*. Journal of Environmental Quality 21:40-45, 1992.

T.J. Schmitt, M.G. Dosskey, and K.D. Hoagland. *Filter strip performance and processes for different vegetation, widths, and contaminants.* Journal of Environmental Quality 28:1479-1489, 1999.

J.E. Schoonover, and K.W.J. Williard. *Ground water nitrate reduction in giant cane and forest riparian buffer zones.* Journal of the American Water Resources Association 39:347-354, 2003.

R.C. Schultz, J.P. Colletti, T.M. Isenhart, W.W. Simpkings, C.W. Mize, and M.L. Thompson. *Design and placement of a multi-species riparian buffer strip.* Agroforestry Systems 29:201-225.

C.B. Schwer, and J.C. Clausen. *Vegetative filter strips of dairy milkhouse wastewater*. Journal of Environmental Quality 18:446-451, 1989.

J.K. Shisler, R.A. Jordan, R.N. Wargo. *Coastal wetland buffer delineation*. New Jersey Department of Environmental Protection, 1987.

R.C. Simmons, A.J. Gold, and P.M. Groffman. *Nitrate dynamics in riparian forests: groundwater studies.* Journal of Environmental Quality 21:659-665, 1992.

T.B. Spruill. *Effectiveness of riparian buffers in controlling groundwater discharge of nitrate to streams in selected hydrogeological settings of the North Carolina Coastal Plain.* Water Science and Technology 49:63-70, 2004.

D.H. Vanderholm, and E.C. Dickey. American Society of Agricultural Engineers Paper 78-2570, 1978.

G. Vellidis, R. Lowrance, P. Gay, and R.K. Hubbard. *Nutrient transport in a restored riparian wetland*. Journal of Environmental Quality 32:711-726, 2003.

P.G.F. Vidon, and A.R. Hill. *Landscape controls on nitrate removal in stream riparian zones.* Water Resources Research 40:W03201, 2004.

L.B.M. Vought, J. Dahl, L. Pedersen, and J.O. Lacoursiere. *Nutrient retention in riparian ecotones*. Ambio 23(6):343-348, 1994.

S.L.W Wong, and R.H. McCuen. *The Design of Vegetative Buffer Strips for Runoff and Sediment Control*. A technical paper developed as part of a study of stormwater management in coastal areas funded by Maryland Coastal Zone Management Program, 1982.

P.Yates, and J.M. Sheridan. *Estimating the effectiveness of vegetated floodplains/wetlands as nitrate-nitrite and orthophosphorus filters.* Agriculture, Ecosystems and Environment 9:303-314, 1983.

R.A. Young, T. Huntrods, and W. Anderson. *Effectiveness of vegetated buffer strips in controlling pollution from feedlot runoff.* Journal of Environmental Quality 9:483-487, 1980.

J. Zirschky, D. Crawford, L. Norton, S. Richards, D. Reemer. *Ammonia removal using overland flow.* Journal of the Water Pollution Control Federation 61:1225-1232, 1989.

(This page intentionally left blank)

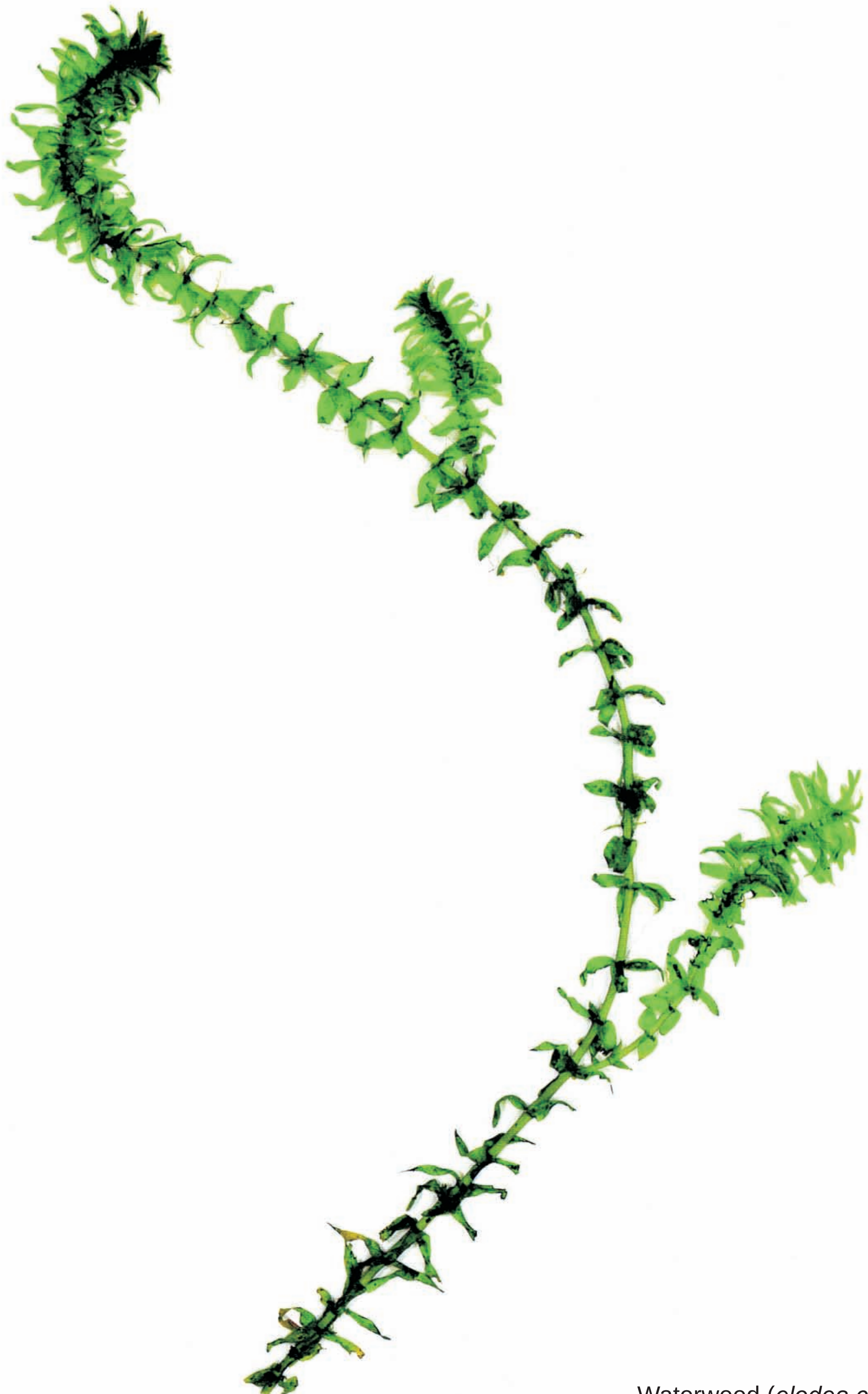
Appendix B

AQUATIC PLANT ILLUSTRATIONS FOR FRIESS LAKE AND LITTLE FRIESS LAKE

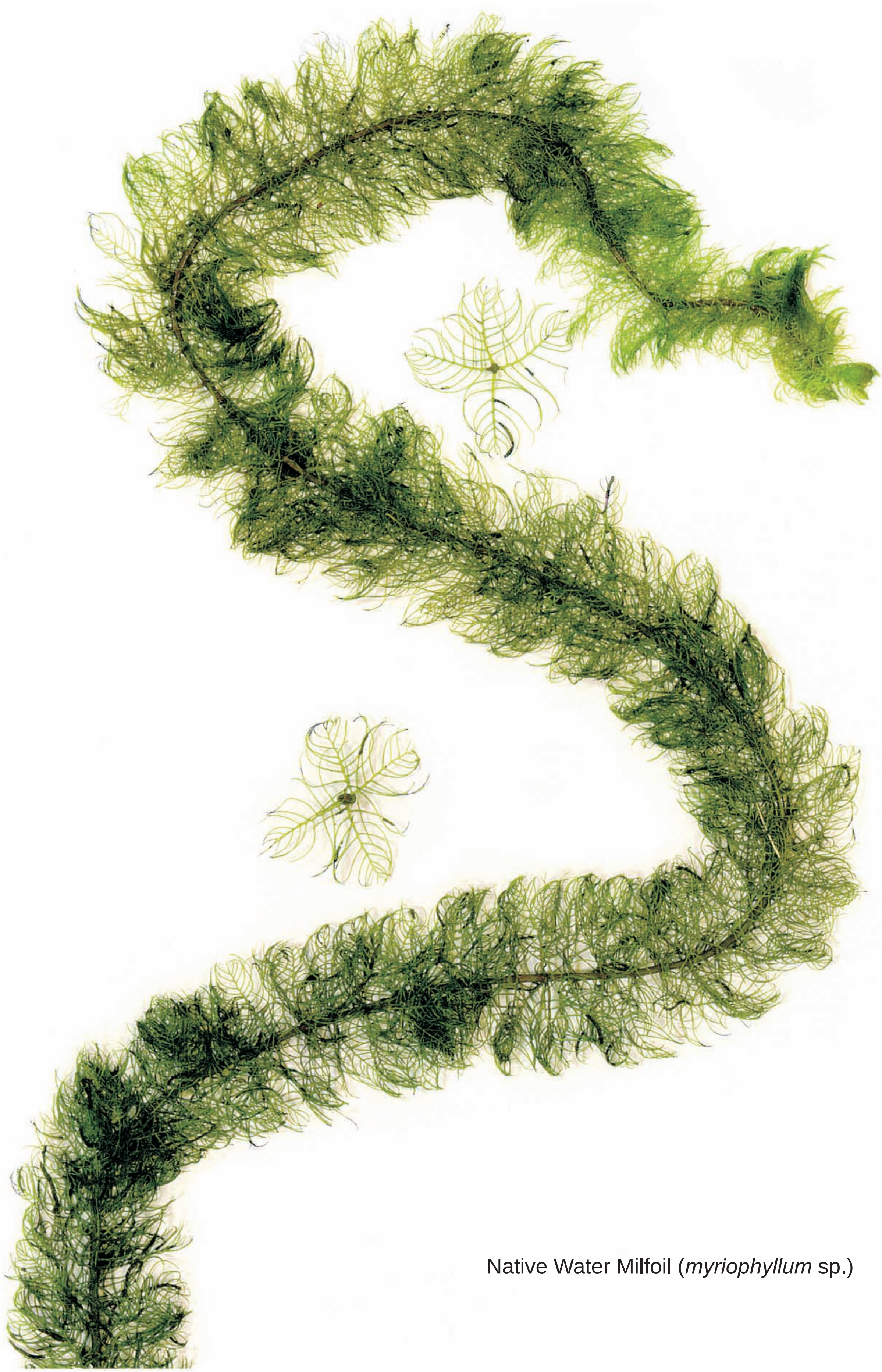
(This page intentionally left blank)

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*)

Spiny Naiad (*najas marina*)

Nitella (*nitella* spp.)

Large-Leaf Pondweed (*potamogeton amplifolius*)

Leafy Pondweed (*potamofeton foliosus*)

Illinois Pondweed (*potamogeton illinoensis*)

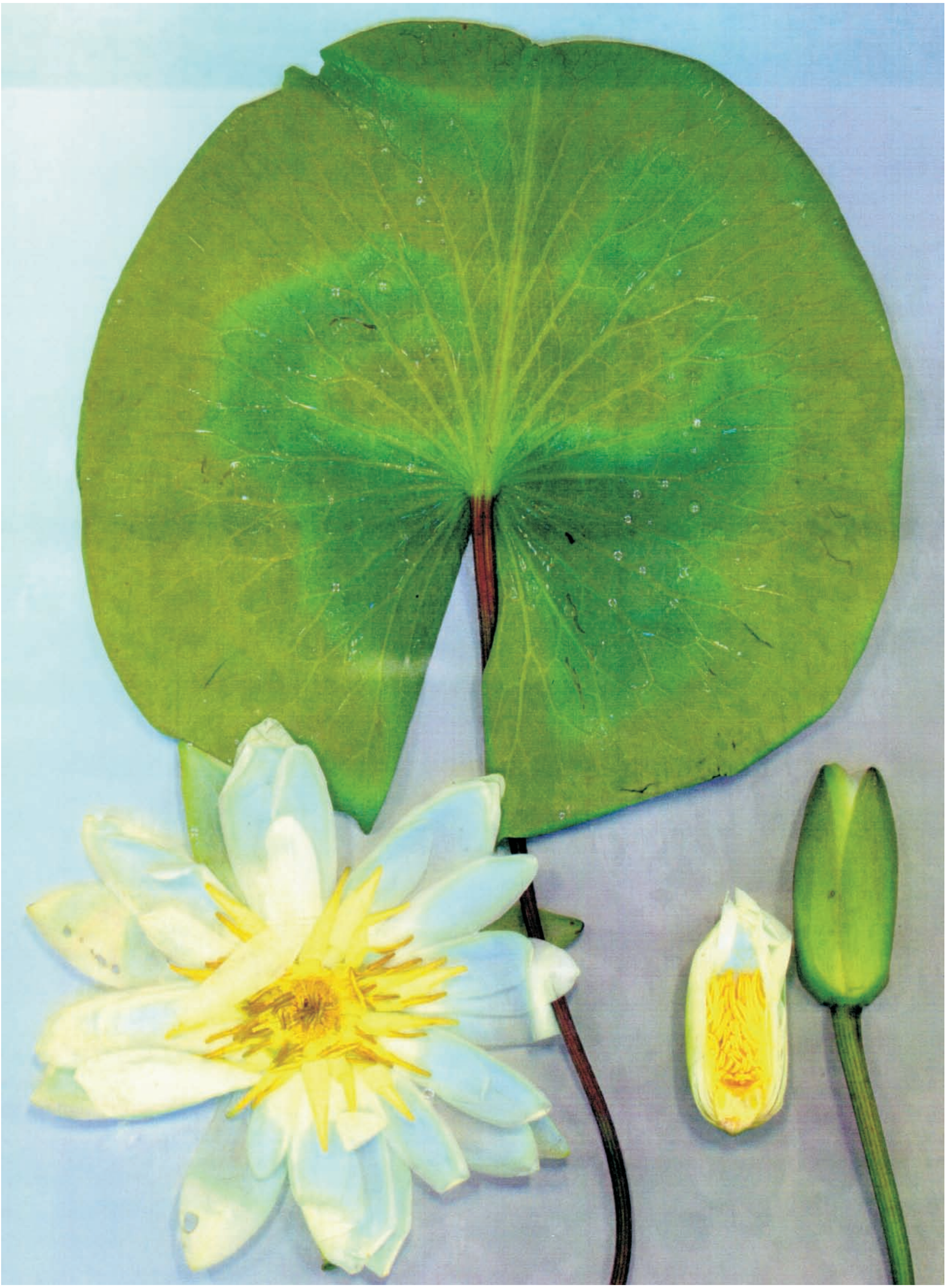
Sago Pondweed (*potamogeton pectinatus*)

White-Stem Pondweed (*potamogeton praelongus*)

Clasping-Leaf Pondweed
(*potamogeton richardsonii*)

Eel Grass / Wild Celery (*valisneria americana*)

Curly-Leaf Pondweed (*potamogeton crispus*)
Exotic Species (nonnative)



White Water Lily (*nymphaea odorata*)

Yellow Water Lily (*nuphar variegatum*)

Appendix C

VILLAGE OF RICHFIELD
RECREATIONAL BOATING ORDINANCE

SEC. 42-71. INTENT OF ARTICLE.

The intent of this article is to provide and ensure safe enjoyment of water recreation resources consistent with public rights and interests and with the size and nature of the water resources.
(Code 1984, § 13.07)

SEC. 42-72. DEFINITIONS.

The following words, terms and phrases, when used in this article, shall have the meanings ascribed to them in this section, except where the context clearly indicates a different meaning:

Slow-no-wake means that speed at which a boat moves as slowly as possible while still maintaining steerage control.

Traffic lane means the surface of the lake that is more than 150 feet distant from and parallel to the shore, or 100 feet distant from the projecting extremities of any pier, wharf or other structure built in or over the water.
(Code 1984, § 13.11)

Cross references: Definitions generally, § 1-2.

SEC. 42-73. APPLICABILITY OF ARTICLE PROVISIONS.

The provisions of this article shall apply to the waters of Amy Belle Lake, Bark Lake, Friess Lake and Little Friess Lake, also known as Bony Lake. When and if the Town of Lisbon, Waukesha County, adopts identical provisions, this article shall apply to Lake Five.
(Code 1984, § 13.08)

SEC. 42-74. ENFORCEMENT OF ARTICLE PROVISIONS.

The provisions of this article shall be enforced by the town lake patrol, a law enforcement unit of the town, consisting of the constable and such other lake patrol officers as the town board may appoint, in accordance with Wis. Stats. § 167.85(4), from time to time, which is created pursuant to Wis. Stats. § 30.79. The responsibilities and duties of any lake patrol officer so appointed shall be limited to enforcement of this article.
(Code 1984, § 13.09)

SEC. 42-75. PENALTIES FOR VIOLATION OF ARTICLE.

State boating penalties as found in Wis. Stats. § 30.80 are adopted by reference in this section.
(Code 1984, § 13.25)

SEC. 42-76. STATE BOATING AND SAFETY LAWS ADOPTED.

The statutory provisions describing and defining water traffic, boats, boating and related activities contained in Wis. Stats. §§ 30.50--30.71 and the rules and regulations of the state department of natural resources are adopted and by reference made a part of this article. Any act required or prohibited by the provisions of such statutes or rule or regulation incorporated by reference is required or prohibited by this article.
(Code 1984, § 13.10)

SEC. 42-77. POSTING OF TOWN BOATING REGULATIONS REQUIRED.

Signs briefly stating town boating regulations, as established in this article, shall be posted at all public launch sites. In addition, the owner or operator of any commercial access site to icebound waters for any vehicles shall appropriately post and maintain such signs provided by the town board.
(Code 1984, § 13.18)

SEC. 42-78. SPEED REGULATIONS.

In addition to the speed regulations in Wis. Stats. § 30.66, the following restrictions shall apply:

(1) No person shall operate a boat powered solely by mechanical means at any time on Amy Belle Lake.

(2) No person shall operate a boat at a speed greater than 25 miles per hour from 10:00 a.m. to 7:00 p.m. on Friess Lake or Lake Five. At all other times the maximum speed shall be slow-no-wake.

(3) No person shall operate a boat at a speed greater than 25 miles per hour during the hours of 1:00 a.m. to 5:00 p.m. on Bark Lake. At all other times the maximum speed shall be slow-no-wake.

(4) No person shall operate a boat at a speed greater than slow-no-wake at all times on Little Friess Lake, also known as Bony Lake.

(5) No person shall operate a boat outside the traffic lane established in section 42-72 on Friess Lake, Lake Five or Bark Lake at a speed greater than slow-no-wake.

(6) No person may operate any vehicle on any icebound lake at a speed greater than 25 miles per hour.
(Code 1984, § 13.12)

SEC. 42-79. EMERGENCY SLOW-NO-WAKE.

(a) **Declaration of emergency**. During periods of abnormally high lake levels as determined by the benchmarks designated in subsection (b) of this section, the town chair is authorized and directed to declare a high lake water emergency for any and all lakes located in the town.

(b) **High water benchmarks designated**.

(1) Bark Lake. The benchmark is the marine edge on Bark River. The markings are: 7.80, declare high water; and 7.30, emergency ends.

(2) Friess Lake. Benchmarks shall be determined at a later date.

(c) **Orders**. During high lake water emergencies the town chair is authorized and directed to issue slow-no-wake orders for any and all lakes located in the town. Copies of such orders shall be posted at all public landings and published in the official town newspaper. When lake levels have returned to normal levels the town chair shall declare a cessation of the high level emergency and rescind the slow-no-wake order and publish such recision in the same manner as provided in this subsection.

(d) **Speed limit**. During the period that the slow-no-wake order is in effect as provided in subsection (b) of this section, no person shall operate a boat at a speed greater than slow-no-wake.

(e) **Penalty**. Any person who violates this section shall be subject to a forfeiture of $50.00 for the first offense and $100.00 for the second and subsequent offenses.
(Code 1984, § 13.121)

SEC. 42-80. PROHIBITED OPERATION.

In addition to the requirements and restrictions set forth in Wis. Stats. § 30.68:

(1) No motor boat shall pass within 100 feet of a swimmer or skindiver's marker unless physical circumstances make compliance impossible.

(2) No person shall operate any boat repeatedly in a circuitous course around any other boat or around any person who is swimming if such circuitous course is within 200 feet of such boat or swimmer nor shall any water skier operate or approach closer than 100 feet to any swimmer or skindiver's marker.

(3) All boats for rent or hire shall have stenciled or printed on the top side of the rear seat thereof the maximum safe carrying capacity of such boat.

(4) No motorboat shall approach or pass another boat in such a manner as to create a hazardous wake or wash.
(Code 1984, § 13.13)

SEC. 42-81. WATER SKIING.

In addition to the requirements and restrictions set forth in Wis. Stats. § 30.68:

(1) No person shall operate a motorboat towing a person on water skis, aquaplane, jet ski or similar device unless there is in the boat a competent person in addition to the operator in a position to observe the progress of the person being towed. An observer shall be considered competent if he can, in fact, observe the progress of the person being towed.

(2) No person shall operate nor shall any boat owner allow a boat to be operated to tow more than two persons on water skis, aquaplanes or other similar devices at any one time, except that on Bark Lake not more than one person may be so towed.

(3) Persons waterskiing or riding aquaplanes or other similar devices shall also conform to all provisions of this article and shall not engage in any activity contrary to the provisions of this article.
(Code 1984, § 13.14)

SEC. 42-82. RAFTS, BUOYS AND MARKERS.

(a) All rafts, platforms, buoys and markers shall be anchored and shall have at least eight inches of freeboard above the waterline so that they will not float or drift in excess of ten feet in any direction from the position that is directly above their anchor.

(b) On Bark Lake no raft or pier shall be located within 100 feet of the traffic lane marked with buoys in accordance with section 42-72.
(Code 1984, § 13.17)

SEC. 42-83. SWIMMING AND SKINDIVING.

In addition to the requirements and restrictions set forth in Wis. Stats. § 30.70, no person shall swim in the traffic lane unless he is accompanied by a manned boat.
(Code 1984, § 13.15)

SEC. 42-84. AIRCRAFT.

It shall be unlawful for any aircraft, whether designed for taking off or landing on water or not, to use any part of the lakes or waters regulated under this article for landing or taking off, except in the case of emergency.
(Code 1984, § 13.16)