COMMUNITY ASSISTANCE
PLANNING REPORT NO. 98
(2nd Edition)

A LAKE MANAGEMENT PLAN FOR FRIESS LAKE

WASHINGTON COUNTY WISCONSIN

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COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 98, 2nd Edition

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WASHINGTON COUNTY, WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
for
the Town of Richfield and the Friess Lake Action Group
with Grant Assistance Provided by the
Wisconsin Department of Natural Resources

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November 28, 1997

TO: All Units and Agencies of Government and Citizen Groups Involved in Water Quality and Water Use Management of Friess Lake

Over the past several years, the Southeastern Wisconsin Regional Planning Commission and others, at the request of the Friess Lake Action Group and the Town of Richfield, have been conducting lake management-related data collection and analysis efforts. These efforts have now been integrated into a lake management plan for Friess Lake, which plan addresses the water quality, recreational use, and natural resource problems of the Lake. The preparation of the plan was a cooperative effort by the Friess Lake Action Group, the Town of Richfield, the Wisconsin Department of Natural Resources, the Washington County Department of Land Conservation, and the Southeastern Wisconsin Regional Planning Commission.

This report documents the recommended lake management plan. The report describes the physical and biological characteristics of Friess Lake and its watershed; the quality of the Lake waters and the factors affecting that quality, including land use and management practices; the recreational use of the Lake; and the shoreline conditions around the Lake. The report concludes with a set of recommended management measures.

The plan presented in this report is intended to provide a guide to the making of decisions concerning the wise use and management of Friess Lake as an aesthetic and recreational asset of immeasurable value. Accordingly, adoption of the plan presented herein by all concerned lake management agencies is urged. The Regional Planning Commission stands ready to assist the various units and agencies of government concerned in adopting and carrying out the plan recommendations over time.

Respectfully submitted,

Philip C. Evenson

Philip C. Evenson
Executive Director

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Chapter I

INTRODUCTION

Friess Lake is an 119-acre lake located on the Oconomowoc River within U.S. Public Land Survey Sections 17 and 18, Township 9 North, Range 19 East, Town of Richfield, Washington County. The Lake offers a variety of water-based recreational opportunities and is the focus of the lake-orientated community surrounding the Lake. However, during recent years, the Lake has experienced various management problems, including excessive plant growth, recreational user conflicts and limitations, and fluctuating water levels. In addition, concerns have been raised regarding variable water quality conditions, the need to protect environmentally sensitive areas, and to prevent the invasion of exotic species.

An initial water quality management plan for Friess Lake was completed by the Southeastern Wisconsin Regional Planning Commission in 1983, under a cooperative agreement with the Wisconsin Department of Natural Resources.[1] That plan was adopted as an amendment to the regional water quality management plan and formed the basis for the recommended actions to protect and enhance lake water quality. The lake water quality management plan was also used in the preparation of the nonpoint source pollution control plan adopted for the upper Oconomowoc River Basin in 1986.[2] The project implementation period for the priority watershed program ended in December of 1994; and, despite the partial implementation of these plans, the findings of the long-term trend water quality monitoring program conducted by the Wisconsin Department of Natural Resources from April 1986 through August 1994 suggest that there has been no significant improvement in the water quality of Friess Lake.

Seeking to improve the usability of Friess Lake and to prevent deterioration of the natural assets and recreational potential of the Lake, the residents concerned, in 1992 formed the Friess Lake Action Group. Recently, the Friess Lake Action Group was requested by the Town Board of the Town of Richfield to develop a grant proposal under Chapter NR 119 (currently NR 191) of the *Wisconsin Administrative Code* that would update and refine the existing water quality management plan for Friess Lake. Since that plan is now 13 years old, and since the priority watershed project has now been completed for the tributary watershed, it was deemed desirable to again evaluate the water use objectives and related lake use objectives for Friess Lake, and to prepare a new water quality management plan for the Lake.

This lake management plan represents part of the ongoing commitment of the Friess Lake Action Group and the Town of Richfield to sound environmental planning with respect to the Lake. This plan was prepared during 1995, by the Regional Planning Commission in cooperation with the Friess Lake Action Group, the Town of Richfield, and the Washington County Land Conservation Department, and represents one of several related actions taken to manage Friess Lake resources.

This report summarizes the results of the water quality sampling programs and related inventories and provides an evaluation and interpretation of the data collected and collated. The inventories include data collected by the Wisconsin Department of Natural Resources under the Long-Term Trend Monitoring Program, data collected under the Self-Help Monitoring Program, and data set forth in the regional water quality management plan.[3] The report presents feasible alternative in-lake measures for enhancing water quality conditions and for providing opportunities for safe and enjoyable lake uses. More specifically, this report describes the physical, chemical, and biological characteristics of the Lake and pertinent related characteristics of the tributary watershed, and the in-lake management measures which may be applied to enhance the water quality conditions and biological

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

[2]*DNR Publication No. WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986.*

[3]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, *February 1979.*

communities of and recreational opportunities provided by the Lake.

The primary objectives which this plan is intended to achieve are: 1) to further the overall conservation and wise use of Friess Lake through the environmentally sound management of vegetation, fishery, and wildlife populations in and around the Lake; 2) to provide the potential for high-quality, water-based recreational experiences by residents and visitors to Friess Lake; and 3) to effectively control the severity of nuisances resulting from recurring excessive aquatic macrophyte and algal growths in portions of Friess Lake basin to better facilitate the conduct of water-based recreation, to improve the aesthetic value of the Lake, and to enhance its resource value. The plan should serve as a practical guide over time for achieving these objectives in a technically sound manner.

Chapter II

PHYSICAL DESCRIPTION

INTRODUCTION

The physical characteristics of a lake and its watershed are important factors in any evaluation of existing and probable future water quality conditions and lake uses, including recreational uses. Characteristics such as watershed topography, lake morphometry, and local hydrology ultimately influence water quality conditions and the composition of plant and fish communities within a lake and, therefore, these characteristics must be considered during the lake management planning process. Accordingly, this chapter provides pertinent information on the physical characteristics of Friess Lake, its watershed, and the climate and hydrology of Friess Lake. Subsequent chapters deal with the land use conditions and the chemical and biological environments of the Lake.

WATERBODY CHARACTERISTICS

Friess Lake is located south of the Village of Slinger and west of the unincorporated settlement of Hubertus in the west central portion of the Town of Richfield, in Washington County. Friess Lake is a flow-through lake and is the first of six major lakes in a chain which is fed and drained by the Oconomowoc River, a tributary of the Rock River in the Mississippi River drainage basin. Friess Lake lies within a glacial valley associated with terminal moraines. The Friess Lake basin was formed as the Michigan and Green Bay Lobes of the continental glacier retreated from Southeastern Wisconsin approximately 12,500 years ago, during the late Wisconsin stage of glaciation. The Lake, like many others in the Region, lies in a depressed area of this interlobate, or "kettle moraine," area that is characterized by unconsolidated glacial sediments consisting predominantly of silty-clay till and sandy outwash deposits. These glacial sediments, ranging in thickness from 100 to 200 feet, are underlain by Silurian dolomite and are overlain by organic deposits formed after glaciation.

Friess Lake has a volume of approximately 3,100 acre-feet and a surface area of about 119 acres. Basic hydrographic and morphometric data for Friess Lake are presented in Table 1. Friess Lake is 0.6 mile long and about 0.2 mile wide at its widest point. The major axis of the lake basin lies in a northwest-southeast direction. The Oconomowoc River is the major inflow to the Lake and enters from the north, as shown on Map 1. The lake outflow is via the Oconomowoc River through Little Friess Lake, a 16-acre embayment located immediately south of the main lake basin. The level of Friess Lake is largely controlled by the rate of inflow and outflow of the Oconomowoc River. There is no functioning water level control structure. However, a small control structure built in the 1960s and subsequently removed in 1982, was located about one mile downstream of the Lake outlet. The Oconomowoc River ultimately discharges into the Rock River in Jefferson County, about 35 miles downstream of the Friess Lake outlet.

The shoreline of Friess Lake is almost entirely developed for residential uses, with the exception of a portion of the western shore which is in open space use. The Lake has a shoreline length of 2.3 miles, with a shoreline development factor of 1.5, indicating that the shoreline of the Lake is about 1.5 times as long as that of a circular lake of the same area. The bathymetry of the Friess Lake basin is illustrated on Map 2.

Erosion of shorelines results in the loss of riparian land, damage to shoreland infrastructure, and interference with lake access and use. Such erosion is usually caused by wind-induced wave erosion, ice movement and motorized boat traffic. A survey of the Friess Lake shoreline, conducted by the Regional Planning Commission staff during the winter of 1996, indicated that most of the shoreline was vegetated and also has shoreline protection structures at various locations, as shown on Map 3. Erosion problems were observed at only a few isolated locations.

Lakeshore area bottom sediments types were surveyed in 1994 by the Commission staff and are shown on Map 4. Sand is the dominant lakeshore bottom material, covering about 90 percent of the bottom along the shoreline. The remainder of the bottom along the shoreline consists of muck and silt, primarily in the vicinity of the inlet and outlet to the Lake. The offshore deeper lake bottom area is covered by soft, flocculent sediments, including muck, marl, detritus, clay, and silt.

Table 1

HYDROLOGY AND
MORPHOMETRY OF FRIESS LAKE

Parameter	Measurement
Size (total)	
Surface Area	119 acres
Total Drainage Area	12,374 acres
Direct Drainage Area	953 acres
Volume	3,102 acre-feet
Residence Time[a]	0.3 year
Shape	
Maximum Length of Lake	0.64 mile
Length of Shoreline	2.3 miles
Maximum Width	0.23 mile
Shoreline Development Factor[b]	1.5
Depth	
Percentage of Lake Area	
Less than 10 Feet	22 percent
10 to 30 Feet	28 percent
Greater than 30 Feet	50 percent
Mean Depth	26 feet
Maximum Depth	48 feet

[a]*Residence time: the time required for a volume equivalent to full volume replacement by inflowing waters to enter the lakes.*

[b]*Shoreline development factor: ratio of shoreline length to that of a circular lake of the same area.*

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

WATERSHED CHARACTERISTICS

The drainage area directly tributary to Friess Lake, that is, that area which drains directly to the Lake rather than draining to the Lake through the Oconomowoc River, covers about 953 acres, or about 1.5 square miles, in extent and is shown in Map 1. The regional water quality management plan, the initial lake management plan, and the Oconomowoc River nonpoint source pollution abatement priority watershed plan all concluded that water quality conditions in Friess Lake were largely dependent upon the inflow of the Oconomowoc River. Thus, consideration was given in this planning effort to not only the direct drainage area to Friess Lake, but also to the area tributary to the Oconomowoc River upstream of Friess Lake. The total tributary drainage area to the Lake, including the area drained by the Oconomowoc River, is 12,374 acres, or about 19.3 square miles, in extent and is also shown in Map 1. Friess Lake thus has a watershed-to-lake area ratio of 104:1.

The hydrology of Friess Lake is dominated by the Oconomowoc River which enters the Lake on the north shore. In addition, an unnamed tributary stream enters the Lake on the eastern lakeshore. The lake outlet, located on the southern shore, is the Oconomowoc River, which subsequently flows through Little Friess Lake—a 16-acre lake located about 700 feet south of Friess Lake—and through five additional major lakes before eventually joining the Rock River about 35 miles downstream at a location in Jefferson County.

Soil Types and Conditions

Soil type, land slope, and land use management are among the more important factors determining lake water quality conditions. Soil type, land slope, and vegetative cover are also important factors affecting the rate, amount, and quality of stormwater runoff. The soil texture and soil particle structure influence the permeability, infiltration rate, and erodibility of soils. Land slopes are also important determinants of stormwater runoff rates and of susceptibility to erosion.

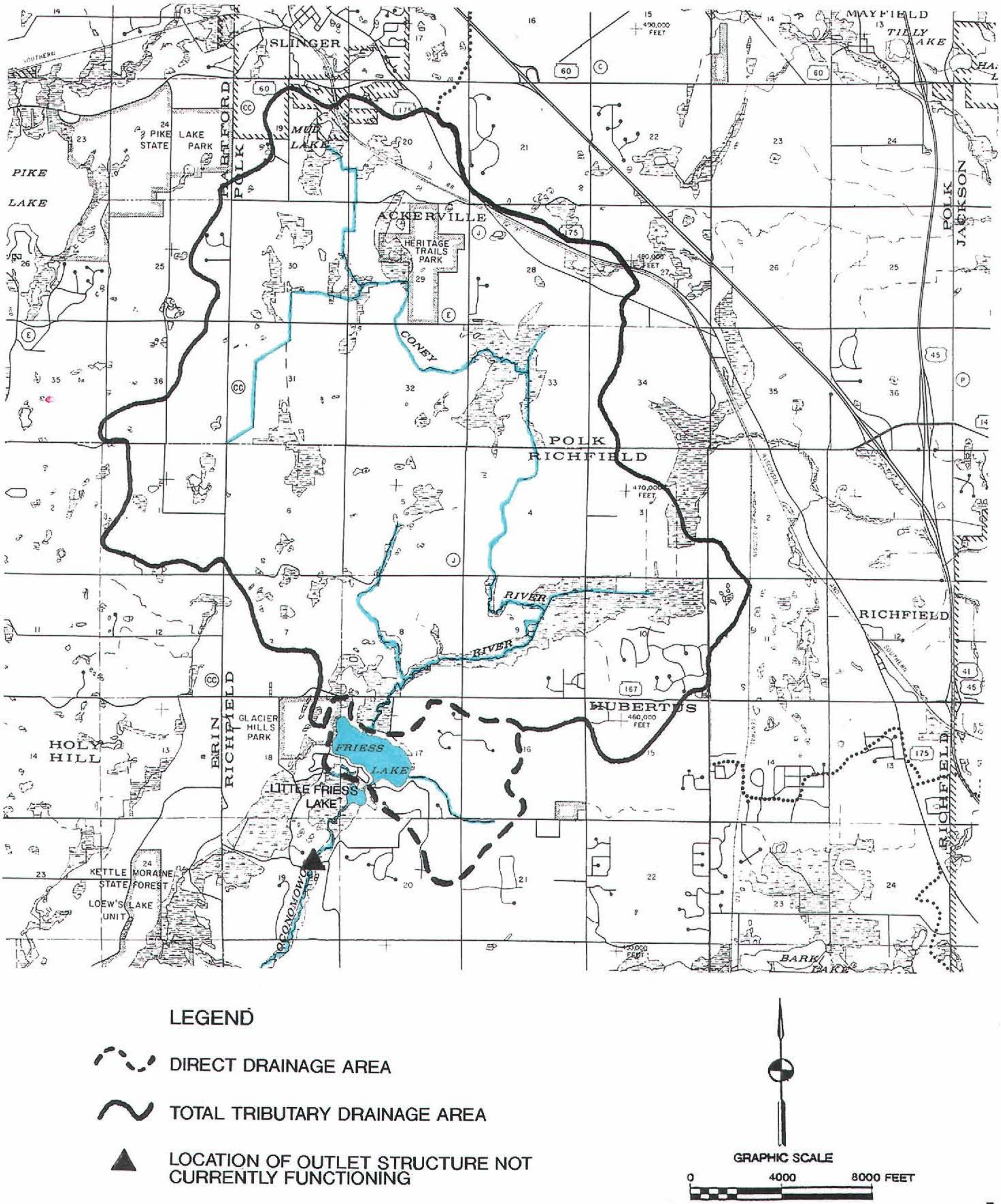
The U.S. Natural Resources Conservation Service, formerly the U.S. Soil Conservation Service, under contract to the Southeastern Wisconsin Regional Planning Commission, completed a detailed soil survey of the Friess Lake area in 1966.[1] The soil survey contained interpretations for planning and engineering applications, as well as for agricultural applications. Using the regional soil survey, an assessment was made of hydrologic characteristics of the soils in the drainage area of Friess Lake. The suitability of the soils for urban residential development was assessed using three common development scenarios: development with conventional onsite sewage disposal systems; development with alternative onsite disposal systems; and development with public sanitary sewers.

Soils within the direct tributary drainage area and total tributary drainage area to Friess Lake were categorized into four main hydrologic groups, as well as an "other" category, as indicated in Table 2. The areal extent of these soils and their locations within the watershed are shown on Map 5. About 38 percent of the direct drainage area is covered by moderately drained soils,

[1]*SEWRPC Planning Report No. 8,* The Soils of Southeastern Wisconsin, *June 1966.*

Map 1

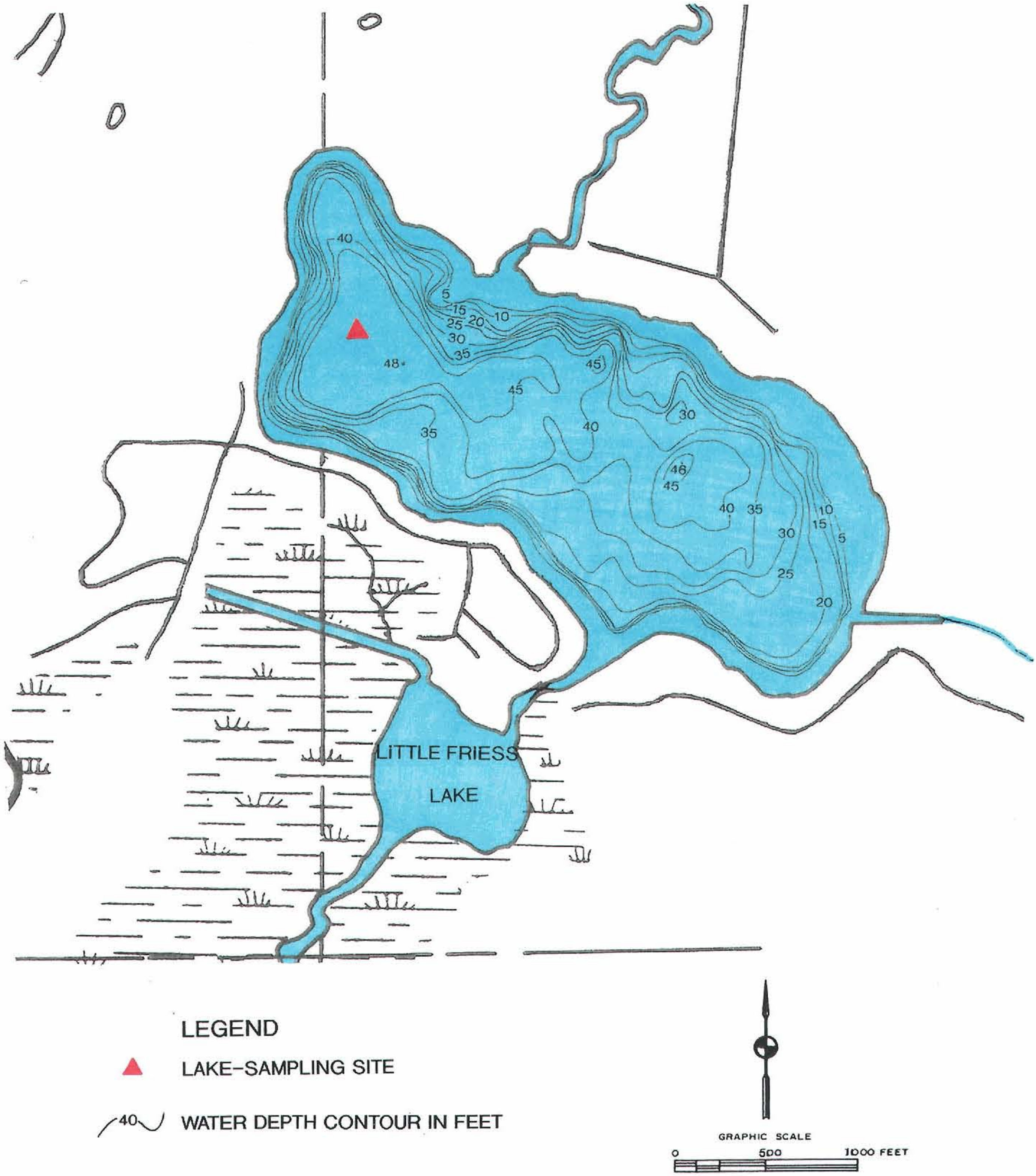
LOCATION MAP OF FRIESS LAKE



Source: SEWRPC.

Map 2

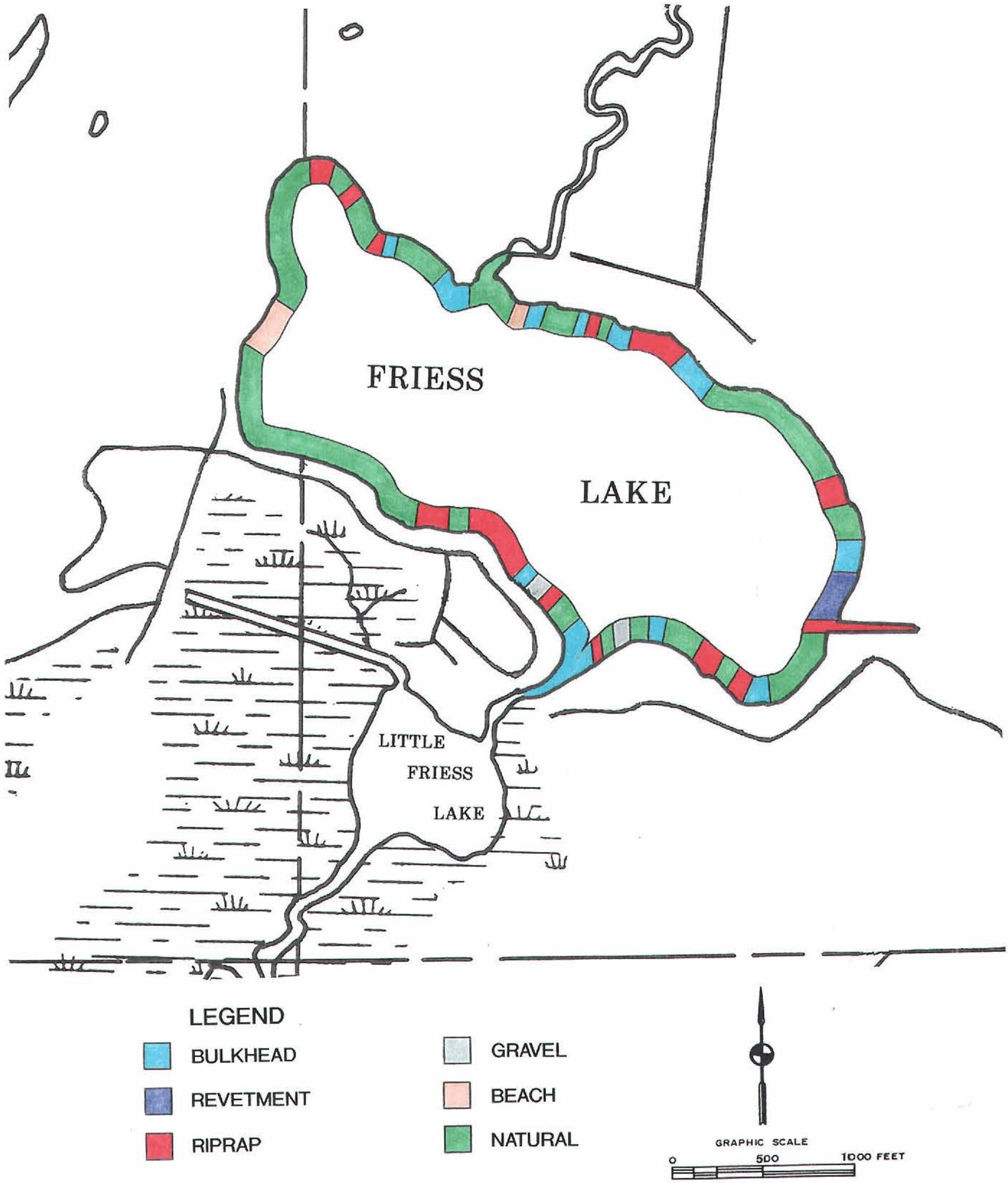
BATHYMETRIC MAP OF FRIESS LAKE



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 3

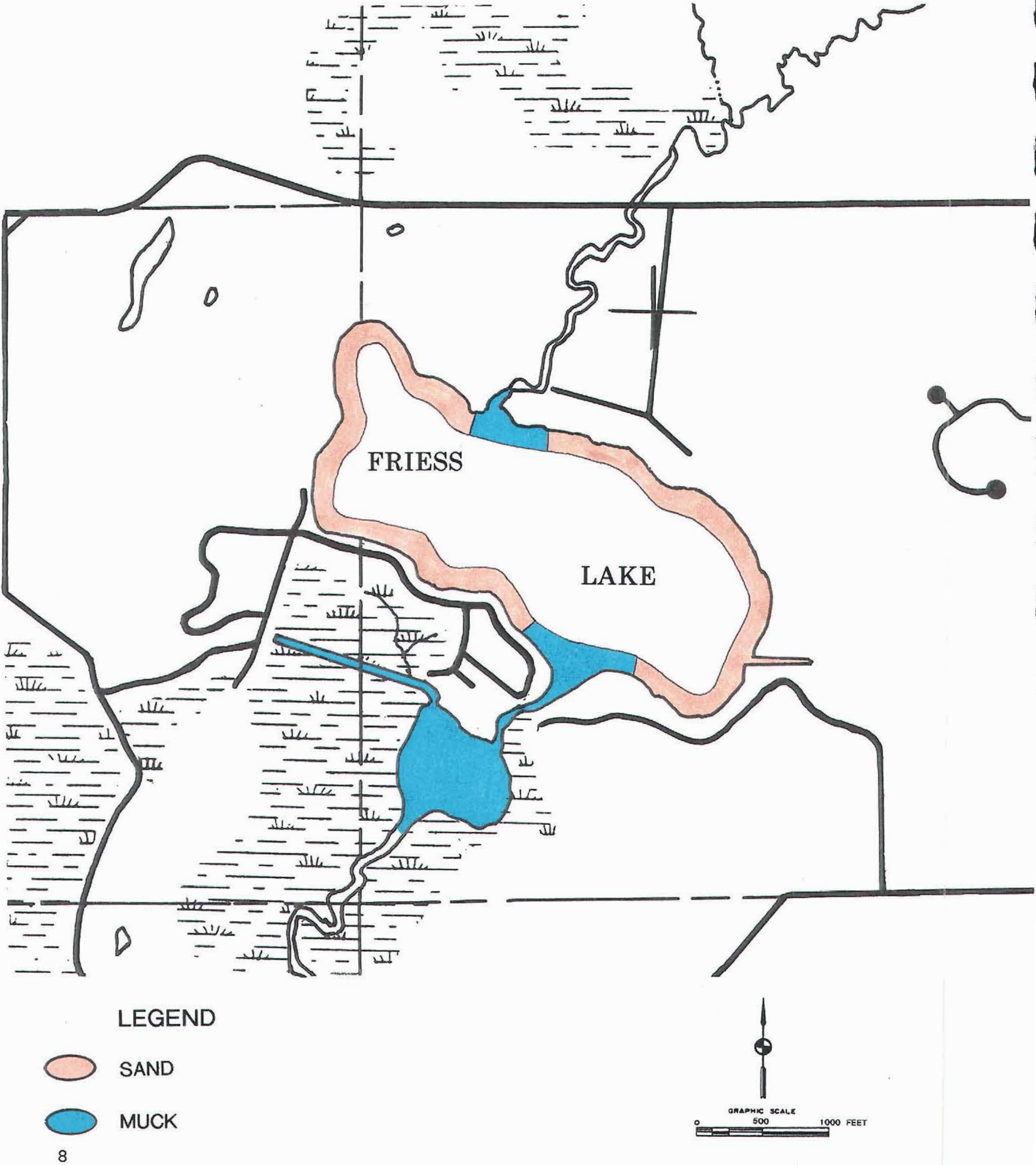
SHORELINE PROTECTION CONDITIONS ON FRIESS LAKE: 1996



Source: SEWRPC.

Map 4

LAKESHORE BOTTOM SEDIMENTS OF FRIESS LAKE: 1994



Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 2

GENERAL HYDROLOGIC SOIL TYPES WITHIN THE TOTAL AND DIRECT DRAINAGE AREAS TO FRIESS LAKE

Group	Soil Characteristics	Direct Drainage Area (acres)	Percent of Total	Total Drainage Area (acres)	Percent of Total
A	Excessively drained to somewhat excessively drained Very rapidly to rapid permeability Low shrink-swell potential	- -	- -	- -	- -
B	Well drained to moderately well drained Texture intermediate between coarse and fine Moderately rapid to moderate permeability Low to moderate shrink-swell potential	358	38	6,903	56
C	Somewhat poorly drained to poorly drained High water table for part or most of the year Mottling, suggesting poor aeration and lack of drainage, generally in A to C horizons	392	41	2,779	22
D	Very poorly drained High water table for most of the year Organic or clay soils Clay soils having high shrink-swell potential	18	2	2,351	19
Other	Group not determined	68	7	171	1
Water	- -	117	12	170	2
- -	Total	953	100	12,374	100

Source: U.S. Natural Resources Conservation Service and SEWRPC.

while 43 percent of that area is covered by poorly drained soils or very poorly drained soils. The remainder of the direct drainage area is covered by water or areas such as man-made fill areas and quarries which are unclassified. About 56 percent of the total tributary drainage area to Friess Lake is covered by moderately well-drained soils, and about 41 percent of that area is covered by poorly drained or very poorly drained soils. The remainder of the tributary drainage area is water or areas such as man-made fill areas and quarries for which no determination has been made.

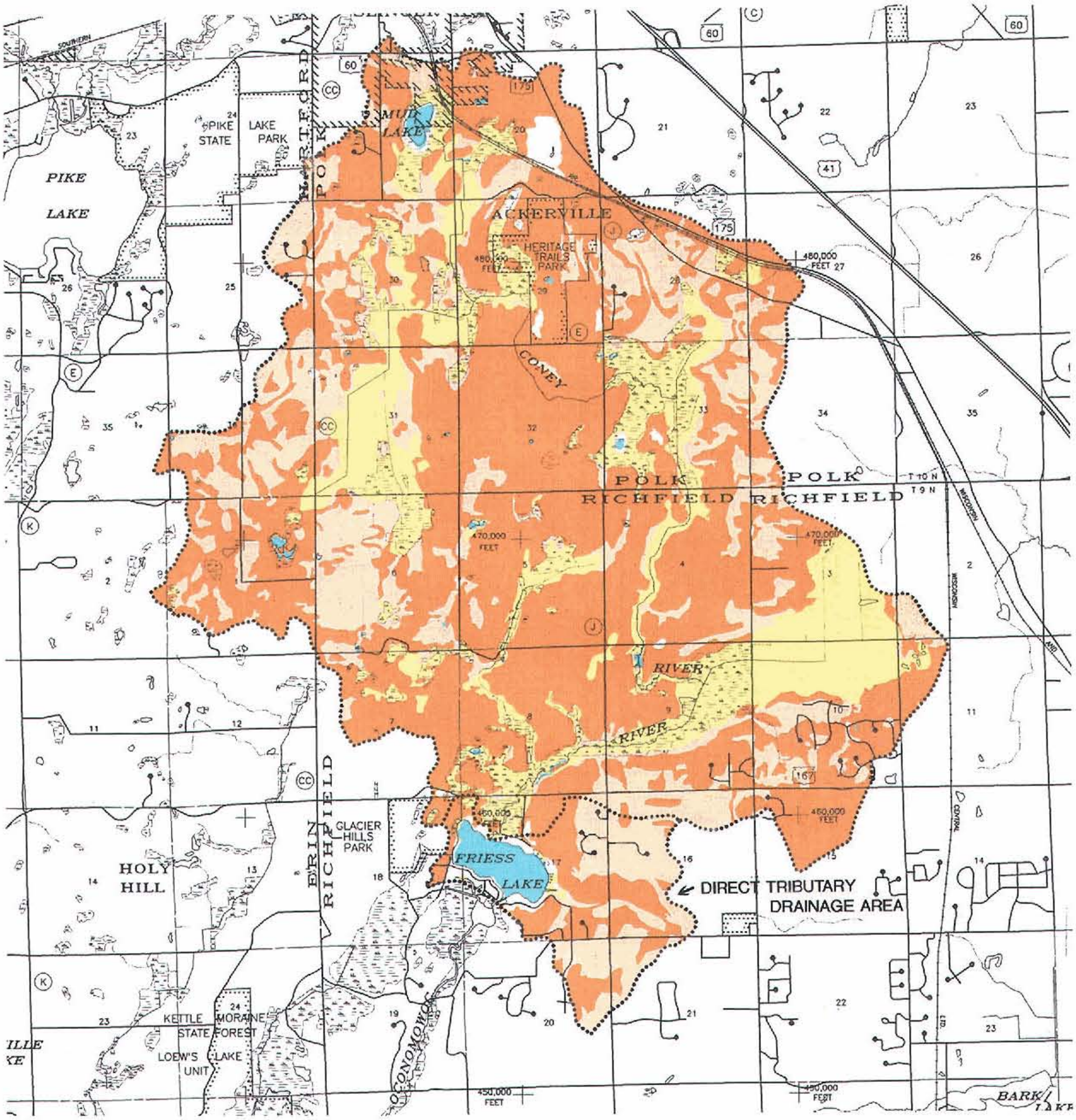
The major specific soil types present within the direct tributary drainage area are: Dodge silt loam, Fox silt loam, Ionia silt loam, Pistakee silt loam, Theresa silt loam, Hochheim Casco-Sisson loam, Houghton muck, and Houghton mucky peat.

As noted above, the soils within the Friess Lake drainage area were classified with respect to suitability for various types of urban and rural development under the Regional soil survey. The suitability for use of onsite sewage disposal systems was updated by the Regional Planning Commission, based upon soil characteristics provided by the detailed soil surveys and the field experience of County and State technicians responsible for overseeing the location and design of such systems. The classifications reflect current soil and site specifications set forth in Chapter ILHR 83 of the *Wisconsin Administrative Code.*

With respect to residential development utilizing conventional onsite sewage disposal systems, as shown on Map 6, about 7 percent of the direct drainage area and about 20 percent of the total tributary drainage area is covered by soils suitable for such development, and about 7 percent of the direct drainage area and 31 percent of the total tributary drainage area by soils unsuitable for such development. The soil suitability could not be determined without further field surveys for 74 percent of the direct drainage area and 48 percent of the total tributary drainage area, respectively. The remaining

Map 5

HYDROLOGIC SOIL GROUPS WITHIN THE TOTAL TRIBUTARY DRAINAGE AREA TO FRIESS LAKE



LEGEND

- GROUP A: Well-drained soils
- GROUP B: Moderately drained soils
- GROUP C: Poorly drained soils
- GROUP D: Very poorly drained soils
- SURFACE WATER
- Hydrologic soil group not determined

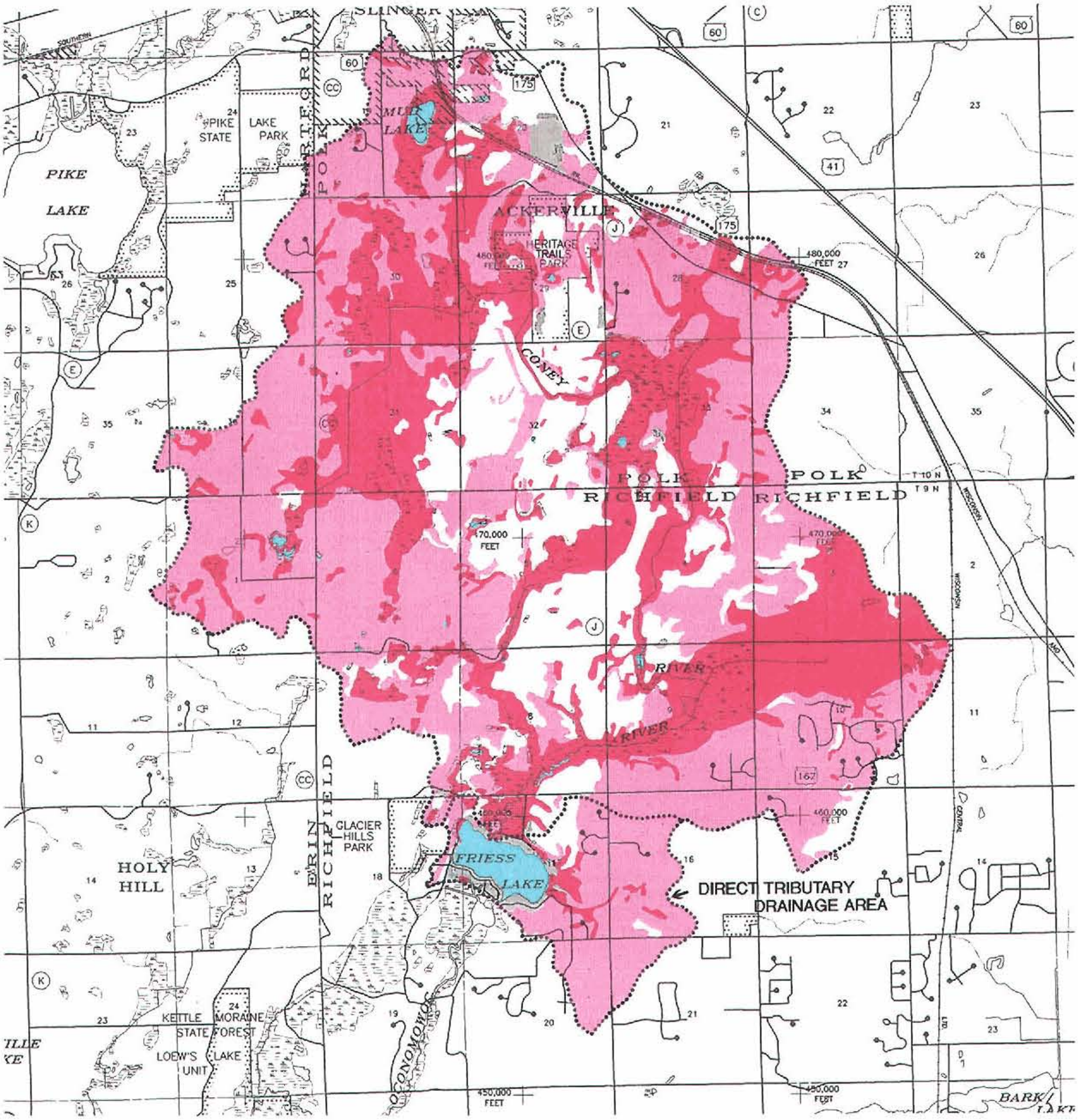
0 2000 4000 6000 FEET

GRAPHIC SCALE

Source: SEWRPC.

Map 6

SUITABILITY OF SOILS FOR CONVENTIONAL ONSITE SEWAGE DISPOSAL SYSTEMS WITHIN THE TOTAL TRIBUTARY DRAINAGE AREA TO FRIESS LAKE



LEGEND

UNSUITABLE: Areas covered by soils which have a high probability of not meeting the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing conventional onsite sewage disposal systems

UNDETERMINED: Areas covered by soils having a range of characteristics and/or slopes which span the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing conventional onsite sewage disposal so that no classification can be assigned

SUITABLE: Areas covered by soils having a high probability of meeting the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing conventional onsite sewage disposal systems

OTHER: Areas consisting for the most part of disturbed land for which no interpretive data are available

SURFACE WATER

GRAPHIC SCALE 0 2000 4000 6000 FEET

Source: SEWRPC.

12 percent of the direct drainage area and 1 percent of the total tributary drainage area was covered by surface water. Much of the existing residential development around the Lake is located in areas covered by soils classified as indeterminant or as disturbed. Some of these residential lands, however, are located in areas covered by soils which are classified as unsuitable for residential development based on the criteria set forth in Chapter ILHR 83 of the *Wisconsin Administrative Code.*

Using alternative onsite sewage disposal systems, such as mound systems, shown on Map 7, yields additional land potentially suitable for urban residential development: about 61 percent of the direct drainage area and 55 percent of the total tributary drainage area of Friess Lake is covered by soils which may be suitable for such development; and about 3 percent of the direct drainage area and 25 percent of the total drainage area by soils unsuitable for such development. Soil suitability cannot be determined without further field surveys for 24 percent of the direct drainage area and 19 percent of the total tributary drainage areas; and, 12 percent and 1 percent of the drainage areas, respectively, was covered by surface waters. As was the case for application of conventional septic tank systems, residential development located around the Lake is located on areas covered by soils which are classified as indeterminant or as disturbed areas for which the suitability for mound-type systems could not be determined. Some of these residential lands, however, are located in areas classified as unsuitable for residential development using alternative onsite sewage disposal systems.

Soil limitations for residential development utilizing sanitary sewer service are shown on Map 8. About 35 percent of both Friess Lake direct drainage area and total tributary drainage area are covered by soils suitable for such development, and about 46 percent of the direct drainage area and 63 percent of the total drainage area by soil having moderate to severe limitations for such development. Soil suitability could not be determined without further field surveys for 7 percent of the direct drainage area and 1 percent of the total drainage area, and 12 percent of the direct drainage and 1 percent of the total tributary drainage areas were covered by surface water. As was the case for development using onsite sewage disposal systems, much of the residential development located around the Lake is located in areas covered by soils which are classified as indeterminant or as disturbed areas for which the suitability for development with public sanitary sewer could not be determined. Some of the residential lands are, however, located in areas with soils classified as having severe limitations for such residential development.

Precipitation and Evaporation

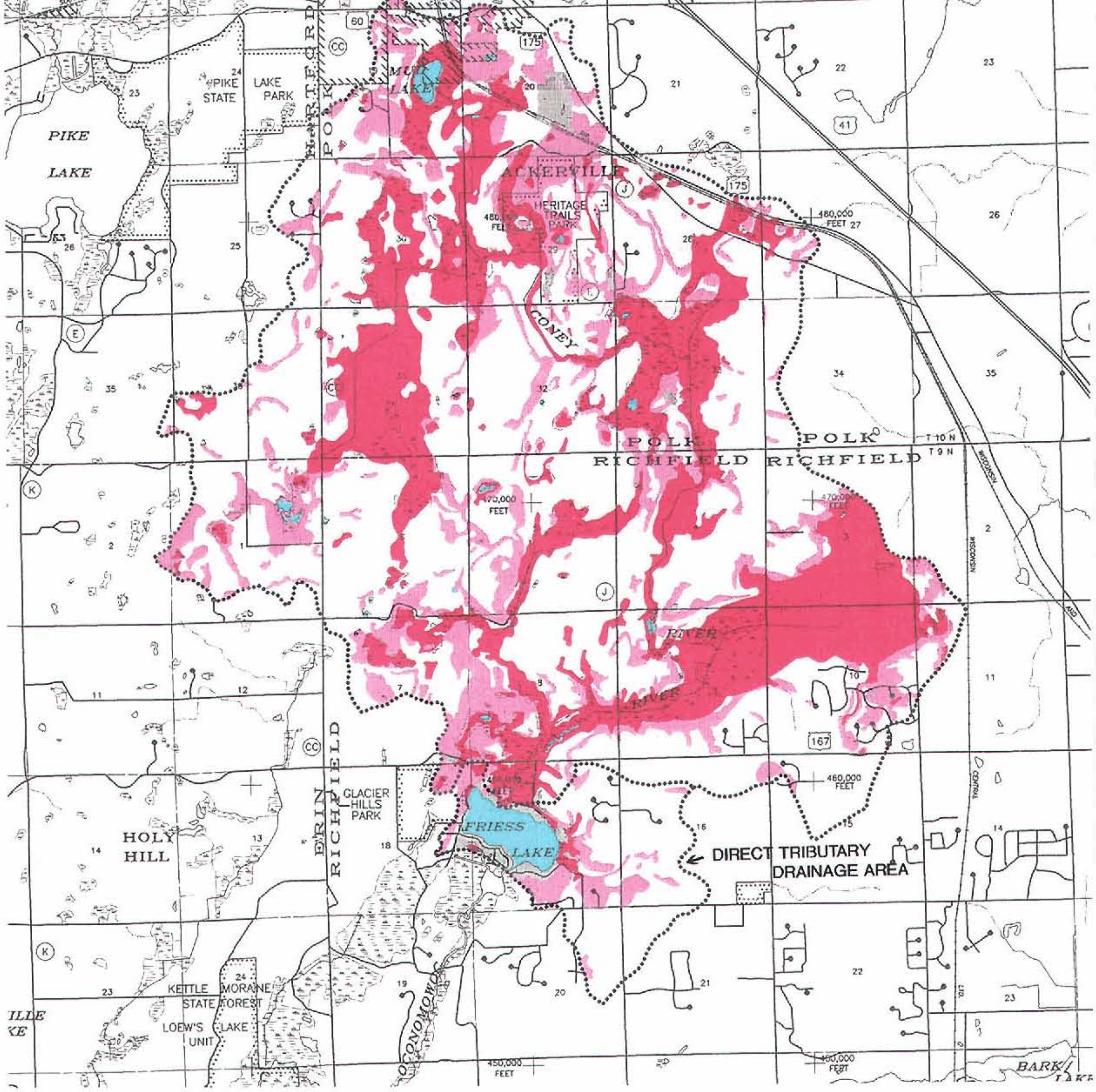
Long-term average monthly air temperature and precipitation values for the Friess Lake area are set forth in Table 3. These averages were taken from official National Oceanic and Atmospheric Administration (NOAA) records for the weather recording station at West Bend, Wisconsin. Table 3 also provides runoff data derived from U.S. Geological Survey (USGS) flow records for the Rock River at Afton, in Jefferson County, Wisconsin.

The mean annual temperature of 45.6°F at West Bend is quite similar to that of other recording locations in Southeastern Wisconsin. The mean annual precipitation at West Bend is about 32.1 inches. More than half the normal yearly precipitation falls during the growing season, from May to September. Runoff rates are also generally higher during this period, even though evapotranspiration rates are high, vegetation cover is good, and the soils are not frozen. Normally, less than 15 percent of the summer precipitation is expressed as surface runoff, but intense summer storms occasionally produce higher runoff fractions. Approximately 40 percent of the annual precipitation occurs during the winter or early spring.

The 12-month period over which the initial Friess Lake water quality sampling study was carried out—May 1976 through April 1977—was a period of average temperatures and extreme drought in Southeastern Wisconsin. Temperatures were generally below normal during the early winter of 1976, above normal in the spring of 1977, and about normal for the remainder of the study period. Precipitation at West Bend during the sampling period was about 18.74 inches, or 38 percent below normal, with the greatest decreases from the averages occurring in June through September 1976. At Afton, Wisconsin, the flow of the Rock River during the study period was 56 percent below normal. During the study period, 11 of the 12 months of the study period—all months except March 1977—experienced below normal amounts of precipitation. Groundwater levels were substantially reduced by this drought, and these reduced groundwater levels were, in turn, reflected in the below-normal flow levels in surface water courses. The hydrologic regime of the Lake during the initial study period, therefore, was likely to have been significantly affected by this drought period.

Map 7

SUITABILITY OF SOILS FOR MOUND SEWAGE DISPOSAL SYSTEMS WITHIN THE TOTAL TRIBUTARY DRAINAGE AREA TO FRIESS LAKE



LEGEND

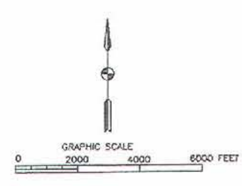
UNSUITABLE: Areas covered by soils which have a high probability of not meeting the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing mound sewage disposal systems

UNDETERMINED: Areas covered by soils having a range of characteristics and/or slopes which span the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing mound sewage disposal systems so that no classification can be assigned

SUITABLE: Areas covered by soils having a high probability of meeting the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing mound sewage disposal systems

OTHER: Areas consisting for the most part of disturbed land for which no interpretive data are available

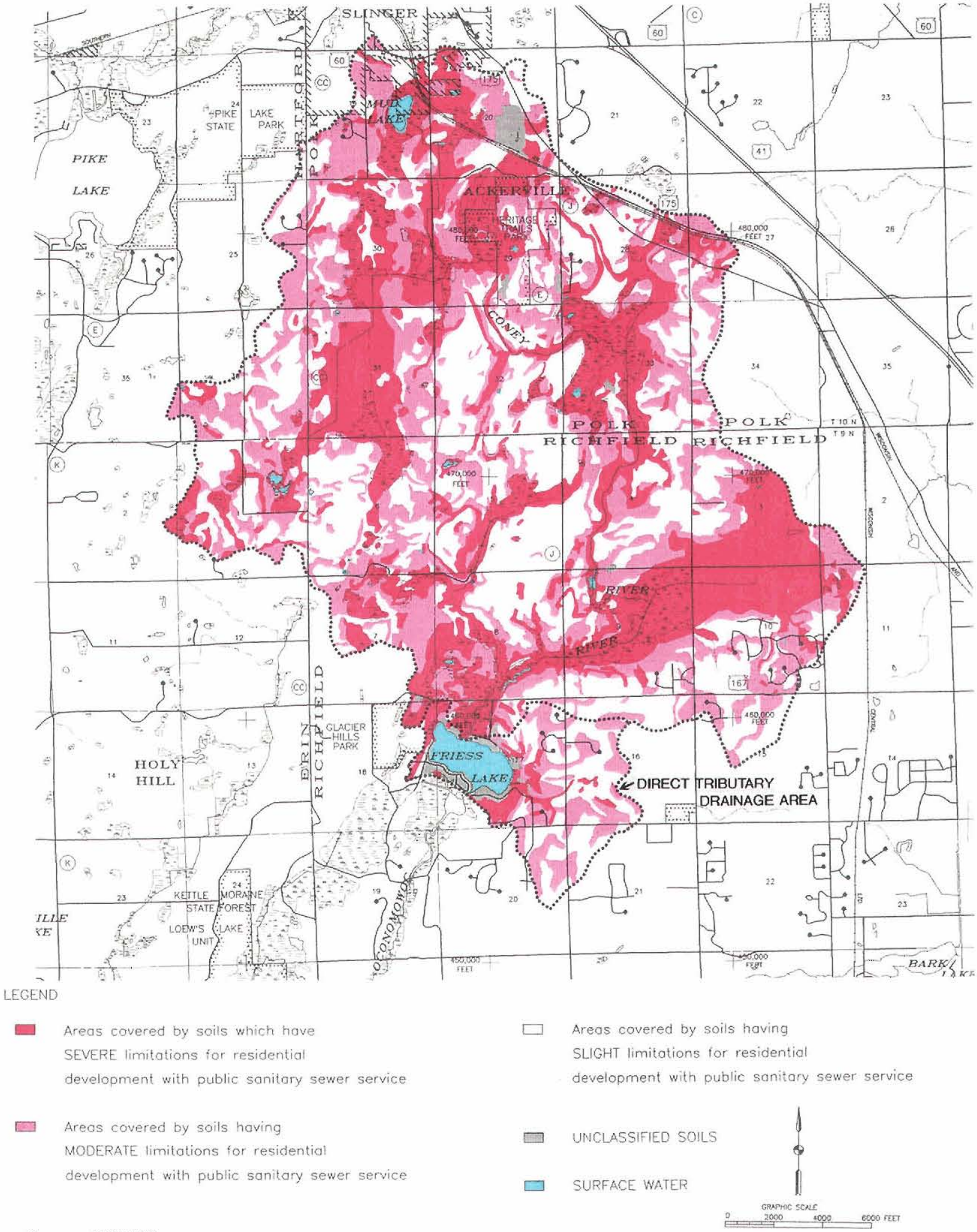
SURFACE WATER



Source: SEWRPC.

Map 8

SUITABILITY OF SOILS FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER WITHIN THE TOTAL TRIBUTARY DRAINAGE AREA TO FRIESS LAKE



Source: SEWRPC.

Table 3

LONG-TERM AND 1993-1994 STUDY YEAR TEMPERATURE, PRECIPITATION, AND RUNOFF DATA FOR THE FRIESS LAKE AREA

Temperature													
Air Temperature Data (°F)	May	June	July	August	September	October	November	December	January	February	March	April	Mean
Long-Term Mean Monthly	55.9	64.9	70.3	69.3	59.4	50.1	37.0	23.3	17.5	21.9	32.8	44.7	45.6
1993-1994 Mean Monthly	57.0	64.0	70.0	71.0	54.0	48.0	36.0	27.0	10.0	17.0	33.0	47.0	44.5
Departure from Long-Term Mean	1.1	-0.9	-0.3	1.7	-5.4	-2.1	-1.0	3.7	-7.5	-4.9	0.2	2.3	-1.1

Precipitation														
Precipitation Data (inches)	May	June	July	August	September	October	November	December	January	February	March	April	Mean	Total
Long-Term Mean Monthly	2.9	3.6	3.8	3.8	4.1	2.6	2.4	1.8	1.3[a]	0.9	2.0	2.9	2.7	32.1
1993-1994	4.3	5.3	3.9	4.1	4.3	0.9	1.5	0.5	2.1	2.3	1.4	2.0	2.7	32.6
Departure from Long-Term Mean	1.4	1.7	0.1	0.3	0.2	-1.7	-0.9	-1.3	0.8	1.4	-0.6	-0.9	0.0	0.5

Runoff													
Runoff Data (inches)	May	June	July	August	September	October	November	December	January	February	March	April	Mean
Long-Term Mean Monthly	2.3	1.7	1.8	1.3	0.9	0.9	0.6	0.6	0.4	0.7	1.7	1.0	1.1
1993-1994	2.4	1.7	1.9	1.4	0.9	0.9	0.6	0.7	0.4	0.6	1.8	1.0	1.2
Departure from Mean Monthly	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	-0.1	0.1	0.0	0.1

[a]Data from West Bend site not available thus data from the next closest site was used.

Source: National Oceanic and Atmospheric Administration and U.S. Geological Survey.

In the study conducted during 1993-1994, conditions in Southeastern Wisconsin approximated more normal conditions. Temperatures were slightly lower than normal during the autumn of 1993, below normal during the mid-winter of 1994, and about normal for the remainder of the study period. Precipitation at West Bend during this period was about 32.6 inches, or about 1 percent above normal, with the greatest increases from the averages occurring in May and June 1993, and in February 1994. The greatest decreases occurred during the periods October through December 1993 and March and April 1994. At Afton, Wisconsin, the flow of the Rock River during this period was slightly higher than normal. Thus, the hydrometeorological condition of the Lake during the current study appears to be more representative of the longer-term conditions on Friess Lake.

Lake Stage

The water level of Friess Lake is primarily determined by the rate of inflow and outflow of the Oconomowoc River. There is no water level control structure at the outlet. A small, unauthorized control structure, located approximately one mile south of Friess Lake at the intersection of the Oconomowoc River and Hubertus Road, was constructed in the 1960s by the Friess Lake Fish and Game Association to help maintain the lake level during times of drought. The flashboards on the structure were removed by residents living on the north shore of the Lake in 1982, because they felt the structure was causing flooding. As of the date of this report, the flashboards have not been replaced.

During the initial study, the water level of the Lake, shown in Figure 1, fell from a high elevation of 954.5 feet above National Geodetic Vertical Datum of 1929 (NGVD), on March 11, 1976, to a low elevation of 953.6 feet NGVD during the fall of 1976, at the height of the drought. Increased rates of precipitation in the spring of 1977 resulted in a lake level of 954.5 feet NGVD by the end of that study period. No lake level data were available for the period of the present study; however, based on the hydrometeorological data set forth above, it may be assumed that the level of the Lake was near normal, and that the lake surface elevation was ranged from about 954.2 feet NGVD to 954.5 feet NGVD.

Water Budget

A long-term water budget for Friess Lake was computed from estimated precipitation, inflow from the Oconomowoc River and from the unnamed tributary, groundwater inflow and outflow, and outflow through the Oconomowoc River based on data collected by USGS at Afton, Wisconsin, between January 1914 and September 1994, and is set forth in Figure 2. An average of about 11,340 acre-feet, or 90 percent, of water enters the Lake annually; about 306 acre-feet, or about 2 percent, falls onto the Lake surface in the form of precipitation; and about 1,000 acre-feet, or about 8 percent, enters the Lake from underground sources.[2] Of this total annual long-term water input, it is estimated that 12,358 acre-feet, or about 98 percent, leaves the Lake through the Oconomowoc River and 288 acre-feet, or 2 percent, is lost to evaporation, resulting in no significant net change in lake water level.

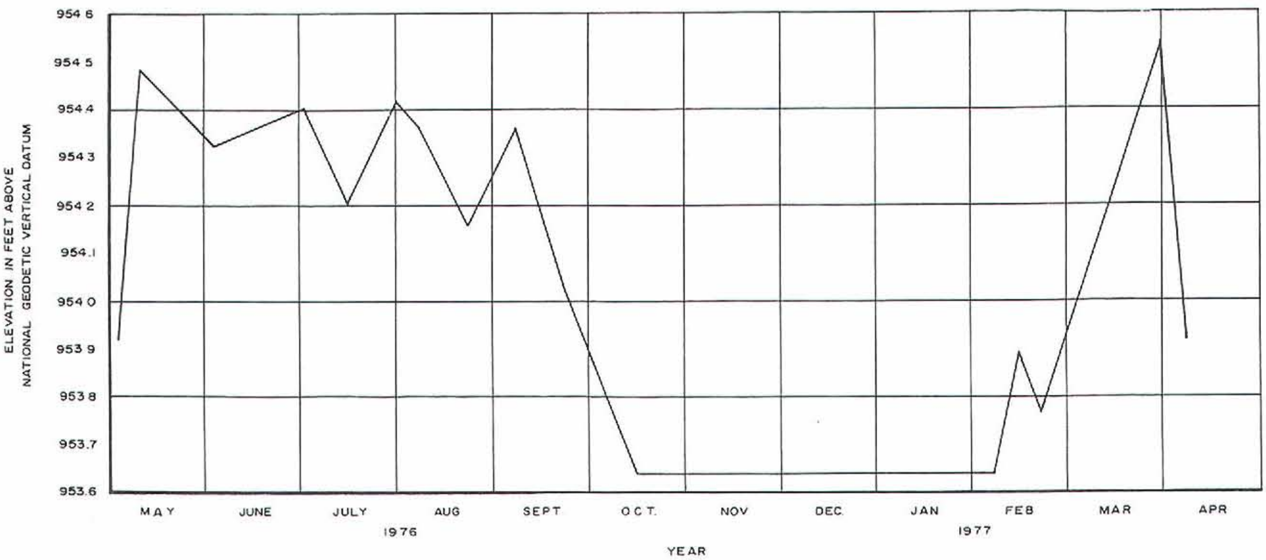
In contrast, during the drought year of the initial study, it was estimated that approximately 5,467 acre-feet of water entered the Lake. Of this total, about 4,061 acre-feet, or 75 percent, was contributed by inflow from the Oconomowoc River; about 125 acre-feet, or 2 percent, was contributed by inflow from the unnamed tributary; direct precipitation contributed about 177 acre-feet, or 3 percent; and about 182 acre-feet, or 3 percent, was contributed by surface runoff from the direct tributary drainage area. Groundwater was estimated to have a net input to the Lake of 922 acre-feet, or 17 percent. Of the total water output from Friess Lake of 5,467 acre-feet, during the year of the initial study, about 5,158 acre-feet, or 94 percent, was discharged via the Oconomowoc River and 309 acre-feet, or 6 percent, evaporated from the surface of the Lake.

The hydraulic residence time is important in determining the expected response time of the Lake to increased or reduced nutrient and other pollutant loadings. The hydraulic residence time for Friess Lake during the study period of May 1976 through April 1977, which was, as already noted, a year of significantly below average precipitation, was approximately seven months. During a year of average climatologic conditions, the hydraulic residence time would be about three months, as suggested by the long-term average water balance for the Lake.

[2] *Groundwater contributions were estimated by rounding up the measured groundwater inflow volume established in the initial plan.*

Figure 1

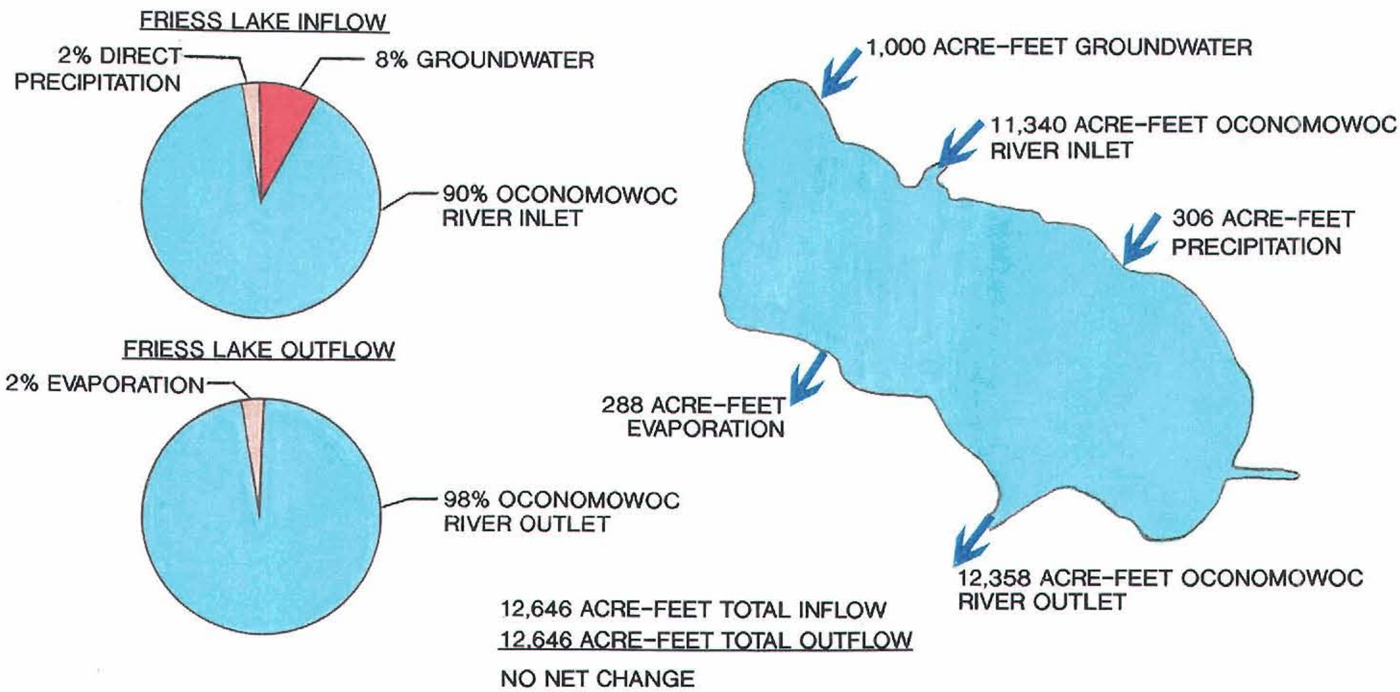
LAKE LEVEL FLUCTUATIONS ON FRIESS LAKE: MAY 1976 THROUGH APRIL 1977



Source: Wisconsin Department of Natural Resources and SEWRPC Community Assistance Planning Report No. 98.

Figure 2

LONG-TERM ANNUAL AVERAGE WATER BUDGET FOR FRIESS LAKE



Source: SEWRPC.

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Chapter III

HISTORICAL, EXISTING, AND FORECAST LAND USE AND POPULATION

INTRODUCTION

Water pollution problems, recreational use conflicts, and the risk of damage to the environment, as well as the ultimate means for abatement of these problems, are primarily a function of human activities within the drainage area of a waterbody and of the ability of the underlying natural resource base to sustain those activities. This is especially true in an area directly tributary to a lake because lakes are highly susceptible to water quality degradation related to human activities in their immediate drainage area, there being no immediate stream segments to attenuate pollutant loads. This type of lake degradation is more likely to interfere with desired water uses and is often more difficult and costly to correct than degradation arising from clearly identifiable point sources of pollution in the watershed. Accordingly, the land uses and attendant population levels in the direct drainage area of a lake are important considerations in any lake management planning effort.

CIVIL DIVISIONS

The geographic extent and functional responsibilities of civil divisions and special-purpose units of government are important factors which must be considered in any water quality management planning effort, since these local units of government provide the basic structure of the decision-making framework within which environment problems must be addressed. Superimposed on the Friess Lake tributary drainage area are the local civil division boundaries, as shown on Map 9.

The drainage area directly tributary to Friess Lake is wholly situated within the Town of Richfield, Washington County.

The total drainage area tributary to Friess Lake includes portions of the Village of Slinger and the Towns of Erin, Hartford, Polk and Richfield, all in Washington County. The area and proportion of the drainage area lying within each jurisdiction concerned is set forth in Table 4.

POPULATION

In the drainage area directly tributary to Friess Lake, significant urban development began in the years following World War II. The resident population approximated 200 persons in 1963. In addition, there were about 110 seasonal or part-time residents residing in 36 housing units located in the direct drainage area in 1963. As indicated in Table 5, the resident population of the drainage area directly tributary to Friess Lake has increased steadily since 1963, reaching a level of about 640 persons in 1990. The number of resident households in the drainage area directly tributary to Friess Lake also has increased steadily between from 1963 and 1990, with the largest increase occurring between 1985 and 1990. This increase was largely attributable to the development east of the immediate lakeshore in the vicinity of CTH J. The number of resident households in the area was estimated at 200 in 1990. In addition to the resident population, there were in 1990 about 130 seasonal or part-time persons accommodated in about 50 housing units located within the drainage area directly tributary to Friess Lake.

Based on the adopted regional land use plan,[1] the population and the number of resident households in the drainage area directly tributary to Friess Lake is expected to remain largely unchanged through the year 2010. However, based upon observations made by the Washington County Land Conservation Department staff during 1994 field inventories, it is likely that additional large-lot residential development has already taken place.

In 1990, the resident population of the total tributary drainage area of Friess Lake was estimated at about 2,780 persons. The number of residents and resident households in the drainage area tributary to Friess Lake also has increased steadily between 1963 and 1990, with the largest increases occurring between 1970 and 1980

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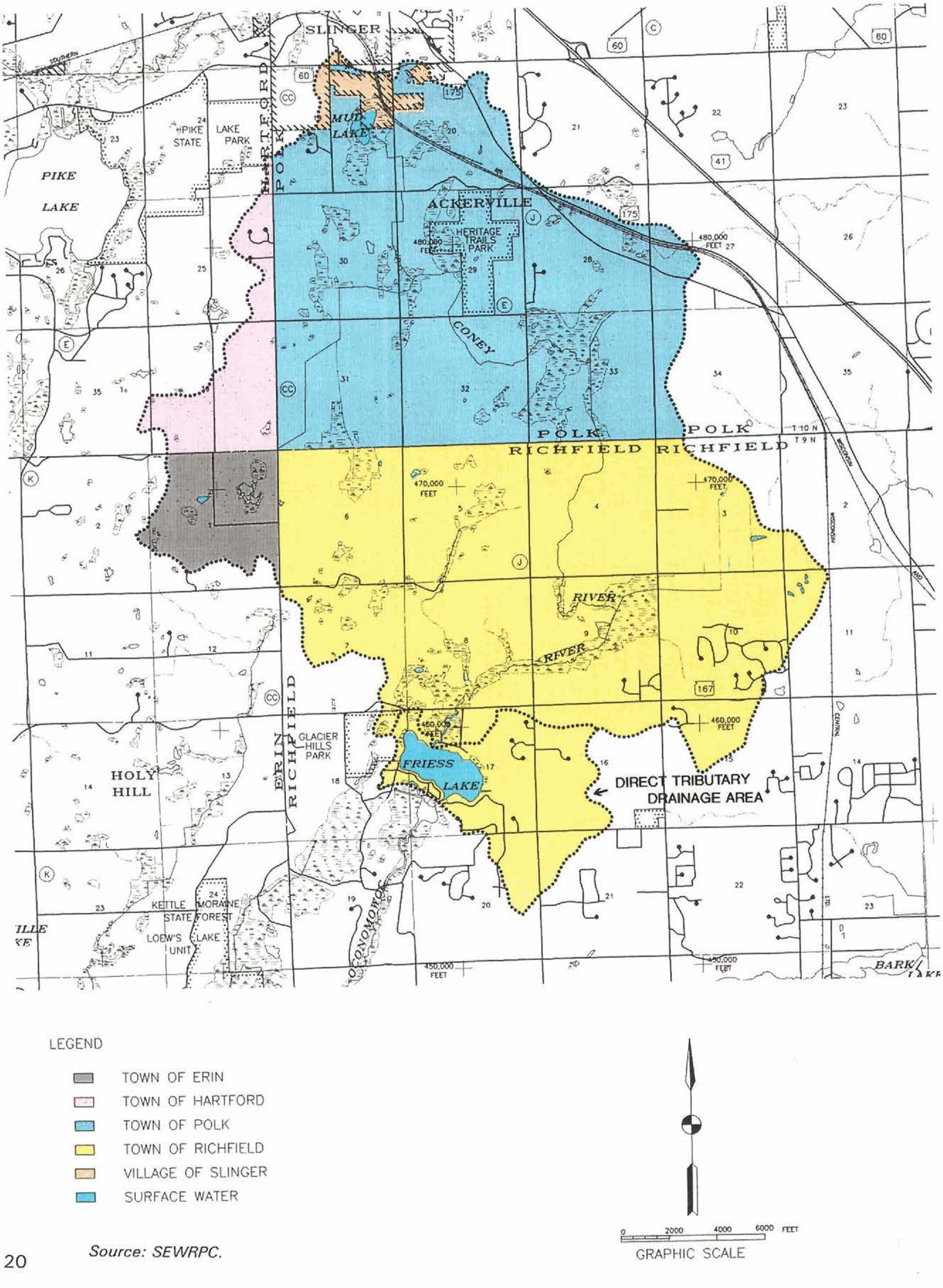
[1] *SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin—2010, *January 1992.*

Map 9

CIVIL DIVISION BOUNDARIES WITHIN THE FRIESS LAKE TOTAL TRIBUTARY DRAINAGE AREA



Source: SEWRPC.

Table 4

AREAL EXTENT OF CIVIL DIVISIONS WITHIN THE FRIESS LAKE TOTAL TRIBUTARY DRAINAGE AREA: 1990

Civil Division	Civil Division Area within Tributary Drainage Area (acres)	Percent of Tributary Drainage Area within Civil Division	Percent of Civil Division within Tributary Drainage Area
Town of Richfield	6,320	50	26
Town of Polk	4,773	39	22
Town of Hartford	586	5	3
Town of Erin	539	5	2
Village of Slinger	156	1	11
Total	12,374	100	- -

Source: SEWRPC.

Table 5

HISTORIC AND FORECAST HOUSEHOLD AND RESIDENT POPULATION LEVELS WITHIN THE DRAINAGE AREA TRIBUTARY TO FRIESS LAKE: 1963-2010[a]

Year	Direct Drainage Area		Total Tributary Drainage Area	
	Number of Residents	Number of Households	Number of Residents	Number of Households
1963	200	65	910	240
1970	410	105	1,630	440
1980	440	135	2,150	670
1985	440	140	2,200	700
1990	640[b]	195[b]	2,775[b]	900[b]
2010	650[c]	200[c]	3,200[c]	1,050[c]

[a]*Drainage area approximated using whole U.S. Public Land Survey one-quarter sections.*

[b]*In addition to the resident population, there were about 130 persons residing in about 130 seasonal or part-time residences in the direct drainage area to Friess Lake, and about 160 persons residing in seasonal or part-time residences in the total tributary area to Friess Lake.*

[c]*Year 2010 data are presented for the high-growth centralized land use plan as set forth in the year 2010 regional land use plan.*

Source: SEWRPC.

and between 1985 and 1990. In addition to this resident population, there were, as of 1990, about 160 seasonal or part-time residents accommodated in about 60 housing units within the drainage area tributary to Friess Lake.

Planned population levels prepared by the Regional Planning Commission, as a basis for the adopted regional land use plan,[2] indicate that the population and numbers of households within the total tributary drainage

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[2]*SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin—2010, *January 1992.*

area to Friess Lake may be expected to increase by about 15 percent over the 1990 levels by the year 2010. However, based upon observations made by the Washington County Land Conservation Department staff during 1994 field surveys, these forecasts will likely be exceeded given the urban development which is occurring in the drainage area primarily in the form of large-lot residential development.

LAND USE

The type, intensity, and spatial distribution of land uses within the Friess Lake watershed are important determinants of lake water quality. In this regard, the current and planned future land use patterns, placed in the context of the historical development of the area, are important considerations in lake management planning for Friess Lake. The movement of European settlers into the Southeastern Wisconsin Region began about 1830. Completion of the U.S. Public Land Survey in the Region in 1836 and the subsequent sale of public lands in Wisconsin brought an influx of settlers into the area. Map 10 shows the original plat of the U.S. Public Land Survey for the Friess Lake area.

Significant urban land use development in the Friess Lake area began in the 1940s. Map 11 and Table 6 indicate the historic urban growth pattern in the total drainage area tributary to Friess Lake.[3] The largest increases in the amount of land converted to urban use occurred between 1975 and 1985.

The existing land use pattern in the drainage area directly tributary to Friess Lake, as of 1990, is shown on Map 12, and quantified in Table 7. About 680 acres, or 72 percent, of the direct drainage area were still in rural land uses, with the dominant rural land use being agricultural, encompassing just over 400 acres, or 43 percent of the direct drainage area. Other rural land uses—wetlands, woodlands, and open lands—comprised about 270 acres, or 29 percent, of the direct drainage area.

As of 1990, urban lands, consisting of residential, commercial, governmental and institutional, transportation and utility, and recreational land uses, encompassed about 270 acres, or 28 percent, of the direct drainage area, with residential being the dominant urban land use, comprising about 200 acres, or 21 percent, of the direct drainage area. Commercial, industrial, governmental and institutional, transportation and communication, and recreational land uses comprise 70 acres, or about 7 percent, of the direct drainage area.

Under year 2010 planned conditions, only a small increase in urban land use is envisioned within the drainage area tributary to Friess Lake compared to 1990 conditions, as shown in Table 7, although some infilling of existing platted lots may be expected to occur. In addition, the redevelopment of properties and reconstruction of existing single family homes may be expected on lakeshore properties. However, recent surveillance indicates that urban growth within the direct drainage area tributary to Friess Lake will exceed this planned level of development as a result of development patterns providing primarily for large-lot residential development. In addition, proposals have been developed for the upgrading of the transportation infrastructure within the drainage area directly tributary to Friess Lake, with STH 167 already reconstructed to the north of the Lake, and CTH J proposed for reconstruction within the planning period to the east of the Lake.[4] If this trend continues, some of the open space areas remaining in the drainage area will be replaced with large-lot urban residential development. This may increase the pollutant loadings to the Lake associated with urbanization and increase the pressure for recreational use of the Lake. This development could occur in the form of residential clusters on smaller lots, thereby preserving portions of the remaining open space and, thus, reducing the impacts on the Lake.

The existing land use patterns in the total drainage area tributary to Friess Lake, as of 1990, are shown on Map 12, and quantified in Table 8. About 10,900 acres, or 88 percent of the total tributary drainage area, were still in rural land uses, with the dominant rural land use being agricultural, encompassing about 7,750 acres, or 63 percent, of the total tributary drainage area. Other rural land uses—wetlands, woodlands, and open lands—comprised just over 3,000 acres, or 24 percent, of the total tributary drainage area.

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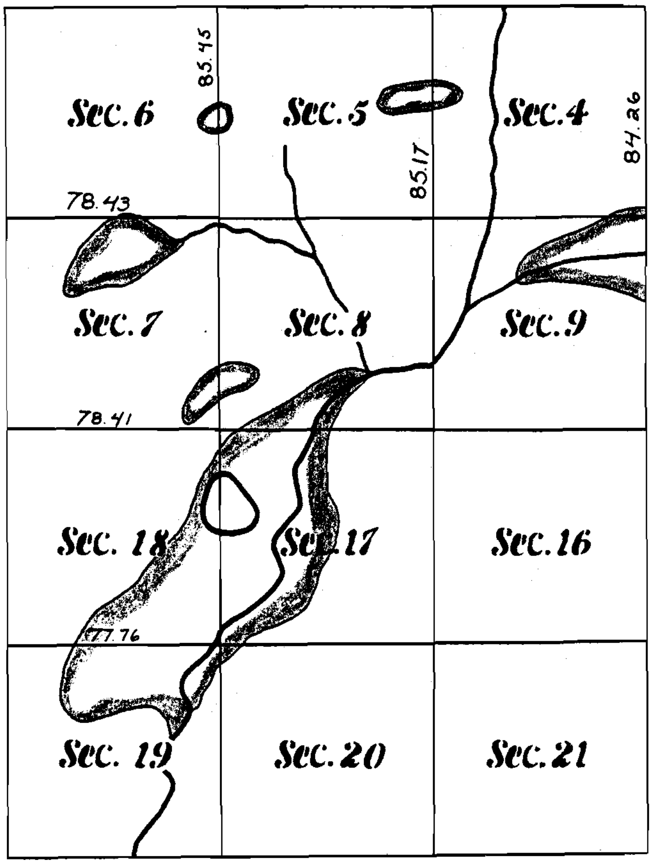
[3]*Urban development, as defined for the purposes of this discussion, includes those areas within which houses or other buildings have been constructed in relatively compact groups, thereby indicating a concentration of urban land uses. Scattered residential developments were not considered urban in this analysis.*

[4]*SEWRPC,* A Transportation Improvement Program for Southeastern Wisconsin: 1998-2000, *November 1997.*

Map 10

ORIGINAL UNITED STATES PUBLIC LAND SURVEY MAP FOR THE FRIESS LAKE AREA: 1836



Source: U.S. Public Land Survey and SEWRPC.

As of 1990, urban lands, consisting of residential, commercial, governmental and institutional, transportation and utility, and recreational land uses, encompassed about 1,510 acres, or 12 percent, of the total tributary drainage area, with residential being the dominant urban land use, comprising about 900 acres, or 7 percent, of the total tributary drainage area. Commercial, industrial, governmental and institutional, transportation and communication, and recreational land uses comprised about 620 acres, or about 5 percent, of the total tributary drainage area.

Under year 2010 planned conditions, about 350 acres of rural land is expected to be converted to urban uses within the Friess Lake total tributary drainage area, resulting in urban land comprising about 23 percent, as shown in Table 8 and on Map 13. In addition, some infilling of existing platted lots may be expected to occur, and the redevelopment of properties and reconstruction of existing single-family homes may be expected on lakeshore properties. Recent surveillance indicates that urban growth within the total drainage area tributary to Friess Lake will exceed this planned level of development as a result of development patterns providing primarily for large-lot residential development. If this trend continues, some of the open space areas remaining in the drainage area will be replaced over time with large-lot urban development. This may increase the pollutant loadings to the Lake associated with urbanization and increase the pressure for recreational use of the Lake. This development could occur in the form of residential clusters on smaller lots, thereby preserving portions of the remaining open space and, thus, reducing the impacts on the Lake.

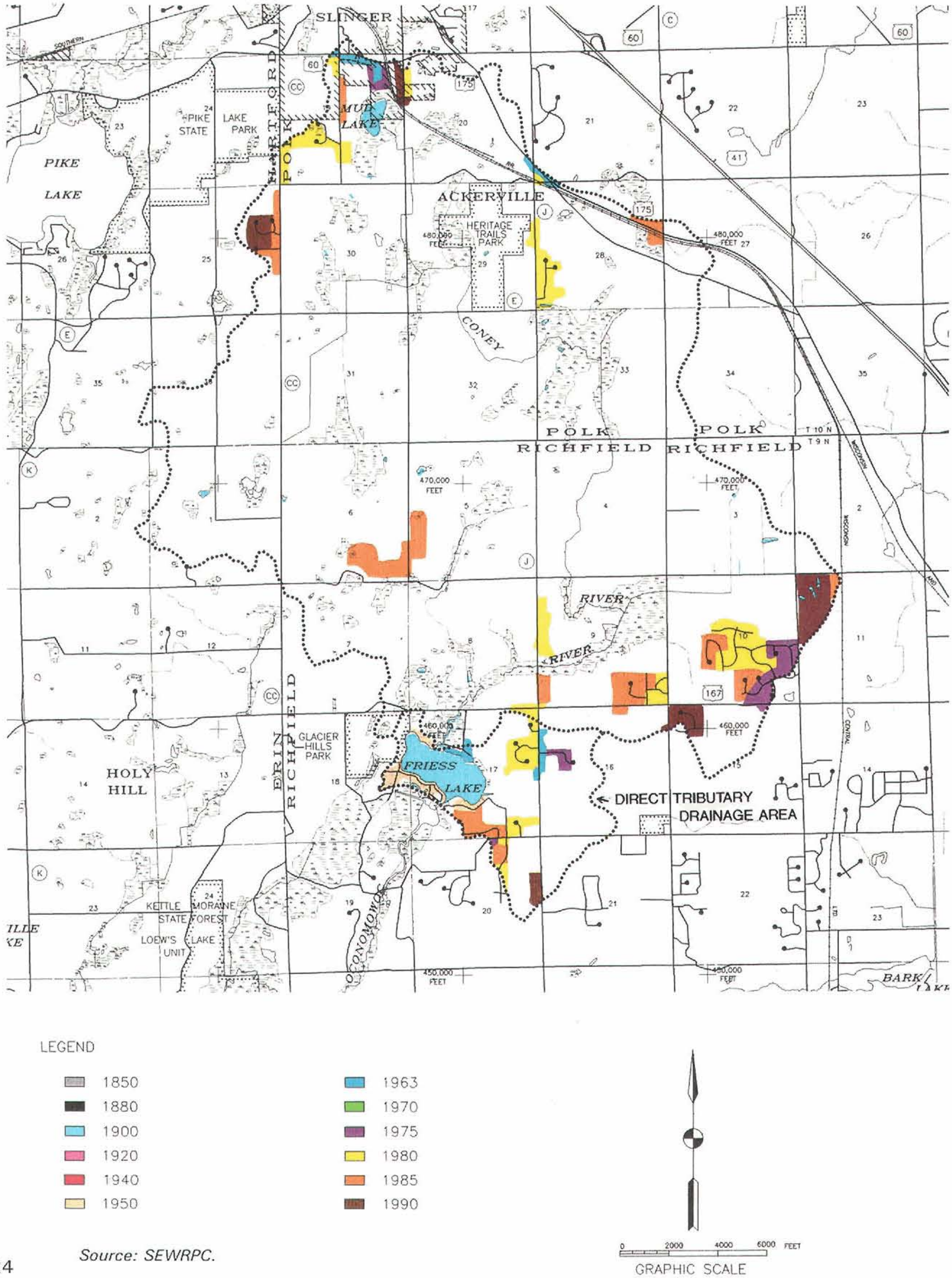
EXISTING ZONING REGULATIONS

The comprehensive zoning ordinance represents one of the most important and significant tools available to local units of government in directing the proper use of lands within their area of jurisdiction. The drainage area directly tributary to Friess Lake is located entirely within the Town of Richfield, while the total drainage area tributary to Friess Lake includes portions of the Village of Slinger and the Towns of Erin, Hartford, and Polk. Both towns and villages in Washington County administer their own zoning ordinances. The generalized zoning districts applicable to the drainage area directly tributary to Friess Lake, as provided for under current zoning regulations, are shown on Map 14. Such zoning is indicative of the total tributary drainage area of the Lake. This existing zoning would permit far more urban development in this drainage basin than envisioned in the adopted regional land use plan.

In addition to the comprehensive zoning ordinances administered by the local authorities in the Friess Lake drainage area, the Washington County Board of Supervisors exercises special-purpose shoreland and floodland zoning in the direct drainage area tributary to Friess Lake, as shown on Map 15. The Washington County Board of Supervisors adopted a Shoreland and Floodland Protection Ordinance in April 1973, and, later, recreated the ordinance in February 1975, pursuant to the requirements of the Wisconsin Water Resources Act of 1965 (Chapter 30, *Wisconsin Statutes*). This Ordinance imposed special land use regulations on all unincorporated lands located within 1,000 feet of the shoreline of any navigable lake, pond or flowage, and within 300 feet of the shoreline of any navigable river or stream, or

Map 11

HISTORIC URBAN GROWTH WITHIN THE FRIESS LAKE TOTAL TRIBUTARY DRAINAGE AREA



Source: SEWRPC.

Table 6

EXTENT OF HISTORIC URBAN GROWTH WITHIN THE DRAINAGE AREA TRIBUTARY TO FRIESS LAKE: 1950-1990

	Direct Drainage Area		Total Tributary Drainage Area	
Year	New Urban Development[a] Occurring Since Previous Year (acres)	Cumulative Extent of Urban Development[a] (acres)	New Urban Development[a] Occurring Since Previous Year (acres)	Cumulative Extent of Urban Development[a] (acres)
1950	50	50	50	50
1963	25	75	56	106
1975	16	91	95	201
1980	72	163	349	550
1985	46	209	325	875
1990	15	224	168	1,043

[a]*Urban development, as defined for the purposes of this discussion, includes those areas within which houses or other buildings have been constructed in relatively compact groups, thereby indicating a concentration of urban land uses. Scattered residential development were not considered in this analysis.*

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

to the landward side of the floodplain, whichever is greater.

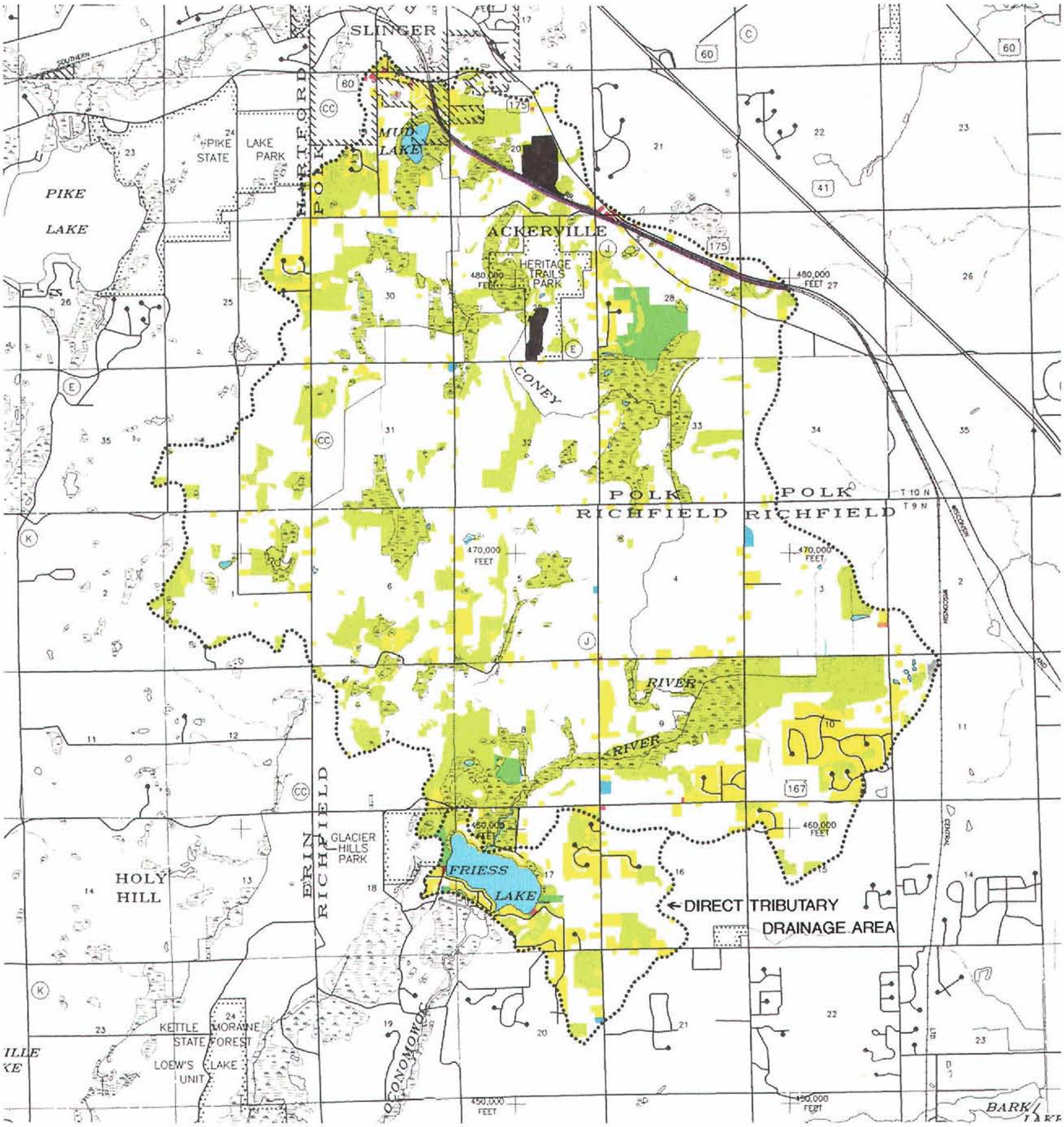
In 1986, the Washington County Shoreland and Floodplain Protection Ordinance was rewritten, separating the Floodplain Protection Ordinance from the Shoreland and Wetland Protection Ordinance. This change was made pursuant to Chapters 23 and 330 of the *Wisconsin Statutes* which require that counties regulate the use of all wetlands, five acres or larger, located in shoreland areas of the unincorporated areas within 300 feet of a stream and 1,000 feet of a lake, or to the landward side of the floodplain, whichever is greater. Preliminary wetland maps for Washington County were prepared for the Wisconsin Department of Natural Resources by the Regional Planning Commission in 1963. In accordance with Chapter NR 115 of the *Wisconsin Administrative Code*, Washington County has updated its shoreland zoning regulations and attendant maps to preclude further loss of wetlands in the shoreland areas, and is presently further refining this Ordinance. It is anticipated that the refined Shoreland and Wetland Protection Ordinance will be adopted during 1998. The Shoreland and Floodland Protection Ordinances are similar in content to, and part of, the local zoning ordinances but includes additional regulations intended to protect waterways and attendant shorelines.

While the existing zoning ordinances have proven generally effective in protecting the wetlands, woodlands, and water resources of the Friess Lake drainage area, concerns have been expressed over the need to protect the lake shoreline and the tributary watershed area from overintensive land use. These concerns have arisen regarding the widespread subdivision development on vacant rural lands in the drainage area in the vicinity of the Lake, primarily in the form of large-lot residential development. Such intense development in the drainage area can have impacts on water quality protection. These developments generally result in a greater area of impervious surface, increased runoff, and increased pollutant loading for certain nonpoint source pollutants associated with urban development, as described in Chapter IV. In addition, within the lakeshore area, new development may be accompanied by the year-round use of formerly seasonal properties and the replacement of existing housing with larger, and, in some cases, more structures.

Control of shoreland redevelopment, and the related intensification of use, is largely addressed through the existing general-use zoning codes which are in place. For the urbanized areas surrounding Friess Lake, these zoning districts include: R-1 which is intended to provide for single-family residential and mini-farm development on lots of no less than four acres in areal extent;

Map 12

EXISTING LAND USE WITHIN THE FRIESS LAKE TOTAL TRIBUTARY DRAINAGE AREA: 1990



LEGEND

- SINGLE-FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- TRANSPORTATION, COMMUNICATIONS, and UTILITIES
- GOVERNMENT and INSTITUTIONAL
- RECREATION
- SURFACE WATER
- WETLANDS and WOODLANDS
- AGRICULTURAL, UNUSED, and OTHER OPEN LANDS
- EXTRACTIVE and LANDFILL

0 2000 4000 6000 FEET

GRAPHIC SCALE

Source: SEWRPC.

Table 7

EXISTING 1990 AND FORECAST 2010 LAND USE WITHIN THE FRIESS LAKE DIRECT DRAINAGE AREA

Land Use Categories	1990		2010	
	Acres	Percent of Drainage Area	Acres	Percent of Drainage Area
Urban				
Residential	203	21	213	22
Commercial	2	<1	2	<1
Industrial	0	0	0	0
Governmental	1	<1	1	<1
Transportation and Utilities	50	5	50	5
Recreational	17	2	22	2
Subtotal	273	28	288	29
Rural				
Agricultural	406	43	354	38
Wetlands	18	2	18	2
Woodlands	138	15	138	15
Water	118	12	118	12
Landfill	0	0	0	0
Other Open Land	0	0	37	4
Subtotal	680	72	665	71
Total	953	100	953	100

Source: SEWRPC.

Table 8

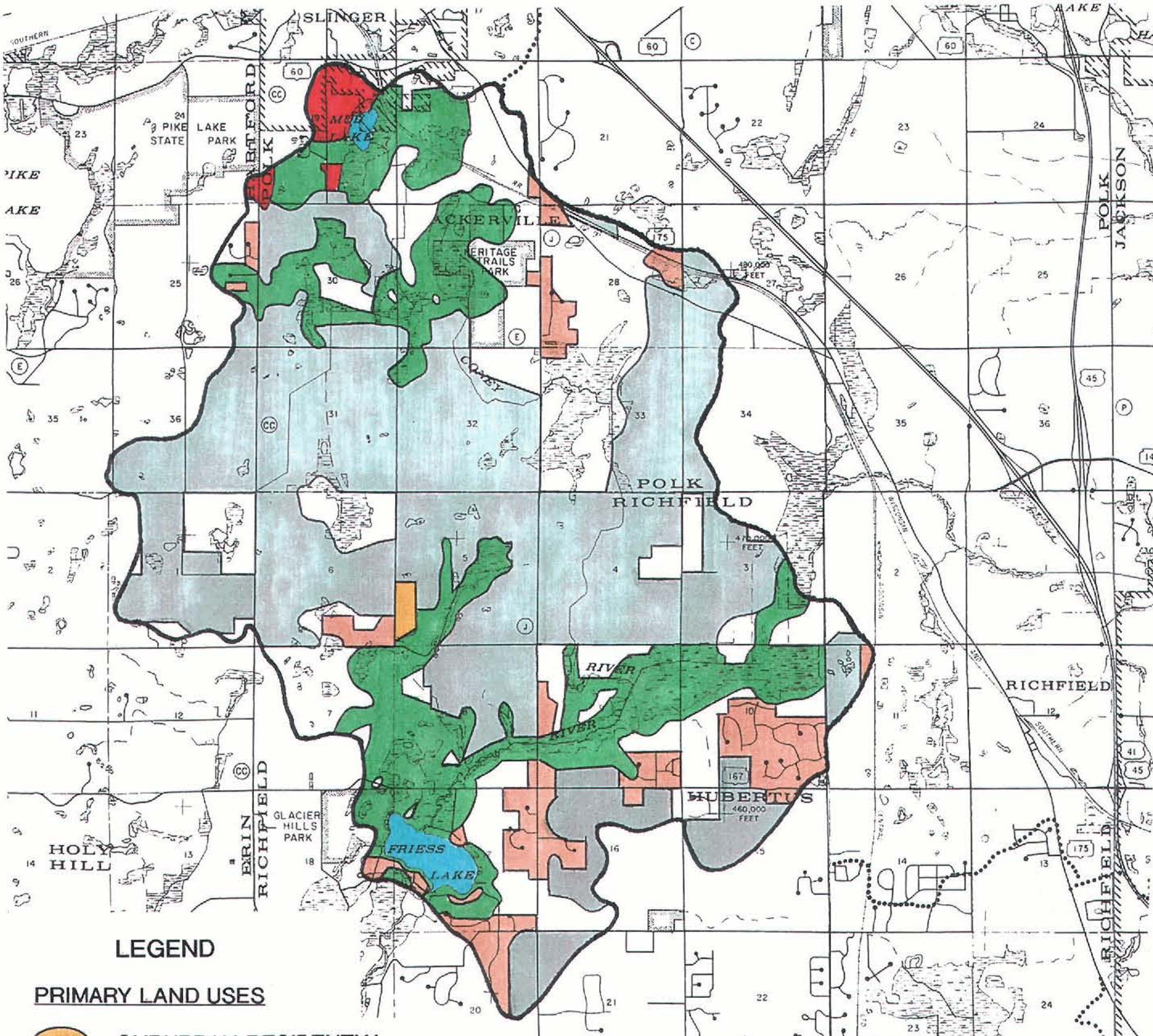
EXISTING 1990 AND FORECAST 2010 LAND USE WITHIN THE FRIESS LAKE TOTAL TRIBUTARY DRAINAGE AREA

Land Use Categories	1990		2010	
	Acres	Percent of Drainage Area	Acres	Percent of Drainage Area
Urban				
Residential	891	7	981	8
Commercial	10	<1	15	<1
Industrial	6	<1	29	<1
Governmental	13	<1	15	<1
Transportation and Utilities	460	4	493	4
Recreational	134	1	334	3
Subtotal	1,514	12	1,867	15
Rural				
Agricultural	7,753	63	7,261	59
Wetlands	1,441	12	1,441	12
Woodlands	1,433	11	1,433	12
Water	159	1	159	1
Landfill	74	<1	74	<1
Other Open Land	0	0	139	1
Subtotal	10,860	88	10,507	85
Total	12,374	100	12,374	100

Source: SEWRPC.

Map 13

PLANNED LAND USE WITHIN THE FRIESS LAKE TOTAL TRIBUTARY DRAINAGE AREA: 2010



LEGEND

PRIMARY LAND USES

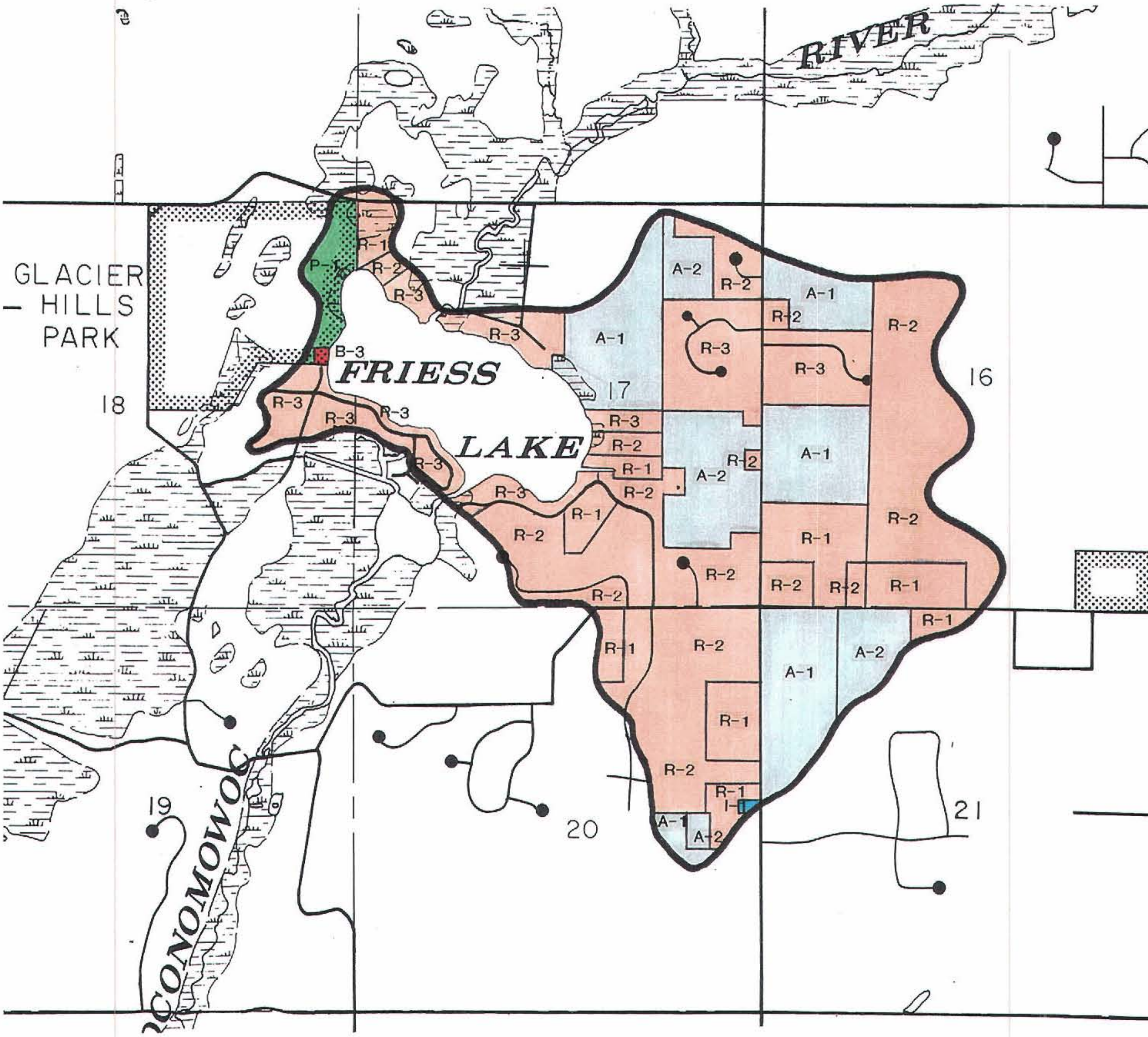
- SUBURBAN RESIDENTIAL (0.2-0.6 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- LOW-DENSITY RESIDENTIAL (0.7-2.2 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- MEDIUM-DENSITY RESIDENTIAL (2.3-6.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- PRIMARY ENVIRONMENTAL CORRIDOR
- PRIME AGRICULTURAL LAND
- OTHER AGRICULTURAL AND RURAL LAND
- WATER

GRAPHIC SCALE
0 4000 8000 FEET

Source: SEWRPC.

Map 14

EXISTING ZONING DISTRICTS WITHIN THE FRIESS LAKE DIRECT DRAINAGE AREA: 1990



LEGEND

- RESIDENTIAL
- COMMERCIAL
- INSTITUTIONAL
- PARK
- AGRICULTURAL

ZONNG DISTRICTS

R-1 SINGLE-FAMILY RESIDENCE (4 ACRES OR GREATER)

R-2 SINGLE-FAMILY RESIDENCE (1.5 - 3.9 ACRES)

R-3 SINGLE-FAMILY RESIDENCE (LESS THAN 1.49 ACRES)

B-3 WATERFRONT BUSINESS

I-1 INSTITUTIONAL

P-1 PARK

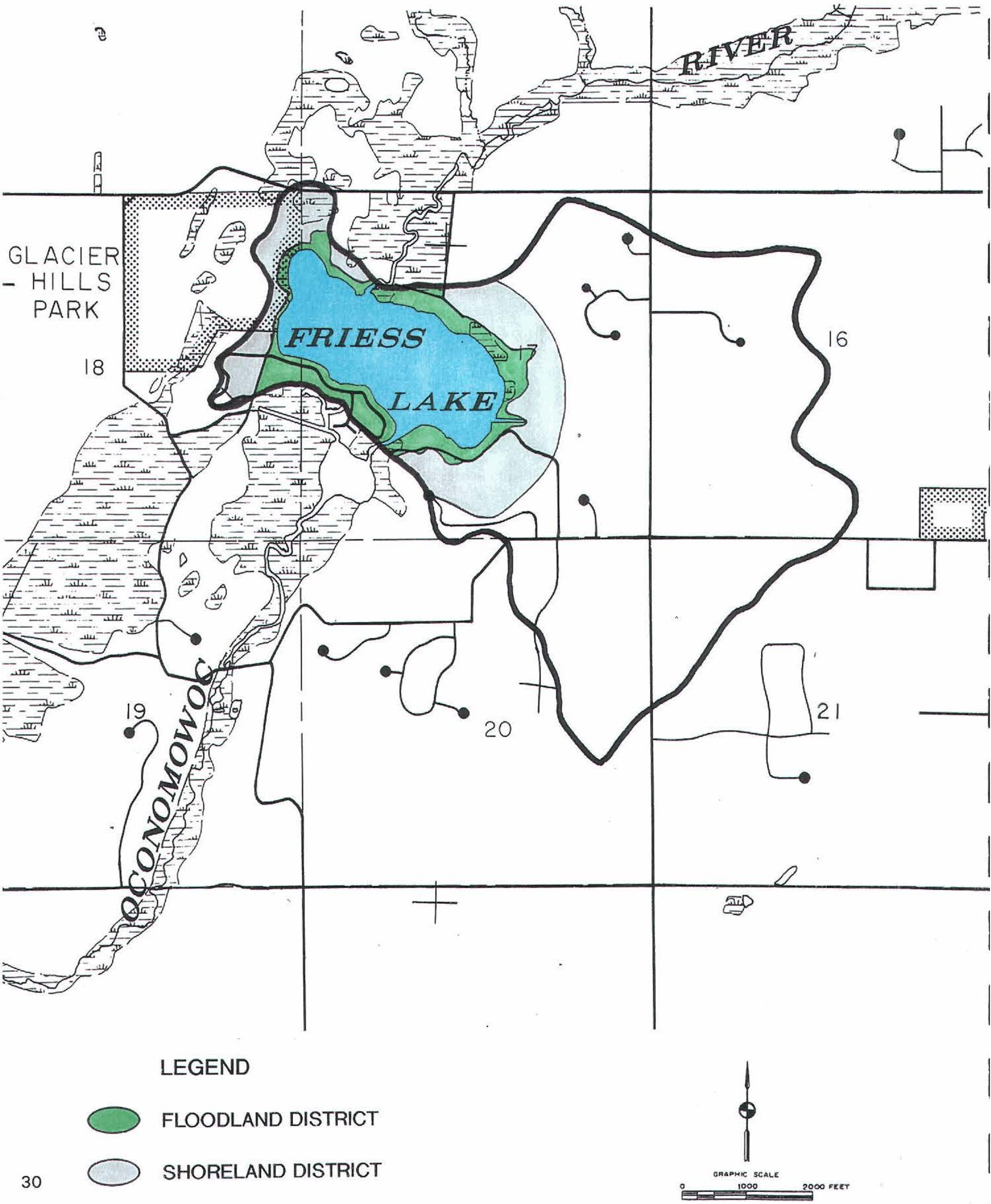
A-1 PRIME AGRICULTURAL

A-2 AGRICULTURAL

Source: Town of Richfield and SEWRPC.

Map 15

EXISTING FLOODLAND AND SHORELAND ZONING DISTRICTS IN THE FRIESS LAKE DIRECT DRAINAGE AREA



Source: Washington County Park and Planning Commission and SEWRPC.

R-2 which is intended to provide for single-family residential development on lots of no less than 1.5 acres in areal extent; and R-3 which is intended to accommodate single-family residential and "accessory" uses in existence within the older, established portions of the Town of Richfield as of December 1983—when Chapter 17 of the Codes and Ordinances of the Town of Richfield, Wisconsin: Zoning Regulations was enacted—that would otherwise be nonconforming around the shoreline of the Lake. The R-3 zoning district has specific limitations on the types of housing units allowed, lot sizes, and building set-back distances. In addition, the R-3 zoning district provides that existing nonconforming parcels may not be altered in any way, excepting that a single-family building may be placed on substandard lots if such lots within an R-3 district were separate and distinct lots of record on January 1, 1981. Notwithstanding, much of the pre-existing development is likely to be governed by the "50 percent rule" which would limit the reconstruction and replacement of nonconforming structures presently within the shoreland zone as provided for in Chapter NR 115.05(3)(e) of the *Wisconsin Administrative Code* and related county regulations. In addition, new construction will be required to meet specific compliance and inspection requirements for onsite sewage disposal systems.

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Chapter IV

WATER QUALITY

INTRODUCTION

The earliest definitive data on water quality conditions in Friess Lake were collected by the Wisconsin Department of Natural Resources and the Regional Planning Commission in 1976 and 1977 as part of the Friess Lake water quality management planning program.[1] In 1985, the Wisconsin Department of Natural Resources (DNR) included Friess Lake in its Long-Term Trend Monitoring Program. Subsequently, data on water quality was collected seasonally from 1986 through 1995. These data taken together are sufficient to permit an initial characterization of trends or changes which may be occurring in the water quality of Friess Lake.

EXISTING WATER QUALITY CONDITIONS

The water quality of Friess Lake was monitored monthly under a cooperative program by the Wisconsin Department of Natural Resources and the Commission during the May 1976 through April 1977 monitoring period, and seasonally by the Wisconsin Department of Natural Resources during the period April 1986 through August 1995 under the Department's Long-Term Trend monitoring program. These data were used in this management plan preparation to describe water quality conditions in the Lake and to characterize the suitability of the Lake for recreational use and the support of fish and aquatic life. The primary station for most sampling activities was located at the deepest point in the Lake, as shown on Map 3 in Chapter II. During the 1976-1977 monitoring period, monthly samples were taken at this station at 10-foot-depth intervals from the surface to about 40 feet in depth. During the 1986-1995 monitoring period, seasonal samples were taken at this station during spring —March or April, summer—June or July, autumn—August, and winter—February at the surface—about 0.5 foot—and bottom—about 45 feet depth of the water column. During periods of stratification as described below, a mid-depth sample—at a depth of between 15 and 25 feet—was also taken.

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

Thermal Stratification

Thermal and dissolved oxygen profiles for Friess Lake are shown in Figures 3 and 4. Water temperatures during the 1976-1977 monitoring period ranged from a minimum of 32°F (0°C) during the winter to a maximum of 80°F (26°C) during the summer. During the 1986-1995 monitoring period, water temperatures ranged from a minimum of 32°F (0°C) in February 1990 to a maximum of 83.3°F (26.5°C) in August 1988. Complete mixing of the Lake was restricted by thermal stratification in both summer and winter.

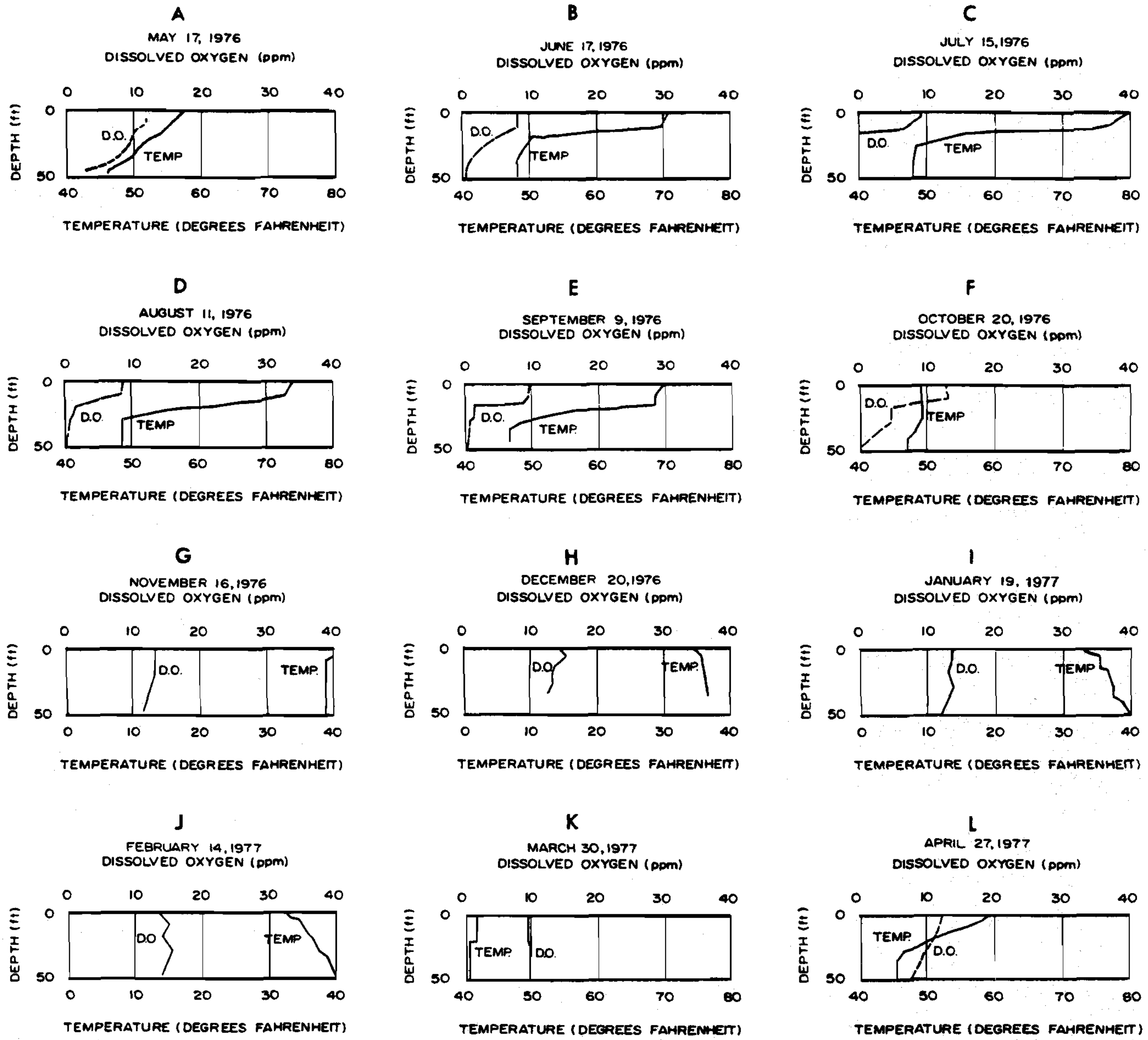
Thermal stratification is a result of the differential heating of lake water and the resulting water temperature-density relationships that develop at various depths within the lake water column. Water is unique among liquids because it reaches its maximum density, or mass per unit of volume, at about 39°F. The development of summer thermal stratification begins in early summer, reaches its maximum in late summer, and disappears in the fall. Stratification may also occur in winter under ice cover. This process is described below.

As summer begins, a lake absorbs solar energy at the surface. Wind action and, to some extent, internal heat transfer mechanisms transmit this energy to the underlying portions of the waterbody. As the upper layer of water is heated by solar energy, a physical barrier begins to form between the warmer surface water and the colder, heavier bottom water, as shown in Figure 3, for the month of June 1976. This "barrier" is marked by a sharp temperature gradient known as the thermocline and is characterized by a 1°C drop in temperature per three feet of depth that separates the warmer, lighter, upper layer of water (called the epilimnion) from the cooler, heavier, lower layer (called the hypolimnion). Although this barrier is readily crossed by fish, provided sufficient oxygen exists, it essentially limits the exchange of water between the two layers. This condition has a major impact on both the chemical and biological activity in a lake.

The autumnal mixing period occurs when air temperatures cool the surface water and wind action results in the erosion of the thermocline: as the surface water cools, it becomes heavier, sinking and displacing the

Figure 3

TEMPERATURE AND DISSOLVED OXYGEN PROFILES FOR FRIESS LAKE: 1976-1977



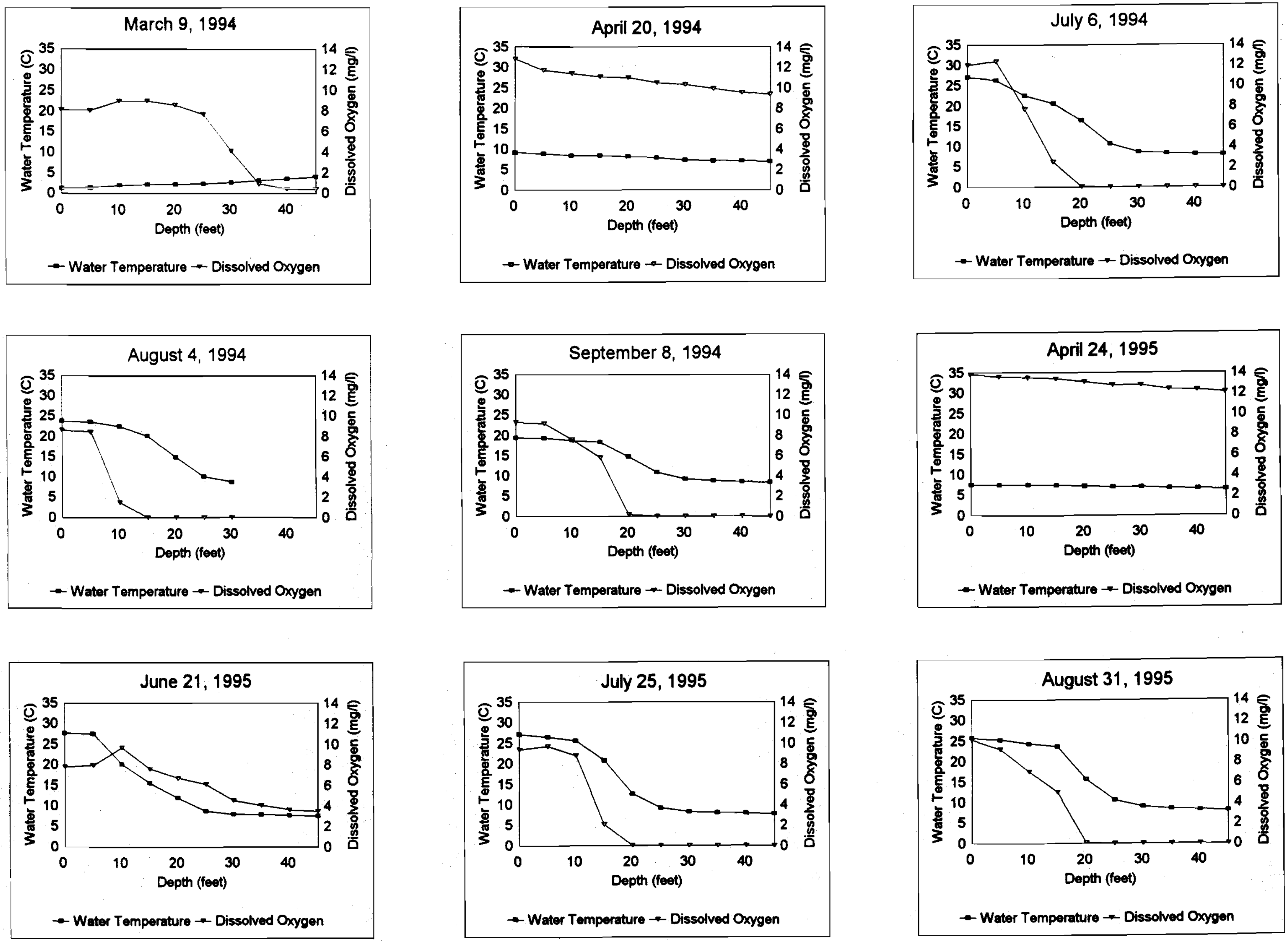
Source: Wisconsin Department of Natural Resources and SEWRPC.

now relatively warmer water below. The colder water sinks and mixes under wind action until the entire column of water is of uniform temperature, as shown in Figure 3, for the month of November 1976. This action, which follows summer stratification, is known as "fall turnover."

When the water temperature drops to the point of maximum water density, 39.2°F, the waters at the lake surface become more dense than the now warmer, less dense bottom waters, and "sink" to the bottom. Eventually, the water column is cooled to the point where the surface waters, cooled to about 32°F, are now lighter

Figure 4

TEMPERATURE AND DISSOLVED OXYGEN PROFILES FOR FRIESS LAKE: 1994-1995



Source: *Wisconsin Department of Natural Resources and SEWRPC.*

than the bottom waters which remain at about 39°F. The lake surface may then become ice covered, isolating the lake water from the atmosphere for a period of up to four months. On Friess Lake, ice cover typically exists from December until early April. As shown in Figure 3, for the month of January 1977, winter stratification occurred as the colder, lighter water and ice remained at the surface, separated from the relatively warmer, heavier water near the bottom of the Lake.

Spring brings a reversal of the process. As the ice thaws and the upper layer of water warms, it becomes more dense and begins to approach the temperature of the warmer, deeper water until the entire water column reaches the same temperature from surface to bottom. This is referred to as "spring turnover" and usually occurs within weeks after the ice goes out, as shown in Figures 3 and 4, for the month of March 1977 and April 1994. After spring turnover, the water at the surface again warms and becomes lighter, causing it to float above the colder, deeper water. Wind and resulting waves carry some of the energy of the warmer, lighter water to lower depths, but only to a limited extent. Thus begins the formation of the thermocline and another period of summer thermal stratification. The entire process is illustrated diagrammatically in Figure 5.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. As shown in Figures 3 and 4, dissolved oxygen levels were generally higher at the surface of Friess Lake, where there was an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels were lowest on the bottom of the Lake, where decomposer organisms and chemical oxidation processes utilized oxygen in the decay process.

When any lake becomes thermally stratified, as described above, the surface supply of dissolved oxygen to the hypolimnion is cut off. Gradually, if there is not enough dissolved oxygen to meet the total demands from the bottom dwelling aquatic life and decaying organic material, the dissolved oxygen levels in the bottom waters may be reduced, even to zero, a condition known as anoxia or anaerobiasis.

The hypolimnion of Friess Lake becomes anoxic during summer stratification. During both the 1976-1977 and the 1986-1995 monitoring periods, dissolved oxygen concentrations at the bottom of the Lake fell to zero by mid- to late-June, as shown in Figure 3, for the months of June, July, August, and September 1976. Even at a depth of approximately 15 feet, oxygen concentrations were at or below the recommended concentration of five milligrams per liter (mg/l), the minimum level necessary to support many species of fish during most years studied.

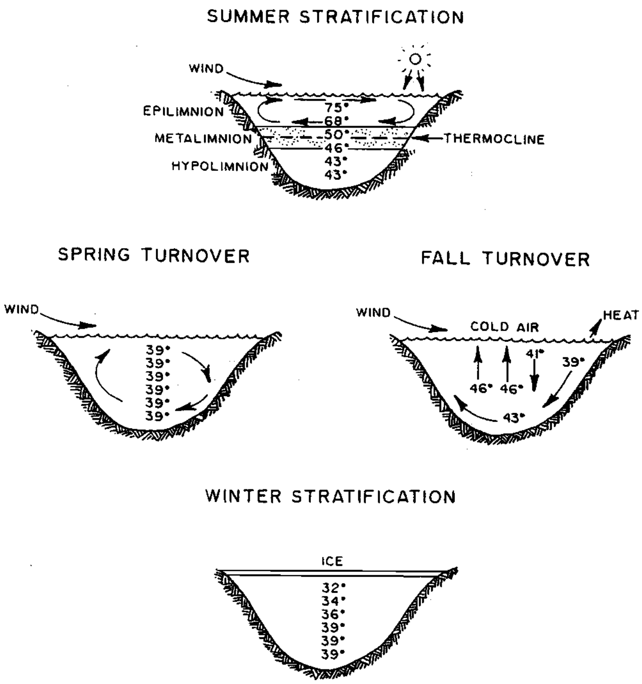
Fall turnover—between September and October in most years—naturally restores the supply of oxygen to the bottom water, although hypolimnetic anoxia can be reestablished during the period of winter thermal stratification. Winter anoxia is more common during the years of heavy snowfall, when snow covers the ice, reducing the degree of light penetration and reducing algal photosynthesis that takes place under the ice. In some lakes in the Region, hypolimnetic anoxia can also occur during winter stratification. Under these condition, anoxia contributes to winter-kill of fish. In Friess Lake, however, dissolved oxygen levels were found to be adequate for the support of fish throughout the winter. At the end of winter, dissolved oxygen concentrations in the bottom waters of the Lake were restored during the period of spring turnover, which generally occurs between March and May in most years.

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

In addition to these biological consequences of anaerobiasis, 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 state 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, espe-

Figure 5

THERMAL STRATIFICATION OF LAKES



Source: University of Wisconsin-Extension and SEWRPC.

cially during early summer, when these nutrients can become available for algal plant growth.

Specific Conductance

Specific conductance is an indicator of the concentration of dissolved solids in the water; as the amount of dissolved solids increases, the specific conductance increases. During winter and summer thermal stratification, specific conductance increases at the lake bottom due to an accumulation of dissolved materials in the hypolimnion, referred to as "internal loading," as shown in Figure 6. As shown in Table 9, the specific conductance of Friess Lake during the spring turnovers of 1986 through 1994 ranged from 380 to 678 microSiemens per centimeter at 25°C (μS/cm), which is somewhat higher than for most other Washington County lakes but within the normal range for lakes in Southeastern Wisconsin.[2] Higher values of specific conductance were measured during periods of summer stratification as shown in Table 10.

Alkalinity and Hardness

Alkalinity is an index of the buffering capacity of a lake, or the capacity of a lake to absorb and neutralize acids. The alkalinity of a lake depends on the levels of bicarbonate, carbonate, and hydroxide ions present in the water. Lakes in Southeastern Wisconsin typically have a high alkalinity because of the types of soil covering, and bedrock underlying, the watersheds. In contrast, water hardness is a measure of the multivalent metallic ions, such as calcium and magnesium, present in the lake. Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$). Applying these measures to the study lake, Friess Lake is a hard water, alkaline lake.

During the 1986-1995 monitoring period, alkalinity averaged about 290 mg/l, while hardness averaged about 336 mg/l, as shown in Table 10. The data are typical of the hard water lakes in the area. The total alkalinity was about average for lakes in Washington County, and within the normal range of lakes in Southeastern Wisconsin.[3]

Hydrogen Ion Concentration (pH)

The pH is a logarithmic measure of hydrogen ion concentration on a scale of 0 to 14 standard units, with 7.0 indicating neutrality. A pH above 7.0 indicates basic (or alkaline) water, a pH below 7.0 indicates acidic water. In Friess Lake, pH was found to range between 7.0 and 8.7 standard units, as shown in Table 10. These values, also, are within the normal range of lakes in the Region.[4] Since Friess Lake has a high alkalinity or buffering capacity, the pH does not fluctuate below 7.0 and the Lake is not susceptible to the harmful effects of acidic precipitation.

Chloride

Chloride concentrations measured during the 1976-1977 monitoring period ranged from 6.0 to 28 mg/l, which range is similar to that of most lakes in Southeastern Wisconsin. Although comparable data have not been gathered during the more recent monitoring program, it is unlikely that the chloride concentration of Friess Lake has changed substantially, given the similarities between the specific conductance values measured during both

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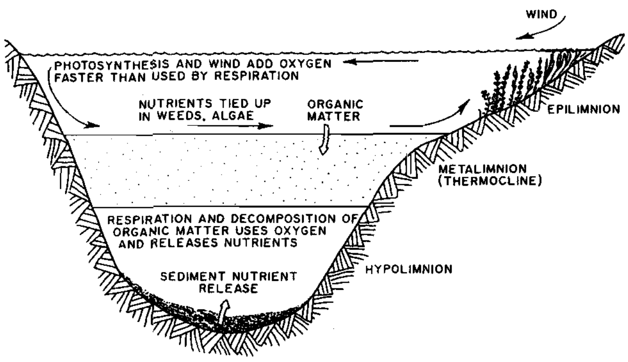
[2] *R.A. Lillie and J.W. Mason,* Limnological Characteristics of Wisconsin Lakes, *Technical Bulletin No. 138, Wisconsin Department of Natural Resources, 1983.*

[3] *Ibid.*

[4] *Ibid.*

Figure 6

LAKE PROCESSING DURING SUMMER STRATIFICATION



Source: University of Wisconsin-Extension and SEWRPC.

investigations. The most important anthropogenic sources of chlorides are believed to include road de-icing salts, sewage wastes, animal wastes, water softener discharges, and natural leaching of rock minerals.

Water Clarity

Water clarity, or transparency, gives an indication of overall water quality; clarity may decrease because of high concentrations of suspended materials, such as algae or silt, or due to high concentrations of dissolved organic substances, such as humic acids which contribute to the "tea staining" typical of most Wisconsin waterbodies. Water clarity is measured with a Secchi disk, a black-and-white, eight-inch-diameter disk, which is lowered into the water until a depth is reached at which the disk is no longer visible. This depth is known as the "Secchi-disk reading" or "Secchi-depth." These readings form an integral part of the DNR Self-Help Monitoring Program in which a citizen volunteer monitor is enrolled as part of the community's water quality monitoring effort, as discussed in Chapter VIII.

Water clarity generally varies throughout the year as algal populations increase and decrease in response to changing weather conditions and nutrient loadings. These same factors make Secchi-disk readings vary from year to year as well. Secchi-disk readings for Friess Lake ranged from a low of one foot in early March 1991, to a high of about 16 feet in early July 1994, as shown in Figure 7. Turbidity, another measure of water clarity, is generally low to moderate throughout the year, as shown in Table 9.

Chlorophyll-a

Chlorophyll-a is the major photosynthetic ("green") pigment in algae. The amount of chlorophyll-a present in the water is an indication of the biomass or amount of algae in the water. Chlorophyll-a concentrations in Friess Lake ranged from a low of 2.0 milligrams per cubic meter (mg/m^3), to a high of 133 mg/m^3 recorded in February 1990, with an average of 24.0 mg/m^3. This longer-term average exceeds the average value of about 14 mg/m^3 recorded during the 1976-1977 monitoring period. Chlorophyll-a concentrations were generally higher in recent years than during the previous monitoring period, possibly in response to the higher observed phosphorus concentrations, noted below and shown in Figure 7. The observed chlorophyll concentrations are consistent with the calculated concentrations derived from empirical models.[5]

These chlorophyll-a concentrations, observed during both monitoring periods, were assessed as being likely to result from excessive algal growth which may be severe enough to impair recreational activities such as swimming and waterskiing. Chlorophyll concentrations in excess of 15 to 20 mg/m^3 generally result in the water appearing "greenish." The longer-term average chlorophyll-a concentration of 24 mg/m^3 is well within the range of values indicative of nuisance algal growth conditions.[6] This value, however, is also within the range of chlorophyll-a concentrations recorded in other lakes in the Region.

Nutrient Characteristics

Aquatic plants and algae require such nutrients as phosphorus, nitrogen, carbon, calcium, chloride, iron, magnesium, sulfur, and silica for growth. In hard water, alkaline lakes, most of these nutrients are generally found in concentrations which exceed the needs of growing plants. However, in lakes where the supply of one or more of these nutrients is limited, plant growth is limited by the amount of that nutrient available. Two of the

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[5]*The Organization for Economic Cooperation and Development (OECD) model predicts an in-lake chlorophyll-a concentration of about 30 micrograms per liter ($\mu g/l$ = mg/m^3) from an in-lake total phosphorus concentration of 0.25 mg/l, using the combined model given in OECD,* Eutrophication of Waters: Monitoring, Assessment and Control, *Organization for Economic Cooperation and Development, Paris, 1982.*

[6]*OECD, ibid.*

Table 9

FRIESS LAKE SPRING OVERTURN WATER QUALITY: 1986-1994

Water Quality Parameter	April 22, 1986		April 9, 1987		April 26, 1989		April 18, 1990		April 18, 1991		April 15, 1992		March 18, 1993		April 20, 1994	
	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
Depth of Sample (feet)	0	45	0	45	0	45	0	48	0	50	0	45	0	42	0	45
Specific Conductance(μS/cm)	415	410	- -	- -	550	525	510	510	430	465	510	510	380	678	673	674
pH	8.0	7.8	8.2	8.1	8.1	8.0	8.3	8.2	8.2	8.2	8.3	8.3	8.0	7.6	8.3	8.3
Water Temperature (°C)	46.4	41.0	46.4	41.9	57.2	42.8	41.9	40.8	46.4	42.6	34.7	34.7	34.2	37.4	48.4	44.6
Color (platinum-cobalt scale)	50	40	50	50	30	30	20	50	40	50	50	40	- -	- -	40	40
Turbidity (Nephelometric turbidity units)	2.1	1.2	3.1	2.4	3.4	1.5	1.2	18.0	1.6	1.5	1.7	1.6	- -	- -	1.8	1.2
Secchi Disk (feet)	4.6	- -	4.3	- -	3.3	- -	6.6	- -	5.8	- -	5	- -	5.6	- -	6.3	- -
Dissolved Oxygen	12.0	4.0	16.6	12.0	15	6.2	13.3	11.2	12.5	10.4	15.6	15.3	8.7	0.6	12.8	9.4
Hardness, as $CaCO_3$	324	341	350	360	340	360	360	360	350	350	330	330	- -	- -	270	290
Calcium	77	82	81	82	70	77	77	78	76	76	72	72	- -	- -	62	65
Magnesium	32	33	37	37	39	40	40	40	38	38	37	36	- -	- -	29	30
Sodium	10	10	10	10	12	12	12	12	11	11	11	11	- -	- -	10	11
Potassium	2.0	2.0	2.0	2.0	2.5	2.5	3.1	3.2	2.6	2.69	2.6	2.57	- -	- -	2.09	2.12
Alkalinity, as $CaCO_3$	270	280	298	298	250	258	264	269	269	272	273	273	- -	- -	296	297
Sulfate	42	44	41	41	74	72	- -	- -	61	61	54	54	- -	- -	31	31
Dissolved Solids	8.1	12.0	9.7	10.0	3.1	5.5	7.8	8.2	7.3	7.4	9.1	9.1	- -	- -	6.8	7.2
Nitrate/Nitrite Nitrogen	1.2	1.2	1.2	1.3	1.2	1.2	1.2	1.1	1.2	- -	1.3	1.3	- -	- -	1.1	1.2
Ammonia Nitrogen	0.0003	0.002	0.0004	0.0003	0.0005	0.005	0.006	0.007	0.002	0.003	0.0006	0.0005	- -	- -	0.004	0.007
Total Nitrogen	- -	1.1	1.4	1.1	1.3	1.3	- -	- -	1.4	1.2	1.2	1.1	- -	- -	1.1	1.1
Total Phosphorus	- -	0.10	0.070	0.059	0.065	0.055	0.094	- -	0.075	0.074	0.074	0.065	0.264	0.158	0.122	0.120
Ortho-phosphorus	0.004	0.077	0.004	0.005	0.005	0.023	0.032	0.053	0.021	0.034	0.002	0.002	- -	- -	0.055	0.092
Iron (μg/l)	- -	- -	- -	- -	0.08	0.05	0.05	0.34	0.07	0.06	0.07	0.07	- -	- -	0.13	0.15
Manganese (μg/l)	40	150	- -	- -	40	84	40	84	40	40	40	40	- -	- -	67	80
Chlorophyll-a (μg/l)	4.2	- -	69	- -	43	- -	26	- -	21	- -	40	- -	- -	- -	36.8	- -

Source: U.S. Geological Survey and SEWRPC.

Table 10

SEASONAL WATER QUALITY DATA FOR FRIESS LAKE: 1986-1995

Parameter[a]	Winter (January to March)		Spring (April to mid-June)		Summer (mid-June to mid-September)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Temperature (°F)						
Range	32-48.4	36.1-44.6	31.7-76.6	34.7-44.6	60.4-83.3	37.2-47.8
Mean[d]	35.8 (7)	39.4 (7)	51.1 (9)	41.4 (9)	73.7 (22)	43.4 (22)
Dissolved Oxygen						
Range	7.8-8.3	0-9.4	8.3-16.6	0-15.3	7.7-17.1	0-7.2
Mean[d]	7.6 (7)	2.1 (7)	12.4 (9)	6.7 (8)	10.2 (22)	0.9 (22)
Conductivity (μS/cm)						
Range	235-673	425-725	380-673	465-678	430-680	520-715
Mean[d]	424 (6)	555 (6)	522 (7)	573 (7)	585 (20)	620 (21)
pH (standard units)						
Range	7.5-8.3	7.3-8.3	7.5-8.3	7.5-8.3	7.0-8.7	7.2-8.0
Mean[d]	7.8 (7)	7.6 (7)	8.1 (9)	7.9 (9)	7.8 (22)	8.0 (22)
Secchi Disk (feet)						
Range	0.9-9.2	- -	3.3-16.1	- -	2.5-16.5	- -
Mean[d]	5.3 (7)	- -	6.9 (9)	- -	5.8 (22)	- -
Total Phosphorus						
Range	0.02-0.27	0.03-0.21	0.02-0.26	0.06-0.24	0.01-0.07	0.12-0.56
Mean[d]	0.12 (7)	0.44 (6)	0.09 (9)	0.12 (8)	0.03 (22)	0.28 (20)

NOTE: Number in parentheses represents number of samples.

[a]*Milligrams per liter unless otherwise indicated.*

[b]*Depth of sample approximately three feet.*

[c]*Depth of sample greater than 45 feet.*

[d]*Number of samples in parentheses.*

Source: U.S. Geological Survey and SEWRPC.

most important nutrients in this respect are phosphorus and nitrogen.

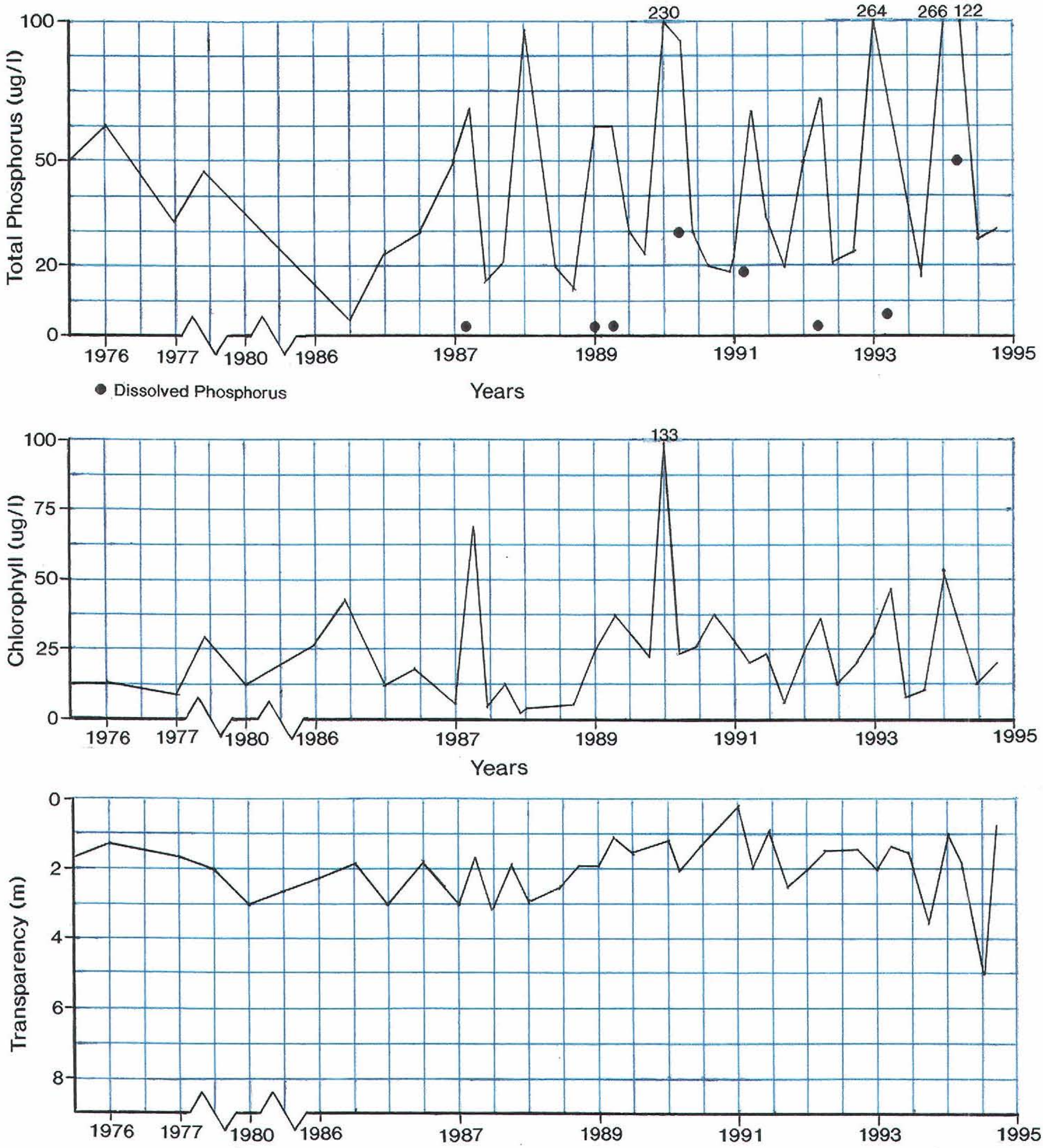
Phosphorus

Both total phosphorus and soluble phosphorus concentrations were measured in Friess Lake. Soluble phosphorus, being dissolved in the water column, is readily available for plant growth. However, its concentration can vary widely over short periods of time as plants take up and release this nutrient. Therefore, total phosphorus is usually considered a better indicator of nutrient status. Total phosphorus includes the phosphorus contained in plants and animal fragments suspended in the lake water, phosphorus bound to sediment particles, and phosphorus dissolved in the water column.

The Southeastern Wisconsin Regional Planning Commission recommends that total phosphorus concentrations in lakes not exceed 0.02 mg/l during spring turnover. This is the level above which nuisance algal and macrophyte growths may occur. The total phosphorus concentrations in Friess Lake at spring turnover were consistently greater than the recommended mean concentration of 0.02 mg/l, generally exceeding 0.05 mg/l in the surface waters of the Lake during most years of record. Spring total phosphorus concentrations of about 0.25 mg/l have

Figure 7

FRIESS LAKE PRIMARY WATER QUALITY INDICATORS: 1976-1995



Source: Wisconsin Department of Natural Resources and SEWRPC.

been observed in surface waters during 1990, 1993 and 1994 as shown in Figure 7. Dissolved phosphorus concentration averaged less than 0.05 mg/l suggesting that the majority of the phosphorus was in particulate form. Particulate phosphorus may be less readily available to algae, more likely to settle out of suspension in the water column, and more susceptible to being washed out of the lake during high-flow events, although the particulate phosphorus that is retained within the lake may become available in subsequent years through the internal loading processes noted. Concentrations of dissolved phosphorus in excess of 0.02 mg/l are indicative of poor water quality.

When aquatic organisms die, they usually sink to the bottom of the lake, where they decompose. Phosphorus from these decomposed organisms is usually stored in the bottom sediments. Because phosphorus is not readily soluble in water, it generally forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions, and accumulates in a particulate form in the lake sediments. However, when the bottom waters become depleted of oxygen during stratification, certain chemical changes occur, especially the change in the oxidation state of iron from the insoluble Fe^{3+} state to the more soluble Fe^{2+} state. The effect of these chemical changes is that phosphorus becomes soluble and is released from the sediments. This process also occurs under aerobic conditions, but generally at a slower rate. As the waters begin to mix during spring and fall turnover, this phosphorus can be mixed throughout the lake and may become available for algal growth. If the turnover event is slow, over several weeks, this hypolimnetic phosphorus is generally readsorbed by the iron and precipitates back to the sediment. If the process is more rapid, a few days or less, some of this phosphorus may be circulated into the upper waters of the lake, generally in a bio-available form, where it can be taken up very rapidly by algae.

While no chemical analyses of the sediments of Friess Lake have been carried out, releases of phosphorus from the sediments can be inferred from an examination of the hypolimnetic phosphorus concentrations. In the hypolimnion, or bottom waters, of Friess Lake, total phosphorus concentrations were high, ranging up to 0.56 mg/l, as shown in Table 10. The average bottom water, total phosphorus concentration in Friess Lake during the 1986-1995 monitoring period was 0.28 mg/l. The dissolved phosphorus concentrations in the bottom waters were also high, ranging up to 0.24 mg/l for samples collected during the summer anoxic periods consistent with the release of phosphorus from the lake sediments. These concentrations are in contrast to the surface water concentrations which averaged 0.03 and 0.02 mg/l, respectively, for total and dissolved phosphorus, during the 1986-1995 monitoring period. However, based on a comparison of the bottom and surface water phosphorus concentrations, the contribution of phosphorus from the anoxic area of Friess Lake to the euphotic zone, or area of light penetration where algal growth occurs, is likely to be small in terms of the total phosphorus load when compared to the external phosphorus load from the watershed. In other words, while phosphorus was released from the sediments into the bottom water of Friess Lake, the phosphorus remained largely trapped in the hypolimnion and did not significantly contribute to the phosphorus pool in the epilimnion. Indeed, there would appear 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.

Nitrogen

Several nitrogen species or fractions were measured annually during the 1986-1995 monitoring period, including total Kjeldahl nitrogen, nitrate and nitrite nitrogen, and total ammonia. Of these fractions, total Kjeldahl nitrogen is analogous to total phosphorus, incorporating both organic and inorganic forms of nitrogen present in the lake water. Nitrate—nitrite is generally present in trace amounts in fresh waters—is the biologically available form, and ammonia plus ammonium is typically the product of microbial decomposition processes and, hence, generally most abundant in the anoxic waters of the hypolimnion.

Total Kjeldahl nitrogen concentrations observed in Friess Lake ranged from 1.1 mg/l to 1.4 mg/l, as shown on Table 9. Average surface water concentrations of total Kjeldahl nitrogen observed during the 1986-1995 monitoring period were 1.3 mg/l; hypolimnetic concentrations averaged 1.1 mg/l during this same period. Nitrate plus nitrite concentrations ranged from 1.1 to 1.3 mg/l in both surface and bottom waters, except during 1993 when concentrations declined to between 0.5 and 0.9 mg/l in surface and bottom waters, respectively—1993 was a year with very high runoff that resulted in a flushing of the Lake with low-nitrogen rain water. Total ammonia ranged from 0.02 mg/l in the surface waters to 0.53 mg/l in the bottom waters of Friess Lake. These concentrations of nitrogen are high but within the ranges observed for various nitrogen fractions in Wisconsin lakes.

Nitrogen-to-Phosphorus Ratio

The ratio of total nitrogen to total phosphorus in lake water, or the N:P ratio, can indicate which nutrient is most likely to be the nutrient limiting aquatic plant growth. Where the nitrogen-to-phosphorus ratio is greater than 14:1, a lake is probably phosphorus-limited, while a ratio of less than 10:1 indicates that nitrogen is probably the limiting nutrient.[7] As shown in Table 11, the nitrogen-to-phosphorus ratios in samples collected from Friess Lake were always 9:1 or greater, and ranged from 12.8 to 20.0, except for one year. This indicates that aquatic plant production was most likely limited by phosphorus. Other factors, such as light and turbulence or through flow, may also limit plant growth; these are discussed further below.

POLLUTION LOADINGS AND SOURCES

Currently, there are no known point source discharges to Friess Lake or to the surface waters tributary to Friess Lake. Nonpoint sources of water pollution include urban sources, such as runoff from residential, commercial, industrial, transportation, construction, and recreational activities; and rural sources, such as runoff from cropland, pasture and woodland. In order to estimate the amount of pollution contributed by these sources to Friess Lake, and eventually to the Oconomowoc chain of lakes downstream, annual loading budgets for phosphorus and sediment were developed as shown in Figure 8.

Estimates of the phosphorus and suspended solids loadings to Friess Lake from total tributary drainage area were made by the Washington County Land Conservation Department using the Wisconsin Nonpoint Source computer model WINHUSLE,[8] and augmented by phosphorus loading estimates for that portion of the drainage area directly tributary to Friess Lake made by Commission staff using the Wisconsin Lakes computer model Wisconsin Lake Model Spreadsheet (WILMS).[9]

Runoff-related contributions were calculated for an average rainfall year using a 10-year data set from West Bend, Wisconsin. Inflow and outflow of surface water was estimated by extrapolating stream flow measurements collected from the Rock River at Afton, Wisconsin—U.S. Geological Survey gauging station number 05430500. Groundwater and atmospheric contributions of phosphorus and suspended solids, previously calculated for use in the initial plan, based on precipitation records and literature values for the different constituents which were considered to be representative of the Friess Lake region,[10] were also used in this analysis.

Phosphorus has been identified as the factor generally limiting aquatic plant growth in Friess Lake, and has been used as the basis for lake water quality modeling in both the initial plan and the current planning studies. Excessive levels of phosphorus in the Lake are likely to result in conditions which interfere with the desired use of the lake.

Based on the results of the modeling conducted, using 1990 data for land uses in the Friess Lake total tributary drainage area, approximately 2,800 pounds of phosphorus are estimated to be delivered to the Lake during an average year, as shown in Table 12 and Figure 8. Of the total annual loading, about 1,980 pounds, or about 70 percent, were contributed by the inflow of the Oconomowoc River. Direct precipitation and groundwater-borne phosphorus loadings—comprising 94 pounds per year and 101 pounds per year, respectively—represent together about 7 percent of the total loading. The contribution of phosphorus to Friess Lake from the drainage area directly tributary to Friess Lake, including the contribution from the area draining to the unnamed tributary draining to the Lake on the east shoreline is estimated to be about 425 pounds per year, or about 15 percent of the total loading. The contribution of phosphorus from onsite sewage treatment systems is estimated to be between 70 and 224 pounds per year, depending on the efficiency of the onsite systems. The residential development immediately surrounding Friess Lake is located in areas covered by soils with indeterminate suitability for use of conventional onsite septic tanks due to the range of soil characteristics and slopes which occur, as shown on Map 5. Provided that the

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[7]*M.O. Allum, R.E. Gessner, and T.H. Gakstatter,* An Evaluation of the National Eutrophication Data, *U.S. Environmental Protection Agency Working Paper No. 900, 1977.*

[8]*K. Baun, and S. Snowdon,* The Wisconsin Nonpoint (WIN) Model Version 2.2, *Wisconsin Department of Natural Resources, 1988.*

[9]*Wisconsin Department of Natural Resources Publication No. PUBL-WR-363-96 REV,* Wisconsin Lake Model Spreadsheet Version 2.0 User's Manual, *June 1994.*

[10]*J.W. Kluesner,* Nutrient Transport and Transformations in Lake Wingra, Wisconsin, *Ph.D. Dissertation, University of Wisconsin-Madison, 1972; T.J. Murphy and P.V. Doskey, "Inputs of Phosphorus from Precipitation to Lake Michigan,"* Journal of Great Lakes Research, *Volume 2, No. 1, pp. 66-70, 1976.*

Table 11

NITROGEN-PHOSPHORUS RATIOS FOR FRIESS LAKE: 1989-1994

	Nutrient Levels		
Date	Nitrogen (mg/l)	Phosphorus (mg/l)	N:P Ratio
April 16, 1989	1.3	0.065	20.0
April 18, 1990	1.2	0.094	12.8
April 18, 1991	1.1	0.075	14.7
April 15, 1992	1.3	0.074	17.6
March 18, 1993	- -	0.074	- -
April 20, 1994	1.1	0.122	9.0

Source: U.S. Geological Survey and SEWRPC.

systems are located, installed, used, and maintained properly, onsite sewage disposal systems may be expected to operate with few problems for periods of about 20 to 25 years. Failure of a conventional septic tank system occurs when the soil surrounding the seepage area will no longer accept or properly stabilize the septic tank effluent. While many older onsite sewage disposal systems may have met *Wisconsin Administrative Code* requirements when installed, these requirements have changed over the years, with the effect that many older systems no longer conform to present practices. Other installations, designed for vacation or seasonal home use, may be now in use year-round and are potentially subject to overloading.

The sediment loading analysis, as summarized in Figure 8, indicates that about 516 tons of sediment is delivered to the Lake annually with about 402 tons, or about 76 percent, of this sediment loading being attributed to the Oconomowoc River inflow.

RATING OF TROPHIC CONDITION

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 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. Lakes that are extremely enriched are often referred to as being hyper-eutrophic or hypertrophic.

Oligotrophic lakes are nutrient-poor lakes. These lakes characteristically support relatively few aquatic plants and often do not contain 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. 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 algal blooms. If the lakes are shallow, fish winterkills may be common. While portions of these lakes are not ideal for swimming and boating, many eutrophic lakes support very productive fisheries. Hypertrophic lakes may be functionally unusable due to excessive plant growth and frequent fish kills.

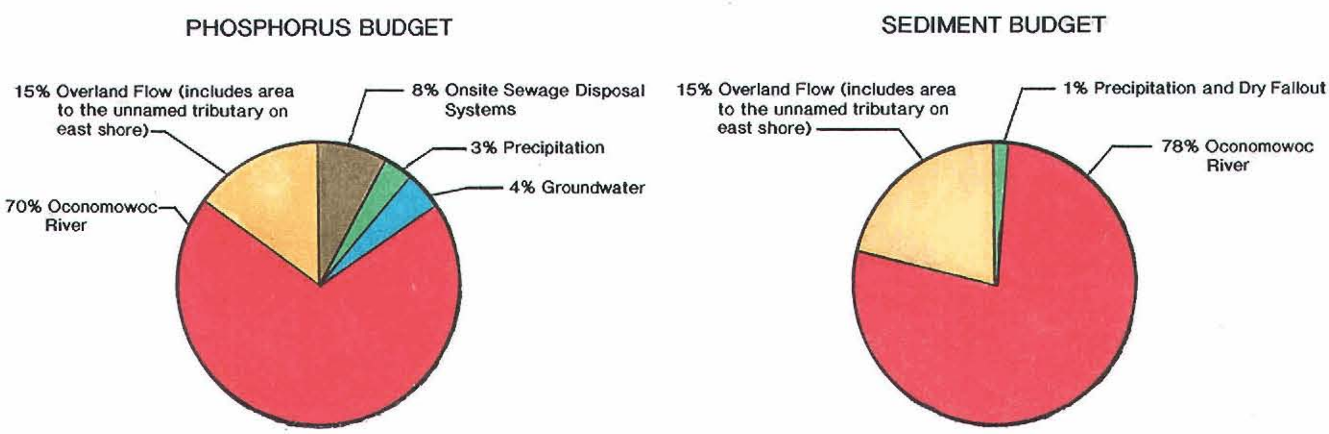
Several numeric "scales," based on one or more water quality parameters have been developed to define the trophic condition of a lake. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numeric scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scales are appropriate for the lake to which it is applied. In this case, two indices are commonly used; namely, the Vollenweider open-ended trophic classification system,[11] and the Carlson Trophic State Index (TSI),[12] as modified in the Wisconsin Trophic State Index

[11] *Organization for Economic Cooperation and Development (OECD),* Eutrophication of Waters: Monitoring, Assessment and Control, *Paris, 1982; S.-O. Ryding and W. Rast,* The Control of Eutrophication of Lakes and Reservoirs, *UNESCO/MAB Series 1, Parthenon Press, 1989; and H. Olem and G. Flock,* The Lake and Reservoir Restoration Guidance Manual, *2nd Edition, US EPA Report EPA-440/4-90-006, Office of Water (WH-553), Washington, DC, 1990.*

[12] *R.E. Carlson, "A Trophic State Index for Lakes,"* Limnology and Oceanography, *Volume 22, No. 2, 1977, pp. 361-369.*

Figure 8

PHOSPHORUS AND SEDIMENT BUDGETS FOR FRIESS LAKE: 1990



Source: Washington County Land Conservation Department and SEWRPC.

(WTSI).[13] The Carlson Index has recently been supplemented by the more appropriate Wisconsin Trophic State Index by the Wisconsin Department of Natural Resources to account for the peculiar characteristics of Wisconsin Lakes, generally related to their higher levels of dissolved humic color.

Vollenweider-OECD Trophic Classification System

The European Organization for Economic Cooperation and Development (OECD) investigated numerous lakes and reservoirs from around the world with the majority of their approximately 750 lakes in Europe and North America, and developed a number of empirical relationships between chlorophyll-a, Secchi-disk transparency, phosphorus, nitrogen, primary productivity, and trophic status. The result was both a set of predictive models and a set of trophic boundary descriptors. Applying the latter to the Friess Lake data given in Table 10 results in the Lake being classified as having a 1 percent probability of being oligotrophic, a 30 percent probability of being mesotrophic, a 60 percent probability of being eutrophic, and a 9 percent probability of being hypertrophic, based on the total phosphorus concentration as shown in Figure 9. Similarly, using chlorophyll-a concentration, the Lake has a 2 percent probability of being mesotrophic, a 22 percent probability of being eutrophic, and a 76 percent probability of being hypertrophic. The Secchi-disk-based classification yields a similar result: a 1 percent probability of being mesotrophic, a 19 percent probability of being eutrophic, and an 80 percent probability of being hypertrophic, as shown in Figure 9. Thus, Friess Lake should be classified as an eutrophic lake.

Trophic State Index

The Trophic State Index (TSI) is computed using total phosphorus, Secchi-disk transparency, and chlorophyll-a measurements to assign a trophic status rating to a lake. TSI values of 40 or less are indicative of oligotrophic lakes, values of 40 to 50 are indicative of mesotrophic lakes, values of 50 to 60 are indicative of eutrophic lakes, and values greater than 60 are indicative of hypertrophic lakes. Correcting for the coloration of waters in Wisconsin, the Wisconsin Trophic State Index (WTSI) ratings of less than 44 are indicative of oligotrophic lakes; ratings of 44 to 53 signify mesotrophic lakes; and ratings higher than 54 are indicative of eutrophic lakes. WTSI ratings of greater than 75 are indicative of hypertrophic lakes.

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[13]*R.A. Lillie, S. Graham, and P. Rasmussen, "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes,"* Research Management Findings, *No. 35, Wisconsin Department of Natural Resources Publication PUBL-RS-735-93, 1993.*

Table 12

PHOSPHORUS LOADS TO FRIESS LAKE: 1990

Inputs	1990 (pounds per year)	Percent of Total
Oconomowoc River Inflow	1,977[a]	70
Surface Drainage, Including Unnamed Tributary on Eastern Shoreline	425[b]	15
Direct Precipitation	94	3
Groundwater	101	4
Onsite Sewage Systems	224[c]	8
Livestock	--[d]	--
Total	2,821	100

[a]*Estimated using WINHUSLE for the total drainage area tributary to Friess Lake.*

[b]*Estimated using WILMS for the drainage area directly tributary to tributary to Friess Lake.*

[c]*Contribution from onsite sewage disposal systems was estimated to range from 70 to 224 pounds per year, depending upon the effectiveness of the systems.*

[d]*Runoff from livestock operations and its attendant contribution to the phosphorus load to Friess Lake is included in the load estimated to be delivered from the Oconomowoc River.*

Source: SEWRPC.

Figure 10 sets forth the TSI calculations for the monitoring period of May 1976 through April 1977 for Friess Lake. The chlorophyll-a values shown in Figure 10, ranging between 40 and 60 on the TSI scale, indicate that the lake water quality is characteristic of a mesotrophic lake, whereas values based on the total phosphorus concentration, ranging from 48 to 73, and Secchi-disk values, ranging from 43 to 55, indicate that the lake is eutrophic.

Longer-term data suggest little change in Friess Lake trophic state. Data obtained from the Wisconsin Department of Natural Resources Long-Term Trend Monitoring Program[14] and other data presented in the regional

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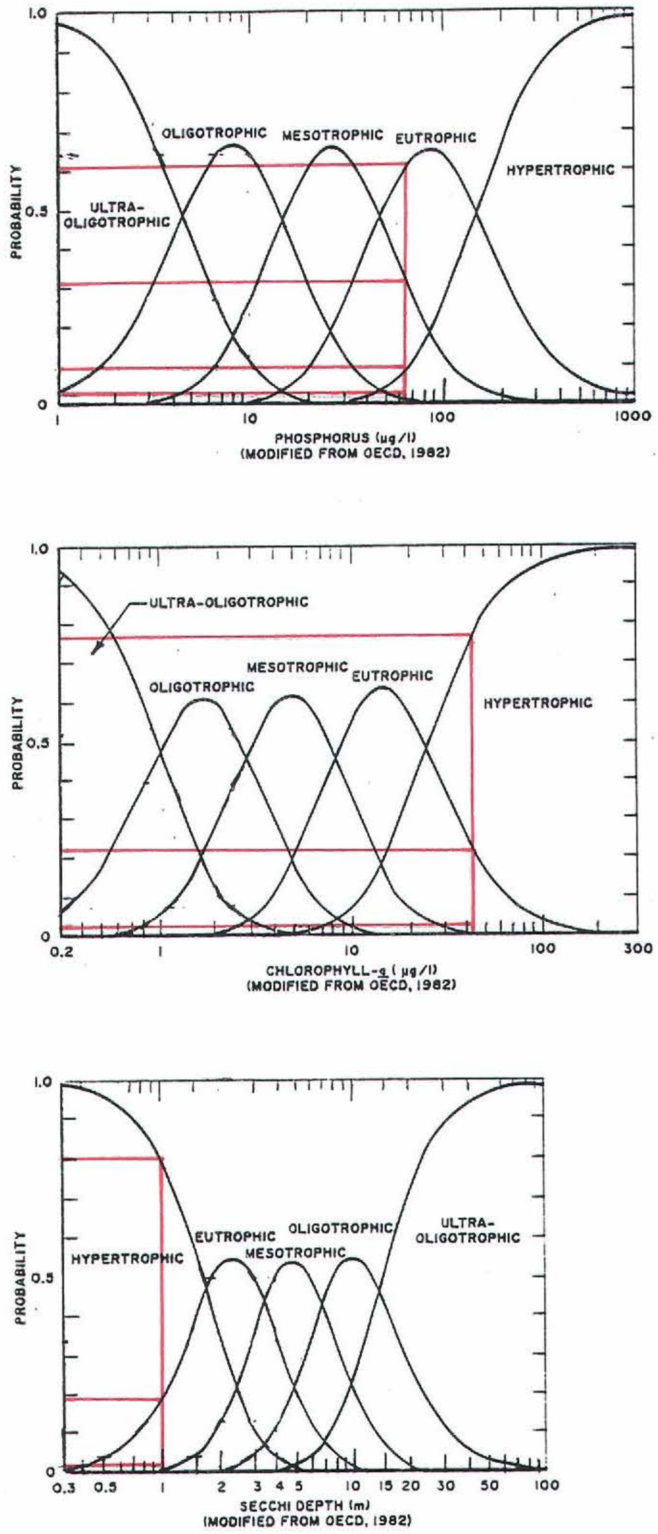
[14]*1986 and 1987 data are contained in draft Wisconsin Department of Natural Resources reports,* Friess Lake, Washington County: Long Term Trend Lake 1986 *and* Friess Lake, Washington County: Long Term Trend Lake 1987. *Total phosphorus TSI values ranged from 50 to about 56 in 1986, and from about 45 to approximately 70 in 1987; chlorophyll-a TSI values ranged from about 51 to about 56 in 1986, and from about 41 to approximately 65 in 1987; and Secchi-disk TSI values ranged from about 50 to about 70 in 1986, and from about 37 to approximately 60 in 1987.*

Figure 9

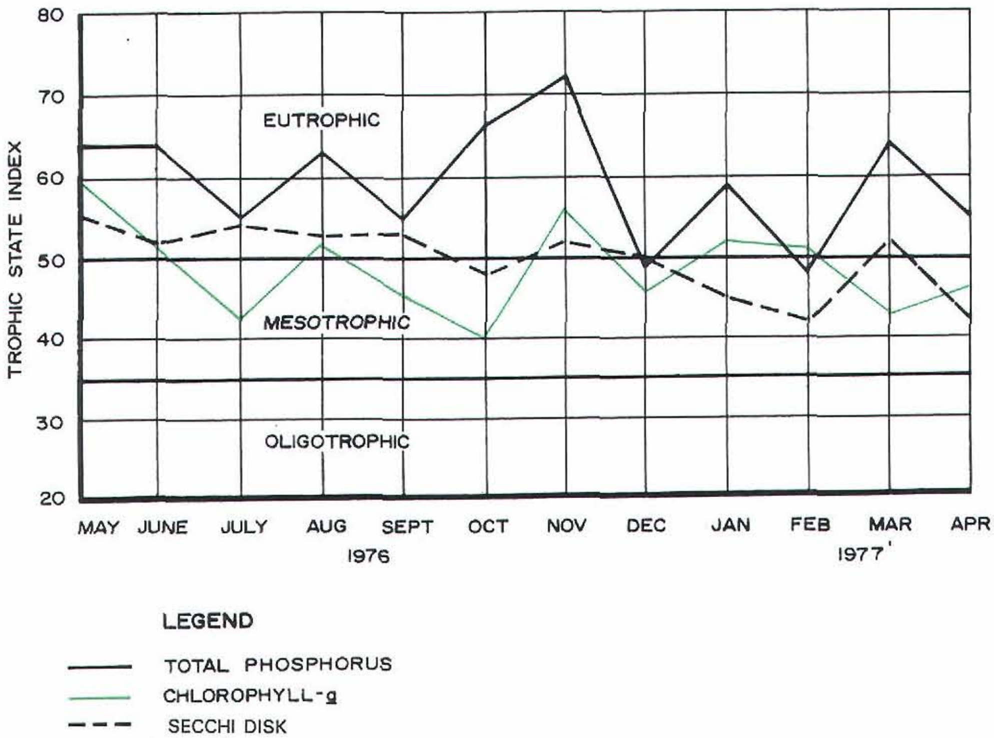
TROPHIC STATE CLASSIFICATION OF FRIESS LAKE BASED ON THE VOLLENWEIDER MODEL



Source: S.-O. Ryding and W. Rast, The Control of Eutrophication of Lakes and Reservoirs, Vol. 1, 1989; and SEWRPC.

Figure 10

TROPHIC STATE INDEX CALCULATIONS FOR FRIESS LAKE: 1976-1977



Source: Wisconsin Department of Natural Resources and SEWRPC.

water quality management plan update and status report, gathered from a variety of sources and compiled on the US EPA STORET data base,[15] suggest that the Lake is eutrophic. WTSI values calculated for Friess Lake range from 50, using Secchi-disk transparency data, to 62, using total phosphorus data. Chlorophyll-a data result in a WTSI value of 58. These data, as shown in Figure 11, are also that Friess Lake is eutrophic.

Based on the above classifications and analyses, it may be concluded that the characteristics of Friess Lake are indicative of a eutrophic lake.

Water Quality Index

The Lillie and Mason Water Quality Index compares the range of conditions in a specific waterbody to a range of conditions observed in other Wisconsin lakes. Ratings of water quality, ranging from very poor to excellent reflect a statistical analysis of lake condition as related to a multiple recreational uses. This rating system is approximately analogous to the trophic system described above and in other indices, with excellent water quality equivalent to ultraoligotrophic conditions and very poor water quality being equivalent to hypertrophic conditions. The ratings applied to Friess Lake cover a wide range, with most indicators being in the fair to poor range based on average values, as shown in Figure 12.

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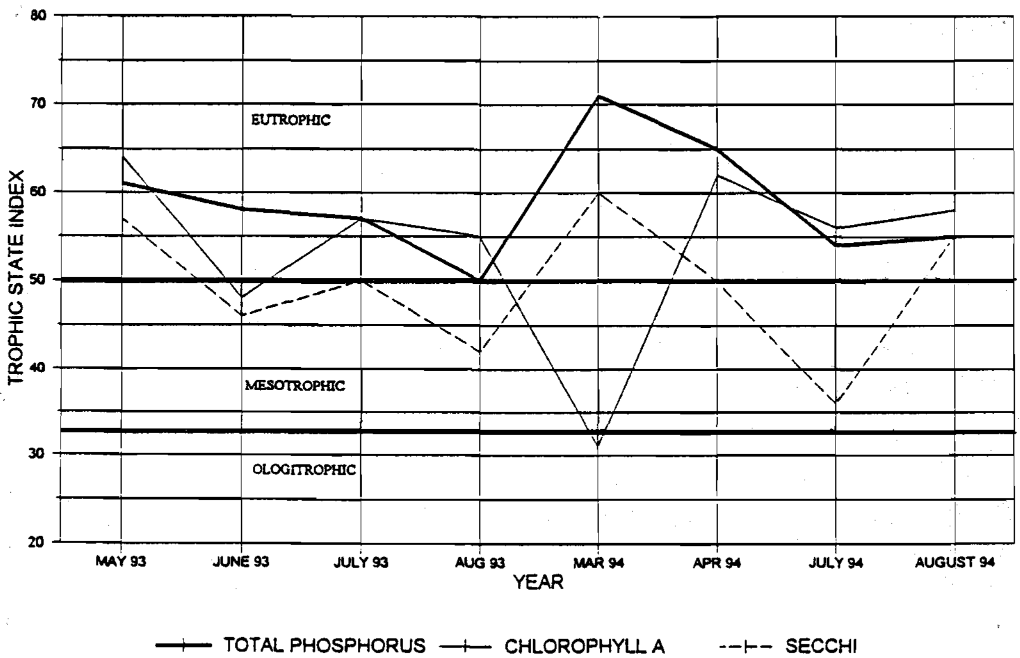
[15]*SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995. TSI values for Friess Lake reported herein range from 49 based on 1979-81 satellite imagery as reported in Wisconsin Department of Natural Resources Publication,* Wisconsin Lakes—A Trophic Assessment Using Landsat Digital Data, *1983, to 59 based on post-1981 water chemistry data; pre-1981 data compiled in the US EPA STORET data base yield a TSI value of 54.*

Figure 11

TROPHIC STATE INDEX CALCULATIONS FOR FRIESS LAKE: 1993-1994



Source: SEWRPC.

SUMMARY

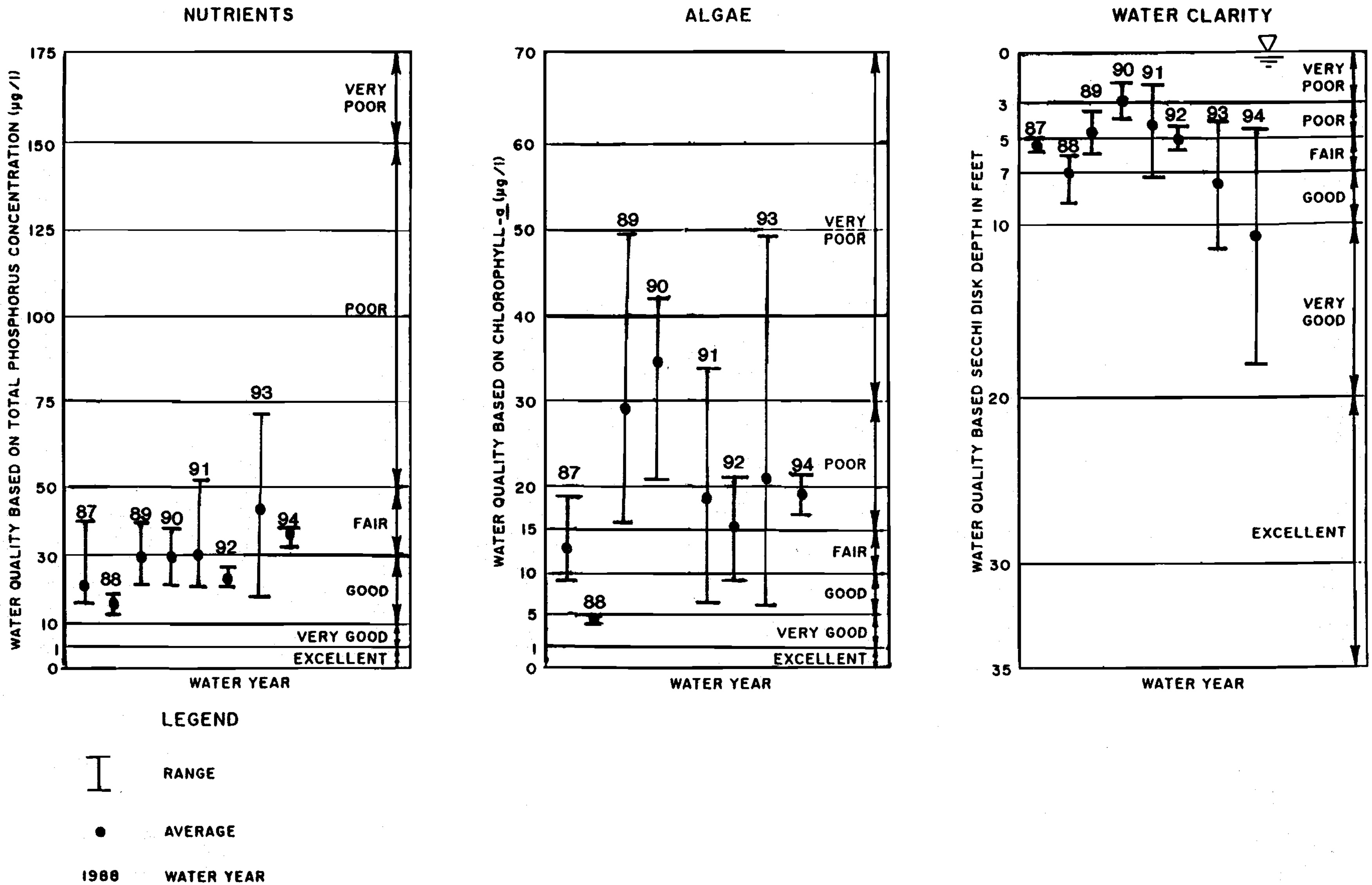
Friess Lake represents a typical hard-water alkaline lake that has been subjected to high levels of pollution. Physical and chemical parameters measured during the monitoring period indicate that water quality is within fair to poor water quality range. Total phosphorus values were found to be higher than the level considered to cause nuisance algal and macrophyte growths. During summer stratification, the water below a depth of approximately 15 feet was found to be low in, or devoid of, oxygen, while the upper layers remain well-oxygenated and supported an healthy fish population (see Chapter V). Winter kill does not seem to be a problem in Friess Lake because dissolved oxygen levels were found to be adequate for the support of fish throughout the winter. Internal releases of phosphorus from the bottom sediments did occur but were likely to be small when compared to the total external nutrient load.

There were no known point sources of pollutants in the Friess Lake watershed. Nonpoint sources of pollution include stormwater runoff from urban and agricultural areas. Suspended solids and phosphorus loadings from the total tributary drainage area of Friess Lake were estimated using the WINHUSLE model. Phosphorus loads from the drainage area directly tributary to Friess Lake were estimated using the WILMS model. These models describe the long-term average conditions in the watershed. During an average year, it is estimated that about 2,800 pounds of phosphorus enter the Lake. The Oconomowoc River contributed the largest amount of phosphorus, about 70 percent of the load. Based on the Vollenweider-OECD open-ended trophic state classification system and the Wisconsin Trophic State Index ratings calculated from Friess Lake data—1987 through 1995—Friess Lake may be classified as an eutrophic lake.

Important water quality considerations to be considered further in subsequent sections of this report are the potential impacts of continued urban growth in the Oconomowoc River basin upstream of Friess Lake on water quality conditions and alternatives for protecting Friess Lake from problems that may arise from these sources. In addition, lake management actions that will maintain or reduce other pollution sources are also to be considered.

Figure 12

FRIESS LAKE PRIMARY WATER QUALITY INDICATORS: 1987-1994



Source: U.S. Geological Survey and SEWRPC.

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Chapter V

AQUATIC BIOTA, NATURAL RESOURCE BASE, AND ECOLOGICALLY VALUABLE AREAS

INTRODUCTION

Friess Lake is an important part of the natural resource base of southwestern Washington County. The Lake, its biota, and the adjacent park and residential lands combine to contribute to the quality of life in the area. When located in partially urban and urbanizing settings, resource features such as lakes are typically subjected to intensive recreational use and high levels of pollutant discharges, common forms of stress to aquatic systems which may result in the deterioration of these natural resource features. For this reason, the formulation of sound management strategies must be based on a thorough knowledge of the pertinent characteristics of the resource features. Accordingly, this chapter provides information concerning the natural resource features of the drainage area tributary to Friess Lake, including data on primary environmental corridors, aquatic plants, fish, and wildlife.

AQUATIC PLANTS

Aquatic plants include larger plants, or macrophytes, and microscopic algae, or phytoplankton. These plants form an integral part of the aquatic food web, converting inorganic nutrients present in the water and sediments into organic compounds which are directly available as food for other aquatic organisms. In this process, known as photosynthesis, plants utilize energy from sunlight and release oxygen required by other aquatic life forms.

To document the types, distribution, and relative abundance of aquatic macrophytes in Friess Lake for the aforereferenced 1983 plan, a survey was conducted in August 1976. Further aquatic plant surveys were done on Friess Lake as part of the Long-Term Trend Monitoring Program during the summers of 1986, 1992, and 1995. An additional survey was conducted by the Commission staff in August of 1994.

Phytoplankton, commonly referred to as algae, are at the base of the food chain and vital to all life in a lake. Surveys to document the types, distribution, and relative abundance of phytoplankton in Friess Lake were completed by the Wisconsin Department of Natural Resources during the period of May 1976 through April 1977, during which 17 samples were taken, and April through August of 1986, during which four samples were taken.

Aquatic Macrophytes

Aquatic macrophytes are an important factor in the ecology of Southeastern Wisconsin lakes. They can be either beneficial or a nuisance, depending on their distribution and abundance. Table 13 summarizes the ecological benefits to be derived from some of the more common aquatic plant species found in the Friess Lake. Generally, macrophytes in lakes are an asset because they provide habitat for other forms of aquatic life and may remove nutrients and pollutants from the water that otherwise could contribute to excessive algae growth. Aquatic plants become a nuisance when their locations and densities reach levels that interfere with swimming and boating activities, and the normal functioning of a lake's ecosystem. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate, wave action, and type and size of fish populations present, determine the distribution and abundance of aquatic macrophytes in a lake. Some nonnative species, lacking natural controls, may be especially favored by the habitats available in many of the lakes in Southeastern Wisconsin, and can exhibit explosive growths to the detriment not only of lake users but also of indigenous aquatic life and native plant species.

Based upon the 1976 survey, four distinct areas with different plant communities were identified. In more recent surveys, as many as 11 different plant communities were identified. Map 16 shows the location of these communities as identified in the 1994 survey. The major changes in plant species distribution have occurred along the northern and southern shores of Friess Lake, where diversity of the species has increased and significant changes in species dominance have occurred.

The macrophyte species present in the Lake are indicated in Table 14, along with their relative abundance and changes in occurrence since the 1976 survey. Aquatic macrophytes were generally sparse in the Lake. Some

Table 13

AQUATIC PLANT SPECIES PRESENT IN FRIESS LAKE AND THEIR ECOLOGICAL SIGNIFICANCE

Aquatic Plant Species Present	Ecological Significance[a]
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 valuable as fish food
Lemna minor (small duckweed)	Important food for wildfowl; attracts small aquatic animals
Myriophyllum spicatum (Eurasian water milfoil)	None known
Najas flexilis (slender naiad)	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Nuphar sp. (yellow water lily)	Leaves, stems, and flowers are eaten by deer; roots eaten by beavers and porcupines; seeds eaten by wildfowl; leaves provide harbor to insects, in addition to shade and shelter for fish
Nymphaea sp. (white water lily)	Provides shade and shelter for fish; seeds eaten by wildfowl; rootstocks and stalks eaten by muskrats; roots eaten by beaver, deer, moose, and porcupine
Potamogeton amplifolius (large-leaf pondweed)	Provides support for insects and produces good food supply for fish and ducks
Potamogeton crispus (curly-leaf pondweed)	Provides food, shelter, and shade for some fish and food for wildfowl
Potamogeton illinoensis (Illinois pondweed)	Provides some food for ducks and shelter for fish
Potamogeton pectinatus (sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton robinsii (Robinson's pondweed)	Provides food and shelter for fish, especially northern pike
Potamogeton zosteriformis (flat-stemmed pondweed)	Provides some food for ducks
Typha augustafolia (cattail)	Supports insects; stalks and roots important food for muskrats and beavers; attracts marsh birds, wildfowl, and songbirds; in addition to being used as spawning grounds by sunfish and shelter for young fish
Vallisneria americana (water celery)	Provides good shade and shelter, supports insects, and is valuable fish food

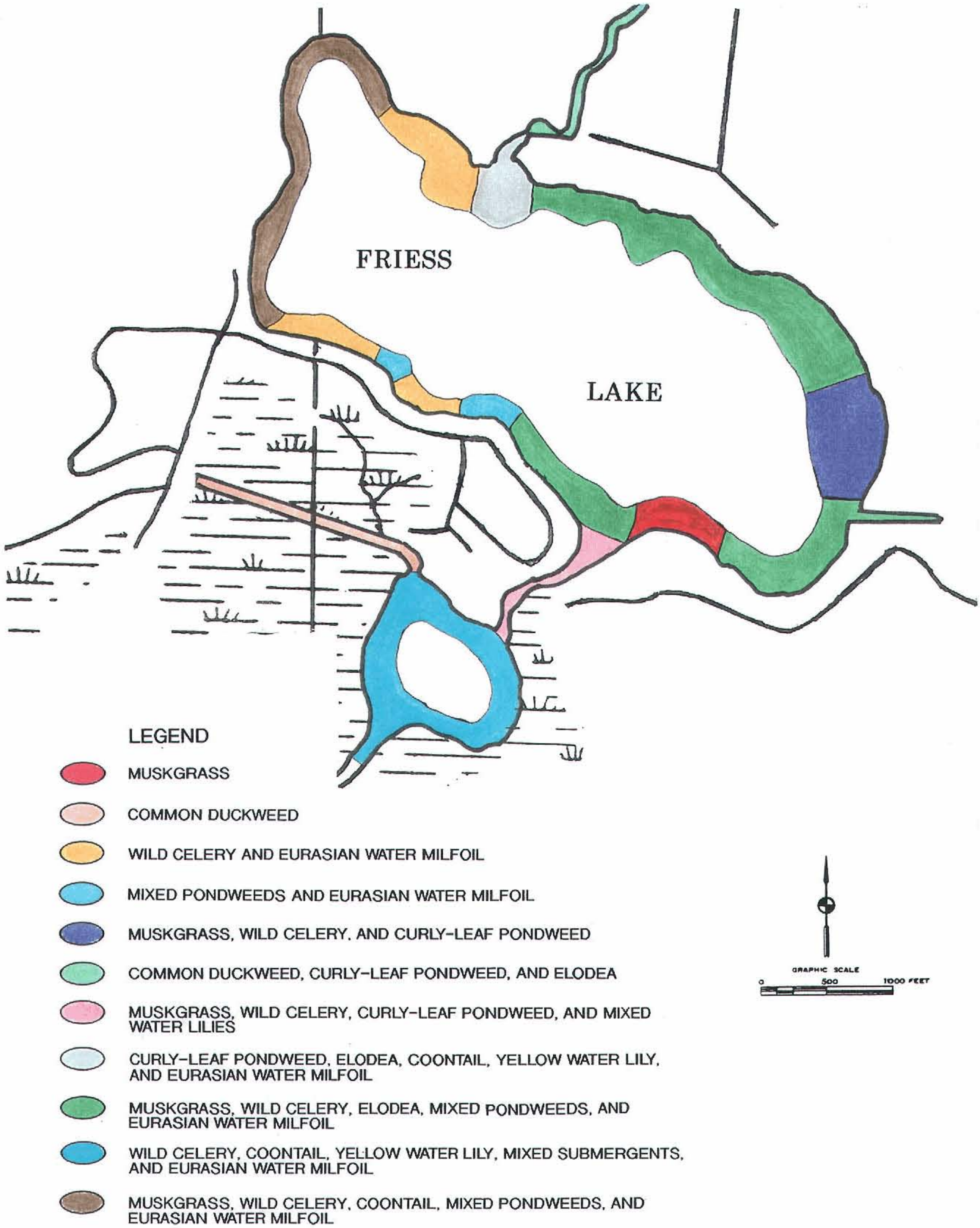
[a] Information obtained from A Manual of Aquatic Plants, by Norman C. Fassett and Guide to Wisconsin Aquatic Plants, Wisconsin Department of Natural Resources.

Source: SEWRPC.

species, however, have become abundant in recent years. Of particular significance is the reported increase of less desirable species, such as Eurasian water milfoil, and the decrease or disappearance of species common to lakes with better water quality, such as large-leaf pondweed. The increase in the abundance of selected species in some areas is likely attributed to the deposition of silt and sediment along the shoreline adjacent to the Lake inlet, and is consistent with the reported areas of "muck" identified by Commission staff during the 1994 survey and shown in Map 2. Such bottom sediments are generally more conducive to rooted plant growth, espe-

Map 16

AQUATIC PLANT COMMUNITY DISTRIBUTION IN FRIESS AND LITTLE FRIESS LAKES: 1994



Source: SEWRPC.

Table 14

FRIESS LAKE MACROPHYTE SURVEY RESULTS

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

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

Source: Wisconsin Department of Natural Resources and SEWRPC.

cially of the invasive plants such as Eurasian water milfoil which is abundant in the inlet.

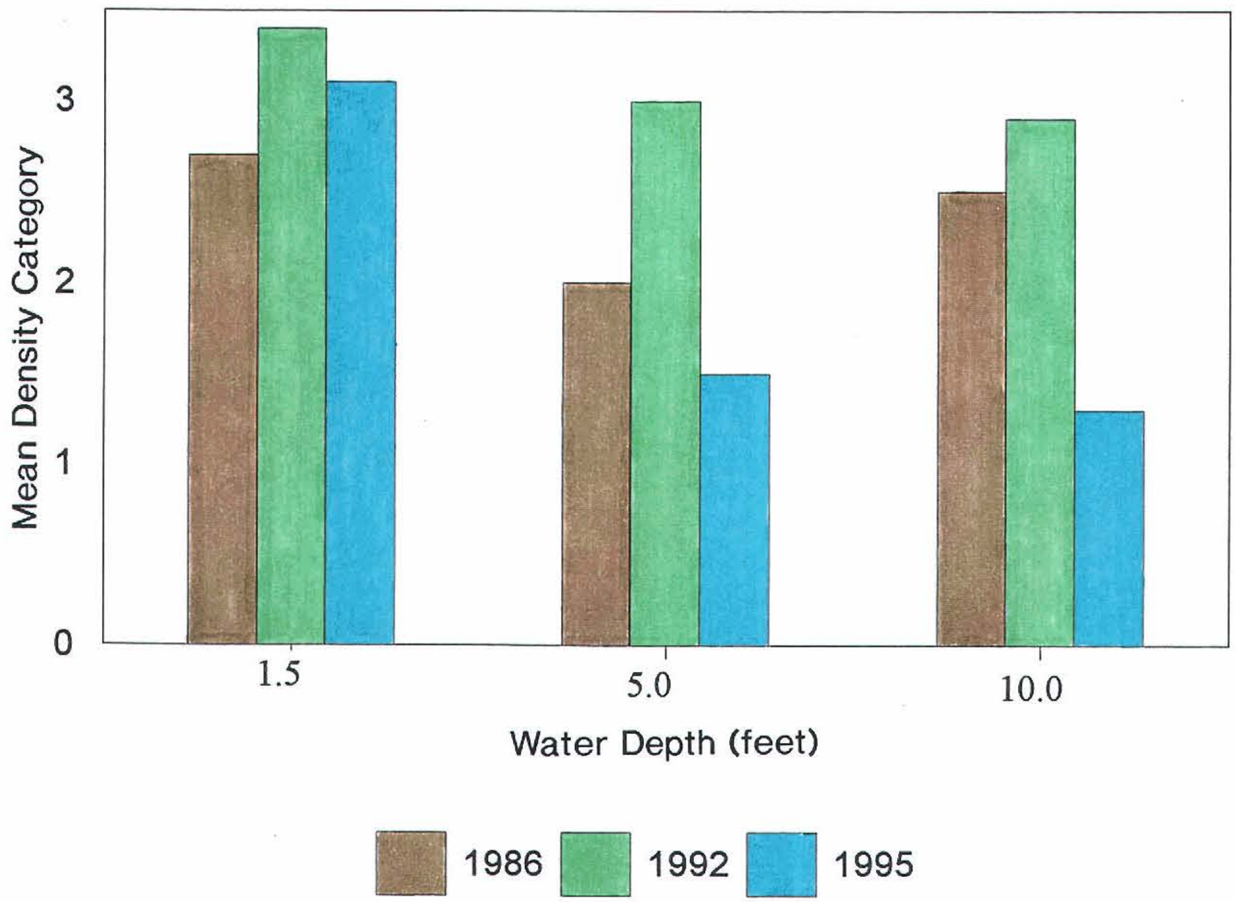
The most common macrophytes found in the 1976 survey were Sago pondweed (*Potamogeton pectinatus*), Richardson's pondweed (*Potamogeton richardsonii*), eel grass (*Vallisneria americana*), and yellow water lily (*Nuphar variegatum*). Overall, aquatic plant densities in Friess Lake were very low compared with those of the majority of major inland lakes in Southeastern Wisconsin. As noted, the macrophyte community in Friess Lake was generally viewed as beneficial in that it provided habitat for fish and wildlife, minimized shoreline erosion, and provided for the removal of nutrients from the water column which might otherwise result in excessive growth of algae. Enhancement of desirable macrophyte species, such as wild rice (*Zizania aquatica*), wild celery (*Vallisneria americana*), and certain pondweeds (*Potamogeton* spp.), was recommended for certain portions of the Lake to provide better habitat for fish and wildlife. This recommendation has not yet been implemented; however, some of these species are now found in the Lake.

Subsequent changes in aquatic macrophyte species distributions and abundance, as set forth in Table 14, may be contributing to a deterioration of fish and wildlife habitat in the Lake. The dominant species found in the 1995 survey were Eurasian water milfoil (*Myriophyllum spicatum*) and coontail (*Ceratophyllum demersum*) Eurasian water milfoil was most abundant in shallow water of less than five feet in depth, as shown in Figure 13. This plant is an exotic aquatic plant native to Europe, Asia, and northern Africa. Eurasian water milfoil can outcompete important native aquatic plant communities which can lead to loss of plant diversity, degraded water quality, and reduced habitat for fish, invertebrates and wildlife.[1] Curly-leaf pondweed (*Potamogeton crispus*),

[1] *Wisconsin Department of Natural Resources,* Eurasian Water Milfoil in Wisconsin: A Report to the Legislature, *1992.*

Figure 13

DEPTH DISTRIBUTION OF EURASIAN WATER MILFOIL IN FRIESS LAKE



Source: SEWRPC.

another exotic aquatic plant, was also found in Friess Lake.

While the extent and relative abundance of aquatic macrophytes in Friess Lake was not identified as a severe limitation to recreational use in the 1983 plan—such macrophytes as were present generally providing beneficial fish habitat—subsequent changes in species composition and abundance have led to localized recreational use problems currently being experienced, especially in shallow water areas around piers and docks and in the shallow water areas of the northern lake shore. While such problems are not yet widespread, careful monitoring of the situation is required in order to avoid such problems in the future. The maximum depth at which aquatic plant growth occurred was about 10 feet.

Phytoplankton

Phytoplankton, or algae, are small, generally microscopic plants that are found in all lakes and streams. They occur in a wide variety of forms, as single cells or colonies, and can be either attached or free floating. Phytoplankton are primary producers that form one of the bases of the aquatic food chain. Through photosynthesis, they convert energy and nutrients to the compounds necessary to support life in the aquatic system; oxygen, which is vital to higher forms of life in lakes and streams, is produced as a by-product in the photosynthetic process. Phytoplankton abundance varies seasonally with fluctuations in solar irradiance, and turbulence due to prevailing winds and nutrient availability. In lakes with high nutrient levels, heavy growths of phytoplankton, or algae blooms may occur.

Algae are generally grouped according to their dominant pigment color: green algae (chlorophytes) are an important source of food for zooplankton—or microscopic animals—and phytoplanktivorous fishes in the lakes of Southeastern Wisconsin, while blue-green algae (cyanophytes or cyanobacteria) are less often utilized. Thus, cyanophytes have a tendency to become over-abundant and are often subject to dramatic population increases or blooms when nutrients, especially phosphorus, are abundant. Many blue-green algae also have a buoyancy regulatory mechanism contained within their cellular structure, which allows these plants to outcompete other algal classes by making optimal use of sunlight near the lake surface. *Anabaena circinalis*, common in Friess Lake, is one such blue-green algae. Results of these surveys are summarized in Table 15. Blue-green algae were the dominant algal class in the Lake and the most abundant group of algae collected during the 1976-1977 survey. Blue-green algae comprised over 75 percent of all the algae present in samples collected between June 1976 through February 1977, and between April through August in the 1986 survey. Blue-green algae are common indicators of nutrient enrichment or eutrophication. The presence of these algae is consistent with the water quality indicators described in Chapter IV that suggested that Friess Lake is an eutrophic waterbody. *Aphanizomenon flos-aquae, Chroococcus dispersus, C. limneticus, Anabaena circinalis, A. variabilis, A. planctonica*, and *Lyngbya* sp., all cyanophytes, were the dominant algae in Friess Lake during the 1986 survey. Diatoms such as *Cyclotella comta* and *Fragilaria crotonensis*, cryptomonads or golden-brown algae such as *Cryptomonas ovata* and *Chroomonas minuta*, and dinoflagellates such as *Ceratium hirundinella* and *Gymnodinium* sp. were also reported as common. Of these, only *Aphanizomenon flos-aquae* was reported as abundant in the 1976 survey. *Anacystis* (*Microcystis*), reported under bloom conditions in 1976, was not observed during the 1986 survey.

Aquatic Plant Management

Records of aquatic plant management efforts on Wisconsin lakes were not maintained by the Wisconsin Department of Natural Resources prior to 1950. Therefore, while previous interventions were likely, the first recorded efforts to manage the aquatic plants in Friess Lake took place in 1953. Aquatic plant management activities in Friess Lake can be categorized as chemical macrophyte control and chemical algal control. Manual removal of plant material from around docks and piers is also undertaken by individual householders riparian to the Lake.

Excessive macrophyte growth on Friess Lake has historically resulted in a control program based on chemical controls. Since 1941, the use of chemicals to control aquatic plants has been regulated in Wisconsin. In 1926, sodium arsenite, an agricultural herbicide, was first applied to lakes in the Madison area, and, by the 1930s, sodium arsenite was widely used throughout the State for aquatic plant control. No other chemicals were applied in significant amounts to control macrophytes until recent years, when a number of organic chemical herbicides have come into general use. Approximately 400 pounds of sodium arsenite were applied to 88 acres of Friess Lake in 1953, the only year its use was recorded. This is a fraction of the mass of sodium arsenite applied to other Wisconsin lakes—for example, the 10 lakes *receiving the largest* amounts of sodium arsenite in Southeastern Wisconsin received a combined total of over 1,000,000 pounds of the chemical.

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

During anaerobic conditions, arsenic may be released from the bottom sediments to the water column above. In this way, some arsenic probably continues to be removed from Friess Lake. However, any sediments containing arsenic are continually being covered by new sediments; thus the level of arsenic in the water and in the surface sediments may be expected to decrease with passage of time. Because of the limited amounts applied, and because of the approximately 44-year intervening period since application, it is expected that there would not be any significant release of arsenic into the water column. Sediment samples taken by the Wisconsin

Table 15

FRIESS LAKE PHYTOPLANKTON SURVEY RESULTS

Phytoplankton Species	1976-1977 Survey	1986 Survey[a]
Cyanophytes		
Anabaena circinalis	--	X
A. planctonica	--	X
A. variabilis	--	X
Anacystis spp.	X	--
Aphanizomenon flos-aquae	X	X
Aphanothece sp.	X	--
Chroococcus dispersus	--	X
Chroococcus limneticus	--	X
Coelosphaerium sp.	X	--
Gomphosphaeria aponina	--	X
Lyngbya sp.	--	X
Merismopedia tenuissima	X	--
Diatoms		
Cyclotella comta	--	X
Fragilaria crotonensis	--	X
Synedra ulna	--	X
Dinoflagellates		
Ceratium furcoides	--	X
Ceratium hirundinella	--	X
Gymnodinium sp.	--	X
Crytomonads		
Chroomonas minuta	--	X
Chroomonas reflexa	--	X
Chroomonas ovata	--	X
Chlorophytes		
Ankyra lanceolata	--	X
Oocystis sp.	--	X
Pediastrum boryanum	--	X
Quadrigula chodati	--	X
Staurastrum paradoxum	--	X
Chrysophytes		
Dinobryon sociale	--	X

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

Source: Wisconsin Department of Natural Resources and SEWRPC.

Department of Natural Resources in 1994 indicated that the sediments containing arsenic are of low concentration and are covered.

As shown in Table 16, the aquatic herbicides Diquat, Aquathol, and 2,4-D have also been applied to Friess Lake to control aquatic macrophyte growth since 1984. Diquat and Aquathol 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 actually kill many other aquatic plants such as pondweeds (*Potamogeton* spp.), bladderwort (*Utricularia* sp.), and naiads (*Najas* spp.) which are valuable habitat species. Aquathol kills primarily pondweeds but does not control such nuisance species as Eurasian water milfoil (*Myriophyllum spicatum*).

The herbicide 2,4-D is a systemic herbicide which is absorbed by the leaves and translocated to other parts of the plant; it is more selective than the other herbicides listed above and is generally used to control Eurasian water milfoil. However, it will also kill more valuable species, such as water lilies (*Nymphaea* sp. and *Nuphar* sp.). The present restrictions for use of these herbicides are given in Table 17.

At present, the Friess Lake Action Group holds the State permits for chemical treatment of aquatic plants required under Chapter NR 107, *Wisconsin Administrative Code.* Chemicals are applied in selected years on a contractual basis by a local applicator. Herbicide application usually takes place in late spring or early summer with, occasionally, a second treatment of a smaller area, if necessary, in late July or early August. Map 17 shows the areal extent of that portion of Friess Lake to which chemicals were applied between 1988 and 1994. All chemicals for aquatic plant control used today are approved by the U.S. Environmental Protection Agency and the Wisconsin DNR and are registered in terms of the Federal Insecticide, Fungicide, and Rodenticide Act as amended in 1972.

In addition to the chemical herbicides used to control large aquatic plants, algicides have also been applied to Friess Lake. As shown in Table 16, Cutrine Plus and copper sulfate have been applied to Friess Lake, on occasion, since 1972, primarily to control the macroscopic alga, *Chara* sp. Like arsenic, copper, the active ingredient in many algicides including Cutrine Plus, may accumulate in the bottom sediments. Excessive levels of copper have been found to be toxic to fish and benthic organisms but have not been found to be generally harmful to humans.

AQUATIC ANIMALS

Aquatic animals include microscopic zooplankton, benthic bottom-dwelling invertebrates, fish and reptiles, amphibians, mammals, and waterfowl that inhabit the Lake and its shorelines. These make up the primary and secondary consumers of the food web.

Table 16

HERBICIDE USE AT FRIESS LAKE FROM 1953 THROUGH 1994

Year	Macrophyte Control					Algal Control	
	Sodium Arsenite (pounds)	Diquat (gallons)	Aquathol K (gallons)	2,4-D (gallons)	2,4-D (pounds)	Copper Sulfate (pounds)	Cutrine-Plus (gallons)
1953	400	- -	- -	- -	- -	- -	- -
1972	- -	- -	- -	- -	- -	160	- -
1973	- -	- -	- -	- -	- -	200	- -
1974	- -	- -	- -	- -	- -	190	- -
1975	- -	- -	- -	- -	- -	210	- -
1976	- -	- -	- -	- -	- -	200	- -
1977	- -	- -	- -	- -	- -	200	- -
1978	- -	- -	- -	- -	- -	- -	- -
1979	- -	- -	- -	- -	- -	100	- -
1980	- -	- -	- -	- -	- -	190	- -
1981	- -	- -	- -	- -	- -	130	- -
1982	- -	- -	- -	- -	- -	150	- -
1983	- -	- -	- -	- -	- -	- -	- -
1984	- -	- -	- -	0.5	- -	- -	75.0
1985	- -	- -	- -	- -	- -	- -	- -
1986	- -	- -	- -	- -	- -	- -	- -
1987	- -	- -	- -	0.5	4.0	- -	225.0
1988	- -	- -	0.5	1.0	- -	- -	0.5
1989	- -	- -	- -	- -	- -	- -	- -
1990	- -	- -	- -	26.0	- -	- -	- -
1991	- -	6.0	- -	41.0	- -	- -	6.0
1992	- -	- -	- -	- -	- -	- -	- -
1993	- -	- -	- -	- -	- -	- -	27.5
1994	- -	2.0	2.5	- -	- -	- -	0.4
Total	400	8.0	3.0	69.0	4.0	1,730	334.4

Source: Wisconsin Department of Natural Resources.

Table 17

PRESENT RESTRICTIONS ON WATER USES AFTER APPLICATION OF AQUATIC HERBICIDES[a]

Use	Days after Application			
	Cutrine Plus	Diquat	Hydrothol and Aquathol	2,4-D
Drinking	0[b]	14	7-14	- -[c]
Fishing	0	14	3	0
Swimming	0	1	- -[c]	0
Irrigation	0	14	7-14	- -[c]

[a]*The U.S. Environmental Protection Agency has indicated that, if these water use restrictions are observed, pesticide residues in water, irrigated crops, or fish should not pose an unacceptable risk to humans and other organisms using or living in the treatment zone.*

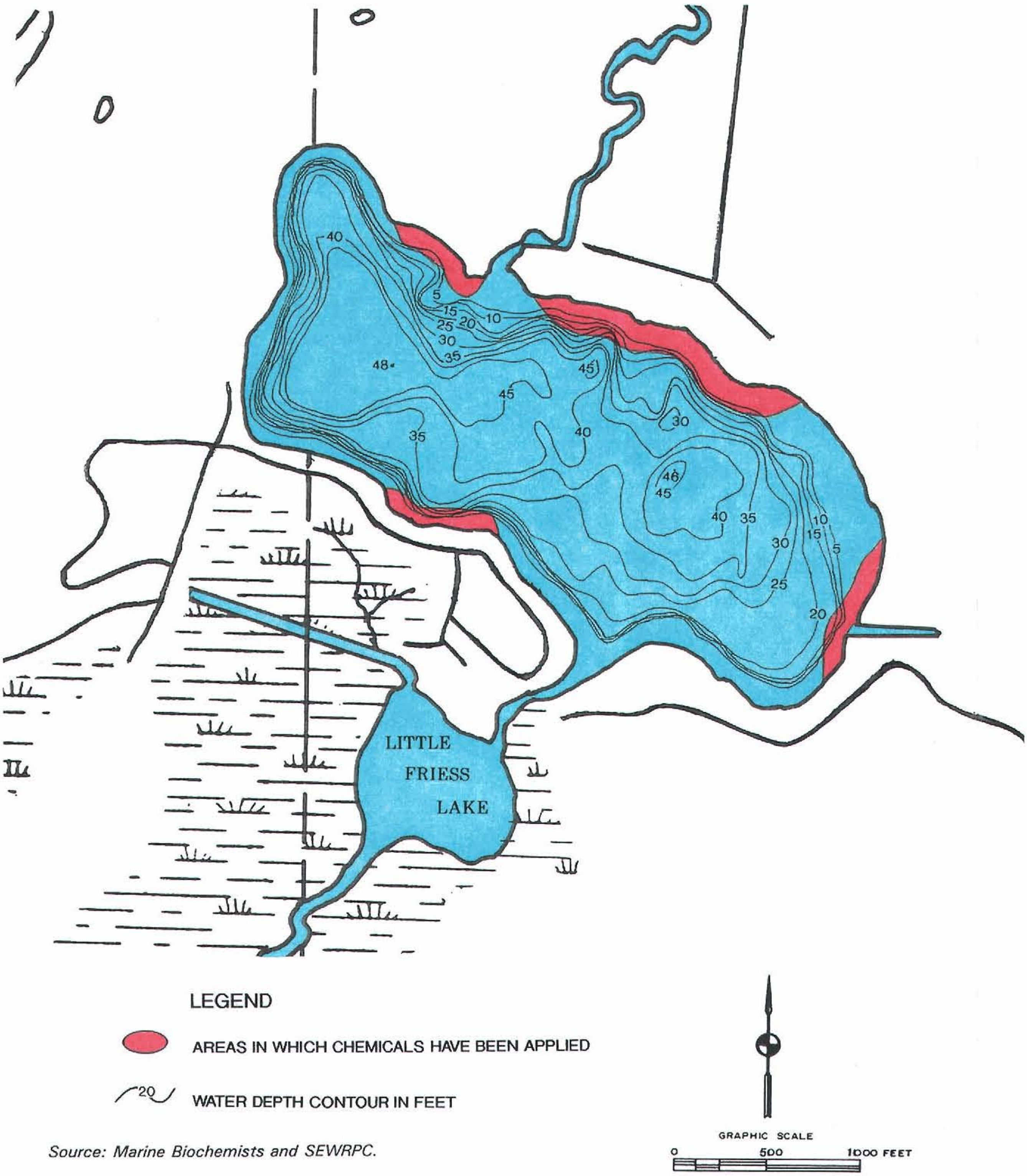
[b]*If water is used as a potable water source, the residual copper content must not exceed 1.0 part per million.*

[c]*2,4-D products are not to be applied to waters for irrigation, animal consumption, drinking, or domestic uses, such as cooking and watering vegetation.*

Source: Wisconsin Department of Natural Resources.

Map 17

SHORELINE AREAS OF FRIESS LAKE HISTORICALLY TREATED WITH HERBICIDES



Source: Marine Biochemists and SEWRPC.

Zooplankton

Zooplankton are minute free-floating animals inhabiting the same environment as the phytoplankton which form an important component of the food web. Zooplankton are primary consumers in the aquatic food chain, feeding to a large extent on such phytoplankton as green algae and diatoms. The zooplankton in turn, are preyed upon by fish, particularly the larva and fry of bluegills, pumpkinseeds, sunfish, and largemouth bass. A survey conducted by the Wisconsin Department of Natural Resources was completed in 1986 and in 1988 to document the types and relative abundance of zooplankton in Friess Lake. A survey was also conducted in 1976 and 1977 as part of the monitoring for the 1983 report.

As shown in Table 18, 19 species of zooplankton were found in Friess Lake during the 1988 survey. The populations of most species were at their peaks in spring and early summer, although fall peaks were noted for some species. *Daphnia galeata mendotae* was the dominant animal in the zooplankton community during these studies. *Daphnia galeata mendotae* was also one of the largest cladoceran zooplankters found in Friess Lake and are a major food item in the diets of planktivorous fish. Unlike the aquatic plant communities, the zooplankton community in Friess Lake remained relatively stable in its composition.

Benthic Invertebrates

The benthic, or bottom dwelling, macroinvertebrate communities of lakes, includes such organisms as sludge worms, midges, and caddis fly larvae. Like the zooplankton, these organisms are an important part of the food chain, acting as processors of the organic material that accumulates on the lake bottom. Some benthic macroinvertebrate organisms are opportunistic in their feeding habits, while others are openly predaceous.

Benthic organisms have been used to assess the existing and recent past water quality of a lake. The diversity of benthic communities present is one of the factors that often reflects lake trophic status; in general: the greater the diversity, the less eutrophic the lake. However, there is no single "indicator organism" to indicate trophic status; rather, the entire community must be assessed. In this regard, the time of year during which the assessment is made is an important consideration, and, since these populations fluctuate widely during the summer months, early spring or winter is considered to be the best time for sampling benthic populations.

Friess Lake was sampled in early spring of both 1976 and 1977 prior to metamorphosis and adult emergence. No subsequent samples have been taken, although a small number of ostracods and cladocerans have been taken in the zooplankton samples. Notwithstanding, the 1976-1977 samples revealed that the benthic fauna of Friess Lake was composed of only one insect species—the phantom midge, *Chaoborus punctipennis*—and very small numbers of microcrustacea. The microcrustacea consisted of individuals of the orders Cladocera and Ostracoda.

The presence of *Chaoborus punctipennis* in small numbers indicated that the dissolved oxygen concentration of the deeper profundal areas is very low or absent for extended periods during the summer and winter. This condition prevents the establishment of other benthic animals that need higher dissolved oxygen concentrations during periods of lake stratification. The ability of *Chaoborus punctipennis* to migrate vertically allows it to exist by resting in the bottom muds during daylight hours and proceed vertically into the more oxygen-rich waters to feed upon zooplankton during the night. An improved trophic status would encourage a larger population of chaoborid species and an increased diversity in the benthic community.

Fish

Friess Lake supports a relatively large and diverse fish community. Studies conducted by the Wisconsin Department of Natural Resources as reported in the 1983 plan, indicated that 22 different fish species have been captured in the Lake, as shown in Table 19. However, there are likely additional species in the Lake on a seasonal basis, since other fish species are known to occur in the Oconomowoc River chain. Subsequently, no further fish surveys have been conducted on Friess Lake.

Important predator fish in Friess Lake include walleyed pike (*Stizostedion vitreum*), northern pike (*Esox lucius*), and largemouth bass (*Micropterus salmoides*). Largemouth bass are considered to be common, while the northern pike and walleyed pike are present.[2] Panfish, including bluegill (*Lepomis macrochirus*), rock bass (*Ambloplites rupestris*) and black crappie (*Pomoxis nigromaculatus*), were also considered to be present in the Lake. "Panfish" is a common term applied to a broad group of smaller fish with a relatively short and unusually board shape. The habits of panfish vary widely among the different species, but their cropping of the

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[2]*Wisconsin Department of Natural Resources Publication PUBL-FM-800-91,* Wisconsin Lakes, *1991.*

Table 18

FRIESS LAKE ZOOPLANKTON SURVEY RESULTS

Species	1976-77 Survey	1986 Survey[a]	1988 Survey[a]
Cyclopoid copepods			
Acanthocyclops vernalis	X	X	X
Diacyclops bicuspidatus thomasi	X	X	X
Mesocylops edax	X	X	X
Orhtocyclops modestus	X	- -	X
Tropocyclops prasinus	- -	X	X
Cyclopoid copepodids	- -	- -	X
Cyclopod nauplii[b]	- -	- -	X
Calanoid Copepods			
Skistodiaptomus oregonensis	X	X	X
S. pallidus	X	- -	- -
Calanoid copepodids[b]	- -	- -	X
Calanoid nauplii[b]	- -	- -	X
Cladocerans			
Alona reticulata	- -	- -	X
Bosmina longirostris	X	- -	X
Chydorus sphaericus	X	X	X
Daphnia galeata mendotae	X	X	X
D. pulicaria	X	X	X
D. retrocurva	- -	- -	X
D. rosea	X	- -	- -
D. schodleri	X	- -	- -
Diaphamosoma birgei	- -	- -	X
D. leuchtenbergianum	X	X	- -
Eubosmina coregoni	X	X	- -
Leptodora kindtii	X	- -	- -
Chaoborids			
Chaoborus punctipennis	X	X	X
Ostracods			
Ostracoda	X	- -	X

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

[b]*There are three stages in the life cycle of copepods: egg stage; naupilar larva; and copepodid. Nauplii and copepodids are each, in turn, divided into six stages, the sixth copepodid being the adult. In analyzing the Friess Lake collections, nauplii and copepodids were not separated into their different development groups within each stage, but were grouped into nauplii and copepodids. Unlike cladocera, reproduction is strictly sexual, with males and females produced in approximately equal numbers.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

plentiful supply of insect and plants, coupled with prolific breeding rates, leads to large populations with rapid turnover. Some lakes within Southeastern Wisconsin have stunted, or slow growing panfish populations because their numbers are not controlled by predator fishes. Panfish frequently feed on fry of predator fish and, if the panfish population is overabundant, they may quickly deplete the predator fish population.

Rough fish is a broad term applied to species such as carp that do not readily bite on hook and line, but feed on game fish, destroy habitat needed by more desirable species, and which are commonly considered within Southeastern Wisconsin undesirable for human consumption because of numerous bones of undesirable flavors. Carp are known to be present in Friess Lake but do not represent a significant problem.

Table 19

FISH SPECIES FOUND IN
FRIESS LAKE FISH SURVEY: 1976

Common Name	Scientific Name
Black Bullhead	Ictalurus melas
Black Crappie	Pomoxis nigromaculatus
Bluegill	Lepomis macrochirus
Bluntnose Minnow	Pimephales notatus
Brook Silverside	Labidesthes sicculus
Brown Bullhead	Ictalurus nebulosus
Carp	Cyprinus carpio
Channel Catfish	Ictalurus punctatus
Common Shiner	Notropis cornutus
Green Sunfish	Lepomis cyanellus
Johnny Darter	Etheostoma nigrum
Lake Chubsucker	Erimyzon sucetta
Largemouth Bass	Micrpterus salmoids
Mudminnow	Umbra limi
Northern Pike	Esox lucius
Pumpkinseed	Lepomis gibbosus
Rock Bass	Ambloplites rupestris
Tadpole Madtom	Noturus gyrinus
Walleyed Pike	Stizostedion vitreum
White Sucker	Catostomus commersoni
Yellow Bullhead	Ictalurus natalis
Yellow Perch	Perca flavescens

Source: Wisconsin Department of Natural Resources and SEWRPC.

Fishing is the major summer and winter recreational activity on the Lake. Wetland areas adjacent to the upstream portions of the Oconomowoc River and Little Friess Lake provide prime northern pike spawning habitat. Areas of the shoreline where sand and gravel predominate provide generally suitable largemouth bass and bluegill spawning habitat. The Lake has not been stocked in recent years, and no stocking programs are planned in the immediate future.

Other Wildlife

Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the Friess Lake study, it is possible, by polling naturalists and wildlife managers familiar with the area, to complete a list of amphibians, reptiles, birds, and mammals which may be expected to be found in the area under existing conditions. The technique used in compiling the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to likely exist, or have known to existed, in Washington County; associating these lists with the historic and remaining habitat areas as inventoried; and projecting the appropriate amphibian, reptile, bird, and mammal species into the Friess Lake area. The net result of the application of this technique is an appreciation of those species which were once present in the drainage area, those species which are still expected to be present under currently prevailing conditions, and those species which could be expected to be lost or gained as a result of urbanization within the area.

Amphibians and reptiles are vital components of the ecosystem in an environmental unit like the Friess Lake drainage area. Examples of amphibians native to the area include frogs, toads, and salamanders. Turtles and snakes are examples of reptiles common to the Friess Lake area. Table 20 presents a summary of the 13 amphibian and 11 reptile species normally expected to be present in the Friess Lake area under present conditions and identifies those species most sensitive to urbanization.

A large number of birds, ranging in size from large game birds to small songbirds, are found in the Friess Lake area. Table 21 lists those birds that normally occur in the drainage area. Each bird is classified as to whether it maybe expected to breed within the area, visits the area only during the annual migration periods, or visits the area only on rare occasions.

A variety of mammals, ranging in size from large animals like the northern white-tailed deer to small animals like the pygmy shrew, are found in the Friess Lake area. Table 22 lists 33 mammals whose ranges are known to extend into the area.

The complete spectrum of wildlife species originally native to Washington County has, along with its habitat, undergone significant change in terms of diversity and population size since the European settlement of the area. This change is a direct result of the conversion of land by the settlers from its natural state to agricultural and urban uses, beginning with the clearing of the forest and prairies, the draining of wetlands, and ending with the development of extensive urban areas. Successive cultural uses and attendant management practices, both rural and urban, have been superimposed on the land use changes and have also affected the wildlife and wildlife habitat. In agricultural areas, these cultural management practices include draining land by ditching and tiling and the expanding use of fertilizers, herbicides, and pesticides. In urban areas, cultural management practices that affect wildlife and their habitat include the use of fer-

Table 20

AMPHIBIANS AND REPTILES OF THE FRIESS LAKE AREA

Scientific (family) and Common Name	Species Reduced or Dispersed with Full Area Urbanization	Species Lost with Full Area Urbanization
Amphibians		
Proteidae		
Mudpuppy	X	- -
Ambystomatidae		
Blue-Spotted Salamander	- -	X
Eastern Tiger Salamander	X	- -
Salamandridae		
Central Newt	X	- -
Bufonidae		
American Toad	X	- -
Hylidae		
Western Chorus Frog	X	- -
Blanchard's Cricket Frog[a]	- -	X
Northern Spring Peeper	- -	X
Eastern Gray Tree Frog	- -	X
Ranidae		
Bull Frog	- -	X
Green Frog	X	- -
Northern Leopard Frog	- -	X
Wood Frog	- -	X
Reptiles		
Chelydridae		
Common Snapping Turtle	X	- -
Kinosternidae		
Musk Turtle (Stinkpot)	X	- -
Emydidae		
Painted Turtle	X	- -
Blanding's Turtle[b]	- -	X
Colubridae		
Northern Water Snake	X	- -
Northern Brown Snake	X	- -
Red-Bellied Snake	X	- -
Eastern Garter Snake	X	- -
Eastern Smooth Green Snake	- -	X
Western Fox Snake	- -	X
Eastern Milk Snake	- -	X

[a]*Likely to be extirpated from the watershed.*

[b]*Identified as endangered in Wisconsin.*

Source: H.T. Jackson, Mammals of Wisconsin, 1961, and SEWRPC.

tilizers, herbicides, and pesticides; road salting; heavy motor vehicle traffic that produces disruptive noise levels and air pollution; and the introduction of domestic pets.

WILDLIFE HABITAT AND RESOURCES

Wildlife habitat areas remaining in the Region were inventoried by the Wisconsin DNR and the Southeastern

Table 21

BIRDS KNOWN OR LIKELY TO OCCUR WITHIN THE FRIESS LAKE AREA

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Podicipedidae			
Pied-Billed Grebe	X	--	X
Ardeidae			
American Bittern	--	--	X
Great Blue Heron	--	--	X
Green-Backed Heron	X	--	X
Gruidae			
Sandhill Crane	--	--	X
Anatidae			
Tundra Swan	--	--	X
Canada Goose	X	--	X
Wood Duck	X	--	X
Green-Winged Teal	--	--	X
American Black Duck	--	X	X
Mallard	X	X	X
Northern Pintail	--	--	X
Blue-Winged Teal	X	--	X
Northern Shoveler	--	--	X
American Widgeon	--	--	X
Redhead	--	--	X
Ring-Necked Duck	--	--	X
Lesser Scaup	--	--	X
Common Goldeneye	--	--	X
Bufflehead	--	--	X
Cathartidae			
Turkey Vulture	--	--	X
Accipitridae			
Northern Goshawk	--	R	X
Cooper's Hawk	--	X	X
Northern Harrier	--	R	X
Broad-Winged Hawk	--	--	X
Red-Tailed Hawk	X	X	X
Phasianidae			
Ring-Necked Pheasant (introduced)	X	X	NA
Rallidae			
Virginia Rail	R	--	X
Sora	R	--	X
American Coot	--	--	X
Charadriidae			
Semipalmated Plover	--	--	X
Killdeer	X	--	X
Scolopacidae			
Greater Yellowlegs	--	--	X
Lesser Yellowlegs	--	--	X
Solitary Sandpiper	--	--	X
Spotted Sandpiper	P	--	X
Upland Sandpiper	P	--	P
Semipalmated Sandpiper	--	--	P
Pectoral Sandpiper	--	--	X
Common Snipe	P	P	X

Table 21 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Scolopacidae (continued)			
American Woodcock	X	- -	X
Wilson's Phalarope	- -	- -	X
Dunlin	- -	- -	P
Laridae			
Ring-Billed Gull	- -	- -	X
Herring Gull	- -	- -	X
Forster's Tern	R	- -	P(E)
Black Tern	- -	- -	X
Columbidae			
Rock Dove[a]	X	X	NA
Mourning Dove	X	X	X
Cuculidae			
Black-Billed Cuckoo	P	- -	X
Yellow-Billed Cuckoo	P	- -	X
Strigidae			
Eastern Screech Owl	X	X	NA
Great Horned Owl	X	X	NA
Snowy Owl	- -	- -	R
Barred Owl	P	P	NA
Long-Eared Owl	- -	R	R
Short-Eared Owl	- -	- -	R
Northern Saw-Whet Owl	- -	- -	X
Caprimulgidae			
Common Nighthawk	X	- -	X
Whippoorwill	- -	- -	X
Apodidae			
Chimney Swift	X	- -	X
Trochilidae			
Ruby-Throated Hummingbird	X	- -	X
Alcedinidae			
Belted Kingfisher	X	- -	X
Picidae			
Red-Headed Woodpecker	- -	- -	X
Yellow-Bellied Sapsucker	- -	- -	X
Downy Woodpecker	X	X	NA
Hairy Woodpecker	X	X	NA
Northern Flicker	X	R	X
Tyrannidae			
Olive-Sided Flycatcher	- -	- -	X
Eastern Wood-Peewee	- -	- -	X
Yellow-Bellied Flycatcher	- -	- -	X
Willow Flycatcher	P	- -	X
Least Flycatcher	- -	- -	X
Eastern Phoebe	X	- -	X
Great Crested Flycatcher	X	- -	X
Eastern Kingbird	X	- -	X
Alaudidae			
Horned Lark	- -	- -	X

Table 21 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Hirundinidae			
Purple Martin	X	--	X
Tree Swallow	X	--	X
Northern Rough-Winged Swallow	X	--	X
Bank Swallow	X	--	X
Cliff Swallow	X	--	X
Barn Swallow	X	--	X
Corvidae			
Blue Jay	X	X	X
American Crow	X	X	X
Paridae			
Black-Capped Chickadee	X	X	X
Sittidae			
Red-Breasted Nuthatch	--	X	X
White-Breasted Nuthatch	X	X	NA
Certhiidae			
Brown Creeper	--	P	X
Troglodytidae			
Carolina Wren	--	--	R
House Wren	X	--	X
Winter Wren	--	--	X
Sedge Wren	X	--	X
Marsh Wren	X	--	X
Muscicapidae			
Golden-Crowned Kinglet	--	X	X
Ruby-Crowned Kinglet	--	--	X
Blue-Gray Gnatcatcher	R	--	X
Eastern Bluebird	X	--	X
Veery	R?	--	X
Gray-Cheeked Thrush	--	--	X
Swainson's Thrush	--	--	X
Hermit Thrush	--	--	X
Wood Thrush	X	--	X
American Robin	X	X	X
Mimidae			
Gray Catbird	X	--	X
Brown Thrasher	X	--	X
Motacillidae			
Water Pipit	--	--	X
Bombycillidae			
Bohemian Waxwing	--	R	--
Cedar Waxwing	X	X	X
Lanniidae			
Northern Shrike	--	R	X
Sturnidae			
European Starling[a]	X	X	X
Vireonidae			
Solitary Vireo	--	--	X
Yellow-Throated Vireo	--	--	X

Table 21 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Vireonidae (continued)			
Warbling Vireo	X	--	X
Red-Eyed Vireo	X	--	X
Philadelphia Vireo	--	--	X
Emberizidae			
Blue-Winged Warbler	R	--	X
Golden-Winged Warbler	--	--	X
Tennessee Warbler	--	--	X
Orange-Crowned Warbler	--	--	X
Nashville Warbler	--	--	X
Northern Parula	--	--	X
Yellow Warbler	X	--	X
Chestnut-Sided Warbler	--	--	X
Magnolia Warbler	--	--	X
Cape May Warbler	--	--	X
Black-Throated Blue Warbler	--	--	X
Yellow-Rumped Warbler	--	--	X
Black-Throated Green Warbler	--	--	X
Blackburnian Warbler	--	--	X
Palm Warbler	--	--	X
Bay-Breasted Warbler	--	--	X
Blackpoll Warbler	--	--	X
Black-and-White Warbler	--	--	X
American Redstart	R?	--	X
Ovenbird	R	--	X
Northern Waterthrush	--	--	X
Connecticut Warbler	--	--	X
Mourning Warbler	--	--	X
Common Yellowthroat	X	--	X
Wilson's Warbler	--	--	X
Canada Warbler	--	--	X
Scarlet Tanager	X	--	X
Northern Cardinal	X	X	NA
Rose-Breasted Grosbeak	X	--	X
Indigo Bunting	--	--	X
Dickcissel	--	--	R
Rufous-Sided Towhee	X	--	X
American Tree Sparrow	--	X	X
Chipping Sparrow	X	--	X
Clay-Colored Sparrow	--	--	X
Field Sparrow	X	--	X
Vesper Sparrow	P	--	X
Savannah Sparrow	X	--	X
Grasshopper Sparrow	P	--	X
Henslow's Sparrow	P	--	X
Fox Sparrow	X	--	X
Song Sparrow	X	X	X
Lincoln's Sparrow	--	--	X
Swamp Sparrow	X	R	X
White-Throated Sparrow	--	R	X
White-Crowned Sparrow	--	--	X
Dark-Eyed Junco	--	X	X
Lapland Longspur	--	R	X
Snow Bunting	--	R	X
Boblink	X	--	X

Table 21 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Emberizidae (continued)			
Red-Winged Blackbird	X	X	X
Eastern Meadowlark	X	R	X
Western Meadowlark	R	- -	X
Rusty Blackbird	- -	R	X
Common Grackle	X	X	X
Brown-Headed Cowbird	X	X	X
Orchard Oriole	R	- -	R
Northern Oriole	X	- -	X
Purple Finch	- -	X	X
Common Redpoll	- -	X	X
Pine Siskin	- -	X	X
American Goldfinch	X	X	X
House Finch (introduced)	P	- -	X
Ploceidae			
House Sparrow[a]	X	X	NA

NOTE: Breeding: Nesting species
Wintering: Present January through February
Migrant: Spring and/or fall transient

NA - not applicable
X - present, not rare
R - rare
(E) - endangered species in Wisconsin
? - seasonal status uncertain
P - possibly present

[a]*Alien, or nonnative, bird species.*

Source: SEWRPC.

Wisconsin Regional Planning Commission in 1985. The wildlife habitat areas were categorized as either Class I, high value; Class II, medium value; or Class III, good value, habitat areas.[3]

Class I wildlife habitat area are the highest value habitat in the Region in that they contain a good diversity of wildlife, are adequate in size to meet all habitat requirements for the species concerned, and are generally located in proximity to other wildlife areas. Class II wildlife habitat areas generally lack optimal conditions for one of the three aforementioned criteria for Class I areas. However, they do retain a good plant and animal diversity. Class III wildlife habitat are remnant in nature that they generally lack optimal conditions for two or more of the three aforementioned criteria for Class I wildlife habitat but are, nevertheless, important if located in close proximity to other wildlife habitat areas, if they provide travel corridors linking other habitat areas, if they provide important forage habitat, or if they provide the only available range in an area. It is in this respect that Class III wildlife habitat areas may also serve as regionally significant habitat in Southeastern Wisconsin.

As shown on Map 18, the Friess Lake direct drainage area contains approximately 272 acres of wildlife habitat, while the total tributary drainage area to Friess Lake contains about 3,930 acres of wildlife habitat. About three acres, or less than 1 percent of the direct drainage area were classified as Class I habitat; 89 acres, or about 10 percent of the direct drainage area, were classified as Class II habitat; and 180 acres, or about 20 percent of

[3]*SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin—2010, *January 1992.*

Table 22

MAMMALS OF THE FRIESS LAKE AREA

Didelphidae
Virginia Opossum
Soricidae
Cinereous Shrew
Short-Tailed Shrew
Vespertilionidae
Little Brown Bat
Silver-Haired Bat
Big Brown Bat
Red Bat
Hoary Bat
Leporidae
Mearns's Cottontail Rabbit
Sciuridae
Southern Woodchuck
Striped Ground Squirrel (gopher)
Ohio Chipmunk
Minnesota Grey Squirrel
Western Fox Squirrel
Southern Flying Squirrel
Castoridae
American Beaver
Cricetidae
Northern White-Footed Mouse
Meadow Vole
Common Muskrat
Muridae
Norway Rat (introduced)
House Mouse (introduced)
Zapodidae
Meadow Jumping Mouse
Canidae
Northeastern Coyote
Eastern Red Fox
Gray Fox
Procyonidae
Upper Mississippi Valley Raccoon
Mustelidae
New York Long-Tailed Weasel
Bang's Short-Tailed weasel
Upper Mississippi Valley Mink
Northern Plains Skunk
Canada Otter (occasional visitor)
American Badger (occasional visitor)
Cervidae
Northern White-Tailed Deer

Source: SEWRPC.

the direct drainage area, were classified as Class III habitat. Of the lands within the total tributary drainage area, 1,300 acres, or about 10 percent of the total area, are identified as Class I habitat, 1,500 acres, or about 10 percent, as Class II habitat, and about 1,120 acres, or about 10 percent, as Class III habitat. Of the total wildlife habitat areas, woodlands and wetlands cover approximately 138 acres and 18 acres of the direct drainage area, and 1,433 acres and 1,440 acres of the total tributary drainage area, respectively, providing much of this habitat. The extensive amount of urbanization and agricultural land use in the watershed, however, has resulted in the loss of a significant portion of the wildlife habitat which once existed.

WETLANDS

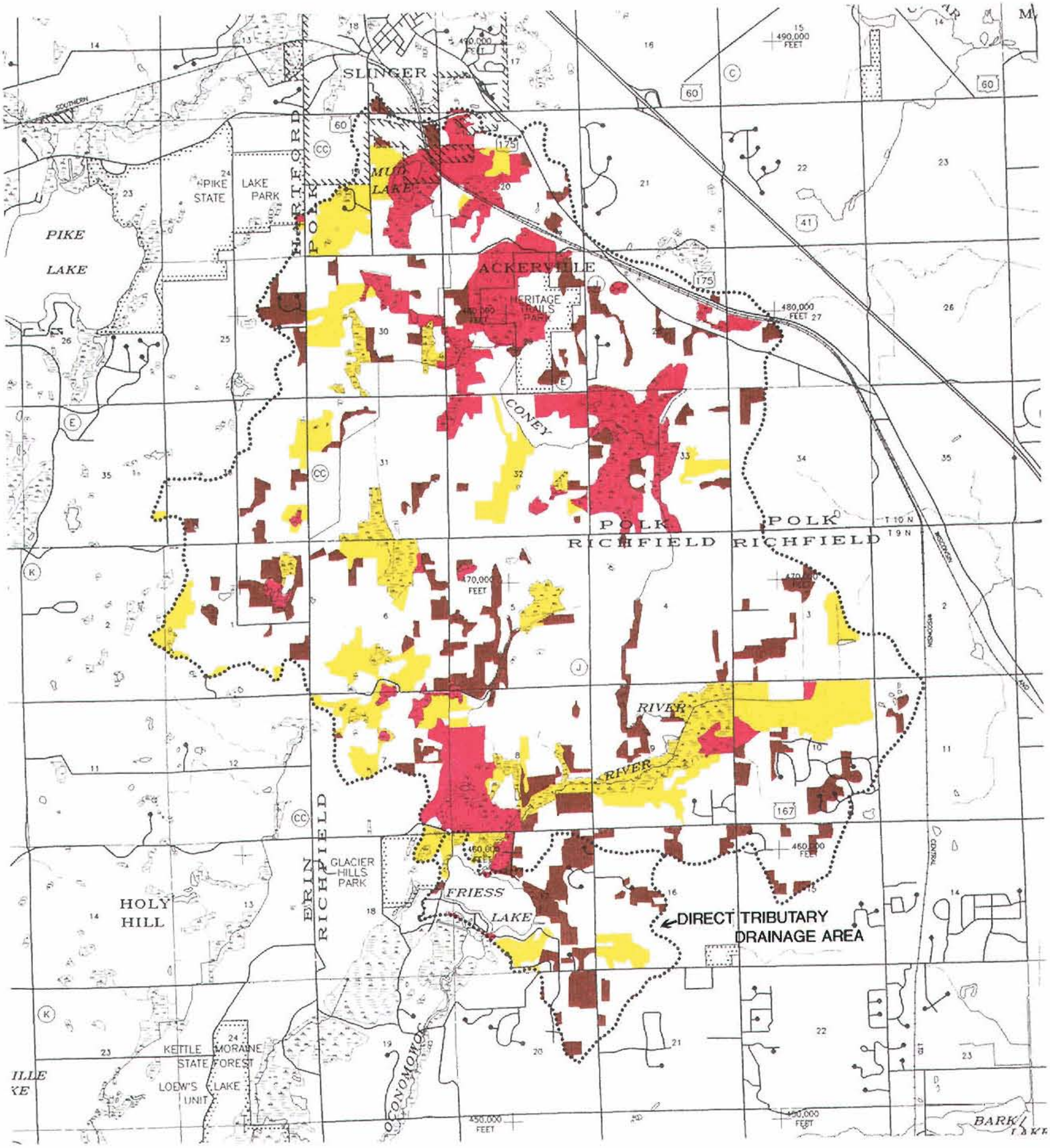
Wetlands are defined by the U.S. Natural Resources Conservation Service (NRCS) as "areas that have a predominance of hydric soils and that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions." The U.S. Army Corps of Engineers (USACE) and USEPA definition used by the Commission in the Southeastern Wisconsin Region is essentially the same as the NRCS definition.

A third definition, which is applied by the Wisconsin Department of Natural Resources and set forth in Chapter 23 of the *Wisconsin Statutes*, defines a wetland as "an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions." In practice, the Department definition differs from the Federal/Commission definition in that the Department considers very poorly drained, poorly drained, and some of the somewhat poorly drained soils as wetland soils meeting their wetland criterion. The Federal and Commission definition considers only the poorly drained and poorly drained soils as meeting the "hydric soil" criterion. Thus, the State definition as actually applied is more inclusive than the Federal and Commission definition in that the Department may include some soils that do not show hydric field characteristics as wet soils, however, are, in fact, capable of supporting wetland vegetation, a condition which may occur in some floodlands.[4]

[4] *Although prior converted cropland is not subject to Federal wetland regulations unless cropping ceases for five consecutive years and the land reverts to a wetland condition, the State may consider prior converted cropland to be subject to State wetland regulations if the land meets the criteria set forth in the State wetland definition before it has not been cropped for five consecutive years.*

Map 18

WILDLIFE HABITAT AREAS WITHIN THE FRIESS LAKE TOTAL TRIBUTARY DRAINAGE AREA



LEGEND

- CLASS I, high-value habitat
- CLASS II, medium-value habitat
- CLASS III, good-value habitat

Source: SEWRPC.

0 2000 4000 6000 FEET
GRAPHIC SCALE

As a practical matter, application of either the DNR wetland definition or the USEPA, USACE, and Regional Planning Commission definition has been found to produce reasonably consistent wetland identifications and delineations in the majority of situations within the Southeastern Wisconsin Region. That consistency is due in large part to the provision in the Federal wetland delineation manual, which allows for the application of professional judgment in cases where satisfaction of the three criteria for wetland identification is unclear.

Wetlands in Southeastern Wisconsin are classified predominantly as deep marsh, shallow marsh, bog, fen, low prairie, southern sedge meadow, fresh (wet) meadow, shrub carr, southern wet and wet-mesic hardwood forest, and conifer swamp. Wetlands form an important part of the landscape in and adjacent to Friess Lake in that they perform an important set of natural functions that make them ecologically and environmentally invaluable resources. Wetlands affect the quality of water by acting as a filter or a buffer zone allowing silt and sediments to settle out. They also influence the quantity of water by providing water during periods of drought and holding it back during periods of flood. When located along shorelines of lakes and streams, wetlands help protect those shorelines from erosion. Wetlands also may serve as groundwater discharge and recharge areas in addition to being important resources for overall ecological health and diversity by providing essential breeding and feeding grounds, shelter, and escape cover for many forms of fish and wildlife.

Wetlands are poorly suited to urban use. This is due to high soil compressibility and instability, high water table, low load-bearing capacity, and high shrink-swell potential of wetland soils, and, in some cases, to the potential for flooding. In addition, metal conduits placed in some types of wetland soils may be subject to rapid corrosion. These constraints, if ignored, may result in flooding, wet basements and excessive operation of sump pumps, unstable foundations, failing pavements, broken sewer and water lines, and excessive infiltration of clear water into sanitary sewerage systems. In addition, there are significant onsite preparation and maintenance costs associated with the development of wetlands, particularly as they relate to roads, foundations, and public utilities.

The Regional Planning Commission maintains an inventory of wetlands which is updated every five years. As shown on Map 19, in 1990, about 20 acres of the direct drainage area and about 1,440 acres of the total drainage area to Friess Lake were covered by wetlands. The amount and distribution of wetlands in the area should remain relatively constant if the recommendations contained in the adopted regional land use plan are followed.

WOODLANDS

Woodlands are defined as those areas containing a minimum of 17 or more trees per acre with a diameter of at least four inches at breast height. The woodlands are classified as mature pine plantations, dry, dry-mesic, mesic, wet mesic, wet hardwoods, and conifer swamp forests. The last three classifications are also considered wetlands. The drainage area directly tributary to Friess Lake has 138 acres of woodlands which contain all of the native upland woodland classifications. Specifically, as shown on Map 19, upland woods in the Friess Lake direct drainage area include southern dry hardwoods consisting primarily of white oak (*Quercus alba*), burr oak (*Quercus macrocarpa*), shagbark hickory (*Carya ovata*), and black cherry (*Prunus serotina*); southern dry-mesic hardwoods consisting primarily of northern red oak (*Quercus rubra*), paper birch (*Betula papyrifera*), and white ash (*Fraxinus americana*); and mesic hardwoods consisting primarily of sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), and basswood (*Tilia americana*). Woodland tracts in the Friess Lake direct drainage area occur primarily as isolated woodlots which are, in some cases, undergoing urban development. Two very good quality mesic hardwood stands occur in the Friess Lake direct drainage area. These two stands are located in the northeast one-quarter of Section 17 and the northeast one-quarter of Section 20, Township 9 North, Range 18 East, Town of Richfield.

The amount and distribution of woodlands in the area should also remain relatively stable if the recommendations contained in the regional land use plan are followed.

DESIGNATED NATURAL AREAS

The Washington County park and open space plan which, as updated in 1997,[5] contains an inventory and recommendation for preservation of designated natural areas located within the tributary drainage area to Friess Lake. Natural areas are defined as tracts of land or water so little modified by human activity, or which

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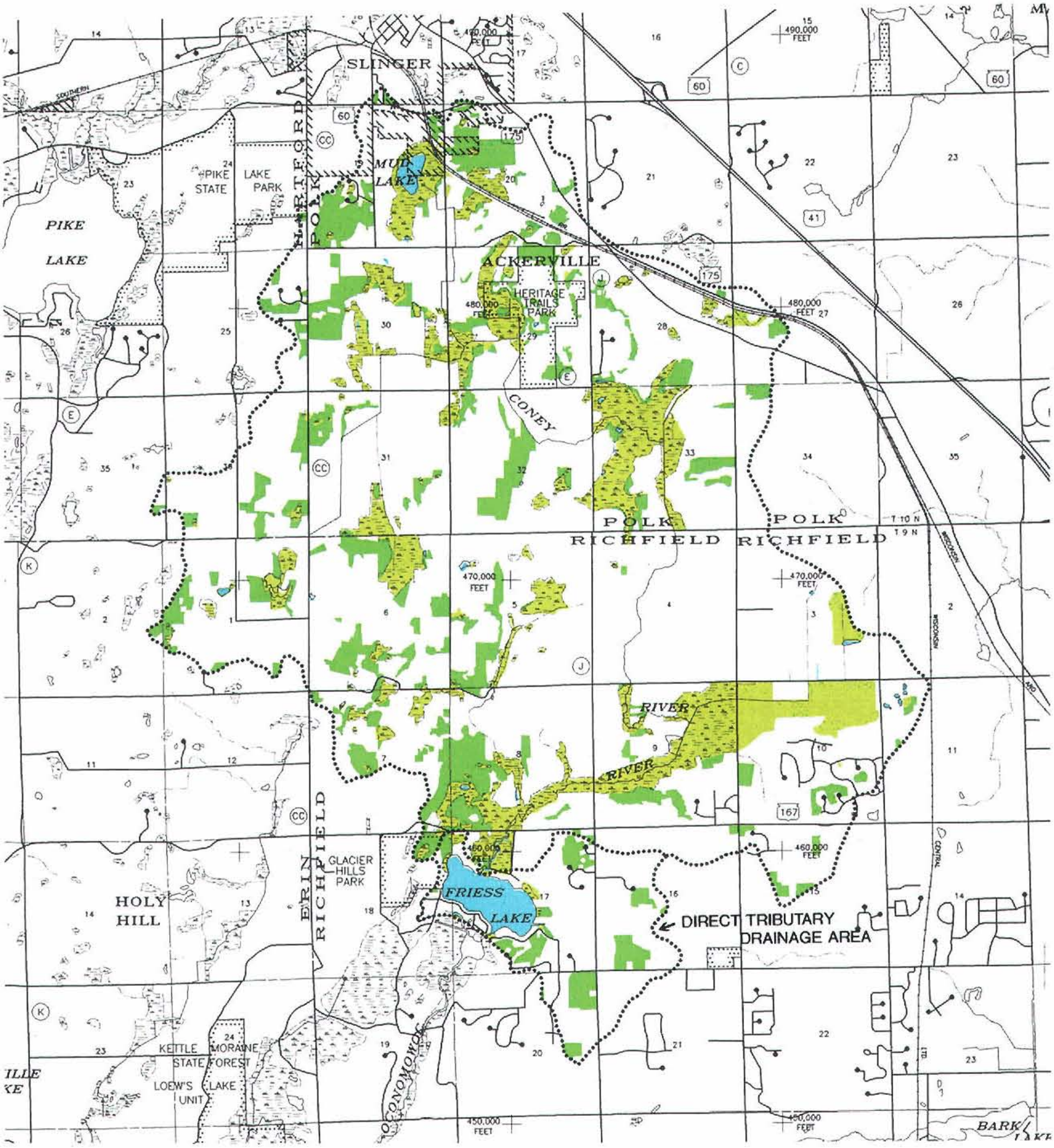
[5]*SEWRPC Community Assistance Planning Report No. 136, 2nd Edition,* A Park and Open Space Plan for Washington County, *August 1997.*

Map 19

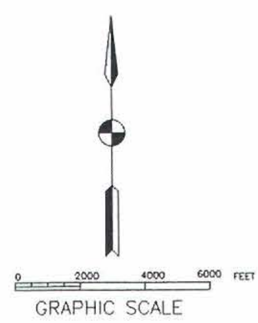
EXISTING WETLANDS WITHIN THE FRIESS LAKE TOTAL TRIBUTARY DRAINAGE AREA



LEGEND

- WOODLANDS
- WETLANDS
- SURFACE WATER

Source: SEWRPC.



have sufficiently recovered from the effects of such activity, that they contain intact native plant and animal communities believed to be representative of the pre-European-settlement landscape. Natural areas identified under the plan are classified as being statewide or greater significance, or "NA-1" areas; of countywide or regional significance, or "NA-2" areas; or of local significance, or "NA-3" areas. Based upon this definition, six natural areas are identified within, or partially within, the Friess Lake drainage area. Four of these six areas were classified as "NA-2," including Mud Lake Upland Woods and Mud Lake Meadow which are under private ownership; Daniel Boone Bogs owned by the Daniel Boone Conservation Club; and the Glacier Hill Bogs and Upland Woods which are owned partially by Washington County and are partially under private ownership. The remaining two natural areas were classified as "NA-3," which includes the County Trunk J Swamp which is owned partially by the Kettle Moraine Audubon Society and partially under private ownership and the Heritage Hills Bog which is partially privately owned and partially owned by Washington County.

ENVIRONMENTAL CORRIDORS

One of the most important tasks undertaken by the Regional Planning Commission in its work program has been the identification and delineation of those areas of the Region having high concentrations of natural, recreational, historic, aesthetic, and scenic resources and which, as such, should be preserved and protected in order to maintain the overall quality of the environment. Such areas normally include one or more of the following seven elements of the natural resource base which are essential to the maintenance of both the ecological balance and the natural beauty of the Region: 1) lakes, rivers, and streams, and the associated undeveloped shorelands and floodlands; 2) wetlands; 3) woodlands; 4) prairies; 5) wildlife habitat areas; 6) wet, poorly drained, and organic soils; and 7) rugged terrain and high-relief topography. While the foregoing seven elements constitute integral parts of the natural resource base, there are five additional elements which, although not a part of the natural resource base per se, are closely related to, or centered on, that base, and, therefore, are important considerations in identifying and delineating areas with scenic, recreational, and educational value. These additional elements are: 1) existing outdoor recreation sites; 2) potential outdoor recreation and related open space sites; 3) historic, archaeological, and other cultural sites; 4) significant scenic areas and vistas; and 5) natural and scientific areas.

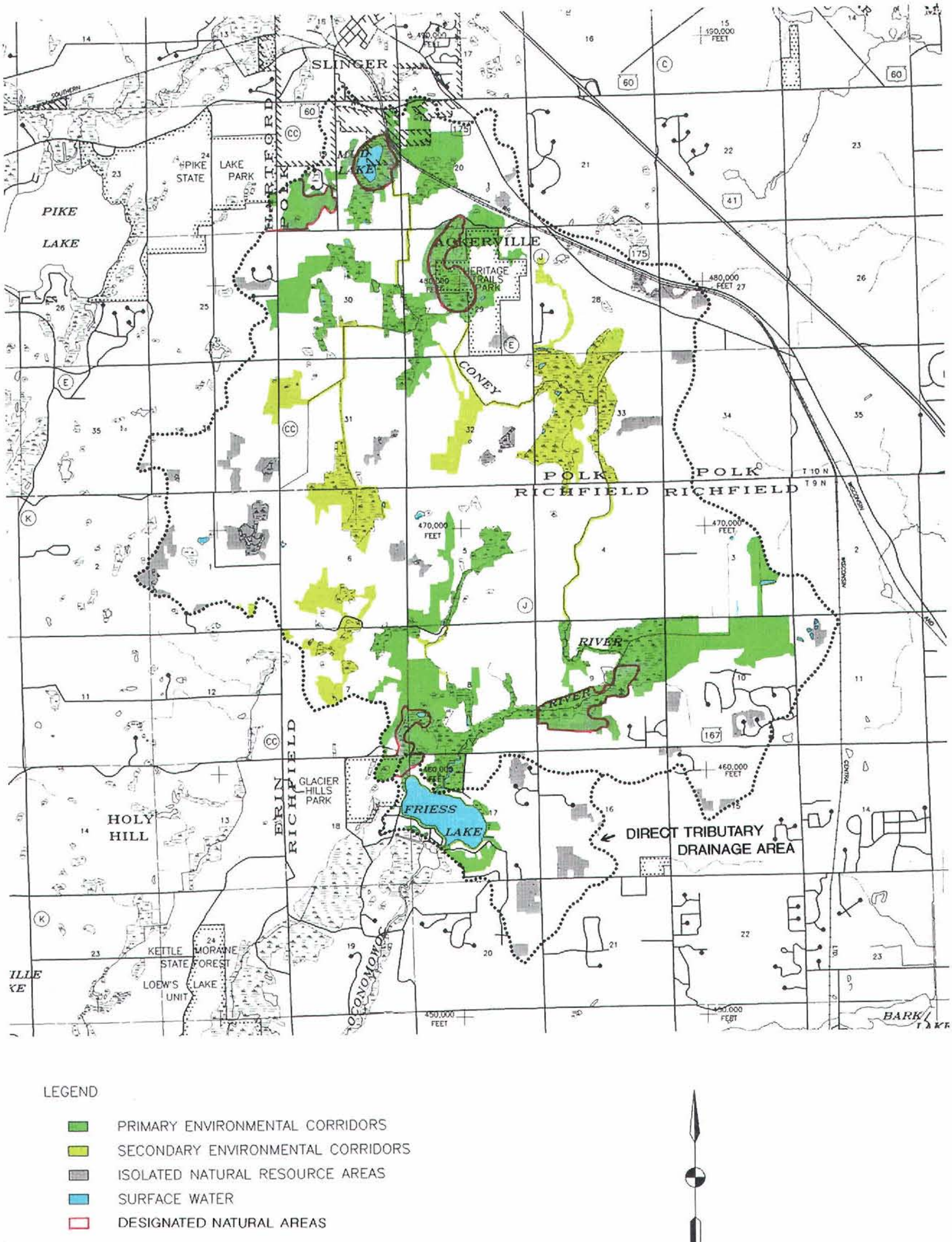
In Southeastern Wisconsin, the delineation of these 12 natural resource and natural resource-related elements on maps results in an essentially linear pattern of relatively narrow, elongated areas which have been termed "environmental corridors" by the Commission. Primary environmental corridors include a wide variety of the abovementioned important resource and resource-related elements and are at least 400 acres in size, two miles in length, and 200 feet in width. The primary environmental corridors identified in the Friess Lake direct drainage area, shown on Map 20, are contiguous with environmental corridors and isolated natural resource areas lying outside the lake drainage area boundary. All of the specially designated natural areas noted in the previous sections are located within the designated primary environmental corridor lands.

It is important to note here that, because of the many interlocking and interacting relationships between living organisms and their environment, the destruction or deterioration of one element of the total environment may lead to a chain reaction of deterioration and destruction. The drainage of wetlands, for example, may have far-reaching effects, since such drainage may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas of interconnecting lake and stream systems. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater which serves as a source of domestic, municipal, and industrial water supply and provides a basis for low flows in rivers and streams. Similarly, the destruction of woodland cover, which may have taken a century or more to develop, may result in soil erosion and stream siltation and in more rapid runoff and increased flooding, as well as destruction of wildlife habitat. Although the effects of any one of these environmental changes may not, in and of itself, be overwhelming, the combined effects may lead eventually to the deterioration of the underlying and supporting natural resource base, and of the overall quality of the environment for life. The need to protect and preserve the remaining environmental corridors within the Friess Lake direct tributary drainage area thus becomes apparent and critical.

Primary environmental corridors were first identified within the Region in 1963 as part of the original regional land use planning effort of the Commission, and were subsequently refined under the Commission watershed studies and regional park and open space planning programs. The primary environmental corridors in Southeastern Wisconsin generally lie along major stream

Map 20

ENVIRONMENTALLY VALUABLE AREAS WITHIN THE FRIESS LAKE TOTAL TRIBUTARY DRAINAGE AREA



Source: SEWRPC.

valleys and around major lakes, and contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all of the major bodies of surface water and related undeveloped floodlands and shorelands.

Primary environmental corridors in the Friess Lake direct drainage area in 1990 encompassed about 80 acres, or 8 percent of the drainage area. Some 1,930 acres of primary environmental corridor were contained within the total tributary drainage area of the Lake, comprising 16 percent of the land area. A further 823 acres of secondary environmental corridor also exist within the total tributary drainage area to Friess Lake, as shown on Map 20.

Environmental corridors may be subject to urban encroachment because of their desirable natural resource amenities. Unplanned or poorly planned intrusion of urban development into these corridors, however, not only tends to destroy the very resources and related amenities sought by the development, but tends to create severe environmental and development problems as well. These problems include, among others, water pollution, flooding, wet basements, failing foundations for roads and other structures, and excessive infiltration of clear water into sanitary sewer systems. The preservation of as yet undeveloped corridors is one of the major ways in which the water quality of Friess Lake can be maintained at relatively little additional cost to the taxpayers of the area.

In addition to the primary environmental corridors, other, small concentrations of natural resource base elements exist within the Friess Lake direct and total tributary drainage areas. These resource base elements are isolated from the environmental corridors by urban development or agricultural uses and, although separated from the environmental corridor network, have important natural values. Isolated natural resource areas may provide the only available wildlife habitat in an area, provide good locations for local parks and nature study areas, and lend an aesthetic character or natural diversity to an area. Important isolated natural resource features within Southeastern Wisconsin include a geographically well-distributed variety of isolated wetlands, woodlands, and wildlife habitat. These isolated natural resource features should also be protected and preserved in a natural state whenever possible. Such isolated areas five or more acres in size within the Friess Lake direct and total tributary drainage area as of 1990, are also shown on Map 20. The combined area of the isolated natural resource areas identified on the map total about 94 acres, or 10 percent of the direct drainage area, and about 450 acres, or 3 percent of the total tributary drainage area.

SUMMARY

The Lake does suffer from an excessive abundance of aquatic plants in selected areas, predominantly the nuisance species *Myriophyllum spicatum* (Eurasian water milfoil) and *Ceratophyllum demersum* (coontail). These aquatic plants have historically been managed using a combination of chemical and manual control. Chemical controls when used (see Table 16), are generally applied in late spring, with a possible follow-up treatment in late summer. Manual controls are effected by individual riparian residents with a variety of equipment.

The Lake supports a vigorous, well-balanced, fish community, including sport fish, panfish, and rough fish that are heavily sought by anglers. The fishery is not stocked by the Wisconsin Department of Natural Resources.

Other aquatic life and wildlife in the direct drainage area of the Lake include amphibians and reptiles, birds, and small and large mammals. While many of the wetland habitats frequented by many of these animals are expected to remain intact, the predominantly hardwood forest woodlands that house much of the terrestrial fauna are prime areas for further urban residential and recreational development (see Tables 7 and 8). Nevertheless, the Friess Lake direct and total drainage areas provide an adequate refuge for a healthy and diverse fauna.

The preservation of the shorelands and major portion of the drainage area tributary to Friess Lake which are incorporated into the primary environmental corridor lands as recommended in the adopted Regional and County park and open space plans would be an important step toward the preservation of a relatively high quality of the environment in the Friess Lake area.

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Chapter VI

CURRENT WATER USES AND WATER USE OBJECTIVES

INTRODUCTION

Nearly all major lakes in the Southeastern Wisconsin Region serve multiple purposes, ranging from recreation to receiving waters for stormwater management. Recreational uses range from noncontact, passive recreation such as picnicking and walking along the shoreline, to full-contact, active recreation such as swimming and water skiing. Water use objectives and supporting water quality standards have been adopted by the Southeastern Wisconsin Regional Planning Commission as set forth in the adopted regional water quality management plan[1] for all major lakes and streams in the Region. The current water uses as well as the water use objectives and supporting water quality standards for Friess Lake are discussed in this chapter.

CURRENT WATER USES

Existing Public Parks and Recreational Facilities

Friess Lake provides opportunities for a variety of water-based outdoor recreational activities, including fishing, boating, swimming, and nature studies. However, public access opportunities are limited. In 1976, the Wisconsin Department of Natural Resources identified two privately owned access sites on the Lake which were found to be well maintained and in good condition. Subsequently, one site, located on the southern shore of the Lake, discontinued boat launching activities, leaving a single site on the western shore of the lake as the sole privately owned access point for recreational boating activities on the Lake. This site continues to be maintained. No public boating access site is located on the Lake, although a County park—Glacier Hills County Park—is situated on the northwestern shore. That park, however, has no facilities for public lake access, although, carry-in boating access may be possible at this site. One other publicly owned carry-in boating access site exists at the STH 167 road crossing immediately upstream of the Lake. Consequently, Friess Lake lacks adequate public access as defined in Section NR 1.90 through NR 1.95 of the *Wisconsin Administrative Code.*[2]

Fishing is the most popular summer and winter outdoor recreation activity on Friess Lake. Friess Lake provides a high-quality habitat for northern pike, largemouth bass, and panfish. Waterskiing, pleasure boating, and swimming are also popular active recreational activities on Friess Lake. In addition, passive recreation activities are routinely carried out on the shoreland.

Waterfowl and other marsh animals, including shorebirds, muskrats, and pheasants, are found in the wetland areas surrounding the Lake, along the Oconomowoc and Coney Rivers, and at the inlet and outlet of the Lake. Nature study opportunities also exist in the surrounding

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[1]*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. See also SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[2]*The Wisconsin Department of Natural Resources, under guidelines established in the* Wisconsin Administrative Code, *Chapters NR 1.90 and NR 1.93, recommends that at least one public recreational boating access site, open to the general public, be provided on all major inland lakes. Further, Sections NR 1.90 through NR 1.95 require the development of adequate public recreational boating access for the Lake is to receive natural resource enhancement services from the State for in-lake and watershed management programs. Natural resource enhancement services are defined in Paragraph NR 1.90(2)(d) of the* Wisconsin Administrative Code *as "funding or activities that increase the recreational or environmental values of a waterway," including, but not limited to, "fish stocking, removal or other fish population management, habitat development, financial assistance for aquatic plant harvesting and lake restoration grants." It is a requirement of the lake management planning grant program that public recreational boating access to lakes lacking adequate access be addressed in lake management planning activities funded under this program. These issues in respect of public recreational boating access to Friess Lake are discussed further in Chapters VII and VIII.*

woodlands, which provide habitat for squirrels, rabbits, and deer. To this end, the Kettle Moraine Audubon Society owns a portion of the river frontage adjacent to the Friess Lake School and operates an active outreach program in the Joint School District No. 11. There is no evidence that the lake and surrounding area is extensively utilized for hunting or trapping, although, as previously noted, the Daniel Boone Hunters Club does maintain a preserve within the direct drainage area to Friess Lake.

It is important to note that the provision of park and open space sites in the Friess Lake drainage area should be guided, to a large extent, by the recommendations contained in the Washington County park and open space plan.[3] The purpose of that plan is to guide the preservation, acquisition, and development of land for park, outdoor recreation, and related open spaces purposes and to protect and enhance the underlying and sustaining natural resource base of the County. With respect to the drainage area tributary to Friess Lake, the plan recommends the maintenance of existing park and open space sites in the area. In addition, the plan recommends that the undeveloped lands in the primary environmental corridor around Friess Lake be retained and maintained as natural open space through zoning or public acquisition. That plan also recognizes the current Wisconsin Department of Natural Resources regulations and policies regarding lake access and recommends that a public access site be developed on Friess Lake.

Wisconsin Department of Natural Resources Recreational Rating

A rating technique has been developed by the Wisconsin Department of Natural Resources to characterize the recreational value of inland lakes. As shown in Table 23, under this rating technique, Friess Lake would receive 58 out of the possible 72 points, placing it among those lakes in Southeastern Wisconsin providing diverse, high-quality outdoor recreational opportunities. To ensure that Friess Lake will continue to provide such recreational opportunities, the resource values of the lake must be protected and preserved.

WATER USE OBJECTIVES

The regional water quality management plan recommends the adoption of full recreational and warmwater sport fishery objectives for Friess Lake. The findings of the inventories of the natural resource base set forth in Chapter III through V indicate that the resources of the area are generally supportive of these objectives, although remedial measures will be required if the Lake is to fully meet the objectives. The scope of the recreational uses actually engaged in on Friess Lake, as described above, are sufficiently broad to be consistent with the recommended water use objective providing for full recreational use.[4]

WATER QUALITY STANDARDS

The water quality standards supporting the warmwater fishery and full recreation use objectives as established for planning purposes in the regional water quality management plan, are set forth in Table 24. These standards are similar to those set forth in Chapters NR 102 and 104 of the *Wisconsin Administrative Code*, but were refined for regional water quality management planning purposes. Standards are recommended for temperature, pH, dissolved oxygen, fecal coliforms, residual chlorine, un-ionized ammonia nitrogen, and total phosphorus. These standards are intended to apply to the epilimnion of the lakes. The total phosphorus standard is intended to apply to spring turnover concentrations measured in the lake. Such contaminants as oil, debris, and surface films; odors, tastes, and color-producing substances; and toxins are not permitted in concentrations harmful to the public or to aquatic life as set forth in Chapter NR 102 of the *Wisconsin Administrative Code*.

The adoption of these standards was intended to specify conditions in the waterways concerned that mitigated against excessive macrophyte and algal growths and promoted all forms of recreational use, including angling, in these waters. Of particular concern in Friess Lake is the standard for total phosphorus of 0.02 milligrams per liter. Based upon review of the current conditions and the controllable phosphorus inputs into Friess Lake, it is expected that the phosphorus standard will likely not be fully attainable. Thus, the alternative lake management measures considered in Chapter VII include not only measures to reduce the pollutant loading to the Lake, but also in-lake measures—such as aquatic plant management—to treat the symptom of higher-than-desirable nutrient concentrations. Implementation of remedial measures in the Oconomowoc River watershed upstream of Friess Lake is especially important, given

[3]*SEWRPC Community Assistance Planning Report No. 136, 2nd Edition,* A Park and Open Space Plan for Washington County, *August 1997.*

[4]*SEWRPC Planning Report No. 30, Volume Two, Map 1, p. 14, op. cit.*

Table 23

RECREATIONAL RATING OF FRIESS LAKE

Space: Total Area—311 acres   Total Shore Length—4.7 miles

Ratio of Total Area to Total Shore Length: 0.103:1

Quality (18 maximum points for each item)

Fish:					
X 9	High production	_ 6	Medium production	_ 3	Low production
X 9	No problems	_ 6	Modest problems such as infrequent winterkill, small rough fish problems	_ 3	Frequent and overbearing problems such as winterkill, carp, excessive fertility
Swimming:					
X 6	Extensive sand or gravel substrate (75 percent or more)	_ 4	Moderate sand or gravel substrate (25 to 50 percent)	_ 2	Minor sand or gravel substrate (less than 25 percent)
_ 6	Clean water	X 4	Moderately clean water	_ 2	Turbid or darkly stained water
_ 6	No algae or weed problems	X 4	Moderate algae or weed problems	_ 2	Frequent or severe algae or weed problems
Boating:					
_ 6	Adequate water depths (75 percent of basin more than five feet deep)	_ 4	Marginally adequate water depths (50 to 75 percent of basin more than five feet deep)	X 2	Inadequate depths (less than 50 percent of basin more than five feet deep)
_ 6	Adequate size for extended boating (more than 1,000 acres)	_ 4	Adequate size for some boating (200 to 1,000 acres)	X 2	Limit of boating challenge and space (less than 200 acres)
X 6	Good water quality	_ 4	Some inhibiting factors such as weedy bays, algae blooms, etc.	_ 2	Overwhelming inhibiting factors such as weed beds throughout
Aesthetics:					
_ 6	Existence of 25 percent or more wild shore	X 4	Less than 25 percent wild shore	_ 2	No wild shore
X 6	Varied landscape	_ 4	Moderately varied	_ 2	Unvaried landscape
X 6	Few nuisances such as excessive algae carp, etc.	_ 4	Moderate nuisance conditions	_ 2	High nuisance condition

Total Quality Rating: 58 out of a possible 72

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 24

RECOMMENDED WATER QUALITY STANDARDS TO SUPPORT RECREATIONAL AND WARMWATER FISH AND AQUATIC LIFE USE

Water Quality Parameter	Water Quality Standard
Maximum Temperature	89°F[a,b]
pH Range	6.0-9.0 standard units
Minimum Dissolved Oxygen	5.0 mg/l[b]
Maximum Fecal Coliform	200/400 MFFCC/100 ml[c]
Maximum Total Residual Chlorine	0.01 mg/l
Maximum Un-ionized Ammonia Nitrogen	0.02 mg/l
Maximum Total Phosphorus	0.02 mg/l[d]
Other	--[e,f]

[a] *There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the existing natural temperature shall not exceed 3°F for lakes.*

[b] *Dissolved oxygen and temperature standards apply to the epilimnion of stratified lakes and to the unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inland lakes. Trends in the period of anaerobic conditions in the hypolimnion of stratified inland lakes should be considered important to the maintenance of water quality, however.*

[c] *The membrane filter fecal coliform count per 100 milliliters (MFFCC/100 ml) shall not exceed a monthly geometric mean of 200 per 100 ml based on not less than five samples per month, nor a level of 400 per 100 ml in more than 10 percent of all samples during any month.*

[d] *This standard for lakes applies only to total phosphorus concentrations measured during spring when maximum mixing is underway.*

[e] *All waters shall meet the following minimum standards at all times and under all flow conditions: Substances that will cause objectionable deposits on the shore or in the bed of any body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in the waters of the State. Materials producing color, odor, taste, or unsightliness shall not be present in amounts which are acutely harmful to animal, plant, or aquatic life.*

[f] *Unauthorized concentrations of substances are not permitted that alone or in combination with other material present are toxic to fish or other aquatic life. Standards for toxic substances are set forth in Chapter NR 105 of the Wisconsin Administrative Code.*

Source: SEWRPC.

the relatively short water residence time in Friess Lake (Figure 2) and the major role of the river water in determining the nutrient and pollutant loading on the Lake (Figure 9).

SUMMARY

The regional water quality management plan includes recommendations for full recreational use and a warmwater sport fishery as the water use objectives for Friess Lake. Based upon discussions with the Friess Lake Action Group, it is concluded that strong support exists for those water use objectives. The present recreational uses being conducted on an around Friess Lake are consistent with the recommended use objectives. In addition, the existing fishery is consistent with the warmwater sport fishery objective. The achievement of these objectives is expected to require management interventions aimed at controlling sediment and nutrient loading, algal and plant growth responses, and habitat degradation in the Lake. These actions will form the basis for the management plan hereafter recommended.

Chapter VII

ALTERNATIVE WATER QUALITY MANAGEMENT MEASURES

INTRODUCTION

Based upon review of the inventories and analyses set forth in Chapter II through VI, eight issues were identified requiring consideration in the formulation of alternative and recommended lake management measures. These issues are related to: 1) land use and zoning, 2) nonpoint source pollution, 3) onsite sewage disposal systems, 4) ecologically valuable areas and aquatic plants, 5) water quality, 6) lake water levels, 7) fisheries, and 8) public recreational use and boating access. The management measures considered herein are focused primarily on those measures which are applicable to the Friess Lake Action Group, a potential future lake rehabilitation and protection district, and the Town of Richfield, with lesser emphasis given to those measures which are applicable to others with jurisdiction within the broader total drainage area tributary to Friess Lake.

LAND USE AND ZONING

A basic element of any management planning effort for any lake is the promotion of sound land use development and management in the tributary watershed. The type and location of future urban and rural land uses in the watershed 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 forms of land management; and, to a limited degree, the water quality of the Lake.

Existing 1990 and planned year 2010 land use patterns and existing zoning regulations in the tributary drainage area to Friess Lake are described in Chapter III. Under the planned year 2010 conditions set forth in the adopted regional land use plan,[1] urban land uses within the Friess Lake total tributary drainage area would increase by only about 350 acres, resulting in urban land comprising about 23 percent of the total watershed area. In addition, some infilling of existing platted lots may be expected to occur, and the redevelopment of properties and reconstruction of existing single-family homes may be expected on lakeshore parcels. However, recent surveillance indicates that urban growth within the total drainage area tributary to Friess Lake will exceed this planned level of development as a result of development patterns providing primarily for large-lot residential development. The existing zoning would permit for more urban development in the drainage area than envisioned in the regional land use plan. If this trend continues, some of the open space areas remaining in the drainage area will be replaced over time with large-lot urban development. Increases in urban land uses and impervious surfaces will increase runoff into the Lake and may increase some pollutant loadings unless mitigative measures are taken. In addition, groundwater recharge patterns may be altered and there may be an increase in recreational use pressures on the Lake.

Given the concerns noted above, three optional management measures have been considered related to land use planning and zoning in the tributary drainage area to Friess Lake. These measures are: 1) zoning restrictions on shoreland development; 2) broader general land use regulations in the drainage area tributary to Friess Lake; and 3) wetland protection measures.

Shoreland Development Restrictions

The first measure considered relates to the limitation, through the local zoning process, on land use development or redevelopment proposals along the shoreline of Friess Lake which have potential adverse impacts on the Lake and its desired character. In the case of the areas immediately surrounding Friess Lake, the current zoning is generally consistent with the recommendations set forth in the regional land use plan, and significant changes in the development patterns are restricted due to floodplain and shoreland district zoning. Thus, the only action needed is the monitoring of potential zoning changes which could result in a significant change in the character of the shoreline development.

Land Use Regulations within the Total Drainage Area Tributary to Friess Lake

In the case of the total tributary drainage area to Friess Lake, the current zoning generally permits far more urban development than envisioned in the adopted

[1] *SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin—2010, *January 1992.*

regional land use plan. One option for minimizing the effect of future development on Friess Lake is to carefully review the applicable zoning ordinances and to propose changes addressing the conflicts noted. Changes in the zoning ordinance could be considered to minimize the areal extent of the development by providing specific provisions and incentives to cluster residential development on smaller lots while preserving portions of the open space on each property or group of properties considered for development.

Wetland Protection Measures

Wetland and groundwater recharge area protection can be accomplished through regulation and acquisition, and both are measures that should be considered for inclusion in the Friess Lake management plan. Wetlands in the Friess Lake drainage area are currently regulated by the U.S. Army Corps of Engineers 404 Permit Program, the Wisconsin Shoreland Zoning Program, and local zoning ordinances. The wetlands protected under these regulatory programs are shown on Map 19. Nearly all wetland areas in the Friess Lake direct drainage area are protected under one or more of the Federal, State, County, and local regulations.

All three of the alternative land use and zoning measures discussed above are considered to be viable measures for inclusion in the recommended Friess Lake management plan. No specific direct costs are associated with these measures.

NONPOINT POLLUTION SOURCES

An estimate of the nonpoint pollution sources from the various pollution sources in the drainage area is presented in Chapter IV. Because of the rolling topography and relatively impervious soils, not all areas of the drainage area tributary to Friess Lake contribute runoff to the Lake during normal rainfall periods. Those areas where the runoff is limited are shown on Map 21.

Watershed management measures may be used to reduce nonpoint source pollutant loadings from such rural sources as runoff from cropland and pasture land; from such urban sources as runoff from residential, commercial, industrial, transportation, and recreational land uses; and from construction activities. The alternative, watershed-based nonpoint source pollution control measures considered in this report are based upon the recommendations set forth in the regional water quality management plan,[2] the Oconomowoc River priority watershed plan,[3] and the Washington County soil erosion control plan.[4]

The regional water quality management plan recommends that the nonpoint source pollutant loadings from tributary to Friess Lake be reduced by about 25 percent, in addition to urban construction erosion control, streambank and shoreline erosion control, and onsite sewage disposal system management. The Oconomowoc River Priority Watershed plan made similar recommendations, providing for a reduction in phosphorus loading of about 30 percent. Data provided in Chapter IV and VI indicate a that a reduction in phosphorus concentrations within Friess Lake of about 75 percent would be required to fully meet the water quality standard associated with full recreational use objectives. As described in Chapter IV, the most readily controllable loadings within the watershed to the Lake are loadings associated with runoff from the direct drainage area tributary to the Lake and from onsite sewage disposal systems. These loadings constitute only about 23 percent of the total loading to Friess Lake, when internal recycling is considered. Phosphorus loadings from the remainder of the tributary area contributed by the Oconomowoc River account for about 70 percent of the total loading.

The project implementation period for the Oconomowoc River Priority Watershed Project ended in December of 1994. Under that program, a significant level of the recommended rural nonpoint source measures were implemented. However, the recommended urban nonpoint source component was largely unimplemented,

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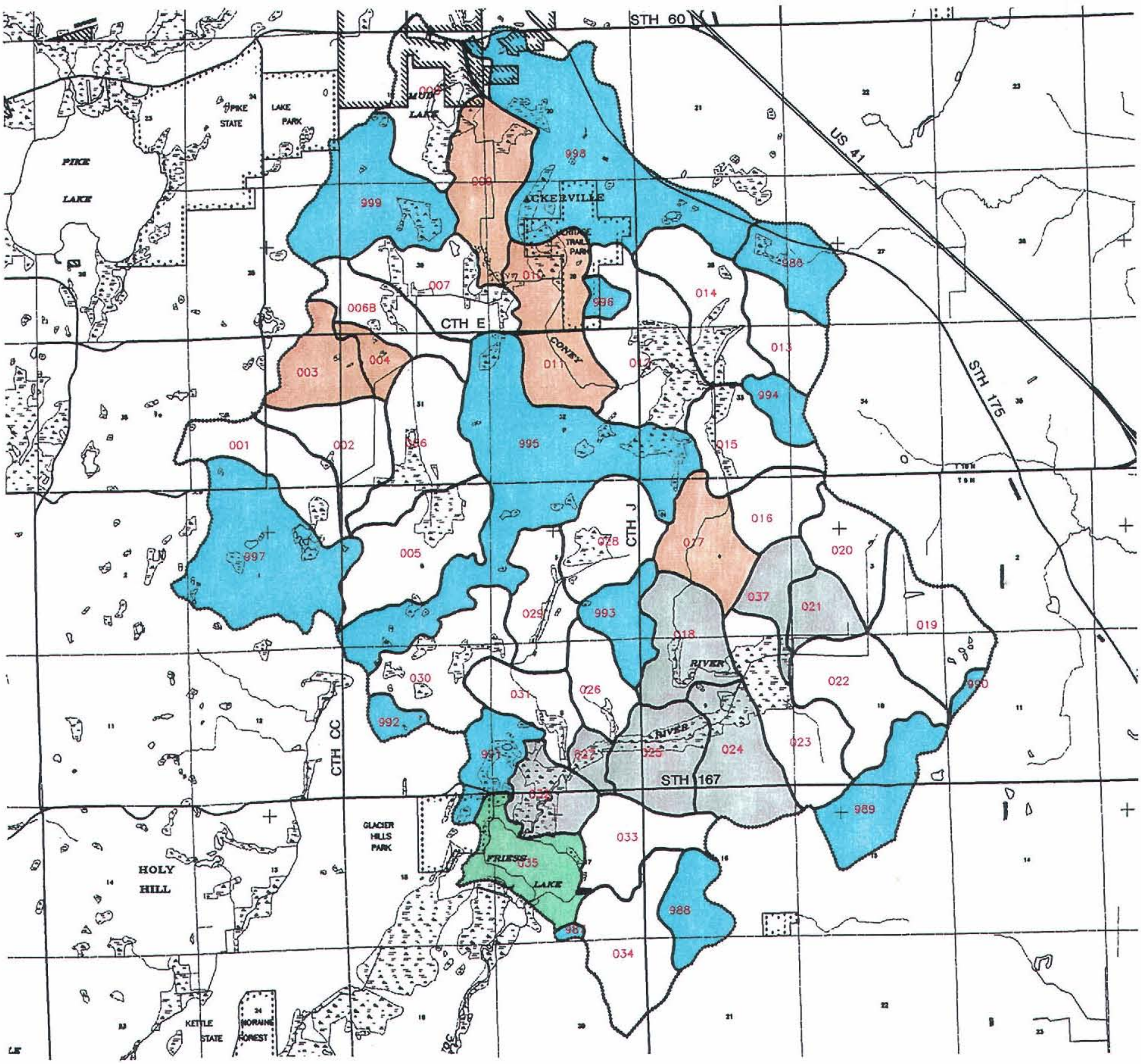
[2]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One,* Inventory Findings, *September 1978; Volume Two,* Alternative Plans, *February 1979; and Volume Three,* Recommended Plan, *June 1979, as updated in SEWRPC Memorandum Report No.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

[3]*Wisconsin Department of Natural Resources Publication No. WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986.*

[4]*SEWRPC Community Assistance Planning Report No. 170,* Washington County Agricultural Soil Erosion Control Plan, *March 1989.*

Map 21

FRIESS LAKE SUBBASINS WITH HIGH SEDIMENT AND PHOSPHORUS YIELDS: 1994



LEGEND

NONCONTRIBUTING AREAS FOR FRIESS LAKE

RURAL AREAS WITH HIGH SEDIMENT AND PHOSPHORUS YIELDS

URBAN AND URBANIZING AREAS WITH HIGH SEDIMENT AND PHOSPHORUS YIELDS

RIPARIAN AREAS WHERE CONSIDERATION SHOULD BE GIVEN TO ONSITE SEWAGE TREATMENT SYSTEMS

0 1/4 1/2 3/4 1 MILE

GRAPHIC SCALE

NOTE: Due to the topography and multiple depressions in the study area, the actual contributing drainage area of Friess Lake excludes the areas noted.

Source: Washington County Land Conservation Department and SEWRPC.

except for construction erosion control measures. Furthermore, given the extent and nature of the tributary area to Friess Lake, further nonpoint source pollutant loading reductions of 25 to 50 percent are the maximum which can be practically expected. Thus, it is unlikely that management measures to reduce nonpoint source pollutant loadings to the Lake will result in the phosphorus standard being fully achieved. Nevertheless, consideration should be given to reducing the pollutant loadings from these controllable sources to the extent practicable in order to minimize the negative results of higher than desirable nutrient loadings.

Three optional management measures have been considered to control nonpoint source pollution loadings within the tributary drainage area to Friess Lake. These measures are: 1) urban nonpoint source controls; 2) rural nonpoint source controls; and 3) an instream sedimentation basin.

Appendix A presents a list of alternative nonpoint source pollution management measures that could be considered for use in the drainage area tributary to Friess Lake to reduce loadings from nonpoint sources of pollution. Information on the cost and effectiveness of the measures is also presented in this appendix.

Urban and Urbanizing Area Nonpoint Source Controls

Based on a preliminary evaluation, it is estimated that potentially applicable urban nonpoint source control measures within the drainage area tributary to Friess Lake include wet detention basins, grassed swales, and good urban "housekeeping" practices. Generally, the application of low-cost urban housekeeping practices may be expected to reduce nonpoint source loadings from urban lands by about 25 percent. Public education 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. 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; and reduced use of street deicing salt.

Proper design and application of urban nonpoint source control measures such as grassed swales and detention basins requires the preparation of a detailed stormwater management plan that addresses stormwater drainage problems and controls nonpoint sources of pollution. Based on a preliminary evaluation, however, it is estimated that the practices which could be viable in the existing urban areas within the immediate vicinity of Friess Lake are limited largely to good urban housekeeping practices and grassed swales. However, structural measures, such as detention ponds, could be considered for installation as part of the development process and upgrading of the transportation infrastructure in urbanizing areas of the tributary drainage area.

Developing areas can generate significantly higher pollutant loadings than established areas of similar size. Developing areas include a wide array of activities, including urban renewal projects, individual site development within the existing urban area, and new land subdivision development. As noted previously, observations made by the Washington County Land Conservation Department staff indicate that the rate of urbanization in the Friess Lake drainage area is exceeding that set forth in the recommended land use plan.

Construction sites can be expected to produce suspended solids and phosphorus at rates several times higher than established urban land uses. Control of sediment loss from construction sites can be provided by measures set forth in the model ordinance developed by the Wisconsin Department of Natural Resources in cooperation with the League of Municipalities and adopted by Washington County.[5] These controls are temporary measures taken to reduce pollutant loadings from construction sites during stormwater runoff events. Construction erosion controls may be expected to reduce pollutant loadings from construction sites by about 75 percent. Such practices are expected to have only a minimal impact on the total pollutant loading to the Lake due to relatively small amount of land proposed to be developed. However, such controls are important pollution control measures in order to minimize severe localized short-term loadings of phosphorus and sediment from the drainage area and the upstream tributary area. The control measures considered viable include such revegetation practices as temporary seeding, mulching, and sodding and such

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[5]*A model erosion control ordinance is set forth in the publication by the Wisconsin League of Municipalities and Wisconsin Department of Natural Resources, entitled* Wisconsin Construction Site Best Management Practices Handbook, *and published in 1989. The Washington County ordinance is similar to, but predates, this model.*

runoff control measures as filter fabric fences, straw bale barriers, storm sewer inlet protection devices, diversion swales, sediment traps, and sedimentation basins.

Based upon the above, the use of urban nonpoint source pollution control measures and construction erosion control measures are considered to be viable measures for inclusion in the recommended Friess Lake management plan.

Rural Nonpoint Source Controls

The topography and soils in the drainage area are such that upland erosion from agricultural and other rural lands is a major contributor of sediment to streams and lakes in the Oconomowoc River watershed upstream of Friess Lake. Sediment erosion rates were initially quantified for all croplands, woodlots, pastures, and grasslands in the Friess Lake drainage area under the Oconomowoc River Priority Watershed planning program and then updated for this current study. These data were utilized in determining the percentage pollutant load reduction that could be achieved in the Friess Lake drainage area and the extent of the areas to which the practices were to be applied.

As recommended in the regional water quality management and Washington County agricultural soil erosion control plans, detailed farm conservation plans will be required to adapt and refine these recommendations for individual farm units. Conservation plans are detailed plans, generally prepared with the assistance of the U.S. Soil Conservation Service or County Land Conservation Department staffs, intended to guide agricultural activity in a manner which conserves soil and water resources. The conservation plan indicates desirable soil management practices, cropping patterns, and rotation cycles, considering the specific topography, hydrology, and soil characteristics of the farm, together with the specific resources of the farm operator and the operator's objectives as owner or manager of the land.

On the basis of 1980 land use conditions, which appeared to be largely consistent with the 1988 inventory used in the County soil erosion control plan, it was estimated that about 3,126 tons per annum of sediment was eroded from rural lands within a one-eighth-mile corridor adjacent to streams and rivers within the drainage area tributary to Friess Lake. Approximately 840 tons, or 27 percent, of this erosion came from lands with annual soil losses which exceeded the target level of three tons per acre per year established in the Washington County agricultural soil erosion control plan and the priority watershed plan.[6] A reduction in soil loss of about 1,943 tons per year was estimated as being achievable by installing basic conservation and management practices on about 1,350 acres of land.[7] Application of conservation practices providing this level of control was estimated to result in about a 30 percent decrease in soil loss, and a reduction of about 40 percent of the phosphorus loadings, from the land surface of agricultural lands in the Friess Lake drainage area.[8]

To date, data provided by the Washington County Land Conservation Department indicate that nonpoint source control measures have been applied to approximately 1,893 acres of rural lands within the Friess Lake watershed.[9] Recent estimates of soil losses, calculated using the WINHUSLE model as described in Chapter IV, suggest that considerable reductions in soil loss have been achieved. Using 1990 land use data, the Washington County Land Conservation Department estimated that 1,985 tons of soil were delivered to streams flowing to Friess Lake. This rate of soil loss from the land surface represents a 37 percent reduction from the 3,126 tons calculated for 1980 conditions. Nevertheless, the sediment load delivered to Friess Lake of 516 tons per year continues to be high, and ongoing efforts to implement and maintain rural land best management practices remain viable options to be considered for inclusion in the recommended Friess Lake management plan. Particular attention should be directed toward the upper and

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[6] *Washington County Land Conservation Department,* Oconomowoc River Watershed Project Sign-up Phase Summary: Washington County Portion, *Report submitted to the Oconomowoc River Advisory Committee Annual Meeting, April 1990.*

[7] *Washington County Land Conservation Department Annual Report, April 1990.*

[8] *Wisconsin Department of Natural Resources, Publication No. WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986.*

[9] *Washington County Land Conservation Department Annual Report, April 1990 reported that implemented conservation practices to control rural soil erosion included contouring—29 acres, contour strip-cropping—117 acres, changes in crop rotations—1,094 acres, and conservation tillage—497 acres. About 156 acres were placed into the Conservation Reserve Program.*

middle reaches of the Coney River as indicated on Map 21.

In addition, the continued protection of the wetland and floodland areas adjacent to the stream courses draining to Friess Lake is considered an important measure for reducing rural nonpoint pollution. In particular, the restoration of the streambank along the Coney River between CTH E and STH 167, and the protection of wetlands in the vicinity of the STH 167 bridge on the Oconomowoc River, should be considered as priority interventions. Should urban development not proposed under the regional land use plan threaten to destroy or degrade natural resources located within the primary environmental corridors, appropriate public or private agencies should consider acquisition of such lands for resource and open space preservation purposes.

The costs of rural nonpoint source pollution control practices were previously eligible expenses under the Chapter NR 120 Wisconsin Nonpoint Source Pollution Abatement Program.[10] Maintenance of land management practices installed under the Oconomowoc River Priority Watershed Program remains cost-eligible in certain circumstances under the Chapter NR 120 Program. In addition, some costs associated with the purchase of lands and reestablishment of wetlands along water courses upstream of Friess Lake could also be cost-share eligible under the Chapter NR 191 Lake Protection Grant Program.

Based upon the above, the continued and expanded use of rural nonpoint source pollution control measures is considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

Instream Sedimentation Basin

The Friess Lake Action Group reports that an instream sedimentation basin had been created and maintained in the Oconomowoc River bed upstream of the STH 167 bridge adjacent to the Wittenberger Farmstead, as shown on Map 22. The basin is no longer evident in that it has been filled in with sediment and is no longer maintained. Because of the high sediment loads and particulate nutrient loads entering the Lake, the use of such a basin, if properly designed, would be one means of reducing the pollutant loading carried from upstream into Friess Lake. The purpose of the basin would be to intercept the particulate matter before it enters Friess Lake. In addition, the proposed reconstruction of CTH J may afford an opportunity to place a stormwater detention basin on the unnamed tributary entering Friess Lake from the east. Given the potential development of this portion of the drainage area tributary to Friess Lake, and the proposed extent of the CTH J reconstruction, consideration of such a basin could serve to mitigate the potentially higher pollutant loads that could enter the Lake from this tributary. Creation of such basins would require a detailed evaluation, including hydrologic and hydraulic analyses and pollutant removal efficiency and, if found to be effective and affordable, permitting under Chapter 30 of the *Wisconsin Statutes*. These permits are administered by the Wisconsin Department of Natural Resources, Division of Water, Bureau of Fishery Management and Habitat Protection.

The development of an instream sedimentation basin is considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

ONSITE SEWAGE DISPOSAL SYSTEMS

As reported in Chapter IV, onsite sewage disposal systems are estimated to contribute about 8 percent of the total phosphorus loading to Friess Lake. In addition to lake water quality considerations, sewage disposal options in the area have implications for groundwater quality and property values. In the regional water quality management plan the concentrations of urban development located along the shorelines of Friess Lake were not included within recommended public sanitary sewer service areas. Information available at the time of preparation of that plan did not indicate the need and cost-effectiveness for providing centralized sanitary sewer service to the Friess Lake community. Thus, the areawide water quality management plan as currently adopted recommends that sewage disposal needs be provided through onsite sewage disposal systems. The regional plan, however, also recommended that sewerage needs in such areas be periodically reevaluated in light of changing conditions.

Two optional management measures have been considered for sewage disposal by the urban development

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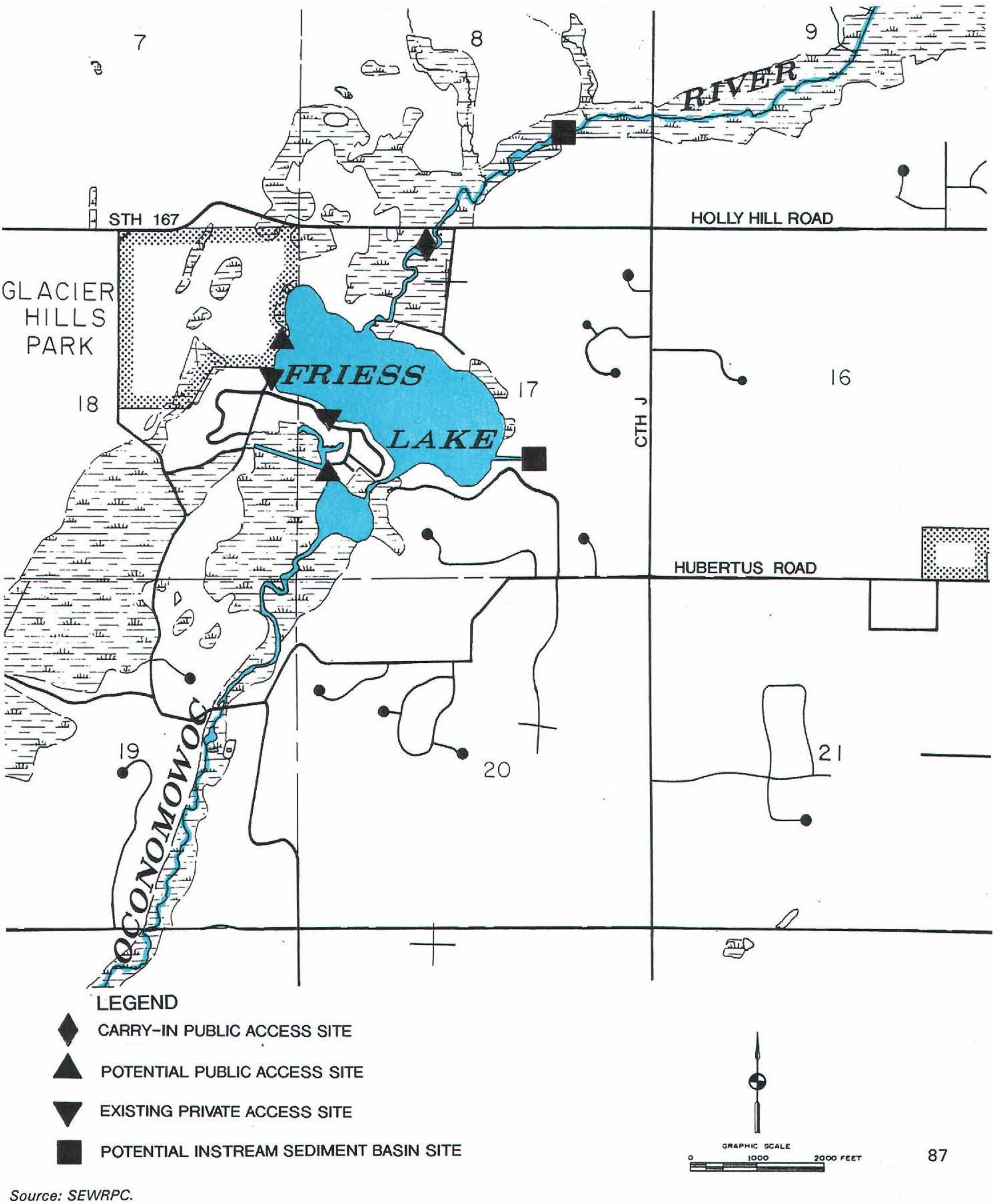
[10]*So set forth in Wisconsin Department of Natural Resources Publication No. PUBL-WR-194-86, op. cit., the sign-up period for cost-sharing funds offered through the Chapter NR 120 Oconomowoc River Priority Watershed Project ended on December 31, 1989; the project itself was closed on December 31, 1994. Since that time, cost-share funding is limited to the repair of installed best management practices initially cost-shared under the Priority Watershed Project.*

Map 22

PLAN ALTERNATIVES FOR DEVELOPMENT OF PUBLIC RECREATIONAL BOATING ACCESS AND PLACEMENT OF AN INSTREAM SEDIMENT BASIN



Source: SEWRPC.

surrounding Friess Lake. These measures are: 1) continued reliance on, and management of, the onsite sewage disposal systems; and, 2) construction of a public sanitary sewer system to serve all, or portions of, the area. Under the latter alternative, consideration could be given to collection and conveyance to an existing centralized sewerage system or to one or more remote clustered soil absorption sites.

Onsite Sewage Disposal Alternative

Under the first alternative, the urban development surrounding Friess Lake would continue to rely on onsite sewage disposal systems, including, in some cases, holding tanks. The residential development located around the Lake is located on areas covered by soils which are classified as indeterminant or as disturbed areas for which the suitability for conventional mound-type systems could not be determined. Some of these residential lands, however, are located in areas with soils classified as unsuitable for residential development using alternative onsite sewage disposal systems. In some cases, holding tanks have been installed as replacement onsite sewage disposal systems. A 1990 study[11] conducted by a consulting firm for the Town of Richfield noted the Friess Lake area as one of the eight areas in the Town where onsite sewerage system problems were identified. The report indicated that the existing systems in the Friess Lake study area identified in that plan were estimated to be failing or were encountering problems. In addition, there were 36 holding tanks identified in that study area. The fact that significant portions of the urban lands surrounding the Lake are in the identified regulatory floodplain, coupled with the relatively high groundwater water table in the area, indicates that continued long-term use of onsite sewage disposal systems will include the use of increasing numbers of holding tanks.

If onsite sewage disposal systems are to be considered as the means for sewage disposal, consideration should be given to developing an onsite sewage disposal system management program. The basic objective of an onsite sewage disposal management program is to ensure the proper installation, operation, and maintenance of existing systems, and of any new systems that may be required to serve existing urban development in the drainage area tributary to Friess Lake. The management program would typically be the responsibility of the individual property owners. The Friess Lake Action Group could assist through an integrated homeowner information and education program. In addition, the Washington County Land Use and Parks Department, would serve as a resource in this program and would continue to perform its regulatory, permitting, and advisory functions related to onsite sewage disposal systems.

As another management option, the Friess Lake Action Group or the Town of Richfield could facilitate an onsite sewage disposal system management program by contracting with a hauler on behalf of all Friess Lake residences, thereby potentially reducing the costs to individuals while ensuring community benefit. Under an expanded version of this option, the onsite sewage disposal system management program could potentially include the establishment of a sanitary district or lake management district with sanitary district powers to raise and administer funds; inspect, design, and construct upgraded systems; ensure proper operation and maintenance of the systems; and monitor the performance of the systems.

A continuing informational and educational effort should also be included in an onsite sewage system management program. This effort could be coordinated with other lake-oriented public informational and educational programs and would advise homeowners of the rules, regulations, and system limitations governing onsite sewage disposal systems, and encourage preventive maintenance programs.

The continued use of onsite sewage disposal systems with a proper management program are considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

Public Sanitary Sewerage System Alternative

Under the second alternative, a public sanitary sewer system would be installed to serve urban development along the shoreline of Friess Lake. The nearest existing public sanitary sewerage systems to the Friess Lake area are the City of Hartford and Village of Slinger systems, each located about five miles to the north; and the Village of Sussex system located about six miles to the southeast. It is unlikely that a new public sewage treatment plant to serve the Friess Lake area would be cost-effective or implementable given current Wisconsin Department of Natural Resources policies which discourage construction of new small sewage treatment plants. However, connection to one of these existing sewerage systems may be viable if there was an iden-

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[11] *Strand Associates, Inc.,* Preliminary Needs Determination on On-Site Wastewater Disposal Systems for Town of Richfield, Wisconsin, *April 1990.*

tified need to provide a public sewer system to serve the urban development surrounding the Lake. Given the distance to these systems, such a connection would not likely be economically feasible considering only the Friess Lake area. Such a connection may be feasible if carried out as part of a broader sewer service area plan. For example, such a system could be considered to serve other selected areas in the Town of Richfield, such as the Bark Lake area where onsite sewage disposal system problems have been documented.

A preliminary evaluation of the need for a broader sanitary sewerage system to serve selected areas in the Town was conducted by a consultant in 1990.[12] That study identified several areas, including the Friess Lake area, which were noted as having the potential for a high percentage of onsite system failures with the attendant need for the use of holding tanks. The preliminary study recommended that the further evaluations regarding the cost-effectiveness of alternative sewerage systems be conducted for selected areas. However, following public review of the preliminary report, no action was taken.

Another option which could be considered for the Friess Lake area is the construction of a public sanitary sewer collection system to serve portions of the urban development surrounding the Lake with conveyance to centralized soil absorption systems at remote locations. Such systems could be located in areas with suitable space and soil conditions.

Under either option providing for a public sanitary sewerage system, it would be necessary to create a sanitary or utility district or lake rehabilitation and protection district with sanitary district powers to install, operate, and maintain the sewerage system.

The development of a public sanitary sewer system to serve portions of the urban development in the vicinity of Friess Lake is considered to be a viable measure for inclusion in the recommended Friess Lake management plan. However, the alternative for providing for a public sanitary sewerage system will require more detailed facility planning to further evaluate the cost-effectiveness alternatives. Such evaluation could be best done on a communitywide basis.

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[12] *Ibid.*

ECOLOGICALLY VALUABLE LANDS AND AQUATIC PLANTS

Friess Lake and its tributary drainage area contain ecologically valuable areas, including significant areas of diverse aquatic and wetland vegetation suitable for fish spawning and located within and immediately adjacent to the Lake. As described in Chapter III, the potential problems associated with ecologically valuable areas in and near Friess Lake include the potential loss of wetlands and other important ecologically valuable areas due to urbanization or other encroachments; the degradation of wetlands and aquatic habitat due to the presence of invasive species, including Eurasian water milfoil; and disturbances associated with recreational boating.

Two optional management measures have been considered for purposes of protecting and maintaining the ecologically valuable areas, including the aquatic plant communities, while supporting the recreational uses of Friess Lake and its tributary drainage. These measures are: 1) aquatic plant management; and 2) shoreline protection measures. In addition to these measures, the land use management pressures discussed previously and the measures related to recreational boating discussed in a later section, will also be beneficial for the protection of the ecologically valuable areas and aquatic plant management.

Aquatic Plant Management Measures

Aquatic plant management refers to a group of management and restoration measures aimed at both removal of nuisance vegetation and manipulation of species composition in order to enhance and provide for recreational water use. Generally, aquatic plant management measures are classed into four groups: physical measures which include water level management; manual and mechanical removal measures which include harvesting and removal; chemical measures which include using aquatic herbicides; and biological controls which include the use of various organisms, including insects. Of these, chemical and biological controls are stringently regulated and require a State permit. Harvesting is probably the measure best applicable to large areas, while chemical controls may be best suited to use in confined areas and for initial control of invasive plants.

Aquatic Herbicides

Chemical treatment with aquatic herbicides is a short-term method of controlling heavy growths of aquatic macrophytes and algae. Chemicals are applied to the growing plants in either liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophyte growth are the relatively low cost and the ease, speed, and convenience of application. However, the potential disadvantages associated with chemical control include the following:

1. The short-term, lethal effects of chemicals are relatively well known; however, properly applied chemical applications should not result in such effects. Potential long-term, sublethal effects, especially on fish, fish-food organisms, and humans, are relatively unknown.

2. The elimination of macrophytes eliminates their competition with algae for light and nutrients. Algal blooms may then develop unless steps are taken simultaneously to control the sources of nutrient input.

3. Since much of the dead plant materials is left to decay in the lake, nutrients contained in them are rapidly released into the water and fuel the growth of algae. The decomposition of the dead plant material also consumes dissolved oxygen and increases the potential for fish kills. Accretion of additional organic matter in the sediments as a result of decomposition also increases the organic content of the soils and predisposes the sediments toward reintroduction of other (or the same) nuisance plant species. Long term deposition of plant material may result in the need for other management measures, such as dredging.

4. The elimination of macrophyte beds destroys important cover, food sources, and spawning areas for desirable fish species.

5. Adverse impacts on other aquatic organisms may be expected. At the concentrations used for macrophyte control, Diquat has been known to kill the zooplankton *Daphnia* and *Hyella*, both important fish foods. *Daphnia*, which is present in Friess Lake, is the primary food for the young of nearly all fish species found in the Region's lakes.[13]

6. Areas must be treated again in the following season and weed beds may need to be treated more than once in a summer.

7. Many of the chemicals available are nonselective, often affecting nontarget, desirable species as well as the "weeds."

The advantages and disadvantages of chemical macrophyte control also apply to the chemical control of algae. Copper, the active ingredient in algicides, may accumulate in the bottom sediments, where excessive amounts are toxic to fish and benthic animals. Fortunately, copper is rapidly eliminated from human systems and few cases of copper sensitivity among humans are known.[14]

Costs of chemical treatments vary widely. Large, organized treatments are more efficient and tend to decrease unit costs for commercial applications compared to individual treatments. Other factors, such as the type of chemical used and the number of treatments needed, are also important. Estimated costs for lakes in Southeastern Wisconsin range from $240 to $480 per acre. Current treatment costs on Friess Lake are approximately $3,000 to $4,000 per year.

Chemical treatments must be permitted by the State under Chapter NR 107 of the *Wisconsin Administrative Code.*

Because the demonstrated need to control aquatic plants, including algae, in selected areas of Friess Lake and the relatively low cost of chemical treatment and because current management decisions have indicated a need for some chemical treatment, chemical treatment, including application of copper sulfate where appropriate, is considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

Aquatic Plant Harvesting

Aquatic macrophytes are mechanically harvested with specialized equipment consisting of a cutting apparatus which cuts up to five feet below the water surface and a conveyor system which picks up the cut plants and hauls them to shore. Advantages of macrophyte harvesting include the following:

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[13] *P.A. Gilderhus, "Effects of Diquat on Bluegills and Their Food Organisms,"* The Progressive Fish-Culturist, *Vol. 2, No. 9, 1967, pp. 67-74.*

[14] *J.A. Thornton, and W. Rast, "The Use of Copper and Copper Compounds as an Algicide,"* Copper Compounds Applications Handbook, *H.W. Richardson, ed., Marcel Dekker, New York, 1997.*

1. Harvesting removes the plants from the lake. The removal of this plant biomass decreases the rate of accumulation of organic sediment. A typical harvest of submerged macrophytes from eutrophic lakes in Southeastern Wisconsin can yield between 140 and 1,100 pounds of biomass per acre per year.[15]

2. Harvesting removes plant nutrients, including nitrogen and phosphorus, which would otherwise "refertilize" the lake as the plants decay. A typical harvest of submerged macrophytes from eutrophic lakes in Southeastern Wisconsin can remove between four and 34 pounds of nitrogen and 0.4 to 3.4 pounds of phosphorus per acre per year. In addition to the physical removal of nutrients, plant harvesting may reduce internal nutrient recycling. Several studies have shown that aquatic macrophytes can act as nutrient pumps, recycling nutrients from the bottom sediments into the water column. Ecosystem modeling results have indicated that a harvest of 50 percent of the macrophytes in Lake Wingra, Wisconsin, could reduce instantaneous phosphorus availability by about 30 percent, with a maximum reduction of 40 to 60 percent, depending on the season.[16]

3. Repeated macrophyte harvesting may reduce the regrowth of certain aquatic macrophytes. The regrowth of milfoil has been reported to have decreased as harvesting frequency was increased.[17]

4. Where dense growths of filamentous algae are closely associated with macrophyte stands, they may be harvested simultaneously.

5. The macrophyte stalks remaining after harvesting provide cover for fish and fish-food organisms, and stabilize the bottom sediment against wind erosion.

6. Selective macrophyte harvesting may reduce stunted populations of panfish in lakes where excessive cover has adversely influenced predator-prey relationships. By allowing an increase in predation on young panfish, both gamefish and the remaining panfish may show increased growth.[18]

7. The cut plant material can be used as mulch.

The disadvantages of macrophyte harvesting include the following:

1. Harvesting is most effective in water depths greater than two feet. Large harvesters cannot operate in shallow water or around docks and buoys.

2. The reduction in aquatic macrophytes by harvesting reduces their competition with algae for light and nutrients. Thus, algal blooms may develop.

3. Fish, especially young-of-the-year bluegills and largemouth bass, as well as fish-food organisms, can be caught in the harvester. As much as 5 percent of the juvenile fish population can be removed by harvesting. A Wisconsin Department of Natural Resource study found that four

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[15]*James E. Breck, Richard T. Prentki, and Orie L. Loucks, editors,* Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting, *Proceedings of Conference at Madison, Wisconsin, February 14-16, 1979.*

[16]*E.B. Welch, M.A. Perkins, K. Lynch, and P. Hufschmidt, "Internal Phosphorus Related to Rooted Macrophytes in a Shallow Lake," in James E. Breck et al., editors pp. 81-99; G.B. Lie, "The Influence of Aquatic Macrophytes on the Chemical Cycles of the Littoral," op. cit., pp. 101-106; K.H. Landers, "Nutrient Release from Senescing Milfoil and Phytoplankton Response," 1979, op. cit., pp. 127-143; J.W. Barko and R.M. Smart, "The Role of* Myriophyllum spicatum *in the Mobilization of Sediment Phosphorus," op. cit., pp. 177-190; Orie L. Loucks and P.R. Weiler, "The Effects of Harvest Removal of Phosphorus on Remineralized* P *Sources in a Shallow Lake," op. cit., pp. 191-210.*

[17]*S. Nichols and G. Cottam, "Harvesting As A Control for Aquatic Plants,"* Water Resources Bulletin, *Vol. 8, No. 6, December 1972, pp. 1,205-1,210; J.K. Neel, S.A. Peterson, and W.L. Smith, "Weed Harvest and Lake Nutrient Dynamics," EPA-660/3-73-001, 1973.*

[18]*James E. Breck, and J.F. Kitchell, "Effects of Macrophyte Harvesting on Simulated Predator-Prey Interactions," edited by Breck et al., 1979, pp. 211-228.*

pounds of fish were removed per ton of plants harvested.[19]

4. The reduction in aquatic macrophyte biomass by harvesting or chemical control can reduce the diversity and productivity of macroinvertebrate fish-food organisms feeding on the epibiota.[20] Bluegills generally move into the shoreline area after sunset, where they consume these macroinvertebrates. After sunrise they migrate to open water, where they graze, primarily on zooplankton.[21] If harvesting or chemical control shifts the dominance of the littoral macroinvertebrate fauna to sediment dwellers, the macroinvertebrate component of the bluegill diet could be restricted. This would increase predation pressure on zooplankton and reduce the growth rate of the panfish; it could eventually lead to undesirable ramifications throughout the food web in a lake.

5. Launching harvesting equipment in shallow water can be a problem. Most commercially available equipment requires two to four feet of water to float the harvester off its trailer. If water depth is not adequate, a crane may be required to place the harvester in the water. In this regard, the lack of a public access site would create additional difficulties for harvester operation in Friess Lake.

6. Macrophyte harvesting may influence the community structure of macrophytes by favoring such plants as milfoil (*Myriophyllum* sp.) that propagate from cut fractions. This may allow these plants to spread into new areas through the rerooting of the cut fractions.

7. The efficiency of macrophyte harvesting is greatly reduced around piers, rafts, and buoys because of the difficulty in maneuvering the harvesting equipment in those restricted areas, and because of the liability that ban be incurred as a result. Manual methods have to be used in these areas.

8. High capital and labor costs are associated with harvesting programs. Macrophyte harvesting on Friess Lake could be carried out by Town staff or be contracted to a private company. The estimated annual cost of harvesting by Town staff would be about $5,000 to $10,000. These monies are largely staff costs and operating costs such as fuel, oil, and maintenance. The cost of new harvesting equipment, when needed, would be about $90,000.

Because of the limited need for control of aquatic plants in Friess Lake and because the current need is for the control of Eurasian water milfoil, a plant not well-suited to mechanical harvesting in this Lake due to the low number and poor diversity of other plant species, harvesting is not considered a viable measure to be included in the recommended Friess Lake management plan.

Biological Controls

Another alternative approach to controlling nuisance weed conditions, in this particular case Eurasian water milfoil, is biological control. Classical biological control has been successfully used to control both weeds and herbivorous insects.[22] Recent documentation states that *Eurhychiopsis lecontei*, an aquatic weevil species, has the potential as a biological control agent for Eurasian water milfoil. In 1989, the weevil was discovered during a study investigating a decline of Eurasian water milfoil growth in a Vermont pond. *Eurhychiopsis* proved to have significant negative effects on Eurasian water milfoil in the field and in the lab. The adult weevil feeds on the milfoil causing lesions which make the plant more susceptible to pathogens such as bacteria or fungi while the weevil larvae burrows in the stem of the plant causing enough tissue damage for the plant to lose

[19] *Wisconsin Department of Natural Resources,* Environmental Assessment Aquatic Nuisance Control (NR 107) Program, *3rd Edition, 1990, 213 pp.*

[20] *James E. Breck, Richard T. Prentki, and Orie L. Loucks, editors,* Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting, *Proceedings of Conference at Madison, Wisconsin, February 14-16, 1979.*

[21] *Ibid.*

[22] *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; C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology, *John Wiley, New York, New York, USA.*

buoyancy and collapse.[23] The few studies that have been done since that time have indicated the following potential advantages to use of this weevil as a means of Eurasian water milfoil control:

1. *Eurhychiopsis lecontei* is known to cause fatal damage to the Eurasian water milfoil plant and over a period of time has the potential to cause a decrease in the milfoil population.

2. *Eurhychiopsis lecontei* larvae are easy to produce.

3. *Eurhychiopsis lecontei* are not known to cause damage to existing native aquatic plants.

The potential disadvantages of using *Eurhychiopsis lecontei* include:

1. The studies done on *Eurhychiopsis* are very recent and more tests are necessary to determine if there are significant adverse effects.[24]

2. Since the upper portion of the Eurasian water milfoil plant is preferred by the weevil, harvesting would have to be extremely limited or not used at all in conjunction with this type of aquatic plant management control.

Very few studies have been completed using *Eurhychiopsis lecontei* as a means of aquatic plant management control, thus, its use would only be viable as an experimental project on Friess Lake at this time.

Manual Harvesting
Due to an inadequate depth of water it is not always possible for harvesters to reach the shoreline of every property. Another measure to be considered involves manual harvesting by raking. Specialty rakes are available which are designed to manually remove aquatic plants from the shoreline area. A few such rakes could be made available by the Friess Lake Action Group or a future lake district for the riparian owners to use on a trial basis to test their operability before purchasing them. The advantage of the rake is that it is easy and quick to use, immediately removing the plants where as chemical treatment involves a waiting period. Using this method also removes the plants from the lake avoiding the accumulation of organic matter on the lake bottom adding to the nutrients which favor more plant growth. Manual harvesting is considered a viable measure for inclusion in the recommended Friess Lake management plan.

Lake Bottom Covering
Lake bottom covers and light screens provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. They have been used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motorboating. Sand and gravel are usually readily available and relatively inexpensive to use as cover materials, but plants readily recolonize areas so covered in about a year. Synthetic material, such as polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years. The screens are flexible and can be anchored to the lake bed in spring or draped over plants in summer.

The advantages of bottom covers and screens are that control can be confined to specific areas, the covers and screens are usually unobtrusive and create no disturbance on shore, and the covers are relatively easy to install over small areas. The disadvantages of bottom covers and screens are that they do not reduce eutrophication of the lake, they are expensive, they are difficult to spread and anchor over large areas or obstructions, they can slip on steep grades or float to the surface after trapping gases beneath them, and they may be difficult to remove or relocate.

Screens and covers should not be used in areas of strong surfs, heavy angling, or shallow waters where motorboating occurs. They should also not be used where aquatic vegetation is desired for fish and wildlife habitat. To minimize interference with fish spawning, screens should be placed before or after spawning. A permit from the Wisconsin Department of Natural Resources is required for use of sediment covers and light screens. Permits require inspection by the Department staff during the first two years, with subsequent permits issued for three-year periods.

[23]*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.*

[24]*The use of* Eurhychiopsis *on an experimental basis to control Eurasian water milfoil is being monitored in selected Wisconsin lakes by the Wisconsin Department of Natural Resources and the University of Wisconsin-Stevens Point from 1995 through 1998.*

The estimated cost of lake bottom covers that would control plant growth along a typical shoreline property, an area of about 700 square feet, ranges from $40 for burlap to $220 for aquascreen. Because of the limitations involved, lake bottom covers as a method to control aquatic plant growth is not considered viable for general use in Friess Lake, but may offer an option to householders currently using chemical or manual aquatic plant control techniques around individual piers or docks.

Public Information

Aquatic plant management usually centers on the eradication of nuisance aquatic plants for the improvement of recreational lake use. The majority of the public 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 impacts. Thus, public information is an important component of an aquatic plant management program and should include information and education on:

1. The types of aquatic plants in Friess Lake and their value to water quality, fish, and wildlife.

2. The preservation of existing stands of desirable plant species.

3. The identification of nuisance species and the methods of preventing their spread.

4. Alternative methods for controlling existing nuisance plants including the positive and negative aspects of each method.

An organized aquatic plant identification/education day is one method of providing hands-on education to lake residents. Other sources of information and technical assistance include the Wisconsin Department of Natural Resources and the University of Wisconsin-Extension Service. The aquatic plant species list provided in Chapter V may serve as a checklist for individuals interested in identifying the plants near their residences. Residents can observe and record changes in the abundance and types of plants in their part of a lake on an annual basis.

Of the submerged floating and free-floating aquatic plant species found in Friess Lake, Eurasian water milfoil is one of the few species likely to cause lake-use problems. As discussed in Chapter V, milfoil, like most aquatic plants, can reproduce from fragments and often forms dense beds. Residents should be encouraged to collect fragments that wash ashore after storms, from weekend boat traffic, and after harvesting—the plant fragments can be used as mulch on flower gardens or ornamental planting areas. Citizen monitoring to provide an early warning of increased colonization and growth of Eurasian water milfoil can be a component of this public informational and educational program.

Milfoil and other aquatic plants can be transported between lakes as fragments on boats and boat trailers. To prevent unwanted introductions of plants into lakes, boaters should remove all plant fragments from their boats and trailers when exiting the lake. Posters and pamphlets are available from the Wisconsin Department of Natural Resources and the University of Wisconsin-Extension Services that provide information and illustrations of milfoil, discuss the importance of removing plant fragments from boats, and remind boaters of their duty in this regard.

The development of a public informational and educational program related to aquatic plant management, as well as other lake-oriented issues, is considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

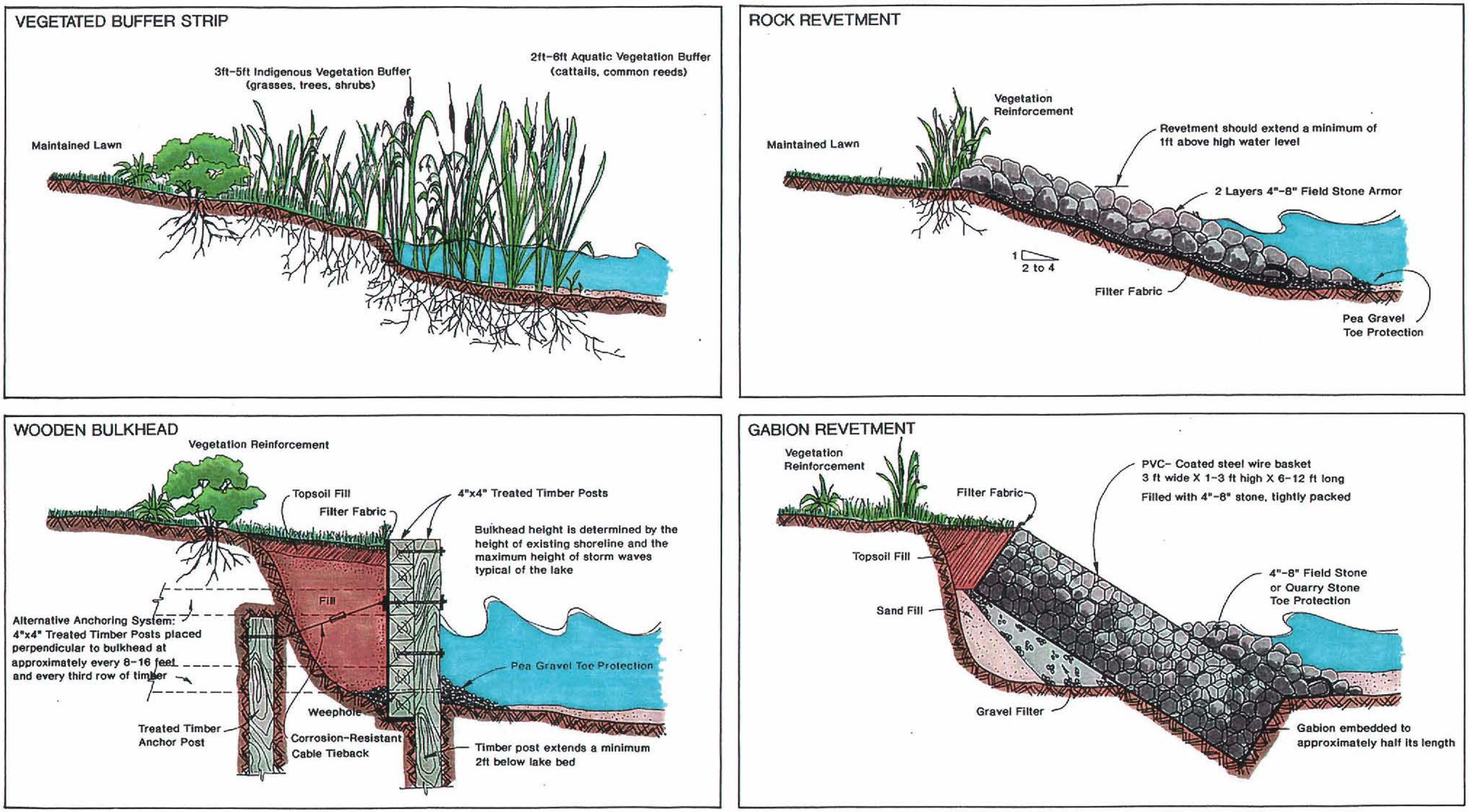
Shoreline Maintenance

Shoreline erosion not only interferes with such activities as swimming, but also results in the retreat of the land by sloughing into the Lake and in the deposition of sediment and nutrients into the Lake itself, which contributes to the formation of bottom sediments suitable for supporting excessive aquatic plant growth. Such erosion is usually caused by wind-induced wave erosion, ice movement and motorized boat traffic, as noted in Chapter II. A survey of the Friess Lake shoreline conducted by the Regional Planning Commission staff indicated that much of the shoreline was vegetated and also has shoreline protection structures at various locations. Erosion problems were observed at only a few isolated locations.

Four alternative shoreline erosion control techniques were considered: vegetative buffer strips, rock revetments, wooden bulkheads, and gabions. The alternatives considered, as shown in Figure 14, 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 technique 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.

Figure 14

PLAN ALTERNATIVES FOR SHORELINE EROSION CONTROL



Source: SEWRPC. NOTE: Design specifications shown herein are for typical structures. The detailed design of shore protection measures must be based on detailed analysis of local conditions.

The use of vegetated buffer strips and riprap or rock revetment methods of shoreline protection are considered the most viable measures for use on Friess Lake in order to maintain a more natural appearance and to preserve shoreline habitat for aquatic life.

WATER QUALITY

The reduction of external nutrient loadings to Friess Lake by the measures described above should help to prevent deterioration of lake water quality conditions, but are not expected to eliminate existing water quality and lake-use problems. In mesotrophic and eutrophic lakes, particularly in the presence of such anaerobic conditions as occur in the hypolimnion of Friess Lake during the summer, significant amounts of phosphorus can be released from the existing sediments to the overlying water column. Consequently, the water quality improvements expected from a reduced external nutrient input may be masked by this condition. Because of this and because of other characteristics of the Lake, such as increasingly abundant macrophyte growth, which can result in restricted water use potential, the application of in-lake rehabilitation techniques is considered.

The applicability of specific in-lake rehabilitation techniques is highly dependent on lake characteristics. The success of any lake rehabilitation technique can seldom be guaranteed since the technology is still in the early stages of development. Because of the relatively high cost of applying most techniques, a cautious approach to implementing in-lake rehabilitation techniques is generally recommended. Certain in-lake rehabilitation techniques should be applied only to lakes in which: 1) nutrient inputs have been reduced below the critical level, 2) there is a high probability of success in applications of the particular technology to lakes of similar size, shape, and quality, and 3) the possibility of adverse environmental impacts is minimal. Finally, it should be noted that some in-lake rehabilitation techniques require the issuance of permits from appropriate State and Federal agencies prior to implementation.

This group of in-lake management practices considered for possible application to Friess Lake includes a variety of measures designed to directly modify the magnitude of either a water quality determinant or biological response, although specific measures aimed at managing aquatic plants and fishes are detailed separately.

Four optional management measures have been considered for the purpose of improving water quality in Friess Lake by in-lake changes. These measures are: 1) dilution/flushing; 2) phosphorus precipitation/inactivation; 3) aeration/destratification; and 4) nutrient load reduction.

Dilution/Flushing

Dilution is a restoration measure which reduces the impact of contamination by blending—diluting—contaminated waters with less contaminated waters, or using less contaminated waters to push—flush—the contaminated waters out of the lake basin. Costs are extremely variable and depend upon the availability and location of a suitable source of flushing or diluent water; where pumping is required, this technique can be very costly. Effectiveness also varies directly with the quality of the diluent and flushing water quality. Impacts can include over-topping of, and/or damage to, control structures—hydraulic over-loading—and transferal of the problem contaminants downstream. Use of this technique in Friess Lake is limited by the lack of an available "clean" water source and is not considered viable for inclusion in the recommended Friess Lake management plan.

Phosphorus Precipitation/Inactivation

Nutrient inactivation is a restoration measure that is designed to limit the biological availability of phosphorus by chemically binding the element in the lake sediments using a variety of divalent or trivalent cations—highly positively charged elements. Aluminum sulphate (alum), ferric chloride and ferric sulphate are commonly used cation sources. The use of these techniques to remove phosphorus from nutrient-rich lake waters is an extension of common water supply and wastewater treatment processes. Costs depend on the lake volume and type and dosage of chemical used, with alum costing about $150 per ton. Approximately 100 tons of alum can treat a lake of about 40 acres. Effectiveness depends in part on the ability of the alum flocculent to form a stable "blanket" on the lake bed. This is dependent upon flushing time, turbulence, lake water acidity (pH) and rate of continued sedimentation. Impacts can include the release of potentially toxic quantities of free aluminum into the water. Improved water clarity can also encourage the spread of rooted aquatic plants.

As previously noted, the water quality of Friess Lake is such that internal loading of phosphorus presently forms a relatively minor component of the total phosphorus load to the lake. Therefore, unless the dominant external sources of nutrient to the lake are controlled by the watershed-based management practices, nutrient inactivation is not considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

Aeration/Destratification
Aeration, including hypolimnetic aeration and artificial circulation, is a management measure designed to partially or completely oxygenate the water column of a lake. Hypolimnetic aeration is the process of injecting oxygen into the water column, while artificial circulation is the process of destratifying and mixing the water column. The two processes are related in that compressed or pumped air is the medium used to inject oxygen and/or circulate the water. Costs associated with the hardware required for an aeration system including piping and compressors, and operating costs tend to be high, ranging from $160 to $2,600 per acre per year. Effectiveness has been site and use dependent.

In complete aeration, water is lifted to the surface, where it can come in contact with the atmosphere. At the water atmospheric exchange, the greatest absorption of oxygen to the water takes place. With artificial circulation, water temperatures in the lake become relatively uniform from top to bottom. Complete circulation has been shown in some cases to reduce algal species. However, in some cases, phosphorus and turbidity have increased where sediments and phosphorus are resuspended into the upper areas of the lake. Another adverse impact of complete circulation may be the reduction in ecological diversity resulting from a uniform water temperature within the Lake.

Because of the cost and potential negative aspects of this technique and the limited water surface area of Friess Lake which could benefit from the measures, it is not considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

The purpose of hypolimnetic aeration is to provide oxygen to the hypolimnion of a stratified lake without disrupting the stratification. To provide hypolimnetic aeration, the bottom water is typically airlifted through a vertical tube, with the oxygenated water returned to the hypolimnion. Aeration of the hypolimnion increases the decomposition of organic matter and promotes adsorption of phosphorus by the hydrous oxides of iron and manganese present in the lake bottom sediments. As a result, the concentration of phosphorus in the bottom waters may be reduced and the oxygen levels improved providing better conditions for fish and other aquatic life.

Hypolimnetic aeration has been effective in temporarily reducing the internal phosphorus cycling and decreasing undesirable gases on the lake bottom. Phosphorus concentrations in the water column may not be reduced sufficiently to improve water quality if phosphorus inputs from external sources cannot be controlled. This method is not a long-range solution for algae control and the benefits often disappear once the aeration is ceased. Because of the cost and applicability of this practice to only limited water surface areas on Friess Lake, the measure is not considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

Nutrient Load Reduction
Nutrient diversion and contaminant load reduction/elimination are restoration measures which are designed to reduce the trophic state or degree of over-feeding of, and pollution levels within, a waterbody and thereby control the growth response of the aquatic plants in the system. Control of nutrients and contaminants in surface water runoff in the watershed is generally preferable to attempting such control within a lake. In-lake control of nutrients and contaminants generally involves removal of sediments by dredging, encapsulation of nutrients by chemical binding, or creating an oxygen regime that limits the release of the contaminant. Hypolimnetic withdrawal or the removal of nutrient rich bottom waters from stratified lakes is a special case of flushing, while direct injection of nitrate into an anaerobic hypolimnion—the Riplox technique using a nitrogenous oxygen source—is a special case of aeration; both can also be used in reducing the internal nutrient supply to a lake. Costs are generally high, involving an engineered design and usually some form of pumping or excavation. Effectiveness is variable. Impacts include the rerelease of nutrients and contaminants into the environment. For these reasons this measure is not considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

LAKE WATER LEVEL

This group of in-lake management measures consists of actions designed to modify the depth of water in the waterbody. Generally, the objective of such manipulation is to enhance a particular class of recreational uses and/or to control the types and densities of organisms within a waterbody. Water level management refers to the manipulation of lake water levels, especially in manmade lakes, in order to change or create specific types of habitat and thereby manage species composition within a waterbody. Water level management may also be used to control aquatic plant growth and to manage fisheries.

Three optional management measures have been considered for the purpose of lake-level management in Friess Lake. These measures are: 1) drawdown; 2) water level stabilization; and 3) dredging.

Drawdown

With regard to aquatic plant management, periodic drawdowns can reduce the growth of some shoreland plants by exposing the plants to climatic extremes, while the growth of others is unaffected or enhanced. Both desirable and undesirable plants are affected by such actions. Costs are primarily associated with loss of use of the waterbody surface area during drawdown—provided there is a means of controlling water level in place, such as a dam or other outlet control structure. Effectiveness is variable, with the most significant side effect being the potential for increased plant growth. Drawdown can also affect the lake fisheries both indirectly—by reducing the numbers of food organisms—and directly—by reducing available habitat and desiccating (drying out) eggs and spawning habitat.

Sediment exposure and desiccation by means of lake drawdown has been used as a means of stabilizing bottom sediments, retarding nutrient release, reducing macrophyte growth, and reducing the volume of bottom sediments. During the period of drawdown, the exposed sediments are allowed to oxidize and consolidate. It is believed that by reducing the sediment oxygen demand and increasing the oxidation state of the surface layer of the sediments, drawdown may retard the subsequent movement of phosphorus from the sediments. Sediment exposure may also curb sediment nutrient release by physically stabilizing the upper flocculent sediment-water interface zone of the sediments which plays an important role in the exchange reaction and mixing of the sediments with the overlying water. Drawdown may thus deepen the lake by dewatering and compacting the bottom sediments. The amount of compaction depends upon the organic content of the sediment, the thickness of sediment exposed above the water table, and the timing and duration of the drawdown. Based on sediment types in Friess Lake, it is estimated that, generally, a minimal reduction in volume of exposed sediments may be feasible. More significant compaction may be possible in the inlet area of the Lake where the soils are primarily organic in nature, as shown on Map 2.

The timing of a drawdown project is an important factor affecting the success of the project. Winter drawdowns have been employed successfully in several projects in Wisconsin.[25] The potential advantages of a winter drawdown are: 1) it would not interfere with summer boating, fishing, recreation, and irrigation activities, 2) the freezing and thawing of the sediments would facilitate dewatering, 3) the frozen sediment would provide a surface for access of earth-moving equipment, and 4) the freezing of the sediment would provide increased macrophyte mortality. The longer the sediments are exposed, the greater the benefit of the drawdown. Lakes are typically drawn down after Labor Day and so left until March of the following year, allowing seven months of sediment exposure. A disadvantage of the over-winter drawdown is the increased potential for a fish winterkill due either to an oxygen deficit or to a whole lake freeze. Added to this is the unpredictability of the results, the impairment of recreational uses, and the temporary nature of the beneficial effects of a drawdown. Thus, drawdown is not considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

Water Level Stabilization

The converse of the drawdown and flooding cycles described above is the maintenance of a more stable water level on the Lake. The construction of a low head weir at the outlet of Little Friess Lake by the Friess Lake Fish and Game Association in the 1960s was designed to enhance the water level stability of the Lake. Although the flashboards that created the dam were removed by residents in 1982, various subsequent attempts to replace the structure have been reported. These efforts have been undertaken as the result of public perceptions that the Lake environment was "better" during the period of higher, more stable water levels.[26] As recently as 1995, a consulting firm, Ecological Balance Consultants, stated that the removal of the dam resulted in "ecological damage" and proposed the repair or replacement of the "culvert dam."[27] The basis of ecological damage cited by this firm included: 1) explosive weed growth caused by light penetration to depths previously outside of the photic zone or zone of light penetration; 2) increased turbidity caused by wave action on previously inundated areas;

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[25]*Wisconsin Department of Natural Resources Technical Bulletin No. 75,* Survey of Lake Rehabilitation Techniques and Experiences, *1974.*

[26]*Friess Lake Action Group,* In litt., *May 1995.*

[27]*Ecological Balance Consultants,* In litt., *July 1995.*

3) higher water temperatures caused by greater heat absorption in the more shallow water column; and 4) desiccation of the shallow littoral areas of the Lake displacing organisms and promoting the growth of undesirable species.

While this evidence is consistent, to a degree, with the data presented in Chapters IV and V, there are other factors besides lake levels which are related to, and are more likely to be responsible for, the observed conditions. Thus, other interpretations may be placed on the same data. For example, the turbidity of the Lake is variable with season, as shown in Figure 8, suggesting a relationship between turbidity—decreased Secchi-disk transparency—and external sediment loading in spring, and between turbidity and biological productivity in summer, both of which are typically more significant processes in lakes in the Region than internal sediment resuspension in the exposed shallows.[28] Further, as set forth in Chapter V, the growths of aquatic plants and changes in species composition in Friess Lake noted by Ecological Balance Consultants are more likely to be related to the increasing enrichment of the waterbody and sediments. Such enrichment is most likely to be the consequence of external nutrient loads arising from the tributary drainage area of the Lake. Finally, there is little evidence that a drop in water level of the magnitude suggested by the removal of the flashboards—a maximum of two feet—can measurably affect water column temperatures. Application of Fick's equation for vertical heat diffusion in water[29] to Friess Lake data results in a negligible change in heat transfer due to the perceived depth change, compared with the influence of seasonal and interannual variations in atmospheric temperature and wind speed.

Stabilization of the water levels of Friess Lake can, in fact, enhance the growth of undesirable plants by providing a stable environment in which invasive species can outcompete the native plants accustomed to the more variable environment. Species such as coontail, milfoil and some pondweeds prefer stable water conditions.[30] Because control of the invasive Eurasian water milfoil population in Friess Lake is an important consideration, maintenance of a lake environment conducive to this species would be inappropriate in the context of this recommendation. Further, the maintenance of a control structure on the Lake outlet could encourage the retention of particulates—including particulate phosphorus, providing additional habitat for species such as Eurasian water milfoil which thrive in "muck," although the degree of enhanced sediment retention may not be significant given the small increase in pool elevation. Finally, stabilization of the water levels may adversely affect potamodrometic fishes—including most game species—which require a fluctuating water level, such as occurs in the spring of the year, to initiate their breeding cycle.

Other consequences of an increase in lake pool level would include the creation of a significant area of shallow water, especially along the northern and western shores of the Lake, providing additional habitat for rooted aquatic plants, and increasing the risk of flooding and high groundwater problem to low-lying properties on these shores by reducing the flood storage capacity of the Lake and potentially raising the adjacent groundwater levels. Map 15 illustrates the low-lying areas and the areas likely to experience the greatest increase in macrophyte growth. Rooted plants, such as cattails and bulrushes which are best suited to a variable water level and which presently exist in other parts of the Lake basin, can have both positive and negative impacts. These rooted plants protect the exposed shoreline of the Lake as noted below and offer some habitat value—especially the bulrush. In large numbers, however, these plants can interfere with lake access and the seed pods of the cattail have been known to cause a degree of nuisance during periods of seed dispersal.

Given all of these considerations, stabilization of the water levels in Friess Lake is not considered to be a viable measure for inclusion in the recommended Friess Lake management plan. This conclusion is consistent with current Wisconsin Department of Natural Resources policy which encourages the maintenance and restoration of natural water level variations and the minimization

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[28] *Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *1983.*

[29] *For a further discussion of the methodology employed, see P.R.B. Ward, "Physical Limnology," in J.A. Thornton and W.K. Nduku,* Lake McIlwaine: The Eutrophication and Recovery of a Tropical African Man-made Lake, *Monographiae Biologicae Volume 49, Dr. W. Junk Publishers, The Hague, The Netherlands, 1982.*

[30] *G. Dennis Cooke, Eugene B. Welch, Spencer A. Peterson, and Peter R. Newroth,* Restoration and Management of Lakes and Reservoirs, Second Edition, *Lewis, Boca Raton, Florida, 1993.*

of the degree of regulation of the natural waters of the State.

Dredging

Sediment removal is a restoration measure that carried out using a variety of techniques, both land-based and water-based, depending on the extent and nature of the sediment removal to be carried out. While dredging results in an immediate increase in lake depth, such increases may be short-lived if the sources of the sediment being deposited in the lake are not controlled within the drainage area tributary to the lake.

For large-scale applications, a barge-mounted hydraulic or cutter-head dredge is generally used, while for smaller-scale operations a mud-cat or drag-line bucket, shore-based system is typically employed. Both methods are expensive, especially if a suitable disposal site is not located close to the dredge site. Costs start at between $10 and $15 per cubic yard—sediment removal alone starts at between $3.00 and $5.00 per cubic yard.

Dredging is the only restoration technique that directly removes the accumulated products of degradation and sediment from a lake system and can return a lake to a younger "age." If carried to the extreme, dredging can be used to construct a new lake on the present site with a size and depth to suit the management objectives. Dredging has been used to increase water depth; remove toxic materials; decrease sediment oxygen demand, preventing fish winterkills and nutrient recycling; and decrease macrophyte growth.

Dredging may have generally short-term, adverse effects on the Lake. These adverse effects could include increased turbidity caused by sediment resuspension, oxygen depletion as organic sediment mix with overlying water, water temperature alterations, and destruction on benthic habitats. There may also be impacts at upland disposal sites, such a odor problems, restricted use of the site, and disturbances associated with heavy truck traffic. In the longer-term, disruption of the lake ecosystem by dredging can encourage the colonization of disturbed portions of the lakebed by less desirable species of aquatic plants and animals, including Eurasian water milfoil which is present in Friess Lake.

Dredging of lakebed material from navigable waters of the State requires a Wisconsin Department of Natural Resources Chapter 30.20 permit and a U.S. Army Corps of Engineers Chapter 404 permit. In addition, current solid waste disposal regulations define dredge material as a solid waste. Chapter NR 180.13 of the *Wisconsin Administrative Code* requires that any dredging project of over 3,000 cubic yards submit preliminary disposal plans to the Wisconsin Department of Natural Resources for the review and potential solid waste licensing of the disposal site. Because some sodium arsenite was applied to Friess Lake in the 1950s and 1960s, as noted in Chapter V, sediment samples may need to be analyzed to determine the extent and severity of any residual arsenic contamination.

Dredging Friess Lake could be accomplished with several different types of equipment, including a hydraulic cutterhead dredge mounted on a floating barge; or bulldozer and backhoe equipment if part of the Lake was drained; or clamshell, or bucket, dragline dredge from the shoreline.

Hydraulic cutterhead dredging is the most common employed method in the United States. The dredge is typically a rotating auger or cutterhead on the end of a ladder that is lowered to the sediment-water interface. Sediment excavated by the cutterhead pump in a slurry of 10 to 20 percent solids by centrifugal pump to the disposal site. This pumping usually limits the distance between the lake and disposal site to less than a mile, even using intermediate booster pumps. Because of the large volume of slurry produced, a relatively large disposal site, whether returned to the lake or a stream, would have to meet effluent water quality standards of the State and would be subject to State permitting.

Draining the lake and removing sediment with conventional earth moving equipment has some advantages over hydraulic dredging since it would not require a large disposal or dewatering site in the immediate area. Draining is also more advantageous than dragline dredging because it would not require the removal of a large number of trees and would involve less disturbance of the shoreline to provide access for trucks and equipment.

Because more than one-half of Friess Lake is greater than 30 feet deep, and since the Lake does not experience severe winter dissolved oxygen problems, the main objective of a dredging program at Friess Lake would be to reduce the size of the littoral zone, thereby reducing the areal extent of macrophyte growth. The theoretical maximum depth of macrophyte colonization in Friess Lake, under present conditions of water clarity, is about 9.5 feet. To reduce the extent of macrophyte growth, sections of the bottom would have to be deepened to 10 feet or more by dredging. A slope of four on one or less should be maintained to prevent slumping of the organic sediments and to ensure the safety of recreational users.

Based upon the foregoing, dredging is not considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

FISHERY

Friess Lake provides a quality habitat for a healthy, warmwater fishery. Adequate water quality, dissolved oxygen levels, sand/gravel shorelines, and a moderate and diverse plant community contribute to the maintenance of a fish population that is dominated by desirable sport fish. Winterkills and the presence of rough fish are not problems.

Four optional management measures have been considered for purposes of fishery management in Friess Lake. These measures are: 1) habitat protection; 2) habitat creation; 3) species modification; and 4) regulations and public involvement.

Habitat Protection

Habitat protection refers to a range of conservation measures designed to maintain existing fish spawning habitat, including measures such as restricting recreational and other intrusions into gravel-bottomed shoreline areas during the spawning season. Use of natural vegetation in shoreland management zones and other "soft" shoreline protection options aid in habitat protection. Costs are generally low, unless habitat is already degraded. Ordinance modification might be required to impose boating restrictions or similar seasonal constraints on recreational use. Effectiveness is variable depending in part on community acceptance and enforcement. Generally, it is more effective to maintain a good habitat than to restore a habitat after it is degraded.

Loss of habitat should be a primary concern of any fish management program. The environmentally valuable areas identified in Chapter V are the most important areas to be protected. Limiting or restricting power boats in these areas will prevent significant disturbance of fish nests and aquatic plant beds. Aquatic plant control should be avoided in these areas. Dredging, filling, and the construction of piers and docks should be discouraged in these areas.

Fishery habitat protection is considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

Habitat Creation

In lakes where vegetation is lacking or where plant species diversity is low, artificial habitat may need to be developed. Spawning habitat improvement and creation refers to a range of restoration measures designed to repair, replace or create additional habitat areas for fish in a lake. Techniques to be considered include interception and diversion, especially of turbid waters, shoreland management zones, and flushing gravel beds or underwater springs to keep these areas free of silt prior to the spawning season. Water level management for fishery purposes may also be considered for spawning habitat improvement in certain circumstances, as might the creation of artificial spawning habitat through the construction of rock reefs and gravel beds at depths of 1.5 to 4.0 feet. In such cases, provision of additional structures for protection of juvenile fishes should be a concurrent activity. Brush piles, cribs, stake beds, pipe pyramids and rubble piles can provide necessary cover and habitat for food organisms.[31] Costs are generally modest, especially if there is donated labor. Effectiveness has been demonstrated, but not well documented. Impacts are few, if any. State permits may be needed to implement these activities. However, because there is sufficient habitat for a healthy fish community in Friess Lake, habitat creation programs are not considered to be viable measures for inclusion in the recommended Friess Lake management plan.

Modification of Species Composition

Species composition management refers to a group of conservation and restoration measures which include selective harvesting of undesirable fish species and stocking of desirable species designed to enhance the angling resource value of a lake. These measures include water level manipulation both to aid in the breeding of desirable species—for example, increasing water levels in spring to provide additional breeding habitat for pike—and to disadvantage undesirable species—for example, drawing a lake down to concentrate forage fish and increase predation success and also to strand juveniles and desiccate the eggs of undesirable species. Costs, as with water level management above, are primarily associated with loss of use; effectiveness is

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[31] *Northern pike spawning habitat can be created by impounding small streams entering the lake. In Friess Lake, however, the extensive shallows and marshy habitats that are prime northern pike habitat currently exist at the Lake inlet. Wetland and floodland protection measures designed to protect these areas have been recommended above. Likewise, walleyed pike spawning beds can be constructed from rocks and boulders, but the success has varied among lakes.*

good but by no means certain; and side effects include collateral damage to desirable fish populations.

More extreme measures include fisherees that place a bounty on undesirable species—a means of increasing angling pressure, or selective cropping, of certain fishes, poisoning, and enhancement of predation by stocking. In lakes with an unbalanced fishery, dominated by carp and other rough fish, chemical eradication has been used to manage the fishery. The fish toxicant Rotenone is used to eradicate the existing fish population with the desired predator fish and panfish reintroduced. Lake drawdown is often used along with the chemical treatment. Drawdown will expose spawning areas and eggs and concentrate fish in shallow pools, thereby increasing their availability to anglers, commercial harvesters, or chemical eradication treatments. The newly created habitat will also benefit desired gamefish populations. Fish barriers are usually used to prevent reintroduction of undesirable species from up- or downstream. Chemical eradication is a drastic, costly measure and the end result may be highly unpredictable, although effectiveness is generally good. Because the rough fish are not currently abundant, such extreme measures are not recommended for Friess Lake where the fisheries value of the resource has been assessed as good to excellent.

The more common management measure is stocking of game fishes, with the mixture of species being determined by the stocking objectives, usually supplementing an existing population, maintaining a population that cannot reproduce itself, adding a new species to a vacant niche in the food web, replacing species lost due to a natural or man-made disaster, or establishing a fish population in a depopulated lake. Costs vary with species stocked and their relative availability, the numbers to be stocked and their year class or age, and the location and timing of the stocking. Effectiveness is variable, depending on the aforementioned factors, but can be good for many species. Impacts on other parts of the fish community are possible, especially if nonnative fish species are stocked, and other stresses may be imposed by an altered species composition and population structure.

Fish stocking is a management method used to supplement naturally reproducing species or to maintain populations of species with poor natural reproduction. Stocking of sport fish encourages angler use of a lake and can be used to maintain a balanced predator-prey relationship. Proper stocking of fish requires a thorough understanding of the existing fish population. Predator fish should not normally be stocked to control a panfish population that is already stunted. Once panfish become so abundant that the population is stunted, the number of predators required to control them is probably higher than the capacity of the lake in question for predators.[32] Overstocking or stocking when native predators are already present in adequate numbers may result in one or more of the following problems: 1) competition of stocked fish and native fish may force stocked fish out of a lake and into adjacent water bodies where their presence may be undesirable, 2) overcrowded fish populations may be more susceptible to bacterial, viral, and parasitic infections, and 3) overstocking may have an unfavorable effect on angling success.[33] The importance of a balanced predator-prey relationship in Friess Lake, using walleyed pike and perch as an example, is shown diagrammatically in Figure 15.

In Friess Lake, the lack of adequate public access, as defined in Section NR 1.90 through NR 1.95 of the *Wisconsin Administrative Code*, would preclude the stocking of northern pike and walleyed pike by the Wisconsin Department of Natural Resources. Stocking of largemouth and smallmouth bass is not normally needed where habitat conditions are favorable and is seldom successful where they are not.[34]

The development of a fishery stocking program and continuation of limited rough fish removal by angling-related programs are the only species modification elements considered to be potentially viable for Friess Lake. However, the need for the fishery stocking program should be evaluated further by conduct of a fish survey to better determine the make-up of the fishery in Friess Lake.

Regulations and Public Information

To reduce the risk of overharvest, the Department of Natural Resources has placed restrictions on the number and size of certain fish species caught by anglers. The open season, size limits, and bag limits for the fish species of Friess Lake are given in Table 25. Enforce-

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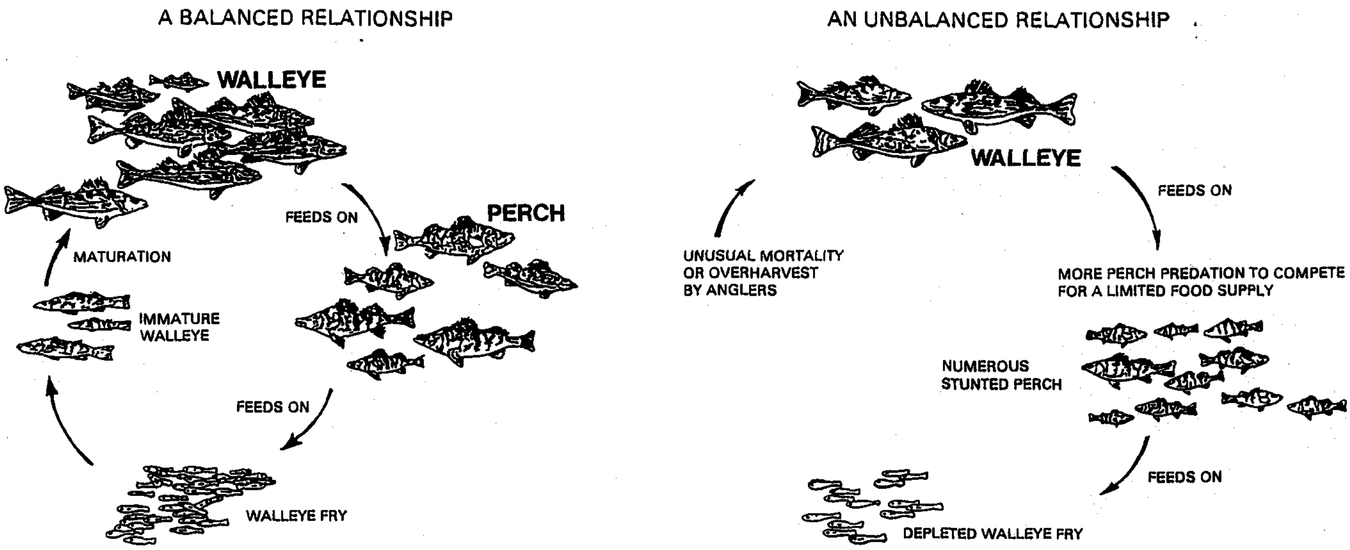
[32]*H. Snow, "Effects of Stocking Northern Pike in Murphy Flowage, Wisconsin," Wisconsin Department of Natural Resources Technical Bulletin No. 50, 1974, 25 pp.*

[33]*G.C. Becker,* Fishes of Wisconsin, *The University of Wisconsin Press, Madison, Wisconsin, 1983.*

[34]*Wisconsin Department of Natural Resources,* Fish and Wildlife Comprehensive Plan, *1979.*

Figure 15

THE PREDATOR-PREY RELATIONSHIP



Source: Wisconsin Department of Natural Resources.

ment of these regulations is critical to the success of any sound fish management program.

RECREATIONAL USE AND PUBLIC ACCESS

Two management measures have been considered related to recreational use of Friess Lake. These measures are: 1) public access; and 2) recreational use zoning.

Public Access

The Wisconsin Department of Natural Resources has indicated that a public boat launch should be provided at Friess Lake. Friess Lake currently does not meet the public boating access standard as set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. Determination of the amount of access that can be accommodated at Friess Lake is dependent on the areal extent of the open water lake surface. Friess Lake, with a surface area of 119 acres, falls in the 100-499 acre category for recreational use lakes established in Section NR 1.91, *Wisconsin Administrative Code*. As previously noted, the minimum number of car-trailer units that could be accommodated at Friess Lake, in a manner consistent with the Section NR 1.91 guidelines, would be one car-trailer unit per 30 open water acres plus a handicapped accessible unit, for a total of not less than six units for lakes of between 50 and 150 acres in open water extent. The maximum number of car-trailer units would be one car-trailer unit per 15 open water acres plus a handicapped accessible unit. Applying these standards to Friess Lake, the minimum public boating access development would be six car-trailer units, including one handicapped-accessible unit, and the maximum public boating access development would be nine car-trailer units, including one handicapped-accessible unit. The existing publicly owned access site at the STH 167 highway bridge is limited to carry-in access upstream of Friess Lake. In addition, the existing privately owned access sites at Anderson's Supper Club and Wally and Bea's Tavern are not subject to private provider agreements as set forth in Section NR 1.91(7), and, hence, are not considered in evaluating the current access suitability under the provisions of Chapter NR 1 of the *Wisconsin Administrative Code*. Conclusion of a private provider agreement with either or both of these facilities is an option. Provision of public boating access consistent with the Wisconsin Department of Natural

Table 25

1996 OPEN SEASON, SIZE LIMITS, AND BAG LIMITS FOR FISH SPECIES IN FRIESS LAKE[a]

Species	Open Season	Daily Limit	Minimum Size
Northern Pike	May 4 to March 1	2	26 inches
Walleyed Pike	May 4 to March 1	5	15 inches
Largemouth Bass	May 4 to March 1	5	14 inches
Bluegill, Pumpkinseed (sunfish), Crappie, and Yellow Perch	Open all year	50	None
Bullhead	Open all year	None	None
Rough Fish	Open all year	None	None

[a]The limits and sizes set forth in this table are for Friess Lake. Daily limits and minimum sizes vary between lakes.

Source: Wisconsin Department of Natural Resources.

Resources standards is recommended in the Washington County park and open space plan.[35] Standards set forth in the regional park and open space plan would provide for the use of a maximum of no more than seven fast boats on Friess Lake.[36] The optimum number of parking spaces for Friess Lake can be estimated by the number of fast boats in use at any one time by the owners of property with Lake frontage. Assuming the latter figure at five percent of the number of dwelling units on the Lake, this would indicate no car-trailer parking spaces suitable for fast boat transportation would be warranted.

Two sites for a public boat access site have been considered at the locations shown on Map 22. One site is located in Glacier Hills County Park and the other is located downstream of Friess Lake on Little Friess Lake. The Wisconsin Department of Natural Resources staff have been in communication with the Town of Richfield and the Friess Lake Action Group regarding the provision of public access to Friess Lake. As a result of these discussions, a potential site for a future public boat access site has been identified by the Friess Lake Action Group on Little Friess Lake at a site shown on Map 22. This site could accommodate provision of car-trailer parking spaces sufficient to meet the standards set forth in Chapter NR 1, and could potentially be operated under a private provider agreement between the Friess Lake Action Group and the Wisconsin Department of Natural Resources. This site has the advantage of being located away from the residential areas of the Friess Lake shorelands, while being readily accessible from Friess Lake Drive just south of Glacier Hills County Park.[37] The disadvantage of this site is that it is located south of the main body of Friess Lake and requires that boats launched at this site traverse a shallow, narrow river-like portion of the Lake to reach Friess Lake proper. Notwithstanding, Wisconsin Department of Natural Resources staff have indicated that a launch constructed at the site shown on Map 22 could be considered as conforming to the requirements of Chapter NR 1, subject to Departmental review of site development plans.

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[35]*SEWRPC Community Assistance Planning Report No. 136, 2nd Edition,* A Park and Open Space Plan for Washington County, *August 1997.*

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

[37]*Washington County staff reported in 1995 that the Glacier Hills County Park property, which is ideally situated for a public boat launch, is subject to a deed restriction that expressly forbids construction of a recreational boating access on this property.*

Based upon the above, the establishment of improved public access is considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

Recreational Use Zoning

Measures are available to control lake and lake shoreland use. On land, shoreland zoning requiring set backs and shoreland buffers can protect and preserve views both from the water and from the land, control development around a lake to minimize its environmental impacts, and manage public and private access to a waterbody. On water, recreational use zoning can provide for safe and multiple purpose use of waterbody by various groups of lake users and protect environmentally sensitive areas in a lake. Use zoning can also take the form of allocating times of use, such as the annual fishing season established by the state. A key issue in zoning a waterbody for use is equity; the same rules must apply to both riparian owners and off-lake users. This condition is usually met in situations where use zoning is motivated by the protection of fish habitat, for example, as both on- and off-lake users would have use of an enhanced fishery. Costs are minimal—associated with creating and posting the ordinance—and effectiveness can be good with regular and consistent enforcement. Impacts are not known.

In the final analysis, there is the option to adapt recreational uses of a system to its quality and constraints. Sometimes recreational use management can alter public expectations of a system and lead to increased satisfaction among users. Because the desired recreational uses on Friess Lake are not known in a quantitative sense—for example, numbers of users engaging in specific activities at particular times of day or on particular days—the conduct of a user and recreational use survey is recommended. Such a survey could be carried out by the Friess Lake Action Group as most of the membership of this association consists of riparian householders, and used by the Town of Richfield to develop an appropriate lake recreational use zoning scheme.

The use of recreational use zoning is considered to be a viable measure for inclusion in the recommended Friess Lake management plan.

PUBLIC INFORMATION AND EDUCATION

As part of many of the management measures discussed above, a public informational and educational program dealing with lake-oriented issues is considered a viable supporting management measure.

Educational and informational brochures and pamphlets, of interest to householders and supportive of the recreational use and shoreland zoning regulations, are available from University of Wisconsin Extension and the Wisconsin Department of Natural Resources. These latter cover topics such as beneficial lawn care practices, household chemical use guidelines, and rainwater use guidelines. These brochures could be provided to householders through local media, direct distribution or targeted library/civic center displays. Such interventions could also rekindle public interest in the activities of the Friess Lake Action Group. Many of the foregoing ideas can also be integrated into ongoing, larger-scale municipal activities, such as lakeside litter collections, which can reinforce anti-littering campaigns, recycling drives and similar pro-environment activities.

Finally, the participation of Friess Lake residents in the Department of Natural Resources volunteer "Self-Help Monitoring" program, which involves citizens in taking Secchi-disk transparency readings in the Lake at regular intervals, should be continued. Data gathered as part of this program should be presented by the volunteer at the annual meeting of the Friess Lake Action Group, where the citizen-monitors could be given some recognition for their work. The Lake Coordinator of the Department of Natural Resources Southeast District could assist in enlisting more volunteers in this program. The information gained at first hand by the public during participation in this program increases the credibility of the proposed changes in the nature and intensity of use to which the Lake is subjected.

SUMMARY

This chapter has described a number of options that could be employed in managing the types of problems found to occur in Friess Lake and its watershed, and which could, singly, or in combination, assist in achieving and maintaining the water quality objectives set forth in Chapter VI. Based on an evaluation of the management measures on the basis of the effectiveness of the measures in improving the lake water quality by dealing with pollutant loadings at their source and on the basis of cost and technical feasibility of the measure, some alternative measures were eliminated from further consideration. The remaining measures are considered further in a recommended lake management plan as described in Chapter VIII. Selected characteristics of all the measures considered are summarized in Table 26.

Table 26

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR FRIESS LAKE

Issue	Alternative Measure	Description	Estimated Costs: Capital	Estimated Costs: Operation and Maintenance	Considered Viable for Inclusion in Recommended Lake Management Plan
Land Use Zoning	Shoreline development restrictions	General zoning, floodland, and shoreland zoning	- -	- -	Yes
	Land use regulation	General zoning district revisions	- -	- -	Yes
	Wetland protection	Permit program, shoreland zoning	- -	- -	Yes
Nonpoint Pollution Sources	Urban nonpoint source pollutant control	Detention and infiltration basins, grassed swales, and interception/ diversion practices	- -	Variable	Yes
	Construction erosion control	Soil stabilization and surface roughening	$250 per acre	$25 per acre	Yes
	Rural nonpoint source pollutant control	Conservation tillage, contour farming, contour strip cropping, crop rotation, grassed waterways, and pasture management practices	- -	- -	Yes
	Instream sediment basin	Basin on Oconomowoc River inlet	- -[a]	- -[a]	Yes
Onsite Sewage Disposal Systems	Onsite sewage disposal system management	Inspection and maintenance of all riparian onsite sewage disposal systems on a regular basis by Town of Richfield and/ or Friess Lake Action Group	- -	- -	Yes
	Public sanitary sewer system	Conduct feasibility study potentially for selected areas townwide	- -[a]	- -[a]	Yes
Ecologically Valuable Areas and Aquatic Plants	Aquatic plant management and wetland preservation	Herbicides	- -	$8,000	Yes
		Harvesting	$90,000	$20,000	No
		Biological controls	- -	- -	No
		Manual harvesting	- -	- -	Yes
		Lake bottom covering	- -	$40 to $220 per 700 square feet	No
		Public information	- -	- -	Yes
		Shoreline maintenance	$7.50 to $36 per linear foot	- -	Yes
Water Quality	Dilution/flushing	Reduce contaminant concentrations in Lake	- -	- -	No
	Nutrient/toxicant inactivation	Alum treatment	- -	$72,000	No
		Nutrient load reduction	- -[a]	- -[a]	No
	Aeration	Circulation of water column	$300,000	$160 to $2,600 per acre	No
Water Level	Water level management	Drawdown, stabilization, dredging	- -	- -	No
Fish	Fish management	Habitat protection	- -	- -	Yes
		Habitat creation	- -	- -	No
		Stocking	- -	$0.70 to $0.75 per fish	- -[b]
		Regulations	- -	- -	Yes
		Fish survey	- -	- -	Yes
Access	Recreational use zoning	Provide public access	- -[a]	- -[a]	Yes
		Space and time zoning to maximize public safety	- -	- -	Yes
Information and Education	Educational measures	Public information programming	- -	- -	Yes

[a]Detailed feasibility study needed to properly estimate cost.

[b]Dependent upon results of fish survey.

Source: SEWRPC.

Chapter VIII

RECOMMENDED MANAGEMENT PLAN FOR FRIESS LAKE

INTRODUCTION

This chapter presents a recommended management plan, including attendant costs, for Friess Lake. The plan is based upon analysis of the land use, land and water management, and biological water quality and pollution source inventory findings; and an evaluation of alternative management measures described in Chapter VII of this report. The recommended plan is designed to address the eight issues identified as requiring consideration under this planning program. These issues are related to: land use and zoning, nonpoint source pollution, onsite sewage disposal systems, ecologically valuable areas and aquatic plants, water quality, lake water levels, fisheries, and public recreational use and boating access. By addressing these issues, the plan sets forth means for: 1) improving water quality conditions; 2) reducing the severity of perceived existing problems due to changes in the species composition of the biological communities present in the Lake; and 3) improving opportunities for water-based recreational activities. The recommended plan is comprised of components which were selected from among the alternative management measures described in Chapter VII, considering the degree to which the desired water use and related biological and recreational use objectives may be expected to be met by the alternative measures and considering the costs and feasibility of implementation.

The recommended management measures for Friess Lake are graphically summarized on Maps 23 and 24 and are listed in Table 27. It should be noted that this plan was developed using a process that involved frequent consultations with the Town of Richfield through the Friess Lake Action Group, the designated organization charged with the task of developing this management plan. It is recommended that this organization continue to participate in the implementation of this plan, in association with the Town. As such, the recommended management measures have been focussed primarily on those which are applicable to the Friess Lake Action Group, or a future lake rehabilitation and protection district, and the Town of Richfield, with lesser emphasis given to measures which are applicable to others with jurisdiction within the broader total drainage area tributary to Friess Lake.

LAND USE AND ZONING

A fundamental element of a sound management plan and program for Friess Lake is the proper development the lands lying in the tributary drainage area to the Lake. The type and location of urban and rural land uses in the drainage area determines the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, various land management measures; and, ultimately, the water quality of the Lake. Land uses are also an important consideration with respect to groundwater recharge and quality protection. Three specific management measures related to land use and zoning are included in the recommended plan: shoreland development restrictions, general land use regulations in the drainage area tributary to Friess Lake, and environmental corridor and wetland protection measures.

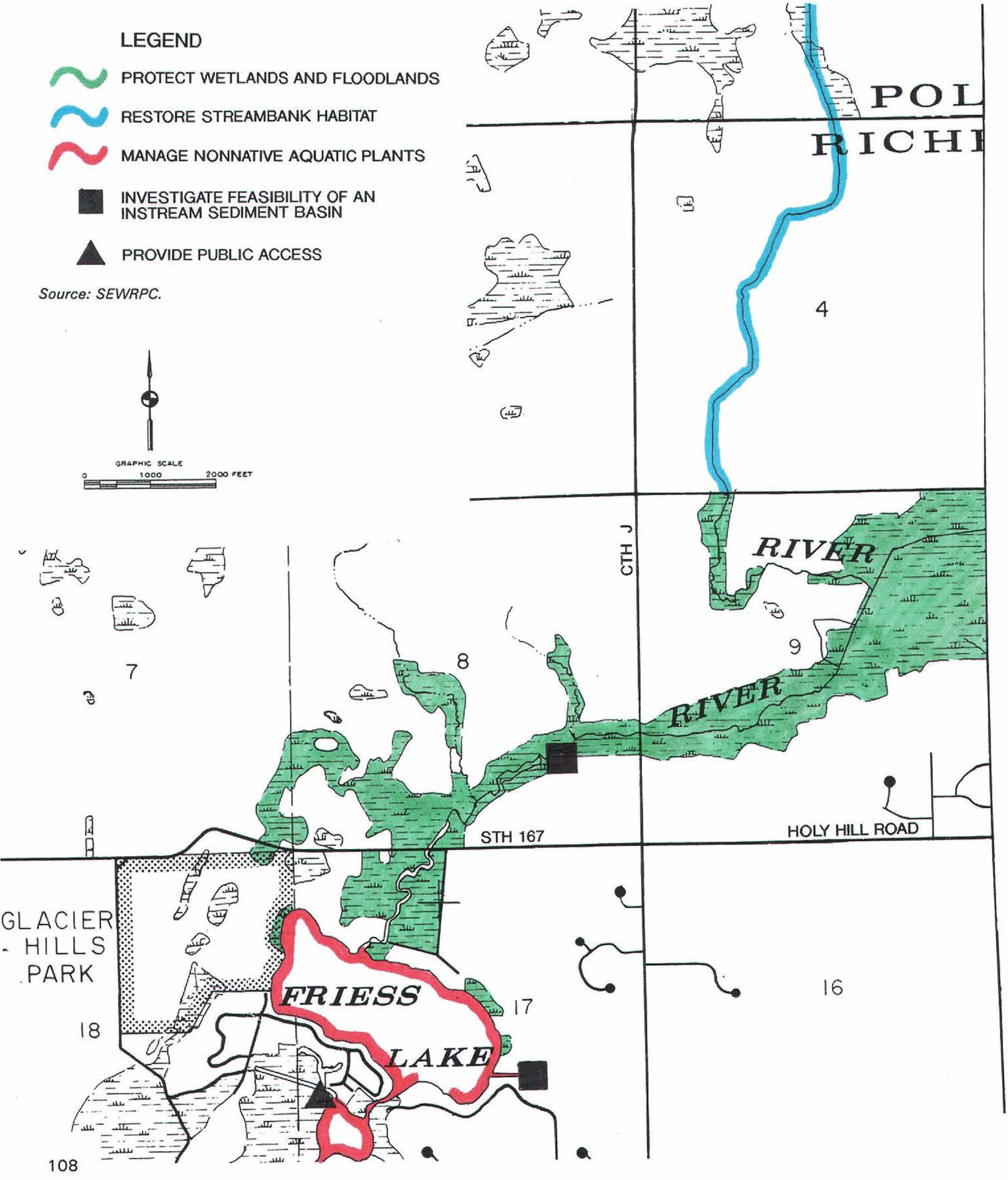
Shoreland Development Restrictions

A land use issue which has the potential to affect the Lake is major new shoreline development or the redevelopment of existing lakefront properties with increased roof areas, parking areas, and areas of other impervious surfaces. Replacement of a pervious land surface with an impervious surface will increase the rate at which stormwater enters the Lake and increase certain pollutant loadings to the Lake. Conversion from seasonal to year-round usage may also place additional burdens on onsite sewage disposal systems. While these effects can be moderated to some extent through structural stormwater management measures and onsite sewage disposal system maintenance, there is likely to be some residual adverse impact on the Lake from significant new development or redevelopment involving higher intensity land uses. For this reason, maintenance of the historic low- and medium-density shoreline residential land use on Friess Lake to the maximum extent practical is recommended.

The current zoning for the areas immediately surrounding Friess Lake is generally consistent with maintaining the current character of the lakeshore. The potential for significant changes in the development patterns is restricted due to floodplain and shoreland district zoning. Thus, the only action recommended is the monitoring, by the Friess Lake Action Group, of potential zoning

Map 23

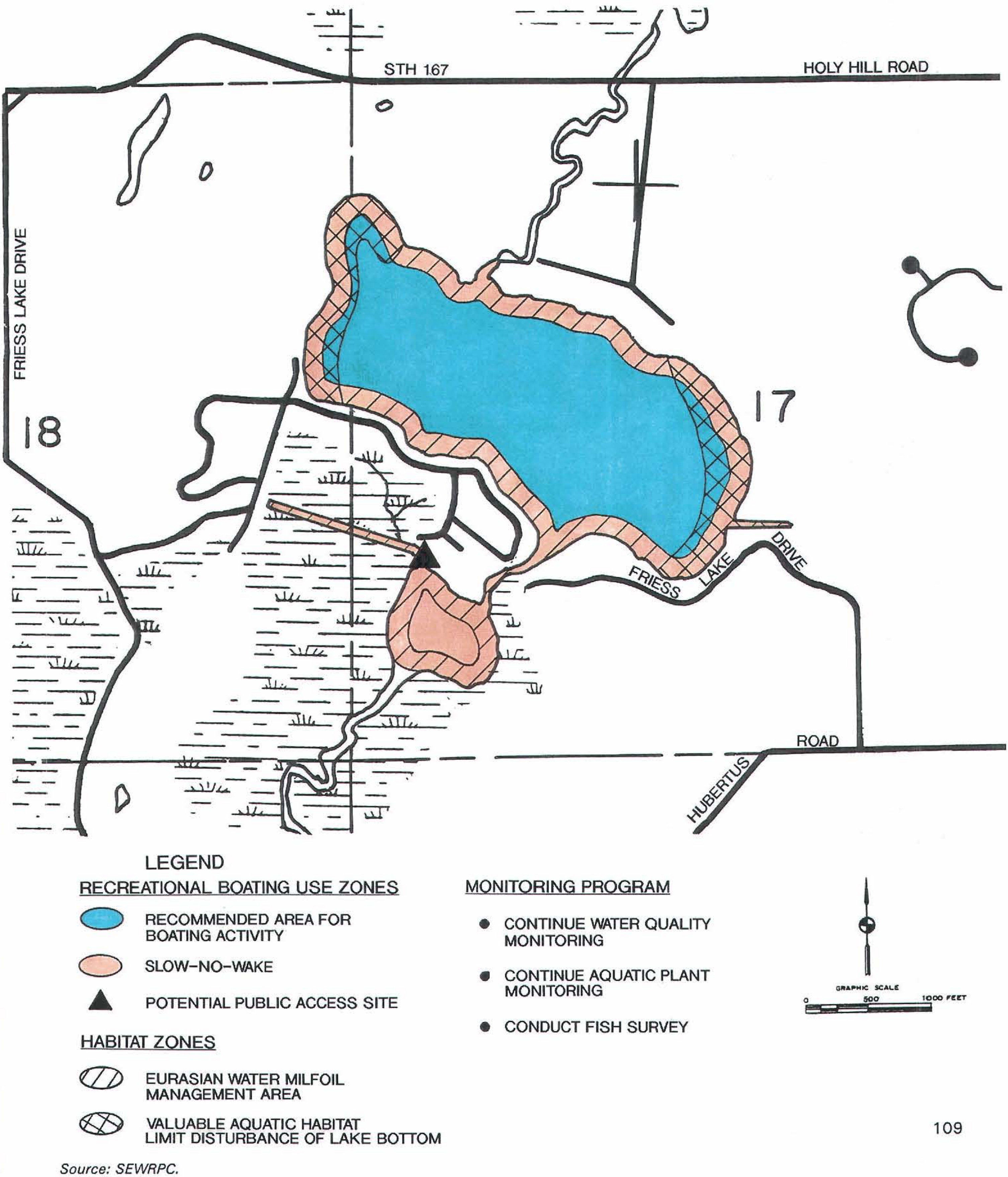
PROPOSED LAKE MANAGEMENT PLAN FOR FRIESS LAKE



Source: SEWRPC.

Map 24

RECOMMENDED IN-LAKE PROTECTION MEASURES FOR FRIESS LAKE



Source: SEWRPC.

Table 27

RECOMMENDED MANAGEMENT PLAN FOR FRIESS LAKE

Issue	Alternative Measures	Location	Management Measures	Management Responsibility[b]	Estimated Cost 1995-2010[a]		Potential Funding Sources[b]
					Capital	Average Annual Expenditure	
Land Use and Zoning	Shoreline development restrictions	Lakeshore areas	Maintain historic lake front residential dwelling densities to extent practicable	County, municipalities, FLAG	- -	- -	- -
	Land use regulation	Entire watershed	Observe guidelines set forth in the regional land use plan	County, municipalities	- -	- -	- -
	Wetland protection	Entire watershed	Establish adequate protection of wetlands and environmental corridors	County, municipalities	- -[c]	- -[c]	DNR
Nonpoint Pollution Sources	Urban nonpoint source controls	Entire watershed	Implementation and maintenance of recommended urban control practices	County, FLAG	- -[d]	- -[d]	- -
	Construction site erosion control	Entire watershed	Continue enforcement of existing ordinances	County, municipalities	$250 per acre[e]	$25 per acre[e]	Private firms, individuals
	Rural nonpoint source controls	Entire watershed	Implement and maintain rural land best management practices	County	- -[c,f]	- -[c,f]	DNR
	Instream sediment basin	Oconomowoc River Inlet, unnamed stream	Conduct feasibility study for sedimentation basins	FLAG	- -[c,g]	- -[c,g]	DNR
Onsite Sewage Disposal Systems	Onsite sewage disposal system management	Lakeshore area	Develop onsite sewage disposal system management plan, including informational and educational program to promote sound practices and periodic inspections	County, FLAG	- -[d]	- -[d]	- -
			Consider formation of a public inland lake protection and rehabilitation district with sanitary district powers	Town, FLAG	- -[d,k]	- -[d,k]	- -
	Public sanitary sewer	Lakeshore area	Develop feasibility study for public sanitary sewer system	FLAG, Town of Richfield	- -[g]	- -[g]	- -
Ecologically Valuable Areas and Aquatic Plant Management	Aquatic plant management and monitoring	Entire Lake	Update aquatic plant management survey every three to five years	FLAG, DNR	- -	$ 400[h]	DNR
		Within 100 feet of the shoreline	Chemical treatment limited to control of milfoil growth around docks	FLAG, DNR[i]	- -	$3,500	- -
		Valuable aquatic habitat areas	Encourage and protect native aquatic plant growth	FLAG	- -	- -	- -
	Shoreland management	Lakeshore areas	Maintain shoreline protection structures	FLAG	- -[d]	- -[d]	Private individuals

Table 27 (continued)

Issue	Alternative Measures	Location	Management Measures	Management Responsibility[b]	Estimated Cost 1995-2010[a] Capital	Average Annual Expenditure	Potential Funding Sources[b]
Water Quality Management	Water quality monitoring	Entire Lake	Participate in DNR Self-Help Monitoring Program supplemented by the long-term trend monitoring	FLAG, DNR	- -	- -[j]	DNR
Fish Management	Habitat protection	Selected near-shore and inlet river areas	Protect existing spawning and habitat areas	FLAG	- -[d]	- -[d]	- -
	Fish survey	Entire Lake	Conduct fishery survey and implement citizen-based creel survey	FLAG, DNR	- -	$2,000[c]	DNR
Access	Develop new access site	West shore of Little Friess Lake	Construct and maintain access site, as required	FLAG, Town of Richfield, DNR	- -[c]	- -[c]	DNR
	Recreational use zoning	Nearshore areas and Little Friess Lake	Enforce current boating ordinance	Town of Richfield, DNR	- -[d]	- -[d]	DNR
		Entire Lake	Conduct user and use survey	FLAG	- -[d]	- -[d]	- -
Information Program	Public informational programming	Entire watershed	Continue public awareness and informational programming	FLAG, County[k]	- -	$ 500[l]	UWEX, DNR

[a]All costs expressed in January 1997 dollars.

[b]Unless otherwise specified, DNR is Wisconsin Department of Natural Resources; County is Washington County; Municipalities are Towns of Richfield, Polk, and Erin and the Village of Slinger; FLAG is Friess Lake Action Group; and UWEX is the University Wisconsin-Extension.

[c]Partial funding available through Wisconsin Department of Natural Resources grant programs.

[d]Measures recommended generally involve low or no cost and would be borne by private property owners; cost is included under public informational and educational component.

[e]Cost varies with amount of land under development in any given year.

[f]Costs vary and will depend upon preparation of individual farm plans.

[g]Detailed feasibility study needed to properly estimate cost.

[h]This cost is based upon surveys conducted at about five-year intervals at $2,000 per survey. This cost could be reduced or eliminated if the Friess Lake Action Group joined the Self-Help Aquatic Plant Monitoring Program in which volunteers are trained to complete aquatic plant surveys on their lake.

[i]This activity requires a Wisconsin Department of Natural Resources permit.

[j]The DNR Self-Help Monitoring Program involves no cost but does entail a time commitment from the volunteer.

[k]County assistance is provided through the County UWEX office.

[l]Expenditures used for compiling and distributing newsletters and other public informational and educational materials.

Source: SEWRPC.

changes which could result in a significant change in the character of the shoreline development.

Land Use Regulation within the Tributary Drainage Area to Friess Lake

The recommended land use for the drainage area tributary to Friess Lake has a 2010 design year and is described in Chapter III. The content of, and framework for, the plan is the year 2010 regional land use plan as prepared and adopted by the Regional Planning Commission.[1] The recommended land use plan for the drainage area tributary to Friess Lake is shown in graphic summary form on Map 13. Under the recommended plan, by the year 2010 urban lands in the drainage area tributary Friess Lake are expected to increase by about 350 acres. Urban land use development should be allowed to occur, but only in areas which are covered by soils suitable for the intended use; which are not subject to special hazards such as flooding; and which are not environmentally sensitive, that is, are not encompassed within the environmental corridors described in Chapters III and V.

Recent surveillance indicates that urban growth within the drainage area tributary to Friess Lake will exceed this level of planned development as a result of development patterns providing primarily for large-lot residential development. Furthermore, the current zoning generally permits far more urban development than envisioned in the adopted regional land use plan. It is recommended that the Towns of Polk, Richfield, and Erin review the current zoning regulations and adjust those regulations to ensure the development occurs in the manner generally consistent with the regional land use plan, including preservation of the environmental corridor lands. Changes in the zoning ordinance could be considered to minimize the areal extent of the development by providing specific provisions and incentives to cluster residential development on smaller lots while preserving portions of the open space on each property or group of properties considered for development.

Wetland Protection

Wetlands encompass about 20 acres within the direct drainage area to Friess Lake and about 1,440 acres of the total drainage area tributary to Friess Lake, as well as the entire lake shoreline. Wetlands in the Friess Lake drainage area are currently regulated by the U.S. Army Corps of Engineers 404 Permit Program, the Wisconsin Shoreland Zoning Program, and local zoning ordinances. Nearly all wetland areas in the Friess Lake direct drainage area are protected under one or more of the Federal, State, County, and local regulations. The designated environmental corridor area, as shown on Map 20, contains nearly all of the remaining wetlands, woodlands, and floodlands in the tributary area to Friess Lake. Protection of the important wetlands, as well as woodlands and floodlands, would be accomplished through local zoning actions, as described above.

However, should urban development not proposed or envisioned under the land use plan threaten to destroy or degrade natural resources located within the primary environmental corridors, appropriate public or private agencies should consider acquisition of such lands for resource and open space preservation purposes. The purchase of specific critical properties or the acquisition of conservation easements, as a means of protecting them from encroachment or further degradation, or as a means of facilitating their rehabilitation and restoration, is possible with financial aids through the Chapters NR 50/51 Stewardship Grant Program and the Chapter NR 191 Lake Protection Grant Program, both chapters set forth in the *Wisconsin Administrative Code.*

NONPOINT POLLUTION SOURCES

Based upon a review of the sources of phosphorus loadings to Friess Lake, as described in Chapters IV and VII, the most significant sources of phosphorus to the Lake in its tributary drainage area are rural and urban nonpoint sources. The needed levels of control were initially identified in the regional water quality management plan[2] and were refined under the Oconomowoc

[1] *SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin—2010, *January 1992.*

[2] *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, as updated in SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

River nonpoint source priority watershed project plan,[3] and the Washington County soil erosion control plan.[4]

Three management measures related to nonpoint source pollution abatement are included in the recommended plan: urban nonpoint source controls; rural nonpoint source controls; and the further investigation and design of an instream sedimentation basin.

Urban Nonpoint Source Controls

Urban Area Nonpoint Source Controls

Based upon review of the existing land use patterns, it is estimated that the practices which could be viable in the existing urban areas within the immediate vicinity of Friess Lake are limited largely to good urban housekeeping practices and grassed swales. However, structural measures, such as detention ponds, could be considered for installation as part of the development process in urbanizing areas of the tributary drainage area. The areas where urban practices are considered most applicable are shown on Map 25. The development of such urban nonpoint source pollution abatement measures for the Friess Lake area is expected to be primarily the responsibility of private property owners. Accordingly, it is recommended that the Friess Lake Action Group work with property owners to achieve good urban land management practices. Such practices should consist of good urban housekeeping practices, such as fertilizer and pesticide use management, critical area protection, litter and pet waste controls, and leaf and yard waste storage and disposal controls. The promotion of these measures will require a public informational and educational programs which can be included in the program related to this topic and other lake-oriented issues.

As an initial step in carrying out the recommended urban practices, it is recommended that a fact sheet identifying specific residential land management practices beneficial to the water quality of Friess Lake be prepared and distributed to riparian property owners by the Friess Lake Action Group with the assistance of the University of Wisconsin-Extension service. The recommended urban measures if carried out in the entire tributary drainage area may be expected to provide about a 25 percent reduction in urban nonpoint source pollution runoff, and about a 10 percent reduction in total phosphorus loading to the Lake.

Urbanizing Area Nonpoint Source Controls

Washington County has included provisions for soil erosion control and stormwater management in its Land Division Ordinance. The soil erosion control provisions are similar to those set forth in the model ordinance developed by the Wisconsin Department of Natural Resources in cooperation with the Wisconsin League of Municipalities.[5] The County enforces the ordinance in the shoreland areas and in larger-scale developments such as subdivisions and planned unit developments. Individual development sites and other construction sites are controlled under local zoning ordinance provisions with enforcement by local building inspectors.

Construction site erosion controls may include the use of silt fences, sedimentation basins, and rapid revegetation of disturbed areas; the control of "tracking" from the site; and careful planning of the construction sequence to minimize the areas disturbed. Construction site erosion control is particularly important in minimizing the more severe localized short-term nutrient and sediment loadings to Friess Lake that can result from uncontrolled construction sites. The only recommended measure is the enforcement of the current zoning ordinance provisions.

Rural Nonpoint Source Pollution Controls

The ongoing implementation of nonpoint source pollution controls in rural areas is recommended. Such implementation is proposed to be a cooperative effort of the Washington County Land Conservation Committee and private landowners. Additional technical assistance can be provided by the U.S. Department of Agriculture, Natural Resources Conservation Service; the Wisconsin Department of Agriculture, Trade and Consumer Protection; and the University of Wisconsin-Extension. The Washington County Land Conservation Department has indicated that a reduction of about 37 percent in the soil losses from rural lands in the drainage area tributary to Friess Lake is achievable. This level is considered to be consistent with the recommendations set forth in the Oconomowoc River Nonpoint Source Priority Watershed project plan. Inventories conducted by the Washington County Land Conservation Department defined those

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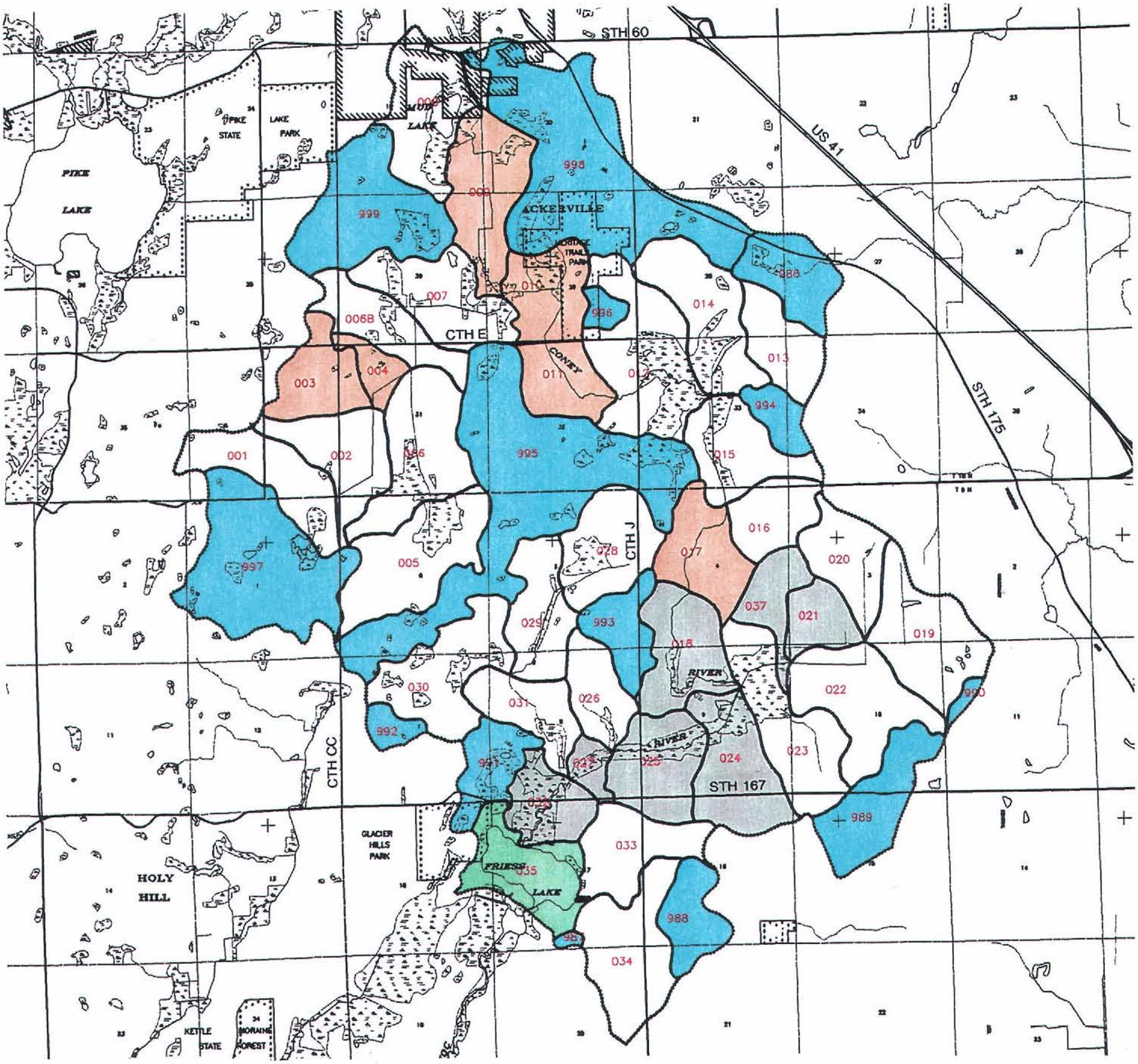
[3]*Wisconsin Department of Natural Resources Report No. PUBL-WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986.*

[4]*SEWRPC Community Assistance Planning Report No. 170,* Washington County Agricultural Soil Erosion Control Plan, *March 1989.*

[5]*Wisconsin League of Municipalities and Wisconsin Department of Natural Resources,* Wisconsin Construction Site Best Management Practices Handbook, *1989.*

Map 25

WATERSHED MANAGEMENT PLAN FOR FRIESS LAKE



LEGEND

LAND USE MANAGEMENT

DOES NOT DRAIN TO FRIESS LAKE

IMPLEMENT AND MAINTAIN RURAL LAND MANAGEMENT PRACTICES

IMPLEMENT AND MAINTAIN URBAN LAND MANAGEMENT PRACTICES

INSPECT AND MAINTAIN ONSITE SEWAGE TREATMENT SYSTEMS

0 1/4 1/2 3/4 1 MILE

GRAPHIC SCALE

Source: SEWRPC.

areas where rural nonpoint source controls were most needed and would be most effective in the drainage areas tributary to Friess Lake, as shown on Map 25.

Highly localized, detailed, and site-specific measures are required to effectively reduce soil loss and contaminant runoff in rural areas. These measures are best defined and implemented at the local level through the preparation of detailed farm conservation plans. Practices which are considered most applicable in the Friess Lake area include conservation tillage and pasture management. In addition, it is recommended that consideration be given to cropping patterns and crop rotation cycles, with attention to the specific topography, hydrology, and soil characteristics of each farm. Implementation of these measures is estimated to reduce soil loss from agricultural lands by about 30 percent and phosphorus loads by about 40 percent. The cost of these measures varies and depends upon the details of the recommended farm conservation plans. The costs may be expected to be incurred to a large extent for purposes of agricultural land erosion control in any case.

In addition to the agricultural land management measures noted above, the restoration of the streambank along the Coney River between CTH E and STH 167, and the protection of wetlands in the vicinity of the STH 167 bridge on the Oconomowoc River were identified by the Washington County Land Conservation Department as important rural nonpoint source pollution abatement steps. These measures are also recommended, as shown on Map 23.

Instream Sedimentation Basin

As noted in Chapter VII, the Washington County Land Conservation Department has documented a significant level of control of nonpoint source pollution from rural lands. Within the drainage area tributary to Friess Lake, significant amounts of particulate matter, and associated nonpoint source pollutants, continue to be carried into Friess Lake from the drainage basin by the Oconomowoc River. For this reason, additional measures to minimize the sediment and nutrient load entering Friess Lake were determined to be viable for inclusion in the recommended plan. Further evaluation of development of an instream sedimentation basin upstream of Friess Lake in the Oconomowoc River is recommended. However, prior to construction of such a basin, it is recommended that a detailed evaluation of the hydrologic, hydraulic, and pollutant retention efficiency of such a basin be conducted, and discussions with the Wisconsin Department of Natural Resources staff be initiated, in order to identify the most effective and affordable design for this basin.

ONSITE SEWAGE DISPOSAL SYSTEMS

As set forth in Chapters IV and VII, onsite sewage disposal systems are estimated to contribute about 8 percent of the total phosphorus loading to Friess Lake. In addition, such systems have implications for groundwater quality and property values throughout the drainage area tributary to Friess Lake. Proper management of onsite sewage disposal systems was identified as an important issue for the urban development surrounding Friess Lake. Two management measures related to onsite sewage disposal are included in the recommended management plan: adoption of an onsite sewage disposal system management program and further investigation and evaluation of the provision of a public sanitary sewer system to serve all, or portions, of the area.

Onsite Sewage Disposal System Management Program

Notwithstanding the potential for a future development of a public sanitary sewer service system, it is recommended that the Friess Lake Action Group work with the Washington County Land Use and Park Department to develop an onsite sewage disposal system management program. It is also recommended that the Friess Lake Action Group assume the lead in providing the public informational and educational programs to encourage property owners to have the existing onsite systems inspected and any needed remediation measures undertaken. Homeowners should be advised of the rules and regulations governing, and the limitations of, onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs.

The purpose of the recommended inspection program would be to identify any malfunctioning sewage disposal systems. Ideally, each system would be inspected once every three years, with about one-fifth of all systems inspected annually. A secondary benefit of an inspection program would be the knowledge system owners would gain from the periodic inspection of these systems and identification of any shortcomings. It is recommended that the Friess Lake Action Group investigate facilitating such inspections and maintenance by contracting with a septic hauler on behalf of the Friess Lake residents, thereby potentially accomplishing this inspection and maintenance program at lesser cost than if it were undertaken by individual homeowners. Under an expanded version of this option, the onsite sewage disposal system management program could potentially include the establishment of a sanitary district or lake management district with sanitary district powers to raise and administer funds; inspect, design, and construct upgraded systems; ensure proper operation and maintenance of the systems; and monitor the performance of the systems.

Public Sanitary Sewerage System

In the regional water quality management plan, the concentrations of urban development located around the shorelines of Friess Lake were not included within a recommended public sanitary sewer service area. Information available at that time did not indicate a need to provide centralized sanitary sewer service to the lake community. Thus, the adopted regional water quality management plan recommends that sewage disposal needs in the lake community concerned be provided through onsite sewage disposal systems. The regional plan, however, also recommends that sewage disposal needs in these communities be periodically reevaluated in light of changing conditions. One such periodic evaluation was completed in 1990 by Strand Associates, Inc., who concluded that the Friess Lake community should be included in any future sewer service area planning within the Town of Richfield.[6] Based upon the findings of that report, it is recommended that further consideration be given to the potential for serving all, or portions of, the urban development around Friess Lake with a public sanitary sewer system.

The evaluation would consider two subalternatives, as well as continue use of onsite sewage disposal systems. Under the first public sewer system alternative, consideration would be given to installation of a public sanitary sewer system to serve all, or portions of, the urban development surrounding Friess Lake. That system would be connected to one of the nearest existing public sanitary sewerage systems to the Friess Lake area—the City of Hartford and Village of Slinger systems, each located about five miles to the north, or the Village of Sussex system located about six miles to the southeast. Given the distance to these systems, such a connection would not likely be economically feasible considering only the Friess Lake area. Such a connection may be feasible if carried out as part of a broader sewer service area plan which would also consider service and other selected areas in the Town of Richfield, such as the Bark Lake area where onsite sewage disposal system problems have been documented.

Another subalternative to be considered for the Friess Lake area is the construction of a public sanitary sewer collection system to serve portions of the urban development surrounding the Lake with conveyance to centralized soil absorption systems at remote locations. Such systems could be located in areas with suitable space and soil conditions. This option would not require consideration of a townwide evaluation.

Under either option providing for a public sanitary sewerage system, it would be necessary to create a sanitary or utility district or lake protection and rehabilitation district with sanitary district powers to install, operate, and maintain the sewerage system.

ECOLOGICALLY VALUABLE LANDS AND AQUATIC PLANTS

As set forth in Chapter VII, the protection and preservation of the environmental corridors in the vicinity of, and around, Friess Lake are important contributors to the protection of the water quality of Friess Lake. Two management measures related to ecologically valuable areas and aquatic plants are included in the recommended management plan: aquatic plant management and shoreline protection measures.

Aquatic Plant Management and Monitoring

It is recommended that the Friess Lake Action Group work with the Wisconsin Department of Natural Resources to continue to conduct aquatic macrophyte surveys at three- to five-year intervals, depending upon the observed degree of change in the aquatic plant communities. At present such surveys are conducted regularly as part of the Department of Natural Resources Long-Term Trend Monitoring Program. In addition, supplemental citizen-based observations of plant communities, and, particularly, of the changes in distribution of nuisance plant species such as Eurasian water milfoil, should be undertaken and compiled by the Friess Lake Action Group. Further, records of the aquatic plant control program should be maintained by the Friess Lake Action Group and should include descriptions of: 1) the major areas and species composition of nuisance plant growth, and 2) areas and species chemical treated. This information, in conjunction with the formal aquatic macrophyte surveys, will allow evaluation of the effectiveness of the aquatic plant control program and allow adjustments to be made to maximize its benefit.

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[6] *Strand Associates, Inc.,* Preliminary Needs Determination on On-Site Wastewater Disposal Systems for Town of Richfield, Wisconsin, *April 1990.*

Modifications of the existing aquatic plant management activities are recommended to enhance the use of the Lake while maintaining the quality and diversity of the biological communities. The following guidelines are recommended:

1. Manual harvesting is recommended as the primary management method around individual piers and docks where small-scale removal of aquatic plants is desired.

2. Chemical herbicide use should be strictly limited to the absolute minimum required to control nuisance growth of nonnative nuisance species, such as Eurasian water milfoil and curly-leaf pondweed. Only herbicides that selectively control nuisance species, such as 2,4-D, should be used.

3. Chemical herbicide use should be restricted to those areas of nonnative nuisance aquatic macrophyte growth in shallow water within 50 feet of docks and other areas where manual harvesting is not feasible.

4. Use of algicides, such as Cutrine Plus, should be limited to areas of significant filamentous or planktonic algae problems in the Lake. Valuable macroscopic algae, such as *Chara* and *Nitella*, can be killed by this chemical.

The recommended plan partitions Friess Lake into zones for aquatic plant management, as shown on Map 23, with control measures in each zone designed to optimize desired recreational opportunities and to protect the aquatic resources.

Shoreline Protection Measures

Most of the Friess Lake shoreline is in stable condition with few areas of erosion. Continued maintenance of existing revetments and bulkheads by the respective property owners is recommended. It is recommended that new or replacement shoreline protection structures be limited to those measures such as vegetative buffer strips and rock revetments which provide a visually natural or semi-natural aspect. Placement of structures within Friess Lake is subject to permitting by the Wisconsin Department of Natural Resources.

WATER QUALITY

As set forth in Chapter VII, the water quality of Friess Lake is determined in large part by the quality of the inflowing water entering the Lake from the upstream tributary drainage areas of the Oconomowoc and Coney rivers. For this reason, the principal means of managing water quality within Friess Lake are primarily the control of both urban and rural nonpoint source pollutant loads, as well as management of onsite sewage disposal systems, as set forth above.

The only recommended in-lake management measure related to water quality is monitoring. Continued enrollment of one or more Friess Lake residents as Wisconsin Department of Natural Resources Self-help Monitoring Program volunteers is recommended. Such enrollment can be accomplished through the Southeast District Office of the Department at no cost to the Lake Management District. A firm commitment of time is required of the volunteers. In addition, participation in the trophic state index (TSI) self-help monitoring program, measuring nutrients, chlorophyll-a, and temperature, is recommended. Such monitoring should be conducted in at least one location and at least five times per year. Such data would supplement the ongoing seasonally based monitoring being carried out by the Wisconsin Department of Natural Resources under the Long-Term Trend Monitoring Program.

LAKE WATER LEVEL

As set forth in Chapter VII, water level management may be used to change or create specific types of habitat and, thereby, manage species composition in lakes, or to improve the recreational use opportunities of lakes. While various management measures were considered, as discussed in Chapter VII, including drawdown, water level stabilization, and dredging, it is recommended that lake levels within the Friess Lake basin be allowed to fluctuate naturally. Artificial lake level controls do not appear to be warranted at the present time.

FISHERY MANAGEMENT

As set forth in Chapter VII, fishing is considered to be an important recreational use of Friess Lake. Integral to the maintenance of a balanced fishery in Friess Lake is the protection and preservation of fish breeding habitat, and a knowledge of the fish species composition present within the Lake. Two management measures related to fishery management are included in the recommended management plan: habitat protection and fishery surveys.

Habitat Protection

Habitat protection measures recommended for Friess Lake are, in part, provided for under the recommended ecologically valuable areas and aquatic plant management measure programs described previously. The measures set forth within these programs are designed to provide for the protection of fish habitat by promoting awareness of fish breeding areas, avoiding disturbance of these areas during spring and autumn, reducing the use of aquatic plant herbicides in these areas, and maintaining stands of native aquatic plants by controlling the spread of nonnative species such as Eurasian water milfoil.

In particular, it is recommended that environmentally sensitive lands including wetlands along the lakeshore and influent River be preserved and protected. This recommendation extends to the maintenance of the floodplain wetlands in the vicinity of STH 167 at the Lake inlet and the streambank segments between STH 167 and CTH E. Interventions, such as aquatic plant harvesting or chemical treatment, in these areas, and at the lake outlet to Little Friess Lake, should be confined to the maintenance of navigational access channels.

Monitoring of Fish Species Composition

In addition to the recommendations set forth with respect to habitat protection, two further, specific actions are recommended with respect to fisheries management; namely, the conduct of a fishery survey, and an assessment of angling pressures.

It is recommended that a fishery survey be conducted by the Wisconsin Department of Natural Resources, which would have several objectives:

1. Identification of any changes in fish species composition—including an assessment of carp population—that may have taken place in the Lake since the previous survey, in 1976-1977;

2. Attribution of any changes in fish populations, species composition, and condition factors to such known interventions as stocking programs, water pollution control activities, and aquatic plant management programs;

3. Determination of refined and updated information on fish breeding areas, breeding success, and survival rates.

The second action recommended relative to fisheries monitoring is the assessment of angling pressures on the Lake. It is recommended that this program provide data to determine the intensity of public use of the Friess Lake fishery through creel surveys, citizen reporting activities, and evaluation of the fish survey data by the Wisconsin Department of Natural Resources. Given the fishing pressures on the Lake, it would be useful to conduct a one-time analysis of fish tissues for metal and toxic contamination. This task could be included in the fish survey, when it would be possible to obtain representative samples from among the fish species collected during the survey. The Friess Lake Action Group could participate in this assessment by assisting the Wisconsin Department of Natural Resources in the collection of creel census data and by supporting citizen reporting activities.[7]

RECREATIONAL USE AND BOATING ACCESS

Two management measures related to recreational use of Friess Lake are included in the recommended plan: public access, and recreational use survey and zoning.

Public Recreational Boating Access

As set forth in Chapter VII, Friess Lake currently lacks adequate public access as set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. This limits the ability of the Friess Lake Action Group and local governmental units to acquire grant funding and other services from the State of Wisconsin that may otherwise be available to assist in the implementation of the recommendations set forth in this plan.

To meet the access requirements set forth in the *Wisconsin Administrative Code*, and establish eligibility for enhancement services, a private provider agreement could be concluded with one or both of the existing privately owned access site owners as provided for in Section 1.91(7) of the *Wisconsin Administrative Code*. Alternatively, the Friess Lake Action Group has identified a potential public boating access site on Little Friess Lake. This site is of sufficient size and proximity to the Lake that a public recreational boating access site consistent with the minimum access standard of six car-trailer units, inclusive of one handicapped-accessible unit, set forth in Chapter NR 1 of the *Wisconsin Admin-*

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[7]*Pursuant to Chapter NR 1 of the* Wisconsin Administrative Code, *fish stocking and related activities are considered enhancement services provided by the Wisconsin Department of Natural Resources and are predicated upon there being adequate public recreational boating access as set forth within Chapter NR 1. Friess Lake does not currently have adequate public recreational boating access, although provision of such access is proposed in this plan.*

istrative Code, could be developed. Therefore, it is recommended that the Friess Lake Action Group, in cooperation with the Town of Richfield and the Wisconsin Department of Natural Resources, develop an access site to the standards set forth in the *Wisconsin Administrative Code*. However, due to the size of the Lake and its current usage, it is recommended that the access be designed primarily to encourage slow-speed watercraft.

Recreational Use Survey and Zoning

It is recommended that the Town of Richfield implement the provision of the current Town Lake Use Ordinance and operate the water safety patrol on Friess Lake. Notwithstanding the present lack of adequate public recreational boating access as described above, the safety patrol, operated on Friess Lake by the Town of Richfield, may be eligible for partial State cost-share funds under Section 30.77 of the *Wisconsin Statutes*.

Recreational use conflicts have been reported to occur on Friess Lake on a limited basis. The level of community concern in this regard may intensify as public boating access to the Lake is developed. Therefore, it is recommended that the Friess Lake Action Group quantitatively identify the nature and degree of concern expressed by the Friess Lake community through the conduct of a recreational use and user survey of Friess Lake. Data to be gathered would include numbers and types of boats, areas of the Lake used, times of use, and numbers of people participating in various types of water-based recreation. Additional data on the perceptions of Friess Lake residents could be gathered through a questionnaire survey of the Friess Lake Action Group's membership and other users as appropriate. The objective of these surveys would be to identify the uses, intensity of uses, and locations of uses to which Friess Lake is put, and identify real or perceived recreational use conflicts occurring or likely to occur on the Lake. Ultimately, such data could contribute to the development of revisions to the lake recreational use zoning plan and related ordinances necessary to support such a plan by the Town of Richfield should recreational use conflicts occur, be deemed necessary.

AUXILIARY PLAN RECOMMENDATIONS

It is recommended that the Friess Lake Action Group assume the lead in the development of a public informational and educational program dealing with various lake management-related topics including, onsite sewage disposal system management, water quality management, land management, groundwater protection, aquatic plant management, fishery management, and recreational use. A Friess Lake Action Group newsletter could provide an medium for the conduct of such a program.

Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the recreational use and shoreland zoning regulations, are available from the Wisconsin Department of Natural Resources and the University of Wisconsin-Extension. These cover topics such as beneficial lawn care practices and household chemical use. Such brochures should be provided to homeowners through local media, direct distribution or targeted library and civic center displays. Such distribution can also be integrated into ongoing, larger-scale activities, such as lakeside litter collections, which can reinforce anti-littering campaigns, recycling drives, and similar environmental protection activities.

PLAN IMPLEMENTATION AND COSTS

The actions recommended in this plan largely represent an extension of ongoing actions being carried out by the Friess Lake Action Group, the Town of Richfield, Washington County, and the Wisconsin Department of Natural Resources. The recommended plan introduces few new elements, although some of the plan recommendations represent expansions of current programs. This is particularly true in the case of the fisheries and aquatic plant management programs, where the field surveys recommended in this plan will permit more efficient management of these resources.

Generally, fisheries and aquatic plant management practices and public awareness campaigns currently implemented by the Friess Lake Action Group and Town of Richfield are recommended to be continued with the refinements proposed herein. Some aspects of these programs lend themselves to citizen involvement through volunteer-based creel surveys, participation in the Wisconsin Department of Natural Resources Self-Help Monitoring Program, and identification with environmentally sound owner land management attitudes. It is recommended that the Friess Lake Action Group assume the lead in the promotion of these citizen actions, with a view toward building community commitment and involvement. Assistance is generally available from agencies such as the Wisconsin Department of Natural Resources and the University of Wisconsin-Extension.

The suggested lead agency or agencies for initiating program-related activities, by plan element, and the estimated costs of these elements, linked to possible funding sources where such are available, are summarized in

Table 27. It should be noted that the governmental and nongovernmental agencies identified in Table 27 could be supplemented be the creation of a Chapter 33, *Wisconsin Statutes*, public inland lake protection and rehabilitation district as recommended in the 1983 lake management plan. Such a district would be better positioned to implement the plan recommendations as this agency would be able to direct focused efforts toward lake management, unlike the Town and County, which have many other priority issues demanding their attention, and the Friess Lake Action Group, which has limited financial resources upon which to draw. Should such a district be created by the electors of the Friess Lake community, it is recommended that the Friess Lake Protection and Rehabilitation District assume primary responsibility for implementation of this plan.

APPENDIX

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Appendix A

NONPOINT SOURCE POLLUTION CONTROL MEASURES

Nonpoint, or diffuse, sources of water pollution include urban sources such as runoff from residential, commercial, industrial, transportation, and recreational land uses; construction activities; and onsite sewage disposal systems and rural sources such as runoff from cropland, pasture, and woodland, atmospheric contributions, and livestock wastes. These sources of pollutants discharge to surface waters by direct overland drainage, by drainage through natural channels, by drainage through engineered stormwater drainage systems, and by deep percolation into the ground and subsequent return flow to the surface waters.

A summary of the methods and estimated effectiveness of nonpoint source water pollution control measures is set forth in Table A-1. These measures have been grouped for planning purposes into two categories: basic practices and additional. Application of the basic practices will have a variable effectiveness in terms of control level of pollution control depending upon the subwatershed area characteristics and the pollutant considered. The additional category of nonpoint source control measures has been subdivided into four subcategories based upon the relative effectiveness and costs of the measures. The first subcategory of practices can be expected to generally result in about a 25 percent reduction in pollutant runoff. The second and third subcategory of practices, when applied in combination with the minimum and additional practices, can be expected to generally result in up to a 75 percent reduction in pollutant runoff, respectively. The fourth subcategory would consist of all of the preceding practices, plus those additional practices that would be required to achieve a reduction in ultimate runoff of more than 75 percent.

Table A-1 sets forth the diffuse source control measures applicable to general land uses and diffuse source activities, along with the estimated maximum level of pollution reduction which may be expected upon implementation of the applicable measures. The table also includes information pertaining to the costs of developing the alternatives set forth in this chapter.[1] These various individual nonpoint source control practices are summarized by group in Table A-2.

Of the sets of practices recommended for various levels of diffuse source pollution control presented in Table A-2, not all practices are needed, applicable, or cost-effective for all watersheds, due to variations in pollutant loadings and land use and natural conditions among the watersheds. Therefore, it is recommended that the practices indicated as needed for nonpoint source pollutant control be refined by local level nonpoint source control practices planning, which would be analogous to sewerage facilities planning for point source pollution abatement. A locally prepared plan for nonpoint abatement measures should be better able to blend knowledge of current problems and practices with a quickly evolving technology to achieve a suitable, site specific approach to pollution abatement.

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[1] *Costs are presented in more detail in the following SEWRPC Technical Reports: No. 18,* State of the Art of Water Pollution Control in Southeastern Wisconsin, *Volume Three,* Urban Storm Water Runoff, *July 1977, and Volume Four,* Rural Storm Water Runoff, *December 1976; and No. 31,* Costs of Urban Nonpoint Source Water Pollution Control Measures, *June 1991.*

Table A-1

GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF DIFFUSE SOURCE WATER POLLUTION CONTROL MEASURES

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban	Litter and pet waste control ordinance	Prevent the accumulation of litter and pet waste on streets and residential, commercial, industrial, and recreational areas	2-5	Ordinance administration and enforcement costs are expected to be funded by violation penalties and related revenues
	Improved timing and efficiency of street sweeping, leaf collection and disposal, and catch basin cleaning	Improve the scheduling of these public works activities, modify work habits of personnel, and select equipment to maximize the effectiveness of these existing pollution control measures	2-5	No significant increase in current expenditures is expected
	Management of onsite sewage treatment systems	Regulate septic system installation, monitoring, location, and performance; replace failing systems with new septic systems or alternative treatment facilities; develop alternatives to septic systems; eliminate direct connections to drain tiles or ditches; dispose of septage at sewage treatment facility	10-30	Replace one-half of estimated existing failing septic systems with properly located and installed systems and replace one-half with alternative systems, such as mound systems or holding tanks; all existing and proposed onsite sewage treatment systems are assumed to be properly maintained; assume system life of 25 years. The estimated cost of a septic tank system is \$5,000-\$6,000 and the cost of an alternative system is \$10,000. The annual maintenance cost of a disposal system is \$250. An in-ground pressure system is estimated to cost \$6,000-\$10,000 with an annual operation and maintenance cost of \$250. A holding tank would cost \$5,500-\$6,500 with an annual operation and maintenance cost of \$1,800
	Increased street sweeping	On the average, sweep all streets in urban areas an equivalent of once or twice a week with vacuum street sweepers; require parking restrictions to permit access to curb areas; sweep all streets at least eight months per year; sweep commercial and industrial areas with greater frequency than residential areas	30-50	Estimate curb miles based on land use, estimated street acreage, and Commission transportation planning standards; assume one street sweeper can sweep 2,000 curb miles per year; assume sweeper life of 10 years; assume residential areas swept once weekly, commercial and industrial areas swept twice weekly. The cost of a vacuum street sweeper is approximately \$120,000. The cost of the operation and maintenance of a sweeper is about \$25 per curb/mile swept
	Increased leaf and clippings collection and disposal	Increase the frequency and efficiency of leaf collection procedures in fall; use vacuum cleaners to collect leaves; implement ordinances for leaves, clippings, and other organic debris to be mulched, composted, or bagged for pickup	2-5	Assume one equivalent mature tree per residence plus five trees per acre in recreational areas; 75 pounds of leaves per tree; 20 percent of leaves in urban areas not currently disposed of properly. The cost of the collection of leaves in a vacuum sweeper and disposal is estimated at \$180-\$200 per ton of leaves
	Increased catch basin cleaning	Increase frequency and efficiency of catch basin cleaning; clean at least twice per year using vacuum cleaners; catch basin installation in new urban development not recommended as a cost-effective practice for water quality improvement	2-5	Determine curb miles for street sweeping; vary percent of urban area served by catch basins by watershed from Commission inventory data; assume density of 10 catch basins per curb mile; clean each basin twice annually by vacuum cleaner. The cost of cleaning a catch basin is approximately \$10
	Reduced use of deicing salt	Reduce use of deicing salt on streets; salt only intersections and problem areas; prevent excessive use of sand and other abrasives	Negligible for pollutants addressed in this plan but helpful for reducing chlorides and associated damage to vegetation	Increased costs, such as for slower transportation movement, are expected to be offset by benefits such as reduced automobile corrosion and damage to vegetation

Table A-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban (continued)	Improved street maintenance and refuse collection and disposal	Increase street maintenance and repairs; increase provision of trash receptacles in public areas; improve trash collection schedule; increase cleanup of parks and commercial centers	2-5	Increase current expenditures by approximately 15 percent
	Parking lot stormwater temporary storage and treatment measures	Construct gravel-filled trenches, sediment basins, or similar measures to store temporarily the runoff from parking lots, rooftops, and other large impervious areas; if treatment is necessary, use a physical-chemical treatment measure such as screens, dissolved air flotation, or a swirl concentrator	5-10	Design gravel-filled trenches for 24-hour, five year recurrence interval storm; apply to off-street parking acreages. For treatment—assume four-hour detention time. The capital cost of stormwater detention and treatment facilities is estimated at $40,000-$80,000 per acre of parking lot area, with an annual operation and maintenance cost of about $200 per acre
	Onsite storage—residential	Remove connections to sewer systems; construction onsite stormwater storage measures for subdivisions	5-10	Remove roof drains and other connections from sewer system wherever needed; use lawn aeration if applicable; apply dutch drain storage facilities to 15 percent of residences. The capital cost would approximate $500 per house, with an annual maintenance cost of about $25
	Stormwater infiltration—urban	Construct gravel-filled trenches for areas of less than 10 acres or basins to collect and store temporarily stormwater runoff to reduce volume, provide groundwater recharge and augment low stream flows	45-90	Design gravel-filled trenches or basins to store the first 0.5 inch of runoff; provide at least a 25-foot grass buffer strip to reduce sediment loadings. The capital cost of a stormwater infiltration is estimated at $12,000 for a six-foot deep, 10-foot wide trench, and at $70,000 for a one-acre basin, with an annual maintenance cost of about $10-$350 for the trench, and of about $2,500 for the basin
	Stormwater storage—urban	Store stormwater runoff from urban land in surface storage basins or, where necessary, subsurface storage basins	10-35	Design all storage facilities for a 1.5 inch of runoff event, which corresponds approximately to a five-year recurrence interval event with a storm event being defined as a period of precipitation with a minimum antecedent and subsequent dry period of from 12 to 24 hours; apply subsurface storage tanks to intensively developed existing urban areas where suitable open land for surface storage is unavailable; design surface storage basins for proposed new urban land, existing urban land not storm sewered, and existing urban land where adequate open space is available at the storm sewer discharge site. The capital cost for stormwater storage would range from $35,000 to $110,000 per acre of basin, with an annual operation and maintenance cost of about $40-$60 per acre
	Stormwater treatment	Provide physical-chemical treatment which includes screens, microstrainers, dissolved air flotation, swirl concentrator, or high-rate filtration, and/or disinfection, which may include chlorination, high-rate disinfection, or ozonation to stormwater following storage	10-50	To be applied only in combination with stormwater storage facilities above; general cost estimates for microstrainer treatment and ozonation were used; same costs were applied to existing urban land and proposed new urban development. Stormwater treatment has an estimated capital cost of from $900-$7,000 per acre of tributary drainage area, with an average annual operation and maintenance cost of about $35-$100 per acre

Table A-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Rural	Conservation practices	Includes such practices as strip cropping, contour plowing, crop rotation, pasture management, critical area protection, grading and terracing, grassed waterways, diversions, wood for management, fertilization and pesticide management, and chisel tillage	Up to 50	Costs for Natural Resources Conservation Service (NRCS)-recommended practices are applied to agricultural and related rural land; the distribution and extent of the various practices were determined from an examination of 56 existing farm plan designs within the Region. The capital cost of conservation practices ranges from $3,000-$5,000 per acre of rural land, with an average annual operation and maintenance cost of from $5-$10 per rural acre
	Animal waste control system	Construct stream bank fencing and crossovers to prevent access of all livestock to waterways; construct a runoff control system or a manure storage facility, as needed, for major livestock operations; prevent improper applications of manure on frozen ground, near surface drainageways, and on steep slopes; incorporate manure into soil	50-75	Cost estimated per animal unit; animal waste storage (liquid and slurry tank for costing purposes) facilities are recommended for all major animal operations within 500 feet of surface water and located in areas identified as having relatively high potential for severe pollution problems. Runoff control systems recommended for all other major animal operations. It is recognized that dry manure stacking facilities are significantly less expensive than liquid and slurry storage tanks and may be adequate waste storage systems in many instances. The estimated capital cost and average operation and maintenance cost of a runoff control system is $100 per animal unit and $25 per animal unit, respectively. The capital cost of a liquid and slurry storage facility is about $1,000 per animal unit, with an annual operation and maintenance cost of about $75 per unit. An animal unit is the weight equivalent of a 1,000-pound cow
	Base-of-slope detention storage	Store runoff from agricultural land to allow solids to settle out and reduce peak runoff rates. Berms could be constructed parallel to streams	50-75	Construct a low earthen berm at the base of agricultural fields, along the edge of a floodplain, wetland, or other sensitive area; design for 24-hour, 10-year recurrence interval storm; berm height about four feet. Apply where needed in addition to basic conservation practices; repair berm every 10 years and remove sediment and spread on land. The estimated capital cost of base-of-slope detention storage would be about $500 per tributary acre, with an annual operation and maintenance cost of $25 per acre
	Bench terraces	Construct bench terraces, thereby reducing the need for many other conservation practices on sloping agricultural land	75-90	Apply to all appropriate agricultural lands for a maximum level of pollution control. Utilization of this practice would exclude installation of many basic conservation practices and base-of-slope detention storage. The capital cost of bench terraces is estimated at $1,500 per acre, with an annual operation and maintenance cost of $100 per acre

Table A-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban and Rural	Public education programs	Conduct regional- and county-level public education programs to inform the public and provide technical information on the need for proper land management practices on private land, the recommendations of management programs, and the effects of implemented measures; develop local awareness programs for citizens and public works officials; develop local contact and education efforts	Intermediate	For first 10 years includes cost of one person, materials, and support for each 25,000 population. Thereafter, the same cost can be applied to for every 50,000 population. The cost of one person, materials, and support is estimated at $55,000 per year
	Construction erosion control practices	Construct temporary sediment basins; install straw bale dikes; use fiber mats, mulching and seeding; install slope drains to stabilize steep slopes; construct temporary diversion swales or berms upslope from the project	20-40	Assume acreage under construction is the average annual incremental increase in urban acreage; apply costs for a typical erosion control program for a construction site. The estimated capital cost and operation and maintenance cost for construction erosion control is $250-$5,500 and $250-$1,500 per acre under construction, respectively
	Materials storage and runoff control facilities	Enclose industrial storage sites with diversions; divert runoff to acceptable outlet or storage facility; enclose salt piles and other large storage sites in crib and dome structures	5-10	Assume 40 percent of industrial areas are used for storage and to be enclosed by diversions; assume existing salt storage piles enclosed by cribs and dome structures. The estimated capital cost of industrial runoff control is $2,500 per acre of industrial land. Material storage control costs are estimated at $75 per ton of material
	Stream protection measures	Provide vegetative buffer zones along streams to filter direct pollutant runoff to the streams; construct stream bank protection measures, such as rock riprap, brush mats, tree revetment, jacks, and jetted willow poles where needed	5-10	Apply a 50-foot-wide vegetative buffer zone on each side of 15 percent of the stream length; apply stream bank protection measures to 5 percent of the stream length. Vegetative buffer zones are estimated to cost $21,200 per mile of stream, and streambank protection measures cost about $37,000 per stream mile
	Pesticide and fertilizer application restrictions	Match application rate to need; eliminate excessive applications and applications near or into surface water drainageways	0-3	Cost included in public education program
	Critical area protection	Emphasize control of areas bordering lakes and streams; correct obvious erosion and other pollution source problems	Intermediate	Intermediate

[a]*Not all control measures are required for each subwatershed. The characteristics of the watershed, the estimated required level of pollution reduction needed to meet the applicable water quality standards, and other factors will influence the selection and estimation of costs of specific practices for any one subwatershed. Although the control measures costed represent the recommended practices developed at the regional level on the basis of the best available information, the local implementation process should provide more detailed data and identify more efficient and effective sets of practices to apply to local conditions.*

[b]*The approximate effectiveness refers to the estimated amount of pollution produced by the contributing category (urban or rural) that could be expected to be reduced by the implementation of the practice. The effectiveness rates would vary greatly depending on the characteristics of the watershed and individual diffuse sources. It should be further noted that practices can have only a "sequential" effect, since the percent pollution reduction of a second practice can only be applied against the residual pollutant load which is not controlled by the first practice. For example, two practices of 50 percent effectiveness would achieve a theoretical total effectiveness of only 75 percent control of the initial load. Further, the general levels of effectiveness reported in the table are not necessarily the same for all pollutants associated with each source. Some pollutants are transported by dissolving in water and others by attaching to solids in the water; the methods summarized here reflect typical pollutant removal levels.*

[c]*For highly urbanized areas which require retrofitting of facilities into developed areas, the costs can range from $400,000 to $1,000,000 per acre of storage.*

Source: SEWRPC.

Table A-2

ALTERNATIVE GROUPS OF DIFFUSE SOURCE WATER POLLUTION CONTROL MEASURES PROPOSED FOR STREAMS AND LAKE WATER QUALITY MANAGEMENT

Pollution Control Category	Level of Pollution[b] Control	Practices to Control Diffuse Source Pollution from Urban Areas[c]	Practices to Control Diffuse Source Pollution from Rural Areas[b]
Basic Practices	Variable	Construction erosion control; onsite sewage disposal system management; streambank erosion control	Streambank erosion control
	25 percent	Public education programs; litter and pet waste control; restricted use of fertilizers and pesticides; construction erosion control; critical areas protection; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; material storage facilities and runoff control	Public education programs; fertilizer and pesticide management; critical area protection; crop residue management; chisel tillage; pasture management; contour plowing; livestock waste control
Additional Diffuse Source Control Practices[a]	50 percent	Above, plus: Increased street sweeping; improved street maintenance and refuse collection and disposal; increased catch basin cleaning; stream protection; increased leaf and vegetation debris collection and disposal; stormwater storage; stormwater infiltration	Above, plus: Crop rotation; contour strip-cropping; grass waterways; diversions; wind erosion controls; terraces; stream protection
	75 percent	Above, plus: An additional increase in street sweeping, stormwater storage and infiltration; additional parking lot stormwater runoff storage and treatment	Above, plus: Base-of-slope detention storage
	More than 75 percent	Above, plus: Urban stormwater treatment with physical-chemical and/or disinfection treatment measures	Bench terraces[c]

[a]In addition to diffuse source control measures, lake rehabilitation techniques may be required to satisfy lake water quality standards.

[b]Groups of practices are presented here for general analysis purposes only. Not all practices are applicable to, or recommended for, all lake and stream tributary watersheds. For costing purposes, construction erosion control practices, public education programs, and material storage facilities and runoff controls are considered urban control measures and stream protection is considered a rural control measure.

[c]The provision of bench terraces would exclude most basic conversation practices and base-of-slope detention storage facilities.

Source: SEWRPC.