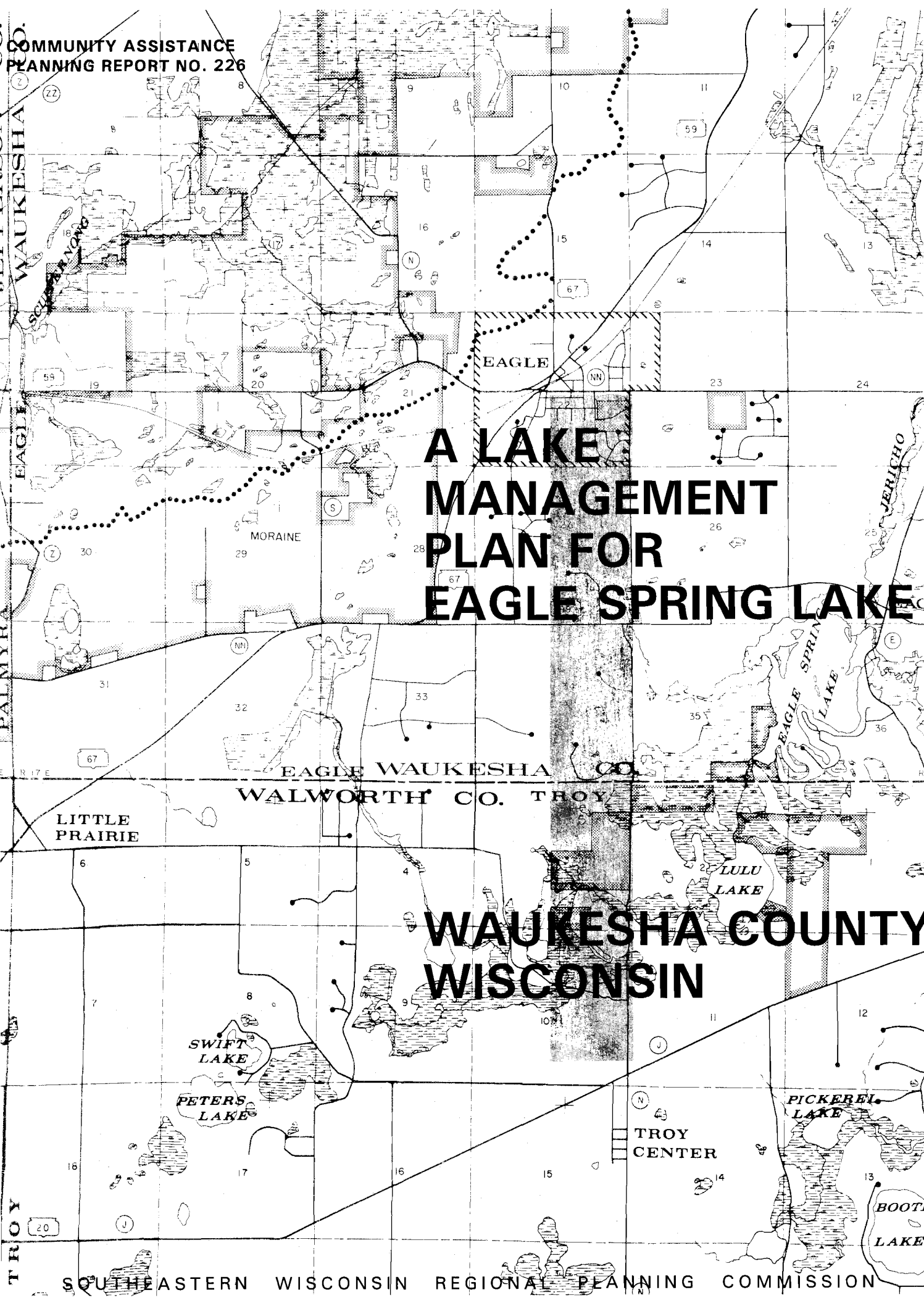
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 226



A LAKE MANAGEMENT PLAN FOR EAGLE SPRING LAKE WAUKESHA COUNTY WISCONSIN

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COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 226

A LAKE MANAGEMENT PLAN FOR EAGLE SPRING LAKE

WAUKESHA COUNTY, WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
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October 28, 1997

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

Over the past several years, the Southeastern Wisconsin Regional Planning Commission and others, at the request of the Eagle Spring Lake Management District, have been conducting lake management-related data collection and analysis efforts. These efforts have now been integrated into a lake management plan for Eagle Spring 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 Eagle Spring Lake Management District, the U.S. Geological Survey, the Wisconsin Department of Natural Resources, the Waukesha County Department of Parks and Land Use, and the Southeastern Wisconsin Regional Planning Commission.

This report documents the recommended lake management plan. The report describes the physical and biological characteristics of Eagle Spring 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 development decisions concerning the wise use and management of Eagle Spring Lake as an aesthetic and recreational asset of immeasurable value. Accordingly, adoption of the plan presented herein by all concerned water use 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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FOREWORD

"The face of the water, in time, became a wonderful book - a book that was a dead language to the uneducated passenger, but which told its mind to me without reserve, delivering its most cherished secrets as clearly as if it uttered them with a voice. And it was not a book to be read once and thrown aside, for it had a new story to tell every day." Mark Twain, Life on the Mississippi.

Every lake resident develops his or her own special relationship with the Lake. Each of us has a portion of our individual identity that is tied to this special relationship. Many families have extensive histories associated with Eagle Spring Lake and the Lake community, while others of us are relative newcomers. Regardless of the length of our relationship with the Lake, it is vitally important that each of us, as riparians, learn to read the water, and recognize our responsibilities for preserving the health and beauty of this Lake and its associated natural resources.

A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin, should serve as a springboard toward educating Lake residents concerning these responsibilities. The plan outlines the Lake's history, describes the Lake's physical and biological characteristics and provides an overview of current accepted practices for lake management. The plan provides guidance for present, and future, Lake residents in the management of their individual properties and for their role as participants and leaders in lake management activities.

April 3, 1997
James Wilhelm, Chairman
Eagle Spring Lake Management District

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Chapter I

INTRODUCTION

Eagle Spring Lake, is an impounded 311-acre drainage lake, located on the Mukwonago River within U.S. Public Land Survey Sections 25, 26, 35 and 36, Township 5 North, Range 17 East, Town of Eagle, Waukesha County. The Lake offers a variety of water-based recreational opportunities and is the focus of the lake-oriented community surrounding the Lake. However, during recent years, the lake has experienced various management problems, including excessive plant growth and recreational user conflicts and limitations. In addition, concerns have been raised regarding variable water quality conditions and the need to protect environmentally sensitive areas and to prevent the invasion of exotic plant species.

Planning efforts relating to Eagle Spring Lake have included the preparation of a regional water quality management plan.[1] That plan identified surface water quality problems within the Region and the Mukwonago River watershed; identified the major sources of pollution; and provided recommendations for abating those sources to achieve specified water use objectives and attendant water quality standards. In 1985, the then existing Eagle Springs Lake Sanitary District, prepared a sewerage system facility plan[2] to evaluate alternative means of providing sanitary sewer service to the urban development surrounding Eagle Springs Lake. That plan evaluated the condition of the onsite sewage disposal systems serving the area and described and evaluated alternatives for sanitary sewage disposal including continued use of onsite systems and several options providing for a public sanitary sewer system to serve the area. The plan recommended the provision of a public sanitary sewer system with connection to the Village of Mukwonago sewerage system for sewage treatment purposes. The regional water quality management plan was reviewed and amended[3] in 1985 to include the recommendations for the eventual provision of a public sanitary sewer system to serve the urban development surrounding the Eagle Spring Lake area with the area being connected to the Village of Mukwonago sewerage system for treatment purposes. The recommendations regarding the provision of a public sanitary sewer system have not been implemented as of 1997. A proposal to implement this recommendation was made to the Eagle Spring Lake Management District during 1996. Upon investigation and evaluation by the Lake District Commission. This proposal was subsequently withdrawn, and the Eagle Spring Lake Management District Commission is continuing to identify and evaluate alternatives for sewage disposal, including public sanitary sewerage, around Eagle Spring Lake.

Seeking to improve the usability of Eagle Spring Lake and to prevent deterioration of the natural assets and recreational potential of the Lake, the residents concerned, in 1990, converted the Eagle Spring Lake Sanitary District into a public lake rehabilitation and protection district—the Eagle Spring Lake Management District. Under the provisions of Section 33.235 of the Wisconsin Statutes the Lake Management District has sanitary powers, as well as the broader lake management powers associated with a lake rehabilitation and protection district.

Since formation, the Eagle Spring Lake Management District has undertaken a program to evaluate water quality conditions and identify specific management measures needed to improve the water quality and recreational use potential of Eagle Spring Lake. This program involved the conduct of

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

[2] *Strand Associates, Inc., Environmental Information Document and Cost Effectiveness Analysis, Eagle Spring Lake Sanitary District, October, 1985.*

[3] *SEWRPC, Amendment to The Regional Water Quality Management Plan, Eagle Spring Lake Sanitary District, December, 1985.*

a hydrologic and water quality monitoring program conducted by the U.S. Geological Survey from October 1990 through September 1996, to determine the existing water budget and water quality of the Lake and to quantify pollutant loadings to the Lake. In addition, a sediment survey[4] and watershed inventory were conducted by private consultants under contract to the Eagle Spring Lake Management District, using funds provided by the Sanitary District and by voluntary donations.

This lake management plan represents an ongoing commitment by the Eagle Spring Lake Management District to sound environmental planning. This Plan was prepared by the Regional Planning Commission in cooperation with the District and it incorporates the data and analyses developed in the aforementioned lake management related studies. In addition, this plan also incorporates pertinent data collected by the Wisconsin Department of Natural Resources as part of the process for designating the upstream lake—Lulu Lake—and downstream reach of the Mukwonago River—between Eagle Spring Lake and Lower Phantom Lake as Outstanding Resource Waters under the provisions of Chapter NR 102 of the Wisconsin Administrative Code. This plan also incorporates fishery data and recommendations provided by the Wisconsin Department of Natural Resources staff specifically for the Eagle Spring Lake Management Plan. As part of this planning program, an updated aquatic plant survey was conducted in both Eagle Spring Lake and Lulu Lake which is immediately upstream. This report presents feasible alternative in-lake measures for enhancing the water quality conditions and for providing opportunities for safe and enjoyable use of the Lake. More specifically, this report describes the physical, chemical, and biological characteristics of the Lake and pertinent related characteristics of the tributary watershed, as well as the feasibility of various watershed and in-lake management measures which may be applied to enhance the water quality conditions, biological communities, and recreational opportunities of the Lake.

The primary objectives which this plan is intended to achieve are: 1) to contribute to the overall conservation and wise use of the Eagle Spring Lake through the environmentally sound management of vegetation, fish, 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 Eagle Spring Lake; and 3) to effectively control severity of nuisance resulting from recurring excessive aquatic macrophyte growths in portions of Eagle Spring 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. Further, it is an objective of this plan to contribute to the control of point and nonpoint sources of water pollution within the drainage area tributary to Eagle Spring Lake, as recommended in the adopted regional water quality management plan to protect lake water quality in support of the aforementioned goals. The plan should serve as a practical guide over time for achieving these objectives in a technically sound manner.

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[4]*Swanson Environmental, Inc., Eagle Springs [sic] Lake Sediment Sampling and Analysis, May 1990.*

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 lake 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 the 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 Eagle Spring Lake, its watershed, and on the climate and hydrology of Eagle Spring Lake. Subsequent chapters deal with the land use conditions and chemical and biological environments of the Lake.

WATERBODY CHARACTERISTICS

Eagle Spring Lake is located in the Town of Eagle, southeast of the Village of Eagle and directly west of the Village of Mukwonago. The Lake is a flow-through lake with extensive shallow areas and a single deep basin. The lake level is controlled by two outlet control structures located on the northeastern shore of the Lake. These structures have been repaired and replaced over time, resulting in variations in lake levels and lake bathymetry reported over time.[1] The outlet structures currently have fixed discharge elevations which maintain a depth of about 12 feet in the deepest portion of the Lake. The original basin of Eagle Spring Lake was formed as the Michigan and Green Bay Lobes of the continental glacier retreated from Southeastern Wisconsin 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.

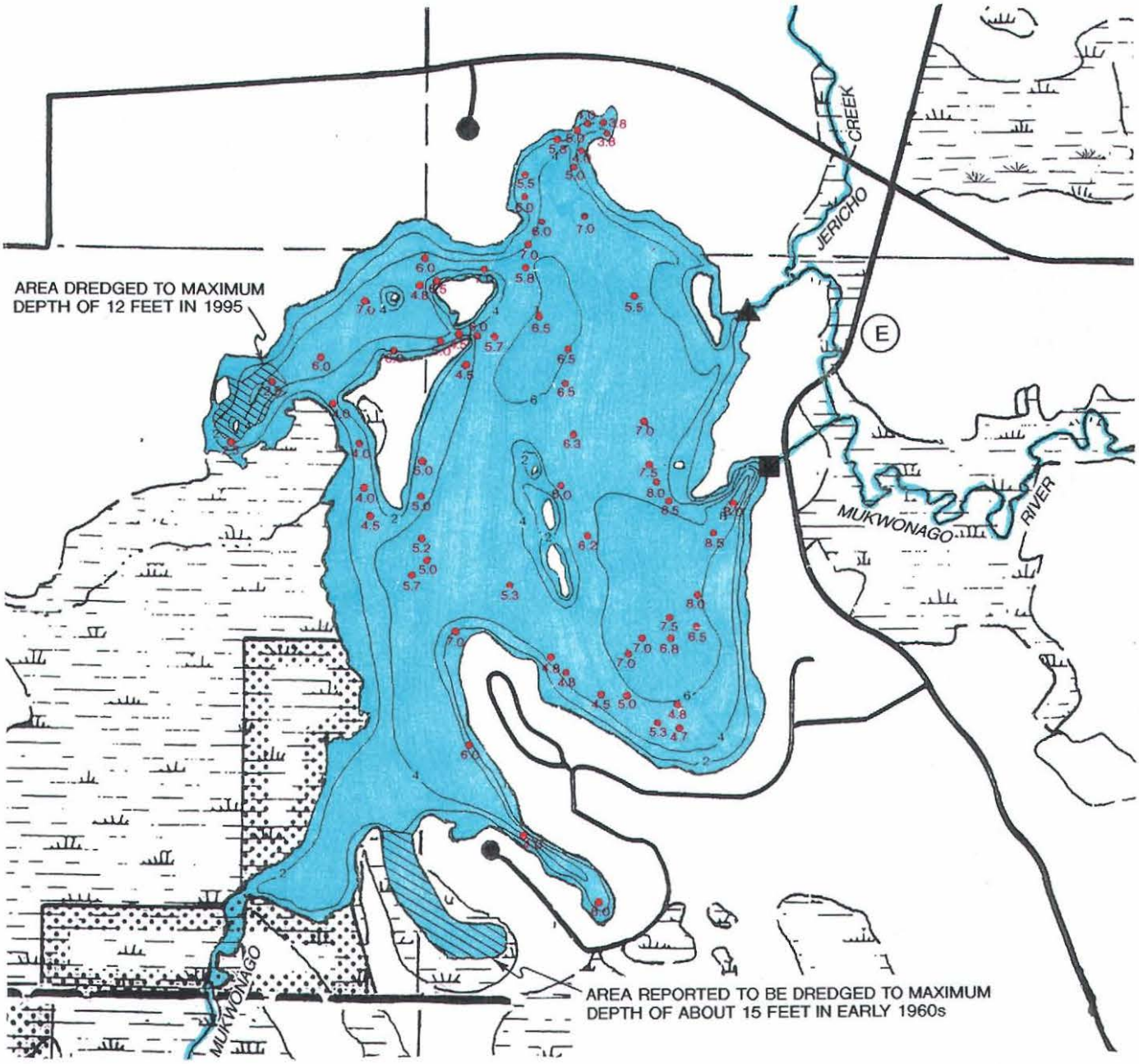
The Mukwonago River constitutes the major inflow to the Lake and enters from the south where it discharges from Lulu Lake, situated immediately upstream of Eagle Spring Lake and accessible from Eagle Spring Lake by a navigable channel. The bathymetry of Eagle Spring Lake, as of August 1969, is shown on Map 1. It is estimated that this bathymetric profile has subsequently been modified as a result of limited dredging of the northwestern lake basin in 1995-96. Nevertheless, based upon depth soundings obtained by the Eagle Spring Lake Management District in January 1994, it would appear that the bathymetric profile shown on Map 1 is substantially similar to that determined during the

---

[1] *The maximum depth of Eagle Spring Lake was reported as 12 feet in the Wisconsin Conservation Department Report, Surface Water Resources of Waukesha County, published in 1963; as eight feet in the Wisconsin Department of Natural Resources Lake Use Report No. FX-19, Eagle Spring Lake, Waukesha County, Wisconsin, published in 1969; and as eight feet in the Wisconsin Department of Natural Resources Publication No. PUBL-FM-800 95REV, Wisconsin Lakes, published in 1995. In 1995-1996, the Eagle Spring Lake Management District undertook a limited dredging of the northwestern embayment of the Lake which restored the maximum Lake depth to 12 feet. The current Lake surface elevation of between 819.9 feet and 820.2 feet NGVD-29 was established by the Wisconsin Public Service Commission in 1954 by Order 2WP-997-54. However, it should be noted that historically the elevation of the gauge readings was incorrectly considered to be about 2.65 feet lower in relation to National Geodetic Vertical Datum of 1929 (NGVD-29).*

Map 1

BATHYMETRIC MAP OF EAGLE SPRING LAKE



LEGEND

- 4 — WATER DEPTH CONTOUR IN FEET REPORTED BY WISCONSIN DEPARTMENT OF NATURAL RESOURCES: 1969
- 7.0 — WATER DEPTH IN FEET REPORTED BY EAGLE SPRING LAKE MANAGEMENT DISTRICT: 1994
- ▲ DAM SITE
- ■ SECONDARY FIXED OVERFLOW STRUCTURE

GRAPHIC SCALE
0 500 1000 FEET

Source: SEWRPC.

1994 survey.[2] The lake outflow is controlled by two outlet structures—a dam with manually operated control gate and a former mill race—both located at the east side of Eagle Spring Lake just west of CTH E. The confluence of Jericho Creek and the Mukwonago River is located about 350 feet downstream of the dam structure. The southern most lake outlet joins the Mukwonago River about 500 feet below the dam structure. The Mukwonago River continues easterly and passes through Lower Phantom Lake and ultimately discharges into the Fox River in Waukesha County, about 8.5 miles downstream from Eagle Spring Lake. The stretches of the Mukwonago River, both upstream and downstream of Eagle Spring Lake, including Lulu Lake and extending downstream to Lower Phantom Lake, have been designated as Outstanding Resource Waters in Chapter NR 102 of the Wisconsin Administrative Code.

Eagle Spring Lake has a surface area of 311 acres with a maximum depth of 12 feet and a mean depth of about four feet. About 20 percent of the lake area is less than three feet deep. The shoreline of Eagle Spring Lake, except for the western shoreline, is almost entirely developed for residential uses. The western shoreline remains in open space use, including a major wetland complex associated with the Mukwonago River inlet. Eagle Spring Lake has a shoreline length of 4.7 miles, and a shoreline development factor of 2.5, indicating that the lake shoreline is fairly irregular and about twice as long as a circular lake of the same area. The Lake has a volume of approximately 1,244 acre-feet. The hydrographical characteristics are summarized in Table 1 and the bathymetry of the Lake is shown in Map 1.

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[2]*The soundings obtained by the Eagle Spring Lake Management District in January 1994 were not "tied" to the gauged lake level at that date. However, the data were generally within about one foot of the depths shown on Map 1, which difference approximates the difference between the minimum official ordered operating elevation of 819.9 feet NGVD-29 and the estimated surface water elevation of about 820.7 feet NGVD-29 estimated to have been prevailing at the time of the survey.*

Erosion of shorelines results in the loss of land, damage to shoreland infrastructure, and interference with access and lake use. Such erosion is usually caused by wind-wave erosion, ice movement and motorized boat traffic. A survey of the Eagle Spring Lake shoreline, conducted during the summer of 1993 by Waukesha County Department of Parks and Land Use, Land Conservation Division staff, identified existing shoreline protection conditions around this lake, as shown on Map 2. Most were in a good state of repair. Most of the developed shoreland of Eagle Spring Lake had in 1994 some form of shoreline protection. Only the undeveloped western shore was unprotected except for extensive growths of aquatic vegetation.

Lake bottom sediment types were surveyed in 1990 by Swanson Environmental, Inc., and are shown on Map 3. Over 85 percent of the surveyed bottom was covered by muck. Portions of the near shore area—precisely along the developed shoreline—contained sand or gravel bottom. This is due, in part, to the placement of imported sand along the shoreline to develop a more useable beach area. The depths of the soft sediments ranged from less than one foot to more than 10 feet in the western embayment. Chemical analyses performed on sediment samples obtained by Swanson Environmental are reported in Chapter IV of this document.

WATERSHED CHARACTERISTICS

Because of the importance of the Mukwonago River to the hydrology and water quality of the Lake, the area drained by the Mukwonago River has been included in the drainage area considered in this study, as shown on Map 4. The drainage area, including the entire area upstream of Eagle Spring Lake drained by the Mukwonago River is 16,697 acres, or about 26.0 square miles in extent. Eagle Spring Lake has a watershed-to-lake ratio of about 54:1.

The hydrology of Eagle Spring Lake is modified by the presence of the upstream Lulu Lake and the dam and supplementary outlet structure at the Lake's two outlets. Map 5 reproduces the 1874 plat map of the Eagle Spring Lake area. A comparison of the present surface area of Eagle Spring Lake, as shown on Map 1, with the 1874 map, graphically

Table 1

HYDROLOGY AND MORPHOMETRY OF EAGLE SPRING LAKE

Parameter	Measurement
Size (total)	
Surface Area	311 acres
Total Drainage Area	16,697 acres
Volume	1,244 acre-feet
Residence Time	0.1 years
Shape	
Maximum Length of Lake	6,225 feet
Length of Shoreline	4.7 miles
Maximum Width	3,450 feet
Shoreline Development Factor[b]	2.5
Depth	
Mean Depth	3.6 feet
Maximum Depth	12.0 feet

[a]Residence time: 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: SEWRPC.

indicates the extent to which the lake area has expanded since the river was dammed.

Soil Types and Conditions

Soil type, land slope, and land use and management practices 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 then U.S. Soil Conservation Service—now the U.S. Natural Resources Conservation Service—under contract to the Southeastern Wisconsin Regional Planning Commission completed a detailed soil survey of the entire seven-county planning region, including the Eagle Spring Lake area in 1966.[3] The soil survey contained interpretations for planning and engineering applications and for suitability for various types of urban land uses, 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 Eagle Spring Lake. The suitability of the soils for urban residential development was assessed using three common development scenarios: development with conventional onsite sewage disposal systems (septic tank systems); development with alternative onsite sewage disposal systems (mound systems); and development with public sanitary sewers.

Soils within the drainage area of Eagle Spring Lake were categorized into four main hydrologic soil 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 6. About 91 percent of the Eagle Spring Lake drainage area is covered by the moderately well-drained soils.

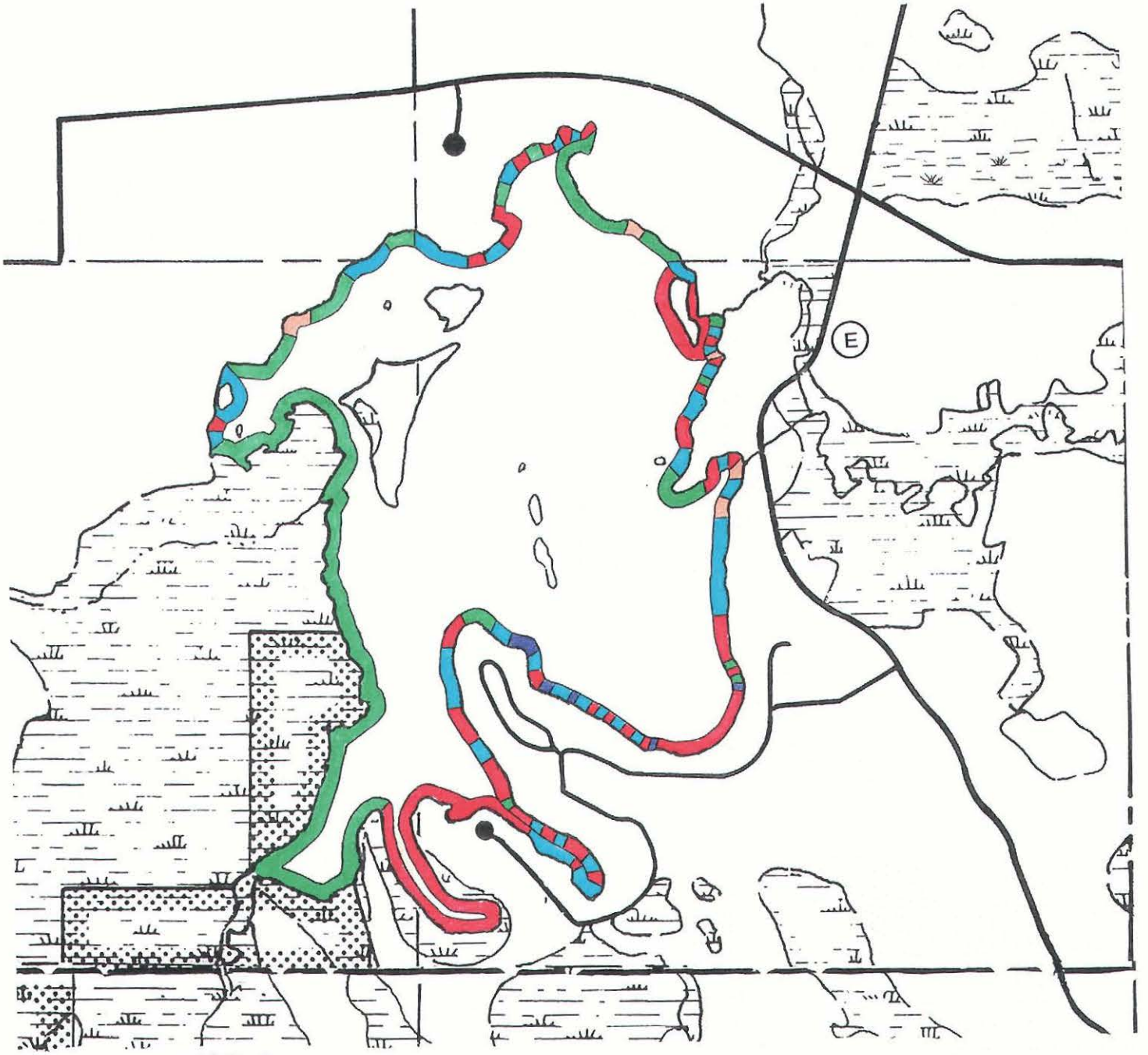
As already noted, the regional soil survey included interpretations of the suitability of the mapped soils for various types of urban and rural development. The suitability ratings of the various soils for use of onsite sewage disposal systems were updated by the Regional Planning Commission based upon soil characteristics determined by the detailed soil surveys and the experience of County and State technicians responsible for overseeing the location and design of such systems. The new ratings reflect the current soil and site specifications set forth in Chapter Comm 83—formerly ILHR 83—of the Wisconsin Administrative Code.

With respect to residential development utilizing conventional onsite sewage disposal systems, as shown on Map 7, about 66 percent of the Eagle Spring Lake drainage area is covered by soils suitable for such development. About 13 percent of the drainage area is covered by soils unsuitable for such development. The soil suitability could not be determined without further field surveys for about

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

Map 2

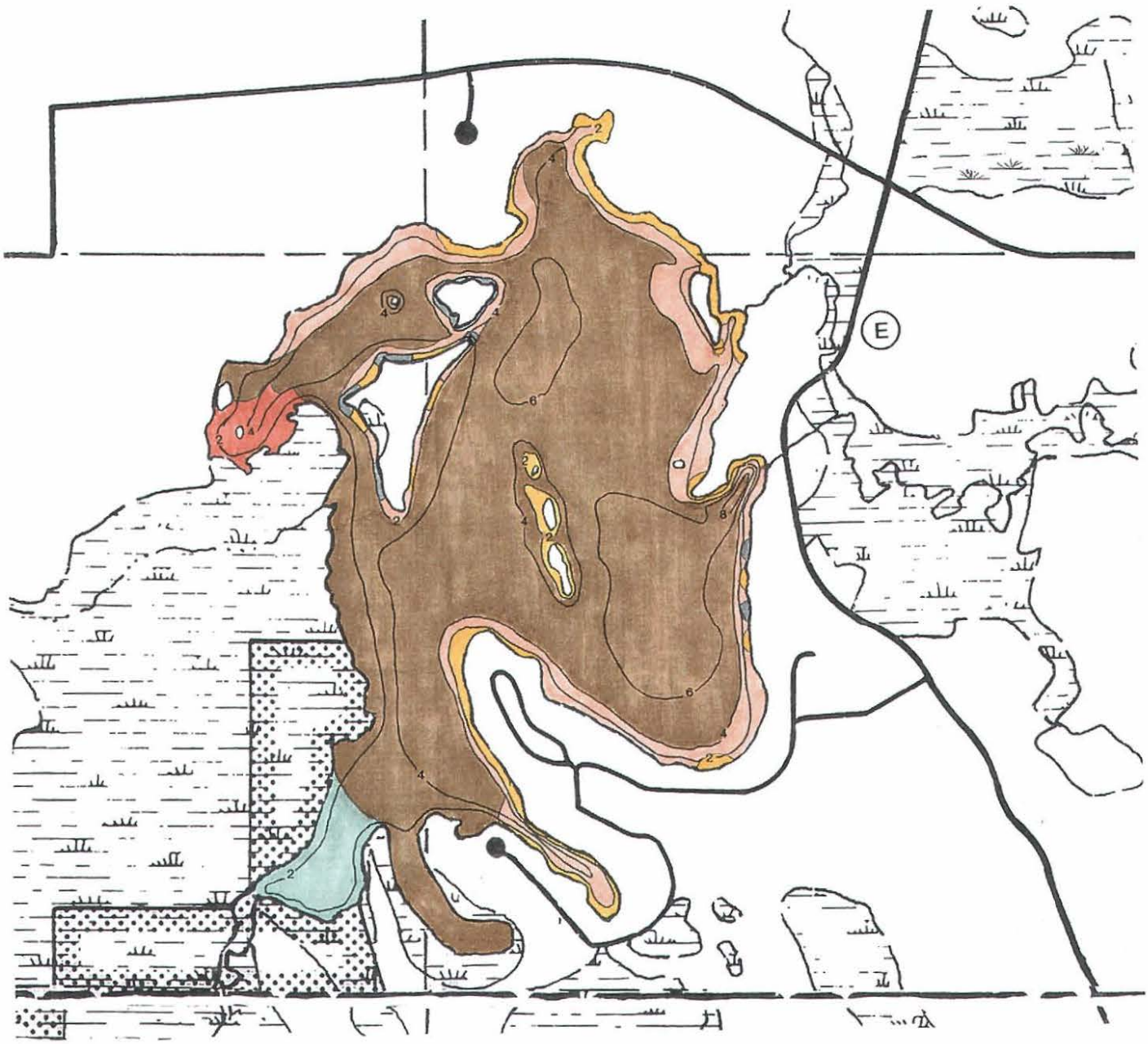
SHORELINE PROTECTION STRUCTURES ON EAGLE SPRING LAKE: 1994



Source: SEWRPC.

Map 3

BOTTOM SUBSTRATES IN EAGLE SPRING LAKE



LEGEND

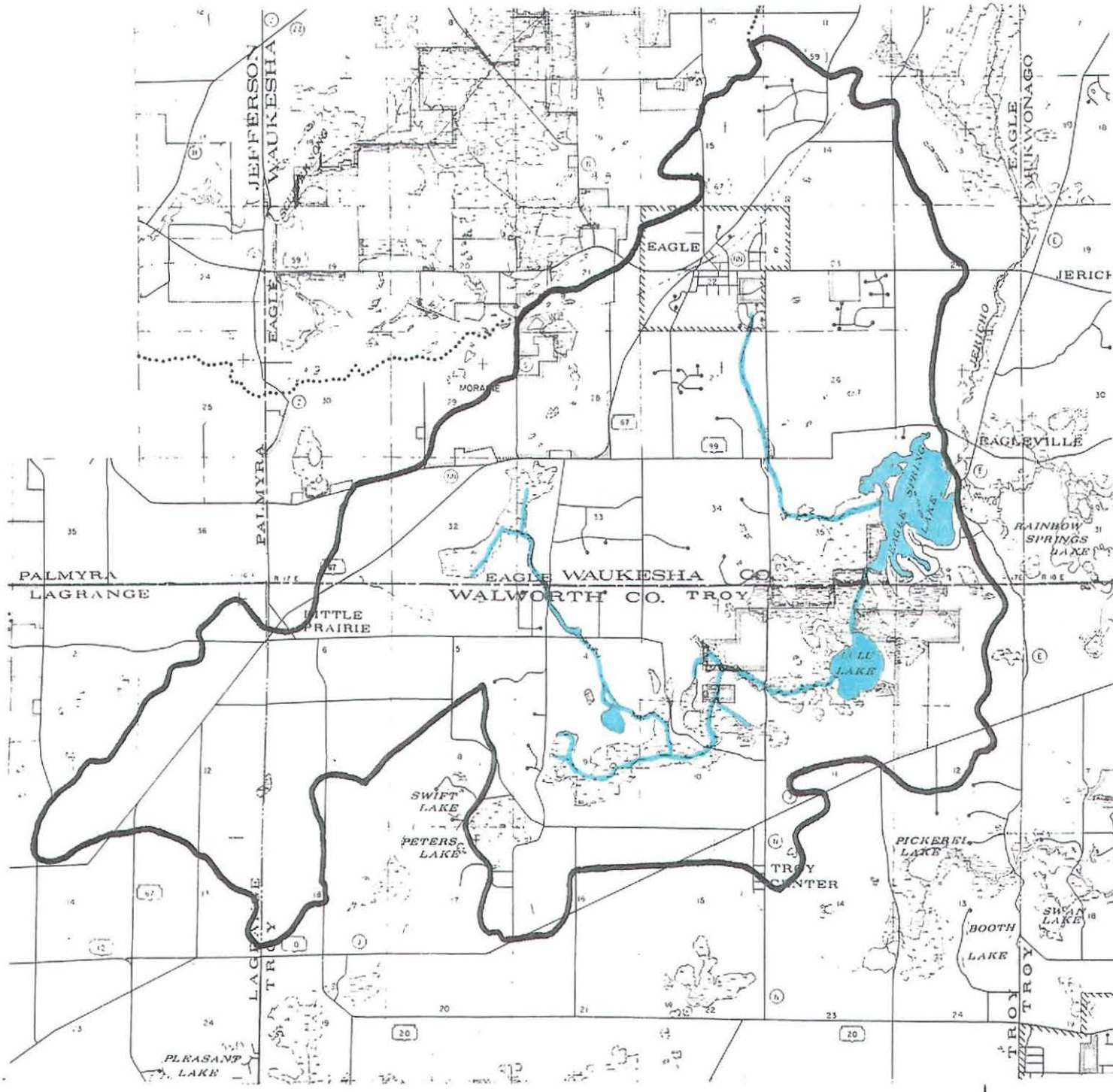
- MUCK
- MARL
- SAND
- GRAVEL
- RUBBLE
- SILT, SAND AND MARL

GRAPHIC SCALE
0 500 1000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 4

DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE



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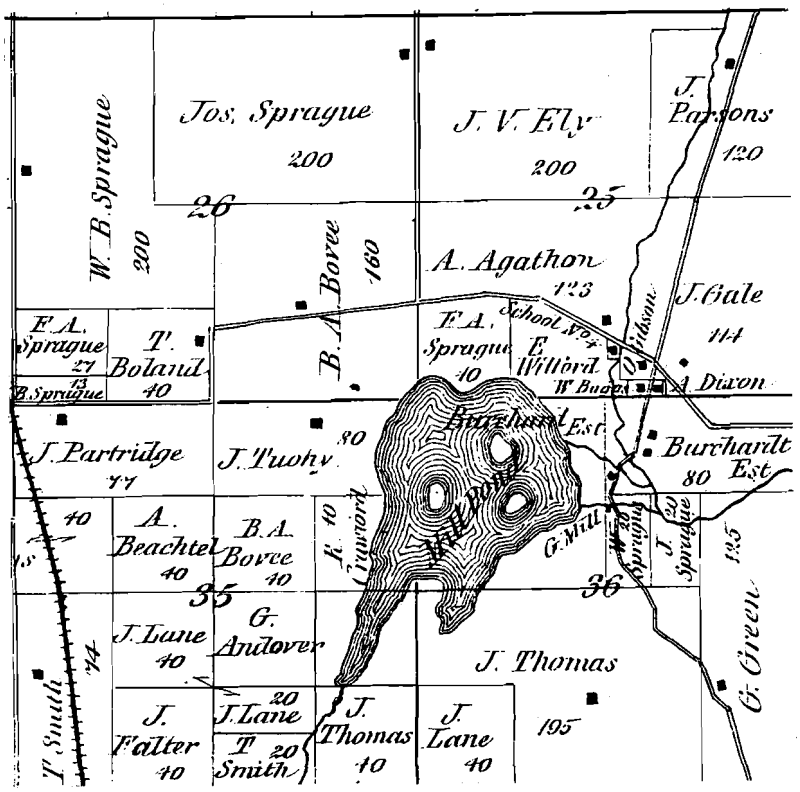
TRIBUTARY DRAINAGE AREA BOUNDARY

Source: SEWRPC.

Map 5

HISTORIC PLAT MAP FOR EAGLE SPRING LAKE AREA: 1873



Source: Waukesha County 1873 Plat Book by Worley and Bracher.

17 percent of the land in the drainage area. The remainder of the areas considered were covered by surface water or disturbed land for which no interpretive data are available. While a large portion of the drainage area tributary to Eagle Spring Lake is covered by soils considered suitable for the use of conventional onsite sewage disposal system, it should be noted that most of the developed lakeshore areas surrounding Eagle Spring Lake are underlain by soils for which the suitability for such systems are currently undetermined on a generalized basis. Thus, site specific assessments of soil suitability for onsite sewage disposal systems should be undertaken on a case-by-case basis. Furthermore, many of the developed lands have lot sizes and slopes which are considered unsuitable for the continued long-term use of conventional onsite sewage disposal systems.

Using alternative onsite sewage disposal systems, such as mound systems, as shown on Map 8, yields little additional land which may be suitable for urban residential development: about 66 percent of the Eagle Spring Lake drainage area is covered by soils suitable for such development and about 13 percent by soils unsuitable for such development. Soil suitability could not be determined without further field surveys for about 17 percent of the drainage area. The remainder of the areas considered were covered by surface water or disturbed land for which no interpretive data are available. While a large portion of the drainage area tributary

Table 2

GENERAL HYDROLOGIC SOIL TYPES WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE

Group	Soil Characteristics	Total Tributary Drainage Area (acres)	Percent of Total
A	Well drained; very rapidly to rapid permeability. Low shrink-swell potential	91	1
B	Moderately well drained; texture intermediate between coarse and fine; moderately rapid to moderate permeability; low to moderate shrink-swell potential	14,689	91
C	Poorly drained; high water table for part or most of the year; mottling, suggesting poor aeration and lack of drainage, generally present in A to C horizons	18	<1
D	Very poorly drained; high water table for most of the year; organic or clay soils; clay soils having high shrink-swell potential	1,152	7
Other	Group not determined	218	1
- -	Total	16,168	100

Source: SEWRPC.

to Eagle Spring Lake is covered by soils suitable for the use of alternative onsite sewage disposal systems, it should be noted that most of the developed lakeshore areas surrounding Eagle Spring Lake is underlain by soils for which the suitability for such systems are currently undetermined on a generalized basis. Thus, site specific assessments of alternative onsite sewage disposal systems should be undertaken on a case-by-case basis.

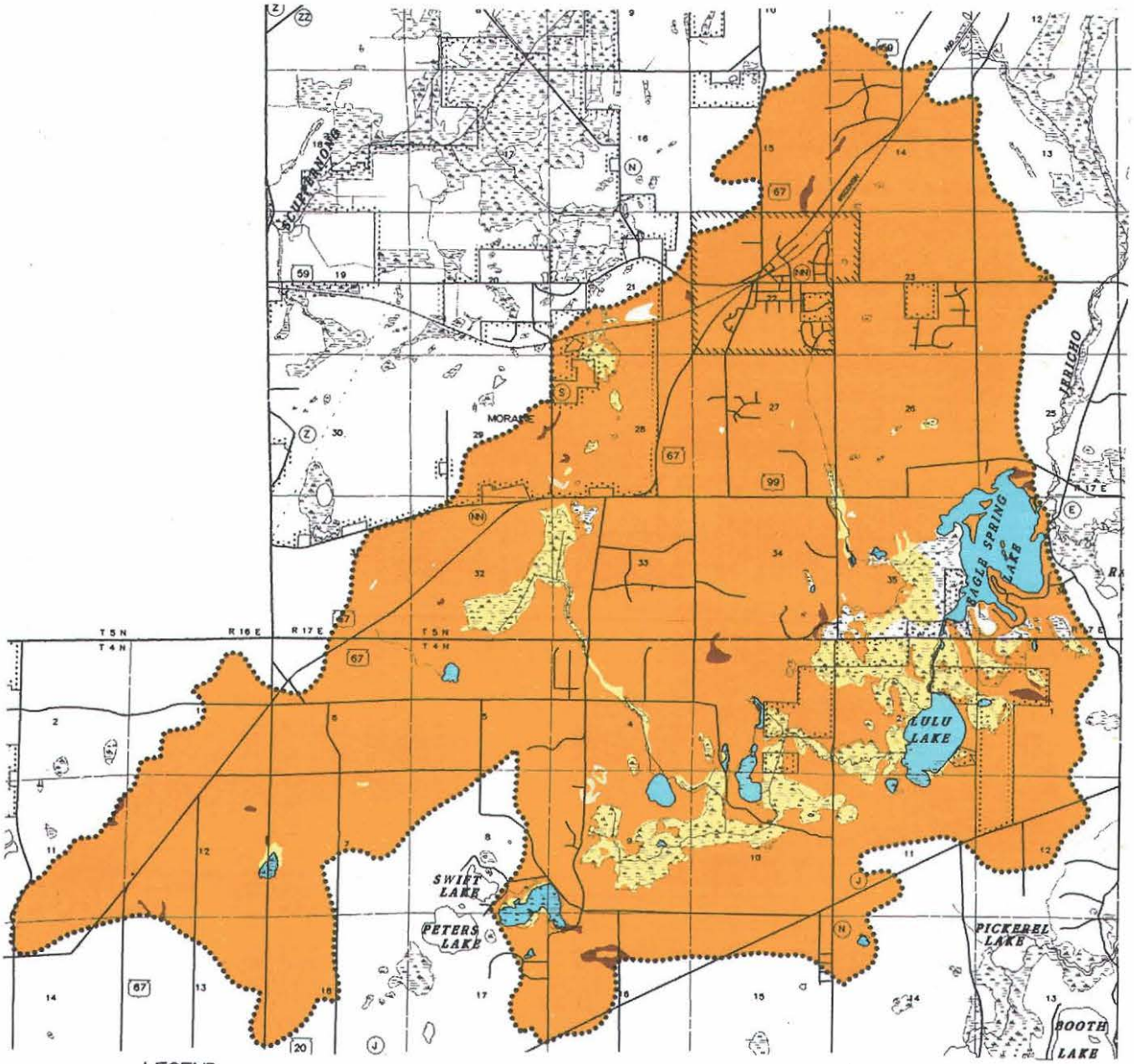
Soil limitations for residential development utilizing sanitary sewer service are shown on Map 9. About 70 percent of the Eagle Spring Lake drainage area is covered by soils suitable for such development and about 25 percent by soils unsuitable for such development. As of 1995, the urban development surrounding the Eagle Spring Lake drainage area was not served by sanitary sewers. The proposed year 2010 sanitary sewer service area for the Eagle Spring Lake area and other service areas proposed to be served by the Village of Mukwonago sewage treatment plant, in the adopted regional water quality management plan, are delineated on Map 10. The regional plan calls for approximately 576 acres, or 18 percent of the drainage area, to be served by sanitary sewers by the year 2010.[4]

The provision of capacity in the Rainbow Springs-Mukwonago portion of the recommended Eagle Spring-Mukwonago Intercommunity Trunk Sewer is noted in the regional plans as one option for providing for connection of the Eagle Spring Lake area to the Village of Mukwonago sewerage system. As of late 1995, however, the Eagle Spring Lake Management District Commissioners, after full and due consideration of a then current proposal to provide such capacity, were unwilling to commit the necessary funds to that specific proposal, to acquire the proposed future capacity in the Rainbow Springs-Mukwonago trunk sewer given concerns regarding the financial cost of such capacity and the ability of other interested parties in carrying out the scheme of which the sewerage

[4]*SEWRPC, Amendment to the Regional Water Quality Management Plan—2000, Eagle Spring Lake Sanitary District, December 1985.*

Map 6

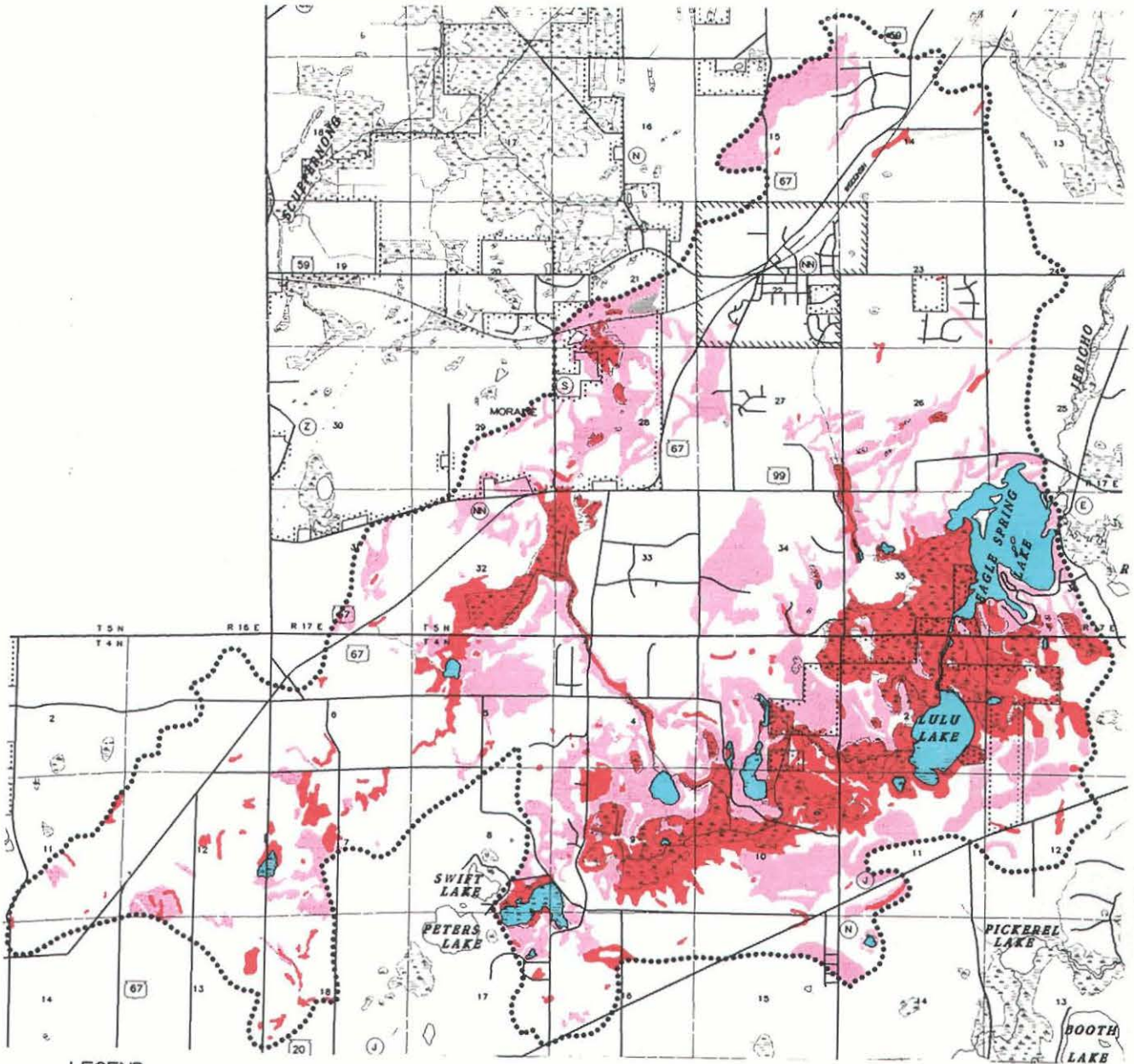
HYDROLOGIC SOIL GROUPS WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE



Source: SEWRPC.

Map 7

SUITABILITY OF SOILS WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE FOR CONVENTIONAL ONSITE SEWAGE DISPOSAL SYSTEMS UNDER CURRENT ADMINISTRATIVE RULES: FEBRUARY 1991



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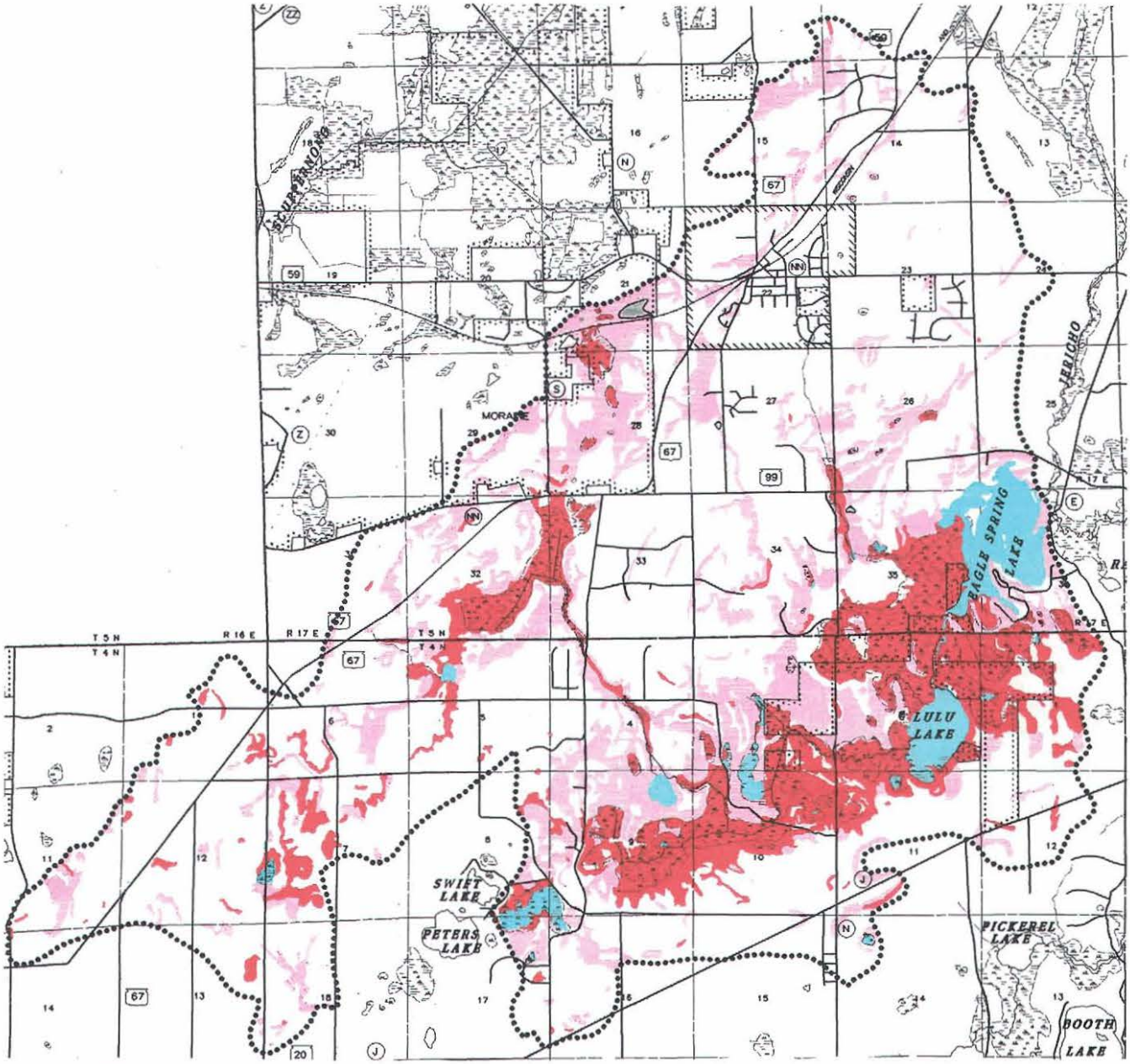
- UNSUITABLE: Areas covered by soils which have a high probability of not meeting the criteria of Chapter ILHR 83 of the Wisconsin Administrative Code governing conventional onsite sewage disposal systems.
- UNDETERMINED: Areas covered by soils having a range of characteristics and/or slopes which span the criteria of Chapter ILHR 83 of Wisconsin Administrative Code governing conventional onsite 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 conventional onsite 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 WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE FOR MOUND SEWAGE DISPOSAL SYSTEMS UNDER CURRENT ADMINISTRATIVE RULES: FEBRUARY 1991



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

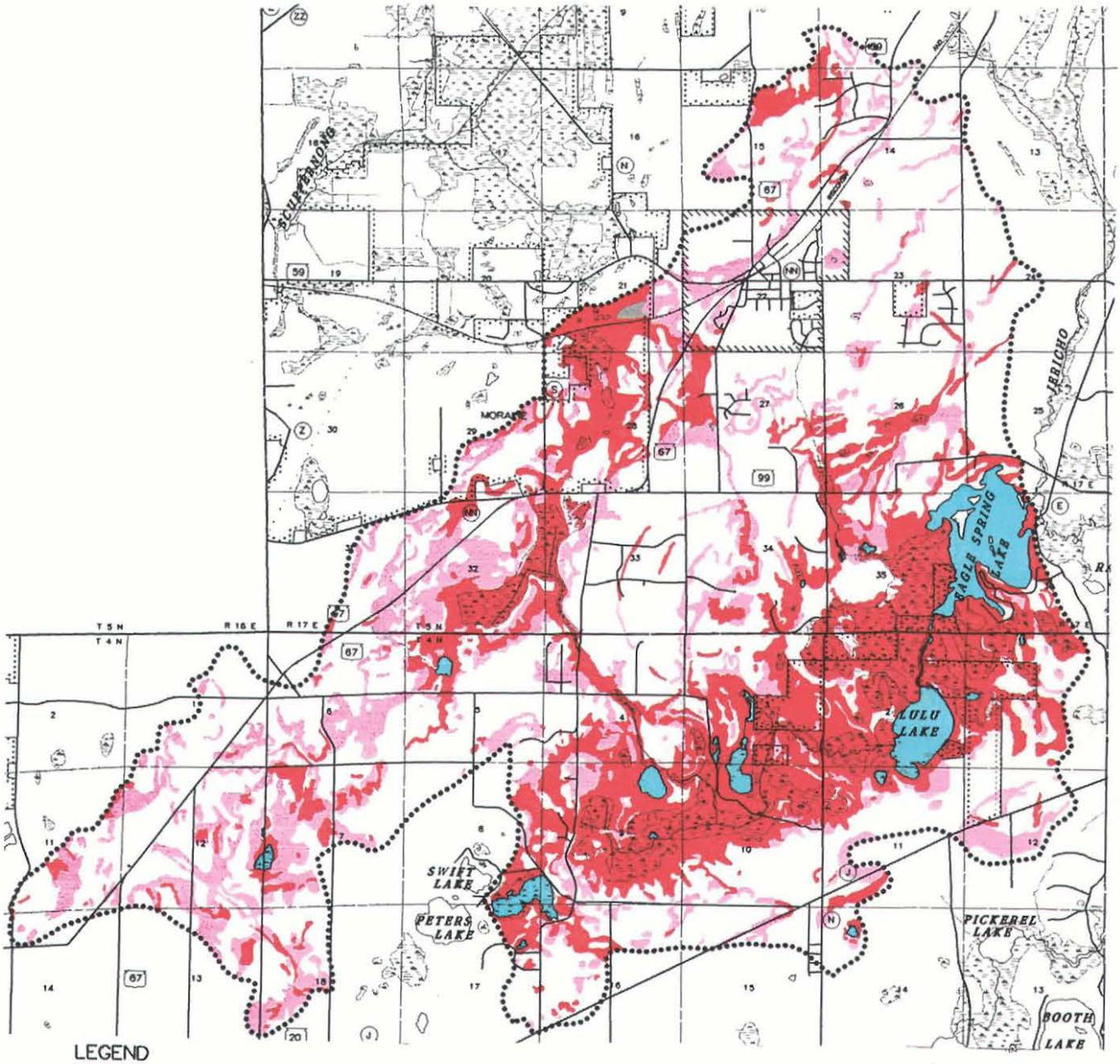
0 2500 5000

GRAPHIC SCALE IN FEET

Source: SEWRPC.

Map 9

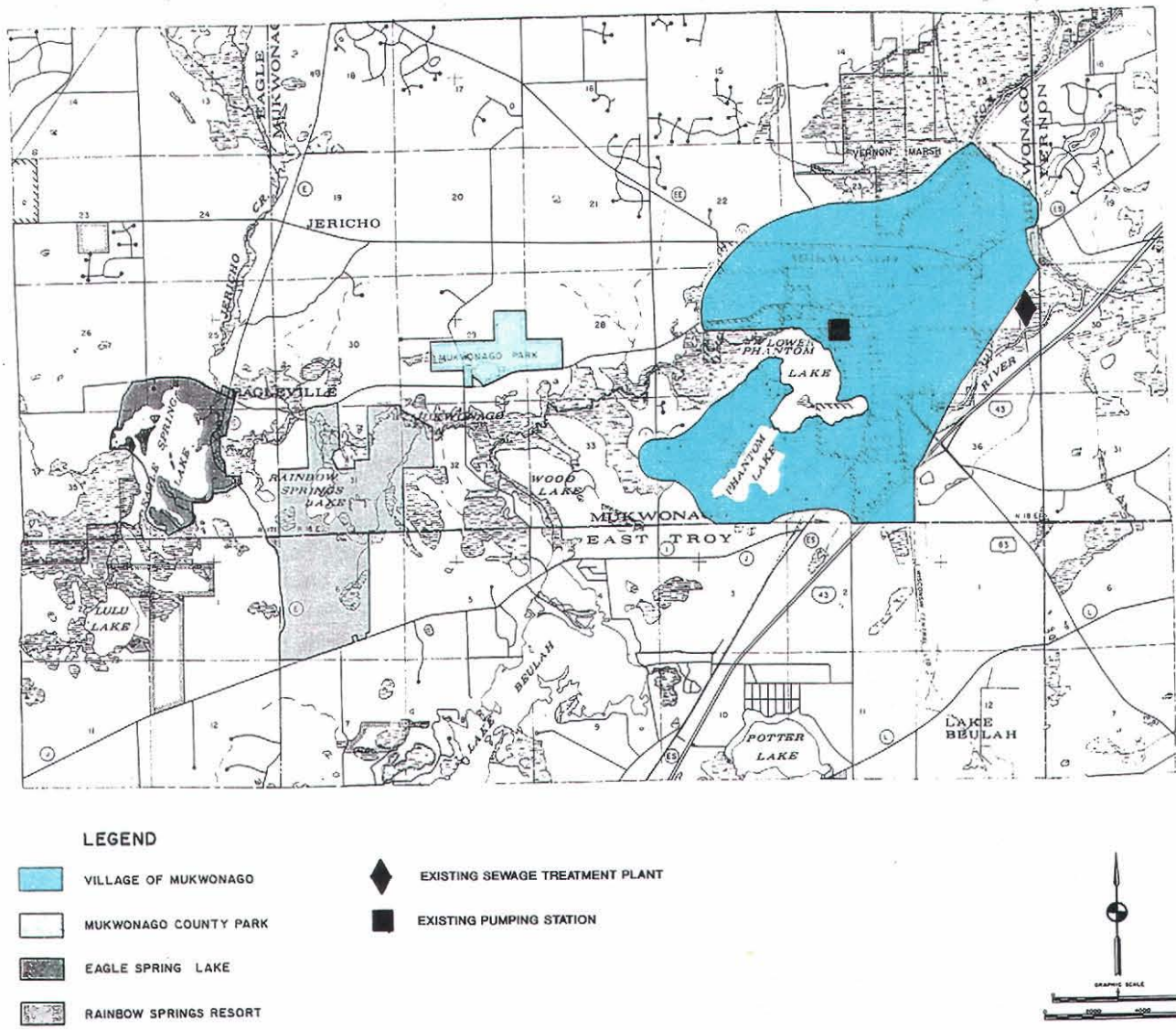
SUITABILITY OF SOILS WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER



Source: SEWRPC.

Map 10

PLANNED SANITARY SEWER SERVICE AREAS ATTENDANT TO THE MUKWONAGO SEWAGE TREATMENT PLANT: 1995



Source: SEWRPC.

system formed a part.[5] Thus, the best means of providing for public sanitary sewer service to Eagle Spring Lake and the connection to the Village of Mukwonago will have to be evaluated in subsequent facilities planning at such time as there is local interest in providing for such service.

Climate and Hydrology

Long-term average monthly air temperature and precipitation values for the Eagle Spring Lake area are set forth in Table 3. In addition, Table 3 provides monthly air temperature, runoff, and precipitation data for the 1994 study year during the period that lake hydrology and water quality data were obtained for use in this report. Table 3 also provides runoff data for both periods—long-term and the 1994 study year—derived from U.S. Geological Survey flow records for the Mukwonago River, station number 05544200, at Mukwonago, Waukesha County, Wisconsin. Groundwater levels were not measured during this study.

The mean summer and winter temperatures of 60.6°F and 30.5°F at Burlington are similar to those of other recording locations in Southeastern Wisconsin. Mean annual precipitation at Burlington is 36.98 inches. More than half of the normal yearly precipitation falls during the growing season, from May through September. Runoff rates are generally low during this period because evapotranspiration rates are high, vegetation cover is abundant, and soils are not frozen. Normally, less than 15 percent of the summer precipitation becomes surface runoff, but intense summer storms occasionally produce higher percentages of runoff. Peak runoff usually occurs during winter and early spring when about 30 percent of the annual precipitation, in the form of snowmelt and/or rain, falls on frozen ground.

As Table 3 indicates, in 1994 precipitation was 4.6 inches, or 12 percent, above the long-term average at Burlington. In April and June, the wettest months, had 7.71 and 7.84 inches of precipitation were experienced, respectively, or 4.37 and 3.79 inches above the long-term average, respectively. This abundant precipitation was off-set by below normal precipitation during much of the remainder of the year. However, the net result of the two months of heavy rainfall, when combined with the data from the remainder of the year, resulted in near normal runoff volumes in 1994, at the U.S. Geological Survey streamflow gauge located on the Mukwonago River at Mukwonago.

Although groundwater levels were not measured during this study, the slope of the water table indicates that groundwater flows occur from northwest to southeast across the lake area.[6] A net outflow of water from the lakes in an easterly direction, similar to the surface drainage pattern, is likely.

Water Budget

Based upon available data, an analysis of the available hydrologic and climate data discussed previously, an average annual water budget for Eagle Spring Lake was computed and is set forth in Figure 1. During the 12-month period, October 1993 through September 1994, an estimated 13,901 acre-feet of water entered the Lake. The Mukwonago River and other surface and groundwater features contributed approximately 93.7 percent of the known inflow. The remaining 6.3 percent of the known inflow came from direct precipitation onto the lake surface. An estimated 13,781 acre-feet of water was lost from the Lake via the outlet—94.5 percent—and evaporation from the lake surface—5.5 percent. As the net gain of water in Eagle Spring Lake, based upon lake stage readings obtained by the Wisconsin Department of Natural Resources, was found to be negligible, about 120 acre-feet of water was estimated to be lost from the Lake by other means, most likely through a net loss of groundwater. In the longer term—1973 through 1994—water flows into and out of Eagle Spring Lake are estimated to amount to approximately 15,412.3 acre-feet and 15,291.8 acre-feet annually, respectively, with the Mukwonago River remaining the principal source of water to the system.

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[5] *As of early 1997, the development project that proposed to construct the Rainbow Springs-Mukwonago portion of the trunk sewer was abandoned.*

[6] *U.S. Geological Survey Water-Resources Investigations Open-File Report No. 79-43, Water Table Map of Waukesha County, Wisconsin, May 1979.*

Table 3

LONG-TERM AND 1994 STUDY YEAR CLIMATOLOGICAL, PRECIPITATION, AND RUNOFF DATA FOR THE EAGLE SPRING LAKE AREA

Climatological													
Air Temperature Data (°F)	October	November	December	January	February	March	April	May	June	July	August	September	Mean
Long-Term Mean Monthly[a]	49.9	37.4	23.4	17.4	21.6	33.1	45.8	45.8	66.6	71.4	73.0	61.5	45.6
1994 Study Year Mean Monthly	47.9	35.4	26.1	22.2	21.1	30.3	42.6	45.5	62.7	69.2	71.1	56.6	44.2
Departure from Long-Term Mean	-2.0	-2.0	2.7	4.8	-0.5	-2.8	-3.2	-0.3	-3.9	-2.2	-1.9	-4.9	-1.4

Precipitation														
Precipitation Data (inches)	October	November	December	January	February	March	April	May	June	July	August	September	Mean	Total
Long-Term Mean Monthly[a]	2.45	2.55	1.82	1.36	1.09	2.39	3.34	2.99	4.05	4.55	3.98	3.57	2.84	36.98
1994 Study Year Mean Monthly	0.75	1.83	0.96	2.81	1.18	2.20	7.71	2.53	7.84	4.55	2.68	3.34	3.20	41.58
Departure from Long-Term Mean	-1.70	-0.72	-0.86	1.45	0.09	-0.19	4.37	-0.46	3.79	0.0	-1.30	-0.23	0.36	4.60

Runoff													
Runoff Data (inches)	October	November	December	January	February	March	April	May	June	July	August	September	Mean
Long-Term Mean Monthly[a]	0.77	0.90	0.89	0.72	0.84	1.26	1.25	0.99	0.79	0.70	0.69	0.78	0.88
1994 Study Year Mean Monthly	0.76	0.84	0.81	0.53	1.14	1.22	0.76	0.74	0.52	0.60	1.00	0.41	0.78
Departure from Mean Monthly	-0.01	-0.06	-0.08	-0.19	0.3	-0.04	-0.49	-0.25	-0.27	-0.1	0.31	-0.37	-0.10

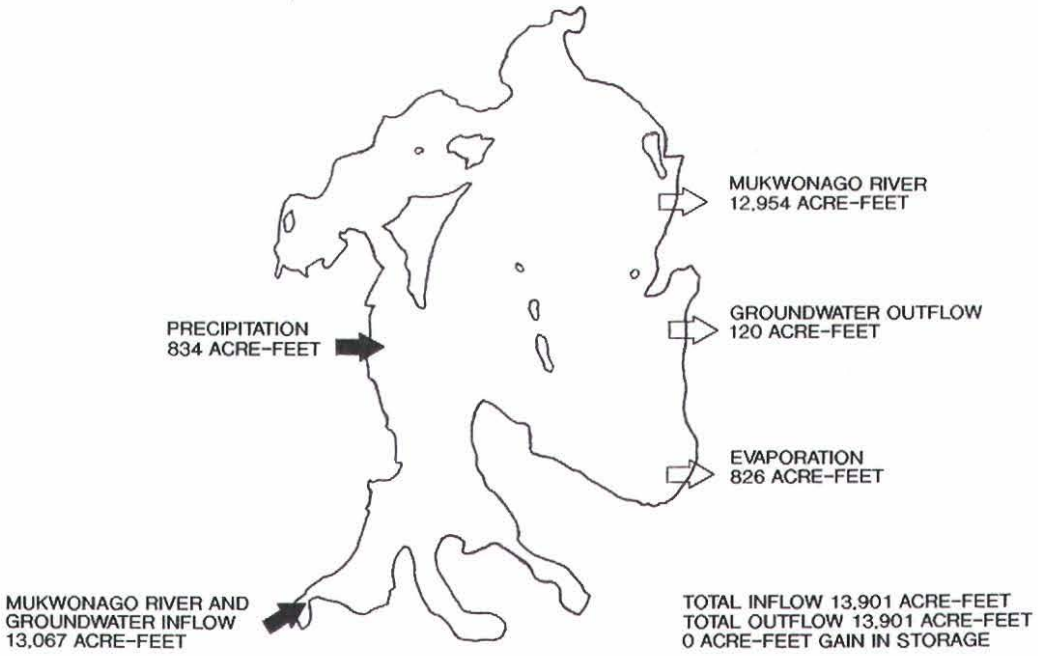
[a] *1973 through 1994.*

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

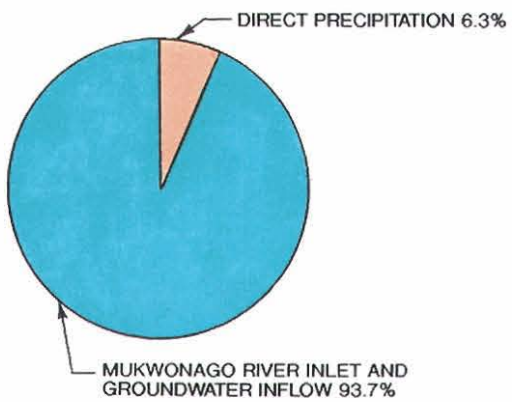
The hydraulic residence time, or the time required for a volume equivalent to the full volume of the Lake to enter the lake basin, was approximately 33 days, or 0.09 year, during the study period and is estimated to be about 29 days, or 0.08 year, during an average year. The hydraulic residence time is important in determining the expected response time of the Lake to increased or decreased nutrient and pollutant loadings. The smaller the lake volume and/or greater the rate of inflow, the shorter the hydraulic residence time will be. The residence time of Eagle Spring Lake implies that the water quality of the Lake will be a direct reflection of the quality of the influent Mukwonago River.

Figure 1

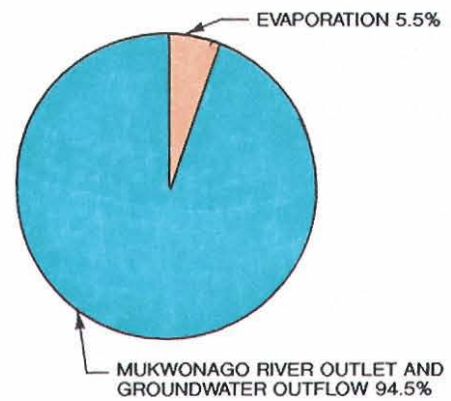
HYDROLOGIC BUDGET FOR EAGLE SPRING LAKE: 1993-1994



EAGLE SPRING LAKE INFLOW



EAGLE SPRING LAKE OUTFLOW



Source: SEWRPC.

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Chapter III

HISTORICAL, EXISTING, AND PLANNED LAND USE AND POPULATION

INTRODUCTION

Water pollution problems, recreational use conflicts, and deterioration of the natural environment are all primarily a function of the human activities within the drainage area of a waterbody, as are the ultimate solutions to these problems. This is especially true with respect to lakes which are highly susceptible to deterioration by human activities because of relatively long pollutant retention times, and because of the variety of often conflicting uses to which lakes are subject. Furthermore, urban development is often concentrated in the direct drainage areas and around the shorelines of lakes, where there are no intermediate stream segments to attenuate pollutant runoff and loadings. Accordingly, the population levels and land use and management in the tributary drainage area of a lake must be important considerations in any lake management efforts.

Civil Divisions

The geographic extent and functional responsibilities of civil divisions and special-purpose units of government are important factors related to land use and management, since these local units of government provide the basic structure of the decision-making framework within which land use development and redevelopment must be addressed. Superimposed on the Eagle Spring Lake drainage area are the local civil division boundaries shown on Map 11. The drainage area tributary to Eagle Spring Lake includes portions of the Village of Eagle and the Town of Eagle in Waukesha County and the Towns of LaGrange and Troy in Walworth County. The area and proportion of the drainage area lying within each jurisdiction concerned, as of 1990, is set forth in Table 4.

Population

As indicated in Table 5, the resident population of the drainage area tributary to Eagle Spring Lake has increased steadily since 1960. The 1990 resident population of the drainage area, estimated at 3,470 persons, was almost twice the estimated 1960 population. Population forecasts prepared by the Regional Planning Commission, as a basis for the preparation of the regional land use plan,[1] indicate that the resident population of the drainage area tributary to Eagle Spring Lake will increase to between 3,500 and 5,800 persons. Under the County development plan,[2] a considerably higher resident population could be anticipated in the tributary drainage area to Eagle Spring Lake, as is discussed in the following section on land use.

As indicated in Table 5, the number of resident households in the drainage area tributary to Eagle Spring Lake has also increased steadily since 1960. Based upon forecasts developed for the regional land use plan, the number of resident households in the area would increase from about 1,120 households in 1990 to between about 1,230 and 1,900 in the year 2010. Under the County development plan, a higher number of households would be anticipated under buildout conditions in the drainage area tributary to Eagle Spring Lake, as is discussed in the following section on land use.

As indicated in the next section, based upon an inventory of the development which has occurred, or has been committed to since 1990 in the tributary drainage area, as of 1996 the resident population and household levels in the tributary drainage area likely have already exceeded the levels recommended in the adopted regional plan. Urban development is occurring rapidly in the drainage area, primarily in the form of single-family residences on large lots. Given this development pattern and trend, it is likely that the resident

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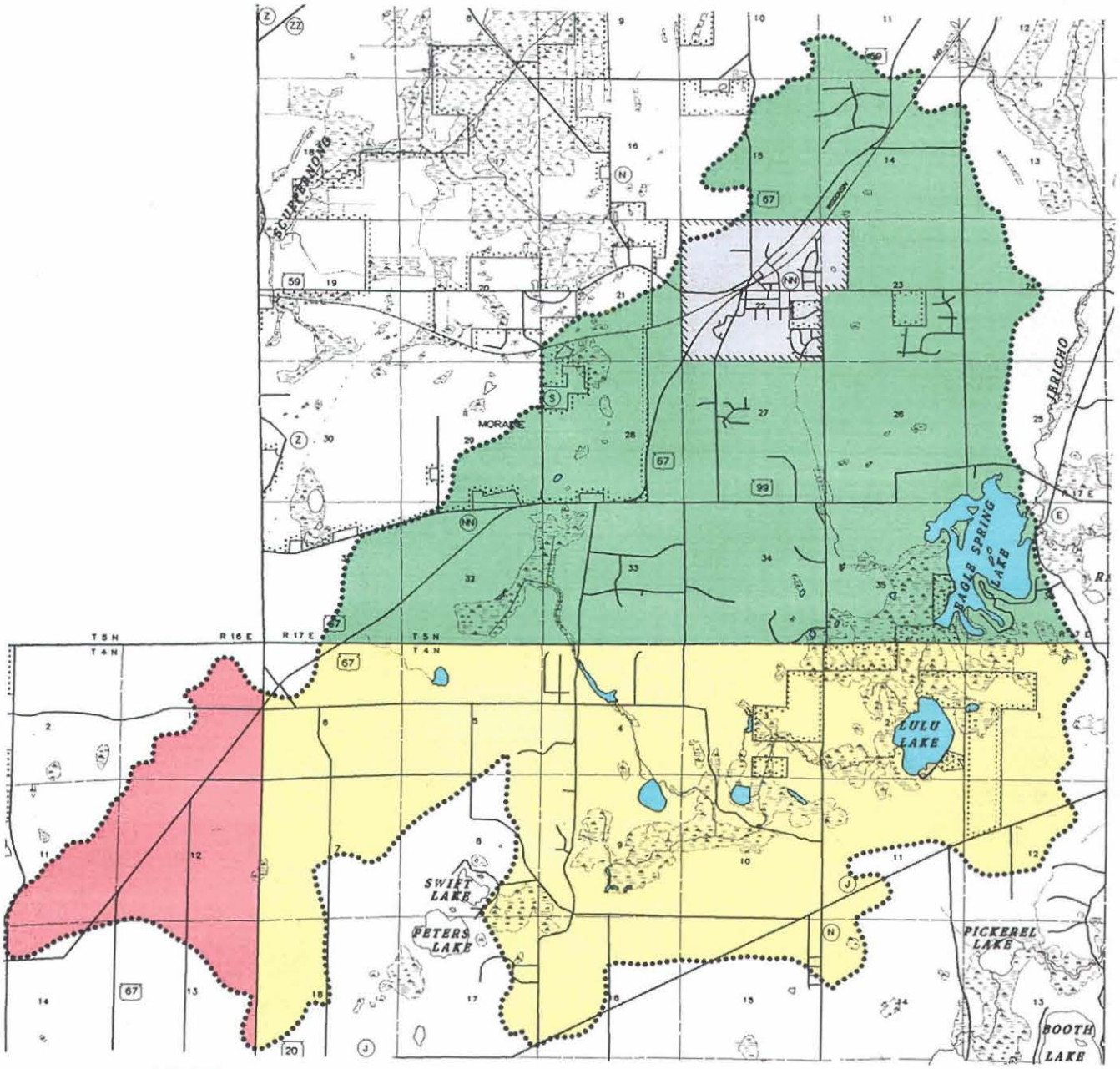
[1] *SEWRPC Planning Report No. 40, A Regional Land Use Plan for Southeastern Wisconsin—2010, January, 1992.*

[2] *SEWRPC Community Assistance Planning Report No. 209, A Development Plan for Waukesha County, Wisconsin, August 1996.*

Map 11

CIVIL DIVISION BOUNDARIES WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE



Source: SEWRPC.

Table 4

AREAL EXTENT OF CIVIL DIVISION BOUNDARIES WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE

Civil Division	Civil Division Area within Study Area (acres)	Percent of Study Area within Civil Division	Percent of Civil Division within Study Area
Town of LaGrange	1,400	8	6
Town of Troy	7,026	42	31
Town of Eagle	7,602	46	34
Village of Eagle	669	4	96
Total	16,697	100	--

Source: SEWRPC.

population and household levels will substantially exceed the lower end of the range of year 2010 population levels.

In addition to the year-round resident population and households, there were, as of 1990, about 265 seasonal residents and 100 seasonal housing units within the drainage area tributary to Eagle Spring Lake.

Land Use

The type, intensity, and spatial distribution of the various land uses within the Eagle Spring Lake drainage area are important determinants of lake water quality and recreational use demands. The current and planned future land use patterns, placed in context of the historical development in the area are, therefore, important considerations in any lake management planning effort for Eagle Spring Lake.

The movement of European settlers into the Southeastern Wisconsin Region began about 1830. Completion, within Southeastern Wisconsin of the U.S. Public Land Survey in 1836, and the subsequent sale of public lands in Wisconsin brought a rapid influx of settlers into the area.

Urban development began to occur in the drainage area tributary to Eagle Spring Lake shortly after the completions of the U.S. Public Land Survey with the early development occurring with the current Village of Eagle area. Development began to occur around Eagle Spring Lake in the early 1900s. Map 12 and Table 6 indicate the historical urban growth pattern in the drainage area since 1850. The most rapid increase in urban land use development in the tributary drainage area occurred between 1975 and 1990, when 1,280 acres of drainage area were converted from rural to urban land uses. As shown on Map 12, the urban development surrounding Eagle Spring Lake occurred largely between 1900 and 1940.

The existing land use pattern in the drainage area tributary to Eagle Spring Lake, as of 1990, is shown on Map 13, and is quantified in Table 7. As indicated in Table 7, about 2,000 acres, or about 12 percent of the tributary drainage area, were devoted to urban land uses. The dominant urban land use was residential, encompassing 1,179 acres, or about 59 percent of the area in urban use. As of 1990, about 14,700 acres, or about 88 percent of the Eagle Spring Lake drainage area, were still devoted to rural land uses. About 10,351 acres, or about 70 percent of the rural area, were in agricultural land uses. Woodlands, wetlands, and surface water, including the surface area of Eagle Spring Lake, accounted for approximately 4,324 acres, or about 29 percent of the area in rural uses.

Under year 2010 conditions, no significant changes in land use conditions within the drainage area tributary to Eagle Spring Lake are envisioned in the regional land use plan, although some infilling of existing platted lots and some backlot development may be expected to occur. In addition, the redevelopment of properties and the reconstruction of existing single-family homes may be expected on lakeshore properties. Recent surveillance indicates

Table 5

HISTORIC AND FORECAST RESIDENT POPULATION AND HOUSEHOLD LEVELS WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE: 1960-2010[a]

Year	Number of Residents	Number of Households
1960	1,800	450
1970	1,990	550
1980	2,930	920
1985	3,050	990
1990	3,470	1,120
2010[b]	3,510-5,800	1,230-1,900

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

[b] *Under the intermediate-growth centralized land use plan as set forth in the year 2010 regional land use plan, the number of residents and households in the area by the year 2010 would be 3,510 and 1,230, respectively. Under the high-growth decentralized land use alternative, the number of residents and households in the area by the year 2010 would be 5,800 and 1,900, respectively.*

Source: SEWRPC.

Table 6

EXTENT OF URBAN GROWTH WITHIN THE DIRECT DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE: 1920-1990

Year	Extent of New Urban Development Occurring Since Previous Year (acres)[a]	Cumulative Extent of Urban Development (acres)[a]
1850	15	15
1880	22	37
1900	9	46
1920	65	111
1940	93	204
1950	13	217
1963	88	305
1970	11	316
1975	16	332
1980	782	1,114
1985	228	1,342
1990	271	1,613

[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 developments were not considered in this analysis.*

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

that large-lot subdivision development is occurring in the areas in which such development was not envisioned in the adopted regional land use plan. The areas either under development for urban use, or committed to development for such use, since 1990, with densities of three to five acres per dwelling unit are shown on Map 13. These areas total about 750 acres, an amount equal to over 60 percent, of the total land area devoted in 1990 to residential urban uses within the drainage area tributary to Eagle Spring Lake. If this trend continues, much of the open space areas remaining in the drainage area will be replaced over time with large-lot urban development. This may significantly increase the pollutant loadings to the Lake associated with urbanization and increase the pressure for recreational use of the Lake. Under the full build-out condition envisioned under the Waukesha County development plan[3] completed in 1996, most of the undeveloped lands outside the environmental corridors and other environmentally sensitive areas, could potentially be developed for low-density urban uses. This development could occur in the form of residential clusters on smaller lots, and thereby preserving portions of the remaining open space and, thus, reducing the impacts on the Lake.

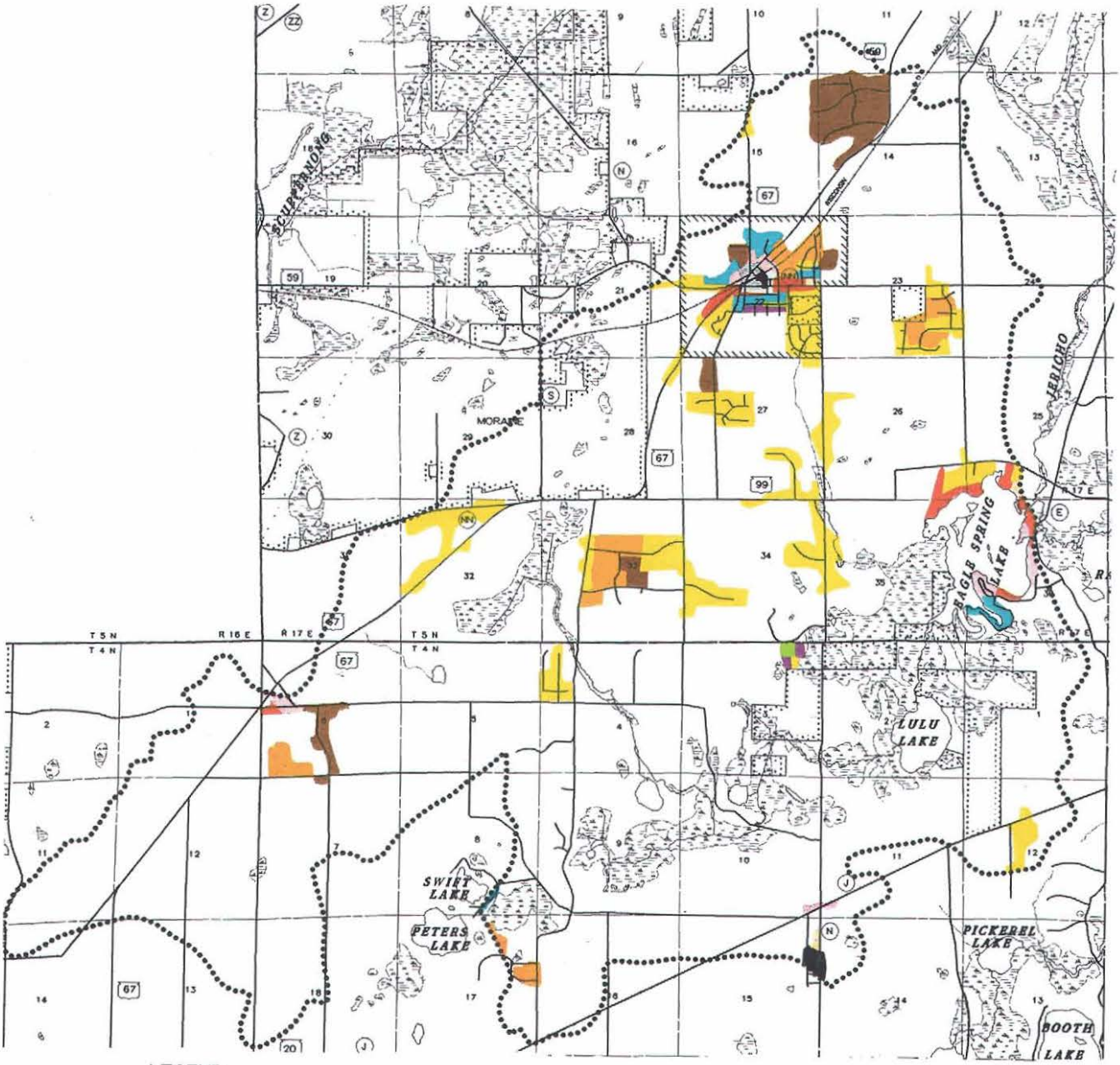
EXISTING ZONING REGULATIONS

The comprehensive zoning ordinance represents one of the most important and significant tools available

[3] *SEWRPC Community Assistance Planning Report No. 209, A Development Plan for Waukesha County, Wisconsin, August 1996.*

Map 12

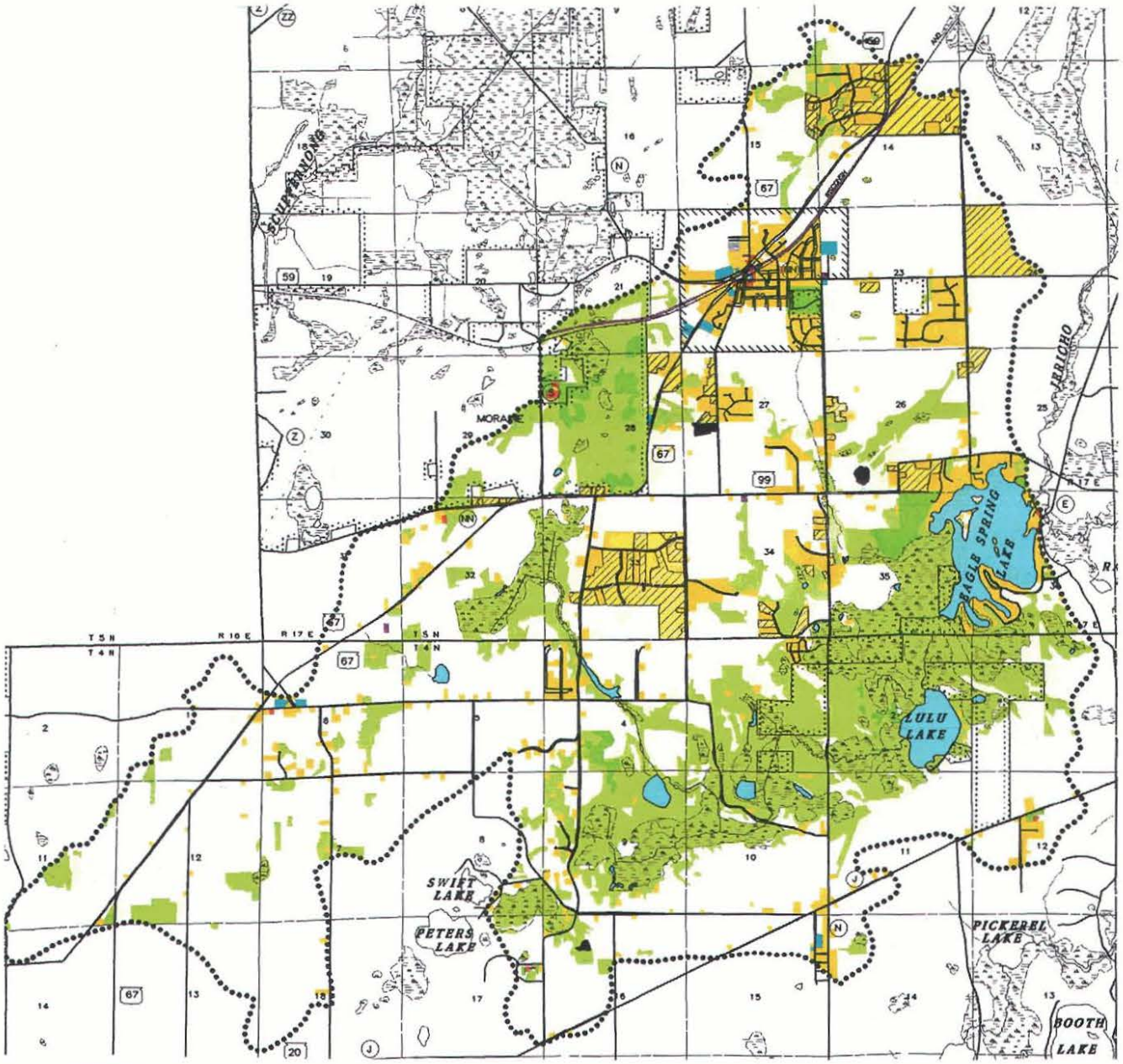
HISTORIC URBAN GROWTH WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE



Source: SEWRPC.

Map 13

EXISTING LAND USES WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE: 1990



LEGEND

- SINGLE-FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- TRANSPORTATION, COMMUNICATIONS, AND UTILITIES
- GOVERNMENT AND INSTITUTIONAL
- RECREATIONAL
- SURFACE WATER
- WOODLANDS AND WETLANDS
- AGRICULTURAL, UNUSED, AND OTHER OPEN LANDS
- EXTRACTIVE AND LANDFILL
- ADDITIONAL AREAS COMMITTED TO OR UNDER CONSTRUCTION SINCE 1990 WITH SUBURBAN DENSITY DEVELOPMENT (3.0 to 4.9 acres of lot area per dwelling unit)

0 2500 5000

GRAPHIC SCALE IN FEET

Source: SEWRPC.

Table 7

EXISTING LAND USE WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE: 1990

Land Use Categories	Acres	Percent of Major Category	Percent of Total Tributary Drainage Area
Urban			
Residential	1,179	59	7
Commercial	13	1	<1
Industrial	12	<1	<1
Governmental	33	2	<1
Transportation, Communication, and Utilities	545	27	3
Recreation	220	11	1
Subtotal	2,002	100	12
Rural			
Agricultural	10,351	70	62
Wetlands and Woodlands	3,887	26	23
Water	437	3	3
Extractive	9	<1	<1
Landfill	11	<1	<1
Subtotal	14,695	100	88
Total	16,697	--	100

Source: SEWRPC.

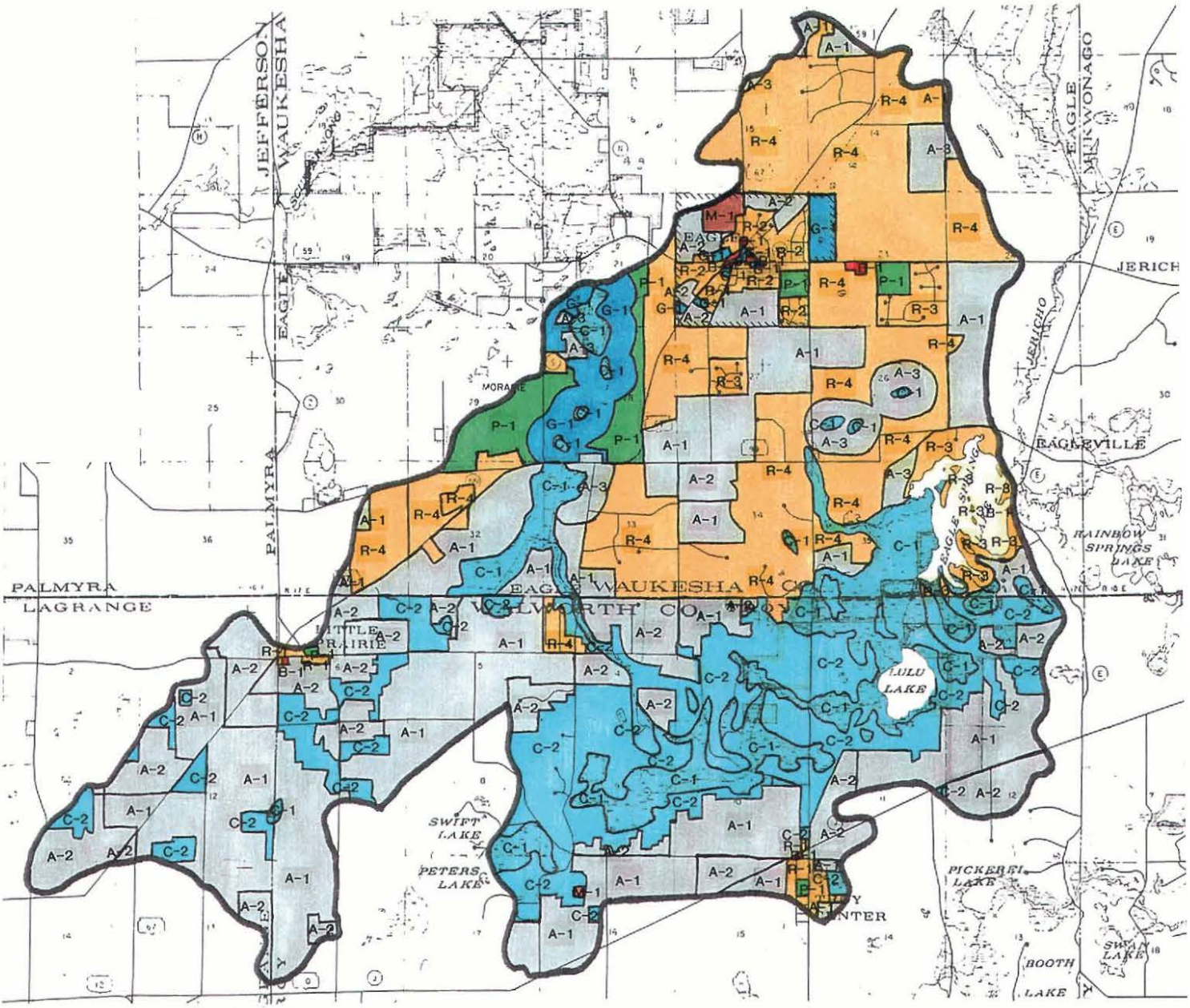
to local units of government in directing the proper use of lands within their area of jurisdiction. As already noted, the drainage area tributary to Eagle Spring Lake includes portions of the Village of Eagle and the Town of Eagle in Waukesha County and the Towns of LaGrange and Troy in Walworth County. The Town of Eagle is under the jurisdiction of Waukesha County and its Zoning Ordinance, while the Towns of LaGrange and Troy are under the jurisdiction of Walworth County and its Zoning Ordinance. The Village of Eagle administers its own zoning ordinance. The current generalized zoning districts applicable to the drainage area tributary to Eagle Spring Lake, as provided for under the current zoning regulations are shown on Map 14. The existing zoning in this Waukesha County portion of the drainage basin would permit far more urban development than envisioned in the adopted regional plan.

In addition to the comprehensive zoning ordinances administered in the Eagle Spring Lake drainage area, both the Waukesha County and Walworth County Boards of Supervisors exercise special-purpose shoreland and floodland zoning in the drainage area. These special-purpose zoning ordinances, prepared pursuant to the requirements of the Wisconsin Water Resources Act of 1965 (Chapter 30, Wisconsin Statutes), impose 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 to the landward side of the floodplain, whichever is greater. The Shoreland and floodland protection zoning ordinances is similar in content to the Waukesha and Walworth County Zoning Ordinances but include additional regulations intended to protect waterways and the attendant shorelines.

Other pertinent land use and management regulations include wetland and shoreland protection ordinances. Chapters 23 and 330 of the Wisconsin Statutes requires 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

Map 14

EXISTING ZONING DISTRICTS WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE: 1990



LEGEND

- RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- GOVERNMENTAL
- PARK
- AGRICULTURAL
- OTHER RURAL LAND
- WATER

ZONING DISTRICTS

- R-1 HIGH-DENSITY RESIDENTIAL
- R-2 MEDIUM-DENSITY RESIDENTIAL
- R-3 LOW-DENSITY RESIDENTIAL
- R-4 SUBURBAN-DENSITY RESIDENTIAL
- B-1 LOCAL BUSINESS
- M-1 MANUFACTURING
- P-1 PARK
- G-1 GOVERNMENT/INSTITUTION
- C-1 LOWLAND CONSERVANCY
- C-2 UPLAND CONSERVANCY/RESIDENTIAL
- A-1 PRIME AGRICULTURAL
- A-2 AGRICULTURAL
- A-3 AGRICULTURAL/RESIDENTIAL

Source: SEWRPC.

greater. Wetland maps for Waukesha and Walworth Counties were prepared for the Wisconsin Department of Natural Resources by the Regional Planning Commission in 1981 and 1982. In accordance with Chapter NR 115 of the Wisconsin Administrative Code, Waukesha and Walworth Counties have updated their shoreland zoning regulations and attendant maps to preclude further loss of wetlands in the shoreland areas.

The existing zoning ordinances have proven to be relatively effective in protecting the wetlands and water resources of the Eagle Spring Lake drainage area in the Walworth County portion of the drainage area, but not in the Waukesha County portion. If continued, current trends will result in the loss of a considerable amount of the open space in the area tributary to Eagle Spring Lake. Concern has been expressed by residents of the area over the widespread development of urban and suburban development on former agricultural lands in the vicinity of the Lake in the Waukesha County portion of the drainage basin. In addition, infilling and replacement of existing housing with larger structures, especially within the shoreland surrounding Eagle Spring Lake has, to a limited extent, taken place. Such redevelopment of the watershed and lakefront may be undesirable from the point of view of water quality protection—as it generally results in a greater area of impervious surface, increased runoff, and increased pollutant loading. This may be accompanied by the year-round use of formerly seasonal lakefront properties—potentially resulting in an over-loading of onsite sewage disposal systems. Control of shoreland redevelopment, and the related intensification of use, is not specifically addressed in the existing zoning codes, although new construction may 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 Eagle Spring Lake were collected by the Wisconsin Department of Natural Resources in the late 1960s.[1] Data collected in that monitoring effort indicate that Eagle Spring Lake had relatively good water quality and that there was little evidence of pollution or excessive fertilization.

More recently, however, residents of Eagle Spring Lake have expressed concerns about trends in water quality conditions; and, in 1990, the Eagle Spring Lake Management District initiated a water quality monitoring program in order to provide information on Lake water quality for use in the development of a lake management plan. The U.S. Geological Survey, in cooperation with the Eagle Spring Lake Management District, then conducted an intensive water quality monitoring program for Eagle Spring Lake from October 1991 through September 1996.[2] This study involved the determination of physical and chemical characteristics of the Lake's water, including dissolved oxygen and water temperature profiles, pH, specific conductance, water clarity, and nutrient and chlorophyll-a concentrations. Additional data are currently continuing to be collected.

The in-lake water quality monitoring investigations were funded by the State and Lake Management District under the Lake Management Planning Grant Program provided for under Chapter NR 119—now Chapter NR 190—of the Wisconsin Administrative Code. The data obtained through that program and the earlier investigation were used in the development of this lake protection plan, which was also funded in part through the State Lake Management Planning Grant Program.

EXISTING WATER QUALITY CONDITIONS

The data collected during the study period 1991 through 1994 were used to determine 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. Water quality samples were taken from the main basin of the Lake once per season during the 1991 through 1994 monitoring period. The primary sampling station was located at the deepest point in the Lake, as shown on Map 15. The findings are summarized in Table 8 and Figure 2. More detailed information on these water quality data, including locations and procedures, may be found in reports published by the U.S. Geological Survey.[3]

Thermal Stratification

Thermal and dissolved oxygen profiles for Eagle Spring Lake are shown in Figure 3. Water temperatures ranged from approximately 40°F during the winter to approximately 80°F during the summer. Complete mixing of the Lake was not seriously restricted by thermal stratification in the summer or by ice cover in the winter.

Thermal stratification is the result of differential heating of lake water and the resulting water temperature-density relationships. In shallow lakes, such as Eagle Spring Lake, the prevailing winds normally provide enough energy to the system to overcome the resistance to circulation created by

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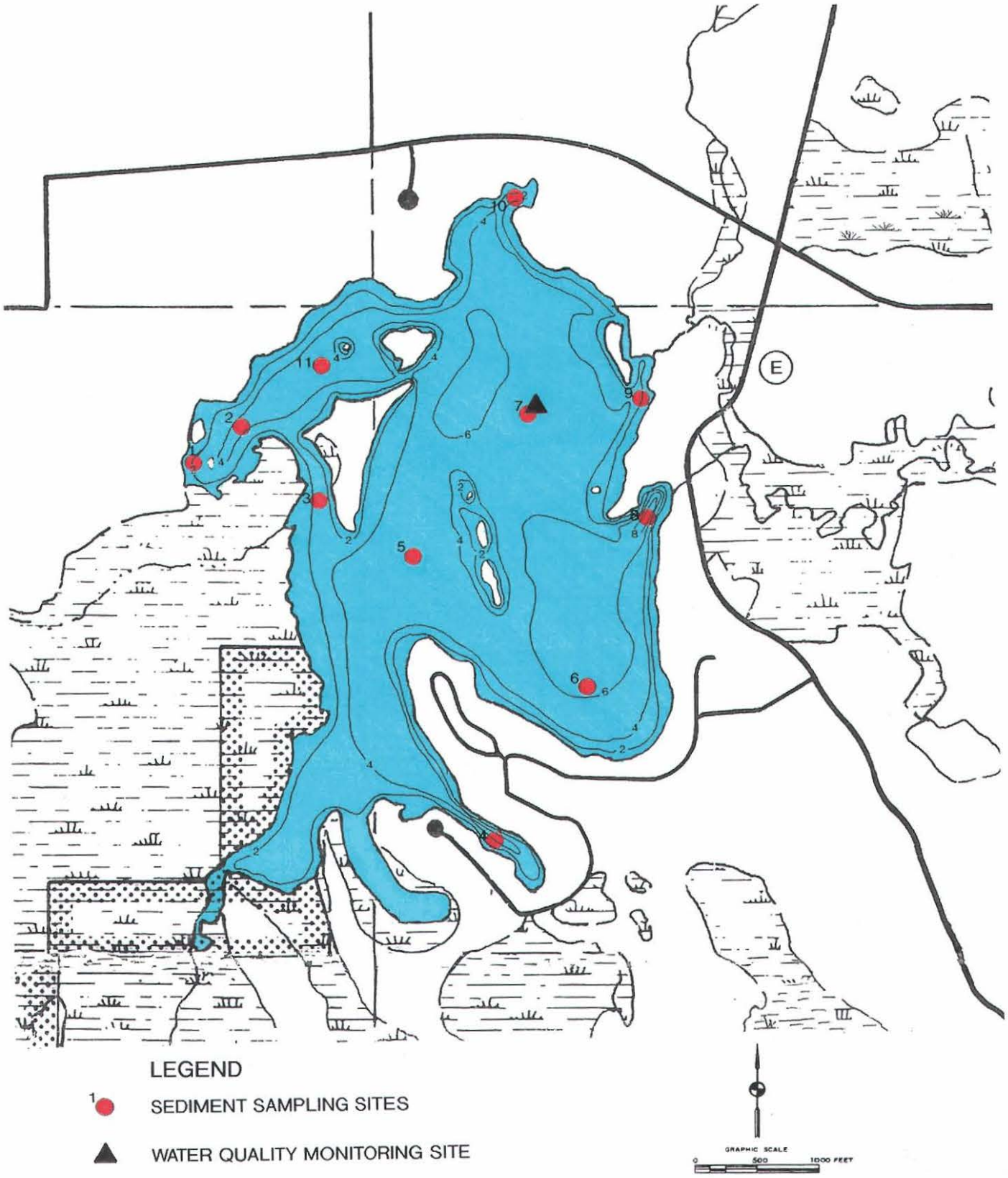
[1] *Wisconsin Department of Natural Resources Lake Use Report No. FX-19, Eagle Spring Lake, Waukesha County, Wisconsin, 1969; see also Wisconsin Department of Natural Resources Lake Use Report No. FX-39, Lulu Lake, Walworth County, Wisconsin, 1969, for the upstream waterbody.*

[2] *U.S. Geological Survey Water-Data Reports WI-91-1 through WI-96-2, Water Resources Data - Wisconsin, Water Year 1991 through Water Year 1996, published annually, March 1992 through March 1997.*

[3] *U.S. Geological Survey, op. cit.*

Map 15

LOCATION OF MONITORING STATIONS ON EAGLE SPRING LAKE



Source: SEWRPC.

Table 8

SEASONAL WATER QUALITY DATA FOR EAGLE SPRING LAKE: 1991-1994

Water Quality Parameter	Winter (mid-December to mid-March)		Spring (mid-March to mid-June)		Summer (mid-June to mid-September)	
	Shallow	Deep	Shallow	Deep	Shallow	Deep
Water Temperature (°F)						
Range	33.8-40.3	38.3-42.8	46.4-79.5	45.5-77.9	71.6-85.1	53.6-85.1
Mean	38.1 (3)	40.6 (3)	57.4 (6)	56.8 (6)	76.6 (10)	70.0 (10)
Dissolved Oxygen (mg/l)						
Range	10.6-17.8	7.7-18.2	10.0-13.6	10.2-13.7	7.8-11.7	7.8-11.4
Mean	15.9 (3)	14.9 (3)	11.9 (6)	12.2 (6)	9.9 (10)	9.2 (10)
Specific Conductivity (μS/cm at 25°C)						
Range	510-565	569-623	411-472	412-474	420-516	417-710
Mean	542 (3)	597 (3)	438 (6)	437 (6)	461 (10)	532 (10)
Alkalinity (mg/l)						
Range	--	--	190-220	190-220	--	--
Mean	--	--	207 (4)	208 (4)	--	--
Hardness, as $CaCO_3$ (mg/l)						
Range	--	--	220-250	210-250	--	--
Mean	--	--	232 (4)	230 (4)	--	--
pH (standard units)						
Range	7.6-7.9	7.6-7.8	8.3-9.0	8.4-8.9	7.9-8.8	7.3-8.7
Mean	7.7 (3)	7.7 (3)	8.5 (6)	8.6 (6)	8.3 (10)	8.0 (10)
Secchi-Disk (feet)						
Range	--	--	4.3-5.6	--	3.6-7.3	--
Mean	--	--	5.0 (6)	--	5.1 (10)	--
Turbidity (Nephelometric turbidity units)						
Range	--	--	1.2-1.6	1.0-1.7	--	--
Mean	--	--	1.4 (4)	1.4 (4)	--	--
Nitrate Nitrogen (mg/l)						
Range	--	--	0.9-1.2	0.9-1.2	--	--
Mean	--	--	1.1 (4)	1.1 (4)	--	--
Total Ammonia (mg/l)						
Range	--	--	0-0.3	0-0.2	--	--
Mean	--	--	0.2 (4)	0.2 (4)	--	--
Organic Nitrogen (mg/l)						
Range	--	--	0.30-0.50	0.40-0.60 0.48	--	--
Mean	--	--	0.43 (4)	(4)	--	--
Total Nitrogen, as N (mg/l)						
Range	--	--	1.4-1.6	1.5-1.6	--	--
Mean	--	--	1.5 (2)	1.6 (2)	--	--
Total Phosphorus, as P (mg/l)						
Range	--	--	0.006-0.023	0.007-0.039	0.009-0.019	0.013-0.030
Mean	--	--	0.012 (6)	0.015 (6)	0.014 (10)	0.020 (10)
Orthophosphorus, as PO_4P (mg/l)						
Range	--	--	<0.002-0.003	<0.002-0.003	--	--
Mean	--	--	<0.002 (4)	<0.002 (4)	--	--
Calcium, as Ca (mg/l)						
Range	--	--	47-51	46-52	--	--
Mean	--	--	49 (4)	49 (4)	--	--
Magnesium, as Mg (mg/l)						
Range	--	--	24-30	24-30	--	--
Mean	--	--	27 (4)	27 (4)	--	--
Sodium, as Na (mg/l)						
Range	--	--	4.0-5.0	4.5-5.0	--	--
Mean	--	--	4.7 (4)	4.7 (4)	--	--
Potassium, as K (mg/l)						
Range	--	--	1.0-1.2	1.0-1.1	--	--
Mean	--	--	1.1 (4)	1.0 (4)	--	--

Table 8 (continued)

Water Quality Parameter	Winter (mid-December to mid-March)		Spring (mid-March to mid-June)		Summer (mid-June to mid-September)	
	Shallow	Deep	Shallow	Deep	Shallow	Deep
Sulfate, as SO_4 (mg/l)						
Range	--	--	14-20	14-20	--	--
Mean	--	--	16 (4)	16 (4)	--	--
Chloride (mg/l)						
Range	--	--	11-13	11-13	--	--
Mean	--	--	12 (4)	12 (4)	--	--
Chlorophyll-a						
Range	--	--	4.0-7.0	--	4.9-10.0	--
Mean	--	--	5.7 (6)	--	7.4 (10)	--
Iron, as Fe (µg/l)						
Range	--	--	<50[a]	<50[a]	--	--
Mean	--	--			--	--

NOTE: Number in parentheses represents number of samples.

[a]*Less than 50 (µg/l) falls below detection limits*

Source: Wisconsin Department of Natural Resources and SEWRPC.

the temperature-related density gradients and keep the water column well-mixed year round.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. As shown in Figure 3, dissolved oxygen levels were generally constant throughout the water column of Eagle Spring Lake. This constancy occurs where there is an interchange between the water and the atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis.

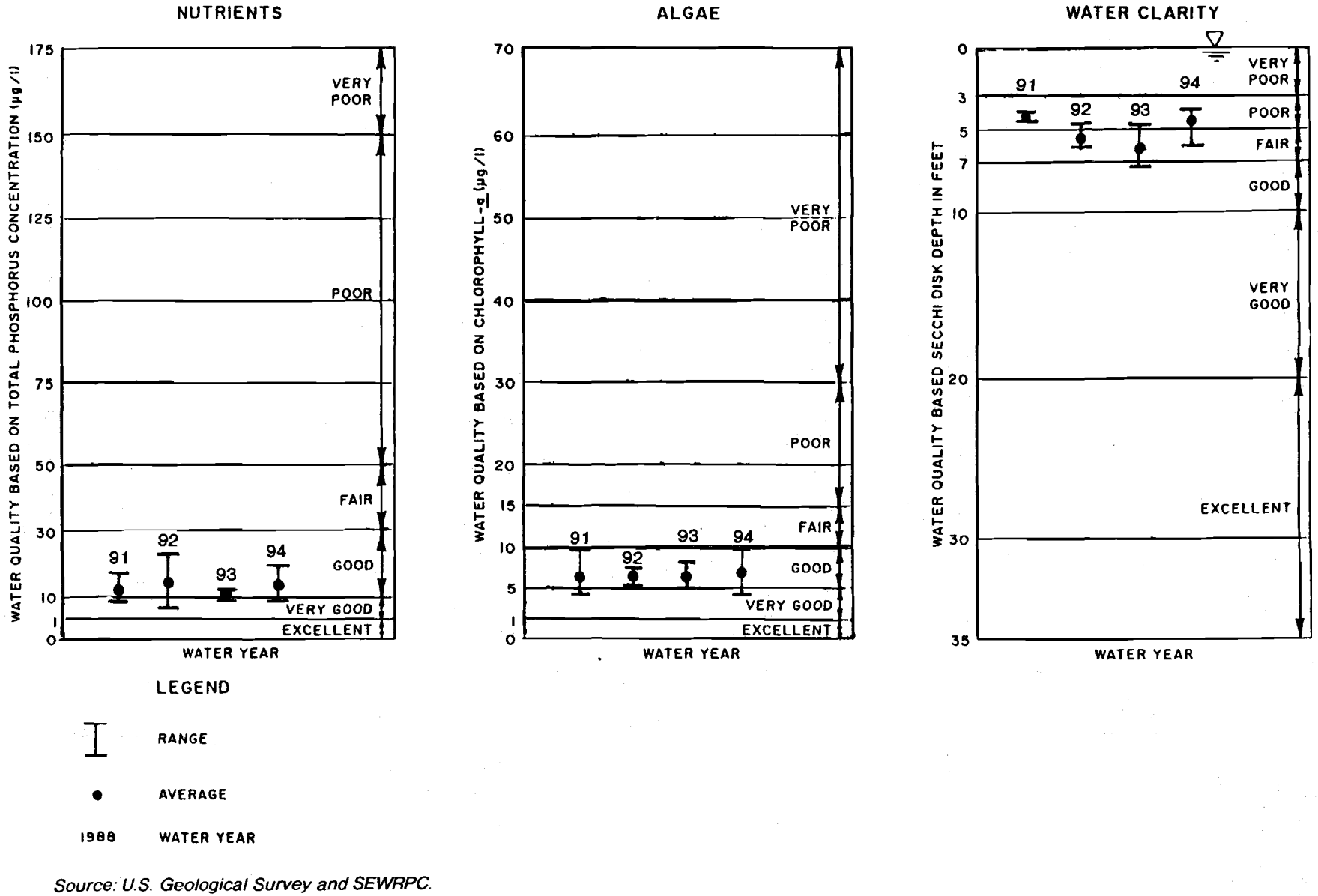
When oxygen concentration gradients were observed in the Lake, such as in June and August 1991, dissolved oxygen levels were generally highest on the bottom of the Lake, where photosynthetic production of oxygen by benthic—bottom-dwelling—plants elevated the concentrations of this element. Only rarely, such as in August 1992, was the inverse situation true, as is more common in other lakes. In such situations, decomposer organisms and chemical oxidation processes utilized oxygen in the decay process. This latter process is enhanced when a lake becomes thermally stratified and the surface supply of dissolved oxygen to the bottom waters of the lake—the hypolimnion—is cut off, or when a lake is sufficiently deep that biotic production of oxygen cannot take place across the entire lake bottom due to a lack of sunlight to drive the photosynthesis reaction. Gradually, if there is not enough dissolved oxygen to meet the total demands from the decaying 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 Eagle Spring Lake, when the Lake did, albeit infrequently, exhibit thermal stratification, did not become anoxic during the study periods, although hypolimnetic anoxia is common in many of the lakes in Southeastern Wisconsin during summer stratification. In some lakes in the Region, anoxia also occurs during winter stratification; thick ice and deep snow cover may prevent adequate photosynthetic aeration of the water column. This condition may result in fish winterkills if the supply of dissolved oxygen in the water is not sufficient to meet the total winter demand. In Eagle Spring Lake, however, dissolved oxygen levels at all depths were found to be adequate for the support of fish throughout the winter.

Another water quality implication of hypolimnetic anoxia lies in the release of nutrients, especially phosphorus, and some salts, notably iron and manganese, into the water column from the sediments, primarily because of a change in the chemical state

Figure 2

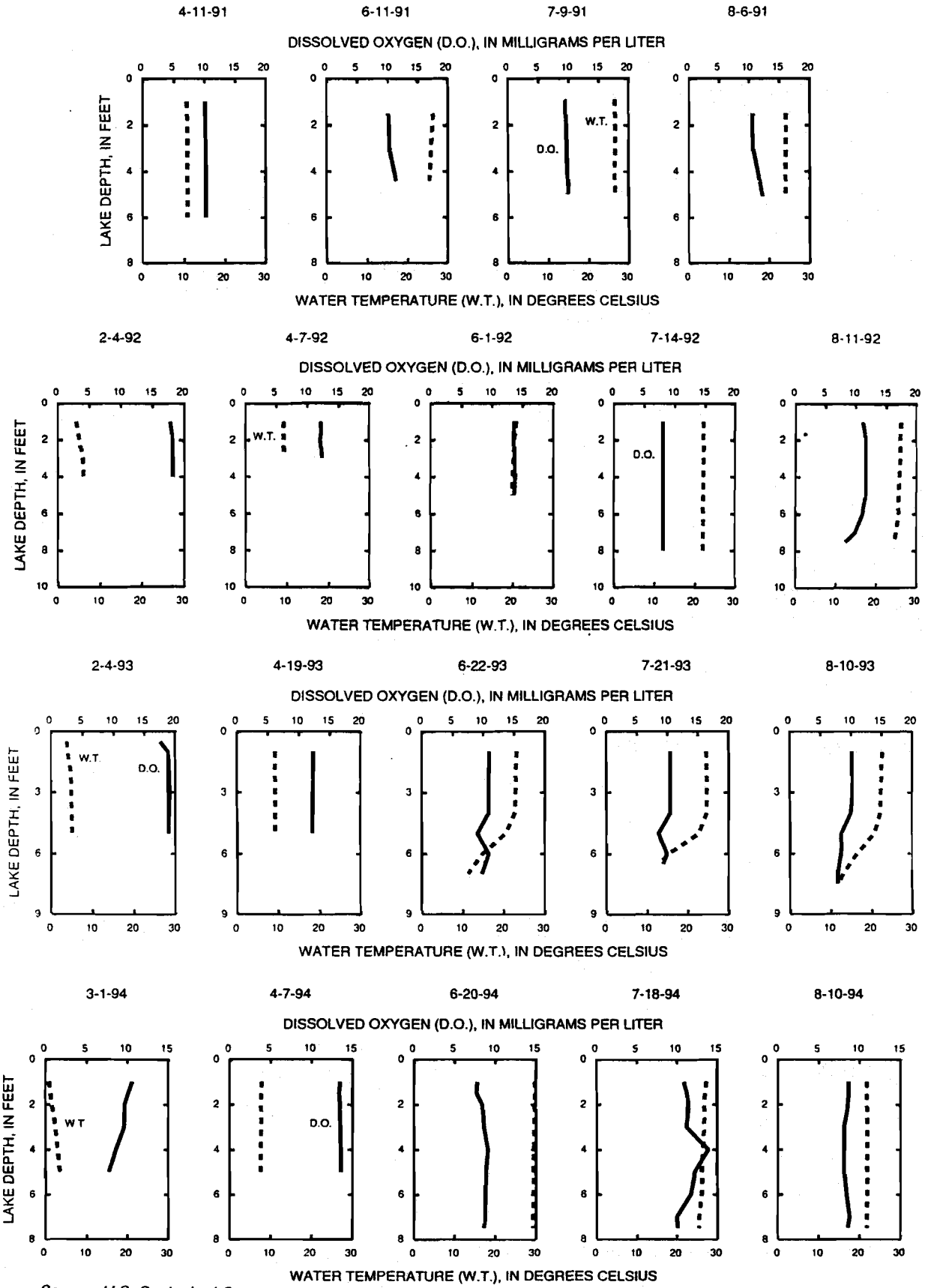
EAGLE SPRING LAKE PRIMARY WATER QUALITY INDICATORS: 1991-1994.



Source: U.S. Geological Survey and SEWRPC.

Figure 3

TEMPERATURE AND DISSOLVED OXYGEN PROFILES FOR EAGLE SPRING LAKE: 1991-1994



Source: U.S. Geological Survey.

of the metals. This "internal loading" can affect water quality significantly if these nutrients and salts are mixed into the epilimnion as the result of an intense storm, especially during spring, when these nutrients can become available for algal or plant growth. This phenomenon also was not observed with any frequency in Eagle Spring Lake, as indicated by the specific conductance data set forth in Figure 4, with June through August 1993 being the only period during the study that increased specific conductance was observed in the bottom waters of the Lake.

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 periods of thermal stratification, specific conductance can increase at the lake bottom due to an accumulation of dissolved materials in the hypolimnion, referred to as "internal loading." As shown in Table 8, the specific conductance of Eagle Spring Lake during spring of 1991 through 1994 ranged from 411 to 474 micro-Siemens per centimeter (μS/cm) at 25°C, which is within the normal range for lakes in Southeastern Wisconsin.[4] No significant surface to bottom conductivity gradients were observed, with the exception of the summer period during 1993, when specific conductance increased with depth from between 475 and 516 μS/cm at the surface to over 710 μS/cm at about the seven feet depth.

Chloride

Chloride concentrations in Eagle Spring Lake ranged from 11 to 13 milligrams per liter (mg/l) during spring of 1991 and 1994, as shown in Table 8. The most important anthropogenic source of chlorides is believed to be the salts used on streets and highways for winter snow and ice control. The concentrations measured in Eagle Spring Lake were within the normal range of lakes in Southeastern Wisconsin.[5]

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 the 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, Eagle Spring Lake may be classified as a hard-water alkaline lake. During the springs of 1991 to 1994, alkalinity averaged 207 mg/l, while hardness averaged 232 mg/l, as listed in Table 8. These values were within the normal range of lakes in Southeastern Wisconsin.[6]

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 indicating neutrality. A pH above 7 indicates basic (or alkaline) water, a pH below 7 indicates acidic water. In Eagle Spring Lake, the pH was found to range between 7.3 and 9.0 standard units, as shown in Table 8. Since Eagle Spring Lake has a high alkalinity, or buffering capacity, the pH does not fluctuate below 7 and the Lake is not susceptible to the harmful effects of acidic deposition.

Water Clarity

Water clarity, or transparency, provides an indication of overall water quality; clarity may decrease because of turbidity caused by high concentrations of suspended materials, such as algae and zooplankton, or because of color caused by high concentrations of dissolved organic substances. 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." Such readings comprise an important part of the Wisconsin Department of Natural Resources Self-Help Monitoring Program

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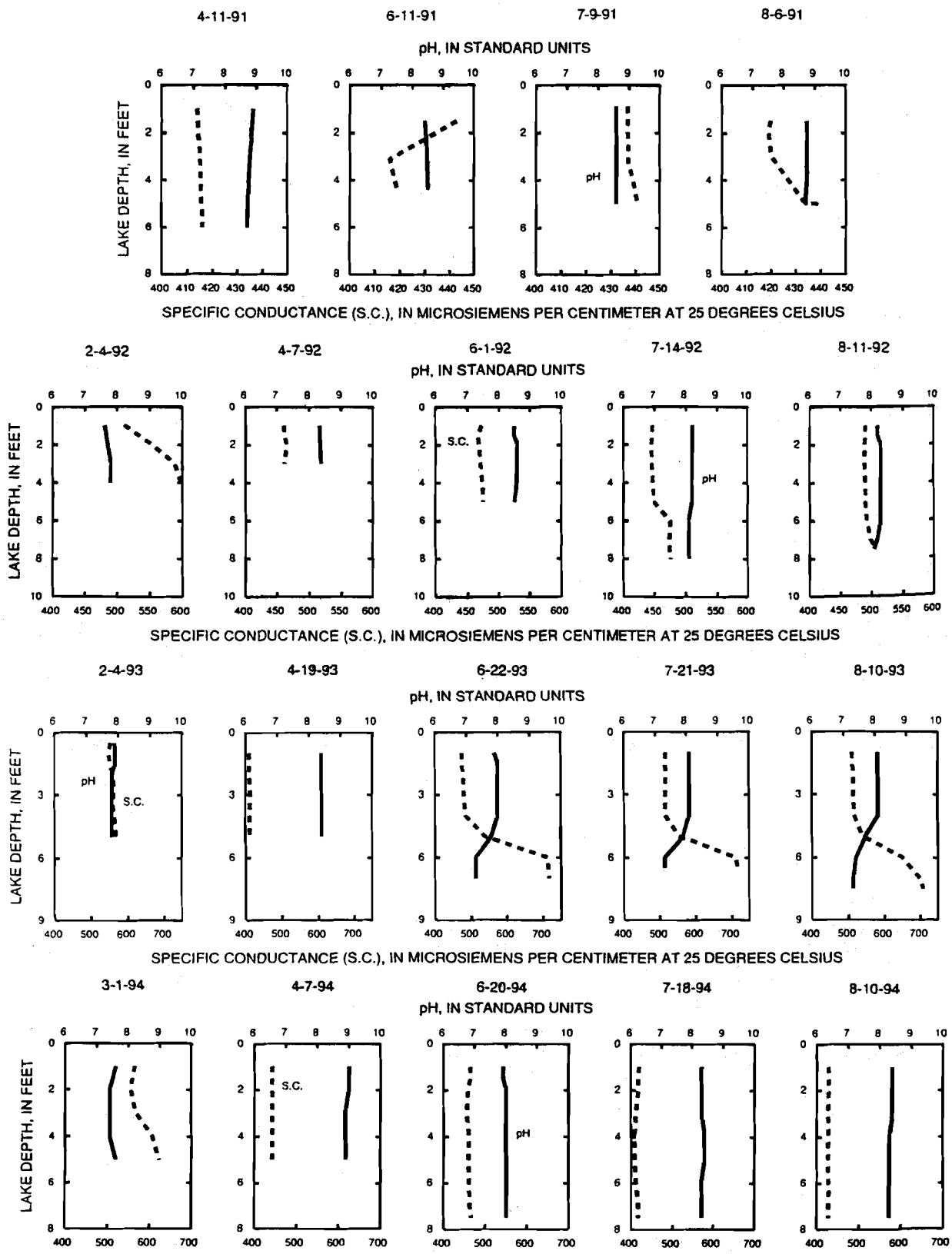
[4] *R.A. Lillie and J.W. Mason, Limnological Characteristics of Wisconsin Lakes, Technical Bulletin No. 138, Wisconsin Department of Natural Resources, 1983.*

[5] *Ibid.*

[6] *Ibid.*

Figure 4

SPECIFIC CONDUCTANCE AND pH PROFILES FOR EAGLE SPRING LAKE: 1991-1994



Source: U.S. Geological Survey.

in which citizen volunteers assist in lake water quality monitoring efforts.

Water clarity generally varies throughout the year as algal populations increase and decrease in response to changes in weather conditions and nutrient loadings. These same factors make Secchi-disk readings vary from year to year as well. Secchi-disk readings for Eagle Spring Lake were between about three and 7.5 feet, with an average of about five feet, and ranged to being close to, or coincident with, the lake bottom. As shown in Figure 2, these values indicate fair to poor water quality compared to other lakes in Southeastern Wisconsin.[7]

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 biomass or amount of algae in the water. Chlorophyll-a concentrations in Eagle Spring Lake ranged from a low of 4 micrograms per liter (μg/l) in June 1994, to a high of 10 μg/l in July 1991. These values were within the range of chlorophyll-a concentrations recorded in other lakes in the Region[8] and indicate good water quality, as illustrated in Figure 2.

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 most important nutrients, in this respect, are phosphorus and nitrogen.

The ratio of total nitrogen to total phosphorus in lake water, or the N:P ratio, can indicate which nutrient is likely to be limiting plant growth. A nitrogen-to-phosphorus ratio greater than 14 to 1, indicates that phosphorus is probably the limiting nutrient, while a ratio of less than 10 to 1 indicates that nitrogen is probably the limiting nutrient.[9] As shown in Table 9, the nitrogen-to-phosphorus ratios in samples collected from Eagle Spring Lake in 1991-94 were always greater than 100. This indicates that plant production was most likely consistently limited by phosphorus. Other factors, such as light, turbulence, and through-flow, may also limit plant growth. These factors are considered further below.

Both total phosphorus and soluble phosphorus concentrations were measured for Eagle Spring 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 plant 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 0.020 mg/l during the period of spring mixing, or turnover. This is the level considered necessary to prevent nuisance algal and macrophyte growths. During the study years, the total spring phosphorus concentrations in Eagle Spring Lake were generally found to be less than 0.02 mg/l, as shown in Table 8. Throughout the 1991 through 1994 study period, total phosphorus in the surface waters of Eagle Spring Lake averaged 0.013 mg/l, indicating good water quality, as illustrated in Figure 2.

Total phosphorus concentrations were found to be higher in the bottom waters, ranging from 0.007 to 0.039 mg/l, as shown in Table 8. The average bottom water total phosphorus concentration in Eagle Spring Lake during the study period was 0.015 mg/l.

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[7] *Ibid.*

[8] *Ibid.*

[9] *M.O. Alum, R.E. Gessner, and J.H. Gokstatter, An Evaluation of the National Eutrophication Data, U.S. Environmental Protection Agency Working Paper No. 900, 1977.*

Table 9

NITROGEN-PHOSPHORUS RATIOS FOR EAGLE SPRING LAKE: 1994

Date	Nutrient Levels		
	Nitrogen (mg/L)	Phosphorus (mg/L)	N:P Ratio
April 11, 1991	1.4	0.010	140
April 7, 1992	1.7	0.006	283
April 19, 1993	1.6	0.013	123
April 7, 1994	1.4	0.009	156

Source: U.S. Geological Survey and SEWRPC.

When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed. Phosphorus from these organisms is then either stored in the bottom sediments or re-released into the water column. Because phosphorus is not highly soluble in water, it readily forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions and accumulates, predominantly, in the lake sediments. If the bottom waters become depleted of oxygen during stratification, however, certain chemical changes occur, 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 more readily released from the sediments. This process also occurs under aerobic conditions, but generally at a slower rate than under anaerobic conditions. As the waters mix, this phosphorus may be widely dispersed throughout the lake waterbody and become available for algal growth.

The 1991 through 1994 data indicated that there was little internal loading of phosphorus from the bottom sediments of Eagle Spring Lake. As shown in Table 8, the dissolved phosphorus concentrations in the bottom waters were relatively low, ranging from 0.013 to 0.030 mg/l for samples collected during the summer, when such releases of phosphorus are most likely to occur. Thus, the contribution of phosphorus from the bottom waters of Eagle Spring Lake may be considered negligible in terms of the total phosphorus load.

CHARACTERISTICS OF BOTTOM SEDIMENT

The sediments of Eagle Spring Lake consist almost entirely of muck. Core samples taken from 11 sites within the Lake basin were analyzed during 1990 by Swanson Environmental, Inc.[10] Analyses of sediment cores from the 11 locations within the Lake were conducted to determine the levels of various nutrients and metals at increasing sediment depths. Map 15 shows the sampling locations and Table 10 lists the concentrations recorded at the referenced locations. Limited additional sediment analyses for heavy metals and pesticides were conducted by Swanson Environmental, Inc., during 1994 on two further sediment samples obtained from the northwestern portion of the Lake.[11]

According to a U.S. Environmental Protection Agency (EPA) classification system for sediments, phosphorus concentrations greater than 650 milligrams per kilogram (mg/kg) are indicative of "heavily polluted"[12] lakes. In Eagle Spring Lake, this indicator was consistently present at less than this threshold value. Sediment phosphorus concentrations varied from not detectable to 83 mg/kg, and were generally found to be highest in the central and western portions of the lake basin. The sediment phosphorus concentrations also showed considerable vertical variation within the cores, with the surface phosphorus concentrations being consistently lower than the concentrations recorded at depth from within the cores, with the exception of the core taken at Station 1, where the surface phosphorus concentration exceeded that at the bottom of the core.

Nitrogen followed a similar pattern, with ammonia being the most commonly observed nitrogen form.

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[10] *Swanson Environmental, Inc., Eagle Springs [sic] Lake Sediment Sampling and Analysis, May 1990.*

[11] *Swanson Environmental, Inc., Eagle Springs [sic] Lake, August 1994.*

[12] *U.S. Environmental Protection Agency, Guidelines for the Pollutional Classification of Great Lakes Harbor Sediment, 1977.*

Table 10

EAGLE SPRING LAKE SEDIMENT CHEMISTRY

Parameter[a]	Sediment Core Site								
	1T	1B	2T	2B	3T	3B	4T	5T	5B
Arsenic	0.3	0.2	0.2	0.2	0.3	0.1	1.0	0.5	1.1
Copper	2.0	ND	2.0	1.0	ND	1.0	2.0	4.0	2.0
Lead	ND	3.0	4.0	2.0	ND	2.0	7.0	8.0	35.0
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia-Nitrogen	35.5	58.5	27.6	25.3	110.0	200.0	21.6	50.6	175.0
Nitrate-Nitrogen	150.0	ND	ND	180.0	ND	150.0	ND	ND	ND
Nitrite-Nitrogen	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphorus	17.0	ND	ND	ND	10.0	63.0	14.0	ND	38.0
Percent Solids	6.4	14.3	17.4	19.4	13.9	15.8	60.9	15.7	39.9

Parameter[a]	Sediment Core Site									
	6T	6B	7T	7B	8T	9T	10T	10B	11T	11B
Arsenic	0.3	ND	0.4	ND	1.2	0.2	0.3	3.0	0.7	0.2
Copper	1.0	2.0	ND	ND	ND	1.0	1.0	1.0	1.0	ND
Lead	ND	6.0	5.0	ND	21.0	13.0	13.0	16.0	10.0	4.0
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia-Nitrogen	110.0	250.0	85.0	230.0	89.0	32.4	55.1	140.0	63.0	198.0
Nitrate-Nitrogen	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrite-Nitrogen	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphorus	51.0	72.0	ND	19.0	ND	ND	ND	83.0	ND	ND
Percent Solids	12.9	17.9	13.4	14.7	29.5	39.5	14.8	52.6	25.9	15.5

NOTE: ND means concentrations were not found above the detection limits for the parameter noted.

[a]*Parameters measured in milligrams per kilogram (mg/kg).*

Source: Swanson Environmental, Inc., and SEWRPC.

Ammonia-nitrogen concentrations ranged from 21.6 mg/kg to 250 mg/kg, with the higher concentrations being found in the deeper sediments, with the exception of the core taken at Station 2, where the surface ammonia concentration was somewhat higher than that at the bottom of the core. Nitrate-nitrogen was the only other commonly observed nitrogen fraction found in the Eagle Spring Lake sediments ranging from not detectable to 180 mg/kg. Nitrate was found only along the western shore of the Lake in the areas which had the greatest sediment accumulation. At Station 1 the surface nitrate concentration exceeded that at the bottom of the core. At Stations 2 and 3 nitrate concentrations were greatest at depth with no detection of nitrate occurring at the remaining sites.

These vertical variations of phosphorus and nitrogen within the cores taken may imply a diminishing pollutant loading from surface water runoff. However, most of the land uses in the area tributary to the Lake have been relatively stable and there have been no major controls put in place to minimize the impacts. Potentially improved agricultural land management practices or the conversion of row crops to pasture or other types of agricultural uses could be at least partially responsible for the observed phenomenon. Further, the presence of clear concentration gradients with depth in the sediment cores would suggest a relative lack of bioturbation—or mixing of the sediments by bottom dwelling animals—or resuspension—by wind waves and currents—which would result in a more even distribution of nutrient concentrations within the sediment profile. Indeed, this latter assumption is borne out by the inverse sorting of particulates observed in terms of the grain size distributions especially at Stations 3, 6, and 11, where coarser

particles were found to lie atop finer particles. These factors indicate the potential for pollutant loadings being discharged to the Lake via contaminated groundwater influx.

Arsenic, copper and lead concentrations varied both spatially and with depth in the sediment profile, with the highest concentrations generally recorded in the shallow sediments near the eastern shoreline. Between 1950 and 1963, 4,360 pounds of sodium arsenite were applied to Eagle Spring Lake to control aquatic plant growth in the lake basin. Sodium arsenite applications occurred annually in 1951 through 1953, in 1956, and again annually in 1961 through 1963. The 1951 application amounted to 400 pounds; the 1952, 1953, and 1956 applications amounted to 600 pounds each; and the 1961 through 1963 applications amounted to 720 pounds each of the chemical herbicide. No applications of sodium arsenite have taken place in the Lake since 1963. If it is assumed that the majority of the sediment arsenic detected in Eagle Spring Lake is from this source, it is not surprising to find that arsenic concentrations tended to be higher in the surface portions of the cores than in the lower portions. Exceptions to this generalization occurred at Stations 5 and 10. With the exception of the samples obtained from the lower portion of the cores taken at Stations 6 and 7, where the arsenic concentrations were not detectable, arsenic concentrations ranged from 0.1 mg/kg to 3.0 mg/kg with the higher concentrations occurring in the surface sediments at Stations 4 and 8 and in the lower sediments at Station 10. Such a distribution is consistent with a lack of bioturbation and resuspension.

With the exception of Stations 3 and 6, copper concentrations also tended to be higher in the surface layers of the sediments than in the bottom portions of the cores. This would further suggest the lack of bioturbation and resuspension, and would be consistent with the relatively recent applications of copper-based algicides to the lake. Copper concentrations ranged from not detectable at Station 7 to 4.0 mg/kg at Station 5.

Lead concentrations, generally followed a similar pattern of distribution as the other two metals with surface concentrations commonly being higher than concentrations measured lower in the cores. Stations 3, 5, 6, and 10 were exceptions to this generalization, with the highest recorded lead concentration occurring in the lower portions of the core taken in the main lake basin at Station 5—35 mg/kg.

Mercury was not detectable in any of the sediments sampled during the survey.

Comparing these data to the draft sediment quality screening criteria of the Wisconsin Department of Natural Resources—set forth in summarized form in Table 11—suggests that the sediment quality of Eagle Spring Lake generally meets the State quality guidelines at most sampling station sites. Lead is one exception to this generalization. The measured lead concentration at Station 5 of 35 mg/kg marginally exceeds the recommended guideline lowest effect level (LEL) concentration of 31 mg/kg. This slightly elevated concentration of lead could reflect the presence of lead shot in the lake sediments given the location of Station 5 near a popular duck hunting venue. The measured ammonia concentrations at Stations 3, 5, 6, 7, 8, 10, and 11 also exceeded the recommended guideline LEL value of 75 mg/kg.

POLLUTION LOADINGS AND SOURCES

Currently, there are no known point source discharges of pollutants to Eagle Spring Lake or to the surface waters tributary to Eagle Spring Lake. Nonpoint sources of water pollution include urban sources, such as runoff from residential, commercial, transportation, construction, and recreational activities; and rural sources, such as runoff from agricultural lands and onsite sewage disposal systems. The tributary drainage area of Eagle Spring Lake is about 26.1 square miles in size, including about 9.7 square miles that drains to the Lake without passing through Lulu Lake, and about 16.4 square miles which drain to Lulu Lake or the Mukwonago River upstream of Lulu Lake. As already noted, inflow to Eagle Spring Lake is primarily through the Mukwonago River, which passes through upstream Lulu Lake prior to entering Eagle Spring Lake. The water quality significance of the differing tributary drainage areas is thus related to the retention of phosphorus and sediments within the upstream waterbody and wetland areas.

Table 11

WISCONSIN DEPARTMENT OF NATURAL RESOURCES DRAFT SEDIMENT QUALITY SCREENING CRITERIA[a]

Chemical	Lowest Effect Level (LEL)	Medium Effect Level (MEL)	Severe Effect Level (SEL)
Arsenic	6	33	85
Copper	25	110	390
Lead	31	110	250
Mercury	0.15	0.2	1.3
Ammonia-Nitrogen	75	--	--

[a]Units are in mg/kg—dry sediment.

Source: Wisconsin Department of Natural Resources.

In order to estimate the amount of pollution contributed by these sources to Eagle Spring Lake, annual loading budgets for phosphorus and sediment were developed for the watershed under the study using the unit area load model. The results of that model were checked by comparison to analysis prepared by the Commission staff utilizing the Wisconsin Lake Model Spreadsheet (WILMS) version 1.01, and to data provided by Ms Fay U. Amerson, consultant to the Eagle Spring Lake Management District. The data from these three sources compared relatively well within the expected range. The resulting estimated phosphorus budget for Eagle Spring Lake, is shown in Table 12. A total annual phosphorus loading of about 2,050 pounds is estimated to be contributed to Eagle Spring Lake. Of this total, it is estimated that about 1,315 pounds per year, or 64 percent of the total loading, was contributed by runoff from rural land; and about 511 pounds per year, or 25 percent, was contributed by runoff from urban land. The remaining phosphorus loading was contributed by onsite sewage disposal systems and precipitation. Phosphorus release from the Lake bottom sediments—internal loading—may also contribute phosphorus to the Lake. However, this loading was assumed to be negligible as Eagle Spring Lake rarely stratified during the study period and phosphorus releases from bottom sediments are generally due to the reactions induced by stratification.

As of 1995, the entire drainage area tributary to Eagle Spring Lake was served by onsite sewage disposal systems. Approximately 300 onsite sewage disposal systems exist in the riparian residential land area surrounding Eagle Spring Lake. Those onsite systems located on the western and northern shorelines may be expected to discharge to the groundwater reservoir, which, in turn, discharges to Eagle Spring Lake. Onsite sewage disposal systems are designed to remove phosphorus by adsorption to soil in the drainfield. The removal capacity decreases with increasing soil particle size; and all soils have a fixed adsorptive capacity that can eventually become exhausted. Onsite sewage disposal systems include conventional septic tank systems, mound systems, and holding tanks. Holding tanks store wastewater temporarily until it is pumped and conveyed by tank truck to a sewage treatment plant, storage lagoon, or land disposal site. All other types of onsite systems discharge effluent to the groundwater reservoir.

Provided that the systems are located, installed, used, and maintained properly, the 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. The residential development surrounding Eagle Spring Lake is located in areas covered by soils where the suitability for conventional septic tanks is undeterminate due to the range of characteristics and slopes which occur, as shown on Map 7. Thus, systems may be functioning properly. However, as discussed further in Chapter VII, a local facility planning program[13] conducted in 1985 for the then existing Eagle Spring Lake Sanitary District concluded that about 43 percent of the onsite sewage disposal systems serving the urban development surrounding the Lake would have to be replaced with holding tanks over a 20-year period. That study also estimated that the majority of the remaining systems would have to undergo major repair or replacement during a 20-year plan-

[13]*Strand Associates, Inc., Environmental Information Document and Cost Effectiveness Analysis; Eagle Spring Lake Sanitary District, October 1985.*

Table 12

ESTIMATED TOTAL PHOSPHORUS LOADS TO EAGLE SPRING LAKE: 1990

Pollution Source	Total Loading (pounds per year)	Percent Distribution
Urban Runoff		
Residential	318	15
Commercial	15	1
Industrial	14	1
Communications	60	3
Governmental and Institutional	44	2
Recreational	60	3
Subtotal	511	25
Rural Runoff		
Agricultural	1,141	55
Woodlands and Wetlands	117	6
Surface Water	57	3
Subtotal	1,315	64
Atmospheric	57	3
Onsite Sewage Disposal Systems	168	8
Total	2,051	100

Source: SEWRPC.

ning period. The analysis of the local facility planning program concluded that a public sanitary sewerage system should be constructed to serve the area.

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. Also, some installations, designed for vacation or seasonal home use are now in use year-round and are potentially subject to overloading.

Approximately 23 percent of the total phosphorus loading on the Lake, or 470 pounds, is estimated to be used by the biomass within the Lake or deposited in the lake sediments,[14] resulting in a net downstream transport of 1,580 pounds of phosphorus, or 77 percent of the total phosphorus loading on the Lake. The phosphorus mass retained in the Lake is typically reduced by the Eagle Spring Lake Management District aquatic plant harvesting program, which removes phosphorus from the Lake[15] as a component of the aquatic plant biomass.

Sediment Loads

Bottom sediment conditions have an important effect on the condition of a lake. As the sediment is deposited, valuable benthic habitats are buried, macrophyte-prone substrates are increased, fish

[14] *D.P. Larsen and H.T. Mercier, "Phosphorus retention capacity of lakes," Journal of the Fisheries Research Board of Canada, Volume 33, pp. 1742-1750, 1976.*

[15] *T.M. Burton, D.L. King, and J.L. Ervin, "Aquatic Plant Harvesting As A Lake Restoration Technique," Proceedings of the U.S. Environmental Protection Agency National Lake Restoration Conference, EPA 440/5-79-OD1, 1979. See also, U.S. Environmental Protection Agency Report No. EPA-440/4-90-006, The Lake and Reservoir Restoration Guidance Manual—Second Edition, August 1990.*

spawning areas are covered, and aesthetic nuisances develop. Sediment particles also act as transport mechanisms for other substances, such as phosphorus, nitrogen, organic materials, pesticides, and heavy metals.

The annual sediment load to Eagle Spring Lake was estimated to be about 180 tons. About 100 tons per year, or 55 percent of the total sediment load, was estimated to be contributed by runoff from rural land, and approximately 80 tons per year, or 45 percent of the total sediment load, was estimated to be contributed by runoff from urban land.[16] Sediment transport out of Eagle Spring Lake was estimated to be about 140 tons after accounting for in-lake retention of sediments in Eagle Spring Lake.

RATING OF TROPHIC CONDITION

Lakes are commonly classified according to their degree of nutrient enrichment or trophic status. The ability of a lake to support a variety of recreational activities and healthy fish and aquatic life communities is often correlated to the degree of nutrient enrichment that has occurred. There are three terms usually used to describe the trophic status of a lake: oligotrophic, mesotrophic, and eutrophic. Oligotrophic lakes are nutrient-poor lakes. These lakes characteristically support relatively few aquatic plants and often do not contain productive fisheries. Because of the naturally fertile soils and the intensive land use practices employed in the State, there are relatively few oligotrophic lakes in Southeastern Wisconsin. Mesotrophic lakes are moderately fertile lakes that support abundant aquatic plant growths and may support productive fisheries. Nuisance growths of algae and weeds are usually not exhibited by mesotrophic lakes. Many of the cleaner lakes in Southeastern Wisconsin are classified as mesotrophic. Eutrophic lakes are defined as nutrient-rich lakes. These lakes are often characterized by excessive growths of aquatic weeds and frequent algal blooms. Many eutrophic lakes support very productive fisheries. In shallow eutrophic lakes, fish winterkills may also be common. Many of the more polluted lakes in Southeastern Wisconsin are classified as eutrophic. Extremely eutrophic lakes may be described by a further descriptor, hypertrophic or hypereutrophic.

Several numeric "scales," based on one or more water quality indicators, have been developed to define the trophic condition of a lake. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numeric scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scale used is appropriate for the lake to which it is applies. In this case, two indices, specific to Wisconsin lakes, have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[17] and the Carlson Trophic State Index (TSI).[18] In addition, the Wisconsin Trophic State Index value (WTSI) is presented.[19] The WTSI is a refinement of the Carlson TSI designed to account for the greater humic acid content—brown water color—present in Wisconsin lakes, and has been adopted by the Wisconsin Department of Natural Resources for use in lake management investigations.

Using the Vollenweider trophic system and applying the data in Table 8, Eagle Spring Lake would be classified as being between the mesotrophic and oligotrophic state based upon phosphorus levels, as shown in Figure 5. Based upon chlorophyll-a levels, the Lake would be classified as being mesotrophic, and based upon Secchi-disk readings the Lake would be classified as eutrophic, as shown in

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[16] *Using the method of Larsen and Mercier, op. cit.*

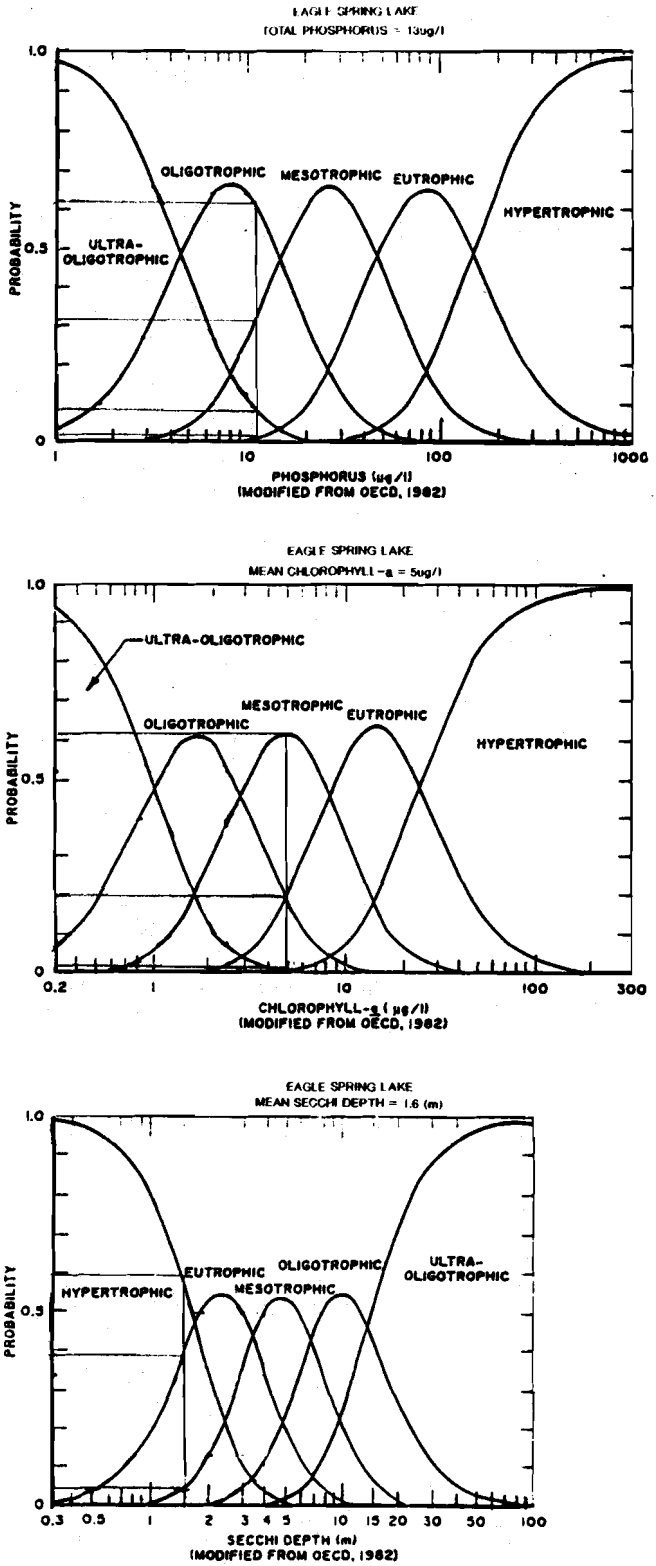
[17] *H. Olem and G. Flock, The Lake and Reservoir Restoration Guidance Manual, Second Edition, U.S. Environmental Protection Agency Report EPA-440/4-90-006, Office of Water (WH-553), Washington, D.C., August 1990.*

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

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

Figure 5

TROPHIC STATE CLASSIFICATION OF EAGLE SPRING LAKE BASED UPON THE VOLLENWEIDER MODEL



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

Figure 5. While these indicators result in widely varying lake trophic state classifications, it may be concluded that Eagle Spring Lake should be classified as a mesotrophic lake, or a lake with acceptable water quality for most uses, given that the shallow nature of the Lake may result in the resuspension of bottom sediments that could result in a more turbid conditions than might be anticipated in a lake of similar area but greater depth. In this case, and for this reason, greater weight has been attached to the phosphorus and chlorophyll-based probability distributions.

Trophic State Index

The Trophic State Index (TSI) assigns a numerical trophic condition rating based on Secchi-disk transparency, and total phosphorus and chlorophyll-a concentrations. The original Trophic State Index developed by Carlson has been modified for Wisconsin lakes by the Wisconsin Department of Natural Resources using data on 184 lakes throughout the State.[20] The Trophic State Index ratings for Eagle Spring Lake are shown in Figures 6 and 7 as a function of sampling date. Based on the Trophic State Index rating of 49 and Wisconsin Trophic State Index rating of 52, Eagle Spring Lake may also be classified as mesotrophic under both of these systems.

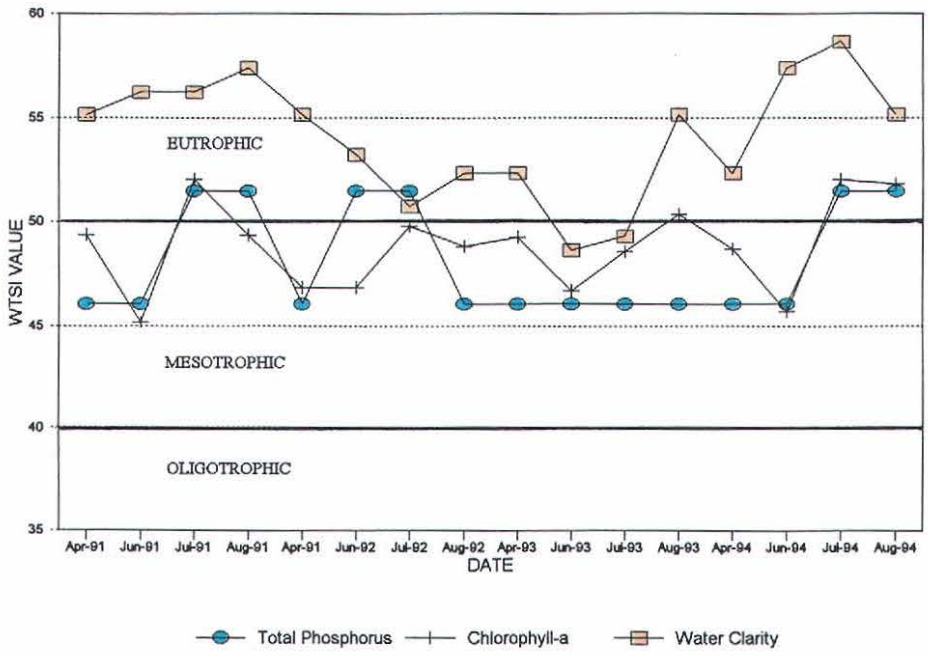
SUMMARY

Eagle Spring Lake represents a typical hard-water, alkaline lake that has not been subjected to high levels of pollution. Physical and chemical parameters measured during the study period—with the exception of water clarity—indicated that the water quality is within the "good" range, compared to other regional lakes. Total phosphorus levels were found to be generally below the level considered to cause nuisance algal and macrophytic growths. Summer stratification was rarely observed in Eagle Spring Lake. Winterkill was not a problem in Eagle Spring Lake, because dissolved oxygen levels were found to be adequate for the support of fish

[20] *R.A. Lillie, S. Graham, and P. Rasmussen, op. cit.*

Figure 6

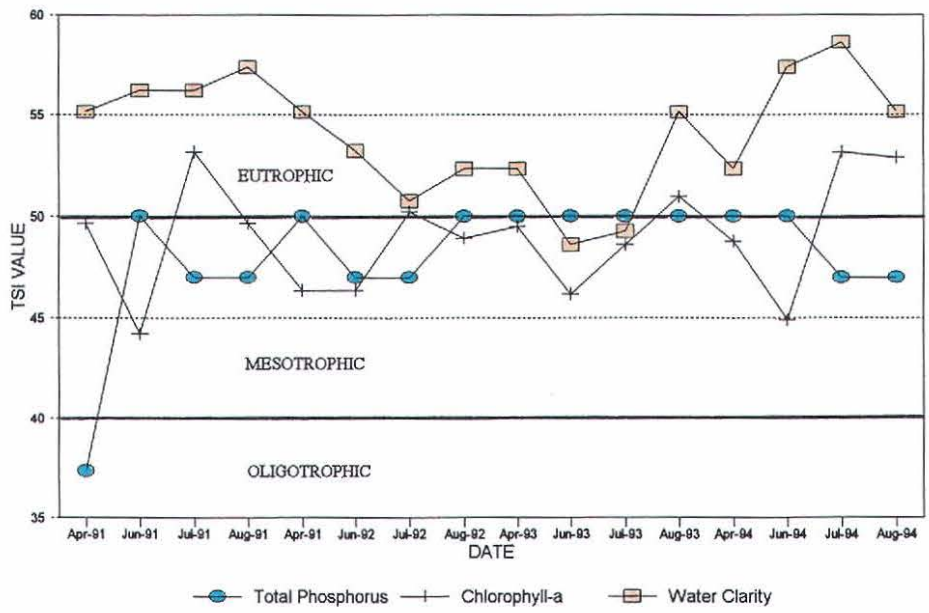
TROPHIC STATE OF EAGLE SPRING LAKE BASED UPON WISCONSIN TROPHIC STATUS INDEX: 1991-1994



Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 7

TROPHIC STATE OF EAGLE SPRING LAKE BASED UPON CARLSON'S TROPHIC STATUS INDEX: 1991-1994



Source: Wisconsin Department of Natural Resources and SEWRPC.

throughout the winter. Internal releases of phosphorus from the bottom sediments were not considered to be a problem in Eagle Spring Lake.

There were no known point sources of pollutants in the Eagle Spring Lake watershed. Nonpoint sources of pollution included stormwater runoff from urban and agricultural areas. Sediment and phosphorus loadings from the watershed were estimated.

In 1995, the total annual phosphorus load to Eagle Spring Lake was estimated to be about 2,050 pounds. Runoff from the rural lands contributed the largest amount of phosphorus, about 64 percent of the total phosphorus load, with the runoff from urban land contributing about 25 percent of the total phosphorus load. Onsite sewage disposal systems and precipitation contributed the balance. Approximately 23 percent, or 470 pounds, of the total phosphorus loading is estimated to remain in the Lake by conversion to biomass or through sedimentation, resulting in a net transfer of 1,580 pounds of phosphorus downstream.

Based on the Vollenweider phosphorus loading model and the Trophic State Index ratings calculated from Eagle Spring Lake data, Eagle Spring Lake may be classified as a mesotrophic lake.

Chapter V

AQUATIC BIOTA AND ECOLOGICALLY VALUABLE AREAS

INTRODUCTION

Eagle Spring Lake is an important element of the natural resource base of the Town of Eagle. 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 urban settings, resource features such as lakes and wetlands are typically subject to extensive recreational use and high levels of pollutant discharges, common forms of stress to aquatic systems, and this 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 individual resource features, as well as of the urban development in the area concerned. Accordingly, this chapter provides information concerning the natural resource features of the Eagle Spring Lake watershed, including data on primary environmental corridors, wetlands, aquatic macrophytes, fish, and wildlife. Recreational activities relating to the use of these natural resource features are described in Chapter VI.

AQUATIC PLANTS

Aquatic plants include larger plants, or macrophytes, and microscopic algae, or phytoplankton. These 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.

Aquatic Macrophytes

Aquatic macrophytes play an important role in the ecology of Southeastern Wisconsin lakes. They can be either beneficial or a nuisance, depending on their distribution and abundance, and the activities taking place on the waterbody. Macrophytes are usually an asset because they provide food and habitat for fish and other aquatic life, produce oxygen, and may remove nutrients and pollutants from the water that could otherwise cause algal blooms or other problems. Aquatic macrophytes become a nuisance when their presence reaches densities that interfere with swimming and boating and the normal functioning of a lake ecosystem. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate, wave action, and type of fish populations present, determine the distribution and abundance of aquatic macrophytes in a lake. Some nonnative plant species, lacking natural controls, may be especially favored by the habitats available in this Region and can exhibit explosive growths to the detriment not only of lake users but also of indigenous aquatic life and native plant species.

To document the types and relative abundances of aquatic macrophytes in Eagle Spring Lake, an aquatic plant survey was conducted by staff of the Southeastern Wisconsin Regional Planning Commission during July 1994. The survey of aquatic plant communities in Eagle Spring Lake was conducted in association with the Lake Management District. The aquatic plant survey was designed to determine species composition. A species list, compiled from the results of this aquatic plant survey, is set forth in Table 13.

During the July 1994 survey, 20 species of plants were identified in Eagle Spring Lake, many of which were common to abundant. Species that interfere with the recreational and aesthetic use of the Lake, such as Myriophyllum spicatum, Ceratophyllum demersum, and Potamogeton crispus, were found to be present in the Lake, all but the latter being found to be common. Plant growth occurred throughout the Lake. Musk grass (Chara spp.) and wild celery (Vallisneria americana) were the dominant species in many areas of the main basin, and were especially abundant in the southern portion of the main lake basin at depths of up to six feet. Ceratophyllum demersum and Potamogeton pectinatus were common in the northern portion of the

Table 13

AQUATIC PLANT SPECIES PRESENT IN EAGLE SPRING LAKE AND THEIR POSITIVE ECOLOGICAL SIGNIFICANCE

Aquatic Plant Species Present	Abundance	Ecological Significance[a]
Ceratophyllum demersum (coontail)	Common	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara Vulgaris (muskgrass)	Abundant	Excellent producer of fish food, especially for young trout, bluegills, and small and largemouth bass; stabilizes bottom sediments; and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed)	Common	Provides shelter and support for insects which are valuable as fish food
Lemna minor (lesser duckweed)	Common	Provides important food for wildfowl and attracts small aquatic animals
Myriophyllum sp. (native milfoil)	Common	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	Common	None known
Najas flexilis (bushy pondweed)	Common	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	Common	Provides good food and shelter for fish and food for ducks
Nuphar sp. (yellow water lily)	Common	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 tuberosa (white water lily)	Common	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 crispus (crispy-leaf pondweed)	Scarce	Provides food, shelter, and shade for some fish and food for wildfowl
Potamogeton gramineus (variable pondweed)	Scarce	Provides food important to ducks and food and cover for fish
Potamogeton illinoensis (Illinois pondweed)	Scarce	Provides some food for ducks and shelter for fish
Potamogeton natans (floating-leaf pondweed)	Common	Provides good food for ducks late in the season
Potamogeton pectinatus (sago pondweed)	Common	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton zosteriformis (flat-stemmed pondweed)	Scarce	Provides some food for ducks
Ranunculus sp. (water buttercup)	Scarce	Provides food for trout, upland game birds, and wildfowl
Typha latifolia (cattail)	Common	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
Utricularia sp. (bladderwort)	Common	Provides good food and cover for fish
Vallisneria americana (water celery)	Abundant	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.

main lake basin at depths of four to six feet. Myriophyllum spicatum was largely confined to the southeastern embayment. The distribution of these plant communities is shown on Map 16.

Due to the navigable connection between Eagle Spring Lake and Lulu Lake, a survey of aquatic plant communities in Lulu Lake was also conducted by Commission staff during July 1994. The species list, compiled from the results of this aquatic plant survey, is set forth in Table 14. This survey identified some 21 species of plants, many of which were found to be common to abundant. Species that interfere with the recreational and aesthetic use of the Lake, such as Myriophyllum spicatum, Ceratophyllum demersum, and P. crispus, were also found to be present in the Lake, but all were found to be scarce. Plant growth occurred primarily along the periphery of Lulu Lake to water depth of up to 15 feet. Musk grass (Chara spp.), bushy pondweed (Najas flexilis), and spiny naiad (Najas marina) were the dominant species in many areas of the main basin which are at depths of up to 15 feet. Ceratophyllum demersum occurred in the vicinity of the Mukwonago River inlet of the Lake. Myriophyllum spicatum was largely confined to the northern shores adjacent to the Mukwonago River outlet from the Lake to Eagle Spring Lake, appearing to have been introduced to Lulu Lake from Eagle Spring Lake by the boat traffic that routinely traverses the short section of river between the two Lakes. The distribution of these plant communities is shown on Map 17.

The Eagle Spring Lake inlet area, downstream of Lulu Lake, is a large wetland-waterway complex. Aquatic plant control programs should not extend into this area or into the upper reaches of the impoundment except for a narrow navigation channel to provide access along the Mukwonago River between the main basins of Eagle Spring and Lulu Lakes.

In general, Eagle Spring and Lulu Lakes support a healthy and diverse aquatic macrophyte community. Portions of Eagle Spring Lake, however, included species such as milfoil and coontail to the extent where dense mats of vegetation form leaving potential for interfering with boat traffic. Further, field reconnaissance by Commission staff in 1996 indicated that Eurasian water milfoil has spread beyond the areas identified in the 1994 aquatic plant survey, as shown on Map 16.

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, in single cells or colonies, and can be either attached or free floating. Phytoplankton abundance varies seasonally with fluctuations in solar irradiance, turbulence due to prevailing winds, and nutrient availability. In lakes with high nutrient levels, heavy growths of phytoplankton, or algal blooms, may occur.

Algal blooms have occurred on Eagle Spring Lake, as indicated by chlorophyll-a concentrations in excess of 20 micrograms per liter, as summarized in Table 8, but have not been perceived as a major problem to date. Therefore, identification and quantification of those algae present within the Lake were not included as part of prior U.S. Geological Survey or Wisconsin Department of Natural Resources studies.

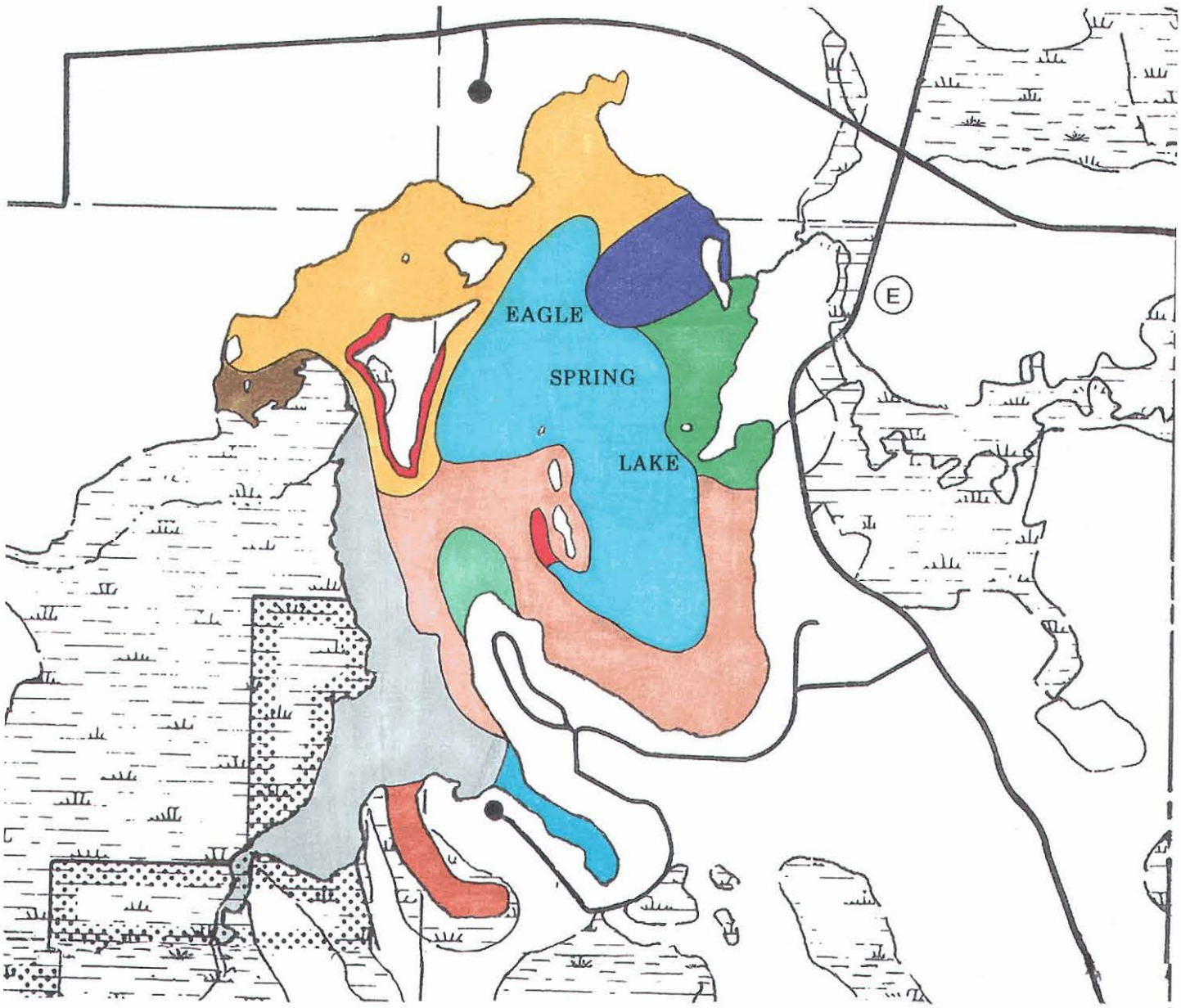
Aquatic Plant Management

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 Eagle Spring Lake took place in 1951. Aquatic plant management activities in Eagle Spring Lake can be categorized as macrophyte harvesting, chemical macrophyte control, and chemical algae control.

Perceived excessive macrophyte growth on Eagle Spring Lake has historically resulted in control programs that have used both harvesting and chemicals. Under the present macrophyte control program, the Eagle Spring Lake Management District harvests macrophytes with two Aquarius Systems H-220 harvesters. Typically, macrophytes growing throughout the Lake are cut. No State permits are currently required to mechanically harvest vegetation in lakes, although the harvested plant material must, under State regulations, be removed from the water.

Map 16

AQUATIC PLANT COMMUNITY DISTRIBUTION IN EAGLE SPRING LAKE: 1994



LEGEND

- MIXED SUBMERGENTS WITH FEW FLOATING AND EMERGENT SPECIES
- EURASIAN WATER MILFOIL, COONTAIL, COMMON WATER WEED, AND WILD CELERY
- MUSKGRASS, WILD CELERY, AND BUSHY PONDWEED
- MIXED PONDWEEDS, SPINY NAIAD, AND MUSKGRASS
- MUSKGRASS, BUSHY AND SAGO PONDWEED
- MIXED WATER LILIES, SAGO PONDWEED, AND MUSKGRASS
- MUSKGRASS, WHITE WATER LILY, AND CLASPING-LEAF PONDWEED
- NEEDLE SPIKE RUSH, MUSKGRASS, WILD CELERY, AND WATER MILFOIL
- COONTAIL, WILD CELERY, NATIVE WATER MILFOIL, MUSKGRASS, VARIABLE-LEAF, AND SAGO PONDWEED
- MUSKGRASS, SPINY NAIAD, VARIABLE-LEAF PONDWEED, YELLOW WATER LILY, AND SOFT STEM BULRUSH
- MIXED WATER LILIES AND CATTAILS, GREAT BLADDERWORT, MUCKGRASS, AND FLOATING-LEAF PONDWEED

GRAPHIC SCALE
0 500 1000 FEET

NOTE: Further field surveys conducted by the Commission staff in 1996 indicated that Eurasian water milfoil has been identified throughout all of the above areas.

Source: SEWRPC.

Table 14

AQUATIC PLANT SPECIES PRESENT IN LULU LAKE AND THEIR POSITIVE ECOLOGICAL SIGNIFICANCE

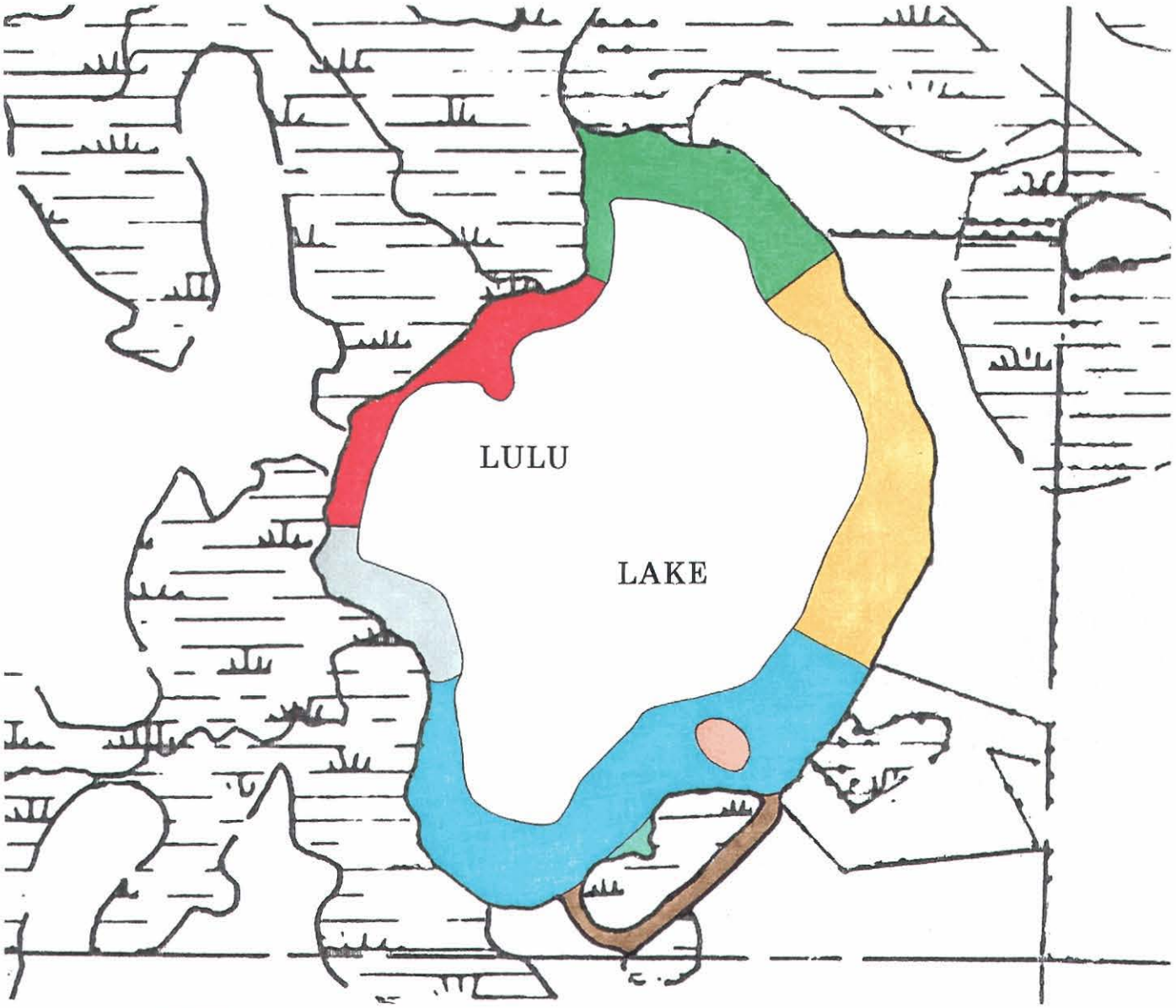
Aquatic Plant Species Present	Abundance	Ecological Significance[a]
Ceratophyllum demersum (coontail)	Scarce	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara Vulgaris (muskgrass)	Abundant	Excellent producer of fish food, especially for young trout, bluegills, and small and largemouth bass; stabilizes bottom sediments; and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed)	Scarce	Provides shelter and support for insects which are valuable as fish food
Lemna minor (lesser duckweed)	Scarce	Provides important food for wildfowl and attracts small aquatic animals
Myriophyllum sp. (native milfoil)	Scarce	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	Scarce	None known
Najas flexilis (bushy pondweed)	Abundant	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	Abundant	Provides good food and shelter for fish and food for ducks
Nuphar sp. (yellow water lily)	Common	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 tuberosa (white water lily)	Common	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 crispus (crispy-leaf pondweed)	Scarce	Provides food, shelter, and shade for some fish and food for wildfowl
Potamogeton foliosus (leafy pondweed)	Scarce	Provides important food for wildfowl and food and shelter for fish
Potamogeton gramineus (variable pondweed)	Scarce	Provides food important to ducks and food and cover for fish
Potamogeton illinoensis (Illinois pondweed)	Scarce	Provides some food for ducks and shelter for fish
Potamogeton natans (floating-leaf pondweed)	Scarce	Provides good food for ducks late in the season
Potamogeton pectinatus (sago pondweed)	Scarce	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton richardsonii (Richardson's pondweed)	Scarce	Provides good food and cover for fish and supports insects
Potamogeton zosteriformis (flat-stemmed pondweed)	Scarce	Provides some food for ducks
Typha sp. (cattail)	Common	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
Utricularia sp. (bladderwort)	Scarce	Provides good food and cover for fish
Vallisneria americana (water celery)	Scarce	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.

Map 17

AQUATIC PLANT COMMUNITY DISTRIBUTION IN LULU LAKE: 1994



LEGEND

- MIXED PONDWEEDS, WATERWEED, MUSKGRASS, AND WILD CELERY
- MUSKGRASS, MIXED PONDWEEDS, WHITE WATER LILY, AND NATIVE WATER MILFOIL
- SOFT-STEM BULRUSH, MUSKGRASS, BUSHY PONDWEED, AND SPINY NAIAD
- MIXED PONDWEEDS, SPINY NAIAD, NATIVE WATER MILFOIL, AND WILD CELERY
- MUSKGRASS, SPINY NAIAD, GREAT BLADDERWORT, BUSHY PONDWEED, AND YELLOW WATER LILY
- MIXED CATTAILS, BULRUSH AND PONDWEEDS, SPINEY NAIAD, AND WHITE AND YELLOW WATER LILIES
- COONTAIL, FLAT-STEM PONDWEED, FLOATING-LEAF PONDWEED, AND WHITE AND YELLOW WATER LILIES
- SOFT-STEM BULRUSH, MUSKGRASS, MIXED PONDWEEDS, SPINY NAIAD, AND EURASIAN WATER MILFOIL

GRAPHIC SCALE
0 250 500 FEET

Source: SEWRPC.

Since 1941, the use of chemicals to control aquatic plants has been regulated in Wisconsin. Chemical herbicides are known to have been applied to Eagle Spring Lake from at least 1951 through 1982, after which the practice was discontinued.

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 came into general use. The amounts of sodium arsenite applied to Eagle Spring Lake, and years of application during the period 1951 through 1963, are listed on Table 15; the total amount of sodium arsenite applied over this 13-year period being about 4,360 pounds.

Sodium arsenite was typically sprayed onto the surface of Eagle Spring Lake within an area of up to 200 feet from the shoreline. Treatment typically occurred between mid-June and mid-July. The amount of sodium arsenite used was calculated to result in a concentration of about 10 milligrams per liter (mg/l) sodium arsenite (about 5 mg/l arsenic) in the treated lake water. The sodium arsenite typically remained in the water column for less than 120 days. Although the arsenic residue was naturally converted from a highly toxic form to a less toxic and less biologically active form, much of the arsenic residue was deposited in the lake sediments.

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

Although anaerobic conditions are uncommon on Eagle Spring Lake, some arsenic may be released from the bottom sediments to the water column during the infrequent periods of anaerobiasis that do occur. In this way, some arsenic probably continues to be "flushed out" of Eagle Spring Lake. However, the arsenic-laden sediments 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. There is some evidence, as indicated in Chapter IV, that the arsenic-laden sediments in Eagle Spring Lake have been covered by such additional debris which has entered the Lake and do not appear to be releasing arsenic into the water column. No significant sediment arsenic concentrations were reported by Swanson Environmental, Inc., under contract to the Lake Management District, during their 1990 survey. The concentrations measured are summarized in Table 10 and were within the Lowest Effect Level (LEL) guidelines proposed by the Wisconsin Department of Natural Resources.[1]

As shown in Table 15, the aquatic herbicides Diquat, Aquathol, and 2,4-D have also been applied to Eagle Spring Lake to control aquatic macrophyte growth. 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 kill many other aquatic plants such as pondweeds (Potamogeton spp.), bladderwort (Utricularia sp.), and naiads (Najas spp.). Aquathol and Hydrothol kill 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 species such as water lilies (Nymphaea sp. and Nuphar sp.). The present restrictions on water use after application of these herbicides are given in Table 16.

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[1] *Wisconsin Department of Natural Resources, (DRAFT) Inventory of Statewide Contaminated Sediment Sites and Development of a Prioritization System, June 1994.*

Table 15

HISTORIC CHEMICAL CONTROLS ON EAGLE SPRING LAKE: 1951-1997

Year[a]	Macrophyte Control				Algal Control	
	Sodium Arsenite (pounds)	Diquat (gallons)	Aquathol K (gallons)	2,4-D (pounds)	Copper Sulfate (pounds)	Cutrine-Plus (gallons)
1951	400	0	0	0	20.0	0.0
1952	600	0	0	0	0.0	0.0
1953	600	0	0	0	30.0	0.0
1956	600	0	0	0	0.0	0.0
1961	720	0	0	0	0.0	0.0
1962	720	0	0	0	0.0	0.0
1963	720	0	0	0	0.0	0.0
1969	0	3	0	0	200.0	0.0
1973	0	0	25	0	0.0	0.0
1974	0	0	20	0	15.0	0.0
1975	0	0	23	0	39.3	11.5
1978	0	0	9	0	0.0	8.5
1980	0	0	0	50	0.0	0.0
1981	0	0	0	40	0.0	0.0
1982	0	0	0	40	0.0	0.0
Total	4,360	3	77	130	304.3	20.0

[a]*During years not included, no chemical controls were used.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

In addition to the chemical herbicides used to control large aquatic plants, algicides have also been applied to Eagle Spring Lake up until 1979. As shown in Table 15, copper sulfate and Cutrine Plus have been applied to Eagle Spring Lake, on occasion. 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 harmful to humans. No significant copper concentrations were reported by Swanson Environmental, Inc., under contract to the Lake Management District, during their 1990 survey. The concentrations measured are summarized in Table 10 and were within the LEL guidelines proposed by the Wisconsin Department of Natural Resources.[2] Restrictions on water uses after application of Cutrine Plus are also given in Table 16.

AQUATIC ANIMALS

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

Zooplankton

Zooplankton are minute, free-floating animals inhabiting the same environment as phytoplankton. 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 larvae and fry of bluegills, pumpkinseeds, sunfish, and largemouth bass. While the zooplankton population is an indicator of the trophic status of a

[2]*Wisconsin Department of Natural Resources, op. cit.*

Table 16

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	14	7-14	--[b]
Fishing	0	14	3	0
Swimming	0	1	--	0
Irrigation	0	14	7-14	--[b]

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

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

Source: Wisconsin Department of Natural Resources.

lake and of the diversity of aquatic habitat, zooplankton were not sampled during the U.S. Geological Survey inventory; and no information on the species composition or relative abundance is available for Eagle Spring Lake. However, given the composition and condition of the fish community in Eagle Spring Lake, it may be assumed that the zooplankton population is sufficiently robust and diverse to support a relatively healthy fishery.

Fish of Eagle Spring Lake

Eagle Spring Lake is known for its fishing and is the site of an annual carp-fishing jamboree and numerous other fishing-related community events. Eagle Spring Lake supports an unbalanced fish community with moderate diversity, but heavily skewed toward predatory fishes. Thus, although the Wisconsin Department of Natural Resources Publication No. PUBL-FM-800 95REV, Wisconsin Lakes, 1995, indicates that panfish are common, and that largemouth bass and northern pike are present, Wisconsin Department of Natural Resources fish surveys conducted from 1992 through 1994 suggested diminishing numbers of panfish during this period. Notwithstanding, the surveys recorded the presence of 14 species of fish representing six families, as shown in Table 17. The numbers of fish collected during the surveys are shown in Figures 8 and 9.

Because of abundant suitable habitat, northern pike were stocked in the Lake by the Wisconsin Department of Natural Resources during 1992, following the fisheries survey conducted by the Department in May of that year. However, no northern pike were found during a follow-up survey conducted in May of 1993, and only one fish was found in May of 1994. Stocking was continued in the years 1993 through 1996.

Important predator fishes in Eagle Spring Lake include northern pike and largemouth bass. These species are carnivorous, feeding primarily on other fish, crayfish, and frogs. These species are among the largest and most prized game fish sought by Eagle Spring Lake anglers. Surveys conducted by the Wisconsin Department of Natural Resources indicate a decline in the bass population from a rate of 294 bass caught per mile of nearshore lake area inventoried using fish shocking equipment in 1992 to 177 bass caught per mile in 1996, as indicated in Figure 10. Nevertheless, these fisheries surveys continue to indicate a fish population heavily dominated by predator species, particularly the largemouth bass, and a stunted, deficient prey species, the bluegill. As already noted, and as shown in Table 18, the Wisconsin Department of Natural Resources currently stocks the Lake with northern pike to supplement the natural fishery.

Table 17

SPECIES OF FISH IDENTIFIED DURING EAGLE SPRING LAKE FISH SURVEYS: 1992-1994

Common Name	Family Name	Scientific Name
Largemouth Bass	Centrarchidae	Micropterus salmoides
Grass Pickerel	Esocidae	Esox americanus vermiculatus
Yellow Bullhead	Ictaluridae	Ictalurus natalis
Northern Pike	Esocidae	Esox lucius
Bluegill	Centrarchidae	Lepomis macrochirus
Pumpkinseed	Centrarchidae	Lepomis gibbosus
Warmouth	Centrarchidae	Lepomis gulosus
Common Shiner	Cyprinidae	Notropis cornutus
Rock Bass	Centrarchidae	Ambloplites rupestris
Green Sunfish	Centrarchidae	Lepomis cyanellus
Black Crappie	Centrarchidae	Pomoxis nigromaculatus
Bowfin	Amiidae	Amia calva
Lake Chubsucker	Catostomidae	Erimyzon sucetta
Carp	Cyprinidae	Cyprinus carpio

Source: Wisconsin Department of Natural Resources.

"Panfish" is a common term applied to a broad group of smaller fish with a relatively short and usually broad shape makes them a perfect size for the frying pan. Panfish species known to have existed in Eagle Spring Lake include bluegills, pumpkinseeds, rock bass, green sunfish, and black crappies. The habitats of panfish vary widely among the different species, but their cropping of the plentiful supply of insects and plants, coupled with prolific breeding rates, leads to large populations with a 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 the fry of predator fish and, if the panfish population is overabundant, they may quickly deplete the predator fry population. Figure 11 illustrates the importance of a balanced predator-prey relationship, using walleyed pike and perch as an example. In the case of Eagle Spring Lake, there appears to be a lack of bluegills, particularly of larger individuals. As indicated in Figure 10, findings of surveys conducted by the Wisconsin Department of Natural Resources indicate that the overall bluegill population has declined from 135 caught per mile in 1992 to 24 caught per mile in 1994. The decrease in bluegill population is most likely a result of overharvest in conjunction with overpredation arising from changes in the amount of refugia available to the fishes potentially related to aquatic plant management measures, creating an unbalanced predator-prey relationship.[3]

"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 in Southeastern Wisconsin as undesirable for human consumption. Rough fish species which have been found in Eagle Spring Lake include carp, lake chubsucker, and bowfin.[4] Programs which have contributed to the changes in the Lake's fishery include the carp removed during the carp fishing event held annually and the ongoing fish stocking program.

Eagle Spring Lake is currently managed for the production of bluegills, largemouth bass, and northern pike. It is assumed that an overharvest of larger bluegills may have contributed to an unbalanced, slow-growing panfish population. In order to enhance and maintain sport fishing opportunities for anglers using Eagle Spring Lake, the Wisconsin Department of Natural Resources has, as already noted, stocked the Lake with northern pike, as shown in Table 18. The Department plans to continue to stock Eagle Spring Lake with northern pike annually, depending on their availability from the Department's fish hatcheries.

Other Wildlife

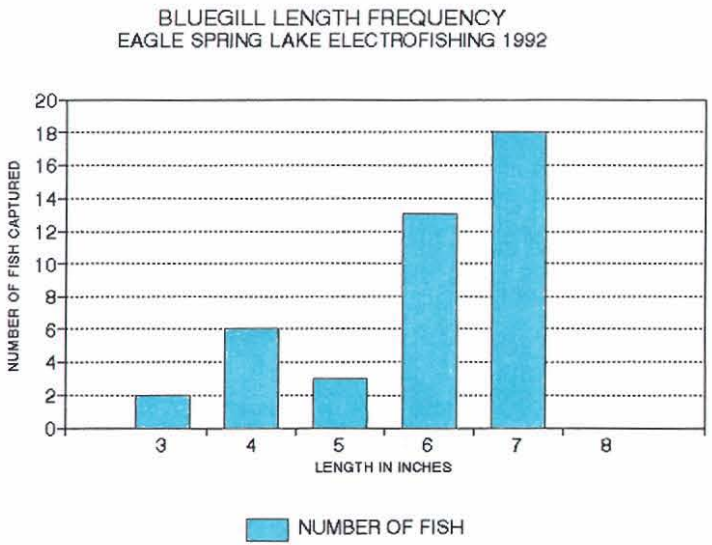
Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the Eagle Spring Lake study, a field reconnaissance was undertaken by the Wisconsin Department of Natural Resources during July 1992. The technique used in compiling the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to exist, or known to have existed in the Eagle Spring Lake area; associating these lists with the historic

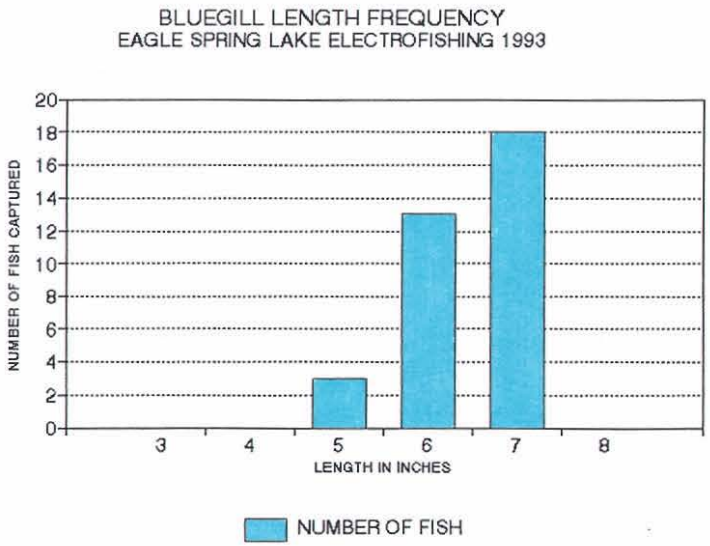
[3] *Karen Wilson and Steve Carpenter, "Making the Weedline Work for Your Lake," Wisconsin Natural Resources, Vol. 21, No. 2, pp. 4-8, April 1997.*

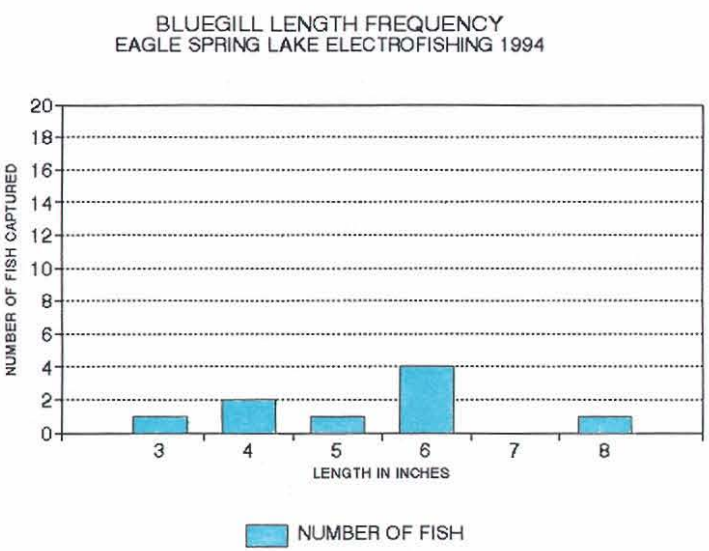
[4] *Wisconsin Department of Natural Resources Published Reports, Eagle Spring Lake Electrofishing Surveys 1992-1994.*

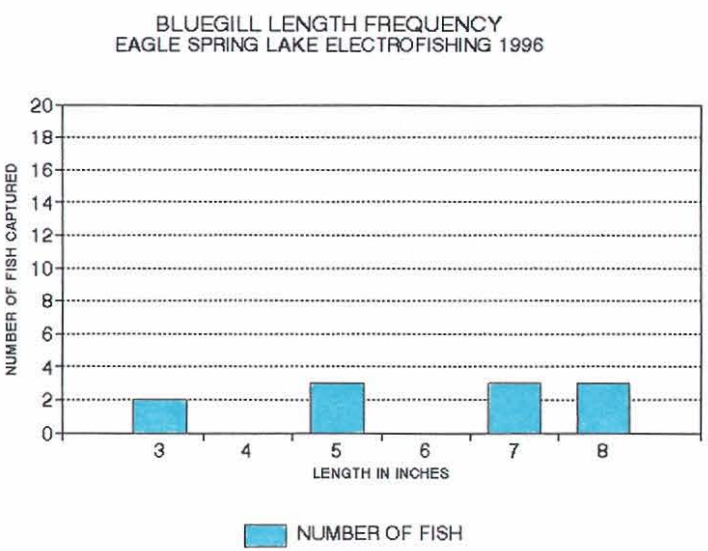
Figure 8

BLUEGILL LENGTH FREQUENCY





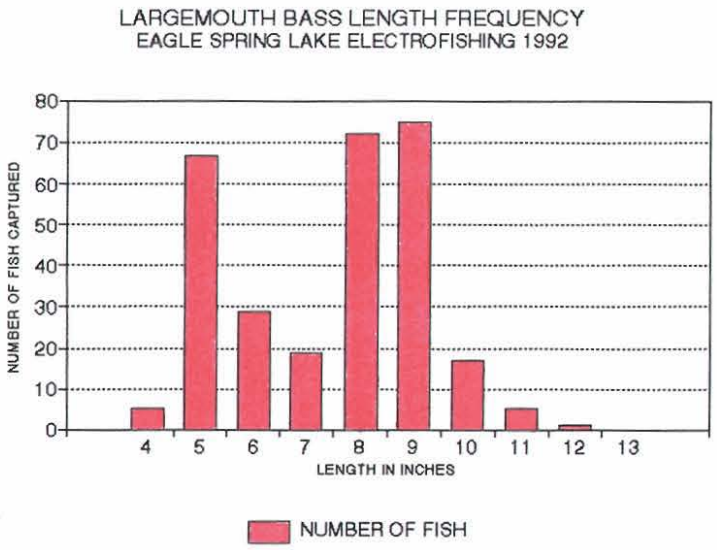


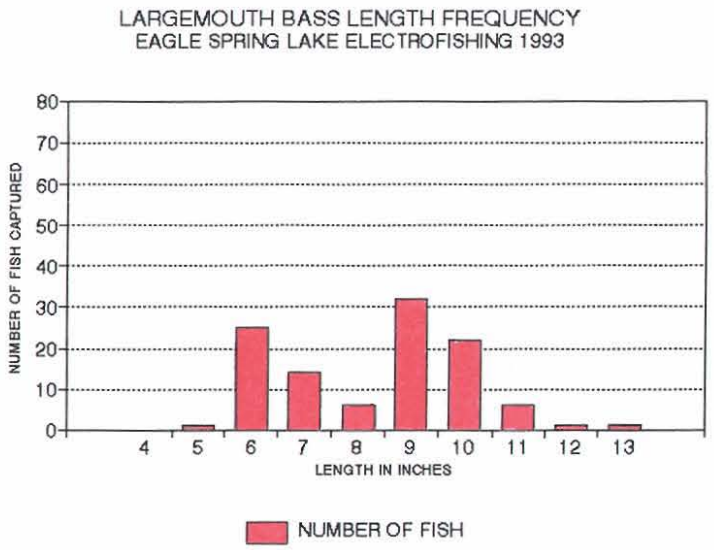


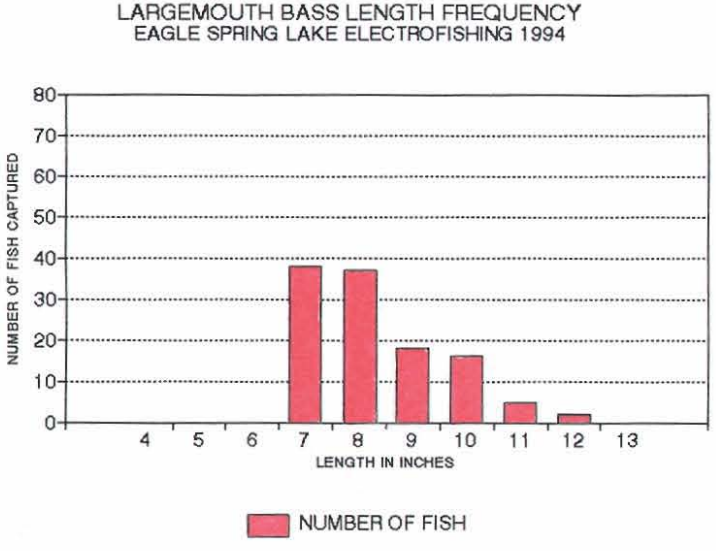
Source: Wisconsin Department of Natural Resources and SEWRPC.

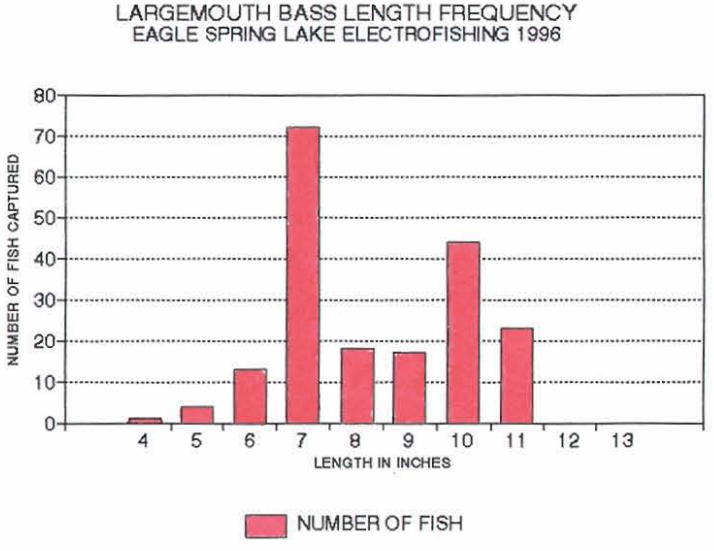
Figure 9

LARGEMOUTH BASS LENGTH FREQUENCY





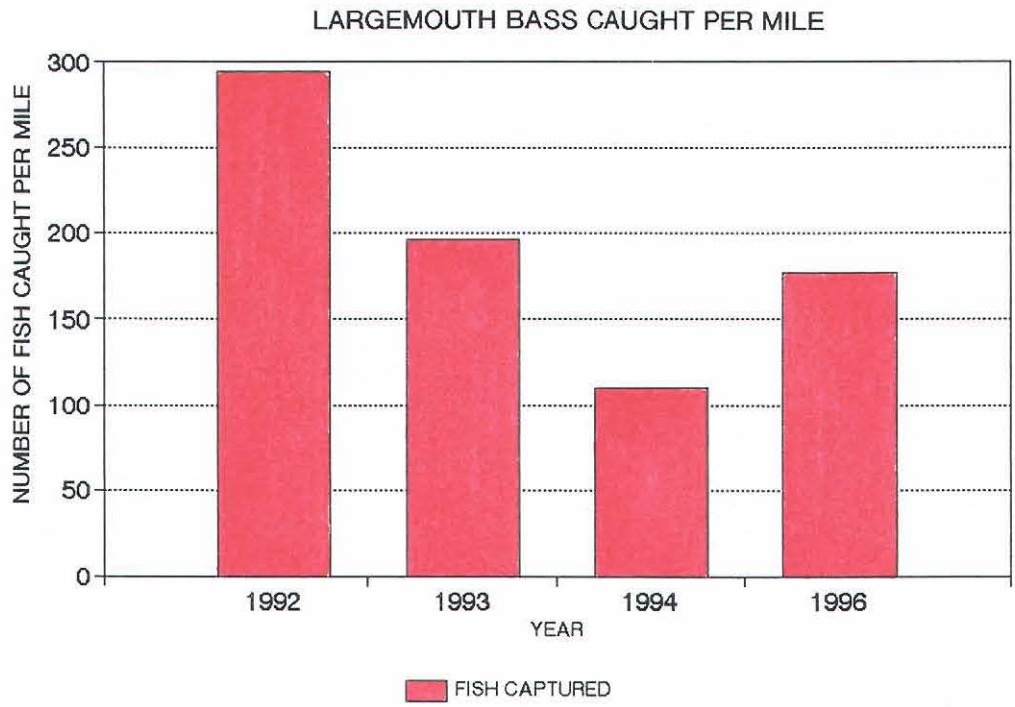


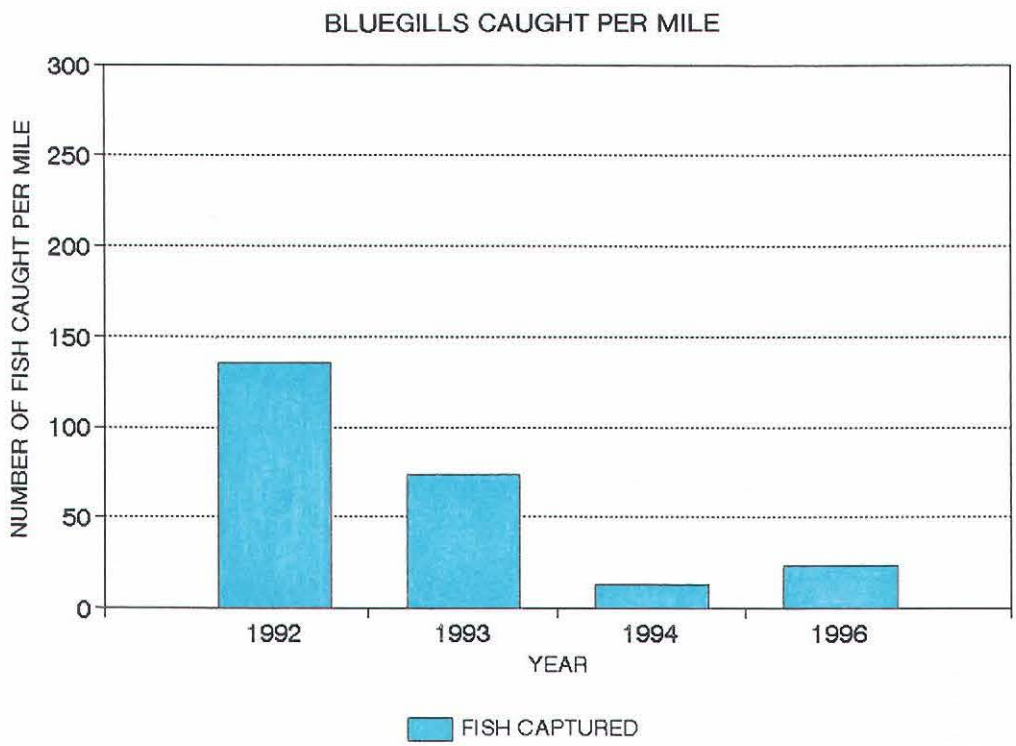


Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 10

EAGLE SPRING LAKE ELECTROFISHING: 1992-1994 AND 1996





Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 18

EAGLE SPRING LAKE FISH STOCKING RECORD

Fish Species	Year Stocked	Number Stocked
Northern Pike	1992	307 fingerlings
Northern Pike	1993	500 fingerlings
Northern Pike	1994	1,555 fingerlings

Source: Wisconsin Department of Natural Resources.

and remaining habitat areas in the Eagle Spring Lake area as inventoried; and projecting the appropriate amphibian, reptile, bird, and mammal species into the Eagle Spring Lake area. The net result of the application of this technique is a listing of those species which were probably once present in the drainage area; those species which may be expected to still be present under currently prevailing conditions; and those species which may be expected to be lost or gained as a result of urbanization within the area.

Given the rural nature of all but the immediate shoreland area of Eagle Spring Lake, many animals and numbers of waterfowl commonly inhabit areas of the watershed, especially in the still undeveloped areas southwest of the Lake and upstream of the Lake. Blanding's turtle, a threatened species, is resident in Lulu Lake. Mink, muskrat, beaver, white-tailed deer, red and grey fox, grey and fox squirrel, and cottontail rabbits are mammals reported to frequent the area. Mallards, wood duck, and blue-winged teal are the most numerous waterfowl and are known to nest in the area. Many game birds, songbirds, waders, and raptors also reside or visit the Lake and its environs. Sandhill cranes and loons are notable migratory visitors. In addition, bald eagles, osprey, black terns, loggerhead shrikes, peregrine falcons, barn owls, and Cooper's hawks—all threatened or endangered species—have been reported to have been seen in the vicinity of Eagle Spring and Lulu Lakes.

Amphibians and reptiles are vital components of the ecosystem in an environmental unit like the Eagle Spring 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 Eagle Spring Lake area. Table 19 lists the 15 amphibian and 17 reptile species normally expected to be present in the Eagle Spring Lake area under present conditions and identifies those species most sensitive to urbanization.

Most amphibians and reptiles have definite habitat requirements which are adversely affected by advancing urban development as well as by certain agricultural land management practices. The major detrimental factors affecting the maintenance of amphibians in a changing environment is the destruction of breeding ponds, urban development occurring in migration routes, and changes in food sources brought about by urbanization.

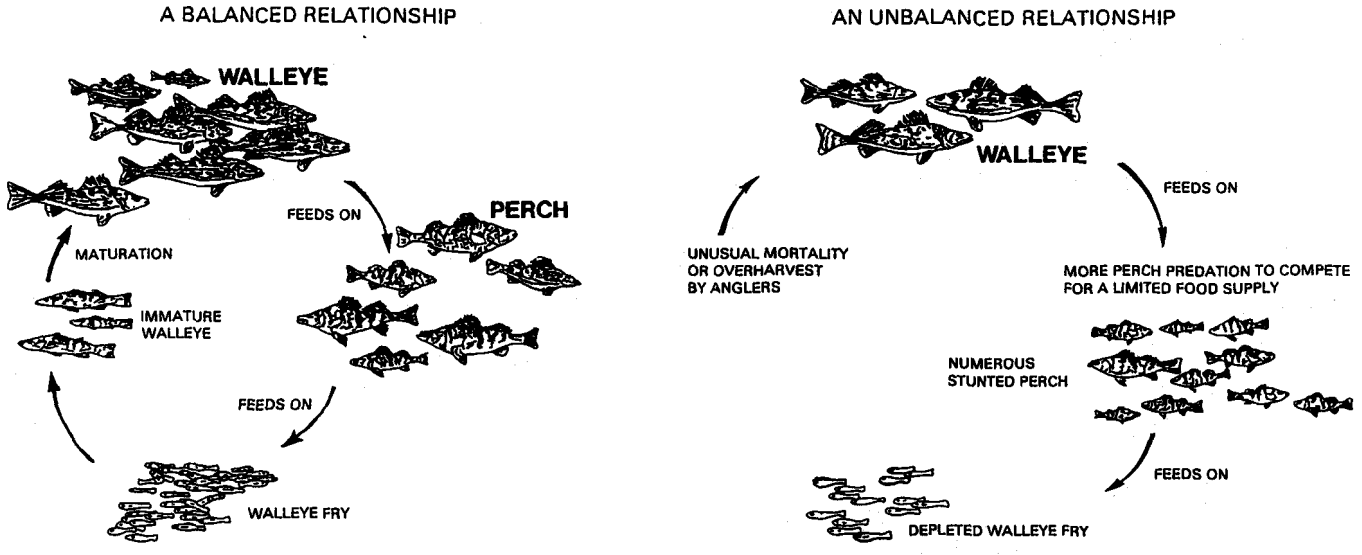
A large number of birds, ranging in size from large game birds to small songbirds, are found in the Eagle Spring Lake area. Table 20 lists those birds that normally occur in the drainage area. Each bird is classified as to whether it breeds within the area, visits the area only during the annual migration periods, or visits the area only on rare occasions. The Eagle Spring Lake drainage area supports a significant population of waterfowl, including mallard and teal. Larger numbers move through the drainage area during migrations when most of the regional species may also be present.

Because of the mixture of lowland and upland woodlots, wetlands, and agricultural lands still present in the area, along with the favorable summer climate, the area supports many other species of birds. Hawks and owls function as major rodent predators within the ecosystem. Swallows, whippoorwills, woodpeckers, nuthatches, and flycatchers, as well as several other species, serve as major insect predators. In addition to their ecological roles, birds such as robins, red-winged blackbirds, orioles, cardinals, kingfishers, and mourning doves serve as subjects for bird watchers and photographers.

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 Eagle Spring Lake area. Table 21 lists 37 mammals whose ranges are known to extend into the area.

Figure 11

THE PREDATOR-PREY RELATIONSHIP



Source: Wisconsin Department of Natural Resources.

The complete spectrum of wildlife species originally native to Waukesha 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 fertilizers, herbicides, and pesticides; road salting for snow and ice control; heavy motor vehicle traffic that produces disruptive noise levels and air pollution and nonpoint source water pollution; and the introduction of domestic pets.

WILDLIFE HABITAT AND RESOURCES

Wildlife habitat areas remaining in the Region were inventoried by the Regional Planning Commission in 1985 in cooperation with the Wisconsin Department of Natural Resources. The five major criteria used to determine the value of these wildlife habitat areas are listed below:

1. Diversity
   An area must maintain a high but balanced diversity of species for a temperate climate, balanced in such a way that the proper predatory-prey (consumer-food) relationships can occur. In addition, a reproductive interdependence must exist.

2. Territorial Requirements
   The maintenance of proper spatial relationships among species, allowing for a certain minimum population level, can occur only if the territorial requirements of each major species within a particular habitat are met.

Table 19

AMPHIBIANS AND REPTILES OF THE EAGLE SPRING 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
Cope's Gray Tree Frog	--	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		
Western Painted Turtle	X	--
Midland Painted Turtle	X	--
Blanding's Turtle[b]	--	X
Trionychidea		
Eastern Spiny Softshell	X	--
Colubridae		
Northern Water Snake	X	--
Northern Brown Snake	X	--
Red-Bellied Snake	X	--
Eastern Garter Snake	X	--
Chicago Garter Snake	X	--
Butler's Garter Snake	X	--
Eastern Hognose Snake	--	X
Eastern Smooth Green Snake	--	X
Western Fox Snake	--	X
Eastern Milk Snake	--	X

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

[b] *Indentified as threatened in Wisconsin.*

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

Table 20

BIRDS KNOWN OR LIKELY TO OCCUR IN THE EAGLE SPRING 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	- -	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
Mute Swan	X	X	X
Red-Breasted Merganser	- -	- -	X
Hooded Merganser	- -	- -	X
Common Merganser	- -	- -	X
Cathartidae			
Turkey Vulture	- -	- -	X
Accipitridae			
Northern Goshawk	- -	R	X
Cooper's Hawk	X	X	X
Northern Harrier	- -	R	X
Broad-Winged Hawk	- -	- -	X
Red-Tailed Hawk	X	X	X
Bald Eagle	- -	- -	X
Osprey	- -	- -	X
Phasianidae			
Ring-Necked Pheasant (introduced)	X	X	NA
Rallidae			
Virginia Rail	X	- -	X
Sora	X	- -	X
American Coot	- -	- -	X
Charadriidae			
Semipalmated Plover	- -	- -	X
Killdeer	X	- -	X
Scolopacidae			
Greater Yellowlegs	- -	- -	X
Lesser Yellowlegs	- -	- -	X

Table 20 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Scolopacidae (continued)			
Solitary Sandpiper	--	--	X
Spotted Sandpiper	P	--	X
Upland Sandpiper	P	--	P
Semipalmated Sandpiper	--	--	P
Pectoral Sandpiper	--	--	X
Common Snipe	P	P	X
American Woodcock	X	--	X
Wilson's Phalarope	--	--	X
Dunlin	--	--	P
Gaviidae			
Northern Common Loon	--	--	X
Laridae			
Ring-Billed Gull	--	--	X
Herring Gull	--	--	X
Forster's Tern	R	--	P(E)
Black Tern	X	--	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-Breasted Woodpecker	X	X	X
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

Table 20 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Tyrannidae (continued)			
Willow Flycatcher	P	- -	X
Least Flycatcher	- -	- -	X
Eastern Phoebe	X	- -	X
Great Crested Flycatcher	X	- -	X
Eastern Kingbird	X	- -	X
Alaudidae			
Horned Lark	P	- -	X
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
Ruby-Crowned Kinglet	- -	- -	X
Blue-Gray Gnatcatcher	X	- -	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

Table 20 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Lanniidae			
Northern Shrike	- -	R	X
Sturnidae			
European Starling[a]	X	X	X
Vireonidae			
Solitary Vireo	- -	- -	X
Yellow-Throated Vireo	X	- -	X
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	- -	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

Table 20 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Emberizidae (continued)			
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
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: John E. Bielefeldt, Racine County Naturalist, Tom Bintz, Eagle Spring Lake Resident, and SEWRPC.

3. Vegetative Composition and Structure
The composition and structure of vegetation must be such that the required levels for nesting, travel routes, concealment, and protection from weather are met for each of the major species.

4. Location with Respect to Other Wildlife Habitat Areas
It is very desirable that a wildlife habitat maintain proximity to other wildlife habitat areas.

5. Disturbance
Minimum levels of disturbance from human activities are necessary, other than those activities of a wildlife management nature.

On the basis of these five criteria, the wildlife habitat areas in the Eagle Spring Lake drainage area were categorized as either Class I, High-Value; Class II, Medium-Value; or Class III, Good-Value, habitat areas.

Class I wildlife habitat areas contain a good diversity of wildlife, are adequate in size to meet all of

Table 21

MAMMALS OF THE EAGLE SPRING 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
Woodland Deer Mouse
Prairie Deer Mouse
Northern White-Footed Mouse
Meadow Vole
Prairie Vole
Common Muskrat
Muridae
Norway Rat (introduced)
House Mouse (introduced)
Zapodidae
Hudsonian Meadow Jumping Mouse
Canidae
Northeastern Coyote
Eastern Red Fox
Gray Fox
Procyonidae
Upper Mississippi Valley Raccoon
Mustelidae
Least Weasel
Bang's Short-Tailed Weasel
Long-Tailed
Weasel
Mink
Northern Plains Skunk
Otter (occasional visitor)
Cervidae
White-Tailed Deer

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

the habitat requirements for the species concerned, are generally located in proximity to other wildlife habitat areas, and meet all five criteria listed above. Class II wildlife habitat areas generally fail to meet one of the five criteria in the preceding list for a high-value wildlife habitat. However, they do retain a good plant and animal diversity. Class III wildlife habitat areas are remnant in nature in that they generally fail to meet two or more of the five criteria for a high-value wildlife habitat, but may, nevertheless, be important if located in proximity to medium- or high-value habitat areas if they provide corridors linking wildlife habitat areas of higher value or if they provide the only available range in an area.

As shown on Map 18, about 2,594 acres, or about 16 percent of the drainage area tributary to Eagle Spring Lake, were classified in the 1985 inventory as Class I habitat; 2,008 acres, or 12 percent, were classified as Class II habitat; and 1,488 acres, or 9 percent, were classified as Class III habitat.

WETLANDS

Wetlands are defined by the Regional Planning Commission 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." This definition, which is also used by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency, is essentially the same as the definition used by the U.S. Natural Resource Conservation Service.[5]

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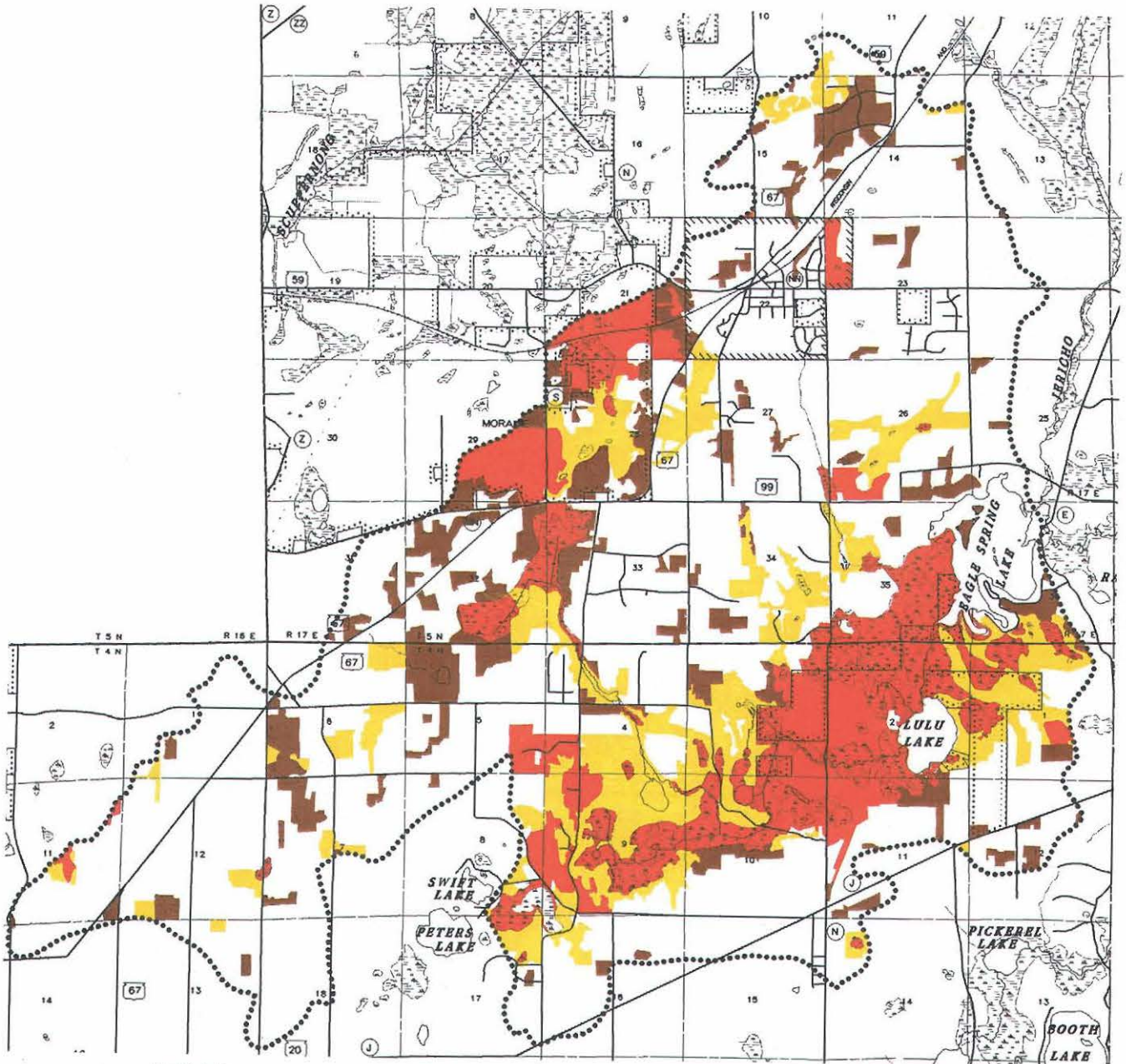
[5]*Lands designated as prior converted cropland, that is, lands that were cleared, drained, filled, or otherwise manipulated to make them capable of supporting a commodity crop prior to December 23, 1985, may meet the criteria of the U.S. Natural Resource Conservation Service wetland definition, but they would not be regulated under Federal wetland programs. If such lands are not cropped, managed, or maintained for agricultural production, for five consecutive years, and in that time the land reverts back to wetland, the land would then be subject to Federal wetland regulations.*

Map 18

WILDLIFE HABITAT AREAS WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE



Another definition, which is applied by the State of Wisconsin Department of Natural Resources and which is 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 Regional Planning Commission definition in that the Department considers very poorly drained, poorly drained, and some of the somewhat poorly drained soils as wetland soils meeting the Department "wet condition" criterion. The Commission definition only considers the very 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 definitions in that the Department may include some soils that do not show hydric field characteristics as wet soils capable of supporting wetland vegetation, a condition which may occur in some floodlands.[6]

As a practical matter, experience has shown that application of the Wisconsin Department of Natural Resources, the U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, and the Regional Planning Commission definitions, 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 judgement 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, southern sedge meadow, fresh (wet) meadow, shrub carr, alder thickets, low prairie, fens, bogs, southern wet- and wet-mesic hardwood forest, and conifer swamp. Wetlands form an important part of the landscape in and adjacent to Eagle Spring 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 the 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 within the Region which is updated every five years. As shown on Map 19, in 1990, wetlands covered about 1,440 acres, or 9 percent, of the drainage area tributary to Eagle Spring Lake. 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 by the Regional Planning Commission as those areas containing a minimum

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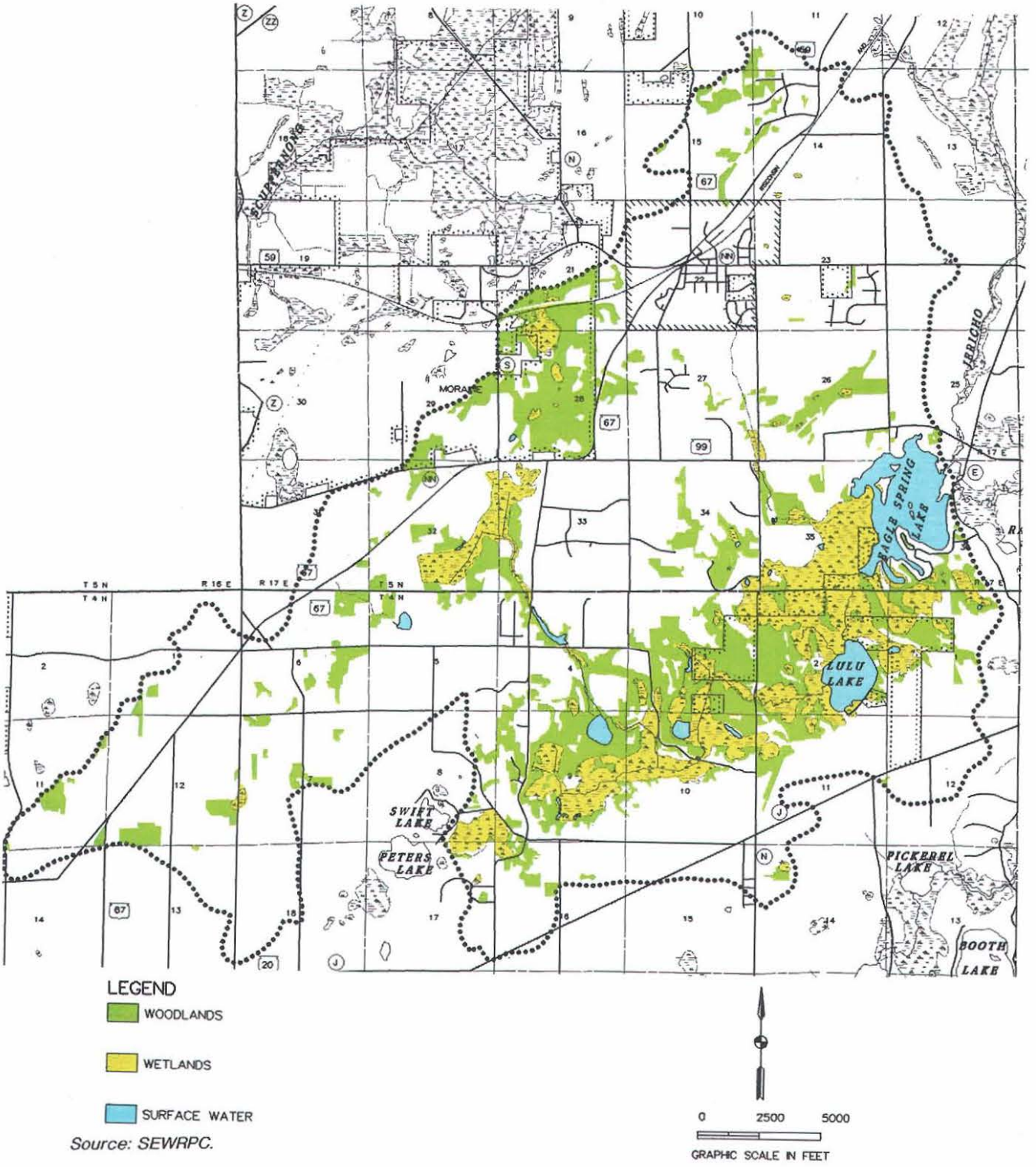
[6] *Although prior converted cropland is not subject to Federal wetland regulations unless cropping ceases for five consecutive years and the land reverts to a wetland condition, the State may consider prior converted cropland to be subject to State wetland regulations if the land meets the criteria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

Map 19

EXISTING WETLANDS WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE



Source: SEWRPC.

of 17 trees per acre with a diameter of at least four inches at breast height (4.5 feet above the ground).[7] The woodlands are classified as dry, dry-mesic, mesic, wet-mesic, wet hardwood, and conifer swamp forests; the last three are also considered wetlands. The Regional Planning Commission also maintains an inventory of woodlands within the Region which is updated every five years. In the drainage area tributary to Eagle Spring Lake, shown on Map 19, approximately 2,446 acres of woodland were inventoried in 1990. These woodlands covered about 15 percent of the drainage area. The major tree species include the black willow (Salix nigra), cottonwood (Populus deltoides), green ash (Fraxinus pennsylvanica), silver maple (Acer saccharinum), American elm (Ulmus americana), basswood (Tilia americana), northern red oak (Quercus borealis), and shagbark hickory (Carya ovata). Some isolated stands of tamarack (Larix laricina) also exist in the drainage area, together with such other upland species as the white oak (Quercus alba), burr oak (Quercus macrocarpa), black cherry (Prunus serotina), American beech (Fagus grandifolia), and paper birch (Betula papyrifera).

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. If, however, urban development is allowed to continue within the watershed much of the remaining woodland cover may be expected to be lost.

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 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 aforementioned important resource and resource-related elements and are, by definition, at least 400 acres in size, two miles in length, and 200 feet in width. The primary environmental corridors identified in the Eagle Spring Lake drainage area are contiguous with environmental corridors and isolated natural areas lying within the Mukwonago River watershed, and, consequently, meet these size and natural resource element criteria.

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 in interconnected lake and stream ecosystems. The resulting deterioration of surface

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[7] *SEWRPC Technical Record, Vol. 4, No. 2, "Refining the Delineation of the Environmental Corridors in Southeastern Wisconsin," March 1981.*

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 supplies 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 in the 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 Eagle Spring Lake direct 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 valleys and around major Lakes and contain almost all the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all the major bodies of surface water and related undeveloped floodlands and shorelands.

Primary Environmental Corridors

Primary environmental corridors in the Eagle Spring Lake drainage area are shown on Map 20. About 4,221 acres, or 25 percent, of the drainage area were identified as primary environmental corridor. Portions of this area are also included within the Lulu Lake State Natural Area boundary which currently encompasses about 1,660 acres. It is anticipated that this area will be increased to 2,310 acres based on proposed purchases by the Wisconsin Department of Natural Resources and The Nature Conservancy.[8] An additional 114 acres, or 0.7 percent of the drainage area, were classed as secondary environmental corridor, while 303 acres, or 2 percent, were identified as isolated natural features located within the drainage area.

Environmental corridors are subject to urban encroachment because of their desirable natural resource amenities. Unplanned or poorly planned intrusion of urban development into these corridors not only tends to destroy the very resources and related amenities sought by the development, but also tends to create severe environmental and developmental 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 sewerage systems. The preservation of as yet undeveloped corridors is one of the major ways in which the water quality can be protected and perhaps improved at relatively little additional cost to the taxpayers of the area.

In the Eagle Spring Lake drainage area, the river banks and lakeshores located within the environmental corridors should be candidates for immediate protection through proper zoning or through public ownership. Of the areas not already publicly owned, the remaining areas of natural shoreline, shown on Map 2, are perhaps the most sensitive areas in need of greatest protection.

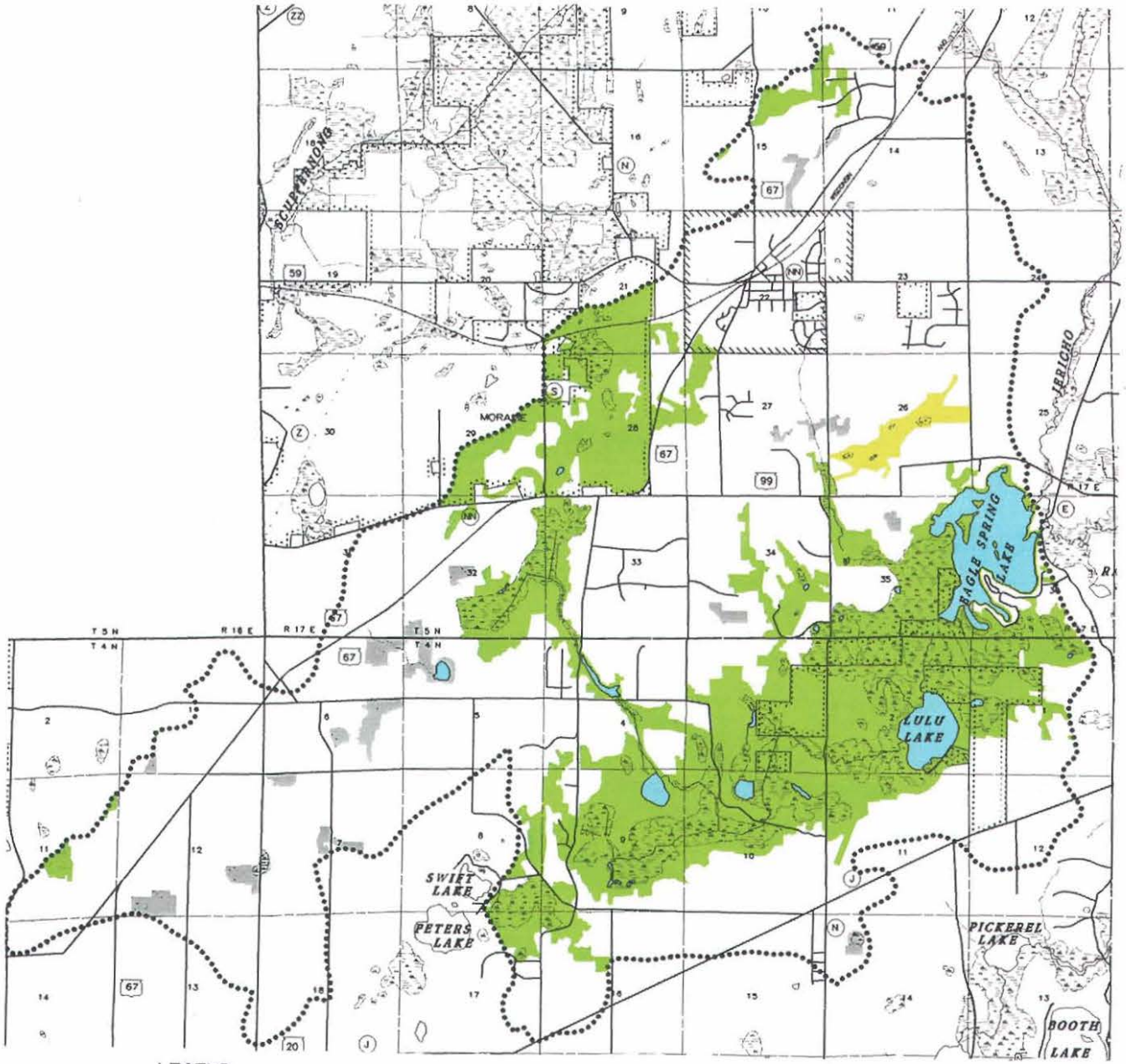
SUMMARY

Eagle Spring Lake has avoided some of the more severe water quality and environmental impacts characteristic of waterbodies in Southeastern Wisconsin and still presents a relatively unblemished vista for the casual observer. However, the Lake does suffer from an excessive abundance of aquatic plants, predominantly the nuisance species Myriophyllum spicatum (Eurasian water milfoil). This aquatic plant has historically been managed using a combination of chemical and mechanical control. Chemical controls, previously effected with sodium arsenite and more recently with various synthetic organic herbicides (Diquat, Aquathol, and 2,4-D, have been applied in late spring, with a possible follow-up treatment in late summer. No chemical controls have been applied to Eagle Spring Lake since 1982. Mechanical controls are currently effected with two Aquarius H-220 harvesters.

[8] *Wisconsin Department of Natural Resources, Lulu Lake State Natural Area Boundary Expansion Feasibility Study, October 1994.*

Map 20

ENVIRONMENTALLY VALUABLE AREAS WITHIN THE DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE



Source: SEWRPC.

The Lake is currently managed for the production of bluegills, largemouth bass, and northern pike. Northern pike are stocked by the Wisconsin Department of Natural Resources.

Other aquatic life and wildlife in the 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. Nevertheless, the Eagle Spring Lake drainage area provides an adequate refuge for a healthy and diverse fauna.

The incorporation of much of the shorelands into the primary environmental corridor, and the creation of the Lulu Lake State Natural Area by the Wisconsin Department of Natural Resources and The Nature Conservancy has done much to preserve and maintain the relatively high quality environment at Eagle Spring Lake. Efforts to preserve the environmental corridors in essentially natural open uses must be continued, and efforts to effectively limit urban development in the drainage basin of the Lake must be instituted if the quality of the Lake as an environmental, aesthetic, and recreational asset is to be preserved.

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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 runoff. 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 Eagle Spring Lake are discussed in this chapter.

RECREATIONAL USE

Existing Recreation Use and Facilities

Eagle Spring Lake provides an ideal setting for the provision of parks and open space sites and facilities. There is a publicly owned open space site—being the northern portion of the Lulu Lake State Natural Area—and a publicly owned lake access site along the Eagle Spring Lake shoreline. In addition, three privately owned recreational sites, comprising a golf course, a park, and one private boat launching site, exist around the lakeshore. These sites are shown on Map 21. Existing recreational facilities in the vicinity of Eagle Spring Lake, including surrounding park areas, the Kettle Moraine State Forest, State Historical Society Old World Wisconsin site, McMiller Sportsmen Center, and Eagle Spring Golf Course, situated off the lakeshore, are also shown on Map 21.

The lake-access site is on the eastern shore of Eagle Spring Lake near the outflow to the Mukwonago River, and is considered to be adequate public access pursuant to Chapter NR 1 of the Wisconsin Administrative Code. The Lulu Lake State Natural Area, adjoining the southwestern shoreline of Eagle Spring Lake, is a portion of a 1,660 acre reserve comprising oak openings, a leatherleaf bog, calcareous fen and sedge meadow wetland. It is proposed that this natural area be expanded to a total area of 2,310 acres through the purchase of additional lands by the Wisconsin Department of Natural Resources and The Nature Conservancy.[2]

Water-based outdoor recreational activities on Eagle Spring Lake include boating, fishing, swimming, and other active and passive recreational pursuits. Because of its size, Eagle Spring Lake receives some powerboat use. However, because of its limited depth and aquatic plant growth, the predominant use is fishing and pleasure boating. Boat surveys conducted on June 25 and June 27, 1996, indicated that 14 and 13 watercraft of various types were in use on the Lake at one time on those days, respectively, as set forth in Table 22. In addition, about 260 boats were moored on the Lake or stored on shore. Most of the watercraft not in use were powerboats, pontoon boats, and fishing boats, with lesser numbers of canoes, paddle boats, sailboats, and personal watercraft ("jetskis").

Seasonal community and private events and activities take advantage of the aesthetic qualities of the Lake, including the annual Carp-Out Fisheree.

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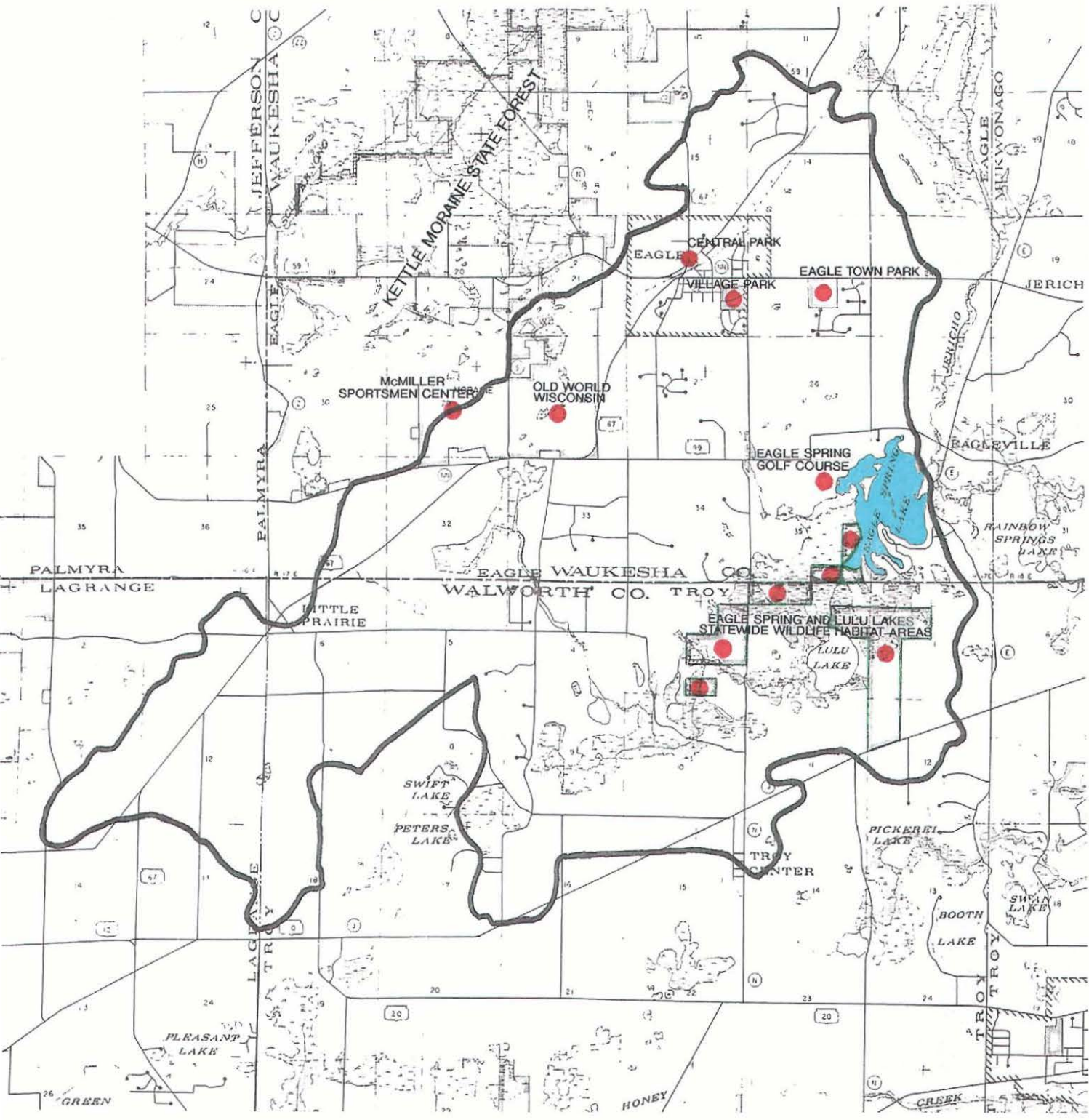
[1] *SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, September 1978; Volume Two, Alternative Plans, February 1979; Volume Three, Recommended Plan, June 1979. See also SEWRPC Memorandum Report No. 93, A Regional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

[2] *Wisconsin Department of Natural Resources, Lulu Lake State Natural Area Boundary Expansion Feasibility Study, October 1994.*

Map 21

PUBLIC AND PRIVATE RECREATIONAL FACILITIES ON AND AROUND EAGLE SPRING LAKE



LEGEND

● RECREATIONAL FACILITIES

Source: SEWRPC.

GRAPHIC SCALE
0 3000 6000 FEET

Table 22

BOATING USE SURVEY ON EAGLE SPRING LAKE: 1996

Date and Time	Weekday Boating Activity (number of watercraft in use)						
	Fishing	Pleasure Boating	Skiing	Sailing	Jetskiing	Other	Total
June 25, 1996							
10:30 a.m. to 11:30 a.m.	2	1	0	0	0	0	3
1:00 p.m. to 2:00 p.m.	5	7	2	0	0	0	14
Total	7	8	2	0	0	0	17
Mean	3	4	1	0	0	0	8

Date and Time	Weekend Boating Activity (number of watercraft in use)						
	Fishing	Pleasure Boating	Skiing	Sailing	Jetskiing	Other	Total
June 27, 1996							
10:00 a.m. to 10:45 a.m.	8	2	2	1	0	0	13
1:00 p.m. to 2:00 p.m.	6	4	1	0	1	0	12
Total	14	6	3	1	1	0	25
Mean	7	3	1	0	0	0	11

Source: SEWRPC.

Ice fishing is a popular winter pastime on Eagle Spring Lake.

It is important to note that the provision of park and open space sites in the drainage area tributary to Eagle Spring Lake should be guided, to a large extent, by the recommendations contained in the Waukesha 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 space purposes and to protect and enhance the underlying and sustaining natural resource base of the Town. With respect to the Eagle Spring Lake drainage area, including the lands along the Mukwonago River and the shoreline of Eagle Spring Lake, the plan recommends the maintenance of existing park and open space sites in the area, and the development of a portion of the Mukwonago River County Trail linking the Lake with Mukwonago County Park. In addition, the plan recommends that the undeveloped lands in the primary environmental corridor drainage area tributary to Eagle Spring Lake be retained and maintained as natural open space.

Wisconsin Department of Natural Resources Recreational Rating

A recreational rating technique has been developed by the Wisconsin Department of Natural Resources to characterize the recreational value of inland lakes. In 1969, Eagle Spring Lake received 56 out of the possible 72 points, indicating that moderately diverse recreational opportunities are provided by the Lake. Based upon a 1996 assessment by the Commissioners of the Eagle Spring Lake Management District and Commission staff, Eagle Spring Lake continues to provide a moderately diverse recreational experience, but it would appear that the rating has declined slightly to about 49 out of 72 points, as shown in Table 23. Favorable features include the boating and angling opportunities provided, while unfavorable features include variable

[3] *SEWRPC Community Assistance Planning Report No. 137, A Park and Open Space Plan for Waukesha County, December 1989.*

Table 23

WISCONSIN DEPARTMENT OF NATURAL RESOURCES RECREATIONAL RATING OF EAGLE SPRING LAKE

Space: Total Area—311 acres	Total Shore Length—4.7 miles	
Ratio of Total Area to Total Shore Length: 0.103		
Quality (18 maximum points for each item)		
Fish:		
X 9 High production	___ 6 Medium production	___ 3 Low production
___ 9 No problems	X 6 Modest problems such as infrequent winterkill, small rough fish problems	___ 3 Frequent and overbearing problems such as winterkill, carp, excessive fertility
Swimming:		
___ 6 Extensive sand or gravel substrate (75 percent or more)	X 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	___ 4 Moderate algae or weed problems	X 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)	X 4 Adequate size for some boating (200 to 1,000 acres)	___ 2 Limit of boating challenge and space (less than 200 acres)
___ 6 Good water quality	___ 4 Some inhibiting factors such as weedy bays, algae blooms, etc.	X 2 Overwhelming inhibiting factors such as weed beds throughout
Aesthetics:		
X 6 Existence of 25 percent or more wild shore	___ 4 Less than 25 percent wild shore	___ 2 No wild shore
X 6 Varied landscape	___ 4 Moderately varied	___ 2 Unvaried landscape
___ 6 Few nuisances such as excessive algae carp, etc.	X 4 Moderate nuisance conditions	___ 2 High nuisance condition
Total Quality Rating: 49 out of a possible 72		

Source: Wisconsin Department of Natural Resources and SEWRPC.

water quality, primarily as a result of turbidity, and extensive aquatic macrophyte growth. In general, Eagle Spring Lake provides good opportunities for a variety of outdoor recreational activities, particularly boating, fishing, and aesthetic enjoyment.

Recreational Use Conclusions

The scope of uses engaged in on Eagle Spring Lake is sufficiently broad to be consistent with the recommended use objectives of full recreational use and the support of a healthy warmwater sport

fishery as set forth in the regional water quality management plan.

WATER USE OBJECTIVES

The regional water quality management plan recommended the adoption of full recreational and warmwater sport fisheries objectives for Eagle Spring Lake. The findings of the inventories of the natural resource base, set forth in Chapters III through V indicate that the use of the Lake and the resources of the area are generally supportive of such objectives, although it is expected that remedial measures will be required if the Lake is to fully meet the objectives.

The recommended warmwater sport fishery objective is supported in Eagle Spring Lake by a sport fishery based largely on largemouth bass and panfish. These fishes have traditionally been sought-after in Eagle Spring Lake. As discussed in Chapter V, the bass population appears to be stunted due to the overabundance of these fishes, which in turn has led to a stunted panfish population which is heavily predated by the bass, in part, as a result of the extensive harvesting of aquatic plants from within the Lake which removes cover and increases the potential for the panfish to be predated upon.[4] Nevertheless, the low bass reproductive rates observed during the period between 1992 through 1994 could be an indication that the overabundance of this species may be self-correcting. Reduced populations of bass, together with areas of restored native aquatic flora, would also reduce predation pressures on the panfish populations, bringing the whole system more into balance.

In addition to the designation of Eagle Spring Lake for full recreational uses and maintenance of a warmwater sport fishery, the Wisconsin Legislature, pursuant to Section 281.15 of the Wisconsin Statutes, has designated the surface water resources within and upstream and downstream of Eagle Spring Lake as outstanding or exceptional resource waters as set forth in Chapter NR 102 of the Wisconsin Administrative Code. The Mukwonago River between Eagle Spring Lake and Lower Phantom Lake has been designated as an Exceptional Resource Water. Exceptional resource waters are those surface waters which provide valuable fisheries, hydrologically or geologically unique features, outstanding recreational opportunities, unique environmental settings, and which are not significantly impacted by human activities. Upstream of Eagle Spring Lake, Lulu Lake has been designated as an Outstanding Resource Water. Outstanding resource waters include all State wild and scenic rivers designated under Section 30.26, Wisconsin Statutes.

Designation of surface water resources as outstanding or exceptional resource waters proscribes these waters being reduced in quality, except that exceptional resource waters may receive discharges subject to the anti-degradation provisions of Chapter NR 207 of the Wisconsin Administrative Code.

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 planning purposes in terms of their application. Standards are recommended for temperature, pH, dissolved oxygen, fecal coliforms, and total phosphorus. These standards apply to the epilimnion of the lakes and to streams. The total phosphorus standard applies to spring turnover concentrations measured in the surface waters. Such contaminants as oil, debris, scum; or odor, taste, and color-producing substances; and toxins are not permitted in concentrations harmful to the aquatic life as set forth in Chapters NR 102 of the Wisconsin Administrative Code.

The adoption of these standards is 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. As indicated in Chapter IV, Eagle Spring Lake largely meets these standards for those parameters for which data are available.

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[4] *Karen Wilson and Steve Carpenter, "Making the Weedline Work for Your Lake," Wisconsin Natural Resources, Vol. 21, No. 2, pp. 4-8, April 1997.*

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.

Chapter VII

ALTERNATIVE LAKE MANAGEMENT MEASURES

INTRODUCTION

Based upon discussions with the Eagle Spring Lake District Commissioners, and a review of the inventory and analyses set forth in Chapters II through VI, the following issues were identified as requiring consideration in the formulation of alternative and recommended lake management measures: 1) water quality improvement; 2) aquatic plant management; 3) protection of environmentally sensitive lands; 4) regulation of onsite sewage disposal systems; 5) recreational lake use restrictions; and 6) fishery management.

Potential effective measures for the management of Eagle Spring Lake include watershed management measures, including land use planning and zoning, and in-lake rehabilitation techniques. Watershed management and land use planning and zoning measures can serve to protect the Lake by promoting and maintaining a sound land use pattern in the area; protecting groundwater recharge areas; and reducing pollutant runoff to the Lake, thus, improving water quality and fishery conditions. In-lake rehabilitation techniques would seek to treat directly identified problems of water quality and lake use.

LAND USE PLANNING AND ZONING ALTERNATIVES

A basic element of any water quality management effort for a 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 tributary drainage area to Eagle Spring Lake will determine, to a large degree, the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, stormwater management; and, to some degree, the water quality of the Lake.

Existing 1990 and planned year 2010 land use patterns and existing zoning regulations in the tributary area to Eagle Spring Lake have been described in Chapter III. If the recommendations set forth in the adopted regional land use plan are followed, under year 2010 conditions, no significant changes in land use conditions within the drainage area tributary to Eagle Spring Lake would occur. However, some infilling of existing platted lots and some backlot development would be expected to occur. In addition, the redevelopment and reconstruction of existing single-family homes on lakefront properties may be expected. Recent surveillance indicates that large-lot subdivision development is occurring in the areas in which such development was not envisioned in the adopted regional land use plan. The areas either under development for urban use, or committed to development for such use, since 1990, with densities of three to five acres per dwelling unit total about 750 acres. If this trend continues, much of the open space areas remaining in the drainage area of the Lake will be replaced over time with large-lot urban development. This may be expected to increase the pollutant loadings to the Lake associated with urbanization and increase the pressure for recreational use of the Lake. Under the full buildout condition envisioned under the Waukesha County development plan[1] completed in 1996, most of the undeveloped lands outside the environmental corridors and other environmentally sensitive areas, could potentially be developed for low-density urban uses. Given these concerns, land use development or redevelopment proposals around the shoreline of Eagle Spring Lake and within the drainage area tributary to the Lake must be carefully evaluated as such proposals are advanced for potential impacts on the Lake.

The existing land use zoning within the Walworth County portion of the tributary drainage area to Eagle Spring Lake is generally consistent with the

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[1] *SEWRPC Community Assistance Planning Report No. 209, A Development Plan for Waukesha County, Wisconsin, August 1996.*

recommended planned land use conditions set forth in the adopted regional land use plan. The existing zoning in the Waukesha County portion of the drainage basin, however, permits far more urban development—generally on large suburban-density lots—than envisioned in the adopted regional land use plan. Control of shoreland redevelopment, and the related intensification of use, is not specifically addressed in the existing zoning ordinance and district map, although new construction may be required to meet specific compliance and inspection requirements for onsite sewage disposal systems. One option for minimizing the effect of future development on Eagle Spring Lake is to carefully review the applicable zoning ordinance and to propose changes addressing the concerns 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 and groundwater recharge area protection can be accomplished through land use regulation and public acquisition of sensitive sites; and both are measures that should be considered for inclusion in the recommended Eagle Spring Lake management plan. Wetlands in the Eagle Spring Lake drainage area are shown on Map 19. These wetland areas are currently protected to a degree under 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 Eagle Spring Lake drainage area are included in the environmental corridors delineated by the Regional Planning Commission and protected under one or more of the Federal, State, County, and local regulations. Some areas of wetland have been included into the Lulu Lake State Natural Area or in areas being proposed to be included in the Lulu Lake State Natural Area.[2]

[2]*Wisconsin Department of Natural Resources, Lulu Lake State Natural Area Boundary Expansion Feasibility Study, October 1994.*

WATERSHED MANAGEMENT MEASURES

Watershed management measures may be used to reduce nonpoint source pollutant loadings from such rural sources as runoff from crop and pasture lands, and from livestock wastes; from such urban sources as runoff from residential, commercial, industrial, transportation, and recreational land uses; from construction activities; and from onsite sewage disposal systems. The alternative, watershed-based nonpoint source pollution control measures considered in this report are based upon the recommendations set forth in the adopted regional water quality management plan,[3] the Waukesha County soil erosion control plan,[4] the Walworth County soil erosion control plan,[5] and information presented by the U.S. Environmental Protection Agency.[6]

An estimate of the nonpoint source pollutant loadings from the various pollution sources in the drainage area of the Lake has been presented in

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

[4]*SEWRPC Community Assistance Planning Report No. 159, Waukesha County Agricultural Soil Erosion Control Plan, June 1988.*

[5]*Walworth County Soil Erosion Control Plan, Walworth County Land Conservation Department and R.A. Smith & Associates, Inc., November 1988.*

[6]*U.S. Environmental Protection Agency, Report No. EPA-440/4-90-006, The Lake and Reservoir Restoration Guidance Manual, Second Edition, August 1990; and its technical supplement, U.S. Environmental Protection Agency, Report No. EPA-841/R-93-002, Fish and Fisheries Management in Lakes and Reservoirs: Technical Supplement to The Lake and Reservoirs Restoration Guidance Manual, May 1993.*

Chapter IV. Because of the large areas of wetland complex along the Mukwonago River upstream of Eagle Spring Lake, the relatively rolling topography, and the relatively pervious soils of the upland areas of the tributary watershed, the nonpoint source pollutant contributions from the tributary drainage area are limited. Thus, control of nonpoint sources of water pollution from the rural and residential lands in the tributary watershed can be achieved through relatively low-cost measures. Properly applied, such measures can reduce the pollutant loadings to the Lake by about 25 percent. The pollutant loadings which are the most controllable include, runoff from the residential lands adjacent to the Lake and the onsite sewage disposal systems. The potential exists within the watershed for significant construction site erosion impacts if development continues in the tributary watershed as has been the recent trend.

Appendix A presents a list of alternative nonpoint source pollution management measures that could be considered for use in the Eagle Spring Lake area to reduce loadings from nonpoint sources of pollution. Information on the cost and effectivity of the measures are also presented in Appendix A.

Rural Nonpoint Source Controls

Upland erosion from agricultural and other rural lands is a contributor of sediment to streams and lakes in the Mukwonago River watershed and to Eagle Spring Lake. Estimated phosphorus and sediment loadings from croplands, woodlots, pastures, and grasslands in the drainage area tributary to Eagle Spring Lake were presented in Chapter IV. These data were utilized in determining the pollutant load reduction that could be achieved, the types of practices needed, and the extent of the areas to which the practices need to be applied within the drainage area tributary to Eagle Spring Lake.

Based upon the pollutant loading analysis set forth in Chapter IV, it is estimated that about 1,300 pounds of phosphorus and 100 tons of sediment are contributed annually from agricultural lands in the drainage area tributary to Eagle Spring Lake. Such lands comprise about 23 square miles, or about 88 percent of the drainage area tributary to Eagle Spring Lake. The loadings estimated from the inventories generally did not exceed the target level of agricultural erosion control of three tons per acre per year identified in the Waukesha County and Walworth County agricultural soil erosion control plans as the tolerable levels which can be sustained without impairing productivity. Nevertheless, given the designation of the waters of Lulu Lake as outstanding resource waters, and the waters of the Mukwonago River as exceptional resource waters, the regional water quality management plan recommends measures be taken to provide about a 25 percent reduction in nonpoint source pollutant loading from rural lands in the watershed. Implementation of these recommendations is considered to be adequate for water quality management purposes related to Eagle Spring Lake.

Detailed farm conservation plans will be required to adapt and refine erosion control practices for individual farm units. Generally prepared with the assistance of the U.S. Natural Resources Conservation Service or County Land Conservation Department staffs, such plans identify desirable tillage practices, cropping patterns, and rotation cycles, considering the specific topography, hydrology, and soil characteristics of the farm; identify the specific resources of the farm operator; and articulate the operator objectives of the owners and managers of the land.

Urban Nonpoint Source Controls

Established urban uses comprise about 3.1 square miles, or about 12 percent, of the drainage area tributary to Eagle Spring Lake. The annual phosphorus loading from the urban lands is estimated to be about 500 pounds.

The regional water quality management plan recommends that the nonpoint source pollutant loadings from the urban areas tributary to Eagle Spring Lake be reduced by about 25 percent in addition to reductions from urban construction erosion control, onsite sewage disposal system management, and streambank and shoreline erosion control measures. As described in Chapter IV, all of these loadings together constitute about 33 percent of the total loading to Eagle Spring Lake. Consideration should be given to reducing the pollutant loadings from the controllable sources to the extent practicable in order to minimize the negative results of nutrient loadings on the Lake.

Potentially applicable urban nonpoint source control measures 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.

Particular attention should be given to reducing pollutant loadings from high pollutant loading areas, such as commercial sites, parking lots, and material storage areas. To the extent practicable, parking lot stormwater runoff should be diverted to areas covered by pervious soils and appropriate vegetation, rather than being directly discharged to surface waters. Material storage areas may be enclosed or periodically cleaned, and diversion of stormwater away from these sites may further reduce pollutant loadings.

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 system 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 effective in the drainage area tributary to Eagle Spring Lake are limited largely to good urban housekeeping practices and grassed swales. Review of the distribution of the pollutant loadings relative to the location of the potential sites for the detention basins indicates that such basins would be relatively costly, as well as ineffective, since stormwater flow to the Lake generally occurs in the form of short overland sheet flow, making it difficult to cost-effectively collect and detain stormwater runoff from reasonably large areas at concentrated outfall locations.

Developing Areas

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. The regional land use plan envisions only limited new urban development within the drainage area. As previously noted, however, large-lot suburban-density development is currently taking place in the drainage area tributary to Eagle Spring Lake at rates which exceed the levels envisioned in the adopted regional land use plan.

Construction sites, especially, may be expected to produce suspended solids and phosphorus loadings 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 Wisconsin League of Municipalities.[7] 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 the relatively small amount of land proposed to be developed. However, such controls are important pollution control measures that can abate localized short-term loadings of phosphorus and sediment from the drainage area and the upstream tributary area. The control measures include such revegetation practices as temporary seeding, mulching, and sodding and such runoff control measures as filter fabric fences, straw bale barriers, storm sewer inlet protection devices, diversion swales, sediment traps, and sedimentation basins.

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

At the present time Walworth and Waukesha Counties have adopted construction site erosion control ordinances which are administered and enforced by the counties concerned in both the shoreland and nonshoreland areas of the unincorporated areas of the drainage area tributary to Eagle Spring Lake. The provision of these ordinances apply to all development except single- and two-family residential construction. Single- and two-family construction erosion control measures are to specified as part of the building permit process. In Walworth County, the County staff performs the construction erosion control function under contract to the Towns of LaGrange and Troy. In the Town of Eagle and the Village of Eagle in Waukesha County, this function is performed by the Town and Village. Because of the potential for development, albeit unplanned, in the Waukesha County portion of the drainage area tributary to Eagle Spring Lake, it is important that adequate construction erosion control programs, including enforcement, be in place.

Onsite Sewage Disposal System Management

As reported in Chapter IV, onsite sewage disposal systems are estimated to contribute about 8 percent of the total phosphorus loading to Eagle Spring Lake.[8] In addition to lake water quality considerations, sewage disposal options in the area have implications for groundwater quality and property values. Thus, onsite sewage disposal is an important consideration in the Eagle Spring Lake area. Two basic alternatives are available for abatement of pollution from onsite sewage disposal systems: continued reliance on, and management of, the onsite sewage disposal systems; and, alternatively, the construction of a public sanitary sewer system.

In the adopted regional water quality management plan the concentrations of urban development located along the shoreline of Eagle Spring Lake were not included within recommended public sanitary sewer service areas. Rather, the area was identified as an urban concentration whose sewage disposal needs would continue to 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.

In 1985, the Eagle Spring Lake Sanitary District completed a facility plan[9] which evaluated the then existing onsite sewage disposal systems serving the urban development along the shoreline of Eagle Spring Lake, as well as the immediately adjacent unincorporated community known as Eagleville. The facility plan also evaluated alternative means for providing sanitary sewer service to the area in the future. The area considered in the facility planning effort contained about 280 existing residences and six commercial establishments. The existing onsite sewage disposal systems were evaluated based upon depth to groundwater, lot sizes, soils, and system age and system type. In addition, groundwater quality sampling was conducted. The analyses indicated that over a 20-year period about 120, or 43 percent, of the onsite systems would have to be replaced with holding tanks, and that the majority of the remaining systems would have to undergo major repair or replacement. The analysis concluded that a public sanitary sewerage system should be constructed to serve the area.

Based upon that facility plan the then existing Eagle Spring Lake Sanitary District requested that the Southeastern Wisconsin Regional Planning Commission amend the regional water quality management plan to reflect the findings of the facility planning effort. In response to that request the Commission prepared a plan amendment document.[10] That document included an independent evaluation of the four basic alternatives for the treatment and disposal of sanitary sewage in the Eagle Spring Lake area which were considered in the facility planning effort: 1) conveyance of sewage to the Village of East Troy sewerage system; 2) conveyance of sewage to the Village of Mukwonago sewerage system; 3) disposal of sewage to the groundwater

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[8] *Wisconsin Department of Natural Resources, Wisconsin Lake Model Spreadsheet Version 2.00, June 1994.*

[9] *Environmental Information Document and Cost Effectiveness Analysis; Eagle Spring Lake Sanitary District, Strand Associates, Inc., October 1985.*

[10] *Amendment to the Regional Water Quality Management Plan—2000, Eagle Spring Lake Sanitary District, December 1995.*

through cluster mounds; and 4) disposal of sewage to the groundwater through an aerated lagoon and seepage cell sewage treatment plant.

Based upon the evaluation of the alternative, it was concluded that the Mukwonago connection alternative was more than 10 percent less costly on an equivalent annual basis than any of the other three alternatives considered. Accordingly, the regional water quality management plan was amended to:

1. Create an Eagle Spring Lake sanitary sewer service area as that area is identified on Map 22.

2. Designate the Mukwonago sewage treatment facility as the receiving plant for sewage from the Eagle Spring Lake Sanitary District.

3. Add to the plan a trunk sewer—actually a force main—that would provide for conveyance of sewage from Eagle Spring Lake Sanitary District to the Mukwonago sewage treatment plant, it being recognized in this respect, that should full development of the Rainbow Springs Resort complex proceed, detailed engineering may result in the refinement of the alignment, configuration, and sizing of this proposed connecting trunk sewer.

The capital cost of the recommended public sanitary sewer system was estimated as $4,100,000, with an annual operation and maintenance cost of $75,000.[11]

Until such time as a public sanitary sewer system is provided in the Eagle Spring Lake area, it is recommended that a continuing onsite sewage disposal system management program, including an informational and educational effort should also be carried out. Homeowners should be advised of the rules, regulations, and system limitations governing onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs. The Eagle Spring Lake Management District could facilitate good onsite sewage treatment practices in several ways. The District could assist individual land owners in the maintenance of existing onsite sewage disposal systems by contracting with a hauler on behalf of all Eagle Spring Lake residences, thereby potentially reducing the costs to individuals, while ensuring community benefit. The District could also assist individual homeowners in the replacement of failing or inadequately sized onsite sewage disposal systems through subsidized or low-cost loans.

The uncertainty regarding the provision of a public sanitary sewer system will likely lead to the installation of holding tanks and to modifications and replacements of existing onsite sewage disposal systems. Over time, this will make achieving consensus on the installation of a public sanitary sewer system unlikely. Thus, if the alternative of providing a public sanitary sewer system is to remain viable, it will be necessary for the Eagle Spring Lake Management District, as the only existing unit of government representing the area involved, to promote implementation of the public sanitary sewer system. Alternatively, the District should consider petitioning for a change to the regional water quality management plan to remove the subject area from the area recommended to be provided with public sanitary sewers. Under that alternative, the District should then undertake a more aggressive onsite sewage disposal system management program. That program should include provisions for periodic inspections of the systems and for repair or replacement, as needed, as well as for a preventative maintenance program.

IN-LAKE MANAGEMENT

The reduction of external nutrient loadings to Eagle Spring Lake by the aforedescribed measures should help to prevent further deterioration of lake water quality conditions. These measures should not be expected to eliminate existing water quality and lake-use problems. In mesotrophic and eutrophic lakes, abundant macrophyte growth can result in restricted water use potentials. Thus, the application of in-lake rehabilitation techniques should be considered.

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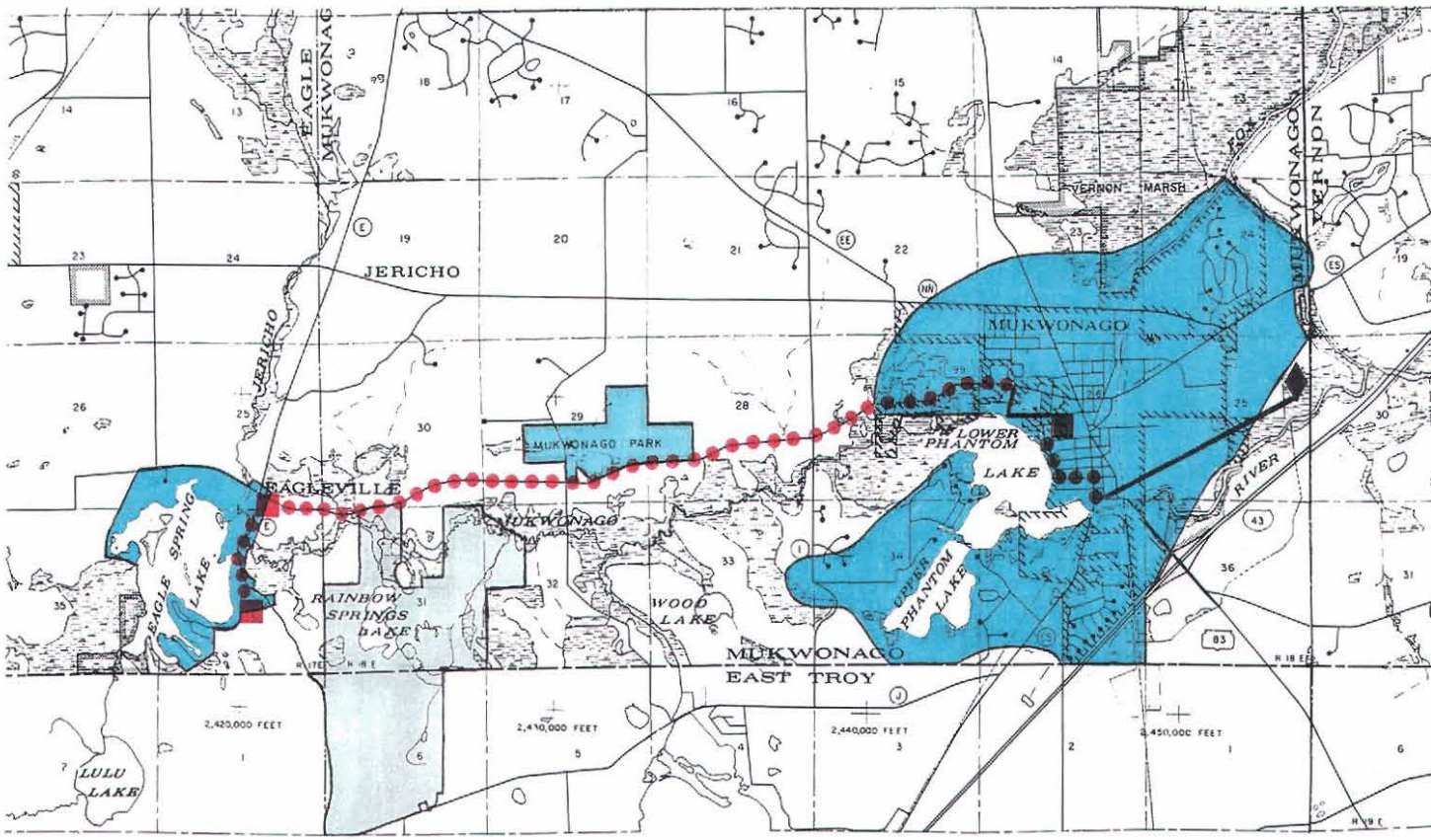
[11] *Costs estimated in 1985 dollars; capital costs escalated to 1997 dollars are estimated to be about $8,250,000, with an annual operation and maintenance cost of about $150,000.*

Map 22

CONVEYANCE OF SEWAGE FROM THE EAGLE SPRING LAKE AREA TO THE VILLAGE OF MUKWONAGO SEWAGE SYSTEM



LEGEND

- VILLAGE OF MUKWONAGO SERVICE AREA
- MUKWONAGO COUNTY PARK
- RAINBOW SPRINGS RESORT
- EAGLE SPRING LAKE SERVICE AREA
- EXISTING SEWAGE TREATMENT PLANT
- EXISTING PUMPING STATION
- EXISTING FORCE MAIN
- EXISTING GRAVITY SEWER
- PROPOSED PUMPING STATION
- PROPOSED FORCE MAIN

Source: SEWRPC.

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 involved 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.

Alternative lake rehabilitation measures include in-lake water quality management, water level management, and aquatic plant and fish management measures. Each of these groups of management measures, together with the attendant costs, are described below.

Water Quality Management Measures

This group of in-lake management practices include a variety of measures designed to directly modify the magnitude of either a water quality determinant or biological response. Specific measures aimed at managing aquatic plants and the fishery are separately considered below.

Phosphorus Precipitation and 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.

Approximately 100 tons of alum, costing about $150 per ton, can treat a lake area of about 40 acres. Effectiveness depends in part on the ability of the alum flocculent to form a stable "blanket" on the lakebed—to wit, on flushing time, turbulence, lake water acidity (pH) and rate of continued sedimentation. Impacts can include the release of toxic quantities of free aluminum into the water. The resulting improved water clarity can also encourage the spread of rooted aquatic plants. The relatively shallow depth of Eagle Spring Lake, and its susceptibility to wind- and boat motor-induced mixing, mediate against the use of nutrient inactivation in Eagle Spring Lake.

Nutrient Load Reduction: Nutrient diversion is a restoration measure, which is designed to reduce the trophic state or degree of over-feeding of a waterbody and thereby control the growth response of the aquatic plants in the system. Control of nutrients in surface water runoff in the watershed is generally preferable to attempting such control within a lake. Many of the techniques presented in the watershed management section above are designed for this purpose.

In-lake control of nutrients generally involves removal of contaminated sediments or encapsulation of nutrients by chemical binding. 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 into the environment. For these reasons this measure is not recommended as a means for nutrient load reduction in Eagle Spring Lake.

Water Level Management Measures

This group of in-lake management measures consists of actions designed to modify the depth of water in the waterbody. Generally, the objectives of such manipulation is to enhance a particular class of recreational uses; to control the types and densities of organisms within a waterbody; or to minimize high water or flooding problems. Consideration can be given to outlet control modifications, drawdown, and dredging.

Outlet Control Modifications: The outflow from Eagle Spring Lake is controlled by two outlet structures—a dam and a small former mill race—both located on the east side of the Lake just west of CTH E, as shown on Map 1. The northerly outlet

is a dam with two 3.5-feet-wide openings controlled by stop boards flanking a center 3.5-feet-wide opening controlled by a manually operated steel lift gate. The southerly outlet is a 3.25-foot-wide mill race structure with one opening controlled by stop boards. In practice, only the northerly outlet structure gate is adjusted for purposes of modifying the lake level. The southerly outlet is privately owned and is currently used to generate electricity.

The present actual operating regime of the dam maintains the lake level at a height which registers between 9.4 and 9.7 feet based upon a gauge located near the dam which is the northernmost of the two lake outlets. These gauge readings are equivalent to elevation 820.53 and 820.83 feet[12] above National Geodetic Vertical Datum of 1929 (NGVD). This elevation is controlled by manual adjustment of the dam operating gate which is carried out periodically by a member of the Eagle Spring Lake Management District based upon observation of lake levels. In practice, the upper end of the operating range is limited to a height of about 9.7 feet on the local gauge by the profile of the roadway located immediately south of the dam. Higher lake elevations than this result in overtopping of the roadway and discharge to the Mukwonago River. The current operating range established by the Wisconsin Department of Natural Resources provides for a range of from 8.84 feet to 9.14 feet on the local gauge, or from elevation 819.97 feet to 820.27 feet NGVD-29. Thus, the current operating levels typically exceed the official ordered maximum water level by up to about 0.6 foot. Based upon a petition by the Eagle Spring Lake District, consideration is currently being given by the Wisconsin Department of Natural Resources Water Division, to change the regulatory water level to be consistent with current Lake Management District operating practices.

Concerns have been raised by residents regarding water levels being both too low and too high. However, given the size and type of lake involved, it is considered reasonable to have an operating water level range of no less than 0.3 foot. Since such a range can be maintained with the existing operating system, no additional operational controls are deemed necessary. However, the existing gate operating system for the dam gate will need to be periodically maintained and repaired to keep it functional.

Given the shallowness of the Lake, the level operating range which has been maintained in recent years appears reasonable. If the target lake levels were to be reduced by any significant amount, aquatic plant growth may be expected to increase in the already limited areas of the Lake which are now in open water. Furthermore, lowering of the lake level from the current operational regime could adversely impact the lake fishery by reducing spawning opportunities. Thus, continued use of a lake level operating range of from about 9.4 to 9.7 feet on the local gauge, or from 820.53 to 820.83 feet NGVD-29, is recommended.

Drawdown: Drawdown refers to a the manipulation of lake water levels, especially in man-made lakes, in order to change or create specific types of habitat and thereby manage species composition within a waterbody. Drawdown may be used to control aquatic plant growth and to manage fisheries. 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

[12] *As noted in Chapter II, the historical elevation of the gauge readings was incorrectly considered to be about 2.65 feet lower in relation to National Geodetic Vertical Datum of 1929 (NGVD-29) than indicated. In November of 1985, the Regional Planning Commission carried out a differential level survey to accurately establish the elevation of Eagle Spring Lake. Accordingly, a correction was made to the benchmark elevation on the dam which increased the elevation of the gauge by 2.65 feet as referred to the NGVD-29.*

and desiccating (drying out) eggs and spawning habitat. In contrast, increasing water levels, especially during spring, can provide enhanced fish breeding habitat for some species such as pike and muskellunge, and increase the food supply for opportunistic feeders such as bass—by providing access to terrestrial insects, for example. Costs are primarily associated with loss of use. Effectiveness is better than for aquatic plant control, but the potential for side effects remains high given that undesirable fish species may also benefit from water level changes.

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.

Possible improvements resulting from a lake drawdown include reduced turbidity from wind action, improved game fishing, an opportunity to collect fish more effectively in fish removal programs, an opportunity to improve docks and dams, and an opportunity to clean and repair shorelines and deepen areas using conventional earth-moving equipment. Depending on the timing and duration of the drawdown, drawbacks include loss of fish breeding habitat, loss of benthic food organisms, and disruption of waterfowl feeding and roosting patterns. Increased turbidity and unpleasant odors from rotting organic matter may occur during the period of the drawdown. Other adverse impacts of lake drawdown include algal blooms after reflooding, loss of use of the lake during the drawdown, changes in species composition, and a reduction in the density of benthic organisms following drawdown and reflooding. In some drawdown projects, it has been found that several years after reflooding, flocculent sediments began to reappear because of algae and macrophyte sedimentation. Therefore, to maintain the benefits of a drawdown project, the lake may have to be drawn down every five to 10 years to recompact any new sediments.

As already noted, the level of Eagle Spring Lake is controlled by a gated, fixed-sill dam with an eight-foot head on the eastern shore of the Lake. A drawdown of up to 4.0 feet could be obtained by opening the gate on the flume. A total breaching of the dam would allow a drawdown of approximately eight feet, exposing the entire lake bottom. However, because of the unpredictability of the results, the impairment of recreational uses, and the temporary nature of the beneficial effects of a drawdown, drawdown is not recommended for Eagle Spring Lake.

Dredging: Sediment removal is a restoration measure that is 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. For large-scale applications, a barge-mounted hydraulic or cutter-head dredge is generally used. For smaller-scale operations a shore-based drag-line system is typically employed. Both methods are expensive, especially if a suitable disposal site is not located close to the dredge site. Costs for removal and disposal begin at between $10 and $15 per cubic yard; with the cost of sediment removal alone beginning at between $3.00 and $5.00 per cubic yard. Effectiveness of dredging varies with the effectiveness of watershed controls in reducing or minimizing the sediment sources. Federal and State permits are required for use of this option. A recommended checklist provided by the Wisconsin Department of Natural Resources is included as Appendix B.

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, in effect, construct a new lake with a size and depth to suit the

management objectives. Dredging has been used in other lakes to increase water depth; remove toxic materials; decrease sediment oxygen demand, preventing fish winterkills and nutrient recycling; and decrease macrophyte growth. The main objective of a dredging program at Eagle Spring Lake would be to increase water depth to permit a greater range of recreational activities and increased public safety. In part, this increase in depth would marginally reduce the areal extent of macrophyte growth. The theoretical maximum depth of macrophyte colonization in Eagle Spring Lake, under present conditions of water clarity, is about eight feet.[13] To reduce the extent of macrophyte growth, sections of the bottom would have to be deepened to nine feet or more by dredging.

Dredging may have serious, though generally short-term, adverse effects on the Lake. These adverse effects could include increased turbidity caused by sediment resuspension, toxicity from dissolved constituents released by the dredging, oxygen depletion as organic sediments mix with the overlying water, water temperature alterations, and destruction of benthic habitats. There may also be impacts at upland spoil disposal sites, such as 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 Eagle Spring Lake.

While dredging results in an immediate increase in lake depth, such increases may be short-lived if the sources of sediment being deposited in the Lake are not controlled within the drainage area tributary to the Lake. As noted in Chapter IV, the sediment load reaching Eagle Spring Lake comes primarily from urban and agricultural lands tributary to the Mukwonago River and other surface water features draining to Eagle Spring Lake. Further sediment is generated from streambank erosion. All of these sources are subject to effective control through the adoption, implementation, and maintenance of recommended control measures within the watershed, which measures should be considered the primary means of limiting sediment accumulation in Eagle Spring Lake prior to consideration being given to dredging. Only after such practices are implemented should major sediment removal projects be considered, and then only in limited areas of the Lake.

Dredging of lakebed material from navigable waters of the State requires a Wisconsin Department of Natural Resources Chapter 30 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 of the Wisconsin Administrative Code requires that any dredging project of over 3,000 cubic yards submit preliminary disposal plans to the Department of Natural Resources for review and potential solid waste licensing of the disposal site. Because sodium arsenite was applied to Eagle Spring Lake in the 1950s and 1960s, as discussed in Chapter V, sediment samples may need to be analyzed to determine the extent and severity of any residual arsenic contamination. However, based upon the sediment data described in Chapter IV, the sediments would not be considered too "heavily polluted" with only sediment concentrations of ammonia-nitrogen exceeding the Wisconsin Department of Natural Resources quality standards at some locations, lead concentrations exceeding the standard by a small amount at one location, and arsenic concentrations below the standard at all of the sample locations.

Dredging Eagle Spring 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 were drained; or a clamshell, or bucket, dragline dredge from the shoreline.

Hydraulic cutterhead dredging is the most commonly 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 is pumped in a slurry of 10 to 20 percent solids by a 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

[13] *U.S. Environmental Protection Agency Report No. EPA-440/4-90-006, op. cit.*

large volume of slurry produced, a relatively large disposal site is typically required. Water returned from the 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.

Assuming dredging of about one-third of the lake area in order to increase the depth by about two feet, about 330,000 cubic yards of material would be dredged. At a cost of between $5.00 and $15 per cubic yard, such a project would have a cost of between $1,650,000 and $4,950,000.

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 for dragline dredging because it does not require the removal of a large number of trees and would probably involve less disturbance of the shoreline to provide access for trucks and equipment.

Because of the considerations noted above, extensive dredging of Eagle Spring Lake is not considered a viable alternative at this time. However, some limited deepening of navigational lanes to permit the free flow of boating traffic is considered a viable alternative. During 1995, a small area in the northwestern nearshore area was dredged, as shown on Map 23.

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 three groups: physical measures which include lake bottom coverings and water level management; mechanical removal measures which include harvesting and manual removal; and chemical measures which include using aquatic herbicides and biological control measures which include the use of various organisms including insects. Of these, chemical and biological measures are stringently regulated and requires a State permit.

Costs of aquatic plant management measures range from minimal for manual removal of plants using rakes and hand-pulling to upwards of $90,000 for the purchase of a mechanical plant harvester and ancillary equipment—the operational costs for which can approach $10,000 to $20,000 per year depending on staffing and operating policies. Harvesting is probably the measure best applicable to larger areas while chemical controls may be best suited to use in confined areas and for initial control of invasive plants. Planting of native plant species is largely experimental in the Lake but can be considered a specialized shoreland management zone at the water's edge. Physical controls and mechanical harvesting may have side effects in the expansion of plant habitat and the spread of reproductive vegetative fragments.

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 disadvantages associated with chemical control include the following:

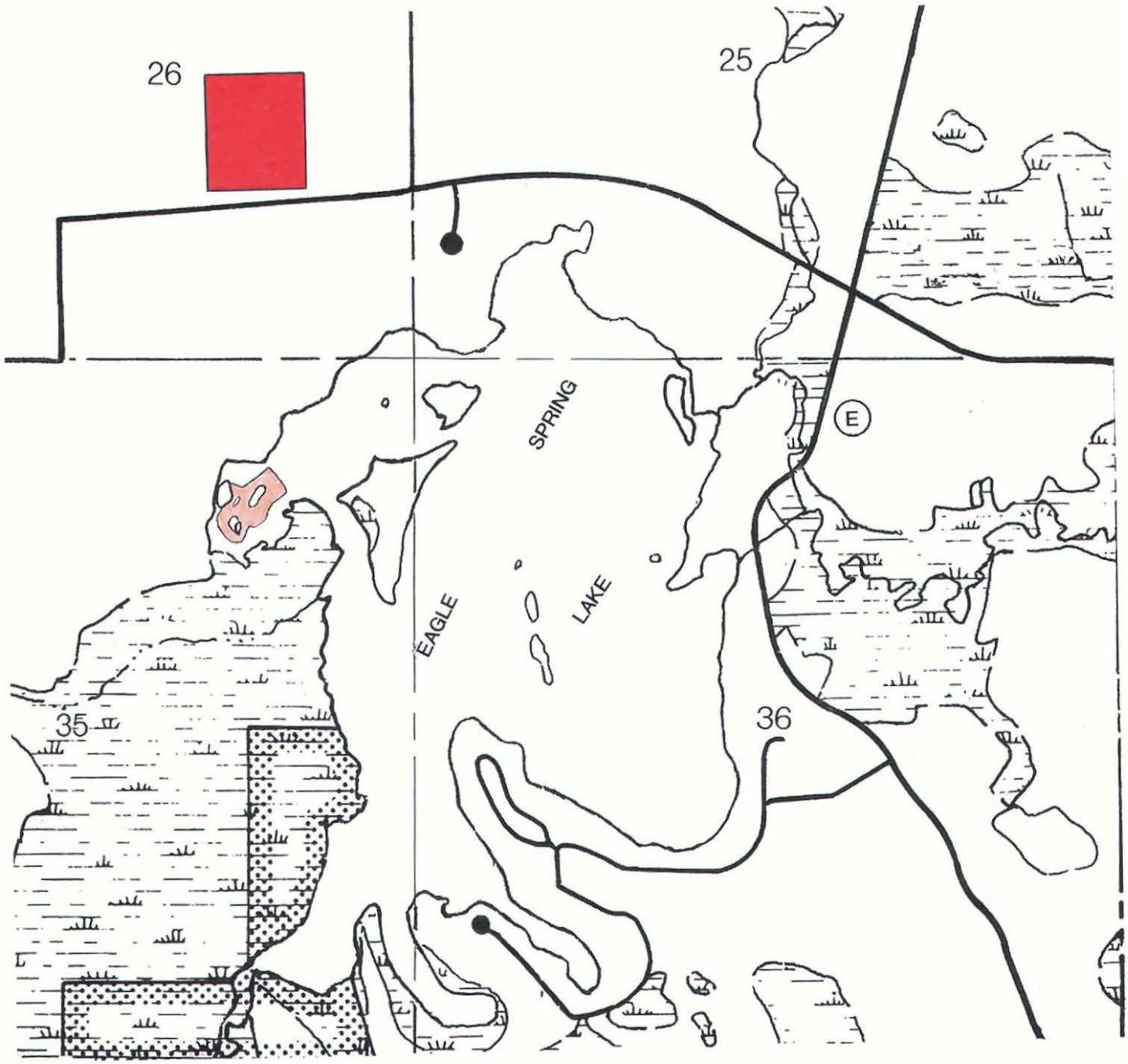
1. The short-term, lethal effects of chemicals are relatively well known. However, properly applied, chemical applications should not result in such effects. Potential long-term, sublethal effects, especially on fish, fish-food organisms, and humans, are relatively unknown.

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 are 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 addi-

Map 23

1995 DREDGE SITE AND SOILS DISPOSAL AREA FOR EAGLE SPRING LAKE



LEGEND

PERMITTED DREDGED MATERIAL DISPOSAL SITE-1995 PROJECT

PROJECT DREDGING AREA-1995 PROJECT

GRAPHIC SCALE
0 500 1000 FEET

Source: U.S. Army Corps of Engineers and SEWRPC.

tional 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 Hyalella, both important fish foods. Daphnia is the primary food for the young of nearly all fish species found in the Region's lakes.[14]

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.[15]

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. 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 in selected areas of Eagle Spring Lake, chemical treatment is considered to be a viable management option to be considered further for Eagle Spring Lake.

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:

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.[16]

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.

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

[15] *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.*

[16] *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.*

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.

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.

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.[17]

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. Operation of harvesting equipment in shallow waters can result in significant increases in turbidity and disruption of the lake bottom and lake bottom-dwelling fauna.

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, are frequently caught in the harvester. As much as 5 percent of the juvenile fish population can be removed by harvesting. A Wisconsin Department of Natural Resources study found that four pounds of fish were removed per ton of plants harvested.[18]

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.[19] 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.[20] 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. 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.

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[17] *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.*

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

[19] *Breck et al., op. cit.*

[20] *Breck et al., op. cit.*

6. Certain species of plants, such as coontail, are difficult to harvest due to lack of root system.

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. Manual methods have to be used in these areas.

8. High capital and labor costs are associated with harvesting programs. Macrophyte harvesting on Eagle Spring Lake could be continued by the Eagle Spring Lake Management District staff or be contracted to a private company. Based upon the number of acres cut in 1993, the estimated annual cost of harvesting by the District staff would be about $12,000. These costs 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.

Various types of harvesters and harvesting practices are available to address the many issues encountered on Eagle Spring Lake. The Eagle Spring Lake Protection and Rehabilitation District currently operates two Aquarius Systems HM-220 aquatic plant harvesters with transporting equipment. Issues that presently need to be addressed are the need to harvest plants for recreational purposes while taking into account the limited depth for operation of the harvester, protection of the ecologically valuable areas and native aquatic plant growth, and implementation of a public information program.

A harvesting program should be designed to provide optimal benefits and minimal adverse impacts. Small fish are common in dense macrophyte beds, but larger fish, such as largemouth bass, do no utilize these dense beds.[21] Narrow channels may be harvested to provide navigational access and "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish. "Shared access" lanes may also be cut, allowing several residents to use the same lane. Increased use of these lanes should keep them open for longer periods than would be the case if a less directed harvesting program was followed. "Clear cutting" of aquatic plants and denuding the lake bottom of flora should be avoided. Top cutting of plans such as Eurasian water milfoil, as shown in Figure 12, is suggested—the harvest of water lilies and other emergent native plants, however, should be avoided. Protecting native aquatic plant communities from disturbances can help prevent Eurasian water milfoil from spreading within a lake. Recent studies show that native plants can effectively compete with Eurasian water milfoil. However, the exotic tends to out compete native plants when the lake's ecosystem is stressed. Stress can be brought on by watershed pollution, shoreline development, changing water levels, boating activity, carp, and aquatic nuisance controls.[22] This maintenance of a healthy aquatic plant community has been found to be the most efficient way of managing aquatic plants, as opposed to other means of managing problems once they occur. Furthermore, native aquatic plant communities contribute most effectively to the maintenance of good water quality by providing suitable habitat for desirable fish and other aquatic organisms which promote stable or increased property values and quality of life.[23]

Because of the demonstrated need for control of aquatic plants in Eagle Spring Lake and because the current lake management decisions have indicated a need for aquatic plant harvesting, harvesting is considered a viable continued management option.

Shoreline Cleanup Crew: Decomposing floating vegetation which builds up along the shorelines limits the use of the riparians shoreline and can be extremely unsightly and foul smelling. Shoreline

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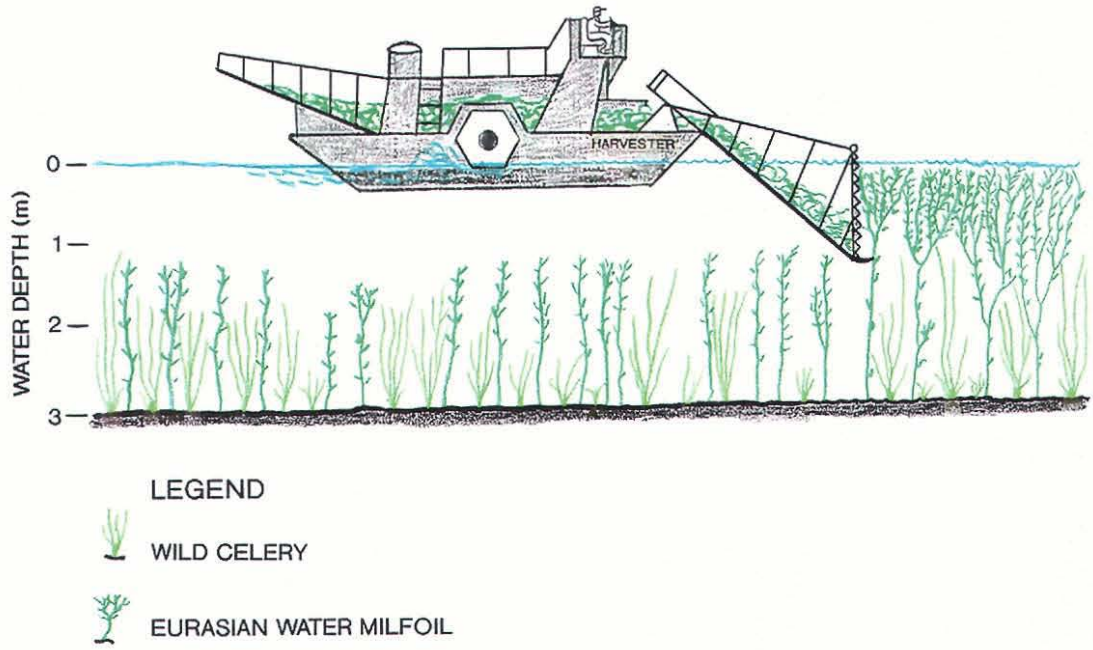
[21] *S. Nichols, "Mechanical and Habitat Manipulation for Aquatic Plant Management: A Review of Techniques," Wisconsin Department of Natural Resources Technical Bulletin No. 77, 1974.*

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

[23] *Roy Bouchard, Kevin J. Boyle, and Holly J. Michael, Water Quality Affects Property Prices: A Case Study of Selected Maine Lakes, Miscellaneous Report 398, February 1996.*

Figure 12

PLANT CANOPY REMOVAL WITH AN AQUATIC PLANT HARVESTER



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

Source: Wisconsin Department of Natural Resources and SEWRPC.

cleanup is a laborious job which can require a substantial amount of labor and time. Given that a significant number of lake home owners are seasonal and/or elderly it is not always feasible for them to clean their shoreline when needed. The Lake Pewaukee Sanitary District has incorporated a shoreline cleanup crew into their harvesting program to alleviate this problem.[24] Retention of two or three people for a continuous cleanup crew would provide for the removal of substantial amounts of vegetation which if not removed would contribute to accumulation of organic sediment to the bottom of the lake and to the continued proliferation of aquatic plants. Such a crew operates using a flat barge occupied by a driver and one to two people wading in the water or standing on the barge to pick up floating vegetation and deposit it onto the barge. This method leaves the rooted vegetated area between piers to the responsibility of the riparian owner. A custom-built flat barge is estimated to cost about $15,000. Because there is not a demonstrated need for the regular cleanup of floating vegetation on Eagle Spring Lake, provision of a shoreline cleanup crew is not currently a recommended management measure.

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 implemented by the Pewaukee Lake Sanitary District involved the purchase of a dozen specially designed rakes which are designed specifically to manually remove aquatic plants from the shoreline area. The rakes were made available for

[24] *Charlie Shong, Lake Pewaukee Sanitary District, oral communication, 1995.*

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. This method also gives the harvester more time to cover larger areas of the lake as maneuvering between the piers takes time and skill.

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.[25] 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 buoyancy and collapse.[26] 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.[27]

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 it is not practical to recommend this type of control on Eagle Spring Lake at this time.

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

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[25] *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.*

[26] *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.*

[27] *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.*

polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years. The screens are flexible and can be anchored to the lakebed 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.

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 $50 for burlap to $250 for aquascreen. Because of the limitations involved, lake bottom covers as a method to control aquatic plant growth are not recommended for Eagle Spring Lake, except on a limited individual homeowner basis.

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 Eagle Spring 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 Eagle Spring 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.

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, and when transiting the channel between Eagle Spring and Lulu Lakes. Providing the opportunity for the removal of plant fragments at the boat landing on Eagle Spring Lake, and provision of signage at the Eagle Spring Lake end of the Eagle Spring Lake-Lulu Lake channel—including provision of disposal containers on the shorelands along this channel, may help motivate boaters to

utilize this practice. Posters and pamphlets are available from the Wisconsin Department of Natural Resources and University of Wisconsin-Extension Service 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 aquatic plant management plan for Eagle Spring Lake which addresses the issue in more detail is included as Appendix C.

Fish Management Measures

Eagle Spring Lake provides a quality habitat for a healthy, warmwater fishery. Although currently unbalanced, adequate water quality, dissolved oxygen levels, sand and gravel shorelines, and diverse plant community exist for the maintenance of a sport fish population in the Lake. Winterkill is not a problem. However, the presence of rough fish is apparent, and an annual "Carp-Out Fisheree" is held to maintain some level of control over the carp population. In addition, due to the abundance of northern pike habitat in the Lake, pike have been stocked for the last four years by the Wisconsin Department of Natural Resources. As discussed in Chapter IV, the panfish population of the Lake has deteriorated over the last three years and is currently limited in numbers and is undersized.

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. For bass this is mid-April to mid-June. Use of natural vegetation in shoreland management zones and other "soft" shoreline protection options aid in habitat protection. Costs are generally low unless the habitat is already degraded. Ordinance modification might be required to impose boating restrictions or similar constraints on recreational use; modification of aquatic plant harvesting operations may also be required to support restoration and protection of native aquatic plant beds. 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, as well as selective harvesting of aquatic plants, 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.

Water level fluctuations can also alter fish habitat. The potential effects of any proposed perturbations in water levels on the fishery should be well-studied before considering implementation. Finally, the importance of maintaining good water quality cannot be overemphasized as a fish habitat protection measure.

Habitat Creation: In lakes where vegetation is lacking or where plant species diversity is low, artificial habitat may need to be developed. Northern pike artificial spawning habitat can be created by impounding small streams entering the lake.[28] Such impoundments usually have extensive shallows and marshy habitats that are prime northern pike habitat. Artificial walleyed pike spawning beds have been constructed from rocks and boulders, but the success has varied among lakes. In lakes that lack a healthy and diverse native aquatic plant community, transplant experiments have also been attempted to increase the available fish habitat.[29] As indicated in Chapter V, the results of the aquatic plant surveys of Eagle Spring Lake indicate that there is sufficient habitat for a healthy fish community. Therefore, habitat creation programs are not recommended for Eagle Spring Lake.

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

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

[29]*D.H. Les, G. Gunterspergen, J. Keough, and F. Stearns, "Feasibility of Increasing Native Aquatic Macrophytes in Lac La Belle and Okauchee Lakes, Wisconsin: Final Report on 1987 Field Study," unpublished report to the Wisconsin Department of Natural Resources, January 1988.*

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

More extreme measures include organized fishing events, such as the annual Eagle Spring Lake "Carp-Out Fisheree," that place a bounty on undesirable species as a means of increasing angling pressure on, or selectively cropping, 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. Lake drawdown is often used along with chemical treatments to expose spawning areas and eggs and concentrate fish in shallow pools, thereby increasing their availability to anglers, commercial harvesters, or chemical eradication treatments. Fish barriers are usually used to prevent reintroduction of undesirable species from up- or downstream, and the habitat thus created will benefit the desired gamefish populations. Chemical eradication is a drastic, costly measure and the end result may be highly unpredictable. Although effectiveness is generally good, such extreme measures are not recommended for Eagle Spring Lake where the fisheries value of the resource has been assessed as good overall.

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/or population structure. Fishes stocked into Eagle Spring Lake are listed in Table 17.

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.[30] 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.

3. Overstocking may have an unfavorable effect on angling success.[31]

In Eagle Spring Lake, stocking of northern pike by the Wisconsin Department of Natural Resources is recommended to supplement the existing game fish

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

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

populations. Largemouth and smallmouth bass stocking is not normally needed where habitat conditions are favorable and is seldom successful where they are not.[32] The estimated annual cost of northern pike stocking is $1,600, based on current stocking programs.

Because of the recent trends in the size and number of panfish population and the size of the largemouth bass population, it is recommended that the Lake District work cooperatively with the Wisconsin Department of Natural Resources to consider modifications to the current fish management program, including the stocking element of that program. Because of the complexity of the problem, it is recommended that a comprehensive fish survey and an angler creel survey be conducted in order to assist in formulating the refined plan.

Regulations and Public Information: To reduce the risk of overharvest, the Wisconsin 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 Eagle Spring Lake are given in Table 25. Enforcement of these regulations is critical to the success of any sound fish management program. Because of the current imbalance in the fishery with regard to the small number and size of panfish, and modifications to the current size and bag limit is considered a viable option to be considered further by the Lake District and the Wisconsin Department of Natural Resources.

Shoreline Maintenance

Shoreline erosion was not evident around Eagle Spring Lake, and no serious problems were identified. The shorelands of Eagle Spring Lake are extensively armored, as shown on Map 3. Four shoreline erosion control techniques were in use in 1995: vegetative buffer strips, rock revetments, wooden and concrete bulkheads, and gabions.

The simplest, least costly, and most natural method of reducing shoreline erosion is the provision of a vegetative buffer strip immediately adjacent to the Lake (Figure 13). This technique employs natural vegetation, rather than maintained lawns, within five to 10 feet of the lakeshore or the establishment of emergent aquatic vegetation from two to six feet lakeward of the eroding shoreline. Aquatic species, such as cattails (Typha spp.) and common reed (Phragmites communis), may be suitable in the littoral areas along the eroding shores. Taller grasses invaded initially by weeds, and later by other species of grasses, forbs, and shrubs, should be encouraged on the shoreline. Some transplanting or seeding with carefully chosen indigenous plant types can decrease the time of this succession of plant species. Desirable plant species which may be expected and encouraged to invade the buffer strip, or which could be planted, include arrowhead (Sagittaria latifolia), cattail (Typha spp.), common reed (Phragmites communis), water plantain (Alisma plantago-aquatica), bur-reed (Sparganium eurycarpum), and blue flag (Iris versicolor) in the wetter areas; and jewelweed (Impatiens biflora), elderberry (Sambucus canadensis), giant goldenrod (Solidago gigantea), marsh aster (Aster simplex), red-stem aster (Aster puniceus), and white cedar (Thuja occidentalis) in the drier areas. In addition, trees and shrubs such as silver maple (Acer saccharinum), American elm (Ulmus americana), black willow (Salix nigra), and red-osier dogwood (Cornus stolonifera) could become established. These plants will develop a more extensive root system than the lawn grass and the above-ground portion of the plants will protect the soil against the erosive forces of rainfall and wave action. A narrow path to the lake can be maintained as lake access for boating, swimming, fishing, and other activities. A vegetative buffer strip would also serve to trap nutrients and sediments washing into the lake via direct overland flow. This alternative would involve only minimal cost.

Rock revetments, or riprap, are a highly effective method of shoreline erosion control applicable to many types of erosion problems, especially in areas of low banks and shallow water. Some of these structures are already in place at Eagle Spring Lake (see Map 3). The technique, as shown in Figure 13, involves the shaping of the shoreline slope, the placement of a porous filter material, such as sand, gravel, or pebbles, on the slope and the placement of rocks on top of the filter material to protect the slope against the actions of waves and ice. The advantages of a rock revetment are that the

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

Table 25

1996 OPEN SEASON, SIZE LIMITS, AND BAG LIMITS FOR FISH SPECIES IN EAGLE SPRING 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 Eagle Spring Lake. Daily limits and minimum sizes vary between lakes.*

Source: Wisconsin Department of Natural Resources.

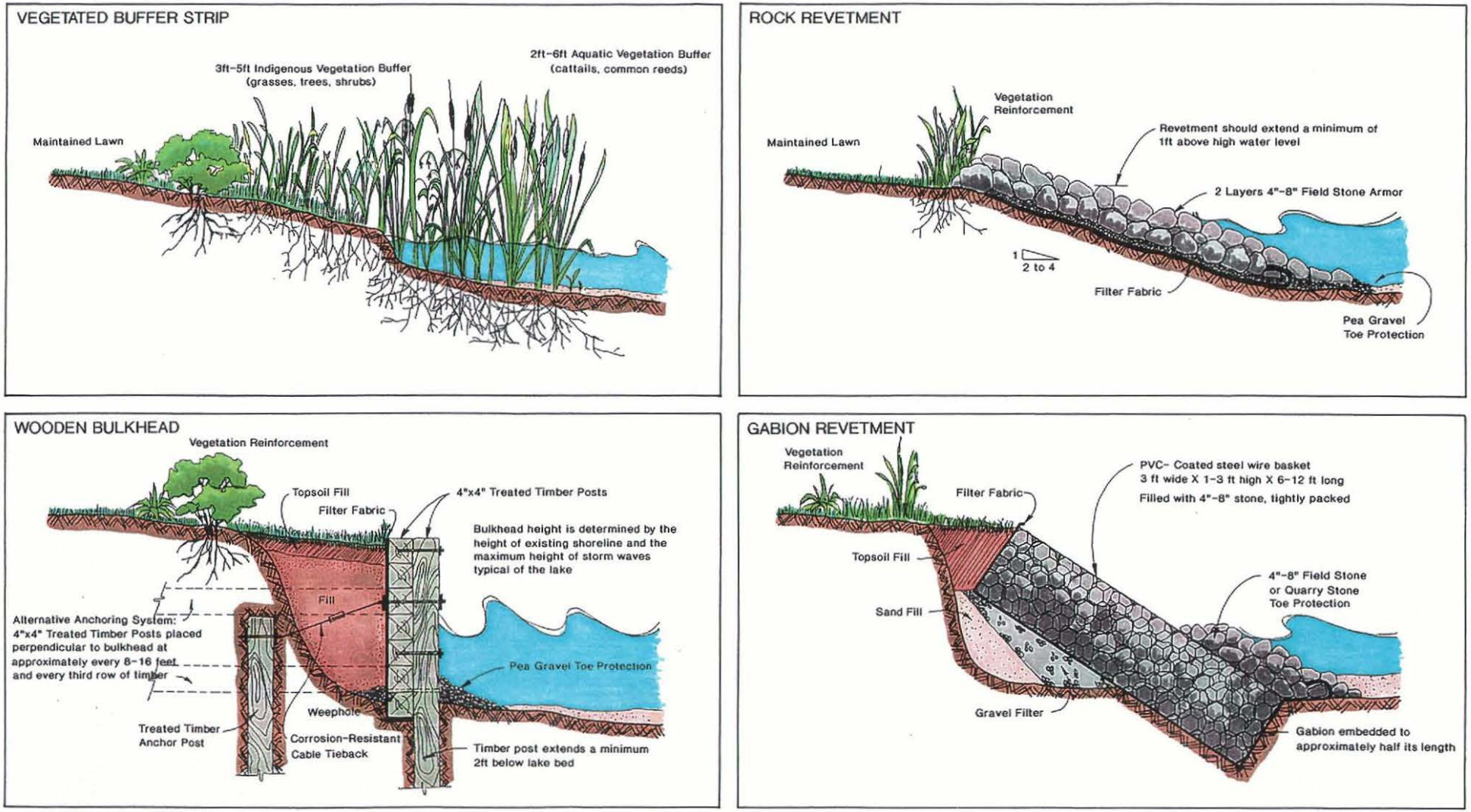
structure is highly flexible and not readily weakened by movements caused by settling or ice expansion, it can be constructed in stages, and it requires little or no maintenance. The disadvantages of a rock revetment are that it limits the use of the immediate shoreline in that the rough, irregular rock surfaces are unsuitable for walking; a relatively large amount of filter material and rocks needs to be transported to the lakeshore; and excavation and shaping of the shore slope may cause temporary disruptions and contribute sediment to the lake. Even if improperly constructed, the revetment may fail because of washout of the filter material. A rock revetment constructed along a 300 foot shoreline by a private contractor would involve a total capital cost of about $7,500, or about $25 per linear foot. By providing labor and some materials, Eagle Spring Lake residents could reduce this cost by up to 50 percent.

Wooden bulkheads, as shown in Figure 13, prevent the sliding of land or slope failure and provide protection against wave action and, to a lesser extent, ice action. A series of horizontal boards are bolted to a series of vertical posts sunk into the soil at the waterline. Alternatively, a close-set series of vertical poles three to six inches in diameter can be erected. A stone toe is usually provided on the lakeward side to protect against undercutting. A sunken cable tieback to an anchored "deadman" may be used to prevent the bulkhead from slipping towards the lake. Advantages of a wooden bulkhead are that it provides substantial protection and maintains the shoreline in a fixed position and that the materials are readily available. Bulkheads, depending on their type, may be considered less visually appealing than rock revetments; are less flexible and more susceptible to ice damage; and are considerably more difficult and expensive to repair than a rock revetment. A wooden bulkhead installed by a private contractor would involve a total capital cost of about $2,200, or about $7.50 per linear foot. As with rock revetments, the provision of labor and some materials by local residents could substantially reduce this cost.

A gabion is a steel wire-mesh basket filled with rock. Gabions are commercially available in a variety of sizes and are constructed and filled with rocks at the site of placement. A single gabion three feet high and three feet wide, sunk into the soil to about one-half its height, as shown in Figure 13, may be expected to protect the shoreline of Eagle Spring Lake adequately. An underlying filter cloth prevents the erosion of finer particles below and behind the gabion, which could cause excessive movement and settling of the gabion. A rock toe may also be provided to prevent undercutting. The advantages of gabions are that they are flexible, relatively easy to construct, and are effective against ice movement. Gabions often become covered with vegetation, which adds to

Figure 13

PLAN ALTERNATIVES FOR SHORELINE EROSION CONTROL



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.

Source: SEWRPC.

their visual appeal. The disadvantages of gabions are their relatively high cost, the potential for damage and breakage of the wire-mesh basket, and the considerable excavation needed to implant them. Gabions installed by a private contractor along a 300-foot shoreline would cost about $10,800, or about $36 per linear foot. If labor and some materials could be provided by local residents, this cost could be substantially reduced.

Recreational Use Zoning

Regulatory measures provide a basis for controlling lake use and use of the shorelands around a waterbody. 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 lakes by various groups of lake users and protect environmentally sensitive areas of a lake. Use zoning can 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/residents 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 appreciate an enhanced fishery. Costs are relatively low—associated with creating and posting the ordinance—and effectiveness can be good with regular/consistent enforcement. Costs increase for measures requiring bouyage.

In the final analysis, there is the option to adapt recreational uses of a waterbody to its quality and constraints. Sometimes recreational use management can alter public expectations of a waterbody and lead to increased satisfaction among users. Restrictive boating ordinances, that limit the time and area of use and the velocity of the boating traffic, have been applied to Eagle Spring Lake to protect such recreational opportunities. These same restrictions could be used to protect sensitive fish breeding areas or aquatic plant beds, for example. Jet skiing and water skiing should be restricted to the perimeter of the main basin of Eagle Spring Lake, and boating traffic through the Mukwonago River between Eagle Spring Lake and Lulu Lake could be restricted to slow-no-wake speeds, as part of zoning recreational use.

Informational and Educational Programs

Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the recreational use and shoreland zoning regulations, are available from the University of Wisconsin-Extension Service, the Wisconsin Department of Natural Resources and the Waukesha County Department of Parks and Land Use. These latter cover topics such as beneficial lawn care practices and household chemical use guidelines. These brochures could be provided to homeowners through local media, direct distribution or targeted school displays. Other Waukesha County lake organizations, in cooperation with the Waukesha County Department of Parks and Land Use, have compiled and distributed information packets to landowners on water quality protection measures and residential "good housekeeping" practices. The annual Carp-Out Fisheree, for example, could form a venue for the distribution of materials of an environmental nature. Such activities could also raise public interest in the activities of the Eagle Spring Lake Management District. Many of the foregoing ideas, such as lakeside litter collections, can be integrated into ongoing, larger-scale municipal activities such as anti-littering campaigns, recycling drives, and similar pro-environment activities.

Finally, the participation of Eagle Spring Lake in the Wisconsin 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 Lake District, where the citizen-monitors could be given some recognition for his or her work. The Lake Coordinator of the Wisconsin 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 options that could be employed in managing the types of problems recorded as occurring in Eagle Spring Lake and which could, singly or in combination, assist in achieving and maintaining the water quality and water use objectives set forth in Chapter VI. Selected characteristics of these measures are summarized in Table 26.

An evaluation of the potential management measures for improving the Eagle Spring Lake water quality was carried out on the basis of the effectiveness, cost, and technical feasibility of the measures. Those alternative measures not considered further at this time are: nutrient precipitation and inactivation, water level control modifications, drawdown, mechanical dredging, reestablishment of an aquatic plant shoreline cleanup crew and biological controls, lake bottom covering, and fish habitat creation. The remaining measures were considered further for incorporation in the recommended plan described in Chapter VIII.

Table 26

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR EAGLE SPRING LAKE

Alternative Measure	Description	Estimated Costs		Considered Viable for Inclusion in Recommended Lake Management Plan
		Capital	Operation and Maintenance	
Land Use Control and Management	Land use development planning and zoning modifications for entire watershed	--	--	Yes
	Density management in lakeshore areas	--	--	Yes
Rural Nonpoint Source Pollution Control	Conservation tillage, contour farming, contour strip cropping, crop rotation, grassed waterways, and pasture and streambank management	--[a,b]	--[a,b]	Yes
Urban Nonpoint Source Pollution Control	Urban housekeeping practices, public educational program, and grassed swales	--[b]	--[b]	Yes
Construction Site Erosion Control	Soil stabilization, surface roughening, barriers, diversion swales, sediment traps and basins	$250 per acre	$25 per acre	Yes
Sanitary Sewer Service	Onsite sewage disposal system management, including inspection and maintenance. Ultimately the provision of a public sanitary sewer system for the urban area surrounding the Lake	$8,250,000[c]	$150,000[c]	Yes
Phosphorus, Precipitation, and Inactivation	Alum treatment	--	$115,000	No
	Nutrient load reduction	--	Variable	No
Water Level Management	Outlet control modifications	--	--	No
	Drawdown	--	--	No
	Large-scale dredging	$5,000,000	--	No
	Small-scale dredging	Variable	--	Yes[d]
Aquatic Plant Management	Herbicides	--	Variable	Yes[e]
	Harvesting	$90,000[f]	$22,000	Yes
	Sediment covering	--	$40 to $220 per 700 square feet	No
	Shoreline cleanup crew	$15,000	$4,000	No
	Manual harvesting	--	--	Yes
	Biological controls	--	--	No
	Bottom covering	$50 to $250	--	No
	Public information and education	--	--[g]	Yes
Fish Management	Habitat protection	--	--	Yes
	Habitat creation	--	--	No
	Stocking	--	$1,200	Yes
	Size and catch number per regulations	--	--	Yes
Shoreline Maintenance	Installation and maintenance of shoreline erosion control structures	$8.00 to $40 per lineal foot	--	Yes

Table 26 (continued)

Alternative Measure	Description	Estimated Costs		Considered Viable for Inclusion in Recommended Lake Management Plan
		Capital	Operation and Maintenance	
Recreational Use Zoning	Space and time zoning to maximize public safety	--	--	Yes
Public Informational and Educational Measures	Public informational and educational programming	--	--	Yes

[a] *Cost dependent upon preparation of individual farm plans.*

[b] *Nonpoint source pollution abatement program is to be detailed as part of the Wisconsin Department of Natural Resources priority watershed planning program includes a project for Eagle Spring Lake to begin in 1997.*

[c] *Cost for future public sanitary sewer system based upon 1985 facilities plan updated to 1997 dollars.*

[d] *To be determined on a case-by-case basis, on a small-scale basis.*

[e] *In limited areas when found necessary to supplement harvesting.*

[f] *Estimated capital cost of new harvesting equipment to replace existing equipment, when needed.*

[g] *Cost included in overall comprehensive informational and educational programs.*

Source: SEWRPC.

Chapter VIII

RECOMMENDED MANAGEMENT PLAN FOR EAGLE SPRING LAKE

INTRODUCTION

This chapter presents a recommended management plan, including attendant costs, for Eagle Spring Lake. The plan is based upon inventories and analyses of land use and land and water management practices; and pollution sources in the drainage area tributary to Eagle Spring Lake; and of the physical and biological quality of the waters of the Lake; on the land use and population forecasts; and on an evaluation of alternative lake management plans. The recommended plan sets forth means for: 1) providing water quality conditions suitable for full-body contact recreational use and the maintenance of healthy communities of warmwater fish and other aquatic life; 2) reducing the severity of existing nuisance problems due to excessive macrophyte growth, which constrain or preclude desired water uses; 3) improving opportunities for water-based recreational activities; and 4) protecting environmentally sensitive areas. The recommended plan was selected from among the alternatives described in Chapter VII, and evaluated on the basis which the feasible alternatives may be expected to meet water use objectives at a reasonable cost.

Analyses of water quality and biological conditions indicate that the general condition of the water in Eagle Spring Lake is good, although water-based recreation is limited by water depths and growths of aquatic macrophytes. The recommended plan sets forth recommendations for: land use regulation and land management in the drainage area tributary to Eagle Spring Lake; onsite sewage disposal system management, including ultimately the consideration of installation of a public sanitary sewer system; in-lake management measures, including water quality monitoring, lake level control, aquatic plant management, fishery management, recreational use zoning, and shoreline protection; and informational and educational programming. These measures complement the watershedwide land use control and management measures recommended in the regional water quality management plan.[1]

The recommended management measures for Eagle Spring Lake are graphically summarized on Map 24 and are listed in Table 27. The recommended plan measures are more fully described in the following paragraphs.

LAND USE AND ZONING MEASURES

A fundamental element of a sound management plan and program for Eagle Spring Lake is the promotion of a sound land use pattern within the drainage area tributary to the Lake. The type and location of urban and rural land uses in the drainage area will, to a considerable degree, determine 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.

The recommended design year 2010 land use plan for the drainage area tributary to Eagle Spring Lake is described in Chapter III. The framework for the plan is the regional land use plan as prepared and adopted by the Regional Planning Commission. The recommended land use plan envisions only limited additional urban land use development within the drainage area tributary to Eagle Spring Lake. Urban land use development should be permitted to occur 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

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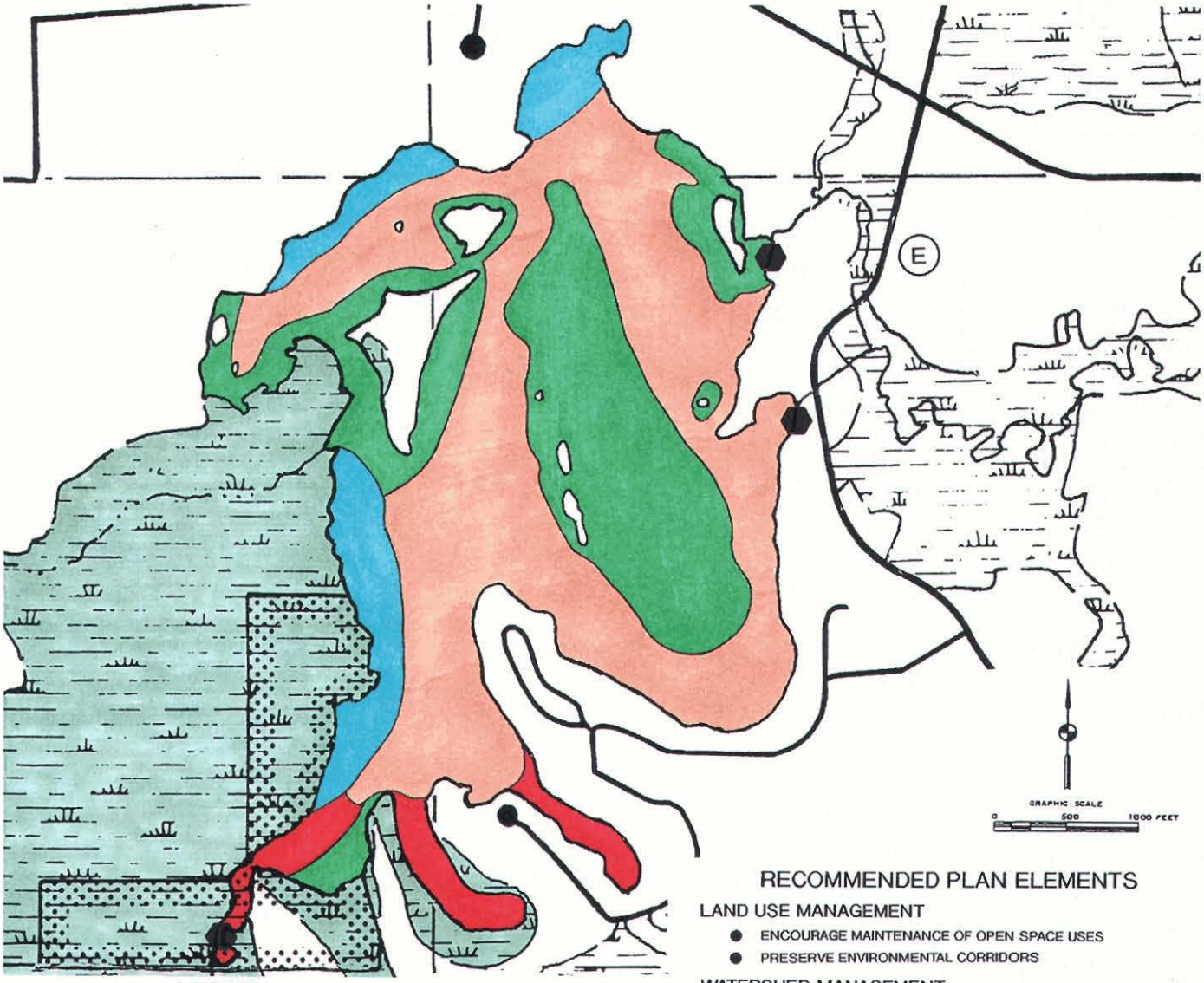
[1] *SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume Three, Recommended Plan, June 1979.*

Map 24

RECOMMENDED LAKE MANAGEMENT PLAN FOR EAGLE SPRING LAKE



LEGEND

MANAGEMENT ZONES

- FISHING: HARVEST NARROW CHANNELS-APPROXIMATELY 15 FEET WIDE PERPENDICULAR TO SHORE ABOUT EVERY 100 TO 200 FEET -USE OF CHEMICALS FOR ALGAE AND AQUATIC PLANT CONTROL NOT RECOMMENDED IN THESE AREAS
- BOATING: HARVESTCHANNELS APPROXIMATELY 50 FEET WIDE PARALLEL TO THE SHORELINE OF THE MAIN BASIN OF THE LAKE -LIMITED USE OF CHEMICALS FOR ALGAE AND AQUATIC PLANT CONTROL RECOMMENDED IN THESE AREAS
- HABITAT: ECOLOGICALLY VALUABLE AREAS-NO AQUATIC PLANT MANAGEMENT ACTIVITIES-USE OF CHEMICALS FOR ALGAE AND AQUATIC PLANT CONTROL NOT RECOMMENDED IN THESE AREAS
- ACCESS: HARVEST NARROW CHANNELS-APPROXIMATELY 15 FEET WIDE AROUND THE PERIMETER OF THE SOUTHERN BAY AREAS AND THE INLET AREA TO PROVIDE BOATING ACCESS FROM THESE AREAS TO THE MAIN BASIN OF THE LAKE-LIMITED USE OF CHEMICALS FOR ALGAE AND AQUATIC PLANT CONTROL RECOMMENDED IN THESE AREAS
- ECOLOGICALLY VALUABLE AREAS TO BE PROTECTED
- SITE FOR PROPELLER CLEANING FACILITY WITH SIGNAGE

RECOMMENDED PLAN ELEMENTS

LAND USE MANAGEMENT

- ENCOURAGE MAINTENANCE OF OPEN SPACE USES
- PRESERVE ENVIRONMENTAL CORRIDORS

WATERSHED MANAGEMENT

- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS
- PROMOTE INSTALLATION OF PUBLIC SANITARY SEWER SYSTEM
- CONDUCT ONSITE SEWAGE DISPOSAL SYSTEM MANAGEMENT PROGRAM
- PREPARE FARM PLANS FOR AGRICULTURAL LANDS

WATER LEVEL MANAGEMENT

- MAINTAIN LAKE WATER LEVELS IN THE RANGE OF 820.53 TO 820.83 FEET ABOVE NGVD-29

MONITORING PROGRAM

- CONDUCT FISH SURVEY
- CONDUCT WATER QUALITY MONITORING

FISH MANAGEMENT

- REVIEW AND REFINE STOCKING PROGRAM AS REQUIRED
- MODIFY ANGLING BAG LIMITS

SHORELINE PROTECTION

- MAINTAIN AND REPAIR EXISTING STRUCTURES

EURASIAN WATER MILFOIL MANAGEMENT PROGRAM

- CONTROL NUISANCE EURASIAN WATER MILFOIL CONDITIONS AS NECESSARY

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

Source: SEWRPC.

Table 27

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR EAGLE SPRING LAKE

Plan Element	Subelement	Location	Management Measures
Land Use and Zoning	Land use development planning	Entire watershed	Observe guidelines set forth in regional land use plan, including protection of environmental corridors
	Zoning modifications	Waukesha County portion of the watershed	Modify zoning ordinances to minimize open space losses and encourage cluster development
		Walworth County portion of the watershed	Maintain current zoning ordinances which minimize open space losses
	Density management	Lakeshore areas	Maintain historic medium- and low-density residential uses
	Protection of primary environmental corridors	Entire watershed	Preserve environmental corridor areas as recommended in regional land use plan and in Walworth and Waukesha County park and open space plans
Watershed Land Management	Urban nonpoint source controls	Entire watershed	Good urban housekeeping practices Develop a stormwater management system plan
	Construction site erosion control	Entire watershed	Continue enforcement of existing ordinances
	Rural nonpoint source controls	Entire watershed	Implement good soil conservation and nutrient management practices by preparation of detailed farm plans
	Onsite sewage disposal system management	Entire watershed	Develop informational and educational program to promote sound maintenance practices and periodic inspections
		Urban development surrounding Lake	Ultimately construct public sanitary sewer
Water Quality Management	Water quality monitoring	Entire Lake	Continue participation in DNR Self-Help Monitoring Program
Lake Level Management	Outlet structure control	- -	Maintain lake level between elevation 820.53 and 820.83 NGVD-29
Aquatic Plant Management	Chemical treatment	Within 50 feet of the shoreline, and areas of nuisance growth	Limited to use of 2,4-D to control of Eurasian water milfoil growth around docks, and purple loosestrife in wetlands and on shorelines
	Major channel harvesting	Boating and access zones	Harvest aquatic plants as required; avoid disturbance of lake bottom
	Minor channel harvesting	Fishing zones	Harvest fishing lanes

Table 27 (continued)

Plan Element	Subelement	Location	Management Measures
Aquatic Plant Management (continued)	Eurasian water milfoil	Entire Lake	Control dense, nuisance areas of Eurasian water milfoil as necessary, using appropriate methods and techniques pursuant to Wisconsin Department of Natural Resources guidelines
Boating Access	Small area dredging	Selected nearshore areas	Dredge boat access lanes where necessary
Fisheries Management	Fish survey	Entire Lake	Implement a fishery survey by the Wisconsin Department of Natural Resources and a citizen-based creel survey conducted by Eagle Spring Lake Management District with assistance from Department of Natural Resources
	Refine fishery management plan	--	Utilize survey findings to refine fishery management strategy
	Refined fish stocking	Entire Lake	Stock fish as required based upon refined plan
	Modification of fishing regulation limits	Entire Lake	Adjust size and number restrictions for anglers based upon analysis of surveys
Habitat Protection and Lake Use Management	Implementation of ordinances	Channel between Eagle Spring and Lulu Lakes	Implementation of "slow-no-wake" restrictions; site for propeller cleaning facility with signage
	Restrict harvesting	Habitat zone	Restrict harvesting to areas shown on Map 24
Shoreland Protection	Maintain structures	Entire Lake	Maintain existing structures
	Vegetative buffer strips	Along lakeshore and tributary streams	Install and maintain erosion control measures
Informational and Educational Program	Public informational and educational programming	Entire watershed	Continue and refine public awareness and informational programming

Source: SEWRPC.

not environmentally sensitive, that is, not encompassed within the Regional Planning Commission-delineated environmental corridors described in Chapter V.

A major land use issue which has the potential to affect Eagle Spring Lake is the potential development for urban uses of the agricultural and other open space lands in the Waukesha County portion of the tributary drainage area. As noted in Chapters III and VII, large-lot residential development is occurring in areas of the lake watershed in which such development was not envisioned in the adopted regional land use plan. If this trend continues, much of the open space areas remaining in the drainage area will be replaced over time with large-lot urban development. This may significantly increase the pollutant loadings to the Lake and increase the pressures for recreational use of the Lake. Under the full buildout condition envisioned

under the Waukesha County development plan[2] most of the undeveloped lands outside the environmental corridors and other environmentally sensitive areas, could potentially be developed for low-density urban uses.

Another land use issue which has the potential to affect the Lake is the redevelopment of existing lakefront properties, replacing lower-density uses with higher-density, multi-family dwellings with increased roof areas, parking areas, and other areas of impervious surfaces. Replacement of a pervious land surface with an impervious surface will increase the rate of stormwater runoff to the Lake; increase pollutant loadings on the Lake; and will reduce groundwater recharge. While these effects can be moderated to some extent through structural stormwater management measures, there is likely to be an adverse impact on the Lake from any redevelopment in the drainage area tributary to the Lake involving conversion to higher-density land uses. For this reason, maintenance of the historic low- and medium-density residential character of the shoreline of Eagle Spring Lake to the maximum extent practical is recommended.

The existing zoning within the Walworth County portion of the tributary drainage area to Eagle Spring Lake is generally consistent with the land use recommendations contained in the adopted regional land use plan. The existing zoning in the Waukesha County portion of the drainage basin, however, permits urban development—generally on large suburban-density lots—over much of the remaining open lands other than the environmental corridors. Control of shoreland redevelopment, and the related intensification of use, is not specifically addressed in the existing zoning codes, although new construction is required to meet specific compliance and inspection requirements for onsite sewage disposal systems. It is recommended that the impact of future land use development on Eagle Spring Lake be minimized through review and modification of the applicable zoning ordinance regulations and zoning district maps to address the concerns noted. Changes in the zoning ordinance are recommended to minimize the areal extent of development by providing specific provisions and incentives for the clustering of residential development on smaller lots while preserving portions of the open space on each property or group of properties considered for development.

Wetland and groundwater recharge area protection can be accomplished through land use regulation and public land acquisition and both measures are included in the recommended Eagle Spring Lake management plan. The wetland areas within the drainage area tributary to the Lake are currently largely protected through the U.S. Army Corps of Engineers 404 Permit Program, State shoreland zoning requirements, and local zoning ordinances. Nearly all wetland areas in the Eagle Spring Lake drainage area are included in the environmental corridors delineated by the Regional Planning Commission and protected under one or more of the existing Federal, State, County, and local regulations. Some wetland areas have been included in the Lulu Lake State Natural Area; others are located in areas proposed for inclusion in that natural area.[3] In this regard, implementation of the recommendations of the adopted park and open space plans for Walworth County[4] and Waukesha County[5] would provide for the protection and preservation of these environmentally sensitive lands.

WATERSHED LAND MANAGEMENT MEASURES

The recommended watershed land management measures are specifically aimed at reducing the water quality impacts on Eagle Spring Lake of

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[2]*SEWRPC Community Assistance Planning Report No. 209, A Development Plan for Waukesha County, Wisconsin, August 1996.*

[3]*Wisconsin Department of Natural Resources, Lulu Lake State Natural Area Boundary Expansion Feasibility Study, October 1994.*

[4]*SEWRPC Community Assistance Planning Report No. 135, A Park and Open Space Plan for Walworth County, February 1991.*

[5]*SEWRPC Community Assistance Planning Report No. 137, A Park and Open Space Plan for Waukesha County, December 1989.*

nonpoint sources of pollution within the tributary drainage area. These measures are set forth in the aforereferenced regional water quality management plan.

As indicated in Chapters IV and VII, the only significant sources of phosphorus loading on the Lake that are subject to control are rural and urban nonpoint sources and onsite sewage disposal systems in the tributary drainage area.

As indicated in Chapter VII, nonpoint source control measures should be considered for the areas tributary to Eagle Spring Lake, including the upstream tributary drainage area. The regional water quality management plan recommended a reduction of about 25 percent in both the rural and urban nonpoint sources plus streambank erosion control, construction site erosion control, and onsite sewage disposal system management be achieved in the drainage area tributary to Eagle Spring Lake.

Nonpoint source pollution abatement controls in the drainage area are recommended to be achieved through a combination of rural agricultural nonpoint controls, construction erosion controls, and urban stormwater management. In addition, it is recommended that the onsite sewage disposal systems in the urban areas surrounding the Lake ultimately be abandoned with the concomital construction of a public sanitary sewer system and the elimination of pollutant loadings from that source. The implementation of the land management practices described below may be expected to result in a reduction of total phosphorus loadings to Eagle Spring Lake of about 25 percent, a reduction considered to be the maximum practicable given the findings of the inventories and analyses conducted under the planning effort.

The recommended management agency responsibilities for watershed land management are set forth in Table 28.

Urban Nonpoint Source Control

The development of urban nonpoint source pollution abatement measures for the Eagle Spring Lake areas should be the responsibility of Walworth and Waukesha Counties, the Town and Village of Eagle in Waukesha County, the Eagle Spring Lake District, and private property owners. The Towns of LaGrange and Troy in Walworth County would have minimal involvement since there is no significant urban development envisioned in the Walworth County portion of the tributary drainage area. Accordingly, it is recommended that the Eagle Spring Lake Management District take an active role to promote urban nonpoint source pollution abatement by sponsoring and coordinating the Wisconsin Department of Natural Resources nonpoint source pollution abatement project for the tributary drainage area to Eagle Spring Lake. The project would be undertaken by Walworth and Waukesha Counties and would also involve the local units of government in the drainage area tributary to Eagle Spring Lake, working cooperatively with the Wisconsin Department of Natural Resources.

As discussed in Chapter VII, it is recommended that the most viable measure to control urban nonpoint sources of pollution will be good urban land management and urban housekeeping practices. Such practices consist of fertilizer and pesticide use management, litter and pet waste controls, and managing leaf and yard waste. The promotion of these measures will require a public informational and educational program. Additionally, the public education program should present information on the groundwater resources of the area and on the measures, such as onsite sewage disposal system management and waste disposal, required to protect these resources.

As indicated in Chapter VII, the inclusion of additional facilities to provide for a high level of urban nonpoint source control, including stormwater treatment facilities such as detention basins, does not appear to be a necessary or effective element of a water quality management plan for the existing urban areas surrounding Eagle Spring Lake. This conclusion was reached because stormwater flow to the Lake is relatively diffuse, with no practical means for concentrating the flow at treatment facilities. Furthermore, the opportunities for effectively utilizing structural measures in other urbanized areas within the tributary area to Eagle Spring Lake are minimal due to the nature of the existing development. Most of such development in the drainage area tributary to the Lake does have a rural drainage system which utilizes roadside swales, as opposed to curb and gutter and storm

Table 28

LOCAL GOVERNMENTAL MANAGEMENT AGENCY RESPONSIBILITIES FOR PLAN IMPLEMENTATION

Plan Element	Subelement	Agency				
		Walworth County	Waukesha County	Eagle Spring Lake Management District	Municipalities within Watershed[a]	Department of Natural Resources
Land Use Management	Land Use development planning and zoning Modifications	X[b]	X[b]	--	X	--
	Protection of environmental corridors	X	X	--	X	--
Watershed Land Management	Urban nonpoint source controls	--	X	X	X[c]	X
	Construction site erosion control	X	X	--	X	--
	Rural nonpoint source controls	X	X	--	--	X
	Onsite sewage disposal system management	X	X	X[d]	X[d,e]	--
	Ultimately install public sanitary sewer system	--	--	X	--	X
Water Quality Management	Water quality monitoring	--	--	X	--	X
Lake Level Management	Outlet structure control	--	--	X	--	--
Aquatic Plant Management	Comprehensive plan refinement	--	--	X	--	X[f]
	Chemical treatment	--	--	X	--	X[g]
	Harvesting	--	--	X	--	--
Fish Management	Fish survey	--	--	X	--	X
	Refine fishery management program	--	--	X	--	X
	Fish stocking	--	--	X	--	X
	Refine current fishing regulations	--	--	X	--	X
Habitat Protection and Lake Use Management	Refinement and implementation of ordinance to protect environmentally sensitive areas	--	--	X	X	X
	Install signage and propeller cleaning station	--	--	X	--	X
Shoreland Protection	Maintenance of structures	--	--	X[d]	--	--
Informational and Educational Program	Public informational and educational programming	X[h]	X[h]	X	--	--

[a] *Municipalities include Towns of Troy and LaGrange in Walworth County and the Village of Eagle in Waukesha County.*

[b] *Current zoning in Walworth County is consistent with plan recommendations; changes to zoning in Waukesha County are recommended.*

[c] *Applies only to Town and Village of Eagle.*

[d] *Resident responsibility; the District and Village can provide guidance and facilitate technical support.*

[e] *Applies to the Village of Eagle only.*

[f] *The Wisconsin Department of Natural Resources reviews aquatic plant management plans, revisions thereof, and boating ordinances for compliance with State rules.*

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

[h] *County assistance is provided through the Land Conservation Division of the County Department of Parks and Land Use, and the University of Wisconsin-Extension.*

Source: SEWRPC.

sewers. Thus, there is currently some control of nonpoint sources effected.

As an initial step in carrying out the recommended urban practices, it is recommended that a fact sheet identifying specific residential land management measures beneficial to the water quality of Eagle Spring Lake be prepared and distributed to property owners by the Eagle Spring Lake Management District with the assistance of the University of Wisconsin-Extension Service and the Walworth and Waukesha County Land Conservation offices. The recommended measures may be expected to provide about a 25 percent reduction in urban nonpoint source pollution runoff, and about a 5 percent reduction in total phosphorus loadings to the Lake.

Construction Site Erosion Control

It is recommended that Waukesha and Walworth Counties continue efforts to control soil erosion attendant to construction activities in accordance with existing ordinances. As noted in Chapter VII, these two Counties have adopted construction erosion control ordinances based on the model ordinance promulgated by the Wisconsin Department of Natural Resources in cooperation with the Wisconsin League of Municipalities.[6] Enforcement of the ordinances by the Counties is generally considered effective. The provision of these ordinances apply to all development except single- and two-family residential construction. The single- and two-family construction erosion control is to be carried out as part of the building permit process. In Walworth County, the County staff performs this function under contract to the Towns of LaGrange and Troy. In the Town of Eagle and the Village of Eagle in Waukesha County, this function is performed by the Town and Village.

Construction site erosion controls may include the use of silt fences, sedimentation basins, 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 Eagle Spring Lake that can result from uncontrolled construction sites.

Construction site erosion control measures may be expected to reduce the phosphorus loading from that source by about 75 percent. However, because of the limited amount of new urban development envisioned within the drainage area tributary to Eagle Spring Lake, the total change in loading to the Lake is expected to be minimal. However, because of the potential for unplanned development in the Waukesha County portion of the area tributary to Eagle Spring Lake, it is, nevertheless, important that adequate construction erosion control programs be in place.

The cost for construction site erosion control will vary depending upon the amount of land under construction at any given time. Typical costs are $250 to $500 per acre under development.

Rural Nonpoint Source Pollution Control

The implementation of nonpoint source pollution controls in rural areas requires the cooperative efforts of the Eagle Spring Lake Management District, Waukesha County and the Waukesha County Land Conservation Committee, Walworth County and the Walworth County Land Conservation Committee, and private landowners. 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 Walworth and Waukesha County Land Conservation offices. As discussed previously, it is recommended that the Eagle Spring Lake Management District, in coordination with the Wisconsin Department of Natural Resources, Walworth and Waukesha Counties, and the local units of government involved, develop a strategy to address nonpoint source pollution. State and Federal soil erosion control and water quality management programs, individually or in combination, can be used to achieve pollutant reduction goals. Such programs include the U.S. Department of Agriculture Environmental Quality Incentive Program (EQIP), the Wisconsin Department of Natural Resources Priority Watershed Program and Lake Protection Grant Program, and various State and local land acquisition initiatives.

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

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 to the Eagle Spring Lake area include conservation tillage, integrated nutrient and pesticide management, and pasture management. In addition, it is recommended consideration be given to cropping patterns and crop rotation cycles, with attention to the specific topography, hydrology, and soil characteristics for each farm. A reduction of about 25 percent in the nonpoint source loading from rural lands, will provide about a 15 percent reduction in total phosphorus loading to Eagle Spring Lake.

The cost of the needed measures will vary depending upon the details of the recommended farm conservation plans. These costs may be expected to be incurred to a large extent for purposes of agricultural land erosion control in any case.

Onsite Sewage Disposal System Management

Onsite sewage disposal systems are estimated to contribute about 8 percent of the total phosphorus loading to Eagle Spring Lake[7]. In addition to lake water quality considerations, sewage disposal options in the area have implications for groundwater quality and property values. Furthermore, as discussed in Chapter VII, a facility planning study conducted by the Eagle Spring Lake Sanitary District in 1985 indicated that over a 20-year period about 40 percent of the onsite sewage disposal systems would have to be replaced with holding tanks and that the majority of the remaining systems would have to undergo major repair or replacement. Such actions could be costly and can result in disruption of lot areas for construction and increased tank truck traffic on local roads. Thus, onsite sewage disposal is an important consideration in any management plan for Eagle Spring Lake.

As indicated in Chapter VII, the regional water quality management plan includes a recommendation for the provision of a public sanitary sewer system to serve the urban development surrounding Eagle Spring Lake and the adjacent unincorporated community known as Eagleville. As shown in Map 22, the local sewer system serving the Lake area would be connected to the Village of Mukwonago sewerage system by means of a trunk sewer—actually a force main. In this regard, the trunk sewer could be designed to also serve the Rainbow Springs Resort complex, if full development of that complex proceeds, as well as Mukwonago County park.

At the August 1995 annual meeting of the Eagle Spring Lake Management District, the Lake District Commission was directed to study, and, if appropriate, begin negotiations with the Town and Village of Mukwonago for, the construction of a public sanitary sewer. A committee of lake residents, operating under the auspices of the Eagle Spring Lake Management District and chaired by a Lake District Commissioner, fully reviewed the 1985 facilities planning study and the regional water quality management recommendations. Costs associated with the project were updated to current equivalent dollar values, and financing mechanisms were reviewed, as was the likelihood of cost-sharing with the Town of Mukwonago and proposed Rainbow Springs Resort. Meetings were held with the Town and Village of Mukwonago. Current lake water quality data, concerns regarding groundwater quality, and the potential for on- and off-lake lot development were evaluated, and alternatives to the proposed public sanitary sewer system were identified and considered.

The Committee's findings were presented to the public and it was decided by vote of the Commissioners of the Eagle Spring Lake Management District that the District should not pursue further involvement in the development of the Mukwonago-Rainbow Springs-Eagle Spring Lake force main project. This decision implies a commitment to the continued use of onsite sewage disposal systems within the District until such time as environmental or financial factors might dictate further consideration of the provision of a public sanitary sewerage system. If, after a reasonable period, it appears unlikely that the District will pursue a public sanitary sewerage system, the District may petition for an amendment of the regional water quality

[7] *Wisconsin Department of Natural Resources, Wisconsin Lake Model Spreadsheet Version 2.00, June 1994.*

management plan removing the District from the sanitary sewer service area.

Under this alternative, the District should work with Waukesha County to develop an aggressive onsite sewage disposal system management program. Such a program should include provisions for periodic inspections of all systems, and for repair or replacement, as needed, as well as for a preventative maintenance program. The District should assume the lead in providing public informational and educational programming to encourage homeowners within the District to have existing onsite sewage disposal systems inspected and maintained. The District should also undertake the development of a preventive maintenance program that would provide for periodic inspection of all onsite sewage disposal systems within the District, and consideration should be given to possible financial assistance in the case of hardship. The cost of this measure is included as part of the cost for the public informational and educational measures and provided through the operating budget of the District.

IN-LAKE MANAGEMENT MEASURES

The recommended in-lake management measures for Eagle Spring Lake are summarized in Table 27 and are graphically summarized on Map 24. The major recommendations include water quality monitoring, lake level control, aquatic plant management, fishery management, habitat protection, and shoreline protection.

Water Quality Monitoring

Continued water quality monitoring of Eagle Spring Lake is recommended. Continued enrollment of one or more Lake Management District 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 status index (TSI) self-help monitoring program, measuring nutrients, chlorophyll-a, and temperature, is recommended. Such monitoring should be conducted five times a year at the same location is currently used by the U.S. Geological Survey at the northeast deep water area.

Lake Level Management

Concerns have been raised by residents regarding water levels being both too low and too high. As indicated in Chapter VII, outflow from Eagle Spring Lake is controlled by two outlet structures—a dam and a small former mill race—both located on the east side of the Lake just west of CTH E, as shown on Map 1. The northerly outlet is controlled by a dam with two 3.5-feet-wide openings controlled by stop boards flanking a center 3.5-feet-wide opening controlled by a manually operated steel lift gate. The southerly outlet consists of a 3.25-foot-wide mill race structure with one opening controlled by stop boards. In practice, only the northerly outlet structure gate is adjusted to control the lake level. The southerly outlet is privately owned and is currently used to generate small amounts of electricity for private use under a State permit issued by the Wisconsin Department of Natural Resources.

The present actual operating regime of the dam is intended to maintain the lake level at an elevation which registers between 9.4 and 9.7 feet on a gauge located near the outlet control dam, which dam controls the northernmost of the two lake outlets. These gauge readings are equivalent to elevations 820.53 and 820.83 feet NGVD-29.[8] The lake elevation is controlled by manual adjustment of the dam operating gate which adjustment is made periodically by a member of the Eagle Spring Lake Management District based upon the observed lake levels. The current operating range established by the Wisconsin Department of Natural Resources is from 8.84 to 9.14 feet on the local gauge, or from elevation 819.97 to 820.27 NGVD-29. Thus, the current operating levels typically exceed the maximum high water level allowed for by up to about 0.6 foot. Based upon a petition by the Eagle Spring Lake District, consideration is currently being given by the Wisconsin Department of Natural

[8] *As noted in Chapter II, a correction was made to the benchmark elevation on the dam which increased the elevation of the gauge by 2.65 feet as referred to the National Geodetic Vertical Datum of 1929.*

Resources Water Division, to change the regulatory water level to be consistent with current Lake Management District operating practices.

Given the size and type of lake involved, it is considered reasonable to have an operating water level range of no less than 0.3 foot. Since such a range can be maintained with the existing operating system, no additional operational controls are deemed necessary. However, the existing gate operating system for the dam gate will need to be periodically be maintained and repaired to keep it functional.

Given the shallowness of the Lake, the level operating range which has been maintained in recent years appears reasonable. If the target lake levels were to be reduced by any significant amount, aquatic plant growth may be expected to increase in the already limited areas of the Lake which are now in open water. Furthermore, lowering of the lake level from the current operational regime could adversely impact the lake fishery by reducing spawning opportunities. Thus, continued use of a lake level operating range of from about 9.4 to 9.7 feet on the local gauge, or from 820.53 to 820.83 feet NGVD-29, is recommended.

Aquatic Plant Monitoring and Management

An aquatic macrophyte control plan consistent with Chapters NR 103 and NR 107 of the Wisconsin Administrative Code is included in Appendix C of this report. The plan recommends that continued aquatic macrophyte surveys be conducted at about five-year intervals, but with variation depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of: major areas of nuisance plant growth; areas harvested and/or chemically treated; species harvested and amounts of plant material removed from lake; and species and approximate numbers of fish caught in the harvest.

A daily harvester log, containing this information, should be maintained. This information, in conjunction with the conduct of the recommended aquatic macrophyte surveys, will allow evaluation of the effectiveness of the aquatic plant control program over time and allow adjustments to be made in the program to maximize its benefit.

Modifications of the existing aquatic plant management program are recommended to enhance the use of Eagle Spring Lake while maintaining the quality and diversity of the biological communities. The following recommendations are made:

1. Mechanical harvesting is recommended as the primary management method. As indicated in Chapter VII, this will, in the long-term, help to maintain good water quality conditions by removing plant materials which are currently contributing to an accumulation of decomposing vegetation and associated nutrient recycling. The harvesting should be carried out by the Lake Management District using its existing harvester and transport equipment.

2. It is recommended that shared-access channels be harvested to minimize the potential detrimental effects on the fish and invertebrate communities. Directing boat traffic through these common channels would help to delay the regrowth of vegetation in these areas.

3. Surface harvesting is recommended, cutting to a depth of approximately two feet to remove the surface canopy of nonnative aquatic plants, such as the Eurasian water milfoil, this should provide a competitive advantage to the low-growing native plants present in the Lake. By not disturbing the low-growing species which generally grow within one to two feet of the lake bottom and in relatively low densities—leaving the root stocks and stems of all cut plants in place—the resuspension of sediments in Eagle Spring Lake will be minimized, and some degree of cover will be provided for panfish populations which are presently heavily predated upon by the bass population in the Lake. Further, cutting should not be general, but focused on boating channels around the perimeter of the main lake basin.

4. It is recommended that the use of chemical herbicides be limited to controlling nuisance growth of exotic species in shallow water around docks and piers where the harvester

is unable to reach. Such use should be evaluated annually and the herbicide applied only on an as needed basis. Only herbicides that selectively control milfoil, such as 2,4-D, should be used. Algicides, such as Cutrine Plus, are not recommended because there are no significant filamentous algae or planktonic algae problems in the Eagle Spring Lake and valuable macroscopic algae, such as Chara and Nitella are killed by this product.

5. It is recommended that chemical application, if required, should be made in early spring to maximize its effectiveness on non-native plant species, to minimize its impact on native plant species, and to act as a preventative measure to reduce the development of nuisance conditions.

6. The control of rooted vegetation between adjacent piers is recommended to be left to the riparian owners concerned, as it is time consuming and costly for the mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. As an alternative option it is recommended that the Lake Management District obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to make available to the residents.

7. It is recommended that ecologically valuable areas be excluded from aquatic plant management activities, especially during fish spawning seasons in early summer and autumn.

8. The incorporation by the Lake Management District of an overall public educational program of information on the types of aquatic plants in Eagle Spring Lake; on the value of and the impacts of these plants on water quality, fish, and on wildlife; and on alternative methods for controlling existing nuisance plants including the positive and negative aspects of each method. This program can be incorporated into the comprehensive informational and educational programs which also would include information on related topics such as water quality, recreational use, fisheries, and onsite sewage disposal systems.

The recommended plan partitions Eagle Spring Lake into zones for aquatic plant management, with control measures in each zone designed to optimize desired recreational opportunities and to protect the aquatic resources. The recommended aquatic plant control zones are shown on Map 24 and the controls recommended for each zone are described in Table 29.

The recommended aquatic plant management plan represents an expansion of the ongoing aquatic plant management program conducted by the Eagle Spring Lake Management District. Implementation of this plan would entail a capital cost of $90,000—the majority of which would be required for the eventual replacement of equipment—and an annual operation and maintenance cost of about $22,000. The aquatic plant management plan is described in further detail in Appendix C.

Boating Access

Dredging is recommended to be used only on a very limited as-needed basis for small-scale projects needed to provide or enhance boating. The associated environmental impacts of any such small-scale projects should be identified and evaluated on a case-by-case basis. The dredging which was undertaken in 1995, not only enhanced boating access in the northwestern portion of the Lake, but also removed overlying sediment from several in-lake springs within this portion of the Lake.

Fish Monitoring and Management

The aquatic plant management strategy set forth above recognizes the importance of fishing as a recreational use of Eagle Spring Lake. Integral to the aquatic plant management strategy is the protection and preservation of fish breeding habitat, especially in the area of the enlarged inlet and headwater wetland complex and the wetland area located along the western shore of the Lake which provides a valuable habitat area. Any interventions such as aquatic plant harvesting in the inlet wetland complex should be confined to the navigation access channel along the southern shore, as shown on Map 24.

Table 29

RECOMMENDED AQUATIC PLANT MANAGEMENT TREATMENTS FOR EAGLE SPRING LAKE

Zone and Priority	Recommended Aquatic Plant Management Plan
Access	• Harvest channels, approximately 15 feet wide, along portions of the southern end of the Lake and inlet area to provide boating access to the main body of the Lake • This zone totals about 12 acres in areal extent • Total area recommended to be harvested is approximately two acres • Limited use of chemicals for algal and aquatic plant control is recommended in this area
Boating	• Harvest channels, approximately 50 feet wide, parallel to the shoreline of the main basin of the Lake to allow boating in the main lake basin area and avoid disturbance of the native flora in the central area of the Lake • This zone totals about 187 acres in areal extent • Total area recommended to be harvested is approximately 28 acres • Chemical use should be restricted to pier and dock areas within 50 feet of the shore in this area
Fishing	• This zone is intended to accommodate fishing from a boat • It is recommended that 15-foot-wide channels be harvested perpendicular to the shore at approximately 100- to 200-foot intervals • This zone totals about 28 acres in areal extent • Total area recommended to be harvested is approximately two acres • The use of chemicals for algal and aquatic plant control is not recommended in this area, especially during the late spring to early summer spawning season
Habitat	• It is recommended that selected areas of the Lake be preserved as high-quality habitat area • This zone and adjacent lands should be used for fish habitat • No harvesting or in-lake chemical application should be permitted, except in special instances where selective herbicide application may be allowed for the control of nuisance species; disturbances should be minimized, especially during the late spring to early summer spawning season • Debris and litter cleanup would be needed in some adjacent areas; the immediate shoreline should be preserved in natural, open use to the extent possible • This zone totals about 84 acres in areal extent

Source: SEWRPC.

Three specific actions are recommended with respect to fisheries management: the conduct of a fishery survey; the assessment of angling pressures; and the formulation of refined stocking and size and bag limitations. The fishery survey should be conducted by the Wisconsin Department of Natural Resources at the request of the Lake Management District and should have the following objectives:

1. To identify changes in fish species composition that may have taken place in the Lake since the previous surveys, in 1992, 1993, and 1994;

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

3. To determine the survival rates and success of stocked fishes introduced into Eagle Spring Lake through the Wisconsin Department of Natural Resources fish stocking program;

4. To refine and update information on fish spawning areas, breeding success, and survival rates.

5. Obtaining confirmation of the lack of disturbance by rough fish populations, could also be obtained through such a survey.

6. Given the fishing pressures on the Lake, it would be desirable to also conduct a one-time analysis of fish tissues for metal and toxic contamination.

The second recommended action relative to a fishery management program is an assessment of angling pressures on the Lake. This assessment should:

1. Provide information on the survival of northern pike currently stocked into Eagle Spring Lake (Table 17);

2. Provide data to determine the intensity of public use of the Eagle Spring Lake fishery through creel surveys, citizen reporting activities, and evaluation of the fish survey data; and

3. Provide data to assess the implications of a possible overharvest of bluegills from the Lake.

These two actions are recommended to provide a sound basis for the District and the Wisconsin Department of Natural Resources to develop a refined stocking program and to revise, as may be found necessary, the current fishing regulations regarding the size and number of fish to be taken seasonally.

The cost of the recommended comprehensive fish survey is estimated to be $16,000. Stocking costs which are currently undertaken by the Wisconsin Department of Natural Resources are dependent on the availability and types of fish stocked but may be expected to average $1,200 annually.

Habitat Protection

The habitat protection measures recommended for Eagle Spring Lake are, in part, provided by the recommended aquatic plant management program. The aquatic plant management plan is designed to provide for habitat protection by avoiding disturbances in fish breeding areas during spring and autumn; reducing the use of aquatic plant herbicides; and maintaining stands of native aquatic plants especially in the inlet area.

In addition, it is recommended that environmentally sensitive lands including wetlands along the western lakeshore and the influent River be preserved. In particular, this recommendation extends to the maintenance of the wetlands located in the western portions of the lake basin and the ecological integrity of Lulu Lake, as shown on Map 24.

It is recommended that "Slow-No-Wake" restrictions be imposed in the portion of the Mukwonago River between Eagle Spring Lake and Lulu Lake, and that propeller cleaning facilities and signage be provided at the end of the channel of Eagle Spring Lake.

Recreational Use Zoning

The principle recreational use zoning actions required include the imposition of "Slow-No-Wake" restrictions on those portions of the Lake bordering sensitive areas such as habitat zones, and where boating activities may be expected to come into conflict with other uses such as angling in the fishing zones. The boating regulation ordinances adopted by the Town of Eagle form the legal basis necessary to carry out this action. Currently the Lake safety patrol functions are carried out on a part-time basis by the Town of Eagle. It is recommended that the Town improve its communication system to allow ready access by telephone for lake residents to report apparent violations of the lake use regulations and, thus, provide for a means to be responsive to actions conflicting with the proper recreational uses of the Lake.

Shoreline Protection

Most of the Eagle Spring Lake shoreline is protected and no areas of erosion, which require additional protection against wind, wave and wake erosion, were identified in the planning effort. Various possible protection options are described in Chapter VII for consideration in the repair or replacement of existing protection structures. Adoption of the vegetated buffer strip method is recommended to be used in lakeshore areas and on the tributary

Mukwonago River wherever practical in order to maintain habitat value and the natural ambience of the lakeshore. Continued maintenance of existing revetments and bulkheads is also recommended.

PUBLIC INFORMATIONAL AND EDUCATIONAL PROGRAMS

It is recommended that the Lake Management District 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. The District newsletter can provide a 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.

The cost for conducting this program is estimated to be about $1,200 per year.

PLAN IMPLEMENTATION AND COSTS

The actions recommended in this plan largely represent an extension of ongoing actions being carried out by the Eagle Spring Lake Management District. The recommended plan introduces few new elements, although some of the plan recommendations represent refinements 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 such as stocking, harvesting, and public awareness campaigns currently implemented by the Eagle Spring Lake Management District are recommended to continue with 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-based land management activities. It is recommended that the District assume the lead in the promotion of such 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, the County University of Wisconsin-Extension office, and the Southeastern Wisconsin Regional Planning Commission.

The major cost relating to new elements herein recommended relates to the eventual replacement of harvesting equipment. Implementation of the recommended plan would entail a capital expenditure of about $90,000 and an annual operation and maintenance expenditure of about $22,000, including existing expenditures, as shown in Table 30, over the next few years. The District's current budget for annual operation and maintenance is approximately $21,000. Some of the capital costs could be met with grants from the Wisconsin Waterways Commission under Chapters NR 103 and NR 107 of the Wisconsin Administrative Code.

The suggested lead agency or agencies for initiating program-related activities, by plan element, are set forth in Table 28, and the estimated costs of these elements, linked to possible funding sources where such are available, are summarized in Table 30.

Eagle Spring Lake is a valuable natural resource in the Southeastern Wisconsin Region. Increases in population, urbanization, income, leisure time, and individual mobility forecast for the Region may be expected to result in additional pressure for development in the drainage area tributary to the Lake and for water-based recreation on the Lake. Adop-

Table 30

ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR EAGLE SPRING LAKE

Plan Element	Subelement	Estimated Cost 1995-2010[a]		Potential Funding Sources[b]
		Capital	Average Annual Operation and Maintenance	
Land Use and Zoning Management	Land use development planning, zoning modifications, and protection of environmental corridors	$ 1,000[c]	--[c]	DNR
	Environmentally sensitive lands	--	--	DNR
Watershed Land Management	Urban nonpoint source controls	--[d]	--[d]	--
	Stormwater management system plan	--[d]	--	DNR
	Construction site erosion control	--[e]	--[e]	Private firms, individuals
	Rural nonpoint source controls	--[d,f]	--[d,f]	USDA, DNR
	Onsite sewage disposal system management	--	--	--
	Ultimately install public sanitary sewer system	$8,250,000[g]	$150,000[g]	DNR
Water Quality Management	Water quality monitoring	--	--[h]	DNR
Lake Level Management	Outlet structure control; maintain lake level between elevation 820.53 and 820.83 NGVD-29	--	--	--
Aquatic Plant Management	Comprehensive plan refinement	$ 1,000	--	DNR, USGS
	Major/minor channel harvesting	$ 90,000[i]	$22,000	DNR (Waterways Commission)
	Chemical treatment	--[j]	--[j]	--
Fish Management	Fish survey	$ 16,000[g]	--[g]	DNR
	Develop refined fishery management plan	--	--	DNR
	Fish stocking	--	$ 1,200	DNR
	Refine current fishing regulations	--	--	DNR
Habitat Protection and Lake Use Management	Implementation of "slow-no-wake" ordinance	--[c]	--	DNR, District
	Development of site for propeller cleaning facility with appropriate signage	$ 1,000	--	DNR, District
Shoreland Protection	Maintenance of structures	--	--	Residents

Table 30 (continued)

Plan Element	Subelement	Estimated Cost 1995-2010[a]		Potential Funding Sources[b]
		Capital	Average Annual Operation and Maintenance	
Informational and Educational Program	Public informational and educational programming	- -	$ 1,200	UWEX, DNR
Total	- -	$109,000, plus cost for public sanitary sewer system	$24,400, plus cost for public sanitary sewer system	- -

[a] *All costs expressed in June 1996 dollars.*

[b] *Unless otherwise specified, USDA is the United States Department of Agriculture, USGS is the United States Geological Survey, DNR is the Wisconsin Department of Natural Resources, County is Walworth and Waukesha Counties, District represents Eagle Spring Lake Management District and UWEX is the University of Wisconsin-Extension.*

[c] *Cost-share assistance may be available for ordinance review, revision, and writing under the NR 191 Lake Protection Grant Program.*

[d] *Costs included under public informational and educational program. Cost-share assistance may be available under the NR 120 Wisconsin Nonpoint Source Pollution Abatement Program, the Federal Environmental Quality Incentives Program, and various local and State water quality improvement and protection initiatives.*

[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] *Cost for future public sanitary sewer system based upon 1985 facilities plan updated to 1996 dollars.*

[h] *The DNR Self-Help Monitoring Program and proposed creel survey involves no cost but does entail a time commitment from the volunteer.*

[i] *Costs are based on the assumption that the existing harvester and ancillary equipment may eventually need replacement; cost-share assistance for harvester purchase may be available from the Wisconsin Waterways Commission Recreational Boating Facilities Grant Program.*

[j] *Likely not to be needed, except in rare instances. No chemical treatments have been carried out on Eagle Spring Lake since 1985.*

Source: SEWRPC.

tion and administration of an effective lake management program for Eagle Spring Lake, based upon the recommendations set forth herein will provide the water quality protection needed to maintain conditions in Eagle Spring Lake suitable for recreational use and for fish and other aquatic life.

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Chapter IX

SUMMARY

The management plan for Eagle Spring Lake as herein described was prepared by the Southeastern Wisconsin Regional Planning Commission and the Eagle Spring Lake Management District. The plan incorporates pertinent data collected by the Wisconsin Department of Natural Resources; the U.S. Geological Survey; Ms. Fay U. Amerson, consultant to the Eagle Spring Lake Management District; and the Waukesha County Department of Parks and Land Use. Inventories and analyses were conducted of existing and recommended future land use patterns within the watershed of the Lake, the associated pollutant loadings and sources, the physiography and natural resource base of the watershed, the recreational uses of the Lake, the shoreline conditions, and the management practices employed both on the Lake and in the watershed. In addition, the planning effort also includes the results of an aquatic plant survey conducted by Commission staff as part of this study, and an analysis of the results from previously conducted water quality sampling programs. Field studies associated with these activities were conducted from 1990 through 1994 by the U.S. Geological Survey, during 1992 through 1994 and in 1996 by the Wisconsin Department of Natural Resources, during 1993 by Ms. Fay U. Amerson, and during 1994 through 1996 by the Commission staff. The Waukesha County Parks and Land Use conducted a shoreline condition inventory during the summer of 1994.

The primary management objectives for Eagle Spring Lake include: 1) to contribute to the overall conservation and wise use of the Eagle Spring Lake through the environmentally sound management of vegetation, fish, and wildlife population in and around the Lake; 2) to provide the potential for high-quality, water-based recreational experiences by residents and visitors to Eagle Spring Lake; and 3) to effectively control the severity of nuisance resulting from recurring excessive aquatic macrophyte growths in portions of the Eagle Spring 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. This plan is intended to serve as a practical guide to achieving these objectives, over time, in a technically sound manner.

Eagle Spring Lake, a 311-acre drainage lake on the Mukwonago River, a tributary of the Fox River, is located downstream of Lulu Lake and upstream of Lower Phantom Lake. The Lake has extensive shallow areas within a single lake basin. The Lake lies within U.S. Public Land Survey Sections 25, 26, 35, and 36, Township 5 North, Range 17 East, Town of Eagle, Waukesha County. The lake level is controlled by two outlet structures located on the northeastern shore of the Lake. The outlet structures have fixed discharge elevations which maintain a depth of about 12 feet in the deepest portion of the Lake and a mean depth of about four feet. The Lake's tributary drainage area totals about 26 square miles.

Eagle Spring Lake is a shallow, well-mixed, mesotrophic waterbody with poor to good water clarity and a relatively rapid through-flow of water. These characteristics contribute to an increasing abundance of aquatic plants, which exert constraints on the recreational uses of Eagle Spring Lake.

INVENTORY AND ANALYSIS FINDINGS

Population

- The 1990 resident population of the drainage area tributary to Eagle Spring Lake was estimated by the Commission at about 3,470 persons, which is almost twice the population estimated to reside in the drainage area in 1960. In addition to the year-around population there were, as of 1990, about 270 seasonal residents within the drainage area tributary to Eagle Spring Lake.

- Population forecasts prepared by the Regional Planning Commission, on the basis of a normative regional land use plan and the Waukesha County development plan, indi-

cate that the population will probably lie between 3,500 and 5,800 persons in the drainage area tributary to the Lake by the year 2010.

Land Use and Zoning

- As of 1990, urban land uses occupied about 2,000 acres, or 12 percent, of the tributary drainage area to Eagle Spring Lake. The dominant urban land use was residential, encompassing about 1,200 acres, or 60 percent, of the urban lands in drainage area. Commercial, industrial, recreational, and other urban land uses comprised about 800 acres, or 40 percent, of the urban land.

- As of 1990, approximately 14,700 acres, or 88 percent, of the tributary drainage area to Eagle Spring Lake were still in rural land uses, with the dominant rural land use being agricultural uses, comprising about 10,400 acres, or 70 percent, of the rural land in the drainage area tributary to Eagle Spring Lake. The remaining rural land uses—wetlands, woodlands, and open lands—constituted about 4,300 acres, or 30 percent, of the drainage area.

- Under year 2010 conditions, no significant changes in land use conditions within the drainage area tributary to Eagle Spring Lake are envisioned in the regional land use plan, although some infilling of existing platted lots and some backlot development may be expected to occur.

- Recent surveillance indicates that suburban-density residential development—three- to five-acre lots—is occurring in areas in which such development was not envisioned in the adopted regional land use plan. These areas totaled about 750 acres in areal extent as of 1996.

- Under full buildout conditions envisioned under the Waukesha County development plan, most of the undeveloped lands outside the environmental corridors and other environmentally sensitive areas within the Waukesha County portion of the tributary drainage area would be developed primarily for low-density urban residential uses.

Water Budget

- During the period October 1993 through September 1994, an estimated 13,900 acre-feet of water entered Eagle Spring Lake. Of this total, about 13,100 acre-feet of water, or 94 percent, were contributed by inflow from the Mukwonago River and other surface and groundwater sources; and about 800 acre-feet, or 6 percent, were contributed by direct precipitation on the lake surface.

- During the period October 1993 through September 1994, about 13,800 acre-feet were estimated as the output from Eagle Spring Lake. Of this total about 13,000 acre-feet, or 94 percent, were discharged via the Mukwonago River; about 800 acre-feet, or 6 percent, evaporated from the surface of the Lake. During the study year, there was an approximately 100 acre-feet storage volume net gain in the Lake.

Water Quality

- Physical and chemical parameters measured during the 1991 through 1994 study period, with the exception of water clarity, indicated that the water quality of Eagle Spring Lake is considered good, relative to other lakes in the region.

- Temperature and dissolved oxygen profiles indicate that complete mixing of Eagle Spring Lake is seldom restricted by thermal stratification.

- The mean concentration of total phosphorus in Eagle Spring Lake, in the spring, was about 0.013 milligrams per liter (mg/l), which is within the Commission-recommended water quality standard for recreational use and the maintenance of warm-water fish and aquatic life of 0.02 mg/l during the spring turnover.

- Eagle Spring Lake is classified as mesotrophic, a term describing a moderately

fertile lake ecosystem that is typical of lakes in Southeastern Wisconsin.

Sediment Quality

- The 1990 sediment survey of Eagle Spring Lake completed by Swanson Environmental, Inc., indicated that over 85 percent of the surveyed bottom was covered by muck and that portions of the nearshore area were comprised of a sand or gravel bottom.

- The sediment phosphorus concentration in Eagle Spring Lake ranged from not detectable to 83 milligrams per kilogram (mg/kg); nitrate-nitrogen concentrations ranged from not detectable to 180 mg/kg; and ammonia-nitrogen concentrations ranged from 22 mg/kg to 250 mg/kg. Sediment arsenic concentrations ranged from not detectable to 3.0 mg/kg. Sediment copper concentrations ranged from not detectable to 4.0 mg/kg. Sediment lead concentrations ranged from not detectable to 35 mg/kg. For the parameters tested, only the highest concentration of sediment lead, thought to be related to water fowl hunting activities, and the sediment ammonia concentrations in the main lake basin exceeded the recommended lowest effect level (LEL) guideline concentrations of 31 mg/kg and 75 mg/kg, respectively, established by the Wisconsin Department of Natural Resources as indicative of mildly contaminated sediments.

Pollutant Loadings

- The total sediment load to Eagle Spring Lake is estimated to be 180 tons during an average year. Of this total load, about 140 tons are estimated to be transported out of Eagle Spring Lake via the Mukwonago River, with the remaining being deposited on the lake bottom.

- The total phosphorus load to Eagle Spring Lake was estimated to be about 2,050 pounds. Of this total, 64 percent was estimated to be contributed by runoff from rural land, and 25 percent was contributed by runoff from urban land. The remaining phosphorus loading was contributed from direct precipitation onto the Lake surface, and from onsite sewage disposal systems. Of this total load, about 1,580 pounds of phosphorus were estimated to be transported out of Eagle Spring Lake via the Mukwonago River. The remaining phosphorus is expected to be used by the biomass within the Lake or deposited in the sediments.

Aquatic Plants

- The aquatic plant survey conducted during July 1994 identified 20 species of aquatic plants, many of which were common to abundant. Aquatic plant growth occurred throughout the Lake.

- In general, Eagle Spring Lake supported a healthy and diverse aquatic macrophyte community; however, portions of the Lake included species such as Eurasian water milfoil to the extent that dense mats of vegetation are formed, potentially interfering with boat traffic and other water based recreational uses.

Fishery

- Wisconsin Department of Natural Resources fish surveys conducted from 1992 through 1994 and in 1996 suggested diminishing numbers of panfish during this period. Notwithstanding, the surveys recorded the presence of 14 species of fish on Eagle Spring Lake.

- Based on surveys conducted by the Wisconsin Department of Natural Resources, Eagle Spring Lake is considered as supporting an unbalanced fish community with moderate diversity, but heavily skewed toward predatory fishes, particularly largemouth bass.

Natural Resource Base

- In 1990, high-value wildlife habitat covered about 6,100 acres, or 36 percent, of the drainage area tributary to Eagle Spring Lake.

- In 1990, wetlands covered about 1,440 acres, or 9 percent, of the drainage area tributary to the Lake. Woodlands covered

about 2,500 acres, or 15 percent, of the drainage area tributary to the Lake.

- Primary environmental corridor covered about 4,200 acres, or 25 percent, of the drainage area tributary to Eagle Spring Lake. In addition, about 115 acres of the drainage area were classified as secondary environmental corridor, and about 300 acres were identified as isolated natural areas. These corridor lands include almost all the remaining high-value woodlands, wetlands, and wildlife habitat areas in and around Eagle Spring Lake, significant portions of which are within or adjacent to the Lulu Lake State Natural Area and its environs.

Recreational Use

- Eagle Spring Lake has one public-access site and one privately owned boating access site. The public-access site is considered to provide adequate public access pursuant to Chapter NR 1 of the Wisconsin Administrative Code. In addition, there is a publicly owned open space site, part of the Lulu Lake Natural Area, and one privately owned recreational site, Eagle Springs Golf Course, located on the shoreline of Eagle Spring Lake.

- In 1996, approximately 260 watercraft were observed by Commission staff to be kept in and near Eagle Spring Lake. Of these, 17 were in active use at one time during the documented weekday and 25 were in use during the documented weekend day.

- In a recreational rating technique developed by the Wisconsin Department of Natural Resources to characterize the recreational value of inland lakes, Eagle Spring Lake received 56 out of the possible 72 points in 1969, and 49 out of 72 points in 1996, indicating that relatively diverse recreational opportunities are provided by the Lake. The slight decline in recent years was related to an increase in turbidity and aquatic plant growth in the Lake.

ALTERNATIVE LAKE MANAGEMENT MEASURES

Alternative management techniques, including watershed, lake rehabilitation, and in-lake measures, were evaluated based on effectiveness, cost, and technical feasibility. Those alternative measures eliminated for further consideration at this time, after careful evaluation, included: nutrient precipitation and inactivation, water level control modifications, drawdown, large-scale mechanical dredging, selected physical and biological aquatic plant management measures, and fish habitat creation. The alternative measures which were incorporated into the recommended plan are described below.

THE RECOMMENDED PLAN

Analyses of water quality and biological conditions indicate that general water quality conditions of Eagle Spring Lake, with the exception of water clarity, are considered to be relatively good compared to other regional lakes. Water-based recreational uses are limited by nuisance growths of aquatic macrophytes in many areas of the Lake. In-lake water quality related measures are recommended for the Lake to meet the full aquatic resources and recreation uses. In addition to in-lake management measures, the recommended plan also sets forth recommendations for land use control and land management measures in the drainage area tributary to the Lake.

The recommended Eagle Spring Lake management measures are graphically summarized on Map 24 and are listed in Table 30. Those measures include:

For protection of the natural resource base:

- Monitoring and participation in County and local land use zoning and permitting processes to minimize the areal extent of new development in the drainage area by promoting land use recommendations and the clustered development concepts, as recommended in the Waukesha County development plan for development within Waukesha County, and the Walworth County land

use plan for development within Walworth County; and to maintain the historic low- to medium-density shoreline development around Eagle Spring Lake.

- The preservation, protection, and enhancement in essentially natural, open space uses of all lands designated as primary environmental corridors. Preservation and protection of these areas would serve to not only reduce nonpoint source pollutant loadings to the Lake, but also to maintain good water quality groundwater flow to the Lake.

For the protection and maintenance of water quality and aesthetic conditions:

- Continued implementation of the nonpoint source controls recommended in the regional water quality management plan.

- For rural areas, the implementation of land management measures. Such measures should be more specifically defined and implemented through preparation of detailed farm conservation plans. It is recommended that such plans be prepared for farms occupying a total of about 1,600 acres of rural land. In addition, it is recommended that consideration be given to cropping patterns and crop rotation cycles, with attention to specific hydrology and soil characteristics of each farm.

- For urban areas, the adoption and implementation of good urban land management and urban housekeeping practices, such as limiting use of fertilizers and pesticides, controlling litter and pet waste, and managing leaf litter and yard waste. In this regard, it is recommended that the Eagle Spring Lake Management District utilize its newsletter to distribute fact sheets to residents describing specific residential land management practices that would be beneficial to the water quality of Eagle Spring Lake.

- Continued enrollment by lake residents in the Wisconsin Department of Natural Resources Self-Help Monitoring Program and participation in the expanded program offered by the Department.

- The continued enforcement by local units of government concerned with construction site erosion ordinances in the entire tributary drainage area to the Lake.

- The development of an onsite sewage disposal system management program which could potentially include the establishment of a program to administer funds; inspect, design, and construct upgraded systems; ensure proper operation and maintenance of the systems; and monitor the performance of systems. Ultimately, the development of a public sanitary sewerage system should be considered.

For the enhancement of recreational opportunities:

- Protection of wetland and floodland areas adjacent to the Mukwonago River, with emphasis on preserving the riparian wetlands adjacent to the State Natural Area abutting the Lake and between Eagle Spring Lake and Lulu Lake.

- Creation of a streambank propeller cleaning station located in the channel between Eagle Spring Lake and Lulu Lake, with appropriate signage at the cleaning station, in addition to the public and private launches, to minimize the spread of Eurasian water milfoil within Eagle Spring Lake and to the upstream lake.

- Modification of the aquatic plant management practices to emphasize harvesting which would create and maintain navigational channels to provide and protect fish habitat, and control of Eurasian water milfoil through top-cutting the plant to a depth of about two feet, leaving low-growing native vegetation intact on the lakebed to stabilize the lake sediments and reduce resuspension of particulate materials by boat traffic within Eagle Spring Lake.

- Management of aquatic plants to encourage the resurgence of native aquatic plant spe-

cies through manual and chemical control of Eurasian water milfoil, where possible. Limited chemical controls may be applied in spring prior to the growth of more desirable plant species to control Eurasian water milfoil in areas where other controls are not feasible.

For the protection and enhancement of fish and other aquatic resources, including wildlife habitat, woodlands, and wetlands:

- Maintenance of the integrity of the environmental corridors upstream and in the vicinity of Eagle Spring Lake, including provision for the restoration and protection of the wetlands, as previously noted.

- Conduct of a fish survey and creel census by the Eagle Spring Lake Management District, in cooperation with the Wisconsin Department of Natural Resources to assess future changes in the species composition of, and in angling related pressures on, the fishery of Eagle Spring Lake. Such a survey would provide information needed to better manage the ongoing fish stocking program for the Lake.

- Protection of fish breeding areas and habitat including measures to minimize disturbances to in-lake fish breeding areas during spring and autumn.

- Continued proper maintenance of the shoreline protection structures, including the repair and/or replacement of failed structures and the erection of suitable structures along eroded shorelines.

For public information and education:

- The continuation of the ongoing public informational and educational program directed toward comprehensive lake management through the use of newsletters and other media.

The recommended plan is based largely on existing and ongoing lake management measures being employed by Eagle Spring Lake Management District. The Eagle Spring Lake Management District is recommended to undertake the primary responsibility for implementing this plan, with assistance from the Town of Eagle and the Wisconsin Department of Natural Resources. This plan would entail a capital expenditure of about $109,000 over the next 20 years and an annual operations and maintenance expenditure of about $24,400, as shown in Table 30, including existing expenditures. Many activities, such as the creel censuses, dissemination of public informational materials, and even some of the streambank restoration actions identified above, could be undertaken by volunteers at little or no cost.

Eagle Spring Lake is a valuable natural resource in the Southeastern Wisconsin Region, and a particularly valuable asset to the Town of Eagle. The delicate, complex relationship between the water quality conditions in Eagle Spring Lake and the land uses within its tributary drainage area is likely to be subject to ongoing pressures as demands for water-based recreation in the Lake, and for urban development within its watershed resulting from increases in population, income, leisure, and individual mobility for the Region. To provide the water quality protection needed to maintain conditions in Eagle Spring Lake conducive to meeting such pressures, it will be necessary to adopt and administer an effective program of lake management based upon comprehensive water quality management and related plans. This plan comprises an important element of such a program and is consistent with previously adopted comprehensive land use, water quality management, recreation and open space, soil erosion control, and sanitary sewer service area plans for the Southeastern Wisconsin Region and Waukesha County.[1]

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[1] *SEWRPC Planning Report No. 40, A Regional Land use Plan for Southeastern Wisconsin—2010, January 1992; SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume Three, Recommended Plan, June 1979; as refined in SEWRPC Memorandum Report No. 93, A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, March 1995.*

APPENDICES

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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.

Appendix B

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
WATERWAY PERMIT STATUTORY REQUIREMENTS

This is a list of common activities for waterway permits and some of their statutory requirements.

A 30-day public notice of a project, prepared by the Department, must be published as a Class 1 notice. This means the applicant must publish it once in a local newspaper. The public then has 30 days from the date of publication to review and comment on the proposal. The Department considers any comments before making a permit decision.

An Environmental Assessment (EA), also prepared by the Department, is a written summary of a thorough investigation of a project, its potential impacts and alternatives. It determines whether or not the proposal requires an Environmental Impact Statement, provides information about the project for the public and assists the Department in making a permit decision.

Activity	Statutory Authority	30-Day Notice?	EA?	Comments
Riprap/Shore Protection	s. 30.12	N	N	To reduce erosion only
Pea Gravel Blanket	s. 30.12	N	N	Depth of soft sediment under 6 inches
Structures	s. 30.12	Y	N	
Piers/Pier Cribs	ss. 30.12, 30.13	Y	N	For navigation only, not decks. Some simple piers may not require a permit
Bridges	ss. 30.12, 30.123	Y	N	Notice required only for streams wider than 35 feet
Culverts	s. 30.123	N	N	
Dredging	s. 30.20	N	Y	EA required only if dredge material exceeds 3,000 cubic yards
Unconnected Pond	s. 30.19(1)(a)*	N	N	Permit required only if pond is within 500 feet of a waterway
Ultimately Connected Pond	s. 30.19(1)(a)*	N	N	Pond with a direct connection to a waterway
Waterway Enlargements	s. 30.19(1)(b)*	Y	Y	
Grading over 10,000 Sq. Ft.	s. 30.19(1)(c)*	Y	N	Soil disturbance or cut and fill
Channel Relocation	s. 30.195	N	Y	EA required only if stream length exceeds 500 feet
Utility Crossing	ss. 30.20, 30.12	N	N	Plow or bore method may not require permit
Diversion	s. 30.18	Y	Y	EA not required for agriculture
Water Levels and Flows	s. 31.02	N	N	
Dams	ss. 31.04, 31.05, 31.07, 31.13	Y	Y	
Transfer of Dam Ownership	31.21	Y	N	
Dam Abandonment/Removal	ss. 31.185, 31.187	Y	N	
Enclosure	s. 30.196	Y	Y	Applicant must be municipality
Bulkhead Line	s. 30.11	Y	N	Established by municipal ordinance approved by DNR

*Milwaukee County is exempt.

DEFINITIONS OF COMMON WATERWAY ALTERATIONS

Riprap — A layer of loose large rock or other large clean material placed along a shoreline *to prevent erosion.*

Pea Gravel Blanket — A thin layer of small gravel placed on the bed of a lake to improve beach conditions. Not appropriate in areas where depth of soft sediment exceeds six inches or in specialized habitats.

Pier — A structure built from the shoreline into the water for navigational purposes, e.g. for mooring watercraft, loading and unloading passengers or cargo. *Not a deck.*

Pier Crib — A permanent structure on the lakebed that holds a pier in place during extreme wave action. Not used on most inland lakes.

Culvert — An enclosed structure used to convey water from upstream to downstream beneath a driveway or road crossing.

Dredging — Removal of material from the bed of a waterway. This includes both navigable and nonnavigable waters.

Unconnected Pond — A pond built within 500 feet of a navigable waterway, but not connected to another waterway by means of any defined channel.

Ultimately Connected Pond — A pond connected to an existing navigable waterway by a nonnavigable drainage course, or an open or closed conduit, either of which tends to confine and direct flow.

Connected Enlargement — Direct physical connection of a waterway to an existing navigable waterway, below the elevation of the Ordinary High Water Mark of the receiving water, by means of an open channel having defined bed and banks.

Grading — Manipulation of soil, filling, or excavating on the bank of a waterway. The "bank" is the unbroken slope which drains to the waterway. A permit is required only if the area disturbed will exceed 10,000 square feet.

Channel Relocation — The alteration of a navigable waterway's existing channel. This includes both straightening a stream and creating meanders in a channel.

Diversion — The temporary removal or surplus water from a waterway for the purpose of maintaining water levels for irrigation.

Enclosure — Placement of a stream within an enclosed drain, conduit, or storm sewer. Only municipalities may apply to enclose streams.

Appendix C

AN AQUATIC PLANT MANAGEMENT PLAN FOR EAGLE SPRING LAKE WAUKESHA COUNTY, WISCONSIN

INTRODUCTION

The aquatic plant management plan is prepared by the Regional Planning Commission staff as an integral part of the Eagle Spring Lake management plan, and represents an important element of the ongoing commitment of the Eagle Spring Lake Management District and the Town of Eagle to sound environmental management with respect to the Lake. The aquatic plant management portion of the lake management plan was prepared on field surveys conducted by Commission staff during 1994, with additional field inspections conducted during 1996. This plan follows the format adopted by the Wisconsin Department of Natural Resources (DNR) for aquatic plant management plans pursuant to Chapters NR 103 and NR 107 of the Wisconsin Administrative Code. Its scope is limited to those management measures which can be effective in the control of aquatic plant growth; those measures which can be readily undertaken by the Lake Management District and the Town in concert with the riparian residents; and those measures which will directly affect the use of Eagle Spring Lake. The aquatic plant management plan for Eagle Spring Lake is comprised of seven elements.

1. A set of aquatic plant management objectives;

2. A brief description of the Lake and its watershed;

3. A statement of the current use restrictions and the need for aquatic plant management in Eagle Spring Lake;

4. An evaluation of alternative means of aquatic plant management and a recommended plan for such management;

5. A description of the recommended plan;

6. A description of the equipment needs for the recommended plan; and

7. A recommended means of monitoring and evaluating the efficacy of the plan.

STATEMENT OF AQUATIC PLANT MANAGEMENT GOALS AND OBJECTIVES

The aquatic plant management program objectives for Eagle Spring Lake were developed in consultation with the Lake Management District and the Town of Eagle. The objectives are to:

1. Effectively control the quantity and density of aquatic plant growths in portions of the Eagle Spring Lake basin to enhance water-related recreational activities; to improve the aesthetic character of the resource; and to preserve and enhance the overall value of the waterbody;

2. Contribute to the overall conservation and wise use of Eagle Spring Lake through the environmentally sound management of vegetation, fish, and wildlife populations in and around the Lake; and,

3. Promote a high-quality, water-based recreational experience for residents and visitors of Eagle Spring Lake.

EAGLE SPRING LAKE AND ITS WATERSHED CHARACTERISTICS

Eagle Spring Lake is a 311-acre impounded through-flow lake with extensive shallow areas located in the southeastern portion of the Town of Eagle in Waukesha County, as shown on Map C-1. Eagle Spring Lake is second in the chain of three major lakes formed on the Mukwonago River above its confluence with the Middle Fox River just upstream of IH 43. The Lake is situated on the Mukwonago River immediately downstream of Lulu Lake and upstream of Lower Phantom Lake. The Mukwonago River forms the principal inflow and outflow of Eagle Spring Lake.

Eagle Spring Lake, has a single, shallow basin containing several islands and two distinct arms or embayments situated along the northwestern and southeastern shores of the Lake. The entire waterbody is considered shallow, with portions of the basin having a marsh-like character, particularly along the southwestern shoreline and adjacent to Lulu Lake.

The total tributary drainage area of Eagle Spring Lake is about 26 square miles. Approximately one-half of this watershed extends into Walworth County. Lulu Lake is included within this watershed.

Eagle Spring Lake has been subjected to a number of studies, including water quality sampling by the U.S. Geological Survey and the Wisconsin Department of Natural Resources.

Land Use and Shoreline Development

The shoreland of Eagle Spring Lake consists primarily of conservation open space and residential development. A public boat launch is provided at a State-owned site near the dam wall. An additional private access site is located on the eastern shore of the Lake. Lands along the southern and southwestern shores—between Eagle Spring and Lulu Lake—have been acquired by the Wisconsin Department of Natural Resources and The Nature Conservancy. As shown in Map C-2, natural vegetation covers the shorelands in these areas while the remaining shoreline is covered mainly by a mix of structural protection measures and limited beach areas. The residential areas are considered to be fully developed, although some limited in filling and backlot development may be possible.[1] Some further trail and access development may occur in the proposed public use natural areas as recommended by SEWRPC Community Assistance Planning Report No. 27, A Park and Open Space Plan for the Town of Eagle, published in April 1979, as refined by the Wisconsin Department of Natural Resources, Environmental Impact Statement on the Acquisition, Management, and Development of the Lulu Lake State Natural Area, Walworth County, Wisconsin, published in March 1987.

Aquatic Plants, Distribution, and Management Areas

The survey of aquatic plant communities in Eagle Spring Lake was conducted by Commission staff, in association with the District's consultant, during July 1994. A species list, compiled from the results of this aquatic plant survey, is set forth in Table C-1. This survey identified 20 species of plants, many of which were common to abundant. The uniform shallowness of Eagle Spring Lake facilitates the growth of aquatic plants throughout the Lake as is shown in Map C-3. A further reconnaissance of the aquatic plant community of Eagle Spring Lake was conducted by Commission staff during 1996.

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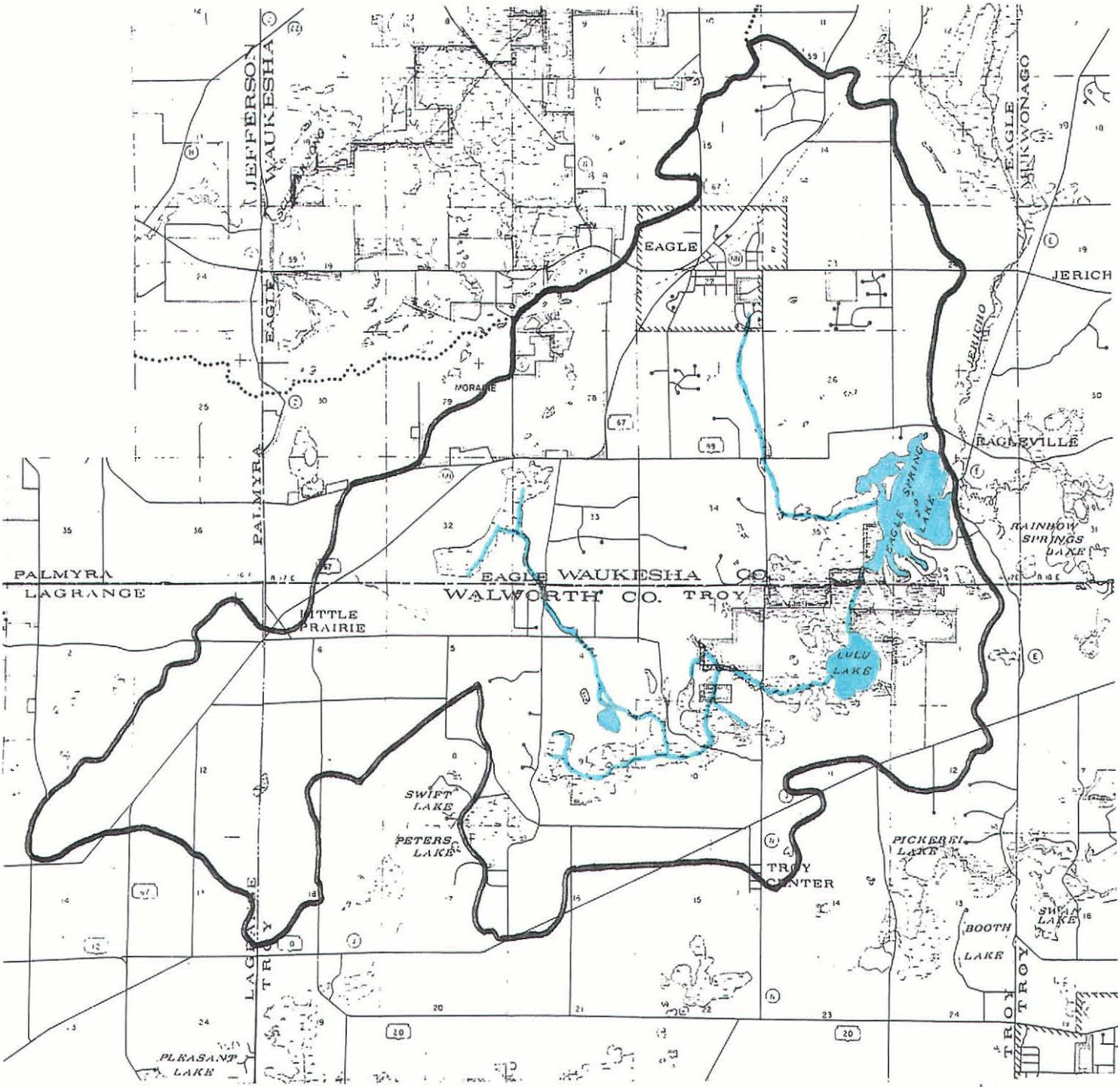
[1] *SEWRPC Planning Report No. 40, A Regional Land Use Plan for Southeastern Wisconsin—2010, January 1992.*

Map C-1

DRAINAGE AREA TRIBUTARY TO EAGLE SPRING LAKE



LEGEND

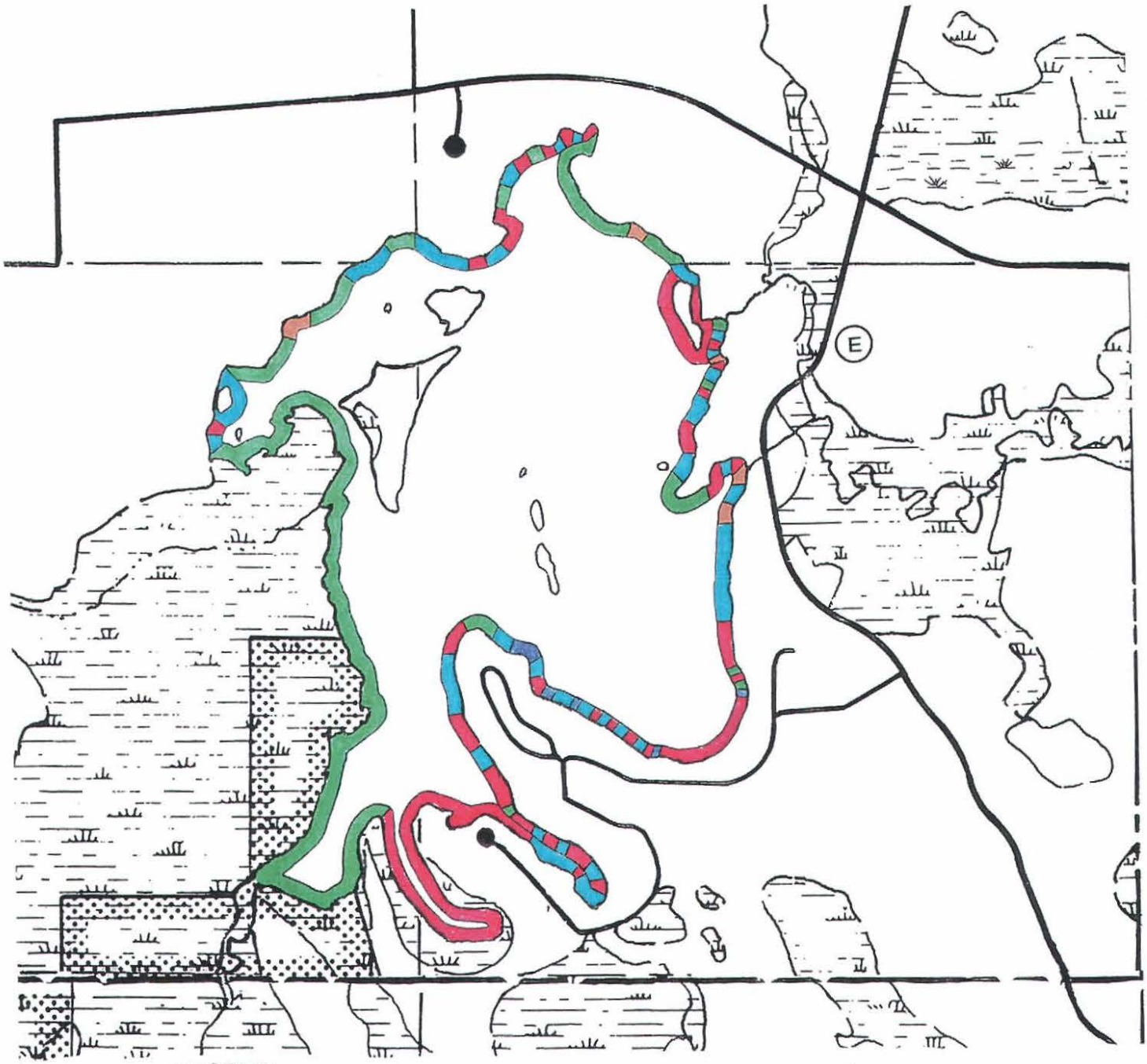
TRIBUTARY DRAINAGE AREA BOUNDARY

Source: SEWRPC.

GRAPHIC SCALE
0 3000 6000 FEET

Map C-2

SHORELINE PROTECTION STRUCTURES ON EAGLE SPRING LAKE: 1994



Source: SEWRPC.

Table C-1

AQUATIC PLANT SPECIES PRESENT IN EAGLE SPRING LAKE AND THEIR POSITIVE ECOLOGICAL SIGNIFICANCE

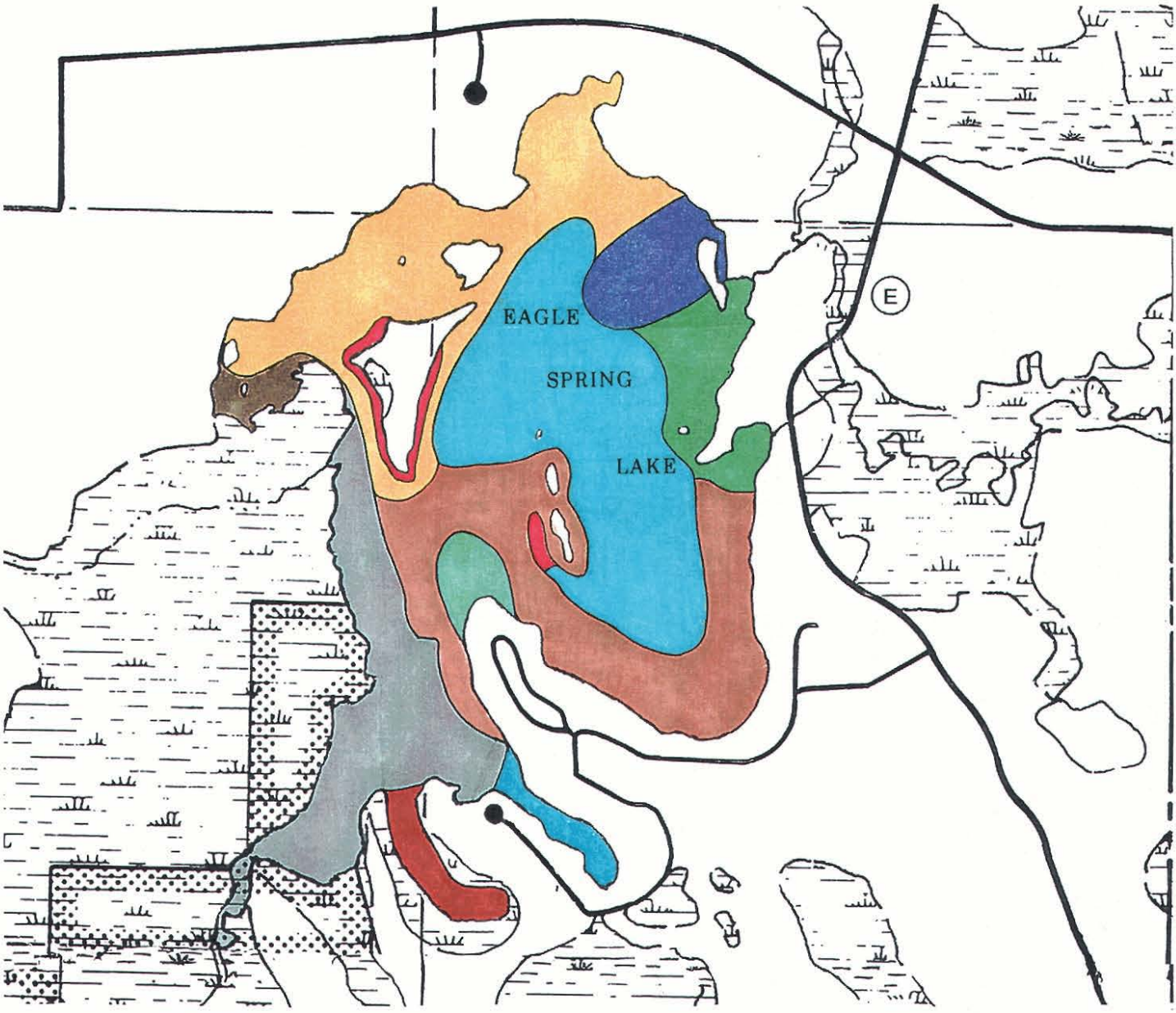
Aquatic Plant Species Present	Abundance	Ecological Significance[a]
Ceratophyllum demersum (coontail)	Common	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara Vulgaris (muskgrass)	Abundant	Excellent producer of fish food, especially for young trout, bluegills, and small and largemouth bass; stabilizes bottom sediments; and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed)	Common	Provides shelter and support for insects which are valuable as fish food
Lemna minor (lesser duckweed)	Common	Provides important food for wildfowl and attracts small aquatic animals
Myriophyllum sp. (native milfoil)	Common	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	Common	None known
Najas flexilis (bushy pondweed)	Common	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	Common	Provides good food and shelter for fish and food for ducks
Nuphar sp. (yellow water lily)	Common	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 tuberosa (white water lily)	Common	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 crispus (crispy-leaf pondweed)	Scarce	Provides food, shelter, and shade for some fish and food for wildfowl
Potamogeton gramineus (variable pondweed)	Scarce	Provides food important to ducks and food and cover for fish
Potamogeton illinoensis (Illinois pondweed)	Scarce	Provides some food for ducks and shelter for fish
Potamogeton natans (floating-leaf pondweed)	Common	Provides good food for ducks late in the season
Potamogeton pectinatus (sago pondweed)	Common	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton zosteriformis (flat-stemmed pondweed)	Scarce	Provides some food for ducks
Ranunculus sp. (water buttercup)	Scarce	Provides food for trout, upland game birds, and wildfowl
Typha latifolia (cattail)	Common	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
Utricularia sp. (bladderwort)	Common	Provides good food and cover for fish
Vallisneria americana (water celery)	Abundant	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.

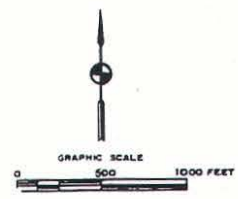
Map C-3

AQUATIC PLANT COMMUNITY DISTRIBUTION IN EAGLE SPRING LAKE: 1994



LEGEND

- MIXED SUBMERGENTS WITH FEW FLOATING AND EMERGENT SPECIES
- EURASIAN WATER MILFOIL, COONTAIL, COMMON WATER WEED, AND WILD CELERY
- MUSKGRASS, WILD CELERY, AND BUSHY PONDWEED
- MIXED PONDWEEDS, SPINY NAIAD, AND MUSKGRASS
- MUSKGRASS, BUSHY AND SAGO PONDWEED
- MIXED WATER LILIES, SAGO PONDWEED, AND MUSKGRASS
- MUSKGRASS, WHITE WATER LILY, AND CLASPING-LEAF PONDWEED
- NEEDLE SPIKE RUSH, MUSKGRASS, WILD CELERY, AND WATER MILFOIL
- COONTAIL, WILD CELERY, NATIVE WATER MILFOIL, MUSKGRASS, VARIABLE-LEAF, AND SAGO PONDWEED
- MUSKGRASS, SPINY NAIAD, VARIABLE-LEAF PONDWEED, YELLOW WATER LILY, AND SOFT STEM BULRUSH
- MIXED WATER LILIES AND CATTAILS, GREAT BLADDERWORT, MUCKGRASS, AND FLOATING-LEAF PONDWEED



NOTE: Further field surveys conducted by the Commission staff in 1996 indicated that Eurasian water milfoil has been identified throughout all of the above areas.

 Source: SEWRPC.

In 1994, musk grass, Chara spp., and wild celery, Vallisneria americana, were the dominant species in many areas of the main basin, and were especially abundant in the southern portion of the main lake basin at depths of up to six feet. Ceratophyllum demersum and Potamogeton pectinatus were common in the northern portion of the main lake basin at depths of four to six feet. Myriophyllum spicatum, commonly known as Eurasian water milfoil, was largely confined to the southeastern embayment. Eurasian water milfoil is an exotic plant species, not native to North America, which proliferates excessively, creating thick beds of vegetation. In shallower depths of water, such as is present over all of Eagle Spring Lake, Eurasian water milfoil is able to grow to the surface making certain recreational uses less enjoyable, in addition to impairing the aesthetic quality of the waterbody. This particular species of milfoil has been known to become the dominant plant present in a lake with its ability to regenerate, to replace native vegetation, and to reduce the quality of fish and wildlife habitat. Further, when Eurasian water milfoil is fragmented by boat propellers, or any other means, the torn shoots are able to sprout new roots, colonizing new sites. These shoots can also cling to boats, trailers, motor props, or bait buckets; and can stay alive for weeks, facilitating transfer to other lakes. Further field surveys in July of 1996 indicated scattered small milfoil beds throughout the Lake which have spread beyond the areas identified in the 1994 survey. For this reason, it is very important to remove all vegetation from boats and trailers before removing them from the water.

A survey of aquatic plant communities in Lulu Lake was also conducted by Commission staff, in association with the District's consultant, during July 1994. A species list, compiled from the results of this aquatic plant survey, is set forth in Table C-2. This survey also identified 20 species of plants, many of which were common to abundant.

Plant growth occurred primarily along the periphery of Lulu Lake to water depth of up to 15 feet. Musk grass, Chara spp., bushy pondweed, Najas flexilis, and spiney naiad, Najas marina, were the dominant species in many areas of the main basin which are at depths of up to 15 feet. Ceratophyllum demersum occurred in the vicinity of the Mukwonago River inlet of the Lake, while Myriophyllum spicatum was largely confined to the northern shores adjacent to the Mukwonago River outlet from the Lake to Eagle Spring Lake, the latter appearing to have been introduced to Lulu Lake from Eagle Spring Lake by the boat traffic that routinely traverses the short section of river between the two Lakes. The distribution of these plant communities is shown on Map C-4.

Given the wetland-like character of the Eagle Spring Lake inlet area, downstream of Lulu Lake, control programs should not extend into this area or the upper reaches of the impoundment except for a narrow, 10-foot-wide navigation channel which will provide access along the Mukwonago River between the main basins of Eagle Spring and Lulu Lakes.

Fisheries, Wildlife, and Waterfowl

Eagle Spring Lake is well known for its fishing and is the site of an annual carp-fishing jamboree and numerous other community events. The Wisconsin Department of Natural Resources Publication No. FM-800-95REV, Wisconsin Lakes, 1995, indicates that panfish are common, and that largemouth bass and northern pike are also present. Because of an abundant northern pike habitat, northern pike were stocked in the Lake by the Department of Natural Resources during 1992, following a fishery survey conducted by the Wisconsin Department of Natural Resources in May of that year. However, no northern pike were found during a follow-up survey conducted in May of 1993, and only one fish was found in May of 1994. Continued stocking was recommended.

The fisheries surveys that have been conducted indicate a fish population heavily dominated by predator species, particularly the largemouth bass, and a stunted, deficient prey species, the bluegill. Protection of the bluegill population by introduction of a voluntary bag limit to minimize overharvest of the fish and protection of existing native aquatic vegetation which acts as a refuge for the fish in the Lake, has been

Table C-2

AQUATIC PLANT SPECIES PRESENT IN LULU LAKE AND THEIR POSITIVE ECOLOGICAL SIGNIFICANCE

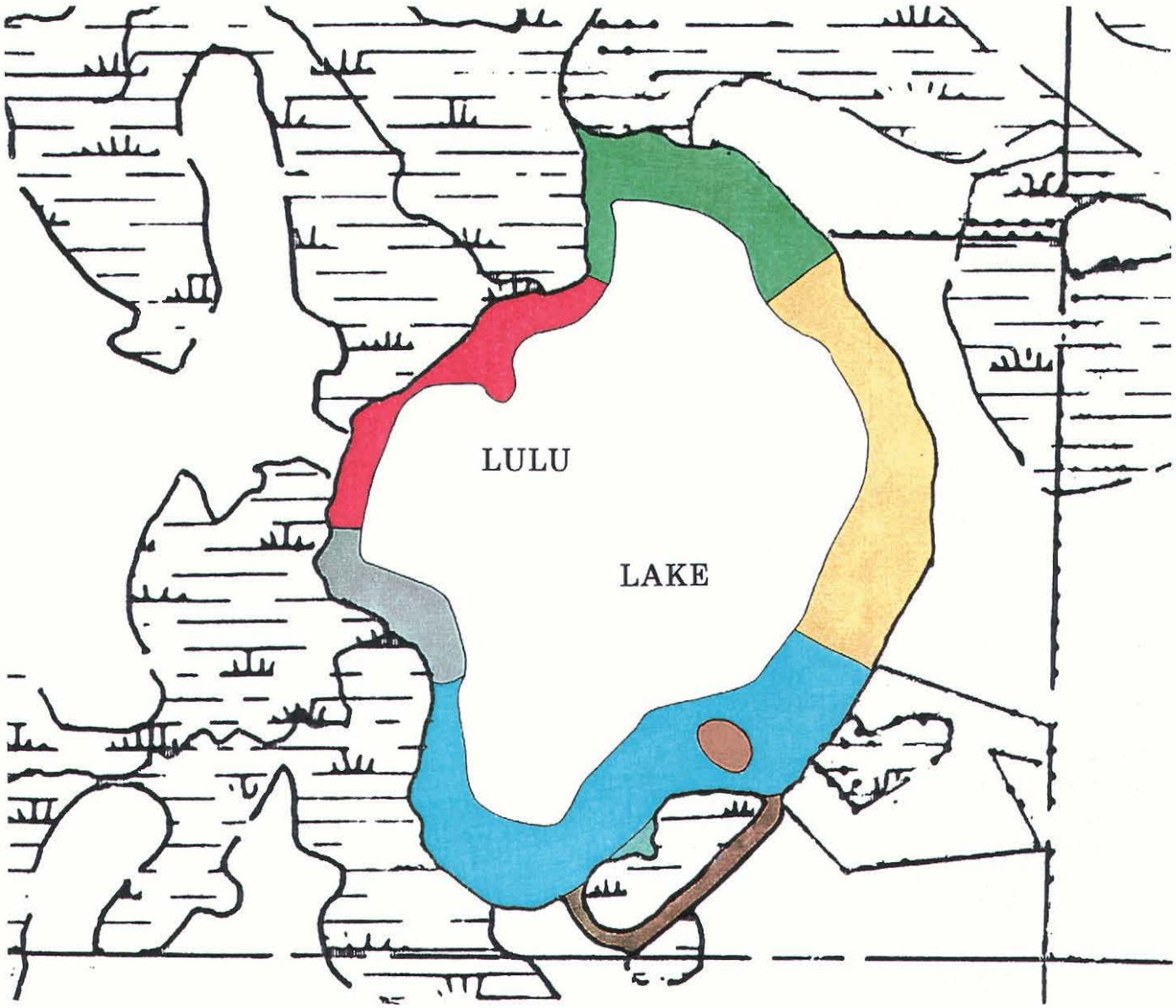
Aquatic Plant Species Present	Abundance	Ecological Significance[a]
Ceratophyllum demersum (coontail)	Scarce	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara Vulgaris (muskgrass)	Abundant	Excellent producer of fish food, especially for young trout, bluegills, and small and largemouth bass; stabilizes bottom sediments; and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed)	Scarce	Provides shelter and support for insects which are valuable as fish food
Lemna minor (lesser duckweed)	Scarce	Provides important food for wildfowl and attracts small aquatic animals
Myriophyllum sp. (native milfoil)	Scarce	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	Scarce	None known
Najas flexilis (bushy pondweed)	Abundant	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	Abundant	Provides good food and shelter for fish and food for ducks
Nuphar sp. (yellow water lily)	Common	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 tuberosa (white water lily)	Common	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 crispus (crispy-leaf pondweed)	Scarce	Provides food, shelter, and shade for some fish and food for wildfowl
Potamogeton foliosus (leafy pondweed)	Scarce	Provides important food for wildfowl and food and shelter for fish
Potamogeton gramineus (variable pondweed)	Scarce	Provides food important to ducks and food and cover for fish
Potamogeton illinoensis (Illinois pondweed)	Scarce	Provides some food for ducks and shelter for fish
Potamogeton natans (floating-leaf pondweed)	Scarce	Provides good food for ducks late in the season
Potamogeton pectinatus (sago pondweed)	Scarce	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton richardsonii (Richardson's pondweed)	Scarce	Provides good food and cover for fish and supports insects
Potamogeton zosteriformis (flat-stemmed pondweed)	Scarce	Provides some food for ducks
Typha sp. (cattail)	Common	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
Utricularia sp. (bladderwort)	Scarce	Provides good food and cover for fish
Vallisneria americana (water celery)	Scarce	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.

Map C-4

AQUATIC PLANT COMMUNITY DISTRIBUTION IN LULU LAKE: 1994



Source: SEWRPC.

proposed to correct this imbalance. These surveys also indicate that the fish populations are in a state of transition, with bass populations declining due to decreased spawning efficiency.

Given the rural nature of all but the immediate shoreland area, many animals and numbers of waterfowl commonly inhabit areas of the watershed, especially in the undeveloped southwestern areas of the Lake and upstream. Mink, muskrat, beaver, white-tailed deer, red and grey fox, grey and fox squirrel, and cottontail rabbits are reported mammals. Mallards, wood duck, and blue-winged teal are the most numerous waterfowl and are known to nest in the area. Many game birds, song birds, waders, and raptors also visit the Lake and its environs. Sandhill cranes and loons are notable migratory visitors. Blanding's turtles, a threatened species, is a resident of Lulu Lake. In addition, bald eagles, osprey, black terns, loggerhead shrikes, peregrine falcons, barn owls, and Cooper's hawks—all threatened or endangered species—have been reported in the area.

Recreation

Eagle Spring Lake is a multi-purpose waterbody serving all forms of recreation, including boating—especially pontoon boats, waterskiing, swimming, and year-around fishing. The Lake is also used as a visual amenity during all four seasons. Significant boat traffic moves between Eagle Spring and Lulu Lakes, with the former being devoted primarily to active recreational pursuits such as waterskiing and the latter to more passive pursuits such as bird-watching and aesthetic appreciation. Waterskiing is presently required by town ordinance to be carried out in a counter-clockwise direction within the main basin of Eagle Spring Lake, following the shoreline, and passing between islands and western shoreline.

There are two private commercial facilities on Eagle Spring Lake which serve as centers for some recreational lake users, both are located adjacent to CTH E, one of which provides a private launch facility. In addition, a public boat launch site is provided for public use. A number of local retailers specializing in sporting goods are situated within a convenient distance of the Lake in the both the Town and Village of Eagle.

Local Ordinances

The Town of Eagle has not adopted and implemented a Shoreland and Floodplain Protection Zoning Ordinance in accordance with Administrative Code NR 117, Wisconsin's Town and Village Shoreland-Wetland Protection Program. However, the Town is governed by the Waukesha County ordinance which has been in force since 1970. The upper portions of the watershed are governed by the Walworth County shoreland and wetland zoning ordinances.

USE RESTRICTIONS IMPOSED BY AQUATIC PLANTS

Excessive plant growth in the main basin of Eagle Spring Lake impedes boating traffic. In particular, excessive plant growth in the riparian zone makes access to the open water difficult without some sort of plant control strategy. At most sites samples, plant growth recorded by Commission staff exceeded a density rating of 3, indicating a moderate density with at least one species present in quantities rated common to abundant at most sites sampled along the waterbody. The results from this survey are shown in Table C-3. Such dense growths also severely restrict shoreline angling and swimming. The result is numerous public complaints throughout the summer season.

The abundance of aquatic plants in the main lake basin adversely affects riparian property values and the aesthetic enjoyment of the residents, and can have significant impact in terms of the aesthetic enjoyment of visitors to the Lake.

Table C-3

AQUATIC MACROPHYTE SPECIES DISTRIBUTION FOR EAGLE SPRING LAKE: 1994

Plant Type	Sites Found	Frequency of Occurrence[a]	Density at Sites Found[b]	Density in Whole Basin[b]
Ceratophyllum demersum (coontail)	5	12	3.2	0.27
Chara sp. (muskgrass)	23	39	3.1	1.20
Elodea canadensis (waterweed)	7	12	2.9	0.34
Myriophyllum spicatum (Eurasian water milfoil)	8	14	2.3	0.31
Myriophyllum sibericum (native milfoil)	12	20	1.8	0.36
Najas flexilis (bushy pondweed)	6	10	1.6	0.17
Najas marina (spiny naiad)	11	19	1.4	0.19
Potamogeton richardsoni (clasping-leaf pondweed)	4	10	1.0	0.02
Potamogeton crispus (curly-leaf pondweed)	1	29	1.0	0.02
Potamogeton pectinatus (sago pondweed)	6	10	1.5	0.15
Potamogeton illinoensis (Illinois pondweed)	2	3	3.0	0.10
Potamogeton gramineus (variable pondweed)	3	5	1.0	0.05
Potamogeton zosteriformis (flat-stemmed pondweed)	4	7	1.0	0.07
Potamogeton natans (floating-leaf pondweed)	8	14	1.1	0.15
Utricularia vulgaris (great bladderwort)	7	12	1.4	0.17
Vallisneria americana (eel grass)	21	36	2.7	0.97
Nuphar variegatum (yellow water lily)	9	15	3.4	0.53
Nymphaea sp. (white water lily)	10	17	3.6	0.61
Lemna minor (lesser duckweed)	2	3	1.5	0.05
Scirpus validus (soft-stem bulrush)	1	2	1.0	0.02
Ranunculus sp. (water crowfoot)	1	2	1.0	0.02
Sparganium minimum (small bur reed)	1	2	1.0	0.02
Eleocharis acicularis (needle spike rush)	2	3	2.0	0.05

[a]*The percentage of all the sampling stations in which a particular species was noted.*

[b]*Density is expressed in the five-point DNR rating scale where a score of five equals abundant and a score of one equals scarce.*

Source: SEWRPC.

PAST AND PRESENT AQUATIC PLANT MANAGEMENT PRACTICES

Aquatic herbicides have been used on Eagle Spring Lake under permits issued by the DNR since the 1950s, when records of such control programs began to be kept by the DNR. However, aquatic plant control programs on Eagle Spring Lake probably predate the DNR record-keeping system by several decades. This program initially involved the chemical treatment of aquatic plant growths with sodium arsenite. Eagle Spring Lake received about two tons of sodium arsenite during the 20-year period from 1950 to 1969. Applications of sodium arsenite were discontinued in 1969 after arsenic accumulations were found in the lake sediments and concerns were expressed over possible human health impacts. No health impacts, however, have been recorded, and sedimentological analyses conducted in May of 1990 revealed sediment arsenic concentrations that were well within Wisconsin Department of Natural Resources proposed sediment quality guidelines,[2] ranging from 0.13 to 3.0 parts per million (ppm), while DNR guidelines suggest a lowest effect level for arsenic of greater than 6.0 ppm. More recent uses of chemical treatments have made

[2]*Wisconsin Department of Natural Resources, (DRAFT) Inventory of Statewide Contaminated Sediment Sites and Development of a Prioritization System, June 1994.*

Table C-4

HISTORIC CHEMICAL CONTROLS ON EAGLE SPRING LAKE: 1951-1997

Year[a]	Macrophyte Control				Algal Control	
	Sodium Arsenite (pounds)	Diquat (gallons)	Aquathol K (gallons)	2,4-D (pounds)	Copper Sulfate (pounds)	Cutrine-Plus (gallons)
1951	400	0	0	0	20.0	0.0
1952	600	0	0	0	0.0	0.0
1953	600	0	0	0	30.0	0.0
1956	600	0	0	0	0.0	0.0
1961	720	0	0	0	0.0	0.0
1962	720	0	0	0	0.0	0.0
1963	720	0	0	0	0.0	0.0
1969	0	3	0	0	200.0	0.0
1973	0	0	25	0	0.0	0.0
1974	0	0	20	0	15.0	0.0
1975	0	0	23	0	39.3	11.5
1978	0	0	9	0	0.0	8.5
1980	0	0	0	50	0.0	0.0
1981	0	0	0	40	0.0	0.0
1982	0	0	0	40	0.0	0.0
Total	4,360	3	77	130	304.3	20.0

[a]*During years not included, no chemical controls were used.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

use of more specific herbicides such as 2,4-D, as set forth in Table C-4, although no chemical herbicides are known to have been applied since 1982.

Since the mid-1980s, harvesting has been used to control aquatic plant growth in Eagle Spring Lake. The Eagle Spring Lake Management District has purchased and operates two Aquarius Systems HM-220 harvesters on the Lake, and removes about 700 cubic yards of plant material from the Lake annually. This control program has been viewed favorably by the public.

ALTERNATIVE METHODS FOR AQUATIC PLANT CONTROL

Background

Various aquatic plant management techniques—manual, mechanical, physical, and chemical—are potentially applicable on Eagle Spring Lake. A number of these methods have been employed with varying success on Eagle Spring Lake in the past.

Physical Controls

One physical method of aquatic plant control involves drawing down of a waterbody in order to change or create specific types of habitat and thereby manage species composition within the waterbody. Such drawdown was not considered practical on Eagle Spring Lake due to the heavy recreational demands placed on the Lake throughout the year. Drawdown can also encourage the growth of some plant species. For these reasons, drawdown is not a recommended technique for Eagle Spring Lake at this time.

Other physical controls, such as the placement of bottom barriers and use of shoreline protection structures such as riprap, may be more practicable for Eagle Spring Lake. Limited use of pea gravel as an aquatic plant control measure has been proposed by Eagle Spring Lake. A Section 404 permit application to place pea gravel adjacent to private property to control the growth of coontail on the southern shore of the main lake basin was made in 1980. Extensive use of shoreline protection structures has occurred adjacent to the residential areas of Eagle Spring Lake as shown previously on Map C-2. These structures have been installed primarily to control erosion of the shoreline. There is currently only limited opportunity for installing additional areas of riprap. The use of such techniques along the western shoreline of the Lake is not to be recommended as the macrophyte growth in this area forms an ecologically valuable biological filter for the Lake and corridor linkage to Lulu and the State-owned natural area.

Another physical control option, deepening of the lake bottom, has also been employed at Eagle Spring Lake. Sediment removal has taken place at the southernmost embayment, adjacent to the Mukwonago River inlet to Eagle Spring Lake, and in the northernmost embayment—the latter action having been permitted during 1994 as a means of restoring groundwater flow to the bay. The retention of the undisturbed Nuphar sp. beds adjacent to the shoreline and the reintroduction of Chara sp. into the deepened area was proposed as a aquatic plant management measure during this latter dredging project. The propensity for invasive species such as Eurasian water milfoil to become established in areas of the Lake where the bottom sediments have been disturbed, as may have occurred in the southernmost embayment, would suggest that such actions not be recommended for widespread application in Eagle Spring Lake.

Chemical Controls

Chemical controls are viewed by the community as having uncertain long-term environmental impacts as well as possible consequences for human health. While the herbicides which have been used on Eagle Spring Lake have met applicable U.S. Environmental Protection Agency standards and have been applied by registered applicators, the use of chemical control techniques may contribute to an ongoing aquatic plant problem by augmenting the natural rates of accumulation of decayed organic matter in the Lake's sediments, releasing the nutrients contained in the plants back into the water column where they can be reused in new plant, including biomass production. The use if chemical control measures may also contribute to the oxygen demand that produces anoxic conditions in the Lake, damaging or destroying nontarget plant species that provide needed habitat for fish and other aquatic life. Hence, this option is not feasible on the scale required to control the infestations of aquatic plants in Eagle Spring Lake. Chemicals which have been used in the past on Eagle Spring Lake are shown in Table C-4.

However, chemical control is considered a suitable technique for the control of the relatively small-scale infestations of Eurasian water milfoil and purple loosestrife which are found in Eagle Spring Lake. Chemical applications in early spring have been found to be extremely effective in controlling the abundance of milfoil and facilitating the resurgence of growth of native plant species in lakes in Southeastern Wisconsin. If considered necessary, chemical applications should be conducted in accordance with current DNR administrative rules, under the authority of a State permit, by a licensed applicator working under the supervision of DNR staff. Records accurately delineating treated areas and the type and amount of herbicide used in each area, should be carefully recorded and used as a reference in applying for permits in the following year. A recommended checklist is provided as Figure C-1.

Manual Controls

Manual methods of aquatic plant control, such as raking or hand-pulling, while environmentally sound, are difficult to employ on a large-scale. Although very effective for small-scale application—for example, in and around docks and piers—manual techniques are generally not practical for large-scale plant control methods. Manual means are considered a viable option on Eagle Spring Lake to control nearshore plant growths.

Figure C-1

DISTRICT CHECKLIST FOR HERBICIDE APPLICATION

- ☐ Nuisance report completed defining areas of potential treatment
- ☐ Permit filed with the Wisconsin Department of Natural Resources
- ☐ Certified applicator hired[a]
- ☐ Required public notice in the newspaper
- ☐ Public informational meeting (required if five or more parties request a meeting)
- ☐ Posting of areas to be treated in accordance with regulations (discussed previously in report)
- ☐ Weather conditions cooperating
  - — Wind direction and velocity
  - — Temperature

[a]*A licensed applicator will determine the amount of herbicide to be used, based upon discussions with appropriate staff from the Wisconsin Department of Natural Resources, and will keep records of the amount applied.*

Source: SEWRPC.

Mechanical Controls

Based on previous experience of the use of mechanical harvester technologies on Eagle Spring Lake, mechanical harvesting of aquatic plants appears to be a practicable and efficient primary means of controlling plant growth in an environmentally sensitive manner. Harvesting removes the plant biomass and nutrients from the Lake. While mechanical harvesting can potentially impact fish and other aquatic life caught up by the machine, disturb loosely consolidated lake bottom sediments, and result in the fragmentation and spread of some aquatic plants, it has also been shown to have some benefit in ultimately reducing the regrowth of other plants and removing phosphorus from the Lake.[3] Harvesting also removes attached, epiphytic algal growths with the harvested plant material, and leaves sufficient plant material in the Lake to continue to provide forage and shelter for fish and other aquatic life, while stabilizing the lake sediments to prevent increased turbidity due to wind/wave resuspension.

A harvesting program should be designed to provide optimal benefits and minimal adverse impacts. Small fish are common in dense macrophyte beds, but larger fish, such as largemouth bass, do not normally utilize these dense beds. Narrow channels may be harvested to provide navigational access and "cruising lanes"

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[3]*Environmental Protection Agency, The Lake and Reservoir Restoration Guidance Manual, 2nd Edition, August 1990, p. 146.*

for predator fish to migrate into the macrophyte beds to feed on smaller fish. Shared access lanes may also be cut, allowing several residents to use the same lane. Increased use of these lanes should keep them open for longer periods than would be the case if a less directed harvesting program was followed. Because of the demonstrated need for control of aquatic plants in Eagle Spring Lake, and because the current lake management decisions have indicated a need for aquatic plant harvesting, harvesting is considered a viable management option which should be continued by the Eagle Spring Lake Management District.

Shoreline Cleanup Crew: Decomposing floating vegetation which builds up along the shorelines limits the use of the riparian shoreline and can be unsightly and foul smelling. Shoreline cleanup is a laborious job which can require substantial amounts of labor and time. Given that a significant number of lake homeowners are seasonal or elderly, it is not always feasible for the riparian owners to clean their shoreline when needed. The Lake Pewaukee Sanitary District has incorporated a shoreline cleanup crew into their harvesting program to alleviate this problem.[4] On Pewaukee Lake the shoreline cleanup crew harvested nearly as much vegetation as did the machine operated harvesters.[5] This method leaves the maintenance of the rooted vegetated area between the piers to the responsibility of the riparian owner. Because floating vegetation is not currently considered a significant problem, this method of aquatic plant management is not recommended at this time.

Biological Controls: Another alternative approach to controlling nuisance aquatic plant conditions is biological control. Classical biological control has been successfully used to control both weeds and herbivorous insects.[6] 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 effects on Eurasian water milfoil in the field and in the laboratory. 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 burrows in the stem of the plant causing enough tissue damage for the plant to lose buoyancy and collapse.[7] This type of control remains experimental in Wisconsin and is not recommended at this time, pending the outcome of investigations being conducted between 1995 and 1998 by the Wisconsin Department of Natural Resources and the University of Wisconsin-Stevens Point.

Information and Education

In addition to these in-lake rehabilitation methods, an ongoing campaign of community information will support the aquatic plant management program by encouraging the use of shoreland buffer strips, responsible use of household and garden chemicals, and environmentally friendly household and garden practices to minimize the input of nutrients from these riparian areas. In addition, the community information campaign should emphasize the need to clean boats and motors/propellers when removing boats from the Lake and on launching boats into the Lakes. This information campaign should also stress the need to clean boats and motors of aquatic plants prior to the boats entering Lulu Lake via the Mukwonago River channel. Plants removed from boats and motors at either end of the channel should be retained onboard and disposed of by composting at the boat launch or homestead and not introduced into the water. Growths of milfoil at the

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[4] *Charlie Shong, Lake Pewaukee Sanitary District, oral communication, 1995.*

[5] *Ibid.*

[6] *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, Kohl Wiley, New York, New York, USA.*

[7] *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.*

northern end of Lulu Lake are likely to have originated in Eagle Spring Lake and further spread of this undesirable plant species should be avoided. Placement of appropriate signage at the mouth of the Mukwonago River channel in both Eagle Spring and Lulu Lakes—possibly combined with a slow-no-wake instruction—and at the public boat launch, would be an appropriate reminder. This information program will also remind riparian residents of the habitat and other benefits, such as shoreline stabilization, provided by the aquatic flora of the Lake, and promote the preservation of a healthy aquatic flora in the Lake.

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

Harvesting Plan

The recommended aquatic plant management plan consists of integrated uses of mechanical and manual harvesting design to minimize the negative impacts on the ecologically valuable areas of the Lake, while providing the control needed to achieve the desired recreational uses of the Lake.

In order to implement the recommended aquatic plant management program the following management actions are recommended:

1. The continued operation by the Eagle Spring Lake Management District of the existing harvesters and transport equipment.

2. Shared access channels should be harvested to minimize the potential detrimental effects on the fish and invertebrate communities. Directing boat traffic through these common channels would help to delay the regrowth of vegetation in these areas.

3. Shallow harvesting, cutting at approximately two feet to remove the surface canopy of nonnative plants such as Eurasian water milfoil, to provide a competitive advantage to the low-growing native plants in the Lake is recommended. By not disturbing these low-growing species, which generally grow within one to two feet of the lake bottom and in relatively low densities, and leaving the root stocks and stems of the cut plants in place, the resuspension of sediments in the Lake will be minimized. This type of harvesting should be focused, primarily, on boating channels around the perimeter of the main lake basin, and, secondarily, on other areas with extensive growths of Eurasian water milfoil.

4. Chemical herbicides, if found to be necessary, should be limited to controlling nuisance growths of exotic species in shallow water around docks and piers. Only herbicides that are selective in their control, such as 2,4-D, should be used. Algicides, such as Cutrine Plus, are not recommended because there are no significant filamentous algae or planktonic algal problems in the Lake, and valuable macroscopic algae, such as Chara and Nitella, are killed by this product.

5. It is recommended that chemical application, if required, should be made in early spring to maximize its effectiveness on nonnative plant species, minimize its impact on native plant species, and act as a preventative measure to reduce the development of nuisance conditions.

6. The control of rooted vegetation between adjacent piers is recommended to be left to the riparian owners concerned, as it is time consuming and costly for the mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. As an alternative option it is recommended that the Lake Management District obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to make available to the residents.

7. It is recommended that ecologically valuable areas be restricted from aquatic plant management activities especially during fish spawning seasons in early summer and autumn.

8. The incorporation by the Lake Management District of an overall public education program of information on the types of aquatic plants in Eagle Spring Lake and the value of and the impacts of these plants on water quality, fish, and on wildlife; and alternative methods for controlling existing nuisance plants, including the positive and negative aspects of each method. An organized aquatic plant identification day is one method of providing effective education to lake residents. Other sources of information and technical assistance include the Department of Natural Resources Aquatic Plant Monitoring Program and the University of Wisconsin-Extension Service. The aquatic plant species list provided in Chapter V, and the illustrations provided in Appendix D, may assist individuals interested in identifying plants near their residences. Residents should be encouraged to observe and document changes in the abundance and types of aquatic plants in their part of the Lake on annual basis.

The recommended aquatic plant management plan for Eagle Spring Lake is graphically summarized on Map C-5. As indicated on the map, it is proposed that aquatic plant management activities be restricted in certain ecologically valuable areas of the Lake. For this reason, aquatic plant management activities are recommended to be confined to zones related to access, boating, fishing, and habitat areas of the Lake. Aquatic plant management operations are recommended to be concentrated in the main basin of the Lake and in the areas recommended for fishing and boating.

The ecologically valuable areas, identified as habitat areas, should be restricted from harvesting. The upper reaches of the impoundment, in the vicinity of the southwestern shoreline, Mukwonago River, and Lulu Lake, have more of a wetland character and are recommended to be excluded from aquatic plant management operations, except for provision of an access channel between the two Lakes, and operations associated with the eradication of Eurasian water milfoil in this area. In addition, harvesting should not take place in shallow waters—generally three feet or less—to avoid disturbance of fish spawning areas and beds of native aquatic plants. Special care should be taken to avoid disturbing major spawning areas of bass in Eagle Spring Lake during spring spawning season—May 1st to June 30th, annually.

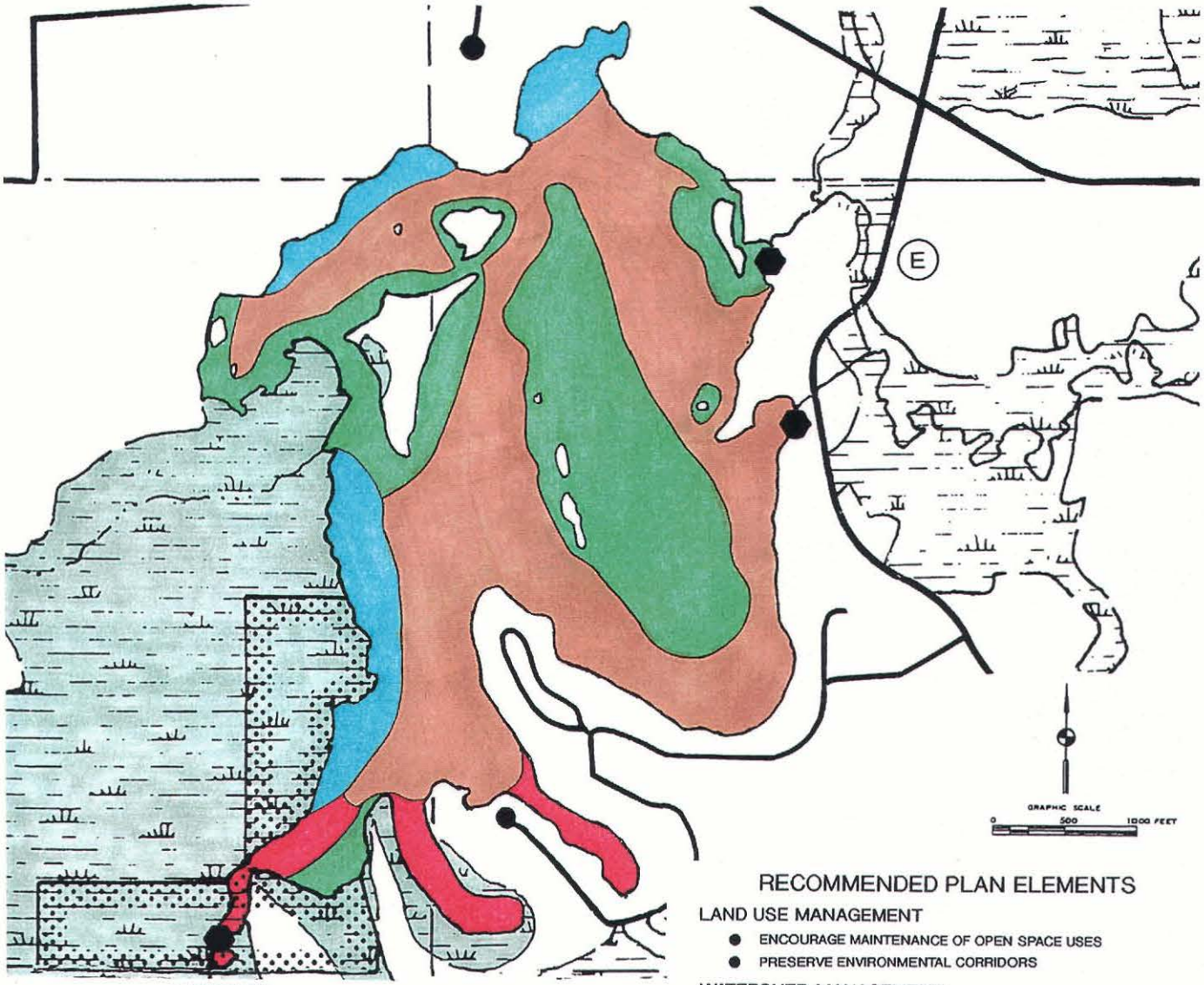
The primary objective of the management program is to accommodate recreational uses of the Lake, and to enhance the public perception of the Lake without inflicting irreparable damage to the structure and functioning of the lake ecosystem. To accomplish this objective, specific control measures should be applied in each of the various lake zones identified on Map C-5. The recommended sequence of the harvester operations on Eagle Spring Lake is portrayed in Figure C-2. The recommended aquatic plant management treatments that should be applied in each of the four lake zones are shown in Table C-5.

Depth of Harvesting and Treatment of Fragments

The Aquarius Systems HM-220 aquatic plant harvester has a maximum cutting depth of five feet. While this exceeds the actual water depth of fully one-third of the impoundment, it is not the intention of the owners or operators of the equipment to denude the impoundment of aquatic plants, given the heavy angling use of the waterbody; its morphology, which is not conducive to extensive motorized boat traffic; and the program goals. Sufficient plant materials will be retained in the impoundment to minimize resuspension of lake bottom sediments and to maintain desirable plant communities, such as those dominated by the low-growing Chara spp. All plant cuttings and fragments will be collected *in situ* by the harvesters. Those fragments accumulating along the shoreland areas will be collected by the District or the riparian homeowners. Fragments can be used by the homeowners as garden mulch.

Map C-5

RECOMMENDED LAKE MANAGEMENT PLAN FOR EAGLE SPRING LAKE



LEGEND

MANAGEMENT ZONES

- FISHING: HARVEST NARROW CHANNELS–APPROXIMATELY 15 FEET WIDE PERPENDICULAR TO SHORE ABOUT EVERY 100 TO 200 FEET –USE OF CHEMICALS FOR ALGAE AND AQUATIC PLANT CONTROL NOT RECOMMENDED IN THESE AREAS
- BOATING: HARVESTCHANNELS APPROXIMATELY 50 FEET WIDE PARALLEL TO THE SHORELINE OF THE MAIN BASIN OF THE LAKE –LIMITED USE OF CHEMICALS FOR ALGAE AND AQUATIC PLANT CONTROL RECOMMENDED IN THESE AREAS
- HABITAT: ECOLOGICALLY VALUABLE AREAS–NO AQUATIC PLANT MANAGEMENT ACTIVITIES–USE OF CHEMICALS FOR ALGAE AND AQUATIC PLANT CONTROL NOT RECOMMENDED IN THESE AREAS
- ACCESS: HARVEST NARROW CHANNELS–APPROXIMATELY 15 FEET WIDE AROUND THE PERIMETER OF THE SOUTHERN BAY AREAS AND THE INLET AREA TO PROVIDE BOATING ACCESS FROM THESE AREAS TO THE MAIN BASIN OF THE LAKE–LIMITED USE OF CHEMICALS FOR ALGAE AND AQUATIC PLANT CONTROL RECOMMENDED IN THESE AREAS
- ECOLOGICALLY VALUABLE AREAS TO BE PROTECTED
- SITE FOR PROPELLER CLEANING FACILITY WITH SIGNAGE

RECOMMENDED PLAN ELEMENTS

LAND USE MANAGEMENT

- ENCOURAGE MAINTENANCE OF OPEN SPACE USES
- PRESERVE ENVIRONMENTAL CORRIDORS

WATERSHED MANAGEMENT

- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS
- PROMOTE INSTALLATION OF PUBLIC SANITARY SEWER SYSTEM
- CONDUCT ONSITE SEWAGE DISPOSAL SYSTEM MANAGEMENT PROGRAM
- PREPARE FARM PLANS FOR AGRICULTURAL LANDS

WATER LEVEL MANAGEMENT

- MAINTAIN LAKE WATER LEVELS IN THE RANGE OF 820.53 TO 820.83 FEET ABOVE NGVD-29

MONITORING PROGRAM

- CONDUCT FISH SURVEY
- CONDUCT WATER QUALITY MONITORING

FISH MANAGEMENT

- REVIEW AND REFINE STOCKING PROGRAM AS REQUIRED
- MODIFY ANGLING BAG LIMITS

SHORELINE PROTECTION

- MAINTAIN AND REPAIR EXISTING STRUCTURES

EURASIAN WATER MILFOIL MANAGEMENT PROGRAM

- CONTROL NUISANCE EURASIAN WATER MILFOIL CONDITIONS AS NECESSARY

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

Source: SEWRPC.

Buoyage

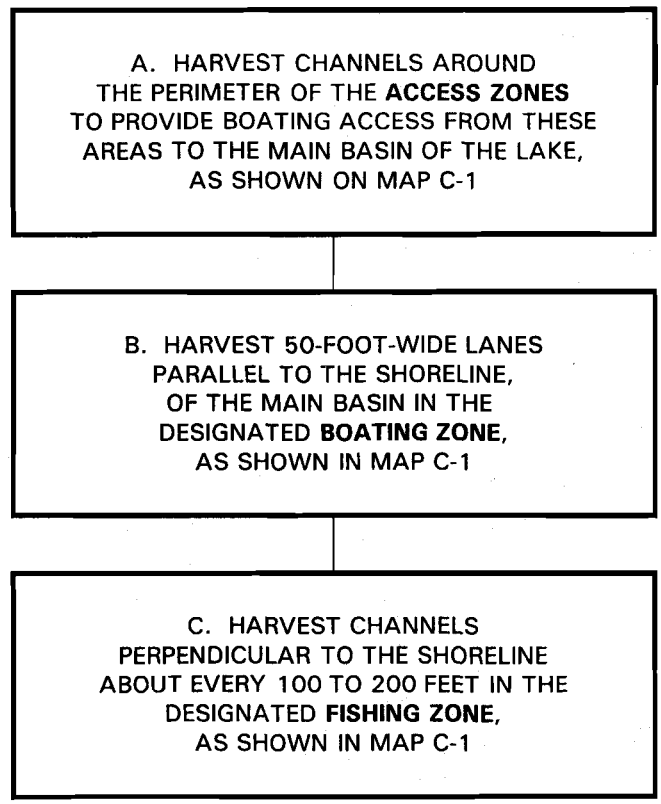
Temporary marker buoys may be used to direct harvesting operations in the lake basin by marking the areas to be cut. However, the size of the Lake generally precludes the need for such buoys, except insofar as they are required for the control of boating traffic on the Lake. The harvester operators will be provided with a laminated copy of the harvesting plan and made familiar with the plan and local landmarks to the degree necessary to carry out the plan without the use of buoyage. Harvesting operations are regularly supervised by District Commissioners.

Harvested Plant Material Disposal and Transfer Site(s)

Plant material will be removed from the harvesters on a transporter and conveyed to off-loading area, where it will be transferred to a dump truck using a conveyor and transported to disposal sites identified by the Eagle Spring Lake Management District. Plant material will be collected and disposed of daily to avoid leaching of nutrients back into the impoundment and to minimize the visual degradation of the environment near the boat launching site. The operators will stringently police the off-loading site to ensure minimal disruption of boaters and of the people using the riparian areas of the Lake.

Figure C-2

HARVESTING SEQUENCE FOR EAGLE SPRING LAKE[a]



[a]No harvesting should be conducted in Habitat Zone or within 100 feet of the island areas.

Source: SEWRPC.

Precautions to Protect Wildlife and Ecologically Valuable Areas

Operators will be provided with a laminated copy of the approved harvesting plan map and sequence chart, as set forth in Map C-5 and Figure C-2, showing the limits and priorities of harvesting operations. A copy of these items should be kept on the harvesters at all times. Operations will be forbidden in the upper reaches of the Lake, along the southwestern shore, except for the navigation channel described above, to prevent disturbance of the wetland areas, and in those areas of three feet or less in depth to protect bass habitat and spawning areas. Harvesting operations in the areas identified as suitable for bass spawning will be restricted until the beginning of June to permit undisturbed spawning. Harvesting in all areas will be to a maximum depth of one foot above the lake bottom in order to provide adequate protection for the lake bottom, to minimize resuspension of the bottom sediments, and to allow low-growing native plants present within the system, such as Chara sp., to retain their competitive advantage over less-desirable invasive species, such as the Eurasian water milfoil.

Public Information

It is the policy of the Eagle Spring Lake Management District to maintain an active dialogue with the community. This dialogue is carried out through the medium of the public press and in public fora through various District Commissioner meetings, public meetings, and other scheduled hearings. Further, the Eagle

Table C-5

RECOMMENDED AQUATIC PLANT MANAGEMENT TREATMENTS FOR EAGLE SPRING LAKE

Zone and Priority	Recommended Aquatic Plant Management Plan
Access	• Harvest channels, approximately 15 feet wide, along portions of the southern end of the Lake and inlet area to provide boating access to the main body of the Lake • This zone totals about 12 acres in areal extent • Total area recommended to be harvested is approximately two acres • Limited use of chemicals for algal and aquatic plant control is recommended in this area
Boating	• Harvest channels, approximately 50 feet wide, parallel to the shoreline of the main basin of the Lake to allow boating in the main lake basin area and avoid disturbance of the native flora in the central area of the Lake • This zone totals about 187 acres in areal extent • Total area recommended to be harvested is approximately 28 acres • Chemical use should be restricted to pier and dock areas within 50 feet of the shore in this area
Fishing	• This zone is intended to accommodate fishing from a boat • It is recommended that 15-foot-wide channels be harvested perpendicular to the shore at approximately 100- to 200-foot intervals • This zone totals about 28 acres in areal extent • Total area recommended to be harvested is approximately two acres • The use of chemicals for algal and aquatic plant control is not recommended in this area, especially during the late spring to early summer spawning season
Habitat	• It is recommended that selected areas of the Lake be preserved as high-quality habitat area • This zone and adjacent lands should be used for fish habitat • No harvesting or in-lake chemical application should be permitted, except in special instances where selective herbicide application may be allowed for the control of nuisance species; disturbances should be minimized, especially during the late spring to early summer spawning season • Debris and litter cleanup would be needed in some adjacent areas; the immediate shoreline should be preserved in natural, open use to the extent possible • This zone totals about 84 acres in areal extent

Source: SEWRPC.

Spring Lake Management District holds regular public meetings. Where necessary, personal contacts with homeowners will be made.

Harvesting Schedule

The harvesting season should begin no earlier than May 15th and will end no later than September 15th of each year. Harvesting should average 30 to 35 hours per week over a five-day week, depending on weather conditions and plant growth, to minimize recreational conflicts. Further, harvesting should be confined to daylight hours to minimize public disturbances resulting from harvester and plant removal operations. As provided for above, the harvesting operations should also be modified to protect fish spawning areas and other ecologically valuable areas of the Lake as set forth on Map C-5.

EQUIPMENT NEEDS AND OPERATION

The Eagle Spring Lake Management District currently owns and operates two Aquarius Systems HM-220 harvesters, with one transporter, each with 10-year anticipated life spans. Replacement of one of these units when necessary may be expected to cost about $130,000.

Harvester/Transporter: Aquarius Systems Model HM-220 or equivalent.

Costs: Aquatic Plant Harvester with 6,500 pound capacity	$65,000
Compatible Transporter	62,000
Total Cost	$127,000

Maintenance Schedule, Storage, and Related Costs

Routine maintenance will be performed by the Eagle Spring Lake Management District in accordance with the manufacturer's recommended maintenance schedule. Maintenance costs will be borne by the Eagle Spring Lake Management District. Winter storage of the harvesting equipment will be the responsibility of the Eagle Spring Lake Management District.

Insurance Coverage

Insurance coverage on the harvesters will be incorporated into the policy held by the Eagle Spring Lake Management District on all capital equipment. Liability insurance for the operation of the harvesters will also be borne by the District. The relevant certificates of insurance will be held by the Eagle Spring Lake Management District.

Operators, Training, and Supervision

The harvesters will be owned and operated by the Eagle Spring Lake Management District, who will be responsible for day-to-day operations of the equipment. The District will provide operator training as required. Initial training will be provided by Aquarius Systems on delivery of the machinery.

Day-to-day supervision will be by Eagle Lake Management District Commissioners.

EVALUATION AND MONITORING

Daily Record-Keeping Relating to the Harvesting Operation

Daily harvesting activities will be recorded by the operators of harvesting equipment in an operations log. An annual summary of the harvesting program will be submitted to the Eagle Spring Lake Management District Commission, or designated Committee thereof, and made available to the public at that time. The summary will also be published at the annual meeting of the Eagle Spring Lake Management District.

It is the intention of the Eagle Spring Lake Management District to undertake a periodic, formal review of the harvesting program as set forth in the Management Plan for Eagle Spring Lake, a copy of which has been lodged with the Department's Southeast District Office.

Daily Record-Keeping Relating to the Harvesters

Daily maintenance and service records showing engine hours, fuel consumed and oil used, will be recorded in a harvester operations log.

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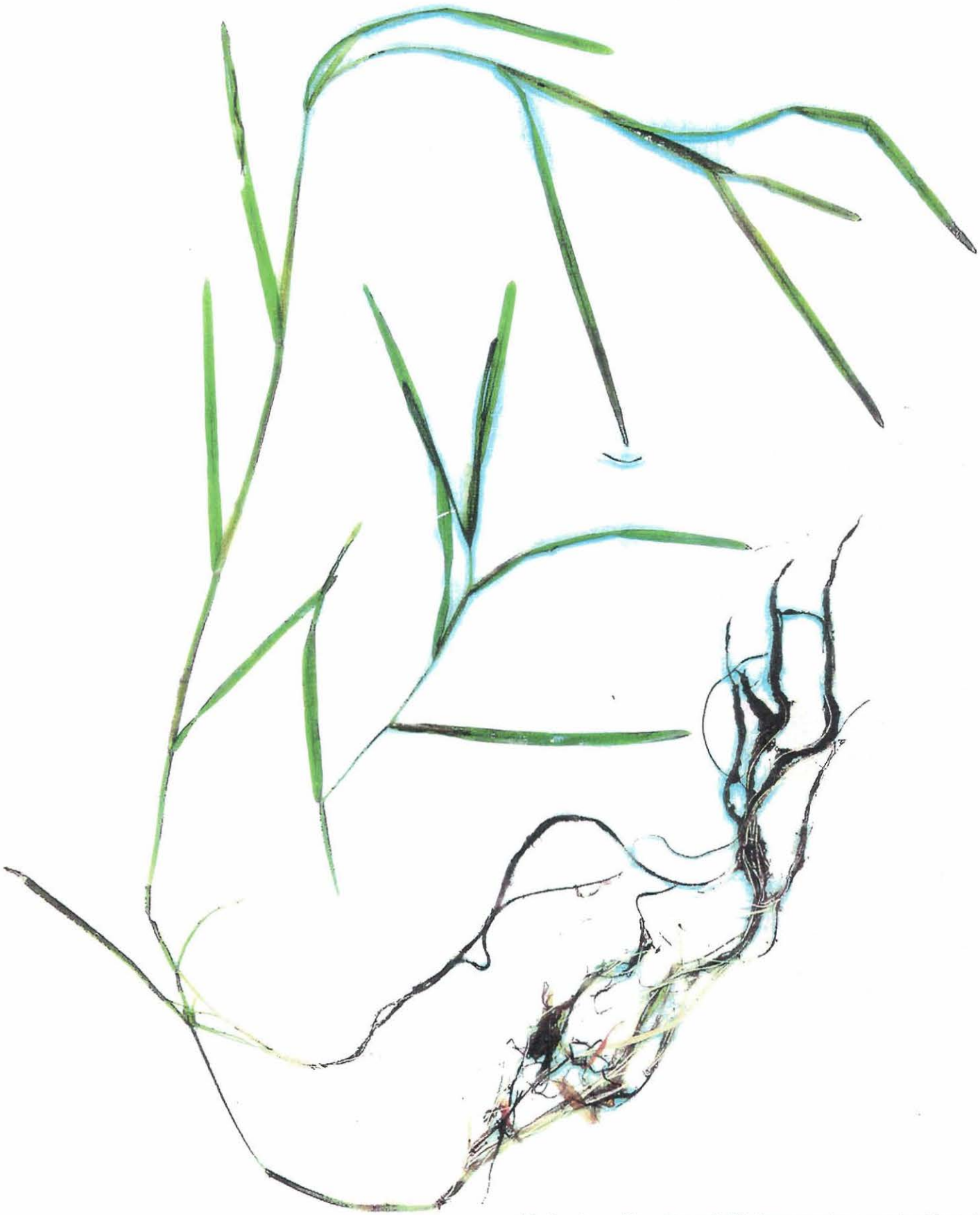
Appendix D

ILLUSTRATIONS OF COMMON AQUATIC PLANTS IN EAGLE SPRING LAKE

Clasping Leaf Pondweed (Potamogeton richardsonii)

Curly Leaf Pondweed (Potamogeton crispus)



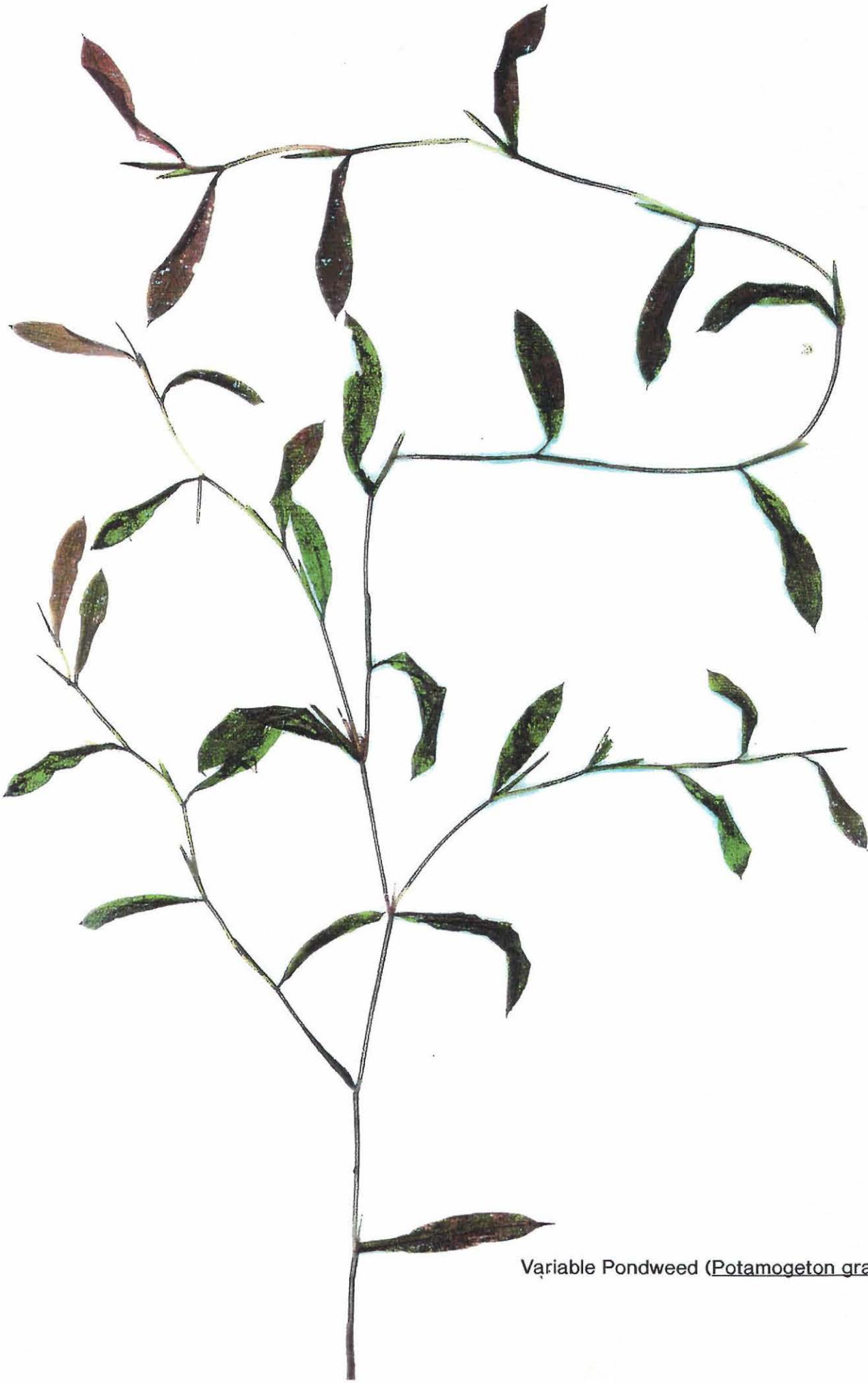
Flat-stem Pondweed (Potamogeton zosteriformis)

Floating Leaf Pondweed (Potamogeton natans)

Illinois Pondweed (Potamogeton illinoensis)

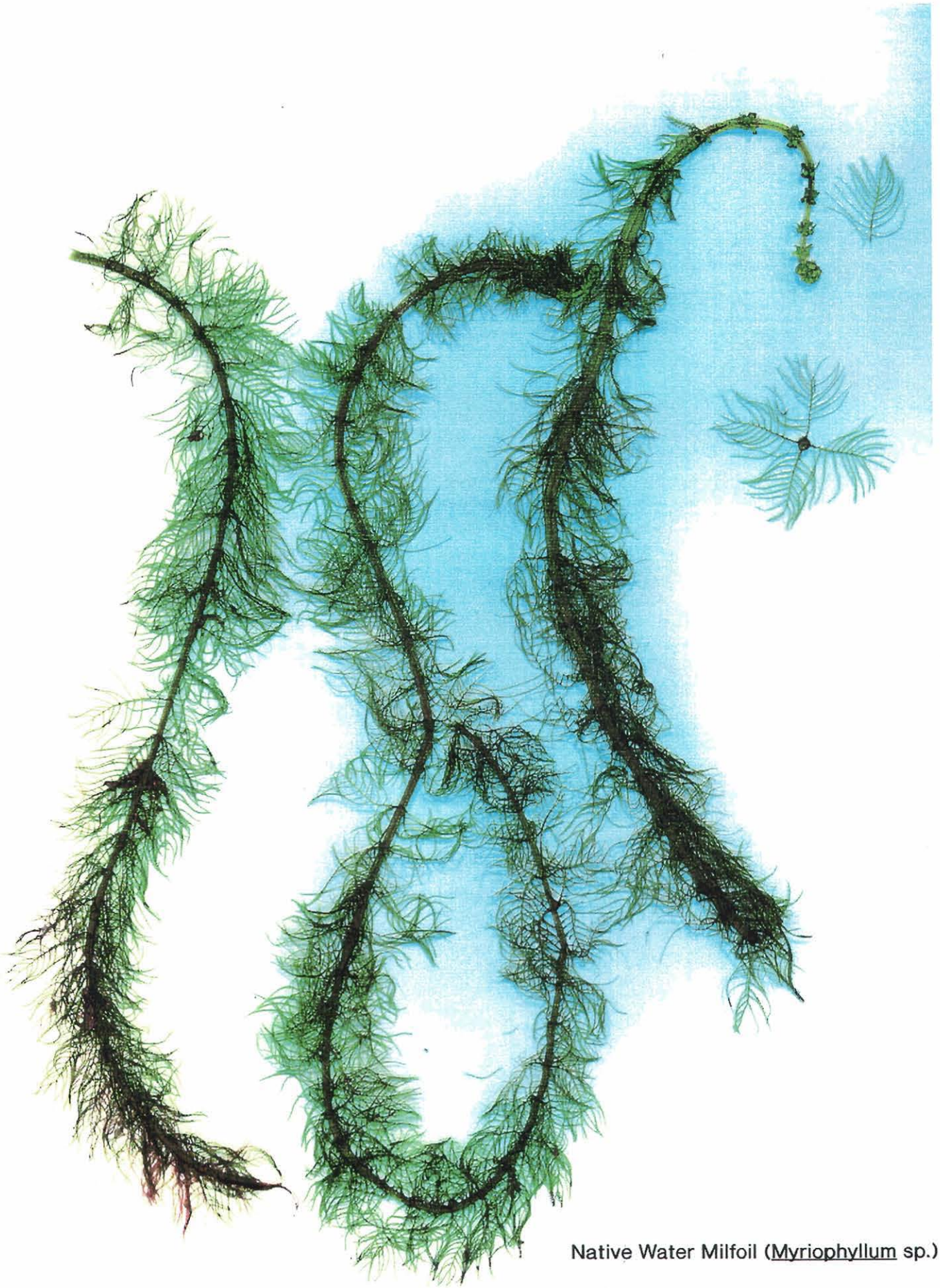
Leafy Pondweed (Potamogeton foliosus)

Sago Pondweed (Potamogeton pectinatus)



Variable Pondweed (Potamogeton gramineus)

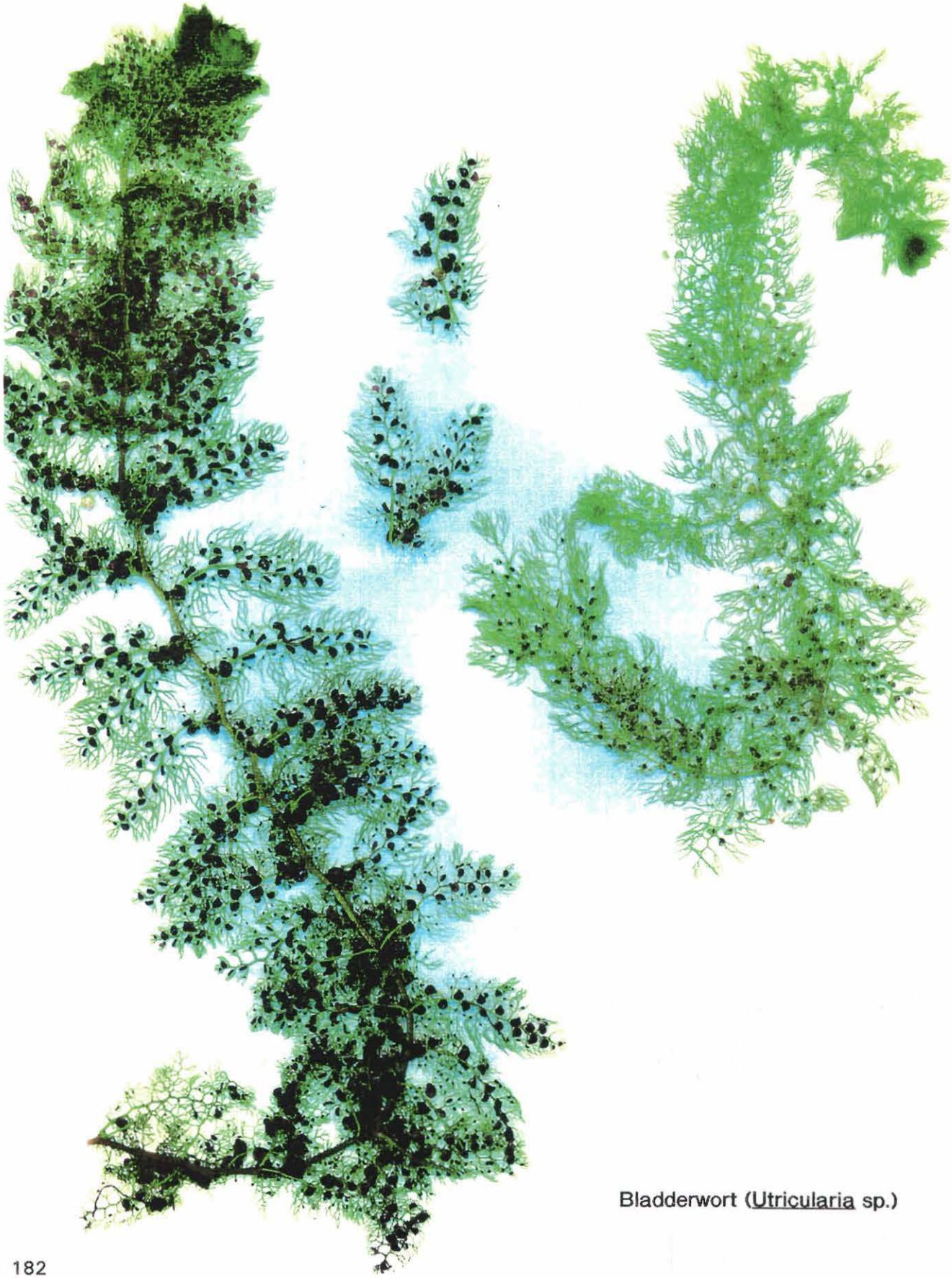
Eurasian Water Milfoil (Myriophyllum spicatum)



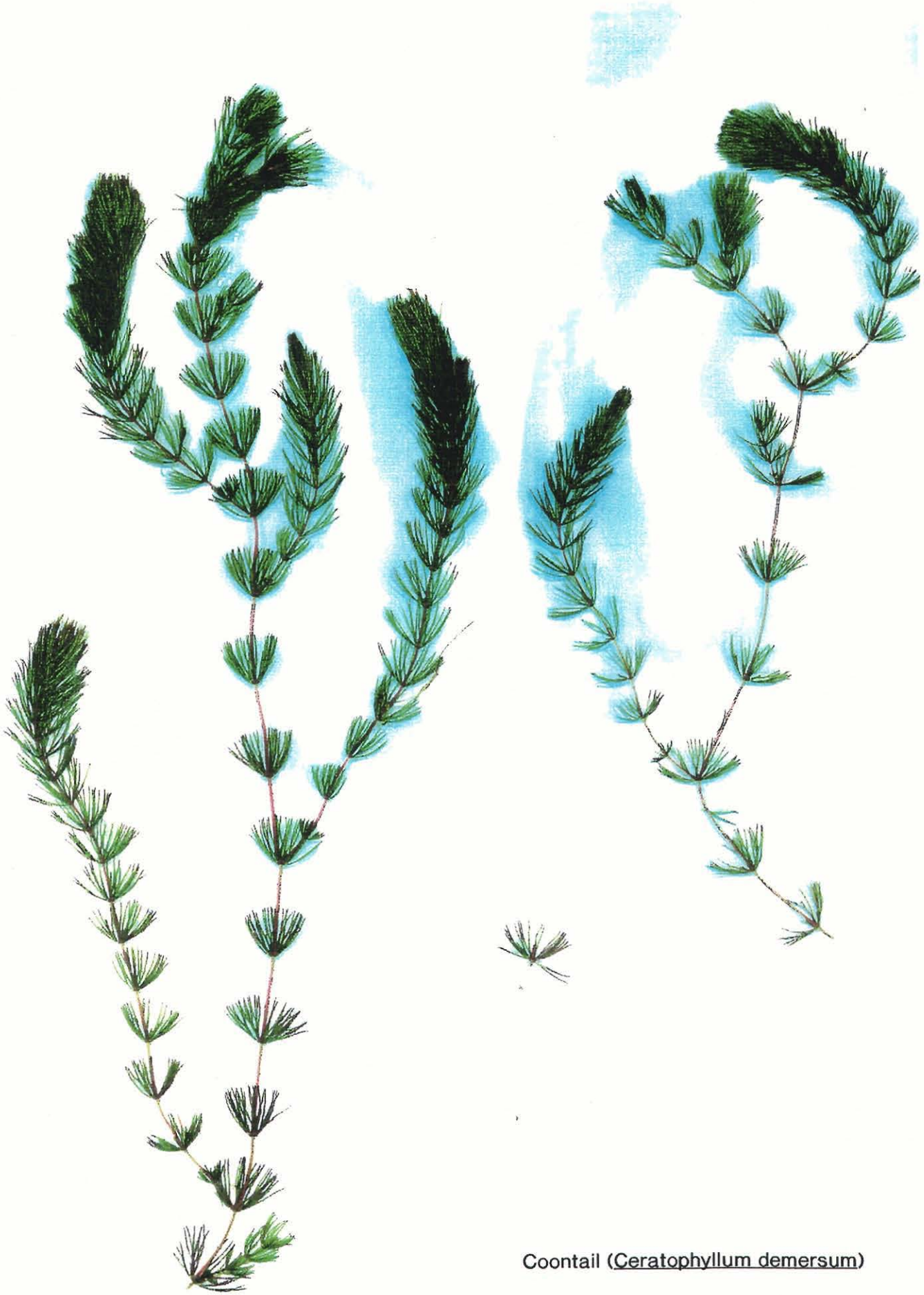
Native Water Milfoil (Myriophyllum sp.)

Bushy Pondweed (Najas flexilis)

Spiney Naiad (Najas marina)

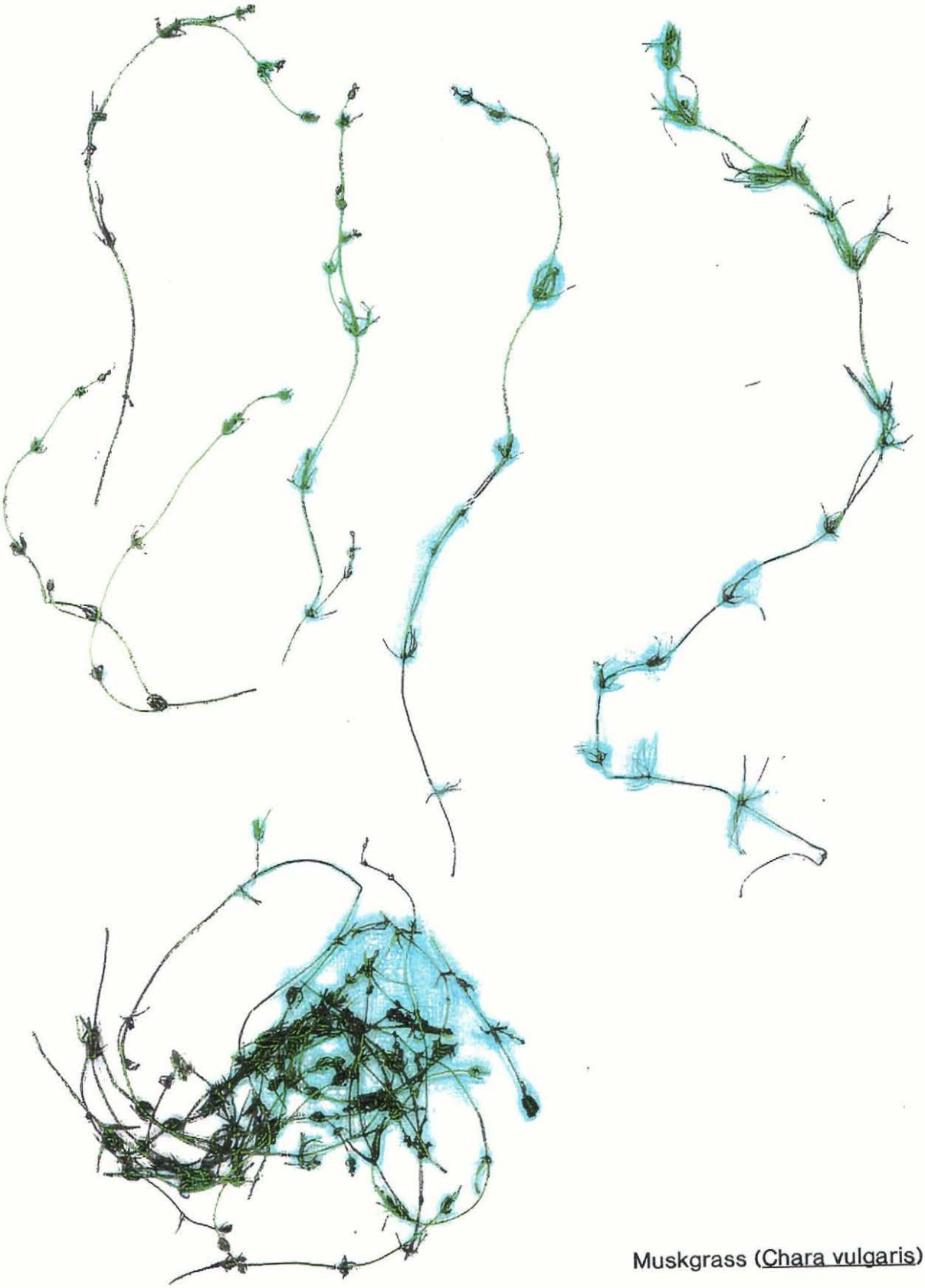


Bladderwort (Utricularia sp.)



Coontail (Ceratophyllum demersum)

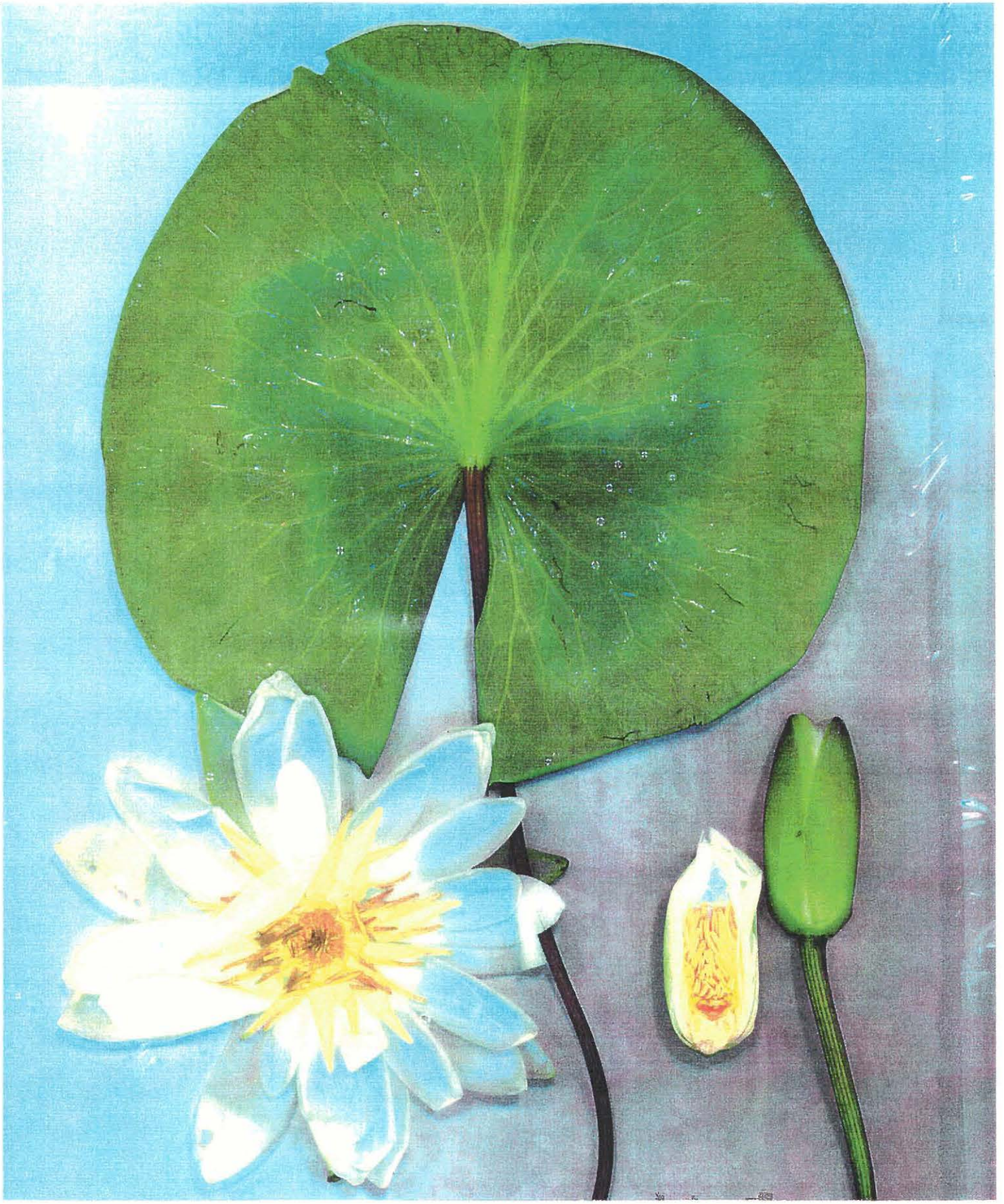
Eel Grass/ Wild Celery (Vallisneria americana)



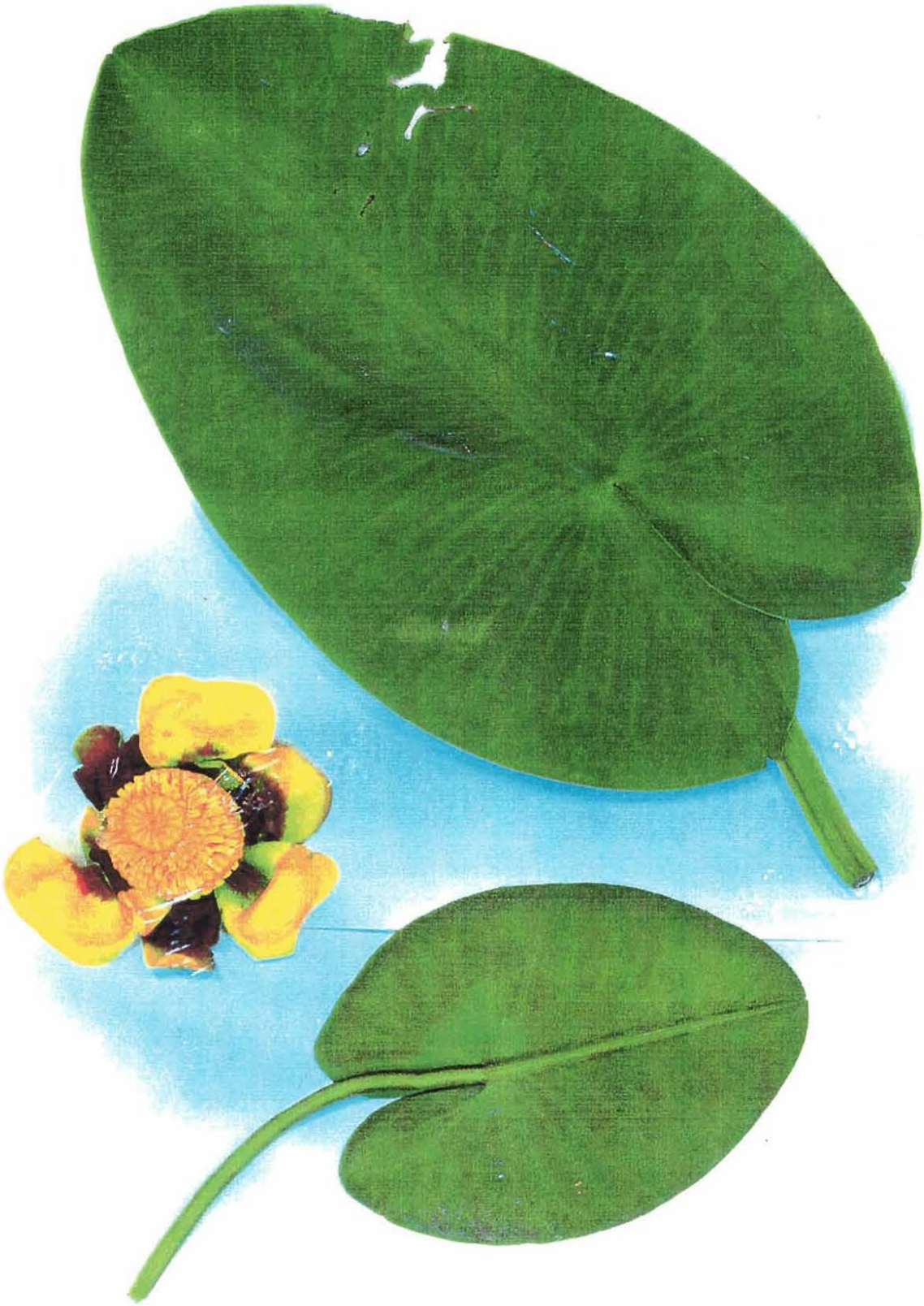
Muskgrass (Chara vulgaris)

Waterweed (Elodea canadensis)

Cattail (Typha augustifolia)



White Water Lilly (Nymphaea tuberosa)



Yellow Water Lilly (Nuphar variegatum)

Yellow Water Crowfoot (Ranunculus flabellaris)

NOTE: Plant species in photograph are not to scale.

Source: Steve D. Eggers and Donald M. Reed, Wetland Plants and Plant Communities of Minnesota & Wisconsin, 2nd Edition, 1997.

Lesser Duckweed (Lemna minor)

NOTE: Plant species in photograph are not to scale.

Source: Steve D. Eggers and Donald M. Reed, Wetland Plants and Plant Communities of Minnesota & Wisconsin, 2nd Edition, 1997.