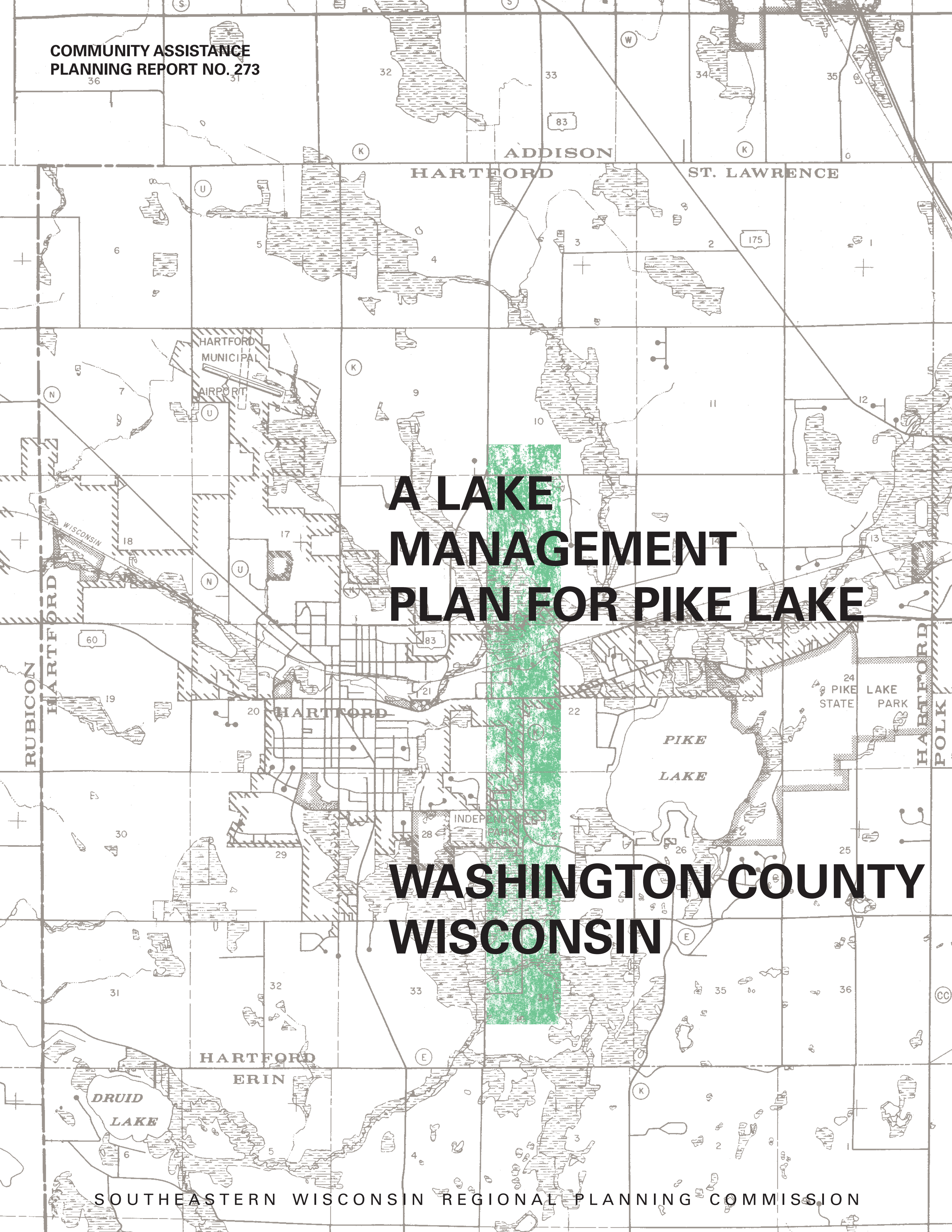
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 273



A LAKE MANAGEMENT PLAN FOR PIKE LAKE

WASHINGTON COUNTY WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due to Dr. Jeffrey A. Thornton, CLM, PH, and Dr. Thomas M. Slawski, SEWRPC Principal Planners; Mr. Robert P. Biebel, former SEWRPC Chief Environmental Engineer and current Special Projects Environmental Engineer, Ms. Christine M. Hinz, former SEWRPC Planner; Mr. Edward J. Schmidt, SEWRPC GIS Planning Specialist, and Ms. Laurie Sellnow, former SEWRPC Intern, for their contributions to the conduct of this study and the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 273

A LAKE MANAGEMENT PLAN FOR PIKE LAKE
WASHINGTON COUNTY, WISCONSIN

Prepared by the

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

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

December 2005

Inside Region $ 5.00
Outside Region $ 10.00

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

Figure Page

Chapter VIII

LIST OF MAPS

Map Page

Chapter II

Chapter III

Chapter IV

Chapter V

Chapter VIII

Chapter I

INTRODUCTION

Pike Lake is a 470-acre[1] lake located within U.S. Public Land Survey Sections 22, 23, 26, and 27, Township 10 North, Range 18 East, Town of Hartford, Washington County. The watershed draining directly to the Lake is about 4,000 acres, about 15 percent of which is currently in urban land usage. The Lake is both fed and drained by the Rubicon River, a tributary stream to the Rock River system. The Rubicon River enters and leaves the Lake through an extensive wetland complex at its northern extreme. In addition to the Rubicon River drainage system, two small, intermittent streams enter the Lake from the south: one, locally known as Glasgow Creek, enters the Lake from the southeast, and the other, unnamed stream, enters the Lake from the southwest, as well as a number of small streams and springs draining to the Lake from the eastern shore.

The Rubicon River drainage area is located south of the watershed draining to the East Branch of the Rock River, north of the Oconomowoc River drainage area, also part of the Rock River watershed, both draining to the Mississippi River, and west and southwest of the Milwaukee River watershed, which drains to Lake Michigan. The total land area tributary to Pike Lake, including that portion draining to the Lake through the Rubicon River drainage system, is about 8,000 acres in areal extent.

The Lake is an important asset to the residents of the County and the Region, and is a popular recreational destination for residents of and visitors to the State, serving as the centerpiece of one of the more heavily used parks within the Wisconsin State Park System, the eponymous Pike Lake Unit of the Kettle Moraine State Forest. The Lake is located in close proximity to the metropolitan Milwaukee area and adjacent to the rapidly growing urban centers of the City of Hartford and Village of Slinger, and their environs, in southwestern Washington County.

The current water use objectives for Pike Lake include: 1) providing water quality suitable for full body contact recreational use and the maintenance of a healthy fishery and other desirable forms of aquatic life; 2) significantly reducing the severity of the occasional nuisance problems associated with excessive weed and algae growth which constrain or preclude intended water uses; and 3) improving opportunities for water-based recreation. With

---

[1]*In SEWRPC Planning Guide No. 5,* Floodland and Shoreland Development Guide, *November 1968, the area of Pike Lake was reported to be 522 acres, as measured from 1956 aerial photographs. This surface area of 522 acres also is reported in Wisconsin Department of Natural Resources Publication PUB-FH-800 2001,* Wisconsin Lakes, *published during 2001. Based on year 2000 aerial photographs, the area of Pike Lake was estimated to be approximately 470 acres. These differences in area may be attributed to differences in the improved survey control available to accurately establish the scale of the latter, as opposed to the earlier, photographs; differences in the scales of the photographs; and the inclusion of wetland areas along the northern shoreline of the lake in the lake surface area determination, as well as to some actual changes in lake water levels.*

respect to the recreational usage of the Lake, the Pike Lake Unit of the Kettle Moraine State Forest provides significant opportunities for lake-oriented recreation, while the conclusion of a private provider agreement pursuant to Chapter NR 1 of the *Wisconsin Administrative Code* provides adequate public recreational boating access to the Lake. Nevertheless, during recent years, Pike Lake has experienced various management problems, the symptoms of which have included excessive aquatic plant growth, recreational user conflicts and limitations, and variations in water quality. In addition, concerns have been raised regarding the need to protect environmentally sensitive areas within and adjacent to the Lake, and to prevent the invasion of exotic species.

Pursuant to the Washington County waterbody classification system, adopted under Chapter 23 of the Washington County Code, Pike Lake is classed as a Class III waterbody. This classification is based upon lake surface area, shoreline development factor, water residence time, the ratio of shoreline length to number of platted lots, maximum depth, and composition of the lake fishery. They are generally the larger, deeper waterbodies in Washington County. Consequently, Class III waterbodies comprise those waters that have been historically heavily developed for residential and recreational use in the County, are those lakes in need of active management. The streams flowing into and out of Pike Lake, the Rubicon River and its tributaries, are indicated as Class II waterbodies. This classification is based upon stream average width, average depth, and composition of the stream fishery. Class II waterbodies are those streams to be maintained in a currently good quality and include those streams designated as containing threatened or endangered species or species of special concern.

Seeking to improve the usability of Pike Lake, protect its natural assets, and develop its recreational use potential in a manner consistent with the waterbody classifications applied to the Lake and its attendant stream system, the Pike Lake Protection and Rehabilitation District requested the Southeastern Wisconsin Regional Planning Commission to complete a lake management plan for the Lake. For this purpose, the Pike Lake Management District applied for and received cost-share funding for plan preparation through the Chapter NR 190 Lake Management Planning Grant Program, administered by the Wisconsin Department of Natural Resources (WDNR). To this end, this lake management plan represents part of the ongoing commitment of the Pike Lake Management District, and the City and Town of Hartford and Village of Slinger, to the sound environmental planning with respect to the Lake. The plan was prepared during 2003 by the Regional Planning Commission in cooperation with the Pike Lake Management District, and represents one of several actions taken to manage Pike Lake and its natural resources.

This report discusses the physical, chemical, and biological characteristics of the Lake, as documented during previous phases of this watershed-based study and completed by the U.S. Geological Survey, the Wisconsin Department of Natural Resources, and the Regional Planning Commission, or which are currently underway. In addition, pertinent related characteristics of the tributary drainage area form the basis for the determination of the current condition of the waterbody and the consequent evaluation of the feasibility of various water quality management alternatives which may enhance water quality conditions, habitat, and recreational use potential of the Lake. Chapter II of this report provides a physical description of Pike Lake and its tributary watershed, including a typical water budget for the Lake. Chapter III sets forth inventory information on land use and population growth within the drainage basin tributary to Pike Lake. Chapters IV and V set forth inventory information on water quality and the biological communities of the Lake, respectively, while Chapter VI summarizes the water quality standards and guidelines applicable to Pike Lake and inventory information on the human uses of the Lake. Alternative and recommended lake and watershed management measures are set forth in Chapters VII and VIII. Specific information on nonpoint source pollution control measures, aquatic plant management measures, and applicable recreational use ordinances are presented as appendices. In addition, applicable point source pollution abatement considerations are addressed.

In developing this plan, the Pike Lake Protection and Rehabilitation District created, during early 2003, a Pike Lake Watershed Advisory Committee, comprised of representatives of the City and Town of Hartford, the Village of Slinger, Washington County, the U.S. Geological Survey, WDNR, Regional Planning Commission, and local landowners. The Advisory Committee was formulated to "develop and implement a watershed protection plan, supported by the State, local municipalities and watershed public, to protect and improve the water quality of the Pike Lake watershed." In achieving this mission, the Committee reviewed a preliminary draft of this plan, and comments received were incorporated into the final draft of the plan as appropriate. Further, the recommended plan elements conform to the standards set forth in Chapter 30 of the *Wisconsin Statutes* and requirements set forth in the relevant *Wisconsin Administrative Codes* governing lake and watershed management in the drainage basin tributary to Pike Lake.[2] Accordingly, this lake management plan should constitute a practical, as well as technically sound, guide for the management of Pike Lake and its tributary drainage basin.

[2]*This plan has been prepared pursuant to the statutory standards set forth in Chapter 30,* Wisconsin Statutes, *and the relevant requirements elaborated in the* Wisconsin Administrative Code *as set forth in Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 102, "Water Quality Standards for Wisconsin Surface Waters;" Chapter NR 103, "Water Quality Standards for Wetlands;" Chapter NR 107, "Aquatic Plant Management;" and Chapter NR 109, "Aquatic Plants Introduction, Manual Removal and Mechanical Control Regulations."*

Chapter II

PHYSICAL DESCRIPTION

INTRODUCTION

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

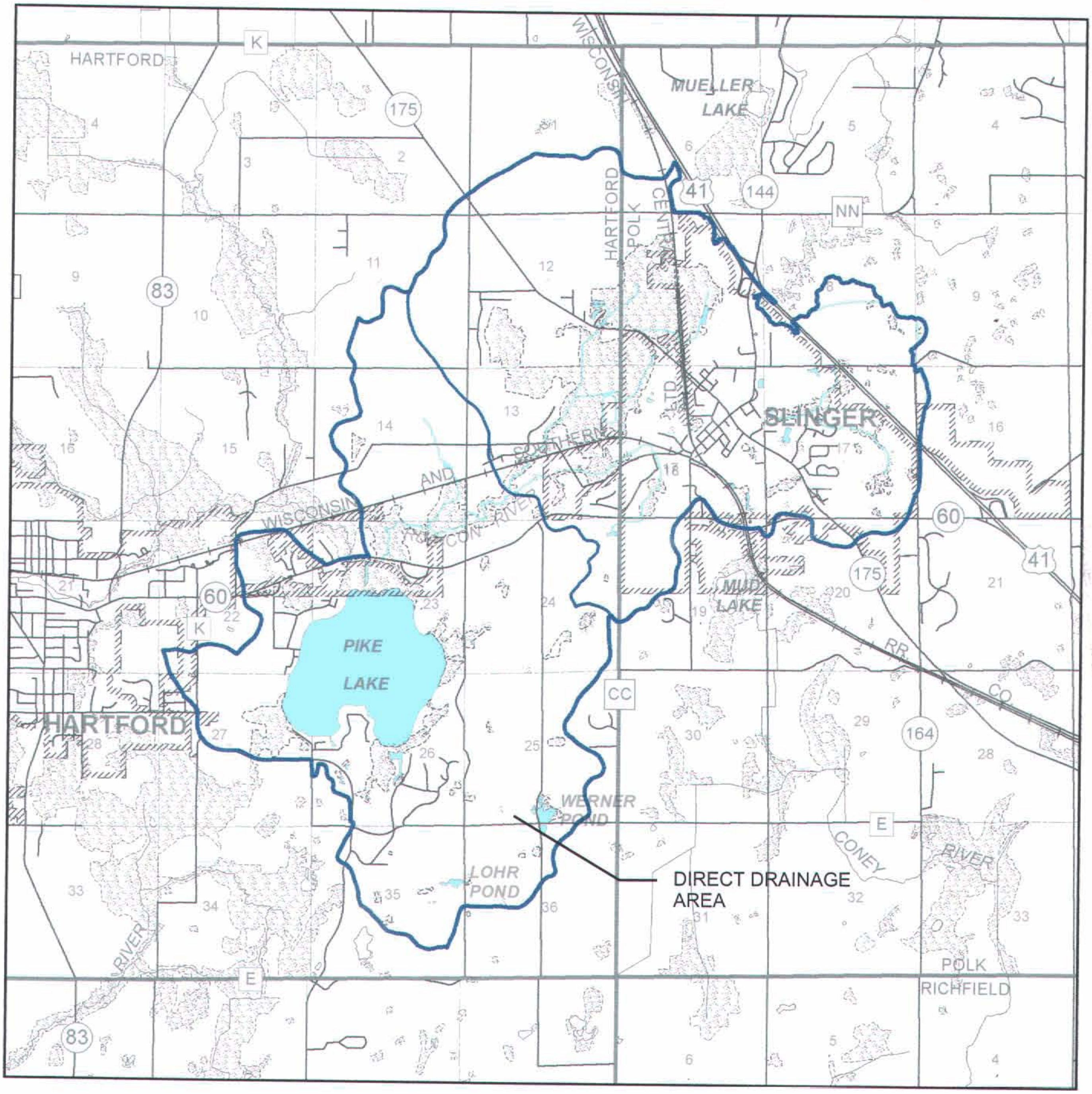
LAKE BASIN AND SHORELAND CHARACTERISTICS

Pike Lake is located in the City and Town of Hartford. Portions of the City of Hartford, the Village of Slinger, and Towns of Hartford and Polk lie within the total drainage area tributary to Pike Lake, as shown on Map 1. Pike Lake is a drainage or through flow lake, having both a defined inflow and outflow, lying within a terminal moraine of the Green Bay glacier. The Lake level is presently controlled artificially by the dam located at the outlet. Basic hydrographic and morphometric data for Pike Lake are presented in Table 1. About 39 percent of Pike Lake has a water depth of less than five feet, 34 percent has a water depth of between five and 30 feet, and 27 percent of the Lake has a water depth of more than 30 feet. The mean depth is about 14 feet and the maximum depth is about 45 feet. Pike Lake is about 1.2 miles long and about 1.1 miles wide at its widest point. The major axis of the lake basin lies in a generally north-south direction. Pike Lake has a volume of approximately 6,942 acre-feet, and a surface area of about 470 acres. The Lake has a shoreline length of about 3.8 miles, with a shoreline development factor of 1.5, indicating that the circumference of the Lake is about 1.5 times longer than that of a circular lake of the same area. The bathymetry of the Pike lake basin is illustrated on Map 2.

As described further in Chapter III, the western and southern shorelines of Pike Lake are mostly developed for residential uses, with some scattered commercial uses comprised primarily of restaurants and businesses catering to lake users. The eastern shoreline is occupied by the Pike Lake Unit of the Kettle Moraine State Forest, while a significant wetland area occurs along the Lake's northern shoreline. A public beach and picnic area are located within the State Park. Public recreational boating access to Pike Lake is provided on the western shore of the Lake, pursuant to a private provider agreement with a lakeshore business, and, as of 2004, is considered adequate pursuant to the recreational boating access standards set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. There is no public recreational boating access to the Lake from the State Park site. Additional access is provided via Town roads, but no parking facilities are provided at these sites.

Map 1

SURFACE WATER RESOURCES IN THE DRAINAGE AREA TRIBUTARY TO PIKE LAKE



SURFACE WATER

STREAM

SUBWATERSHED BOUNDARY

Source: SEWRPC.

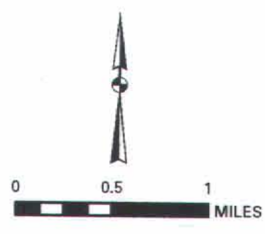


Table 1

HYDROLOGY AND MORPHOMETRY OF PIKE LAKE: 2000

Parameter	Measurement
Size	
Area of Lake	470 acres
Area of Total Drainage Area	7,966 acres
Area of Direct Tributary Drainage Area	3,998 acres
Lake Volume	6,942 acre-feet
Residence Time[a]	1.1 years
Shape	
Shape Length of Lake	1.2 miles
Length of Shoreline	3.8 miles
Width of Lake	1.1 miles
Shoreline Development Factor[b]	1.4
Depth	
Depth Area of Lake Less than Five Feet	39 percent
Area of Lake 10 to 30 Feet	34 percent
Area of Lake More than 30 Feet	27 percent
Mean Depth[c]	14 feet
Maximum Depth	45 feet

[a]*The "residence time" is estimated as the time period required for a volume of water equivalent to the volume of the lake to enter the lake during a year of normal precipitation.*

[b]*The shoreline development factor is the ratio of the shoreline length to the circumference of a circular lake of the same area.*

[c]*The mean depth is equal to the lake volume divided by the lake surface area.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with recreational access and lake use. Such erosion is usually caused by wind-wave erosion, ice movement, and motorized boat traffic. A survey of Pike Lake shoreline, conducted during the summer of 2002 by Regional Planning Commission staff, identified existing shoreline protection structures around the Lake, as shown on Map 3. Most were in a good state of repair. Most of the developed shoreland of Pike Lake had some form of shoreline protection in 2002. However, improperly installed and failing shoreline protection structures, and the erosion of natural shorelines on Pike Lake, are ongoing, but limited, causes for concern. The majority of the natural shoreline of the Lake is located on the eastern shores of Pike Lake, within the Pike Lake Unit of the Kettle Moraine State Forest.

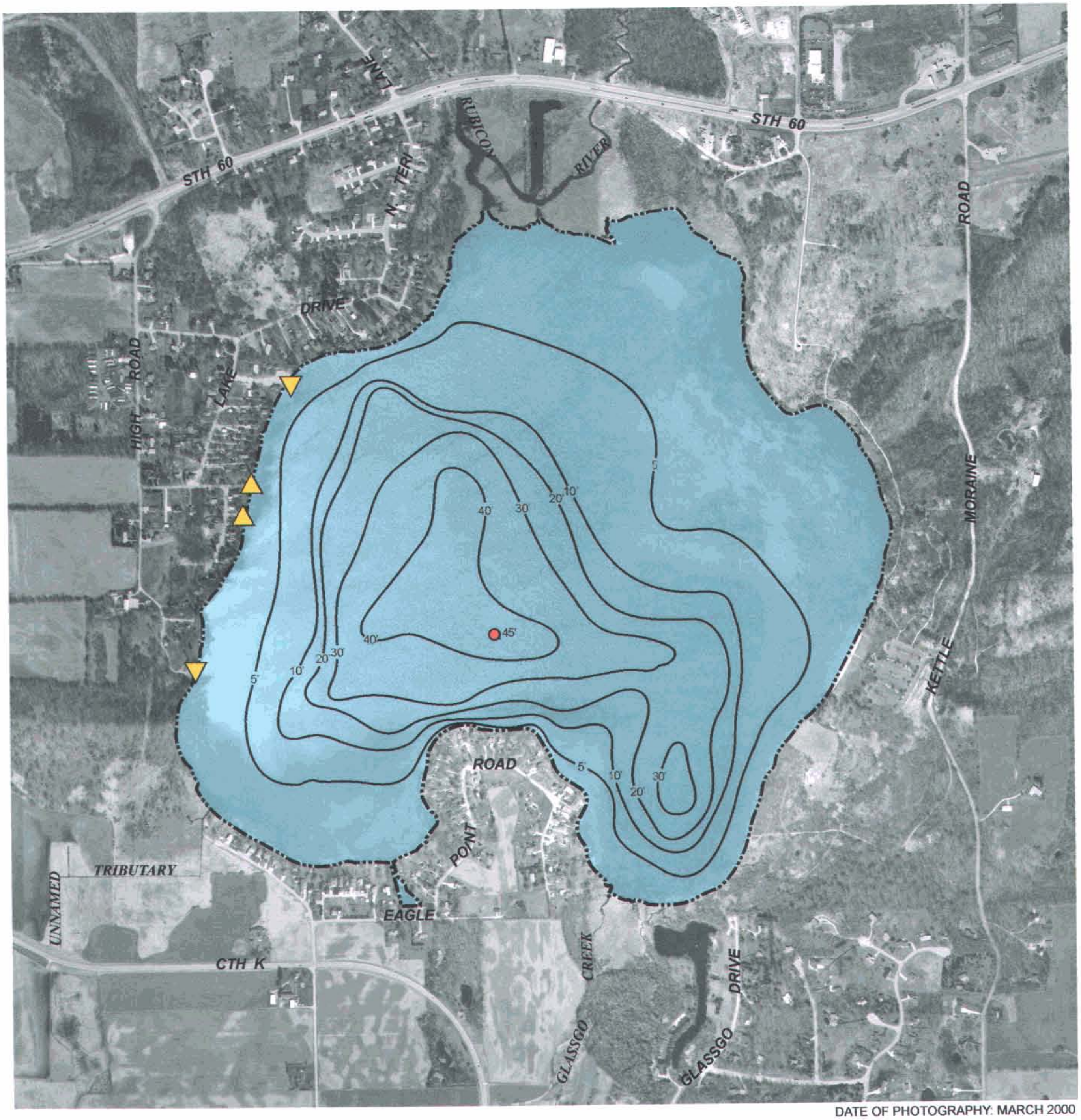
Lake bottom sediment types are shown on Map 4. Sand and gravel are the dominant shore materials, covering about 90 percent of the bottom along the shoreline. Some of the sand deposits in the nearshore area are reported to have been enhanced through the artificial nourishment of beach areas. The remainder of the bottom along the shoreline consists of muck and silt, primarily in the vicinity of the inlets to the lake. The remaining lake bottom is covered by soft, flocculent sediments, including muck, marl, detritus, clay, and silt.

WATERSHED CHARACTERISTICS

The drainage area directly tributary to Pike Lake, that is, those lands that surround and drain directly to the Lake rather than draining to the Lake through the Rubicon River, is about 4,000 acres, or approximately 6.25 square miles, in areal extent, as shown on Map 1. The total drainage area to the Lake, which includes the direct drainage

Map 2

BATHYMETRIC MAP OF PIKE LAKE



—20'— WATER DEPTH CONTOUR IN FEET

● MONITORING SITE

△ PUBLIC ACCESS SITE

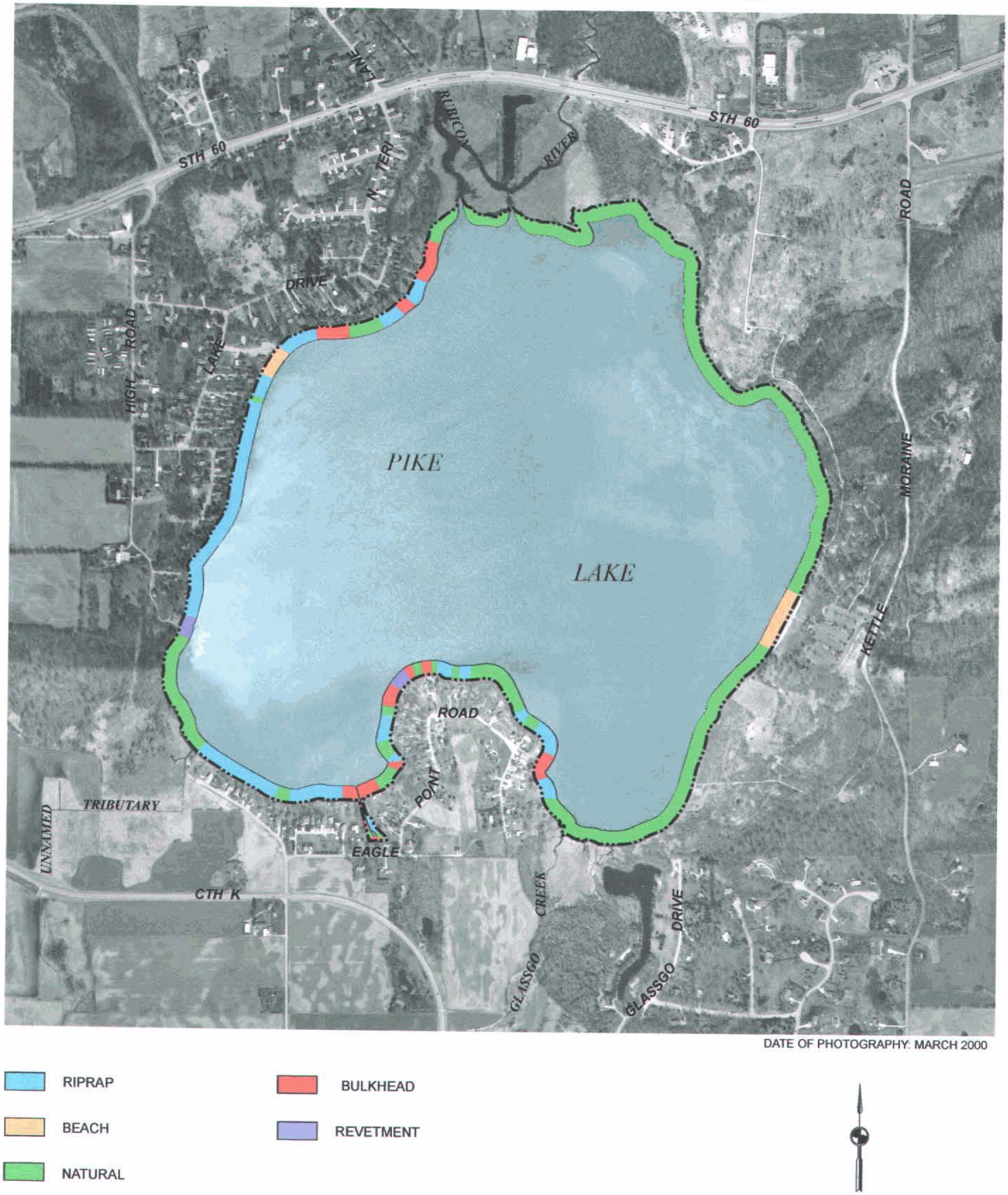
▽ PRIVATE ACCESS SITE

GRAPHIC SCALE 0 600 1200 FEET

Source: U.S. Geological Survey and SEWRPC.

Map 3

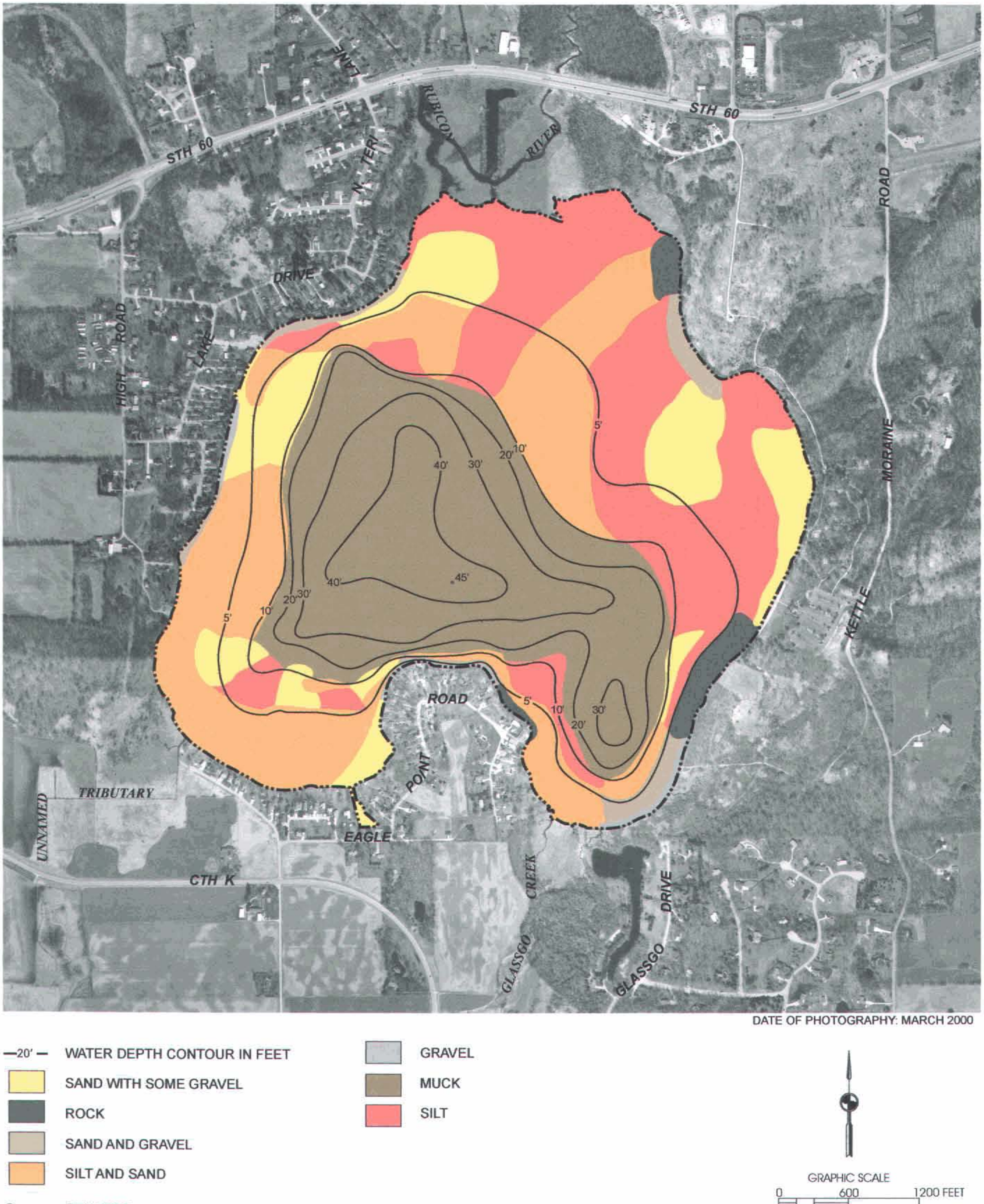
SHORELINE PROTECTION STRUCTURES ON PIKE LAKE: 2001



Source: SEWRPC.

Map 4

SEDIMENT SUBSTRATE DISTRIBUTION IN PIKE LAKE: 2001



Source: SEWRPC.

area as well as the upstream drainage system draining to the Lake through the Rubicon River, is about 8,000 acres, or approximately 12.5 square miles in areal extent. This additional drainage area is also shown on Map 1. Pike Lake has a watershed-to-lake surface area ratio of about 15:1, which ratio is relatively low for lakes within Wisconsin which are reported to have an average watershed-to-lake surface area ratio of about 110:1.[1] The watershed:lake surface area ratio is calculated from the total drainage area tributary to Pike Lake.

Pike Lake has one primary inlet and outlet formed by the Rubicon River, as shown on Map 2. The River enters the Lake from the north through a natural channel which flows in a southerly direction, through a wetland complex, into the main lake basin. The Rubicon River leaves Pike Lake through a natural channel located approximately 400 feet west of the inlet, flowing northerly and westerly through the City of Hartford. Two intermittent, unnamed tributary streams also enter the Lake from the southeast and southwest, respectively; the southeastern-most tributary is locally known as Glasgow Creek. In addition, a number of springs and small streams enter the Lake from the east. The Rubicon River eventually drains to the Rock River about 35 miles downstream, within Dodge County.

The proximity of the inlet and outlet of the Lake led to the implementation during 1994 of a proposal to link these watercourses in order to provide the means to bypass the nutrient-rich waters of the Rubicon River.[2] As of 2003, the U.S. Geological Survey is monitoring water quality conditions in the Lake in an effort to evaluate the efficacy of this bypass. Preliminary results from this investigation suggest that this bypass system is effective in modifying the phosphorus load to the Lake, with up to about 85 percent of the observed phosphorus load being diverted through the outlet rather than entering Pike Lake. However, the significant retention of sediment within the bypass channel observed during the U.S. Geological Survey study might suggest that the future efficacy of this bypass may be limited; of the approximately four feet design depth of the channel, only about 0.5 feet of depth was reported to remain active due to the accumulation of sediment within the channel.

Map 5 suggests that manipulation of the Pike Lake outflow is of long-standing. As of 1892, as shown on Map 5, the lake outlet is described as a canal, linking Pike Lake to the (West Branch) of the Rubicon River, through a lock located at, or close to, the site of the present dam. This suggests that Pike Lake, at that time, may have been a terminal lake system, with an inflow but no natural outflow. Given the presence of wetlands in this area, however, it is likely that the lake did overflow on occasion with the outflow passing through these wetland areas to the downstream portions of the Rubicon River. The construction of the canal appears to have followed this routing through the wetlands, creating a formal outlet from Pike Lake to the Rubicon River. The canal shown on Map 5 is located to the west of the current outlet, and its route currently is indicated as wetland on Map 21 in Chapter V of this report. Comparison of Maps 2 and 5 reveals the relationship between the current lake outlet configuration and that mapped during the 1892 land survey, with the old canal route being clearly visible in the year 2000 aerial photography. The extensive wetland complex that currently characterizes the northern shorelands of Pike Lake is not shown on Map 5, suggesting encroachment of the wetland plant community into the shallow water zone of the Lake during the previous century.

Soil Types and Conditions

Soil type, land slope, and land use 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. Soil texture and soil particle structure influence the permeability, infiltration rate, and erodibility of soils. Land slopes are important determinants of stormwater runoff rates and of the susceptibility of soils to erosion. The erosivity of the runoff can be moderated or modified by vegetation.

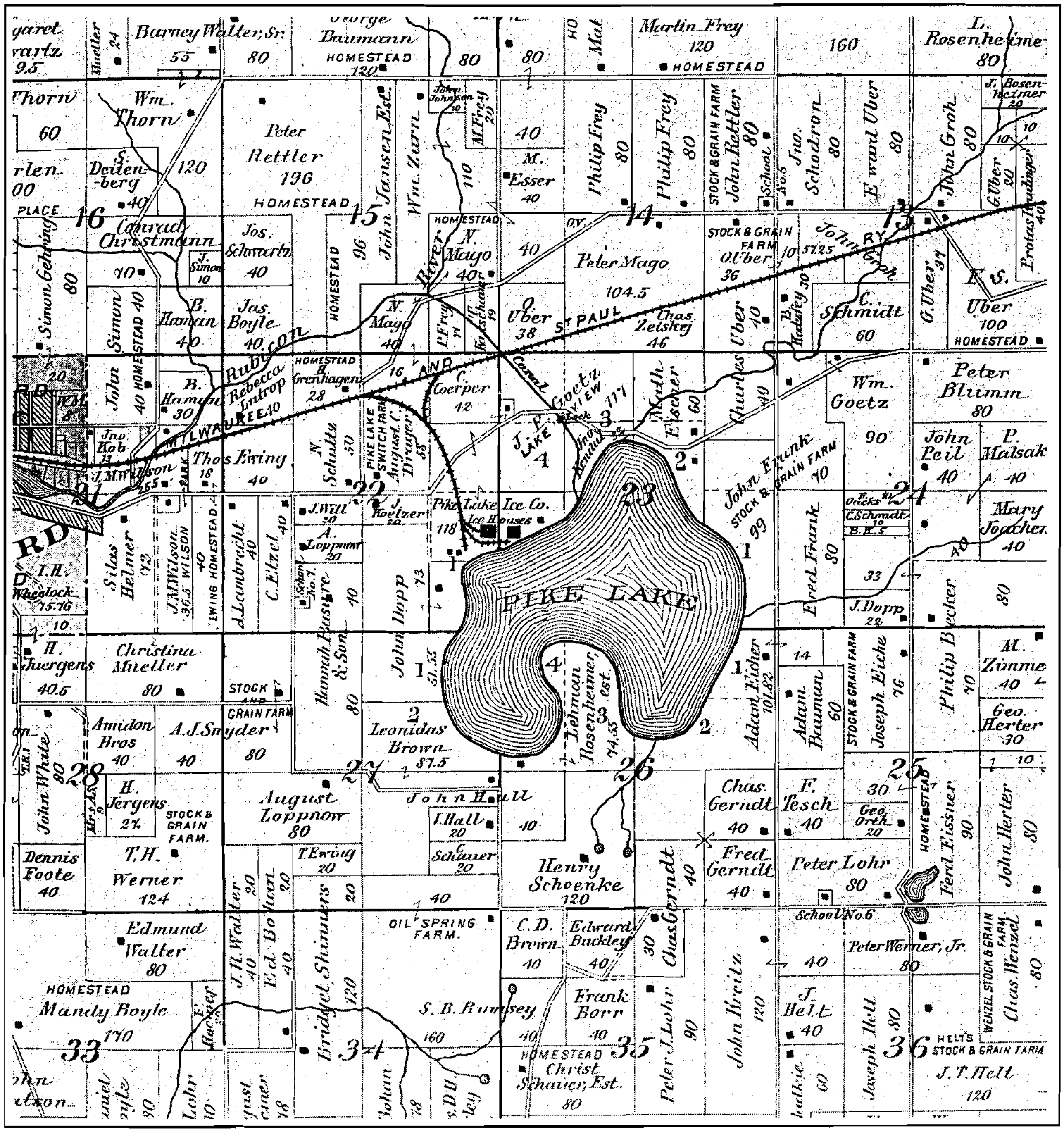
---

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

[2]*See Wisconsin Department of Natural Resources Publication No. PUBL-WR-190-95 REV,* Upper Rock River Basin Water Quality Management Plan, *July 1995.*

Map 5

U.S. PUBLIC LAND SURVEY MAP OF PIKE LAKE: 1892



Source: C.M. Foote & Company, Minneapolis, Minnesota.

The U.S. Natural Resources Conservation Service, formerly the U.S. Soil Conservation Service, under contract to the Southeastern Wisconsin Regional Planning Commission, completed a detailed soil survey of the Pike Lake area in 1966.[3] The soil survey contained interpretations for planning and engineering applications, as well as for agricultural applications. Using the regional soil survey, an assessment was made of hydrologic characteristics of the soils in the drainage area of Pike Lake. The suitability of the soils for urban residential development was assessed using three common development scenarios. These ratings reflected the requirements of Chapter Comm 83 of the *Wisconsin Administrative Code* governing onsite sewage disposal systems as it existed through the year 2000. During 2000, the Wisconsin Legislature amended Chapter Comm 83 and adopted new rules governing onsite sewage disposal systems. These rules, which had an effective date of July 1, 2000, significantly altered the existing regulatory framework, and, effectively, have increased the area in which onsite sewage disposal systems may be utilized. Notwithstanding, the residential lands within the drainage area tributary to Pike Lake currently are served by a public sanitary sewerage system pursuant to recommendations set forth in the adopted regional water quality management plan.[4] The existing year 2001 sanitary sewer service area for the Pike Lake area, and the planned year 2020 amendments to the sanitary sewer service area, served by the City of Hartford public sewage treatment facility,[5] are delineated on Map 6. Portions of the total tributary drainage area of Pike Lake are also served by the Village of Slinger public sewage treatment plant. The existing year 2005 sanitary sewer service area served by the Village of Slinger public sewage treatment facility, and the planned year 2020 amendments to the sanitary sewer service area,[6] also are delineated on Map 6.

Notwithstanding, the interpretations associated with the soil survey are such that they continue to provide insights into the potential for land-based sources of pollution to affect the Lake water quality either as a consequence of overland flows during storm events or through groundwater interflows in the Lake. Therefore, Map 7 presents the soil ratings for onsite sewage disposal systems as determined pursuant to the then-existing requirements of Chapter Comm 83 of the *Wisconsin Administrative Code* governing onsite sewage disposal systems as of early 2000. It is useful to note that about one-tenth of the lands within the drainage area tributary to Pike Lake are covered by soils that are categorized as having few limitations for onsite sewage disposal systems, while the major portion, or about 55 percent, of the tributary drainage area was covered by soils that could not be classified. About one-third of the lands were categorized as unsuitable for onsite sewage disposal systems, suggesting a potential sensitivity to disturbance and likelihood of being permeable to pollutants.

Soils within the drainage area tributary to Pike Lake were categorized generally into four principal hydrologic groups as indicated in Table 2. Soils that could not be categorized were included in an "other" group. About four-fifths of the drainage area is covered by moderately drained soils, about one-eighth by very poorly drained soils, and the balance by approximately equal proportions of well-drained and poorly drained soils. The areal extent of these soils and their locations within the watershed are shown on Map 8.

---

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

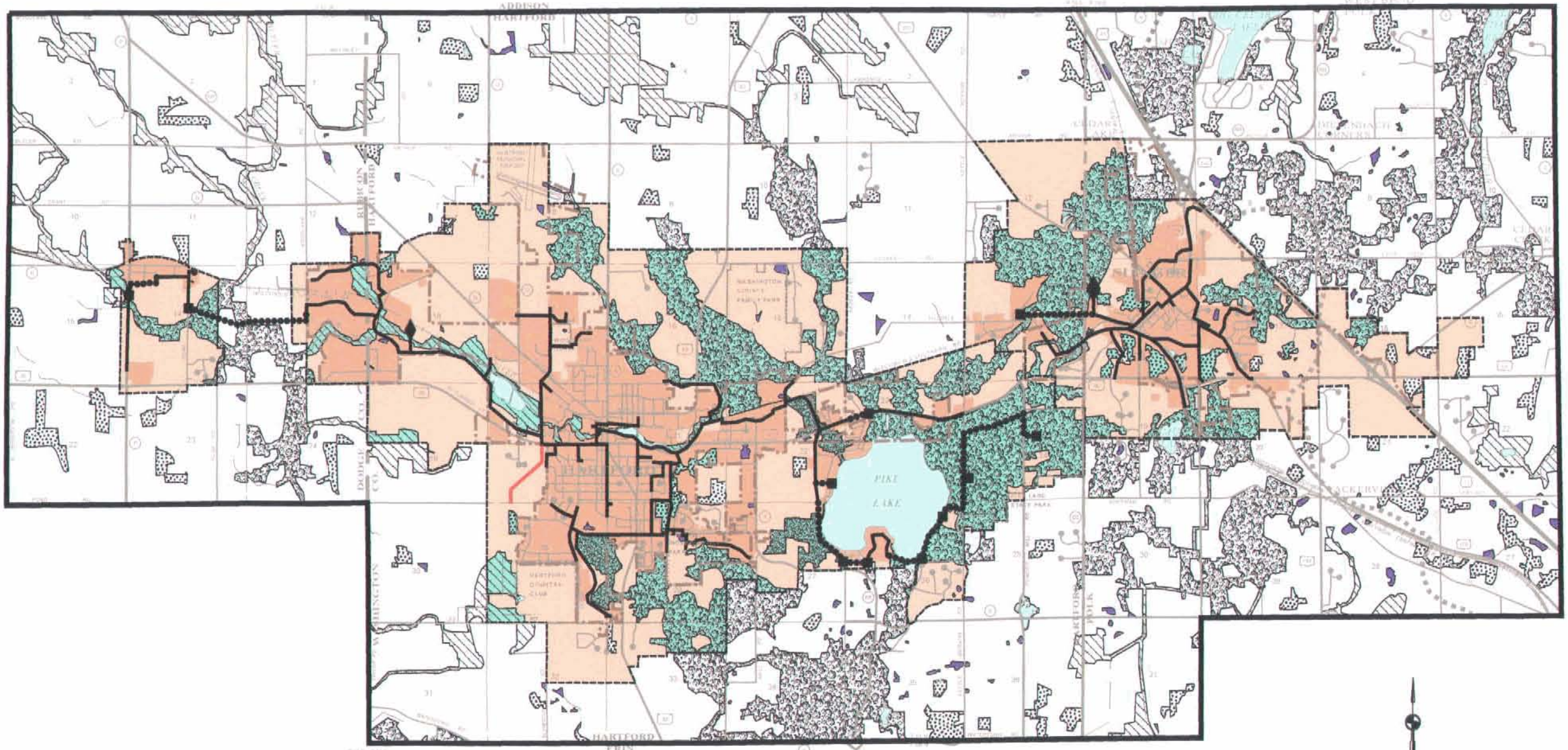
[4]*See SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One,* Inventory Findings, *September 1978; Volume Two,* Alternative Plans, *February 1979; and Volume Three,* Recommended Plan, *June 1979; SEWRPC Memorandum Report No. 93,* A Regional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

[5]*SEWRPC Community Assistance Planning Report No. 92, 3rd Edition,* Sanitary Sewer Service Area for the City of Hartford and Environs, Washington County, Wisconsin, *September 2001.*

[6]*SEWRPC Community Assistance Planning Report No. 128, 3rd Edition,* Sanitary Sewer Service Area for the Village of Slinger and Environs, Washington County, Wisconsin, *December 1998; SEWRPC,* Amendment to the Regional Water Quality Management Plan: Village of Slinger, *June 2002.*

Map 6

PLANNED SANITARY SEWER SERVICE AREAS IN THE DRAINAGE AREA TRIBUTARY TO PIKE LAKE



- PRIMARY ENVIRONMENTAL CORRIDOR
- SECONDARY ENVIRONMENTAL CORRIDOR
- ISOLATED NATURAL RESOURCE AREA
- WETLANDS AND SURFACE WATER AREAS LESS THAN FIVE ACRES IN SIZE
- AREA SERVED BY SANITARY SEWERS TRIBUTARY TO THE CITY OF HARTFORD SEWAGE TREATMENT PLANT: 2000
- HARTFORD AND ENVIRONS PLANNED SANITARY SEWER SERVICE AREA: 2020
- ENVIRONMENTALLY SIGNIFICANT LANDS WITHIN THE PLANNED SANITARY SEWER SERVICE AREA WHERE THE EXTENSION OF SEWERS TO SERVE NEW INTENSIVE URBAN DEVELOPMENT IS NOT PERMITTED. NEW SEWERED DEVELOPMENT IS CONFINED TO LIMITED RECREATIONAL AND INSTITUTIONAL USES AND RURAL-DENSITY RESIDENTIAL DEVELOPMENT IN UPLAND AREAS.
- PLANNED SANITARY SEWER SERVICE AREA BOUNDARY
- EXISTING PUBLIC SEWAGE TREATMENT FACILITY
- EXISTING TRUNK SEWER
- PLANNED TRUNK SEWER
- EXISTING FORCE MAIN
- EXISTING PUMPING STATION

GRAPHIC SCALE

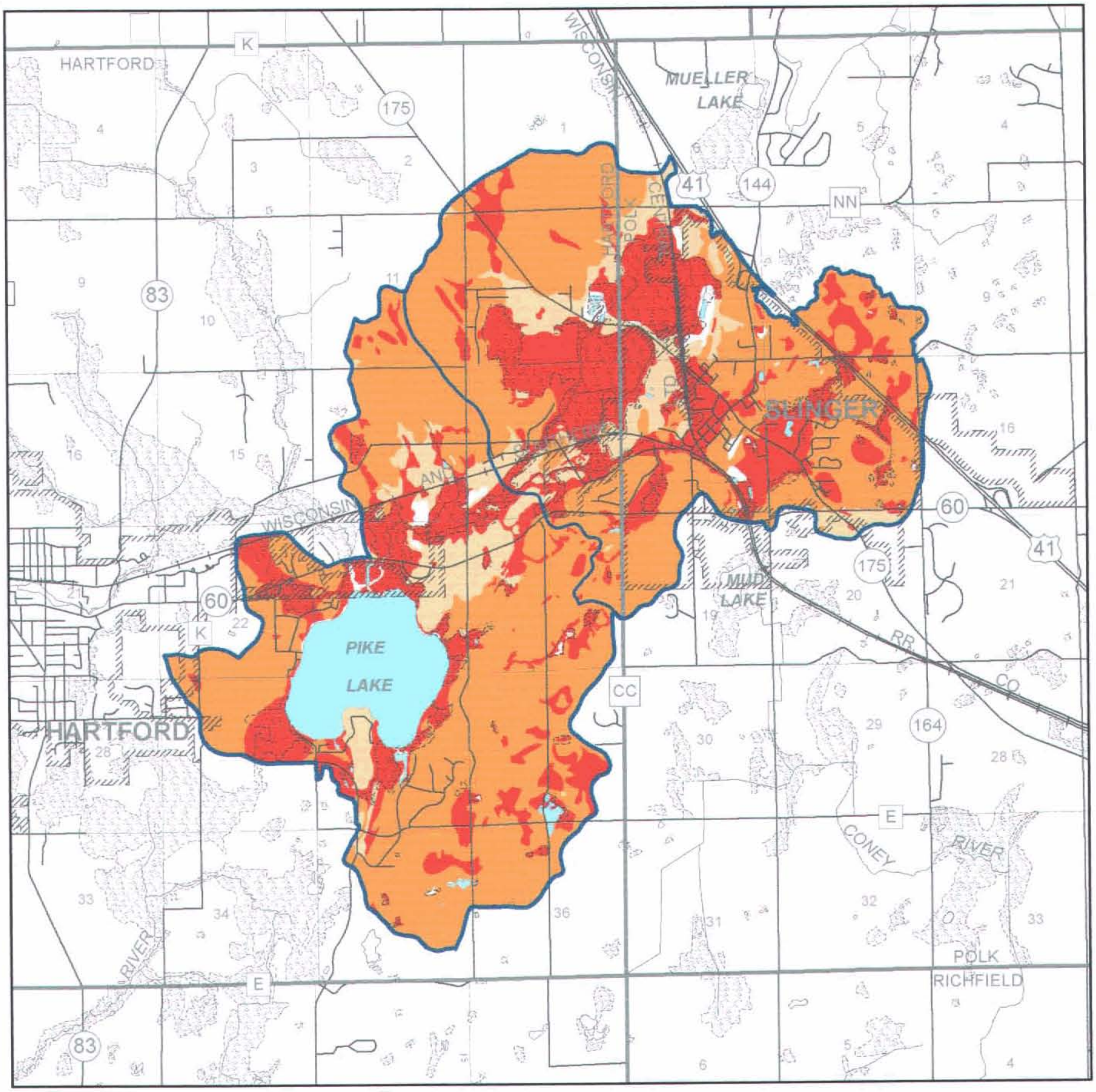
0 ½ 1 MILE

0 1760 3520 5280 7040 FEET

Source: SEWRPC.

Map 7

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



UNSUITABLE: Areas covered by soils which have a high probability of not meeting the June 2000 criteria of Chapter Comm 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 June 2000 criteria of Chapter Comm 83 of the *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 June 2000 criteria of Chapter Comm 83 of the *Wisconsin Aministrative 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

0 0.5 1 MILES

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

Table 2

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

Group	Soil Characteristics	Direct Tributary Drainage Area (acres)	Percent of Total	Total Tributary Drainage Area (acres)	Percent of Total
A	High infiltration rates Well-drained and excessively drained sandy or gravelly soils High rate of water transmission and low runoff potential	17.6	0.4	45.2	0.6
B	Moderate infiltration rates Moderately well drained Moderately coarse textures Moderate rate of water transmission	2,889.2	72.2	5,917.7	74.4
C	Slow infiltration rates Moderately fine or fine-textured or layers that impede downward movement of water Slow rate of water transmission	78.9	2.0	128.8	1.6
D	Very slow infiltration rates Clay soils with high shrink-swell potential, soils with a high permanent water table; soils with a clay layer at or near the surface; shallow soils over nearly impervious substrate Very slow rate of water transmission	492.7	12.3	1,330.0	20.0
Other	Group not determined	20.5	0.5	29.8	0.4
Water	- -	499.5	12.5	514.9	6.3
- -	Total	3,998.4	100.0	7,966.4	100.0

Source: SEWRPC.

The major soil types present within the tributary drainage area are: Calanus silt loam, Ehlers silt loam, Fox silt loam, Hochheim silt loam, Lamartine silt loam, Theresa silt loam, Hochheim-Hennepin loam, Houghton muck peat, and Palms muck.

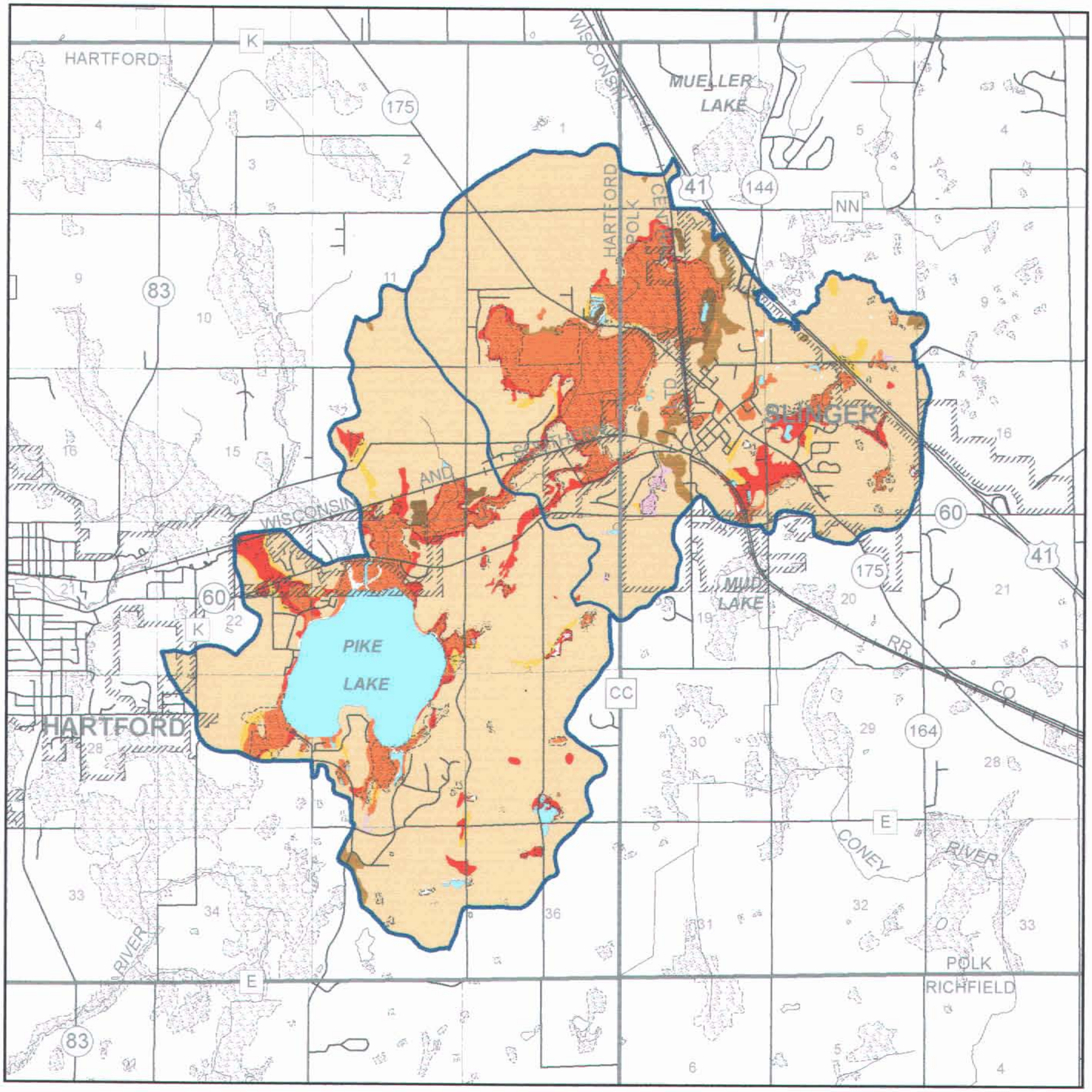
Geology

The bedrock and the surfacial deposits overlying the bedrock directly and indirectly affect the quantity and quality of surface water and groundwater in the Pike Lake drainage area. Water from within the surfacial glacial sand and gravel deposits supplies the shallow wells and springs that occur within the watershed. Underlying the unconsolidated surfacial deposits is the Niagara limestone (dolomite) formation. The fissures in the dolomite serve as water storage basins and are frequently tapped by moderately deep wells for water supply purposes. The Niagara dolomite is underlain by an impervious layer of Maquoketa shale. In some areas of the Pike Lake drainage basin, in the pre-Pleistocene valleys in the vicinity of the lake basin and, to the northwest, underlying the City of Hartford, the Niagara dolomite is absent and the uppermost bedrock unit is the Maquoketa shale.[7] Beneath the Maquoketa shale are dolomite and sandstone formations that constitute the "deep sandstone aquifer," but which do not intersect the surface drainage system and, therefore, are relatively unimportant to the surface

[7]*SEWRPC Technical Report No. 37,* Groundwater Resources of Southeastern Wisconsin, *June 2002.*

Map 8

HYDROLOGIC SOIL GROUPS WITHIN THE DRAINAGE AREA TRIBUTARY TO PIKE LAKE



GROUP A: WELL-DRAINED SOIL

GROUP A / B: WELL-DRAINED SOIL/MODERATELY DRAINED SOIL (Well-drained soil if water table is lowered through provision of a drainage system. Moderately drained soil if water table is not lowered.)

GROUP A / D: WELL-DRAINED SOIL / VERY POORLY DRAINED SOIL (Well-drained soil if water table is lowered through provision of a drainage system. Very poorly drained soil if water table is not lowered.)

GROUP B: MODERATELY DRAINED SOIL

GROUP B / D: MODERATELY DRAINED SOIL / POORLY DRAINED SOIL (Moderately drained soil if water table is lowered through provision of a drainage system. Very poorly drained soil if water table is not lowered.)

GROUP C: POORLY DRAINED SOIL

GROUP C / D: POORLY DRAINED SOIL / VERY POORLY DRAINED SOIL (Poorly drained soil if water table is lowered through provision of a drainage system. Very poorly drained soil if water table is not lowered.)

GROUP D: VERY POORLY DRAINED SOIL

SURFACE WATER

0 0.5 1 MILES

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

water systems of the area. This bedrock is rich in available calcium and magnesium, and contributes to the presence of very fertile waters within Washington County.[8]

Land Form and Internally Drained Areas
A belt of drift hills occupies much of the drainage area tributary to Pike Lake. These hills, which extend across the western half of the County, have been described as one of "the best examples of the Kettle Moraine in Wisconsin." The kettle moraine ranges are oriented generally in a northeast-to-southwest direction, having been formed as the interlobate moraine created by the Green Bay and Michigan glaciers. Elevations in the vicinity of Pike Lake range from about 1,000 feet above the National Geodetic Vertical Datum of 1929 (NGVD) in the valleys to about 1,150 feet above NGVD on the ridges. Such variations in elevation result from the movement and deposition of glacially transported materials, and often encompass internally drained areas lacking a direct surface water connection to the stream and lake systems within whose drainage areas these waterbodies lie. Lohr Pond and Werner Pond, located in the southeastern portion of the Pike Lake drainage area as shown on Map 1, are examples of such waterbodies within the Pike Lake watershed.[9] These internally drained areas of the drainage basin form a relatively small proportion of the drainage area tributary to Pike Lake, and many of these areas are connected hydrologically with the Pike Lake drainage system through the groundwater system. Groundwater flows into Pike Lake generally from the east, and flows out of Pike Lake as surface outflows through the Rubicon River drainage system. Map 9 shows the general groundwater distribution and flow pattern around Pike Lake.

Land surface slopes within the drainage area tributary to Pike Lake range from less than 1 percent to greater than 20 percent in the watershed, with the more steeply sloping lands located to the east of the lake basin, as shown on Map 10. In general, slopes of over 12 percent have limitations for urban residential development and, if developed, can present potential erosion and drainage problems. Based upon soil-slope interpretations, about 1,200 acres, or about 15 percent of the drainage area tributary to Pike Lake, have slopes within this range. A further 1,200 acres have slopes of between 6 percent and 12 percent, while the balance of the lands, comprising about 5,000 acres excluding surface waters and about 100 acres of highly disturbed lands, has slopes of less than 6 percent. These relatively flat areas generally coincide with the wetland areas north of the Lake and west of the Village of Slinger, among others, as shown on Map 10.

CLIMATE AND HYDROLOGY

Long-term average monthly air temperature and precipitation values for the Pike Lake area are set forth in Table 3. These averages were taken from official National Oceanic and Atmospheric Administration (NOAA) records for the recording weather station located at Hartford, Wisconsin. The records of this station may be considered typical of the area. Table 3 also sets forth stormwater runoff values derived from U.S. Geological Survey (USGS) flow records for the Rock River at Afton, in Jefferson County, Wisconsin, downstream from the confluence of the Rubicon and Rock Rivers. The mean annual temperature of 44.4°F at Hartford is similar to that of other recording locations in Southeastern Wisconsin. The mean annual precipitation at Hartford is about 31.8 inches. More than half the normal yearly precipitation falls during the growing season, from May to September. Runoff rates are generally low during this period, since evapotranspiration rates are high, vegetative cover is good, and soils are not frozen. Normally, about 15 percent of the summer precipitation is expressed as surface runoff, but intense summer storms occasionally produce higher runoff fractions. In contrast, approximately 30 percent of the annual precipitation occurs during the winter or early spring (December to April) when the ground is frozen, resulting in high surface runoff during those seasons.

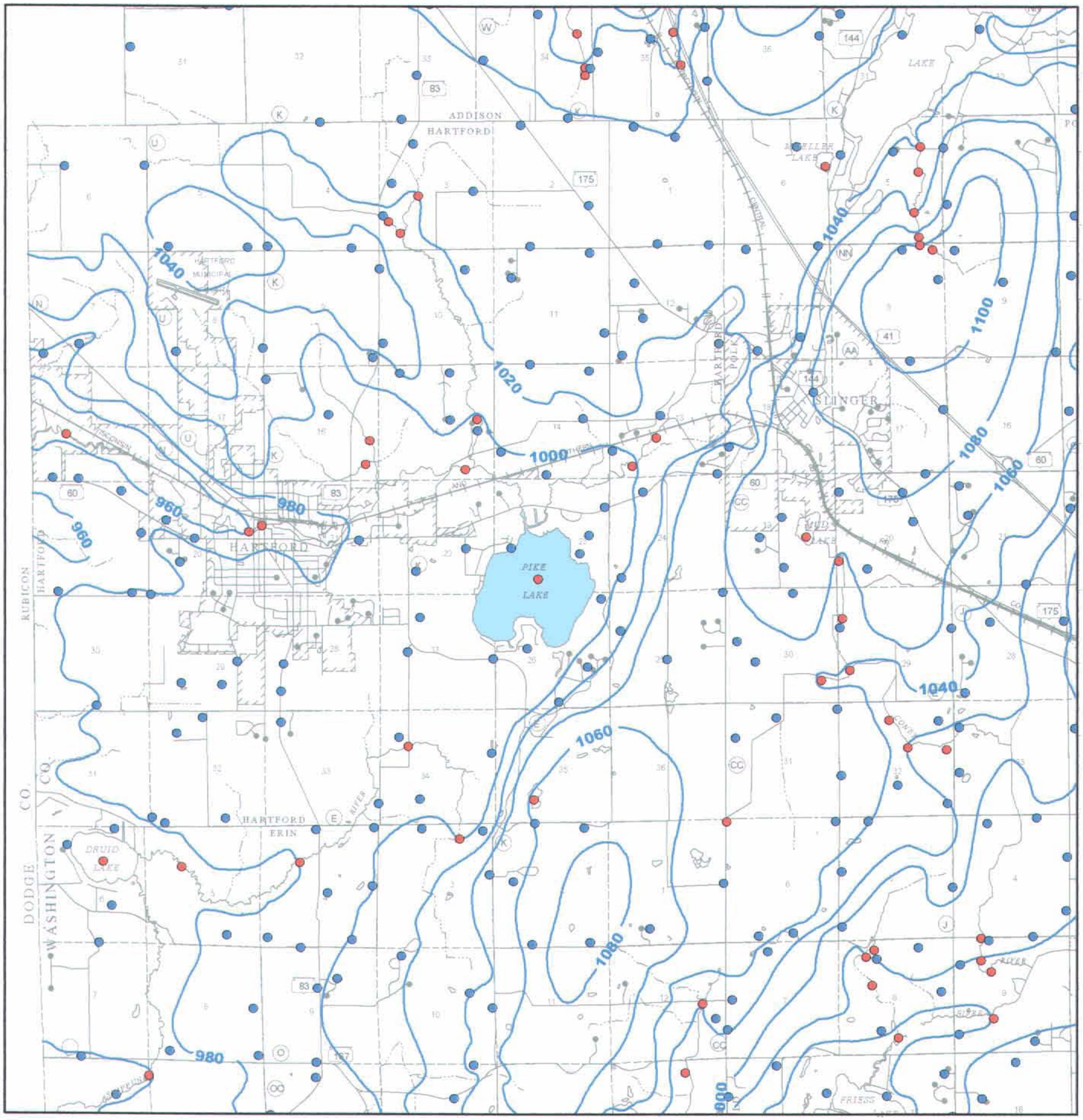
---

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

[9]Ibid.

Map 9

GENERALIZED WATER TABLE ELEVATION AND DIRECTION OF GROUNDWATER FLOW IN THE VICINITY OF PIKE LAKE



—980— AVERAGE WATER-TABLE ELEVATION IN FEET ABOVE NGVD (29)

SURFACE WATER POINT

WELL DATA POINT

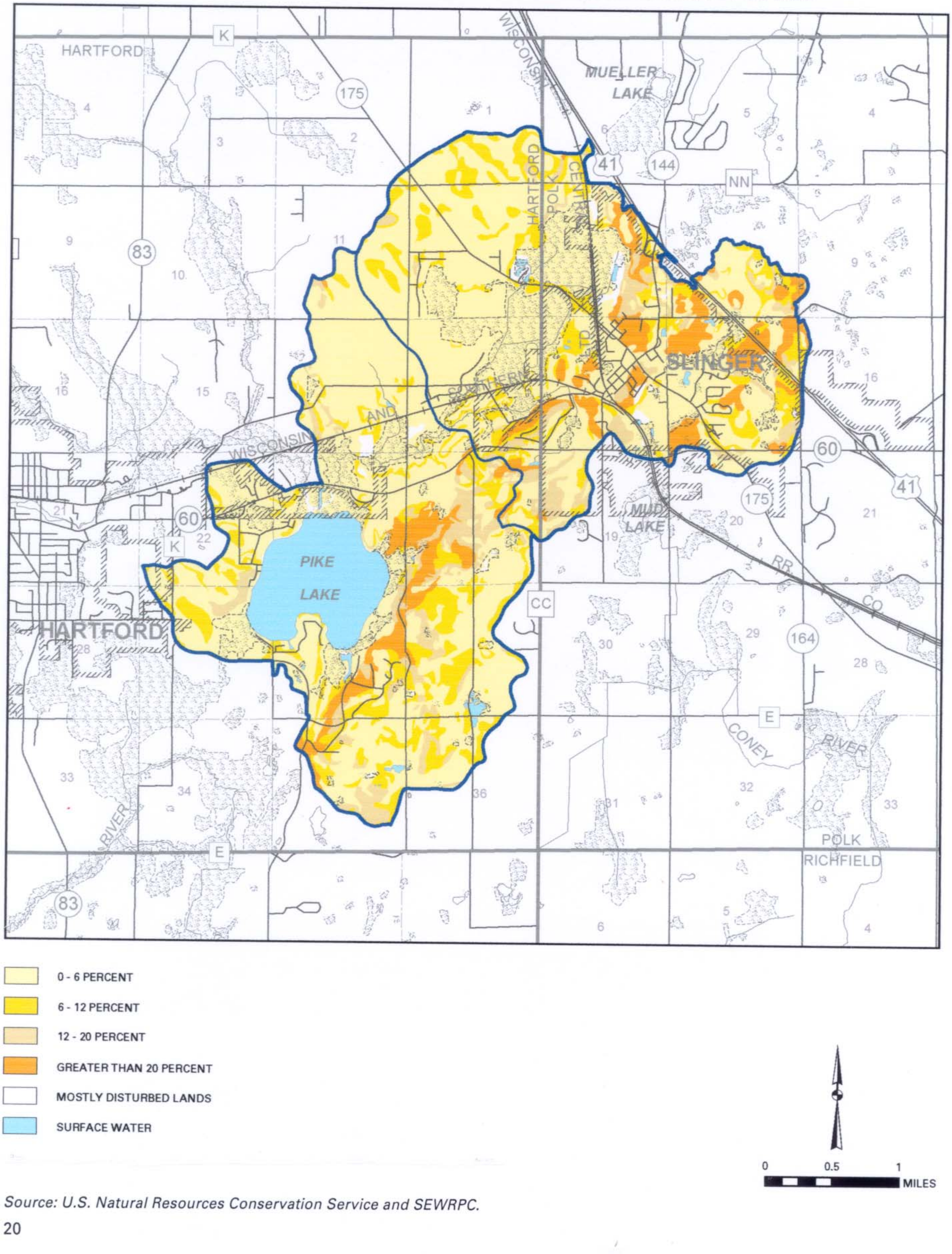
N

GRAPHIC SCALE
0 3,500 7,000 10,500 Feet

Source: Wisconsin Geological and Natural History Survey and SEWRPC.

Map 10

LAND SURFACE SLOPES WITHIN THE DRAINAGE AREA TRIBUTARY TO PIKE LAKE



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

Table 3

LONG-TERM AND 2001 STUDY YEAR CLIMATOLOGICAL AND RUNOFF DATA FOR THE PIKE LAKE AREA

Climatological Data	Temperature (°F)												Mean Annual
	January	February	March	April	May	June	July	August	September	October	November	December	
Long-term Mean Monthly Air Temperature—°F (Hartford)	14.7	18.7	31.4	44.3	55.9	65.2	70.3	67.6	59.3	48.6	35.0	20.9	44.4
2001 Mean Monthly Air Temperature—°F (Hartford)	19.5	19.9	29.5	49.3	58.1	64.3	70.8	71.0	58.5	47.9	44.6	30.2	47.0
Departure from Normal Mean Monthly Air Temperature—°F (Hartford)	4.8	1.2	-1.9	5.0	2.2	-0.9	0.5	3.4	-0.8	-0.7	9.6	9.3	2.6

Climatological Data	Precipitation (inches)												
	January	February	March	April	May	June	July	August[a]	September	October	November	December	Annual
Long-term Mean Monthly Precipitation—Inches (Hartford)	1.13	0.97	2.05	2.72	3.00	3.65	3.74	3.80	4.26	2.60	2.16	1.72	31.80
2001 Precipitation—Inches (Hartford)	0.70	1.93	0.21	3.74	3.44	5.36	2.34	4.30	4.58	3.31	1.30	1.29	32.50
Departure from Normal Precipitation—Inches (Hartford)	-0.43	0.95	-1.84	1.02	0.44	1.71	-1.40	0.50	0.32	0.71	-0.86	-0.43	0.70

Hydrological Data	Runoff (inches)												
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Long-term Runoff—Inches (Rock River at Afton) (1914-2001)	0.45	0.49	1.15	1.37	0.90	0.61	0.50	0.40	0.40	0.48	0.53	0.51	7.79
2001 Runoff—Inches (Rock River at Afton)	0.50	0.72	1.25	1.56	1.26	1.24	0.72	0.51	0.85	0.54	0.58	0.49	10.22
Departure from Normal Runoff—Inches (Rock River at Afton)	0.05	0.23	0.10	0.19	0.36	0.63	0.22	0.11	0.45	0.06	0.05	-0.02	2.43

[a]*August 2001 data for the West Bend station: data not available for Hartford.*

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

The 12-month period during which the water quality sampling program for the Pike Lake study was carried out, January through December 2001, was a period of variable temperatures and rainfall in southeastern Wisconsin, as indicated in Table 3. Temperatures were generally above normal during the year, although early spring, early summer, and fall were somewhat below normal during 2001, as shown in Table 3. Precipitation at Hartford during the sampling period was about 32.5 inches, or slightly above normal, on average, during much of the spring and summer; winter precipitation was consistently less than the long-term average during this year.

The volume of Pike Lake is primarily determined by the rates of inflow and outflow. Runoff, which governs the inflow and outflow rates at Pike Lake, was slightly higher during the study period than the long-term average runoff rate for the Rock River basin, as shown in Table 3. The lake level, however, is regulated, in part, by an outlet control structure, which permits dam operators to maintain a fairly stable lake level within the lake basin even during periods of climatic and hydrologic variability.

These climatic and hydrological data can be used to compute a water budget for Pike Lake. During the current study period, it is estimated that 6,800 acre-feet of water were contributed from tributary streams, 1,400 acre-feet through direct precipitation onto the lake surface, and 600 acre-feet of water through groundwater inflows to the Lake. Thus, of the approximately 8,800 acre-feet of water entering the Lake during 2001, about 77 percent was contributed by stream flow, about 16 percent by direct precipitation, and about 7 percent by groundwater inflow. About 1,300 acre-feet were lost from Pike Lake during the study year due to evaporation from the lake surface, and about 7,500 acre-feet were discharged through the Rubicon River, assuming no change in Lake level during this period. As noted previously, groundwater outflow was assumed to be negligible, with groundwater inflow leaving the lake as surface flow through the Rubicon River outlet.

These estimated values compare favorably with the measurements made of the Lake's water budget during 1999 and 2000.[10] Measured inflow to the Lake was comprised of direct precipitation, inflow through the Rubicon River comprised of contributions from both point and nonpoint sources, direct runoff to the Lake from the local land area surrounding the Lake, the direct drainage area tributary to Pike Lake, and groundwater inflows. Of these, the Rubicon River delivered about 55 percent of the approximately 8,600 acre-feet of water flowing into Pike Lake annually, averaged during this period. Less than 10 percent of the total water load originated from the Village of Slinger wastewater treatment facility. Runoff to the Lake from the direct drainage area, and direct precipitation onto the Lake surface, both accounted for a further volume equal to about 20 percent of the total water load, respectively. Groundwater inflows to Pike Lake provided the balance of the inflowing water. Of this volume, about 15 percent was lost to evaporation from the Lake surface, and 85 percent through surface outflows to the Rubicon River. Groundwater losses were assumed to be negligible. These data are shown in Table 4.

Previously, a water budget for Pike Lake was computed for the period 1976 through 1977, using estimated rates of precipitation, inflow from the Rubicon River and the unnamed tributaries, direct tributary surface runoff, groundwater inflow and outflow, and outflow to the Rubicon River, along with pertinent evaporation and lake level data. During the 1976-77 study year, which coincided with a period of below average precipitation and runoff, it was estimated that 3,500 acre-feet of water entered the Lake. Of this total, about 1,675 acre-feet, or 47 percent, were contributed by inflow from the Rubicon River; about 700 acre-feet, or 20 percent, by direct precipitation; about 670 acre-feet, or 19 percent, by groundwater inflow; and about 490 acre-feet, or 14 percent, by runoff from the direct drainage area. Of the total water output from Pike Lake during this period, about 2,290 acre-feet, or 65 percent of the 3,495 acre-feet lost from the Lake, were discharged via the Rubicon River, and about 1,205 acre-feet, or 35 percent of the outflow, were evaporated from the Lake surface. The balance of about 40 acre-feet went into storage, resulting in a higher lake level during this period.

---

[10] *U.S. Geological Survey Scientific Investigations Report No. 2004-5141,* Water Quality, Hydrology, and the Effects of Changes in Phosphorus Loading to Pike Lake, Washington County, Wisconsin, with Special Emphasis on Inlet-to-Outlet Short-Circuiting, *2004.*

Table 4

WATER BUDGET FOR PIKE LAKE: 1999 AND 2000

Element	1999 (acre-feet)	2000 (acre-feet)
Inflows		
Direct Precipitation	1,615	1,372
Rubicon River		
Slinger Wastewater Treatment Plant	762	665
Rubicon River (excluding treatment plant discharge)	4,534	3,483
Direct Runoff to Pike Lake	2,029	1,559
Groundwater	620	622
Total	9,560	7,701
Outflows		
Evaporation	1,134	1,134
Rubicon River	8,312	6,652
Groundwater	0	0
Total	9,446	7,786
Change in Lake Storage	14	(85)

Source: U.S. Geological Survey and SEWRPC.

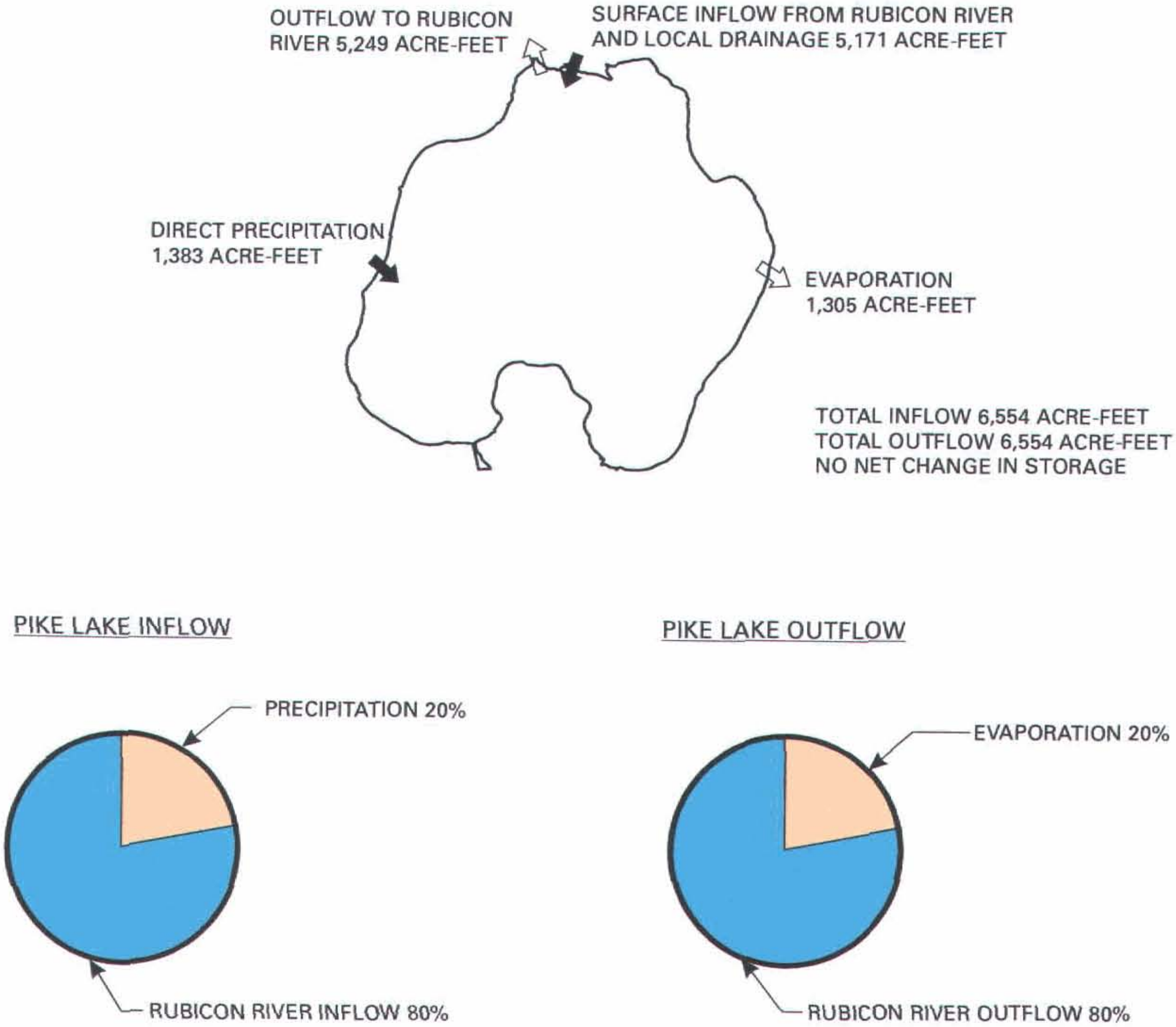
A long-term budget for Pike Lake was computed from estimated long-term precipitation rates and inflow volumes from the tributary streams, and estimated outflows through the Rock River, based upon data collected by the U.S. Geological Survey at Afton, Wisconsin, between 1914 and 2001. This long-term water budget for Pike Lake is set forth in Figure 1. An average of about 5,200 acre-feet, or about 80 percent of the water entering the Lake, are contributed by surface runoff, and about 1,400 acre-feet, or about 20 percent, are contributed by precipitation directly onto the Lake surface. Of this total long-term annual inflow, it is estimated that about 1,300 acre-feet, or about 20 percent of the inflow volume, are lost to evaporation from the Lake surface, and about 5,250 acre-feet, or approximately 80 percent, are discharged from the Lake to the Rubicon River. The long-term water balance for Pike Lake assumes no significant net change in Lake water level.

During 1976, five pairs of groundwater level observation and groundwater quality sampling wells, located around the Lake, were used to measure the direction and flow of groundwater around Pike Lake, and evaluate the effect of groundwater inflows and outflows on the water budget of Pike Lake. Groundwater flow was observed to be from the southeast toward the northwest side of the Lake. The net volume of groundwater entering and leaving the Lake was assumed to be nearly equal during this study.

Based on the annual and long-term water budgets for Pike Lake, a hydraulic or water residence time was calculated. The hydraulic residence time is an important determinant of the expected response time of a lake to increased or reduced nutrient and other pollutant loadings. The hydraulic residence time for Pike Lake during the study period was approximately 0.8 years, reflecting the above normal levels of precipitation and rates of surface runoff during 2001. During a year with average climatologic conditions, the hydraulic residence time may be expected to be somewhat greater, or approximately 1.05 years, as calculated using the long-term rainfall and runoff records for the watershed. During the 1976-1977 study period, a period of below average rainfall, the water residence time of Pike Lake increased to about 1.9 years. These values may be considered to reflect the natural range of climatic induced variability in rainfall and runoff within this portion of the Rubicon River watershed.

Figure 1

HYDROLOGIC BUDGET FOR PIKE LAKE: 1914-2001



Source: U.S. Geological Survey and SEWRPC.

Chapter III

HISTORICAL, EXISTING, AND FORECAST LAND USE AND POPULATION

INTRODUCTION

Water pollution problems, and ultimate solutions to those problems, are primarily a function of the human activities within the drainage area of a waterbody and of the ability of the underlying natural resource base to sustain those activities. This is especially true in an area directly tributary to a lake because lakes are highly susceptible to water quality degradation attendant to human activities in the direct drainage area. This lake degradation is more likely to interfere with desired water uses, and is often difficult and costly to correct. Accordingly, the land uses and population levels in the direct drainage area of a lake are important considerations in lake water quality management.

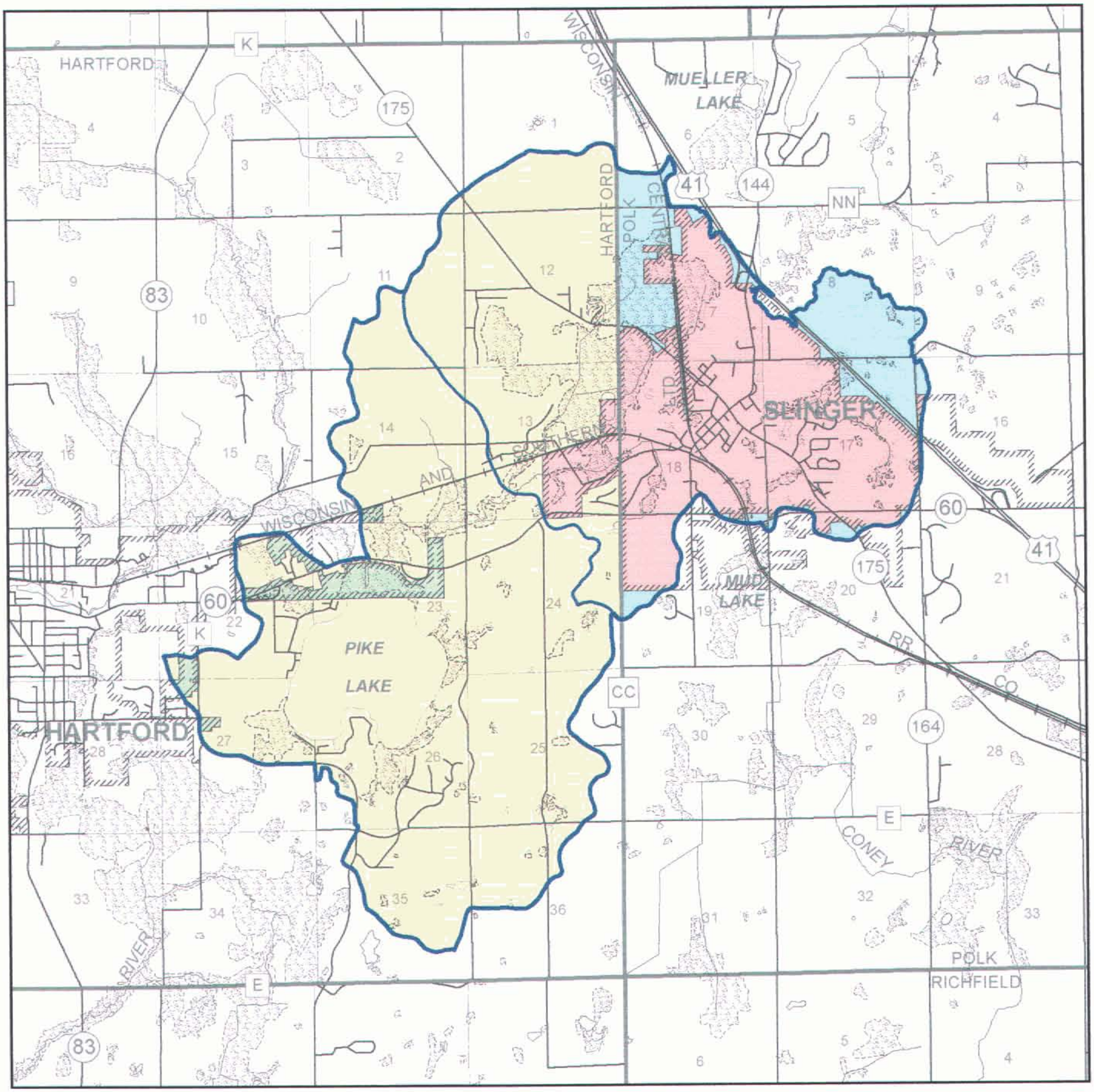
CIVIL DIVISIONS

The geographic, as well as functional jurisdictions of general and special purpose units of government are also important factors which must be considered in a lake water quality management, since these local units of government provide the basic structure of the decision-making framework within which intergovernmental environmental problems must be addressed. Superimposed on the irregular drainage area of Pike Lake are the local civil division boundaries, shown on Map 11. The governmental units within the drainage area tributary to Pike Lake include portions of the City and Town of Hartford, the Village of Slinger, and Town of Polk. Of these, the City and Town of Hartford constitute the drainage area directly tributary to Pike Lake, or that portion of the drainage area which drains directly, or through minor tributary streams, to Pike Lake without passing through a major upstream waterbody; in this case, the Rubicon River. The area and proportion of the drainage area lying within the jurisdiction of each civil division, as of 2000, is set forth in Table 5. The geographic boundaries of the civil divisions are important factors which must be considered in any water quality management planning effort for a lake, since these local units of government provide the basic structure for the decision-making framework within which intergovernmental environmental problems must be addressed.

Washington County also administers a number of programs and administrative functions which relate directly to lake and watershed management in the Pike Lake area, as does the Wisconsin Department of Natural Resources. The Wisconsin Department of Natural Resources is a major stakeholder in the Pike Lake area, managing the Pike Lake Unit of the Kettle Moraine State Forest, a 650-acre recreational area within the drainage area directly tributary and riparian to Pike Lake.

Map 11

CIVIL DIVISION BOUNDARIES IN THE TOTAL DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 2000



CITY OF HARTFORD

TOWN OF HARTFORD

TOWN OF POLK

VILLAGE OF SLINGER

Source: SEWRPC.

0 0.5 1 MILES

Table 5

AREA SUMMARY FOR MUNICIPALITIES WITHIN THE DRAINAGE AREA TRIBUTARY TO PIKE LAKE

Municipality	Area (acres)	Percent
City of Hartford	78	1.0
Town of Hartford	5,589	70.1
Town of Polk	1,057	13.3
Village of Slinger	1,242	15.6
Total	7,966	100.0

Source: SEWRPC.

In addition to these general purpose units of government, the Pike Lake Protection and Rehabilitation District is a special-purpose unit of government created pursuant to Chapter 33 of the *Wisconsin Statutes* and having specific responsibilities for lake management. This District was formed in 1983 and encompasses the properties riparian to the Lake. Public inland lake protection and rehabilitation districts, or lake management districts, may undertake programs of lake protection or rehabilitation including water quality, aquatic plant, and fisheries management activities, and, under certain conditions, maintain and operate a water safety patrol, develop and enforce ordinances, and perform the functions of a town sanitary district.[1]

POPULATION

As indicated in Table 6, the resident population of the drainage area directly tributary to Pike Lake has increased in a relatively steady manner since 1950. In 1980 the resident population of the direct drainage area was estimated at 870 persons, or about double the estimated 1950 population of 410 persons. As of 2000, the resident population was reported to be approximately three-times that of 1950, or about 1,150 persons residing in about 450 housing units. The number of housing units reported to be within the drainage area directly tributary to Pike Lake increased from about 300 units during the decade between 1990 and 2000.

Population forecasts prepared by the Regional Planning Commission, also shown in Table 6, indicate that the population of the drainage area directly tributary to Pike Lake may be expected to continue to increase over the next two decades, with an anticipated growth in population of about 500 persons. This population growth may be expected to place continued and increasing stress on the natural resource base of the Pike Lake drainage area, and both water resource demands and use conflicts may be expected to increase.

In addition to the population within the drainage area tributary to Pike Lake, there is about 0.7 square mile of land in the eastern portion of the planned Slinger sewer service area lying beyond the drainage area. Thus, there is an additional population over and above the population within the drainage area tributary to Pike Lake that will contribute wastewater to the Village of Slinger treatment plant and the Rubicon River, into which the plant discharges.

LAND USE

The type, intensity, and spatial distribution of the various land uses within the drainage area tributary to Pike Lake are important determinants of lake water quality and recreational use demands. The existing land use pattern placed in the context of the historical development of the area, therefore, are important considerations in any lake management planning effort for Pike Lake.

The movement of European settlers into the Southeastern Wisconsin Region began about 1830. Completion of the U.S. Public Land Survey in Southeastern Wisconsin in 1836 and the subsequent sale of the public lands brought a rapid influx of settlers into the area. Map 5 in Chapter II shows the 1892 plat of the U.S. Public Land Survey for

[1]*University of Wisconsin-Extension, Publication No. PUBL-FH-821.96,* A Guide to Wisconsin's Lake Management Law, Tenth Edition, *1996.*

Table 6

HISTORIC AND FORECAST RESIDENT POPULATION LEVELS OF THE DRAINAGE AREA DIRECTLY TRIBUTARY TO PIKE LAKE: 1950-2020

Year	Population in the Direct Tributary Drainage Area
1950	410
1960	560
1970	700
1980	870
1990	756
2000	1,151
2020	1,700

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

the Pike Lake area. Significant urban land use development began in the Pike Lake area in about 1920. Map 12 and Table 7 indicate the historic urban growth pattern in the direct drainage area of the lake since 1950. A significant increase in the amount of land converted to urban use occurred prior to 1950, and has continued relatively steadily through the 1990s. Within the total drainage area tributary to Pike Lake, the greatest increases in urban lands within the wider watershed have occurred during the 1980s, as shown in Table 7.

In 1995, about 86 percent of the direct drainage area was in various rural land uses, with the dominant rural land use being agricultural, encompassing about 2,170 acres, or about 54 percent of the direct drainage area. Other rural land uses, surface waterbodies, wetlands, woodlands, and open lands, comprised about 1,290 acres, or 32 percent of the direct drainage area. Urban land uses, consisting of residential, commercial, governmental and institutional, transportation, and recreational land uses, encompassed about 540 acres, or about 14 percent of the direct drainage area. Urban residential uses were the dominant urban land use, comprising about 300 acres, or about 8 percent of the direct drainage area. Commercial, industrial, governmental and institutional, and recreational land uses combined comprised about 240 acres, or 6 percent of the direct drainage area. As of 2000, agricultural and other rural land uses continued to decline, with agriculture, the dominant rural land use, encompassing about 2,100 acres. Woodlands, wetlands and other rural land uses encompassed a further 1,300 acres, as shown in Table 8. Urban land uses increased to about 590 acres, with urban residential lands comprising the largest urban land use, accounting for about 320 acres or about one-half of the urban land uses in the drainage area directly tributary to Pike Lake.

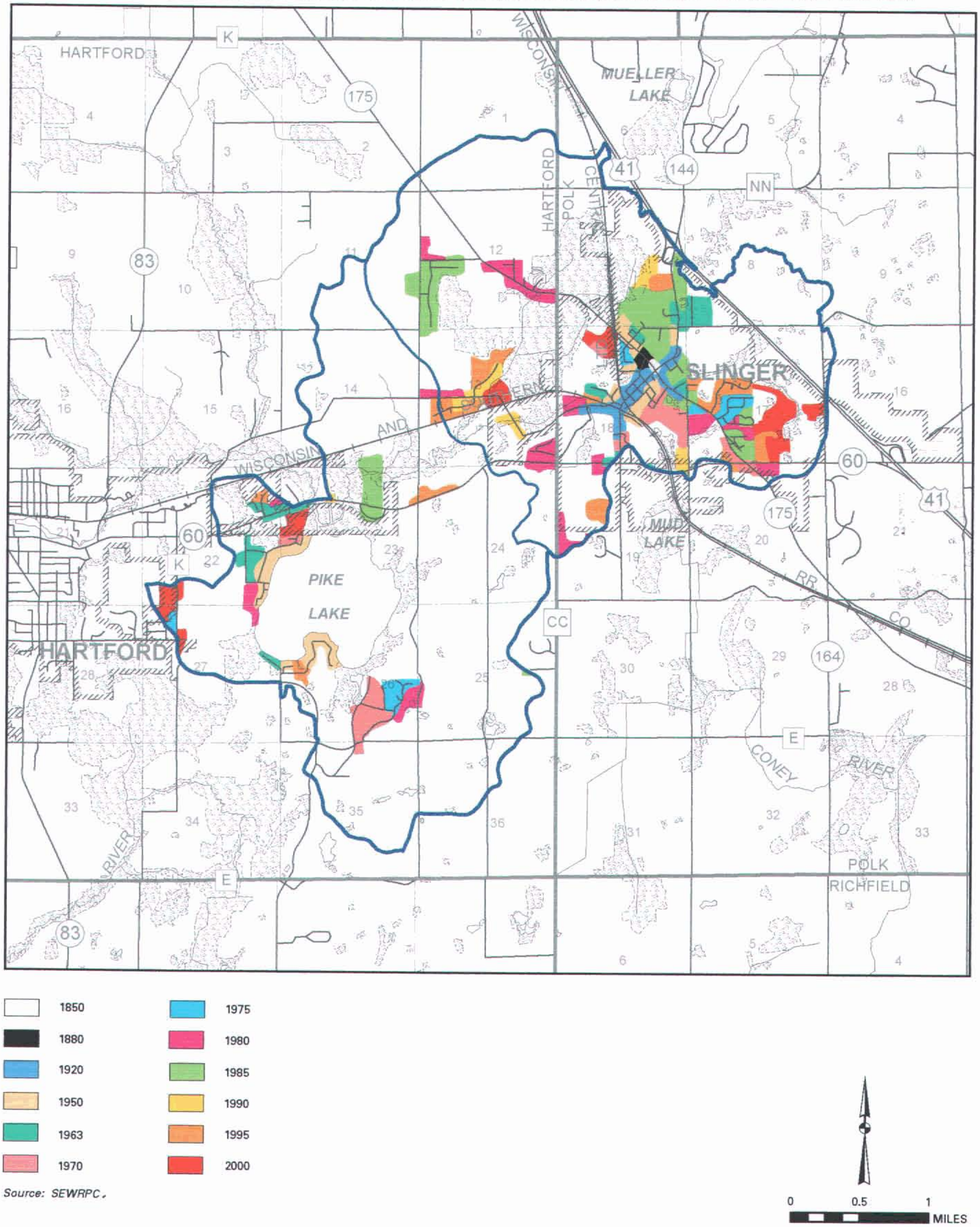
Within the total drainage area tributary to Pike Lake, during 1995, urban land uses accounted for about 20 percent of the land area, comprising about 1,620 acres of the drainage area. Rural land uses accounted for about 6,340 acres, or about 80 percent of the total land area within the drainage basin, with agricultural uses comprising about one-half of this total area. As of 2000, agricultural lands comprised about 3,740 acres of the approximately 6,080 acres of rural lands, as shown in Table 9. While such land uses continued to decline in the drainage area tributary to Pike Lake, rural lands continued to form the largest percentage of land usage in the total drainage area, accounting for about 76 percent of the land area. Urban land uses comprised about 1,890 acres, or approximately 24 percent of the land area draining to Pike Lake. Urban residential lands, extending over approximately 950 acres, comprised the largest urban land use, accounting for about one-half of all such uses. Map 13 shows the existing land uses within the total drainage area and drainage area directly tributary to Pike Lake.

The extent of residential development within the urban areas of the drainage area tributary to Pike Lake is expected to increase, as shown on Map 14. Within the drainage area directly tributary to the Lake, urban residential uses are expected to increase by about 270 acres, to about 590 acres or approximately 15 percent of the direct drainage area, as shown in Table 8. Most of this residential development is expected to occur on lands formerly devoted to agricultural uses. Rural agricultural uses are expected to decrease to about 1,750 acres, or approximately 44 percent of the direct drainage area.

A similar change in land usage is anticipated to occur in the total drainage area tributary to Pike Lake, as shown on Map 15 and quantified in Table 9. Urban residential uses are expected to almost double, to about 1,720 acres, or approximately 22 percent of the direct drainage area, as shown in Table 9, while rural agricultural uses are expected to decrease by about 1,160 acres, to about 2,580 acres or approximately 35 percent of the total drainage area.

Map 12

HISTORIC URBAN GROWTH WITHIN THE TOTAL DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 1850-2000



Source: SEWRPC.

Table 7

EXTENT OF HISTORIC URBAN GROWTH IN THE DIRECT DRAINAGE AREA OF PIKE LAKE: 1850-2000

Year	Direct Drainage Area		Total Tributary Drainage Area	
	Extent of New Urban Development Occurring Since Previous Year (acres)[a]	Cumulative Extent of Urban Development (acres)[a]	Extent of New Urban Development Occurring Since Previous Year (acres)[a]	Cumulative Extent of Urban Development (acres)[a]
1850	- -	- -	- -	- -
1880	- -	- -	4	4
1900	- -	- -	9	13
1920	- -	- -	76	89
1950	74	74	131	210
1963	52	126	115	325
1970	61	187	133	458
1975	32	219	68	526
1980	42	261	205	731
1985	50	311	292	1,023
1990	4	315	69	1,092
1995	40	355	180	1,272
2000	49	404	150	1,422

[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 urban in this analysis.

Source: SEWRPC.

Of the agricultural lands within the drainage basin, about 1,740 acres of the drainage area directly tributary to Pike Lake, and about 2,760 acres within the total drainage area, or between 45 and 35 percent of the drainage areas, respectively, are anticipated to remain in agricultural use. Certain other lands immediately surrounding the Lake, together with connected areas containing a concentration of high-value woodlands, wetlands, and wildlife habitat areas as described in Chapter V, have been designated as environmental corridor lands in the adopted regional land use and regional natural areas and critical species habitat protection and management plans, and are expected to be preserved in essentially natural or open space uses.

The estimated area of impervious surface coverage is anticipated to increase slightly during the 20-year planning period. As shown in Tables 10 and 11, impervious surfaces are estimated to cover 8 percent of the drainage area directly tributary to Pike Lake and about 10 percent of the total tributary drainage area. Impervious surfaces are comprised of roadways, rooftops, sidewalks, and parking lots, among others which do not allow the natural percolation of precipitation into the ground. Rather, these surfaces act to promote surface runoff, which, in turn, transports sediments, nutrients and other contaminants that accumulate on these surfaces into surface waterways, contributing to their degradation. In recent years, changes to the *Wisconsin Administrative Code*, particularly the promulgation of Chapter NR 151, seek to address this by requiring the implementation of practices that will reduce the runoff from impervious surfaces and capture contaminants prior to the time they enter natural water courses. These requirements are set forth in greater detail in Chapter VII of this report. The amount of impervious surface in the drainage area tributary to Pike Lake increased between 1995 and 2000, and is expected to increase slightly under planned year 2020 conditions, to about 10 percent of the drainage area directly tributary to the Lake and 14 percent of the total drainage area.

To provide wastewater treatment services to the envisioned new urban density development, the adopted regional water quality management plan, as refined by the City of Hartford and Village of Slinger sewer service area plans, documented in SEWRPC Community Assistance Planning Report No. 92, 3rd Edition, *Sanitary Sewer Service for*

Table 8

EXISTING AND PLANNED LAND USE WITHIN THE DIRECT DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 2000 AND 2020

Land Use Categories[a]	2000 Acres	2000 Percent of Direct Tributary Drainage Area	2020 Acres	2020 Percent of Direct Tributary Drainage Area
Urban				
Residential	318	8.0	585	14.6
Commercial	15	0.4	41	1.0
Industrial	12	0.3	18	0.5
Governmental and Institutional	11	0.3	30	0.8
Transportation, Communication, and Utilities	194	4.8	267	6.7
Recreational	36	0.9	36	0.9
Subtotal	586	14.7	977	24.5
Rural				
Agricultural and Other Open Lands	2,115	52.9	1,749	43.7
Wetlands	379	9.5	380	9.5
Woodlands	395	9.9	394	9.9
Surface Water	498	12.4	498	12.4
Extractive	25	0.6	- -	- -
Landfill	- -	- -	- -	- -
Subtotal	3,412	85.3	3,021	75.5
Total	3,998	100.0	3,998	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

the City of Hartford, Washington County, Wisconsin, published in September 2001, and in SEWRPC Community Assistance Planning Report No. 128, 3rd Edition, *Sanitary Sewer Service Area for the Village of Slinger and Environs, Washington County, Wisconsin*, published in December 1998, make specific recommendations pertinent to the drainage area tributary to Pike Lake. These recommendations, which are shown on Map 6 in Chapter II, envision that urban residential development will occur at medium densities along the western shores of the Lake and in the northeastern portions of the drainage area directly tributary to the Lake. Additional urban density development is envisioned adjacent to the Village of Slinger, as shown on Map 15. As noted above, urban density residential land use is envisioned to approximately double by the year 2020. The majority of this planned urban density development is within areas planned to be served by sanitary sewers. Outside of these sewer service areas, residential development is expected to occur at low densities on lands already platted and subdivided for urban residential use.

LAND USE REGULATIONS

The comprehensive zoning ordinance represents one of the most important and significant tools available to local units of government in directing the proper use of lands within their area of jurisdiction. As already noted, the drainage area tributary to Pike Lake includes portions of the City of Hartford, the Village of Slinger, and the Towns of Hartford and Polk, all in Washington County. The City, Village, and Towns administer their own zoning ordinances, as shown in Table 12, although the Washington County ordinances form an overlay to the local zoning code with respect to shoreland and floodland zoning issues in the Towns.

Table 9

EXISTING AND PLANNED LAND USE WITHIN THE TOTAL DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 2000 AND 2020

Land Use Categories[a]	2000 Acres	2000 Percent of Total Tributary Drainage Area	2020 Acres	2020 Percent of Total Tributary Drainage Area
Urban				
Residential	945	11.9	1,718	21.6
Commercial	68	0.9	130	1.6
Industrial	62	0.8	141	1.8
Governmental and Institutional	98	1.2	128	1.6
Transportation, Communication, and Utilities	585	7.3	808	10.1
Recreational	127	1.6	148	1.9
Subtotal	1,885	23.7	3,073	38.6
Rural				
Agricultural and Other Open Lands	3,739	46.9	2,576	32.3
Wetlands	1,030	12.9	1,031	12.9
Woodlands	773	9.7	772	9.7
Surface Water	514	6.5	514	6.5
Extractive	25	0.3	- -	- -
Landfill	- -	- -	- -	- -
Subtotal	6,081	76.3	4,893	61.4
Total	7,966	100.0	7,966	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

General Zoning

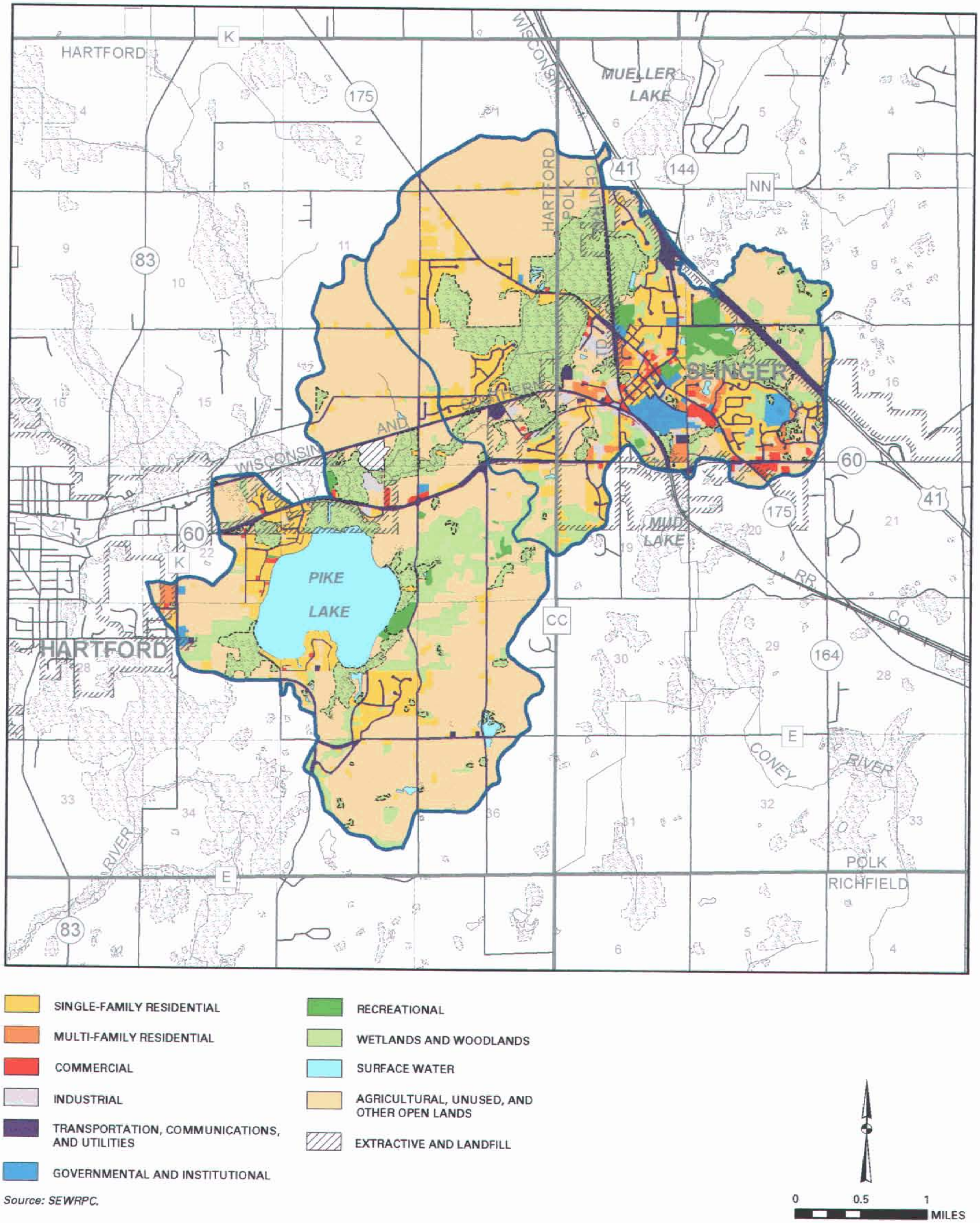
Cities in Wisconsin are granted comprehensive, or general, zoning powers under Section 62.23 of the *Wisconsin Statutes*. The same powers are granted to villages under Section 61.35 of the *Statutes*. Counties are granted general zoning powers within their unincorporated areas under Section 59.69 of the *Statutes*. In Washington County, towns have adopted village powers and subsequently utilize the city and village zoning authority conferred in Section 62.23 of the *Statutes*. General zoning is in effect in all communities in Washington County. All of the municipalities in Washington County, within the drainage area tributary to Pike Lake, have adopted their own zoning ordinances, as shown in Table 12. The current generalized zoning districts applicable to the drainage area tributary to Pike Lake are shown on Map 16.

Floodland Zoning

Section 87.30 of the *Wisconsin Statutes* requires that cities, villages, and counties with respect to their unincorporated areas, adopt floodland zoning to preserve the floodwater conveyance and storage capacity of floodplain areas and to prevent the location of new flood damage-prone development in flood hazard areas. The minimum standards which such ordinances must meet are set forth in Chapter NR 116 of the *Wisconsin Administrative Code*. The required regulations govern filling and development within a regulatory floodplain, which is defined as the area subject to inundation by the 100-year recurrence interval flood event, the event which has a 1 percent probability of occurring in any given year. Under Chapter NR 116, local floodland zoning regulations must prohibit nearly all forms of development within the floodway, which is that portion of the floodplain required to convey the 100-year recurrence peak flood flow. Local regulations also must restrict filling and development within the flood fringe, which is that portion of the floodplain located outside the floodway that

Map 13

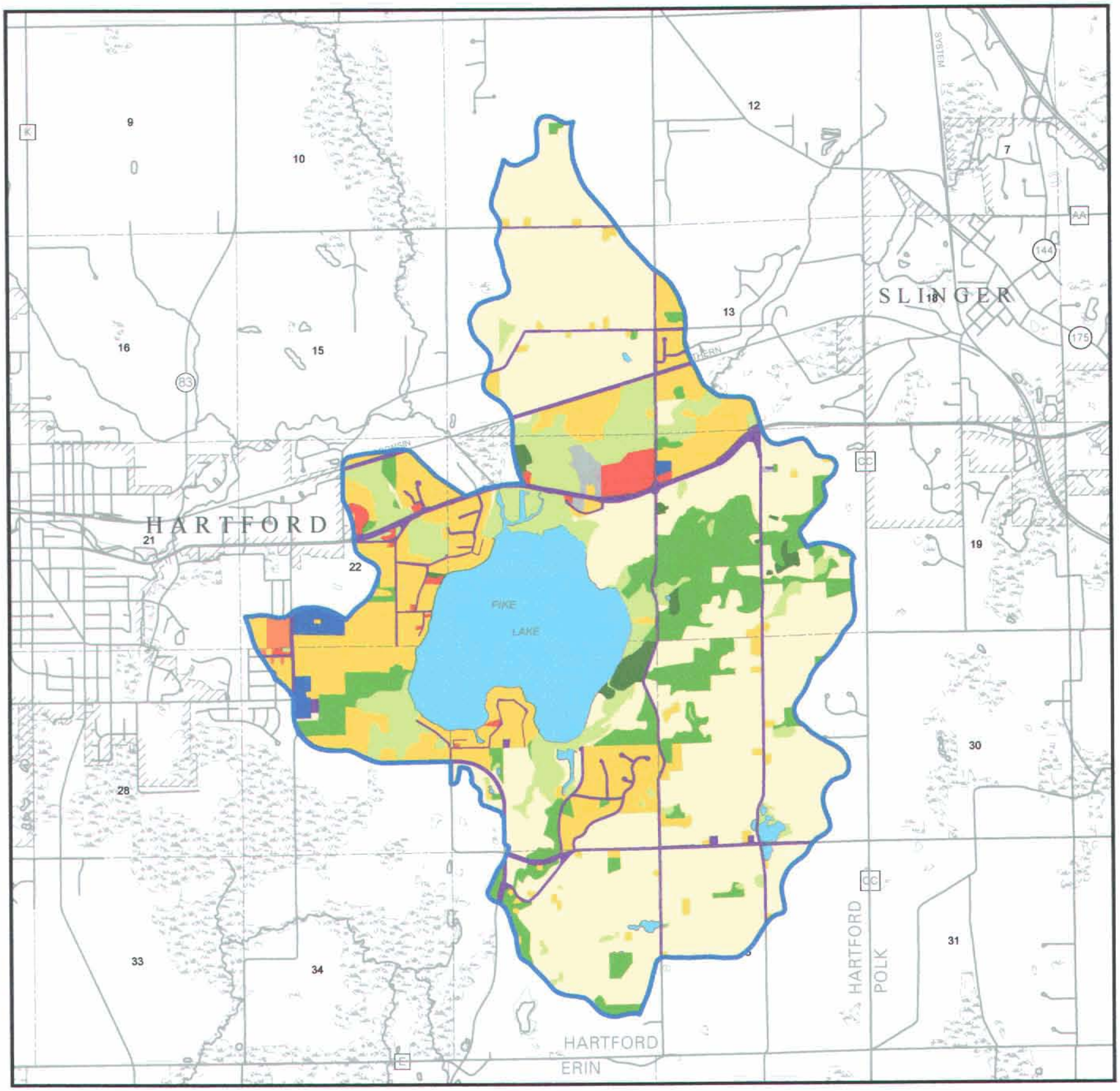
EXISTING LAND USE WITHIN THE TOTAL DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 2000



Source: SEWRPC.

Map 14

PLANNED LAND USE WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO PIKE LAKE: 2020



SINGLE-FAMILY RESIDENTIAL

MULTI-FAMILY RESIDENTIAL

COMMERCIAL

INDUSTRIAL

TRANSPORTATION, COMMUNICATIONS, AND UTILITIES

GOVERNMENTAL AND INSTITUTIONAL

RECREATIONAL

WOODLAND

WETLAND

AGRICULTURAL AND OTHER OPEN SPACE

SURFACE WATER

N

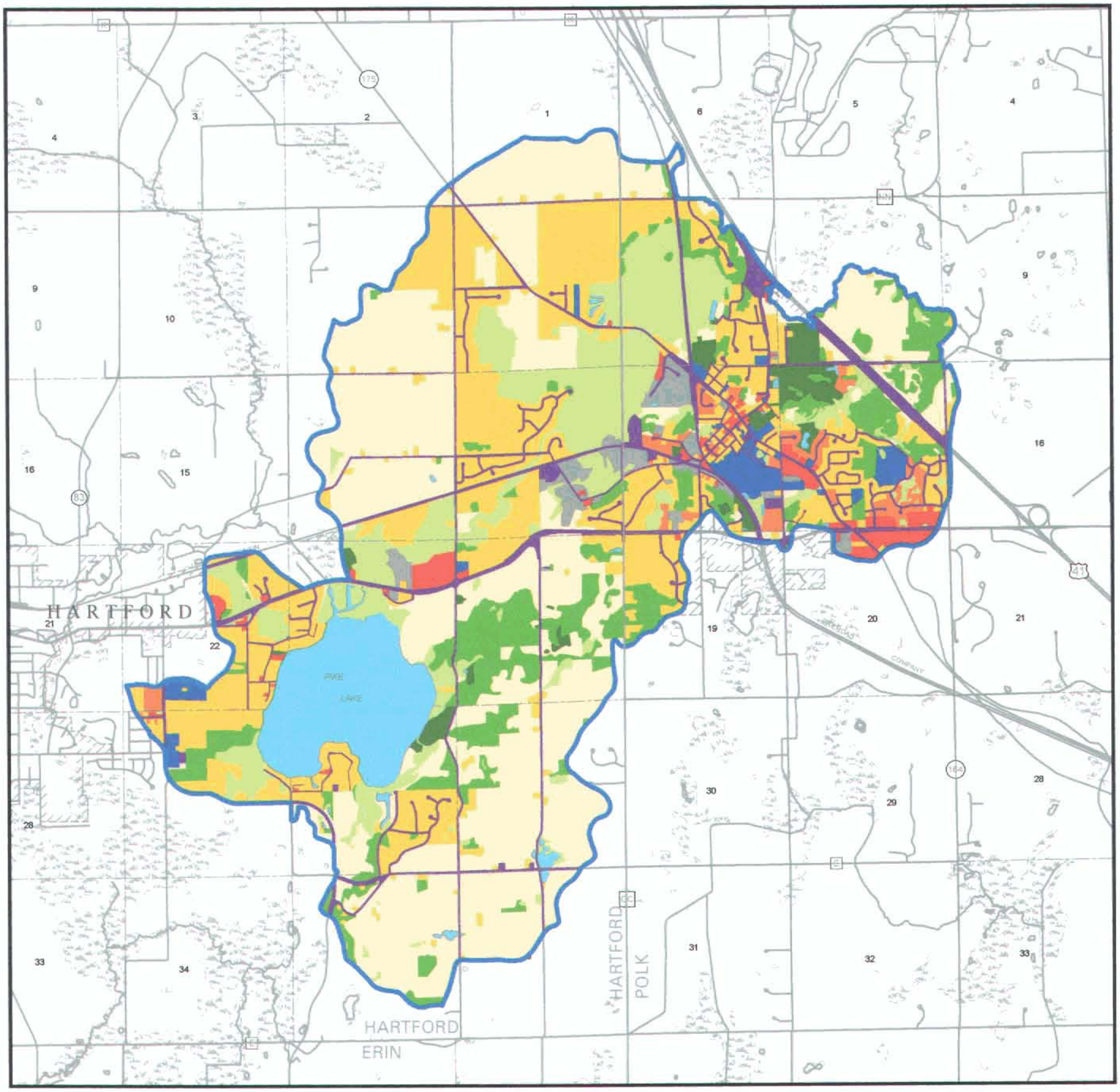
Graphic Scale

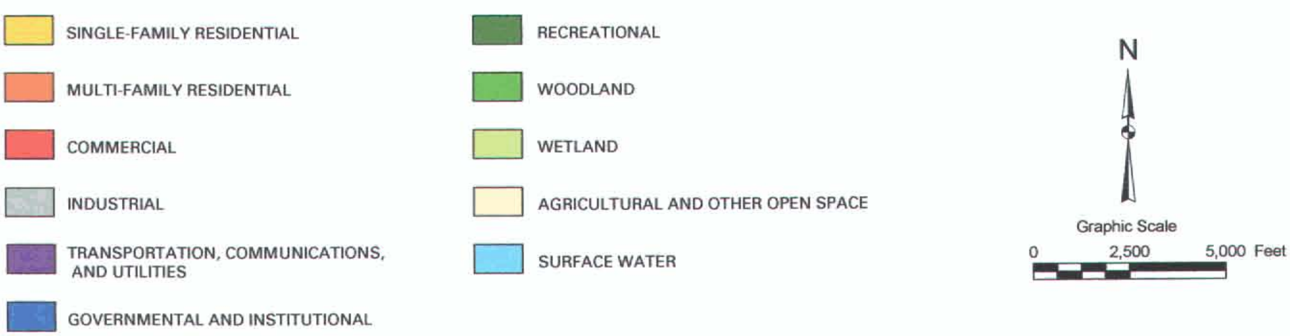
0 2,000 4,000 Feet

Source: SEWRPC.

Map 15

PLANNED LAND USE WITHIN THE TOTAL DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 2020





Source: SEWRPC.

Table 10

ESTIMATED IMPERVIOUS SURFACE COVER WITHIN THE DIRECT DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 1995 AND 2020

Land Use Categories[a]	1995			2020		
	Acres	Impervious (acres)	Percent of Drainage Area	Acres	Impervious (acres)	Percent of Drainage Area
Urban						
Residential	303	57	1.4	619	116	2.9
Commercial	8	3	<0.1	37	13	0.3
Industrial	13	9	0.2	13	9	0.2
Governmental and Institutional	8	3	<0.1	18	6	0.1
Transportation, Communication, and Utilities	170	108	2.7	256	162	4.0
Recreational	41	3	<0.1	41	3	<0.1
Subtotal	543	183	4.3	984	309	7.5
Rural						
Agricultural and Other Open Lands	2,166	87	2.1	1,741	70	1.7
Wetlands	395	21	0.5	395	21	0.5
Woodlands	391	19	0.4	391	19	0.4
Water	487	25	0.6	487	25	0.6
Extractive	16	1	<0.1	- -	- -	- -
Subtotal	3,455	153	3.6	3,014	135	3.2
Total	3,998	336	7.0	3,998	444	10.7

[a]*Parking included in associated use.*

Source: SEWRPC.

Table 11

ESTIMATED IMPERVIOUS SURFACE COVER WITHIN THE TOTAL DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 1995 AND 2020

Land Use Categories[a]	1995			2020		
	Acres	Impervious (acres)	Percent of Drainage Area	Acres	Impervious (acres)	Percent of Drainage Area
Urban						
Residential	841	170	2.1	1,643	332	4.1
Commercial	57	20	0.2	121	42	0.5
Industrial	54	29	0.3	140	75	0.9
Governmental and Institutional	72	25	0.3	111	38	0.4
Transportation, Communication, and Utilities	464	306	3.8	703	463	5.8
Recreational	136	11	0.1	157	13	0.1
Subtotal	1,624	561	6.8	2,875	963	11.8
Rural						
Agricultural and Other Open Lands	3,993	153	1.9	2,758	106	1.3
Wetlands	1,040	52	0.6	1,040	52	0.6
Woodlands	791	39	0.4	791	39	0.4
Water	502	26	0.3	502	26	0.3
Extractive	16	1	<0.1	- -	- -	- -
Subtotal	6,342	271	3.2	5,091	223	2.6
Total	7,966	832	10.0	7,966	1,187	14.4

[a]*Parking included in associated use.*

Source: SEWRPC.

Table 12

LAND USE REGULATIONS WITHIN THE DRAINAGE AREA TRIBUTARY TO PIKE LAKE IN WASHINGTON COUNTY BY CIVIL DIVISION: 2002

Community	Type of Ordinance				
	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Erosion Control and Stormwater Management
Washington County	- -[a]	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Floodland and shoreland only	Adopted
City of Hartford	Adopted	Adopted	Adopted	Adopted	Adopted
Village of Slinger	Adopted	Adopted	Adopted	Adopted	- -[b]
Town of Hartford	Adopted	County ordinance	County ordinance	County ordinance	County ordinance
Town of Polk	Adopted	County ordinance	County ordinance	Adopted	County ordinance

[a]*In 1986, Washington County rescinded its general zoning ordinance and all nine towns which were subject to the general County zoning ordinance have since adopted town zoning ordinances. With respect to floodland and shoreland ordinances, the Towns are subject to County overlay zoning authority, while, with respect to subdivision and stormwater management ordinances, the Towns have discretion as to whether they adopt the County ordinance or their own ordinance, which is equally or more restrictive.*

[b]*No specific ordinance, but staff report that the Village of Slinger follows the County ordinance provisions.*

Source: SEWRPC.

would be covered by floodwater during the 100-year recurrence flood. Permitting the filling and development of the flood fringe area, however, reduces the floodwater storage capacity of the natural floodplain, and may thereby increase downstream flood flows and stages. It should be noted that towns may enact floodland zoning regulations which may be more restrictive than those in the county shoreland and floodland zoning ordinances. Floodland ordinances are in effect within all parts of the drainage area tributary to Pike Lake, as shown in Table 12.

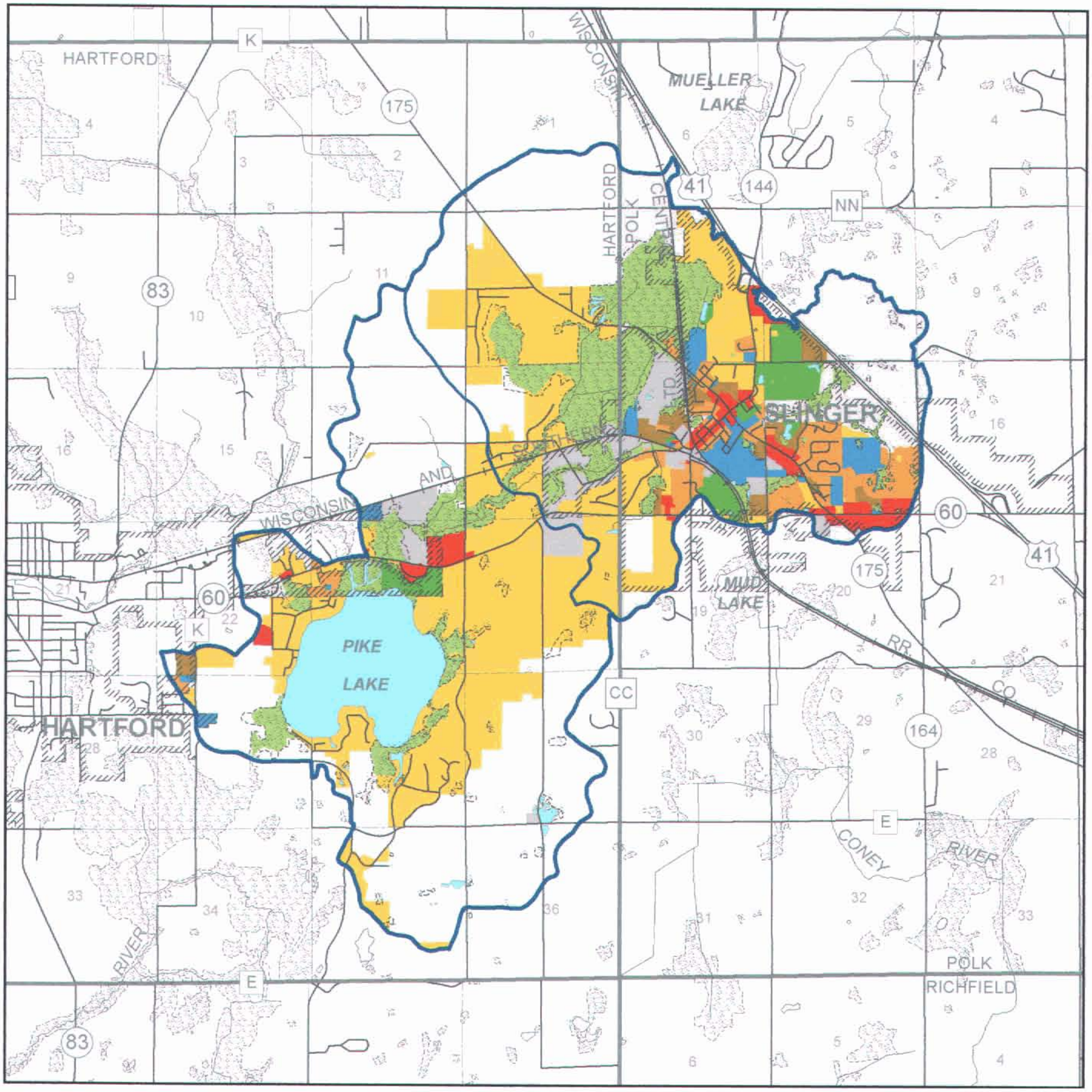
Shoreland Zoning

Under Section 59.692 of the *Wisconsin Statutes*, counties in Wisconsin are required to adopt zoning regulations within statutorily defined shoreland areas, those lands within 1,000 feet of a navigable lake, pond, or flowage, or 300 feet of a navigable stream, or to the landward side of the floodplain, whichever distance is greater, within their unincorporated areas. Minimum standards for county shoreland zoning ordinances are set forth in Chapter NR 115 of the *Wisconsin Administrative Code*. Chapter NR 115 sets forth minimum requirements regarding lot sizes and building setbacks; restrictions on cutting of trees and shrubbery; and restrictions on filling, grading, lagooning, dredging, ditching, and excavating that must be incorporated into county shoreland zoning regulations. In addition, Chapter NR 115, as recodified in 1980, requires that counties place all wetlands five acres or larger and within the statutory shoreland zoning jurisdiction area into a wetland conservancy zoning district to ensure their preservation after completion of appropriate wetland inventories by the Wisconsin Department of Natural Resources.

In 1982, the State Legislature extended shoreland-wetland zoning requirements to cities and villages in Wisconsin. Under Sections 62.231 and 61.351, respectively, of the *Wisconsin Statutes*, cities and villages in Wisconsin are required to place wetlands five acres or larger and located in statutory shorelands into a shoreland-wetland conservancy zoning district to ensure their preservation. Minimum standards for city and village shoreland-wetland zoning ordinances are set forth in Chapter NR 117 of the *Wisconsin Administrative Code*. It should be noted that the basis for identification of wetlands to be protected under Chapters NR 115 and NR 117 is the Wisconsin Wetlands Inventory. Mandated by the State Legislature in 1978, the Wisconsin Wetlands Inventory resulted in the preparation of wetland maps covering each U.S. Public Land Survey township in the State. The inventory was completed for counties in Southeastern Wisconsin in 1982, the wetlands being delineated by the Regional Planning Commission on its 1980, one inch equals 2,000 feet scale, ratioed and rectified aerial photographs as discussed in Chapter V.

Map 16

EXISTING GENERALIZED ZONING DISTRICTS APPLICABLE TO LANDS WITHIN THE TOTAL DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 2000



AGRICULTURAL (35 ACRES OR MORE)

AGRICULTURAL (5.0 TO 34.9 ACRES)

COMMERCIAL

LOWLAND CONSERVANCY

GOVERNMENTAL AND INSTITUTIONAL

INDUSTRIAL

RECREATIONAL

HIGH-DENSITY RESIDENTIAL

MEDIUM-DENSITY RESIDENTIAL

LOW-DENSITY RESIDENTIAL

SURFACE WATER

Source: SEWRPC

0 0.5 1 MILES

All of the incorporated municipalities within the total drainage area tributary to Pike Lake have adopted shoreland or shoreland-wetland zoning ordinances, as shown in Table 12. County shoreland zoning ordinances are in effect in all unincorporated areas of the drainage area tributary to Pike Lake, as also shown in Table 12.

Subdivision Regulations

Chapter 236 of the *Wisconsin Statutes* requires the preparation of a subdivision plat whenever five or more lots of 1.5 acres or less in area are created either at one time or by successive divisions within a period of five years. The *Statutes* set forth requirements for surveying lots and streets, for plat review and approval by State and local agencies, and for recording approved plats. Section 236.45 of the *Statutes* allows any city, village, town, or county that has established a planning agency to adopt a land division ordinance, provided the local ordinance is at least as restrictive as the State platting requirements. Local land division ordinances may include the review of other land divisions not defined as "subdivisions" under Chapter 236, such as when fewer than five lots are created or when lots larger than 1.5 acres are created.

The subdivision regulatory powers of towns and counties are confined to unincorporated areas. City and village subdivision control ordinances may be applied to extraterritorial areas, as well as to the incorporated areas. It is possible for both a county and a town to have concurrent jurisdiction over land divisions in unincorporated areas, or for a city or village to have concurrent jurisdiction with a town or county in the city or village extraterritorial plat approval area. In the case of overlapping jurisdiction, the most restrictive requirements apply. Each of the incorporated communities within the tributary drainage area to Pike Lake has adopted their own subdivision ordinance, as shown in Table 12. The subdivision control ordinance adopted during 2000 and administered by Washington County applies only to the statutory shoreland areas of the County.

Construction Site Erosion Control and Stormwater Management Regulations

Section 62.23 of the *Wisconsin Statutes* grants authority to cities and villages in Wisconsin to adopt ordinances for the prevention of erosion from construction sites and the management of stormwater runoff from lands within their jurisdictions. Towns also may adopt village powers and subsequently utilize the authority conferred on cities and villages under Section 62.23 to adopt their own erosion control and stormwater management ordinances.

Construction site erosion control and stormwater management ordinances were in effect in many of the communities within the tributary drainage area to Pike Lake during 2002, with the exception of the Village of Slinger, as shown in Table 12. The Towns of Hartford and Polk have adopted erosion control and stormwater management ordinances by reference to the County ordinance.

Washington County has adopted a construction erosion control and stormwater management ordinance. These ordinances apply to the unincorporated towns within the County. This ordinance requires persons engaging in land disturbing activities to employ soil erosion control practices on affected sites that are consistent with those set forth in the *Wisconsin Construction Site Best Management Practice Handbook* or equivalent practices. In general, these practices are designed to minimize soil lost from disturbed sites through prior planning and phasing of land disturbing activities and use of appropriate onsite erosion control measures.

Chapter IV

WATER QUALITY

HISTORICAL DATA

Limnological studies of Pike Lake date back to the early 1900s, when pioneering University of Wisconsin limnologists E.A. Birge and C.W. Juday collected basic information on the Lake.[1] Subsequently, R.J. Poff and C.W. Threinen of the then Wisconsin Conservation Department collected water quality data on Pike Lake during the early 1960s.[2] Their data suggested that the Lake was not dissimilar in quality to other Lakes in the Region, being a hard water, moderately fertile Lake. In recent years, data on the Lake have been collected by the Wisconsin Department of Natural Resources, with the most recent data, during 2000, being collected by the U.S. Geological Survey.[3] A major water quality planning study of Pike Lake was conducted by the Wisconsin Department of Natural Resources and Regional Planning Commission during 1976-1977, but remained incomplete until this planning program was initiated during 2000. These latter studies involved the determination of the physical and chemical characteristics of the Lake's water, including dissolved oxygen concentration and water temperature profiles, pH, specific conductance, water clarity, and nutrient and chlorophyll-*a* concentrations.

EXISTING WATER QUALITY CONDITIONS

Water quality data, gathered under the auspices of the Wisconsin Department of Natural Resources monitoring programs for the period from 1960 through 1979, are summarized in Table 13. A subset of these data was used during the initial 1976-1977 planning program to determine water quality conditions in the Lake, and to characterize the suitability of the Lake for recreational use and for the support of fish and aquatic life. These data are shown in Table 14. Ongoing Wisconsin Department of Natural Resources water quality monitoring extended these data through 1998. These data are set forth, together with the post-1972 data, in Table 15. Most recently, for the purposes of the current planning program, these early data were supplemented with selected data collected by the U.S. Geological Survey during 2000, summarized in Table 16. The primary sampling station used for the various sampling studies was located at the deepest portion of Pike Lake, as shown on Map 17.

---

[1]*E.A. Birge arid C. Juday, "The Dissolved Gases of the Water and their Biological Significance,"* The Inland Lakes of Wisconsin, *Wisconsin Geological Natural History Survey, Bulletin No. 22, 1911.*

[2]*R.J. Poff and C.W. Threinen,* Surface Water Resources of Washington County, *Wisconsin Conservation Department, 1963.*

[3]*See U.S. Geological Survey Open-File Report 01-86,* Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 2000, *2001.*

Table 13

SEASONAL WATER QUALITY CONDITIONS IN PIKE LAKE: 1960-1979

Parameter[a]	Fall (mid-September to mid-December)	Winter (mid-December to mid-March)	Spring (mid-March to mid-June)	Summer (mid-June to mid-September)
Physical Properties				
Alkalinity, as $CaCO_3$				
Range	185-206	220-246	200-240	197-214
Mean	199	232	226	204
Standard Deviation	- -	- -	- -	- -
Number of Samples	5	4	4	3
pH (units)				
Range	7.9-8.3	7.8-8.3	7.7-8.4	7.5-8.4
Mean	8.1	8.0	8.0	8.4
Standard Deviation	- -	- -	- -	- -
Number of Samples	21	21	41	40
Conductivity, as mS/cm				
Range	403-600	532-676	422-563	408-563
Mean	469	605	472	473
Standard Deviation	- -	- -	- -	- -
Number of Samples	21	21	41	40
Turbidity (FTU)				
Range	2.3-4.8	1.4-2.2	1.2-3.2	1.4-3.7
Mean	2.8	2.0	2.0	1.9
Standard Deviation	- -	- -	- -	- -
Number of Samples	6	6	5	4
Metals/Salts				
Dissolved Calcium				
Range	36-39	30-67	29-63	23-80
Mean	37	55	43	52
Standard Deviation	- -	- -	- -	- -
Number of Samples	5	4	8	7
Dissolved Chloride				
Range	25-42	36-48	9-38	6-39
Mean	29	35	31	29
Standard Deviation	- -	- -	- -	- -
Number of Samples	20	4	21	3
Dissolved Iron (µg/l)				
Range	0.09	- -	- -	- -
Mean	0.09	- -	- -	- -
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -
Dissolved Magnesium				
Range	22-42	36-41	20-39	21-50
Mean	38	37	31	38
Standard Deviation	- -	- -	- -	- -
Number of Samples	5	4	15	3
Dissolved Manganese (µg/l)				
Range	0.03	- -	- -	- -
Mean	0.03	- -	- -	- -
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -

Table 13 (continued)

Parameter[a]	Fall (mid-September to mid-December)	Winter (mid-December to mid-March)	Spring (mid-March to mid-June)	Summer (mid-June to mid-September)
Metals/Salts (continued)				
Dissolved Potassium				
Range	0.8-4.3	2.0-3.1	1.6-4.0	1.9-4.7
Mean	3.3	2.5	2.7	4.5
Standard Deviation	- -	- -	- -	- -
Number of Samples	5	4	7	5
Dissolved Sodium				
Range	6-17	11-16	3-17	3-28
Mean	12	14	12	13
Standard Deviation	- -	- -	- -	- -
Number of Samples	5	4	6	5
Dissolved Sulfate				
Range	21-29	30-36	12-35	25-29
Mean	26	33	28	26
Standard Deviation	- -	- -	- -	- -
Number of Samples	5	4	6	5
Nutrients				
Dissolved Nitrogen, Ammonia				
Range	0.03-0.16	0.03-0.32	0.03-0.60	0.03-1.67
Mean	0.14	0.15	0.21	0.24
Standard Deviation	- -	- -	- -	- -
Number of Samples	21	21	42	40
Dissolved Nitrogen, NO_2+NO_3				
Range	0.042-0.294	0.125-0.519	0.044-0.800	0.012-0.400
Mean	0.160	0.279	0.421	0.213
Standard Deviation	- -	- -	- -	- -
Number of Samples	21	21	42	40
Total Nitrogen, Organic				
Range	0.72-1.92	0.67-1.41	0.53-1.79	0.17-2.86
Mean	0.88	1.20	1.08	1.10
Standard Deviation	- -	- -	- -	- -
Number of Samples	21	21	42	40
Dissolved Orthophosphorus				
Range	0.006-0.040	0.004-0.044	0.004-0.038	0.005-0.059
Mean	0.008	0.023	0.015	0.018
Standard Deviation	- -	- -	- -	- -
Number of Samples	21	21	42	40
Total Phosphorus				
Range	0.02-0.16	0.01-0.05	0.01-0.15	0.01-0.32
Mean	0.03	0.03	0.05	0.09
Standard Deviation	- -	- -	- -	- -
Number of Samples	21	21	42	40

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

[b]*Depth of sample approximately 1.5 feet.*

[c]*Depth of sample greater than 30 feet.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 14

SEASONAL WATER QUALITY CONDITIONS IN PIKE LAKE: MAY 1976-APRIL 1977

Parameter[a]	Fall (mid-September to mid-December)	Winter (mid-December to mid-March)	Spring (mid-March to mid-June)	Summer (mid-June to mid-September)
Physical Properties				
Alkalinity, as $CaCO_3$				
Range	204-206	220-246	205	197-214
Mean	205	230	205	203
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	3	2	3
pH (units)				
Range	7.9-8.2	7.8-8.3	7.7-8.4	7.5-8.4
Mean	- -	- -	- -	- -
Standard Deviation	- -	- -	- -	- -
Number of Samples	- -	- -	- -	- -
Conductivity, as mS/cm				
Range	483-600	532-637	480-563	464-551
Mean	526	574	524	509
Standard Deviation	- -	- -	- -	- -
Number of Samples	18	18	37	36
Turbidity (FTU)				
Range	2.7-3.0	1.4-1.5	1.6-1.7	2.6-3.7
Mean	2.8	1.5	1.6	3.0
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	3	2	3
Metals/Salts				
Dissolved Calcium				
Range	36	42-50	54	50
Mean	36	45	54	50
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	3	2	3
Dissolved Chloride				
Range	31-42	36-48	9-38	14-39
Mean	35	40	31	28
Standard Deviation	- -	- -	- -	- -
Number of Samples	18	18	37	36
Dissolved Iron (μg/l)				
Range	0.09	- -	- -	- -
Mean	0.09	- -	- -	- -
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -
Dissolved Magnesium				
Range	41-42	36-37	37-39	50
Mean	42	36	38	50
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	3	2	3
Dissolved Manganese (μg/l)				
Range	0.03	- -	- -	- -
Mean	0.03	- -	- -	- -
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -

Table 14 (continued)

Parameter[a]	Fall (mid-September to mid-December)	Winter (mid-December to mid-March)	Spring (mid-March to mid-June)	Summer (mid-June to mid-September)
Metals/Salts (continued)				
Dissolved Potassium				
Range	2.4	2.0-2.5	2.3-2.4	4.1-4.7
Mean	2.4	2.2	2.4	4.3
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	3	2	3
Dissolved Sodium				
Range	12-13	11-16	11-12	14-28
Mean	12	14	12	19
Standard Deviation	- -	- -	- -	- -
Number of Samples	3	4	2	3
Dissolved Sulfate				
Range	29	34-36	30-32	26-27
Mean	29	35	31	26
Standard Deviation	- -	- -	- -	- -
Number of Samples	2	3	2	3
Nutrients				
Dissolved Nitrogen, Ammonia				
Range	0.03-0.16	0.04-0.30	0.03-0.48	0.03-1.67
Mean	0.07	0.10	0.10	0.30
Standard Deviation	- -	- -	- -	- -
Number of Samples	18	18	37	36
Dissolved Nitrogen, NO_2+NO_3				
Range	0.042-0.183	0.125-0.372	0.044-0.519	0.012-0.294
Mean	0.159	0.224	0.251	0.077
Standard Deviation	- -	- -	- -	- -
Number of Samples	18	18	37	36
Total Nitrogen, Organic				
Range	0.72-1.92	0.67-1.25	0.53-1.79	0.17-2.86
Mean	1.02	0.93	0.87	0.92
Standard Deviation	- -	- -	- -	- -
Number of Samples	18	18	37	36
Dissolved Orthophosphorus				
Range	0.006-0.040	0.004-0.014	0.004-0.026	0.006-0.059
Mean	0.008	0.006	0.010	0.013
Standard Deviation	- -	- -	- -	- -
Number of Samples	18	18	37	36
Total Phosphorus				
Range	0.02-0.16	0.01-0.05	0.01-0.07	0.01-0.10
Mean	0.03	0.02	0.03	0.03
Standard Deviation	- -	- -	- -	- -
Number of Samples	18	18	37	36

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

[b] *Depth of sample approximately 1.5 feet.*

[c] *Depth of sample greater than 30 feet.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 15

WATER QUALITY CONDITIONS IN PIKE LAKE: 1973-1998

Parameter[a]	Annual Shallow[b]	Annual Deep[c]
Physical Properties		
Alkalinity, as $CaCO_3$		
Range	180-230	182-250
Mean	207	213
Standard Deviation	- -	- -
Number of Samples	23	20
Hardness, as $CaCO_3$		
Range	182-286	191-375
Mean	250	265
Standard Deviation	- -	- -
Number of Samples	20	17
Color		
Range	10-25	15-25
Mean	17	18
Standard Deviation	- -	- -
Number of Samples	13	9
Dissolved Oxygen		
Range	0.1-17.8	0.0-14.1
Mean	10.2	3.3
Standard Deviation	- -	- -
Number of Samples	77	55
pH (units)		
Range	7.3-9.0	6.6-8.6
Mean	8.3	7.6
Standard Deviation	- -	- -
Number of Samples	64	45
Secchi Depth (feet)		
Range	2.6-21.0	- -
Mean	6.9	- -
Standard Deviation	- -	- -
Number of Samples	66	- -
Specific Conductance (μS/cm)		
Range	386-647	421-705
Mean	521	592
Standard Deviation	- -	- -
Number of Samples	17	16
Temperature (°F)		
Range	0-82	36-64
Mean	60	49
Standard Deviation	- -	- -
Number of Samples	75	53
Turbidity (FTU)		
Range	0.9-4.2	1.5-7.3
Mean	2.0	2.8
Standard Deviation	- -	- -
Number of Samples	20	16
Metals/Salts		
Dissolved Calcium		
Range	33-82	35-106
Mean	46	51
Standard Deviation	- -	- -
Number of Samples	20	17
Dissolved Chloride		
Range	20-71	20-71
Mean	40	40
Standard Deviation	- -	- -
Number of Samples	9	9
Dissolved Iron (μg/l)		
Range	0.05-0.10	0.05-0.10
Mean	0.05	0.05
Standard Deviation	- -	- -
Number of Samples	6	6

Parameter[a]	Annual Shallow[b]	Annual Deep[c]
Metals/Salts continued)		
Dissolved Magnesium		
Range	15-44	16-44
Mean	34	34
Standard Deviation	- -	- -
Number of Samples	20	17
Dissolved Manganese (μg/l)		
Range	40	40
Mean	40	40
Standard Deviation	- -	- -
Number of Samples	8	8
Dissolved Potassium		
Range	1.1-4.7	0.6-4.0
Mean	2.7	2.6
Standard Deviation	- -	- -
Number of Samples	16	11
Dissolved Silica		
Range	0.2-4.2	0.2-2.5
Mean	1.6	1.2
Standard Deviation	- -	- -
Number of Samples	13	10
Dissolved Sodium		
Range	5-38	4-39
Mean	20	20
Standard Deviation	- -	- -
Number of Samples	16	14
Dissolved Sulfate SO_4		
Range	22-35	21-36
Mean	28	29
Standard Deviation		
Number of Samples	17	15
Nutrients		
Dissolved Nitrogen, Ammonia		
Range	0.009-0.290	0.014-0.079
Mean	0.062	0.020
Standard Deviation	- -	- -
Number of Samples	26	20
Dissolved Nitrogen, NO_2+NO_3		
Range	0.08-0.49	0.02-0.48
Mean	0.29	0.24
Standard Deviation	- -	- -
Number of Samples	19	13
Total Nitrogen, Organic		
Range	0.42-0.77	0.39-0.88
Mean	0.52	0.58
Standard Deviation	- -	- -
Number of Samples	7	7
Dissolved Orthophosphorus		
Range	0.002-0.009	0.002-0.025
Mean	0.003	0.004
Standard Deviation	- -	- -
Number of Samples	19	14
Total Phosphorus		
Range	0.013-0.830	0.02-0.60
Mean	0.038	0.16
Standard Deviation	- -	- -
Number of Samples	75	55
Biological		
Chlorophyll-*a* (μg/l)		
Range	0.6-33.3	- -
Mean	10.6	- -
Standard Deviation	- -	- -
Number of Samples	62	- -

Table 15 Footnotes

[a]Milligrams per liter unless otherwise indicated.

[b]Depth of sample approximately 1.5 feet.

[c]Depth of sample greater than 30 feet.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 16

WATER QUALITY CONDITIONS IN PIKE LAKE: 2000

Parameter[a]	February 16		July 17		August 18	
	Shallow	Deep	Shallow	Deep	Shallow	Deep
Physical Properties						
pH (units)						
Range	9.9	7.5	8.3	7.2	8.2	7.1
Conductivity, as mS/cm						
Range	702	957	600	712	607	737
Dissolved Oxygen						
Range	14.1	1.0	9.5	0.0	8.2	0.0
Temperature, in °F						
Range	34	40	79	51	73	52
Secchi Depth (feet)						
Range	- -	- -	4.2	- -	6.9	- -
Nutrients						
Dissolved Nitrogen, Ammonia						
Range	- -	- -	0.023	- -	- -	- -
Dissolved Nitrogen, NO_2+NO_3						
Range	- -	- -	0.021	- -	- -	- -
Total Nitrogen, Organic						
Range	- -	- -	1.34	- -	- -	- -
Dissolved Orthophosphorus						
Range	- -	- -	0.004	- -	- -	- -
Total Phosphorus						
Range	- -	- -	0.024	- -	- -	- -
Biological						
Chlorophyll-*a* (µg/l)						
Range	- -	- -	6	- -	6	- -

[a]Milligrams per liter unless otherwise indicated.

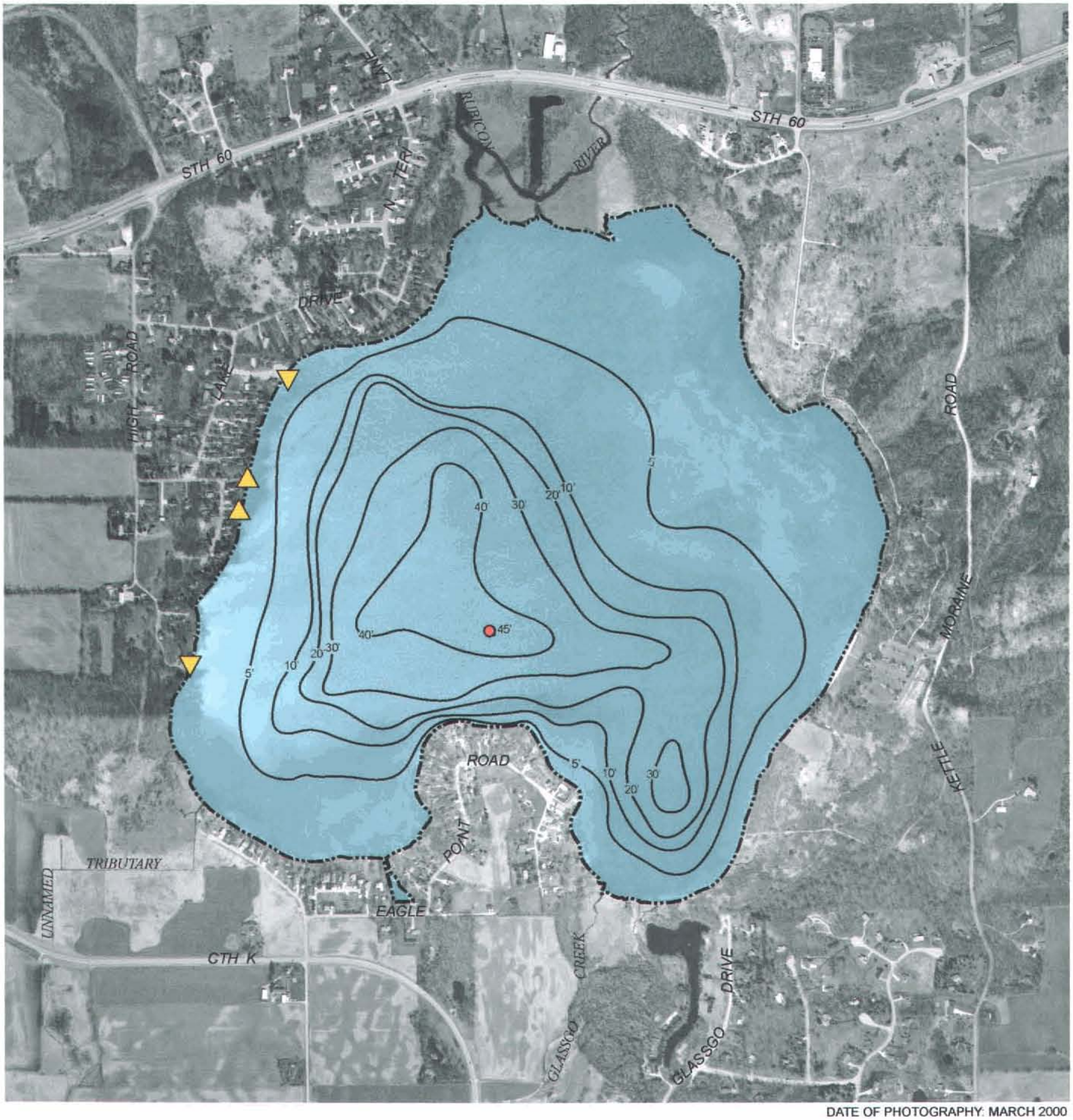
[b]Depth of sample approximately 1.5 feet.

[c]Depth of sample approximately 40 feet.

Source: U.S. Geological Survey and SEWRPC.

Map 17

BATHYMETRIC MAP OF PIKE LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

—20'— WATER DEPTH CONTOUR IN FEET

● MONITORING SITE

△ PUBLIC ACCESS SITE

▽ PRIVATE ACCESS SITE

GRAPHIC SCALE 0 600 1200 FEET

Source: U.S. Geological Survey and SEWRPC.

Thermal Stratification

Typical monthly temperature and dissolved oxygen profiles taken at the primary sampling station during 2000 are shown in Figure 2. Water temperatures in Pike Lake ranged from a minimum of 32°F (0°C) during the winter to a maximum of 83°F (27°C) during the summer. Based upon the 1976-1997 data, the Lake was dimictic, which means that it mixes completely two times per year, and is subject to thermal stratification during summer and winter. The data shown in Figure 2 are not incompatible until a dimictic state, which is typical of many of the Region's waterbodies. This mixing process is described below.

Thermal stratification is a result of the differential heating of the lake water, and the resulting water temperature-density relationships at various depths within the lake water column. This process is illustrated diagrammatically in Figure 3. Water is unique among liquids because it reaches its maximum density, or mass per unit of volume, at about 39°F. The development of summer thermal stratification begins in early summer, reaches its maximum in late summer, and disappears in the fall. Stratification may also occur during winter under ice cover. The annual thermal cycle within Pike Lake is described below.

As summer begins, the Lake absorbs solar energy at the surface. Wind action and, to some extent, internal heat transfer mechanisms transmit this energy to the underlying portions of the waterbody. As the upper layer of water is heated by solar energy, a physical barrier, created by differing water densities between warmer and cooler water, begins to form between the warmer surface water and the colder, heavier bottom water. This "barrier" is marked by a sharp temperature gradient known as the thermocline and is characterized by a 1°C drop in temperature per one meter (or about a 2°F drop in temperature per three feet) of depth that separates the warmer, lighter, upper layer of water (called the epilimnion) from the cooler, heavier, lower layer (called the hypolimnion), as shown in Figure 4. Although this barrier is readily crossed by fish, provided sufficient oxygen exists, it essentially prohibits the exchange of water between the two layers. This condition has a major impact on both the chemical and biological activity in a lake. In Pike Lake, based upon the data set forth in Figure 2 for July and August 2000, much of the hypolimnion is anoxic, or devoid of dissolved oxygen.

The autumnal mixing period occurs when air temperatures cool the surface water and wind action results in the erosion of the thermocline: as the surface water cools, it becomes heavier, sinking and displacing the now relatively warmer water below. The colder water sinks and mixes under wind action until the entire column of water is of uniform temperature, as shown in Figure 3. This action, which follows summer stratification, is known as "fall turnover."

When the water temperature drops to the point of maximum water density, 39.2°F, the waters at the lake surface become denser than the now warmer, less dense bottom waters, and "sink" to the bottom. Eventually, the water column is cooled to the point where the surface waters, cooled to about 32°F, are now lighter than the bottom waters which remain at about 39°F. The lake surface may then become ice covered, isolating the lake water from the atmosphere for a period of up to four months. On Pike Lake, ice cover is reported to typically exist from December until early April. As shown in Figures 2 and 3, winter stratification occurred as the colder, lighter water and ice remained at the surface, separated from the relatively warmer, heavier water near the bottom of the lake.

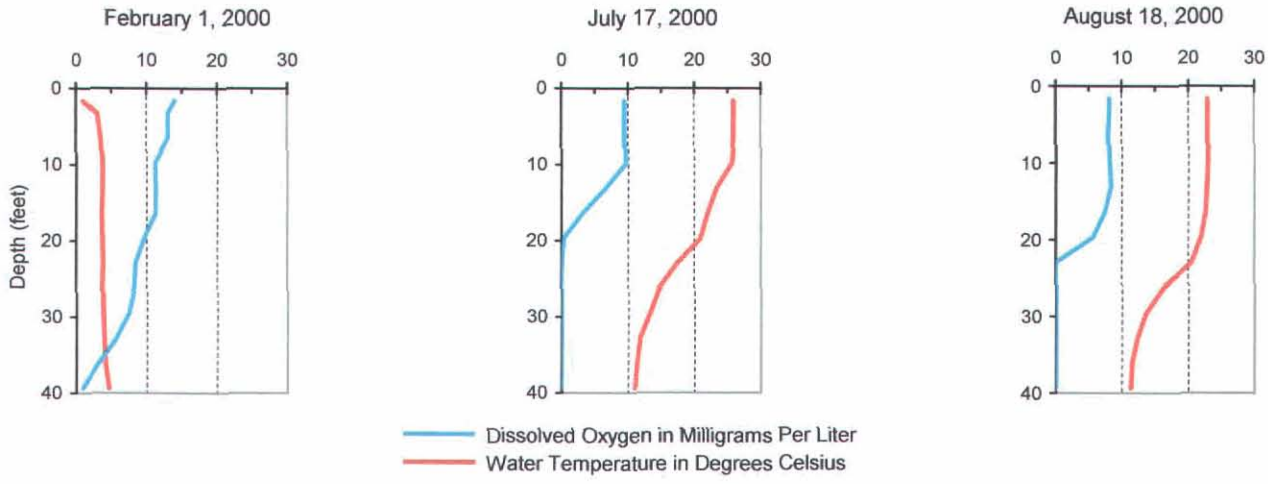
Spring brings a reversal of the process. As the ice thaws and the upper layer of water warms, it becomes denser and begins to approach the temperature of the warmer, deeper water until the entire water column reaches the same temperature from surface to bottom. This is referred to as "spring turnover"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

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. As shown in Figure 2, dissolved oxygen levels were generally higher at the surface of Pike Lake, where there was an

Figure 2

DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR PIKE LAKE: 2000



Source: U.S. Geological Survey and SEWRPC.

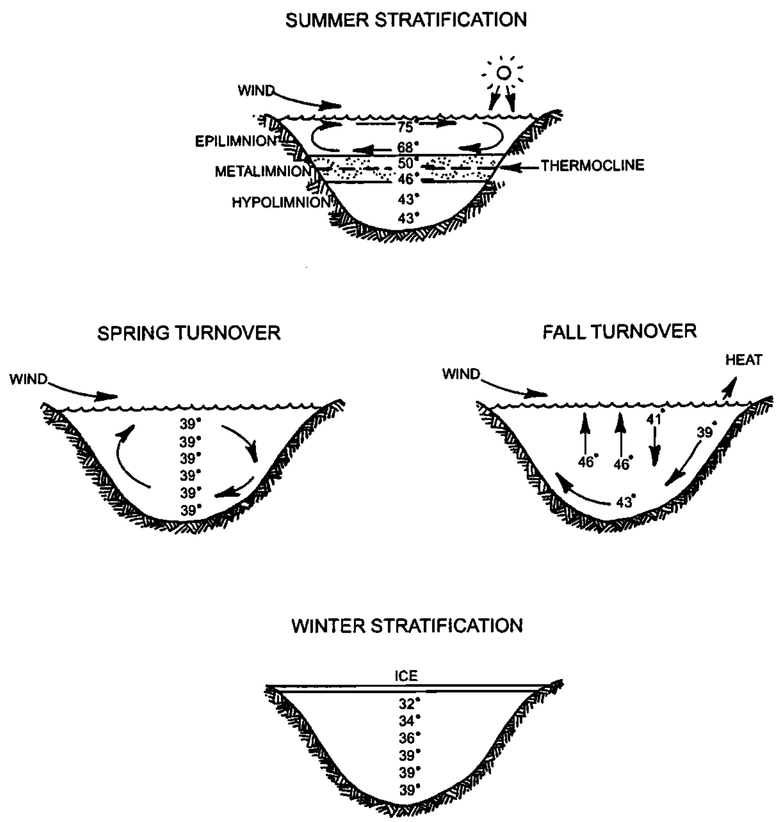
interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels were lowest on the bottom of the Lake, where decomposer organisms and chemical oxidation processes utilized oxygen in the decay process. When any lake becomes thermally stratified, as described above, the surface supply of dissolved oxygen to the hypolimnion is cut off. Gradually, if there is not enough dissolved oxygen to meet the total demands from the bottom dwelling aquatic life and decaying organic material, the dissolved oxygen levels in the bottom waters may be reduced, even to zero, a condition known as anoxia or anaerobiasis, as shown in Figures 3 and 4.

During 2000, dissolved oxygen concentrations in the surface waters of Pike Lake ranged from about 8.2 milligrams per liter (mg/l) during summer to about 14.1 mg/l during winter. Hypolimnetic dissolved oxygen concentrations dropped to zero during late summer, as shown in Figure 2. Based upon the 1976-1977 data, dissolved oxygen concentrations at the bottom of the Lake fell to zero by mid- to late-June, dropping below the recommended concentration of five mg/l, the minimum level necessary to support many species of fish, at about 20 feet in depth. Similar profiles were observed during 2000, as shown in Figure 2.

Fall turnover, during September 1976, and likely to occur between September and October in most years, naturally restores the supply of oxygen to the bottom water, although hypolimnetic anoxia can be reestablished during the period of winter thermal stratification, as was observed during December 1976. Data for February 2000, shown in Figure 2, suggest that low dissolved oxygen concentrations may occur regularly in the hypolimnion during the winter months. Winter anoxia is more common during the years of heavy snowfall, when snow covers the ice, reducing the degree of light penetration and reducing algal photosynthesis that takes place under the ice. In some lakes in the Region, hypolimnetic anoxia can occur during winter stratification. Under these conditions, anoxia can contribute to the winter-kill of fish. At the end of winter, dissolved oxygen concentrations in the bottom waters of the Lake are restored during the period of spring turnover, which generally occurs between March and May.

Figure 3

THERMAL STRATIFICATION OF LAKES



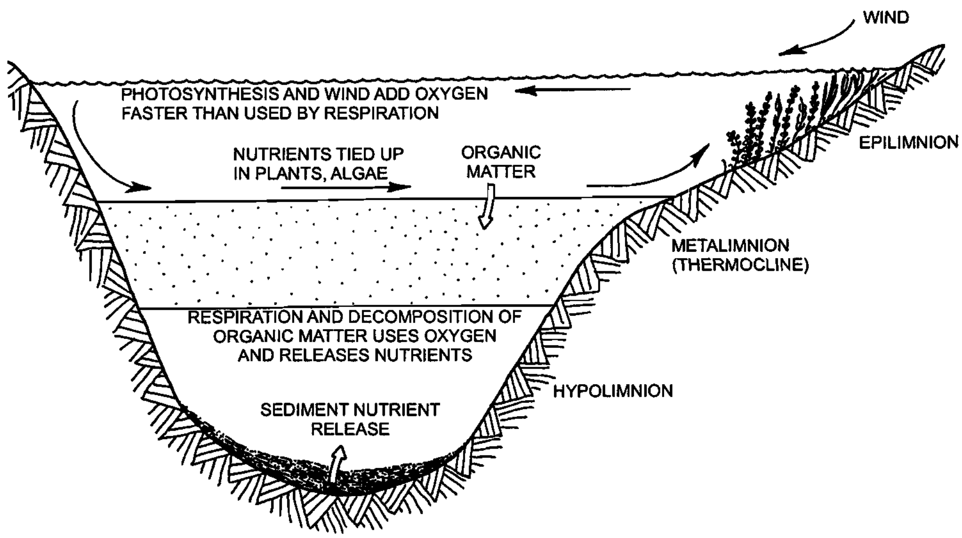
Source: University of Wisconsin-Extension and SEWRPC.

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

In addition to these biological consequences, the lack of dissolved oxygen at depth can enhance the development of chemoclines, or chemical gradients, with an inverse relationship to the dissolved oxygen concentration. For example, the sediment-water exchange of elements such as phosphorus, iron, and manganese is increased under anaerobic conditions, resulting in higher hypolimnetic concentrations in these elements. Under anaerobic conditions, iron and manganese change oxidation states enabling the release of phosphorus from the iron and manganese complexes to which they are bound under aerobic conditions. This "internal loading" can affect water quality significantly if these nutrients and salts are mixed into the epilimnion, especially during early summer when these nutrients can become available for algal and rooted aquatic plant growth. The likely import of internal loading to the nutrient budget of Pike Lake is discussed further below.

Figure 4

LAKE PROCESSING DURING SUMMER STRATIFICATION



Source: University of Wisconsin-Extension and SEWRPC.

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. This is a consequence of the "internal loading" phenomenon noted above. As shown in Figure 5, the specific conductance of Pike Lake ranged from 600 to 957 microSiemens per centimeter (μS/cm) at 25°C during 2000. During the 1976-1977 planning study, conductivity ranged from 464 to 637 μS/cm, and was somewhat higher than for most other lakes in Southeastern Wisconsin.[4]

Chloride

During the 1976-1977 planning study, chloride concentrations ranged from nine to 48 mg/l, which were reported to be somewhat lower than the concentrations found in many lakes in Southeastern Wisconsin.[5] However, an increasing trend in chloride concentrations has been observed within the Southeastern Wisconsin Region, as shown in Figure 6. Peak chloride concentrations ranged up to 71 mg/l during the period 1973 to 1998, as shown in Table 15. The most important anthropogenic sources of chlorides to Pike Lake are believed to be the salts used in domestic water softener systems, and on streets and highways for winter snow and ice control.

Alkalinity

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 soils and underlying

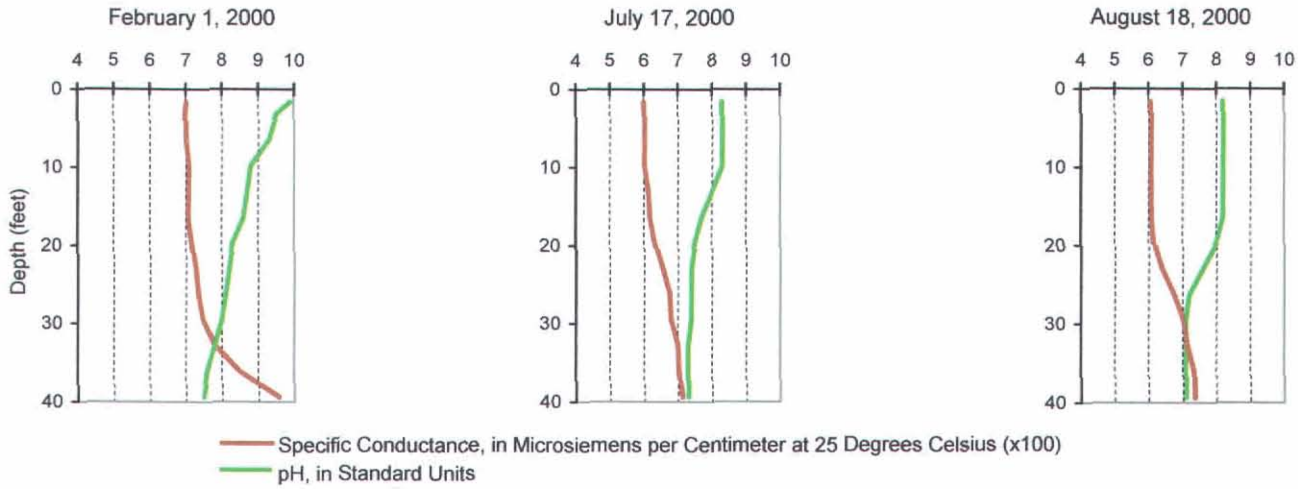
---

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

[5]Ibid.

Figure 5

SPECIFIC CONDUCTANCE AND pH PROFILES FOR PIKE LAKE: 2000



Source: U.S. Geological Survey and SEWRPC.

bedrock in the Region's watersheds. In contrast, water hardness is a measure of the multivalent metallic ion concentrations, such as those of calcium and magnesium, present in a lake. Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$). Applying these measures to the study lake, Pike Lake may be classified as a hard-water alkaline lake. During the 1976-1977 study period, the alkalinity averaged about 215 mg/l, as shown in Table 13, and continued at about the same level through 1998, as shown in Table 15. Hardness ranged from 182 mg/l to 286 mg/l during this latter period, as shown in Table 15. 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, and a pH below 7 indicates acidic water. In Pike Lake, pH fluctuated between 7.5 and 8.4 standard units during the 1976-1977 planning period, and between 7.1 and about 9.9 standard units during the 2000 study period, as shown in Tables 13 through 16. Since Pike Lake has a high alkalinity or buffering capacity, and because the pH does not fluctuate below 7, the Lake is not considered to be susceptible to the harmful effects of acidic deposition. Nevertheless, pH did tend to decrease with depth, as shown in Figure 5.

Water Clarity

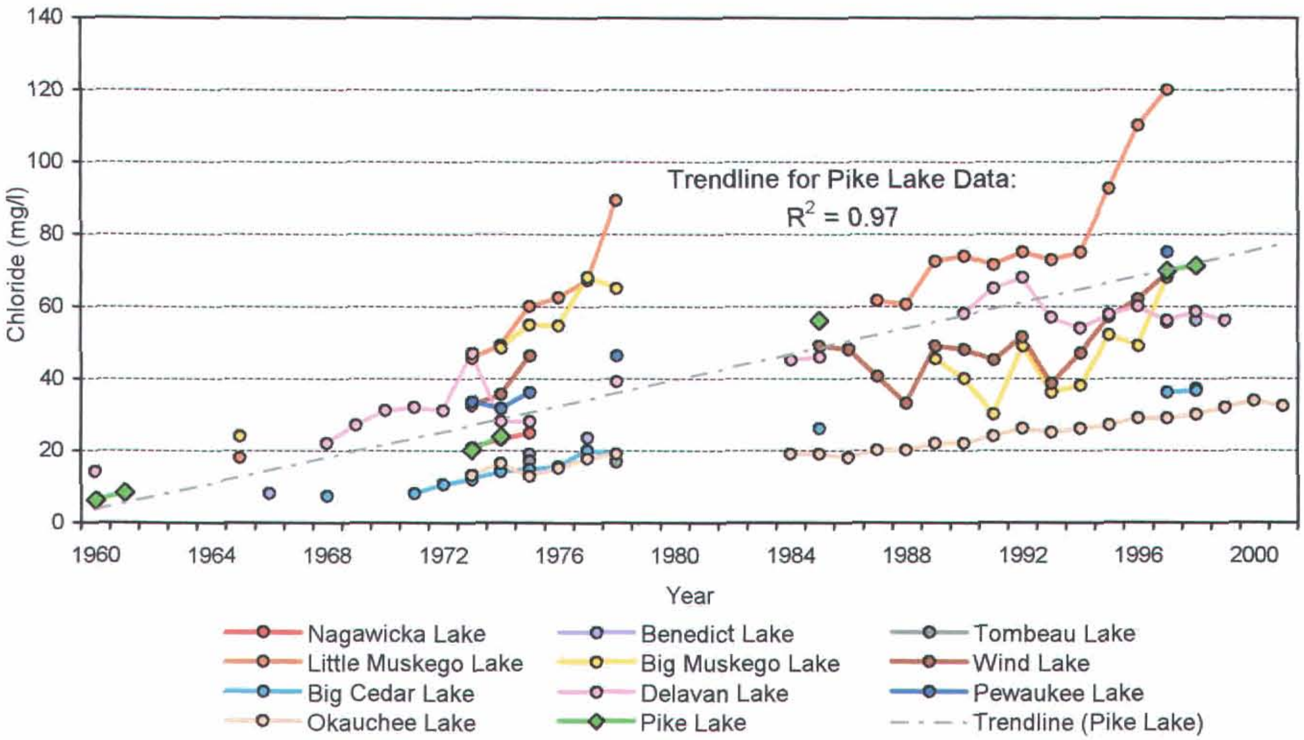
Water clarity, or transparency, provides an indication of overall water quality; clarity may decrease because of turbidity caused by high concentrations of organic and inorganic suspended materials, such as algae and zooplankton, and suspended sediment, and/or because of color caused by high concentrations of dissolved organic substances. Water clarity is measured with a Secchi-disc, 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-disc reading." Such measurements comprise an important part of the Wisconsin Department of Natural Resources Self-Help Monitoring Program in which citizen volunteers assist in lake water quality monitoring efforts.

---

[6]Ibid.

Figure 6

CHLORIDE CONCENTRATION TRENDS FOR ASSORTED LAKES IN SOUTHEASTERN WISCONSIN: 1960-2001



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

Water clarity generally varies throughout the year as algal populations increase and decrease in response to changes in weather conditions and nutrient loadings. Secchi-disc measurements for the year 2000 study period averaged about 7.25 feet. The lower reading was recorded during July, primarily because of the growth of free-floating algae. As shown in Figure 7, these values indicate poor to good water quality compared to other lakes in Southeastern Wisconsin.[7] During the 1976-1977 study period, Secchi disc transparencies ranged from 3 feet to about 17.5 feet, with the deeper readings being reported during the winter months. Transparencies of up to 21 feet have been measured in Pike Lake, as shown in Table 15.

Chlorophyll-*a*

Chlorophyll-*a* is the major photosynthetic ("green") pigment in algae. The amount of chlorophyll-*a* present in the water is an indication of the biomass or amount of algae in the water. During the 1976-1977 study period, chlorophyll-*a* values in Pike Lake ranged from a low of 0.1 milligram per cubic meter (mg/m^3) in May 1976, to a high of 10.4 mg/m^3 on July 3, 1976, with an average of 3.7 mg/m^3. Values of 6.0 mg/m^3 were reported during the year 2000 study. All of these values are within the range of chlorophyll-*a* concentrations recorded in other lakes in the Region[8] and generally indicate fair to very good water quality, as illustrated in Figure 7. Chlorophyll-*a* levels above about 10 μg/l range result in a green coloration of the water that may be severe enough to impair

[7] Ibid.

[8] Ibid.

Figure 7

PRIMARY WATER QUALITY INDICATORS FOR PIKE LAKE: 1973-2000

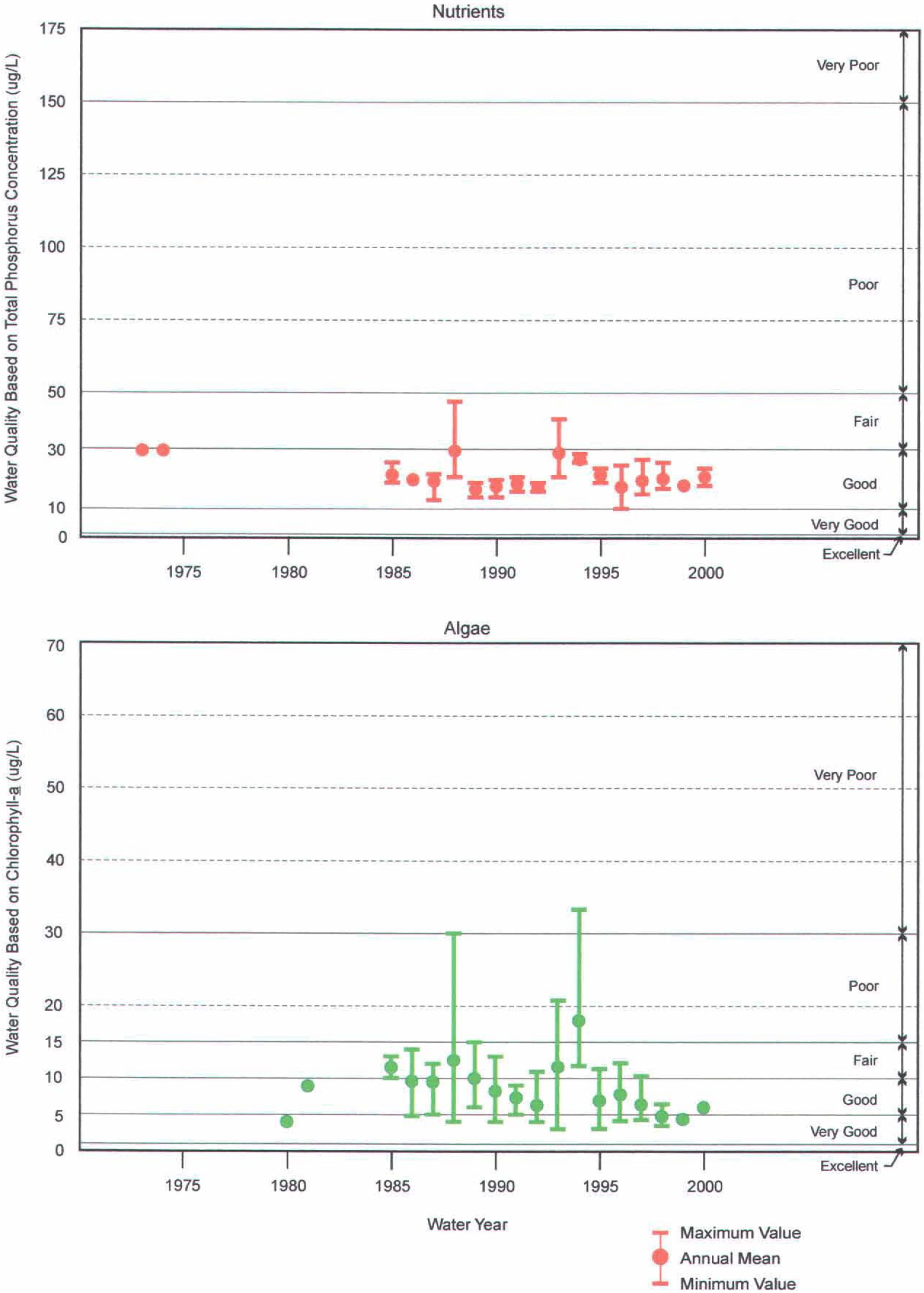
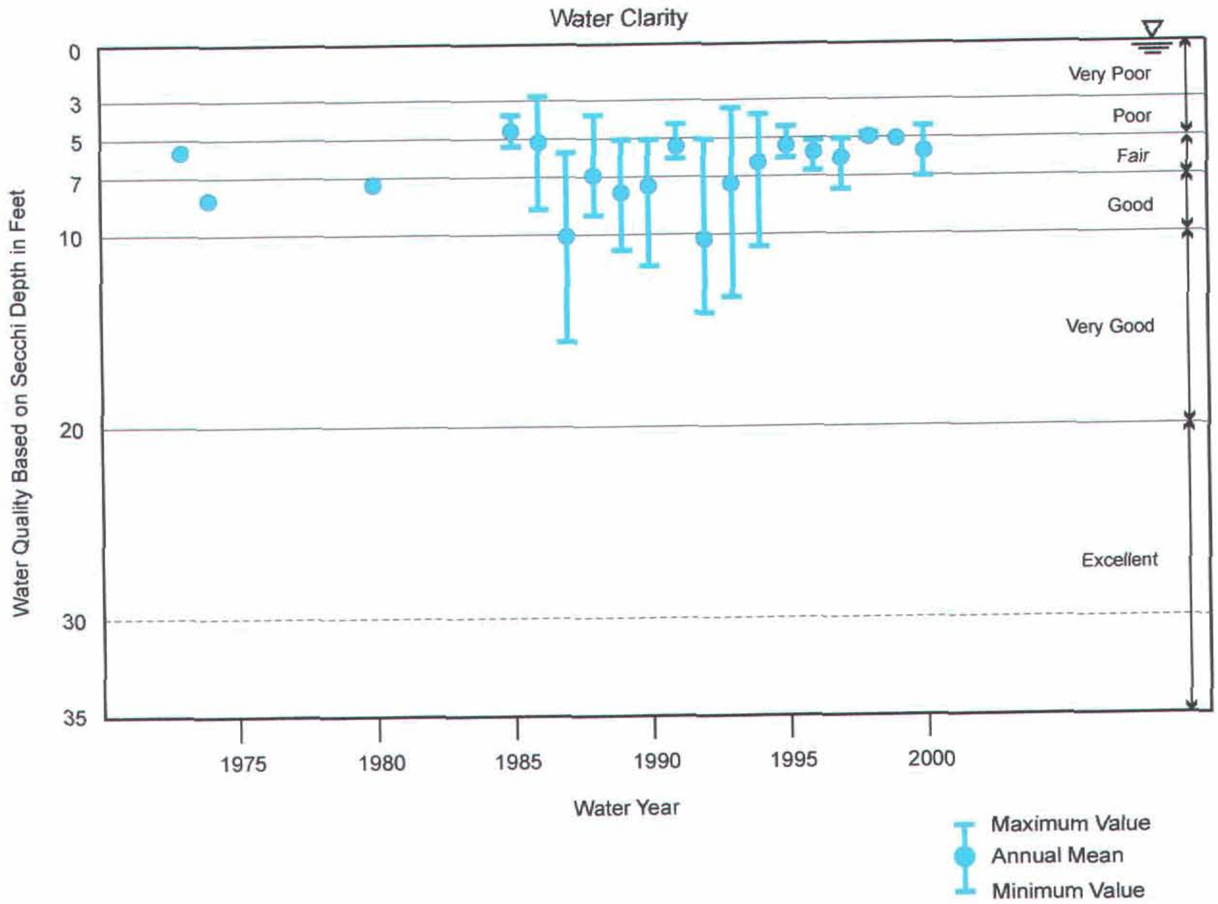


Figure 7 (continued)



Source: U.S. Geological Survey and SEWRPC.

recreational activities such as swimming and skiing.[9] Values in excess of this level have been reported from Pike Lake, with chlorophyll-*a* concentrations exceeding 20 μg/l during three years of record, 1987, 1993, and 1994, as shown in Figure 7.

Nutrient Characteristics

Aquatic plants and algae require such nutrients as phosphorus and nitrogen for growth. In hard-water alkaline lakes, most of these nutrients are generally found in concentrations that exceed the needs of growing plants. However, in lakes where the supply of one or more of these nutrients is limited, plant growth is limited by the amount of that nutrient available. The ratio of total nitrogen (N) to total phosphorus (P) in lake water indicates which nutrient is the factor most likely limiting aquatic plant growth in a lake.[10] Where the N:P ratio is greater

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

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

than 14:1, phosphorus is most likely to be the limiting nutrient. If the ratio is less than 10:1, nitrogen is most likely to be the limiting nutrient. As shown in Table 17, the nitrogen-to-phosphorus ratios in samples collected from Pike Lake were always greater than 10:1. This indicates that plant production was most likely consistently limited by phosphorus. In fact, the summer N:P ratio was frequently equal to or greater than 22:1. This indicates that summer aquatic plant growth in Pike Lake is generally limited by phosphorus.

Both total phosphorus and soluble phosphorus concentrations were measured for Pike 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. In lakes where wastewater discharges dominate the inflow, dissolved or orthophosphate phosphorus can comprise the major form of phosphorus. Hence, these lakes tend to be characterized by high levels of biological production, as the nutrient is present in a form that is most suitable for uptake by the aquatic plants. Conversely, in lakes whose inflows are dominated by runoff from an undisturbed watershed, dissolved phosphorus is present in much lower concentrations, and in-lake productivity is less abundant.[11]

Total phosphorus concentrations in Pike Lake were found to exceed the levels necessary to support periodic nuisance algae blooms. The recommended water quality standard for phosphorus, which is set forth in the Commission's adopted regional water quality management plan for lakes, is 0.02 mg/l of total phosphorus or less during spring turnover. This is the level considered in the regional plan as necessary to limit algae and aquatic plant growth to levels consistent with the recreational and warmwater fishery and other aquatic life water use objectives.

In Pike Lake, during the 1976-1977 planning period, the mean concentration of total phosphorus was 0.05 mg/l on an average annual basis, indicating fair to poor water quality, as illustrated in Figure 7. Dissolved phosphorus, or orthophosphate, concentrations ranged from 0.004 mg/l to 0.059 mg/l in the surface waters. During the year 2000 study period, surface water total phosphorus concentrations averaged 0.02 mg/l, with hypolimnetic total phosphorus concentrations averaging 0.11 mg/l during this period. Dissolved phosphorus concentrations ranged from 0.004 mg/l at the surface to 0.051 mg/l in the hypolimnion during July 2000.

Seasonal gradients of phosphorus concentration were observed during the year 2000 study period between the epilimnion and hypolimnion. Such gradients reflect the biogeochemistry of this growth element. When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed. Phosphorus from these organisms is then either stored in the bottom sediments or rereleased into the water column. Because phosphorus is not highly soluble in water, it readily forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions and accumulates, predominantly, in the lake sediments. If the bottom waters become depleted of oxygen during stratification, however, certain chemical changes occur, 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 year 2000 data indicated that there was internal loading of phosphorus from the bottom sediments of Pike Lake. As noted above, the dissolved phosphorus concentrations in the bottom waters were relatively high, ranging from about 0.02 mg/l to 0.05 mg/l for samples collected during the summer when such releases of phosphorus are

---

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

Table 17

NITROGEN-PHOSPHORUS RATIOS FOR PIKE LAKE: 1976-2000

Date	Nutrient Levels		
	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	N:P Ratio (mg/l)
May 17, 1976	1.35	0.02	67.5
June 2, 1976	1.09	0.03	36.3
June 17, 1976	0.53	0.02	26.5
June 30, 1976	0.75	0.02	37.5
July 14, 1976	2.01	0.02	100.5
July 28, 1976	0.44	0.02	22.0
August 11, 1976	1.13	0.05	22.6
August 25, 1976	0.75	0.01	75.0
September 9, 1976	0.46	0.02	15.3
September 22, 1976	0.81	0.02	40.5
October 20, 1976	1.02	0.03	34.0
December 20, 1976	0.97	0.02	48.5
January 19, 1977	0.78	0.03	26.0
February 15, 1977	1.04	0.05	20.8
March 30, 1977	0.68	0.03	22.7
April 13, 1977	0.78	0.02	39.0
April 11, 1985	0.70	0.02	35.0
June 24, 1985	0.90	0.03	30.0
July 16, 1985	0.80	0.02	40.0
October 30, 1985	0.60	0.02	30.0
March 6, 1986	0.44	0.01	44.0
April 9, 1987	0.70	0.02	35.0
April 26, 1989	0.80	0.03	26.7
April 18, 1991	1.00	0.04	25.0
April 15, 1992	0.80	0.03	26.7
April 20, 1994	1.00	0.02	50.0
April 12, 1995	1.20	0.05	24.0
May 7, 1996	0.90	0.03	30.0
May 6, 1997	0.90	0.03	30.0
April 1, 1998	0.89	0.03	29.7
July 17, 2000	1.34	0.02	55.8

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

most likely to occur. While the magnitude of this release and its concomitant effects in contributing to algal growth in the surface waters of the Lake may be moderated by a number of circumstance, including the rate of mixing during the spring and fall overturn events, the contribution of phosphorus from the bottom waters of Pike Lake should be considered in terms of the total phosphorus load.

Groundwater Quality

During the 1976-1977 study, groundwater quality was monitored in eight paired observation wells around Pike Lake. Groundwater contributions of inorganic nitrogen ranged between 0.001 and 0.620 mg/l for nitrite (NO_2); between 0.07 and 8.16 mg/l for nitrate (NO_3) nitrogen; and, between 0.03 and 1.14 mg/l for ammonia nitrogen (NH_3). Mean values for these constituents were 0.064 mg/l, 0.87 mg/l and 0.21 mg/l, respectively. Total phosphorus values ranged from 0.01 to 0.09 mg/l, with a mean value of 0.02 mg/l. Nutrient concentrations were not considered to be excessive in the well waters examined, and no bacterial contamination of significance was found, membrane filtered fecal coliform bacterial counts (MFFCC) for the wells sampled averaged 10 MFFCC/100 milliliters of sample. Other groundwater quality parameters are given in Table 18.

Table 18

WATER QUALITY VALUES FOR PIKE LAKE INLETS, OUTLET, AND GROUNDWATER WELLS: 1976-1977

Water Quality Parameter[a]	Deepest In-lake Point		Rubicon River Lake Inlet		Unnamed Tributary Lake Inlet		Rubicon River Lake Outlet		Groundwater Wells[b]	
	Range	Mean[c]	Range	Mean[c]	Range	Mean[c]	Range	Mean[c]	Range	Mean[c]
Nitrite Nitrogen	- -	- -	0.002-0.126	.022	0.002-0.023	0.010	0.002-0.095	0.016	0.001-0.620	0.064
Nitrate Nitrogen	- -	- -	0.59-2.81	1.50	0.06-1.28	0.24	0.51-3.59	1.78	0.07-8.16	0.87
Ammonia Nitrogen	- -	- -	0.03-0.16	0.03	0.03-0.16	0.05	0.03-0.34	0.05	0.03-1.14	0.21
Organic Nitrogen	- -	- -	0.28-1.72	0.72	0.34-1.19	0.77	0.26-2.85	0.77	0.12-1.58	0.82
Total Nitrogen	- -	- -	1.26-4.23	2.26	0.47-2.14	1.08	1.38-6.39	2.61	1.25-8.33	3.14
Reactive Phosphorus	- -	- -	0.040-0.140	0.074	0.006-0.041	0.015	0.004-0.099	0.051	0.004-0.070	0.019
Total Phosphorus	- -	- -	0.05-0.41	0.10	0.01-0.09	0.04	0.02-0.23	0.10	0.01-0.09	0.02
Chloride	- -	- -	47-144	68	32-51	39	11-21	16	1-467	86
Conductivity (micromhos/cm)	- -	- -	626-886	745	444-626	546	480-628	584	550-2,236	882
pH (standard units)	- -	- -	7.5-8.3	- -	7.6-8.4	- -	7.6-8.4	- -	7.7-8.0	- -
Total Suspended Solids	0.4-37.0	7.0	0.6-22.7	6.8	1.0-12.0	4.2	1.0-77.7	22.6	- -	- -
Biochemical Oxygen Demand	0.80-5.22	2.46	0.22-10.80	3.24	1.10-9.20	3.52	0.10-8.40	3.06	- -	- -
Chemical Oxygen Demand	8.2-25.7	16.7	7.2-79.5	30.5	12.9-49.2	27.3	7.5-85.5	24.2	- -	- -
Calcium	- -	- -	- -	- -	- -	- -	- -	- -	56-96	74
Magnesium	- -	- -	- -	- -	- -	- -	- -	- -	39-60	46
Sodium	- -	- -	- -	- -	- -	- -	- -	- -	5-182	49
Potassium	- -	- -	- -	- -	- -	- -	- -	- -	1.5-2.6	1.9
Sulfate	- -	- -	- -	- -	- -	- -	- -	- -	5-28	15
Iron	- -	- -	- -	- -	- -	- -	- -	- -	0.06-1.57	1.2
Manganese	- -	- -	- -	- -	- -	- -	- -	- -	0.03-0.14	0.04
Fecal Coliform Count (no./100 ml)	- -	- -	- -	- -	- -	- -	- -	- -	10-20	10
Turbidity (Formazin units)	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

[a]*All values in mg/l, unless otherwise specified.*

[b]*Samples taken at six sites.*

[c]*Number of samples in parentheses.*

[d]*Nitrite and nitrate nitrogen are measured together.*

Source: Wisconsin Department of Natural Resources.

POLLUTION LOADINGS AND SOURCES

Pollutant loads to a lake are generated by various natural processes and human activities that take place in the drainage area tributary to a lake.[12] These loads are transported to the lake through the atmosphere, across the land surface, and by way of inflowing streams. Pollutants transported by the atmosphere are deposited onto the surface of the lake as dry fallout and direct precipitation. Pollutants transported across the land surface enter the lake as direct runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Pollutants transported by streams enter a lake as surface water inflows. In addition to identifiable or point source discharges from industries and wastewater treatment facilities, nonpoint sourced pollutants comprise the principal route by which contaminants enter a waterbody. 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 Pike Lake is about 7,966 acres in areal extent, including about 3,998 acres that drain to the Lake without passing through any upstream waterbodies. As already noted, inflow to Pike Lake is primarily through the Rubicon River and a series of local drainageways, including Glasgow Creek and the unnamed tributaries located along the southwestern and eastern shores of the Lake.

Point Sources

Currently, the Village of Slinger wastewater treatment facility forms the single significant point source discharge of pollutants within the Pike Lake drainage area.[13] This plant, constructed in 1950 with a major reconstruction in 1981 pursuant to recommendations set forth in the adopted regional water quality management plan,[14] discharges indirectly to the Rubicon River through a wetland complex. In addition, the Pike Lake Unit of the Kettle Moraine State Forest operated a private soil absorption wastewater treatment plant within the drainage area. The Pike Lake Unit of the Kettle Moraine State Forest treatment facility was abandoned, as recommended in the regional water quality plan, during 1990 and connected to the City of Hartford sewerage system. The City of Hartford wastewater treatment facility discharges treated effluent to the Rubicon River downstream of Pike Lake.

The Village of Slinger wastewater treatment facility was reported to discharge an annual average volume of treated wastewater of approximately 0.33 million gallons per day (mgd) in 1990, which increased to about 0.60 mgd during 2001 and 2002. The design capacity of the sewage treatment facility is about 0.76 mgd.[15] The wastewater treatment facility employs a secondary treatment process, which is comprised of an activated sludge oxidation ditch system and clarification followed by chlorination and dechlorination and effluent aeration. Chemicals are added for phosphorus removal purposes. In 1990, the plant was estimated to treat 420 pounds of biochemical oxygen demand (as BOD) and approximately 660 pounds of suspended solids per day. The current (year 2002) plant loadings are about 900 pounds of BOD, 890 pounds of suspended solids, and 31 pounds of

---

[12]*Sven-Olof Ryding and Walter Rast,* op. cit.*; Jeffrey A. Thornton, Walter Rast, Marjorie M. Holland, Geza Jolankai, and Sven-Olof Ryding,* op. cit.

[13]*SEWRPC Community Assistance Planning Report No. 128, 3rd Edition,* Sanitary Sewer Service Area for the Village of Slinger and Environs, Washington County, Wisconsin, *December 1998; see also SEWRPC,* Amendment to the Regional Water Quality Management Plan: Village of Slinger, *June 2002.*

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

[15]*During 2003, the Village had a reevaluation of the sewage treatment plant capacity prepared which indicates that the capacity of 1.0 mgd on an average daily hydraulic loading capacity and 1,501 pounds of BOD on an organic loading basis could be achieved by minor equipment modifications. See the report prepared by McMahon Associates, Inc., entitled,* Capacity Analysis and Re-Rating of the Village of Slinger Wastewater Treatment Facility, *dated November 21, 2002.*

phosphorus on an average daily basis. The current (year 2002) plant effluent characteristics include average concentrations of 4.0 mg/l of BOD, 4.0 mg/l of suspended solids, and 0.6 mg/l of phosphorus. At current plant hydraulic loadings, this results in about 7,000 pounds of BOD, 7,000 pounds of suspended solids, and 1,000 pounds of phosphorus per year. The annual hydraulic loading from the plant is estimated to be 650 acre-feet per year.

Nonpoint Sources

Nonpoint-sourced phosphorus, suspended solids, and urban-derived metals input to and output from Pike Lake were estimated using the Wisconsin Lake Model Spreadsheet (WILMS version 3.0),[16] and unit area load-based models developed for use within the Southeastern Wisconsin Region. Contaminant loads were estimated for base year 1995 land use conditions, and for forecast year 2020 land use conditions.

Phosphorus Loadings

During the present study, 1995 and Commission planned year 2020 land use data, derived from the adopted regional land use plan, were used to estimate phosphorus loads to the Lake. Phosphorus has been identified as the factor generally limiting aquatic plant growth in Pike Lake. Thus, excessive levels of phosphorus in the Lake are likely to result in conditions that interfere with the desired use of the Lake.

With the implementation of the remedial measures set forth in the adopted regional water quality management, changes in the nutrient, sediment, and metal loadings to Pike Lake may be anticipated. These changes were evaluated during the present study using the WILMS and unit area loading models. Forecast nutrient, sediment, and metals loads for Pike Lake based upon 1995 land use and planned 2020 land use are set forth in Tables 19 and 20, respectively. The forecast data for the 1995 land use conditions, resulting in a likely in-lake phosphorus concentration of about 0.035 mg/l, compared relatively well with the range of observed phosphorus levels within the Lake, averaging about 0.038 mg/l, as noted in Table 15.

The estimated phosphorus budget for Pike Lake, based on the WILMS analysis, is set forth in Table 19 for 1995 and planned 2020 land use conditions. An annual total phosphorus load of between about 3,700 and 8,400 pounds, with a most likely total phosphorus loading of about 5,300 pounds, was estimated to be contributed to Pike Lake. Given the good agreement between the forecast in-lake total phosphorus concentration and observed in-lake phosphorus concentration obtained using the lower estimate, it was estimated that 3,000 pounds per year, or about 66 percent of the total loading, was contributed by runoff from rural land; 560 pounds per year, or about 12 percent, was contributed by runoff from urban land; and about 1,000 pounds, or about 22 percent, from point source contributions arising from the Village of Slinger wastewater treatment plant. Measured phosphorus loads contributed by the Village of Slinger wastewater treatment plant were similar to those predicted using the WILMS model, being reported to be about 1,000 pounds of phosphorus.[17] The total phosphorus load to Pike Lake estimated using the WILMS model for year 1995 conditions, of about 4,700 pounds, is slightly higher than the measured total phosphorus loads reported by the U.S. Geological Survey for year 1999 and year 2000, of about 3,500 pounds and 2,400 pounds, respectively, summarized in Table 21.

Phosphorus release from the lake bottom sediments, internal loading, may also contribute phosphorus to the Lake. However, the net impact of this loading was assumed to be negligible given the good agreement between predicted and observed phosphorus concentrations.

---

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

[17]*McMahon Associates, Inc.,* op. cit.; *U.S. Geological Survey Scientific Investigations Report No. 2004-5141,* Water Quality, Hydrology, and the Effects of Changes in Phosphorus Loading to Pike Lake, Washington County, Wisconsin, with Special Emphasis on Inlet-to-Outlet Short-Circuiting, *2004.*

Table 19

ESTIMATED EXTERNAL SOURCES OF PHOSPHORUS TO PIKE LAKE

Source	1995		2020	
	Pounds[a]	Percentage[a]	Pounds[a]	Percentage[a]
Urban[b]				
High-Density (industrial and transportation uses)	462	10	752	14
Medium-Density (commercial and governmental uses)	46	1	83	2
Low-Density (single-family and suburban-density residential uses)	38	1	73	1
Onsite Sewage Disposal Systems	15	<1	15	<1
Subtotal	561	12	923	17
Rural				
Mixed Agricultural	2,850	61	1,969	38
Pasture/Grass	12	<1	14	<1
Extractive	7	<1	- -	- -
Wetlands	93	3	93	2
Woodlands	35	1	35	1
Surface Water	43	1	43	1
Subtotal	3,040	66	2,154	42
Point Source Inputs	1,060	22	2,130	41
Total	4,661	100	5,207	100

[a] *Percentages estimated from WILMS model results.*

[b] *Includes the contribution from onsite sewage disposal systems that remain in use outside of the portion of the tributary drainage area to Pike Lake served by public sanitary sewerage systems, estimated within the WILMS model as ranging from approximately 15 pounds per year to as much as 405 pounds per year, depending upon soil type, system condition, and system location. For purposes of this analysis, 15 pounds per year were used as the contribution from onsite sewage disposal systems as that value provided the loading that was best correlated to the measured in-lake phosphorus concentrations.*

Source: SEWRPC.

Under planned 2020 conditions, as set forth in the adopted regional land use plan, the annual total phosphorus load to the Lake is anticipated to increase slightly as agricultural activities within the drainage area tributary to Pike Lake are replaced by urban residential land uses. The most likely annual total phosphorus load to the Lake under buildout conditions is estimated to be 5,200 pounds. This increase may be exacerbated by the increasing utilization of agro-chemicals in urban landscaping. Studies within the Southeastern Wisconsin Region indicate that urban residential lands fertilized with a phosphorus-based fertilizer can contribute up to two-times more dissolved phosphorus to a lake than lawns fertilized with a phosphorus-free fertilizer or not fertilized at all.[18] Notwithstanding, it may be anticipated that rural lands, estimated to contribute 2,150 pounds of phosphorus per year, will continue to contribute somewhat greater masses of phosphorus to Pike Lake than urban lands, estimated to contribute 950 pounds of phosphorus per year. An estimated 2,100 pounds of phosphorus per year are

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

Table 20

ESTIMATED CONTAMINANT LOADS FROM LAND USE ACTIVITIES[a] TO PIKE LAKE: 1995 AND 2020

Land Use	1995					
	Area (acres)	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	841	42.0	227	16.8	117.7	0.0
Commercial	57	22.3	68	12.5	84.9	0.6
Industrial	54	20.3	63	11.9	80.5	0.5
Communications and Utilities	464	2.2	51	0.0	0.0	0.0
Governmental	72	18.4	97	5.0	57.6	0.0
Recreational	136	1.6	37	- -	- -	- -
Surface Water	502	47.2	65	- -	- -	- -
Wetlands	1,040	1.9	42	- -	- -	- -
Woodlands	791	1.5	32	- -	- -	- -
Agricultural	3,993	898.4	3,434	- -	- -	- -
Total	7,966	1,055.8	4,116	46.2	340.7	1.1

Land Use	2020					
	Area (acres)	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	1,643	82.2	444	32.9	230.0	0.0
Commercial	121	47.4	145	26.6	180.3	1.2
Industrial	140	52.6	164	30.8	208.6	1.4
Communications and Utilities	703	3.3	77	0.0	0.0	0.0
Governmental	140	28.4	150	7.8	88.8	0.0
Recreational	157	1.9	42	- -	- -	- -
Surface Water	502	47.2	65	- -	- -	- -
Wetlands	1,040	1.9	42	- -	- -	- -
Woodlands	791	1.5	32	- -	- -	- -
Agricultural	2,758	620.6	2,372	- -	- -	- -
Total	7,966	887.0	3,533	98.1	707.7	2.6

[a]Does not include loading from point sources. In this case, about 30 and 50 pounds of phosphorus per year for 1995 and 2020 conditions, respectively, and about 7,000 pounds and 12,000 pounds of sediment per year for 1995 and 2020 conditions, respectively.

Source: SEWRPC.

estimated to be contributed by the Village of Slinger wastewater treatment plant, although this load may be expected to be somewhat lower than forecast based upon current levels of treatment.[19]

Sediment Loadings

The estimated sediment budget for Pike Lake under 1995 land use conditions is shown in Table 19. An annual sediment load of about 1,000 tons of sediment was estimated to be contributed to Pike Lake. Of the likely annual sediment load, it was estimated that 900 tons per year, or 85 percent of the total loading, was contributed by runoff from agricultural lands, with the balance being contributed from urban lands and by direct precipitation onto the Lake surface.

[19]*McMahon Associates, Inc.,* op. cit.*; U.S. Geological Survey Scientific Investigations Report No. 2004-5141,* op. cit.

Table 21

MEASURED TOTAL PHOSPHORUS BUDGET FOR PIKE LAKE: 1999 AND 2000

Element	1999 (acre-feet)	2000 (acre-feet)
Inflows		
Direct Precipitation	70	60
Rubicon River		
Slinger Wastewater Treatment Plant	1,283	1,039
Rubicon River (excluding treatment plant discharge)	1,431	897
Direct Runoff to Pike Lake	640	401
Groundwater	44	44
Total	3,469	2,441
Outflows		
Evaporation	0	0
Rubicon River	2,504	1,678
Groundwater	0	0
Total	2,504	1,678
Retention in Lake	965	763

Source: U.S. Geological Survey and SEWRPC.

Under 2020 conditions, as set forth in the adopted regional land use plan, the annual sediment load to the Lake is anticipated to decrease slightly, to about 900 tons. The majority of the sediment load is still anticipated to be derived from rural agricultural lands, which are estimated to contribute 620 tons of sediment, or about 70 percent of the annual sediment load, to the Lake. An increased mass of sediment, however, is anticipated to be contributed from urban lands, estimated to be 215 tons of sediment per year, with the balance being contributed by nonagricultural rural lands, estimated to be 50 tons of sediment per year, an estimated 45 tons of which are estimated to be contributed by direct precipitation and dry fallout onto the lake surface.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[20] Table 20 sets forth the estimated loadings of copper, zinc, and cadmium likely to be contributed to Pike Lake from urban development surrounding the Lake. The majority of these metals becomes associated with sediment particles,[21] and is likely to be encapsulated into the bottom sediments of the Lake. The heavy metal concentrations likely to be observed in the Lake as a consequence of these loads, under both current and future conditions, are within the guidelines established for the protection of fish and aquatic life, based upon the forecast loads and annual average inflow from the Rubicon River and surrounding drainage area directly tributary to the Lake.[22]

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

[21]*Werner Stumm and James J. Morgan,* op. cit.

[22]*Frits van der Leeden, Fred L. Troise and David Keith Todd,* The Water Encyclopaedia, Second Edition, *Lewis Publishers, 1990.*

The estimated heavy metal budget for Pike Lake, under 1995 land use conditions, is shown in Table 20. About 45 pounds of copper, 340 pounds of zinc, and one pound of cadmium were estimated to be contributed annually to Pike Lake from urban lands.

Under 2020 conditions, as set forth in the adopted regional land use plan, the annual heavy metal loads to the Lake are anticipated to increase by approximately two-fold. The most likely annual loads to the Lake under year 2020 conditions are estimated to be 100 pounds of copper, 700 pounds of zinc, and three pounds of cadmium.

In-Lake Sinks

Of the annual total phosphorus load entering Pike Lake, it is estimated that 65 percent of the total phosphorus load, or about 2,400 pounds of phosphorus, is retained within the Lake. This mass of phosphorus is either used by the biomass within the Lake or deposited in the lake sediments. The balance of the phosphorus entering the Lake is transported downstream.

RATING OF TROPHIC CONDITION

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

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

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

Eutrophic lakes are nutrient-rich lakes. These lakes often exhibit excessive aquatic macrophyte growths and/or experience frequent algae blooms. If the lakes are shallow, fish winterkills may be common. While portions of such lakes are not ideal for swimming and boating, eutrophic lakes may support very productive fisheries.

Several numeric "scales," based on one or more water quality indicators, have been developed to define the trophic condition of a lake. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numeric scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scale used is appropriate for the lake to which it is applies. In this case, two indices, appropriate for Wisconsin lakes, have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[23] and the Carlson Trophic State Index (TSI).[24] In addition, the Wisconsin Trophic State Index value (WTSI) is presented. The WTSI is a refinement of the Carlson TSI designed to account for the

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

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

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.[25]

Vollenweider Trophic State Classification

Using the Vollenweider trophic system and applying the data in Table 16, Pike Lake would be classified as having about a 65 percent probability of being mesotrophic based upon phosphorus levels, as shown in Figure 8. The Lake would have about a 15 percent probability, each, of being eutrophic and oligotrophic, and less than a 5 percent probability of being ultra-oligotrophic, based upon mean annual phosphorus concentrations. Based upon chlorophyll-*a* levels, the Lake would be classified as having a 60 percent probability of being mesotrophic, with about a 30 percent probability of being eutrophic, about a 10 percent probability of being oligotrophic, as shown in Figure 8. Based upon Secchi-disc readings, the Lake would be classified as having a 65 percent probability of being hypertrophic, with a 30 percent probability of being eutrophic, and a 5 percent probability of being mesotrophic, as shown in Figure 8. While these indicators result in slightly differing lake trophic state classifications, it may be concluded that Pike Lake should be classified as a mesotrophic lake, or a lake with acceptable water quality for most uses.

Trophic State Index

The Trophic State Index (TSI) assigns a numerical trophic condition rating based on Secchi-disc 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.[26] The Wisconsin Trophic State Index (WTSI) rating for Pike Lake is approximately 45, suggesting that Pike Lake may be classified as mesotrophic.

SUMMARY

Pike Lake represents a typical hard-water, alkaline lake that is considered to have relatively good water quality. Physical and chemical parameters measured during the study period indicated that the water quality was within the "poor" to "good" range, depending upon the parameters considered. Total phosphorus levels were found to be generally at the level considered to cause nuisance algal and macrophytic growths. Summer stratification was commonly observed in Pike Lake. Nevertheless, the surface waters of the Lake remained well oxygenated and supported a healthy fish population. Winterkill, and internal releases of phosphorus from the bottom sediments of the Lake, were not considered to be problems in Pike Lake.

The Village of Slinger wastewater treatment facility was the single point source of pollutants in the Pike Lake watershed. Nonpoint sources of pollution included stormwater runoff from urban and agricultural areas. Agricultural land uses were the largest source of nonpoint pollutants, but are diminishing in importance as urban land uses increase in areal extent. In 1995, the total annual phosphorus load to Pike Lake was estimated to be 4,700 pounds. Runoff from the rural lands contributed the largest amount of phosphorus, about 66 percent of the total phosphorus load, with the runoff from urban lands contributing about 12 percent of the total phosphorus load. In addition, direct precipitation onto the Lake surface and the wastewater treatment plant contributed about 22 percent of the total phosphorus load. Agricultural lands constituted the primary source of phosphorus to the Lake under current land use conditions within the drainage area tributary to the Lake. Under forecast 2020 conditions, both urban lands are anticipated to contribute a greater percentage of phosphorus to Pike Lake, although rural lands will continue to contribute the greater proportion of the annual load.

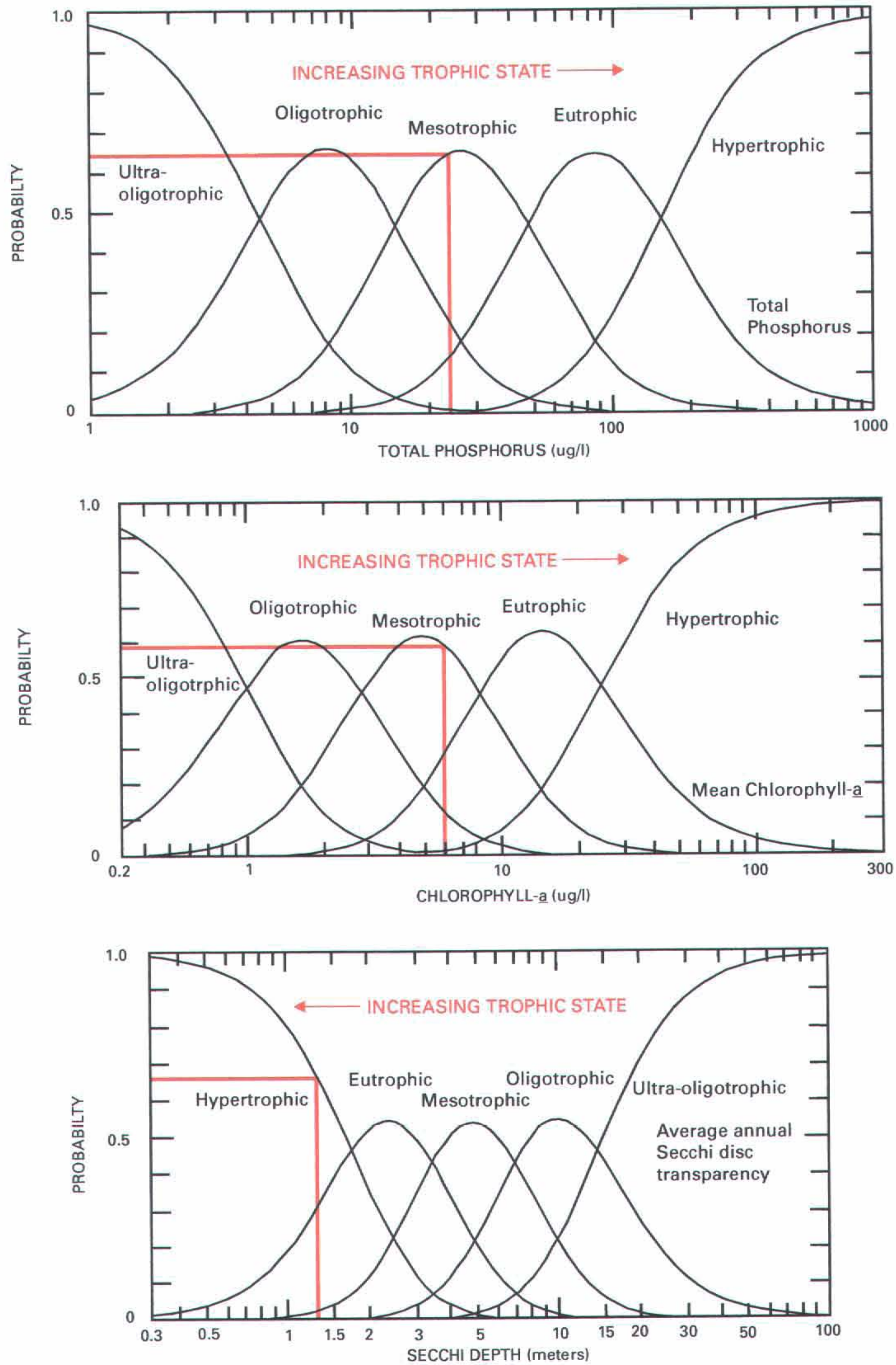
---

[25]*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.*

[26]Ibid.

Figure 8

TROPHIC STATE CLASSIFICATION OF PIKE LAKE BASED UPON THE VOLLENWEIDER MODEL: 2000



Source: U.S. Geological Survey and SEWRPC.

Approximately 65 percent, or 2,400 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 about 1,300 pounds of phosphorus downstream.

Based on the Vollenweider phosphorus loading model and the Wisconsin Trophic State Index ratings calculated from year 2000 Pike Lake data, Pike Lake may be classified as a mesotrophic lake.

Chapter V

AQUATIC BIOTA AND ECOLOGICALLY VALUABLE AREAS

INTRODUCTION

Pike Lake is an important element of the natural resource base providing a valuable ecological resource for the southwestern portion of Washington County. The Lake, its biota, and the adjacent park and residential lands combine to contribute to the quality of life in the area. Through the Pike Lake Unit of the Kettle Moraine State Forest, these ecological resource benefits also extend to the State.

When located in urban settings, resource features such as lakes and wetlands are typically subject to extensive recreational use pressure and high levels of pollutant discharges, common forms of stress to aquatic systems, and these may result in the deterioration of the 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 Pike Lake watershed, including data on aquatic macrophytes, fish, wildlife, wetlands and woodlands, and environmental corridors. Recreational activities are described and quantified in Chapter VI.

AQUATIC PLANTS

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

To document the types, distribution, and relative abundance of aquatic macrophytes and phytoplankton in Pike Lake, surveys were conducted as part of both the initial planning program and the current planning effort. These aquatic plant surveys were conducted during the summers of 1976 and 2001. Subsequently, an aquatic plant reconnaissance was conducted during 2003. Phytoplankton populations were sampled only during the 1976-1977 survey. These data are summarized below.

Phytoplankton

Phytoplankton, or algae are small, generally microscopic plants that are found in all lakes and streams. They occur in a wide variety of forms, as single cells or colonies, and can be either attached or free floating. Algae are primary producers that form one of the bases of the aquatic food chain. Through photosynthesis, they convert energy and nutrients to the compounds necessary to support life in the aquatic system. Oxygen, which is vital to higher forms of life in a lake or stream, is also produced in the photosynthetic process. 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, ort algal blooms, may occur. Algal blooms have occasionally been perceived as a problem in Pike Lake

Green algae (Chlorophyta) are the most important source of food for zooplankton, or microscopic animals, in the lakes of Southeastern Wisconsin. Blue-green algae (Cyanophyta) are not ordinarily utilized by zooplankton or fish populations, and may become over-abundant and out of balance with the organisms that feed on them. Dramatic population increases, blooms, of blue-green algae may occur when excessive nutrient supplies are available, optimum sunlight and temperature conditions exist, and there is a lack of competition from other aquatic plant species and insufficient grazing by zooplankton.

Algal blooms may reach nuisance proportions in fertile, or eutrophic-lakes, resulting in the accumulation of surface scums or slime. In some cases, heavy concentrations of wind-blown algae accumulate on shorelines, where they die and decompose, causing noxious odors and unsightly conditions. The decaying algae consume oxygen, sometimes depleting available supplies and resulting in fish kills. Also, certain species of decomposing blue-green algae may release toxic materials into the water.

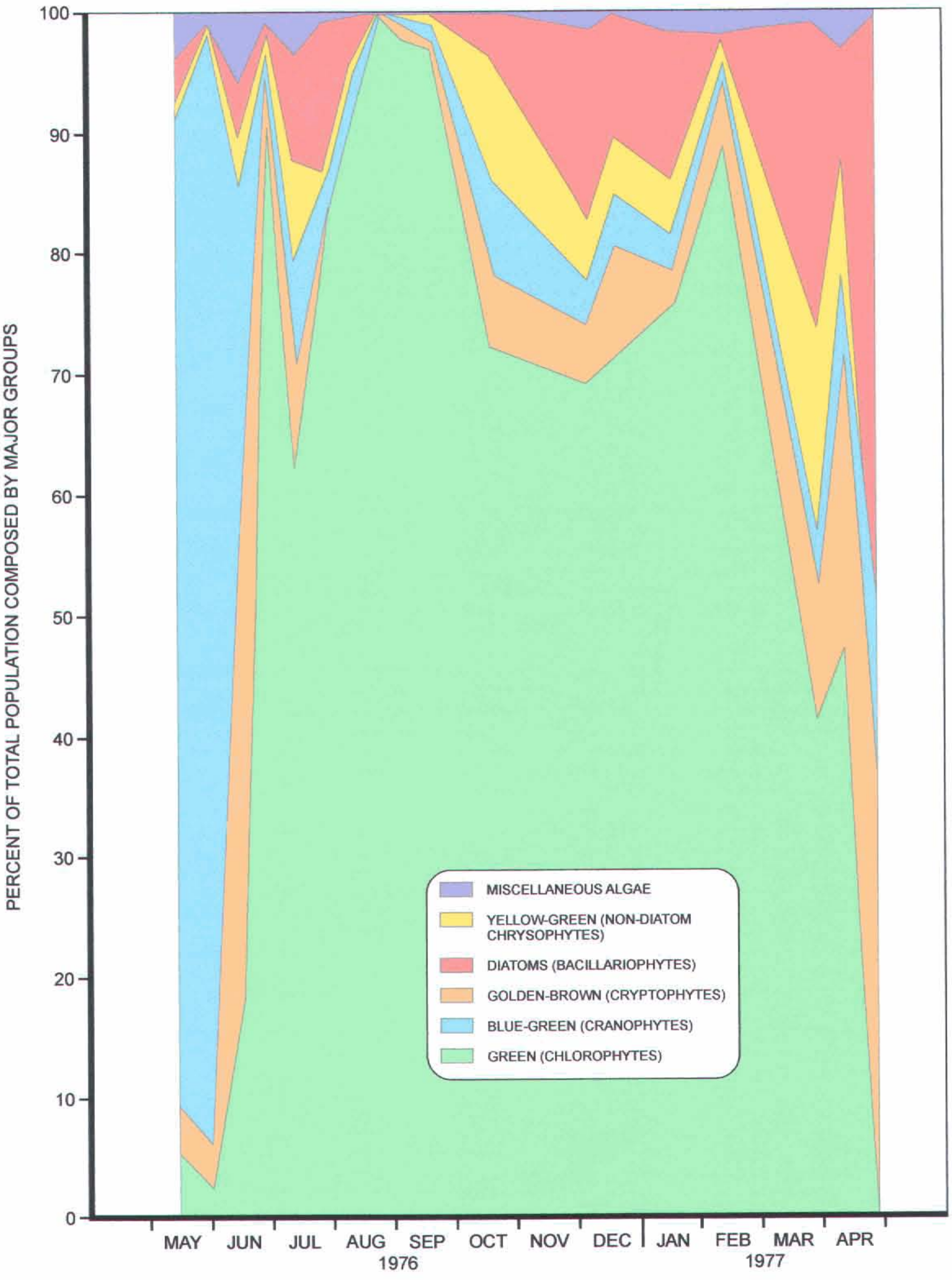
The types and concentrations of algae found in Pike Lake are presented in Figures 9 and 10. In Pike Lake, algal populations were highest in late-August and mid-September 1976. The lowest concentrations of cells occurred during mid-May and mid-June 1976, and in January and late-April 1977. Green algae made up 83 percent and 92 percent, respectively, of the mid-May and early-June algal communities sampled during 1976. *Schroederia setigera* was present in concentrations in excess of one million cells per liter in samples collected during May 1976. *Sphaerocystis schroeteri* was present in numbers exceeding 12 million cells per liter in the samples collected during early-June 1976. By mid-June 1976, the dominant population shifted from green algae to predominantly golden-brown algae (Cryptophyta), with *Chroomonas* spp. being present in numbers greater than one-half million cells per liter. As the summer progressed, between late-June 1976 and mid-April 1977, blue-green algae became the dominant group, with *Microcystis* spp. (= *Anacystis* spp.) being the dominant species. This alga ranged in abundance from several million cells per liter to more than a billion cells per liter, creating a floating film on the surface of the water and, on several occasions, during August and September 1976, these scums made the windward shore unsuitable for swimming due to unaesthetic and odoriferous accumulations. The prevalence of blue-green algae throughout most of the year is characteristic of a highly productive lake and is suggestive of relatively poor water quality. By the end of April 1977, blue-green algae decreased in number and diatoms (Bacillariophytes) doubled to over one million cells per liter. The dominant diatom species, *Astrionella formosa,* is typically found in Southeastern Wisconsin lakes during the spring. Other algal groups encountered during the study included nondiatom Chrysophytes and other miscellaneous algal groups, none of which reached dominant status.

The chlorophyll-*a* concentrations of 6.0 mg/m^3, reported during the year 2000 study, generally indicate fair to very good water quality, as illustrated in Figure 7. This concentration is less than the threshold level of about 10 μg/l range, above which algal populations generally are at densities that result in a green coloration of the water that may be severe enough to impair recreational activities such as swimming and skiing.[1] While chlorophyll-*a* concentrations have exceeded this level during three years of record—1987, 1993, and 1994—the current values are such that a detailed evaluation of the phytoplankton community was not undertaken during the current planning project. Rather, concern was focused on the larger aquatic plants as set forth below.

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

Figure 9

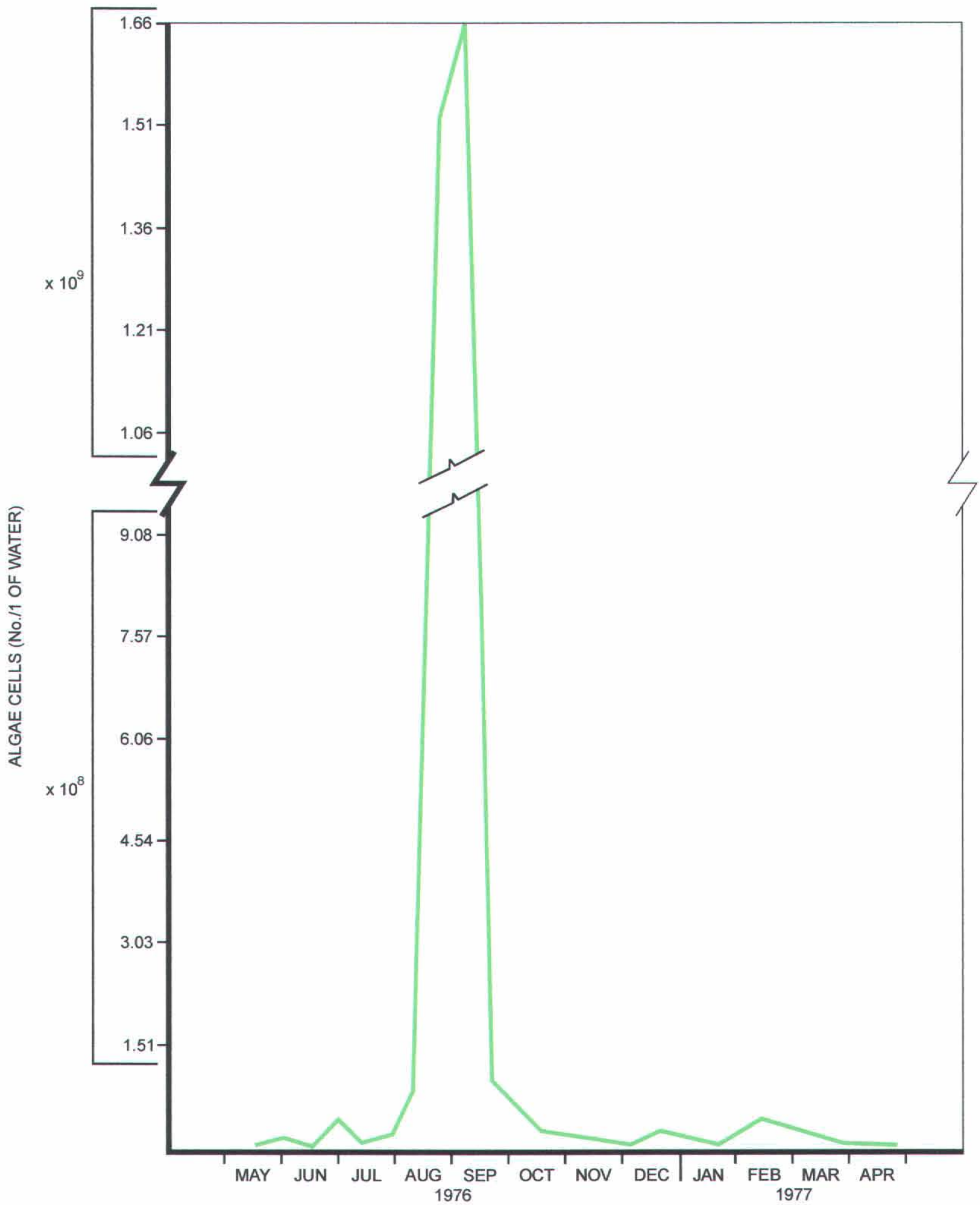
TYPES OF ALGAE FOUND IN PIKE LAKE: 1976-1977



Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 10

MONTHLY ALGAE POPULATIONS FOR PIKE LAKE: 1976-1977



Source: Wisconsin Department of Natural Resources and SEWRPC.

Macrophytes
Aquatic macrophytes play an important role in the ecology of Southeastern Wisconsin lakes. Macrophytes provide habitat for other forms of aquatic life and may remove nutrients from the water that otherwise could contribute to excessive algal growth. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate composition, wave action, and the type and size of fish populations present, determine the distribution and abundance of aquatic macrophytes in a lake.

To document the types, distribution, and relative abundance of aquatic macrophytes in Pike Lake, aquatic plant surveys were conducted on the Lake during August 1976 and June 2001, with a follow-up reconnaissance conducted during July 2003. The vegetation was identified by species, and the frequency of occurrence and the relative abundance was recorded for each species, along the entire shoreline of the Lake. Illustrations of representative macrophyte species identified in Pike Lake are set forth in Appendix A.

During the 1976 survey, 14 species of submerged and emergent aquatic plants were reported from the Lake, as shown in Table 22. Four distinct areas with different plant communities were identified. Map 18 shows the location of these four distinct areas. In general, macrophyte growth in Pike Lake was sparse to moderate during this study period. Notwithstanding, the aquatic plant community in the Lake was relatively diverse. The dominant aquatic plant in Area 1, as shown on Map 18, was Eurasian water milfoil (*Myriophyllum spicatum*), followed by bushy pondweed (*Najas flexilis*), and muskgrass (*Chara* spp., also known as stonewort). An abundant growth of muskgrass was present in Area 2, with moderately dense populations of large-leaf pondweed (*Potomogeton amplifolius*) also present. Emergent species along the shoreline included bulrush (*Scirpus* sp.) and wild rice (*Zizania aquatica*). Area 3 had the sparsest growth of the four areas. Muskgrass was the most abundant species, with sparse concentrations of milfoil, eel grass (*Vallisneria americana*) and bushy pondweed. The heaviest concentrations of plant growth were recorded in Area 4. Moderately abundant concentrations of milfoil, muskgrass, large-leaf pondweed, and floating-leaf pondweed (*Potamogeton natans*) were present. Patchy growths of bulrush also were present. The macrophyte species present in the Lake are indicated in Table 22, along with their frequency of occurrence and relative abundance.

During the 2001 aquatic plant survey, seventeen species of aquatic plants were observed in Pike Lake. Muskgrass (*Chara* spp.) remained the dominant aquatic plant species in the Lake, closely followed in occurrence and density by Eurasian water milfoil (*Myriophyllum spicatum*). Sago pondweed (*Potamogeton pectinatus*) and spiny naiad (*Najas marina*) were also commonly reported aquatic plants during the 2001 survey, with eel grass (*Vallisneria americana*) being the next most abundant, as shown in Table 23. The plants were relatively evenly distributed around the Lake, as shown on Map 19, although aquatic plant growth was relatively sparse along the more steeply sloping southern shorelands of the Lake. Eurasian water milfoil was most prevalent in the deeper water areas of the Lake, between about seven and 10 feet in depth, and in the very shallow water areas along the eastern and western shores.

In general, Pike Lake supports a healthy and diverse aquatic macrophyte community. The beneficial nature of the aquatic plant community in Pike Lake, as well as the importance of this community in maintaining the ecological balance in the lake, is generally recognized by the lakeshore residents, although some residents report difficulties with navigation in portions of the Lake. Generally, the diversity of the plant community in and adjacent to the Lake contributes to the wildlife habitat value of the area, as set forth below. Fish, waterfowl, pheasants, muskrats, and other wetland wildlife species dependent on aquatic vegetation for feeding and nesting, brooding, or loafing areas are known to make use of the Lake. The positive ecological values of the aquatic plants reported from Pike Lake are set forth in Table 24.

Aquatic Plant Management
Records of aquatic plant management efforts on Wisconsin lakes were not maintained by the WDNR prior to 1950. Thus, while previous interventions were likely, the first recorded efforts to manage the aquatic plants in Pike Lake have taken place since 1950. Aquatic plant management activities in Pike Lake can be categorized as chemical algal control, summarized in Table 25, and manual macrophyte harvesting. Currently, all forms of

Table 22

PIKE LAKE MACROPHYTE SPECIES AND RELATIVE ABUNDANCE BY LAKE AREA: 1976

Lake Shore Section Number	Scientific Name	Common Name	Relative Abundance
1	*Myriophyllum spicatum*[a]	Eurasian water milfoil	Moderate
	Najas flexilis	Bushy pondweed	Sparse
	Chara spp.	Muskgrass	Sparse
	Vallineria sp.	Eel grass	Very sparse
	Potomogeton amplifolius	Large-leaf pondweed	Very sparse
	Potomogeton filiformis	Pondweed	Very sparse
2	*Chara* spp.	Muskgrass	Abundant
	Potomogeton amplifolius	Large-leaf pondweed	Moderate
	Potomogeton pectinatus[a]	Sago pondweed	Sparse
	Scirpus spp.	Bulrush	Sparse
	Nymphaea sp.	White water lily	Very sparse
	Nuphar sp.	Yellow water lily	Very sparse
	Lemna minor	Duckweed	Very sparse
	Najas flexilis	Bushy pondweed	Very sparse
	Potomogeton natans	Water smartweed	Very sparse
	Zizania aquatica	Wild rice	Very sparse
3	*Chara* spp.	Muskgrass	Moderate
	Vallisneria sp.	Eel grass	Sparse
	Myriophyllum spicatum	Eurasian water milfoil	Sparse
	Najas flexilis	Bushy pondweed	Very sparse
	Scirpus spp.	Bulrush	Very sparse
	Nuphar sp.	Yellow water lily	Very sparse
4	*Potomogeton pectinatus*	Sago pondweed	Moderate
	Myriophyllum spicatum	Eurasian water milfoil	Sparse
	Scirpus sp.	Bulrush	Sparse
	Chara spp.	Muskgrass	Sparse
	Potomogeton amplifolius	Large-leaf pondweed	Sparse
	Nuphar sp.	Yellow water lily	Sparse
	Potomogeton natans	Water smartweed	Very sparse
	Lemna minor	Duckweed	Very sparse

[a] *Alien or nonnative species.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

aquatic plant management are subject to permitting by the Wisconsin Department of Natural Resources pursuant to authorities granted the Department under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code.*

Chemical Controls

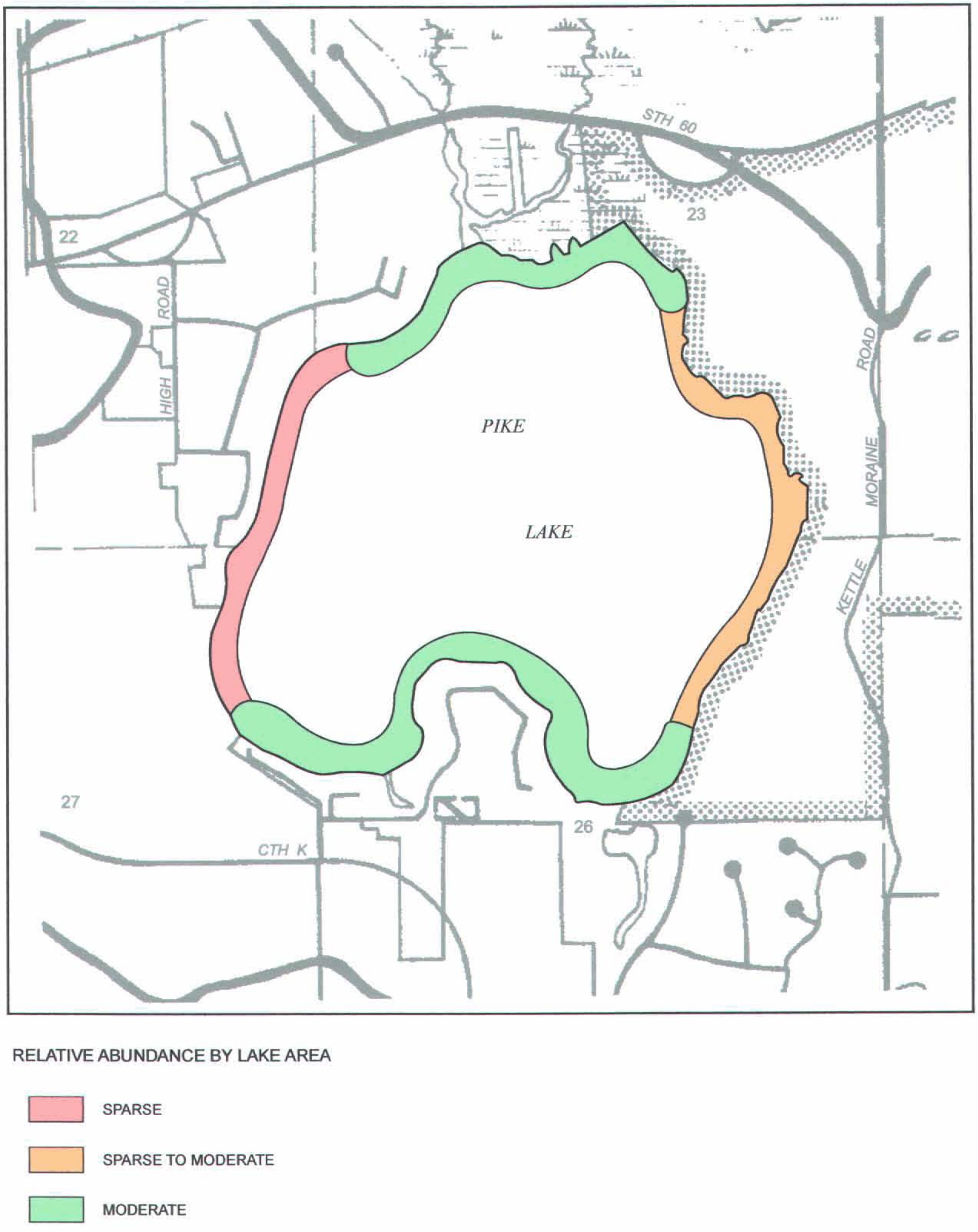
Perceived excessive algal growths on Pike Lake resulted in one application of a chemical control program during 1982. Although applied for on two other occasions, no other herbicide treatments to control aquatic plants and algae were undertaken. Recorded chemical herbicide treatments that have been applied to Pike Lake from 1950 through 2002 are set forth in Table 25. In Wisconsin, the use of chemicals to control aquatic plants and algae has been regulated since 1941, even though records of aquatic herbicide applications have only been maintained by the Wisconsin Department of Natural Resources since 1950.

Manual Controls

Manual harvesting of aquatic plants around piers and docks is not quantified, as permits governing the conduct of shoreland aquatic plant management programs have only recently been required by the Wisconsin Department of

Map 18

AQUATIC PLANT COMMUNITY DISTRIBUTION IN PIKE LAKE: 1976



Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 23

FREQUENCY OF OCCURRENCE AND DENSITY RATINGS OF SUBMERGENT AQUATIC PLANT SPECIES IN PIKE LAKE: JUNE 2001

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence (percent)	Relative Density	Importance Value
Ceratophyllum demersum (coontail)	9	9.9	2.3	0.23
Chara vulgaris (muskgrass)	58	63.7	3.4	2.15
Elodea canadensis (waterweed or Elodea)	4	4.4	2.0	0.09
Myriophyllum sp. (native water milfoil)	3	3.3	1.7	0.05
Myriophyllum spicatum (Eurasian water milfoil)	58	63.7	2.7	1.69
Najas flexilis (bushy pondweed)	5	5.5	1.2	0.07
Najas marina (spiny naiad)	42	46.2	2.1	0.98
Potamogeton crispus (curly-leaf pondweed)	3	3.3	1.0	0.03
Potamogeton gramineus (variable pondweed)	8	8.8	1.6	0.14
Potamogeton illinoensis (Illinois pondweed)	1[a]	- -	- -	- -
Potamogeton natans (floating-leaf pondweed)	2	2.2	1.5	0.03
Potamogeton pectinatus (Sago pondweed)	41	45.1	2.2	0.98
Potamogeton richardsonii (clasping-leaf pondweed)	3	3.3	2.3	0.08
Potamogeton zosteriformis (flat-stem pondweed)	22	24.2	2.2	0.53
Ranunculus longirostris (stiff water crowfoot)	2	2.2	2.0	0.04
Vallisneria americana (eel grass or water celery)	35	38.5	2.4	0.93
Zosterella dubia (water stargrass)	5	5.5	1.4	0.08

NOTE: There were 91 sites sampled during the July 2001 survey.

[a]*Illinois pondweed was observed, but not sampled, therefore, it was not included in the analysis of density and frequency of occurrence.*

Source: SEWRPC.

Natural Resources. As of 2003, manual removal of aquatic plants from lakes outside of a 30-foot-wide linear shoreland corridor is governed by Chapter NR 109 of the *Wisconsin Administrative Code*. No data on permits issued to Pike Lake residents are available, although riparian property owners and residents report periodic application of manual harvesting techniques along portions of the shoreline of the Lake.

AQUATIC ANIMALS

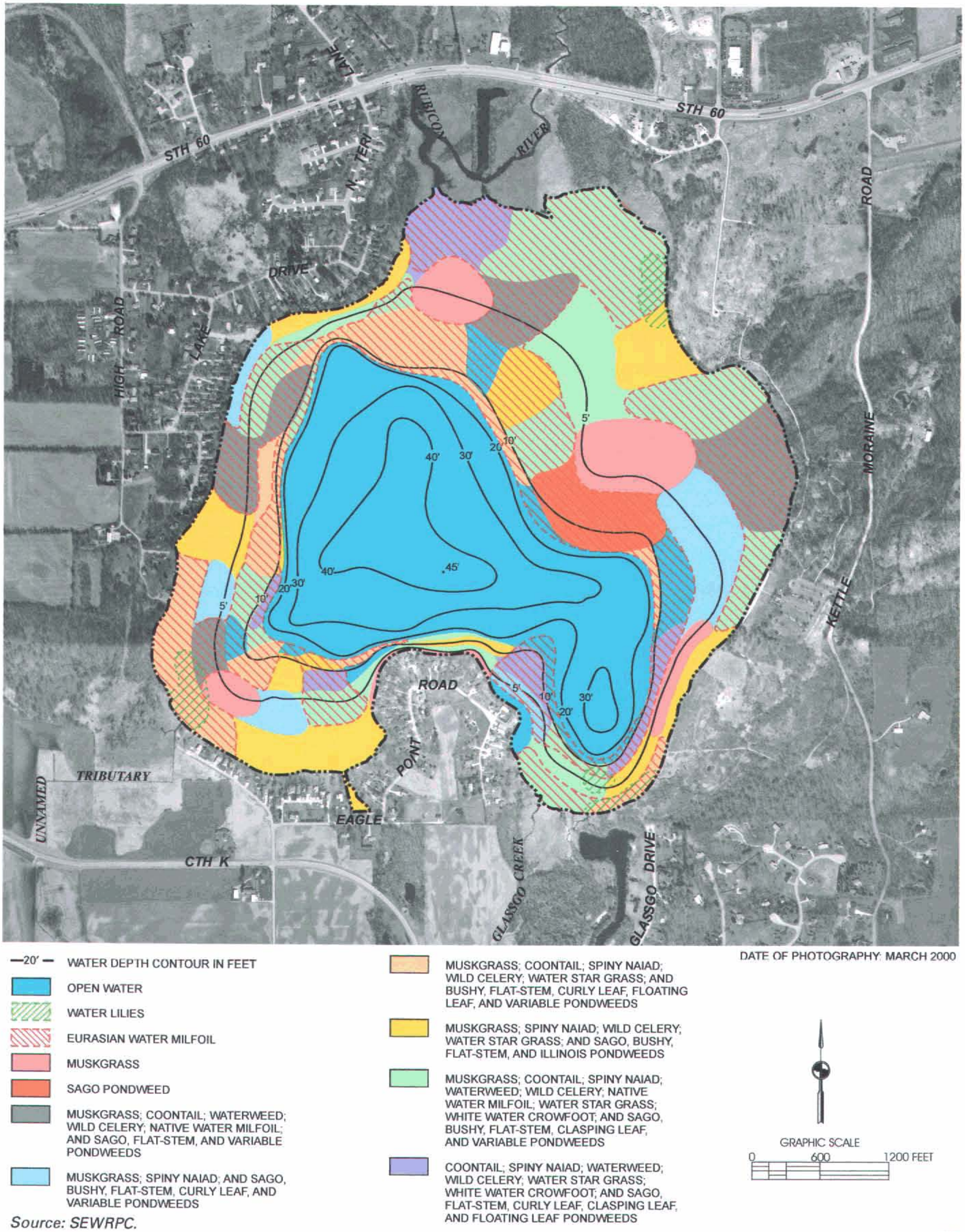
Zooplankton

Zooplankton are microscopic animals which inhabit the same environment as phytoplankton, microscopic plants. An important link in the food chain, crustacean zooplankton feed mostly on algae and, in turn, are a good food source for fish. Zooplankton were collected from the deepest area of the Lake during the 1976-1977 study period. As shown in Table 26, 12 species of zooplankton were reported to have been found in Pike Lake during this period. The abundance of selected species of zooplankton in Pike Lake is shown in Figure 11.

Zooplankton populations were at their peak in spring, late-summer, and fall, with *Daphnia galeata mendotae* being the dominant animal in the zooplankton community throughout most of the year. *Daphnia galeata mendotae* is a common zooplankter in lakes in Wisconsin. *Daphnia pulicaria* and *Daphnia schodleri* were abundant during the spring, but were generally found in lower concentrations throughout the rest of the year. These three species, which are members of the subclass Cladocera, are major food items in the diets of plankton-eating fish.

Map 19

AQUATIC PLANT DISTRIBUTION IN PIKE LAKE: 2001



Source: SEWRPC.

Table 24

PIKE LAKE AQUATIC PLANT ECOLOGICAL SIGNIFICANCE

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides good shelter for young fish and supports insects; valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	Excellent producer of fish food, especially for young trout, bluegills, small and largemouth bass; stabilizes bottom sediments, and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed or elodea)	Provides shelter and support for insects which are valuable as fish food
Lemna minor (lesser duckweed)	A nutritious food source for ducks and geese, also provides food for muskrat, beaver, and fish, while rafts of duckweed provide shade and cover for insects, in addition extensive mats of duckweed can inhibit mosquito breeding
Myriophyllum sp. (native water milfoil)	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	None known
Najas flexilis (bushy pondweed)	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	Provides good food and shelter for fish and food for ducks
Potamogeton crispus (curly-leaf pondweed)	Provides food, shelter and shade for some fish and food for wildfowl
Potamogeton gramineus (variable pondweed)	Provides habitat for fish and food for waterfowl, in addition to muskrat, beaver, deer, and moose
Potamogeton illinoensis (Illinois pondweed)	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl
Potamogeton natans (floating-leaf pondweed)	Provides food and shelter for fish and food for wildfowl
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton richardsonii (clasping-leaf pondweed)	Provides food, shelter and shade for some fish, food for some wildfowl, and food for muskrat. Provides shelter and support for insects, which are valuable as fish food
Potamogeton zosteriformis (flat-stem pondweed)	Provides some food for ducks
Ranunculus longirostris (stiff water crowfoot)	Provides food for trout, upland game birds, and wildfowl
Vallisneria americana (eel grass or water celery)	Provides good shade and shelter, supports insects, and is a valuable fish food
Zosterella dubia (water stargrass)	Provides food and shelter for fish, locally important food for waterfowl

Source: SEWRPC.

The subclass Copepoda was represented in Pike Lake by the calanoid copepod, *Skistodiaptornus oregonensis*, which was the dominant copepod present through most of the year. The cyclopoid copepods, *Cyclops bicuspidatus thomasi*, *Mesocyclops edax* and *Tropocyclops prasinus*, were also reported. Unlike cladocerans, reproduction in copepods is strictly sexual with males and females being produced in approximately equal

Table 25

CHEMICAL CONTROL OF AQUATIC PLANTS IN PIKE LAKE: 1950-2002

Year	Total Acres Treated	Algae Control			Macrophyte Control					
		Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine + (gallons)	Sodium Arsenite (pounds)	2, 4-D (gallons)	Diquat (gallons)	Endothall (gallons)	Aquathol (gallons)	Fluridone (gallons)
1950-1980	--	--	--	--	--	--	--	--	--	--
1981	--	--	--	--	--	--	--	--	--	--
1982	0.05	--	--	0.25	--	--	--	--	--	--
1983	--	--	--	--	--	--	--	--	--	--
1984	--	--	--	--	--	--	--	--	--	--
1985	--	--	--	--	--	--	--	--	--	--
1986	--	--	--	--	--	--	--	--	--	--
1987	--	--	--	--	--	--	--	--	--	--
1988[a]	--	--	--	--	--	--	--	--	--	--
1989	--	--	--	--	--	--	--	--	--	--
1990[a]	--	--	--	--	--	--	--	--	--	--
1991	--	--	--	--	--	--	--	--	--	--
1992-2002	--	--	--	--	--	--	--	--	--	--
Total	0.05	--	--	0.25	--	--	--	--	--	--

[a]*Aquatic herbicide permit applied for, but no treatment conducted.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

numbers. Copepods have three life cycle stages: egg, nauplii or larva, and copepodid. Eggs are normally contained within the body of the female zooplankter. However, the abundance of nauplii and copepodids in Pike Lake during the study year also is presented in Figure 11.

Benthic Invertebrates

The benthic, or bottom dwelling, macroinvertebrate communities of lakes include such organisms as sludge worms, midges, and caddis fly larvae. These organisms are frequently used to assess the existing and recent past water quality of a lake. In addition, these organisms form an important part of the food web, acting as processors of the organic material that accumulates on the lake bottom and frequently being grazed, in turn, by bottom feeding fishes. Some benthic macroinvertebrate organisms are opportunistic in their feeding habits, while others are openly predaceous. The diversity of the benthic community reflects the trophic status of a lake, with less enriched lakes typically having a greater diversity. Notwithstanding, there is no single "indicator organism" that determines the trophic status, or level of enrichment of a lake; rather the entire community must be assessed. The time of year for this assessment consequently becomes an important consideration since these populations fluctuate widely during the summer months as a result of life stage of the organisms, climatic variability, and localized water quality changes. An early-spring or winter sampling is considered to be the best opportunity for making an overall assessment of the benthic community composition. For this reason, Pike Lake was sampled during the early spring of 1976 and 1977, prior to metamorphosis and adult emergence. Samples were collected in the two deepest areas of the Lake. Because larvae of the Chironomidae were not reared to adult stages, the species names are considered to be tentative.

The benthic fauna of Pike Lake were found to be very diverse. Several species that inhabit waters that typically do not become anoxic were present. The 1976 sample contained two species of mayfly larvae, *Hexagenia limbata*, and a member of the genus *Caenis*, all of which occur only in well oxygenated areas. In addition, the midge population was relatively diverse, with three species of *Chaoborus*, including the phantom midge *Chaoborus albatus*, and several species of the family Chironomidae, the most abundant being *Chironomus plumosus*. This diverse fauna is indicative of a mesotrophic state that is consistent with the water quality evaluation set forth in Chapter IV.

Table 26

CRUSTACEAN ZOOPLANKTON FOUND IN PIKE LAKE: 1976-1977

Type	1976-1977 Survey
Bosmina longirostris	X
Ceriodaphnia lacustris	X
Chydorus sphaericus	X
Cyclops bicuspidatus thomasi	X
Daphnia galeata mendotae	X
Daphnia pulicaria	X
Daphnia retrocurva	X
Daphnia schodleri	X
Diaphanosoma leuchtenbergianum	X
Mesocyclops edax	X
Skistodiaptomus oregonensis	X
Tropocyclops prasinus	X

Source: Wisconsin Department of Natural Resources and SEWRPC.

Zebra mussels, *Dreissenia polymorpha*, are a non-native species of shellfish currently being introduced into inland lakes from the Laurentian Great Lakes system, where they are considered an invasive species originally introduced into the Great Lakes in ballast water carried by ships from Europe. Zebra mussels are having a varied impact on inland lakes in the Upper Midwest, with many lakes experiencing improved water clarity as a result of the filter feeding proclivities of these animals. This improved clarity has led to increased growths of rooted aquatic plants, including Eurasian water milfoil. Curiously, within the Southeastern Wisconsin Region, zebra mussels have been observed attaching themselves to the stalks of the Eurasian water milfoil plants, dragging these stems out of the zone of light penetration due to the weight of the zebra mussel shells, and interfering with the competitive strategy of the Eurasian water milfoil plants. This, in turn, has contributed to improved growths of native aquatic plants, in some cases, and to the growths of filamentous algae too large to be ingested by the zebra mussels in others. During the aquatic plant survey of 2001, adult zebra mussels were observed in Pike Lake by Regional Planning Commission staff. Specimens were collected and subsequently identified by WDNR staff, who confirmed the presence of zebra mussels in the Lake. As of 2004, Pike Lake is currently on the WDNR zebra mussel watch list. However, the likely impact of zebra mussel on Pike Lake remains unknown.

Fishes of Pike Lake

Pike Lake supports a large and diverse fish community. Studies conducted by the Wisconsin Department of Natural Resources indicated that 26 different fish species have been captured in the Lake. Fish species recorded from Pike Lake are shown in Table 27.

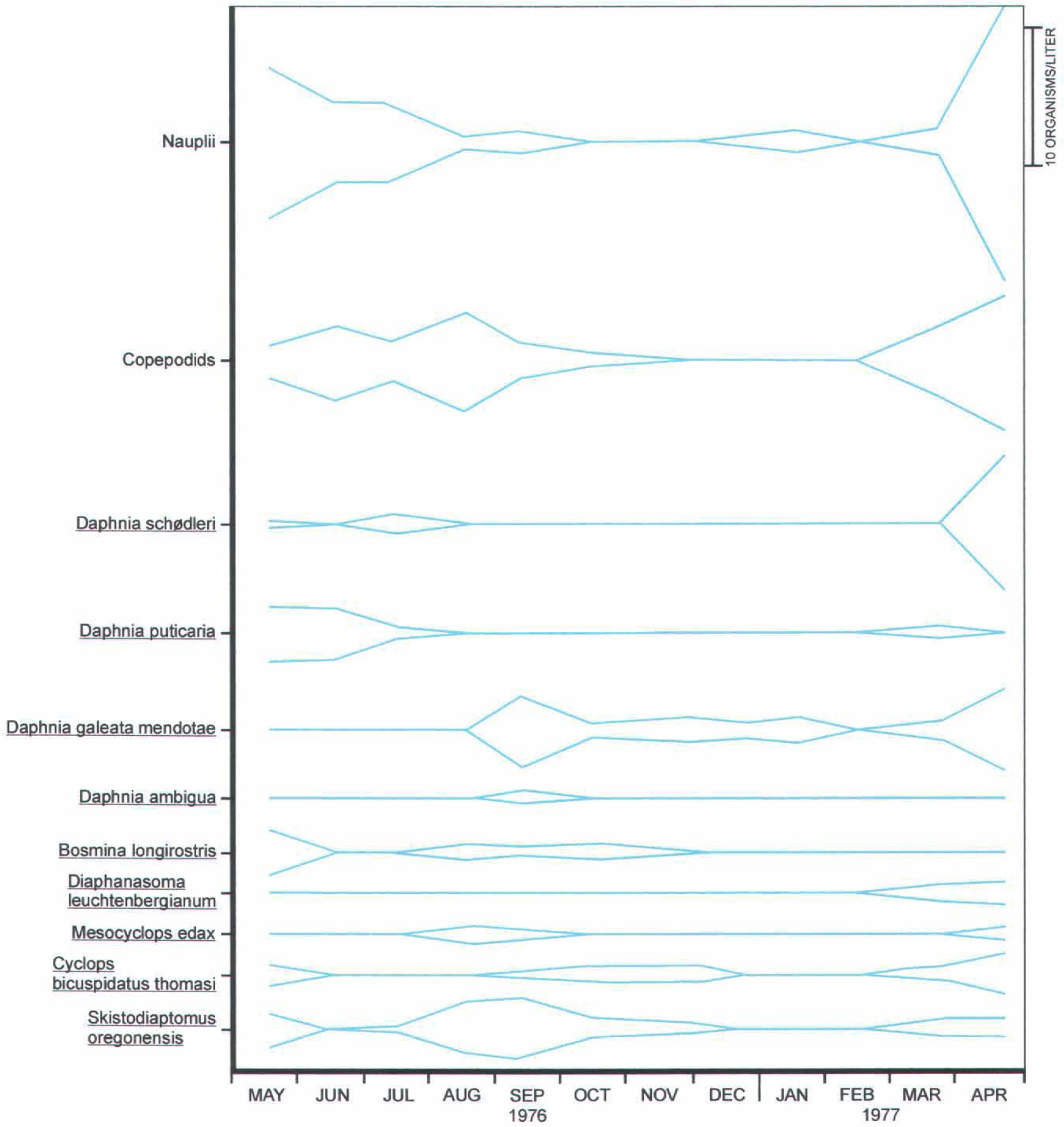
"Panfish" is a common term applied to a broad group of smaller fish with a relatively short and usually broad shape that makes them a perfect size for the frying pan. A wide range of panfish is present in the Lake, as shown in Table 27. Panfish species known to exist in Pike Lake include yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), rock bass (*Ambloplites rupestris*), and green sunfish (*Lepomis cyanellus*). 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 predatory fishes and, if the panfish population is overabundant, they may quickly deplete the predator fry population. Figure 12 illustrates the importance of a balanced predator-prey relationship, using walleyed pike and perch as an example.

"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 are commonly considered in Southeastern Wisconsin as undesirable for human consumption. Rough fish species which have been found in Pike Lake include carp (*Cyprinus carpio*), white sucker (*Catostomus commersoni*), and bowfin (*Amia calva*).

"Game fish" is the term applied to those fishes that are typically sought by anglers, and which are generally considered to be desirable species. Northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*Micropterus dolomieui*) are also present and reproduce naturally in Pike Lake; however, their populations are relatively low.

Figure 11

ABUNDANCE OF ZOOPLANKTON, NAUPLII, AND COPEPODIDS FOUND IN PIKE LAKE: 1976-1977



Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 27

FISH SPECIES OCCURRING IN PIKE LAKE

Species	Family	Scientific Name
Bowfin	Amiidae	*Amia calva*
Longnose Gar	Lepisosteidae	*Lepisosteus osseus*
White Sucker	Catostomidae	*Catostomus commersoni*
Rock Bass	Centrarchidae	*Ambloplites ruperstris*
Green Sunfish	Centrarchidae	*Lepomis cyanellus*
Pumpkinseed	Centrarchidae	*Lepomis gibbosus*
Bluegill	Centrarchidae	*Lepomis macrochirus*
Smallmouth Bass	Centrarchidae	*Micropterus dolomieui*
Largemouth Bass	Centrarchidae	*Micropterus salmoides*
White Crappie	Centrarchidae	*Promoxis annularis*
Black Crappie	Centrarchidae	*Promoxis nigromaculatus*
Common Carp	Cyprinidae	*Cyprinus carpio*
Pugnose Shiner	Cyprinidae	*Notropis anogenus*
Golden Shiner	Cyprinidae	*Notemigonus crysoleucas*
Blackchin Shiner	Cyprinidae	*Notropis heterodon*
Blacknose Shiner	Cyprinidae	*Notropis heterolepis*
Bluntnose Minnow	Cyprinidae	*Pimephales notatus*
Fathead Minnow	Cyprinidae	*Pimephales promelas*
Banded Killifish	Cyprinodontidae	*Fundulus diaphanus*
Blackstripe Topminnow	Cyprinodontidae	*Fundulus notatus*
Northern Pike	Esocidae	*Esox lucius*
Brook Stickleback	Gasterosteidae	*Culaea inconstans*
Brown Bullhead	Ictaluridae	*Ictalurus nebulosus*
Black Bullhead	Ictaluridae	*Ictalurus melas*
Yellow Bullhead	Ictaluridae	*Ictalurus natalis*
Iowa Darter	Percidae	*Etheostoma exila*
Least Darter	Percidae	*Etheostoma microperca*
Johnny Darter	Percidae	*Etheostoma nigrum*
Yellow Perch	Percidae	*Perca flavescens*
Walleyed Pike	Percidae	*Stizotedion vitreum vitreum*
Central Mudminnow	Umbridae	*Umbra limi*

Source: Claggett (1981); Fago (1982); Becker (1964), and the Wisconsin Department of Natural Resources.

In 1963,[2] the WDNR reported that the Lake was managed for panfish and walleyed pike, with yellow perch the principle game fish. Carp were reported to be common in the shallow areas, but were not considered to constitute a management problem. In 1974,[3] a fisheries survey reported the following fish species: rock, smallmouth, and largemouth bass; bowfin; common carp; johnny, Iowa, and least darter; blackchin, blacknose, pugnose, and golden shiner; white sucker; northern pike; walleyed pike; bluntnose and fathead minnow; banded killifish; and yellow perch. In 1975,[4] a fisheries survey reported, rock, smallmouth, and largemouth bass; bowfin; common carp; golden shiner; white sucker; northern pike; walleyed pike; and yellow perch. According to the WDNR, as of

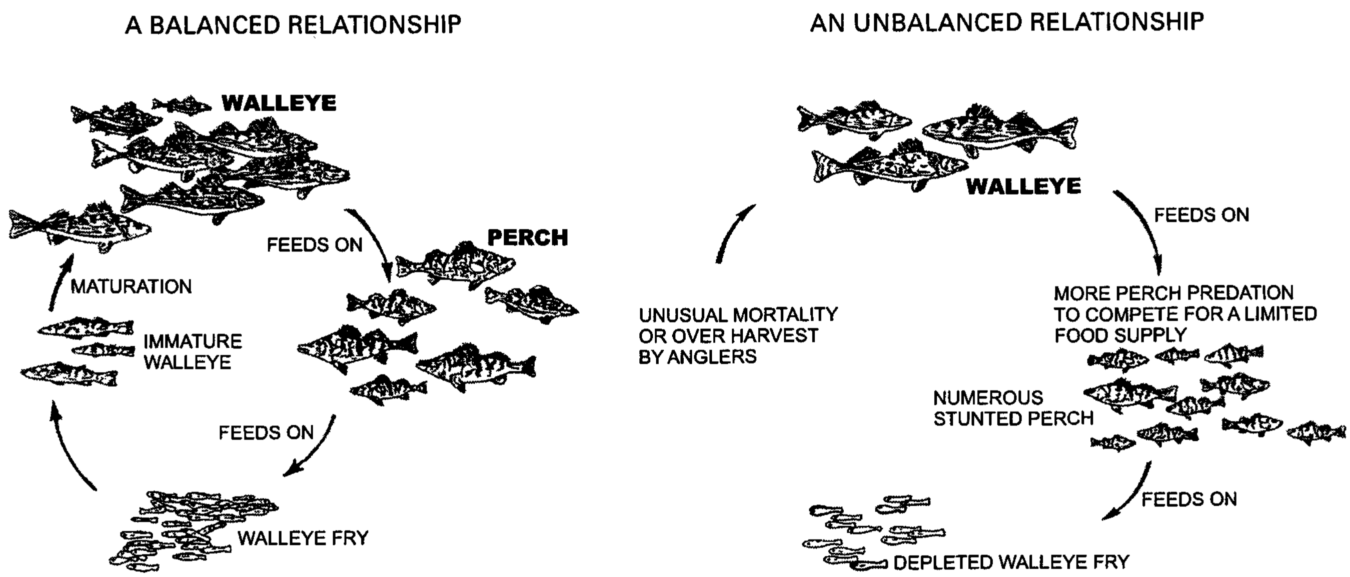
[2]*Wisconsin Conservation Department,* Surface Water Resources of Washington County, *1963.*

[3]*D. Fago, Wisconsin Department of Natural Resources Research Report No. 148,* Retrieval and Analysis System Used in Wisconsin's Statewide Fish Distribution Survey, Second Edition, *December 1988.*

[4]Ibid.

Figure 12

THE PREDATOR-PREY RELATIONSHIP



Source: Wisconsin Department of Natural Resources.

1995,[5] Pike Lake was reported to have an abundant walleyed pike population, with northern pike, largemouth and smallmouth bass, and panfish being present. During 2004, the WDNR reported that the Pike Lake fish community was essentially unchanged from that reported during 1974-1975, suggesting that the Lake remains a high quality resource. A fish consumption advisory had been issued for this Lake. The Southeastern Wisconsin Regional Planning Commission (SEWRPC) reports the pugnose shiner as a State-designated threatened species, and the least darter as a State species of special concern.[6]

The Rubicon River both enters and leaves the Lake on its north shore in a cattail and sedge marsh. About 40 percent of the shoreline is marsh associated with the riverine inflow and outflow portion of the Lake; an estimated 180 acres of wetland adjoin the stream. A fish refuge has been established on the channel above the dam and the Rubicon River below the dam for a distance of about 0.5 mile as protection for walleyed and northern pike during spawning runs. Modification of the inlet and outlet of the Lake was completed in 1993 in order to permit low flows to bypass the Lake in the expectation of minimizing nutrient loading to Pike Lake.[7]

The 2002-2003 regulations governing the harvest of fishes from the waters of the State are summarized in Table 28.

---

[5]*Wisconsin Department of Natural Resources, PUBL-FM-800 95REV.*

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

[7]*R.A. Smith & Associates, Inc.,* NR 103 Practicable Alternatives Analysis: Pike Lake Inlet Re-Diversion Project, *February 1993.*

Table 28

FISHING REGULATIONS APPLICABLE TO PIKE LAKE: 2003-2004

Species	Open Season	Daily Limit	Minimum Size
Northern Pike	May 3 to March 1	2	26 inches
Walleyed Pike	May 3 to March 1	5	15 inches
Largemouth and Smallmouth Bass	May 3 to March 1	5 in total	14 inches
Rock, Yellow and White Bass	Open all year	None	None
Bluegill, Pumpkinseed (sunfish), Crappie, and Yellow Perch	Open all year	25 in total	None
Bullhead and Rough Fish	Open all year	None	None

Source: Wisconsin Department of Natural Resources Publication No. PUBL-FH-301 2003, Guide to Wisconsin Hook and Line Fishing Regulations 2003-2004, *January 2003; and SEWRPC.*

Fisheries Management

Fish management efforts have been primarily directed toward the introduction and maintenance of walleyed pike in the Lake. As shown in Table 29, millions of walleyed pike, fry and fingerlings, were stocked in Pike Lake between 1933 and 1961. However, a study of recruitment, growth, and management of walleyed pike in Pike Lake conducted between 1959 and 1982 indicated that natural reproduction and growth of the native walleyed pike population was sufficient to maintain a viable fishery in the lake.[8] Consequently, there has been no stocking of walleyed pike, or any other game fish species, since 1961.

Other Wildlife

Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the Pike Lake study, it is possible, by polling naturalists and wildlife managers familiar with the area, to complete a list of amphibians, reptiles, birds, and mammals which may be expected to be found in the area under existing conditions. The technique used in compiling the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to exist, or known to have existed, in the Pike Lake area; associating these lists with the historic and remaining habitat areas in the Pike Lake area as inventoried; and projecting the appropriate amphibian, reptile, bird, and mammal species into the Pike Lake area. The net result of the application of this technique is a listing, summarized in Tables 30 through 32, 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.

A variety of mammals, ranging in size from large animals like the northern white-tailed deer to small animals like the least shrew, are expected to be found in the Pike Lake area. Mink, muskrat, beaver, white-tailed deer, red and grey fox, grey and fox squirrel, and cottontail rabbits are mammals reported to frequent the area. Table 30 lists 38 mammals whose ranges are known to extend into the area.

A large number of birds, ranging in size from large game birds to small songbirds, also are expected to be found in the Pike Lake area. Table 31 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 Pike Lake drainage area supports a significant population of waterfowl, including mallard and teal. Larger numbers of birds move through the drainage area during migrations when most of the regional species may also be present.

---

[8]*D. Marz,* Recruitment, Growth, Exploitation, and Management of Walleyes in a Southeastern Wisconsin Lake, *Wisconsin Department of Natural Resources Technical Bulletin No. 40, 1968.*

Table 29

WALLEYED PIKE STOCKED IN PIKE LAKE: 1933-1961[a]

Year	Size	Number	Size	Number
1933-1944	Fry	33,391,185	- -	0
1945	Fry	400,000	Fingerlings	2,000
1946	Fry	1,600,000	Fingerlings	2,080
1947	Fry	415,000	- -	0
1948	Fry	415,000	- -	0
1949	- -	0	Fingerlings	3,450
1950	- -	0	Fingerlings	2,356
1951	- -	0	- -	0
1952	- -	0	Fingerlings	16,300
1953	- -	0	- -	0
1954	- -	0	Fingerlings	4,100
1955-1958	- -	0	- -	0
1959	- -	0	Fingerlings	4,909
1960	- -	0	Fingerlings	5,900
1961	- -	0	Fingerlings	4,380

[a]*Donald Marz,* Recruitment, Growth, Exploitation and Management of Walleyes in a Southeastern Wisconsin Lake, *Wisconsin Department of Natural Resources Technical Bulletin No. 40, 1968.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Mallards, wood ducks, blue-winged teal and Canada geese 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. Ospreys and loons are notable migratory visitors.

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 the 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. Threatened species migrating in the vicinity of Pike Lake include the Cerulean warblers, the Acadian flycatcher, great egret, and the Osprey. Endangered species migrating in the vicinity of Pike Lake include the common tern, Caspian tern, Forster's tern, and the loggerhead shrike.

Amphibians and reptiles are vital components of the ecosystem in an environmental unit like the Pike 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 Pike Lake area. Table 32 lists the 14 amphibian and 15 reptile species normally expected to be present in the Pike Lake area under present conditions and identifies those species most sensitive to urbanization.

Most amphibians and reptiles have definite habitat requirements that 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.

The complete spectrum of wildlife species originally native to Washington County has, along with its habitat, undergone significant change in terms of diversity and population size since the European settlement of the area. This change is a direct result of the conversion of land by the settlers from its natural state to agricultural and

Table 30

MAMMALS OF THE PIKE LAKE AREA

Scientific (family) and Common Name	Scientific Name
Didelphidae	
Virginia Opossum	*Didelphis virginiana*
Soricidae	
Cinereous Shrew	Sorex cinereus
Short-Tailed Shrew	*Blarina brevicauda*
Least Shrew	*Cryptotis parva*
Vespertilionidae	
Little Brown Bat	*Myotis lucifugus*
Silver-Haired Bat	*Lasisoncteris octivagans*
Big Brown Bat	*Eptesicus fuscus*
Red Bat	*Lasiurus borealus*
Hoary Bat	*Lasiurus cinereus*
Leporidae	
Cottontail Rabbit	*Sylvilgus floridanus*
Sciuridae	
Woodchuck	*Marmota monax*
Thirteen-lined Ground Squirrel (gopher)	*Spermophilus tridencemilineatus*
Eastern Chipmunk	*Tamias striatus*
Grey Squirrel	*Sciurus carolinensis*
Western Fox Squirrel	*Sciurus niger*
Red Squirrel	*Tamiasciurus hudsonicus*
Southern Flying Squirrel	*Glaucomys volans*
Castoridae	
American Beaver	*Castor canadensis*
Cricetidae	
Woodland Deer Mouse	*Peromyscus maniculatus*
Prairie Deer Mouse	*Peromyscus leucopus bairdii*
White-Footed Mouse	*Microtus pennsylvanicus*
Meadow Vole	*Microtus ochrogaster*
Common Muskrat	*Ondatra zibethicus*
Muridae	
Norway Rat (introduced)	*Rattus norvegicus*
House Mouse (introduced)	*Mus musculus*
Zapodidae	
Meadow Jumping Mouse	*Zapas hudonius*
Canidae	
Coyote	*Canis latrans*
Eastern Red Fox	*Vulpes vulpes*
Gray Fox	*Urocyon cinereoargenteus*
Procyonidae	
Raccoon	*Procyon lotor*
Mustelidae	
Least Weasel	*Mustela nivalis*
Short-Tailed Weasel	*Mustela erminea*
Long-Tailed Weasel	*Mustela frenata*
Mink	*Mustela vison*
Badger (occasional visitor)	*Taxidea taxus*
Striped Skunk	*Mephitis mephitis*
Otter (occasional visitor)	*Lontra canadensis*
Cervidae	
White-Tailed Deer	*Odecoileus virginianus*

Source: H.T. Jackson, Mammals of Wisconsin, *1961, U.S. Department of Agriculture Integrated Taxonomic Information System, National Museum of Natural History, Smithsonian Institute, and SEWRPC.*

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; the use of road salt for snow and ice control; the presence of 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 within Southeastern Wisconsin were initially 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 that the proper predator-prey (consumer-food) relationships can occur. In addition, a reproductive interdependence must exist.

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

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 by human activities are necessary (other than those activities of a wildlife management nature).

Table 31

BIRDS KNOWN OR LIKELY TO OCCUR IN THE PIKE LAKE AREA

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Gaviidae			
Common Loon[a]	--	--	X
Podicipedidae			
Pied-Billed Grebe	X	--	X
Horned Grebe	--	--	X
Phalacrocoracidae			
Double-Crested Cormorant	--	--	X
Ardeidae			
American Bittern[a]	X	--	X
Least Bittern[a]	X	--	X
Great Blue Heron[a]	X	R	X
Great Egret[b]	--	--	X
Cattle Egret[a,c]	--	--	R
Green Heron	X	--	X
Black-Crowned Night Heron[a]	--	--	X
Anatidae			
Tundra Swan	--	--	X
Mute Swan[c]	X	X	X
Snow Goose	--	--	X
Canada Goose	X	X	X
Wood Duck	X	--	X
Green-Winged Teal	--	--	X
American Black Duck[a]	--	X	X
Mallard	X	X	X
Northern Pintail[a]	--	--	X
Blue-Winged Teal	X	--	X
Northern Shoveler	--	--	X
Gadwall	--	--	X
American Widgeon[a]	--	--	X
Canvasback[a]	--	--	X
Redhead[a]	--	--	X
Ring-Necked Duck	--	--	X
Lesser Scaup[a]	--	--	X
Greater Scaup	--	--	R
Common Goldeneye[a]	--	X	X
Bufflehead	--	--	X
Red-Breasted Merganser	--	--	X
Hooded Merganser[a]	R	--	X
Common Merganser[a]	--	--	X
Ruddy Duck	--	--	X
Cathartidae			
Turkey Vulture	X	--	X
Accipitridae			
Osprey[a]	--	--	X
Bald Eagle[a,d]	--	--	R
Northern Harrier[a]	X	R	X
Sharp-Shinned Hawk	X	X	X
Cooper's Hawk[a]	X	X	X

Table 31 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Accipitridae (continued)			
Northern Goshawk[a]	- -	R	X
Red-Shouldered Hawk[b]	R	- -	X
Broad-Winged Hawk	R	- -	X
Red-Tailed Hawk	X	X	X
Rough-Legged Hawk	- -	X	X
American Kestrel	X	X	X
Merlin[a]	- -	- -	X
Phasianidae			
Grey Partridge[c]	R	R	- -
Ring-Necked Pheasant[c]	X	X	- -
Wild Turkey	X	X	- -
Rallidae			
Virginia Rail	X	- -	X
Sora	X	- -	X
Common Moorhen	X	- -	X
American Coot	X	R	X
Gruidae			
Sandhill Crane	X	- -	X
Charadriidae			
Black-Bellied Plover	- -	- -	X
Semi-Palmated Plover	- -	- -	X
Killdeer	X	- -	X
Scolopacidae			
Greater Yellowlegs	- -	- -	X
Lesser Yellowlegs	- -	- -	X
Solitary Sandpiper	- -	- -	X
Spotted Sandpiper	X	- -	X
Upland Sandpiper[a]	R	- -	X
Semi-Palmated Sandpiper	- -	- -	X
Pectoral Sandpiper	- -	- -	X
Dunlin	- -	- -	X
Common Snipe	R	- -	X
American Woodcock	X	- -	X
Wilson's Phalarope	- -	- -	X
Laridae			
Ring-Billed Gull	- -	- -	X
Herring Gull	- -	X	X
Common Tern[e]	- -	- -	R
Caspian Tern[e]	- -	- -	R
Forster's Tern[e]	- -	- -	R
Black Tern[a]	X	- -	X
Columbidae			
Rock Dove[c]	X	X	- -
Mourning Dove	X	X	X
Cuculidae			
Black-Billed Cuckoo	X	- -	X
Yellow-Billed Cuckoo[a]	X	- -	X
Strigidae			
Eastern Screech Owl	X	X	- -
Great Horned Owl	X	X	- -
Snowy Owl	- -	R	- -
Barred Owl	X	X	- -

Table 31 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Strigidae (continued)			
Long-Eared Owl[a]	- -	X	X
Short-Eared Owl[a]	- -	R	X
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	X
Picidae			
Red-Headed Woodpecker[a]	X	R	X
Red-Bellied Woodpecker	X	X	- -
Yellow-Bellied Sapsucker	- -	R	X
Downy Woodpecker	X	X	- -
Hairy Woodpecker	X	X	- -
Northern Flicker	X	R	X
Tyrannidae			
Olive-Sided Flycatcher	- -	- -	X
Eastern Wood Pewee	X	- -	X
Yellow-Bellied Flycatcher[a]	- -	- -	X
Acadian Flycatcher[b]	R	- -	X
Alder Flycatcher	R	- -	X
Willow Flycatcher	X	- -	X
Least Flycatcher	R	- -	X
Eastern Phoebe	X	- -	X
Great Crested Flycatcher	X	- -	X
Eastern Kingbird	X	- -	X
Alaudidae			
Horned Lark	X	X	X
Hirundinidae			
Purple Martin[a]	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			
Tufted Titmouse	R	R	- -
Black-Capped Chickadee	X	X	X
Sittidae			
Red-Breasted Nuthatch	R	X	X
White-Breasted Nuthatch	X	X	- -
Certhiidae			
Brown Creeper	- -	X	X

Table 31 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Troglodytidae			
Carolina Wren	- -	- -	R
House Wren	X	- -	X
Winter Wren	- -	- -	X
Sedge Wren[a]	X	- -	X
Marsh Wren	X	- -	X
Regulidae			
Golden-Crowned Kinglet	- -	X	X
Ruby-Crowned Kinglet[a]	- -	- -	X
Blue-Gray Gnatcatcher	X	- -	X
Eastern Bluebird	X	- -	X
Veery[a]	X	- -	X
Gray-Cheeked Thrush	- -	- -	X
Swainson's Thrush	- -	- -	X
Hermit Thrush	- -	- -	X
Wood Thrush[a]	X	- -	X
American Robin	X	X	X
Mimidae			
Gray Catbird	X	- -	X
Brown Thrasher	X	- -	X
Bombycillidae			
Bohemian Waxwing	- -	R	- -
Cedar Waxwing	X	X	X
Laniidae			
Northern Shrike	- -	- -	X
Loggerhead Shrike[e]	- -	- -	R
Sturnidae			
European Starling[c]	X	X	X
Vireonidae			
Bell's Vireo	- -	- -	R
Solitary Vireo	- -	- -	X
Yellow-Throated Vireo	X	- -	X
Warbling Vireo	X	- -	X
Philadelphia Vireo	- -	- -	X
Red-Eyed Vireo	X	- -	X
Parulidae			
Blue-Winged Warbler	X	- -	X
Golden-Winged Warbler[a]	R	- -	X
Tennessee Warbler[a]	- -	- -	X
Orange-Crowned Warbler	- -	- -	X
Nashville Warbler[a]	- -	- -	X
Northern Parula	- -	- -	X
Yellow Warbler	X	- -	X
Chestnut-Sided Warbler	- -	- -	X
Magnolia Warbler	- -	- -	X
Cape May Warbler[a]	- -	- -	X
Black-Throated Blue Warbler	- -	- -	X
Yellow-Rumped Warbler	- -	R	X
Black-Throated Green Warbler	- -	- -	X
Cerulean Warbler[b]	R	- -	R
Blackburnian Warbler	- -	- -	X

Table 31 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Parulidae (continued)			
Palm Warbler	- -	- -	X
Bay-Breasted Warbler	- -	- -	X
Blackpoll Warbler	- -	- -	X
Black-and-White Warbler	- -	- -	X
Prothonotary Warbler[a]	- -	- -	R
American Redstart	X	- -	X
Ovenbird	X	- -	X
Northern Waterthrush	- -	- -	X
Connecticut Warbler[a]	- -	- -	X
Mourning Warbler	R	- -	X
Common Yellowthroat	X	- -	X
Wilson's Warbler	- -	- -	X
Kentucky Warbler[b]	- -	- -	R
Canada Warbler	R	- -	X
Hooded Warbler[b]	R	- -	R
Thraupidae			
Scarlet Tanager	X	- -	X
Cardinalidae			
Northern Cardinal	X	X	- -
Rose-Breasted Grosbeak	X	- -	X
Indigo Bunting	X	- -	X
Emberizidae			
Dickcissel[a]	R	- -	X
Eastern Towhee	X	- -	X
American Tree Sparrow	- -	X	X
Chipping Sparrow	X	- -	X
Clay-Colored Sparrow	R	- -	X
Field Sparrow	X	- -	X
Vesper Sparrow[a]	X	- -	X
Savannah Sparrow	X	- -	X
Grasshopper Sparrow[a]	X	- -	X
Henslow's Sparrow[b]	R	- -	X
Fox Sparrow	- -	R	X
Song Sparrow	X	X	X
Lincoln's Sparrow	- -	- -	X
Swamp Sparrow	X	X	X
White-Throated Sparrow	- -	R	X
White-Crowned Sparrow	- -	- -	X
Dark-Eyed Junco	- -	X	X
Lapland Longspur	- -	R	X
Snow Bunting	- -	R	X
Icteridae			
Bobolink[a]	X	- -	X
Red-Winged Blackbird	X	X	X
Eastern Meadowlark[a]	X	R	X
Western Meadowlark[a]	R	- -	X
Yellow-Headed Blackbird	X	- -	X
Rusty Blackbird	- -	R	X
Common Grackle	X	X	X
Brown-Headed Cowbird	X	R	X
Orchard Oriole[a]	R	- -	R
Baltimore Oriole	X	- -	X

Table 31 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Fringillidae			
Purple Finch	- -	X	X
Common Redpoll	- -	X	X
Pine Siskin[a]	- -	X	X
American Goldfinch	X	X	X
House Finch	X	X	X
Evening Grosbeak	- -	X	X
Passeridae			
House Sparrow[c]	X	X	- -

NOTE: Total number of bird species: 219
Number of alien, or nonnative, bird species: 7 (3 percent)

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

X - Present, not rare
R - Rare

[a]*State-designated species of special concern. Fully protected Federal and State laws under the Migratory Bird Act.*

[b]*State-designated threatened species.*

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

[d]*Federally designated threatened species.*

[e]*State-designated endangered species.*

Source: Samuel D. Robbins, Jr., Wisconsin Birdlife, Population & Distribution, Past and Present, *1991; John E. Bielefeldt, Racine County Naturalist; Zoological Society of Milwaukee County and Birds Without Borders-Aves Sin Fronteras,* Report for Landowners on the Avian Species Using the Pewaukee, Rosendale and Land O' Lakes Study Sites, *April-August, 1998; Wisconsin Department of Natural Resources; and SEWRPC.*

On the basis of these five criteria, the wildlife habitat areas in the Pike 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 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. Nevertheless, Class III habitat areas may 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 habitat in an area.

As shown on Map 20, approximately 2,800 acres, or about 35 percent of the total drainage area tributary to Pike Lake, were classified in the 1985 inventory as wildlife habitat. Of the current area of wildlife habitat, about 1,540 acres, or about 20 percent of the total drainage area, were classified as Class I habitat; approximately 760 acres, or about 10 percent, were classified as Class II habitat; and about 480 acres, or about 5 percent, were classified as Class III habitat.

Table 32

AMPHIBIANS AND REPTILES OF THE PIKE LAKE AREA

Scientific (family) and Common Name	Scientific Name	Species Reduced or Dispersed with Full Area Urbanization	Species Lost with Full Area Urbanization
Amphibians			
Proteidae			
Mudpuppy	*Necturus maculosus maculosus*	X	- -
Ambystomatidae			
Blue-Spotted Salamander	*Ambystoma laterale*	- -	X
Spotted Salamander	*Ambystoma maculatum*		
Eastern Tiger Salamander	*Ambystoma tigrinum tigrinum*	X	- -
Salamandridae			
Central Newt	*Notophthalmus viridescens louisianensi*	X	- -
Bufonidae			
American Toad	*Bufo americanus americanus*	X	- -
Hylidae			
Western Chorus Frog	*Pseudacris triseriata triseriata*	X	- -
Blanchard's Cricket Frog[a,b]	*Acris crepitans blanchardi*	X	- -
Northern Spring Peeper	*Hyla crucifer crucifer*	- -	X
Gray Tree Frog	*Hyla versicolor*	- -	X
Ranidae			
Bull Frog[c]	*Rana catesbeiana*	- -	X
Green Frog	*Rana clamitans melanota*	X	- -
Northern Leopard Frog	*Rana pipiens*	- -	X
Pickerel Frog[c]	*Rana palustris*	- -	X
Reptiles			
Chelydridae			
Common Snapping Turtle	*Chelydra serpentina serpentina*	X	- -
Kinosternidae			
Musk Turtle (stinkpot)	*Sternotherus odoratus*	X	- -
Emydidae			
Western Painted Turtle	*Chrysemys picta belli*	X	- -
Midland Painted Turtle	*Chrysemys picta marginata*	X	- -
Blanding's Turtle[d]	*Emydoidea blandingii*	- -	X
Trionychidea			
Eastern Spiny Softshell	*Trionyx spiniferus spiniferus*	X	- -
Colubridae			
Northern Water Snake	*Nerodia sipedon sipedon*	X	- -
Midland Brown Snake	*Storeria dekayi wrightorum*	X	- -
Northern Red-Bellied Snake	*Storeria occipitomaculata occipitomaculata*	X	- -
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*	X	- -
Chicago Garter Snake	*Thamnophis sirtalis semifasciata*	X	- -
Butler's Garter Snake[d]	*Thamnophis butleri*	X	- -
Eastern Hognose Snake	*Heterodon platyrhinos*	- -	X
Smooth Green Snake	*Opheodrys vernalis vernalis*	- -	X
Eastern Milk Snake	*Lampropeltis triangulum triangulum*	- -	X

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

[b]*State-designated endangered species.*

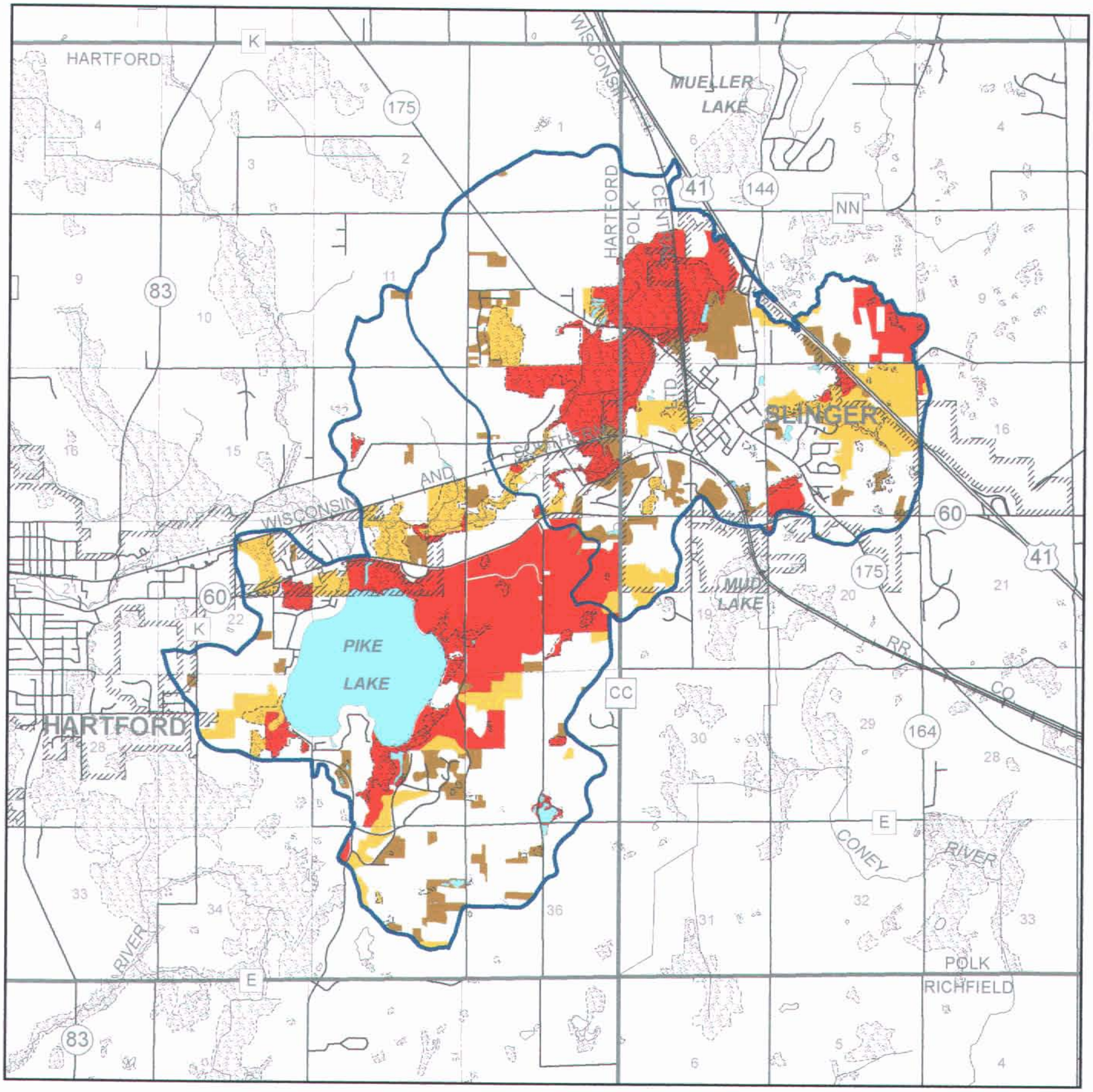
[c]*State-designated special concern species.*

[d]*State-designated threatened species.*

Source: Gary S. Casper, Geographical Distribution of the Amphibians and Reptiles of Wisconsin, *1996, Wisconsin Department of Natural Resources, Kettle Moraine State Forest, Lapham Peak Unit; and SEWRPC.*

Map 20

WILDLIFE HABITAT IN THE DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 1985



CLASS I, HIGH-VALUE HABITAT

CLASS II, MEDIUM-VALUE HABITAT

CLASS III, GOOD-VALUE HABITAT

SURFACE WATER

Source: SEWRPC

0 0.5 1 MILES

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.[9]

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 that may occur in some floodlands.[10]

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 that allows for the application of professional judgment in cases where satisfaction of the three criteria for wetland identification is unclear.

Wetlands in Southeastern Wisconsin are classified predominantly as deep marsh, shallow marsh, bog, fen, low prairie, southern sedge meadow, fresh (wet) meadow, shrub carr, southern wet and wet-mesic hardwood forest, and conifer swamp. As of 2000, the major wetland communities located in the total drainage area tributary to Pike Lake, as shown on Map 21, encompassed approximately 1,035 acres, or approximately 13 percent of the tributary drainage area. In the drainage area directly tributary to the Lake, wetlands comprised about 390 acres, or about 10 percent of the drainage area. Wetland types included sedge meadow, shrub carr, fresh (wet) meadow, deep and shallow marsh, and southern wet and wet-mesic hardwood forest.

Sedge meadows are stable wetland plant communities that tend to perpetuate themselves if dredging activities and water level changes are prevented from occurring. Sedge meadows in Southeastern Wisconsin are characterized by the tussock sedge (*Carex stricta*) and, to a lesser extent, by Canada blue-joint grass (*Calamagrostis canadensis*). Sedge meadows that are drained or disturbed to some extent typically succeed to shrub carrs. Shrub

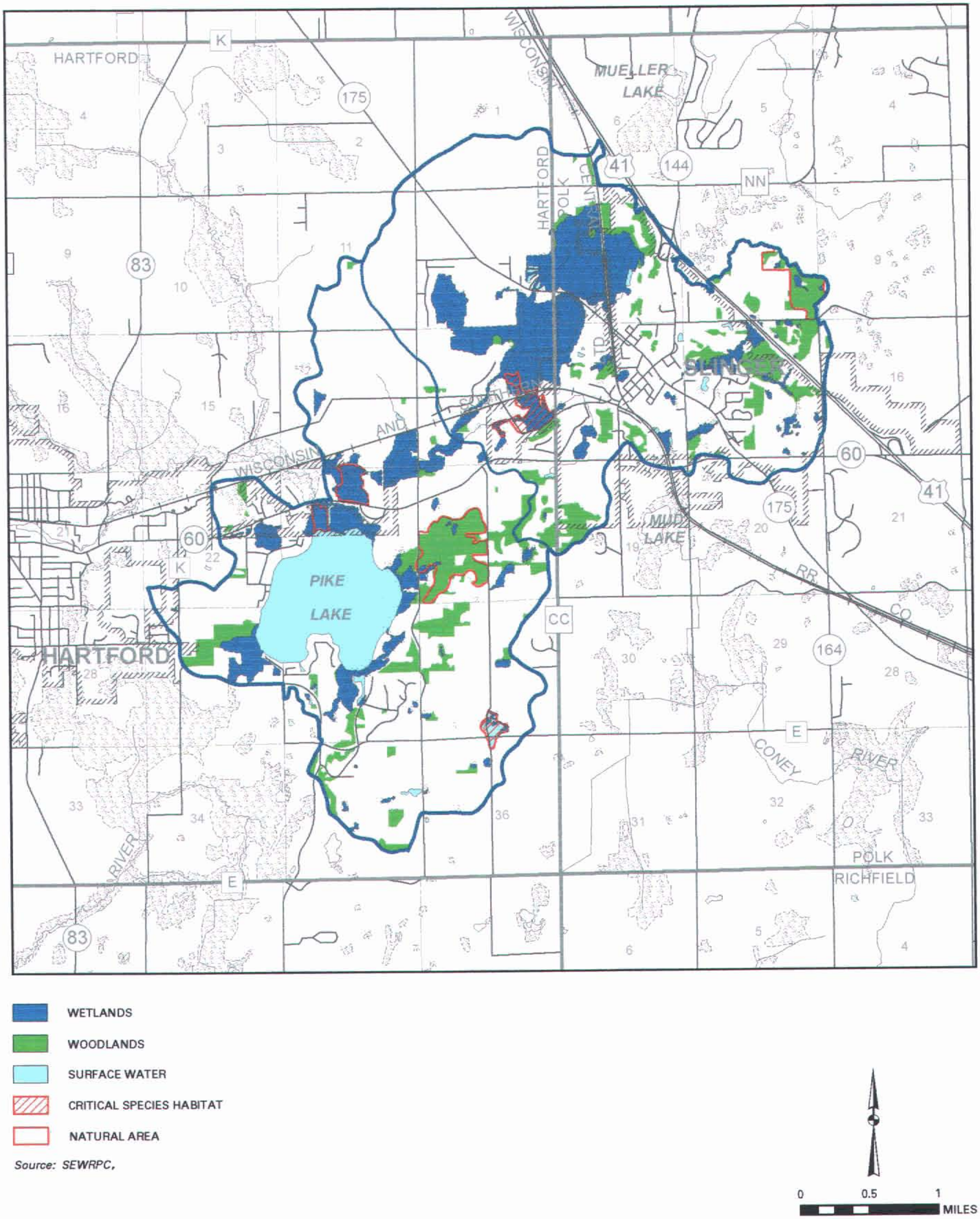
---

[9]*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.*

[10]*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 21

WETLANDS AND WOODLANDS IN THE DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 2000



Source: SEWRPC.

carrs, in addition to the sedges and grasses found in the sedge meadows, contain an abundance of shrubs such as willows (*Salix* spp.) and red osier dogwood (*Cornus stolonifera*). In extremely disturbed shrub carrs, the willows, red osier dogwood, and sedges are replaced by such exotic plants as honeysuckle (*Lonicera* sp.), buckthorn (*Rhamnus* sp.), and the very aggressive reed canary grass (*Phalaris arundinacea*).

Fresh (wet) meadows are essentially lowland grass meadows which are dominated by Canada blue-joint grass, and forbes such as marsh (*Aster simplex*), red-stem (*Aster puniceus*), and New England (*Aster novae-angliae*) asters, and giant goldenrod (*Solidago gigantea*). Several disturbed fresh (wet) meadows are located throughout the Pike Lake direct drainage area, and are largely associated with sedge meadows and shrub carrs. Many of these fresh meadows have been subject to grazing, plowing, and drainage, and consequently, are dominated by reed canary grass.

Areas of deep and shallow marsh also occurred in the Pike Lake direct drainage area, primarily adjacent to the Rubicon River where it enters the lake along the northern shore. These deep and shallow marsh areas were dominated by broadleaf cat-tail (*Typha latifolia*) soft-stem bulrush (*Scirpus validus*) and hard-stem bulrush (*Scirpus atrovirens*).

Southern wet and wet-mesic hardwood forest occurred in scattered areas adjacent to the eastern shoreline of the lake and in the south-central portion of the direct drainage area. These lowland forests were characterized by the prevalence of black willow (*Salix nigra*), cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), silver maple (*Acer saccharinum*), and American elm (*Ulmus americana*). Several clumps of tamarack (*Larix laricina*), adjacent to these areas, were also present.

WOODLANDS

Woodlands in Southeastern Wisconsin are defined as those areas containing 17 or more trees per acre which have at least a four-inch-diameter at breast height, that is, at a height of 4.5 feet above ground. In addition, the native woodlands are classified as dry, dry-mesic, mesic, wet-mesic, and wet hardwoods, and conifer swamp forests. The latter three woodland classifications are also considered to be wetlands. As of 2000, the total drainage area tributary to Pike Lake contained about 800 acres of woodlands, covering approximately 10 percent of the drainage area. Woodlands in the drainage area directly tributary to the Lake covered approximately 400 acres. These woodlands consisted of all of the native upland woodland classifications. Specifically, as shown on Map 21, upland woodlands in the drainage area directly tributary to Pike Lake included southern dry hardwoods consisting primarily of white oak (*Quercus alba*), burr oak (*Quercus macrocarpa*), shagbark hickory (*Carya ovata*), and black cherry (*Prunus serotina*); southern dry-mesic hardwoods consisting primarily of northern red oak (*Quercus borealis*), paper birch (*Betula papyrifera*), and white ash (*Fraxinus americana*); and mesic hardwoods consisting primarily of sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), and basswood (*Tilia americana*). Woodland tracts in the drainage area directly tributary to Pike Lake occurred primarily as scattered woodlots, although a relatively large contiguous upland woodland was located in Pike Lake State Park, on the eastern shore of the Lake.

ENVIRONMENTAL CORRIDORS

The Environmental Corridor Concept

One of the most important tasks undertaken by the Regional Planning Commission as part of its work program was the identification and delineation of those areas of the Region having high concentrations of natural, recreational, historic, aesthetic, and scenic resources which 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.

The delineation of these 12 natural resource and natural resource-related elements on a map 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 above mentioned 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 Pike Lake direct drainage area are contiguous with environmental corridors and isolated natural resource areas lying outside the lake drainage area boundary and, consequently, do meet these size and natural resource element criteria.

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

In the drainage area tributary to Pike Lake, the riverbanks 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, and riparian wetland areas, are perhaps the most sensitive areas in need of greatest protection. In this regard, the regional natural areas and critical species habitat protection and management plan recommends public acquisition of specific lands.[11] Within the drainage area tributary to Pike Lake, as shown on Map 21, the state-owned Pike Lake Woods, within the Pike Lake Unit of the Kettle Moraine State Forest adjoining the eastern shoreline of Pike Lake, totaling 131 acres, is already in public ownership. The Pike Lake Sedge Meadow, a wetland totaling 14 acres in areal extent, and the Slinger Upland Woods, a woodland totaling 196 acres in areal extent, are recommended for acquisition by the Town of Hartford and the Town of Polk, respectively. The STH 60 swamp, a 32-acre wetland, was also recommended for acquisition by an appropriate agency or organization. Two, other, small unnamed wetland areas, a 40-acre site and a 17-acre site, both in the Town of Hartford, were identified as critical species habitat, with the larger site recommended for acquisition by the Village of Slinger; the smaller site was not recommended for acquisition and was suggested to remain in private ownership.

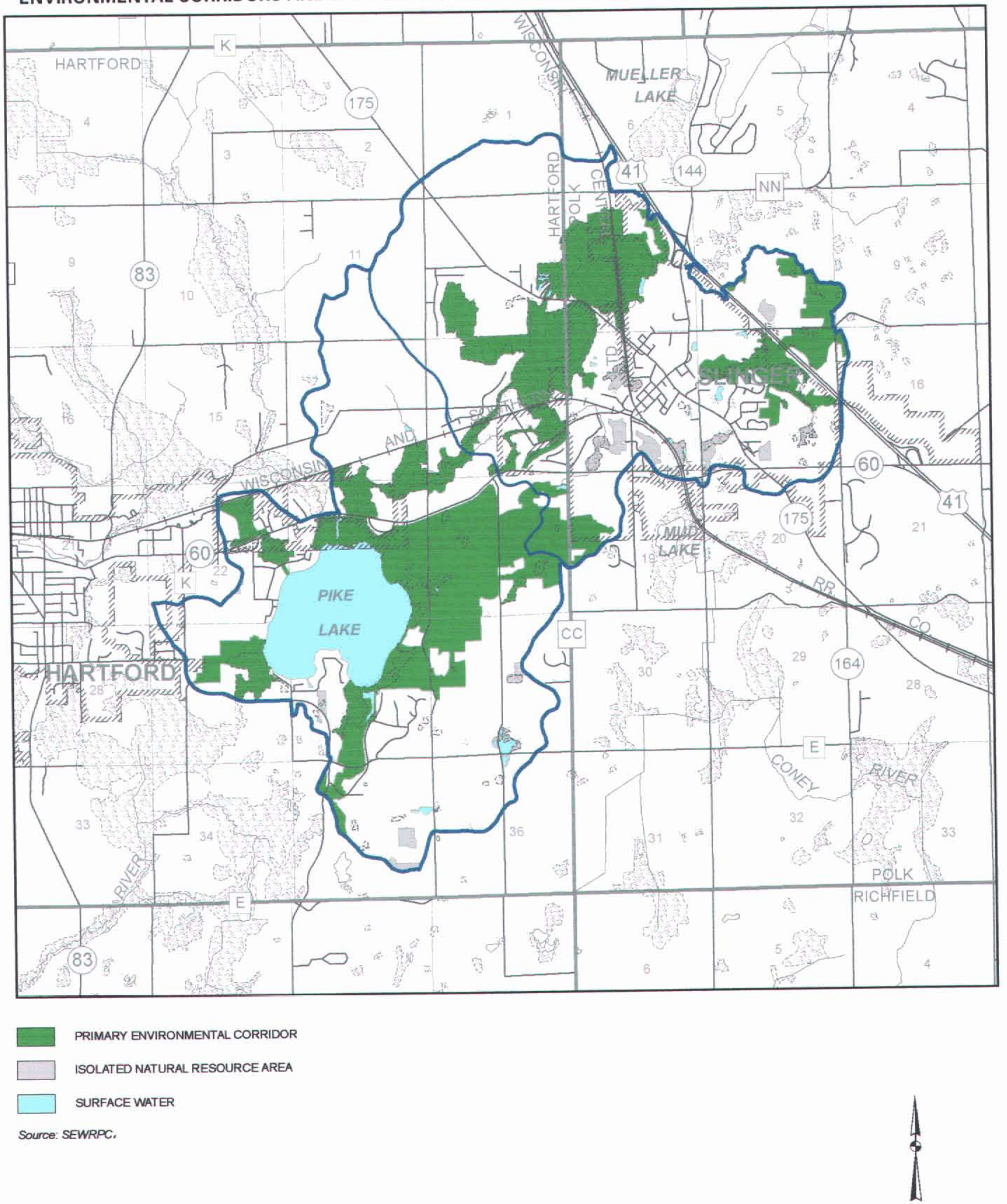
Primary Environmental Corridors

The primary environmental corridors in Southeastern Wisconsin generally lie along major stream valleys and around major lakes, and contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all of the major bodies of surface water and related undeveloped floodlands and shorelands. As shown on Map 22, primary environmental corridors in the total drainage area tributary to Pike Lake encompassed about

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

Map 22

ENVIRONMENTAL CORRIDORS AND NATURAL AREAS IN THE DRAINAGE AREA TRIBUTARY TO PIKE LAKE: 2000



Source: SEWRPC.

2,140 acres, or about 27 percent of the drainage area, as of 1995. About 1,100 acres of these lands were located within the portion of the drainage area directly tributary to the Lake. About 500 acres of primary environmental corridor lands, or about 12 percent of the drainage area directly tributary to the Lake and about 6 percent of the total drainage area, were associated with surface waters within the drainage system.

Primary corridors may be subject to urban encroachment because of their desirable natural resource amenities. Unplanned or poorly planned intrusion of urban development into these corridors, however, not only tends to destroy the very resources and related amenities sought by the development, but tends to create severe environmental and development problems as well. These problems include, among others, water pollution, flooding, wet basements, failing foundations for roads and other structures, and excessive infiltration of clear water into sanitary sewerage systems. The preservation of such corridors, thus, is one of the major ways in which the water quality of Pike Lake can be maintained and perhaps improved.

No secondary environmental corridors were identified within the drainage area tributary to Pike Lake. Secondary environmental corridors are located generally along intermittent streams or serve as links between segments of primary environmental corridors. Secondary environmental corridors contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive agricultural purposes or urban land uses, and facilitate surface water drainage, maintain "pockets" of natural resource features, and provide for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species.

Isolated Natural Resource Areas

In addition to the primary environmental corridors, other small concentrations of natural resource base elements exist within the Pike Lake drainage area. These concentrations are isolated from the environmental corridors by urban development or agricultural lands and, although separated from the environmental corridor network, have important natural values. These isolated natural resource areas may provide the only available wildlife habitat in a localized area, provide good locations for local parks and nature study areas, and lend a desirable aesthetic character and diversity to the area. Important isolated natural resource features include a variety of isolated wetlands, woodlands, and wildlife habitat. These isolated natural resource features should also be protected and preserved in a natural state whenever possible. Such isolated areas five or more acres in size within the total drainage area tributary to Pike Lake also are shown on Map 22 and total about 130 acres, or about 2 percent of the drainage area. About 50 acres are within the portion of the drainage area directly tributary to Pike Lake. Approximately 10 acres of these isolated natural resources are associated with surface waters.

SUMMARY

Pike Lake is a reflection of its tributary drainage area. As noted in Chapter IV, Pike Lake is a typical hard-water, alkaline lake that is considered to have relatively good water quality. While total phosphorus levels were found to be generally at the level considered to cause nuisance algal and macrophytic growths, chlorophyll-*a* concentrations were such in recent years as to suggest that algal growth was not an issue in the Lake during the year 2000 study. In contrast, the increasing abundance of rooted aquatic plants, especially Eurasian water milfoil, was remarked as an issue of concern. Notwithstanding, the Lake provides suitable habitat for a self-sustaining game fish population, and stocking of fishes has not occurred in recent years.

The Pike Lake drainage area provides a range of habitats for birds, large and small mammals, and reptiles and amphibians, with about 20 percent of the drainage area being considered to be valuable wildlife habitat. While the area of wildlife habitat has declined since the initial delineation of habitat areas in 1985, about one-half of the area delineated as wildlife habitat is considered to be very high value. Much of the highest value wildlife habitat is protected and preserved within the confines of the Pike Lake Unit of the Kettle Moraine State Forest, although extensive wetland areas and limited woodland areas in the vicinity of the Village of Slinger have been identified as potential sites for acquisition by local government in the adopted regional natural areas and critical species habitat protection and management plan. These latter areas include the Slinger Upland Woods, recommended to be acquired by the Town of Polk, and a 40-acre unnamed wetland site, recommended to be acquired by the

Village of Slinger. All of these areas are within the primary environmental corridor lands delineated within the total drainage area tributary to the Lake.

The primary environmental corridors contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, as well as the major surface water resources and related undeveloped floodlands and shorelands. The preservation of such corridors, thus, is one of the major ways in which the water quality of Pike Lake can be maintained and perhaps improved.

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 recreational activities such as picnicking and walking along the shoreline, to full-contact, active recreational activities such as swimming, boating, and waterskiing. To accommodate this range of uses, the State of Wisconsin has developed water use objectives for the surface waters of the State, and has promulgated these objectives in Chapters NR 102 and NR 104 of the *Wisconsin Administrative Code*. Complementary water use objectives and supporting water quality guidelines have been adopted by the Southeastern Wisconsin Regional Planning Commission, as set forth in the adopted regional water quality management plan, for all major lakes and streams in the Region.[1] The current water uses, as well as the water use objectives and supporting water quality guidelines for Pike Lake, are discussed in this chapter.

RECREATIONAL USES AND FACILITIES

Pike Lake is located within about a one hour drive from much of the metropolitan Milwaukee area, and within easy driving distance of the Madison metropolitan area and the so-called Fox Cities metropolitan area. Its location, accessibility, and degree and type of shoreline development, including the Pike Lake Unit of the Kettle Moraine State Forest, one of the most heavily utilized parks in the State park system, contribute to a more intensive recreational usage than is found on many other lakes in Southeastern Wisconsin. The Lake supports a full range of lake uses, providing opportunities for a variety of water-based outdoor recreational activities, including fishing, boating, swimming, and nature studies. Although the Pike Lake Unit of the Kettle Moraine State Forest lacks a recreational boating access ramp, the Park nevertheless provides a focus for both active and passive recreational activities within the Pike Lake area. Public recreational boating access to the Lake is provided through a nearby resort, under a private provider agreement pursuant to the guidelines set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. The Lake is deemed to have adequate public recreational boating access.

---

[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; and Volume Three, *Recommended Plan*, June 1979. See also SEWRPC Memorandum Report No. 93, *A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995.

Pike Lake Unit of the Kettle Moraine State Forest
Ample opportunities for swimming and sunbathing are present at Pike Lake. The Pike Lake Unit of the Kettle Moraine State Forest, located on the east side of the lake, has a 500-foot sand beach and parking for about 290 vehicles. The Wisconsin Department of Natural Resources, at intervals during the park's existence, has proposed the expansion of the beach and parking facilities at the Pike Lake Unit of the Kettle Moraine State Forest to meet the continuing demand for recreational access to the park's water-based recreational facilities. Camping, hiking, and nature study also are popular activities at the park.

Other Park and Open Space Sites
Outside of the Pike Lake Unit of the Kettle Moraine State Forest, a number of private facilities offer a range of recreational activities, including boat launching facilities. Many fine, natural, unimproved private swimming beaches also exist along sandy portions of the Pike Lake shoreline. Development of recreational opportunities on and adjacent to Pike Lake is currently governed by recommendations set forth in the adopted park and open space plan for Washington County.[2] Continued provision of public recreational boating access opportunities, consistent with the levels set forth in Chapter NR 1 of the *Wisconsin Administrative Code*, is specifically recommended, although development of a public recreational boating access within the Pike Lake Unit of the Kettle Moraine State Forest is unlikely.[3]

Recreational Boating
A survey of recreational boating pressure on Pike Lake during 1976 indicated that Pike Lake was primarily used by anglers during the spring and early autumn months. Weekday boat usage on the Lake was primarily by anglers. On summer weekends, however, use levels were highest, and were dominated by sailing craft, water-ski boats, and pleasure boats, in declining order of importance. Boating traffic was observed to remain fairly constant throughout the boating season, with many of the boats in use being fishing boats which required less lake surface area than boats used for other recreational activities. Consequently, no overcrowding or unsafe boating conditions were considered to exist at the time of this initial survey.

Since 1976, recreational boating activity is likely to have increased. About 250 watercraft of various descriptions were observed on and around Pike Lake during 2001, as shown in Table 33. Most of these watercraft were fishing boats, accounting for about 65 of the watercraft, or approximately one-quarter of the total. Of the balance, about 60 watercraft were pontoon boats, and about 30 were powerboats. About 20 craft, or less than 10 percent of the total number of watercraft, were personal watercraft (jetskis®). Of the nonmotorized watercraft, paddleboats formed the largest proportion of the watercraft, accounting for about 35 boats. Canoes and kayaks comprised about 20 craft, and about 15 sailboats were observed.

During 2001 and 2002, boat counts by Commission staff during both week and weekend days in July and August resulted in a total of about 120 watercraft of all descriptions, fishing, pontoon, skiing, sailing, and rowing vessels and personal watercraft, being observed in operation, as shown in Table 34. Of these, about 25 were observed to be in operation during weekday mornings and afternoons, with the balance being observed to be in operation during weekend mornings and afternoons. About 60 watercraft were observed to be in operation during July 2002, which weekend was considered to be more typical of a fair weather weekend day than that reported on during 2001. Fishing boats comprised the largest number of watercraft in operation on the Lake during both periods. During these periods, the densities of high-speed watercraft on the Lake ranged from about one boat per 50 acres

---

[2]*SEWRPC Community Assistance Planning Report No. 136, 3rd Edition,* A Park and Open Space Plan for Washington County, *March 2004.*

[3]*In litt., Mr. Roman H. Koenings, Superintendent, Wisconsin Conservation Department, to Mrs. Elmer Thur, dated May 26, 1961; reaffirmed in litt., Mr. A. E. Ehly, Director: Bureau of Parks and Recreation, Wisconsin Department of Natural Resources, to Mr. Elmer E. Thur, Vice-President, Pike Lake Advancement Association, Inc., dated September 19, 1969.*

Table 33

WATERCRAFT ON PIKE LAKE: AUGUST 2001

Power Boats	Fishing Boats	Pontoon Boats	Canoes	Paddle Boats	Sail Boats	Kayaks	Personal Watercraft	Other	Total
34	63	58	21	36	14	2	19	1	248

Source: SEWRPC.

Table 34

RECREATIONAL USE SURVEY ON PIKE LAKE: 2001 AND 2002

Date and Time	Weekday Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
June 29, 2001										
10:00 a.m. to 11:00 a.m.	0	2	0/2	0	0	14	6	0/2	15	41
1:20 p.m. to 2:20 p.m	0	4	0/2	1	2	55	5	1/2	34	106
Total for the Day	0	6	4	1	2	69	11	5	49	147
Percent	0	4	3	1	1	47	8	3	33	100

Date and Time	Weekend Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
August 18, 2001										
9:30 a.m. to 10:30 a.m.	1	1	0	0	0	3	32	0	25	62
12:00 p.m. to 1:00 p.m.	0	1	0	0	0	6	6	0	65	78
Total for the Day	1	2	0	0	0	9	38	0	90	140
Percent	1	1	0	0	0	6	28	0	64	100

Date and Time	Weekend Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
July 20, 2002										
7:50 a.m. to 8:50 a.m.	8	0	0	0	0	1	34	1/0	7	51
1:30 p.m. to 2:30 p.m.	3	0	3/3	0	2	73	13	0/1	109	207
Total for the Day	11	0	6	0	2	74	47	2	116	258
Percent	4	0	2	0	1	29	18	1	45	100

NOTE: This survey was redone in 2002 due to rainy weather conditions during the 2001 survey. The "Pike Tyke" fishing contest, from 8:00 –12:00 a.m., accounted for many of the fishing boats observed on the Lake.

Source: SEWRPC.

to about one boat per 15 acres. Such densities are consistent with those considered appropriate for the conduct of safe high-speed boating activities pursuant to the adopted Regional guidelines, and would be consistent with public perceptions that the Lake is heavily used, especially on fair weather weekends.

In 1975, the Wisconsin Department of Natural Resources identified eight public access sites around Pike Lake. Of these, three sites were privately owned, two consisted of roadside rights-of-way along STH 60, and three were provided through lands owned by the Town of Hartford. Of these eight sites, three were found to be in need of maintenance, and five sites were found to be well maintained and in good condition. While the Wisconsin Department of Natural Resources considered the public sites to provide adequate access opportunity under the then-prevailing guidance, until recently, the Lake lacked adequate public recreational boating access opportunities under the guidelines established in Chapter NR 1 of the *Wisconsin Administrative Code*. Pursuant to this Chapter, between 17 and 33 car-trailer unit parking spaces would be required for the Lake to be deemed to have adequate public recreational boating access. As of 2003, this level of access is currently provided under a private provider agreement by a lakeshore marina situated on the southwestern shoreline of the Lake.[4]

Recreational boating activities on Pike Lake are regulated by state boating and water safety laws, and by the specific provisions of Town of Hartford Ordinance, Chapter 11, *Lakes and Waters*, regulating recreational boating activities and swimming. The ordinance is summarized in Appendix B.

Angling

Pike Lake provides a high quality habitat for walleyed and northern pike, largemouth bass, and panfish. The size and the numbers of fish in the Lake provide a range of angling opportunities to both the Lake residents and other Lake users alike. Waterskiing, pleasure boating, and swimming are popular recreational activities on Pike Lake. Ice fishing is a popular recreational activity on the lake, especially during winter weekends. Winter recreation activities in Pike Lake State Park also include snowmobiling and cross-country skiing.

Wisconsin Department of Natural Resources Recreational Rating

In general, Pike Lake provides opportunities for a variety of outdoor recreational activities in a high-quality setting. An outdoor recreational rating technique was developed by the Wisconsin Department of Natural Resources to summarize the outdoor recreational value of inland lakes. As shown in Table 35, Pike Lake scored 64 out of a possible 72 rating points, placing it among those lakes in Southeastern Wisconsin providing diverse, high-quality outdoor recreational opportunities. To ensure that Pike Lake will continue to provide such recreational opportunities, the resource values of the Lake must be protected and preserved.

WATER USE OBJECTIVES

The regional water quality management plan recommended adoption of full recreational use and warmwater fisheries objectives for Pike 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 Pike Lake by a sport fishery based largely on largemouth bass and panfish. These fishes have traditionally been sought after in Pike Lake.

---

[4]*Chapter NR 1 of the* Wisconsin Administrative Code *requires that public inland lakes have adequate public recreational boating access in order for the lake to be eligible for financial and/or technical assistance from the Wisconsin Department of Natural Resources. Such assistance includes the ability to access state lake rehabilitation, nonpoint source water pollution control, fish management, and/or water safety aides.*

Table 35

WISCONSIN DEPARTMENT OF NATURAL RESOURCES RECREATIONAL RATING OF PIKE LAKE

Space: Total Area = 522 acres			Total Shore Length = 1.2 miles		
Quality (18 maximum points for each item)					
Fish:					
X 9	High production	__ 6	Medium production	__ 3	Low production
X 9	No problems	__ 6	Modest problems, such as infrequent winterkill, small rough fish problems	__ 3	Frequent and overbearing problems, such as winterkill, carp, excessive fertility
Swimming:					
__ 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 algal or weed problems	X 4	Moderate algal or weed problems	__ 2	Frequent or severe algal or weed problems
Boating:					
X 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)	__ 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)
X 6	Good water quality	__ 4	Some inhibiting factors, such as weedy bays, algal blooms, etc.	__ 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
X 6	Few nuisances, such as excessive algae, carp, etc.	__ 4	Moderate nuisance conditions	__ 2	High nuisance condition
Total Quality Rating: 64 out of a possible 72					

Source: Wisconsin Department of Natural Resources and SEWRPC.

WATER QUALITY GUIDELINES

The water quality guidelines supporting the warmwater fishery and full recreational use objectives, as established for planning purposes in the regional water quality management plan, are set forth in Table 36. These guidelines are similar to the standards set forth in Chapters NR 102 and 104 of the *Wisconsin Administrative Code*, but were refined for planning purposes in terms of their application. Guidelines are recommended for temperature; pH; and dissolved oxygen, fecal coliform, and total phosphorus concentrations. These guidelines apply to the epilimnion of lakes and to streams. The total phosphorus guideline applies to spring turnover concentrations measured in the

Table 36

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 that 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.

surface waters. Such contaminants as oil, debris, and scums; odors, tastes, 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 guidelines is intended to specify conditions in the waterways concerned that mitigate against excessive macrophyte and algal growths and promote all forms of recreational use, including angling, in these waters. Implementation of these guidelines will maintain Pike Lake in a mesotrophic condition.

LAKE WATER QUALITY OBJECTIVES

The Pike Lake Watershed Advisory Committee, created by the Pike Lake Protection and Rehabilitation District during early 2003, was formulated to "develop and implement a watershed protection plan, supported by the State, local municipalities and watershed public, to protect and improve the water quality of the Pike Lake watershed." During their deliberations, the Committee recommended that Pike Lake be managed as a mesotrophic waterbody. Currently, as noted in Chapter IV, the Lake is meso-eutrophic, or slightly more enriched than would be consistent with the guidelines of the Advisory Committee.

Reducing the trophic state from meso-eutrophic to mesotrophic would require achieving an annual average in-lake phosphorus concentration of approximately 0.02 mg/l or less, which value would sustain an annual average chlorophyll-*a* concentration of about 10 μg/l. Chlorophyll-*a* concentrations in excess of this value generally result in a visible green coloration of the water, and the likely occurrence of visible algae being present in the Lake water. The 0.02 mg/l recommended maximum total phosphorus concentration is the maximum surface water total phosphorus concentration, measured at spring overturn, recommended in lakes in Southeastern Wisconsin.[5] Exceeding this concentration greatly increases the likelihood of algal blooms, abundant rooted aquatic plant growths, and conditions that the casual or recreational user would describe as unpleasant or objectionable. The current spring overturn concentration of total phosphorus in the Lake is about 0.03 mg/l.

As suggested above, implementation of measures to reduce the total phosphorus load to the system are warranted, if the Lake is to be restored to a mesotrophic condition. Data shown in Table 36 suggest that an annual average total phosphorus concentration of about 0.02 mg/l is feasible, with total phosphorus concentrations ranging between 0.01 mg/l and 0.05 mg/l in the Lake during the 1980s and 1990s. Indeed, the forecast reduction in total phosphorus load due to planned land use changes, set forth in Chapter IV, indicates that the Lake may be expected to approach an annual average total phosphorus concentration of about 0.02 mg/l, based upon planned 2020 conditions as set forth in the adopted regional land use plan. The reduction in phosphorus loading, noted in Chapter IV, reflects changing land use conditions within the watershed, with agricultural land uses being replaced over time with urban land uses. Conversion of lands, pursuant to, among others, the provisions of Chapter 23, Shoreland, Wetland and Floodplain Zoning, of the *Washington County Code*, Chapters NR 151 through 155 of the *Wisconsin Administrative Code*, and related local level ordinances, will require that development occur with the provision of appropriate stormwater management practices, including water quality enhancement.

APPLICABLE WATERBODY CLASSIFICATIONS

At their February 2001 meeting, the Washington County Board of Supervisors adopted Chapter 23, Shoreland, Wetland and Floodplain Zoning, of the *Washington County Code of Ordinances*, implementing a graduated scale of waterbody protection pursuant to authorities granted the County under Chapter NR 115 of the *Wisconsin Administrative Code*. Integral to these refined provisions was the classification of lakes and streams based upon both physical characteristics and biological characteristics. Chemical characteristics were not directly represented in the adopted classification system, although they are related, to some extent, to the physical aspects of the waterbodies. The criteria adopted by Washington County for the classification of lakes included: surface area, maximum depth, retention time, shoreline development factor, the ratio of shoreline length to the number of platted lots, and fisheries significance. Based upon the natural areas and critical species habitat protection and management plan, adopted by Washington County on December 9, 1997, additional points were awarded to those waterbodies that were wholly encompassed within areas designated as natural area or critical species habitat. This modification recognized current County policy as an additional element in the lake classification process insofar as the highest quality water resources in the County were concerned.

This adopted classification system established a classification system that separates lakes into three groups. Class I waters are those lakes to be protected or preserved as high-quality resource waters. These waters are generally small, shallow lakes with a high-quality fishery. These are the lakes that are most susceptible to severe water pollution problems. Class II waters are those lakes to be maintained in a currently good quality. Class III waters, comprising those waterbodies that have been historically heavily developed for residential and recreational use in the County, are those lakes in need of active management. These are generally large, deep waterbodies. Pike Lake is designated as a Class III waterbody.

---

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

At their February 2001 meeting, the Washington County Board of Supervisors also established a classification system that separates streams into three classes, based upon both physical and biological characteristics. As in the case of lakes, the classification criteria did not include explicit consideration of water chemistry. The criteria approved by Washington County included: average depth, average width, and fisheries significance. Class I waters are those streams to be protected or preserved as high-quality resource waters. These waters are generally headwater streams with a high-quality fishery and include trout streams and streams designated as coldwater systems. Class II waters are those streams to be maintained in a currently good quality and include those streams designated as systems containing threatened or endangered species or species of special concern. Class III waters, comprising those streams that have been historically heavily developed for residential use and economic purposes in the County, are those streams in need of active management. Class III streams include those streams designated as warmwater systems. For ease of administration, and upon the advice of Wisconsin Department of Natural Resources staff, the named streams are considered to include all regulated tributary streams within the named stream reach. The Rubicon River is designated as a Class II waterbody.

Based on the Ordinance, the largest and most developed waterbodies in Washington County, including Pike Lake, would receive a level of protection that approximates the current levels of protection afforded these lakes under existing *Wisconsin Statutes* and County ordinance. The majority of other waterbodies within Washington County would receive a somewhat higher degree of protection in order to maintain their existing water quality and habitat value. In no case would the level of protection from those waters be less than that provided under applicable *Wisconsin Statutes* and administrative code requirements, while the higher levels of protection could include provisions for mitigation or alternative means of achieving compliance with the enhanced code requirements, in addition to increased setbacks from the shoreline, increased lot size relative to the amount of impervious surface, and related provisions intended to minimize anthropogenic impacts on these watercourses.

Alternative lake and watershed management measures to achieve and sustain a mesotrophic state in Pike Lake, consistent with these requirements, are described in Chapter VII. Selected measures, considered both technically and economically feasible, are formulated into the recommended lake management plan set forth in Chapter VIII.

Chapter VII

ALTERNATIVE LAKE MANAGEMENT MEASURES

INTRODUCTION

Based upon review of the inventories and analyses set forth in Chapters II through VI, six issues were identified requiring consideration in the formulation of alternative and recommended lake management measures. These issues are related to: 1) wastewater; 2) nonpoint source pollution and land use; 3) stormwater; 4) in-lake water quality; 5) ecologically valuable areas, aquatic plants and fisheries; and, 6) hydrology and inflow/outflow management. The management measures considered herein are focused primarily on those measures which are applicable within the Pike Lake Protection and Rehabilitation District, and to the City of Hartford, the Village of Slinger, and the Town of Hartford, with lesser emphasis given to those measures which are applicable to others with jurisdiction within the broader total drainage area tributary to Pike Lake. Potential measures for water quality management of Pike Lake include both point and nonpoint source pollution controls, and in-lake rehabilitation techniques.

Point source pollution controls address the quality and quantity of wastewaters discharged to the Lake and its tributary streams. Nonpoint source pollution controls address runoff from the urban and rural lands tributary to the Lake, including the control of pollutants entering the Lake by direct overland runoff, drainage through natural or man-made channels, direct precipitation onto the Lake surface, and groundwater flows. In-lake rehabilitation techniques either directly treat the symptoms of nutrient enrichment, or alter the characteristics of the lake basin which may be interfering with the achievement of desired water use objectives, including diversion of inflows and management of outflows.

WATERSHED MANAGEMENT ALTERNATIVES

Pollution Abatement and Stormwater Management

All human activities upon the land surface result in some degree of mobilization of contaminants and modification of surface runoff patterns that can affect lakes and streams, their quality, and biotic condition. Many human activities can be mitigated to a large extent by the implementation of sound planning, provision of sanitary sewer services, appropriate nonpoint source pollution abatement measures, and the actions of an informed public. In the first instance, sound land use development and management in the tributary watershed, and protection of environmentally sensitive lands, are the fundamental building blocks for protecting lake and stream water quality and habitat, and preserving human use opportunities that will support a broadly-based recreational and residential community. Where appropriate densities of dwellings and other urban land uses exist, provision of waterborne sewerage services, with concomitant provision of secondary or tertiary wastewater treatment, can mitigate the delivery of contaminants to receiving waters, and have proven effective in reducing levels of enrichment of lakes and waterways. In addition, specific nonpoint source pollution control and abatement measures should be integrated into land use regulations and promoted by a far-reaching informational and educational program within the drainage area tributary to individual lakes and streams. Each of these measures is elaborated further below.

Land Use Management and Zoning

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 Pike 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.

Development in the Shoreland Zone

Existing 1995 and planned year 2020 land use patterns and existing zoning regulations in the tributary area to Pike Lake have been described in Chapter III. If the recommendations set forth in the adopted regional land use plan are followed, under year 2020 conditions, urban residential development within the drainage area tributary to Pike Lake would approximately double. Much of this residential development is likely to occur on agricultural lands. Nearly all of the planned new urban development is located beyond the riparian and shoreland zones. Within those areas, it is envisioned that there will be some infilling of existing platted lots and some backlot development, as well as the redevelopment and reconstruction of existing residential and commercial structures on lakefront properties at approximately current densities of impervious surface area. Recent surveillance indicates that this type of development is currently occurring. Accordingly, given the potential impact of lakeshore development and redevelopment on the lake resources, land use development or redevelopment proposals around the shoreline of Pike Lake and within the drainage area directly tributary to the Lake should be evaluated for potential impacts on the Lake, as such proposals are advanced.

Recent studies of the potential impact of riparian landscaping activities on the nutrient loadings to lakes in Southeastern Wisconsin have suggested that urban residential lands can contribute up to twice the mass of phosphorus to a lake when subjected to an active program of urban lawn care than similar lands managed in a more natural fashion.[1] The application of agrochemicals to such lands, in excess of the plant requirements, therefore, results in enhanced nutrient loading directly to the adjacent waterbodies. To address these concerns, a number of communities are debating the enactment of fertilizer control ordinances in addition to the public informational programming discussed below; some communities, such as the Big Cedar Lake Protection and Rehabilitation District, also have purchased bulk lots of phosphorus-free lawn and garden fertilizers for resale to riparian landowners. Given the increasing importance of urban land uses within the riparian area of Pike Lake, and within its drainage area, consideration of a comprehensive program to regulate urban agricultural practices appears to be warranted.

Development in the Tributary Drainage Area

The level of development envisioned in the adopted regional and local land use plans for the drainage basin tributary to Pike Lake indicates continuing urban development, generally on large suburban-density lots. Careful review of applicable zoning ordinances to incorporate levels and patterns of development consistent with the plan within the drainage area tributary to Pike Lake is recommended. Changes in the zoning ordinances could be considered to better reflect the land use patterns recommended in the adopted land use plans. Consideration should be given to minimizing the areal extent of 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, utilizing the principles of conservation development.[2]

---

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

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

Development of lake- and stream-front properties within unincorporated areas of Washington County, and lands annexed to incorporated areas, subsequent to February 2001, are governed by the provisions of Chapter 23 of the *Washington County Code*, which sets a graduated scale of performance standards for such development based upon the sensitivity of the waterbody to development related impacts, among other criteria:

- The Rubicon River is a Class II waterbody, which suggests that the stream corridor is moderately developed, with some sensitivity to development-related impacts. Consequently, lot sizes and setbacks of principle structures exceed statewide minima established pursuant to Chapter NR 115 of the *Wisconsin Administrative Code*. By requiring greater setback distances, among other provisions, the *Washington County Code* seeks to limit runoff of contaminants to the stream, thereby protecting and preserving the biological diversity and water quality of this resource.

- Pike Lake is classified as a Class III waterbody pursuant to the Chapter 23 of the *Washington County Code*. Class III waterbodies are subject to the statewide minima established pursuant to Chapter NR 115 of the *Wisconsin Administrative Code*.

Given the increasing importance of urban land uses within the total drainage area tributary to Pike Lake, consideration of the periodic review of applicable land use plans and zoning requirements to ensure conformity with best land management practices appears to be warranted.

Stormwater Management on Development Sites
With respect to stormwater management on development sites, as noted in Chapter III, the City of Hartford had adopted stormwater management ordinances, and the Towns of Hartford and Polk were subject to the provisions of Chapter 17 of the *Washington County Code*. While the Village of Slinger did not have an adopted stormwater management ordinance, stormwater management provisions, consistent with the *Washington County Code*, generally were included as specific conditions for development within the Village. These ordinances reflect current best practices insofar as the determination of stormwater flows, mitigation of flooding potential, and the control of contaminants from land use activities are concerned. Periodic review of these ordinances and their provisions for consistency with best management practices, and to ensure their currency with the state-of-the-art, should be undertaken on a regular basis to facilitate control of urban-sourced contaminants that would likely be delivered to the Lake. Periodic review of stormwater management practices and regulations, therefore, appears to be warranted.

Protection of Environmentally Sensitive Lands
Environmentally sensitive lands within the drainage area tributary to Pike Lake include wetlands, woodlands, and wildlife habitat areas. Nearly all of these areas within the Pike Lake drainage area are included in the environmental corridors and isolated natural resource area features delineated by the Regional Planning Commission. Upland areas, woodlands, and wildlife habitat areas, currently, are protected primarily through local land use regulation, while wetlands enjoy a wider range of protections set forth in State and Federal legislation.

Wetlands, Woodlands, and Wildlife Habitat
Wetland protection can be accomplished through land use regulation and, in cases where land use regulations may not offer an adequate degree of protection, through public acquisition of sensitive sites. These wetland areas are currently protected to a degree by current zoning and regulatory programs administered by the U.S. Army Corps of Engineers, WDNR, and County and municipal authorities under one or more of the Federal, State, County, and local regulations. Wetlands adjacent to lakes and streams help enhance water quality conditions and provide natural floodwater storage within the landscape, while preserving desirable open space characteristics for residents of the area to participate in a wide range of resource-oriented recreational activities. Protection of these areas, in particular, can assist in avoiding the creation of new environmental and developmental problems as urbanization proceeds within the watershed.

Some of the wetland, woodland, and wildlife habitat areas within the drainage area tributary to Pike Lake, however, have been recommended for public acquisition in the adopted regional natural areas and critical species habitat management and protection plan. Some of these lands, including the Pike Lake Woods, are currently under protective ownership, while other lands, such as the STH 60 Swamp and Pike Lake Sedge Meadow, are proposed to be placed, or placed more fully, into protective ownership.[3] Public acquisition of these lands, including acquisition by not-for-profit conservation organizations, as recommended in the adopted regional natural areas and critical species habitat protection and management plan appears to be warranted.

Inlet and Adjacent Wetland Complex Modifications
Wetlands also function to protect water quality. Studies by the U.S. Geological Survey indicate that wetlands may act to retain potential contaminants, or modify the delivery of contaminants to lakes. In the case of Delavan Lake,[4] the Mound Road wetland system was constructed to provide such water quality protection and benefit to Delavan Lake. This wetland system, constructed on the site of a prior converted wetland that had been utilized historically for agricultural purposes for a considerable period prior to the restoration of the wetland system, is located astride Jackson Creek, the primary inflowing stream to Delavan Lake.

With respect to the influence of the Mound Road wetland on the phosphorus loading to Delavan Lake, the differences between the loads entering the wetland from the drainage area tributary to Jackson Creek and those leaving the wetland at Mound Road suggested some degree of phosphorus retention within the wetland complex. While the constructed wetland would appear to have the attributes of both a source, during 1995, and sink, during 1994, of phosphorus during specific years based upon prevailing climatic conditions, the principal beneficial function of the wetland was to modify the timing of the delivery of the phosphorus load to the Lake such that the phosphorus does not enter Delavan Lake during the summer growing season, thereby moderating the biological response to the annual load to phosphorus to the Lake, regardless of whether the wetland acted as a source or a sink for phosphorus.[5] During both 1994 and 1995, the wetland complex served as a net depositional area for suspended sediments carried by the Jackson Creek. These trends are supported by the observation that the eastern and northern sedimentation basins located within the Mound Road wetland complex have accumulated about two to three feet and about one foot of retained sediment, respectively.

In the case of Pike Lake, the proximity of the Rubicon River inlet and outlet led to the proposal and ultimate construction of a bypass channel through the wetland complex, linking the two portions of the river.[6] The bypass was constructed during 1994. As of 2003, monitoring data collected by the U.S. Geological Survey suggested that the bypass was effective in modifying the phosphorus load to the Lake, with up to about 85 percent of the

---

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

[4]*See SEWRPC Community Assistance Planning Report No. 253,* A Lake Management Plan for Delavan Lake, Walworth County, Wisconsin, *May 2002.*

[5]*U.S. Geological Survey Water-Resources Investigations Report 87-4168,* Hydrology and Water Quality of Delavan Lake in Southeastern Wisconsin, *August 1988; see also Dale M. Robertson, Gerald L. Goddard, Daniel R. Helsel, and Kevin L. MacKinnon, "Rehabilitation of Delavan Lake, Wisconsin,"* Lake and Reservoir Management, *Volume 16, Number 3, pages 155-176, 2000; D.M. Robertson, S.J. Field, J.F. Elder, G.L. Goddard and W.F. James,* Phosphorus Dynamics in Delavan Lake Inlet, Southeastern Wisconsin, 1994, *U. S. Geological Survey Water-Resources Report 96-4160, 1996; W.F. James, C.S. Smith, J.W. Barko, and S.J. Field,* Direct and Indirect Influences of Aquatic Macrophyte Communities on Phosphorus Mobilization from Littoral Sediments of an Inlet Region in Lake Delavan, Wisconsin, *U. S. Army Corps of Engineers, Technical Report W-95-2, September 1995.*

[6]*Wisconsin Department of Natural Resources Publication No. PUBL-WR-190-95 REV,* Upper Rock River Basin Water Quality Management Plan, *July 1995.*

observed phosphorus load being diverted through the outlet.[7] However, significant retention of sediment was observed within the bypass channel by the U.S. Geological Survey, suggesting a reduction in its future efficacy; of the approximately four feet design depth of the channel, only about 0.5 feet of depth was reported to remain active due to the accumulation of sediment within the channel. Given this experience, the preservation and utilization of wetlands to provide for water quality benefit is a feasible and practicable alternative for lake management in the Region, and further consideration of this alternative appears to be warranted.

The U.S. Geological Survey developed a number of scenarios for the management of phosphorus loading to Pike Lake. These scenarios are documented in the U.S. Geological Survey Report, *Hydrology and Water Quality of Pike Lake, Washington County, Wisconsin*, a draft of which was prepared during March 2004. The scenarios ranged from no short circuiting and no management of controllable phosphorus sources in the drainage area tributary to Pike Lake, through various combinations of external phosphorus controls and short circuiting efficiencies, to the elimination of point sources. In addition, the U.S. Geological Survey also modeled scenarios that included up to a 100 percent increase in point source and nonpoint source phosphorus discharges. The increased point source phosphorus load represents a condition that is indicated as likely to be approached in the anticipated year 2020 facilities plan for the Village of Slinger wastewater treatment plant.[8] These scenarios are summarized in Table 37. This analysis clearly suggests the efficacy of the short-circuiting alternative, and supports the need for restoration of the bypass channel as a management option that should be considered, in combination with nonpoint source pollution abatement practices as outlined below.

Point Source Pollution Abatement

Public Sanitary Sewerage System Management

Concentrations of urban development located along the shoreline of Pike Lake have been included within public sanitary sewer service areas serving the City of Hartford and the Village of Slinger, as recommended in the (amended) regional water quality management plan. As noted in Chapter II, only the Village of Slinger wastewater treatment facility is located upstream of the Lake and discharges treated effluents to a tributary of the Rubicon River. This plant currently is providing tertiary treatment of sewage, and monitoring data indicate that the plant is operating in a manner consistent with the current Wisconsin Pollution Discharge Elimination System (WPDES) permit requirements.[9] The City of Hartford wastewater treatment facility discharges to the Rubicon River system downstream of the Lake.

---

[7]*U.S. Geological Survey Scientific Investigations Report No. 2004-5141,* Water Quality, Hydrology and the Effects of Changes in Phosphorus Loading to Pike Lake, Washington County, Wisconsin, with Special Emphasis on Inlet-to-Outlet Short-Circuiting, *2004.*

[8]*Ruekert & Mielke, Inc.,* Wastewater Treatment Facilities Facility Plan, Village of Slinger, Washington County, Wisconsin, *September 2001; see also McMahon Associates, Inc.,* Capacity Analysis and Re-Rating of the Village of Slinger Wastewater Treatment Facility, *November 2002, and McMahon Associates, Inc.,* Facility Plan Amendment of the Village of Slinger Wastewater Treatment Facility Plan, *March 2003—flows to the plant are anticipated to increase from the year 2000 volume of about 0.6 million gallons per day (MGD) to about 1.5 MGD in year 2020. This increased flow could convey up to about 4,600 pounds of phosphorus, or between about 1,000 and 2,000 pounds more phosphorus per year than the inflowing total phosphorus load measured during 1999 and 2000 by the U.S. Geological Survey.*

[9]*SEWRPC Community Assistance Planning Report No. 92, 3rd Edition,* Sanitary Sewer Service Area for the City of Hartford and Environs, Washington County, Wisconsin, *September 2001; SEWRPC Community Assistance Planning Report No. 128, 3rd Edition,* Sanitary Sewer Service Area for the Village of Slinger and Environs, Washington County, Wisconsin, *December 1998; SEWRPC,* Amendment to the Regional Water Quality Management Plan: Village of Slinger, *June 2002. See also McMahon Associates, Inc.,* Capacity Analysis and Re-Rating of the Village of Slinger Wastewater Treatment Facility, *November 2002.*

Table 37

CONTRIBUTIONS OF PHOSPHORUS FOR VARIOUS PHOSPHORUS LOADING SCENARIOS FOR PIKE LAKE

Scenario	Direct Precipitation and Groundwater Loads (pounds)	Point Source Load (pounds)	Nonpoint Source Load (pounds)	Total Load (pounds)
Year 2000 Measured Phosphorus Load (= 65 percent short circuiting): Base Loading Condition	104	357	710	1,171
50 Percent Decrease in Controllable Sources	104	179	355	637
25 Percent Decrease in Controllable Sources	104	268	533	905
100 Percent Increase in Controllable Sources	104	714	1,420	2,238
75 Percent Increase in Controllable Sources	104	625	1,242	1,971
50 Percent Increase in Controllable Sources	104	536	1,065	1,705
25 Percent Increase in Controllable Sources	104	447	888	1,439
No Short Circuiting	104	1,039	1,298	2,441
100 Percent Short Circuiting	104	0	401	505
75 Percent Short Circuiting	104	260	626	990
100 Percent Decrease (elimination) in Point Sources	104	0	710	814
100 Percent Increase in Point Sources	104	714	710	1,528

Source: U. S. Geological Survey and SEWRPC.

Options for the provision of public sanitary sewerage services to the Hartford and Slinger communities are set forth in the adopted regional water quality management plan.[10] Application of Wisconsin Department of Natural Resources guidelines for the siting of wastewater treatment facilities indicated the interconnection of the City of Hartford treatment plant and the Pike Lake community to be a feasible alternative. This alternative has been adopted in the aforereferenced sanitary sewer area plans. A further alternative, the interconnection of the Village of Slinger and the City of Hartford wastewater treatment facilities, was deemed not to be feasible, in part, due to the then completion of the City of Hartford treatment plant and the advanced state of planning for the Village of Slinger facility. This investment, which has been progressively upgraded over time, generally suggests that further plant expansions, of the two plants, remain the most cost-effective means of providing wastewater treatment for the Village and City and their environs. Notwithstanding, the location of the City of Hartford sewage treatment facility west of the City center places that facility at a significant pumping distance from the Village. Consequently, given this distance, the number of stream crossings, the likely construction impacts, and the current age and capacities of the City of Hartford and Village of Slinger sewage treatment plants, the option of interconnecting the Village of Slinger and City of Hartford sewerage systems and abandoning the Village of Slinger treatment facility is not considered a viable alternative.

Onsite Sewage Disposal System Management

While the immediate lakeshore is sewered, and a major portion of the drainage area tributary to the Lake is proposed to be served by public sanitary sewerage systems as noted above, limited areas of the watershed tributary to Pike Lake continue to be served by private onsite sewage disposal systems. As reported in Chapter IV,

[10]*SEWRPC Planning Report No. 16,* A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, *February 1974; 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.*

onsite sewage disposal systems are estimated to contribute only a minor proportion of the total phosphorus load to the Lake, which proportion is anticipated to decline as public sanitary sewerage services are extended within the drainage area pursuant to the adopted regional water quality management plan[11] and sewer service area plans.[12] Notwithstanding, given that these loadings are controllable, continuing application of onsite sewage disposal system management practices and implementation of a periodic program of inspections for all remaining onsite sewage disposal systems appear to be warranted.

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 portions of the drainage area not within the planned public sanitary sewer service area. Where onsite sewage disposal systems remain the primary wastewater treatment method, homeowners in areas served by onsite systems should be advised of the rules, regulations, and system limitations governing onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs. Washington County currently has such a program in place, pursuant to Chapter Comm 83 of the *Wisconsin Administrative Code*, for onsite sewage disposal systems installed after 1980. Currently, consideration is being reportedly given by the Wisconsin Legislature to extending this inspection program to all onsite sewage disposal systems.

Nonpoint Source Pollution Abatement

Watershed management measures may be used to minimize nonpoint source pollutant loadings from the watershed by locating development within a drainage basin in accordance with sound planning principles. Beyond such actions, specific interventions may be required to control the mass of contaminants, generated by various land use activities, that is transported to the Lake.[13] Rural sources of contaminants arise as pollutants transported by runoff from cropland and pastureland; urban sources include contaminants transported by runoff from residential, commercial, industrial, transportation, and recreational land uses, and from construction sites. Alternative, watershed-based nonpoint source pollution control measures considered in this report are based upon the recommendations set forth in the regional water quality management plan,[14] and in the Washington County land and water resource management plan.[15]

The regional water quality management plan recommends that the nonpoint source pollutant loadings from the areas tributary to Pike Lake be reduced by up to 25 percent in urban and rural areas, in addition to implementation of urban construction erosion controls, stream bank erosion controls, and onsite sewage disposal system management practices. As described in Chapter IV, the most readily controllable loadings are associated primarily with runoff from urban lands within the drainage area directly tributary to the Lake as well as from urbanizing lands throughout the total drainage area tributary to the Lake that are linked to the Lake by way of streams and

---

[11]*SEWRPC Memorandum Report No. 93,* op. cit.

[12]*SEWRPC Community Assistance Planning Report No. 92, 3rd Edition, op. cit.; SEWRPC Community Assistance Planning Report No. 128, 3rd Edition,* op. cit.*; SEWRPC,* Amendment to the Regional Water Quality Management Plan: Village of Slinger, op. cit.

[13]*Nonpoint source pollution abatement and runoff management requirements are set forth in Chapter NR 151 of the* Wisconsin Administrative Code*: Subchapter II sets forth Agricultural Performance Standards and Prohibitions, Subchapter III sets forth Non-Agricultural Performance Standards, and Subchapter IV sets forth Transportation Facility Performance Standards.*

[14]*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.*

[15]*Washington County,* Land & Water Resource Management Plan, *September 2000.*

stormwater drainage systems. These loadings constituted about 15 percent of the total phosphorus, and about 10 percent of the sediment, loadings to Pike Lake, and 100 percent of the heavy metals loadings, based upon 1995 land uses. The contributions of phosphorus, sediment and heavy metals from urban lands are expected to increase as agricultural lands are progressively converted to urban uses. Runoff from agricultural lands within the drainage area tributary to the Lake also constitute readily controllable loadings, constituting about 75 percent of the total phosphorus, and about 85 percent of the sediment, loadings to Pike Lake. However, application of integrated nutrient and pest management practices on many of the remaining, active farms in the watershed is considered to have potentially moderated controllable contaminant loadings from this source, although extension of these practices throughout agricultural lands can contribute further reductions in current loadings. Pollutant loadings from the remainder of the tributary area, and from direct deposition onto the Lake surface, contributed the balance of the total loadings.

While some proportion of these contaminant loads may be attenuated as a consequence of the extensive wetland areas along the Rubicon River upstream of Pike Lake, the ability of these wetlands to assimilate pollutants is wholly dependent upon the maintenance of their structure and function within their ecosystems. These features can be overwhelmed by inappropriate land uses that result in the degradation of the wetlands, diminishing their ability to capture contaminants, or creating contaminant loads of such magnitude that the wetlands are overloaded. Thus, the control of nonpoint sources of water pollution at their sources is an important consideration. Properly applied, such controls can reduce the pollutant loadings to a lake by about 25 percent or more. Consequently, application of appropriate nonpoint source pollution abatement practices and regulations appears to be warranted.

Appendix C presents a list of alternative nonpoint source pollution management measures that could be considered for use in the Pike Lake area to reduce loadings from nonpoint sources of pollution. Information on the cost and effectivity of the measures is also presented in Appendix C. It should be noted that appropriate public informational programming, described below, provides a means of disseminating information on various nonpoint source control measures that can be targeted to specific sectors of the community. Many of the measures are low-cost or no-cost measures that can be implemented by individual landowners. Selected measures are discussed below and further consideration of these alternatives appears to be warranted.

Rural Nonpoint Source Controls

Upland erosion from agricultural and other rural lands is a contributor of sediment to streams and lakes. Estimated phosphorus and sediment loadings from croplands, woodlots, pastures, and grasslands in the drainage area tributary to Pike 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 Pike Lake.

Based upon the pollutant loading analysis set forth in Chapter IV, a total annual phosphorus load of about 3,700 pounds is estimated to be contributed to Pike Lake. Of that mass, it is estimated that 3,000 pounds per year, or 80 percent of the total loading, were contributed by runoff from rural land. In addition, it is estimated that 900 tons of sediment, or about 85 percent of the total sediment load to Pike Lake, were contributed annually from agricultural lands in the drainage area tributary to the Lake. As of 1995, such lands comprised about 4,000 acres, or about 50 percent of the drainage area tributary to Pike Lake, which area is anticipated to diminish to about 2,750 acres, or about 35 percent, of the tributary drainage area by the year 2020.

While agricultural land uses are anticipated to be a declining form of land usage within the drainage area tributary to Pike Lake, the agricultural operations that remain within the drainage area will continue to contribute a significant proportion of the sediment load to the waterbody. Table 19 suggests that, based upon estimated contaminant loadings, agricultural land uses will continue to contribute about 70 percent of the total sediment load, or about 620 tons of sediment annually, to Pike Lake. Thus, detailed farm conservation plans are likely to continue to be required to adapt and refine erosion control and nutrient and pest management practices for individual farm units. Generally prepared with the assistance of staff from the U.S. Natural Resources Conservation Service or County Land Conservation Division, such plans identify desirable tillage practices, cropping patterns, and rotation cycles. The plans also consider 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. Pursuant to Chapter NR 151 of the *Wisconsin Administrative Code*, farm operators are encouraged to limit soil loss due to farming operations to that estimated utilizing the revised universal soil loss equation (RUSLE) as being tolerable ("t") for a given soil type. Animal wastes arising from livestock operations are required to be contained in appropriately-sized manure storage facilities, as set forth in Chapter ATCP 50 of the *Wisconsin Administrative Code*, and may be land spread in accordance with the aforementioned farm plan and nutrient management plans.

Urban Nonpoint Source Controls

As of 1995, established urban land uses comprised about 1,600 acres, or about 20 percent, of the total drainage area tributary to Pike Lake. The annual phosphorus loading from these urban lands was estimated to be 560 pounds, or about 15 percent of the total load of phosphorus to the Lake. This is anticipated to increase to about 30 percent of the total load of phosphorus under year 2020 conditions. Those urban-sourced pollutant loadings that are most controllable include runoff from the residential lands adjacent to the Lake, and urban runoff from areas with a high proportion of impervious surface. The potential also exists within the Pike Lake watershed for significant construction site erosion impacts if development continues in the tributary drainage area as has been the recent trend.

Potentially applicable urban nonpoint source control measures include stormwater management measures, 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 educational 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 continued use of reduced quantities of street deicing salt. Within Southeastern Wisconsin, a number of municipalities are currently considering urban fertilizer restrictions, with phosphate-phosphorus fertilizer restrictions having currently been adopted by, among others, the Lauderdale Lakes Lake Management District and Town of Delavan, both in Walworth County. Similarly, many local governments in the Region have maintained salt-reduction campaign goals for the winter months, through an application of a sand-salt mixture. Surplus sand remaining within the roadway during spring often is collected using street sweeping equipment. At least one municipality, the City of Delafield in Waukesha County, is considering the use of calcium chloride in place of the traditional sodium chloride-based road salt.

Pursuant to Chapter NR 151 of the *Wisconsin Administrative Code*, particular attention also should be given to reducing pollutant loadings from high pollutant loading areas, such as commercial sites, parking lots, and material storage areas. Appropriate stormwater management plans, consistent with the standards set forth in Chapter NR 216 of the *Wisconsin Administrative Code*, are required for new development. Proper design and application of structural urban nonpoint source control measures, such as grassed swales and detention basins, requires the preparation of detailed stormwater management systems plans that address stormwater drainage problems and controls nonpoint sources of pollution. In residential areas, the use of rain gardens, or adsorption fields, is becoming increasingly popular with these gardens providing an additional landscaping option for homeowners and householders.[16] These facilities can also be installed as communal facilities within conservation subdivisions. Likewise, 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, as required pursuant to the performance standards set forth in Chapter NR 151 of the *Wisconsin Administrative Code*. Material storage

[16]*U.S. Environmental Protection Agency, "Urban Runoff Notes,"* Nonpoint Source News-Notes, *Issue #42, August/September 1995.*

areas may be enclosed or periodically cleaned, and diversion of stormwater away from these sites may further reduce pollutant loadings. Street sweeping, increased catch basin cleaning, stream protection, leaf litter and vegetation debris collection, and stormwater storage and infiltration measures can enhance the control of nonpoint-sourced pollutants from urban and urbanizing areas, and reduce urban nonpoint source pollution loads by up to about 50 percent.

As has been noted above, the City of Hartford has adopted a stormwater management ordinance applicable to new development within the areas under their jurisdiction, while the Towns of Hartford and Polk utilize the County ordinance for stormwater management. While these measures limit the potential impacts of new development, they do not address impacts from existing land uses nor do they address the cumulative impacts of past development. Therefore, additional measures to reduce nonpoint source pollution from existing development would appear to be warranted.

Developing Area Nonpoint Source Controls
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 and county development plans envision only limited new urban development within the drainage area. However, as previously noted, some large-lot suburban-density development is currently taking place in the drainage area tributary to Pike Lake, together with the redevelopment of existing, platted lakefront lots.

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, in a manner consistent with the provisions of Chapter NR 151 of the *Wisconsin Administrative Code*, 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.[17] 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.

At the present time, Washington County has adopted construction site erosion control ordinances within Chapter 17 of the *Washington County Code*, which provisions are administered and enforced by the County, in both the shoreland and nonshoreland areas of the unincorporated areas of the drainage area tributary to Pike Lake. The provisions of these ordinances apply to all development except single- and two-family residential construction regulated under Section Comm 21.125 of the *Wisconsin Administrative Code*, and land disturbing activities of less than one acre in areal extent within shoreland, wetland, and floodplain zones. Single- and two-family construction erosion control measures are to be specified as part of the building permit process. In the incorporated areas of the City of Hartford and Village of Slinger, this function is performed by the respective City and Village. Because of the potential for development, some of it albeit unplanned, in the drainage area tributary to Pike Lake, it is important that adequate construction erosion control programs, including enforcement, be in place.

---

[17] *Wisconsin League of Municipalities and Wisconsin Department of Natural Resources,* Wisconsin Construction Site Best Management Practices Handbook, *April 1994.*

IN-LAKE MANAGEMENT ALTERNATIVES

The reduction of external nutrient loadings to Pike Lake by the aforedescribed measures should help to prevent further deterioration of lake water quality conditions. These measures, however, may not completely eliminate existing water quality and lake-use problems. In mesotrophic and eutrophic lakes, the nutrients previously delivered to, and retained in, such lakes can continue to result in abundant macrophyte growths that can result in restricted water use potentials, even after the implementation of watershed-based management measures. Given that Pike Lake falls within this trophic range, the application of in-lake rehabilitation techniques should be considered.

The applicability of specific in-lake rehabilitation techniques is highly dependent on lake-specific characteristics. The success of any lake rehabilitation technique can seldom be guaranteed, and 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 fisheries management measures. Each of these groups of management measures is described further below.

Water Quality Improvement Measures

This group of in-lake management practices includes 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 fisheries 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 sulfate (alum), ferric chloride, and ferric sulfate 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.

Nutrient inactivation is not recommended for Pike Lake due to the generally soft sediments and shallow depth of management areas, the susceptibility to wind- and boat motor-induced mixing, and the overall pollutant loading which mediate against the effective use of nutrient inactivation.

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, and impacts include the rerelease of nutrients into the environment. While some limited deepening of specific areas within the lake basin may be warranted for navigational purposes, the widespread use of in-lake nutrient load reduction measures is not warranted in Pike Lake, especially given that internal loading from the lake sediments does not appear to be an important nutrient course to the water column. As noted in Chapter IV, the good agreement between predicted and observed phosphorus concentrations in the Lake strongly suggests that the external nutrient load to the Lake accounts for the entire phosphorus concentration in the Lake water column.

Aeration and Destratification

Aeration, or the process of injecting air into the hypolimnion, primarily during periods of stratification, using a system of mechanical air compressors and diffuser piping, is intended to counteract the tendency of a lake to stratify and develop hypolimnetic anoxia. Aeration acts directly on the effects of biochemical oxygen demand in the bottom waters of the lake by supplementing the quantity of available oxygen, and is considered most important during periods when the hypolimnion is isolated from the atmosphere. This is in contrast to whole-lake circulation or destratification, whereby air is pumped into the hypolimnion with the intent of preventing stratification from taking place, with the further intent of keeping the lake well-mixed all year round.

Costs associated with the hardware required for an aeration system including piping and compressors, and operating costs tend to be high, ranging from $160 to $2,600 per acre per year. Effectiveness has been site and use dependent. Potential negative impacts include increased lake water temperatures, and more rapid heating and cooling, incidences of gas bubble disease in fish, and enhanced transfer of nutrients and algae throughout the water column. Algal growth may or may not be controlled depending on the species of algae present in the lake; generally, blue green algal blooms decrease in frequency while green algal and diatom growth may be stimulated. The use of aeration, including both hypolimnetic aeration and destratification measures, as an alternative lake management measure has had limited field trials and often mixed results,[18] and few case studies have been documented.

In Southeastern Wisconsin, aeration has been used experimentally in Little Muskego Lake.[19] During 1987, the Little Muskego Lake Management District purchased and installed a Clean-Flo Laboratories continuous laminar flow inversion aeration system. The purpose of this system was primarily fourfold: 1) to remove muck, 2) to control aquatic plants, 3) to improve water clarity, and 4) to improve the lake fishery. Aeration, or the process of injecting air into the hypolimnion, primarily during periods of stratification, using a system of mechanical air compressors and diffuser piping, is intended to counteract the tendency of a lake to stratify and develop hypolimnetic anoxia. Aeration acts directly on the effects of biochemical oxygen demand in the bottom waters of the lake by supplementing the quantity of available oxygen, and is considered most important during periods when the hypolimnion is isolated from the atmosphere. This is in contrast to whole-lake circulation, whereby air is pumped into the hypolimnion with the intent of preventing stratification from taking place, with the further intent of keeping the lake well-mixed all year round.

The aeration system at Little Muskego Lake appeared to be able to modify significantly the thermal structure of the Lake's water column. However, it appeared unable to satisfy the oxygen demand completely in the lowest portion of the hypolimnion. This condition is entirely consistent with the highly organic nature of the lake-bottom

---

[18]*U.S. Environmental Protection Agency Report No. EPA 841-B-01-006,* Managing Lakes and Reservoirs, Third Edition, *North American Lake Management Society and Terrene Institute, 2001.*

[19]*SEWRPC Community Assistance Planning Report No. 222,* A Lake Management Plan for Little Muskego Lake, Waukesha County, Wisconsin, *June 1996.*

sediments noted by both Kendziorski[20] and Midwest Engineering Services.[21] Consequently, the aeration system served to increase phosphorus concentrations in the surface waters of the Lake,[22] which, in turn, increased chlorophyll-*a* concentrations and decreased Secchi disc transparency. Water temperatures in the hypolimnion or lake bottom waters were observed to increase as more heat was transferred from the surface of the Lake to the deeper waters, while conductivity and pH in the bottom waters were observed to decrease as a result of reduced releases of minerals and nutrients.[23]

The experiences gained during the conduct of the aeration and destratification pilot project at Little Muskego Lake offer guidance on the potential use of aeration and destratification techniques elsewhere in the Southeastern Wisconsin Region:

- This pilot project clearly demonstrated that aeration can effectively circulate the water column of inland lakes. However, based upon the data presented in SEWRPC Community Assistance Planning Report No. 222, *op. cit.*, aeration systems have to be adequately sized and positioned within a lake basin to be effective. The system employed at Little Muskego Lake appeared to be undersized.

- The project further demonstrated that the consequence of the use of an undersized system was that the aerator acted as a nutrient pump, eroding phosphorus from the remnant hypolimnion and transporting it to the surface, euphotic zone where it contributed to enhanced algal growth.

- Based upon public testimony offered during the planning program, the project also demonstrated that aeration can be a very visible lake management action that results in a perception among the public that "something is being done" about lake water quality concerns; however, testimony was also offered suggesting that the upwelling created by the aeration system was a cause for concern among some recreational boaters and other lake users.

- Based upon other public testimony offered during the planning program, the project suggested that there were public perceptions that ranged from very favorable to very unfavorable, persons reporting positive impressions commonly based their impressions on increased fish captures, while persons reporting negative impressions commonly based their impressions on decreased fish captures. While the fishery formed a common basis for these antithetical impressions, the former group was determined to have based their impressions on increased captures of planktivorous panfish while the latter based their impressions on decreased captures of game fish.

- The project also demonstrated that there is a significant cost likely to be incurred in the use of aeration systems, including both the capital costs of piping, diffusers, and pumps, and the ongoing operational costs of fuel for the compressors that drive the pumps.

---

[20]*Casey Kendziorski, Jr., P.E., Feasibility Report,* Removal of Sediment and Muck from Little Muskego Lake, *Milwaukee, Wisconsin, December 1967.*

[21]*Midwest Engineering Services, Inc., Project Report No. 7-31010-2,* Lake Sediment Exploration and Analysis: Little Muskego Lake, Muskego, Wisconsin, *Waukesha, Wisconsin, May 1993.*

[22]*This response is illustrated by the slightly higher concentration of total phosphorus observed during the period of aerator operations than subsequently, and is typical of the responses observed elsewhere: see Wisconsin Department of Natural Resources, Technical Bulletin No. 75,* Survey of Lake Rehabilitation Techniques and Experiences, *DNR, Madison, Wisconsin, 1974, pp. 18-19.*

[23]*See B. Bostrom, J.M. Andersen, S. Fleischer, and M. Jansson, "Exchange of Phosphorus Across the Sediment-Water Interface," in G. Persson and M. Jansson (eds.),* Phosphorus in Freshwater Ecosystems, *Kluwer Academic Publishers, Boston, 1988.*

- Based upon public testimony offered during the planning program, the project generated some complaints from persons living in the vicinity of the pump house regarding the noise created by the compressor system when it was actively operating.

- The recommended lake management plan for Little Muskego Lake, based upon a review of the foregoing and consideration of the relative costs of alternative lake management actions to control nutrient inputs to Little Muskego Lake, concluded that aeration was not a recommended alternative for reasons of costs and limited control of a relatively minor portion of the total phosphorus load to the Lake. Rather, the lake management plan for Little Muskego Lake recommended use of the same level of funding to address watershed-based nonpoint pollution sources, which continue to be the major pathway by which plant nutrients such as phosphorus enter the Lake.

Experiences reported by the U.S. Environmental Protection Agency generally reflect similar experience to that documented in Little Muskego Lake: increased oxygen concentrations in the deeper water portions of the waterbody, reduced concentrations of iron and manganese in the bottom waters, increased turbidity and phosphorus concentrations in the surface waters, reduced surface scums of algae, increased transfer of nutrients from the lake bottom to the lake surface, and increased incidences of unfavorable circulation patterns and surface conditions.[24] Given this experience, aeration is not generally recommended as a feasible and practicable alternative for lake management in the Region, and is not recommended for Pike Lake.

Aquatic Plant and Fisheries Management

Fisheries Management Measures

Pike Lake provides a quality habitat for a healthy, warmwater fishery. Currently, adequate water quality, dissolved oxygen levels, sand and gravel shorelines, and diverse plant community exist for the maintenance of a sportfish population in the Lake. While winterkills have occurred in the past, winterkill is currently not a problem. The Lake supports an abundant population of walleyed pike, with northern pike, largemouth bass, smallmouth bass, long nose gar, and panfish being reported to be present. In addition, the pugnose shiner, a State Threatened Species, and the least darter, a State Special Concern species, have been reported to be present in the Lake. Carp were reported to be common in the shallow areas of the Lake during the 1963 fisheries survey,[25] but currently are not considered to constitute a management problem.[26] A fish consumption advisory has been issued for the Lake.

Habitat Protection

Habitat protection refers to a range of conservation measures designed to maintain existing fish spawning habitat, including measures such as restricting recreational use and other intrusions into gravel-bottomed shoreline areas during the spawning season. For bass and pike, this is mid-April to mid-June.[27] Use of natural vegetation in shoreland management zones and other "soft" shoreline protection options aids in habitat protection. Costs are generally low, unless the habitat is already degraded. Modification of aquatic plant harvesting operations may be considered to support restoration and protection of native aquatic plant beds and maintenance of fish breeding habitat during the early summer period. 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 fisheries management program. The environmentally valuable areas identified within the Lake and its watershed are the most important areas to be protected. In this regard, too,

---

[24]Ibid.

[25]*Wisconsin Conservation Department,* Surface Water Resources of Washington County, *1963.*

[26]*John E. Nelson, "Comprehensive Fish Community Survey of Pike Lake, Washington County, WBIC 858300, Year 2000," Wisconsin Department of Natural Resources Memorandum, 2001.*

[27]*George C. Becker,* Fishes of Wisconsin, *The University of Wisconsin Press, Madison, 1983.*

a fish refuge has been established on the channel of the Rubicon River both above the dam and below the dam for a distance of about 0.5 miles as protection for walleyed and northern pike during spawning runs. Maintenance of Lake water levels within natural limits, and the maintenance of good water quality, cannot be overemphasized as fish habitat protection measures.

Shoreline Maintenance

Shoreline maintenance refers to a group of measures designed to reduce and minimize shoreline loss due to erosion by waves, ice, or related actions of the water. Currently, the majority of the developed shoreline of Pike Lake is protected by some type of structural measure, as shown on Map 3. Four shoreline erosion control techniques were in use in 2000: vegetative buffer strips, rock revetments, wooden and concrete bulkheads, and beach. Maintenance of a vegetated buffer strip immediately adjacent to the Lake is the simplest, least costly, and most natural method of reducing shoreline erosion. This technique employs natural vegetation, rather than maintained lawns, within five to 10 feet of the lakeshore and the establishment of emergent aquatic vegetation from two to six feet lakeward of the shoreline.

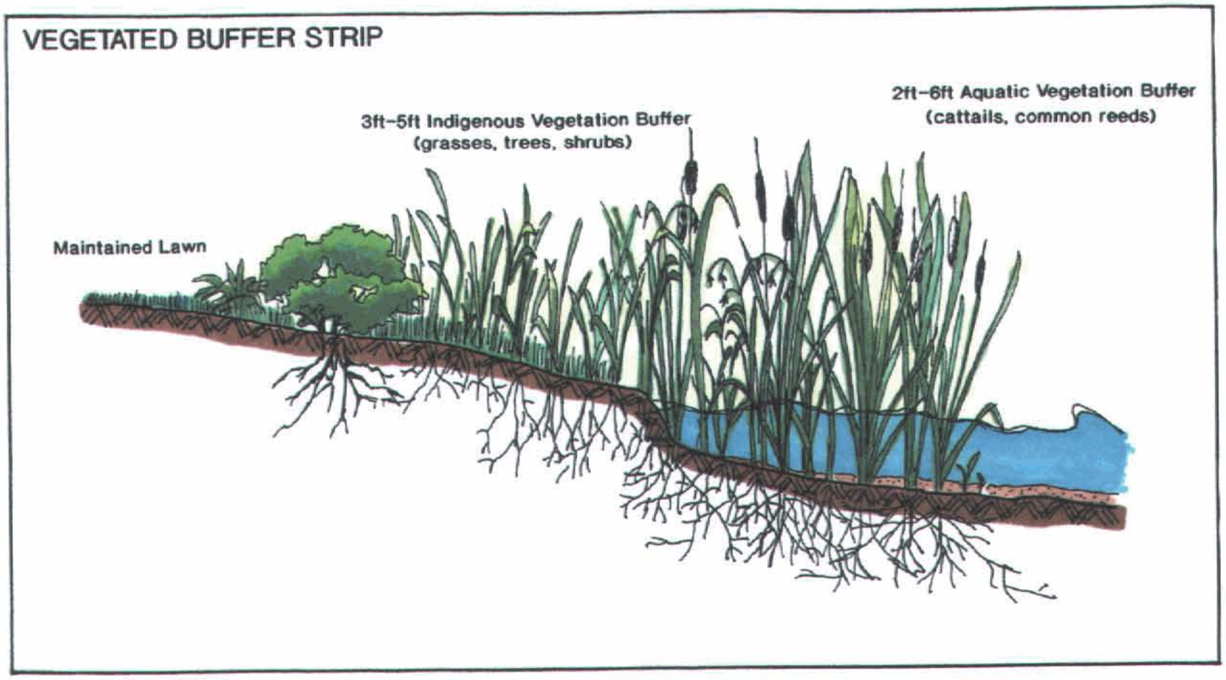
Desirable plant species that may be expected and encouraged to invade a buffer strip, or which could be planted, include arrowhead (*Sagittaria latifolia*), cattail (*Typha* spp.), common reed (*Phragmites communis*), water plantain (*Alisma plantago-aquatica*), bur-reed (*Sparganium eurycarpum*), and blue flag (*Iris versicolor*) in the wetter areas; and jewelweed (*Impatiens biflora*), elderberry (*Sambucus canadensis*), giant goldenrod (*Solidago gigantea*), marsh aster (*Aster simplex*), red-stem aster (*Aster puniceus*), and white cedar (*Thuja occidentalis*) in the drier areas. In addition, trees and shrubs such as silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), black willow (*Salix nigra*), and red-osier dogwood (*Cornus stolonifera*) could become established. These plants will develop a more extensive root system than the lawn grass and the aboveground portion of the plants will protect the soil against the erosive forces of rainfall and wave action. A narrow path to the Lake can be maintained as lake access for boating, swimming, fishing, and other activities. A vegetative buffer strip would also serve to trap nutrients and sediments washing into the Lake via direct overland flow. This alternative would involve only minimal cost.

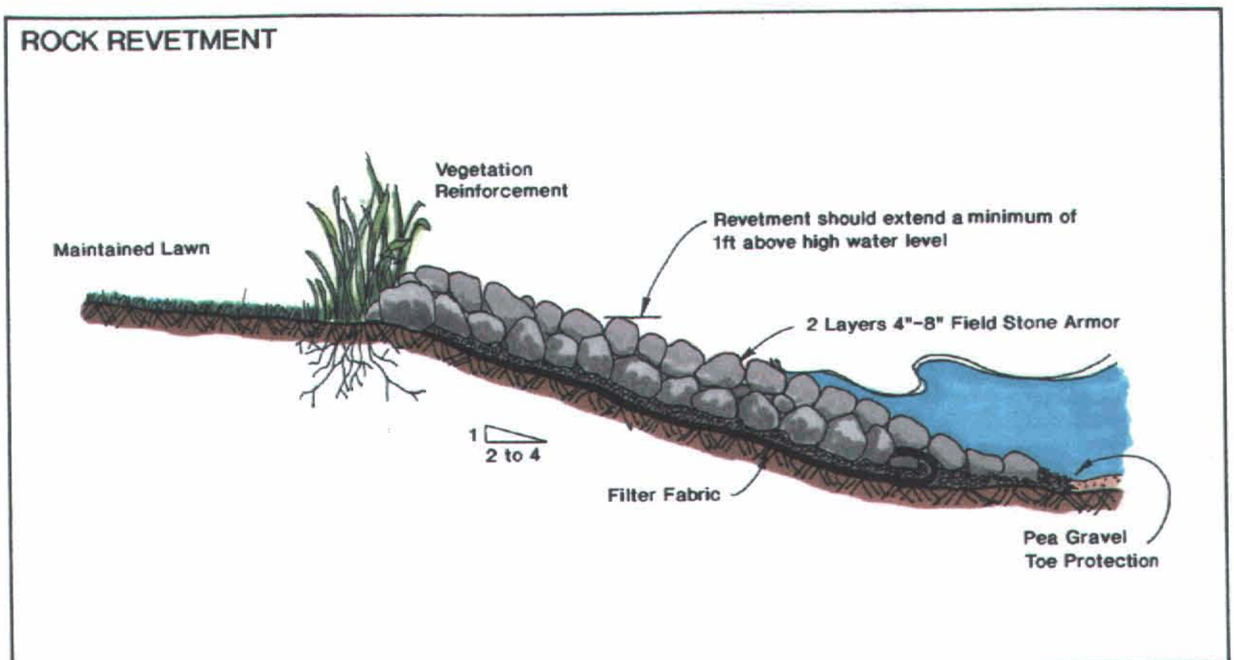
Rock revetments, or riprap, are a highly effective method of shoreline erosion control applicable to many types of erosion problems, especially in areas of low banks and shallow water. Many of these structures are already in place at Pike Lake. The technique involves the shaping of the shoreline slope, the placement of a porous filter material, such as sand, gravel, or pebbles, on the slope and the placement of rocks on top of the filter material to protect the slope against the actions of waves and ice. The advantages of rock revetments are that they are highly flexible and not readily weakened by movements caused by settling or ice expansion, they can be constructed in stages, and they require little or no maintenance. The disadvantages of rock revetments are that they limit some uses of the immediate shoreline. The rough, irregular rock surfaces are unsuitable for walking; require a relatively large amount of filter material and rocks to be transported to the lakeshore; and can cause temporary disruptions and contribute sediment to the lake. If improperly constructed, revetments may fail because of washout of the filter material. A rock revetment is estimated to cost $25 to $35 per linear foot.

The use of vegetated buffer strips and riprap, as shown in Figure 13, is recommended, especially in those areas of Pike Lake subject to significant wind-wave, boat wake, and ice scour erosion. In those portions of the Lake subject to direct action of wind waves and ice scour, the use of riprap would provide a more robust means of stabilizing shorelines, while elsewhere along the lakeshore creation of vegetated buffer strips would provide not only shoreline erosion protection but also enhanced shoreland habitat for fish and wildlife. In this regard, it should be noted that the selection of appropriate shoreland protection structures is subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*. Chapter NR 328, adopted during 2004, promotes

Figure 13

PLAN ALTERNATIVES FOR SHORELINE EROSION CONTROL





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

Source: SEWRPC.

the use of natural shorescaping practices where practicable, and provides for the maintenance of existing riprap and placement of limited new riprap structures, within the context of the State's shoreland permitting system.

Modification of Species Composition
Species composition management refers to a group of conservation and restoration measures that include selective harvesting of undesirable fish species and stocking of desirable species designed to enhance the angling resource value of a lake. These measures also 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 and selective cropping of certain fish species, 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 Pike Lake.

As noted in Chapter V, Pike Lake is currently managed for warmwater sportfish, and selective stocking is undertaken by the WDNR and private sport fish organizations. Continued fish stocking by the WDNR and the private organizations is recommended for Pike Lake, subject to monitoring and creel surveying data collected from the Lake by the WDNR. Additional fish population control measures do not appear to be warranted at this time, although rough fish populations should continue to be monitored.

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 Pike Lake are given in Table 38. Enforcement of these regulations is critical to the success of any sound fish management program.

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 classified 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 in turn include the use of various organisms, including insects. All aquatic plant management measures are stringently regulated and require 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 $100,000 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.

Table 38

WISCONSIN STATE FISHING REGULATIONS: 2002-2003

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 and Smallmouth Bass	May 4 to March 1	5	14 inches
Bluegill, Pumpkinseed (sunfish), Crappie, and Yellow Perch	Open all year	25	None
Bullhead and Rough Fish	Open all year	None	None

Source: Wisconsin Department of Natural Resources Publication No. PUB-FH-301 2002, Guide to Wisconsin Hook and Line Fishing Regulations 2002-2003, *January 2002, and SEWRPC.*

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 relative ease, speed, and convenience of application. Herbicides also offer a degree of selectivity, targeting specific types of aquatic plants. 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 additional organic matter in the sediments as a result of decomposition also increases the organic content of the soils and predisposes the sediments toward reintroduction of other (or the same) nuisance plant species. Long-term deposition of plant material may result in the need for other management measures, such as dredging.

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

5. Adverse impacts on other aquatic organisms may be expected. At the concentrations used for macrophyte control, Diquat has been known to kill the zooplankton *Daphnia* and *Hyalella*, both important fish foods. *Daphnia* is the primary food for the young of nearly all fish species found in the Region's lakes.[28]

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

6. Areas generally must be treated again in the following season and weedbeds may need to be treated more than once in a summer, although certain herbicides may give relief over a period of up to three years in some lakes.

7. Many of the chemicals available often affect nontarget, desirable species, such as water lilies, as well as the "weeds," such as Eurasian water milfoil, as both species share similar biological characteristics, being dicotyledons.

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—Wilson's Disease—are known.[29]

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.*

Although there is a demonstrated need to control aquatic plants in selected areas of Pike Lake, chemical treatment is considered to be a viable management option only in limited, nearshore areas of the Lake, around piers and structures. Widespread use of chemical herbicides is not recommended.

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 that 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.[30]

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

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.

---

[29]*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.*

[30]*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.*

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.[31]

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.[32]

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. 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. 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.[33] 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* spp.) that propagate from cut fractions. This may allow these plants to spread into new areas through the rerooting of the cut fractions.

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

---

[31]*James E. Breck, and J.F. Kitchell, "Effects of Macrophyte Harvesting on Simulated Predator-Prey Interactions," edited by Breck,* et al., Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting, *Proceedings of Conference at Madison, Wisconsin, February 14-16, 1979, pp. 211-228.*

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

[33]*James E. Breck*, et. al., op. cit.

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 may be associated with harvesting programs. Macrophyte harvesting on Pike Lake could be continued by the Town of Hartford and the Pike Lake Protection and Rehabilitation District staff or be contracted to a private company. 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 $282,500.

Various types of harvesters and harvesting practices are available to address the many issues encountered on Pike Lake. A harvesting program for Pike Lake 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 utilize these dense beds.[34] To promote an optimal predator-prey relationship, as shown in Figure 12 in Chapter V, and provide an opportunity for predators or game fish to harvest prey such as panfish, 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. To promote recreational boating activities, "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. However, top cutting of plants such as Eurasian water milfoil, as shown in Figure 14, is suggested. The harvest of water lilies and 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 species tends to outcompete native plants when the lake's ecosystem is stressed.[35] Stress can be brought on by watershed pollution, shoreline development, changing water levels, boating activity, carp, and aquatic nuisance controls. 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.[36]

Aquatic plant harvesting is considered a viable management option for larger-scale control of aquatic macrophytes in Pike Lake. Mechanical harvesting of aquatic plants must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*.

Manual Harvesting
Due to water depth limitations imposed by the size and maneuverability of the harvesters, it is not always possible for harvesters to reach the shoreline of every property. Likewise, because of the cost and other concerns relating to the use of chemical herbicides, alternative measures for the control of aquatic plant growth in specific areas of the Lake should be considered. A number of specially designed rakes are available from commercial outlets to

---

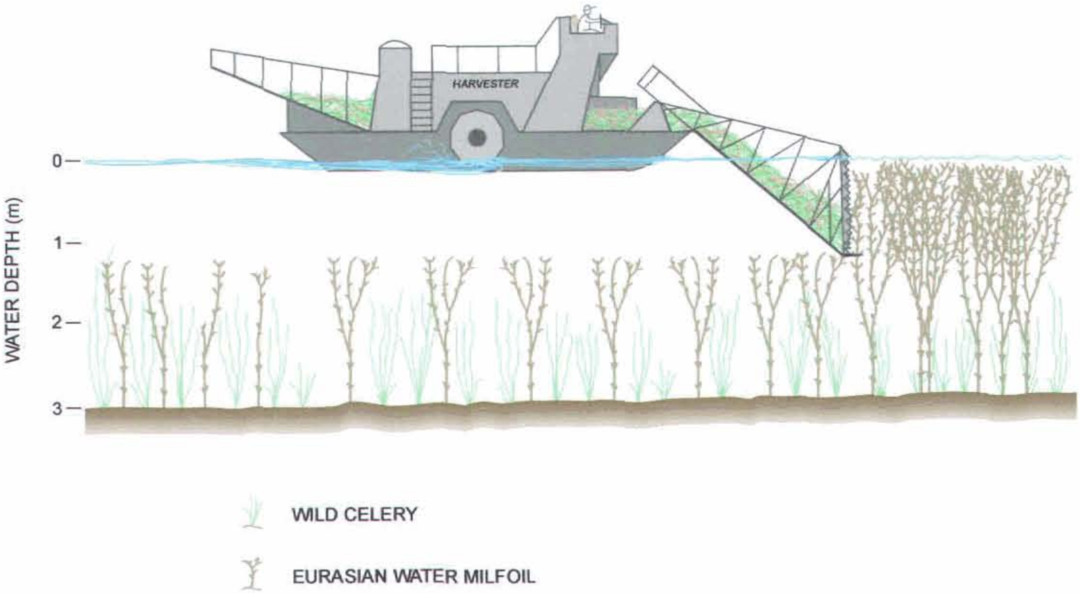
[34]*S. Nichols, Wisconsin Department of Natural Resources Technical Bulletin No. 77,* Mechanical and Habitat Manipulation for Aquatic Plant Management: A Review of Techniques, *1974.*

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

[36]*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 14

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.

assist lakefront homeowners in manually removing aquatic plants from the shoreline area. The advantages of these rakes are that they are easy and quick to use, and result in an immediate result, in contrast to chemical treatments that involve a waiting period. This method also removes the plants from the lake avoiding the accumulation of organic matter on the lake bottom. Unfortunately, manual harvesting is feasible in only very limited areas and is not practical for large-scale use. Nevertheless, manual harvesting does offer a reasonable level of aquatic plant control in the vicinity of docks and piers, and is therefore considered a viable option. Manual harvesting beyond a 30-feet wide recreational corridor, or within a WDNR-delineated environmentally sensitive area, must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*. Pursuant to the provision of this Chapter, piers and other recreational areas must be placed within the 30-feet wide recreational corridor.

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.[37] 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

[37]*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.*

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.[38] 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.[39]

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.

Relatively few studies have been completed using *Eurhychiopsis lecontei* as a means of aquatic plant management control. These have resulted in variable levels of control, and, while priced competitively with aquatic herbicides, is not recommended as being practical for Pike Lake at this time. Use of biological control agents must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*. While the use of biological control agents such as the Eurasian water milfoil weevil and the beetles, *Hylobius transversovittatus*, *Galerucella pusilla*, *Galerucella calmariensis*, *Nanophyes brevis*, and *Nanophyes marmoratus,* used to control infestations of purple loosestrife in wetlands and along shorelands has been shown to be beneficial in certain circumstances, the use of other biological control agents is prohibited in Wisconsin; the use of the grass carp, *Ctenopharyngodon idella*, for aquatic plant control is expressly prohibited.

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 materials, such as polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years. The screens are flexible and can be anchored to the lakebed in spring or draped over plants in summer.

---

[38]*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.*

[39]*The use of* Eurhychiopsis *sp. on an experimental basis to control Eurasian water milfoil was monitored in selected Wisconsin lakes by the Wisconsin Department of Natural Resources and the University of Wisconsin-Stevens Point from 1995 through 1998. These results indicated mixed success, suggesting that this organism has specific habitat requirements that limit its utility as a Eurasian water milfoil control agent within Wisconsin.*

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. Annual removal of such barriers is generally required as a permit condition.

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 $100 for burlap to $300 for aquascreen. Placement of lake bottom screens requires a WDNR permit pursuant to Chapter 30 of the *Wisconsin Statutes*. Because of the limitations involved, placement of lake bottom covers as a method to control aquatic plant growth is not recommended for Pike Lake.

Use of sand blankets and pea gravel deposits has also been proposed as a physical barrier to aquatic plant growth in certain situations. Placement of materials on the bed of a navigable lake or waterway also requires a WDNR permit pursuant to Chapter 30 of the *Wisconsin Statutes*, and the use of these materials is generally confined to the creation and augmentation of swimming beaches. Use of these materials for aquatic plant management purposes is not recommended as deposition of sediments above the sand or gravel layer limits the longer term viability of this technique.

Public Informational Programming

Aquatic plant management usually centers on the eradication of nuisance aquatic plants for the improvement of recreational lake use. The majority of the public views 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. As shown in Table 24, many aquatic plants have positive ecological value within the lake ecosystem, and most native aquatic plants rarely interfere with human water uses. Thus, public information is an important component of an aquatic plant management program and should include informational programming on:

1. The types of aquatic plants in Pike 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 lists provided in Chapter V, and the illustrations of common aquatic plants present in Pike Lake appended hereto as Appendix A, 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 Pike Lake, Eurasian water milfoil is one of the few species likely to cause lake-use problems. Eurasian water milfoil, unlike most aquatic plants, can reproduce from fragments and often forms dense, monotypic beds with little habitat value for fish or waterfowl. Thus, lakeshore residents should be encouraged to collect fragments that wash ashore after storms and, especially, from weekend boat traffic. The plant fragments can be used as mulch on flower gardens or ornamental planting areas. Likewise, lake users should be encouraged to inspect boats and trailers both prior to launch and following recovery as Eurasian water milfoil and other aquatic plants can be transported between lakes as fragments on boats and boat trailers. This effort also limits the likelihood of transporting zebra mussel, *Dreissena polymorpha*, between lakes and into new areas of the Lake.

To prevent unwanted introductions of plants and invasive aquatic animals into lakes, boaters should remove all plant fragments from their boats and trailers when exiting a lake, and allow wet wells, engine water jackets, and bilges to dry thoroughly for up to one week, alternatively, boaters can run their vessels through a car wash, where high pressure, high temperature water sprays can remove and destroy organisms such as the zebra mussel juveniles (veligers).[40] Providing the opportunity for the removal of plant fragments at the boat landing on Pike Lake, and provision of signage at the boat landing, including provision of disposal containers at the boat landing, 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, zebra mussel, and other nonnative aquatic species; discuss the importance of removing plant fragments from boats; and, remind boaters of their duty in this regard.

Recreational Use Management

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, controls development around a lake to minimize its environmental impacts and manages 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, or areas of use, wherein the types or rate of use is controlled, as in the case of shallow water, slow-no-wake speed limits. 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 buoyage.

Currently, watercraft are restricted to slow-no-wake speeds within approximately 200 feet of shore or 150 feet of pierheads. These areas typically coincide with water depths of less than five feet in depth. Demarcation of WDNR-delineated sensitive areas, Eurasian water milfoil control areas, and similar environmentally valuable or sensitive areas of the Lake is a feasible option to be considered further. It is also recommended that consideration be given to the continued enforcement of the Town of Hartford recreational boating ordinance appended hereto as Appendix B, and development of a winter lake use ordinance by the governmental bodies surrounding Pike Lake.

Public recreational boating access to Pike Lake is provided through a private provider agreement signed between the Wisconsin Department of Natural Resources and a local marina. This agreement, pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*, provides for the launching and recovery of watercraft at rates consistent with those charged for entry to state parks, and is subject to periodic review. Maintenance of this agreement for the ongoing provision of public recreational boating access is recommended. Public access to Pike Lake for nonboating recreational purposes is provided through the Pike Lake Unit of the Kettle Moraine State Forest.

---

[40]*See Wisconsin Department of Natural Resources Publication No. PUBL-WR-383 95-REV.*, Zebra Mussel Boater's Guide, *1995; Wisconsin Department of Natural Resources Publication No. PUBL-WR-463 96-REV.*, The Facts...On Eurasian Water Milfoil, *February 1996.*

Given that public recreational boating access to Pike Lake is provided through a private provider agreement, alternatives for the continued provision of public recreational boating access are recommended to be considered. Because, as noted in Chapter VI, provision of public recreational boating access to Pike Lake through the Pike Lake Unit of the Kettle Moraine State Forest is unlikely to be considered, consideration should be given to upgrading the access opportunities provided by the Town of Hartford. Such consideration would require providing parking for between 17 and 33 car-trailer units, including at least one handicapped accessible parking space, within no more than one-quarter mile of the launch ramp. Given the residential nature of the Pike Lake community, acquisition of parking areas would require intrusion of such areas into the residential community—either through acquisition of a residential property and conversion of the property into a parking area or provision of on-street parking that would require widening of the public street within an increased right-of-way—which intrusion is not considered to be feasible. Alternatives include the public acquisition of the current access site and associated parking facility, which carries with it considerable acquisition costs, only a portion of which are potentially cost-shareable under Chapter NR 7 of the *Wisconsin Administrative Code*, or provision of public recreational boating access through the Pike Lake Unit of the Kettle Moraine State Forest. Should the latter be considered, it is recommended that public recreational boating access be provided through the southern portion of the Pike Lake Unit of the Kettle Moraine State Forest, adjacent to the deeper water areas of the Lake but outside of the wetland areas that characterize portions of this site, rather than through the northern portions of the site, adjacent to the current parking area, which lie within the proposed fisheries habitat area.

Notwithstanding, continued provision of public recreational boating access to Pike Lake does allow the Pike Lake community access to state cost-share funding for enhancement services, and is a feasible option to be considered further. In addition, management of stormwater runoff at all access sites and lakeside parking facilities should be considered.

Hydraulic and Hydrologic Management

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 are 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 Operations

The outflow from Pike Lake is controlled by a dam on the Rubicon River outlet located on the northern side of the Lake in the vicinity of STH 60 in the Town of Hartford. The current outlet structure, reconstructed in 1993, is owned and operated by the Pike Lake Advancement Association. The structure has a variable discharge elevation that maintains an operating level governed by the dam operating permit issued by the Wisconsin Department of Natural Resources. Pursuant to this permit, lake elevations are to be maintained within the range of 993.27 to 993.74 feet above National Geodetic Vertical Datum of 1929 (NGVD-29). Any changes in this operating regime are subject to WDNR Chapter 31, *Wisconsin Statutes*, permitting authority. No changes are currently recommended.

Drawdown

Drawdown refers to a manipulation of lake water levels, especially in impounded 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 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. Limited, over-winter drawdowns, conducted pursuant to the dam operating permit, are designed to limit shoreland damage by ice and ice movements during the winter months.

In contrast, 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 noted above, the water level of Pike Lake is controlled by a hydraulic control structure located on the eastern shore of the Lake. A limited drawdown could be obtained by opening the gate on the weir, while a total breaching of the dam would allow a drawdown of approximately five feet, exposing about 40 percent of the 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 Pike Lake.

Water Level Stabilization

Riparian residents have reported significant seasonal changes in the water levels in Pike Lake. While water level management in a lake is a common technique for managing fish and aquatic macrophytes, the consequences of manipulating lake water levels can be both beneficial and deleterious. The major impacts from the riparian owners standpoint is that the fluctuating water levels affect shoreline erosion, interfere with proper pier height and placement, as well as the correct placement of shoreline protection structures.

Periodic changes in precipitation and weather patterns between years often result in fluctuation of water loads to the lake. These fluctuations in turn can affect lake levels. Most plant and animal species can cope with this level of water surface fluctuation without experiencing the consequences, both positive and negative, noted above. Nevertheless, while artificial stabilization of the water surface is not recommended, it is desirable from the point of view of aquatic habitat that water level fluctuations be maintained within natural limits.

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 larger-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.

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, in effect, to 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, prevent fish winterkills and nutrient recycling; restore fish breeding habitat; and decrease macrophyte growth. The objective of a dredging program at Pike Lake should be to increase water depth to maintain recreational boating access and increased public safety.

Notwithstanding, 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, removal of native plant seeds, and destruction of benthic and fisheries 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 Pike Lake. In addition, while dredging can result 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. The sediment load reaching Pike Lake comes from both urban and agricultural lands within the drainage area tributary to Pike Lake. Sediment also may be generated from streambank and shoreland erosion. Many of these sources can be effectively controlled through the adoption, implementation, and maintenance of recommended control measures within the watershed. Such practices should be implemented in the drainage area tributary to the Lake, as noted above, regardless of the likely conduct of any dredging project. Because of these considerations, extensive dredging of Pike Lake is not considered a viable alternative at this time.

Public Informational and Educational Programming

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 Washington County Planning and Parks Department. 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 or public library displays. Many of these ideas can be integrated into ongoing, larger-scale municipal activities such as anti-littering campaigns, recycling drives, and similar pro-environment activities.

In addition to public informational programming, or informal educational programming, discussed above, there are a number of school-based educational opportunities that the community can utilize. Provision of these educational opportunities at the high school and middle school levels is recommended. Programs and curricula such as Project WET and Adopt-A-Lake are available from and supported by the University of Wisconsin-Extension and Washington County. Through these programs, youth have an opportunity to experience "hands on" the aquatic environment and become better informed about current and future lake issues and concerns.

Finally, the participation of the Pike Lake community in the Wisconsin Department of Natural Resources Self-Help Monitoring Program should be continued. Volunteer monitoring under the auspices of the WDNR "Self-Help Monitoring Program" involves citizens in taking Secchi-disc transparency readings in the Lake at regular intervals. The Lake Coordinator of the Wisconsin Department of Natural Resources-Southeast Region can assist in enlisting 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 Pike 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 of the lake watershed inventory. Selected characteristics of these measures are summarized in Table 39.

An evaluation of the potential management measures for improving the Pike 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 include: phosphorus precipitation and inactivation, drawdown by water level control modifications, dredging, biological control of aquatic plants, and lake bottom covering. The remaining measures are recommended to be considered further for incorporation in the recommended plan described in Chapter VIII.

Table 39

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR PIKE LAKE

Alternative Measure	Description	Estimated Costs: 2000 Capital	Estimated Costs: 2000 Operation and Maintenance	Considered Viable for Inclusion in Recommended Lake Management Plan
Land Use Management and Zoning	Implement regional land use plan within watershed	- -	- -	Yes
	Maintain existing density management in lakeshore areas	- -	- -	Yes
	Review and implement zoning codes and land use plans in riparian communities	- -	- -	Yes
	Review and enforce stormwater management ordinances, especially in developing areas	- -	- -	Yes
Protection of Environmentally Sensitive Lands	Implement regional natural areas and critical species habitat protection and management plan recommendations within watershed	- -	- -	Yes
	Consider modification of wetland areas of the Rubicon River inflow to promote water quality benefit	- -	- -	Yes
Public Sanitary Sewerage System Management	Conduct periodic review of sewer service area needs within sewered areas of the watershed	- -	- -	Yes
Onsite Sewage Disposal System Management	Implement onsite sewage disposal system management, including inspection and maintenance	- -	$100[b]	Yes
Nonpoint Source Pollution Abatement	Implement regional water quality management plan and county land and water resource management plan recommendations within watershed	- -	- -	Yes
Rural Nonpoint Source Controls	Develop farm conservation plans that encourage conservation farming and integrated nutrient and pest management practices in agricultural areas of the watershed	- -[a]	- -[a]	Yes
Urban Nonpoint Source Controls	Promote urban good housekeeping practices in urban areas of the watershed	- -[a]	- -[a]	Yes
	Implement and enforce stormwater management ordinances	- -	- -	Yes

Table 39 (continued)

Alternative Measure	Description	Estimated Costs: 2000		Considered Viable for Inclusion in Recommended Lake Management Plan
		Capital	Operation and Maintenance	
Urban Nonpoint Source Controls (continued)	Implement additional urban nonpoint source controls, including street sweeping, catch basin cleaning, leaf litter and garden refuse collection, materials storage facility protection, and stormwater management measures in urban areas of the watershed	- -[a]	- -[a]	Yes
Developing Area Nonpoint Source Controls	Enforce construction site erosion control ordinances	$250 per acre	$25 per acre	Yes
Water Quality Improvement Measures	Conduct alum treatment to achieve phosphorus inactivation in lake sediments	- -	$150 per 40 acres	No
	Promote nutrient load reduction within the Lake through sediment management	- -	Variable	No
	Minimize internal loading through aeration or aeration and destratification	- -	- -	No
Fisheries Management	Protect fish habitat	- -	- -	Yes
	Maintain shoreline and littoral zone fish habitat	- -	- -	Yes
	Continue stocking of selected game fish species and monitor rough fish populations	- -	- -	No
	Enforce size and catch limit regulations	- -	$1,200	Yes
Aquatic Plant Management	Use (limited) aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife	- -	Variable	Yes[d]
	Harvest aquatic plants to provide boating access lanes and fish lanes; remove Eurasian water milfoil canopy to promote growth of native plants	$100,000	$22,000	Yes[e]
	Manually harvest aquatic plants from around docks and piers	$100	- -	Yes
	Employ biological controls using inocula of Eurasian water milfoil weevils	- -	Variable	No
	Use sediment covers to shade out aquatic plant growth around piers and docks	- -	$40 to $220 per 700 square feet	No
	Conduct public informational and educational programming on aquatic plants and options for their management	- -	$100 to $300	Yes
Recreational Use Management	Enforce boating regulations to maximize public safety; improve signage	- -	$1,000[f]	Yes
	Maintain adequate public recreational boating access to maintain eligibility for state cost-share funding for enhancement services	- -	- -	Yes

Table 39 (continued)

Alternative Measure	Description	Estimated Costs: 2000		Considered Viable for Inclusion in Recommended Lake Management Plan
		Capital	Operation and Maintenance	
Hydraulic and Hydrologic Management	Modify outlet control operations; maintain and improve inlet and bypass channel	- -	- -	Yes[c]
	Drawdown	- -	- -	No
	Water level stabilization	- -	- -	No
	Dredging	- -	- -	No
Public Informational and Educational Programming	Support participation of schools in Project WET, Adopt-A-Lake, etc.	- -	- -	Yes
	Continue participation in Self-Help Monitoring Program	- -	$200	Yes

[a]*Cost of nonpoint source management practices to be determined by detailed farm plans and stormwater management plans.*

[b]*Onsite sanitary sewage disposal systems installed after 1983 are subject to regular inspection and maintenance requirements under Washington County Code; the cost shown represents an average pumping cost per property. (Note: the lakeshore areas of Pike Lake are served by public sanitary sewers.)*

[c]*While no change to the current operational regime of the Pike Lake dam is suggested, a review and evaluation of the operational regime is recommended to be conducted as part of a hydraulic and hydrologic study of the entire Rubicon River system. Following completion of the review of the bypass channel function being conducted by the U.S. Geological Survey, consider modification of the inlet and implementation of remedial and maintenance measures to ensure effective operation of the bypass channel.*

[d]*In limited areas when necessary to control exotic, invasive species.*

[e]*Estimated capital cost is for new harvesting equipment to replace existing equipment, when needed.*

[f]*Cost for improved signage.*

Source: SEWRPC.

Chapter VIII

RECOMMENDED MANAGEMENT PLAN FOR PIKE LAKE

INTRODUCTION

This chapter presents a recommended management plan for Pike Lake. The plan is based upon inventories and analyses of land use and land and water management practices, pollution sources in the drainage area tributary to Pike Lake, the physical and biological quality of the waters of the Lake, recreational use and population forecasts, and an evaluation of alternative lake management measures. The recommended plan sets forth the means for: 1) providing water quality 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 or perceived problems which constrain or preclude desired water uses; 3) improving opportunities for water-based recreational activities; and 4) protecting environmentally sensitive areas. The elements of the recommended plan were selected from among the alternatives described in Chapter VII, and evaluated on the basis of those feasible alternatives, set forth in Table 38, that may be expected to best meet the foregoing lake management objectives.

The primary open water-based recreational activities on the Lake are fishing, swimming, and pleasure boating. Winter recreation includes ice fishing and cross-country skiing. An analysis of the status of these activities suggests that the Lake supports a viable warmwater fishery and provides for active recreational use, especially in the deeper water portions of the lake basin. There appear to be few impediments to water-based recreation, although access by recreational watercraft is limited in a few areas of the Lake by water depths and growths of aquatic macrophytes, and swimming opportunities are reported to be limited to some degree due to a perception of excessive algal growth in portions of the Lake. Consequently, the recommended management plan contains recommendations directed toward improving swimming opportunities, as well as maintaining and improving other use opportunities.

The development of the recommended plan involved careful consideration of many tangible and intangible factors bearing upon water quality management, water pollution control, and protection of habitat, with primary emphasis upon the degree to which the desired water use objectives may be expected to be met, and upon the cost-effectiveness of the recommended measures. The plan development process involved review of preliminary drafts of the recommended plan by the Pike Lake Watershed Advisory Committee and the Pike Lake Protection and Rehabilitation District.

Analyses of water quality and biological conditions indicate that the general condition of the water of Pike Lake is good. Nevertheless, based upon a review of the inventory findings and consideration of planned developments within the drainage area tributary to the Lake, measures will be required to continue to protect and maintain the high quality of the Lake for future lake users. Therefore, this plan sets forth recommendations that complement and refine the watershedwide land use controls and management measures recommended in the adopted regional water quality management plan,[1] the Upper Rock River basin plan,[2] and the Washington County land and water resource management plan.[3]

WATERSHED MANAGEMENT MEASURES

Land Use Control and Management

A fundamental element of a sound management plan and program for Pike Lake is the promotion of a sound land use pattern within the drainage area tributary to the Lake. The type and location of rural and urban land uses in the drainage area will determine, to a considerable degree, the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, various land management measures; and, ultimately, the water quality of the Lake.

The recommended land use plan for the drainage area tributary to Pike Lake under year 2020 conditions is described in Chapter III. The framework for the plan is the regional land use plan as prepared and adopted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC), as refined through local land use plans. The recommended land use plans envision that urban land use development within the drainage area tributary to Pike Lake will 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 not environmentally sensitive, that is, not encompassed within the Regional Planning Commission-delineated environmental corridors described in Chapter V.

Development in the Shoreland Zone

A major land use issue which has the potential to affect Pike Lake is the redevelopment of existing lakefront properties, replacing lower-density uses with higher-density dwellings with potential for 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 the potential for an adverse impact on the Lake from significant 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 Pike Lake to the maximum extent practical is recommended.

It is further recommended that all lakefront developments, as well as setback and landscaping provisions, be carefully reviewed by the City and Town of Hartford, Washington County, and the Wisconsin Department of Natural Resources (WDNR). Such review would address specific shoreland zoning requirements, and could consider the stormwater and urban nonpoint source pollution abatement practices proposed to be included in shoreland development activities. Development of lake- and stream-front properties within unincorporated areas of Washington County, and lands annexed to incorporated areas, subsequent to February 2001, are governed by the provisions of Chapter 23 of the *Washington County Code*, which sets a graduated scale of performance standards for such development based upon the sensitivity of the waterbody to development related impacts, among other criteria:

- The Rubicon River is a Class II waterbody, which suggests that the stream corridor is moderately developed, with some sensitivity to development-related impacts. Consequently, lot sizes and

---

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

[2]*Wisconsin Department of Natural Resources Publication PUBL-WR-190-95 REV,* Upper Rock River Basin Water Quality Management Plan, *July 1995.*

[3]*Washington County,* Washington County Land & Water Resource Management Plan, *September 2000.*

setbacks of principle structures exceed statewide minima established pursuant to Chapter NR 115 of the *Wisconsin Administrative Code*. By requiring greater setback distances, among other provisions, the *Washington County Code* seeks to limit runoff of contaminants to the stream, thereby protecting and preserving the biological diversity and water quality of this resource. Provision for shoreland buffers, use of appropriate and environmentally friendly landscaping practices, and inclusion of stormwater management measures that provide water quality benefits are practices to be encouraged and can be considered in mitigation of development impacts on the stream bank.

- Pike Lake is classified as a Class III waterbody pursuant to the Chapter 23 of the *Washington County Code*. Class III waterbodies are subject to the statewide minima established pursuant to Chapter NR 115 of the *Wisconsin Administrative Code*. Provision for shoreland buffers, use of appropriate and environmentally friendly landscaping practices, and inclusion of stormwater management measures that provide water quality benefits are practices to be encouraged.

Development in the Tributary Drainage Area

Another land use issue which has the potential to affect the Lake is the potential development for urban uses of the agricultural and other open space lands in the tributary drainage area. As previously noted, urban development is occurring in areas of the Lake watershed. Planned year 2020 urban development in the watershed, as discussed in Chapter III, includes large-lot residential development as well as more intensive commercial and light industrial development within the western portions of the Village of Slinger. Such development may significantly increase the generation and delivery of urban sourced pollutant loadings to the Lake, as well as increase the pressures for recreational use of the Lake, without remedial measures being implemented. Under the year 2020 condition envisioned under the regional land use plan, as shown on Map 16,[4] a significant portion of the undeveloped lands outside of the environmental corridors and other environmentally sensitive areas, could potentially be developed for such urban uses.

The existing zoning in the drainage basin permits urban-density development over much of the remaining open lands, other than the environmental corridors. It is recommended that the impact of such future land use development on Pike Lake be minimized through review and modification of the applicable zoning ordinance regulations and zoning district maps to address these concerns. Changes in zoning ordinances are recommended to reflect the County Code, and specifically incorporate low impact development measures consistent with the lake and stream classifications applied to the Rubicon River and Pike Lake. These measures minimize the areal extent of development by providing specific provisions and incentives for the clustering of residential development on smaller lots within conservation subdivisions, and allowing mitigation of residential redevelopment sites, thus preserving or restoring significant portions of the open space within each property or group of properties considered for development.

Stormwater Management

It is recommended that the City of and Town of Hartford and Village of Slinger take an active role in promoting urban nonpoint source pollution abatement. Actions to promote urban nonpoint source pollution abatement would include the conduct of specific stormwater management planning within specific portions of the drainage area located within each municipality where further urban development or redevelopment is anticipated. Such a planning program should include a periodic review of the stormwater management ordinances, to ensure that the ordinance provisions reflect state-of-the-art runoff and water quality management requirements, and to ensure that there is harmony between the ordinances governing urban density development in each of the municipalities draining to Pike Lake. Currently, the City of Hartford has adopted stormwater management ordinances, and the Towns of Hartford and Polk are subject to the provisions of Chapter 17 of the *Washington County Code*. While the Village of Slinger did not have an adopted stormwater management ordinance, stormwater management provisions, consistent with the *Washington County Code*, generally were included as specific conditions for

---

[4]*SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997.*

development within the Village. These ordinances should reflect current best practices insofar as the determination of stormwater flows, mitigation of flooding potential, and the control of contaminants from land use activities are concerned. Adoption by the Village of Slinger of stormwater management ordinance provisions consistent with those set forth in the Washington County Code is recommended.[5]

Stormwater management ordinances are recommended to be reviewed for consistency with the provisions of the recently-enacted Chapter NR 151 of the *Wisconsin Administrative Code*. Based upon such a review and refinement, the ordinances should be generally consistent within the drainage area tributary to Pike Lake, and require sound management practices be implemented within the drainage area. Chapter NR 152 of the *Wisconsin Administrative Code* sets forth model construction site erosion control and stormwater management ordinances as Appendices A and B of Chapter NR 152, respectively, which are recommended to serve as guidance for the suggested ordinance review process. Management practices in urban areas implemented to reduce construction site erosion are required under Section NR 151.11 to reduce sediment loss by 80 percent over uncontrolled sediment loads estimated to be generated from the construction site; this level of reduction is to be estimated utilizing technical standards set forth in Subchapter V of Chapter NR 151.[6]

Consideration is recommended to be given to the implementation of demonstration projects for stormwater and shoreline management on public lands surrounding the Lake. Implementation of measures to limit shoreline damage resulting from mooring watercraft adjacent to the swimming beach at the Pike Lake Unit of the Kettle Moraine State Forest are recommended, as are practices to limit stormwater runoff entering the Lake from the parking area of the Pike Lake Unit of the Kettle Moraine State Forest on the eastern shore of the Lake and the public access sites created by Town road rights-of-way on the western shore of the Lake. These areas are accessible by the public and are highly visible from the Lake, providing a high degree of exposure consistent with their proposed roles as demonstration project sites. Implementation of stormwater management practices at the public recreational boating access sites created by the rights-of-way of the Town of Hartford is recommended to include the use of shoreland buffer strips and consideration of porous paving that will limit and interrupt the flow of stormwater into the Lake. (Note: This recommendation should be viewed in conjunction with the provision of car-trailer parking facilities in close proximity of these launch sites recommended under recreational use management measures, below, and the use of porous paving and buffer strips modified accordingly.) Stormwater management practices within the Pike Lake Unit of the Kettle Moraine State Forest should address runoff from the parking area, which currently is situated so as to shed stormwater to the Lake. Redesign of this parking lot should be considered and is recommended to include infiltration areas, modifications in camber designed to funnel runoff into the infiltration areas and vegetated buffer strips, and related actions designed to limit runoff to the Lake, while continuing to provide parking facilities for visitors to this heavily utilized Park.

Management of Environmentally Sensitive Lands

Wetland, woodland, and groundwater recharge area protection can be accomplished through land use regulation and public land acquisition of critical lands. Both measures are recommended for the drainage area tributary to Pike Lake. The wetland areas within the drainage area tributary to the Lake are currently largely protected through the existing regulatory framework provided by the U.S. Army Corps of Engineers permit program, State shoreland zoning requirements, and local zoning ordinances. Nearly all wetland areas in the Pike 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. Consistent and effective application of the provisions of these regulations is recommended.

---

[5]*As noted in Table 12, the Village of Slinger does not have specific stormwater management requirements established through ordinance; however, the current practice of the Village generally follows the County ordinance provisions.*

[6]*Applicable design guidance and technical standards are set forth in, among others, Wisconsin Department of Natural Resources Publication No. PUBL-WR-222 93 Rev,* Wisconsin Construction Site Best Management Practice Handbook, *November 1993.*

Notwithstanding, some wetland and woodland areas have been identified for acquisition in the adopted regional natural areas and critical species habitat protection and management plan, and are shown on Map 21, including the Pike Lake Woods, within the Pike Lake Unit of the Kettle Moraine State Forest adjoining the eastern shoreline of Pike Lake, and already in public ownership; the Pike Lake Sedge Meadow and the Slinger Upland Woods recommended for acquisition by the Towns of Hartford and Polk, respectively; and the STH 60 swamp, recommended for acquisition by an appropriate agency or organization. A smaller, unnamed wetland site, located to the southeast of Pike Lake along CTH E and shown on Map 21, was not recommended for acquisition and was suggested to remain in private ownership.

Nonpoint Source Pollution Control

The recommended watershed land management measures are specifically aimed at reducing the water quality impacts on Pike Lake of nonpoint sources of pollution within the tributary drainage area. These measures are set forth in the aforereferenced regional water quality management plan and the Washington County land and water resource management plan. As indicated in the lake and watershed inventory, the only significant sources of phosphorus loading to the Lake that are subject to potential controls are rural and urban nonpoint sources, and onsite sewage disposal systems in the drainage area. The lakeshore areas tributary to Pike Lake are largely served by a public sanitary sewerage system.

Nonpoint source control measures should be considered for the areas tributary to Pike Lake, including the upstream tributary drainage area. The regional water quality management plan recommended a reduction of about 25 percent in urban and rural nonpoint-sourced pollutants plus streambank erosion control, construction site erosion control, and onsite sewage disposal system management be achieved in the drainage area tributary to Pike Lake. Nonpoint source pollution abatement controls in the drainage area were recommended to be achieved through a combination of rural agricultural nonpoint controls, urban stormwater management, and construction erosion controls. The implementation of the land management practices described below may be expected to result in a reduction in nonpoint-sourced pollutants that is considered to be the maximum practicable given the findings of the inventories and analyses compiled during the planning effort. These measures are consistent with the recommended measures set forth in the Washington County land and water resource management plan.

The implementation of nonpoint source pollution controls requires the cooperative efforts of the City and Town of Hartford, Village of Slinger, Town of Polk, Washington County, and private landowners.

Rural Nonpoint Source Pollution Controls

The implementation of nonpoint source pollution controls in rural areas requires the cooperative efforts of the Town of Hartford, Town of Polk, Washington County, 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 Washington County Land and Water Conservation Division. 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 runoff management and lake protection programs, and various local land acquisition initiatives.

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 within the drainage area tributary to Pike Lake 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 could provide up to about a 20 percent reduction in total phosphorus loading to Pike Lake. Implementation of the recommendations and work planning activities set forth in the Washington County land and water resource management plan would constitute a major step toward implementation of these lake management recommendations.

Rural nonpoint source pollution control measures to be implemented are recommended to be consistent with the performance standards established by the recently-enacted Chapter NR 151 of the *Wisconsin Administrative Code*. Pursuant to Section NR 151.05 of the *Wisconsin Administrative Code*, municipalities are expected to fully implement these standards. Consequently, review and refinement of Town ordinances, as appropriate and necessary, is recommended. Based upon such a review and refinement, the ordinances should be generally consistent within the drainage area tributary to Pike Lake, and require sound management practices be implemented within the drainage area. Performance standards required to be implemented pursuant to Chapter NR 151 would limit soil loss, under Section NR 151.02, to not more than the tolerable ("T") value established for the soil groups present in the watershed. This value is calculated using the Revised Soil Loss Equation (RUSLE), pursuant to the provisions of Chapter ATCP 50 of the *Wisconsin Administrative Code*. Section NR 151.05 also requires that new or substantially modified manure storage facilities be appropriately designed and constructed so as to minimize leakage. Where manure storage facilities do not exist, Section NR 151.08 requires that, among other provisions, a facility be provided, that runoff be managed so as not to enter the waters of the state, and that livestock not be allowed unlimited access to waters of the state. Section NR 151.06 further requires that runoff from barnyards be diverted from feedlots and manure storage areas, except when a diversion is required to protect a private well. Use of manure as a soil amendment is required to be in accordance with a nutrient management plan, which plan is to be developed in accordance with ATCP 50.

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. As noted above, with the promulgation of Chapters NR 153 and NR 154 of the *Wisconsin Administrative Code*, which became effective during October 2003, cost-share funding may be available to encourage installation of appropriate land management measures.

Urban Nonpoint Source Pollution Controls

The development of urban nonpoint source pollution abatement measures for the Pike Lake areas should be the primary responsibility of the City and Town of Hartford and Village of Slinger. In addition to the adoption of stormwater management ordinances, the most viable measures to control urban nonpoint sources of pollution appear to be good urban land management and urban housekeeping practices. Such practices consist of fertilizer and pesticide use management, litter and pet waste controls, and management of leaf litter and yard waste. The promotion of these measures requires an ongoing public informational program. It is recommended that the Pike Lake Protection and Rehabilitation District, in cooperation with the City, the Village and the Town, take the lead in sponsoring such programming for the Pike Lake community through regular public informational meetings and mailings. The District should also ensure that relevant literature, available through the University of Wisconsin-Extension Service and the WDNR, is made available at these meetings and at the local Public Library and government offices. Such low-cost measures complement street sweeping program and litter collection activities.

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 Pike Lake be prepared and distributed to property owners. This fact sheet could be distributed by the Pike Lake Protection and Rehabilitation District, and through the City, Village, and Town as well as the University of Wisconsin-Extension Service and Washington County Land and Water Conservation Division offices. The recommended measures may be expected to provide about a 25 percent reduction in urban nonpoint source pollution runoff and up to about a 5 percent reduction in total phosphorus loadings to the Lake.

Urban nonpoint source pollution control measures to be implemented are recommended to be consistent with the performance standards established by the recently-enacted Chapter NR 151 of the *Wisconsin Administrative Code*. Pursuant to Section NR 151.13 of the *Wisconsin Administrative Code*, municipalities are expected to fully implement these standards. Consequently, review and refinement of City, Village and Town ordinances, as appropriate and necessary, is recommended. Based upon such a review and refinement, the ordinances should be generally consistent within the drainage area tributary to Pike Lake, and require sound management practices be implemented within the drainage area. Performance standards to be implemented pursuant to Chapter NR 151 would require landowners to develop and implement written stormwater management plans for post-construction development sites, as set forth in Section NR 151.12.

Total suspended solids discharge from new development is required to be reduced by 80 percent from estimated sediment loads generated by equivalent rainfalls; a reduction of 40 percent is required to be achieved on redevelopment sites and infill development sites during the period 2002 through 2012, after which the 80 percent reduction standard is to apply. The sediment discharge value is to be calculated using the Source Loading and Management Model (SLAMM), P-8 Model (Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds), or equivalent model. Runoff and hydrologic impacts are required to be assessed using the U.S. Department of Agriculture TR-55 model, although the U.S. Army Corps of Engineers HEC-RAS model may be used to determine surface water elevations. No more than a 0.01 foot increase in water surface elevation is allowed at any point downstream of the development.

Stormwater management practices under the provisions of Section NR 151.12 of the *Wisconsin Administrative Code* would require infiltration. Infiltration is a stormwater management practice that encourages a percentage of the precipitation falling onto a development site to percolate into the groundwater, mimicking the natural infiltration of rainwater into the soils. Such infiltration reduces the volume of water delivered to surface waterbodies, and also enhances recharge of surfacial groundwater aquifers. In residential areas, 90 percent of the predevelopment infiltration volume is required to be infiltrated, provided that the area required for such infiltration does not exceed 1 percent of the area of the project site; in commercial, industrial and institutional areas, 60 percent of the predevelopment infiltration volume is required to be infiltrated, provided that the area required for such infiltration does not exceed 2 percent of the area of the project site.

Under peak discharge conditions, defined as the two-year recurrence interval storm event, the provisions of Section NR 151.12 of the *Wisconsin Administrative Code* would require infiltration of 25 percent and 10 percent of the post-development runoff volume, respectively, for residential areas and for commercial, industrial and institutional areas. Pretreatment of runoff from roadways and parking lots is required, and certain exceptions may apply in high groundwater areas, areas with physical site constraints, and in the vicinity of community water supply well sites. Setbacks of 50 feet from streams, lakes, and wetlands generally apply. This setback distance is increased to 75 feet around NR 102-designated outstanding or exceptional resource waters or NR 103-designated wetlands of special natural resource interest. Reduced setbacks from less susceptible wetlands and drainage channels of not less than 10 feet may be allowed. [Note: Within unincorporated areas of Washington County, and lands annexed to incorporated areas, subsequent to February 2001, the provisions of Chapter 23 of the *Washington County Code* set a graduated scale of performance standards for shoreland development based upon the sensitivity of the waterbody to development related impacts, among other criteria, that generally are more restrictive than the NR 151 setbacks noted, being a minimum of 50 feet in width for Class III waterbodies.]

In addition to these provisions, Section NR 151.13 of the *Wisconsin Administrative Code* requires municipalities to implement informational and educational programming to promote good housekeeping practices in developed urban areas, and related operational programs to be implemented in municipalities subject to stormwater permitting requirements pursuant to Chapter NR 216 of the *Wisconsin Administrative Code*.[7] Under these provisions, operational programs are required to reduce suspended solids in stormwater by 20 percent over uncontrolled sediment loads estimated to be generated from developed urban areas; under stage two requirements applicable from year 2012, the reduction in suspended solids load increases to 40 percent. Appropriate measures to achieve these levels of solids reduction are set forth in Appendix B. Informational and educational programming also is discussed further below. Notwithstanding, conduct of an educational and informational

[7] *The City of Hartford, while meeting the population and population density criteria for small municipal separate storm sewer systems (MS4s), is currently not a regulated small MS4 under the Federal National Pollutant Discharge Elimination System (NPDES) Phase II stormwater permitting requirements.*

program by the Pike Lake Protection and Rehabilitation District and the municipalities, encouraging adoption of good urban housekeeping practices within the drainage area tributary to Pike Lake, is recommended.

Developing Areas and Construction Site Erosion Control

It is recommended that Washington County, the City and Town of Hartford, and the Village of Slinger continue efforts to control soil erosion attendant to construction activities in accordance with existing ordinances. As noted in Chapter III, Washington County has adopted construction erosion control ordinances. Enforcement of the ordinances by the County is generally considered effective. The provisions 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. At the present time, Washington County has adopted construction site erosion control ordinances within Chapter 17 of the *Washington County Code*, which provisions are administered and enforced by the County, in both the shoreland and nonshoreland areas of the unincorporated areas of the drainage area tributary to Pike Lake. The provisions of these ordinances apply to all development except single- and two-family residential construction regulated under Section Comm 21.125 of the *Wisconsin Administrative Code*, and land disturbing activities of less than one acre in areal extent within shoreland, wetland, and floodplain zones. Single- and two-family construction erosion control measures are to be specified as part of the building permit process. In the incorporated areas of the City of Hartford and Village of Slinger, this function is performed by the respective City and Village building inspection program. These ordinances reflect current best practices insofar as the control of contaminants from land use activities is concerned.

Pursuant to the recently-enacted Chapter NR 151 of the *Wisconsin Administrative Code*, nonpoint source pollution control measures are required to be implemented in developing or redeveloping urban areas. Consequently, it is recommended that municipal ordinances be reviewed and refined as necessary to ensure consistency with the performance standards established under Section NR 151.11 of the *Wisconsin Administrative Code*. These provisions require that the sediment load carried in runoff from a construction site be reduced by 80 percent over uncontrolled sediment loads estimated to be generated from developing urban areas. The use of best management practices and construction site erosion controls to achieve the required reductions is recommended.

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 Pike Lake that can result from uncontrolled construction sites. Consideration should be given to incorporating construction site erosion control measures into a formal stormwater management system serving larger developments following construction.

Construction site erosion control measures may be expected to reduce the phosphorus loading from that source by about 75 percent. Because of the potential for development in the tributary drainage area to Pike Lake, it is 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.

Onsite and Public Sewage Disposal System Management

Although the lakeshore areas tributary to Pike Lake are served by public sanitary sewerage systems, portions of the direct and total drainage area to the Lake continue to be served by onsite sewage disposal systems, or privately owned wastewater treatment systems (POWTs) and holding tanks. While such systems have been estimated to contribute less than one percent of the total phosphorus load to the Lake, current County ordinance provisions requiring the regular inspection and maintenance of onsite sewage disposal systems, as required pursuant to Chapter Comm 83 of the *Wisconsin Administrative Code*, are expected to continue to be enforced to minimize potential phosphorus loadings from this source. It also is recommended that Washington County, in cooperation with the City of Hartford, Village of Slinger, and the Towns of Hartford and Polk, assume the lead in providing the public informational and educational programs to encourage affected property owners to have existing onsite systems inspected and any needed remedial measures undertaken, as appropriate. Homeowners should be advised of the rules and regulations governing, and the limitations of onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs, especially of those older systems not yet subject to the inspection requirements of the County ordinance.

Typical costs for a basic inspection and maintenance service range from about $100 to $200 per maintenance cycle which typically extends over a two- to three-year period depending upon equipment type, although more extensive programs could be more expensive. The costs of the informational programming typically have been included within the operating budget of the County.

For those portions of the drainage area tributary to Pike Lake served by public sanitary sewerage systems, it is recommended that the City of Hartford and Village of Slinger assume the lead in providing public informational and educational programs to encourage affected property owners to use their sewerage systems appropriately and wisely. In an analogous recommendation, stenciling of storm drains and related informational programming encourages residents to dispose of waste products safely, avoiding discharge directly to the surface waters or indirectly through the wastewater treatment works to the environment.

Publicly owned wastewater treatment plants, or sewage treatment facilities, are required to have a Chapter 283, *Wisconsin Statutes*, pollution discharge elimination system permit. Wisconsin pollution discharge elimination system (WPDES) permits are required to be consistent with the requirements set forth in the Federal Water Pollution Control Act (Federal Clean Water Act). Permit holders are required to monitor their effluent and regularly report to the Wisconsin Department of Natural Resources on the volume discharged and the amount of selected pollutants discharged from each point source. The frequency and nature of such monitoring are provisions included within the applicable permit. These records are deemed to be public records pursuant to Chapter 19 of the *Wisconsin Statutes*. Permits are valid for a period not to exceed five years, and may be renewed. Renewal of permits is subject to evidence that the permitee has substantially complied with the provisions of the initial permit, including volumes of wastewater treated, nature and quality of the effluent discharges, and other applicable requirements. The permits may specify effluent limitations, standards, and prohibitions, including any pretreatment standards applicable to dischargers of wastewater into the public sewerage system for substances that might interfere with the operation of the publicly owned wastewater treatment facility. Notice of the permit application, or of the renewal or modification of a permit, is to be provided to governmental agencies, including the U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, and to the general public, and a public hearing on the permit may be held, subject to the provisions of Section 283.49, *Wisconsin Statutes*.

Within the drainage area tributary to Pike Lake, the Village of Slinger operates a wastewater treatment facility, which facility was upgraded as recommended in the adopted regional water quality management plan during 1981, as noted in Chapter IV. The plant replaced a smaller Village sewage treatment plant which had been located about one-third of a mile to the southeast of the existing plant site. The Village holds WPDES Permit No. WI-0020290-6, which permit provides for regular monitoring of both inflows to and outflows from the treatment plant. Effluent limitations in terms of daily maximum and monthly average concentrations of biochemical oxygen demand and suspended solids, daily minimum concentrations of dissolved oxygen and pH, weekly average concentrations of ammonia and residual chlorine, and monthly average concentrations of fecal coliform bacteria and total phosphorus are specified, together with sampling location, frequency, and methodology. This permit was renewed pursuant to the provisions of Chapter 283, *Wisconsin Statutes*, during 2003.

Pursuant to the provisions of Chapter NR 110, of the *Wisconsin Administrative Code*, the Village of Slinger wastewater treatment facility is subject to a planning program designed to meet the requirements of the WPDES program and provide for the operation of the wastewater treatment facility over a 20-year planning period. The most recent facilities planning for the Village of Slinger wastewater treatment facility is documented in three reports completed during 2001, 2002, and 2003.[8] The facility plan provides for the treatment of wastewater flows from the Village and its environs through a design year of 2020. Flows to the plant are anticipated to increase from the year 2000 volume of about 0.6 million gallons per day (MGD) to about 1.3 MGD (= 1,450 acre-feet per year) in year 2020, or about 18 percent of the total annual inflow to Pike Lake. This increased flow could convey up to about 4,000 pounds of phosphorus annually,[9] or between about 400 and 1,400 pounds more phosphorus per year than the inflowing total phosphorus load measured during 1999 and 2000 by the U.S. Geological Survey.[10] Consequently, it is recommended that the Village of Slinger wastewater treatment facility maintain its current program of phosphorus reduction which provides for an effluent phosphorus level which is typically about 70 percent of the permitted concentrations, and, as recommended below, that the phosphorus load bypass channel be maintained and operated so as to pass a major portion of this inflowing phosphorus load to the Rubicon River downstream of Pike Lake. It is also recommended that the phosphorus concentration in the discharge from the wastewater treatment plant continue to be monitored as provided for in the WPDES permit, and that the level of phosphorus in the effluent be minimized to the extent practicable based upon available treatment technology.

IN-LAKE MANAGEMENT MEASURES

The recommended in-lake management measures for Pike Lake include water quality monitoring, hydrologic management, fisheries management and habitat protection, shoreland protection, aquatic plant management, recreational use management, and informational and educational programming.

Surface Water Quality Management

Continued water quality monitoring of Pike Lake is recommended. To supplement the more comprehensive monitoring programs conducted on the Lake by the U.S. Geological Survey, enrollment of one or more lake residents as WDNR Self-Help Monitoring Program volunteers is recommended. Such enrollment can be accomplished through the South East Region Office of the Wisconsin Department of Natural Resources. 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 a central station in the deepest portion of the lake basin. TSI monitoring programs are facilitated by the WDNR through the expanded Self-Help Monitoring Program, by the U.S. Geological Survey, or by the University of Wisconsin-Stevens Point Environmental Task Force Laboratory through their lake monitoring programs. Costs range from minimal to about $5,000 per year, depending upon the degree of local effort, with cost-share grant funding available through the Chapter NR 190 Lake Management Planning Grant Program, and additional cost-share funding for U.S. Geological Survey monitoring available from the Federal government.

In addition, monitoring of in-stream water quality in the Rubicon River flowing into and out of Pike Lake is recommended. Volunteer stream monitoring programs have been developed by Washington County and the Rock

---

[8]*Ruekert & Mielke, Inc.,* Wastewater Treatment Facilities Facility Plan, Village of Slinger, Washington County, Wisconsin, *September 2001; see also McMahon Associates, Inc.,* Capacity Analysis and Re-Rating of the Village of Slinger Wastewater Treatment Facility, *November 2002, and McMahon Associates, Inc.,* Facility Plan Amendment of the Village of Slinger Wastewater Treatment Facility Plan, *March 2003.*

[9]*Total phosphorus load estimated based upon the 1 milligram per liter (mg/l) permitted total phosphorus concentration stated in the current Village of Slinger wastewater treatment facility WPDES permit. It should be noted that the wastewater treatment facility has performed well within this discharge standard; hence, these loads represent a "worst case" scenario.*

[10]*U.S. Geological Survey Scientific Investigations Report No. 2004-5141,* Water Quality, Hydrology, and the Effects of Changes in Phosphorus Loading to Pike Lake, Washington County, Wisconsin, with Special Emphasis on Inlet-to-Outlet Short-Circuiting, *2004.*

River Coalition and operate under the Water Action Volunteer (WAV) program. Support for citizen volunteer monitoring of the Rubicon River is recommended. This program is facilitated by the University of Wisconsin-Extension.

Water Quantity and Lake Level Management

As indicated in the lake and watershed inventory set forth in Chapter II, outflow from Pike Lake is controlled by a dam located on the northwestern side of the Lake at STH 60. The present actual operating regime of the dam is intended to maintain the lake level at an elevation which registers between 993.27 and 993.74 feet above National Geodetic Vertical Datum of 1929 (NGVD-29). The lake elevation is controlled by manual adjustment of the dam operating gate which adjustment is made periodically by the Pike Lake Advancement Association, based upon the observed lake levels. Any change in this operating regime would require a petition from the Advancement Association, as owner of the dam, to the WDNR. Given the size and type of lake involved, no additional operational controls or changes in operating regime 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. Based upon the current operating permit, the Pike Lake Advancement Association, as owner of the dam, is responsible for maintaining the gate structure, while other maintenance is to be conducted by the Wisconsin Department of Transportation under an agreement with the Advancement Association dated February 20, 1957.

During 1994, a bypass channel through the wetland complex, linking the inlet and outlet portions of the Rubicon River,[11] was constructed. As of 2003, monitoring data collected by the U.S. Geological Survey suggested that the bypass was effective in modifying the phosphorus load to the Lake, with up to about 85 percent of the observed phosphorus load being diverted through the outlet. However, significant retention of sediment was observed within the bypass channel by the U.S. Geological Survey, suggesting a reduction in its future efficacy; of the approximately four feet design depth of the channel, only about 0.5 feet of depth was reported to remain active due to the accumulation of sediment within the channel. Review of the design proposals for this bypass and comparison of the dimensions of the bypass channel with those of the Rubicon River by SEWRPC staff conducted during January 2004, both upstream and downstream of the Lake, would suggest that the channel is to be wider than necessary. This condition could contribute to the accumulation of sediment within the bypass channel, which would function effectively as a sedimentation area within the wetland complex. Utilization of the lagoon created within the wetland complex at the northernmost extreme of the Lake, immediately south of STH 60, as a sedimentation basin was considered at this time by SEWRPC staff. Implementation of such an alternative would require significant disturbance of the wetland system, beyond that to which it has been currently subjected. Consequently, this alternative was not considered feasible. Rather, restoration of a bypass channel whose physical characteristics more closely reflects those of the inflowing portion of the Rubicon River upstream of Pike Lake, as noted below, was considered to provide the necessary hydraulic conditions to minimize sediment deposition.

Further, the site investigations, conducted during January 2004 by SEWRPC staff, revealed that the diversion structure that redirected the stream flow into the bypass channel had been breached. Consequently, remedial actions to restore the integrity of the bypass channel are warranted and recommended.

With respect to the bypass channel, it is recommended that a detailed stream design be prepared to restore the functioning of the bypass channel. This design should consider the nature and character of the stream system upstream and downstream of the Lake. Qualitative inspection by SEWRPC staff suggest that the bypass channel should be narrowed to approximately 10 feet in width, which width is approximately that of the upstream and downstream portions of the Rubicon River adjacent to the Lake, north of STH 60. It is also recommended that the depth of the bypass mirror that of these same stream segments. The reconstructed bypass channel should follow the existing alignment of the bypass channel so as to limit further disturbances of the wetland complex through which the bypass is routed. Notwithstanding, the reconstructed channel within this "right-of-way" should include,

---

[11]*Wisconsin Department of Natural Resources Publication No. PUBL-WR-190-95 REV,* Upper Rock River Basin Water Quality Management Plan, *July 1995; see also R.A. Smith & Associates, Inc.,* NR 103 Practicable Alternatives Analysis: Pike Lake Inlet Re-Diversion Project, *February 1993.*

to the extent feasible, meanders in the stream course similar to those observed in the upstream portion of the Rubicon River upstream of Pike Lake and north of STH 60. The narrowed hydraulic cross-section of the reconstructed bypass channel should aide in the movement of contaminants through the wetland system and limit the sedimentation observed in the previous channel.

In addition to the physical design of the channel, measures are recommended to limit the likelihood of the Rubicon River forming a new channel to Pike Lake. The initial design of the bypass channel called for an "earthen plug" that would serve to deflect stream flows into the constructed bypass channel. This plug was duly placed, but was subsequently breached by the stream flow, which recreated a stream course to the Lake around the western extreme of the plug. To obviate a similar occurrence, it is recommended that consideration be given to formalizing the lakeward bypass channel by placing appropriate structural practices along the southern bank of the reconstructed bypass channel. The structural practices chosen should be determined during the detailed design phase, but consideration should be given to the use of "biologs" as well as riprap. These structures should be placed carefully so as to maintain a constant elevation across the lakeward bank. By placing these structures at a constant elevation, higher stream flows would be allowed to enter the Lake as sheet flow across the wetland area, maximizing the contaminant control to be achieved with this practice.

Based upon the analysis conducted by the U.S. Geological Survey, summarized in Table 37 in Chapter VII, the short circuiting the phosphorus load entering Pike Lake from the Rubicon River provides the most effective means of minimizing in-lake phosphorus concentrations and maintaining the Lake in a mesotrophic state. Restoring a bypass efficiency of about 75 percent, noted as similar to the efficiency of the bypass during the 1999 U.S. Geological Survey investigation, would maintain an average summer total phosphorus concentration of about 0.018 milligrams per liter (mg/l). Such a total phosphorus concentration would result in an average chlorophyll-*a* concentration of about 6 micrograms per liter (μg/l). Both of these values are below the threshold concentrations of 0.020 mg/l of total phosphorus established for major lakes in the Southeastern Wisconsin region by the Regional Planning Commission in the regional water quality management plan, and 10 μg/l chlorophyll-*a* established by the OECD as the level above which lake waters typically take on a green tinge indicative of an algal bloom condition that interferes with human recreational uses of a waterbody.[12] Secchi disc water clarity would be about seven feet. The U.S. Geological Survey simulations further suggest that these forecast conditions would be little changed should the inflowing phosphorus load be completely eliminated, through the use of an alum drip system within the upstream Rubicon River, for example, or the Rubicon River and its associated phosphorus load be completely diverted away from Pike Lake, for example, by rerouting the Rubicon River north of STH 60 and eliminating the hydrologic connection created by the highway bridge over the Rubicon River northeast of the Lake. These model-based analyses substantiate the foregoing recommendations, and confirm that the restoration of the bypass channel forms a feasible and effective mechanism to maintain Pike Lake in a mesotrophic state.

Fisheries Management

Specific actions recommended with respect to fisheries management are currently limited to the protection of fish habitat in and adjacent to the Lake. Based upon a fisheries survey conducted by WDNR staff during 2000, the Lake was determined to have a healthy fish community. Harvesting of fishes also was determined to be appropriate and additional harvesting regulations and regulation of angling pressure was not deemed to be warranted.[13] Notwithstanding, the conduct of periodic fishery surveys and review of stocking and size and bag limitations, assessment of angling pressures, and analysis of potential contamination of fishes in the Lake, is recommended. Such fishery surveys should be conducted by the WDNR with the following objectives:

---

[12]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, *Volume Two,* Alternative Plans, *February 1979; Organization for Economic Cooperation and Development (OECD),* Eutrophication of Waters: Monitoring, Assessment, and Control, *Paris, 1982.*

[13]*John E. Nelson, "Comprehensive Fish Community Survey of Pike Lake, Washington County, WIBC 858300, Year 2000,"* Wisconsin Department of Natural Resources Memorandum, *2000.*

1. To identify changes in fish species composition that may have taken place in the Lake since the year 2000 survey;

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 refine and update information on fish spawning areas, breeding success, and survival rates;

4. To confirm the lack of disturbance by rough fish populations; and,

5. To determine the need for, and inform the timing of, any additional stocking of northern pike, walleyed pike, and/or other game fish species, as appropriate, by the WDNR, in order to maintain a continuing, viable sport fishery.

Likewise, a periodic assessment of angling pressures should be made based upon the foregoing fisheries data. This assessment should:

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

2. Provide data to assess the impact of harvesting of fishes from the Lake, relative to the bag limits established for Pike Lake.

Thirdly, given the fishing pressures on the Lake, it would be desirable to also conduct an analysis of fish tissues for metal and toxic contamination at the time the fisheries survey are conducted.

These three actions are recommended to provide a sound basis for the District and the WDNR to consider developing a 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.

Habitat Protection

The habitat protection measures recommended for Pike Lake are, in part, provided by the recommended aquatic plant management program set forth below. 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. In particular, this recommendation extends to, and includes, the wetland area located along the northern shoreline of the Lake as shown on Map 21. To this end, the WDNR staff have suggested that motorized boating in the northern one-quarter of the Lake, as well as in the southeastern and southwestern embayments, where water depth is less than five feet, be limited to minimize potential boating-related disturbances on fish habitat.

Coincident with the protection of in-lake habitat is the protection of shoreline vegetation, which provides a buffer for the aquatic environment and absorbs contaminant flows to the nearshore area from land-based activities. Much of the residential portion of the Pike Lake shoreline is protected. While no major areas of erosion, requiring additional protection against wind, wave, and wake erosion, were identified in the planning effort, use of natural shorescaping techniques should be considered for 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 tributary waterways wherever practical in order to maintain habitat value and the natural ambience of the lakeshore. Continued maintenance of existing revetments and other protection structures is also recommended. Conversion of bulkheads to revetments or natural vegetated shoreline or combinations is recommended to be considered where potentially viable at such time as major repairs are found necessary. Natural vegetated buffer strips should also be considered for shorelines, where practical. Guidance provided in the Chapter NR 328 of the *Wisconsin*

Administrative Code sets forth a methodology for determining appropriate shoreline protection structures for inland lakes based upon wind wave action and fetch, substrate, and likely boat wake action.

To this end, implementation of demonstration projects within areas of the lakeshore that are in public ownership is one means of promoting environmentally- and lake-friendly shoreland management practices that contribute to the protection of the lake fishery. Implementation of measures to limit shoreline damage resulting from ice, mooring of watercraft adjacent to the swimming beach at the Pike Lake Unit of the Kettle Moraine State Forest, and stormwater runoff from the parking area of the Pike Lake Unit of the Kettle Moraine State Forest on the eastern shore of the Lake and from the public access sites created by Town road rights-of-way on the western shore of the Lake, were recommended as land use and land management practices above. Recommended stormwater management practices included the use of shoreland buffer strips, porous paving, infiltration areas, and vegetated buffer strips. Of these measures, provision of shoreland and vegetated buffer strips can include the protection and restoration of aquatic plant beds lakeward of the ordinary high water mark, as well as the use of appropriate wetland plants and prairie plants on the landward side of the ordinary high water mark. Figure 13 shows examples of vegetated alternatives for shoreland protection that also contribute to fish and wildlife habitat in and around Pike Lake. Such options are recommended to be considered in shoreland areas, where they are appropriate, when effecting repair of ice damage or in "high traffic areas" adjacent to fish habitat areas, where such practices will contribute to maintaining habitat conditions suitable for warmwater fish communities.

In addition to the foregoing measures, it is also recommended that the City and Town of Hartford and Washington County continue to enforce existing shoreland setback requirements, and construction site erosion control and stormwater management ordinances. Provision of informational materials to shoreland property owners is recommended, as set forth in the informational and educational programming element of this plan.

Aquatic Plant Management

The aquatic plant management strategy set forth below recognizes the importance of fishing, swimming, and recreational boating as recreational uses of Pike Lake. Integral to the aquatic plant management strategy is the protection and preservation of fish breeding habitat, and the maintenance of adequate open water conditions for safe swimming and ease of navigation. In addition, this strategy recognizes the ecosystem values and functions provided within Pike Lake by a healthy and diverse aquatic plant community, and it seeks to maximize these ecosystem level benefits necessary to ensure a balanced lake ecosystem capable of supporting a variety of diverse recreational uses and economic activities. An aquatic macrophyte control plan consistent with Chapters NR 103, NR 107, and NR 109 of the *Wisconsin Administrative Code* is included as Appendix A of this report.

Alternative Methods for Aquatic Plant Control

Various aquatic plant management techniques, manual, mechanical, and chemical, are potentially applicable on Pike Lake. A number of these methods have been employed with varying success on Pike Lake in the past, although there has been no sustained aquatic plant management program on the waterbody. Management of aquatic plants has been conducted by individual property owners on an as-needed basis, with manual controls being the most frequently utilized methodology. Chemical controls, in the form of copper-based algicides, have been used sparingly on Pike Lake. Despite the periodic issuance of permits for the application of chemical herbicides to manage aquatic plant growths on the Lake, no recorded applications of any herbicides have been made. Notwithstanding, the reported increase in abundance of Eurasian water milfoil, which, at the time of the year 2001 survey constituted the dominant plant species reported from the Lake, has achieved such density as to warrant consideration of directed aquatic plant management practices.

Chemical Controls

Of the chemical herbicides available to manage Eurasian water milfoil infestations, diquat is a nonselective herbicide that will kill many aquatic plants, such as the pondweeds, bladderwort, and naiads that occur in Pike Lake and provide significant habitat value for the fishes and wildlife of the Lake; endothall primarily kills pondweeds, but does not control such nuisance species as Eurasian water milfoil; and 2,4-D and fluridone are systemic herbicides that are considered to be more selective when applied at lower dosage rates and generally used to control Eurasian water milfoil. Of these latter herbicides, 2,4-D also will kill high-value species such as water lilies, and fluridone will also affect coontail and elodea. Given that 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 by new plants, inducing biomass production, and that the use of 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, this option is not feasible on the scale required to control the infestations of aquatic plants in Pike Lake. Nevertheless, chemical controls, especially the application of granular 2,4-D, given that the Eurasian water milfoil populations frequently occur in proximity to lily pad beds, as shown on Map 19, may be suitable techniques for the control of relatively small-scale infestations of Eurasian water milfoil.

Chemical applications in early spring have been found to be effective in controlling such infestations of milfoil and facilitating the resurgence of growth of native plant species in lakes in Southeastern Wisconsin. Chemical applications should be conducted in accordance with current administrative rules, under the authority of a State permit, and by a licensed applicator working under the supervision of WDNR staff. Any chemical control agents used should be registered with the Wisconsin Department of Agriculture, Trade, and Consumer Protection, be certified for aquatic use, and be licensed by the U.S. Environmental Protection Agency to avoid the introduction of potentially persistent and bioaccumulative substances into the Lake. Records accurately delineating treated areas and the type and amount of herbicide used in each area, should be carefully documented and used as a reference in applying for permits in the following year.

Manual Controls

Manual methods of aquatic plant control, such as raking or hand-pulling, while environmentally sound, also 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 Pike Lake to control nearshore plant growths, especially around piers and docks.

Mechanical Controls

Mechanical harvesting of aquatic plants appears to be a practical means of controlling plant growth and associated filamentous algae, at least in the deeper water areas of the Lake, with water depths of greater than three feet. The most significant impact of mechanical harvesting is the removal of the organic plant biomass, decreasing nutrient inputs to the Lake. Potential negative impacts of mechanical harvesting, as outlined by the U.S. Environmental Protection Agency,[14] include: the removal of small fish, limited depths of operation, propagation of plant fragments, and time needed to treat specific areas of a waterbody. However, mechanical harvesting does offer temporary relief from nuisance aquatic plant growths, especially when conducted in accordance with a management plan designed to optimize benefits and minimize adverse impacts.

In addition to controlling nuisance aquatic plant growth conditions, harvesting has been shown to promote better balance within the in-lake fishery by providing access for larger game fish, such as the largemouth bass, to smaller prey fishes and organisms which can utilize the dense plant beds. Narrow channels harvested to provide navigational access also provide "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish.

Creation of shared recreational boating access lanes at intervals around the shoreline, allowing several residents to use the same lane, can result in increased use of these lanes and will help to keep them open for longer periods than would be the case if a less directed harvesting program was followed. These lanes can be especially useful in managing the spread of Eurasian water milfoil as a result of recreational boating activities through and across the

---

[14]*H. Olem and G. Flock, U.S. Environmental Protection Agency Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition, *Washington, D.C., August 1990, p. 146.*

Eurasian water milfoil beds located within the five to 10 feet depth contour range. As noted in Chapter V, Eurasian water milfoil forms a canopy of vegetation at or near the water surface, and naturally reproduces through fragmentation. Recreational boating activities that further fragment of the plant exacerbate this natural reproductive method and can lead to infestations of the plant in other areas of the Lake. Because of the need to control this aquatic plant in Pike Lake, especially, and because there is a need to protect and maintain the water lily communities as preferential fish habitat within the Lake, the use of mechanical harvesting should be considered as a viable management option.

While mechanical harvesting is a viable option, the acquisition of an aquatic plant harvester by the Pike Lake Protection and Rehabilitation District may not be feasible at this time. Approximately 45 percent of the Lake surface, where Eurasian water milfoil is prevalent, is less than 10 feet in depth, or about 230 acres. However, of these potential harvestable acres, about 195 acres are in waters of less than five feet in depth, within which the operation of a mechanical aquatic plant harvester is considered problematic. Consequently, Pike Lake, with about 35 harvestable acres, is slightly below the 40-acre threshold of eligibility for state cost-share assistance for purchasing an aquatic plant harvester, established pursuant to Chapter NR 7 of the *Wisconsin Administrative Code*. Thus, further monitoring of the aquatic plant communities appears warranted to ascertain the point at which this threshold is reached before the Pike Lake Protection and Rehabilitation District takes action concerning this recommendation.

Biological Controls

The use of the beetle *Hylobius transversovittatus*, *Galerucella pusilla*, *Galerucella calmariensis*, *Nanophyes brevis*, and *Nanophyes marmoratus* is recommended for controlling infestations of purple loosestrife in wetlands and along shorelands of Pike Lake. The Wisconsin Department of Natural Resources assists communities in establishing populations of these beetles and in empowering local civic groups to acquire the expertise to create, inoculate, and maintain these control agents in areas where significant stands of purple loosestrife occur.

As noted in Chapter VII, the use of *Eurhychiopsis lecontei* as a means of Eurasian water milfoil control is not recommended as being practical for Pike Lake at this time, and the use of the grass carp, *Ctenopharyngodon idella*, for aquatic plant control is expressly prohibited in the State of Wisconsin.

Shoreline Clean-Up

Notwithstanding, decomposing, floating vegetation can build up along the shorelines, and, together with terrestrial leaf litter, can limit the use of shoreline areas, especially affecting swimming and other shoreline-based recreational activities. In addition to being unsightly and potentially foul smelling, this material also contributes to the organic and mucky substrates favored by invasive plant species, such as Eurasian water milfoil. Shoreline cleanup, however, is a laborious job that can require substantial amounts of labor and time, and it is not always feasible for the riparian owners to clean their shoreline when needed. To alleviate this problem, the Pike Lake Protection and Rehabilitation District is recommended to incorporate a shoreline cleanup crew into their aquatic plant management program, and include a shoreline clean-up program as part of the aquatic plant management plan for the Lake.

Informational and Educational Programming

In addition to the in-lake rehabilitation methods, an ongoing campaign of community informational programming can 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, a community information campaign should emphasize the need to clean boats and motors/propellers when removing boats from the Lake and upon launching boats into the Lake to limit the redistribution of invasive organisms. Plants removed from boats and motors should be retained onboard and/or disposed of by composting at the boat launch or homestead to avoid their being reintroduced into the water. An informational program can also remind riparian residents and others of the habitat and ecological benefits, such as shoreline stabilization, provided by the aquatic flora of the Lake, thereby promoting the preservation of a healthy aquatic flora in the Lake.

Educational programs such as Project WET, Adopt-A-Lake, and other school-based programs can help to build community awareness of the value of lake ecosystems, and the need for vigilance on the part of individual citizens and households within the drainage area tributary to the Lake. School groups and other community service organizations also form a cadre of volunteers that can assist in shoreland management programs and in the dissemination and conduct of community informational programs.

Recommended Aquatic Plant Management Measures

It is recommended that continued aquatic macrophyte surveys be conducted at about three- to five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of: major areas of nuisance plant growth; areas harvested and/or chemically treated, species harvested and amounts of plant material removed from the lake, and species and approximate numbers of fish caught in the harvest. 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.

At such time as the harvestable acreage meets and exceeds the 40-acre threshold established by the Wisconsin Waterways Commission pursuant to the aforementioned Chapter NR 7 authorities, the Pike Lake Protection and Rehabilitation District should consider the implementation of an aquatic plant harvesting program on Pike Lake.[15] Use of an aquatic plant harvester with a maximum harvesting depth of about five feet, and a width of harvesting of about seven feet, is recommended. This is a moderately-sized aquatic plant harvester that can achieve an average daily output of harvested aquatic plant material that will allow the District to service most of the Lake on a four- to six-week cycle, which is consistent with the use of the canopy removal harvesting methodology discussed in Chapter VII, see Figure 14. The objective of this aquatic plant management program is recommended to be the enhanced use of Pike Lake while maintaining the quality and diversity of the biological communities. Should aquatic plant harvesting be adopted, the following recommendations are made:

1. Mechanical harvesting is recommended as a primary management method of large-scale aquatic plant management. As indicated in Chapter V, 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. Surface harvesting is recommended, cutting to a depth 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 Pike Lake will be minimized, and some degree of cover will continue to be provided for panfish populations which support the bass population in the Lake. Further, cutting should not be broad-based, but focused on boating channels and selected navigation areas. 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.

---

[15]*Aquatic plant growth in Pike Lake is the result of both in-lake nutrient concentrations and nutrient concentrations in the lake sediments. Sediment nutrients reflect the history of the Lake and the nutrient loads delivered to the Lake over time. As a result, reductions in nutrient loading are not immediately translated into reduced growths of aquatic plant, but, rather, are subject to a "lag period" during which the accumulated reserves of phosphorus are depleted. In the case of Pike Lake, this period may range from about three to six years based upon the mean water residence time of the Lake as set forth in Table 1; see Sven-Olof Ryding and Walter Rast,* The Control of Eutrophication of Lakes and Reservoirs, *Unesco Man and the Biosphere Series, Volume 1, Parthenon Press, Carnforth, 1989; see also Jeffrey A. Thornton, Walter Rast, Marjorie M. Holland, Geza Jolankai, and Sven-Olof Ryding,* The Assessment and Control of Nonpoint Source Pollution of Aquatic Ecosystems, *Unesco Man and the Biosphere Series, Volume 23, Parthenon Press, Carnforth, 1999.*

2. 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. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners. It is recommended that chemical applications, if required, be made by licensed applicators in early spring subject to State permitting requirements to maximize their effectiveness on nonnative plant species, while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions. Such use should be evaluated annually and the herbicide applied only on an as needed basis. Only herbicides that selectively control milfoil, such as 2,4-D, should be used. Periodic use of algicides, such as Cutrine Plus, is recommended to control significant, recurring growths of filamentous or planktonic algas in the Lake.

3. For the control of purple loosestrife in wetland areas adjacent to and around Pike Lake, the use of biological control agents such as the purple loosestrife beetles is recommended. These beetles can be locally grown and inoculated into stands of purple loosestrife by local volunteers under the guidance of the Wisconsin Department of Natural Resources. To this end, local civic groups or schools in the Hartford Union High School and Slinger School Districts should be encouraged to adopt the raising of purple loosestrife beetles as part of their community involvement programming.

4. 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 a mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. The Pike Lake Protection and Rehabilitation District may wish to obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to inform residents of the control options available.

5. The collection of aquatic plant fragments and other debris along shoreline areas by the Pike Lake Protection and Rehabilitation District is recommended.

6. It is recommended that the shallow littoral and wetland areas at the northern and southern extremes of the Lake be excluded to the extent possible from aquatic plant management activities, especially during fish spawning seasons in early summer and autumn. To this end, exclusion of the shoreline and littoral areas of the Lake in the vicinity of the inlet and outlet of the Lake, as suggested in the previously referenced WDNR fisheries management memorandum, is recommended.

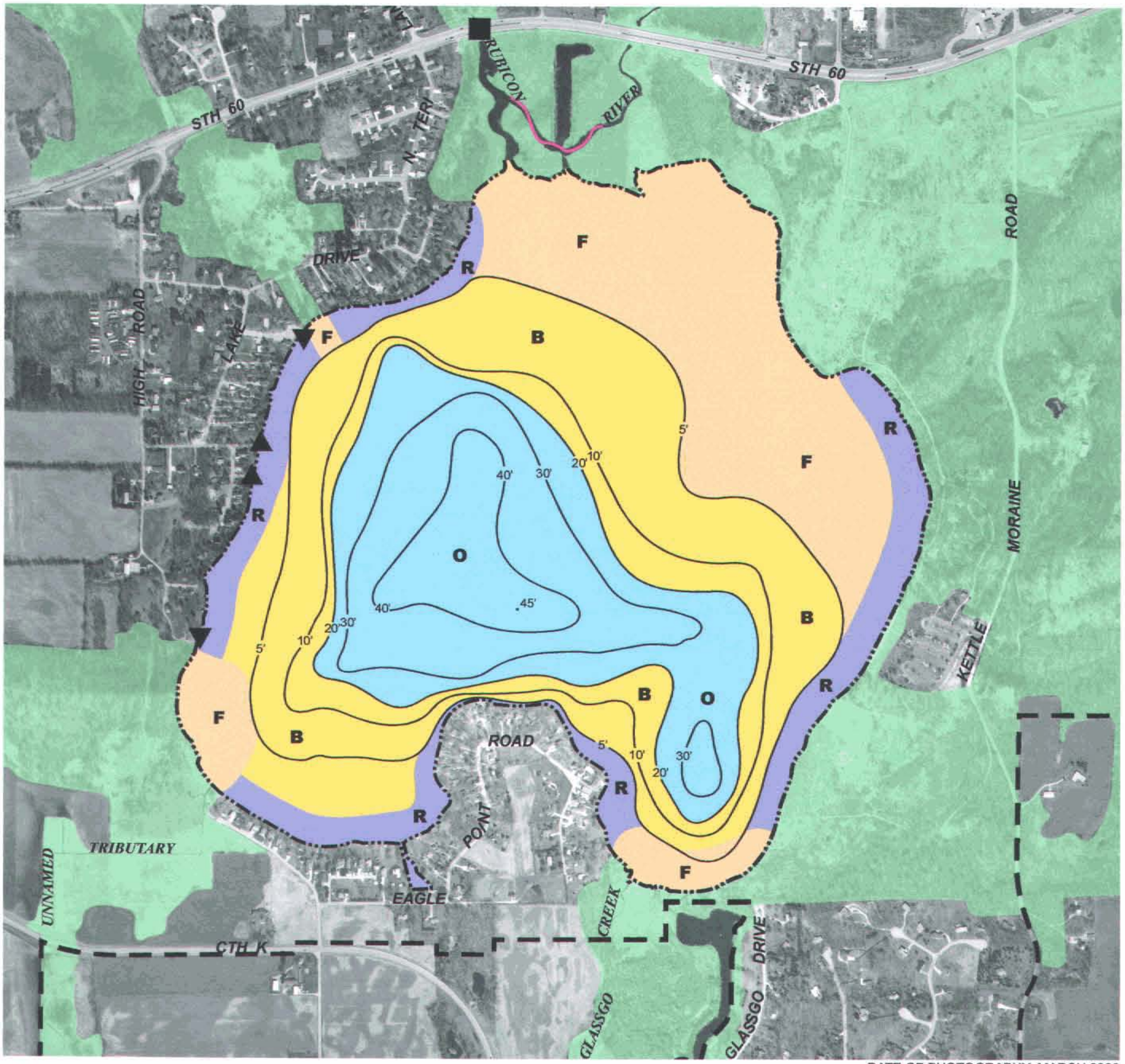
7. It is further recommended that the Pike Lake Protection and Rehabilitation District conduct a public informational program on the types of aquatic plants in Pike Lake; on the value of and the impacts of these plants on water quality, fish, and on wildlife; and on alternative methods for controlling existing nuisance plants including the positive and negative aspects of each method. This program can be incorporated into the comprehensive informational and educational programs that also would include information on related topics, such as water quality, recreational use, and fisheries.

The recommended aquatic plant control areas are shown on Map 23. The control measures in each area are designed to optimize desired recreational opportunities and to protect the aquatic resources.

The recommended aquatic plant management plan represents the initiation of an active aquatic plant management program on the Lake to be conducted by the Pike Lake Protection and Rehabilitation District. Implementation of this plan would entail a capital cost of about $100,000, the majority of which would be required for the eventual acquisition of equipment. Cost-share funding may be available for the acquisition of replacement equipment under the Chapter NR 7 Recreational Boating Facilities Grant Program administered by the Wisconsin Waterways Commission. Annual operation and maintenance costs of about $20,000 are estimated to be incurred by the District for the conduct of this program. It is recommended that continued aquatic macrophyte surveys be conducted at about three- to five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should

Map 23

RECOMMENDED LAKE MANAGEMENT PLAN FOR PIKE LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

—20'— WATER DEPTH CONTOUR IN FEET

■ WATER LEVEL CONTROL STRUCTURE

▲ PUBLIC ACCESS SITE (RECONSTRUCT TO LIMIT RUNOFF)

▼ PRIVATE ACCESS SITE

AQUATIC PLANT MANAGEMENT

B BOATING / RECREATION: SURFACE CUT OF EURASIAN WATER MILFOIL, HARVESTING MODERATE\ PRIORITY

R RIPARIAN ZONE: MAINTAIN SHORELINE PROTECTION STRUCTURES AS NECESSARY INSTALL VEGETATIVE BUFFERS, MANUALLY HARVEST AQUATIC PLANTS AROUND PIERS AND DOCKS

F FISH BREEDING AND HABITAT/ANGLING AREAS - NO AQUATIC PLANT MANAGEMENT MEASURES RECOMMENDED DURING FISH BREEDING SEASON

O OPEN WATER: DEPTH GREATER THAN 20 FEET - NO AQUATIC MANAGEMENT MEASURES RECOMMENDED

LAND USE MANAGEMENT

- PROTECT ENVIRONMENTAL CORRIDOR LANDS
- OBSERVE GUIDELINES SET FORTH IN LOCAL AND REGIONAL LAND USE PLANS, MAINTAIN HISTORIC LAKEFRONT RESIDENTIAL DWELLING DENSITIES
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS

— — BOUNDARY OF HARTFORD SANITARY SEWER SERVICE AREA

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES SELF-HELP MONITORING PROGRAM
- IMPLEMENT RUNOFF MANAGEMENT PRACTICES

FISHERIES MANAGEMENT

- CONTINUE TO MONITOR FISH POPULATIONS, MODIFY STOCKING/ HARVESTING PROGRAM AND REGULATIONS, AS NECESSARY

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

GRAPHIC SCALE

0 600 1200 FEET

Source: SEWRPC.

include descriptions of: major areas of nuisance plant growth; areas harvested and/or chemically treated, species harvested and amounts of plant material removed from the lake, and species and approximate numbers of fish caught in the harvest. 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.

OTHER LAKE MANAGEMENT MEASURES

Recreational Use Management

Public Recreational Boating Access

With respect to boating activities on Pike Lake, it is recommended that current levels of enforcement be maintained. In addition, recreational boating access users should be made aware of the presence of exotic invasive species within Pike Lake, including zebra mussel and Eurasian water milfoil. Appropriate signage should be placed at the recreational boating sites, and supplemental materials on the control of invasive species should be made available to the public. These materials could be provided to riparian householders by means of mail drops or distribution of informational materials at public buildings, such as municipal buildings and the public library, and to nonriparian users by means of informational materials provided at the recreational boating access sites. In addition, it is recommended that the private provider make disposal bins available at the recreational boating access sites for disposal of plant materials and other refuse removed from watercraft using the public recreational boating access sites.[16]

Alternatives for the continued provision of public recreational boating access are recommended to be considered. Such consideration would require providing parking for between 17 and 33 car-trailer units, including at least one handicapped accessible parking, within no more than one-quarter mile of the launch ramp under Chapter NR 1 of the *Wisconsin Administrative Code*. Alternatives include the public acquisition of the current access site and associated parking facility, either by the County, Town or Lake Management District, potentially cost-shareable under Chapter NR 7 of the *Wisconsin Administrative Code*; upgrading of the access opportunities provided by the rights-of-way of roads within the Town of Hartford, requiring provision of adequate parking within a reasonable distance of the Lake, potentially cost-shareable under Chapter NR 7 of the *Wisconsin Administrative Code*; or provision of public recreational boating access through the Pike Lake Unit of the Kettle Moraine State Forest. Each of these alternatives is recommended to be considered. Should public recreational boating access be provided, in part, through the Pike Lake Unit of the Kettle Moraine State Forest, it is recommended that such access be placed within the southern portion of the Park adjacent to the deeper water areas of the Lake. Should public recreational boating access be provided, in part, through the rights-of-way of Town roads, it is recommended that appropriate measures be implemented to minimize stormwater runoff from these sites to the Lake, as noted under the stormwater management practices set forth above.

Public Informational and Educational Programs

It is recommended that the Pike Lake Protection and Rehabilitation District assume the lead in the development of a public informational and educational program. Participation by the City and Town of Hartford, Village of Slinger, and Town of Polk should be encouraged.[17] This program should deal with various lake management-

---

[16]*The Pike Lake Protection and Rehabilitation District should continue to monitor experience with the use of high pressure washing stations for the control of zebra mussel currently being gained within the Laurentian Great Lakes Basin and consider adoption of those measures proven to be successful in limiting the spread of zebra mussel within the Region. The U.S.-Canadian International Joint Commission regularly provides informational materials on this and related subjects.*

[17]*The Town of Polk also includes portions of Big and Little Cedar Lakes: similar recommendations regarding informational programming are set forth in SEWRPC Memorandum Report No. 137,* A Water Quality Protection and Stormwater Management Plan for Big Cedar Lake, Washington County, Wisconsin. *Volume 1,* Inventory Findings, Water Quality Analyses, and Recommended Management Measures, *August 2001, and SEWRPC (Footnote Continued)*

related topics, including onsite sewage disposal system management, water quality management, land management, groundwater protection, aquatic plant management, fishery management, and recreational use. Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the recreational use and shoreland zoning regulations, are available from the WDNR and the University of Wisconsin-Extension Service. These cover topics such as beneficial lawn care practices and household chemical use. In this regard, Section NR 151.14 of the *Wisconsin Administrative Code* requires landowners to limit the application of lawn and garden fertilizer applications to those deemed appropriate based upon soil tests. Relevant 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 Pike Lake Protection and Rehabilitation District and the municipalities are also encouraged to take an active role in encouraging the Hartford Union High School District and Slinger School District to adopt and utilize lake-related educational programs, such as Adopt-A-Lake and Project WET, as means of more closely linking students to the lake environment.

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

Organizational Development

Both public and private organizational options for the management of lakes in the State of Wisconsin exist. Currently, the Pike Lake community is served by both a private organization, in the form of the Pike Lake Advancement Association, and a public lake organization, the Pike Lake Protection and Rehabilitation District, constituted as a public inland lake protection and rehabilitation district pursuant to Chapter 33, *Wisconsin Statutes*. As noted in Chapter I, in developing this plan, the Pike Lake Protection and Rehabilitation District created the Pike Lake Watershed Advisory Committee during early 2003. This Committee is comprised of representatives of the City and Town of Hartford, the Village of Slinger, Washington County, the U.S. Geological Survey, WDNR, Regional Planning Commission, and local landowners, and was formulated to "develop and implement a watershed protection plan, supported by the State, local municipalities and watershed public, to protect and improve the water quality of the Pike Lake watershed."

Chapter 33 of the *Wisconsin Statutes* allows for the modification of the boundaries of public inland lake protection and rehabilitation districts through two mechanisms. The extent to which the drainage area tributary to a lake should be included in a district is an issue to be discussed by the Pike Lake community. While it is rarely practical to include a lake's total tributary drainage area within a lake management district, the entire lakeshore, including all riparian property, is included currently within the boundary of the Pike Lake Protection and Rehabilitation District. Pursuant to Section 33.33, *Wisconsin Statutes*, the jurisdiction of the existing Pike Lake Protection and Rehabilitation District could be extended to encompass the riparian lands tributary to the Rubicon River, or even the lands forming the total drainage area tributary to the Lake. Landowners could petition the District directly for attachment, pursuant to Section 33.33(2)(a), which attachment could be approved by majority vote of the Board of Commissioners of the Pike Lake Management District, provided that the lands so attached were contiguous with the existing district jurisdiction. Alternatively, the Board of Commissioners of the Pike Lake Management District could initiate such attachment by motion, pursuant to Section 33.33(2)(b). Such a course of action, however, because it extends across the jurisdictions of more than one general purpose unit of government, would necessitate action by the Washington County Board of Supervisors prior to such attachment becoming effective. This latter process would invoke a public hearing, as set forth under Section 33.26(3), as amended, and provide affected landowners with the opportunity to address issues of support for the attachment, the necessity of the attachment, the degree to which the public health, comfort, convenience, necessity or the public welfare would be promoted, and the benefit to be derived from the attachment. Given the areal extent of the tributary communities, and the likely diversity of interests and small degree of identification of these

---

Memorandum Report No. 146, An Aquatic Plant Management Plan for Little Cedar Lake, Washington County, Wisconsin, *May 2004.*

communities with the Lake, attachment of lands within the tributary drainage area to the existing Pike Lake Protection and Rehabilitation District would appear to be inappropriate. While there are sound technical and economic reasons for including the Lake's watershed, or even its direct tributary drainage area, within the district, significant political and social difficulties may arise that limit the ability of the district encompassing the entire drainage area to carry out a program of lake protection and rehabilitation activities.

Subchapters V and VI of Chapter 33, *Wisconsin Statutes*, provide for alternative, more broadly-based organizations for Dane County and for the Southeastern Wisconsin Fox River. In terms of the former, the Wisconsin Legislature acted in 1989 to create a Dane County Lakes and Watershed Commission comprised of the county executive, mayor of the City of Madison, two county board supervisors resident within the City of Madison, two county board supervisors resident outside the City of Madison, and a member of the Yahara Lakes Association. The Commission may initiate and conduct studies and research projects, liaise with governmental agencies and other organizations, and develop an informational program. As part of these duties, the Board of Commissioners may plan and implement actions in the areas of water quality, recreational use, and management, and can create advisory bodies to assist the Board in the conduct of their duties. In carrying out these duties, the Board of Commissioners may propose ordinance initiatives for the consideration of the Dane County Board of Supervisors, and may utilize the funding mechanisms available to public inland lake protection and rehabilitation districts, property taxes, special assessments, and special charges, as well as levy fees that the county is empowered to charge, subject to public hearing, to finance the operations of the district. In terms of the latter, the Wisconsin Legislature acted in 1997 to create the Southeastern Wisconsin Fox River Commission. This Commission is comprised of the county executives from Racine and Waukesha Counties, the mayor of the City of Waukesha, the village presidents of the Villages of Waterford, Big Bend, and Mukwonago, the town board chairpersons from the Towns of Waukesha, Waterford, Vernon, and Mukwonago, and one resident of the Village of Big Bend and two residents each of the Towns of Waterford and Vernon, appointed by their respective Boards. Two additional, nonvoting members represent the Southeastern Wisconsin Regional Planning Commission and Wisconsin Department of Natural Resources. The Board of Commissioners have the same powers as those of the Dane County Lakes and Watershed Commission, and may solicit funding through each county's budget process. This type of organization might be better positioned to oversee a watershed-based management program for the Rubicon River, either over the reach upstream of Pike Lake, or over its entire length upstream of its confluence with the Rock River. However, creation of such an organization would require legislative action by the State Legislature.

Consequently, the current alternative, that of creating a watershed advisory committee within the framework of the existing public inland lake protection and rehabilitation district, would continue to remain a viable and practicable approach to engage the wide range of governmental institutions and civil society in watershed management programming. It is therefore recommended that the Pike Lake Watershed Advisory Committee remain in existence as a duly-constituted forum under the auspices of the Pike Lake Protection and Rehabilitation District for the discussion of issues relating to the total drainage area tributary to Pike Lake, and as an appropriate intergovernmental organization for soliciting and exchanging information on issues relevant to the Pike Lake watershed. Membership on this committee should continue to include the City of Hartford, Village of Slinger, and Town of Hartford, Washington County, and the Wisconsin Department of Natural Resources.

PLAN IMPLEMENTATION AND COSTS

The actions recommended in this plan largely represent an extension of ongoing actions being carried out by the Pike Lake Protection and Rehabilitation District, in part, in cooperation with neighboring municipalities, and county and state agencies. The recommended plan introduces several new elements, although some of the plan recommendations represent refinements of current programs. This is particularly true in the case of the fisheries management program, where the field surveys recommended in this plan will permit more efficient management of this resource.

Generally, fisheries management practices, such as monitoring, harvesting, and public awareness campaigns currently implemented by the WDNR in association with the Pike Lake Protection and Rehabilitation District and municipalities, are recommended to continue with refinements as proposed herein. Some aspects of these programs lend themselves to citizen involvement through 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 Pike Lake Protection and Rehabilitation District, in cooperation with the local municipalities, 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 WDNR, the County University of Wisconsin-Extension Service office, and SEWRPC.

A major cost element in the plan relates to the eventual acquisition of aquatic plant harvesting equipment. Implementation of the recommended plan would entail a capital expenditure of about $100,000 for the District and an annual operation and maintenance expenditure of about $20,000, over the next 10 years. The current, annual operation and maintenance budget of the Pike Lake Protection and Rehabilitation District would have to be significantly increased to cover this level of future investment. When it is necessary to acquire the harvesting equipment, some of the capital costs could be offset with grants from the Wisconsin Waterways Commission under Chapters NR 7 Recreational Boating Facilities Grant Program, while additional cost share assistance may be available from the Wisconsin Waterways Commission for the conduct of Eurasian water milfoil control programs using chemical herbicides. Additional lake and watershed management measures may be cost-shared through the Chapter NR 191 Lake Protection Grant Program, Chapter NR 120 Nonpoint Pollution Abatement Program, or NR 153/NR 154 runoff management programs.

The suggested lead agency or agencies for initiating program-related activities, by plan element, are set forth in Table 40, and the estimated costs of these elements, linked to possible funding sources where such are available, are summarized in Table 41. In general, it is recommended that the Pike Lake Protection and Rehabilitation District continue to provide a coordinating role for community-based lake management actions, in cooperation with the appropriate local government units.

CONCLUDING COMMENTS

Full implementation of the foregoing recommendations, as summarized, in part, in Table 42, will maintain the Lake in a mesotrophic state, which condition is consistent with that of the higher quality waterbodies within the Southeastern Wisconsin Region. Using the planned phosphorus load to Pike Lake derived from the data set forth in Table 20, and modifying this load using the estimated load reduction factors for the recommended management practices as shown in Table 42, it is anticipated that the forecast in-lake total phosphorus concentration would increase slightly from the current 1995 land use-based concentration of about 0.025 mg/l, reported in Chapter IV, to a forecast 2020 in-lake phosphorus concentration of about 0.035 mg/l, as shown in Figure 15. This estimated in-lake total phosphorus concentration could be reduced by the reconstruction of the bypass channel, which would further reduce the phosphorus load to the Lake and result in a forecast annual mean total phosphorus concentration of about 0.020 mg/l, which concentration is consistent with the concentration recommended in the adopted regional water quality management plan as necessary to maintain good water quality in lakes in the Region, as also shown in Figure 15. Achieving this in-lake phosphorus concentration would support the full range of recreational uses that are made of Pike Lake. Application of the management measures necessary to achieve this load also would result in concomitant reductions in other nonpoint-sourced contaminants loads as required by Chapter NR 151 of the *Wisconsin Administrative Code*, and related statutory requirements.

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

Table 40

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR PIKE LAKE

Plan Element	Subelement	Location	Management Measures	Management Responsibility
Land Use Control and Management	Land use development planning	Entire watershed	Observe guidelines set forth in the regional land use plan	Washington County, City of Hartford, Village of Slinger, Town of Hartford, Town of Polk
	Density management	Lakeshore areas	Maintain historic lake front residential dwelling densities to extent practicable	Washington County, City of Hartford, Town of Hartford
	Protection of environmentally sensitive lands	Pike Lake Woods, Pike Lake Sedge Meadow, Slinger Uplands Woods, and STH 60 Swamp	Establish adequate protection of wetlands and shorelands, and other environmental corridor lands and isolated natural features, and consider public or private acquisition of features of local or greater significance, as set forth in the regional natural areas and critical species habitat protection and management plan	WDNR, Washington County, Town of Hartford, Town of Polk, Pike Lake Protection and Rehabilitation District
Nonpoint Source Pollution Control	Rural nonpoint source controls	Entire watershed	Promote sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans in accordance with the county land and water resource management plan	USDA, WDATCP, Washington County
	Urban nonpoint source controls	Entire watershed	Promote sound urban housekeeping and yard care practices through informational programming	Washington County, City of Hartford, Village of Slinger, Town of Hartford, Town of Polk, Pike Lake Protection and Rehabilitation District
	Construction site erosion control and stormwater management ordinance	Entire watershed	Develop and enforce construction site erosion control and stormwater management ordinances; review ordinances for concurrency with proposed NR 152	Washington County, City of Hartford, Village of Slinger, Town of Hartford, Town of Polk
		New clustered developments in conservation subdivisions	Develop stormwater management systems where appropriate densities exist	Washington County, City of Hartford, Village of Slinger, Town of Hartford, Town of Polk
	Sewerage system management	Entire watershed	Periodically review current sewer service area facilities plan to continue to provide water-borne sewerage services to urban areas of the watershed	City of Hartford, Village of Slinger,
			Inspect and maintain onsite sewage disposal systems	Washington County, private landowners
Surface Water Quality Management	Water quality monitoring	Entire Lake, and Rubicon River inflow and outflow	Continue participation in WDNR Self-help Monitoring Program; Consider participation in U.S. Geological Survey or University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program	WDNR, Pike Lake Protection and Rehabilitation District

Table 40 (continued)

Plan Element	Subelement	Location	Management Measures	Management Responsibility
Water Quantity and Lake Level Management	Dam operations and Lake level monitoring	Entire Lake	Maintain outlet structure and monitor water levels; Consider reconstruction of bypass channel	WDNR, Town of Hartford, Pike Lake Protection and Rehabilitation District, Pike Lake Advancement Association
Fish Management	Fish survey and stocking program	Selected areas of Lake	Conduct fish survey to determine management and stocking needs; conduct periodic creel census	WDNR
	Shoreland Protection, Habitat Protection and Lake Use Management	Entire lake	Manage aquatic plant harvesting program pursuant to Chapter NR 109 requirements	WDNR, Pike Lake Protection and Rehabilitation District
			Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Washington County, City and Town of Hartford, Pike Lake Protection and Rehabilitation District, WDNR
			Enforce adequate setbacks in shoreland areas	Washington County, City and Town of Hartford, WDNR
			Install construction site erosion control measures as required by local ordinance; enforce construction site erosion control and stormwater ordinance provisions	Private landowners, Washington County, City and Town of Hartford, Village of Slinger, WDNR
			Encourage shoreline restoration projects and creation of buffer strips, and promote consistency in application of landscaping practices in sensitive shoreland areas, through informational programming and demonstration sites	Private landowners, Washington County, City and Town of Hartford, Village of Slinger, Pike Lake Protection and Rehabilitation District, WDNR, UWEX
Aquatic Plant Management	Comprehensive plan refinement	Entire Lake	Update aquatic plant management plan every three to five years	WDNR, Pike Lake Protection and Rehabilitation District
	Major and minor channel harvesting	Selected areas of Lake	Harvest aquatic plants as required to facilitate recreational boating access; restrict harvesting in spring and autumn to avoid disturbances in fish breeding areas and WDNR-delineated sensitive areas	WDNR, Pike Lake Protection and Rehabilitation District
	Chemical treatment	Selected areas of Lake and shoreland	Limited to control of nuisance aquatic plant growth where necessary; specifically target Eurasian water milfoil, curly-leaf pondweed, garlic mustard, and purple loosestrife infestations	WDNR, Pike Lake Protection and Rehabilitation District
	Shoreline maintenance	Lakeshore areas	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and deposition of organic materials in Lake	Pike Lake Protection and Rehabilitation District, private landowners

Table 40 (continued)

Plan Element	Subelement	Location	Management Measures	Management Responsibility
Recreational Use Management	Boating Access	Public access sites	Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines	Private Provider, Pike Lake Protection and Rehabilitation District, WDNR
	Recreational boating and vehicular use	Entire Lake	Continue to enforce and periodically review, recreational boating (summer) and vehicular use (winter) ordinances	Washington County, City and Town of Hartford, Pike Lake Protection and Rehabilitation District, WDNR
Informational and Educational Program	Public informational and educational programming	Entire watershed	Continue public awareness and informational programming	Washington County, Pike Lake Protection and Rehabilitation District, WDNR, UWEX
		Entire Lake	Encourage inclusion of lake studies in environmental curricula (e.g., Project WET, Adopt-A-Lake, etc.)	Hartford Union High School District, Slinger School District, UWEX, Pike Lake Protection and Rehabilitation District, Washington County

Source: SEWRPC.

Table 41

ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR PIKE LAKE

Plan Element	Subelement	Estimated Cost: 2000-2020[a] Capital	Estimated Cost: 2000-2020[a] Annual Operation and Maintenance	Potential Funding Sources[b]
Land Use Control and Management	Land use development planning	- -	- -	County, City, Village, Towns
	Density management in the shoreland zone	- -	- -	City and Town of Hartford
	Protection of environmentally sensitive lands	- -	- -	WDNR Lake Protection Grant and Stewardship Grant Programs, Pike Lake Protection and Rehabilitation District
Nonpoint Source Pollution Control	Rural nonpoint source controls	- -[c]	- -[c]	County, USDA EQIP, WDNR/WDATCP Runoff Management Program
	Urban nonpoint source controls	- -[c]	- -[c]	County, WDNR/WDATCP Runoff Management Program
	Construction site erosion controls and stormwater management ordinances	- -[c]	$250 - $500/acre[c]	County, municipalities, private firms, individuals
	Sewerage system management	- -[c]	$100-$200[c]	City of Hartford, Village of Slinger, County, private firms, individuals
Surface Water Quality Management	Water quality monitoring	- -	- -[d]	Pike Lake Protection and Rehabilitation District, USGS, WDNR Self-Help Monitoring Program
Water Quantity and Lake Level Management	Water quantity monitoring	- -	$5,000[e]	Town of Hartford, USGS
	Reconstruct Bypass Channel	- -[f]	- -	Pike Lake Protection and Rehabilitation District
Fish Management	Fish survey	$16,000[d]	- -[d]	WDNR
	Maintenance of structures	- -	- -	Private firms, individuals
	Minimize shoreland impacts on lake water quality and habitat	- -	- -	County, municipalities, private firms, individuals, WDNR
Aquatic Plant Management	Comprehensive plan refinement	- -	$1,500[g]	Pike Lake Protection and Rehabilitation District, WDNR Lake Management Planning Grant Program
	Aquatic plant harvesting	$100,000[h]	$20,000	Pike Lake Protection and Rehabilitation District, Wisconsin Waterways Commission
	Chemical treatment	- -	$1,000/acre[i]	Wisconsin Waterways Commission, individuals
Recreational Use Management	Maintain recreational boating access; enforce existing boating and winter use ordinances	- -	- -	County, municipalities, WDNR, private provider

Table 41 (continued)

Plan Element	Subelement	Estimated Cost 2000-2020[a] Capital	Estimated Cost 2000-2020[a] Annual Operation and Maintenance	Potential Funding Sources[b]
Informational and Educational Program	Public informational and educational programming	- -	$1,200	Pike Lake Protection and Rehabilitation District, UWEX/ WDNR/WAL Lakes Partnership, school districts
Total	- -	$116,000	$29,050 – 29,400[j]	- -

[a]*All costs expressed in January 2004 dollars.*

[b]*Unless otherwise specified, USDA is the U.S. Department of Agriculture, USGS is the U.S. Geological Survey, WDNR is the Wisconsin Department of Natural Resources, WDATCP is the Wisconsin Department of Agriculture, Trade and Consumer Protection, County is Washington County, City is the City of Hartford, Village is the Village of Slinger, Town is the Town of Hartford and/or the Town of Polk, UWEX is the University of Wisconsin-Extension, and WAL is the Wisconsin Association of Lakes.*

[c] *Costs vary with the amount of land under development during any given year.*

[d]*The WDNR Self-Help Monitoring Program and proposed creel survey involves no cost but does entail a time commitment from the volunteer; monitoring by the USGS can be cost-shared between the Federal agency and local cooperators.*

[e]*USGS hydrological monitoring is proposed.*

[f]*Cost to be determined based upon a detailed engineering and hydrological design. Preparation of detailed engineering designs for the bypass channel is estimated to cost $15,000, with preparation of permit applications and bidding documents estimated to cost a further $25,000. Construction costs are dependent upon the design specifications.*

[g]*Cost-share assistance may be available for lake management planning studies under the NR 190 Lake Management Planning Grant Program.*

[h]*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. Planning costs assume that plan revisions will be completed at a cost of about $5,000 every four years.*

[i]*Cost-share assistance may be available from the Wisconsin Waterways Commission Recreational Boating Facilities Grant Program.*

[j]*Costs exclude the costs to the City of Hartford, Village of Slinger, and Towns of Hartford and Polk related to land use planning and zoning, and exclude costs related to herbicide treatments.*

Source: SEWRPC.

Table 42

ESTIMATED REDUCTION IN EXTERNAL SOURCES OF PHOSPHORUS TO PIKE LAKE FOLLOWING FULL IMPLEMENTATION OF RECOMMENDED MANAGEMENT MEASURES

Source	Forecast 2020		2020 Following Plan Implementation		
	Pounds[a]	Percent	Percent Reduction[b]	Pounds	Percent
Urban[c]					
High-Density (industrial and transportation uses)	752	14	25	544	21
Medium-Density (commercial and governmental uses)	83	2	25	62	2
Low-Density (single-family and suburban-density residential uses)	73	1	25	55	2
Onsite Sewage Disposal Systems	15	<1	- -	15	<1
Subtotal	923	17	- -	676	26
Rural					
Mixed Agricultural	1,969	38	25	1,477	58
Pasture/Grass	14	<1	- -	14	<1
Wetlands	93	2	- -	93	4
Woodlands	35	1	- -	35	1
Water	43	1	- -	43	2
Subtotal	2,154	42	- -	1,662	66
Point Source Inputs	2,130	41	- -	213[d]	8
Total	5,207	100	- -	2,551[e]	100

[a]*Percentages estimated from WILMS model results.*

[b]*Estimated reduction in external nutrient load based upon full implementation of recommended best management practices.*

[c]*Includes the contribution from onsite sewage disposal systems that remain in use outside of the portion of the tributary drainage area to Pike Lake served by public sanitary sewerage systems, estimated within the WILMS model as ranging from approximately 15 pounds per year to as much as 405 pounds per year, depending upon soil type, system condition, and system location. For purposes of this analysis, 15 pounds per year were used as the contribution from onsite sewage disposal systems as that value provided the loading that was best correlated to the measured in-lake phosphorus concentrations.*

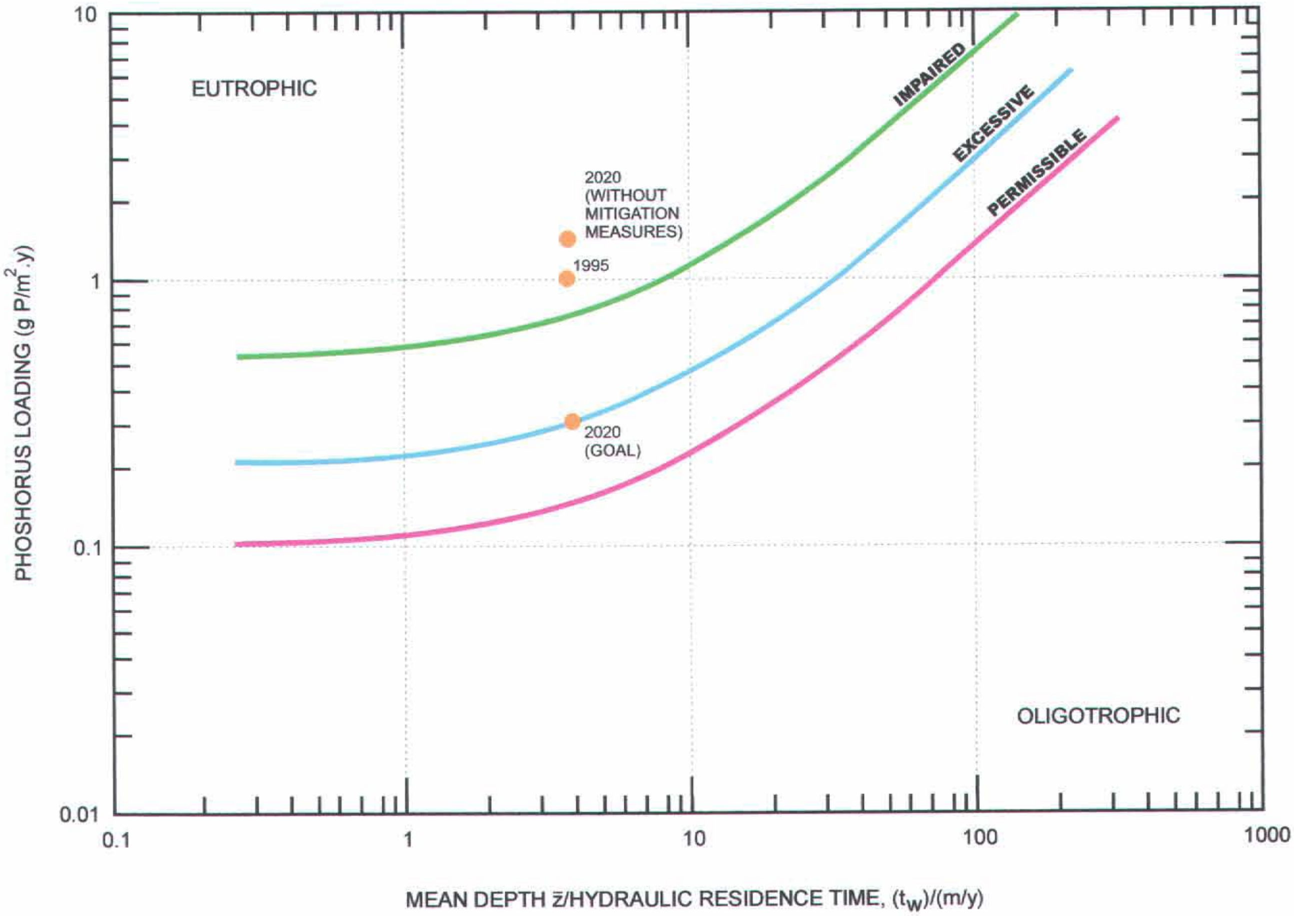
[d] *Total phosphorus loads from the Village of Slinger wastewater treatment facility during 2002 were estimated by both the U.S. Geological Survey and McMahon Associates, Inc., to be 1,000 pounds of phosphorus annually; forecast total phosphorus loads from the facility during the year 2020, based on the current level of treatment, would, consequently, be about 2,700 pounds of phosphorus per year. The future condition with full implementation of the plan assumes an approximately 90 percent reduction in total phosphorus, based upon best available technology for phosphorus reduction.*

[e]*Implementation of the reconstructed bypass channel would reduce this load by a further 25 percent, based upon estimated load reductions measured by the U.S. Geological Survey.*

Source: SEWRPC.

Figure 15

CURRENT AND FORECAST TROPHIC STATUS OF PIKE LAKE: 1995-2020



Source: Organisation for Economic Cooperation and Development, and SEWRPC.

Chapter IX

SUMMARY

The preparation of the lake management plan for Pike Lake was a cooperative effort by the Pike Lake Protection and Rehabilitation District and the Southeastern Wisconsin Regional Planning Commission. The plan incorporates pertinent data assembled and synthesized during the preparation of a previously-unfinished water quality management planning program conducted on Pike Lake by the Southeastern Wisconsin Regional Planning Commission and Wisconsin Department of Natural Resources. These 1976 and 1977 data are supplemented with new data, gathered between 1978 and 2002, collected by the U.S. Geological Survey; Southeastern Wisconsin Regional Planning Commission; and Wisconsin Department of Natural Resources. Inventories and analyses were conducted of existing and recommended future land use patterns within the watershed of the Lake, associated pollutant loadings and sources, the physiography and natural resource base of the watershed,[1] the recreational uses of the Lake, the shoreland conditions, and the management practices employed both on the Lake and in the watershed. In addition, the planning effort included a thorough review of the draft lake management plan by the Pike Lake Watershed Advisory Committee, created by the Pike Lake Management District during early 2003. Field studies associated with these activities were conducted from 1998 through 2002 by the U.S. Geological Survey and the Commission staff.

The primary management objectives for Pike Lake include: protecting and improving water quality in Pike Lake and its component embayments at a level suitable for the maintenance of warmwater fish and other aquatic life, reducing the severity of existing nuisance conditions caused by increasingly excessive macrophyte and algal growth, and improving opportunities for water-based recreational activities.

Pike Lake is a 470-acre drainage lake on the Rubicon River, a tributary stream to the Rock River, located within U.S. Public Land Survey Township 10 North, Range 18 East, Town of Hartford, Washington County. Water levels in the Lake are controlled by a dam, located at the point where the Rubicon River is bridged by STH 60, on the northwestern side of the Lake. The Lake has a maximum depth of about 45 feet, and a mean depth of about 14 feet. The Lake's tributary drainage area totals about 12.5 square miles, of which about 6.2 square miles drains directly to Pike Lake without passing through the Rubicon River.

Pike Lake is a typical hard-water, alkaline lake that is considered to have relatively good water quality. Physical and chemical parameters measured during the study period indicated that the water quality was within the "poor" to "good" range, depending upon the parameters considered. Total phosphorus levels were found to be generally at a level consistent with a mesotrophic state, contributing to nuisance algal and macrophytic growths, which exerts constraints on the recreational usage of the Lake.

---

[1]*See SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997.*

INVENTORY AND ANALYSIS FINDINGS

Population

- The 2000 resident population of the drainage area directly tributary to Pike Lake was estimated to be 1,150 persons, which is about one and one-half times the estimated 1980 population and approximately three times the population estimated to reside within the drainage area directly tributary to Pike Lake in 1950.

- Population forecasts prepared by the Regional Planning Commission, on the basis of a normative regional land use plan and the Washington County development plan, indicate that the population will probably approach 1,700 persons in the drainage area directly tributary to the Lake by the year 2020.

Land Use and Zoning

- As of 2000, approximately 1,624 acres, or about 20 percent of the tributary drainage area, were in urban land use, with the dominant urban land use being residential, encompassing about 840 acres or about one-half of the urban lands in the drainage area. Commercial, industrial, governmental and institutional, transportation, communications and utilities, and recreational lands comprised the balance of the urban lands.

- As of 2000, approximately 6,340 acres, or 80 percent of the tributary drainage area, were in rural land use, with the dominant rural land use being agricultural, encompassing about 4,000 acres or about two-thirds of the rural lands in the drainage area. Woodlands, wetlands, surface water, and open lands comprised the largest portion of the balance of the rural lands.

- Under year 2020 conditions, continued urban growth is anticipated, primarily in residential land uses which are expected to exceed 1,600 acres in areal extent. Urban lands are anticipated to increase to about 2,875 acres. Rural land uses are expected to decrease to about 5,100 acres, primarily due to the conversion of agricultural lands to urban residential land uses. Limited redevelopment and infilling of existing platted lots may also be anticipated.

- As of 2000, treatment of sanitary and household wastewaters from a large portion of the lakefront and adjacent development was provided by public sewage treatment facilities operated by the City of Hartford—discharging to the Rubicon River downstream of Pike Lake, as recommended in the regional water quality management plan.

Water Budget

- The long-term water budget for Pike Lake was computed using the U.S. Geological Survey data for the Rock River, compiled during the period from 1914 through 2001. It is estimated that, annually, 6,600 acre-feet of water enters Pike Lake, 80 percent of which enters from the Rubicon River and by other surface runoff, and 20 percent through direct precipitation onto the lake surface and limited groundwater inflows.

- Of this total, about 1,300 acre-feet of water, or about 20 percent of the inflow, evaporates from the surface of the Lake; about 5,250 acre-feet, or about 80 percent, is discharged via the Rubicon River.

Water Quality

- Physical and chemical characteristics of Pike Lake were measured during 2000 by the U.S. Geological Survey and the Pike Lake Management District.

- Pike Lake was shown to be a typical Southeastern Wisconsin hard-water, alkaline lake having relatively good water quality.

- The Lake is dimictic, mixing completely twice per year during spring and fall. Temperature and dissolved oxygen concentration profiles indicate that complete mixing of Pike Lake is restricted during summer and winter by thermal stratification. Winter kill is not a problem in Pike Lake.

- Water clarity, as measured by a Secchi disc, ranged from a minimum of about three feet in summer to a maximum of about 21 feet during winter, with an average Secchi-disc depth of about seven feet. Chlorophyll-*a* concentrations ranged from a minimum of 0.6 µg/l to a maximum of 33.3 µg/l, indicating that visible green coloration of the water occasionally may be apparent, especially during spring when the maximum concentration was recorded. Total phosphorus concentrations ranged from 0.01 mg/l to 0.05 mg/l in the surface waters, with a mean annual concentration of 0.02 mg/l. This value equals the Commission-recommended water quality standard for recreational use and maintenance of warmwater fish and aquatic life of 0.020 mg/l and is consistent with the chlorophyll-*a* concentrations reported.

- These data indicate that Pike Lake is a mesotrophic lake, being moderately fertile and capable of supporting abundant aquatic plant growths and productive fisheries. Mesotrophic lakes are typical of inland lakes in the Southeastern Wisconsin Region.

Pollutant Loadings

- The total phosphorus load to Pike Lake was estimated to be 4,700 pounds per year, about 1,100 pounds of which were estimated to be contributed from sewage disposal systems within the watershed. Of this total, about 3,500 pounds, or about 95 percent, were estimated to be contributed through the Rubicon River. The balance was contributed by direct precipitation onto the Lake surface, comprising about 100 pounds.

- It also was estimated that under year 2020 conditions, the total phosphorus load to the Lake would increase slightly, to approximately 5,200 pounds per year, due to conversion of agricultural lands. However, this trend may be exacerbated by the increasing use of lawn and garden fertilizers in urban areas that contributes to higher phosphorus concentrations being observed in urban runoff. Public sanitary sewerage systems in the watershed are expected to contribute about 2,100 pounds per year. About 3,000 pounds are expected to be contributed through the Rubicon River and about 100 pounds by direct precipitation.

- Sediment loading to Pike Lake is estimated to be 1,000 tons per year. This load is not expected to change significantly under planned land use conditions. About 900 tons are likely to be contributed from rural lands, and the balance by urban lands and direct precipitation onto the lake surface.

- Heavy metal loads of copper, zinc, and cadmium, are estimated to be contributed solely from urban lands, and are estimated to be 45 pounds per year of copper, 340 pounds of zinc, and one pound of cadmium. Under planned 2020 land use conditions, these loads are expected to increase to about 100 pounds of copper, 700 pounds of zinc, and three pounds of cadmium annually, as urban land use increase in the drainage area.

Aquatic Plants

- Aquatic macrophyte growth in Pike Lake was found to be diverse in composition and moderate to high in abundance. However, the increasing dominance of Eurasian water milfoil in the Lake suggests that some interference with boat traffic and other water-based recreational uses may occur.

- During 1977, the aquatic plant flora was dominated by muskgrass (*Chara* spp.), pondweed (*Potamogeton* spp.), and Eurasian water milfoil (*Myriophyllum spicatum*).

- During the July 2001 aquatic plant survey, aquatic plant growth occurred in waters of less than 15 feet in depth. Eurasian water milfoil (*Myriophyllum spicatum*) and muskgrass (*Chara* spp.) were the dominant aquatic plants in the system. Other common aquatic plants included pondweeds (*Potamogeton* spp.) and water celery or eel grass (*Vallisneria americana*).

Fishery

- Wisconsin Department of Natural Resources fisheries surveys conducted between 1963 and 1999 suggest a relatively stable fish population in the Lake, with 26 species of fishes being recorded.

- Pike Lake supports a relatively large and diverse fish community. The Lake is predominantly a bluegill, largemouth bass, and walleyed pike fishery, with northern pike also being an important sportfish.

Natural Resource Base

- In 1985, wildlife habitat covered about 2,800 acres, or 35 percent of the drainage area directly tributary to Pike Lake, about one-half of this habitat being comprised of high-value habitat capable of supporting a diverse population of wildlife, with adequate land area and appropriate vegetative cover for nesting, cover, and subsistence, and minimal levels of disturbance.

- As of 2000, wetlands covered about 1,035 acres of the total drainage area tributary to Pike Lake, or about 13 percent of the watershed. Woodlands covered a further approximately 800 acres or 10 percent of the total drainage area tributary to the Lake.

- Environmental corridors, or contiguous lands containing the majority of the high value woodlands, wetlands, and wildlife habitat and surface waters within the drainage area tributary to Pike Lake, comprised about 2,270 acres, of which about 95 percent, or about 2,140 acres, were considered to be primary corridor lands. About 130 acres were considered to be isolated natural resource features.

Recreational Use

- As of 2000, there were three recreational boating access sites of Pike Lake, two of which were in public ownership being comprised of road rights-of-way owned by the Town of Hartford, and one provided by a local marina under a private provider agreement with the Wisconsin Department of Natural Resources. Pike Lake has been determined to have adequate public recreational boating access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*.

- During July 2000, approximately 250 watercraft were observed on and around Pike Lake. Of these, about 30 were power boats, about 60 craft were pontoon boats, about 60 were fishing boats, and 20 were personal watercraft. The balance was comprised of sailboats, rowboats, canoes, and similar nonmotorized watercraft.

- In a recreational rating technique developed by the Wisconsin Department of Natural Resources to characterize the recreational value of inland lakes, Pike Lake received 64 out of a possible total of 72 points, indicating that the Lake provides a wide range of recreational opportunities, including angling, swimming, boating, and aesthetic viewing opportunities.

ALTERNATIVE LAKE MANAGEMENT MEASURES

Alternative management techniques, including watershed, lake rehabilitation, and in-lake measures, were evaluated based on effectiveness, cost, and technical feasibility. Techniques assessed included land use management and zoning; protection of environmentally sensitive lands; nonpoint source pollution abatement, including nonpoint source controls in urban areas, rural areas, and developing areas; stormwater management; in-lake water quality management; hydraulic and hydrologic management; fisheries management; aquatic plant management; recreational use management; and public informational and educational programming. As a result of this analysis, in-lake water quality management measures, hydraulic and hydrologic management measures, and certain aquatic plant management measures were eliminated from further consideration at this time. The remaining alternatives were incorporated into the recommended plan described below.

RECOMMENDED PLAN

Analyses of water quality and biological conditions indicate that general water quality conditions of Pike Lake are considered to be comparable to other regional lakes. Water-based recreational uses may be limited in certain areas of the Lake and at certain times of the year. Therefore, in-lake management measures are recommended for the Lake to meet full recreational use and aquatic resource objectives. In addition to the in-lake management measures, additional land use and land management measures are recommended for application within the drainage area tributary to the Lake. The recommended measures are summarized graphically on Map 23 and are listed in Table 40, both in Chapter VIII of this report.

In summary, the lake management measures recommended for Pike Lake include:

For the protection of the natural resource base:

- Observe the guidelines set forth in the adopted regional and local land use plans, through the modification of local land use zoning ordinances to bring local planning and zoning into conformance with these plans, and through maintenance, to the extent practicable, of historic lakefront residential dwelling densities.

- Establish adequate protection of wetlands and shorelands, as well as other environmental corridor lands and isolated natural resource features, through public or private acquisition of features of local or greater significance, based upon recommendations set forth in the adopted regional natural areas and critical species habitat protection and management plan, and county land and water resource management plan.

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

- Continue to implement the recommendations set forth in the regional water quality management plan to provide sanitary sewerage services to the urbanized areas of the Lake drainage area. Wastewater treatment to be provided at the City of Hartford and Village of Slinger treatment facilities as set forth in the adopted regional water quality management plan.

- Continue to implement inspection and maintenance measures with respect to onsite sewage disposal systems in those portions of the watershed not served by public sanitary sewerage services.

- Restrict pollutant loadings carried by stormwater into the Lake through the implementation of stormwater management practices. Install construction site erosion control measures as required by local ordinances and enforce the construction site erosion control and stormwater management ordinance provisions.

- Develop detailed designs for the inlet to restore the functioning of the bypass channel and consider other modifications to the inlet which would reduce pollutant loadings carried by the Rubicon River.

- For rural areas, continue to implement nonpoint source pollution controls through promotion of sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans and implementation of integrated nutrient and pest management practices in accordance with the adopted county land and water resource management plan.

- For urban areas, continue to promote sound urban "good housekeeping" and yard care practices through informational programming. Consider the development of lawn care and shoreland management ordinances in the City and Town of Hartford.

- For developing areas, develop and enforce construction site erosion control and stormwater management ordinances and periodically review such ordinances for concurrency with the *Wisconsin Administrative Code*. Consider the use of conservation subdivision designs with integrated stormwater management systems where appropriate densities exist.

- Continue water quality monitoring through participation in the Wisconsin Department of Natural Resources Self-Help Monitoring Program and U.S. Geological Survey Trophic State Index Monitoring Program.

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

- Conduct periodic fisheries surveys to determine management and stocking needs and maintain stocking programs as appropriate. Enforce size and catch limits.

- Maintain existing shoreline protection structures and repair as necessary using vegetative means insofar as practicable and subject to any applicable Wisconsin Department of Natural Resources permit requirements. Encourage shoreline restoration projects and the creation of shoreland buffer strips, and promote consistency in the application of landscaping practices in sensitive shoreland areas, through informational programming and demonstration sites.

- Maintain the integrity of wetlands, shorelands, and environmental corridor lands, including isolated natural resource features, through public or private acquisition, application of appropriate ordinance provisions and zoning restrictions, and restoration activities, as previously noted.

For the enhancement of recreational opportunities:

- Maintain public recreational boating access opportunities pursuant to guidelines set forth in Chapters NR 1 and NR 7 of the *Wisconsin Administrative Code*. Continue to enforce and periodically review recreational boating ordinances relating to the operation of petroleum-powered watercraft on the Lake and consider the regulation of petroleum-powered vehicles on the ice during winter.

- Harvest aquatic plants as required to facilitate recreational boating access to Pike Lake, minimizing harvesting during the spring and autumn to avoid disturbances to fish breeding areas, as set forth in Chapter NR 109 of the *Wisconsin Administrative Code*. Manually harvest around piers and docks as necessary. Collect floating aquatic plant fragments in shoreland areas to minimize rooting potential of Eurasian water milfoil and accumulation of organic debris.

- Apply appropriate chemical herbicides to limited, selected areas of the Lake where necessary to specifically target Eurasian water milfoil and curly-leaf pondweed infestations in the Lake and purple loosestrife infestations in shoreland wetland areas as set forth in Chapter NR 107 of the *Wisconsin Administrative Code*.

- Consider application of biological control of purple loosestrife infestations, using loosestrife beetles.

For public information and education:

- Continue ongoing public informational and awareness-building programs, and encourage inclusion of lake studies in environmental curricula of local schools through the use, for example, of programs such as Adopt-A-Lake, Project WET, and the Washington County Water Walk programs.

The recommended plan is based largely on existing and ongoing lake management measures being carried out by the Pike Lake Management District, in partnership with the City and Town of Hartford, Washington County, the Wisconsin Departments of Natural Resources, Transportation, and Agriculture, Trade, and Consumer Protection, and the U.S. Geological Survey, among others. It is recommended that the Pike Lake Management District take primary responsibility for implementing this plan, with the ongoing assistance of the other agencies and units of government as necessary and appropriate. It is estimated that the plan would entail a capital expenditure of $116,000, primarily for stormwater management and aquatic plant management actions over the next 20 years, and an annual operations and maintenance expenditure of about $29,500, as summarized in Table 41 in Chapter VIII of this report. Many of the recommended lake management measures set forth above involve actions by homeowners and property owners within the drainage area tributary to the Lake, and, while valuable and important, incur few direct costs to the Pike Lake community as they are undertaken as voluntary actions.

Full implementation of the recommended plan will maintain the Lake in a mesotrophic state, which condition is consistent with that of the higher quality waterbodies within the Southeastern Wisconsin Region. Application of these management measures also would result in reductions in nonpoint-sourced contaminants loads consistent with the requirements of Chapter NR 151 of the *Wisconsin Administrative Code*, and related statutes. It is anticipated that, with full implementation of the recommended management measures, the year 2020 in-lake total phosphorus concentration would be increased slightly, from the current 1995 concentration of about 0.025 mg/l, to about 0.030 mg/l. This estimated in-lake total phosphorus concentration could be reduced to about 0.020 mg/l by the reconstruction of the bypass channel, which concentration is consistent with the concentration recommended in the adopted regional water quality management plan as necessary to maintain good water quality in lakes in the Region. Achieving this in-lake phosphorus concentration would support the full range of recreational uses of Pike Lake. Conversely, failure to fully implement this plan could result in the continued enrichment of Pike Lake and the concomitant loss of lake use values.

Pike Lake is a valuable natural resource in the Southeastern Wisconsin Region. The delicate, complex relationship between water quality conditions in the Lake and land uses within its tributary drainage area is likely to be subject to ongoing pressures and demands for water-based recreation in the Lake and for urban-density development within the tributary drainage area, given the projected increases in population, urbanization, income, leisure time, and individual mobility, forecast for the Region. To provide the water quality protections needed to maintain conditions in Pike Lake conducive to meeting such pressures and providing for the greatest possible range of active and passive recreational water uses, 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 regional land use, water quality protection, recreational use, land and water management, and sanitary sewer service area plan for the drainage area tributary to, and inclusive of, Pike Lake.

APPENDICES

Appendix A

AN AQUATIC PLANT MANAGEMENT PLAN FOR PIKE LAKE, WASHINGTON COUNTY, WISCONSIN

INTRODUCTION

This aquatic plant management plan is prepared by the Southeastern Wisconsin Regional Planning Commission staff as an integral part of the lake management plan for Pike Lake.[1] It represents an important element of the ongoing commitment of the Pike Lake Protection and Rehabilitation District, the City of Hartford, and the Town of Hartford to sound environmental management with respect to the Lake. The plan is based upon field surveys conducted by Commission staff during the summer of 2001, and follows the format adopted by the Wisconsin Department of Natural Resources (WDNR) for aquatic plant management plans pursuant to Chapters NR 103, NR 107, and NR 109 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, the City of Hartford, and Town of Hartford in concert with the riparian residents; and those measures which will directly affect the recreational use of Pike Lake. The aquatic plant management plan for Pike Lake is comprised of eight elements:

1. A set of aquatic plant management objectives;
2. A brief description of the Lake and its watershed;
3. A statement of perceived use restrictions and need for aquatic plant management in Pike Lake;
4. A review of past and present aquatic plant management measures utilized on Pike Lake;
5. An evaluation of alternative means of aquatic plant management and a recommended plan for such management;
6. A description of the recommended plan;
7. A description of the equipment needs for the recommended plan; and
8. A recommended means of monitoring and evaluating the efficacy of the plan.

---

[1]*SEWRPC Community Assistance Planning Report No. 273,* A Lake Management Plan for Pike Lake, Washington County, Wisconsin, *March 2005.*

STATEMENT OF AQUATIC PLANT MANAGEMENT GOALS AND OBJECTIVES

The aquatic plant management program objectives for Pike Lake were developed in consultation with the Pike Lake Protection and Rehabilitation District, the Pike Lake Watershed Advisory Committee, and the Pike Lake community. The primary goal of the aquatic plant management program is to provide a full range of recreational access opportunities for all lake users, focused on those areas of the Lake within which aquatic plants can become overly abundant, in a manner that preserves and maintains the underlying natural resource base of the Lake, through the accomplishment of a number of practical objectives, including:

1. Provision of boating access and access for sport anglers: by providing access channels for watercraft and cruising lanes for visually feeding gamefish to increase yields in areas formerly inaccessible due to abundant or unbalanced aquatic plant growths, and allowing access for sport anglers in these areas.

2. Protection of the lake environment: by managing aquatic plant material in the Lake, and the nutrients and organic matter that accumulate in the Lake bottom sediments through the decay process, spur further aquatic plant growths, and encourage the growth of invasive plant species.

3. Enhancement of the native aquatic plant communities: by limiting the areal extent of invasive plant species such as Eurasian water milfoil, allowing deeper penetration of sunlight into the Lake, and promoting the competitive success of the generally low-growing native aquatic plants, leading to a greater diversity of aquatic plant species.

4. Maintenance of the ecological balance: by encouraging the competitive success and diversity of native plant communities, leading to a more balanced aquatic system better able to support the array of recreational uses to which the Lake is subjected.

5. Cooperation with Lake residents: by providing lakeshore residents with appropriate information on how to maintain their pier areas, manage their lawns and gardens, and utilize the natural resources of the Lake in a sustainable and environmentally friendly manner.

6. Collaboration with the residents of the drainage basin tributary to the Lake: by providing all residents of the drainage area tributary to Pike Lake with appropriate information on how their actions affect the waterways tributary to the Lake, their local environment, and the natural resource base of the Lake and watershed.

7. Acquisition and/or protection of wetlands and environmentally sensitive lands within the drainage basin tributary to the Lake by promoting the conservation of sensitive lands through regulation, zoning, easement, or acquisition to insure their permanent conservancy and the continuation of their ecosystem benefits.

PIKE LAKE AND ITS WATERSHED CHARACTERISTICS

Pike Lake is located within the civil division limits of the City of Hartford and the Town of Hartford, both within Washington County. Surface water enters the Lake primarily through the Rubicon River, with additional surface water inputs from several tributary streams and groundwater inflows.[2] The Lake is a natural drainage lake that was augmented by a low-head dam, last reconstructed in 1957. Prior to the construction of a canal at the Lake outlet in the mid- to late-1800s, the Lake probably overflowed to the downstream Rubicon River only sporadically, through a natural wetland system that characterizes the outlet to the Lake. Pike Lake currently has

---

[2] *See U.S. Geological Survey Scientific Investigations Report No. 2004-5141,* Water Quality, Hydrology, and the Effects of Changes in Phosphorus Loading to Pike Lake, Washington County, Wisconsin, with Special Emphasis on Inlet-to-Outlet Short-Circuiting, *2004.*

both a defined inflow and outflow, formed by the Rubicon River. The Lake level is presently controlled artificially by the dam located at the Lake outlet. A bathymetric map of the Lake is set forth as Map A-1.

The watershed area draining to Pike Lake is approximately 12.5 square miles in areal extent. Portions of the watershed lie in the City of Hartford, the Village of Slinger, and the Towns of Hartford and Polk.

Land Use and Shoreline Development

The importance of the Pike Lake area as an attractive setting for residential development within a reasonable commuting distance of major commercial and industrial centers in Southeastern Wisconsin has increased steadily since the 1850s. In addition, many summer cottages have, over the years, been converted into year-round homes. By 1995, about 1,625 acres, or about 20 percent of the total drainage area tributary to Pike Lake, were in urban land uses, with residential uses being the dominant urban land use. As of 1995, about 6,350 acres, or about 80 percent of the total drainage area tributary to Pike Lake, were still in rural land uses. Of these uses, about 60 percent of the drainage area, or about 4,000 acres, was in agricultural use. The western and southern shorelands of the Lake are generally considered to be fully developed, although some limited infilling, backlot development, and redevelopment of platted lots may be expected to occur. The eastern portions of the lakeshore are comprised of the Pike Lake Unit of the Kettle Moraine State Forest, while a significant wetland area occurs along the Lake's northern shoreline. About one-half of the shoreland around Pike Lake has some form of shoreline protection, with these protection structures being located primarily adjacent to the residential development on the western and southern shores. Map A-2 shows current shoreline conditions as of the year 2000.

Population

As of 2000, there were an estimated 1,150 persons residing within the drainage area directly tributary to Pike Lake. Population forecasts prepared by the Regional Planning Commission as a basis for the adopted regional land use plan[3] indicate that the population within this portion of the drainage area tributary to Pike Lake may be expected to increase to about 1,700 persons by the year 2020.

Aquatic Plants, Distribution and Management Areas

Aquatic Plants in Pike Lake

Aquatic plant surveys have been conducted on Pike Lake during the summers of 1976 and 2001. All of the observed aquatic plants have been commonly observed within lakes in the Southeastern Wisconsin Region. A species list compiled by the Regional Planning Commission staff from data gathered during the year 2001 aquatic plant survey is set forth in Table A-1, along with notes on the ecological significance of each plant. During the 2001 aquatic plant survey, 17 species of aquatic plants were observed in Pike Lake, and representative illustrations of these aquatic plants can be found at the end of this appendix. Muskgrass (*Chara* spp.) remained the dominant aquatic plant species in the Lake, closely followed in occurrence and density by Eurasian water milfoil (*Myriophyllum spicatum*). Sago pondweed (*Potamogeton pectinatus*) and spiny naiad (*Najas marina*) were also commonly reported aquatic plants during the 2001 survey, with eel grass (*Vallisneria americana*) being the next most abundant, as shown in Table A-1. The plants were relatively evenly distributed around the Lake, as shown on Map A-3, although aquatic plant growth was relatively sparse along the more steeply sloping southern shorelands of the Lake. Eurasian water milfoil was most prevalent in the deeper water areas of the Lake, between about seven and 10 feet in depth, and in the very shallow water areas along the eastern and western shores. Changes in the aquatic macrophyte species distribution and abundance in Pike Lake, between 1988 and 2000, are summarized in Table A-2.

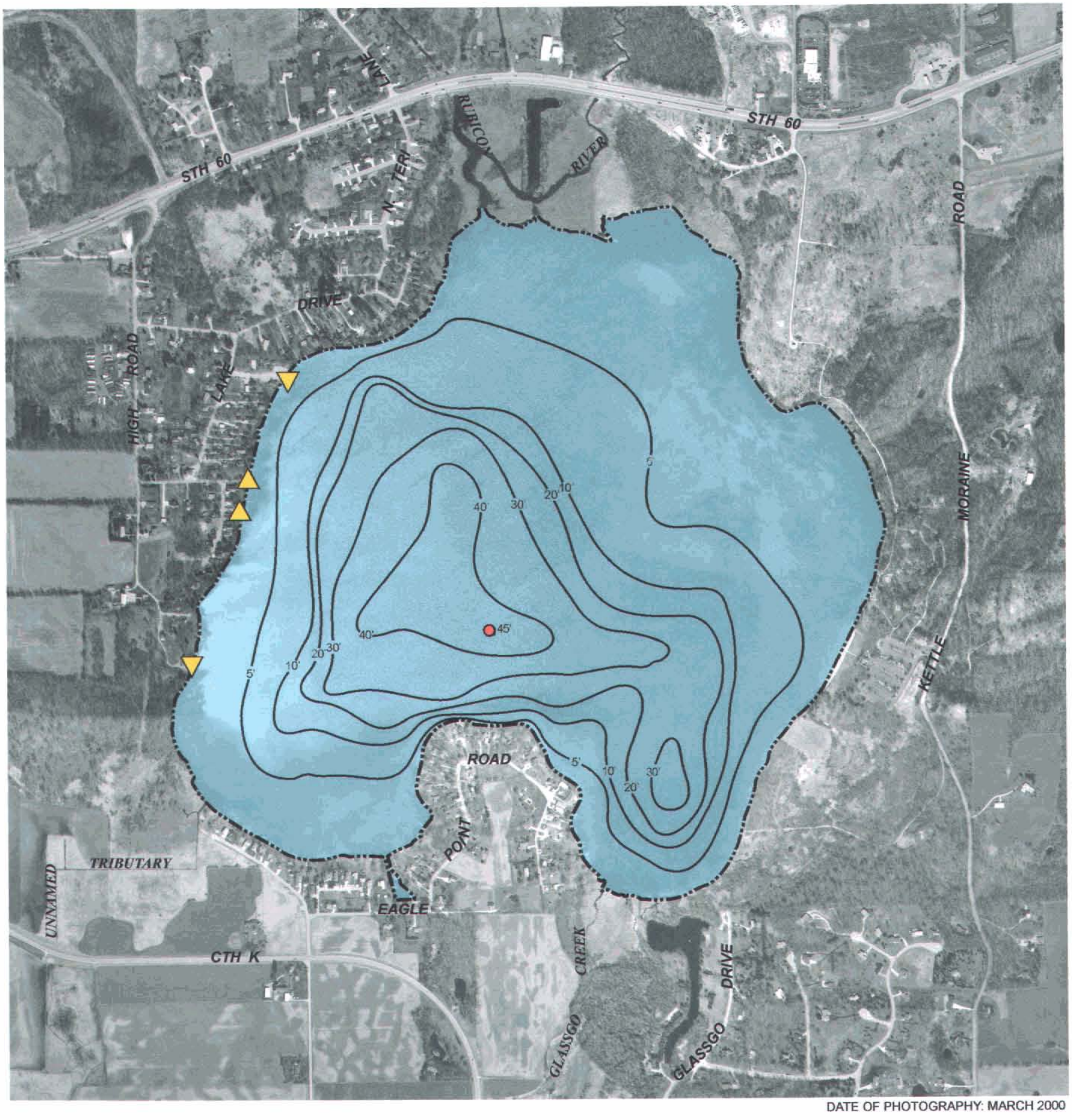
In general, Pike Lake supports a healthy and diverse aquatic macrophyte community. The beneficial nature of the aquatic plant community in Pike Lake, as well as the importance of this community in maintaining the ecological balance in the lake, is generally recognized by the lakeshore residents, although some residents report difficulties

---

[3] *SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997.*

Map A-1

BATHYMETRIC MAP OF PIKE LAKE



—20'— WATER DEPTH CONTOUR IN FEET

MONITORING SITE

PUBLIC ACCESS SITE

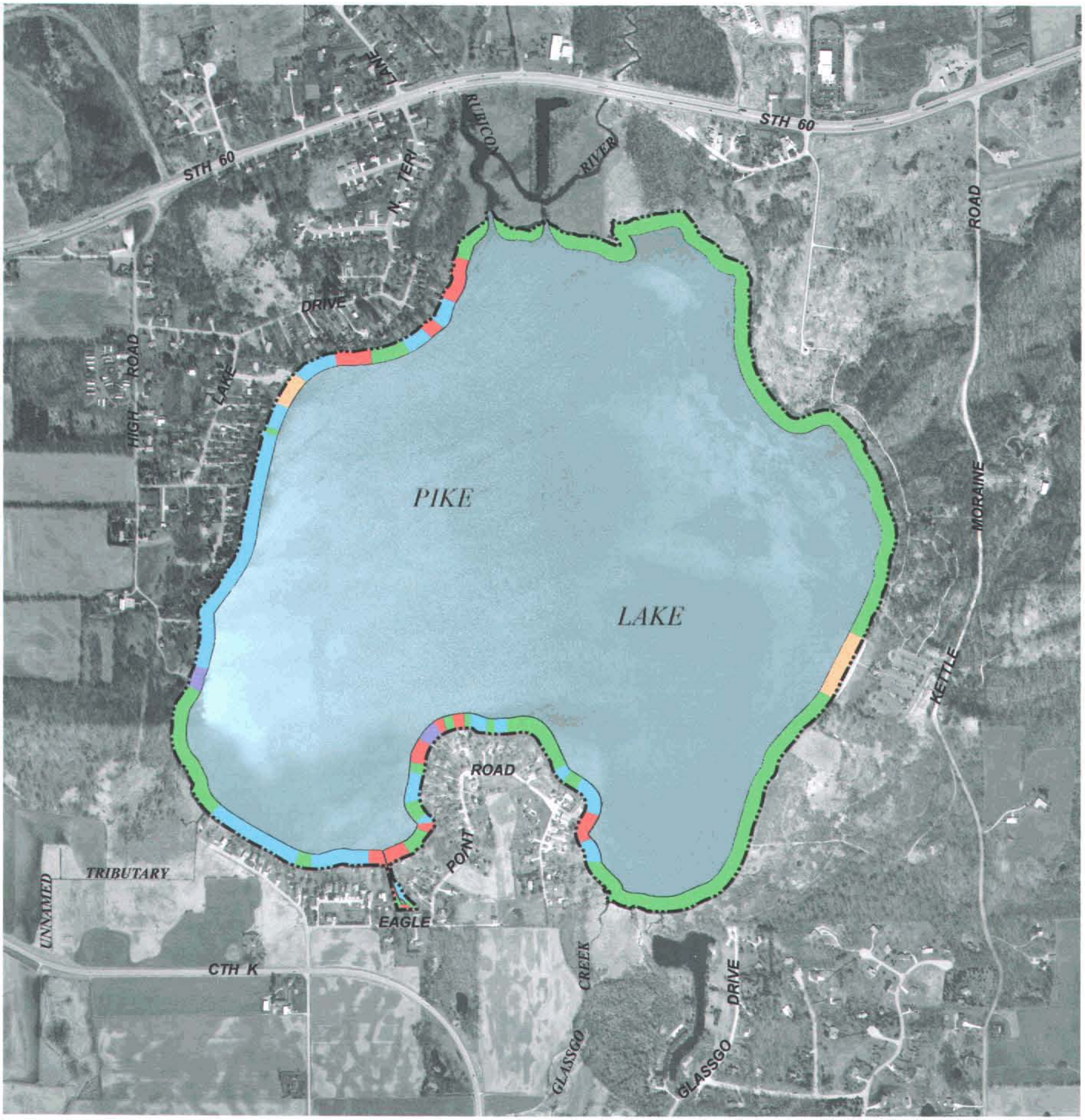
PRIVATE ACCESS SITE

GRAPHIC SCALE 0 600 1200 FEET

Source: U.S. Geological Survey and SEWRPC.

Map A-2

SHORELINE PROTECTION STRUCTURES ON PIKE LAKE: 2001



DATE OF PHOTOGRAPHY: MARCH 2000

RIPRAP
BULKHEAD
BEACH
REVETMENT
NATURAL

Source: SEWRPC.

GRAPHIC SCALE
0 600 1200 FEET

Table A-1

AQUATIC PLANT SPECIES PRESENT IN PIKE LAKE AND THEIR POSITIVE ECOLOGICAL SIGNIFICANCE: 2001

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence (percent)	Relative Density	Importance Value	Ecological Significance
Ceratophyllum demersum (coontail)	9	9.9	2.3	0.23	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	58	63.7	3.4	2.15	Excellent producer of fish food, especially for young trout, bluegills, small and largemouth bass; stabilizes bottom sediments, and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed or Elodea)	4	4.4	2.0	0.09	Provides shelter and support for insects which are valuable as fish food
Myriophyllum sp. (native water milfoil)	3	3.3	1.7	0.05	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	58	63.7	2.7	1.69	None known
Najas flexilis (bushy pondweed)	5	5.5	1.2	0.07	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	42	46.2	2.1	0.98	Provides good food and shelter for fish and food for ducks
Potamogeton crispus (curly-leaf pondweed)	3	3.3	1.0	0.03	Provides food, shelter and shade for some fish and food for wildfowl
Potamogeton gramineus (variable pondweed)	8	8.8	1.6	0.14	Provides habitat for fish and food for waterfowl, in addition to muskrat, beaver, deer, and moose
Potamogeton illinoensis (Illinois pondweed)	1[a]	--	--	--	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl
Potamogeton natans (floating-leaf pondweed)	2	2.2	1.5	0.03	Provides food and shelter for fish and food for wildfowl
Potamogeton pectinatus (Sago pondweed)	41	45.1	2.2	0.98	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish

Table A-1 (continued)

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence (percent)	Relative Density	Importance Value	Ecological Significance
Potamogeton richardsonii (clasping-leaf pondweed)	3	3.3	2.3	0.08	Provides food, shelter and shade for some fish, food for some wildfowl, and food for muskrat. Provides shelter and support for insects, which are valuable as fish food
Potamogeton zosteriformis (flat-stem pondweed)	22	24.2	2.2	0.53	Provides some food for ducks
Ranunculus longirostris (stiff water crowfoot)	2	2.2	2.0	0.04	Provides food for trout, upland game birds, and wildfowl
Vallisneria americana (eel grass or water celery)	35	38.5	2.4	0.93	Provides good shade and shelter, supports insects, and is a valuable fish food
Zosterella dubia (water stargrass)	5	5.5	1.4	0.08	Provides food and shelter for fish, locally important food for waterfowl

NOTE: There were 91 sites sampled during the July 2001 survey.

[a]*Illinois pondweed was observed, but not sampled, therefore, it was not included in the analysis of density and frequency of occurrence.*

Source: SEWRPC.

with navigation in portions of the Lake. Generally, the diversity of the plant community in and adjacent to the Lake contributes to the wildlife habitat value of the area, as set forth below. Fish, waterfowl, pheasants, muskrats, and other wetland wildlife species dependent on aquatic vegetation for feeding and nesting, brooding, or loafing areas are known to make use of the Lake. The positive ecological values of the aquatic plants reported from Pike Lake are set forth in Table A-1.

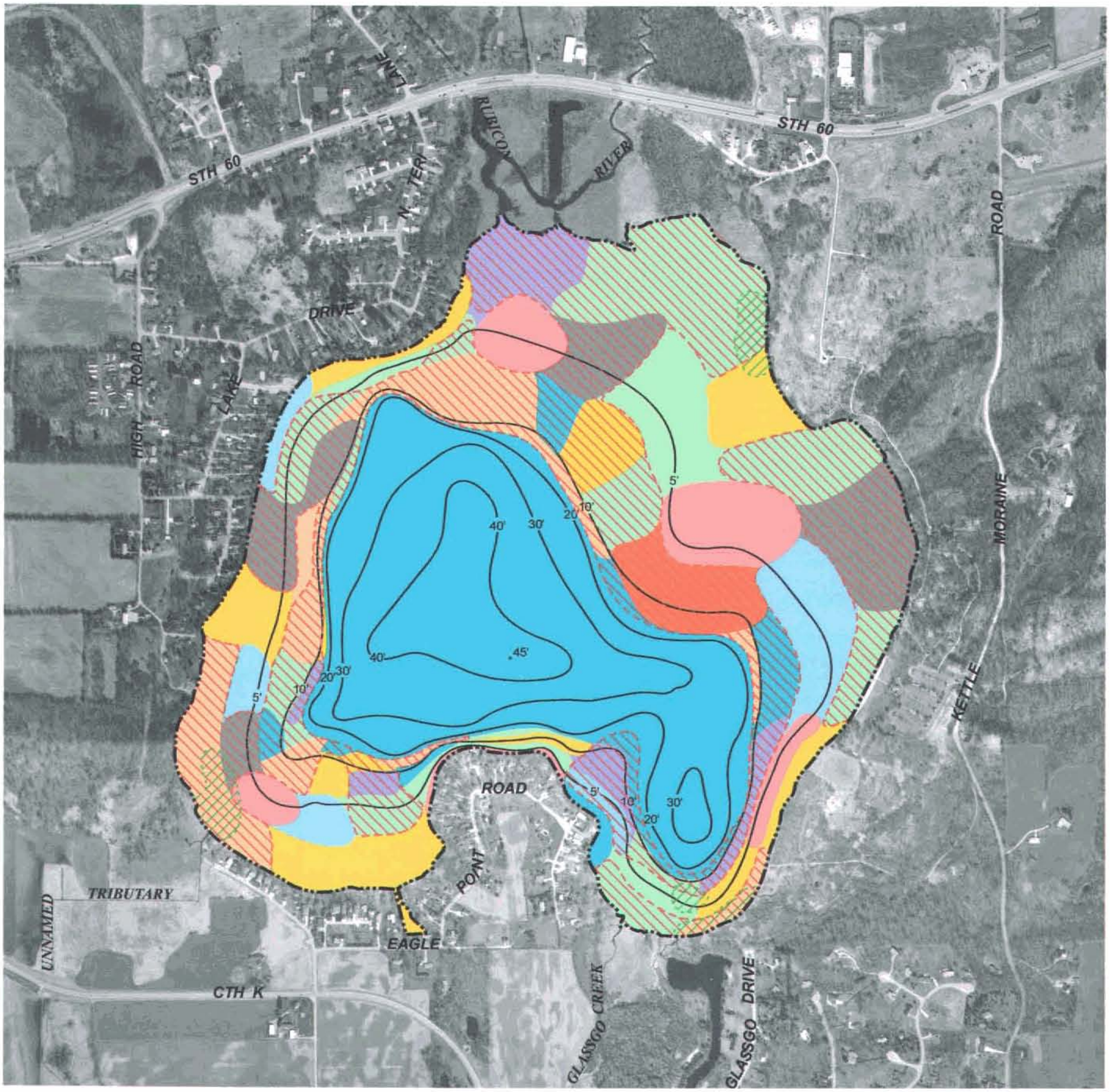
Eurasian Water Milfoil

At the time of the year 2001 Commission survey, Eurasian water milfoil, *Myriophyllum spicatum*, and muskgrass, *Chara vulgaris*, were the co-dominant aquatic plants within the Lake. Eurasian water milfoil is one of eight milfoil species found in Wisconsin and the only one that is known to be exotic or nonnative. Because of its nonnative nature, Eurasian water milfoil has few natural enemies and can exhibit "explosive" growth under suitable conditions, such as the presence of organic-rich sediments, or in areas where the lake bottom has been disturbed. It can displace native plant species and disrupt the ecosystem functioning of a lake as it lacks many of the positive ecological values of native aquatic plants. 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.

Eurasian water milfoil is especially abundant in Pike Lake where depths range from five to 10 feet. The abundant growths of Eurasian water milfoil are known to cause extreme problems for Pike Lake due to their ability to grow to the lake surface, making certain recreational uses less enjoyable, if not dangerous, and impairing the aesthetic qualities of the waterbody. When Eurasian water milfoil is fragmented by boat propellers, or by other means, the fragments are able to sprout new roots and potentially colonize new sites. These fragments can also cling to boats,

Map A-3

AQUATIC PLANT COMMUNITY DISTRIBUTION IN PIKE LAKE: 2001



DATE OF PHOTOGRAPHY: MARCH 2000

- —20'— WATER DEPTH CONTOUR IN FEET
- OPEN WATER
- WATER LILIES
- EURASIAN WATER MILFOIL
- MUSKGRASS
- SAGO PONDWEED
- MUSKGRASS; COONTAIL; WATERWEED; WILD CELERY; NATIVE WATER MILFOIL; AND SAGO, FLAT-STEM, AND VARIABLE PONDWEEDS
- MUSKGRASS; SPINY NAIAD; AND SAGO, BUSHY, FLAT-STEM, CURLY LEAF, AND VARIABLE PONDWEEDS
- MUSKGRASS; COONTAIL; SPINY NAIAD; WILD CELERY; WATER STAR GRASS; AND BUSHY, FLAT-STEM, CURLY LEAF, FLOATING LEAF, AND VARIABLE PONDWEEDS
- MUSKGRASS; SPINY NAIAD; WILD CELERY; WATER STAR GRASS; AND SAGO, BUSHY, FLAT-STEM, AND ILLINOIS PONDWEEDS
- MUSKGRASS; COONTAIL; SPINY NAIAD; WATERWEED; WILD CELERY; NATIVE WATER MILFOIL; WATER STAR GRASS; WHITE WATER CROWFOOT; AND SAGO, BUSHY, FLAT-STEM, CLASPING LEAF, AND VARIABLE PONDWEEDS
- COONTAIL; SPINY NAIAD; WATERWEED; WILD CELERY; WATER STAR GRASS; WHITE WATER CROWFOOT; AND SAGO, FLAT-STEM, CURLY LEAF, CLASPING LEAF, AND FLOATING LEAF PONDWEEDS

GRAPHIC SCALE

0 600 1200 FEET

Source: SEWRPC.

Table A-2

SUBMERGENT PLANT SPECIES IN PIKE LAKE: 1976-2001

Aquatic Plant Species	1976 Survey[a]	2001 Survey
Ceratophyllum demersum (coontail)	- -	X
Chara vulgaris (muskgrass)	X	X
Elodea canadensis (waterweed)	- -	X
Myriophyllum sp. (native water milfoil)	- -	X
Myriophyllum spicatum (Eurasian water milfoil)[b]	X	X
Najas flexilis (bushy pondweed)	X	X
Najas marina (spiny naiad)	- -	X
Potamogeton amplifolius (large-leaf pondweed)[c]	X	- -
Potamogeton crispus (curly-leaf pondweed)[b]	- -	X
Potamogeton filiformis (thread-leaf pondweed)	X	- -
Potamogeton gramineus (variable pondweed)	- -	X
Potamogeton illinoensis (Illinois pondweed)[c]	- -	X
Potamogeton natans (floating-leaf pondweed)	X	X
Potamogeton pectinatus (Sago pondweed)[c]	X	X
Potamogeton praelongus (white-stem pondweed)[c]	- -	- -
Potamogeton richardsonii (clasping-leaf pondweed)[c]	- -	X
Potamogeton zosteriformis (flat-stemmed pondweed)	- -	X
Ranunculus longirostris (stiff water crowfoot)	- -	X
Vallisneria americana (water celery)	X	X
Zosterella dubia (water stargrass)	- -	X

[a]*Survey conducted by Wisconsin Department of Natural Resources.*

[b]*Designated as invasive and nonnative aquatic plant species pursuant to section NR 109.07 of the* Wisconsin Administrative Code.

[c]*Considered a high-value aquatic plant species known to offer important values in specific aquatic ecosystems under Section NR 107.08 (4) of the* Wisconsin Administrative Code.

Source: Wisconsin Department of Natural Resources and SEWRPC.

trailers, motors, propellers, and bait buckets, among other things, and stay alive for weeks, facilitating their transfer to other lakes.[4] In addition, the growth characteristic of the plant, which propels the plant to the water surface where it spreads out and captures the sunlight, limits the growth and success of the lower-growing native aquatic plant species in the Lake. This characteristic frequently leads to monocultural stands of Eurasian water milfoil in lakes in Southeastern Wisconsin, with concomitant impacts throughout the lake ecosystems in the form of reduced species abundances and/or conditions of other organisms dependent upon the native aquatic plant flora. Consequently, the presence of this plant frequently invokes control strategies to restore and protect the native plant communities that form the habitat base in lakes.

Fisheries, Wildlife and Waterfowl

Pike Lake supports a large and diverse fish community. Studies conducted by the Wisconsin Department of Natural Resources indicated that 26 different fish species have been captured in the Lake.

"Panfish" is a common term applied to a broad group of smaller fish with a relatively short and usually broad shape that makes them a perfect size for the frying pan. A wide range of panfish is present in the Lake, including yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), rock bass (*Ambloplites rupestris*), and green

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

sunfish (*Lepomis cyanellus*). 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 predatory fishes and, if the panfish population is overabundant, they may quickly deplete the predator fry population.

"Rough fish" is a broad term applied to species, such as carp, that do not readily bite on hook and line, but feed on game fish, destroy habitat needed by more desirable species, and are commonly considered in Southeastern Wisconsin as undesirable for human consumption. Rough fish species which have been found in Pike Lake include carp (*Cyprinus carpio*), white sucker (*Catostomus commersoni*), and bowfin (*Amia calva*).

"Game fish" is the term applied to those fishes that are typically sought by anglers, and which are generally considered to be desirable species. Northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*Micropterus dolomieui*) are also present and reproduce naturally in Pike Lake; however, their populations are relatively low.

In 1963,[5] the WDNR reported that the Lake was managed for panfish and walleyed pike, with yellow perch the principle game fish. Carp were reported to be common in the shallow areas, but were not considered to constitute a management problem. In 1974,[6] a fisheries survey reported the following fish species: rock, smallmouth, and largemouth bass; bowfin; common carp; johnny, Iowa, and least darter; blackchin, blacknose, pugnose, and golden shiner; white sucker; northern pike; walleyed pike; bluntnose and fathead minnow; banded killifish; and yellow perch. In 1975,[7] a fisheries survey reported, rock, smallmouth, and largemouth bass; bowfin; common carp; golden shiner; white sucker; northern pike; walleyed pike; and yellow perch. According to the WDNR, as of 1995,[8] Pike Lake was reported to have an abundant walleyed pike population, with northern pike, largemouth and smallmouth bass, and panfish being present. A fish consumption advisory had been issued for this Lake. The Southeastern Wisconsin Regional Planning Commission (SEWRPC) reports the pugnose shiner as a State-designated threatened species, and the least darter as a State species of special concern.[9]

The Rubicon River both enters and leaves the Lake on its north shore in a cattail and sedge marsh. About 40 percent of the shoreline is marsh associated with the riverine inflow and outflow portion of the Lake; an estimated 180 acres of wetland adjoin the stream. A fish refuge has been established on both the channel above the dam and the Rubicon River below the dam for a distance of about 0.5 mile as protection for walleyed and northern pike during spawning runs. Modification of the inlet and outlet of the Lake was completed in 1993 in order to permit high flows to bypass the Lake in the expectation of minimizing nutrient loading to Pike Lake.

Given the urban nature of much of the western shorelands of the Lake, only smaller urban tolerant mammals are generally present. A somewhat more diverse animal community, and greater number of waterfowl, make use of the extensive outlying wetland and other habitat areas located throughout the tributary drainage area of Pike Lake. Muskrats and cottontail rabbits are probably the most abundant and widely distributed fur-bearing mammals in the immediate riparian areas. Larger mammals, such as the whitetail deer, are generally confined to the larger

---

[5]*Wisconsin Conservation Department,* op. cit.

[6]*D. Fago, Wisconsin Department of Natural Resources Research Report No. 148,* Retrieval and Analysis System Used in Wisconsin's Statewide Fish Distribution Survey, Second Edition, *December 1988.*

[7]Ibid.

[8]*Wisconsin Department of Natural Resources, PUBL-FM-800 9 REV.*

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

wooded areas and the open meadows found in the park and open space lands within the drainage area tributary to the Lake, such as those provided by the Pike Lake Unit of the Kettle Moraine State Forest. The Pike Lake drainage area supports a significant population of waterfowl including mallards and geese. During migration seasons, a greater variety of waterfowl may be present and in greater numbers. Ospreys and loons are notable migratory visitors. Threatened species migrating in the vicinity of Pike Lake include the Cerulean warblers, Acadian flycatcher, great egret, and osprey. Endangered species migrating in the vicinity of Pike Lake include the common tern, Caspian tern, Forster's tern, and the loggerhead shrike.

Recreational Uses and Facilities

Pike Lake is located within about a one hour drive from much of the metropolitan Milwaukee area, and within easy driving distance of the Madison metropolitan area and the so-called Fox Cities metropolitan area. Its location, accessibility, and degree and type of shoreline development, including the Pike Lake Unit of the Kettle Moraine State Forest, one of the most heavily utilized parks in the State park system, contribute to a more intensive recreational usage than is found on many other lakes in Southeastern Wisconsin. Pike Lake is a multipurpose waterbody serving numerous forms of recreation, including both active and passive recreational uses. Boating, waterskiing, swimming, and fishing are popular activities during open water periods, and ice fishing and snowmobiling are common during closed water periods. The Lake is used year round as a visual amenity, with walking, bird watching, and picnicking being popular passive recreational uses of the waterbody and its surrounds. Although the Pike Lake Unit of the Kettle Moraine State Forest lacks a recreational boating access ramp, the Park nevertheless provides a focus for both active and passive recreational activities within the Pike Lake area. Public recreational boating access to the Lake is provided through a nearby resort, under a private provider agreement pursuant to the guidelines set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. The Lake is deemed to have adequate public recreational boating access.

Since 1976, recreational boating activity is likely to have increased. About 250 watercraft of various descriptions were observed on and around Pike Lake during 2001. Most of these watercraft were fishing boats, accounting for about 65 of the watercraft, or approximately one-quarter of the total. Of the balance, about 60 watercraft were pontoon boats, and about 30 were powerboats. About 20 craft, or less than 10 percent of the total number of watercraft, were personal watercraft (jetskis®). Of the nonmotorized watercraft, paddleboats formed the largest proportion of the watercraft, accounting for about 35 boats. Canoes and kayaks comprised about 20 craft, and about 15 sailboats were observed. Boat counts by Commission staff during both week and weekend days in July and August resulted in a total of about 120 watercraft of all descriptions, fishing, pontoon, skiing, sailing, and rowing vessels and personal watercraft, being observed in operation. Of these, about 25 were observed to be in operation during weekday mornings and afternoons, with the balance being observed to be in operation during weekend mornings and afternoons. About 60 watercraft were observed to be in operation during July 2002, which weekend was considered to be more typical of a fair weather weekend day than that reported on during 2001. Fishing boats comprised the largest number of watercraft in operation on the Lake during both periods.

Local Ordinances

The comprehensive zoning ordinance represents one of the most important and significant tools available to local units of government in directing the proper use of lands within their area of jurisdiction. As already noted, the drainage area tributary to Pike Lake includes portions of the City of Hartford, the Village of Slinger, and the Towns of Hartford and Polk, all in Washington County. The City, Village, and Towns administer their own zoning ordinances, although the Washington County ordinances form an overlay to the local zoning code with respect to shoreland and floodland zoning issues in the Towns.

USE RESTRICTIONS IMPOSED BY AQUATIC PLANTS

Aquatic plant growth in Pike Lake is perceived to be close to densities in portions of the Lake that interfere with recreational usage of the Lake, impeding boat traffic and making some areas of the Lake impassable without aquatic plant control. At some sample sites, plant growth recorded by the Commission staff approached a density rating of 3, indicating a moderate to abundant density. In addition to muskgrass, Eurasian water milfoil is a major contributor to these higher densities. In particular, such excessive plant growth in the five to 10 feet depth zone makes access to the open water extremely difficult, and severely restricts shoreline angling and swimming. The abundance of aquatic plants in Pike Lake also reportedly has a significant impact in terms of the aesthetic enjoyment of visitors to the Lake. During the summer months, these beds of vegetation can become foul smelling and unsightly. The result is numerous public concerns and complaints particularly expressed throughout open water periods.

PAST AND PRESENT AQUATIC PLANT MANAGEMENT PRACTICES

Records of aquatic plant management efforts on Wisconsin lakes were not maintained by the WDNR prior to 1950. Thus, while previous interventions were likely, the first recorded efforts to manage the aquatic plants in Pike Lake have taken place since 1950. Aquatic plant management activities in Pike Lake can be categorized as chemical algal control and manual macrophyte harvesting. Currently, all forms of aquatic plant management are subject to permitting by the Wisconsin Department of Natural Resources pursuant to authorities granted the Department under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*.

Chemical Controls

Perceived excessive algal growths on Pike Lake resulted in one application of a chemical control program during 1982. Although applied for on two other occasions, no other herbicide treatments to control aquatic plants and algae were undertaken. Recorded chemical herbicide treatments that have been applied to Pike Lake from 1950 through 2002 are set forth in Table A-3. In Wisconsin, the use of chemicals to control aquatic plants and algae has been regulated since 1941, even though records of aquatic herbicide applications have only been maintained by the Wisconsin Department of Natural Resources since 1950.

Manual Controls

Manual harvesting of aquatic plants around piers and docks is not quantified, as permits governing the conduct of shoreland aquatic plant management programs have only recently been required by the Wisconsin Department of Natural Resources. As of 2003, manual removal of aquatic plants from lakes outside of a 30-foot-wide linear shoreland corridor is governed by Chapter NR 109 of the *Wisconsin Administrative Code*. No data on permits issued to Pike Lake residents are available, although riparian property owners and residents report periodic application of manual harvesting techniques along portions of the shoreline of the Lake.

ALTERNATIVE METHODS FOR AQUATIC PLANT CONTROL

Background

Various aquatic plant management techniques, manual, mechanical, physical, biological, and chemical, are potentially applicable on Pike Lake. A number of these methods have been employed with varying success on Pike Lake in the past. All aquatic plant management measures require WDNR permits.

Physical Controls

Physical methods of aquatic plant control involve water level manipulation, placement of bottom barriers, and use of shoreline protection structures. Water level manipulations generally focus on drawdowns that reduce the surface level of a waterbody in order to change or create specific types of habitat and thereby manage species composition within the waterbody. Drawdowns were not considered practical on Pike Lake due to the heavy recreational demands placed on the Lake throughout the year. Drawdowns can also encourage algal blooms and the growths of some plant species. For these reasons, drawdowns are not a recommended technique for Pike Lake at this time.

In certain situations, raising or frequently changing the lake level has also been considered as a water level manipulation measure for the control of certain nuisance species. Fluctuating water levels have limited practicality on Pike Lake for reasons of the intensity of year round lake usage, while the ability to raise water levels for aquatic plant management purposes is limited by the topography of the lake basin which would create

Table A-3

CHEMICAL CONTROL OF AQUATIC PLANTS IN PIKE LAKE: 1950-2002

Year	Total Acres Treated	Algae Control			Macrophyte Control					
		Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine-+ (gallons)	Sodium Arsenite (pounds)	2, 4-D (gallons)	Diquat (gallons)	Endothall (gallons)	Aquathol (gallons)	Fluridone (gallons)
1950-1980	--	--	--	--	--	--	--	--	--	--
1981	--	--	--	--	--	--	--	--	--	--
1982	0.05	--	--	0.25	--	--	--	--	--	--
1983	--	--	--	--	--	--	--	--	--	--
1984	--	--	--	--	--	--	--	--	--	--
1985	--	--	--	--	--	--	--	--	--	--
1986	--	--	--	--	--	--	--	--	--	--
1987	--	--	--	--	--	--	--	--	--	--
1988[a]	--	--	--	--	--	--	--	--	--	--
1989	--	--	--	--	--	--	--	--	--	--
1990[a]	--	--	--	--	--	--	--	--	--	--
1991	--	--	--	--	--	--	--	--	--	--
1992-2002	--	--	--	--	--	--	--	--	--	--
Total	0.05	--	--	0.25	--	--	--	--	--	--

[a]*Aquatic herbicide permit applied for, but no treatment conducted.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

unacceptable risks of flooding of residential properties and infrastructure. Thus, for these reasons, raising or frequently changing water levels is not a recommended technique for Pike Lake at this time.

Other physical controls, such as the placement of bottom barriers and use of shoreline protection structures such as vegetated buffer strips, may be more practicable for Pike Lake. Extensive use of shoreline protection structures has occurred adjacent to the residential areas of Pike Lake, primarily to control erosion of the shoreline. Depending upon the nature of the measures used, certain structures, such as vegetated buffer strips and enhanced littoral vegetation, can serve to filter out agro-chemicals that stimulate aquatic plant growth. While there is currently only limited opportunity for installing bottom barriers, increasing the extent of shoreline buffers around the Lake, especially within planned unit developments, provides an important and ready means of moderating the nutrient loads that stimulate the growth of aquatic plants.

Physical control options such as dredging and covering bottom sediments with sand and/or plastic lining are techniques which may be used on a limited scale to eliminate macrophyte growth in localized areas, such as in swimming or boating access areas. Extensive dredging to alleviate excessive macrophyte growth is not recommended.

Chemical Controls

Chemical controls, in the form of algicides, have been used on Pike Lake, as shown in Table A-3. However, an important goal of the Pike Lake Protection and Rehabilitation District has been to manage the aquatic plant communities of the Lake without the use of chemicals. Currently, the use of herbicides on the Lake has been limited to individual applications.

The aquatic herbicides diquat, endothall, 2,4-D, and fluridone have been applied to lakes within the Southeastern Wisconsin Region to control aquatic macrophyte growth, the latter in a largely experimental context. Diquat is a nonselective herbicide that will kill many aquatic plants, such as the pondweeds, bladderwort, and naiads that occur in Pike Lake and that provide significant habitat value for the fishes and wildlife of the Lake. Endothall primarily kills pondweeds, but does not control such nuisance species as Eurasian water milfoil, while 2,4-D and fluridone are systemic herbicides that are considered to be more selective and generally used to control Eurasian water milfoil. However, 2,4-D also will kill high value species such as water lilies, and fluridone will also affect coontail and elodea. In addition, 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 by new plants, inducing biomass production. The use of 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. Limitations on water uses after herbicide applications are summarized in Table A-4.

Large-scale or whole lake treatments of aquatic plants in Pike Lake are not recommended. However, chemical control may be a suitable technique for the control of relatively small-scale infestations of Eurasian water milfoil. Chemical applications in early spring have been found to be effective in controlling such infestations of milfoil and facilitating the resurgence of growth of native plant species in lakes in Southeastern Wisconsin. Chemical applications should be conducted in accordance with current Department of Natural Resources administrative rules, under the authority of a State permit, and by a licensed applicator working under the supervision of WDNR staff. Treated areas and the type and amount of herbicide used in each area should be carefully documented and used as a reference in applying for permits in the following year. A recommended checklist is provided as Figure A-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 Pike Lake to control nearshore plant growths, especially around piers and docks, and are encouraged by the Pike Lake Protection and Rehabilitation District.

Mechanical Controls

Based on previous experience of the use of mechanical harvester technologies on Pike Lake, mechanical harvesting of aquatic plants appears to be a practical and environmentally sensitive method of controlling plant growth and associated filamentous algae. The most significant impact of mechanical harvesting is the removal of the organic plant biomass, decreasing nutrient inputs to the Lake. Potential negative impacts of mechanical harvesting, as outlined by the U.S. Environmental Protection Agency,[10] include: the removal of small fish, limited depths of operation, propagation of plant fragments, and time needed to treat specific areas of a waterbody. However, mechanical harvesting does offer temporary relief from nuisance aquatic plant growths, especially when conducted in accordance with a management plan designed to optimize benefits and minimize adverse impacts.

In addition to controlling nuisance aquatic plant growth conditions, harvesting has been shown to promote better balance within the in-lake fishery by providing access for larger game fish, such as the largemouth bass, to smaller prey fishes and organisms which can utilize the dense plant beds. Narrow channels harvested to provide navigational access also provide "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish.

Creation of shared access lanes, allowing several residents to use the same lane, can result in increased use of these lanes and will help to keep them open for longer periods than would be the case if a less directed harvesting program was followed. These lanes can be especially useful in managing the spread of Eurasian water milfoil as a result of recreational boating activities through and across the Eurasian water milfoil beds located within the five

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

Table A-4

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

Use	Days after Application					
	Copper Sulfate	Diquat	Glyphosate	Endothall	2,4-D	Fluridone
Drinking	- -[b]	14	- -[c]	7-14	- -[d]	- -[e]
Fishing	0	14	0	3	0	0
Swimming	0	1	0	- -	0	0
Irrigation	0	14	0	7-14	- -[d]	7-30

[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]*According to the Wisconsin Department of Natural Resources, if water is to be used as potable water, the residual copper content cannot exceed one part per million (ppm).*

[c]*According to the Wisconsin Department of Natural Resources, if water is to be used as potable water, the drinking water tolerance of glyphosate (Rodeo®) is one part per million (ppm).*

[d]*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.*

[e]*According to the Wisconsin Department of Natural Resources, if water is to be used as potable water, the drinking water tolerance of fluridone (Sonar®) is 0.15 parts per million (ppm).*

Source: Wisconsin Department of Natural Resources.

to 10 feet depth contour range. Eurasian water milfoil forms a canopy of vegetation at or near the water surface, and naturally reproduces through fragmentation. Recreational boating activities that further fragment the plant exacerbate this natural reproductive method and can lead to infestations of the plant in other areas of the Lake. Because of the need to control this aquatic plant in Pike Lake, especially, and because there is a need to protect and maintain the water lily communities as preferential fish habitat within the Lake, the use of mechanical harvesting should be considered as a viable management option.

While mechanical harvesting is a viable option, the acquisition of an aquatic plant harvester by the Pike Lake Protection and Rehabilitation District may not be feasible at this time. Approximately 45 percent of the Lake surface, where Eurasian water milfoil is prevalent, is less than 10 feet in depth, or about 230 acres. However, of these potential harvestable acres, about 195 acres are in waters of less than five feet in depth, within which the operation of a mechanical aquatic plant harvester is considered problematic. Consequently, Pike Lake, with about 35 harvestable acres, is slightly below the 40-acre threshold of eligibility for state cost-share assistance for purchasing an aquatic plant harvester, established pursuant to Chapter NR 7 of the *Wisconsin Administrative Code*. Thus, further monitoring of the aquatic plant communities appears warranted to ascertain the point at which this threshold is reached before the Pike Lake Protection and Rehabilitation District takes action concerning this recommendation.

Biological Controls

An alternative approach to controlling nuisance aquatic plant conditions is biological control. Recent WDNR studies have shown that *Eurhychiopsis lecontei*, an aquatic weevil species, has potential as a biological control agent for the control of Eurasian water milfoil. In 1989, the weevil was "discovered" during a study of the decline of Eurasian water milfoil growth in a Vermont pond. *Eurhychiopsis* subsequently proved to have significant impacts on Eurasian water milfoil both in the field and in the laboratory, and has been found to be far more

Figure A-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.

widespread than previously thought. The adult weevil feeds on the milfoil plant, causing lesions which make the plant more susceptible to pathogens such as bacteria or fungi. During its feeding process, the weevil burrows into the stem of the plant, causing tissue damage to the plant such that its will lose buoyancy and collapse.[11] However, like all predator-prey relationships, the effectiveness of this organism as a Eurasian water milfoil control agent is limited by its numbers at any given time. While these numbers can be artificially enhanced by stocking, the use of these insects is highly labor-intensive and is subject to failure if the insects are exposed to the level of disturbances by boating traffic as might be expected in Pike Lake. Thus, this type of control remains largely experimental in Wisconsin and, because of the sensitivity of the weevils to disturbance and heavy predation by native fishes, is not recommended for widespread application at this time.

In contrast, the use of the beetles *Hylobius transversovittatus*, *Galerucella pusilla*, *Galerucella calmariensis*, *Nanophyes brevis*, and *Nanophyes marmoratus* is recommended for controlling infestations of purple loosestrife in wetlands and along shorelands of Pike Lake. The Wisconsin Department of Natural Resources assists communities in establishing populations of these beetles and in empowering local civic groups to acquire the

[11]*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.*

expertise to create, inoculate, and maintain these control agents in areas where significant stands of purple loosestrife occur.

Informational and Educational Programming
In addition to the in-lake rehabilitation methods, an ongoing campaign of community informational programming can 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, a community information campaign should emphasize the need to clean boats and motors/propellers when removing boats from the Lake and upon launching boats into the Lake to limit the redistribution of invasive organisms. Plants removed from boats and motors should be retained onboard and/or disposed of by composting at the boat launch or homestead to avoid their being reintroduced into the water. An informational program can also remind riparian residents and others of the habitat and ecological benefits, such as shoreline stabilization, provided by the aquatic flora of the Lake, thereby promoting the preservation of a healthy aquatic flora in the Lake.

In addition to informational programming, educational programs such as Project WET, Adopt-A-Lake, and other school-based programs can help to build community awareness of the value of lake ecosystems, and the need for vigilance on the part of individual citizens and households within the drainage area tributary to the Lake. School groups and other community service organizations also form a cadre of volunteers that can assist in shoreland management programs and in the dissemination and conduct of community informational programs. Thus, ongoing informational and educational programming is recommended.

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

It is recommended that continued aquatic macrophyte surveys be conducted at about three- to five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of: major areas of nuisance plant growth; areas harvested and/or chemically treated, species harvested and amounts of plant material removed from the lake, and species and approximate numbers of fish caught in the harvest. 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.

At such time as the harvestable acreage meets and exceeds the 40-acre threshold established by the Wisconsin Waterways Commission pursuant to the aforementioned Chapter NR 7 authorities, the Pike Lake Protection and Rehabilitation District should consider the implementation of an aquatic plant harvesting program on Pike Lake.[12] Use of an aquatic plant harvester with a maximum harvesting depth of about five feet, and a width of harvesting of about seven feet, is recommended. This is a moderately sized aquatic plant harvester that can achieve an average daily output of harvested aquatic plant material that will allow the District to service most of the Lake on a four- to six-week cycle, which is consistent with the use of the canopy removal harvesting methodology

[12]*Aquatic plant growth in Pike Lake is the result of both in-lake nutrient concentrations and nutrient concentrations in the lake sediments. Sediment nutrients reflect the history of the Lake and the nutrient loads delivered to the Lake over time. As a result, reductions in nutrient loading are not immediately translated into reduced growths of aquatic plant, but, rather, are subject to a "lag period" during which the accumulated reserves of phosphorus are depleted. In the case of Pike Lake, this period may range from about three to six years based upon the mean water residence time of the Lake; see Sven-Olof Ryding and Walter Rast,* The Control of Eutrophication of Lakes and Reservoirs, *Unesco Man and the Biosphere Series, Volume 1, Parthenon Press, Carnforth, 1989; see also Jeffrey A. Thornton, Walter Rast, Marjorie M. Holland, Geza Jolankai, and Sven-Olof Ryding,* The Assessment and Control of Nonpoint Source Pollution of Aquatic Ecosystems, *Unesco Man and the Biosphere Series, Volume 23, Parthenon Press, Carnforth, 1999.*

illustrated in Figure A-2, as recommended in the lake management plan for Pike Lake. The objective of this aquatic plant management program is to enhance the use of Pike Lake while maintaining the quality and diversity of the biological communities. Should aquatic plant harvesting be adopted, the following recommendations are made:

1. Mechanical harvesting is recommended as a primary management method of large-scale aquatic plant management. 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. Surface harvesting is recommended, cutting to a depth 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 Pike Lake will be minimized, and some degree of cover will continue to be provided for panfish populations which support the bass population in the Lake. Further, cutting should not be broad-based, but focused on boating channels and selected navigation areas. 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.

2. 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. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners. It is recommended that chemical applications, if required, be made by licensed applicators in early spring subject to State permitting requirements to maximize their effectiveness on nonnative plant species, while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions. Such use should be evaluated annually and the herbicide applied only on an as needed basis. Only herbicides that selectively control milfoil, such as 2,4-D and fluridone, should be used. Periodic use of algicides, such as Cutrine Plus, is recommended to control significant, recurring growths of filamentous or planktonic algae in the Lake.

3. For the control of purple loosestrife in wetland areas adjacent to and around Pike Lake, the use of biological control agents such as the purple loosestrife beetles is recommended. These beetles can be locally grown and inoculated into stands of purple loosestrife by local volunteers under the guidance of the Wisconsin Department of Natural Resources. To this end, local civic groups or schools in the Hartford Union High School and Slinger School Districts should be encouraged to adopt the raising of purple loosestrife beetles as part of their community involvement programming.

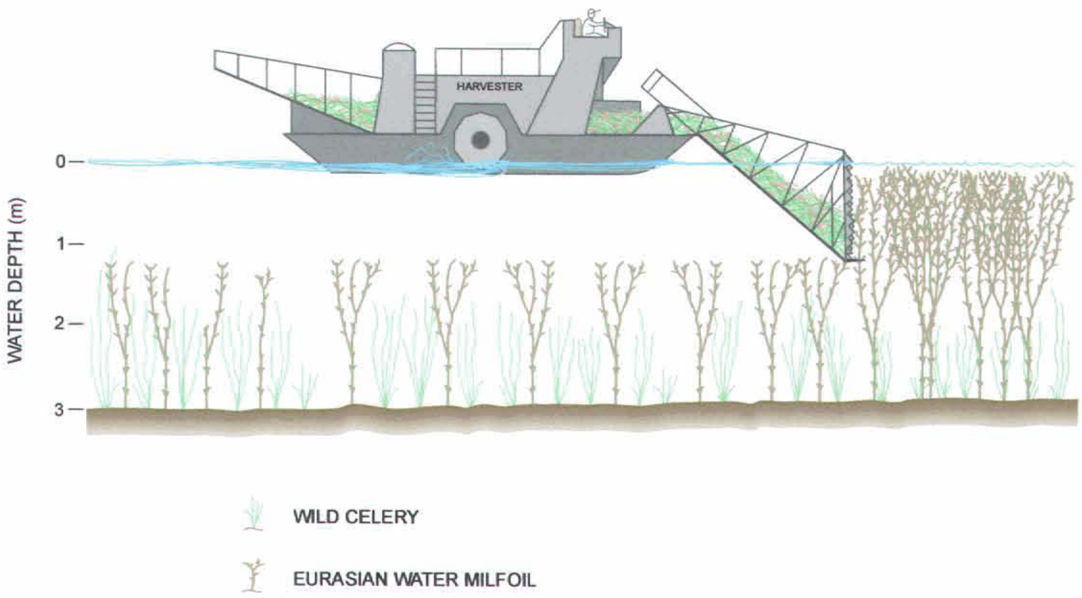
4. The control of rooted vegetation between adjacent piers is recommended to be left to the riparian owners concerned, as it is time consuming and costly for a mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. The Pike Lake Protection and Rehabilitation District may wish to obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to inform residents of the control options available.

5. The collection of aquatic plant fragments and other debris along shoreline areas by the Pike Lake Protection and Rehabilitation District is recommended.

6. It is recommended that the shallow littoral and wetland areas at the northern and southern extremes of the Lake be excluded to the extent possible from aquatic plant management activities, especially during fish spawning seasons in early summer and autumn. To this end, exclusion of the shoreline and littoral areas of the Lake in the vicinity of the inlet and outlet of the Lake, as suggested in the previously referenced WDNR fisheries management memorandum, is recommended.

Figure A-2

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.

7. It is further recommended that the Pike Lake Protection and Rehabilitation District conduct a public informational program on the types of aquatic plants in Pike 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 that also would include information on related topics, such as water quality, recreational use, and fisheries.

The recommended aquatic plant control areas are summarized in Table A-5 and shown on Map A-4. The control measures in each area are designed to optimize desired recreational opportunities and to protect the aquatic resources.

The recommended aquatic plant management plan represents the initiation of an active aquatic plant management program on the Lake to be conducted by the Pike Lake Protection and Rehabilitation District. Implementation of this plan would entail a capital cost of about $100,000, the majority of which would be required for the eventual acquisition of equipment. Cost-share funding may be available for the acquisition of replacement equipment under the Chapter NR 7 Recreational Boating Facilities Grant Program administered by the Wisconsin Waterways Commission. Annual operation and maintenance costs of about $20,000 are estimated to be incurred by the District for the conduct of this program.

Depth of Harvesting and Treatment of Fragments

The H-620 aquatic plant harvester has a maximum cutting depth of 5.6 feet, while the H-420 aquatic plant harvester has a five-feet maximum cutting depth. While these depths exceed the actual water depth of approxi-

Table A-5

RECOMMENDED AQUATIC PLANT MANAGEMENT TREATMENTS FOR PIKE LAKE

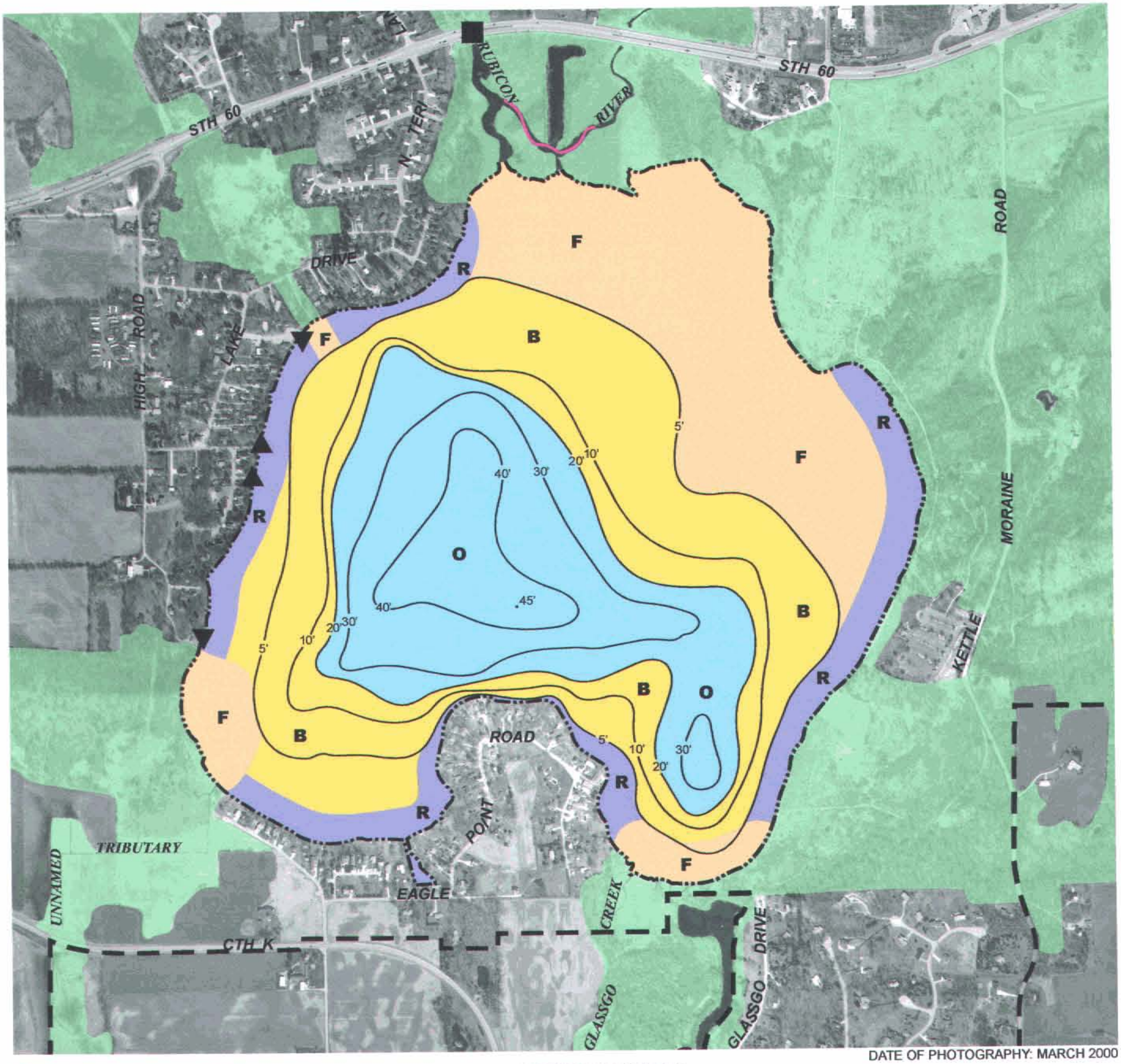
Zone and Priority	Recommended Aquatic Plant Management Treatment
Zone B (general boating and fishing uses) High-Priority Aquatic Plant Control	Harvesting limited to maintaining 30-foot-wide navigational channels, and 30-foot-wide shared access lanes perpendicular to the shoreline extending towards the center of the Lake to allow boat access to the open water area of the Lake, as necessary Limited early season harvesting, late May to early June, may be necessary to provide for fish reproduction within the Lake Chemical use should be restricted to selective control of nuisance species Zone B is intended to accommodate fishing from a boat
Zone F (habitat) No Aquatic Plant Control	It is recommended that selected areas of the Lake be preserved as high-quality habitat area This zone and adjacent lands should be managed 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 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
Zone O (open water) No Aquatic Plant Control	This zone includes areas greater than 15 feet in depth that require no aquatic plant management, and which are used primarily for fishing and boating activities
Zone R (riparian access) Moderate-Priority Aquatic Plant Control	The entire area may not require intensive plant management Nuisance aquatic macrophyte growth within 1,250 feet of the shoreline should be managed so as to provide maximum opportunities for boating, fishing, and limited swimming Areas between piers should not be harvested due to potential liability and maneuverability problems. Residents are encouraged to manually harvest aquatic plants in these areas. Limited applications of aquatic herbicides may be allowed for the control of nuisance species Harvesting limited to maintaining 30-foot-wide navigational channels, and 30-foot-wide shared access lanes perpendicular to the shoreline extending towards the center of the Lake to allow boat access to the open water area of the Lake, as necessary Aquatic plant management activities should be concentrated in areas of abundant macrophyte growth Patterns of harvesting and herbicide treatment will vary yearly dependant on macrophyte abundance Chemical use should be restricted to pier and dock areas and should not extend more than 100 feet from shore; subject to permit requirements
Approximate Total Area to Be Managed	35 acres

Source: SEWRPC.

mately 40 percent of the Lake, it is not the intention of the owners or operators of the equipment to denude the Lake of aquatic plants, given the intensive angling use of the waterbody; its morphology, in which portions may not be conducive to extensive motorized boat traffic; and the program goals. Sufficient plant materials will be retained in the Lake 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*, to the extent practicable, by the harvesters. Those fragments accumulating along the shoreland areas will be collected by the riparian homeowners. Fragments collected by the homeowners can be used as garden mulch and compost.

Map A-4

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR PIKE LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

—20'— WATER DEPTH CONTOUR IN FEET

■ WATER LEVEL CONTROL STRUCTURE

▲ PUBLIC ACCESS SITE (RECONSTRUCT TO LIMIT RUNOFF)

▼ PRIVATE ACCESS SITE

AQUATIC PLANT MANAGEMENT

- **B** BOATING / RECREATION: SURFACE CUT OF EURASIAN WATER MILFOIL, HARVESTING MODERATE PRIORITY
- **R** RIPARIAN ZONE: MAINTAIN SHORELINE PROTECTION STRUCTURES AS NECESSARY INSTALL VEGETATIVE BUFFERS, MANUALLY HARVEST AQUATIC PLANTS AROUND PIERS AND DOCKS
- **F** FISH BREEDING AND HABITAT/ANGLING AREAS - NO AQUATIC PLANT MANAGEMENT MEASURES RECOMMENDED DURING FISH BREEDING SEASON
- **O** OPEN WATER: DEPTH GREATER THAN 20 FEET - NO AQUATIC MANAGEMENT MEASURES RECOMMENDED

LAND USE MANAGEMENT

- PROTECT ENVIRONMENTAL CORRIDOR LANDS
- OBSERVE GUIDELINES SET FORTH IN LOCAL AND REGIONAL LAND USE PLANS, MAINTAIN HISTORIC LAKEFRONT RESIDENTIAL DWELLING DENSITIES
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS
- BOUNDARY OF HARTFORD SANITARY SEWER SERVICE AREA

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES SELF-HELP MONITORING PROGRAM
- IMPLEMENT RUNOFF MANAGEMENT PRACTICES

FISHERIES MANAGEMENT

- CONTINUE TO MONITOR FISH POPULATIONS, MODIFY STOCKING/ HARVESTING PROGRAM AND REGULATIONS, AS NECESSARY

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

GRAPHIC SCALE
0 600 1200 FEET

Source: SEWRPC.

Buoyage

Temporary marker buoys, or the Global Positioning System (GPS), may be used to direct harvesting operations in the lake basin by marking the areas to be cut. The size of the Lake may warrant the use of such buoys. Notwithstanding, 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 will be regularly supervised by Lake Management District staff.

Harvested Plant Material Disposal and Transfer Site(s)

Plant material will be removed from the harvesters on a transporter and conveyed to an off-loading area, where it will be transferred to a dump truck using a conveyor and transported to disposal sites identified by the Pike Lake Management District and the Town of Hartford. 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 launch site. The operators will stringently monitor the off-loading site to ensure minimal disruption of boaters and of the people using the riparian areas of the Lake.

Precautions to Protect Wildlife and Ecologically Valuable Areas

As noted above, harvester operators will be provided with a laminated copy of the approved harvesting plan map and operational sequence chart, as set forth in Map A-4 and Figure A-3, showing the limits and priorities of harvesting operations. A copy of these items will be kept on the harvesters at all times. Operations will be prohibited in the Wisconsin Department of Natural Resources identified NR 107 sensitive 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 Informational Programming

It is the policy of the Pike Lake Protection and Rehabilitation 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 Pike Lake Protection and Rehabilitation District holds regular public informational meetings serving both community members and the schools within their jurisdiction.

Harvesting Schedule

The harvesting season should begin no earlier than mid May and will end no later than mid October of each year. Harvesting should average 40 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 A-4.

EQUIPMENT NEEDS AND OPERATION

At such time as the harvestable acreage meets and exceeds the 40-acre threshold established by the Wisconsin Waterways Commission pursuant to the aforementioned Chapter NR 7 authorities, the Pike Lake Management District should consider the acquisition of a model H-420 or model H-620 harvester or equivalent, and a shore conveyor, each with 10-year anticipated life spans. Acquisition of one harvester and one shore conveyor when necessary may be expected to cost between about $70,000 and $100,000, depending upon the specific model of the harvester purchased, and $22,500, respectively.

Figure A-3

AQUATIC PLANT MANAGEMENT ACTION SEQUENCE FOR PIKE LAKE

A. HARVEST 30-FOOT-WIDE CHANNELS TO OPEN WATER WITHIN **ZONE R**, AS SHOWN ON MAP A-4

B. HARVEST 30-FOOT-WIDE CHANNELS TO OPEN WATER WITHIN **ZONE B**, PERPENDICULAR TO THE SHORELINE, AS SHOWN ON MAP A-4

C. HARVEST, OR APPLY CHEMICAL CONTROL AGENTS IF NECESSARY TO, NUISANCE GROWTHS OF EURASIAN WATER MILFOIL AND CURLY-LEAF PONDWEED WITHIN **ZONE O**, AS SHOWN ON MAP A-4

D. MAINTAIN HABITAT AREAS WITHIN **ZONE F** AS SHOWN ON MAP A-4[a]

NOTE: Sequence A and B could be done concurrently in one area of the Lake as a time-saving measure.

[a]*No harvesting would be conducted in Zone F.*

Source: SEWRPC.

Harvester/Transporter: Aquarius Systems Model H-420 or equivalent, or Aquarius Systems Model H-620 or equivalent.

Shore Conveyor: Aquarius Systems Model S/C-34 or equivalent.

Costs:

Aquatic Plant Harvester with 10,500 or 12,000 pound capacity	$100,000
Shore conveyor	$ 22,500
Total Costs	$122,500

Maintenance Schedule, Storage, and Related Costs

Routine maintenance will be performed on the respective harvesters by the Pike Lake Protection and Rehabilitation District in accordance with the manufacturer's recommended maintenance schedule. Maintenance costs will be borne by the Pike Lake Protection and Rehabilitation District. Winter storage of the harvesting equipment will be the responsibility of the Pike Lake Protection and Rehabilitation District.

Insurance Coverage
Insurance coverage on the harvester will be incorporated into the policy held by the Pike Lake Protection and Rehabilitation District. Liability insurance for the operation of the harvester will also be borne by the District. The relevant certificates of insurance will be held by the Chairperson of the Pike Lake Protection and Rehabilitation District.

Operators, Training, and Supervision
The harvester will be owned and operated by the Pike Lake Protection and Rehabilitation 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 the manufacturer on delivery of the machinery.

Day-to-day supervision will be by the Pike Lake Protection and Rehabilitation District staff.

MONITORING AND EVALUATION

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 Pike Lake Protection and Rehabilitation District Commission, and made available to the public at that time.

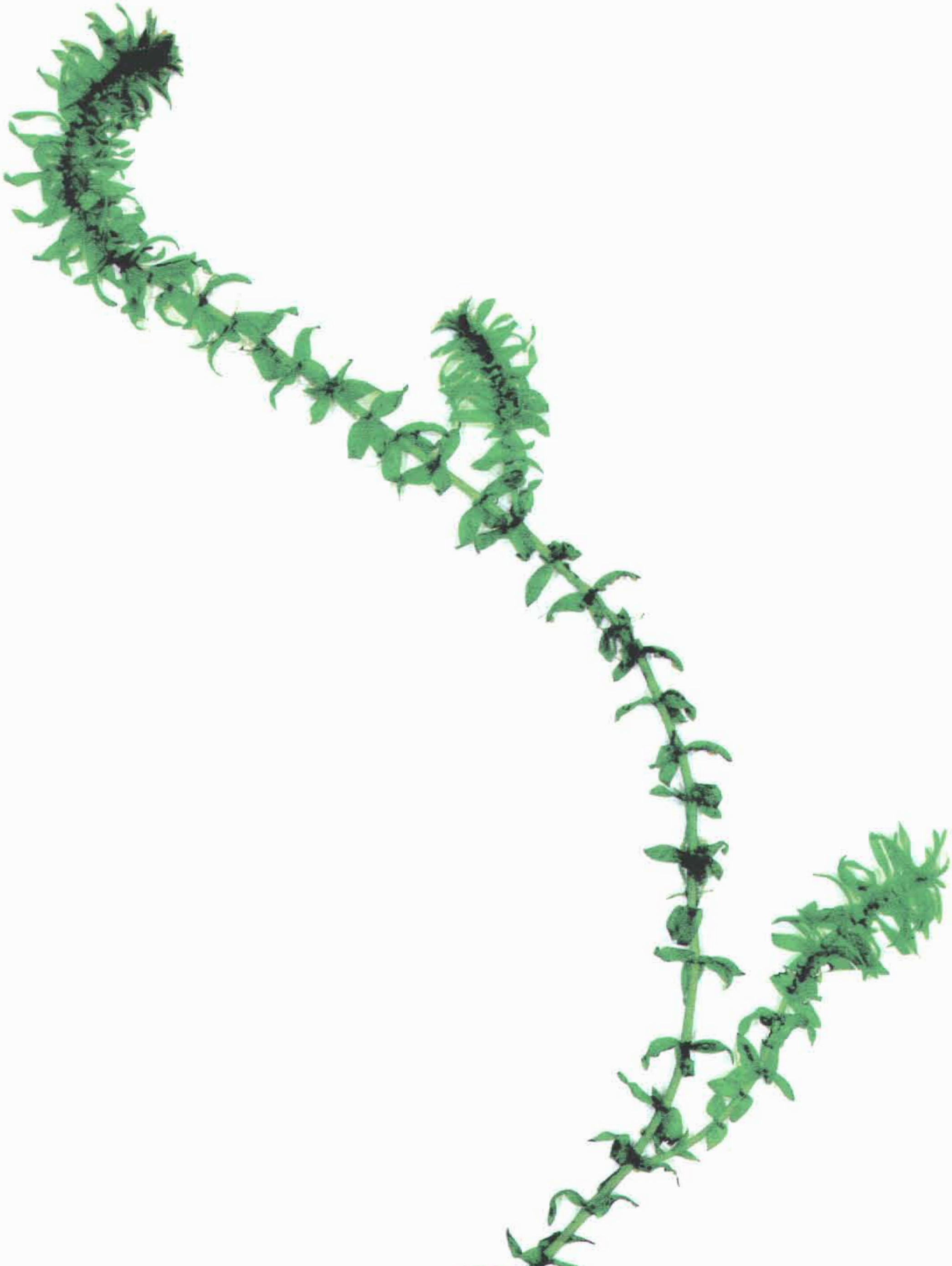
It is the intention of the Pike Lake Protection and Rehabilitation District to undertake the lead in a periodic, formal review of the harvesting program as set forth in the Management Plan for Pike Lake, a copy of which has been lodged with the WDNR's Southeast District Office.

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.

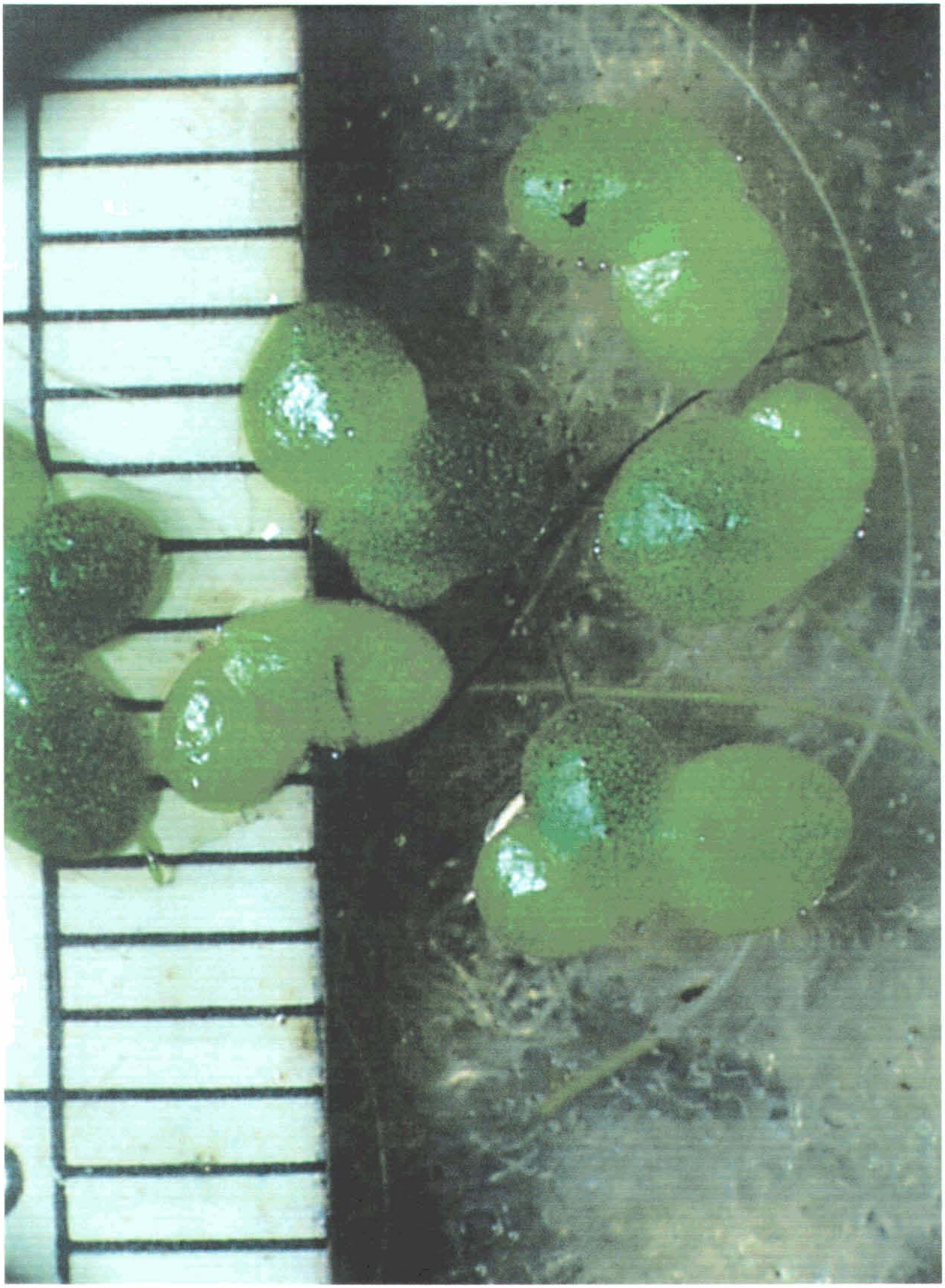
ILLUSTRATIONS OF COMMON AQUATIC PLANTS FOUND IN PIKE LAKE

Coontail (*ceratophyllum demersum*)

Muskgrass (*chara vulgaris*)



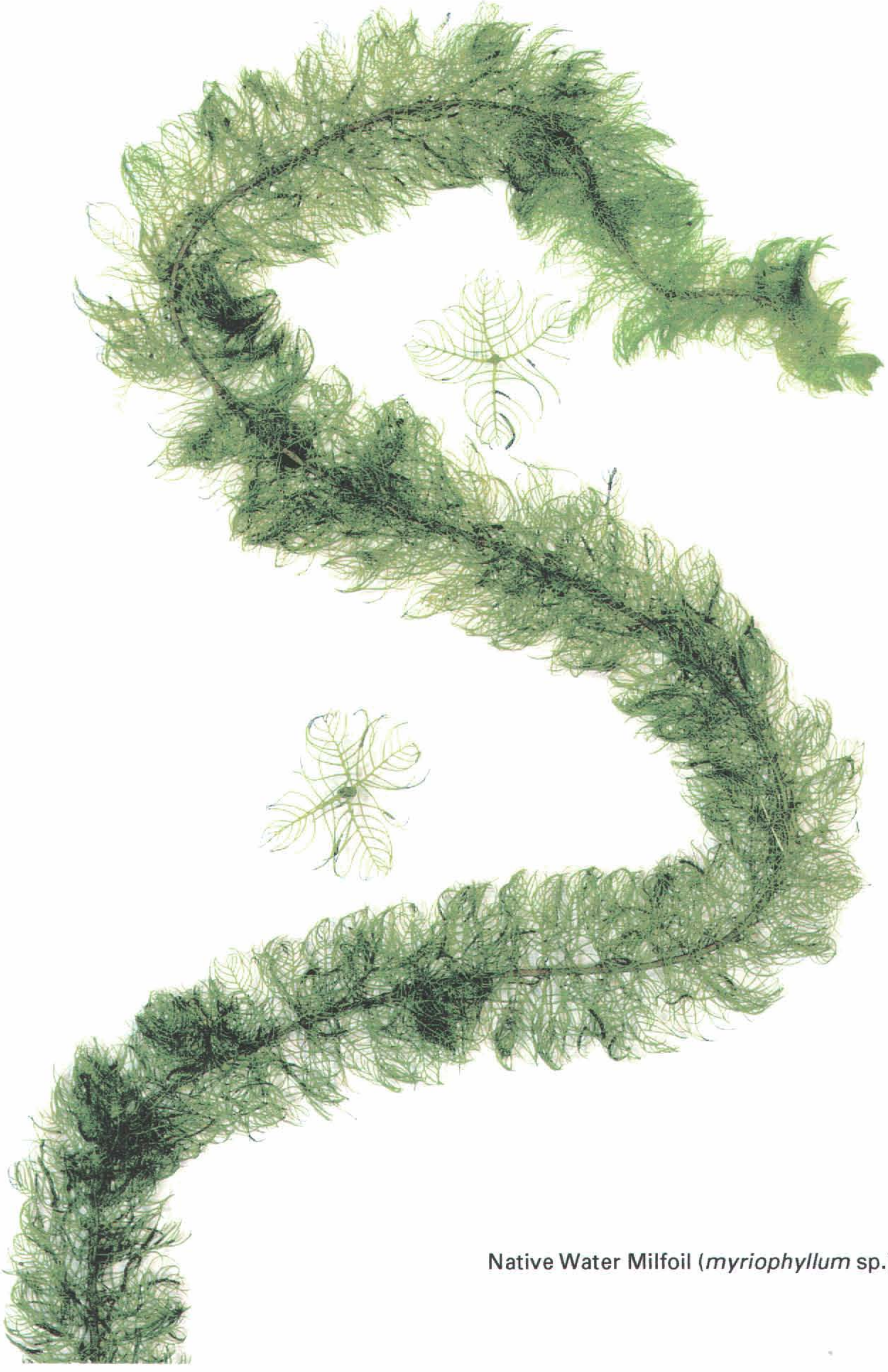
Waterweed (*elodea canadensis*)



Lesser Duckweed (*lemna minor*)

NOTE: Plant species in photograph are not shown proportionate to actual size

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



Native Water Milfoil (*myriophyllum* sp.)

Eurasian Water Milfoil (*myriophyllum spicatum*)

Bushy Pondweed (*najas flexilis*)

Spiny Naiad (*najas marina*)

Curly-Leaf Pondweed (*potamogeton crispus*)

Variable Pondweed (*potamogeton gramineus*)

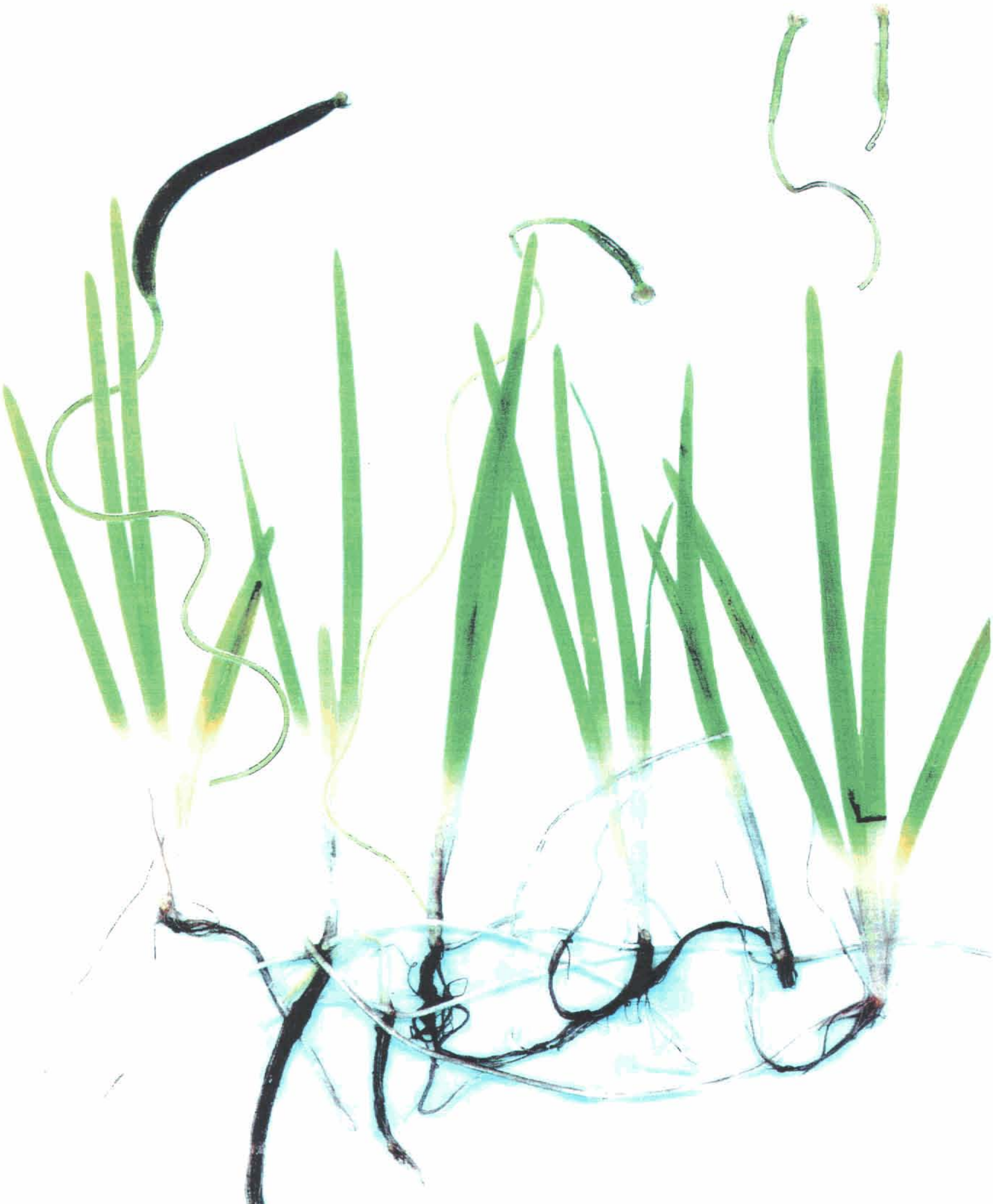
Illinois Pondweed (*potamogeton illinoensis*)

Floating-Leaf Pondweed (*potamogeton natans*)

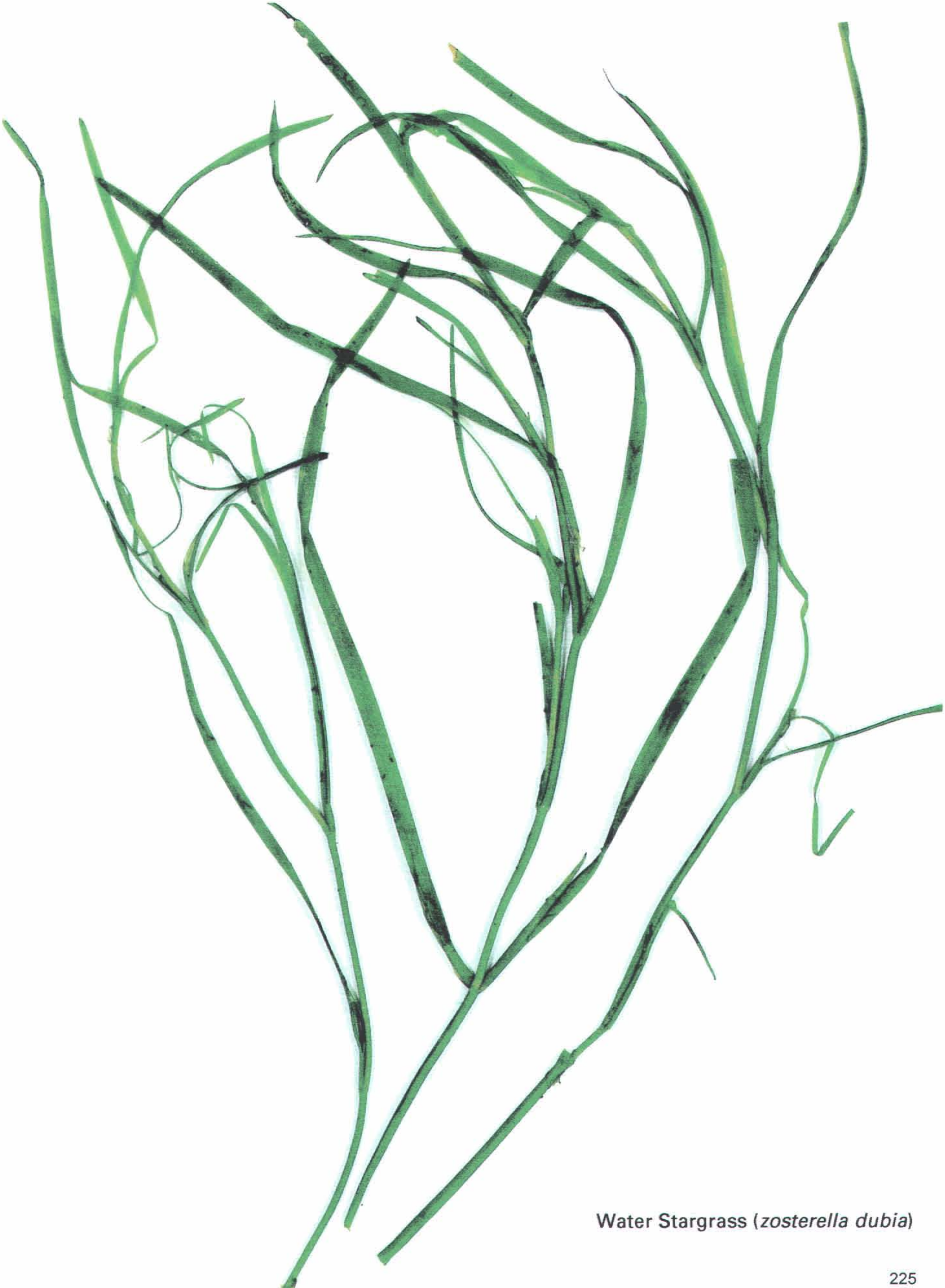
Sago Pondweed (*potamogeton pectinatus*)

Clasping-Leaf Pondweed
(*potamogeton richardsonii*)

Flat-Stem Pondweed (*potamogeton zosteriformis*)



Eel Grass / Wild Celery (*valisneria americana*)



Water Stargrass (*zosterella dubia*)

Appendix B

SWIMMING AND BOATING REGULATIONS FOR PIKE LAKE

CHAPTER 11

LAKES AND WATERS

11.01 APPLICABILITY AND ENFORCEMENT. The provisions of this chapter shall apply to the waters and to persons, vessels, objects or things upon the waters of Pike Lake within the jurisdiction of Resources, which waters are described as a meandered lake in Township 10 North Range 18 East, Town of Hartford, Washington County, Wisconsin. The provisions of this chapter shall be enforced by all officers of the Town.

11.02 STATE BOATING AND WATER SAFETY LAWS ADOPTED. The statutory provisions describing and defining regulations with respect to water traffic, boats, boating and related water activities in the following enumerated sections of the Wisconsin Statutes, exclusive of any provisions therein relating to the penalties to be imposed or the punishment for violation of said statutes, are hereby adopted and by reference made a part of this chapter as if fully set forth herein. Any act required to be performed or prohibited by the provisions of any statute incorporated by reference herein is required or prohibited by this chapter.

30.50	Definitions
30.51	Operations of Unnumbered Boats Prohibited
30.52	Certificate of Number
30.53	Identification Number to be Displayed on Boat: Certificate to be Carried
30.54(2)	Transfer of Ownership of Numbered Boat
30.55	Notice of Abandonment or Destruction of Boat or Change of Address
30.60	Classification of Motor Boats
30.62	Classification of Motor Boats
30.64	Patrol Boats Exempt from Certain Traffic Regulations
30.65	Traffic Rules
30.66	Speed Restrictions
30.67	Accidents and Accident Reports
30.68(1)(a)	Operating With Alcohol Concentration at or Above Specified Levels
30.684(5)	Refusal to Take Chemical Test
30.69	Water Skiing
30.70	Skin Diving
30.71	Boats Equipped With Toilets
30.74	Personal Watercraft Operators

11.03 PUBLIC SWIMMING ZONES. (1) All beaches used by the public shall be identified by markers placed by the owners of such beach. The marker size, design, placement and symbols are to be as prescribed by the Wis. Adm. Code NR 5.09.

(2) No boat of any description shall be allowed in an area so marked.

(3) Any person desiring to designate an area as a public swimming zone shall obtain a permit from the Town Board prior to the placement of the required markers.

(4) This section does not apply in the case of an emergency, or to a patrol or rescue craft.

11.04 SPEED RESTRICTIONS. (1) CREATING HAZARDOUS WAKE OR WASH. No person shall operate a motor boat so as to approach or pass another boat in such a manner as to create a hazardous wake or wash.

(2) HOURS. No person shall operate a motor boat at a speed in excess of a slow-no-wake speed between the hours of 8:00 P.M. or legal sunset, whichever comes sooner, and 10:00 A.M., except that on Saturdays and Sundays no person shall operate a motor boat at a speed in excess of slow-no-wake speed between the hours of 6:00 P.M. and 10:00 A.M.

(3) SLOW-NO-WAKE AREAS. No person shall operate a motor boat at a speed greater than slow-no-wake in areas which have been designated and posted for such speed with regulatory markers. The Town Board, in cooperation with the Pike Lake Protection District, may, from time to time, identify and have marked as slow-no-wake areas such portions of the lake in which, due to shallowness of water, vegetation growth, lake bottom conditions or other factors, the slow-no-wake speed restrictions should be imposed in order to protect water quality or the health, safety and general welfare of lake users.

11.05 ADDITIONAL TRAFFIC RULES. In addition to the traffic rules in §30.65, Wis. Stats., adopted in sec. 11.02 of this chapter, boats propelled by muscular power shall yield the right of way to sail boats when necessary to avoid risk or collision.

11.06 RAFTS AND STRUCTURES. No person shall erect or maintain any raft or stationary structure outside of a public swimming zone unless the sides of any such raft or structure are painted white and it is so anchored that it has at least 12 inches of free board.

11.07 SWIMMING REGULATIONS. (1) DISTANCE FROM SHORE AND BOATS. No person shall swim more than 100 feet from the shore or more than 30 feet from an anchored raft unless he is accompanied by a suitable boat.

(2) HOURS LIMITED. No person shall swim more than 50 feet from the shore line or a pier or more than 30 feet from an accompanying boat between one hour after legal sunset and one hour before legal sunrise.

11.08 WATER SKIING, SURF BOARDS AND SIMILAR DEVICES. (1) TOWING REQUIREMENTS. No person shall operate a boat for the purpose of towing a person on water skis, surf boards or similar devices or permit himself to be towed for such purpose unless there are 2 persons in such boat.

(2) HOURS. No person shall operate a boat for the purpose of towing a water skier, surf board or similar device between the hours of 8:00 P.M. or legal sunset, whichever comes first, and 10:00 A.M., except that on Saturdays and Sundays no person shall operate a boat for the purpose of towing a water skier, surf board, or similar device between the hours of 6:00 P.M. and 10:00 A.M.

(3) LIFE PRESERVER REQUIRED. No person shall water ski, aquaplane or otherwise be towed by a boat without wearing an approved U.S. Coast Guard-type life preserver.

(4) PROHIBITED METHODS OF OPERATION. No person shall operate a boat for the purpose of towing a water skier, surf board or similar device within 100 feet of a canoe or anchored boat.

11.09 RACE, REGATTA, SPORTING EVENT AND EXHIBITION PERMITS. (1) REQUIRED. No person shall direct or participate in any public boat race, regatta, water ski meet or other water sporting event or exhibition unless such event has been authorized by the Town Board and a permit issued therefor by the Water Safety Patrol Officer.

(2) PROVISIONS. A permit issued under this section shall specify the course or area of water to be used by participants in such event and the permittee shall be required to place markers, flags or buoys approved by the Water Safety Patrol Officer designating the specified area. Permits shall be issued only if, in the opinion of the Water Safety Patrol Officer, the proposed use of the water can be carried out safely and without danger or substantial obstruction to other vessels or persons using the lake. Permits shall be valid only for the hours and area specified thereon. In the event that the Water Safety Patrol Officer denies a permit under this section, the applicant shall have the right to seek a review of the denial with the Town Board within 48 hours after said denial.

11.10 LITTERING OF WATERS PROHIBITED. No person shall deposit, place or throw from any boat, raft, pier, platform or similar structure any cans, bottles, debris, refuse, garbage, solid or liquid waste into the waters of the lake.

11.11 MARKERS AND NAVIGATING AIDS REQUIRED. (1) DUTY OF WATER SAFETY PATROL OFFICER. The Water Safety Patrol Officer is authorized and directed to place and maintain suitable markers, navigation aids and signs in such areas of the lake as shall be appropriate to advise the public of the provisions of this chapter and to post and maintain a copy of this chapter at all public access points within the jurisdiction of the Town. Any person aggrieved by the placement of markers, aids or signs by the Water Safety Patrol Officer shall have the right to petition the Town Board for a review of the placement.

(2) STANDARD MARKERS. All markers placed upon the waters of Pike Lake shall comply with the regulations of the Department of Natural Resources.

(3) INTERFERENCE WITH MARKERS PROHIBITED. No person shall, without authority, remove, damage or destroy or moor or fasten, (except to mooring buoys) any water craft to any buoy, beacon or marker placed in the waters of the lake by the authority of the United States, the State or the Town or by any private person pursuant to the provisions of this chapter.

11.12 COMMERCIAL PASSENGER BOATS PROHIBITED. No person shall operate a boat maintained for the purpose of carrying fare-paying passengers.

11.13 SUBORDINATE OFFICERS. In the absence of the Water Safety Patrol Officer, any subordinate Water Safety Patrol Officer may act in his stead in every instance in this chapter.

11.14 DEPOSIT SCHEDULE. Every police officer or Water Safety Patrol Officer or subordinate Water Safety Patrol Officer issuing a citation for violation of this chapter shall indicate on the citation the amount of the deposit, including the penalty assessment and court costs that the alleged violator may make in lieu of court appearance. The amount of the deposit shall be determined in accordance with the State of Wisconsin Revised Uniform Deposit and Bail Schedule for Conservation, Boating, Snowmobile and ATV Violations, which is hereby adopted by reference and made a part thereof.

11.15 PENALTIES. Any person violating the provisions of this chapter shall forfeit not more than $350 for the first offense and shall forfeit not more than $500 upon conviction of the same offense a second or subsequent time within one year.

11.16 SEVERABILITY. If any provision of this chapter is determined to be invalid or unconstitutional, or if the application of this chapter to any person or circumstance is invalid or unconstitutional, such invalidity or unconstitutionality will not affect the other provisions or applications of this chapter which can be given effect aside from the invalid or unconstitutional provisions or application.

11.17 PUBLICATION. This chapter shall, in accordance with §60.80(2), Wis. Stats., take effect the day after its publication as a Class I notice under Ch. 985, Wis. Stats.

Appendix C

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 C-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 C-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 C-2.

---

[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 C-1

GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF NONPOINT SOURCE WATER POLLUTION ABATEMENT

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 wastes on streets and residential, commercial, industrial, and recreational areas	2 to 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 to 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 to 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 to $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 to $10,000 with an annual operation and maintenance cost of $250. A holding tank would cost $5,500 to $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 to 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 to 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 to $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 to 5	Determine curb-miles for street sweeping; vary percent of urban areas 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 C-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 schedules; increase cleanup of parks and commercial centers	2 to 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 to 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 to $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; construct onsite stormwater storage measures for subdivisions	5 to 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 operation and 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 to 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 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 to $350 for the trench and 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 to 35	Design all storage facilities for a 1.5-inch 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 to $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 to 50	To be applied only in combination with stormwater storage facilities above; general cost estimates for microstrainer treatment and ozonation were used; some costs were applied to existing urban land and proposed new urban development. Stormwater treatment has an estimated capital cost of from $900 to $7,000 per acre of tributary drainage area, with an average annual operation and maintenance cost of about $35 to $100 per acre

Table C-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, woodlot management, fertilization and pesticide management, and chisel tillage	Up to 50	Cost 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 to $5,000 per acre of rural land, with an average annual operation and maintenance cost of from $5.00 to $10 per rural acre
	Animal waste control system	Construct streambank 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 to 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 to 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 $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 to 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
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 for management programs, and the effects of implemented measures; develop local awareness programs for citizens and public works officials; develop local contract and education efforts	Indeterminate	For first 10 years, includes cost of one person, materials, and support for each 25,000 population. Thereafter, the same cost can be applied for every 50,000 population. The cost of one person, materials, and support is estimated at $55,000 per year

Table C-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban and Rural (continued)	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 to 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 to $5,500 and $250 to $1,500 per acre under construction, respectively
	Materials storage and runoff control facilities	Enclose industrial storage sites with diversion; divert runoff to acceptable outlet or storage facility; enclose salt piles and other large storage sites in crib and dome structures	5 to 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 stream; construct streambank protection measures, such as rock riprap, brush mats, tree revetment, jacks, and jetted willow poles, where needed	5 to 10	Apply a 50-foot-wide vegetative buffer zone on each side of 15 percent of the stream length; apply streambank 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 to 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	Indeterminate	Indeterminate

[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.

Of the sets of practices recommended for various levels of diffuse source pollution control presented in Table C-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.

Table C-2

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

Pollution Control Category	Level of Pollution[a] Control	Practices to Control Diffuse Source Pollution from Urban Areas[b]	Practices to Control Diffuse Source Pollution from Rural Areas[a]
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[c]	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[b]

[a]*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.*

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

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

Source: SEWRPC.