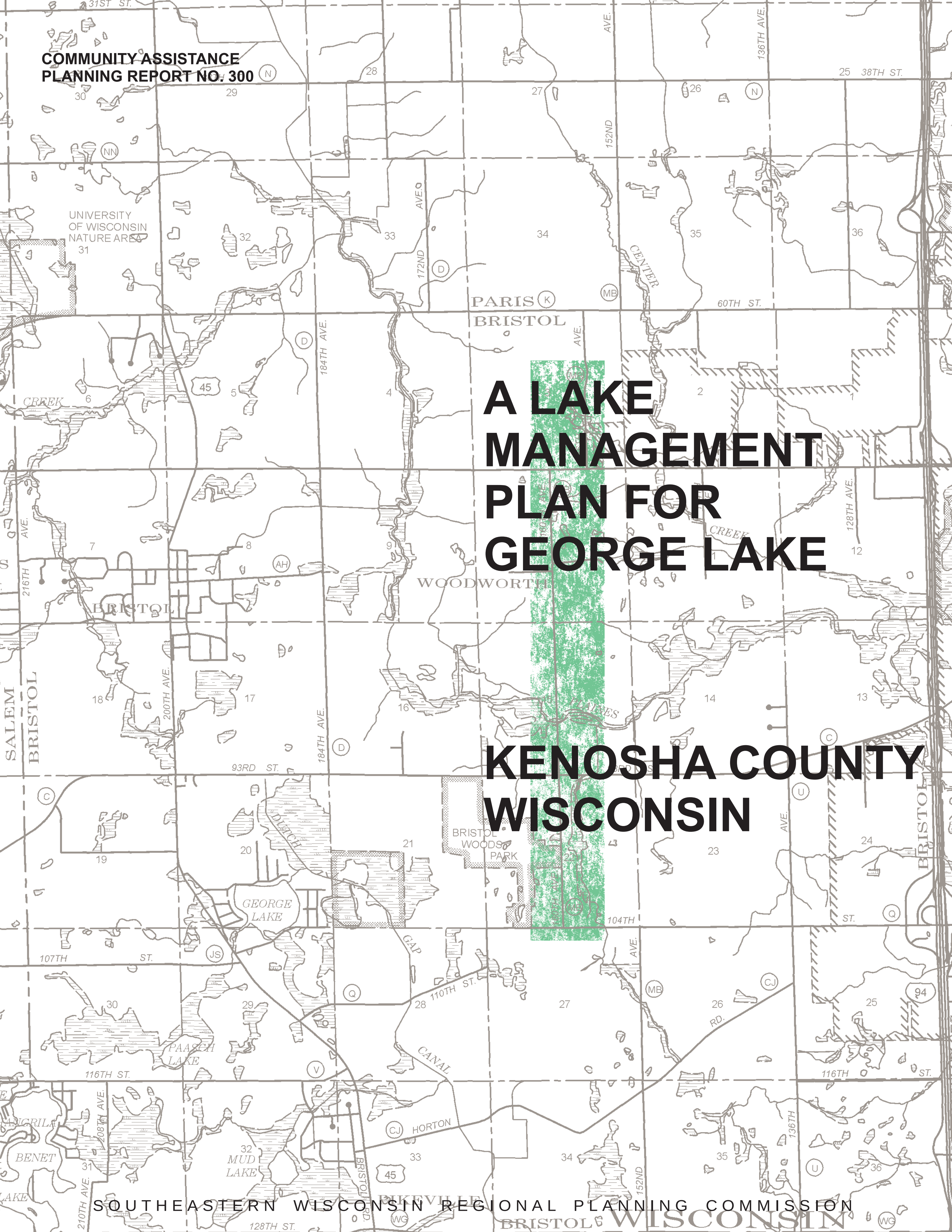
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 300



A LAKE MANAGEMENT PLAN FOR GEORGE LAKE

KENOSHA 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. Edward J. Schmidt, SEWRPC GIS Planning Specialist; and, Mr. Michael A. Borst and Ms. Sara Wilder Teske, SEWRPC Research Aides, for their contributions to the conduct of this study and the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 300

A LAKE MANAGEMENT PLAN FOR GEORGE LAKE
KENOSHA 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.

August 2007

$20.00

(This page intentionally left blank)

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

Table | Page

Chapter VI

Chapter VII

Chapter VIII

LIST OF FIGURES

Figure | Page

Chapter II

Chapter IV

Chapter V

Figure Page

Chapter VII

LIST OF MAPS

Map Page

Chapter II

Chapter III

Chapter V

Chapter VI

Chapter VIII

(This page intentionally left blank)

Chapter I

INTRODUCTION

George Lake is a 59-acre[1] lake located within U.S. Public Land Survey Sections 20 and 29, Township 1 North, Range 21 East, Town of Bristol, Kenosha County. The tributary area draining to the Lake is about 2,187 acres. The Lake is a drained lake, although it does have two intermittent inlets, both draining lands located to the west of the Lake and USH 45 in the Towns of Bristol and Salem: the first, located along the western shore of the Lake, drains a marsh and lowland area; the other, located along the southwestern shore of the Lake, drains a large marsh complex containing Paasch Lake. George Lake is drained through an outlet located at the northeastern corner of the Lake that connects by way of a small unnamed stream to the Dutch Gap Canal, a tributary to the Des Plaines River. Water levels in George Lake are maintained by a small impoundment located at this outlet.

George Lake is an important asset to the residents of Kenosha County and the Southeastern Wisconsin Region. The Lake's location, being approximately equidistant from the metropolitan areas of Milwaukee and Chicago, within the major urban development corridors of IH 94 and USH 45, together with its proximity to the rapidly growing urban centers of the Village of Pleasant Prairie and the Town of Bristol in south central Kenosha County, make it a popular recreational destination for residents of and visitors to the State. The Lake is the central feature of a small urban density residential community dwelling in the shoreland zone.

The current water use objectives for George 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 respect to the recreational usage, George Lake provides significant opportunities for lake-oriented recreation and is considered to have adequate public recreational boating access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*. Notwithstanding, during recent years, George 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.

---

[1]*In Aron and Associates,* George Lake Watershed Evaluation Planning Grant, *1993, and on the Wisconsin Department of Natural Resources (WDNR) official lake map for George Lake, the area of George Lake is reported to be 70 acres, as measured from 1952 aerial photographs. This difference 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 actual changes in lake water levels as well as some possible shoreline in-filling that may have taken place since the 1952 determination.*

Seeking to improve the usability of George 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 George Lake Rehabilitation District (GLRD),[2] at their 2002 annual meeting, resolved that a lake management plan be prepared for George Lake. For this purpose, the GLRD 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). Subsequently, the GLRD requested the Southeastern Wisconsin Regional Planning Commission (SEWRPC) to complete a lake management plan for the Lake. To this end, this lake management plan represents part of the ongoing commitment of the GLRD, and the Towns of Bristol and Salem, to the sound environmental planning with respect to the Lake. The plan was prepared during the period 2003 to 2006 by SEWRPC in cooperation with the GLRD, and represents one of several actions taken to manage George Lake and its natural resources.

This report discusses the physical, chemical, and biological characteristics of the Lake, as documented during previous watershed-studies completed by the WDNR, SEWRPC, and others. In addition, pertinent related characteristics of the tributary 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 George Lake and its tributary area, including a typical water budget for the Lake. Chapter III sets forth inventory information on land use and population growth within the basin tributary to George 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 George Lake and inventory information on the human uses of the Lake. Alternative and recommended lake and tributary area management measures are set forth in Chapters VII and VIII. Specific information on nonpoint source pollution control measures, lake use survey results, and applicable recreational use ordinances are presented as appendices.

The recommended plan elements in this report 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 basin tributary to George Lake.[3] Accordingly, this lake management plan should constitute a practical, as well as technically sound, guide for the management of George Lake and its tributary basin.

---

[2]*The George Lake Rehabilitation District is a public inland protection and rehabilitation district formed in 1975 pursuant to Chapter 33 of the* Wisconsin Statutes*. As such, it is a special purpose unit of government created by petition of the property owners of the District for the purposes of conducting a program of lake management, in cooperation with other units of government and civic organizations. Public inland protection and rehabilitation districts are required to hold an annual meeting for the purposes of adopting a budget, electing commissioners, and conducting other such business as may lawfully come before the districts. See University of Wisconsin-Extension Publication G3818,* People of the Lakes: A Guide for Wisconsin Lake Organizations: Lake Associations & Lake Districts, 11th Edition*, 2006.*

[3]*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 tributary area are important factors in any evaluation of existing and likely future water quality conditions and lake uses, including recreational uses. Characteristics, such as tributary area 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 George Lake and its tributary area, and on the climate and hydrology of the George Lake area. Subsequent chapters deal with the land use conditions, and the chemical and biological environments of the Lake.

LAKE BASIN AND SHORELAND CHARACTERISTICS

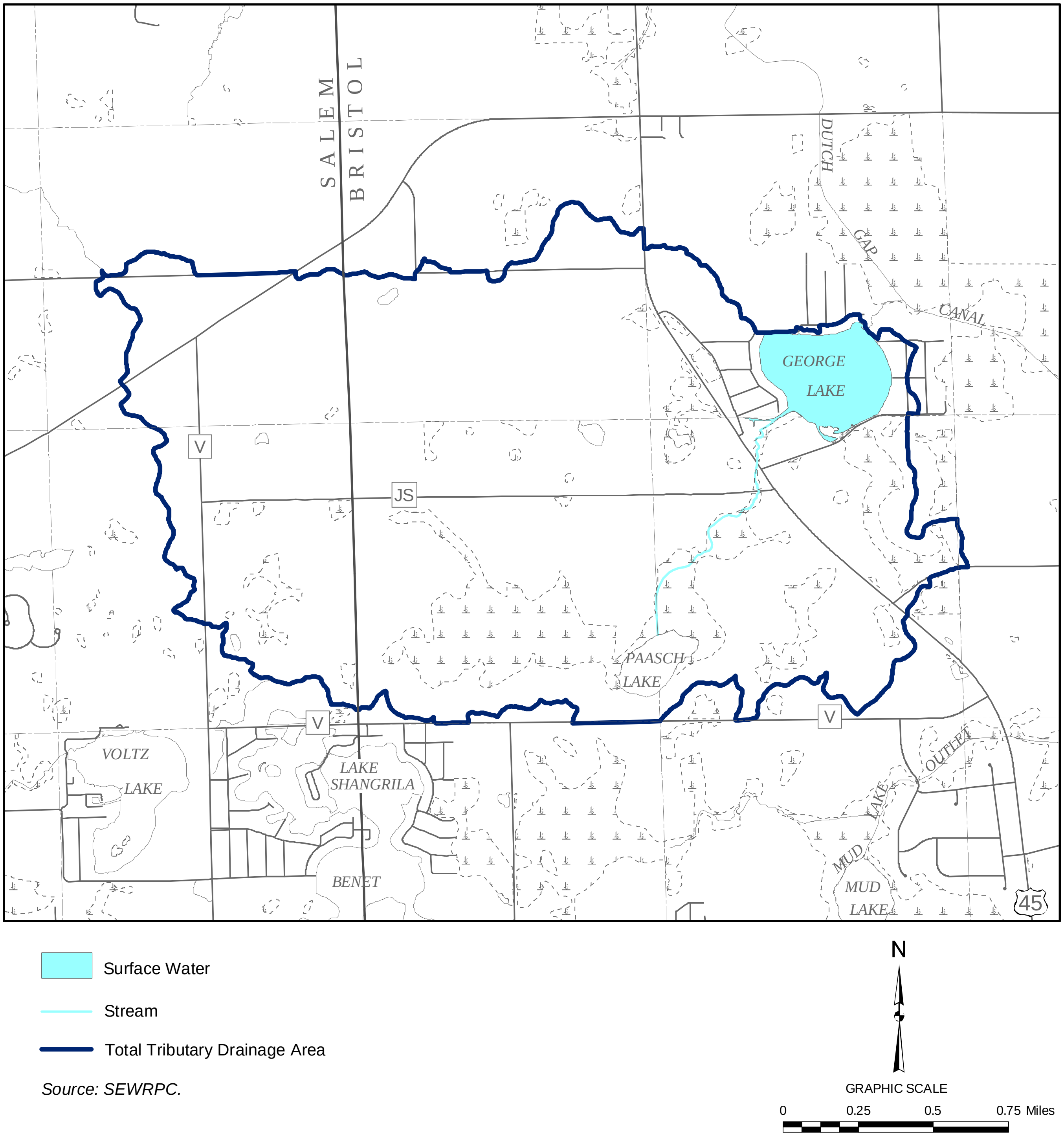
George Lake is located in the Town of Bristol in south central Kenosha County. Portions of the Towns of Bristol and Salem lie within the area tributary to George Lake, as shown on Map 1. George Lake is a drained lake, having no continuously flowing inlet but with a flowing outlet, and, as such, is not primarily groundwater-fed but relies on precipitation and direct drainage from the surrounding land as the principal sources of its water. The level of George Lake is controlled artificially by a three-foot head dam located at the lake outlet. Basic hydrographic and morphometric data for George Lake are presented in Table 1. The mean depth of the Lake is about seven feet and the maximum depth is about 16 feet. George Lake is about 0.6 mile long and about 0.4 mile wide at its widest point. The major axis of the lake basin lies in a generally northwest-southeast direction. George Lake has a volume of approximately 390 acre-feet, and a surface area of about 59 acres. The Lake has a shoreline length of about 1.2 miles, with a shoreline development factor of 1.1, indicating that the Lake is close to circular in shape having a circumference that is only about 1.1 times greater than that of a circular lake of the same area. The bathymetry of the George Lake basin is illustrated on Map 2.

As described further in Chapter III, the western, northern and eastern shorelines of George Lake are mostly developed for residential uses. Two small Town-owned and -operated public beaches are located along the eastern and northern shorelines. Public recreational boating access to George Lake is provided on the southern shore of the Lake and is considered adequate pursuant to the recreational boating access standards set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. Additional access for carry-in watercraft may be possible through a tavern-restaurant facility located on the western side of the Lake, adjacent to a canal that connects with the Lake.

A survey of George Lake shoreline, conducted during the summer of 2003 by Southeastern Wisconsin Regional Planning Commission (SEWRPC) 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 George Lake had some

Map 1

LOCATION OF GEORGE LAKE



Source: SEWRPC.

Table 1

HYDROLOGY AND MORPHOMETRY OF GEORGE LAKE: 2000

Parameter	Measurement
Size	
Area of Lake	59 acres
Extent of Tributary Area	2,187 acres
Lake Volume	390 acre-feet
Residence Time[a]	65.8 days
Shape	
Shape Length of Lake	0.6 mile
Length of Shoreline	1.18 miles
Width of Lake	0.4 mile
Shoreline Development Factor[b]	1.1
Depth	
Mean Depth[c]	6.6 feet
Maximum Depth	16 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.

form of shoreline protection in 2003. However, improperly installed and failing shoreline protection structures, and the erosion of natural shorelines on George Lake, are ongoing, but limited, causes for concern. The majority of the natural shoreline of the Lake is located on the southern shore of George Lake. 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.

Lake bottom sediment types are shown on Map 4. Silt, sand and gravel are the dominant shore materials, covering about 80 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 a mixture of sand and silt or a mixture of silt, sand and gravel. The remaining lake bottom is covered by soft, flocculent sediments, including muck, marl, detritus, clay, and silt.

Sediment thickness and water depth have been issues of concern to the residents of George Lake. These concerns were, in part, a response to an apparent decrease in both lake depth and surface area since the 1952 survey of the Lake conducted by the Wisconsin Department of Natural Resources (WDNR). Public sanitary sewers, installed in the mid-1970s in the George Lake area, and soil conservation practices, instituted in the late 1980s in the George Lake tributary area, have both been major factors in the reduction of sediment loads entering George Lake. Sediment thickness and composition on the lakebed were reported in a 1978 document compiled by Environmental Resource Assessments (ERA).[1] As part of this study, measurements of sediment thicknesses were obtained by probing through the ice. Additional sediment sampling was performed in 1991 by Aquatic Biologists, who, in addition to a chemical analysis of the bottom sediments, reported lake depth.[2] Subsequently, in 1992, SEWRPC updated the 1978 feasibility study with respect to the sedimentation issue. Most recently, during 2005, SEWRPC staff measured sediment depths at 24 sampling sites in George Lake. The depth of overlying water and the thickness of the sediment at each site is shown on Map 5.

TRIBUTARY AREA CHARACTERISTICS

The area tributary to George Lake, that is, those lands that surround and drain directly to the Lake, is about 2,187 acres, or approximately 3.4 square miles, in areal extent, as shown on Map 1. George Lake has a tributary area-to-

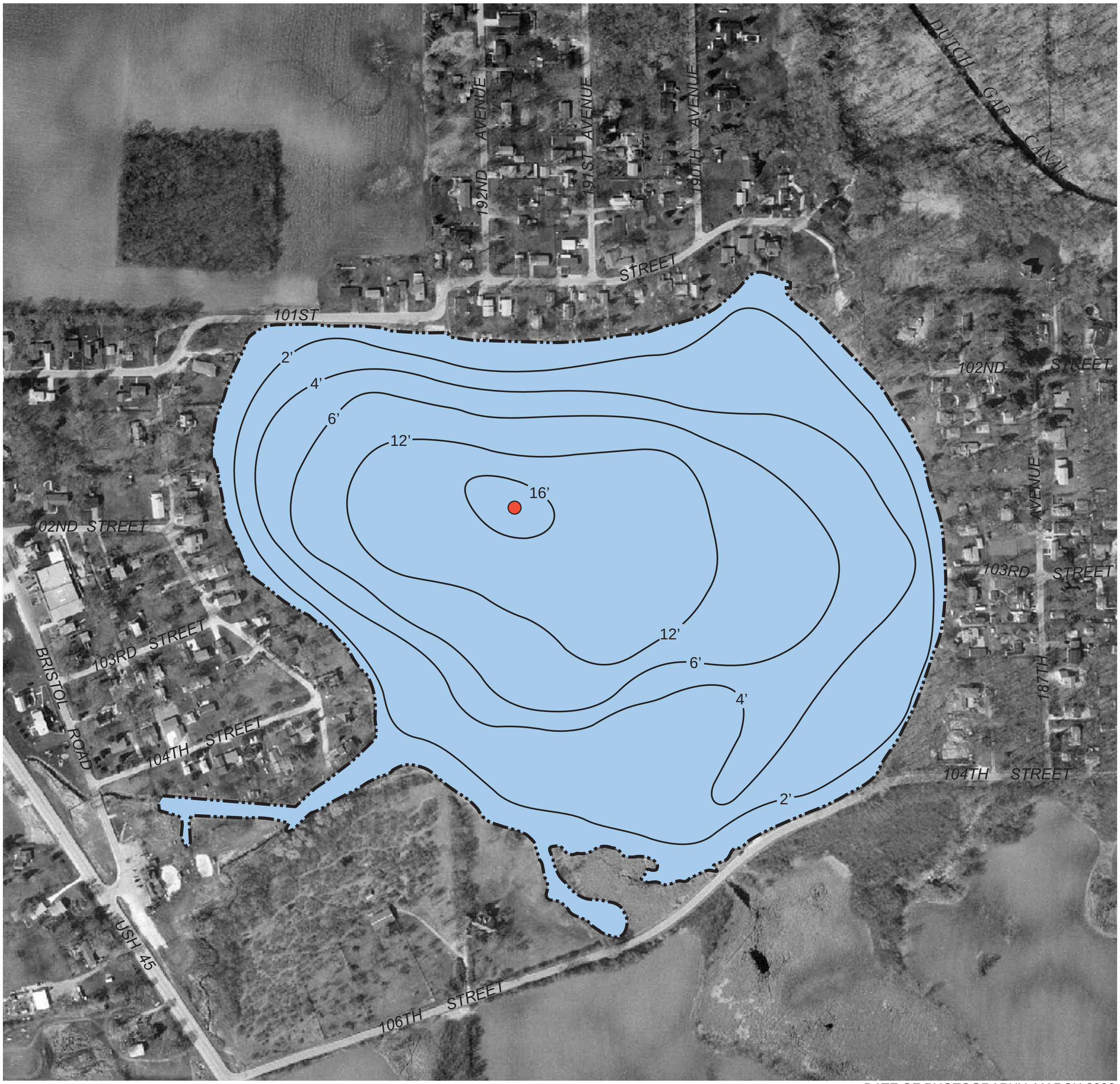
---

[1]*Environmental Resource Assessments,* Final Report on the George Lake Study Kenosha County, Wisconsin, *1978.*

[2]*George Lake Rehabilitation and Protection District Planning Grant #1006-1,* Updated Feasibility Study, Core Sample Results, Water Usage Ordinance, *1994.*

Map 2

BATHYMETRIC MAP OF GEORGE LAKE

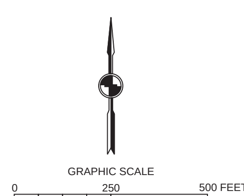


DATE OF PHOTOGRAPHY: MARCH 2000

— 12' — WATER DEPTH CONTOUR IN FEET

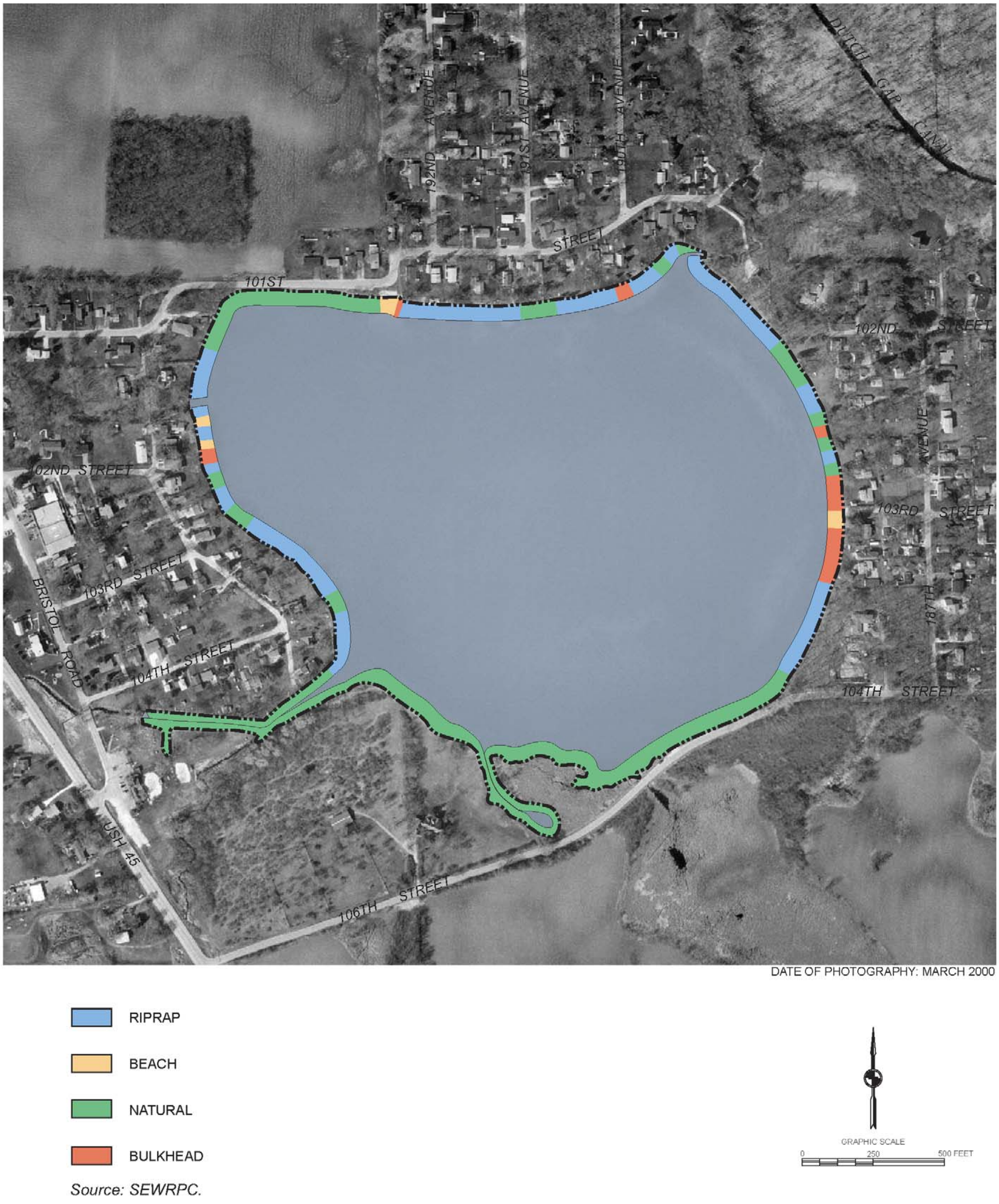
● MONITORING SITE

Source: U.S. Geological Survey and SEWRPC.



Map 3

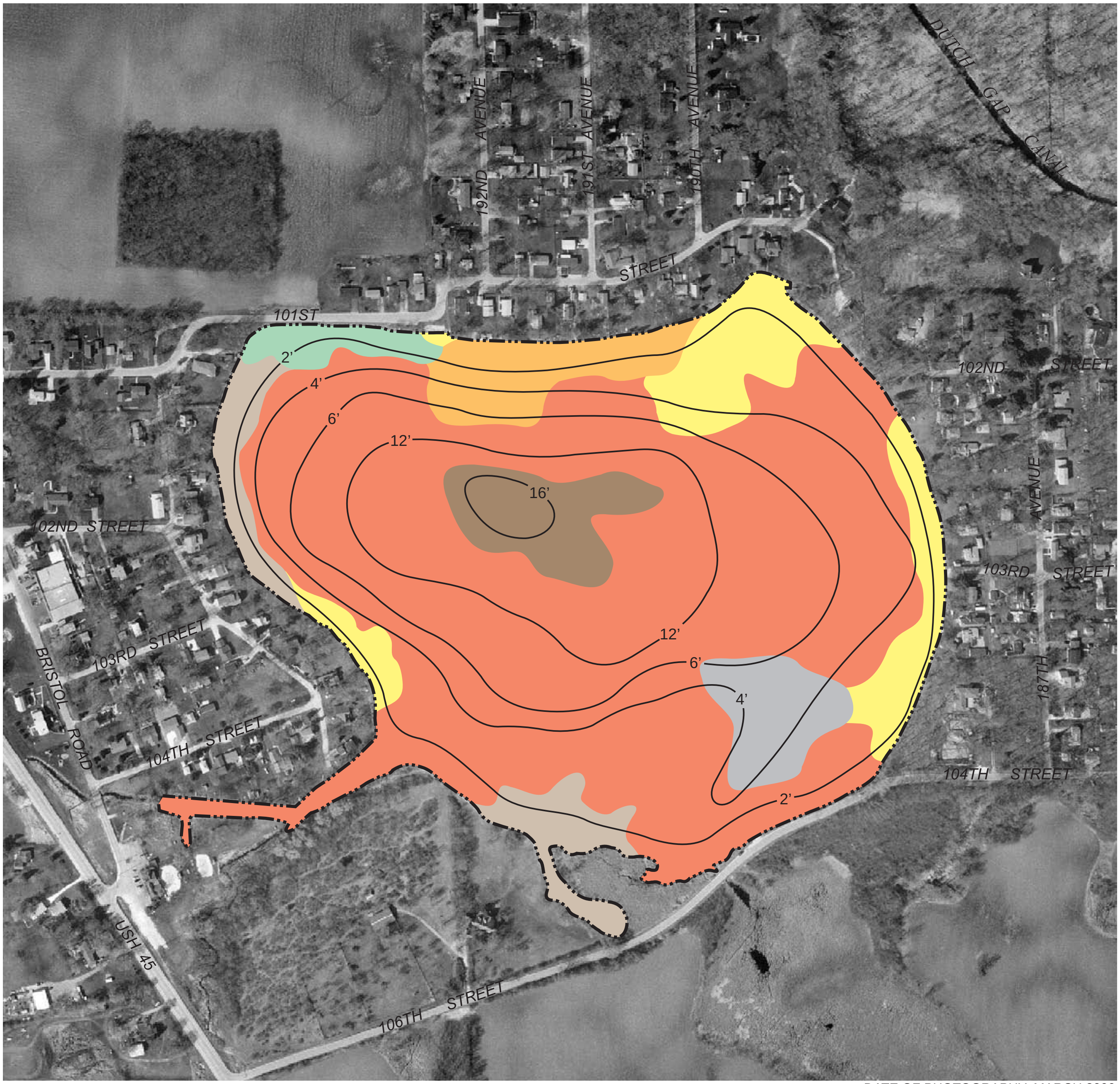
SHORELINE PROTECTION STRUCTURES ON GEORGE LAKE: 2003



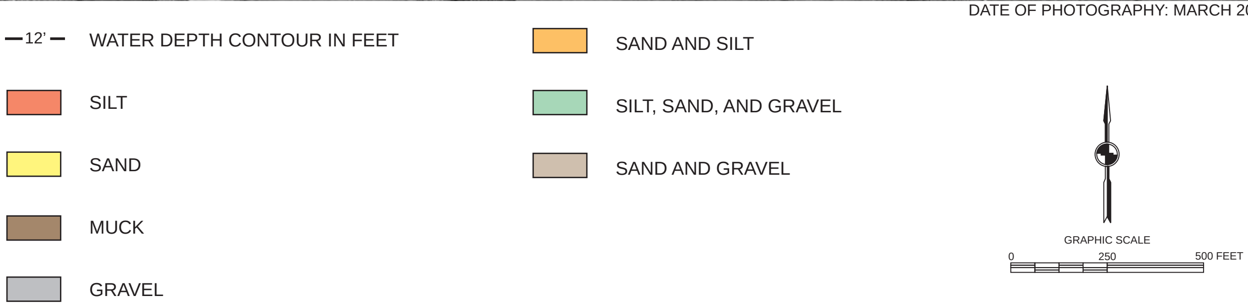
Source: SEWRPC.

Map 4

SEDIMENT SUBSTRATE DISTRIBUTION IN GEORGE LAKE: 2003



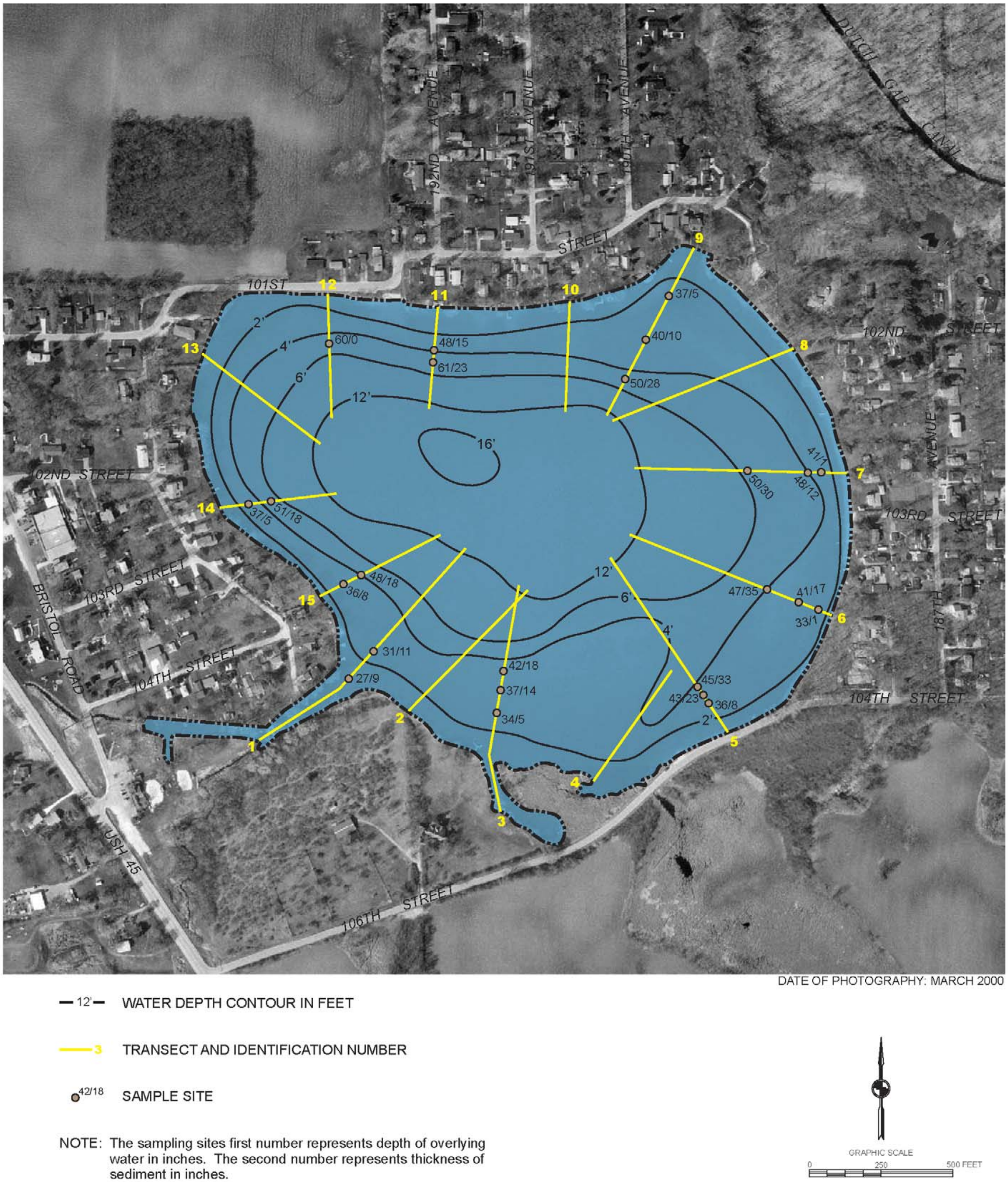
DATE OF PHOTOGRAPHY: MARCH 2000



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 5

DEPTH OF SEDIMENT AND OVERLYING WATER IN GEORGE LAKE: 2005



NOTE: The sampling sites first number represents depth of overlying water in inches. The second number represents thickness of sediment in inches.

Source: Wisconsin Department of Natural Resources and SEWRPC.

lake surface area ratio of about 37:1, which ratio is relatively low for lakes within Wisconsin which, on average, are reported to have a tributary area-to-lake surface area ratio of about 110:1.[3]

George Lake has two intermittent inlets and one outlet, as shown on Map 2. The two intermittent, unnamed tributary streams enter the Lake from the west and southwest, respectively. The lake outlet drains over a fixed crest spillway by way of an unnamed stream that connects with the Dutch Gap Canal which eventually joins the Des Plaines River.

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. The texture of different soil types and the structure of soil particles 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. Soil types and land slope are discussed immediately below; land use is discussed in Chapter III of this report.

The U.S. Natural Resources Conservation Service (NRCS), formerly the U.S. Soil Conservation Service, under contract to SEWRPC, completed a detailed soil survey of the George Lake area in 1966.[4] The major soil types present within the tributary area of George Lake are: Askum silty clay loam, Beecher silt loam, Fox loam, Markham silt loam, and Morley silt loam. The major soil association within the tributary area is the Morley-Beecher-Ashkum association of well-drained to poorly soils that have a silty clay or silty clay loam subsoil.

Using the regional soil survey, an assessment was made of hydrologic characteristics of the soils in the tributary area of George Lake. Soils within the area tributary to George Lake were categorized generally into four principal hydrologic groups as indicated in Table 2. Only about 1 percent of the tributary area is covered by moderately drained soils, about three-fourths of the tributary area by poorly drained soils, and the balance by very poorly drained soils. The areal extent of these soils and their locations within the tributary area are shown on Map 6.

In addition to the identification and delineation of soil types, the soil survey contained interpretations for planning and engineering applications, as well as for agricultural applications. The suitability of the soils for urban residential development was assessed using different 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. Even though, as shown in Map 7, the residential lands within the George Lake Rehabilitation District (GLRD), and the majority of lands within the tributary area of George Lake, are currently served by a public sanitary sewerage system pursuant to recommendations set forth in the adopted regional water quality management plan,[5] interpretations associated with the soil survey in regards to onsite sewage disposal systems are such that they 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

---

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

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

[5]*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.*

Table 2

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

Group	Soil Characteristics	Tributary Drainage Area (acres)	Percent of Total
A/D	Well drained soil/Very poorly drained soil[a]	174	8
B	Moderately well drained; texture intermediate between coarse and fine; moderately rapid to moderate permeability; low to moderate shrink-swell potential	21	1
B/D	Moderately drained soil/Very poorly drained soil[b]	367	16
C	Poorly drained; high water table for part or most of the year; mottling, suggesting poor aeration and lack of drainage, generally present in A to C horizons	1,581	70
Water	- -	103	5
Total		2,246	100

[a]*Well-drained soil if water table is lowered through provision of a drainage system; Very poorly drained soil if water table is not lowered.*

[b]*Moderately drained soil if water table is lowered through provision of a drainage system; Very poorly drained soil if water table is not lowered.*

Source: SEWRPC.

groundwater interflows in the Lake. Therefore, as an index of the likelihood of contaminants entering George Lake, 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 are shown in Map 8. It is useful to note that less than 1 percent of the lands within the area tributary to George Lake are covered by soils that are categorized as having few limitations for onsite sewage disposal systems, while the major portion, over 99 percent, of the tributary area is covered by soils that are classified as unsuitable for onsite sewage disposal systems, suggesting a potential sensitivity to disturbance and likelihood of being permeable to pollutants.

Land surface slopes within the area tributary to George Lake range from less than 1 percent to greater than 20 percent in the tributary area. 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, only about 32 acres, or about 1.5 percent of the area tributary to George Lake, have slopes within this range. A further 198 acres have slopes of between 6 percent and 12 percent, while the balance of the lands, comprising about 1,912 acres excluding surface waters, has slopes of less than 6 percent.

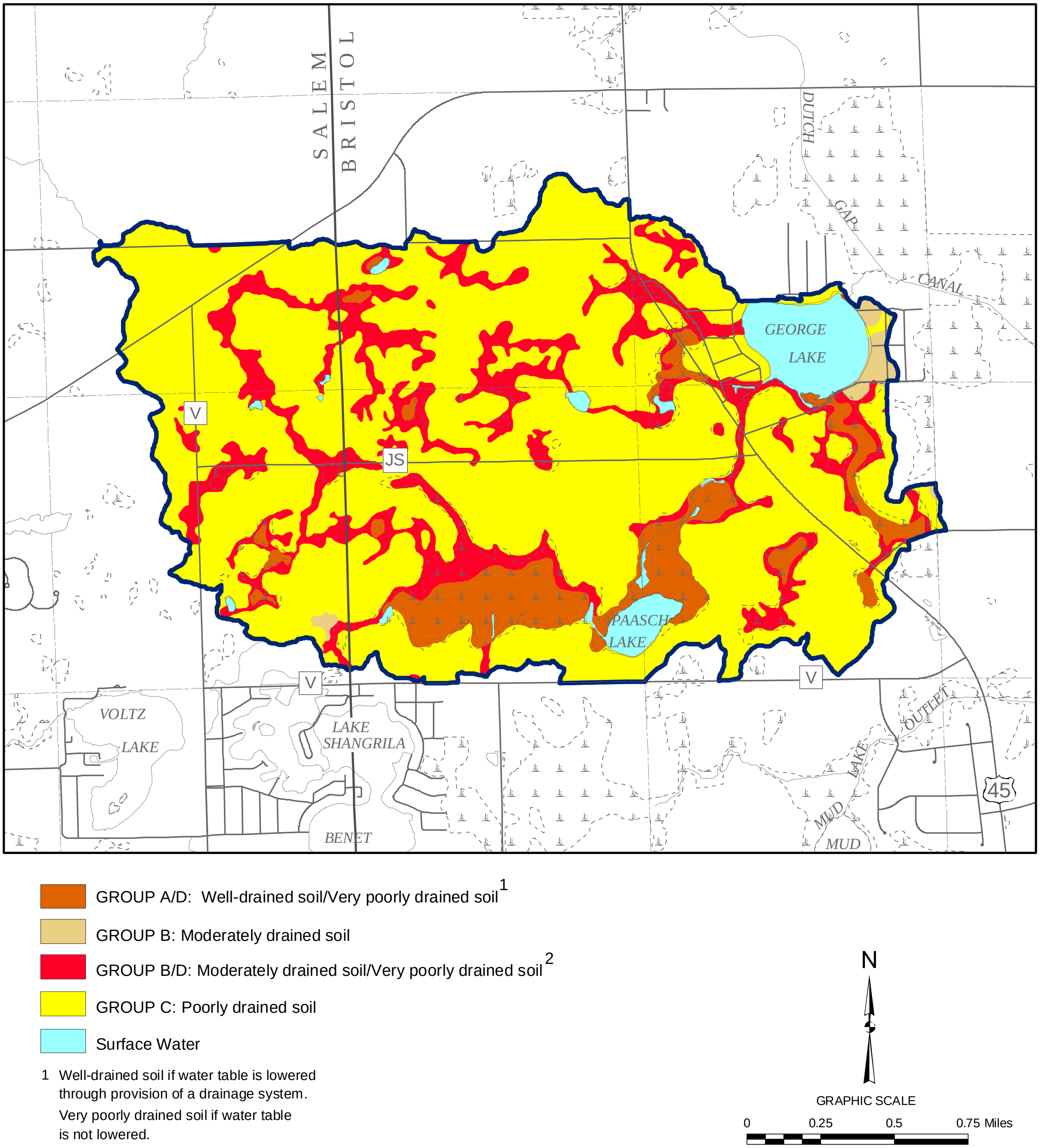
CLIMATE AND HYDROLOGY

Long-term average monthly air temperature and precipitation values for the George 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 Kenosha, 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 Des Plaines River at Russell, in Lake County, Illinois, downstream from the confluence of the George Lake outlet stream and Dutch Gap Canal.

The long-term mean annual temperature of 47.2°F at Kenosha is similar to that of other recording locations in southeastern Wisconsin. The long-term mean annual precipitation at Kenosha is about 34.6 inches. More than half

Map 6

HYDROLOGIC SOIL GROUPS WITHIN THE AREA TRIBUTARY TO GEORGE LAKE



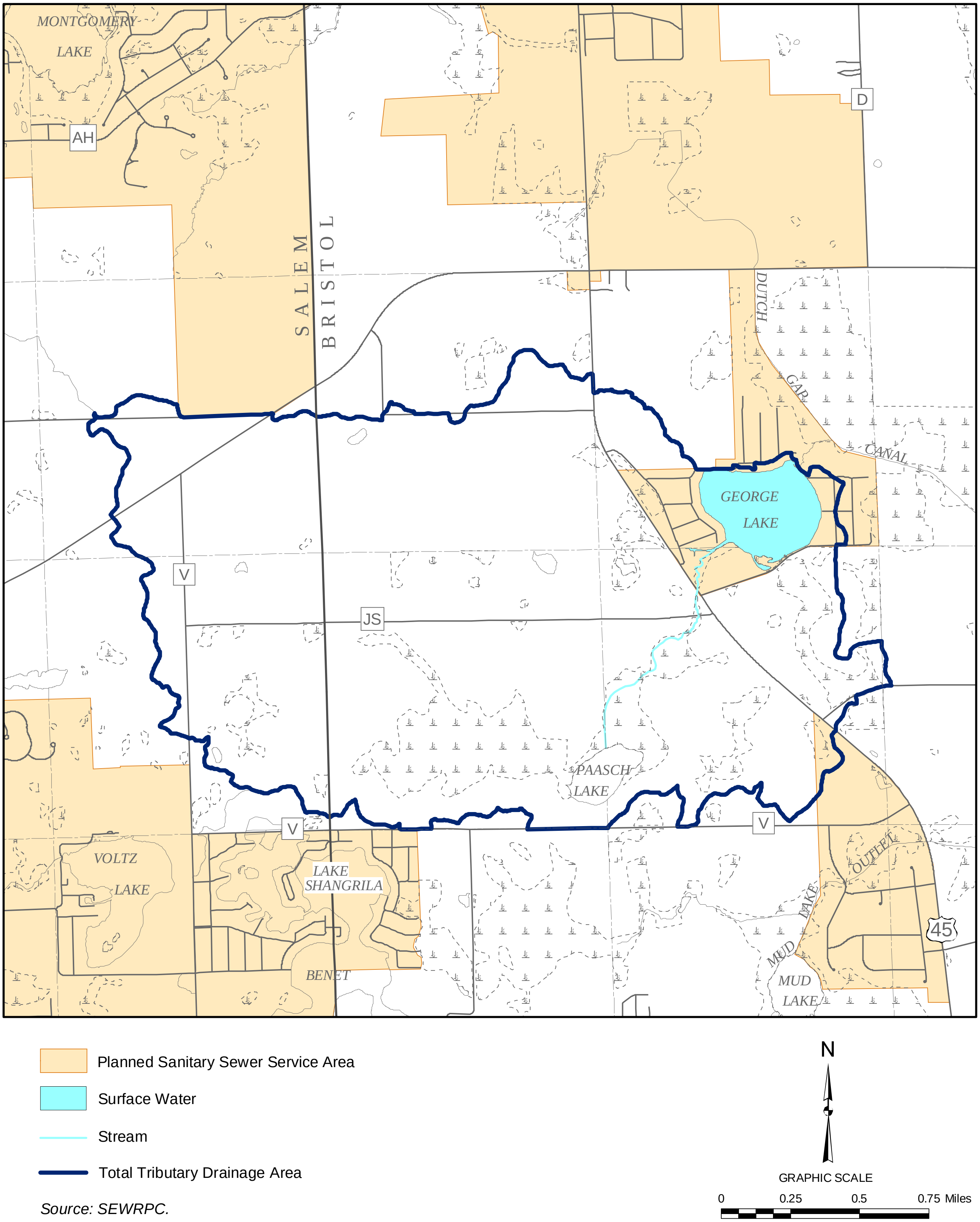
1 Well-drained soil if water table is lowered through provision of a drainage system. Very poorly drained soil if water table is not lowered.

2 Moderately-drained soil if water table is lowered through provision of a drainage system. Very poorly drained soil if water table is not lowered.

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

Map 7

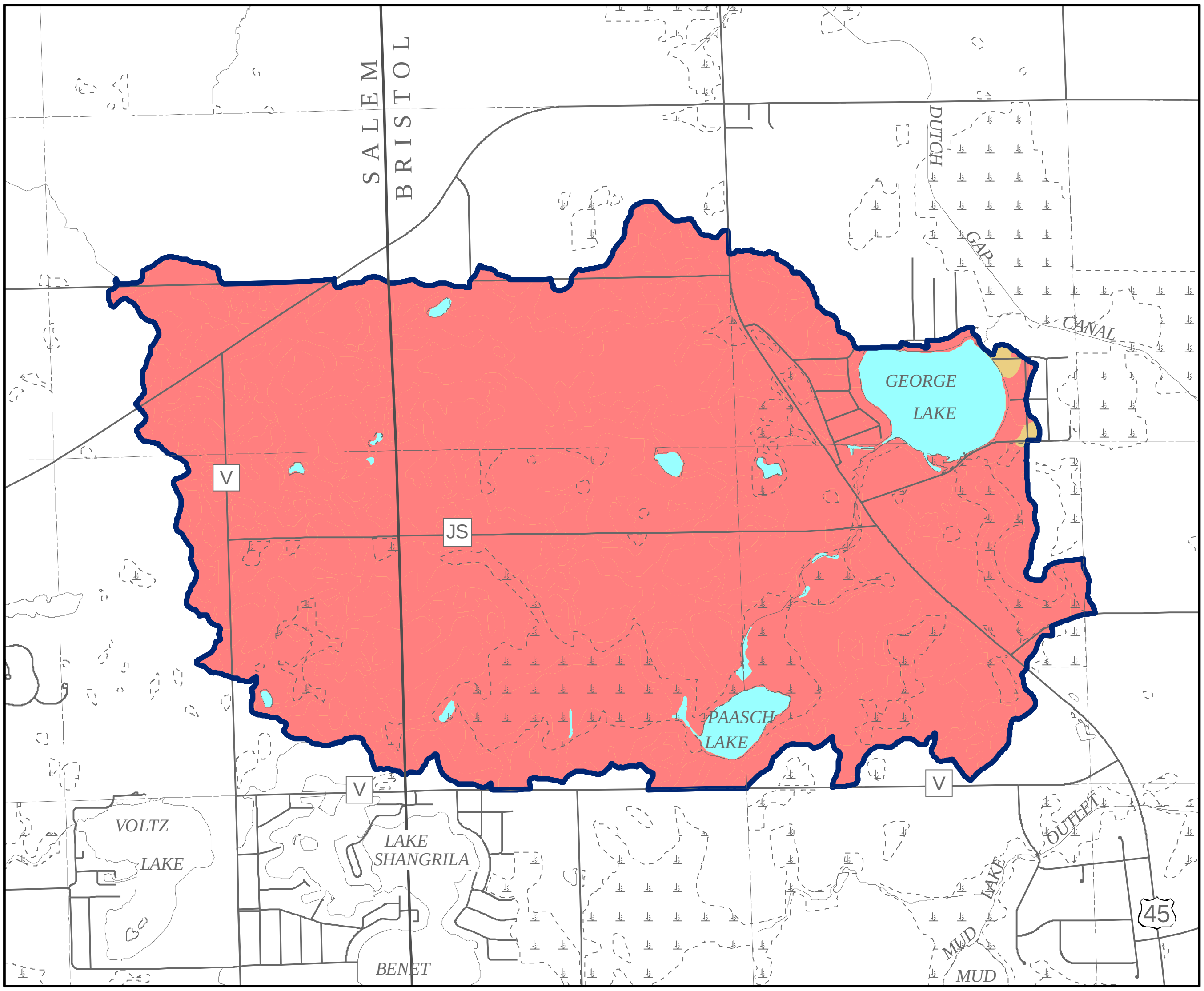
SANITARY SEWER SERVICE AREA FOR GEORGE LAKE



Source: SEWRPC.

Map 8

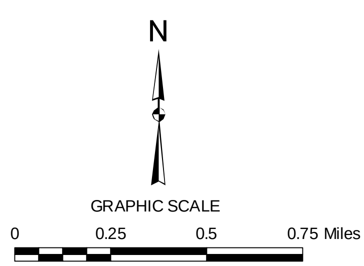
GROUNDWATER CONTAMINATION POTENTIAL WITHIN THE AREA TRIBUTARY TO GEORGE LAKE



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

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

SURFACE WATER



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

Table 3

LONG-TERM AND 2003 STUDY YEAR TEMPERATURE, PRECIPITATION, AND RUNOFF DATA FOR THE GEORGE LAKE AREA

Temperature													
Air Temperature Data (°F)	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Long-Term Mean Monthly	20.8	25.1	34.4	44.1	54.9	65.0	71.3	70.8	62.9	51.7	38.8	26.9	47.2
2003 Mean Monthly	21.1	22.4	34.0	43.3	51.6	62.1	70.0	73.2	63.2	52.1	41.4	32.1	47.2
Departure from Long-Term Mean	0.3	-2.7	-0.4	-0.8	-3.3	-2.9	-1.3	2.4	0.3	0.4	2.6	5.2	0.0

Precipitation														
Precipitation Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean	Total
Long-Term Mean Monthly	1.67	1.29	2.34	3.85	3.38	3.59	3.68	4.19	3.49	2.49	2.68	1.94	2.88	34.59
2003 Mean Monthly	0.43	0.10	2.07	2.09	4.44	2.57	3.65	1.02	1.52	1.56	5.20	2.38[a]	2.25	27.03
Departure from Long-Term Mean	-1.24	-1.19	-0.27	-1.76	1.06	-1.02	-0.03	-3.17	-1.97	-0.93	2.52	0.44[a]	-0.63	-7.56

Runoff													
Runoff Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Total
Long-Term Mean Monthly	0.63	0.91	1.92	2.01	1.19	0.94	0.49	0.37	0.47	0.39	0.62	0.80	10.74
2003 Mean Monthly	0.06	0.01	0.29	0.54	1.19	0.34	0.35	0.13	0.00	0.01	0.46	0.80	4.18
Departure from Mean Monthly	-0.57	-0.90	-1.63	-1.47	0.00	-0.60	-0.14	-0.24	-0.47	-0.38	-0.16	0.00	-6.56

[a]*Precipitation data for December is for Burlington, Wisconsin; all other precipitation data is for Kenosha, Wisconsin. Substitution of Burlington data was necessary due to the incomplete nature of December data for Kenosha.*

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

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.

The 12-month current study period of January through December 2003, was a period of variable temperatures and rainfall in southeastern Wisconsin, as indicated in Table 3. Temperatures were generally at normal during the year, although early spring and early summer were somewhat below normal during 2003, as shown in Table 3. Precipitation at Kenosha during this period was about 27 inches, or below normal, on average, during much of the spring and summer; fall and winter precipitation were also less than the long-term average during this year.

The volume of George Lake is primarily determined by precipitation and direct drainage from surrounding land. Runoff, which influences the inflow and outflow rates at George Lake, was slightly lower during the study period than the long-term average runoff rate for the Des Plaines River basin, as shown in Table 3. The lake level, however, is regulated, in part, by an outlet control structure, which helps 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 George Lake. As part of the aforementioned study conducted by ERA, a series of five pairs of observation wells were drilled around the perimeter of George Lake to monitor water levels and various water quality parameters.[6] Water level fluctuations in the wells indicated that, during the study year of 1977, groundwater entered the Lake only during the early spring. During the current study period, review of groundwater elevations and flow indicated that groundwater generally flows in an easterly direction through the George Lake tributary area, as shown in Map 9, and is unlikely to be a major factor in water moving into or out of George Lake. Water flows into George Lake primarily as precipitation deposited directly onto the lake surface and as runoff from the Lake's tributary area; water is lost from George Lake through evaporation from the lake surface and as outflow to Dutch Gap Canal. During the current study period, it is estimated that 232 acre-feet of water were contributed by precipitation deposited directly onto the lake surface, and 1,447 acre-feet were contributed as surface runoff from the tributary area. Thus, of the approximately 1,679 acre-feet of water entering the Lake during 2003, about 14 percent was contributed by direct precipitation and about 86 percent by surface runoff. About 249 acre-feet were lost from George Lake during the study year due to evaporation from the Lake's surface, and about 1,430 acre-feet were discharged through the outlet stream to Dutch Gap Canal, assuming no change in lake level during this period. Thus, of the water leaving George Lake, approximately 15 percent was due to evaporation, and about 85 percent due to the outflowing stream. As noted previously, groundwater inflow was assumed to be negligible and likely to be in balance with groundwater outflow.

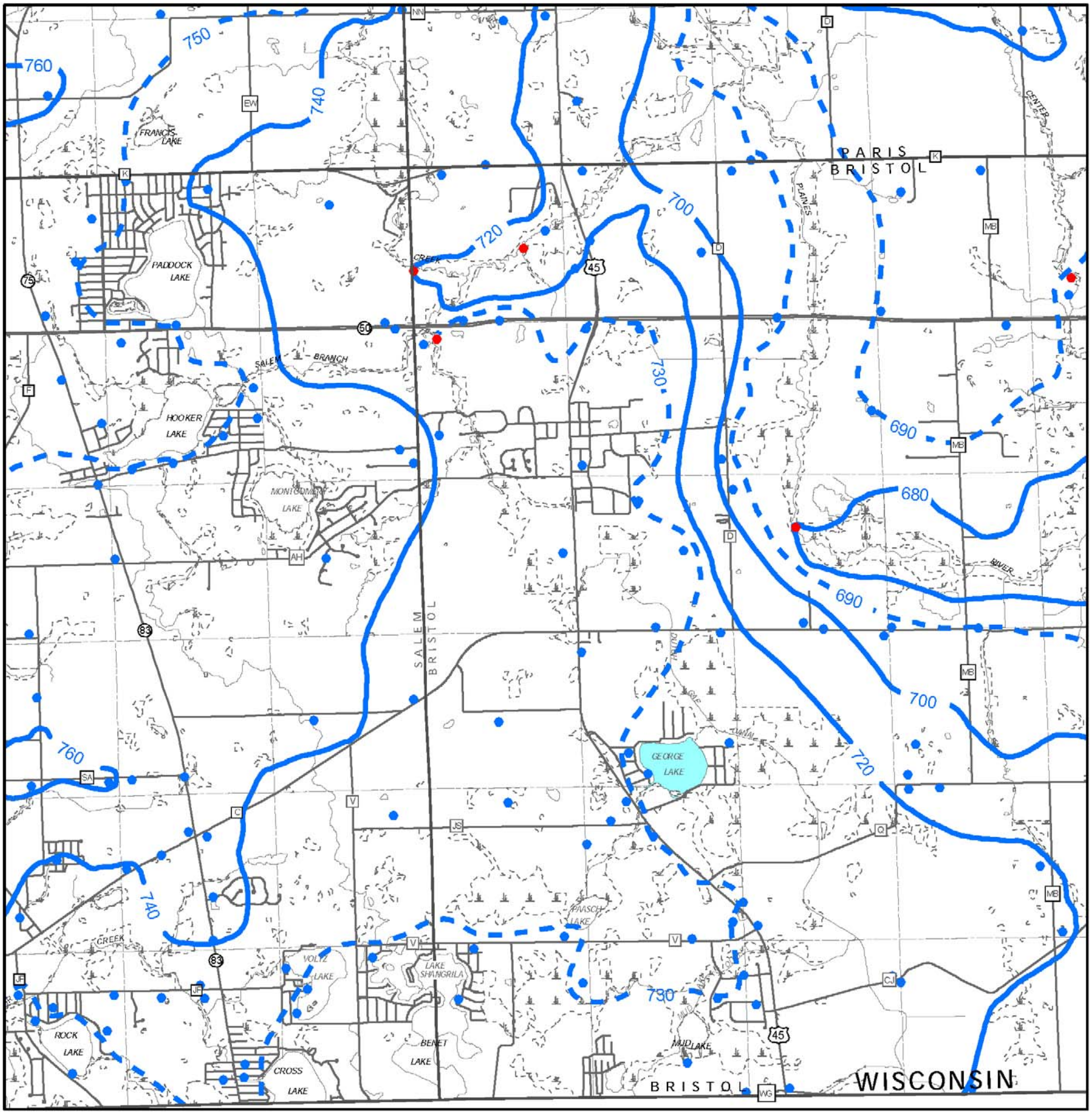
This estimated hydrologic budget for the current study period compares favorably with those made for the Lake on a long-term basis, as indicated in Figure 1. Inflow to the Lake over the long-term was comprised of direct precipitation and runoff to the Lake from the tributary area. Of these, direct precipitation onto the lake surface accounted for about 14 percent of the total water load, and runoff contributed about 86 percent. Of the water lost from George Lake over the long-term, about 12 percent was lost to evaporation from the lake surface, and 88 percent through surface outflows to Dutch Gap Canal. Groundwater gains and losses were again assumed to be negligible. Table 4 shows water budgets for the current study period and for the long-term for George Lake.

Based on the annual and long-term water budgets for George 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. This value expresses the period of time required for a volume of water equal to the volume of the Lake to enter the waterbody. The hydraulic residence time for George Lake during the study period was approximately 0.2 year, or about 66 days.

[6] *Environmental Resource Assessments,* op. cit.

Map 9

FLOW OF GROUNDWATER WITHIN THE VICINITY OF GEORGE LAKE



720 AVERAGE WATER-TABLE ELEVATION (FEET ABOVE NATIONAL GEODETIC VERTICAL DATUM, 1929) AT A 20-FOOT CONTOUR INTERVAL

730 SUPPLEMENTAL CONTOUR AT A 10-FOOT INTERVAL

WELL DATA POINT

SURFACE WATER POINT

N

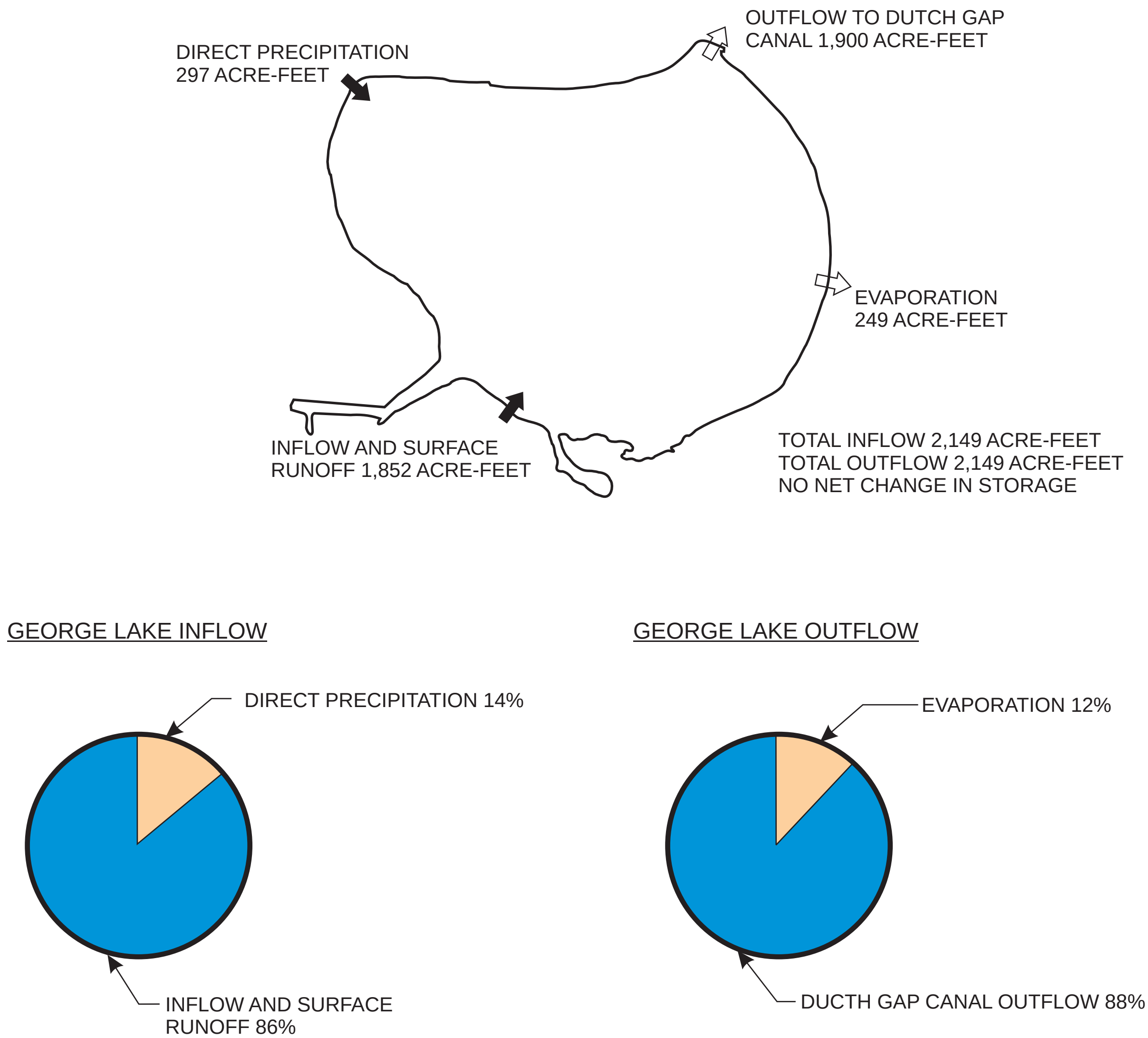
GRAPHIC SCALE

0 0.5 1 1.5 Miles

Source: SEWRPC.

Figure 1

LONG-TERM HYDROLOGIC BUDGET FOR GEORGE LAKE



Source: U.S. Geological Survey and SEWRPC.

Table 4

HYDROLOGIC BUDGETS FOR GEORGE LAKE

Element	2003 (acre-feet)	Long-term (acre-feet)
Inflows		
Direct Precipitation..................	232	297
Direct Runoff to George Lake ..	1,447	1,852
Total	1,679	2,149
Outflows		
Evaporation.............................	249	249
Dutch Gap Canal	1,430	1,900
Total	1,679	2,149

Source: National Oceanic and Atmospheric Administration 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 tributary 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 tributary 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 tributary 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 also are important factors which must be considered in 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 tributary area of George Lake are the local civil division boundaries, shown on Map 10. The governmental units within the area tributary to George Lake include portions of the Towns of Bristol and Salem, both in Kenosha County. The area and proportion of the tributary area lying within the jurisdiction of each civil division, as of 2000, is set forth in Table 5. In addition, Kenosha County administers a number of programs and functions which relate directly to lake and watershed management in the George Lake area, as does the Wisconsin Department of Natural Resources (WDNR).

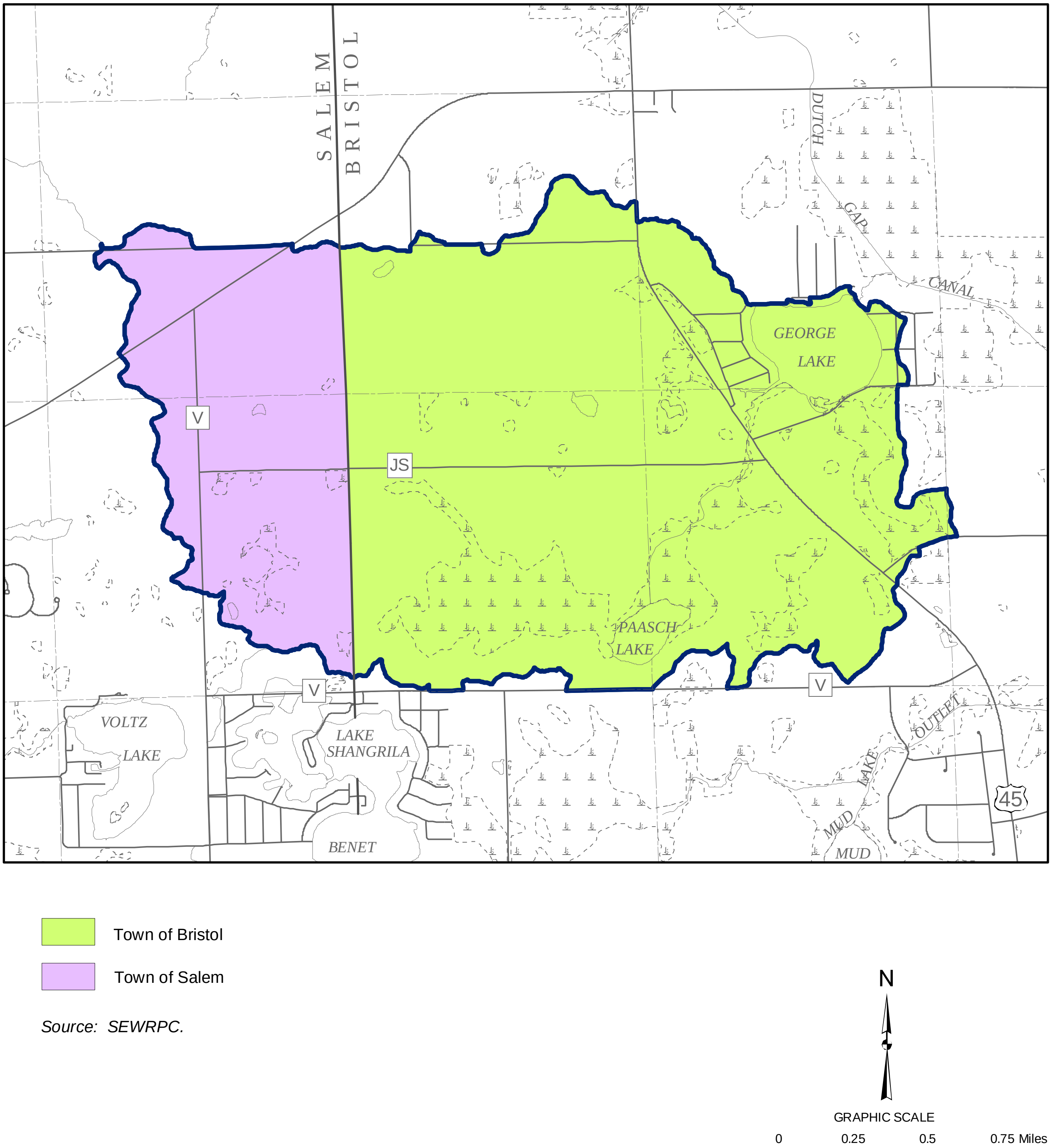
In addition to these general purpose units of government, the George Lake Rehabilitation District (GLRD) is a special-purpose unit of government created pursuant to Chapter 33 of the *Wisconsin Statutes* and having specific responsibilities for lake management. This District was formed in 1975 and encompasses 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]

---

[1]*University of Wisconsin-Extension Publication G3818,* People of the Lakes: A Guide for Wisconsin Lake Organizations: Lake Associations & Lake Districts, 11th Edition, *2006.*

Map 10

CIVIL DIVISION BOUNDARIES WITHIN THE AREA TRIBUTARY TO GEORGE LAKE



Source: SEWRPC.

Table 5

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

Municipality	Area (acres)	Percent
Town of Bristol..............	1,693	75.4
Town of Salem..............	553	24.6
Total	2,246	100.0

Source: SEWRPC.

Table 6

POPULATION AND HOUSEHOLDS WITHIN THE AREA TRIBUTARY TO GEORGE LAKE: 1963-2000

Year	Population	Households
1963	167	58
1970	335	99
1980	526	184
1990	603	201
2000	678	248

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

POPULATION

As indicated in Table 6, the resident population of the area tributary to George Lake has increased in a relatively steady manner since 1963. In 1970 the resident population of the tributary area was estimated at about 335 persons, or approximately twice the estimated 1963 population of 167 persons. The period of greatest growth in both population and number of households in the area tributary to George Lake was from 1963 to 1980 during which period the population experienced an increase of over 300 percent as did the number of households. As of 2000, the resident population was reported to be approximately four times that of 1963, or about 680 persons, residing in about 250 housing units. The number of housing units reported to be within the area tributary to George Lake increased from about 50 units during the decade between 1990 and 2000.

As development in the local area expands, the population of the area tributary to George Lake may be expected to continue to increase over the next two decades. This population growth may be expected to place continued and increasing stress on the natural resource base of the George Lake tributary area, and both water resource demands and use conflicts may be expected to increase.

LAND USE

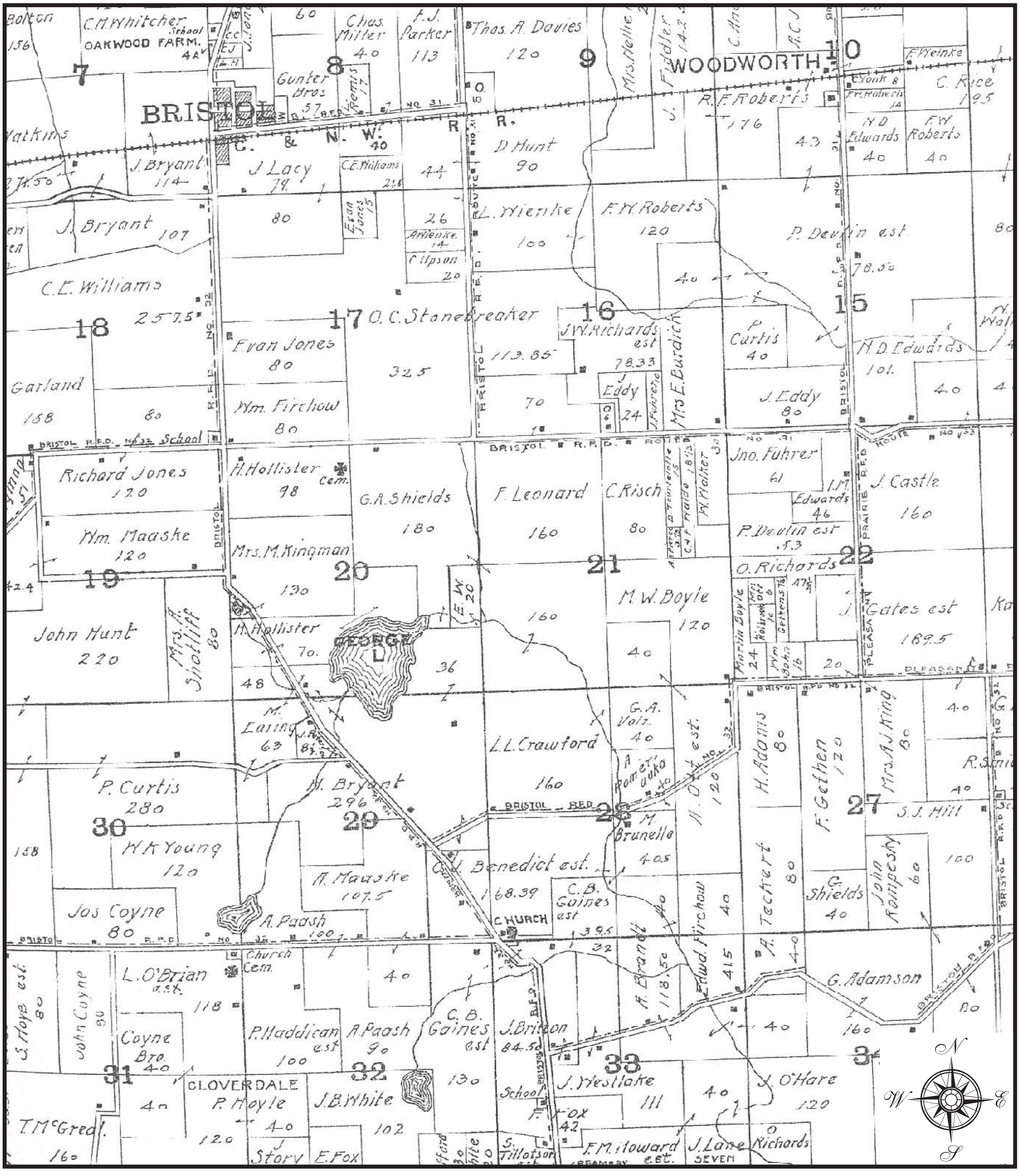
The type, intensity, and spatial distribution of the various land uses within the area tributary to George Lake are important determinants of lake water quality and recreational use demands. The existing land use pattern placed in the context of the historical development of the area, therefore, are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

The movement of European settlers into the Southeastern Wisconsin Region began in 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 11 shows a 1908 plat of the U.S. Public Land Survey for the George Lake area. Significant urban land use development began in the George Lake area in about 1920. Map 12 and Table 7 indicate the historic urban growth pattern in the tributary area of the Lake since 1950. A significant increase in the amount of land converted to urban use in the shoreland area of the Lake occurred prior to 1950. Within the area tributary to George Lake, the greatest increases in urban lands within the wider tributary area have occurred during the 1960s, as shown in Table 7.

As shown in Table 8 and on Map 13, in 2000, about 88 percent of the total area tributary to George Lake remained in various rural land uses, with the dominant rural land use being agriculture, which encompassed about 1,349 acres, or approximately 60 percent of the total tributary area. Other rural land uses such as wetlands, woodlands, and surface waters, comprised about 619 acres, or 28 percent of the tributary area. Urban land uses, consisting of residential, commercial, governmental and institutional, transportation, and recreational land uses, encompassed about 277 acres, or about 12 percent of the total area tributary to George Lake. Residential uses were the dominant urban land use, comprising about 188 acres, or about 8 percent of the Lake's tributary area. All other urban uses, such as commercial, industrial, governmental and institutional, transportation, communication, utilities, and recreational land uses combined comprised about 89 acres, or 4 percent of the tributary area.

Map 11

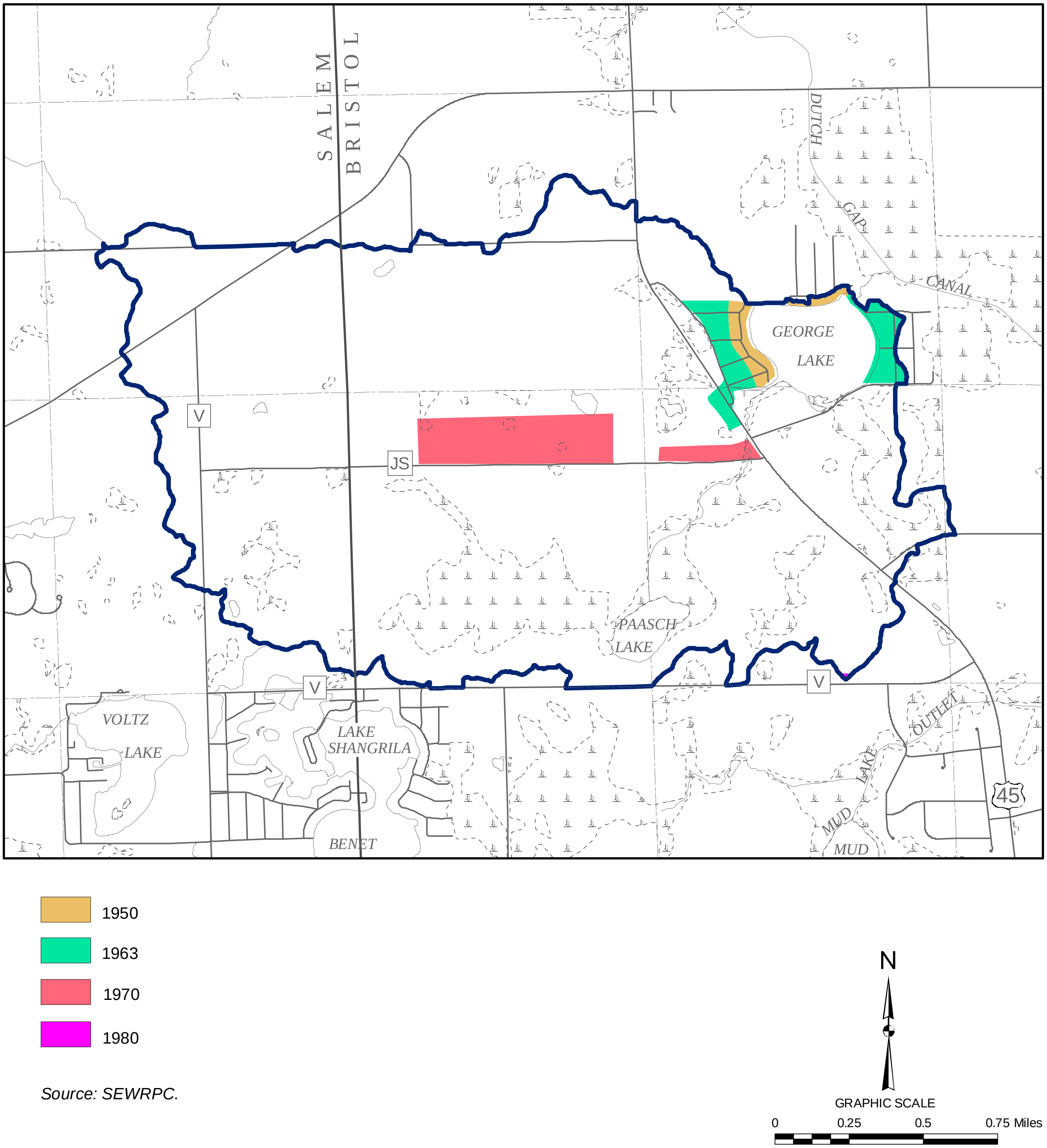
HISTORIC PLAT MAP FOR THE GEORGE LAKE AREA: 1908



Source: P.C. Hennessey and Company, Plat Book of Racine and Kenosha Counties*, Wisconsin, 1908.*

Map 12

HISTORIC URBAN GROWTH WITHIN THE AREA TRIBUTARY TO GEORGE LAKE



Source: SEWRPC.

Table 7

EXTENT OF HISTORIC URBAN GROWTH IN THE TRIBUTARY AREA OF GEORGE LAKE: 1950-1980

	Tributary Area	
Year	Extent of New Urban Development Occurring Since Previous Year (acres)[a]	Cumulative Extent of Urban Development (acres)[a]
1950	16	16
1963	25	41
1970	38	79
1980	<1	79

[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.

Under planned 2020 conditions, the trend toward more intensive urban land usage in southeastern Wisconsin is expected to be reflected in the area tributary to George Lake. Much of this development is expected to occur as agricultural lands are converted to urban lands, primarily for residential use. Within the area tributary to the Lake, urban residential uses are expected to increase by about 39 acres, to about 227 acres or approximately 10 percent of the Lake's tributary area, as shown in Table 8 and Map 14. Rural agricultural uses are expected to decrease to about 1,300 acres, or approximately 58 percent of the tributary area. If this trend continues, some of the open space areas remaining in the drainage area are likely to be replaced with large-lot urban residential development, resulting in the potential for increased pollutant loadings to the Lake. This development could occur in the form of residential clusters on smaller lots within conservation subdivisions, thereby preserving portions of the remaining open space and, thus, reducing the impacts on the Lake.[2] Certain other lands immediately surrounding the Lake, together with connected areas containing a concentration of high-value woodlands, wetlands, and wildlife habitat areas, 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, as described in Chapter V.

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 area tributary to George Lake includes portions of the Towns of Bristol and Salem, both in Kenosha County.

General Zoning

Counties in Wisconsin are granted general zoning powers within their unincorporated areas under Section 59.69 of the *Statutes*. The Towns of Bristol and Salem, parts of both of which lie within the area tributary to George Lake, have adopted the county general zoning ordinance, as shown in Table 9. Towns that have not adopted a county zoning ordinance may adopt village powers, and subsequently utilize the city and village zoning authority conferred in Section 62.23, subject, however, to county board approval where a general-purpose county zoning ordinance exists. Alternatively, a town may adopt a zoning ordinance under Section 60.61 of the *Wisconsin Statutes* where a general-purpose county zoning ordinance has not been adopted, but only after the county board fails to adopt a county ordinance at the petition of the governing body of the town concerned.

Floodland Zoning

Section 87.30 of the *Wisconsin Statutes* requires that 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

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

Table 8

EXISTING AND PLANNED LAND USE WITHIN THE AREA TRIBUTARY TO GEORGE LAKE: 2000 AND 2020

Land Use Categories[a]	2000 Acres	2000 Percent of Tributary Area	2020 Acres	2020 Percent of Tributary Area
Urban				
Residential	188	8.4	227	10.1
Commercial	1	<1.0	1	<1.0
Industrial	1	<1.0	1	<1.0
Governmental and Institutional	<1	<1.0	<1	<1.0
Transportation, Communication, and Utilities	82	3.7	92	4.1
Recreational	5	0.2	5	0.2
Subtotal	277	12.3	326	14.4
Rural				
Agricultural and Other Open Lands	1,349	60.1	1,300	58.0
Wetlands	284	12.7	284	12.7
Woodlands	234	10.4	234	10.4
Surface Water	101	4.5	101	4.5
Extractive	- -	- -	- -	- -
Landfill	- -	- -	- -	- -
Subtotal	1,968	87.7	1,919	85.6
Total	2,245	100.0	2,245	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

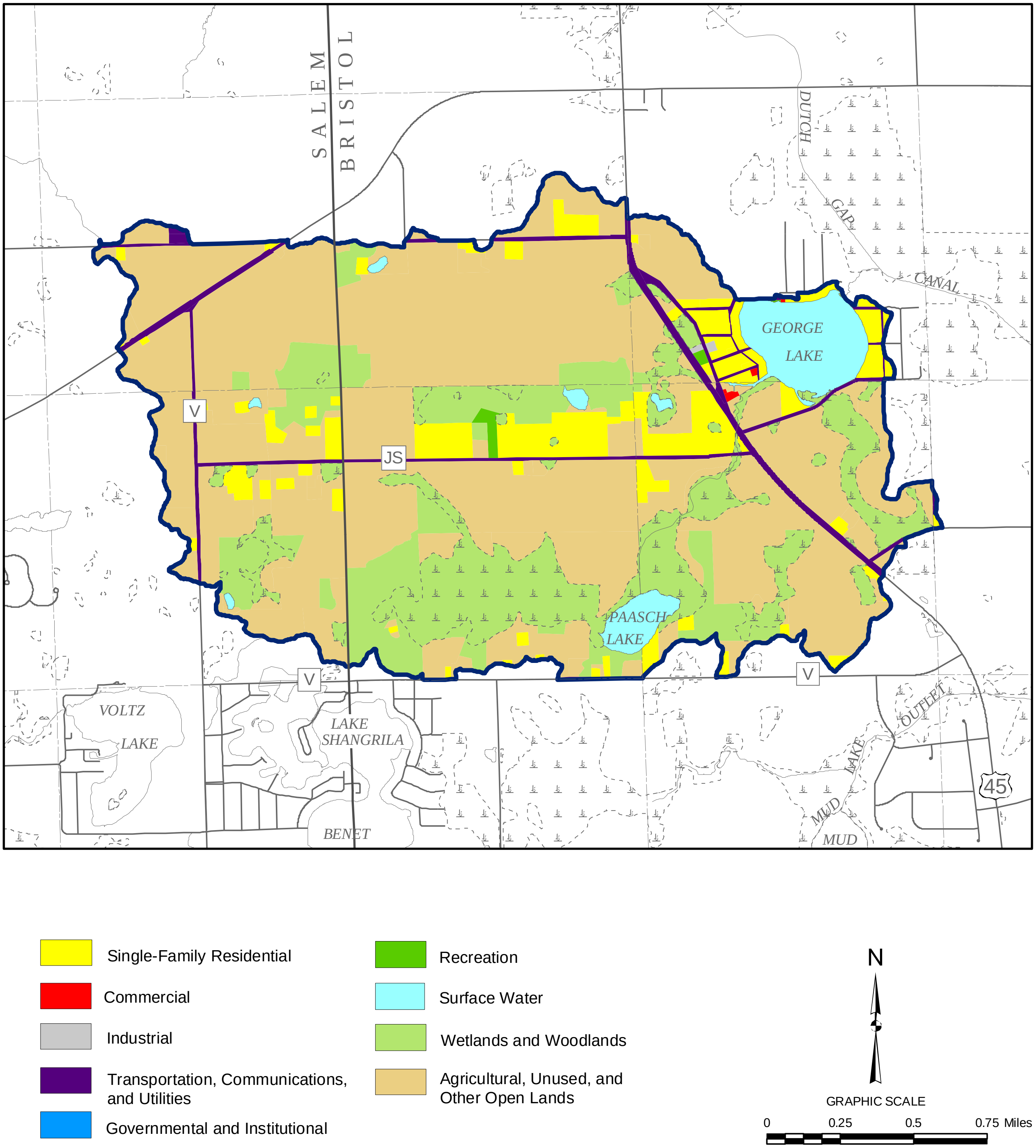
inundation by the 100-year recurrence interval flood event, the event which has a 1 percent probability of occurring in any given year. Under Chapter NR 116, local floodland zoning regulations must prohibit nearly all forms of development within the floodway, which is that portion of the floodplain required to convey the 100-year recurrence peak flood flow. Local regulations also must restrict filling and development within the flood fringe, or that portion of the floodplain located outside of the floodway that would be covered by floodwater during the 100-year recurrence flood. Permitting the filling and development of the flood fringe area reduces the floodwater storage capacity of the natural floodplain, and thereby may 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. Within the area tributary to George Lake, Kenosha County has adopted a countywide floodland zoning ordinance and the Towns of Bristol and Salem have adopted the County floodland zoning ordinance, as shown in Table 9.

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 WDNR.

Map 13

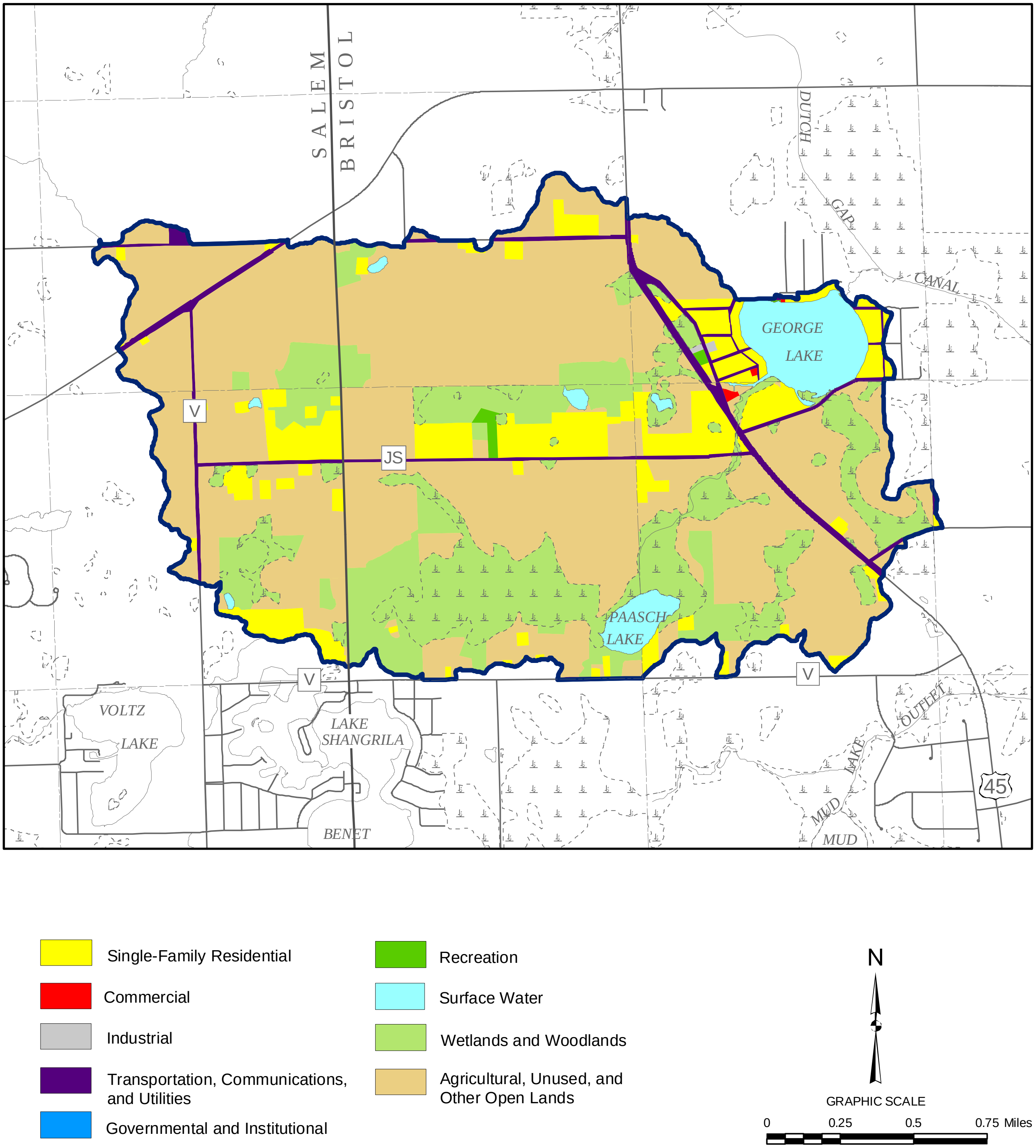
EXISTING LAND USE WITHIN THE AREA TRIBUTARY TO GEORGE LAKE: 2000



Source: SEWRPC.

Map 14

PLANNED LAND USE WITHIN THE AREA TRIBUTARY TO GEORGE LAKE: 2020



Source: SEWRPC.

Table 9

LAND USE REGULATIONS WITHIN THE AREA TRIBUTARY TO GEORGE LAKE IN KENOSHA COUNTY BY CIVIL DIVISION: 2000

Community	Type of Ordinance				
	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
Kenosha County	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Adopted	None
Town of Bristol	County ordinance	County ordinance	County ordinance	Adopted	Adopted
Town of Salem	County ordinance	County ordinance	County ordinance	Adopted	Adopted

Source: SEWRPC.

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 SEWRPC on its 1980, one inch equals 2,000 feet scale, ratioed and rectified aerial photographs as discussed in Chapter V.

County shoreland zoning ordinances are in effect in all unincorporated areas of the area tributary to George Lake, as shown in Table 9.

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. Within the tributary area to George Lake, the Towns of Bristol and Salem have each adopted their own subdivision ordinances, as shown in Table 9.

Construction Site Erosion Control and Stormwater Management Regulations

Towns may adopt village powers and subsequently utilize the authority conferred on cities and villages under Section 62.23 of the *Wisconsin Statutes* to adopt their own erosion control and stormwater management ordinances within their jurisdiction, subject to county board approval where a county ordinance exists. The administrative rules for the State stormwater discharge permit program are set forth in Chapter NR 216 of the *Wisconsin Administrative Code*, which initially took effect on November 1, 1994, and was most recently recreated effective from August 1, 2004. Within the drainage area tributary to George Lake, Kenosha County and the Towns of Bristol and Salem have been identified by the WDNR as being in urbanized areas that have been, or will be, required to obtain stormwater discharge permits unless they receive exemptions.

Stormwater Management
Through 1997 Wisconsin Act 27, the State Legislature required the WDNR and the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) to develop performance standards for controlling nonpoint source pollution from agricultural and nonagricultural land and from transportation facilities.[3] Chapter NR 216 of the *Wisconsin Administrative Code* identifies several categories of municipalities, industries, and construction sites that must obtain permits. The permit requirements are based on the performance standards set forth in Chapter NR 151 of the *Wisconsin Administrative Code*, which became effective on October 1, 2002 and were revised in July 2004.

Agricultural Performance Standards
Agricultural performance standards cover the following areas:

- Cropland sheet, rill, and wind erosion control,
- Manure storage,
- Clean water diversions, and
- Nutrient management.

For existing land that does not meet the Chapter NR 151 standards and that was cropped or enrolled in the U.S. Department of Agriculture (USDA) Conservation Reserve Program (CRP) or Conservation Reserve Enhancement Program (CREP) as of October 1, 2002, agricultural performance standards are required to be met only if cost share funding is available. Existing cropland that met the standards as of October 1, 2002, must continue to meet the standards. New cropland must meet the standards, regardless of whether cost share funds are available.

Nonagricultural (urban) Performance Standards
The nonagricultural performance standards set forth in Chapter NR 151 of the *Wisconsin Administrative Code* encompass two major types of land management. The first includes standards for areas of new development and redevelopment and the second includes standards for developed urban areas. The performance standards address the following areas:

- Construction sites for new development and redevelopment,
- Post construction phase for new development and redevelopment,
- Developed urban areas, and
- Nonmunicipal property fertilizing.

Chapter NR 151 requires municipalities with WPDES stormwater discharge permits to reduce the amount of total suspended solids in stormwater runoff from areas of existing development that were in place as of October 2004 to the maximum extent practicable, according to the following standards:

- By March 10, 2008, the NR 151 standards call for a 20 percent reduction, and

---

[3]*The State performance standards are set forth in the Chapter NR 151, "Runoff Management," of the* Wisconsin Administrative Code*. Additional Code chapters that are related to the State nonpoint source pollution control program include: Chapter NR 152, "Model Ordinances for Construction Site Erosion Control and Storm Water Management," Chapter NR 153, "Runoff Management Grant Program," Chapter NR 154, "Best Management Practices, Technical Standards and Cost-Share Conditions," and Chapter NR 155 "Urban Nonpoint Source Water Pollution Abatement and Stormwater Management Grant Program." Those chapters of the* Wisconsin Administrative Code *became effective in October 2002. Chapter NR 120, "Priority Watershed and Priority Lake Program," and Chapter NR 243, "Animal Feeding Operations," were repealed and recreated in October 2002. The Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) revised Chapter ATCP 50, "Soil and Water Resource Management," to incorporate changes in DATCP programs as required under 1997 Wisconsin Act 27.*

- By October 1, 2013, the standards call for a 40 percent reduction.

Also, permitted municipalities must implement: 1) public information and education programs relative to specific aspects of nonpoint source pollution control; 2) municipal programs for the collection and management of leaf and grass clippings; and, 3) site-specific programs for the application of lawn and garden fertilizers on municipally controlled properties with over five acres of pervious surface. Under the requirements of Chapter NR 151, by March 10, 2008, incorporated municipalities with average population densities of 1,000 people per square mile or more that are not required to obtain municipal stormwater discharge permits must implement these same programs.

Stormwater management practices in urban areas, under the provisions of Section NR 151.12 of the *Wisconsin Administrative Code*, require infiltration, subject to specific exclusions and exemptions as set forth in Sections 151.12(5)(c)5 and 151.12(5)(c)6, respectively. In residential areas, either 90 percent of the predevelopment infiltration volume or 25 percent of the post-development runoff volume from a two-year recurrence interval, 24-hour storm, is required to be infiltrated. However, no more than 1 percent of the area of the project site is required to be used as effective infiltration area; in commercial, industrial and institutional areas, 60 percent of the predevelopment infiltration volume or 10 percent of the post-development runoff volume from a two-year recurrence interval, 24-hour storm, is required to be infiltrated, provided that no more than 2 percent of the rooftop and parking lot areas are required to be used as effective infiltration area. Impervious area setbacks of 50 feet from streams, lakes, and wetlands generally apply. This setback distance is increased to 75 feet around Chapter NR 102-designated Outstanding or Exceptional Resource Waters or Chapter 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.

Construction Site Erosion Control

Regardless of whether a municipality is required to have a stormwater discharge permit under Chapter NR 216 of the *Wisconsin Administrative Code*, Chapter NR 151 requires that all construction sites that disturb one acre or more of land must achieve an 80 percent reduction in the sediment load generated by the site. With certain limited exceptions, those sites required to have construction erosion control permits must also have post-development stormwater management practices to reduce the total suspended solids load from the site by 80 percent for new development, 40 percent for redevelopment, and 40 percent for infill development occurring prior to October 1, 2012. After October 1, 2012, infill development will be required to achieve an 80 percent reduction. If it can be demonstrated that the solids reduction standard cannot be met for a specific site, total suspended solids must be controlled to the maximum extent practicable.

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, as well as related operational programs in those municipalities subject to stormwater permitting requirements pursuant to Chapter NR 216 of the *Wisconsin Administrative Code*.

Construction site erosion control and stormwater management ordinances were in effect in all communities within the tributary drainage area to George Lake in 2000. The Towns of Bristol and Salem have adopted their own ordinances with regards to both construction site erosion control and stormwater management.

Kenosha County has not yet adopted construction site erosion control and stormwater management ordinances. These ordinances would apply to the unincorporated town lands in the County and would require 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*[4] or equivalent practices. In general, these practices are designed to minimize soil loss from disturbed sites through prior planning and phasing of land disturbing activities and use of appropriate onsite erosion control measures.

---

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

Chapter IV

WATER QUALITY

HISTORICAL DATA

Limnological studies of Wisconsin lakes date back to the early 1900s, when pioneering University of Wisconsin limnologists E.A. Birge and C.W. Juday collected basic information on the lakes.[1] More recently, water quality data for George Lake were collected by the Wisconsin Department of Natural Resources (WDNR) from 1976 to 1980. During 1977, as part of a study of George Lake conducted by Environmental Research Assessments (ERA), water quality parameters were measured in the Lake and at its inlets.[2] Intermittently since 1988, water quality data on George Lake have been collected by resident volunteers as part of the WDNR Self-Help Monitoring Program.

George Lake is one of six major lakes in the Des Plaines River watershed. On June 18, 2003, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) adopted a comprehensive plan, requested and funded by Racine and Kenosha Counties, for the Des Plaines River watershed.[3] In this plan, George Lake was noted as being meso-eutrophic to eutrophic in nature, or enriched with the plant nutrients nitrogen and phosphorus. Eutrophic lakes are capable of supporting abundant growths of aquatic plants and sustaining a productive fishery, albeit one likely to become increasingly dominated by pollution tolerant fishes.

EXISTING WATER QUALITY CONDITIONS

Water quality data, gathered under the auspices of the WDNR Self-Help Monitoring Program for the period from 1988 through 2005, as well as earlier data reported by the WDNR and ERA as described above, were used 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. For the purposes of the current planning program, water quality data collected by a resident volunteer as part of the WDNR Self-Help Monitoring Program, are summarized in Tables 10 and 11. The primary sampling station used for the various sampling studies was located at the deepest portion of George Lake, as shown on Map 2. WDNR Self-Help water quality monitoring is ongoing as of the current study period.

---

[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]*Environmental Resource Assessments,* Final Report on the George Lake Study, *1978.*

[3]*SEWRPC Planning Report No. 44,* A Comprehensive Plan for the Des Plaines River Watershed, *Part One* – Chapters 1-10*; Part Two* – Chapters 11-17*; Part Three* – Appendices, *, June 2003.*

Table 10

SEASONAL WATER QUALITY CONDITIONS IN GEORGE LAKE: 1976-1989

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)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Physical Properties								
Alkalinity, as $CaCO_3$								
Range	156-264	162-212	110.0-328.0	202.0-296.0	141.0-266.0	147.0-264.0	108.0-180.0	124.0-190.0
Mean	191.4	187	208.6	249.0	187.6	191.4	131.6	152.7
Standard Deviation	43.3	35.4	69.6	66.5	39.7	45.2	28.4	33.8
Number of Samples	5	2	7	2	7	5	5	3
Hardness, as $CaCO_3$								
Range	- -	- -	- -	- -	- -	- -	- -	- -
Mean	- -	- -	- -	- -	- -	- -	- -	- -
Standard Deviation	- -	- -	- -	- -	- -	- -	- -	- -
Number of Samples	- -	- -	- -	- -	- -	- -	- -	- -
Color (Pt-Co. scale)								
Range	- -	- -	- -	- -	- -	- -	- -	- -
Mean	- -	- -	- -	- -	- -	- -	- -	- -
Standard Deviation	- -	- -	- -	- -	- -	- -	- -	- -
Number of Samples	- -	- -	- -	- -	- -	- -	- -	- -
Dissolved Oxygen								
Range	4.0-11.6	10.2-11.0	0.5-16.6	0.4	6.3-13.8	9.4-13.8	6.5-10.4	0.6-2.2
Mean	8.9	10.6	6.4	0.4	11.4	11.6	8.6	1.2
Standard Deviation	3.4	0.5	5.9	-	2.5	1.6	1.6	0.9
Number of Samples	4	2	6	1	7	5	4	3
pH (units)								
Range	7.4-8.1	7.8	7.5-8.6	7.7-8.0	7.6-8.0	7.6-8.1	7.7-8.8	7.5-7.9
Mean	7.7	7.8	7.9	7.9	7.8	7.9	8.1	7.8
Standard Deviation	0.3	0	0.4	0.2	0.2	0.2	0.4	0.2
Number of Samples	5	2	7	2	7	5	5	3
Secchi Depth (feet)								
Range	0.5-2.8	- -	1.6-5.0	- -	1.6-3.0	- -	1.0-3.0	- -
Mean	1.7	- -	3.5	- -	2.6	- -	2.0	- -
Standard Deviation	1.2	- -	1.4	- -	0.6	- -	00.6	- -
Number of Samples	3	- -	4	- -	5	- -	11	- -
Specific Conductance (µS/cm)								
Range	397-752	411-527	475.0-960.0	719.0-760.0	432.0-640.0	435.0-653.0	383.0-507.0	417.0-497.0
Mean	533.6	469	638.1	739.5	531.6	523.8	431.4	464.7
Standard Deviation	133.3	82.0	154.3	29.0	78.0	85.7	52.5	42.1
Number of Samples	5	2	7	2	7	5	5	3
Temperature (°F)								
Range	41.9-54.8	43.7-49.0	32.9-42.3	40.1	43.7-59.0	41.9-56.3	75.2-77.0	68.9-70.5
Mean	47.4	46.3	36.8	40.1	51.8	48.0	76.0	69.7
Standard Deviation	5.8	3.7	3.7	-	6.8	6.1	0.8	0.8
Number of Samples	4	2	7	1	7	4	4	3
Turbidity (NTU)								
Range	1.3-32	1.3-6.0	1.6-8.7	1.7-7.2	1.5-7.4	5.0-70.0	7.3-17.0	6.5-20.0
Mean	9.9	3.6	4.0	4.5	5.4	19.1	12.9	11.0
Standard Deviation	12.6	3.3	2.7	3.9	2.1	28.5	3.9	7.8
Number of Samples	5	2	7	2	7	5	5	3
Dissolved Solids								
Range	- -	- -	- -	- -	- -	- -	- -	- -
Mean	- -	- -	- -	- -	- -	- -	- -	- -
Standard Deviation	- -	- -	- -	- -	- -	- -	- -	- -
Number of Samples	- -	- -	- -	- -	- -	- -	- -	- -
Metals/Salts								
Dissolved Calcium								
Range	42.0-60.0	42.0-55.0	25.0-102.0	58.0-73.0	38.0-80.0	43.0-80.0	24.0-54.0	36.0-58.0
Mean	49.6	48.5	54.9	65.5	58.1	58.2	35.2	44.3
Standard Deviation	7.4	9.2	24.5	10.6	14.4	13.7	11.8	11.9
Number of Samples	5	2	7	2	7	5	6	3
Dissolved Chloride								
Range	26.0-52.0	24.0-32.0	25.0-53.0	40.0-60.0	25.0-54.0	24.0-55.0	28.0-42.0	28.0-43.0
Mean	38.2	28.0	43.4	50.0	35.6	37.2	36.0	34.0
Standard Deviation	9.9	5.6	10.3	14.1	9.4	11.3	7.3	7.9
Number of Samples	5		7	2	7	5	5	3
Dissolved Iron (µg/l)								
Range	<0.1-0.4	<0.1-0.1	0.03-0.23	0.04	0.0-0.1	0.0-0.1	0.0-0.4	0.0-0.4
Mean	0.2	0.1	0.09	0.04	0.1	0.1	0.1	0.2
Standard Deviation	0.2	<0.1	0.09	-	0.0	0.0	0.1	0.2
Number of Samples	5	2	5	1	7	5	6	3
Dissolved Magnesium								
Range	32.0-40.0	34	26.0-51.0	43.0-44.0	24.0-40.0	26.0-40.0	29.0-39.0	30.0-38.0
Mean	35.4	34	39.3	43.5	30.6	32.2	33.5	33.3
Standard Deviation	2.9	0	8.2	0.7	5.1	5.2	3.2	4.2
Number of Samples	5	2	7	2	7	5	6	3

Table 10 (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)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Metals/Salts (continued)								
Dissolved Manganese (µg/l)								
Range	<0.1-0.2	<0.1	0.0-0.4	0.5	0.02	0.02-0.14	0.0-0.5	0.1-0.4
Mean	0.1	<0.1	0.2	0.4	0.02	0.06	0.1	0.2
Standard Deviation	0.1	0	0.1	-	0.0	0.06	0.2	0.2
Number of Samples	5	2	5	1	5	4	6	3
Dissolved Potassium								
Range	1.9-2.7	0.2-3.6	2.6-18.0	2.7-22.0	1.0-3.8	2.1-3.7	2.4-5.9	1.5-7.2
Mean	2.3	1.9	7.0	12.4	2.5	2.8	3.2	3.5
Standard Deviation	0.4	2.3	7.2	13.6	0.8	0.6	1.3	3.2
Number of Samples	5	2	7	2	7	5	6	3
Dissolved Silica								
Range	- -	- -	- -	- -	- -	- -	- -	- -
Mean	- -	- -	- -	- -	- -	- -	- -	- -
Standard Deviation	- -	- -	- -	- -	- -	- -	- -	- -
Number of Samples	- -	- -	- -	- -	- -	- -	- -	- -
Dissolved Sodium								
Range	10.0-20.0	10.0-13.0	3.3-18.0	3.5-12.0	5.0-32.0	4.0-20.0	13.0-17.0	8.0-17.0
Mean	13.6	11.5	11.0	7.8	16.1	14.0	15.0	13.7
Standard Deviation	2.7	2.1	5.8	6.0	8.1	6.1	1.7	4.9
Number of Samples	5	2	7	2	7	5	6	3
Dissolved Sulfate SO_4								
Range	- -	- -	32.0	- -	37.0	40.0	31.0	30.0
Mean	- -	- -	32.0	- -	37.0	40.0	31.0	30.0
Standard Deviation	- -	- -	-	- -	-	-	-	-
Number of Samples	- -	- -	1	- -	1	1	1	1
Nutrients								
Dissolved Nitrogen, Ammonia								
Range	<0.1-0.4	0.2-0.4	0.4-1.3	0.5-1.2	0.0-0.4	0.0-0.3	0.1-0.3	0.0-1.0
Mean	0.2	0.3	0.9	0.9	0.2	0.2	0.2	0.4
Standard Deviation	0.1	0.2	0.3	0.5	0.1	0.1	0.1	0.6
Number of Samples	5	2	7	2	7	4	5	3
Dissolved Nitrogen, NO_2+NO_3								
Range	0.1-0.7	0.1-0.2	0.0-0.2	0.2-0.7	0.1-2.7	0.3-2.5	0.0-0.2	0.1-0.2
Mean	0.4	0.1	0.2	0.5	1.1	1.3	0.1	0.1
Standard Deviation	0.2	0.1	0.1	0.4	1.2	0.9	0.1	0.1
Number of Samples	5	2	7	2	5	5	5	3
Total Nitrogen, Organic								
Range	0.9-2.3	1.0-1.2	0.9-1.4	0.8-1.1	0.6-1.7	0.7-2.3	1.2-1.6	0.8-1.6
Mean	1.3	1.1	1.2	0.9	1.1	1.4	1.4	1.2
Standard Deviation	0.5	0.1	0.2	0.2	0.4	0.6	0.2	0.4
Number of Samples	5	2	7	2	7	5	5	3
Total Nitrogen, Amm. + Organic								
Range	- -	- -	- -	- -	- -	- -	- -	- -
Mean	- -	- -	- -	- -	- -	- -	- -	- -
Standard Deviation	- -	- -	- -	- -	- -	- -	- -	- -
Number of Samples	- -	- -	- -	- -	- -	- -	- -	- -
Total Nitrogen								
Range	- -	- -	- -	- -	- -	- -	- -	- -
Mean	- -	- -	- -	- -	- -	- -	- -	- -
Standard Deviation	- -	- -	- -	- -	- -	- -	- -	- -
Number of Samples	- -	- -	- -	- -	- -	- -	- -	- -
Dissolved Orthophosphorus								
Range	0.02-0.04	0.03-0.04	0.01-0.04	0.01-0.05	0.00-0.03	0.00-0.03	0.00-0.06	0.03-0.10
Mean	0.03	0.04	0.03	0.03	0.01	0.01	0.04	0.06
Standard Deviation	0.01	<0.01	0.01	0.03	0.01	0.01	0.03	0.04
Number of Samples	5	2	7	2	7	5	5	3
Total Phosphorus								
Range	0.04-0.16	0.06-0.07	0.05-0.12	0.06-0.07	0.0-0.1	0.0-0.2	0.1	0.1
Mean	0.08	0.06	0.07	0.07	0.1	0.1	0.1	0.1
Standard Deviation	0.04	0.01	0.03	0.01	0.0	0.1	0.0	0.0
Number of Samples	5	2	7	2	7	5	6	3
Biological								
Chlorophyll-*a* (µg/l)								
Range	- -	- -	- -	- -	35.5	35.5	36.0	36.0
Mean	- -	- -	- -	- -	35.5	35.5	36.0	36.0
Standard Deviation	- -	- -	- -	- -	0.0	0.0	-	-
Number of Samples	- -	- -	- -	- -	2	2	1	1

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

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

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

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

Table 11

SEASONAL WATER QUALITY GEORGE LAKE: 1990-2005

Measured Data			
Parameter	Spring (mid-March to mid-June)	Summer (mid-June to mid-September)	Fall (mid-September to mid-December)
Secchi Disc Depth (feet)			
Number of Samples	45	70	38
Range	1.3-7.9	1.6-6.9	1.0-6.9
Average	3.6	3.3	3.3
Standard Deviation	1.6	1.3	1.3
Chlorophyll-*a* (μg/l)			
Number of Samples	2	22	8
Range	11.0-23.0	2.0-32.0	23.0-61.0
Average	17.0	13.3	44.6
Standard Deviation	8.5	7.1	13.9
Total Phosphorus (μg/l)			
Number of Samples	10	24	8
Range	35.0-59.0	15.0-63.0	4.7-23.0
Average	42.2	36.1	12.5
Standard Deviation	7.7	9.1	6.2

WTSI Calculations			
Parameter	Spring	Summer	Fall
Secchi Disc Depth			
Number of Samples	45	70	38
Range	47.1-73.3	49.1-71.3	49.3-77.1
Average	60.5	61.0	60.6
Standard Deviation	6.2	5.6	6.1
Chlorophyll-*a* (μg/l)			
Number of Samples	2	22	8
Range	52.0-57.6	38.9-60.2	45.5-57.6
Average	54.8	52.3	52.1
Standard Deviation	4.0	4.6	3.9
Total Phosphorus (μg/l)			
Number of Samples	10	24	8
Range	57.9-65.4	45.7-66.4	51.8-65.9
Average	60.4	57.9	60.7
Standard Deviation	2.5	3.9	4.9

Source: Wisconsin Department of Natural Resources.

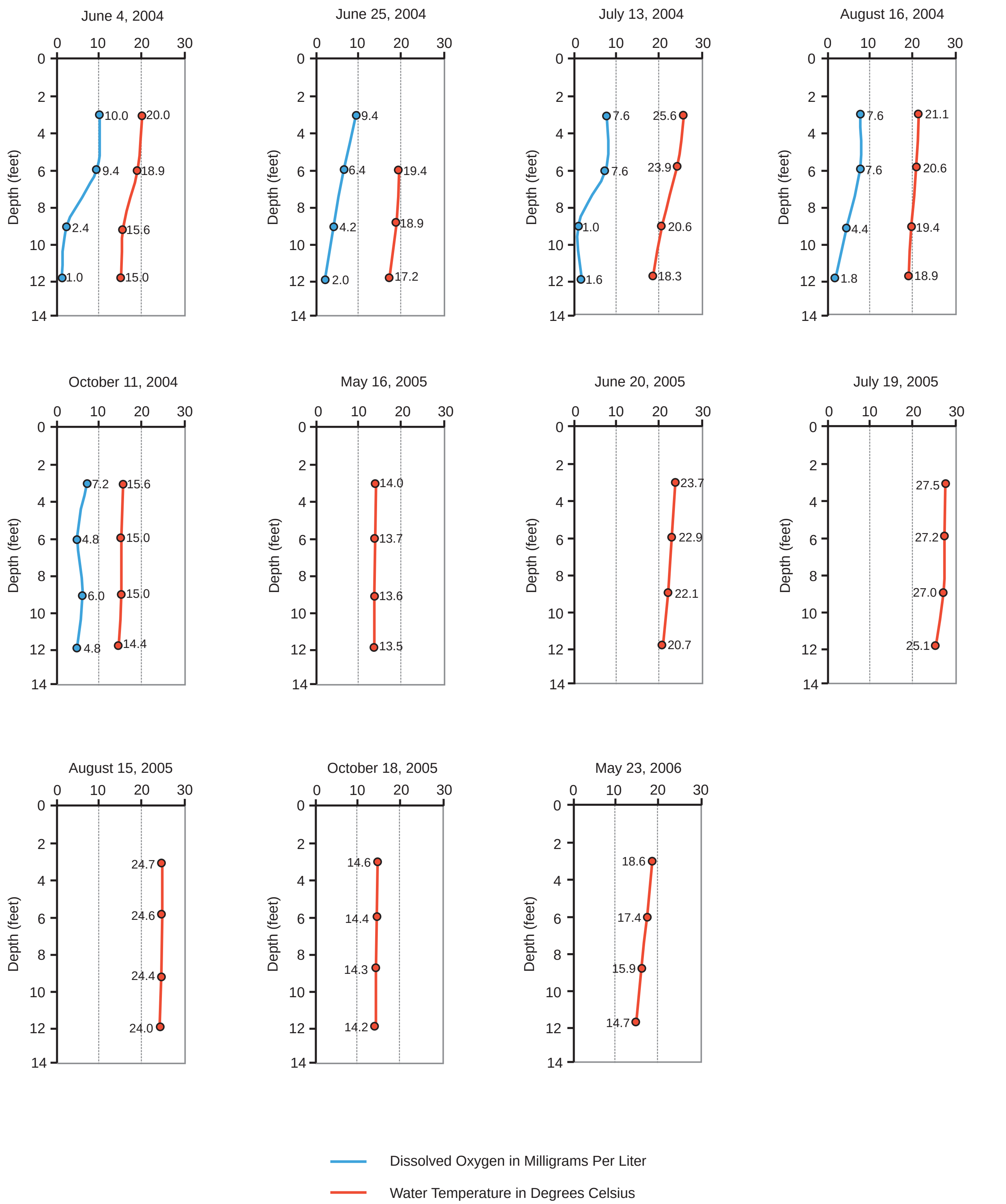
Thermal Stratification

Thermal and dissolved oxygen profiles for George Lake are shown in Figure 2. These data are similar to those reported by ERA in 1978. During the current study period, water temperatures in George Lake ranged from a minimum of 32°F (0°C) during the winter to a maximum of 84°F (29°C) during the summer. Based upon Figure 2, George Lake can be considered to be polymictic, mixing and stratifying multiple times during a year as a result of wind-induced circulation. This condition is typical of shallow lakes and deep water marshes within the Region, and is more common during the summer months when the Lake is exposed to more intense solar irradiation.

Thermal stratification is a result of the differential heating of lake water, and the resulting water temperature-density relationships at various depths within the water column. This process is illustrated diagrammatically in

Figure 2

DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR GEORGE LAKE: 2004-2006



NOTE: Dissolved oxygen data not available from May 16, 2005 through May 23, 2006.

Source: Wisconsin Department of Natural Resources and SEWRPC.

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 thermal stratification typically begins in early summer. Stratification may also occur during winter under ice cover.

As summer begins, the Lake water 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 3. 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 George Lake, based upon the data set forth in Figure 2 for June 4, 2004 and July 13, 2004, the hypolimnion can become anoxic, or devoid of dissolved oxygen.

When air temperatures drop with the passage of a cold front, the surface waters cool. Concurrent wind action can result in the erosion of the thermocline. The surface water cools, becomes heavier, sinking and displacing the relatively warmer water below. The colder water sinks and mixes due to the wind action until the entire column of water is of uniform temperature, as shown in Figure 3. In George Lake, based upon the data set forth in Figure 2 for June 25, 2004 and August 16, 2004, the hypolimnion can become aerated, or replenished with dissolved oxygen. When this action occurs during the autumn, following the period summer stratification, it is known as “fall turnover,” as was observed on October 11, 2004.

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 George Lake, ice cover is reported to typically exist from December until early April. As shown in Figure 3, winter stratification can occur as the colder, lighter water and ice remain 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 and mixing.

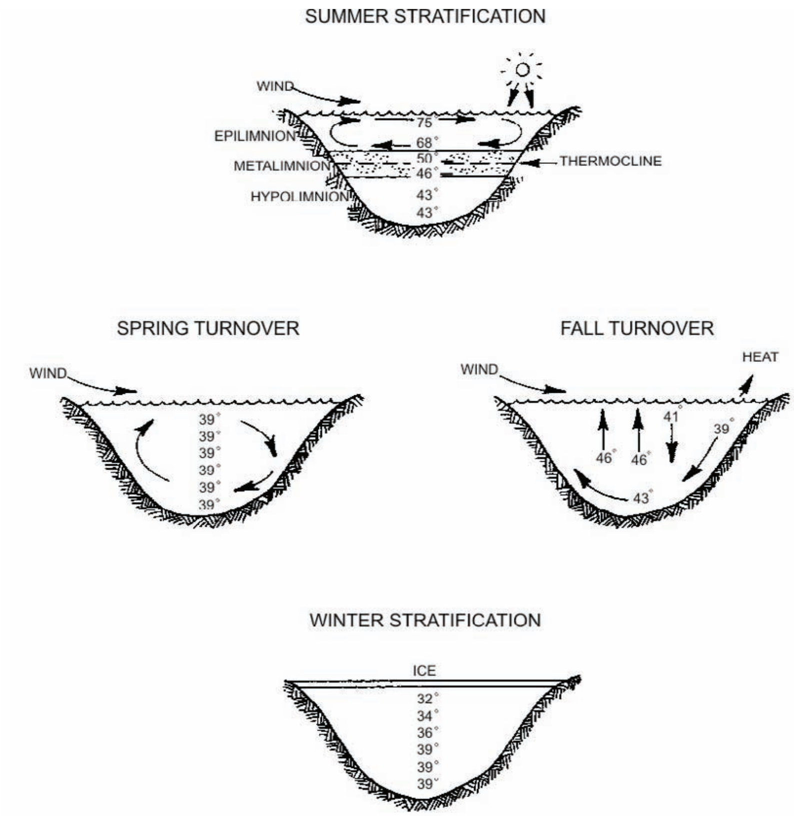
Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem, since most organisms require oxygen to survive. As reported in the aforementioned ERA report, dissolved oxygen data indicated that the Lake could be considered to have good oxygen levels throughout, although there were four times during the sampling period when low oxygen levels were reported. As shown in Table 10, data from the period between 1976 and 1988 indicated good average concentrations of oxygen at all depths during the year, with some low oxygen concentrations at deeper depths during winter and summer.

During the current study, as shown in Figure 2, dissolved oxygen levels were generally higher at the surface of George Lake, where there was interchange between the water and atmosphere, mixing 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 lakes become thermally stratified, as described above, the surface supply of dissolved oxygen to the hypolimnion can

Figure 3

THERMAL STRATIFICATION OF LAKES



Source: University of Wisconsin-Extension and SEWRPC.

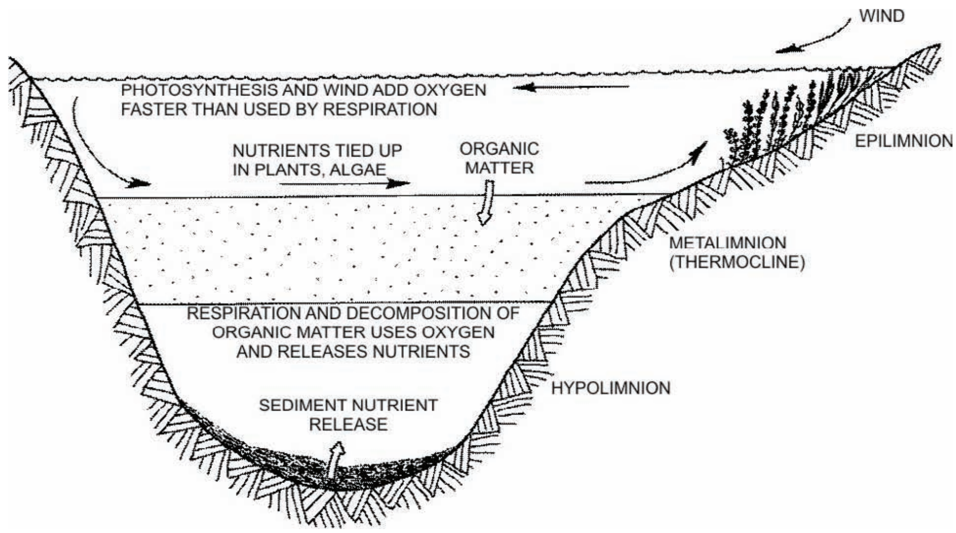
be cut off or reduced, resulting in levels of dissolved oxygen in the bottom waters that may be insufficient to meet the needs of bottom dwelling aquatic life and decaying organic material. Under these conditions, the dissolved oxygen levels may be reduced, even to zero, a condition known as anoxia or anaerobiasis, as shown in Figure 4. In shallow lakes, such as George Lake, the passage of intense weather fronts can cause this condition to be upset.

During 2004, dissolved oxygen concentrations in the surface waters of George Lake ranged from about 7.2 milligrams per liter (mg/l) to about 10.0 mg/l, as shown in Figure 2. Hypolimnetic dissolved oxygen concentrations dropped to near zero on several occasions during the summer months, as shown in the figure. Mixing events and fall turnover, during October 2004, naturally restored the supply of oxygen to the bottom water, although hypolimnetic anoxia can be reestablished during the period of winter thermal stratification. Winter anoxia can occur during the years with heavy snowfalls, 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 and 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.

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

Figure 4

LAKE PROCESSES DURING SUMMER STRATIFICATION



Source: University of Wisconsin-Extension and SEWRPC.

In addition to the 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 George Lake is discussed further below.

Specific Conductance

Specific conductance, the ability of water to conduct an electric current, is an indicator of the concentration of dissolved solids in the water; as the amount of dissolved solids increases, the specific conductance increases. As such, specific conductance is often useful as an indication of possible pollution in a lake’s waters. Freshwater lakes commonly have a specific conductance range of from 10 to 1,000 microSiemens per centimeter (µS/cm), although measurements in polluted waters or in lakes receiving large amounts of land runoff can sometimes exceed 1,000 µS/cm.[4]

Data from the ERA study showed average specific conductivity readings consistently lower than the more current measurements presented in Table 10. For example, in the surface waters of George Lake, specific conductivity during fall averaged 383 µS/cm during the earlier study, compared to 534 µS/cm for the period from 1976 to 1988, as shown in Table 10. Comparing winter averages, the ERA study reported conductivities averaging 327 µS/cm compared with 638 µS/cm reported during the more recent period, as shown in Table 10. In spring, average conductivity was 383 µS/cm during the ERA study, and 532 µS/cm more recently, while, in summer, conductivity averaged 338 µS/cm during the earlier study and 454 µS/cm more recently. A similar pattern existed in the seasonal averages reported at deeper depths. Nevertheless, these values are within the normal range for lakes in southeastern Wisconsin.

[4]*Deborah Chapman,* Water Quality Assessments, second edition, *E&FN Spon, 1996.*

Regionwide increases in specific conductance have been reported over the years, apparently associated with increases in chloride concentrations related to the input of salts from winter highway maintenance and water softeners. Long-term continued increases of specific conductance can serve as an indicator of such increased chloride concentrations and/or with the increased concentrations of other pollutants, with concomitant deleterious effects on aquatic plants and animals inhabiting these environments.

During periods of thermal stratification, specific conductance can increase at the lake bottom due to an accumulation of dissolved materials in the hypolimnion, producing a concentration gradient from surface to bottom waters. This is a consequence of the "internal loading" phenomenon noted above. The specific conductance of George Lake did not exhibit pronounced surface to bottom conductivity gradients either during the earlier ERA study or more recent study, as shown in Table 10.

Chloride

At high concentrations, chloride can directly affect aquatic plant growth and pose a threat to aquatic organisms. The effects of chloride contamination begin to manifest at about 250 mg/l and become severe at concentrations in excess of 1,000 mg/l.[5] Natural chloride concentrations in lake water are directly affected by leaching from underlying bedrock and soils, and by deposition from precipitation events. Higher concentrations can reflect pollution. Lakes in southeastern Wisconsin typically have very low natural chloride concentrations due to the limestone bedrock found in the Region. Limestone is primarily composed of calcium carbonate and magnesium carbonate, and, as such, is rich in carbonates rather than chlorides. Hence, the sources of chloride in southeastern Wisconsin are largely anthropogenic, including sources such as salts used on streets and highways for winter snow and ice control, salts discharged from water softeners, and salts from sewage and animal wastes. The significance of human-originated chlorides is reflected in the chloride concentrations found in lakes in the different regions of Wisconsin, where geological sources of the element are rare. Chloride concentrations in lakes in the more populated and urban southeastern region average about 19 mg/l as contrasted with concentrations of about 2.0 mg/l in lakes in the northeastern and northwestern regions of the State, about 4.0 mg/l in lakes in the central region, and about 7.0 mg/l in lakes in the southwestern region.[6]

Chlorides were measured during the period from 1976 to 1988, as shown in Table 10. Seasonal chloride concentrations at all depths averaged about 36 mg/l in spring and summer, ranging from 24 mg/l to 55 mg/l. This is consistent with the increasing trend in chloride concentrations observed throughout the Southeastern Wisconsin Region, as shown in Figure 5.[7] The most important anthropogenic sources of chlorides to George Lake are believed to be the salts used in domestic water softener systems, and on streets and highways for winter snow and ice control. Precipitation chemistry data reported by the National Atmospheric Deposition Program/National Trends Network from the precipitation monitoring station located in the City of Lake Geneva, Walworth County, indicate a gradually decreasing trend in chloride concentrations in precipitation between 1984 and 2005,[8] which supports the contention that the increasing chloride concentrations in lakes in the Region are not the result of atmospheric deposition.

Alkalinity

Alkalinity is an index of the buffering capacity of a lake, or the ability of a lake to absorb and neutralize acids. Lakes having a low alkalinity and, therefore, a low buffering capacity, may be more susceptible to the effects of acidic atmospheric deposition. The alkalinity of a lake depends on the levels of bicarbonate, carbonate, and

---

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

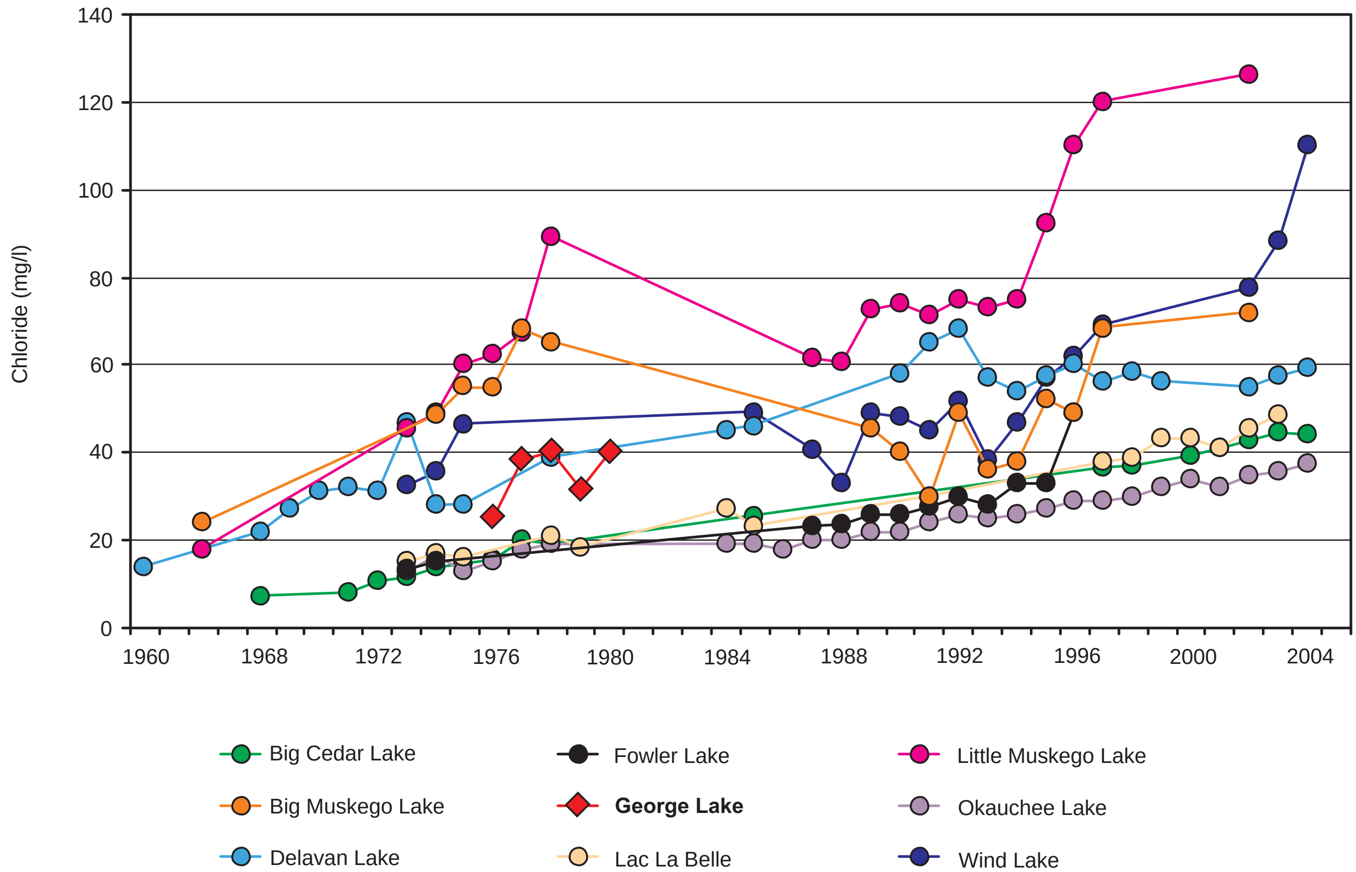
[6]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *1983*

[7]Ibid.

[8]*National Atmospheric Deposition Program, http://nadp.sws.uiuc.edu.*

Figure 5

CHLORIDE CONCENTRATION TRENDS FOR ASSORTED LAKES IN SOUTHEASTERN WISCONSIN: 1960-2004



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

hydroxide ions present in the water. Due, in large part, to the deposits of limestone and dolomite that make up much of the bedrock underlying many of the lakes and their associated tributary areas, lakes in southeastern Wisconsin typically have a high alkalinity, with an average concentration of about 173 mg/l expressed as calcium carbonate.[9]

During the ERA study, alkalinity averaged about 189 mg/l at all depths on an annual basis. As shown in Table 10, during the period from 1976 to 1988, alkalinity in George Lake averaged about 188 mg/l. These more recent values are within the normal range for lakes in the Region.

In contrast to alkalinity, water hardness is a measure of the multivalent metallic ion concentrations, such as those of calcium and magnesium, present in a lake. Generally, lakes with high levels of hardness produce more fish and aquatic plants than lakes whose water is soft.[10] Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$). Hardness for George Lake was not measured, however, based on the alkalinity

---

[9]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[10]*Byron Shaw, Lowell Klessig, Christine Mechenich,* Understanding Lake Data, *University of Wisconsin-Extension Publication No. G3582, 2004.*

measurements, George Lake would probably be classified as a hard-water alkaline lake, which is typical of most lakes in southeastern Wisconsin.

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. The pH of lake water influences many of the chemical and biological processes that occur there. Even though moderately low / high pH may not directly harm fish or other organisms, pH near the ends of the scale can have adverse effects on the organisms living in a lake. Additionally, under conditions of very low (acidic) pH, certain metals, such as aluminum, zinc, and mercury, can become soluble if present in a lake's bedrock or tributary area soils, leading to an increase in concentrations of such metals in a lake's waters with subsequent potentially harmful effects to not only the fish but also to those organisms, including humans, who eat them.[11]

As in the case of alkalinity, the chemical makeup of the underlying bedrock has a great influence on the pH of lake waters. In the case of lakes in the Southeastern Wisconsin Region, where the bedrock is comprised largely of limestone and dolomite, the pH typically is in the alkaline range above a pH of 7. In general, the pH for most natural waterbodies is within the range of about 6.0 to about 8.5.[12] Measurements of pH from lakes in southeastern Wisconsin averaged about 8.1, which, due to the underlying geology of the Region, was the highest recorded from any region in the State—by contrast, lakes in the Northeast are slightly acidic with an average pH of about 6.9.[13] Other factors influencing pH include precipitation as well as biological (algal) activity within the Lake.

Natural buffering of rainfall by carbon dioxide in the atmosphere and the carbonate system in the Lake, its tributary streams and drainage area, all tend to moderate the pH level in George Lake, as well as in the other lakes in the Region. The pH of rain in the southeastern Wisconsin region is typically in the 4.4 range.[14] Data collected as part of the aforementioned National Atmospheric Deposition Program (NADP) indicate that there has been a gradual upward trend in precipitation pH at the City of Lake Geneva monitoring station, from about 4.4 in 1984 to about 5.0 in 2005.[15] In George Lake, pH ranged from 7.6 to 9.2 standard units, averaging 8.1, during the ERA study, and between 7.4 and 8.8 standard units, with an average of about 7.9, in more recent years, as shown in Table 10. Since George 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.

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 WDNR Self-Help Monitoring Program in which citizen volunteers assist in lake water quality monitoring efforts.

Water clarity generally varies throughout the year as algal populations increase and decrease in response to changes in weather conditions and nutrient loadings. Water clarity can also vary from region to region in the State

---

[11]Ibid.

[12]*Deborah Chapman*, op. cit.

[13]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[14]Ibid.

[15]*National Atmospheric Deposition Program, http://nadp.sws.uiuc.edu,* op. cit.

as a reflection of regional differences in lake biogeochemistry. Lakes in the Northeast region generally have low levels of turbidity, as indicated by the region's average Secchi-disc reading of 8.9 feet, compared to the average in the Southeastern Wisconsin Region of 4.9 feet.[16]

Secchi-disc measurements for the period from 1976 through 1988, set forth in Table 10, averaged about 3.3 feet. More recently, during the period from 1990 through 2005, shown in Table 11, seasonal Secchi disk measurements averaged about 3.4 feet. As shown in Figure 6, the trend line for Secchi depths for the time period from 1988 to 2005 indicates a modest, but observable, increase in water clarity, although these more recent values continue to indicate poorer water quality than the average of other lakes in southeastern Wisconsin, as shown in Figure 7.[17]

The Environmental Remote Sensing Center (ERSC), established in 1970 at the University of Wisconsin-Madison, was one of the first remote sensing facilities in the United States. Using data gathered by satellite remote sensing over a three year period, the ERSC generated a map based on a mosaic of satellite images showing the estimated water clarity of the largest 8,000 lakes in the State of Wisconsin. The ERSC remote sensing data for George Lake estimated average water clarity of 3.3 feet.

Two important characteristics affecting water transparency are color and turbidity. Perceived color of lakes is often described as "green" or "brown" or some combination of these colors, and is influenced by dissolved and suspended materials in the water, phytoplankton population levels, as well as various physical factors. Actual, or true, color of lake waters is the result of substances that are dissolved in the water. For example, the brown-stained color of lakes in the northern part of the State is the result of organic acids from certain dissolved humic materials present in those waters. Color was not measured for George Lake during the current study period. Measured values of turbidity in George Lake were significantly higher than average for lakes in the Southeastern Wisconsin Region, reinforcing the Secchi water clarity data that indicate that George Lake has water which is less clear than most of the lakes in the Region.

In recent years, some lakes in southeastern Wisconsin have experienced improved water clarity that may be related to the presence of the zebra mussel, *Dreissena polymorpha,* an invasive, nonnative filter feeding mollusk known to impact water clarity in inland lakes. There has been no report of the presence of this species in George Lake as of the current study period.

Chlorophyll-*a*

Chlorophyll-*a* is the major photosynthetic ("green") pigment in algae. The amount of chlorophyll-*a* present in the water is an indication of the biomass or amount of algae in the water. The median chlorophyll-*a* concentration for lakes in the southeastern region is about 9.9 micrograms per liter (μg/l).[18]

During the period from 1976 to 1988, chlorophyll-*a* values in the surface waters of George Lake averaged 12.5 μg/l in fall, 26.3 μg/l in spring, and 14.3 μg/l in summer. For the period from 1990 through 2005, as shown in Table 11, chlorophyll-*a* concentrations averaged 44.6 μg/l in the fall, 17.0 μg/l in the spring, and 13.3 μg/l in the summer. As shown in Figure 6, average chlorophyll-*a* concentrations between 1990 and 2005 indicated a fairly constant trend.

Chlorophyll-*a* levels above about 10 μg/l range result in a green coloration of the water that may be severe enough to impair recreational activities such as swimming and skiing.[19] As shown in Figure 7, values in excess of this level have been reported from George Lake.

---

[16]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

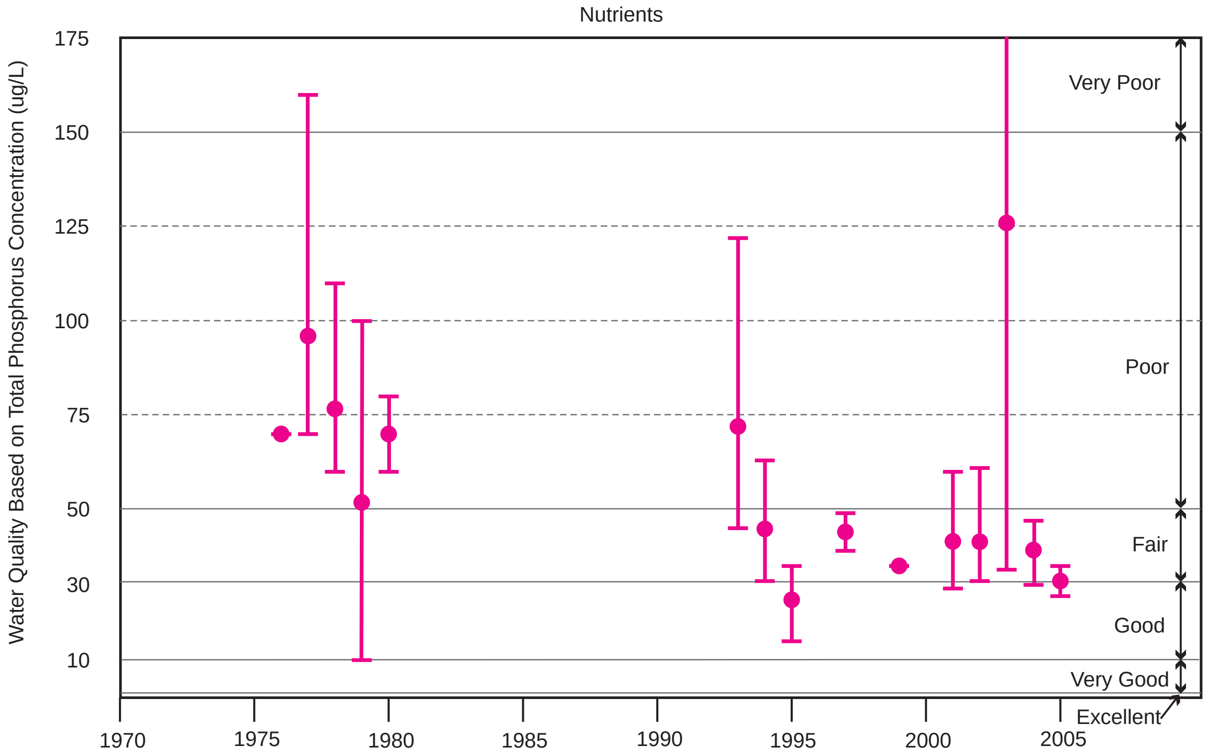
[17]Ibid.

[18]Ibid.

[19]*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 6

PRIMARY WATER QUALITY INDICATORS FOR GEORGE LAKE: 1976-2005



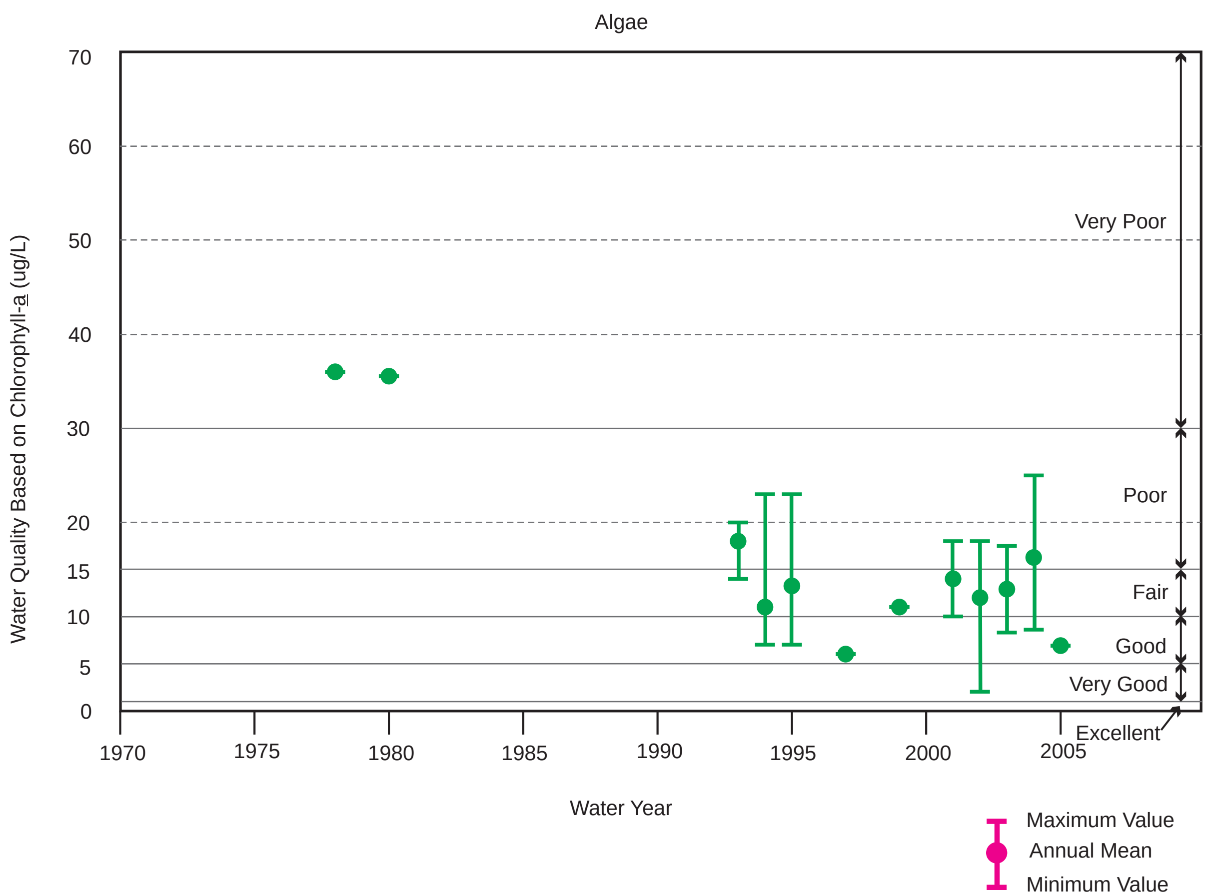
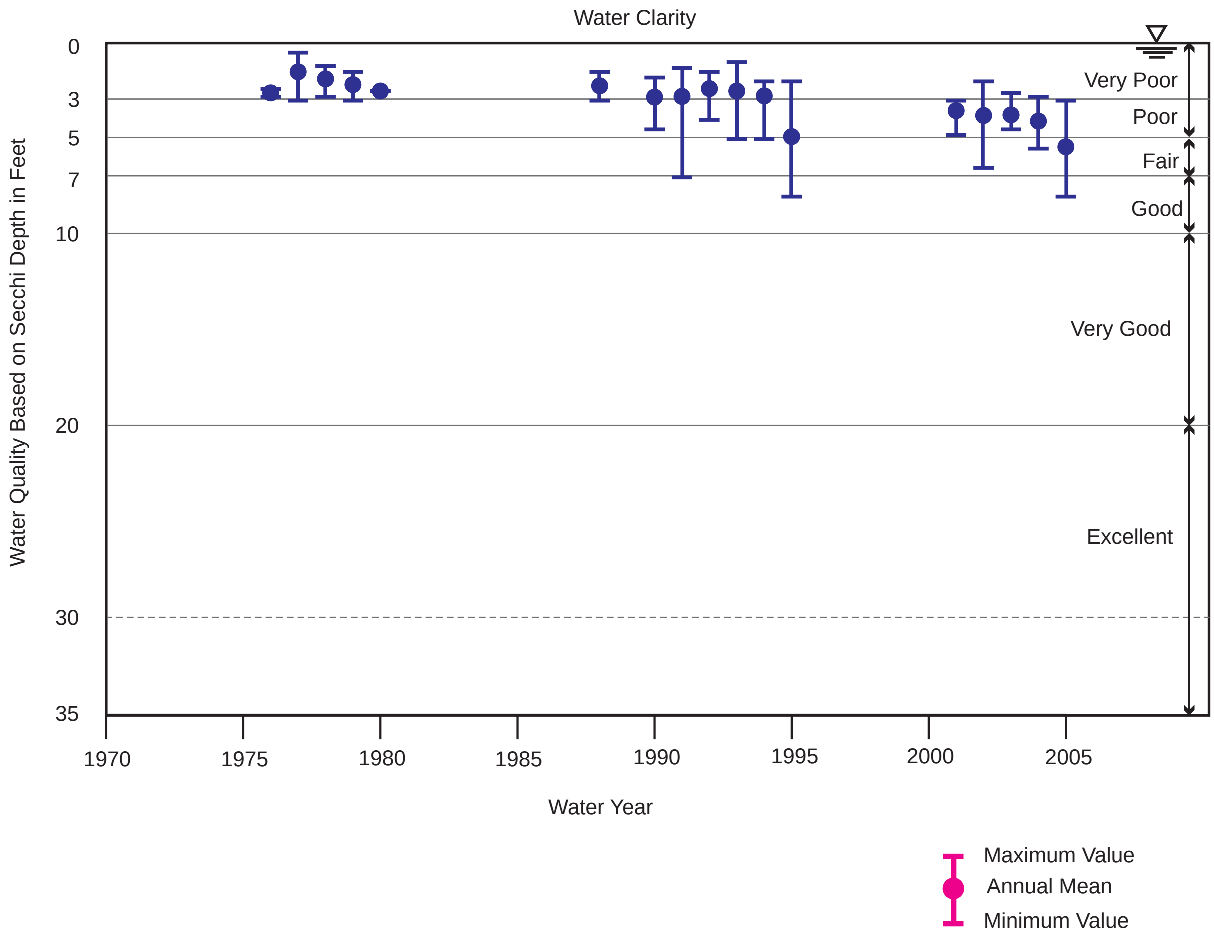


Figure 6 (continued)



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

Nutrient Characteristics

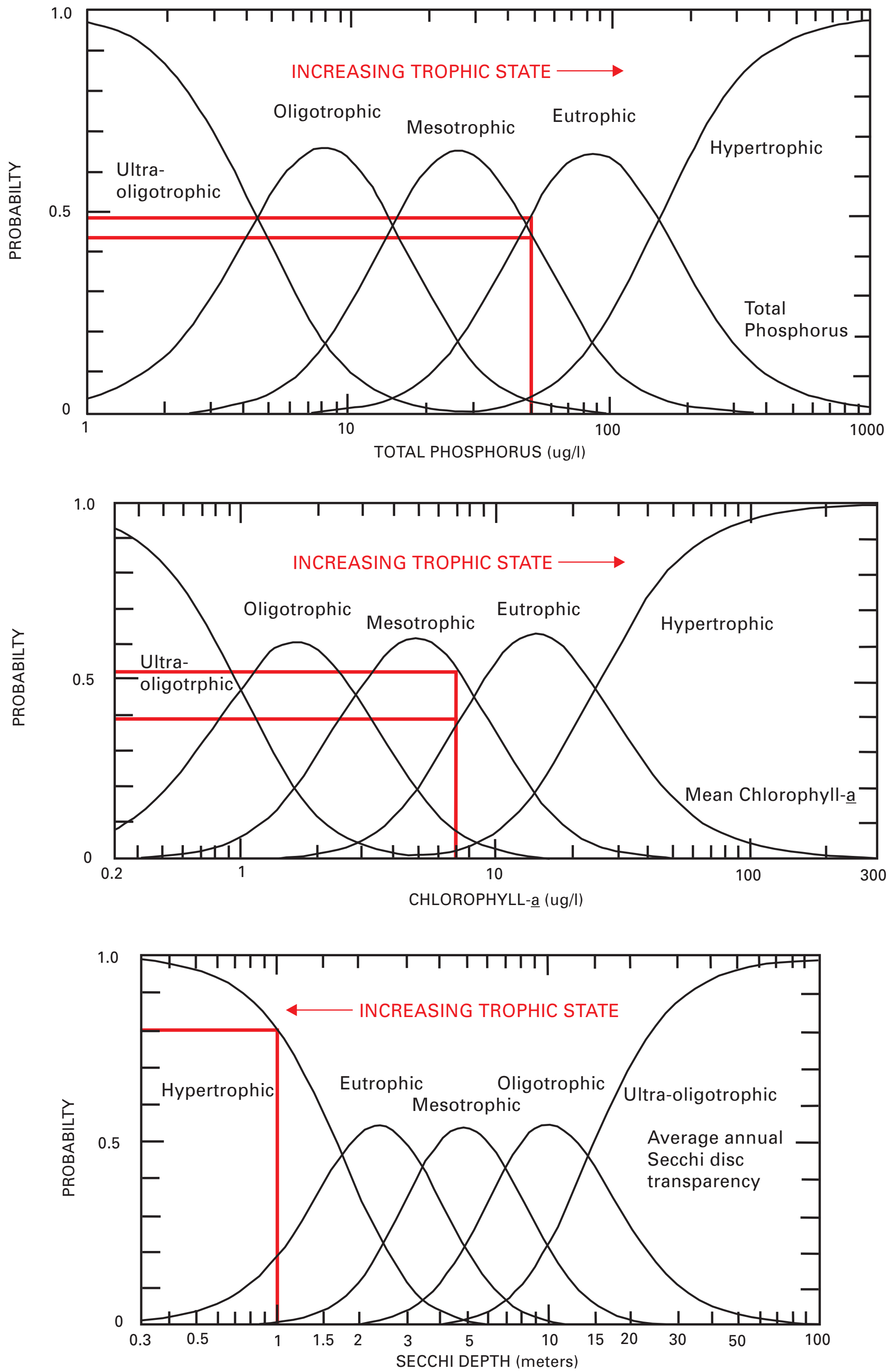
Aquatic plants and algae require nutrients such as phosphorus and nitrogen for growth. In hard-water alkaline lakes, most of these nutrients are generally found in concentrations that exceed the needs of growing plants. However, in lakes where the supply of one or more of these nutrients is limited, 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 to be limiting aquatic plant growth in a lake.[20] Where the N:P ratio is greater than 14:1, phosphorus is most likely to be the limiting nutrient. If the ratio is less than 10:1, nitrogen is most likely to be the limiting nutrient. Using the data for total phosphorus and total organic nitrogen shown in Table 10, the nitrogen-to-phosphorus ratios in samples collected from George Lake were always greater than 10:1, indicating that plant production was most likely limited by phosphorus.

Phosphorus in a lake can exist in several forms. 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

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

Figure 7

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



Source: U.S. Geological Survey and SEWRPC.

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 and stormwater discharges from an urban or agricultural landscape 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.[21]

Total phosphorus concentrations in George 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 George Lake, during the period from 1976 through 1988, as shown in Table 10, the mean concentration of total phosphorus was 0.09 mg/l on an average annual basis, indicating poor water quality, as illustrated in Figure 7. Dissolved phosphorus, or orthophosphate, seasonal average concentrations in the surface waters were 0.03 mg/l in fall and winter, 0.01 mg/l in spring, and 0.04 mg/l in summer. During the period from 1990 through 2005, as shown in Table 11, total phosphorus concentrations averaged 0.042 mg/l in spring, 0.036 mg/l in summer, and 0.013 mg/l in fall. Figure 6 shows a trend line for total phosphorus readings over the time period of 1988 to 2005 indicating basically little change in surface total phosphorus measurements.

The seasonal gradients of phosphorus concentration between the epilimnion and hypolimnion reflect the biogeochemistry of this growth element. During the growing season, nutrients become depleted in the upper waters as plants utilize them for growth. When aquatic organisms die, they usually sink to the bottom of the lake, where they decompose, resulting in an accumulation of nutrients. Phosphorus from these organisms is then either stored in the bottom sediments or rereleased into the water column, particularly under conditions of oxygen depletion, a phenomenon mentioned above as "internal loading."

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 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 the phosphorus becomes soluble again and is released from the sediments. This internal loading 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. When the mixing process is relatively slow, on the order of days to weeks, minerals and nutrients released from the sediments into the hypolimnion of the lake tend to recombine with the multivalent cations in the lake sediments and precipitate out of the water column; if the mixing process is relatively rapid, on the order of hours to days, as may occur due to the passage of an intense storm, the minerals and nutrients may be mixed upward into the epilimnion or surface waters where they are available for plant growth.[22] In polymictic lakes,

---

[21]*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, 1988; 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.*

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

which mix frequently during the year, some of the phosphorus released from the lake sediments can potentially reach the surface waters of the lake, resulting in periodic peaks in algal production, although the frequent mixing generally means that the bottom waters are oxygenated, resulting in a concomitantly slow release of phosphorus from the sediments to the overlying waters.

The data summarized in Table 10 indicate that internal loading of phosphorus from the bottom sediments of George Lake was unlikely during the period of 1976 to 1988.

Groundwater Quality
During the ERA study, groundwater levels were monitored in five pairs of observation wells drilled around the perimeter of George Lake. Water level data from these wells indicated that groundwater generally flowed out of the Lake except for brief periods in early spring. Groundwater quality parameters measured as a part of that study indicated that groundwater was generally hard, containing large amounts of dissolved solids and moderately high amounts of phosphorus. Since direction of groundwater flow was generally away from the Lake, it is unlikely that groundwater is a major contributor to nutrient levels in George Lake.

Groundwater quality was not measured as part of the current study.

POLLUTION LOADINGS AND SOURCES

Pollutant loads to a lake are generated by various natural processes and human activities that take place in the area tributary to a lake.[23] 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 source 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 area of George Lake is about 2,187 acres in areal extent. No known point sources exist within this drainage area. Consequently, as already noted in Chapter II, inflow to George Lake is primarily through direct precipitation onto the Lake surface and runoff from the local drainage area, including the unnamed intermittent tributaries located along the southwestern and western shores of the Lake.

Nonpoint Sources
Nonpoint-source phosphorus, suspended solids, and urban-derived metals input to and output from George Lake were estimated using the Wisconsin Lake Model Spreadsheet (WILMS version 3.0),[24] and unit area load-based models developed for use within the Southeastern Wisconsin Region. Contaminant loads were estimated for base year 2000 land use conditions, and for forecast year 2020 land use conditions.

Phosphorus Loadings
Year 2000 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

---

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

[24]*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.*

limiting aquatic plant growth in George 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 plan, changes in the nutrient, sediment, and metal loadings to George 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 George Lake based upon 2000 land use and planned 2020 land use are set forth in Tables 12 and 13, respectively. The forecast data for the 2000 land use conditions, resulting in a likely in-lake phosphorus concentration of about 0.045 mg/l, compared relatively well with the range of phosphorus levels observed within the Lake in recent years, averaging about 0.042 mg/l in spring and about 0.036 mg/l in summer, as noted in Table 10.

The estimated phosphorus budget for George Lake, based on the WILMS analysis, is set forth in Table 12 for 2000 and planned 2020 land use conditions. An annual total phosphorus load of between about 1,000 and 4,750 pounds, with a most likely total phosphorus loading of about 1,100 pounds, was estimated to be contributed to George Lake. Given the good agreement between the forecast in-lake total phosphorus concentration and observed in-lake phosphorus concentration obtained using the most likely phosphorus loading estimate, it can be estimated that 1,000 pounds per year, or about 95 percent of the total loading, was contributed by runoff from rural land and about 60 pounds per year, or about 5 percent, was contributed by runoff from urban land.

Phosphorus release from the lake bottom sediments, or 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.

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 decrease slightly as agricultural activities within the area tributary to George Lake are replaced by urban residential land uses. The most likely annual total phosphorus load to the Lake under year 2020 conditions is estimated to be 1,060 pounds. This decrease may be obviated 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.[25] Nevertheless, it may be anticipated that rural lands, estimated to contribute about 1,000 pounds of phosphorus per year, will continue to contribute the greatest masses of phosphorus to George Lake. Urban lands are anticipated to continue to contribute about 60 pounds of phosphorus per year.

Sediment Loadings

The estimated sediment budget for George Lake under 1995 land use conditions is shown in Table 13. An annual sediment load of about 320 tons of sediment was estimated to be contributed to George Lake. Of the likely annual sediment load, it was estimated that about 300 tons per year, or 95 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.

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 305 tons. The majority of the sediment load is still anticipated to be derived from rural agricultural lands, which are estimated to contribute about 290 tons of sediment, or about 95 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 300 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 10 tons of which are estimated to be contributed by direct precipitation and dry fallout onto the lake surface.

---

[25]*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 12

ESTIMATED EXTERNAL SOURCES OF PHOSPHORUS IN THE TOTAL DRAINAGE AREA TRIBUTARY TO GEORGE LAKE: 2000 AND 2020

Source	2000		2020	
	Pounds[a]	Percentage[a]	Pounds[a]	Percentage[a]
Urban				
High-Density (commercial and industrial uses)	2	0.2	2	0.2
Medium-Density (multi-family and institutional uses)	38	3.5	42	3.9
Low-Density (single-family and suburban-density residential uses)	18	1.6	20	1.9
Recreational Lands	2	0.2	2	0.2
Subtotal	60	5.5	66	6.2
Rural				
Mixed Agriculture	964	88.1	928	87.2
Wetlands	35	3.2	35	3.3
Woodlands	20	1.8	20	1.9
Water	15	1.4	15	1.4
Subtotal	1,034	94.5	998	93.8
Total	1,094	100.0	1,064	100.0

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

Source: SEWRPC.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[26] Table 13 sets forth the estimated loadings of copper, zinc, and cadmium likely to be contributed to George Lake from urban development surrounding the Lake. The majority of these metals becomes associated with sediment particles,[27] 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 area tributary to the Lake.[28] The estimated heavy metal budget for George Lake, under year 2000 land use conditions, is shown in Table 13. About 0.5 pound of copper, six pounds of zinc, and 0.02 pound of cadmium were estimated to be contributed annually to George 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 remain relatively static. The most likely annual loads to the Lake under year 2020 conditions are estimated to be 0.5 pound of copper, six pounds of zinc, and 0.02 pound of cadmium.

In-Lake Sinks

Of the annual total phosphorus load entering George Lake, it is estimated that 50 percent of the total phosphorus load, or about 500 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.

---

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

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

[28]*Frits van der Leeden, Fred L. Troise and David Keith Todd,* op. cit.

Table 13

ESTIMATED CONTAMINANT LOADS FROM THE TOTAL DRAINAGE AREA TRIBUTARY TO GEORGE LAKE: 2000 AND 2020

Land Use	2000						2020					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	188	3,666	38	0.0	1.9	0.00	227	4,426	45	0.0	2.3	0.00
Commercial	1	784	1	0.2	1.5	0.01	1	784	1	0.2	1.5	0.01
Industrial	1	752	1	0.2	1.5	0.01	1	752	1	0.2	1.5	0.01
Communications, Transportation, and Utilities	82	779	9	0.0	0.0	0.00	92	874	10	0.0	0.0	0.00
Governmental	1	511	2	0.1	0.8	0.00	1	511	2	0.1	0.8	0.00
Recreational	5	120	2	- -	- -	- -	5	120	2	- -	- -	- -
Water	101	18,988	13	- -	- -	- -	101	18,988	13	- -	- -	- -
Wetlands	284	1,051	11	- -	- -	- -	284	1,051	11	- -	- -	- -
Woodlands	234	866	9	- -	- -	- -	234	866	9	- -	- -	- -
Agricultural	1,349	607,050	1,160	- -	- -	- -	1,300	585,000	118	- -	- -	- -
Total	2,246	634,567	1,246	0.5	5.7	0.02	2,246	613,372	1,212	0.5	6.1	0.02

Source: SEWRPC.

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,[29] and the Carlson Trophic State Index (TSI).[30] 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 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.[31]

Vollenweider Trophic State Classification

Using the Vollenweider trophic system and applying the data in Table 10, George Lake would be classified as having about a 50 percent probability of being eutrophic based upon phosphorus levels, as shown in Figure 7. The Lake would have about a 40 percent probability of being mesotrophic, and about a 5 percent probability of being either oligotrophic or hypertrophic, based upon mean annual phosphorus concentrations. Based upon chlorophyll-*a* levels, the Lake would be classified as having a 50 percent probability of being mesotrophic, with about a 40 percent probability of being eutrophic, about a 10 percent probability of being oligotrophic, as shown in Figure 7. Based upon Secchi-disc readings, the Lake would be classified as having a 80 percent probability of being hypertrophic, with a 20 percent probability of being eutrophic, as shown in Figure 7. While these indicators result in slightly differing lake trophic state classifications, it may be concluded that George Lake should be classified as a eutrophic lake, or a lake with a relatively poor water quality for most uses.

---

[29]*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, *Kenosha, D.C., August 1990.*

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

[31]*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.*

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 WDNR using data on 184 lakes throughout the State.[32] The Wisconsin Trophic State Index (WTSI) rating for George Lake, as shown in Figure 8, is approximately 60, suggesting that George Lake should be classified as eutrophic.

SUMMARY

George 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 not commonly observed in George Lake, the Lake exhibiting the characteristics of a polymictic waterbody typical of many shallow lakes in Wisconsin. The surface waters of the Lake generally 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 George Lake.

Nonpoint sources of pollution included stormwater runoff from urban and agricultural areas. Agricultural land uses were the largest source of nonpoint pollutants. In 2000, the total annual phosphorus load to George Lake was estimated to be about 1,100 pounds. Runoff from the rural lands contributed the largest amount of phosphorus, about 95 percent of the total phosphorus load, with the runoff from urban lands contributing about 5 percent of the total phosphorus load. Direct precipitation onto the Lake surface contributed about 1 percent of the total phosphorus load. Agricultural lands constituted the primary source of phosphorus to the Lake under both current and anticipated future land use conditions within the area tributary to the Lake.

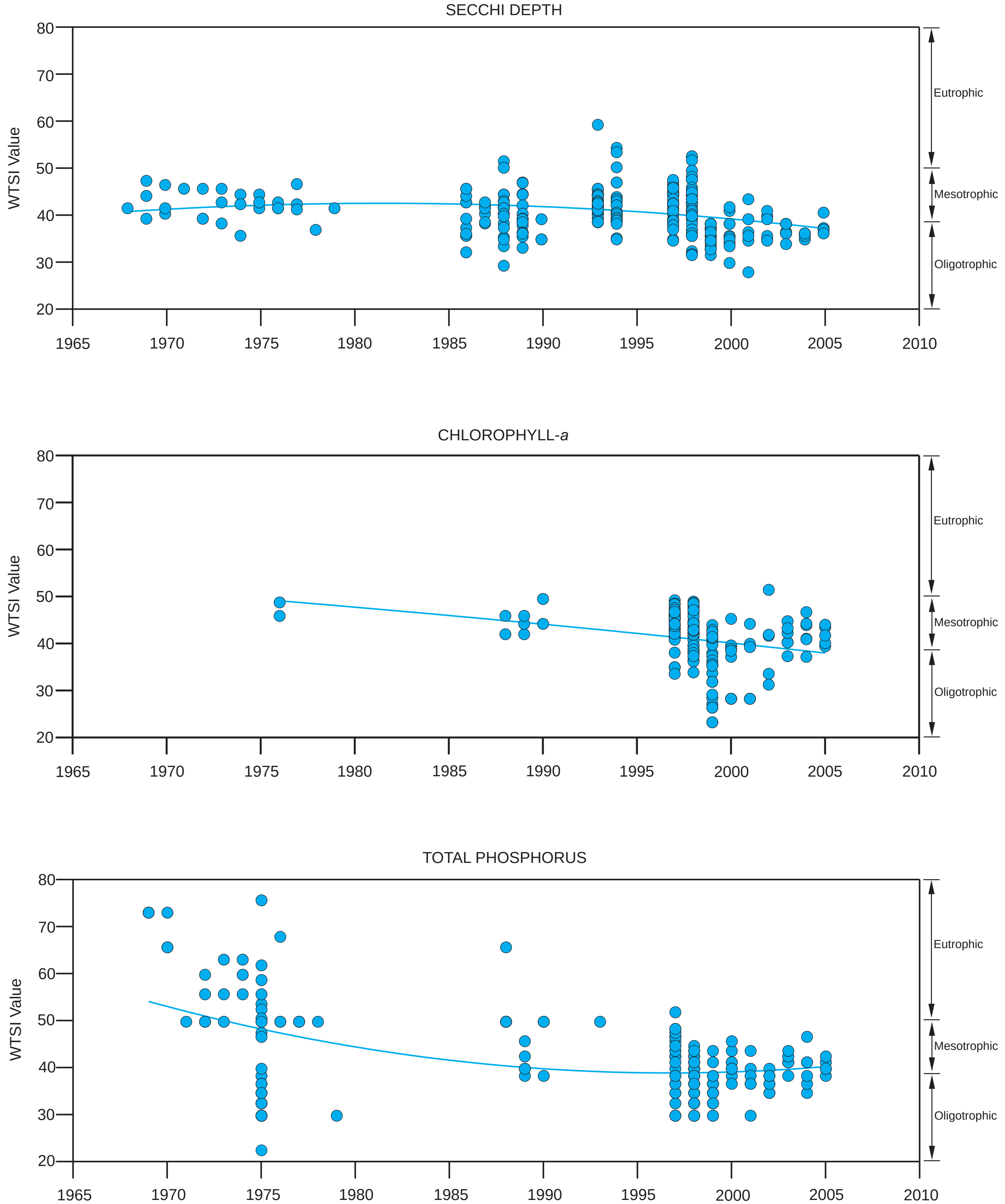
Approximately 50 percent, or 500 pounds, of the total phosphorus loading is estimated to remain in the Lake by conversion to biomass or through sedimentation, resulting in a net transfer of about 600 pounds of phosphorus downstream.

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

[32]Ibid.

Figure 8

TROPHIC STATE INDICES FOR GEORGE LAKE: 1965-2005



Source: Wisconsin Department of Natural Resources and SEWRPC.

(This page intentionally left blank)

Chapter V

AQUATIC BIOTA AND ECOLOGICALLY VALUABLE AREAS

INTRODUCTION

George Lake is an important element of the natural resource base providing a valuable ecological resource for the south-central portion of Kenosha County. The Lake, its biota, its parks and residential lands combine to contribute to the quality of life in the area.

When located in urban or urbanizing 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 George Lake tributary area, 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 George 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 aquatic food webs. As primary producers, they utilize the process of photosynthesis to 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, or algal blooms, may occur. Algal blooms have occasionally been perceived as a problem in George 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, or "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.

Algae species in George Lake were identified and enumerated as part of the aforementioned study conducted by Environmental Resource Assessments (ERA) in 1977.[1] At that time, *Anabaena sp.* was the dominant species throughout the period from April through October of 1977, with *Coelosphaerium naegelianum* and *Cicrocystus aeraginosa* also being common during that time; *Melosira* sp. and *Scenedesmus* sp. were abundant in late spring/early summer. The blue-green algae *Coelosphaerium naegelianum* forms hollow spheres of numerous coccoid algae and may, during bloom periods and the ensuing decomposition period, be deposited as wind-concentrated accumulations along shorelines with resultant odor problems thereby having a negative impact on recreational and aesthetic qualities of the Lake. A detailed evaluation of the phytoplankton community was not undertaken during the current planning project.

The seasonal mean chlorophyll-*a* concentrations of 12 to 45 mg/m^3, reported in Tables 10 and 11 in Chapter IV of this report, generally indicate poor to good water quality, as illustrated in Figure 6 also in Chapter IV of this report. This concentration is above 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.[2]

Macrophytes

Aquatic macrophytes play an important role in the ecology of southeastern Wisconsin lakes. Depending on their type, distribution and abundance, they can be either beneficial or a nuisance. Macrophytes growing in the locations and in densities that do not significantly interfere with human access to the water and recreational uses such as boating and swimming are beneficial in maintaining lake fisheries and wildlife populations. 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.

---

[1]*Environmental Resource Assessments*, Final Report on the George Lake Study Kenosha County, Wisconsin, Addendum, *1978.*

[2]*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.*

To document the types, distribution, and relative abundance of aquatic macrophytes in George Lake, aquatic plant surveys were conducted on the Lake during June and August of 1977 by ERA,[3] in July of 2002 and June of 2003 by Aron and Associates,[4] and during July of 2003 by staff of the Southeastern Wisconsin Regional Planning Commission (SEWRPC). 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.

Results of the 1977 survey indicated that Eurasian water milfoil (*Myriophyllum spicatum*) was the dominant species in June of that year, being widespread throughout the Lake, although there was a sharp drop in abundance of all aquatic plants by August of that year, a development attributed at the time to an excessive algae bloom occurring in the Lake. Eurasian water milfoil is a nonnative, invasive species and is a plant of concern in the system. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can control its potentially explosive growth which the plant typically exhibits in lakes with organic-rich sediments, or where the lake bottom has been disturbed. In such cases, the Eurasian water milfoil populations displace native plant species which can lead to the loss of plant diversity, degradation of water quality, and reduction in habitat value for fish, invertebrates and wildlife. In addition, the plant has been known to cause severe aesthetic and recreational use problems in lakes in southeastern Wisconsin. Other species present at that time, although in relatively small amounts compared to Eurasian water milfoil, were muskgrass (*Chara* spp., also known as stonewort), Sago pondweed (*Potamogeton pectinatus*), curly-leaf pondweed (*Potamogeton crispus)*, and whorled water milfoil (*Myriophyllum verticillatum*).

The 2002 and 2003 surveys conducted by Aron and Associates observed a total of 13 submersed and floating aquatic plant species, as shown in Table 14. Generally, Eurasian water milfoil (*Myriophyllum spicatum*) was, again, the dominant plant in George Lake in 2003 and seemed to have expanded its range since the 1977 survey, dominating all other species at all depths and was judged to have reached nuisance levels in the Lake. Compared to the 1977 survey, aquatic plants in 2003 seemed to be growing to greater depths and in somewhat greater variety, competing better with Eurasian water milfoil in shallower areas and in areas where the bottom substrate was sand or a sand and gravel mixture. Of the native species observed in 2003, coontail, Sago pondweed, and muskgrass were the most common.

In 2003, SEWRPC staff conducted an aquatic plant survey of George Lake, the results of which are shown in Table 15. Illustrations of representative macrophyte species identified in George Lake at that time are set forth in Appendix A. Of the 11 submergent aquatic plants observed in George Lake in July of 2003, the dominant species were coontail *(Ceratophyllum demersum)* and Eurasian water milfoil (*Myriophyllum spicatum*). Also present in significant numbers were curly-leaf pondweed (*Potamogeton crispus)*, muskgrass (*Chara* spp.), and bushy pondweed *(Najas flexilis)*. The distribution of aquatic plant communities in George Lake is shown in Map 15.

In general, George Lake supports a healthy and diverse aquatic macrophyte community. The beneficial nature of the aquatic plant community in George 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 resting areas are known to make use of the Lake. The positive ecological values of the aquatic plants reported from George Lake are set forth in Table 16.

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

---

[3]*Environmental Resource Assessments,* op cit.

[4]*Aron and Associates,* George Lake Aquatic Plant Management Plan, *2004.*

Table 14

AQUATIC PLANT SPECIES IN GEORGE LAKE: JUNE 2002 and JULY 2003

Aquatic Plant Species Present
Coontail (*Ceratophyllum demersum*)
Muskgrass *(Chara vulgaris)*
Duckweed *(Lemna minor)*
Eurasian Water Milfoil *(Myriophyllum spicatum)*
Bushy Pondweed *(Najas flexilis)*
Yellow Water Lily *(Nuphar* sp.*)*
White Water Lily *Nymphaea* sp.*)*
Curly-Leaf Pondweed *(Potamogeton crispus)*
Leafy Pondweed *(Potamogeton foliosis)*
Illinois Pondweed *(Potamogeton illinoensis)*
Sago Pondweed *(Potamogeton pectinatus)*
Water Crowfoot *(Ranunculus longirostris)*
Bladderwort *(Utricularia vulgaris)*

NOTE: There were 60 sites sampled.

Source: Aron and Associates, and SEWRPC.

George Lake have taken place since 1950. Aquatic plant management activities in George Lake can be categorized as chemical control and mechanical macrophyte harvesting. Currently, all forms of aquatic plant management are subject to permitting by the Wisconsin Department of Natural Resources (WDNR) pursuant to authorities granted the Department under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*.

Chemical Controls

Perceived excessive macrophytes growths on George Lake have, through the early 1990s and during the early years of the 2000s, resulted in the application of a chemical control program. Recorded chemical herbicide treatments that have been applied to George Lake are set forth in Table 17. 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 WDNR since 1950.

In 1926, sodium arsenite, an agricultural herbicide, was first applied to lakes in the Madison area, and, by the 1930s, sodium arsenite was widely used throughout the State for aquatic plant control. No other chemicals were applied in significant amounts to control macrophytes until recent years, when a number of organic chemical herbicides came into general use. The amounts of sodium arsenite applied to George Lake, and years of application during the period 1950 through 1967, are listed in Table 17. The total amount of sodium arsenite applied over this 17-year period was about 4,640 pounds.

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

When it became apparent that arsenic was accumulating in the sediments of treated lakes and that the accumulations of arsenic were found to present potential health hazards to both humans and aquatic life, the use of sodium arsenite was discontinued in the State in 1969. Draft sediment quality criteria limits set forth by the WDNR are shown in Table 18. In the 1993 watershed evaluation conducted by Aron and Associates, it was noted that a 1991 analysis of George Lake sediment conducted by Aquatic Biologists Inc. led Aquatic Biologists to conclude that no harmful substances such as arsenic were present in the sediments.[5]

As shown in Table 17, the aquatic herbicides diquat, endothall, and 2,4-D have also been applied to George Lake to control aquatic macrophyte growth. Diquat and endothall (Aquathol) are contact herbicides and kill plant parts exposed to the active ingredient. Diquat use is restricted to the control of duckweed (*Lemna* sp.), milfoil (*Myriophyllum* spp.), and waterweed (*Elodea* sp.). However, this herbicide is nonselective and will kill many other aquatic plants, such as pondweeds (*Potamogeton* spp.), bladderwort (*Utricularia* sp.), and naiads (*Najas* spp.). Endothall primarily kills pondweeds, but does not control such nuisance species as Eurasian water milfoil

[5]*Aron and Associates,* George Lake Watershed Evaluation Planning Grant – 1993, *1993.*

Table 15

FREQUENCY OF OCCURRENCE AND DENSITY RATINGS OF SUBMERGENT PLANT SPECIES IN GEORGE LAKE: JULY 2003

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence[a] (percent)	Relative Density[b]	Importance Value[c]
Coontail (*Ceratophyllum demersum*)	40	74.1	3.3	2.40
Eurasian Water Milfoil *(Myriophyllum spicatum)*	31	57.4	2.7	1.50
Curly-Leaf Pondweed *(Potamogeton crispus)*	17	31.5	1.8	0.60
Muskgrass *(Chara vulgaris)*	11	20.4	3.0	0.60
Bushy Pondweed *(Najas flexilis)*	9	16.7	2.0	0.30
Sago Pondweed *(Potamogeton pectinatus)*	5	9.3	1.0	0.10
Bladderwort *(Utricularia vulgaris)*	3	5.6	1.3	0.10
Small Pondweed (*Potamogeton pusillus)*	3	5.6	1.0	0.05
Water Crowfoot *(Ranunculus longirostris)*	3	5.6	1.3	0.10
Illinois Pondweed *(Potamogeton illinoensis)*	2	3.7	2.5	0.10
Variable Pondweed *(Potamogeton gramineus)*	1	1.9	1.0	0.02

NOTE: There were 54 sites sampled during the July 2003 survey.

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

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

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

Source: SEWRPC.

(*Myriophyllum spicatum*). The herbicide 2,4-D is a systemic herbicide that is absorbed by the leaves and translocated to other parts of the plant; it is more selective than the other herbicides listed above and is generally used to control Eurasian water milfoil. However, it will also kill species such as water lilies (*Nymphaea* sp. and *Nuphar* sp.). The present restrictions on water use after application of these herbicides are given in Table 19.

In addition to the chemical herbicides used to control large aquatic plants, algicides have also been applied to George Lake. As shown in Table 17, copper sulfate (Cutrine Plus) has been applied to George Lake, on occasion. Like arsenic, copper, the active ingredient in many algicides including Cutrine Plus, may accumulate in the bottom sediments. Excessive levels of copper may be toxic to fish and benthic organisms, but, generally, have not been found to be harmful to humans.[6] Restrictions on water uses after application of Cutrine Plus and other copper-containing compounds are also given in Table 19.

Macrophyte Harvesting

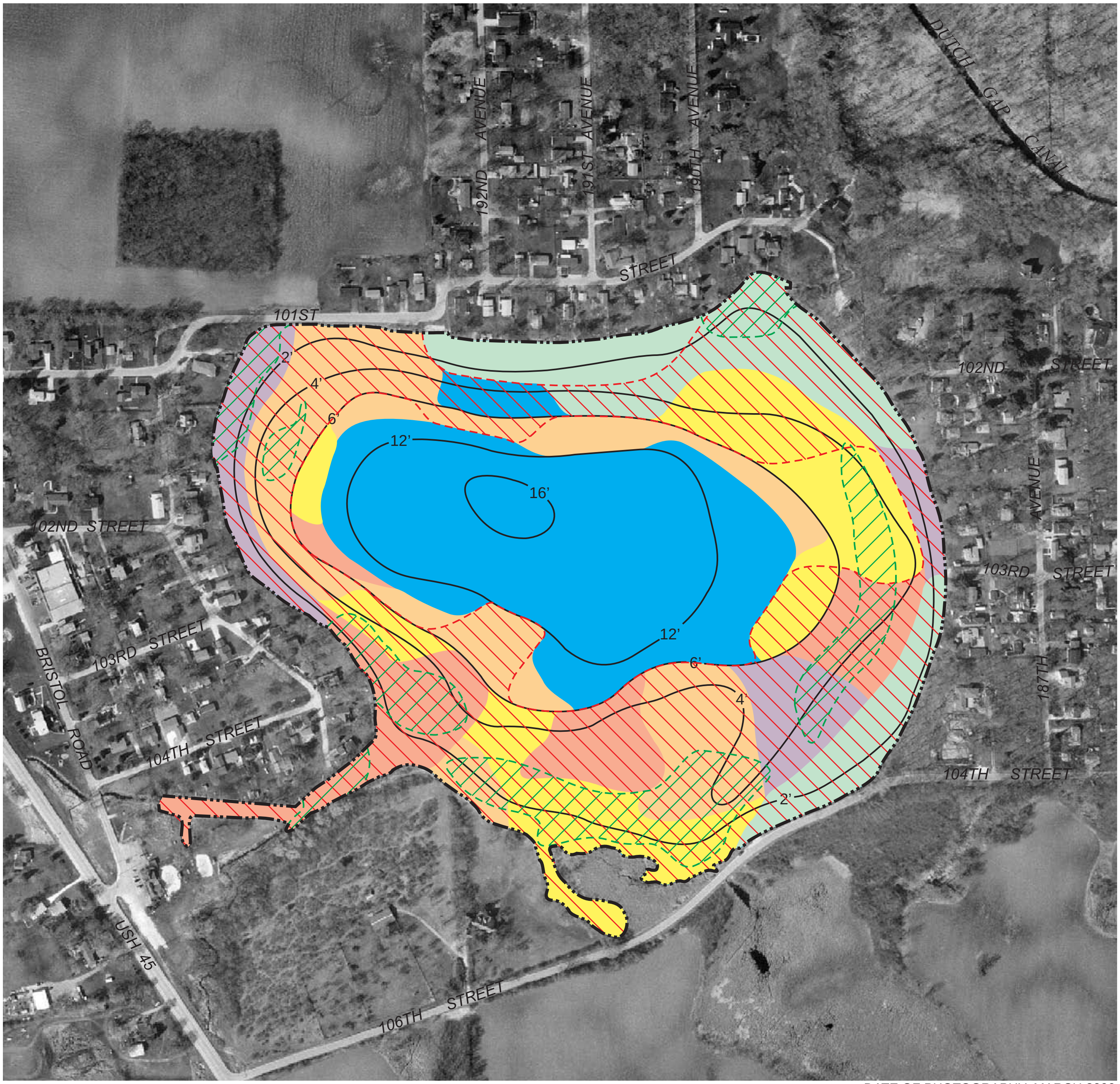
Since 1993, excessive macrophyte growth on George Lake has resulted in a control program primarily utilizing mechanical harvesting, although some limited chemical treatments have been used to complement mechanical harvesting since 2002, as shown in Table 17. The harvesting program emphasizes removal of nuisance plants necessary to facilitate recreational use, rather than 100 percent plant removal. Under this program, harvesting operations are carried out using an Aquarius Systems model EH-220 Aquatic Plant Harvester owned and operated by the George Lake Rehabilitation District. A shore conveyor is used by the District for off-loading and the

---

[6]*Jeffrey A. Thornton and Walter Rast, "The Use of Copper and Copper Compounds as Algicides," in H. Wayne Richardson,* Handbook of Copper Compounds and Applications*, Marcel Dekker, New York, 1997, pp. 123-142.*

Map 15

AQUATIC PLANT COMMUNITY DISTRIBUTION IN GEORGE LAKE: 2003



DATE OF PHOTOGRAPHY: MARCH 2000

- 12' — WATER DEPTH CONTOUR IN FEET
- OPEN WATER
- WATER LILIES
- EURASIAN WATER MILFOIL
- COONTAIL
- COONTAIL AND CURLY-LEAF PONDWEED
- COONTAIL, MUSKGRASS, SMALL PONDWEED, CURLY-LEAF PONDWEED, SAGO PONDWEED, AND ILLINOIS PONDWEED
- COONTAIL, BLADDERWORT, WATER CROWFOOT, BUSHY, PONDWEED, SMALL PONDWEED, CURLY-LEAF PONDWEED, AND SAGO PONDWEED
- COONTAIL, MUSKGRASS, BLADDERWORT, BUSHY PONDWEED, SAGO PONDWEED, CURLY-LEAF PONDWEED, VARIABLE PONDWEED, AND WATER CROWFOOT

GRAPHIC SCALE
0 250 500 FEET

Source: SEWRPC.

Table 16

GEORGE 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
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 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
Nuphar variegata (bullhead pond lily)	Provides food for waterfowl, deer, and small mammals. Offers shade and shelter for fish and habitat for invertebrates
Nymphaea odorata (white water lily)	Provides food for waterfowl, deer, and small mammals. Offers shade and shelter for fish
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 illnoensis (Illinois pondweed)	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton pusillus (small pondweed)	Important food source for a variety of ducks, in addition to providing food for some mammals. Food source and cover for fish.
Ranunculus longirostris (stiff water crowfoot)	Provides food for trout, upland game birds, and wildfowl
Utricularia vulgaris (common bladderwort)	Provides food and cover for fish

Source: SEWRPC.

harvested material is trucked to a nearby site for disposal. Permits are required pursuant to Chapter NR 190 of the *Wisconsin Administrative Code* to cut vegetation in lakes. The harvested material must be removed from the water.

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 George 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

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

Table 17

CHEMICAL CONTROL OF AQUATIC PLANTS IN GEORGE LAKE: 1959-2003

Year	Total Acres Treated	Algae Control: Copper Sulfate (pounds)	Algae Control: Blue Vitriol (pounds)	Algae Control: Cutrine or Cutrine-+	Macrophyte Control: Sodium Arsenite (pounds)	Macrophyte Control: 2, 4-D (gallons)	Macrophyte Control: Diquat (gallons)	Macrophyte Control: Endothall (gallons)	Macrophyte Control: Aquathol (gallons)
1950-1958	N/A	- -	- -	- -	N/A	- -	- -	- -	- -
1959	- -	- -	550	- -	780	- -	- -	- -	- -
1960	40.000	- -	500	- -	1,880	- -	- -	- -	- -
1961	- -	- -	315	- -	1,800	- -	- -	- -	- -
1962-1965	- -	- -	- -	- -	- -	- -	- -	- -	- -
1966	- -	- -	- -	- -	60	60.00	- -	6	6.00
1967	- -	10	- -	- -	120	30.00	20.0	- -	- -
1968	- -	10	- -	- -	- -	- -	5.0	- -	- -
1969	17.000	140	- -	- -	- -	- -	16.0	- -	- -
1970	9.500	110	- -	- -	- -	- -	2.0	2	2.00
1971	2.000	20	- -	- -	- -	- -	- -	- -	5.00
1972	- -	- -	- -	- -	- -	- -	- -	- -	- -
1973	0.300	- -	- -	- -	- -	- -	- -	- -	50 pounds
1974	0.300	- -	- -	- -	- -	- -	- -	- -	50 pounds
1975	- -	- -	- -	- -	- -	- -	- -	- -	- -
1976	0.570	- -	- -	- -	- -	- -	- -	- -	100 pounds
1977	11.140	- -	- -	- -	- -	28.00	- -	- -	50 pounds
1978	4.500	- -	- -	- -	- -	15.00	- -	- -	- -
1979	20.600	- -	- -	- -	- -	28.00	- -	- -	- -
1980-1981	- -	- -	- -	- -	- -	- -	- -	- -	- -
1982	0.490	- -	- -	- -	- -	- -	- -	- -	140 pounds
1983	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1984	16.840	- -	- -	- -	- -	63.00	60 pounds	- -	150 pounds
1985	16.310	- -	- -	- -	- -	46.00	- -	- -	150 pounds
1986	0.293	- -	- -	- -	- -	- -	- -	- -	200 pounds
1987	3.310	- -	- -	- -	- -	- -	1	- -	15.00 and 200 pounds
1988-1989	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1990	12.920	- -	- -	12.5	- -	33.25	10.5	- -	- -
1991	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1992	4.830	- -	- -	10.0	- -	28	2.0	- -	14.75
1993-1994	- -	- -	- -	- -	- -	- -	- -	- -	- -
1995[a]	2.000	- -	- -	- -	- -	- -	- -	- -	- -
1996-1997[b]	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1998-2001	- -	- -	- -	- -	- -	- -	- -	- -	- -
2002	5.300	- -	- -	- -	- -	600 pounds	- -	- -	- -
2003	5.200	- -	- -	- -	- -	600 pounds	- -	- -	- -
2004	10.000	- -	- -	- -	- -	1,000 pounds	- -	- -	- -
2005	16.800	- -	- -	- -	- -	1,680 pounds	- -	- -	- -
2006	10.000	- -	- -	- -	- -	6.00 and 800 pounds	- -	- -	- -
Total	210.200	290	1,365	22.5	4,640	337.30 4,680 pounds	116.5	8	42.80 and 1,090 pounds

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

[a]*1995, 2.0 acres were treated with one gallon of the glyphosate compound "Rodeo."*

[b]*1996-1997, unknown number of acres were treated with unknown number of gallons of "Rodeo."*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Zooplankton

Zooplankton are microscopic animals which inhabit the same environment as phytoplankton, the 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. There are no records available concerning surveys of zooplankton populations in George Lake.

Table 18

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

Chemical	Lowest Effect Level (LEL)	Medium Effect Level (MEL)	Severe Effect Level (SEL)
Arsenic	6.00	33.0	85.0
Copper	25.00	110.0	390.0
Lead	31.00	110.0	250.0
Mercury	0.15	0.2	1.3
Ammonia-Nitrogen	75.00	- -	- -

[a]Units are in mg/kg dry sediment.

Source: Wisconsin Department of Natural Resources.

Table 19

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.

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. Nevertheless, 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. There are no records available concerning benthic populations in George Lake.

Zebra mussels, *Dreissenia polymorpha*, are a nonnative 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 2003, adult zebra mussels were not observed in George Lake by SEWRPC staff and, as of February 2006, George Lake was not listed by the WDNR as a Wisconsin lake infested with Zebra mussel populations.

Fishes of George Lake

George Lake supports a relatively large and diverse fish community. Five surveys conducted between 1959 and 1979 recorded 21 species, with blackchin shiner, white sucker, black bullhead, tadpole madtom, rock bass, and white crappie being found on only one occasion each. Since bullhead and crappie species were not differentiated in several collections, it is probable that black bullhead and white crappie were actually present more frequently than the data indicate. Game species included northern pike, largemouth bass, bluegill, pumpkinseed, green sunfish, rock bass, white and black crappies, yellow perch, and three species of bullhead. Rock bass were recorded only in 1959 and are likely no longer found in the lake.

Currently, the WDNR manages George Lake as a bass-panfish warmwater fishery. A baseline survey, comprised of mini-fyke nets and electrofishing, was conducted by the WDNR in 2003. The most abundant fish in the electrofishing survey was bluegill. Bluegills ranged in length from 2.8 inches to 7.3 inches with a mean length of 4.8 inches. Bluegills had a stock density at the low end of the recommended range for balanced populations. Yellow perch ranged in length from 4.2 inches to 7.3 inches with a mean length of 4.9 inches. Pumpkinseeds averaged 4.6 inches in length. Largemouth bass ranged in length from 9.4 inches to 19.2 inches with a mean length of 13.6 inches. In the largemouth bass sample, 56 percent was greater than or equal to the minimum length of 14 inches. There were two walleye pike collected, one was 12.7 inches long and the other was 17.4 inches long. Additionally, SEWRPC staff reported the presence of the pugnose shiner, a State-designated threatened species, and the least darter, a State species of special concern.[7] Fish species recorded during the 2003 survey of George Lake are shown in Table 20. Another baseline survey is scheduled by the WDNR for 2009.

"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 20. Panfish species known to exist in George Lake include yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*) and warmouth (*Lepomis gulous*). 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 9 illustrates the importance of a balanced predator-prey relationship, using walleyed pike and perch as an example.

---

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

Table 20

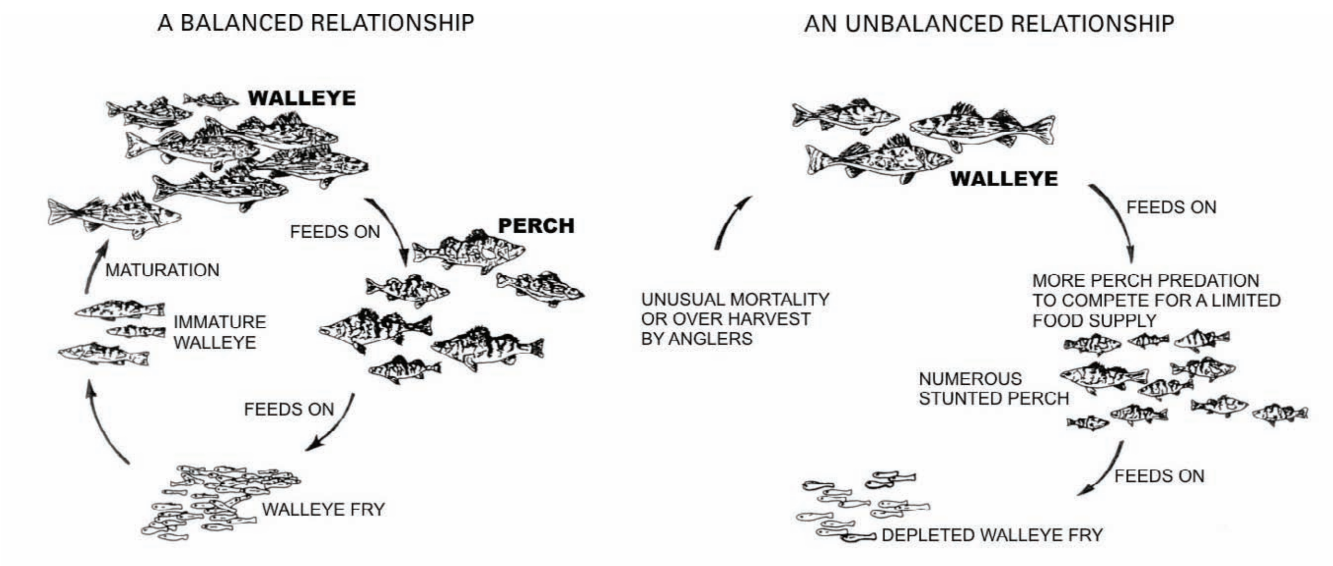
FISH SPECIES OCCURRING IN GEORGE LAKE: 2003

Species	Family	Scientific Name
Pumpkinseed	Centrarchidae	*Lepomis gibbosus*
Warmouth	Centrarchidae	*Lepomis gulosus*
Bluegill	Centrarchidae	*Lepomis macrochirus*
Largemouth Bass	Centrarchidae	*Micropterus salmoides*
Black Crappie	Centrarchidae	*Promoxis nigromaculatus*
Common Carp	Cyprinidae	*Cyprinus carpio*
Golden Shiner	Cyprinidae	*Notemigonus crysoleucas*
Grass Pickeral	Esocidae	*Esox americanus vermiculatus*
Northern Pike	Esocidae	*Esox lucius*
Brown Bullhead	Ictaluridae	*Ictalurus nebulosus*
Yellow Perch	Percidae	*Perca flavescens*
Walleyed Pike	Percidae	*Stizotedion vitreum vitreum*

Source: Wisconsin Department of Natural Resources baseline survey, 2003.

Figure 9

THE PREDATOR-PREY RELATIONSHIP



Source: Wisconsin Department of Natural Resources and SEWRPC.

"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 George Lake include the common carp (*Cyprinus carpio*).

"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*) and largemouth bass (*Micropterus salmoides*), are present and reproduce naturally in George Lake.

Fisheries Management

The entire fishery was treated with Rotenone in 1968 in an effort to control rough fish. The lake was restocked with northern pike, largemouth bass, and bluegills. Among the species found dead in the post-treatment survey were warmouth, tadpole madtom, blackchin shiner, and grass pickerel. These species were not found in subsequent surveys in 1970, 1975, and 1979, and have probably been extirpated from the lake. Lake chubsucker was collected in 1959, 1968, and 1970. It was not found in subsequent surveys made in 1974 and 1979.

Management measures are recommended to include protection of existing, remnant populations of threatened and endangered species, and species of special concern. These populations include lake chubsucker in the Lake Shangrila-Benet Lake system, and in George Lake, both of which drain to the Dutch Gap Canal. Reaches within which these populations have been identified are set forth in this watershed plan, the adopted regional natural areas and critical species habitat protection and management plan for southeastern Wisconsin,[8] and data provided by the WDNR.

The lake is judged to have a good fishery. Fish management efforts have been primarily directed toward the maintenance of a bass-panfish fishery in the Lake through compliance with WDNR State fishing regulations. The 2006-2007 regulations governing the harvest of fishes from the waters of the State are summarized in Table 21. The Lake is judged to provide adequate spawning, nursery, and feeding habitat for largemouth bass, bluegill, and other native panfish and, as such, is not considered to need to have these populations supplemented by stocking. However, due largely to the popularity of northern pike by ice fishermen, supplemental stocking of northern pike every few years has been recommended. Recent stocking of George Lake is shown in Table 22. All stocking of lakes in Wisconsin is regulated by the WDNR through the granting of stocking permits.

Other Wildlife

Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the George 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 George Lake area; associating these lists with the historic and remaining habitat areas in the George Lake area as inventoried; and projecting the appropriate amphibian, reptile, bird, and mammal species into the George Lake area. The net result of the application of this technique is a listing, summarized in Tables 23 through 25, of those species which were probably once present in the tributary 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 George 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 23 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 George Lake area. Table 24 lists those birds that normally occur in the tributary 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 George Lake tributary area supports a significant population of waterfowl, including mallard and teal. Larger numbers of birds move through the tributary area during migrations when most of the regional species may also be present.

---

[8]Ibid.

Table 21

FISHING REGULATIONS APPLICABLE TO GEORGE LAKE: 2006-2007

Species	Open Season	Daily Limit	Minimum Size
Northern Pike	May 6 to March 4	2	26 inches
Walleyed Pike	May 6 to March 4	5	15 inches
Largemouth and Smallmouth Bass	May 6 to March 4	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 2006, Guide to Wisconsin Hook and Line Fishing Regulations 2006-2007*, January 2006; and SEWRPC.*

Table 22

FISH STOCKED INTO GEORGE LAKE: 2002-2004

Year	Species Stocked	Number	Size	Source
2002	Northern Pike	59	10 to 16 inches	Private
2004	Northern Pike	59	10 to 16 inches	Private

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 George Lake include the Cerulean warblers, the Acadian flycatcher, great egret, and the Osprey. Endangered species migrating in the vicinity of George Lake include the common tern, Caspian tern, Forster's tern, and the loggerhead shrike. As will be discussed below, of note is the existence of a large blue heron rookery in a wooded portion of the George Lake tributary area.

Amphibians and reptiles are vital components of the ecosystem in an environmental unit like the George Lake tributary area. Examples of amphibians native to the area include frogs, toads, and salamanders. Turtles and snakes are examples of reptiles common to the George Lake area. Table 25 lists the 14 amphibian and 15 reptile species normally expected to be present in the George 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 Kenosha County has, along with its habitat, undergone significant change in terms of diversity and population size since the European settlement of the area.

Table 23

MAMMALS OF THE GEORGE 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*
Stiped 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.*

This change is a direct result of the conversion of land by the settlers from its natural state to agricultural and urban uses, beginning with the clearing of the forest and prairies, the draining of wetlands, and ending with the development of extensive urban areas. Successive cultural uses and attendant management practices, both rural and urban, have been superimposed on the land use changes and have also affected the wildlife and wildlife habitat. In agricultural areas, these cultural management practices include draining land by ditching and tiling and the expanding use of fertilizers, herbicides, and pesticides. In urban areas, cultural management practices that affect wildlife and their habitat include the use of fertilizers, herbicides, and pesticides; 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 SEWRPC in 1985 in cooperation with the WDNR. 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 24

BIRDS KNOWN OR LIKELY TO OCCUR IN THE GEORGE 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
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

Table 24 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
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	- -
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

Table 24 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
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
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

Table 24 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Regulidae (continued)			
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
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

Table 24 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
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
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

Table 24 Footnotes

[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 George Lake tributary 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 16, approximately 718 acres, or about 33 percent of the area tributary to George Lake, were classified in the 1985 inventory as wildlife habitat. Of the current area of wildlife habitat, about 395 acres, or about 18 percent of the tributary area, were classified as Class I habitat; approximately 281 acres, or about 13 percent, were classified as Class II habitat; and about 42 acres, or about 2 percent, were classified as Class III habitat.

WETLANDS

Wetlands are defined by SEWRPC 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 (USCOE) and the U.S. Environmental Protection Agency (USEPA), is essentially the same as the definition used by the U.S. Natural Resource Conservation Service (NRCS).[9]

Another definition, which is applied by the WDNR 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

---

[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.*

Table 25

AMPHIBIANS AND REPTILES OF THE GEORGE 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.*

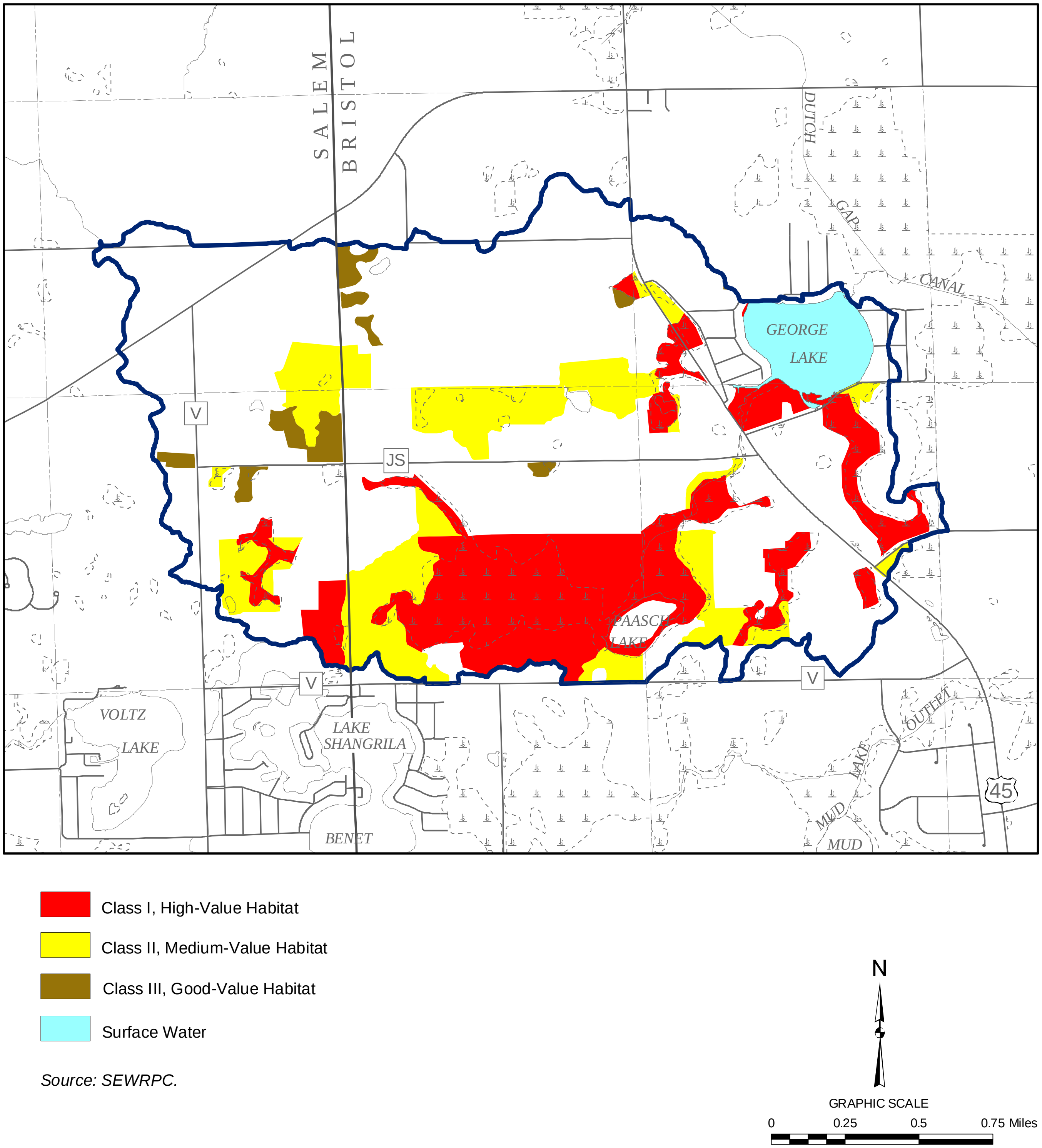
[c]*State-designated special concern species.*

[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 16

WILDLIFE HABITAT AREAS WITHIN THE AREA TRIBUTARY TO GEORGE LAKE:1985



Source: SEWRPC.

supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions." In practice, the WDNR definition differs from the SEWRPC definition in that the WDNR considers very poorly drained, poorly drained, and some of the somewhat poorly drained soils as wetland soils meeting the WDNR "wet condition" criterion. The SEWRPC definition only considers the very poorly drained and poorly drained soils as meeting the "hydric soil" criterion. Thus, the WDNR definition as actually applied is more inclusive than the Federal and SEWRPC definitions in that the WDNR 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 WDNR, USEPA, USCOE, NRCS, and SEWRPC 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 area tributary to George Lake, as shown on Map 17, encompassed approximately 284 acres, or approximately 13 percent of the tributary 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 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 George Lake direct tributary 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 George Lake direct tributary area. 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 of the tributary 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*).

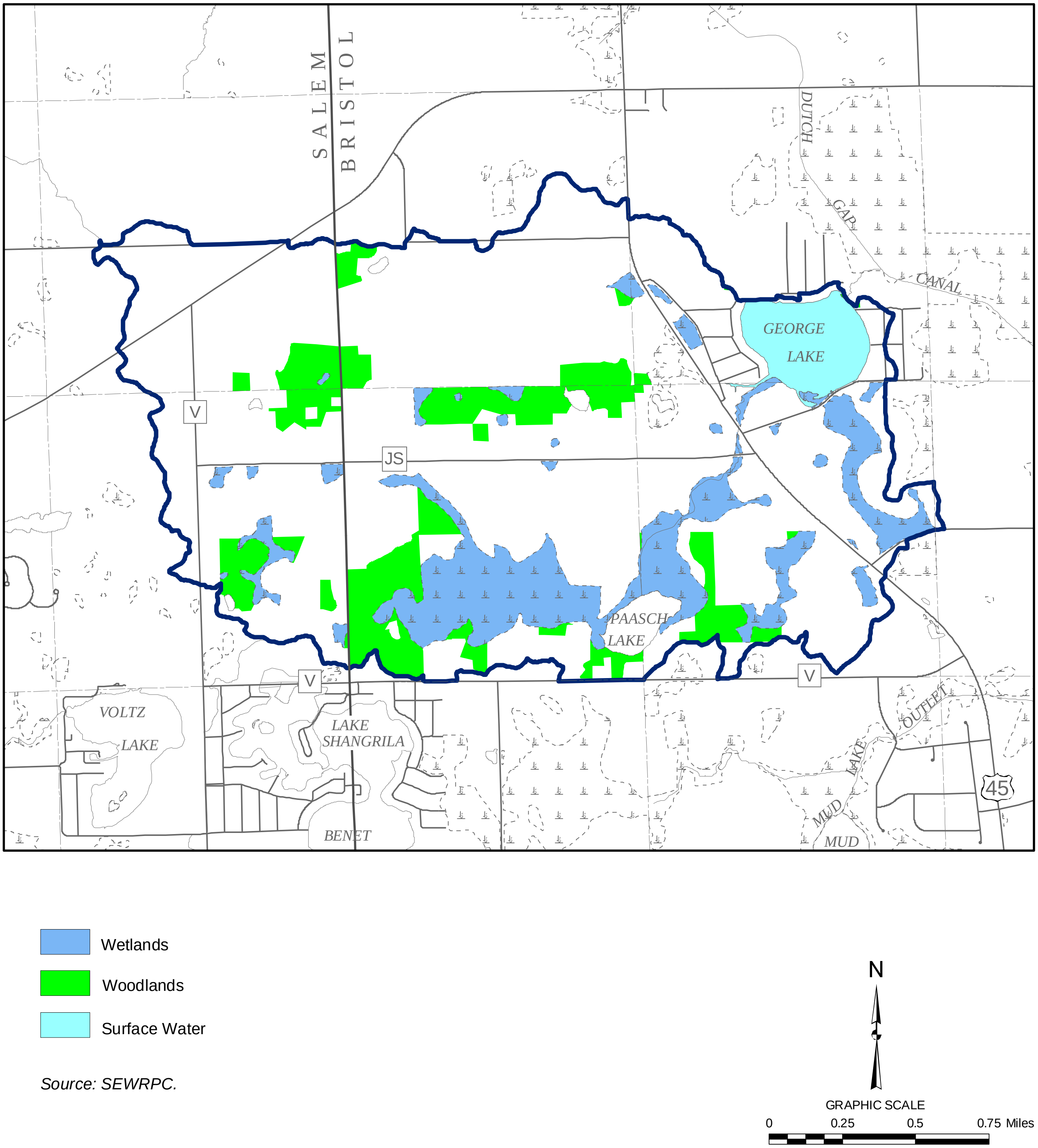
As shown on Map 17, the largest portion of wetlands within the area tributary to George Lake are located southwest of the Lake in the vicinity of Paasch Lake. As part of a 1993 tributary area evaluation conducted by

---

[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 17

WETLANDS AND WOODLANDS WITHIN THE AREA TRIBUTARY TO GEORGE LAKE: 2000



Source: SEWRPC.

Aron and Associates, field observations indicated that the wetlands in the area tributary to George Lake were bounded by agricultural fields with little or no buffer between them.[11] Consequently, nutrients and sediment were able to freely enter these valuable wetland areas. Sedimentation events were noted during the spring of 1993 involving approximately 10 acres of agricultural field on the north side of the Lake in which runoff, laden with sediments from the field, was observed flowing into the Lake after the field had been left uncovered through the winter of 1992.

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 area tributary to George Lake contained about 234 acres of woodlands, covering approximately 10 percent of the tributary area. These woodlands consisted of all of the native upland woodland classifications. Specifically, as shown on Map 17, upland woodlands in the area tributary to George 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 area tributary to George Lake occurred primarily as scattered woodlots.

ENVIRONMENTAL CORRIDORS

The Environmental Corridor Concept

One of the most important tasks undertaken by SEWRPC 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 SEWRPC. Primary environmental corridors include a wide variety of the abovementioned 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 George Lake tributary area are contiguous with environmental corridors and isolated natural resource areas lying outside the lake tributary 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-

---

[11] *Aron and Associates,* George Lake Watershed Evaluation Planning Grant, op. cit.

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 George Lake direct tributary area thus becomes apparent.

In the area tributary to George Lake, the streambanks 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.[12] Within the area tributary to George Lake, there are currently no sites recommended for public acquisition.

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 18, primary environmental corridors in the area tributary to George Lake encompassed about 514 acres, or about 23 percent of the tributary area, as of 2000.

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 George Lake can be maintained and perhaps improved.

No secondary environmental corridors were identified within the area tributary to George 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.

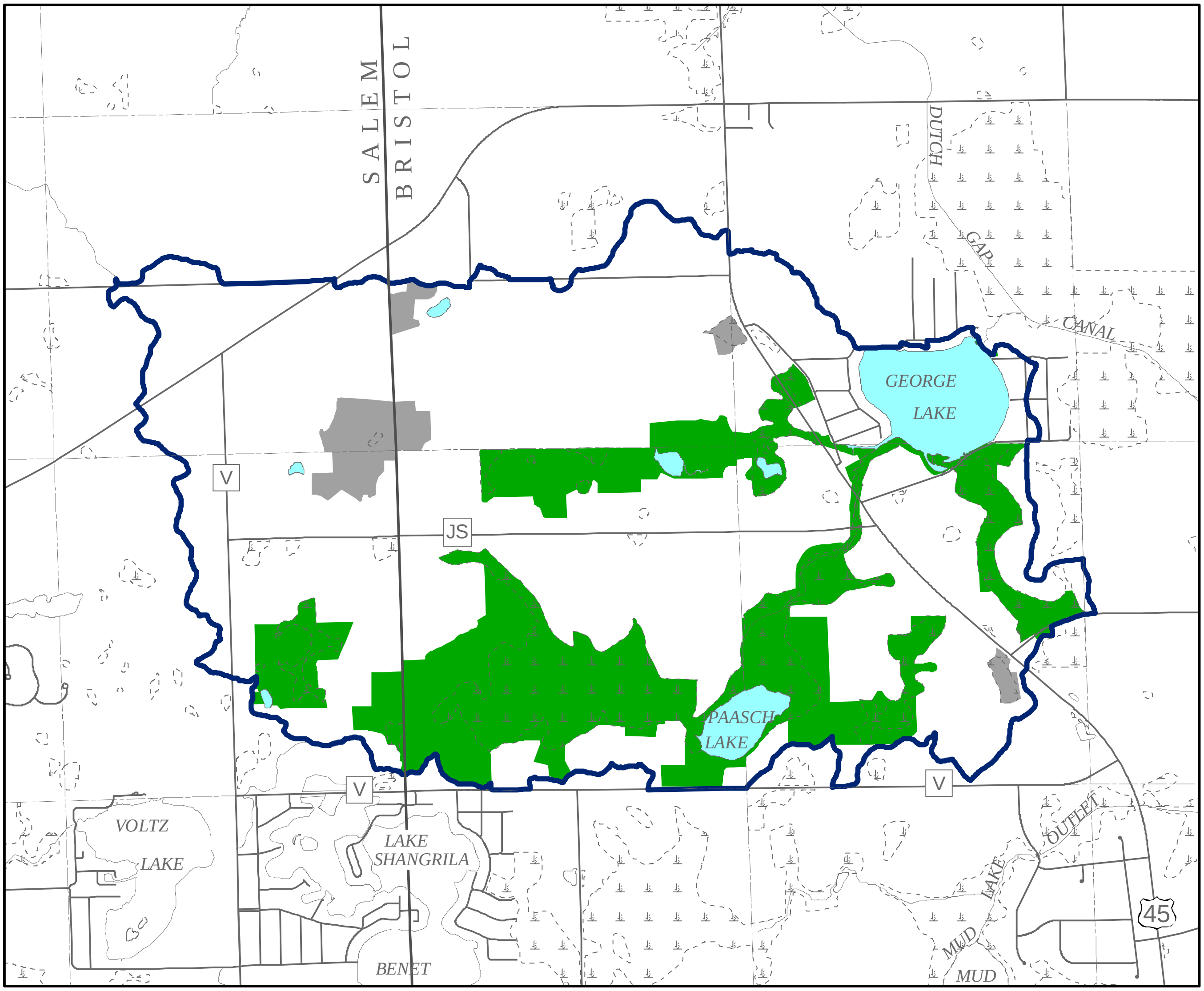
Isolated Natural Resource Areas

In addition to the primary environmental corridors, other small concentrations of natural resource base elements exist within the George Lake tributary 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

[12]*SEWRPC Planning Report No. 42,* op. cit.

Map 18

ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS WITHIN THE AREA TRIBUTARY TO GEORGE LAKE: 2000

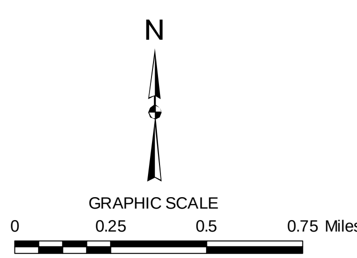


Primary Environmental Corridor

Isolated Natural Resource Area

Surface Water

Source: SEWRPC.



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 area tributary to George Lake also are shown on Map 18 and total about 60 acres, or about 3 percent of the tributary area. The largest of these areas is located in the western end of the tributary area and has, historically, contained a large blue heron rookery as was mentioned above.

Critical Species Habitat
George Lake is designated as a Critical Lake of southeastern Wisconsin and has been given a rating of AQ-3, identifying it as an aquatic area of local significance.[13] The Lake, in addition to providing good waterfowl habitat, provides habitat for the special concern species, lake chubsucker (Erimyzon sucetta).

SUMMARY

George Lake is a reflection of its tributary area. As noted in Chapter IV, George Lake is a typical hard-water, alkaline lake that is considered to have poor to good water quality. Total phosphorus levels were found to be generally at the level considered to cause nuisance algal and macrophytic growths. In recent years, both chlorophyll-*a* concentrations as well as the increasing abundance of rooted aquatic plants, especially Eurasian water milfoil, were remarked as issues of concern. Nevertheless, the Lake provides suitable habitat for a self-sustaining game fish population.

The George Lake tributary area provides a range of habitats for birds, large and small mammals, and reptiles and amphibians, with about 33 percent of the tributary 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.

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 George Lake can be maintained and perhaps improved.

---

[13]Ibid.

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 (SEWRPC), 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 George Lake, are discussed in this chapter.

RECREATIONAL USES AND FACILITIES

George Lake is located within about a one hour drive from much of the metropolitan areas of Milwaukee and Chicago. Its location, accessibility, and degree and type of shoreline development, contribute to a moderate degree of recreational usage by residents and nonresidents alike. 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. Winter recreational uses include cross-country skiing, ice skating, and snowmobiling. The scope of these recreational uses engaged in on George Lake is sufficiently broad to be consistent with the recommended use objectives of full recreational use and the support of a healthy warmwater sport fishery, as set forth in the adopted regional water quality management plan.

Park and Open Space Sites

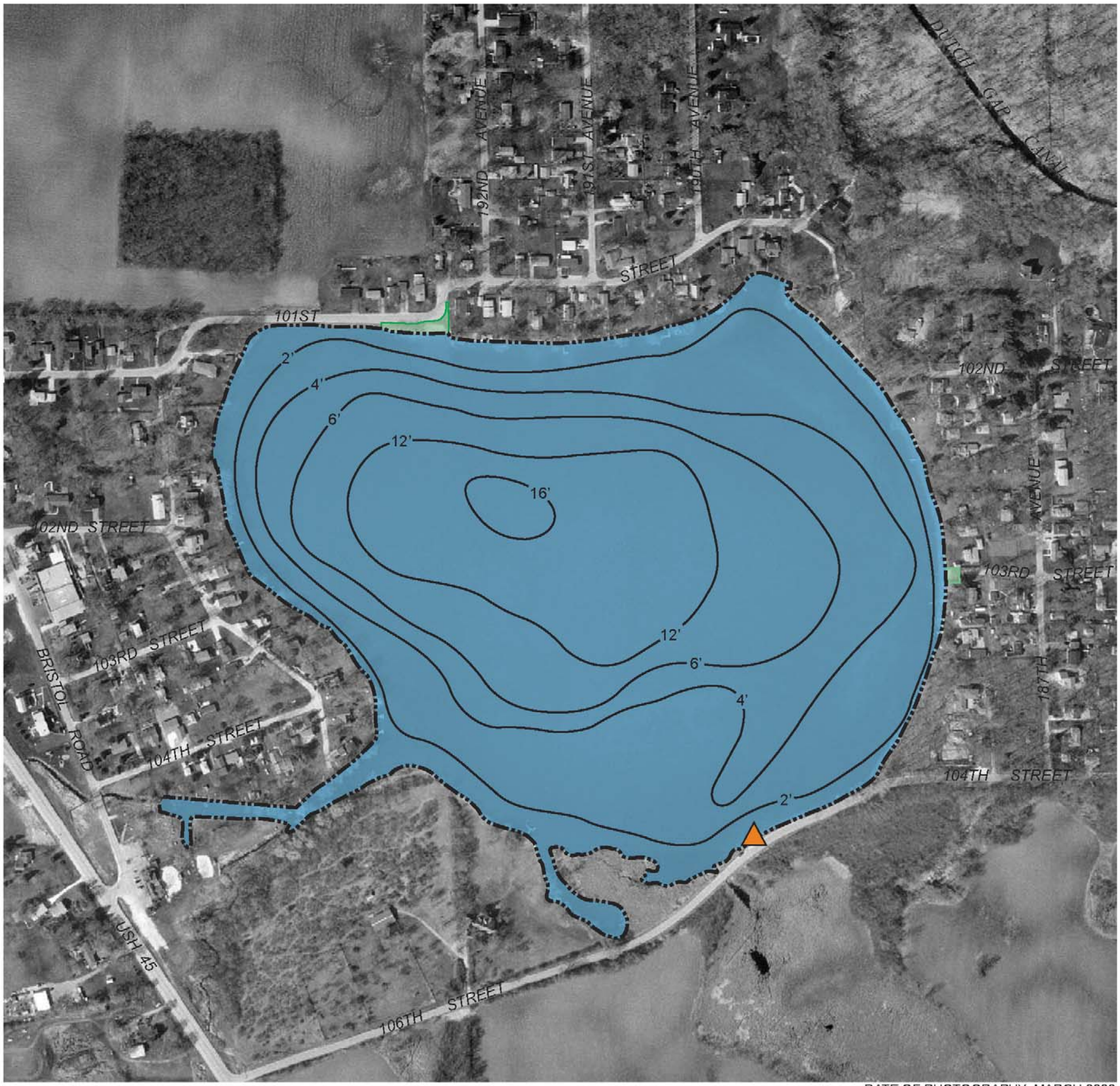
George Lake provides an ideal setting for the provision of parks and open space sites and facilities. As shown on Map 19, there are three public access sites around George Lake, all owned and operated by the Town of Bristol. East Beach, a small park located on 103rd Street at the east end of the Lake, provides a small swim beach and

---

[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.

Map 19

PARKS AND BOAT ACCESS SITES ON GEORGE LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

12' WATER DEPTH CONTOUR IN FEET

BOAT ACCESS SITE

RECREATIONAL AREA

Source: Wisconsin Department of Natural Resources and SEWRPC.

GRAPHIC SCALE 0 250 500 FEET

picnic table; North Beach, located on 101st Street on the north side of the Lake, also provides a swim beach and picnic facilities. Neither park has a designated parking area; both were found to be well maintained and in good condition. Public recreational boating access is provided along the south shore of the Lake where a gravel ramp is provided; roadside parking at the launch site is deemed to be adequate pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*.

Recreational Boating and Activities

During the current study period, surveys were conducted by SEWRPC staff to determine the degree and types of recreational activities, including boating, in which people participate on George Lake. One method for indirectly assessing the degree of recreational boat use on a lake is through counts of docked and moored boats on and around a lake. It has been estimated that, in southeastern Wisconsin, the number of watercraft operating at any given time is approximately 2 to 5 percent of the total number of watercraft docked and moored. About 55 watercraft of various descriptions were observed docked or moored on George Lake or observed as trailered watercraft or watercraft on land at George Lake during the current study period, as shown in Table 26. Of the motorized watercraft, fishing boats and pontoon boats comprised the largest proportion with a combined total of 31 watercraft representing over 85 percent of the motorized watercraft on the Lake; powerboats and personal watercraft (jetskis®) comprised the remaining portion of motorized watercraft. Of the nonmotorized watercraft, paddleboats formed the largest proportion of the watercraft, accounting for about 12 boats, or about 60 percent of the nonmotorized watercraft on the Lake; canoes and kayaks made up most of the other nonmotorized watercraft. There was one sailboat on the Lake. The types of motorized watercraft on the Lake, as well as the relative proportion of nonmotorized to motorized watercraft, reflect the attitudes of the primary users of the Lake, the residents. On Pewaukee Lake, for example, nearly 80 percent of all watercraft on the Lake are motorized compared to less than 65 percent of the watercraft on George Lake. Additionally, of all watercraft on Pewaukee Lake, powerboats make up the largest portion, almost 40 percent, whereas on George Lake the largest portion of all watercraft are fishing boats and pontoon boats which together comprise 55 percent of all watercraft on the Lake; only 5 percent of the watercraft on George Lake are powerboats.

Another way to assess the degree of recreational boat use on a lake is through direct counts of boats in use on a lake at a given time. These counts can be used to calculate the boating density, or the numbers of acres of open water available in which to operate a boat, and are, therefore, an indication of the intensity of recreational boating occurring on a lake. Table 27 shows direct counts made by SEWRPC staff of watercraft in use during a weekday and a weekend day in July of 2006. As shown in the table, powerboating and pontoon boating were observed in use only during the afternoon of the weekday survey and personal watercraft use was observed only during the afternoon of the weekend survey. During these periods, the densities of high-speed watercraft on the Lake ranged from about one boat per 50 acres to about one boat per 25 acres. There is a range of opinions on the issue of what constitutes optimal boating density on a lake. In the mid-1980s, an average area of about 16 acres per power or sail boat was, at that time, considered suitable for the safe and enjoyable use of a boat on a lake. For safe waterskiing and fast boating, an area of 40 acres per boat was suggested in the aforementioned Regional guidelines as the minimum area necessary for safe operations. Those densities observed on George Lake as described above are consistent with those considered appropriate for the conduct of safe high-speed boating activities pursuant to the adopted Regional guidelines.

Table 28 shows how people were using the Lake recreationally during a typical summer weekday and a typical summer weekend day in 2006. The most popular weekday recreational activities were going to the parks, swimming, pleasure boating, and fishing from boats. The most popular weekend recreational activities observed were fishing from boats, going to the parks, and swimming. Overall, fishing from boats had the highest number of participants; park going and swimming were the next most popular activities. Based on observations made by Commission staff during the conduct of these surveys, George Lake appears to provide a recreational setting especially well-suited to families; parents with small children seemed to be the primary users of the beaches and also comprised nearly half of all the pleasure boaters observed. Additionally, of the fishing boats in use on the Lake, more than half were occupied by adults and children together.

Table 26

WATERCRAFT DOCKED OR MOORED ON GEORGE LAKE: JULY 2003[a]

Type of Watercraft								
Powerboat	Pontoon Boat	Fishing Boat	Personal Water Craft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
3	14	17	2	1	7	0	12	56

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

Source: SEWRPC.

Table 27

WATERCRAFT IN USE ON GEORGE LAKE: JULY 2006

Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Water Craft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Saturday, July 8									
10:00 a.m. to 11:00 a.m.	0	0	3	0	0	0	0	0	3
1:30 p.m. to 2:30 p.m.	0	0	1	1	0	0	0	0	2
Thursday, July 13									
10:00 a.m. to 11:00 a.m.	0	0	1	0	0	0	0	0	1
1:30 p.m. to 2:30 p.m.	1	1	2	0	0	1	0	0	5

Source: SEWRPC.

Table 28

RECREATIONAL USE IN/ON GEORGE LAKE: 2006

	Weekend Participants									
Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Saturday, July 8										
10:00 a.m. to 11:00 a.m.	1	0	0	0	0	1	7	0	0	9
1:30 p.m. to 2:30 p.m.	0	0	0	0	1	4	4	2	6	17
Total for the Day	1	0	0	0	1	5	11	2	6	26
Percent	4	0	0	0	4	19	42	8	23	100

	Weekday Participants									
Date and Time	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Thursday, July 13										
10:00 a.m. to 11:00 a.m.	0	0	0	0	0	6	2	0	6	14
1:30 p.m. to 2:30 p.m.	2	10	0	0	0	5	6	1	5	29
Total for the Day	2	10	0	0	0	11	8	1	11	43
Percent	5	23	0	0	0	25	19	2	26	100

Source: SEWRPC.

Recreational boating activities on George Lake are regulated by state boating and water safety laws, and by the specific provisions of Town of Bristol Ordinance, Chapter 6, *Boating and Recreation*, regulating recreational boating activities and swimming. The ordinance is summarized in Appendix B.

Angling
George Lake provides a high quality habitat for 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. Evidence of good fishing is provided by the number of ice fishing shelters that occur on the ice during the winter months and by the numbers of fishing boats and shoreline anglers using the Lake during the summer.

Lake Use and Water Quality Survey
During the summer of 2005, a survey of George Lake residents was conducted by the George Lake Rehabilitation District (GLRD) in cooperation with SEWRPC. The purpose of the survey was to determine the opinions and ideas of residents regarding the state of the Lake and to evaluate the success of the GLRD in implementing measures to protect and enhance the community.

The survey was mailed to 224 residences and generated a response rate of about 20 percent, which is considered a good response. The five major concerns among those responding were: 1) development around the Lake, 2) numbers of water skiers/personal watercraft/waterfowl and wetland preservation, 3) shoreline erosion, 4) stormwater runoff, and 5) sedimentation. Respondents generally felt that although the Lake had poor water quality, it did have good aesthetic quality. Swimming was the favored recreational activity on the Lake and there was a somewhat higher percentage of anglers on the Lake than has been found on many lakes. A more expansive summary of the results of this survey are presented in Appendix C.

Wisconsin Department of Natural Resources Recreational Rating
In general, George Lake provides a variety of outdoor recreational opportunities. Based upon the outdoor recreation rating system developed by the WDNR, George Lake received 43 of a possible 72 points, as shown in Table 29. This rating indicates that, while the Lake provides a range of recreational opportunities, including a highly productive fishery, an adequate number of boat launch sites, and a varied landscape that enhances the natural aesthetics of the Lake, water quality conditions conducive to swimming and boating, and water depths and surface area conducive to boating may not be present.

WATER USE OBJECTIVES

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

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 30. 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 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 excessive macrophyte and algal growths and promote all forms of recreational use, including angling, in these waters. Implementation of these guidelines will restore George Lake to a mesotrophic or meso-eutrophic condition.

Table 29

WISCONSIN DEPARTMENT OF NATURAL RESOURCES RECREATIONAL RATING OF GEORGE LAKE

Space: Total Area = 59 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
__ 9	No problems	X 6	Modest problems, such as infrequent winterkill, small rough fish problems	__ 3	Frequent and overbearing problems, such as winterkill, carp, excessive fertility
Swimming:					
__ 6	Extensive sand or gravel substrate (75 percent or more)	__ 4	Moderate sand or gravel substrate (25 to 50 percent)	X 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	__ 4	Moderate algal or weed problems	X 2	Frequent or severe algal or weed problems
Boating:					
__ 6	Adequate water depths (75 percent of basin more than five feet deep)	__ 4	Marginally adequate water depths (50 to 75 percent of basin more than five feet deep)	X 2	Inadequate depths (less than 50 percent of basin more than five feet deep)
__ 6	Adequate size for extended boating (more than 1,000 acres)	__ 4	Adequate size for some boating (200 to 1,000 acres)	X 2	Limit of boating challenge and space (less than 200 acres)
__ 6	Good water quality	X 4	Some inhibiting factors, such as weedy bays, algal blooms, etc.	__ 2	Overwhelming inhibiting factors, such as weed beds throughout
Aesthetics:					
__ 6	Existence of 25 percent or more wild shore	X 4	Less than 25 percent wild shore	__ 2	No wild shore
__ 6	Varied landscape	X 4	Moderately varied	__ 2	Unvaried landscape
__ 6	Few nuisances, such as excessive algae carp, etc.	X 4	Moderate nuisance conditions	__ 2	High nuisance condition
Total Quality Rating: 43 out of a possible 72					

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 30

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.

(This page intentionally left blank)

Chapter VII

ALTERNATIVE LAKE MANAGEMENT MEASURES

INTRODUCTION

Based upon review of the inventories and analyses set forth in Chapter II through VI, issues were identified requiring consideration in the formulation of alternative and recommended lake management measures. These issues are related to: 1) land use; 2) pollution abatement; 3) water quality; 4) aquatic biota; and, 5) water uses. This Chapter sets forth alternative management measures to address the foregoing concerns, and indicates feasible measures to be carried forward into the recommended lake management plan set forth in Chapter VIII. The management measures considered herein are focused primarily on those measures which are applicable to the George Lake Rehabilitation District (GLRD), and to the Towns of Bristol and Salem.

TRIBUTARY AREA MANAGEMENT ALTERNATIVES

Land Use

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 area. The type and location of future urban and rural land uses in the tributary area to George 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 and Tributary Area

Existing 2000 and planned 2020 land use patterns and existing zoning regulations in the area tributary to George Lake have been described in Chapter II. If the recommendations set forth in the adopted regional land use plan are followed, under year 2020 and 2035 conditions, some additional urban residential development within the area tributary to George Lake would occur.[1] Much of this residential development is likely to occur on agricultural lands. Infilling of existing platted lots and some backlot development, as well as the redevelopment and reconstruction of existing single-family homes on lakefront properties and commercial structures, also may be expected to occur. Recent surveillance indicates that this type of development is currently occurring. Accordingly, given the potential impact of lakeshore development on the lake resources, land use development or redevelopment proposals around the shoreline of George Lake and within the area tributary to the Lake should be evaluated for potential impacts on the Lake, as such proposals are advanced.

---

[1]*See SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997; SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

Careful review of applicable zoning ordinances to incorporate levels and patterns of development consistent with the plan within the area tributary to George Lake is recommended. Changes in the zoning ordinances could be considered to better reflect the land use patterns recommended in the County development plan. 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] To this end, it has been noted that the Town of Bristol does not regulate livestock operations in a manner consistent with current and emerging best practices relative to set backs and protections of watercourses, wetlands, and waterbodies. Review and updating of existing ordinance provisions therefore appears to be warranted.

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.[3] 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 George Lake, and within its tributary area, consideration of a comprehensive program to regulate urban agricultural practices appears to be warranted.

Stormwater Management on Development Sites

With respect to stormwater management on development sites, as of 2000, the Towns of Bristol and Salem had adopted stormwater management ordinances. 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-source contaminants that would likely be delivered to the Lake.

Protection of Environmentally Sensitive Lands

Environmentally sensitive lands within the area tributary to George Lake include wetlands, woodlands, and wildlife habitat areas. Nearly all of these areas within the George Lake tributary area are included in the environmental corridors and isolated natural resource features delineated by the Southeastern Wisconsin Regional Planning Commission (SEWRPC). 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.

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 (USACE), Wisconsin Department of Natural Resources (WDNR), and County and municipal authorities under one or more of the Federal, State, County, and local regulations.

Pollution Abatement

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

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

[3]*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.*

human activities can be mitigated to a large extent by the implementation of sound planning, 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 area, 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. 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 area tributary to individual lakes and streams.

Nonpoint Source Pollution Abatement

Tributary area management measures may be used to minimize nonpoint source pollutant loadings from the tributary area by locating development within a tributary basin in accordance with sound planning. Beyond such actions, specific interventions may be required to control the mass of contaminants, generated by various types of land use activities, that is transported to the Lake. 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 activities. Alternative, tributary area-based nonpoint source pollution control measures considered in this report are based upon the recommendations set forth in the regional water quality management plan,[4] in the Des Plaines River Watershed Plan,[5] and in the Kenosha County land and water resource management plan.[6]

The regional water quality management plan recommends that the nonpoint source pollutant loadings from the areas tributary to George Lake be reduced by up to 25 percent in urban areas and by up to 50 percent in 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 agricultural lands within the area tributary to the Lake and from urban and urbanizing lands throughout the area tributary to the Lake that are linked to the Lake by way of streams and stormwater drainage systems. These loadings, collectively, constituted about 95 percent of the total phosphorus and sediment loadings to George Lake. In addition, the urban and urbanizing lands constituted 100 percent of the heavy metals loadings, based upon 2000 land uses. Phosphorus loadings from the remainder of the tributary area, and from direct deposition onto the Lake surface, contributed the balance of the total loadings. The contributions of phosphorus, sediment and heavy metals from urban lands are expected to increase slightly as agricultural lands are progressively converted to urban uses, if the forecasts set forth in the regional land use plan are implemented during the 30-year planning period.

While some proportion of the contaminant loads may be attenuated as a consequence of the extensive wetland areas, 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.

---

[4]*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 Planning Report No. 44,* A Comprehensive Plan for the Des Plaines River Watershed*, Part One –* Chapters 1-10*; Part Two –* Chapters 11-17*; Part Three –* Appendices*, , June 2003.*

[6]*SEWRPC Planning Report No. 255,* Kenosha County Land and Water Resource Management Plan: 2000-2004*, September 2000.*

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

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 area tributary to George 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 area tributary to George Lake.

Based upon the pollutant loading analysis set forth in Chapter IV, a total annual phosphorus load of about 1,100 pounds is estimated to be contributed to George Lake. Of that mass, it is estimated that about 1,000 pounds per year, or about 95 percent of the total loading, were contributed by runoff from rural lands. In addition, it is estimated that about 300 tons of sediment, or about 95 percent of the total sediment load to George Lake, were contributed annually from agricultural lands in the area tributary to the Lake. As of 2000, such lands comprised about 1,350 acres, or about 60 percent of the area tributary to George Lake, which area is anticipated to diminish slightly to about 1,300 acres in the tributary area by the year 2020.

Consequently, the agricultural operations that exist within the tributary area of George Lake will continue to contribute a significant proportion of the sediment load to the waterbody. Table 13 in Chapter IV of this report suggests that, based upon estimated contaminant loadings, agricultural land uses will continue to contribute about 95 percent of the total sediment load, or about 290 tons of sediment annually, to George 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 (NRCS) or the Division of County Development, Land and Water Conservation of the Kenosha County Department of Planning and Development, 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.

Urban Nonpoint Source Controls

As of 2000, established urban land uses comprised about 280 acres, or about 12 percent, of the area tributary to George Lake. The annual phosphorus loading from these urban lands was estimated to be about 50 pounds, or about 5 percent of the total load of phosphorus to the Lake. This is anticipated to remain at about 5 percent of the total load of phosphorus under year 2020 conditions. Those urban- and agricultural-sourced pollutant loadings that are most controllable include runoff from the farmlands and residential lands adjacent to the Lake, and urban runoff from areas with a high proportion of impervious surface. The potential also exists within the George Lake tributary area for significant construction site erosion impacts if development continues in the tributary 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.

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. To the extent practicable, parking lot stormwater runoff should be diverted to areas covered by pervious soils and appropriate vegetation, rather than being directly discharged to surface waters. Material storage areas may be enclosed or periodically cleaned, and diversion of stormwater away from these sites may further reduce pollutant loadings. 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-source 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 Towns of Bristol and Salem have adopted stringent stormwater management ordinances applicable to new development within the areas under their jurisdiction. 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. Proper design and application of structural urban nonpoint source control measures, such as grassed swales and detention basins, requires the preparation of a detailed stormwater management system plan that addresses stormwater drainage problems and controls nonpoint sources of pollution.

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 tributary area. However, as previously noted, some large-lot suburban-density development is currently taking place in the area tributary to George 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 can be provided by measures set forth in the model ordinance developed by the WDNR in cooperation with the Wisconsin League of Municipalities.[7] These controls are temporary measures taken to reduce pollutant loadings from construction sites during stormwater runoff events. Construction erosion controls may be expected to reduce pollutant loadings from construction sites by about 75 percent. Such practices are expected to have only a minimal impact on the total pollutant loading to the Lake due to the relatively small amount of land proposed to be developed. However, such controls are important pollution control measures that can abate localized short-term loadings of phosphorus and sediment from the tributary 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, Kenosha County has adopted construction site erosion control ordinances which are administered and enforced by the County, in both the shoreland and nonshoreland areas of the unincorporated areas of the lands tributary to George Lake. The provisions of these ordinances apply to all development except single- and two-family residential construction. Single- and two-family construction erosion control measures are to be specified as part of the building permit process. Because of the potential for development, some of it albeit

---

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

unplanned, in the area tributary to George Lake, it is important that adequate construction erosion control programs, including enforcement, be in place.

Public Sanitary Sewerage System Management

At the time of the current study, residential urban development located along the shoreline of George Lake have been included within a public sanitary sewer service area, as recommended in the adopted regional water quality management plan. The regional plan recommends that sewerage needs in such areas be periodically reevaluated in light of changing conditions.

IN-LAKE MANAGEMENT ALTERNATIVES

The reduction of external nutrient loadings to George 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 result in increased macrophyte growths that can result in restricted water use potentials, even after the implementation of tributary area-based management measures. Given that George Lake falls within the meso-eutrophic range, the awareness of in-lake rehabilitation techniques may be of value.

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 Monitoring Measures

As discussed in Chapter IV, water quality information for George Lake has been compiled during the current study period mainly through the efforts of the WDNR Self-Help Monitoring Program with enrollment of volunteers being conducted through the Southeast Region Office of the WDNR. Volunteers enrolled in this program gather data at regular intervals on water clarity through the use of a Secchi disk. Because pollution tends to reduce water clarity, Secchi disk measurements are generally considered one of the key parameters in determining the overall quality of a lake’s water as well as a lake’s trophic status. Secchi disk measurement data is added to the WDNR-sponsored data base containing lake water quality information for most of the lakes in Wisconsin and is accessible on-line through the WDNR website.

The WDNR also offers an Expanded Self-Help Monitoring Program that involves collecting data on several key physical and chemical parameters in addition to the Secchi disk measurements. Under this program, samples of lake water are collected by volunteers at regular intervals and analyzed by the State Laboratory of Hygiene. Data collection is more extensive and, consequently, places more of a burden on volunteers. An alternative is the analytical services provided by the University of Wisconsin-Stevens Point. However, this program also requires volunteers to obtain and transmit the water quality samples to the laboratory. In both cases, the WDNR offers Chapter NR 190 Small Grant funding that can be applied for to defray the costs for lab analysis and sampling equipment.

The U. S. Geological Survey (USGS) offers an extensive water quality monitoring program, within which Federal field personnel conduct a series of approximately five monthly samplings beginning with the spring turnover.

Samples are analyzed for an extensive array of physical and chemical parameters. The USGS also offers an array of other specialized services, including groundwater modeling and monitoring.

Ongoing water quality monitoring by volunteer monitors, supplemented by periodic more detailed water quality monitoring is considered to be a viable option for George Lake.

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 fishery are considered separately 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 considered a viable option for George 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 tributary area is generally preferable to attempting such control within a lake. Many of the techniques presented in the tributary area 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 re-release 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 George 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.

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 use, 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 George Lake is located at the northeastern end of the Lake. The outlet structure, as described earlier in this report, consists of a three foot head dam. Onsite observation by SEWRPC staff in 2006 indicated that the outlet structure appeared to be in good physical condition and operating within its design specifications.

Drawdown
Drawdown refers to a the 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 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 re-flooding, 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.

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 a viable option for George Lake.

Water Level Stabilization
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 a 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 considered a viable option for George Lake, 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 tributary area controls in reducing or minimizing the sediment sources. Federal and State permits are required for use of this option.

Dredging in George Lake could be accomplished using several different types of equipment, including a hydraulic cutterhead dredge mounted on a floating barge in deeper water areas; a bulldozer and backhoe equipment in the shoreland area, especially if the Lake was drawn down; and a clamshell, or bucket, dragline dredge from the shoreline. While the use of conventional earth-moving equipment and shore-based draglines has some advantages over hydraulic dredging, particularly since these methods would not require large disposal and dewatering sites in close proximity to the project area, these methods would be dependent, to some extent, on the drawdown of the Lake. Reducing the water level in the Lake would be especially advantageous for dragline dredging because it would not require the removal of shoreland trees, resulting in less disturbance of the shoreline to provide access for trucks and equipment. Likewise, reduced water levels would allow conventional construction equipment access to the littoral portions of the waterbody. Nevertheless, given the potential recreational use impacts of a drawdown during the summer and winter recreational seasons, use of these methods is not considered feasible.

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

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 George Lake should be to increase water depth to maintain recreational boating access and increased public safety.

Even so, 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 George 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 area tributary to the lake. The sediment load reaching George Lake comes from both urban and agricultural lands within the area tributary to George 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 tributary area. Such practices should be implemented in the area tributary to the Lake, as noted above, regardless of the likely conduct of any dredging project.

As noted above, dredging of lakebed material from navigable waters of the State requires a WDNR Chapter 30 permit and a USACE Chapter 404 permit. In addition, current solid waste disposal regulations define dredged material as a solid waste. Chapter NR 180 of the *Wisconsin Administrative Code* requires that any dredging project of over 3,000 cubic yards submit preliminary disposal plans to the WDNR for review and potential solid waste licensing of the disposal site. Because sodium arsenite was applied to George Lake during the 1950s and 1960s, as noted in Chapter V, sediment samples may need to be analyzed to determine the extent and severity of any residual arsenic contamination. However, analyses conducted by Aquatic Biologists, Inc., would suggest that the sediment quality is within that proposed in draft State sediment quality guidance.

Notwithstanding the considerations noted above, extensive dredging of George Lake is not considered a viable alternative at this time primarily due to the likely costs of such a rehabilitation technique and the lack of potential cost-sharing funds to offset the costs to the local community. Periodic deepening of nearshore areas of the Lake remains a feasible alternative, and should be considered for application in the constructed waterways linking the homes and businesses along with western shores of the Lake to the main lake basin. Likewise, maintenance of the waterway linking the public recreational boating access site to the main lake basin is likely to be necessary.

Aquatic Plant and Fisheries Management

Fisheries Management Measures

George Lake provides a quality habitat for a healthy, warmwater fishery. Currently, adequate water quality, dissolved oxygen levels, bottom substrate materials along the shorelines, and diverse plant community exist for the maintenance of a sportfish population in the Lake. Winterkill is currently not a problem. The Lake supports a largemouth bass-panfish fishery. In addition, the lake chubsucker, a State Special Concern species, has been reported being present in the Lake in surveys conducted in 1959, 1968, and 1970, as mentioned in Chapter V.

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 this is mid-April to mid-June. 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, if being utilized, 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. Such environmentally valuable areas within the Lake and its tributary area are the most important areas to be protected. In addition, limiting or restricting certain activities in those areas of the Lake containing important fish habitat will prevent significant disturbance of fish activities and aquatic plant beds. Within these areas, aquatic plant management measures should be restricted, and dredging, filling, and the construction of piers and docks should be discouraged. It also should be noted that water level fluctuations other than those consequent to natural climatic variability and water quality conditions can affect fish habitat and the breeding success of fishes. In this regard, the 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. Most of the shoreline of George Lake is protected by some type of structural measure. Four shoreline erosion control techniques were in use in 2003: natural vegetative buffer strips, rock and riprap 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 George 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 $50 to $100 per linear foot.

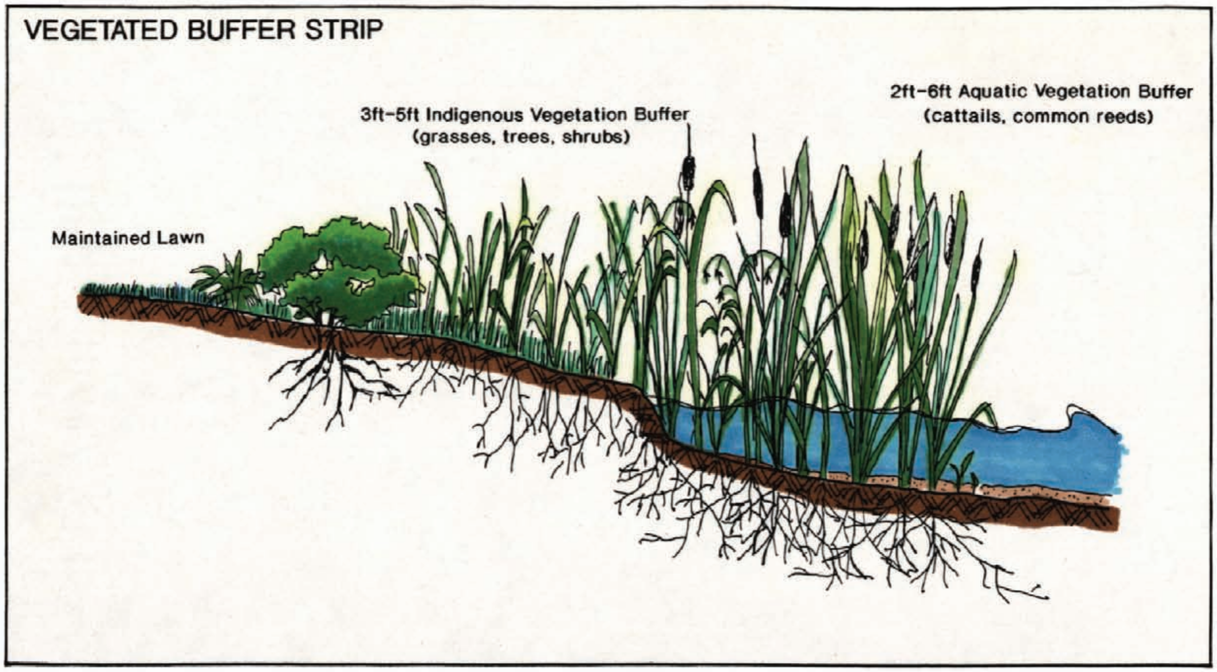
The use of natural vegetated buffer strips and riprap, as shown in Figure 10, is recommended, especially in those areas subject to significant wind-wave, boat wake, and ice scour erosion. In those portions of the Lake subject to direct action of wind waves and ice scour, the use of riprap would provide 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 proposed to be subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*, which Chapter, as of 2002, is currently in draft and under administrative review by the Wisconsin Natural Resources Board.

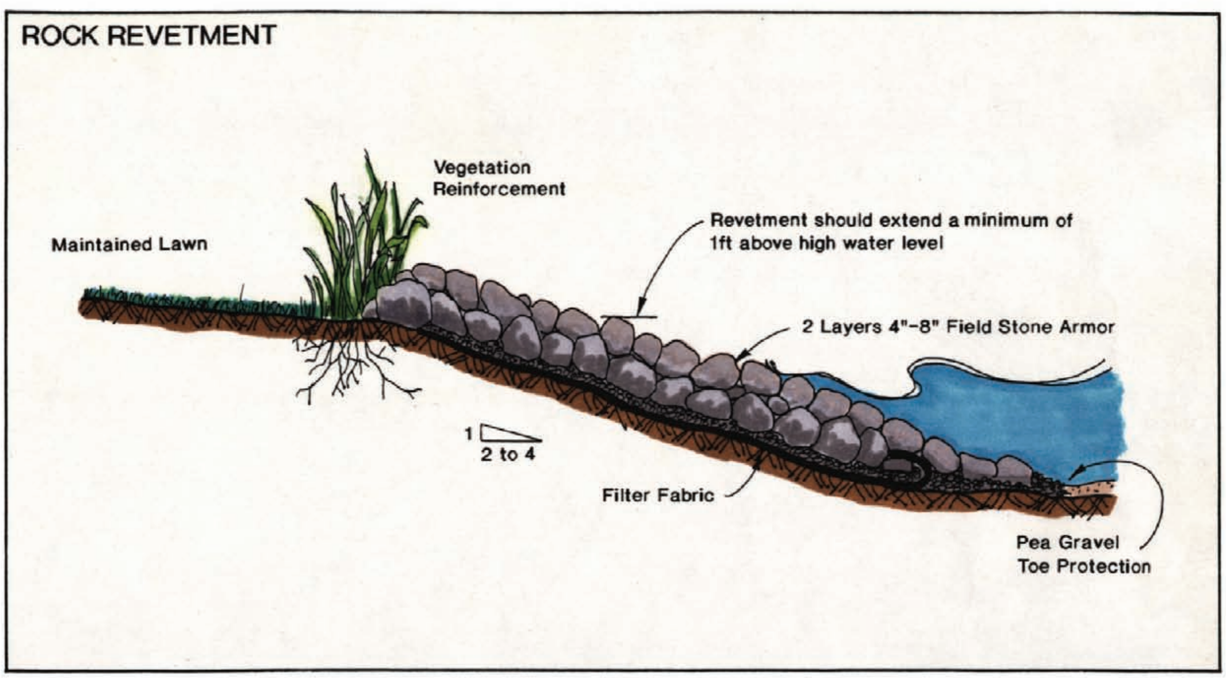
Modification of Species Composition

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.

Figure 10

RECOMMENDED ALTERNATIVES FOR SHORELINE EROSION CONTROL





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

Source: SEWRPC.

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 currently considered viable for George Lake.

As noted in Chapter V, George Lake is currently managed for warmwater sportfish, and selective stocking is undertaken primarily by the WDNR. Continued fish stocking by the WDNR is a viable option for George 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 WDNR 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 George Lake are given in Table 24 in Chapter V of this report. 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 four groups: chemical measures, which include using aquatic herbicides; mechanical measures, which include harvesting and manual removal; biological measures, which include the use of various organisms, including insects; and physical measures, which include lake bottom coverings and water level management. All aquatic plant management measures are stringently regulated and most 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 or exceed $10,000 to $20,000 per year depending on staffing and operating policies. Harvesting is frequently used to manage aquatic plant growths in larger areas while chemical controls may be better suited for the control of invasive plants. Plantings of native aquatic plant species remain largely experimental in lakes, although they should be considered in shoreland management applications along the water's edge. Some measures, such as physical controls and mechanical harvesting may have side effects such as the expansion of specific plant habitat and the spread of reproductive vegetative fragments. The actual selection of a suite of aquatic plant management measures for use in a specific lake is dictated by lake conditions and subject to State permitting requirements, as noted above.

Chemical Measures
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, in combination with external inputs of sediment from nonpoint sources as quantified in Chapter IV, may contribute to 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.[8]

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 target "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 are known.[9]

Costs of chemical treatments vary widely. Large, organized treatments are more efficient and tend to decrease unit costs for commercial applications compared to individual treatments. Other factors, such as the type of chemical used and the number of treatments needed, are also important. Estimated costs for lakes in southeastern Wisconsin range from $240 to $480 per acre. Chemical treatments must be permitted by the State under Chapter NR 107 of the *Wisconsin Administrative Code.*

Because there is a demonstrated need to control aquatic plants in selected areas of George Lake, chemical treatment is considered to be a viable management option, especially to control growth of nonnative aquatic plants such as Eurasian water milfoil and curly-leaf pondweed. Widespread use of chemical herbicides is not considered a viable option.

---

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

[9]*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.*

Manual and Mechanical Measures
Aquatic macrophytes can be cut and removed from inland lakes using either manual and/or mechanical equipment. Mechanical harvesting requires 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. Manual harvesting can be done without equipment, although specialty rakes are available to expedite the control of aquatic plants in nearshore areas and around piers and docks.

The 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.[10]

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.

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.[11]

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.

---

[10]*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.*

[11]*James E. Breck, and J.F. Kitchell, "Effects of Macrophyte Harvesting on Simulated Predator-Prey Interactions," in Breck et al.,* Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting, *1979, pp. 211-228.*

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 WDNR study found that four pounds of fish were removed per ton of plants harvested.[12] To protect the fish community from excessive mortality from harvesting, the WDNR generally recommends harvesting be conducted in areas six feet in depth or greater. Additionally, it is generally recommended that harvesting activities not begin before June 15th in order to reduce disturbing fish spawning activities.

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.[13] 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.

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 George Lake could be conducted through cooperative agreements among various municipalities in the tributary area or be contracted to a private company. The costs of mechanical harvesting 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.

Harvesting programs 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.[14] Narrow channels may be harvested to provide navigational access and “cruising lanes” for predator fish to migrate into the macrophyte beds to feed on smaller fish. “Shared access” lanes may also be cut, allowing several residents to use the same lane. Increased use of these lanes should keep them open for longer periods than would be the case if a less directed harvesting program was followed. “Clear cutting” of aquatic plants and denuding the lake bottom of flora should be avoided. However, top cutting of plans such as Eurasian water milfoil, as shown in Figure 11, is suggested.

---

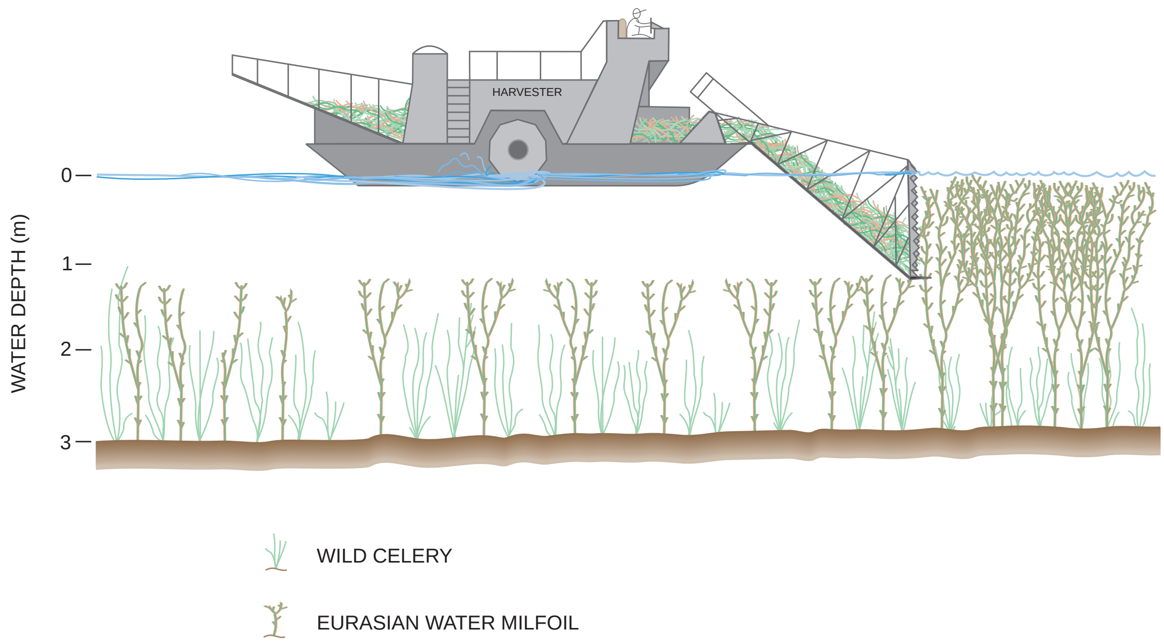
[12]*Wisconsin Department of Natural Resources,* Environmental Assessment Aquatic Nuisance Control (NR 107) Program, *3rd Edition, 1990, 213 pp.*

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

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

Figure 11

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.

Water depth, numbers and arrangement of docks and moored boats, and nature of bottom substrate are important factors when considering mechanical harvesting. As explained above, most harvesting equipment is large and not well-suited to close operation around docks and moored boats where precise control of movement is needed. Areas of shallow depths, two to three feet or less, containing muck or other soft, loose bottom materials are generally not considered to be well suited to harvesting as the equipment tends to churn up these bottom materials, creating turbid water conditions, affecting established benthic communities and fragmenting rooted aquatic macrophytes. Plants such as Eurasian water milfoil, which propagate through the spread of plant fragments, may actually be at an advantage as a result of the chopping action of harvesting equipment. Mechanical harvesting is best suited to areas free of docks and moored watercraft or recreational equipment, where lake bottom materials are firm and water is of sufficient depth to offer a degree of protection against potential lake bottom disruption by harvester equipment. The harvest of water lilies and emergent native plants 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.[15] Stress can be brought on by tributary area 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

---

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

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.[16]

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 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, thereby 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-foot-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-foot-wide recreational corridor.

Because of the demonstrated need for control of aquatic plants, harvesting is considered a viable option in areas of George Lake that are conducive to these methods of management. Except as noted above, harvesting of aquatic plants must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*.

Biological Measures

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.[17] Recent documentation states that *Eurhychiopsis lecontei*, an aquatic weevil species, has the potential as a biological control agent for Eurasian water milfoil. In 1989, the weevil was discovered during a study investigating a decline of Eurasian water milfoil growth in a Vermont pond. *Eurhychiopsis* proved to have significant negative effects on Eurasian water milfoil in the field and in the lab. The adult weevil feeds on the milfoil causing lesions which make the plant more susceptible to pathogens, such as bacteria or fungi, while the weevil larvae burrows in the stem of the plant causing enough tissue damage for the plant to lose buoyancy and collapse.[18] 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:[19]

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.

---

[16]*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.*

[17]*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.*

[18]*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.*

[19]*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.*

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

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

Since the upper portion of the Eurasian water milfoil plant is preferred by the weevil, a potential disadvantage of using *Eurhychiopsis lecontei* would be that other forms of aquatic plant management would have to be extremely limited or not used at all in conjunction with this type of aquatic plant management control.

Relatively few studies concerning the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control have been completed. Such cases have resulted in variable levels of control, and, although priced competitively with aquatic herbicides, the use of *Eurhychiopsis lecontei* is not considered a viable option for George Lake at this time. Use of biological control agents must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*.

In contrast to the use of biological control agents for the control of Eurasian water milfoil, the use of the beetles, *Hylobius transversovittatus*, *Galerucella pusilla*, *Galerucella calmariensis*, *Nanophyes brevis*, and *Nanophyes marmoratus,* for the control of infestations of purple loosestrife in wetlands and along shorelands has been shown to be beneficial in certain circumstances, including use at George Lake. Continuation of the program for the biological control of purple loosestrife is indicated.

It should be noted that 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.

Physical Measures

Lake bottom covers and light screens provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. They have been used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motorboating. Sand and gravel are usually 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.

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 WDNR 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 a viable option for George 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 a viable option 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 16 in Chapter V of this report, 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 George 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 WDNR and the University of Wisconsin-Extension (UWEX). The aquatic plant species lists provided in Chapter V, and the illustrations of common aquatic plants present in George 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 George 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. 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 or into new areas of lakes.

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).[20] Providing the opportunity for the removal of plant fragments at the boat landing on George 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 WDNR and

---

[20]*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.*

UWEX 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 100 feet of piers, docks, rafts, or buoyed restricted areas on any lake. These areas typically coincide with water depths of less than five feet in depth. Demarcation of Eurasian water milfoil control areas and similar environmentally valuable or sensitive areas of the Lake should be considered. It is also recommended that the Town of Bristol continue to enforce recreational boating ordinance and winter lake use ordinance appended hereto as Appendix B.

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 UWEX, WDNR, and Kenosha County. 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.

The GLRD regularly presents seminars and informational programs of general interest to community residents. These programs have included aquatic plant identification, lake history, lake water quality, and related topics.

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 at the middle school level and at the high school level. Such programming as Project WET are available from and supported by UWEX and provide youth the opportunity to experience “hands on” the aquatic environment and become better informed about current and future lake issues and concerns. Therefore, activities of this type, such as Project WET or Adopt-a-Lake, which could be arranged through agreements involving local Lake organizations, municipalities, and school districts and are considered a viable option.

Finally, reporting of water quality sampling results to the public and participation of the George Lake community in the WDNR 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 WDNR-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 George Lake and which could, singly or in combination, assist in achieving and maintaining the water quality and water use objectives set forth in Chapter VI. Selected characteristics of these measures are summarized in Table 31.

An evaluation of the potential management measures for improving the George 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, nutrient load reduction through sediment management, water level control by drawdown or modifications of outlet control operations, dredging, chemical eradication of rough fish, biological control of aquatic plants, lake bottom covering, development of time and/or space zoning schemes for managing surface use, and development of alternative institutions. The remaining measures are considered viable options to be considered further for incorporation in the recommended plan described in Chapter VIII.

Table 31

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR GEORGE LAKE

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Land Use	Zoning	Implement regional land use and county development plans within tributary area	Yes
		Maintain existing density management in lakeshore areas; consider conservation development principles	Yes
		Develop and implement consistent stormwater management ordinances in all riparian communities; periodic review of stormwater ordinances	Yes
	Protecting environmentally sensitive lands	Implement regional natural areas and critical species habitat protection and management plan recommendations within tributary area	Yes
Pollution Abatement	General nonpoint source pollution abatement	Implement regional water quality management plan and county land and water resource management plan recommendations within tributary area; protect wetlands, woodlands, shorelands, and other environmental corridor lands and natural features	Yes
	Rural nonpoint source controls	Develop farm conservation plans that encourage conservation tillage, contour farming, contour strip cropping, crop rotation, grassed waterways, and pasture and streambank management in agricultural areas of the tributary area	Yes
	Urban nonpoint source controls	Promote urban housekeeping practices, public educational programming, and grassed swales	Yes
		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 tributary area	Yes
	Developing Area nonpoint source controls	Enforce construction site erosion control ordinances requiring soil stabilization, surface roughening, barriers, diversion swales, sediment traps and basins	Yes
	Public sanitary sewerage system management	Conduct periodic review of sewer service area needs within sewered areas of the tributary area	Yes
	Onsite sewage disposal system management	Implement onsite sewage disposal system management, including inspection and maintenance	Yes
Water Quality	Water quality monitoring	Continue participation in WDNR Self-Help Monitoring Program; consider participation in WDNR Expanded Self-Help program, University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program, or USGS water quality monitoring program	Yes
	Water quality improvement	Conduct alum treatment to achieve phosphorus inactivation in lake sediments	No
		Promote nutrient load reduction within the Lake basin through sediment management	No
		Modify outlet control operations	No
		Drawdown	No
		Water level stabilization	No
		Dredging	No

Table 31 (continued)

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Aquatic Biota	Fisheries management	Protect fish habitat	Yes
		Maintain shoreline and littoral zone fish habitat by maintaining existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Yes
		Continue stocking of selected game fish species and monitor rough fish populations	Yes
		Chemical eradication of rough fish populations	No
		Enforce size and catch limit regulations	Yes
	Aquatic plant management	Limited use of aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife	Yes[a]
		Mechanically harvest aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants	Yes[b]
		Manually harvest aquatic plants from around docks and piers where feasible	Yes
		Employ biological controls using inocula of Eurasian water milfoil weevils	No
		Continue using biological controls for management of purple loosestrife on an as needed basis	Yes
		Use sediment covers to shade out aquatic plant growth around piers and docks	No
		Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	Yes
Water Use	- -	Enforce boating regulations to maximize public safety; improve signage	Yes
		Develop time and/or space zoning schemes to limit surface use conflicts	No
Ancillary Management Measures	Public Informational and Educational Programming	Conduct public informational programming and educational programming on aquatic plants, options for their management, and other topics of relevance to lake residents utilizing seminars and distribution of informational materials	Yes
		Support participation of schools in Project WET, Adopt-A-Lake, etc.	Yes
		Encourage methods of preventing unwanted intrusions of invasive biota at public recreational boat access	Yes
Institutional Development	- -	Create a lake association for George Lake	No

[a] *Limited areas when necessary to control exotic, invasive species.*

[b] *In areas where water depth, bottom substrate material, and dock/moored watercraft densities are within desirable limits to promote the effectiveness of this method of aquatic plant management .*

Source: SEWRPC.

Chapter VIII

RECOMMENDED MANAGEMENT PLAN FOR GEORGE LAKE

INTRODUCTION

This chapter presents a recommended management plan for George Lake. The plan is based upon inventories and analyses of land use and land and water management practices, pollution sources in the area tributary to George 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 means for: 1) providing water quality conditions suitable for full-body contact recreational use and the maintenance of healthy communities of warmwater fish and other aquatic life, 2) reducing the severity of existing 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 31 in Chapter VII of this report, that may be expected to best meet the foregoing lake management objectives.

Analyses of water quality and biological conditions indicate that the general condition of the water of George Lake is very good. There appear to be few impediments to water-based recreation, although access by recreational watercraft is limited in some portions of the Lake by water depths and growths of aquatic macrophytes. Nevertheless, based upon a review of the inventory findings and consideration of planned developments within the area tributary to the Lake, as set forth in the adopted regional land use plan,[1] 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 for: land use management, including protecting environmentally sensitive lands, in the area tributary to George Lake, pollution abatement, water quality monitoring and improvement, aquatic plant and fisheries management, recreational water use, and informational programming. These measures complement and refine the tributary area land use controls and management measures recommended in the adopted regional water quality management plan,[2] the Des Plaines River watershed plan,[3] and the Kenosha County land and water resource management plan.[4]

---

[1]*See SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997; SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

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

[3]*SEWRPC Planning Report No. 44,* A Comprehensive Plan for the Des Plaines River Watershed, *Part One,* Chapters 1-10*; Part Two,* Chapters 11-17*; Part Three,* Appendices, , *June 2003.*

[4]*SEWRPC Community Assistance Planning Report No. 255,* Kenosha County Land and Water Resource Management Plan: 2000-2004, *September 2000.*

The recommended management measures for George Lake are graphically summarized on Map 20, and are listed in Table 32. The recommended plan measures are more fully described in the following paragraphs. The recommended management agency responsibilities for tributary area land management also are set forth in Table 32.

TRIBUTARY AREA MANAGEMENT MEASURES

Land Use Control and Management

A fundamental element of a sound management plan and program for George Lake is the promotion of a sound land use pattern within the area tributary to the Lake. The type and location of rural and urban land uses in the tributary 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 area tributary to George Lake under year 2020 conditions is described in Chapter II. The framework for the plan is the regional land use plan as prepared and adopted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC). The recommended land use and county development plans envision that urban land use development within the area tributary to George Lake will occur primarily at low densities and 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 SEWRPC-delineated environmental corridors described in Chapter V.

Development in the Shoreland Zone and Tributary Area

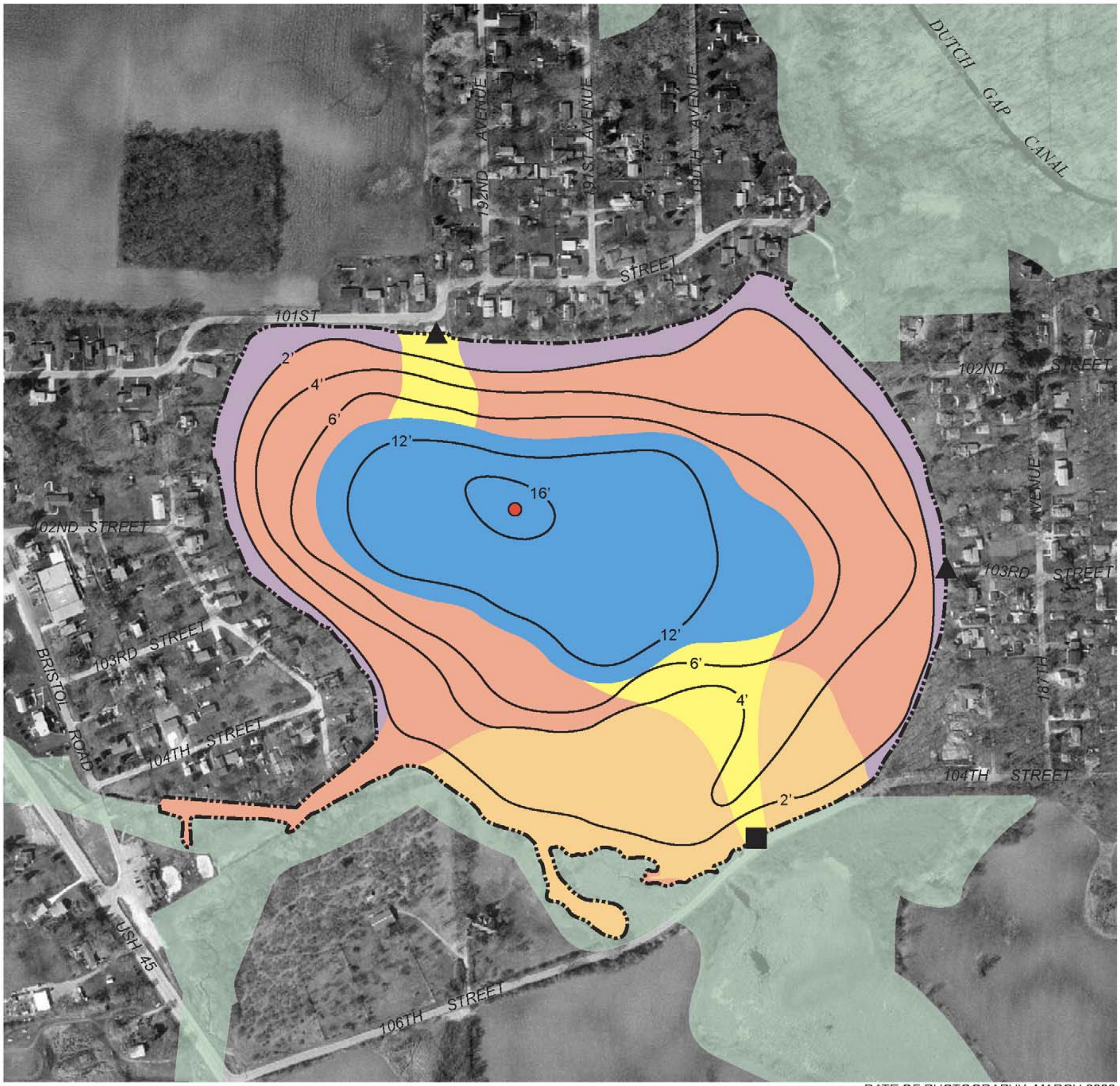
A major land use issue which has the potential to affect George Lake is the redevelopment of existing lakefront properties, replacing lower-density uses with higher-density, multi-family dwellings with potential for increased roof areas, parking areas, and other areas of impervious surfaces. Replacement 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 likely to be an adverse impact on the Lake from significant redevelopment in the 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 George Lake to the maximum extent practical is recommended.

It is further recommended that lakefront developments, as well as setback and landscaping provisions, be carefully reviewed by the Town of Bristol 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. 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.

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 area. As previously noted, large-lot residential development is occurring in areas of the Lake tributary area in which such development was not envisioned in the adopted regional land use plan. In particular, the proposed development of so-called “hobby farms” or small-scale livestock operations on large lots within the Town of Bristol would suggest the need for consideration and promulgation of additional zoning ordinance language to ensure the orderly development and operation of these types of suburban-density development. If this trend continues, much of the open space areas remaining in the tributary area will be replaced over time with large-lot urban development. This may significantly increase the pollutant loadings to the Lake and increase the pressures for recreational use of the Lake. Under the year 2020 and 2035 conditions envisioned in the regional land use plan as refined, a significant portion of the undeveloped lands outside of the environmental corridors and other environmentally sensitive areas, could potentially be developed for low-density urban uses.

Map 20

RECOMMENDED LAKE MANAGEMENT PLAN FOR GEORGE LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

12' WATER DEPTH CONTOUR IN FEET

WATER QUALITY MONITORING
- MONITORING SITE

RECREATIONAL USE MANAGEMENT
- MAINTAIN PUBLIC RECREATIONAL BOATING ACCESS
- PERIODICALLY MONITOR FECAL COLIFORM CONCENTRATIONS AT BEACH

LAND USE MANAGEMENT
- PROTECT ENVIRONMENTALLY SENSITIVE LANDS
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN DRAINAGE AREA
- MAINTAIN HISTORIC LAKEFRONT DENSITIES; OBSERVE GUIDELINES IN REGIONAL LAND USE PLAN
- PERIODICALLY REVIEW SEWER SERVICE AREA FACILITIES PLAN

AQUATIC PLANT MANAGEMENT

CONTROL NONNATIVE SPECIES, ESPECIALLY EURASIAN WATER MILFOIL AND PURPLE LOOSESTRIFE
CHEMICAL CONTROL: HIGH PRIORITY (SPRING TREATMENT)
HARVESTING: HIGH PRIORITY

RECREATIONAL ACCESS
CHEMICAL CONTROL: HIGH PRIORITY (SPRING TREATMENT, TREAT FOR SWIMMER'S ITCH AS REQUIRED)
HARVESTING: HIGH PRIORITY

RIPARIAN ZONE
CHEMICAL CONTROL: MODERATE PRIORITY
HARVESTING: MANUAL CONTROL, HIGH PRIORITY

FISH AND HABITAT AREA
CHEMICAL CONTROL: LIMITED (NONNATIVE SPECIES)
HARVESTING: LIMITED (CRUISING LANES ONLY)

OPEN WATER
CHEMICAL CONTROL: NONE
HARVESTING: NONE

NOTE: PERIODIC NONNATIVE SPECIES CONTROL MAY BE REQUIRED

GRAPHIC SCALE
0 250 500 FEET

Source: U.S. Geological Survey and SEWRPC.

Table 32

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR GEORGE LAKE

Plan Element	Subelement	Location	Management Measure	Management Responsibility
Land Use	Zoning	Entire tributary area	Observe guidelines set forth in the regional land use and Kenosha County development plan	Kenosha County; Towns of Bristol and Salem
		Lakeshore areas	Maintain historic lake front residential dwelling densities to extent practical and continue to enforce setback requirements; consider conservation development principles	
	Protecting environmentally sensitive lands	Entire tributary area	Establish adequate protection of wetlands, woodlands, shorelands, and other environmental corridor lands and natural features	Kenosha County; Towns of Bristol and Salem; GLRD
Pollution Abatement	General nonpoint source pollution abatement	Entire tributary area	Implement recommendations made in the regional and county land and water resource management plans	Kenosha County; Towns of Bristol and Salem
	Rural nonpoint source controls	Entire tributary area	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, Kenosha County
	Urban nonpoint source controls	Entire tributary area	Promote urban housekeeping and yard care practices through public educational programming	Kenosha County; Towns of Bristol and Salem; GLRD
	Developing Area erosion control and stormwater management ordinance	Entire tributary area	Develop and enforce construction site erosion control and stormwater management ordinances; review ordinances for concurrence with NR 151	Kenosha County; Towns of Bristol and Salem
		New clustered developments in conservation subdivisions	Develop stormwater management systems where appropriate densities exist	Kenosha County; Towns of Bristol and Salem
	Public sanitary sewerage system management	Sewered portions of tributary area	Conduct periodic review and refinement of sewer service area needs within sewered areas of the tributary area	Town of Bristol
	Onsite sewage disposal system management	Unsewered portions of the tributary area	Implement onsite sewage disposal system management, including inspection and maintenance; provide system information to residents	Towns of Bristol and Salem
Water Quality	Water quality monitoring	Main Lake basin	Continue participation in WDNR Self-Help Water Quality Monitoring Program; consider participation in WDNR Expanded Self-Help Program, USGS monitoring program or University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program	USGS, WDNR, UW-SP, GLRD

Table 32 (continued)

Plan Element	Subelement	Location	Management Measure	Management Responsibility
Aquatic Biota	Fisheries management	Entire lake	Protect fish habitat	WDNR, GLRD
		Shoreland areas	Enforce adequate setbacks in shoreland areas	Kenosha County, Town of Bristol, GLRD, WDNR
			Maintain shoreline and littoral zone fish habitat by maintaining existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	WDNR, GLRD, private shoreline property owners
			Continue stocking of selected game fish species and monitor rough fish populations; consider conducting periodic creel census	WDNR, GLRD
			Enforce size and catch limit regulations	WDNR
	Aquatic plant management	Entire lake	Conduct periodic reconnaissance surveys of aquatic plant communities Update aquatic plant management plan every three to five years	WDNR, GLRD
			Provide and conduct programming on aquatic plants and various management measures	WDNR, GLRD
		Selected areas of the Lake	Use (limited) aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife[a] Mechanically harvest aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants[b]	WDNR, GLRD
			Manually harvest aquatic plants from around docks and piers where feasible	Private lakefront property owners
		Lakeshore areas	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	WDNR, GLRD, private lakefront property owners
	Invasive species	Entire lake	Continue to monitor population size, make-up, and distribution of invasive species such as purple loosestrife, Eurasian water milfoil	WDNR, GLRD
Water Use	Recreational use management	Entire lake	Enforce and periodically review regulations governing the operation of watercraft and improve posting and notification of regulations and ordinances, including signage and materials at public recreational access site to aid in the identification and control of exotic species	Kenosha County, Town of Bristol, WDNR, GLRD
		Public access site	Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines	

Table 32 (continued)

Plan Element	Subelement	Location	Management Measure	Management Responsibility
Ancillary Management Measures	Public Informational and Educational Programming	Entire tributary area	Conduct public informational programming utilizing seminars and distribution of informational materials; 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; construction may require WDNR Chapter 30 permits	Kenosha County, Town of Bristol, GLRD, WDNR, UWEX, Private landowners
			Conduct public informational and educational programming on aquatic plants and options for their management	
		Entire lake	Support participation of schools in Project WET, Adopt-A-Lake, etc.	

[a] *Limited areas when necessary to control exotic, invasive species.*

[b] *In areas where water depth, bottom substrate material, and dock/moored watercraft densities are within desirable limits to promote the effectiveness of this method of aquatic plant management*.

Source: SEWRPC.

The existing zoning in the tributary area basin permits development, generally on large suburban-density lots, over much of the remaining open lands other than the environmental corridors. Control of shoreland redevelopment, and the related intensification of use, is not specifically addressed in the existing zoning codes. It is recommended that the impact of future land use development on George Lake be minimized through review and modification of the applicable zoning ordinance regulations and zoning district maps to address the concerns noted. Changes in zoning ordinances are recommended to minimize the areal extent of development by providing specific provisions and incentives for the clustering of residential development on smaller lots within conservation subdivisions, thus preserving significant portions of the open space within each property or group of properties considered for development. In addition, it is recommended that current land use plans and zoning requirements be reviewed periodically to ensure appropriate regulation of new development; where necessary, it is recommended that specific ordinances be developed or existing ordinances be refined to reflect current practice in land development and management. Such measures will contribute to the minimization of runoff and contaminant flows to George Lake, especially with respect to new development and redevelopment, and when applied in conjunction with the physical interventions discussed further below.

Stormwater Management

It is recommended that the Towns of Bristol and Salem 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 tributary area located within each municipality where further urban development or redevelopment is anticipated. Such a planning program should include a review of the stormwater management ordinances to ensure that the ordinance provisions reflect state-of-the-art runoff and water quality management requirements.

It is further recommended that the stormwater management requirements and performance standards set forth in Chapter NR 151 of the *Wisconsin Administrative Code* be incorporated into local ordinances, and applied to lands within the drainage area both during and following construction and other land disturbing activities.[5] Stormwater management facilities installed within the drainage basin tributary to George Lake should be monitored and maintained to ensure their effectivity. Placement of additional stormwater management facilities should be considered as necessary to minimize sediment and contaminant loadings to the Lake.

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 area tributary to George Lake. The wetland areas within the area tributary to the Lake are currently largely protected through the existing regulatory framework provided by the U.S. Army Corps of Engineers (USACE) permit program, State shoreland zoning requirements, and local zoning ordinances. Nearly all wetland areas in the George Lake tributary area are included in the environmental corridors delineated by SEWRPC 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. Implementation of the recommendations of the adopted park and open space plan for Kenosha County[6] would complement the protection and preservation of these environmentally sensitive lands.

Nonpoint Source Pollution Control

The recommended tributary area land management measures are specifically aimed at reducing the water quality impacts on George Lake of nonpoint sources of pollution within the tributary area. These measures are set forth in the aforereferenced regional water quality management plan and the Kenosha County land and water resource management plan. As indicated in Chapter IV, the only significant sources of phosphorus loading to the Lake that are subject to potential controls are agricultural and urban nonpoint sources.

Nonpoint source control measures should be considered for the areas tributary to George Lake. The regional water quality management plan recommended a reduction of about 25 percent in urban, and of up to 50 percent in rural, nonpoint-source pollutants plus streambank erosion control, construction site erosion control, and onsite sewage disposal system management be achieved in the area tributary to George Lake.

Nonpoint source pollution abatement controls in the tributary area are 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-source 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 Kenosha County land and water resource management plan.

Rural Nonpoint Source Pollution Controls

The implementation of nonpoint source pollution controls in rural areas requires the cooperative efforts of the Towns of Bristol and Salem, Kenosha County, and private landowners. Technical assistance can be provided by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS); the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP); and the Kenosha County Park Division

---

[5]*Additional code chapters that are related to the State nonpoint source pollution control program include: Chapter NR 152, "Model Ordinances for Construction Site Erosion Control and Storm Water Management," Chapter NR 153, "Runoff Management Grant Program," Chapter NR 154, "Best Management Practices, Technical Standards and Cost-Share Conditions," Chapter NR 155 "Urban Nonpoint Source Water Pollution Abatement and Storm Water Management Grant Program", and Chapter ATCP 50 "Soil and Water Resource Management."*

[6]*SEWRPC Community Assistance Planning Report No. 131,* A Park and Open Space Plan for Kenosha County, *November 1987, amended October 1999.*

of the Department of Public Works. As discussed previously, it is recommended that the Towns of Bristol and Salem, in coordination with the WDNR, Kenosha County, and the local units of government involved, develop a strategy to address nonpoint source pollution. State and Federal soil erosion control and water quality management programs, individually or in combination, can be used to achieve pollutant reduction goals. Such programs include the USDA Environmental Quality Incentive Program (EQIP), the WDNR 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 area tributary to George Lake include conservation tillage, integrated nutrient and pesticide management, and pasture management. Application of these practices within the George Lake drainage area has resulted in proven benefits to farm operators, documented by UWEX in Kenosha County.

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 25 percent reduction in total phosphorus loading to George Lake. Implementation of the recommendations and work planning activities set forth in the Kenosha County land and water resource management plan would constitute a major step toward implementation of these lake management recommendations.

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. Likewise, cost-share funding may be available under the Chapter NR 120 nonpoint source pollution abatement program, targeted runoff management grant program.

Urban Nonpoint Source Pollution Controls

The development of urban nonpoint source pollution abatement measures for the George Lake area should be the primary responsibility of the Town of Bristol, supported by the Town of Salem as necessary. 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 George Lake Rehabilitation District (GLRD), in cooperation with the Towns, take the lead in sponsoring such programming for the George Lake community through regular public informational meetings and mailings. The agency should also ensure that relevant literature, available through UWEX and the WDNR, is made available at these meetings and at the local Public Library and government offices.

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 George Lake be prepared and distributed to property owners. This fact sheet could be distributed by the Town of Bristol, with the assistance of UWEX and Kenosha County. The recommended measures may be expected to provide about a 25 percent reduction in urban nonpoint source pollution runoff and up to about a 1 percent reduction in total phosphorus loadings to the Lake.

Developing Areas and Construction Site Erosion Control

It is recommended that Kenosha County, and the Towns of Bristol and Salem continue efforts to control soil erosion attendant to construction activities in accordance with existing ordinances. As noted in Chapter III, the Towns of Bristol and Salem have adopted construction erosion control ordinances. Enforcement of the ordinances 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. In the Towns of Bristol and Salem, this function is performed by the municipal Building Inspection staff.

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 George 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 area to George 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.

Public Sewer System Management

The lakeshore areas and areas tributary to George Lake are served by public sanitary sewerage systems. It is recommended that the GLRD, in cooperation with the Town of Bristol, assume the lead in providing public informational and educational programs to encourage affected property owners to use their sewage systems appropriately and wisely. In an analogous recommendation, stenciling of storm drains and related informational programming encourages District residents to dispose of waste products safely, avoiding discharge directly to the surface waters or indirectly through the wastewater treatment works to the environment.

IN-LAKE MANAGEMENT MEASURES

The recommended in-lake management measures for George Lake are summarized in Table 32 and are graphically summarized on Map 20. The major recommendations include: water quality monitoring; fisheries management and habitat protection; nonpoint-source pollution abatement; shoreland and wetland protection; aquatic plant management; recreational use management, and informational and educational programming.

Surface Water Quality Management

Continued water quality monitoring of George Lake is recommended. Lake sampling protocol conducted under the current WDNR Self-Help regimen is recommended with various water quality parameters being measured several times a year at a central station in the deepest portion of the lake basin. It is also recommended that consideration be given to enrollment in programs such as the volunteer WDNR Self-Help expanded trophic status index (TSI) Self-Help Monitoring Program, the U.S. Geological Survey (USGS) lake monitoring program, or the University of Wisconsin-Stevens Point (UWSP) Water and Environmental Analysis Laboratory (WEAL) lake monitoring program.

Water Quantity and Lake Level Management

As indicated in Chapter II, outflow from George Lake is controlled by a dam located on the northeastern side of the Lake. Although Lake level is not a major concern among Lake users, it is worth noting that fluctuations in lake levels can present various problems. The placement of shore protection could be more or less effective depending upon the magnitude and frequency of variations in water levels. These variations also affect fish and aquatic life habitat availability, with extreme fluctuations potentially being disadvantageous to mollusks and other less mobile life forms.

Fisheries Management

A baseline fishery survey, consisting of mini fyke nets and electrofishing, is presently scheduled to be conducted by the WDNR in 2009 and should have the following objectives:

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

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.

This action could provide a sound basis for the GLRD 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.

Habitat Protection

The habitat protection measures recommended for George Lake are designed to provide for habitat protection by avoiding disturbances in fish breeding areas during spring and autumn, managing aquatic plants and maintaining stands of native aquatic plants. In particular, this recommendation extends to, and includes, any WDNR-delineated NR 107 sensitive areas that may be located in a lake, although at the time of the printing of this document there were no State designated sensitive areas in George Lake. In addition, it is recommended that environmentally sensitive lands, including wetlands along the lakeshore and in the tributary area be preserved. To this end, wetland setback requirements recommended in the Kenosha County land and water resource management plan should be adopted and enforced in the tributary area to George Lake.[7]

Shoreland Protection

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

In addition to the foregoing measures, it is also recommended that the Town of Bristol continues 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 recreational uses of George Lake. Integral to the aquatic plant management strategy is the protection and preservation of fish breeding habitat.

---

[7]*SEWRPC Community Assistance Planning Report No. 255,* op. cit.

In addition, this strategy recognizes the ecosystem values and functions provided within George Lake by a healthy and diverse aquatic plant community, and 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.

Alternative Methods for Aquatic Plant Control

Various aquatic plant management techniques—chemical, mechanical, biological and physical—are potentially applicable on George Lake. A number of these methods have been employed with varying success on George Lake in the past, although a combination of chemical control and mechanical harvesting has been the major method utilized throughout the Lake in recent years.

Chemical Controls

Chemical controls, in the form of herbicides and algicides, have been used as a means of aquatic plant control on George Lake, more so prior to acquisition of a mechanical harvester in 1993, although limited use of 2,4-D has occurred in complement to harvesting operations since 2002. As noted in Chapter V of this report, the aquatic herbicides diquat, endothal, sodium arsenite, and 2,4-D have been applied to George Lake to control aquatic macrophyte growth; copper sulfate compounds have been used to control swimmer's itch and algae. Diquat is a nonselective herbicide that will kill many aquatic plants, such as the pondweeds, bladderwort, and naiads 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 may kill high-value species such as water lilies, and fluridone also may affect coontail and elodea, although these risks are minimal when the herbicide is applied as recommended. In addition, in some lakes 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 a lake, damaging or destroying nontarget plant species that provide needed habitat for fish and other aquatic life.

Selective use of chemical control is a suitable technique for the control of infestations of Eurasian water milfoil and other nuisance species, especially in areas where other means are not practicable. 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. 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 and Mechanical Controls

Mechanical harvesting of aquatic plants has been the major means of controlling plant growth and associated filamentous algae on George Lake since the early 1990's. 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,[8] 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

---

[8]*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.*

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.

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 George Lake to control nearshore plant growths, especially around piers and docks.

Decomposing, floating vegetation can build up along the shorelines, and, together with terrestrial leaf litter, can limit the use of shoreline areas. Not only is this material unsightly and potentially foul smelling, but it also contributes to the organic and mucky substrates favored by invasive plant species, such as Eurasian water milfoil. Shoreline cleanup is a laborious job that can require substantial amounts of labor and time. To alleviate this problem, the GLRD in cooperation with shoreline property owners, could institute a comprehensive program of shoreline cleanup in parallel with harvesting operations to remove as much floating vegetation as possible.

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 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.

The George Lake community has consistently supported informational and educational programming within their community, have encouraged environmentally sound behaviors within the Lake, but have contributed to shoreland restoration efforts and lake monitoring as well. Thus, ongoing informational and educational programming is recommended.

Recommended Aquatic Plant Management Measures

It is recommended that continued aquatic macrophyte surveys be conducted at about five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of: major areas of nuisance plant growth; areas chemically treated and/or harvested; and in areas where harvesting is conducted, species harvested and amounts of plant material removed from the lake, and species and approximate numbers of fish caught in the harvest. In 2005, operating under a five-year permit issued in 2004, approximately 140 truckloads of Eurasian water milfoil, estimated at 1,555,000 pounds, were harvested from approximately 30 acres of George Lake. It is further recommended that a daily harvester log, containing this information, be maintained. This information, in conjunction with the conduct of the recommended aquatic macrophyte surveys, will allow evaluation of the effectiveness of the aquatic plant control program over time and allow adjustments to be made in the program to maximize its benefit.

To enhance the use of George Lake while maintaining the quality and diversity of the biological communities, the following recommendations are made:

1. Mechanical harvesting and the application of herbicides, subject to WDNR permitting, are recommended as the primary management methods. As indicated in Chapter V, this will, in the long-term, help to maintain good water quality conditions by managing aquatic plants which are currently contributing to an accumulation of decomposing vegetation and associated nutrient recycling.

2. Harvesting should be carried out by the George Lake Rehabilitation District using its existing harvester and transport equipment. It is recommended that shared-access channels be harvested to minimize the potential detrimental effects on the fish and invertebrate communities. Directing boat traffic through these common channels would help to delay the regrowth of vegetation in these areas.

3. Surface harvesting is recommended, cutting to a depth 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 George 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.

4. The use of chemical herbicides is recommended for controlling nuisance growths of nonnative species, especially 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 nonnative species, such as 2,4-D, early-season, low-dose endothall, or other permitted herbicide, should be used. Algicides, such as Cutrine Plus, are not recommended because there are few significant, recurring filamentous algal or planktonic algal problems in George Lake and valuable macroscopic algae, such as *Chara* and *Nitella* are killed by this product.

5. The control of nonnative 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 GLRD 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. While the manual removal of aquatic plants along a 30-feet width of shoreline is permitted pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, additional harvesting along the shoreline of a lakefront property requires an individual permit under Chapter NR 109.

6. The ongoing collection of aquatic plant fragments and other debris along shoreline areas is recommended.

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

8. It is further recommended that the GLRD conduct public informational programming on the types of aquatic plants in George 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, fisheries, and onsite sewage disposal systems.

9. Periodic monitoring of the aquatic plant community is recommended, especially for the early detection and control of future-designated nonnative species that may occur. Such control could be effected with the assistance of funds provided under the Chapter NR 198, aquatic invasive species control grant program, and should be undertaken as soon as possible once the presence of a nonnative, invasive species is observed and confirmed, reducing the risk of spread from waters where they are present and restoring native aquatic communities. Control of currently-designated invasive species, identified pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, using appropriate control measures,[9] is recommended throughout the Lake.

The recommended aquatic plant control areas are shown on Map 20. 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 a continuation of the current aquatic plant management program conducted by the GLRD. Cost-share funding may be available for the acquisition of replacement aquatic plant harvesting equipment under the Chapter NR 7 Recreational Boating Facilities Grant Program administered by the Wisconsin Waterways Commission.

OTHER LAKE MANAGEMENT MEASURES

Recreational Use Management

With respect to boating ordinances applicable to George 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 the exotic invasive species Eurasian water milfoil within George Lake. Appropriate signage should be placed at the public 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 entrance to all municipal public recreational boating access sites. In addition, it is recommended that disposal bins be made available at the public recreational boating access sites for disposal of plant materials and other refuse removed from watercraft using the public recreational boating access sites.

Public Informational and Educational Programs

It is recommended that the GLRD assumes the lead in the development of a public informational and educational program. Participation by the Town of Bristol should be encouraged. This program should deal with various lake management-related topics, including onsite sewage disposal system management, water quality management, land management, groundwater protection, aquatic plant management, fishery management, invasive species, 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 UWEX. These cover topics such as beneficial lawn care practices and household chemical use. Such brochures should be provided to homeowners through local media, direct distribution or targeted library and civic center displays. Such distribution can also be integrated into ongoing, larger-scale activities, such as lakeside litter collections, which can reinforce anti-littering campaigns, recycling drives, and similar environmental protection activities.

---

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

Given the extent of public interest in George Lake, it is recommended that the GLRD consider offering regular informational programs on the Lake and issues related thereto. Such programming can provide a mechanism to raise awareness of the Lake issues, and provide a focal point from which to distribute the informational materials referred to above.

The GLRD and the municipalities are also encouraged to take an active role in encouraging the local school districts 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.

PLAN IMPLEMENTATION AND COSTS

The actions recommended in this plan largely represent an extension of ongoing actions being carried out by the GLRD, the Town of Bristol, in part, in cooperation with neighboring municipalities, and county and state agencies. The recommended plan introduces few new elements, although some of the plan recommendations represent refinements of current programs. This is particularly true in the case of the fisheries and aquatic plant management programs, where the field surveys recommended in this plan will permit more efficient management of these resources.

Generally, aquatic plant and fisheries management practices and public awareness campaigns currently implemented by the GLRD and local municipalities, are recommended to continue with refinements as proposed herein. Some aspects of these programs lend themselves to citizen involvement through participation in the WDNR Self-Help Monitoring Program, and identification with environmentally sound owner-based land management activities. It is recommended that the GLRD, 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, Kenosha County, UWEX, and SEWRPC.

A major cost element in the plan relates to the eventual replacement of harvesting equipment. Implementation of the recommended plan would entail a capital expenditure of about $70,000 for the GLRD and an annual operation and maintenance expenditure of about $20,000, including existing expenditures, over the next 10 years. The current, annual operation and maintenance budgets of the GLRD for the harvester are appropriate to cover this level of future investment. When it is necessary to replace the existing 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 tributary area 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 32, and the estimated costs of these elements, linked to possible funding sources where such are available, are summarized in Table 33. In general, it is recommended that the GLRD continue to provide a coordinating role for community-based lake management actions, in cooperation with the appropriate local government units.

George 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 area tributary to the Lake and for water-based recreation on the Lake. Adoption and administration of an effective lake management program for George Lake, based upon the recommendations set forth herein, will provide the water quality protection needed to maintain conditions in George Lake suitable for recreational use and for fish and other aquatic life.

Table 33

ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR GEORGE LAKE

Plan Element	Management Measure	Estimated Cost 2000-2020[a] Capital	Estimated Cost 2000-2020[a] Annual Operation and Maintenance	Potential Funding Sources[b]
Land Use	Observe regional and county land use plan guidelines	- -	- -	County, Towns
	Density management in the shoreland zone	- -	- -	County, Towns
	Protection of environmentally sensitive lands and environmental corridors	- -	- -	WDNR Lake Protection Grant and Stewardship Grant Programs, GLRD
Pollution Abatement	Implement regional and county land and water resource management plans	- -[c]	- -[c]	County, USDA EQIP, WDNR/WDATCP Runoff Management Program
	Rural nonpoint source controls	- -[c]	- -[c]	County, 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]	Municipalities, county, private firms, individuals
	Stormwater management systems developed where appropriate densities exist	- -	- -	County, Towns
	Public sanitary sewer system management	- -	- -	County, Towns, local sanitary districts
	Onsite sewage system management	- -[c]	$100-$200[c]	County, Towns, local sanitary districts
Water Quality	Continue participation in WDNR Self-Help Water Quality Monitoring Program; consider participation in WDNR Expanded Self-help program, USGS monitoring program or University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program	- -	- -[d]	GLRD, USGS, WDNR
Aquatic Biota	Protect fish habitat	- -	- -	WDNR, GLRD, individuals
	Maintain shoreline and littoral zone fish habitat	- -	- -	County, GLRD, individuals, WDNR
	Continue stocking of selected game fish	- -	- -	WDNR
	Enforce size and catch limit regulations	- -	- -	WDNR
	Conduct periodic reconnaissance surveys of aquatic plant communities	- -	$1,500[e]	WDNR Lake Management Planning Grant Program, GLRD
	Update aquatic plant management plan every three to five years	- -	$1,500[e]	WDNR Lake Management Planning Grant Program, GLRD
	Provide and conduct programming on aquatic plants and various management measures	- -	- -	WDNR Lake Management Planning Grant Program, GLRD
	Use (limited) aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife	- -	$1,000/acre[g]	GLRD, individuals
	Mechanically harvest aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants	$303,000[f]	$160,000	WDNR Lake Management Planning Grant Program, GLRD

Table 33 (continued)

Plan Element	Management Measure	Estimated Cost 2000-2020[a] Capital	Estimated Cost 2000-2020[a] Annual Operation and Maintenance	Potential Funding Sources[b]
Aquatic Biota (continued)	Manually harvest aquatic plants from around docks and piers where feasible	$100	$100	GLRD, individuals
	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	- -	- -	GLRD, individuals
	Continue to monitor invasive species	- -	- -	GLRD, individuals
Water Use	Enforce regulations governing the operation of watercraft; improve signage and materials at public recreational access site to aid in the identification and control of exotic species	$500	$100	Towns, GLRD, WDNR
Ancillary Management Measures	Public informational and educational programming: seminars, programs, Project WET, Adopt-A-Lake	- -	$1,200	GLRD, UWEX/ WDNR/WAL Lakes Partnership, school districts
Total	- -	$303,600	$161,500	- -

[a] *All costs expressed in January 2002 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 Kenosha County, Towns are the Towns of Bristol and Salem, UWEX is the University of Wisconsin-Extension, and WAL is the Wisconsin Association of Lakes, GLRD is the George Lake Rehabilitation District.*

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

[d] *The WDNR Self-Help Monitoring Program 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] *Cost-share assistance may be available for lake management planning studies under the NR 190 Lake Management Planning Grant Program.*

[f] *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 $6,000 every four years.*

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

Source: SEWRPC.

(This page intentionally left blank)

APPENDICES

(This page intentionally left blank)

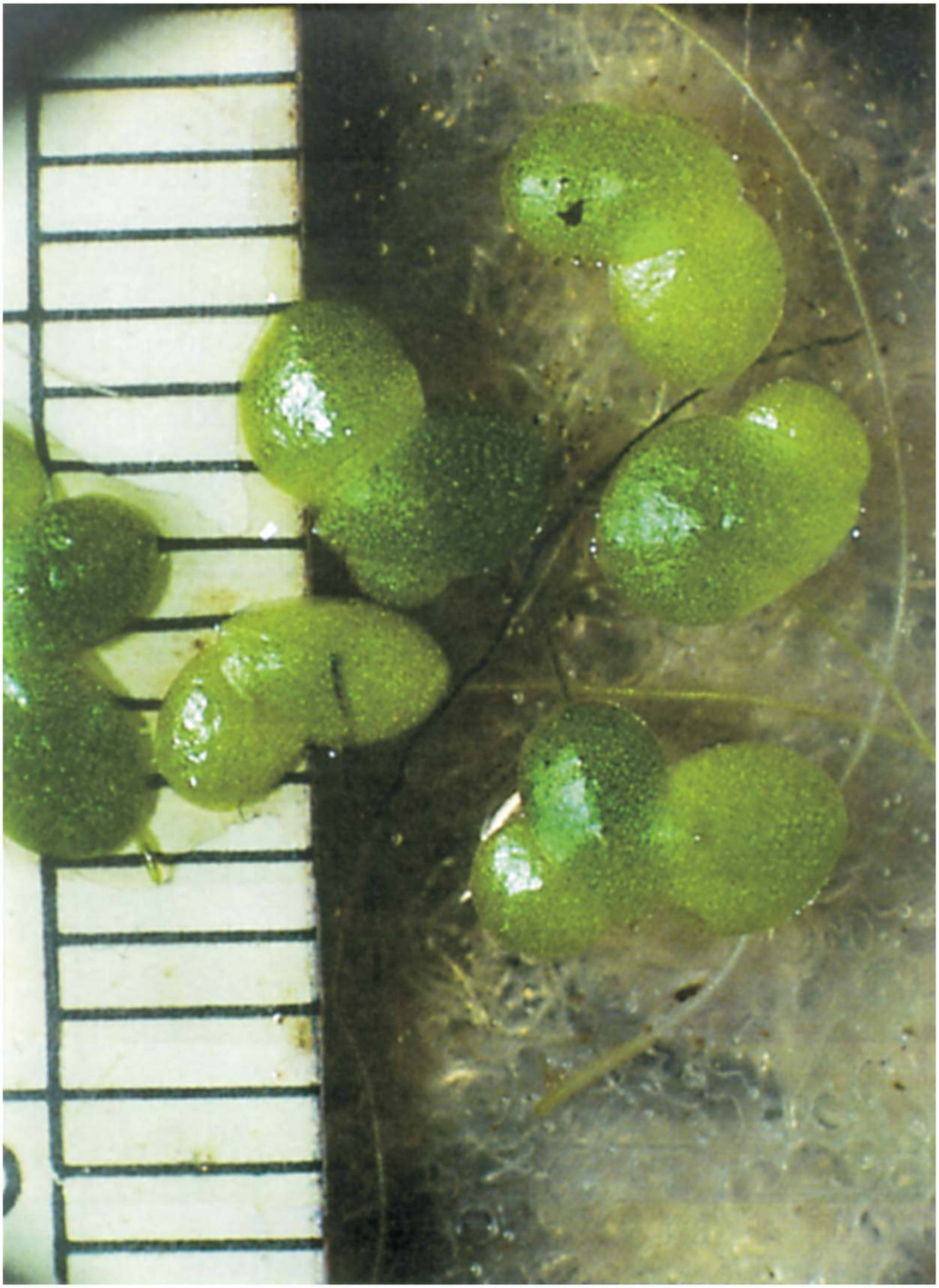
Appendix A

ILLUSTRATIONS OF COMMON AQUATIC PLANTS FOUND IN GEORGE LAKE

(This page intentionally left blank)

Coontail (*ceratophyllum demersum*)

Muskgrass (*chara vulgaris*)



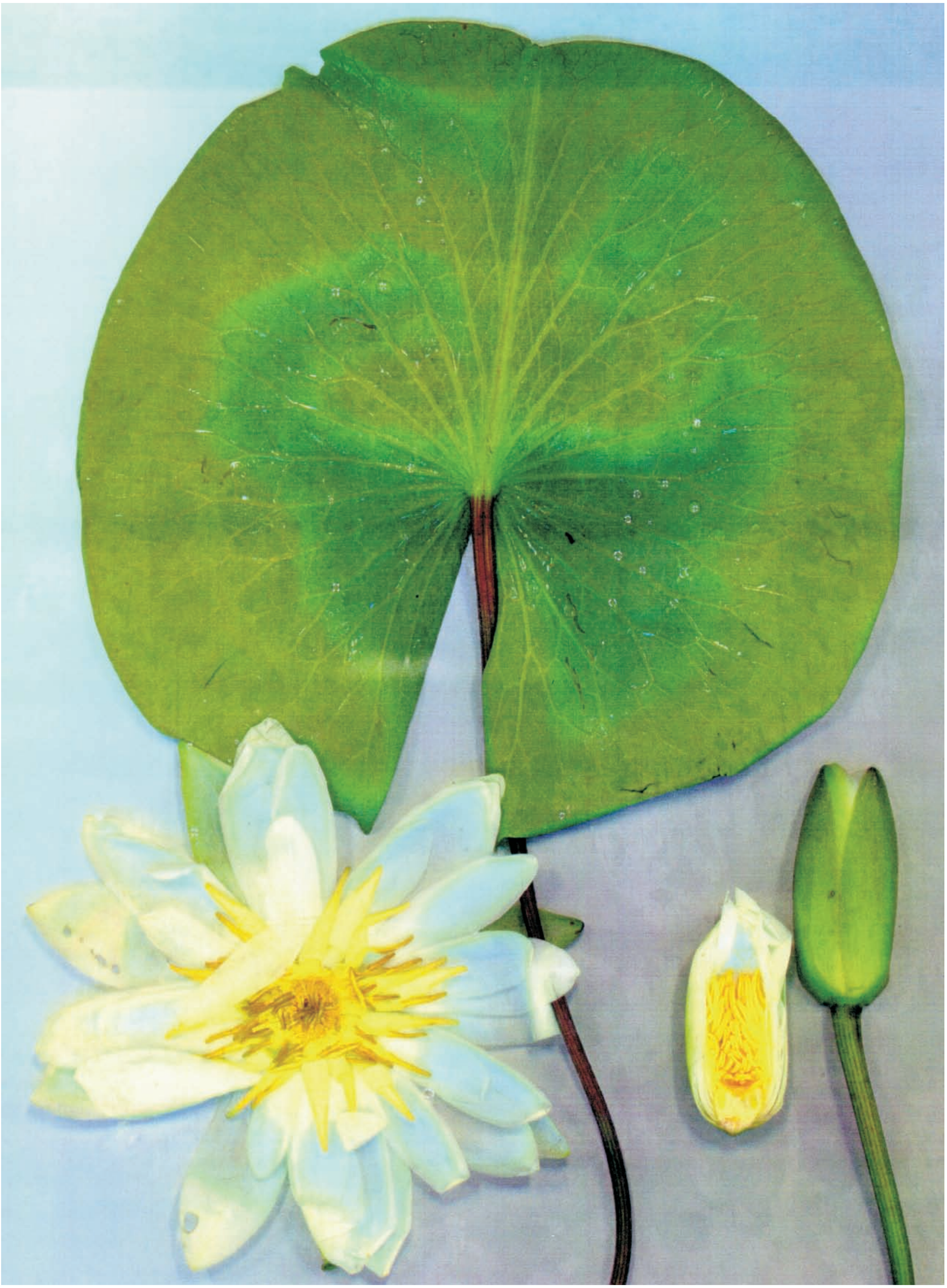
Lesser Duckweed (*lemna minor*)

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*

Eurasian Water Milfoil (*myriophyllum spicatum*)

Bushy Pondweed (*najas flexilis*)



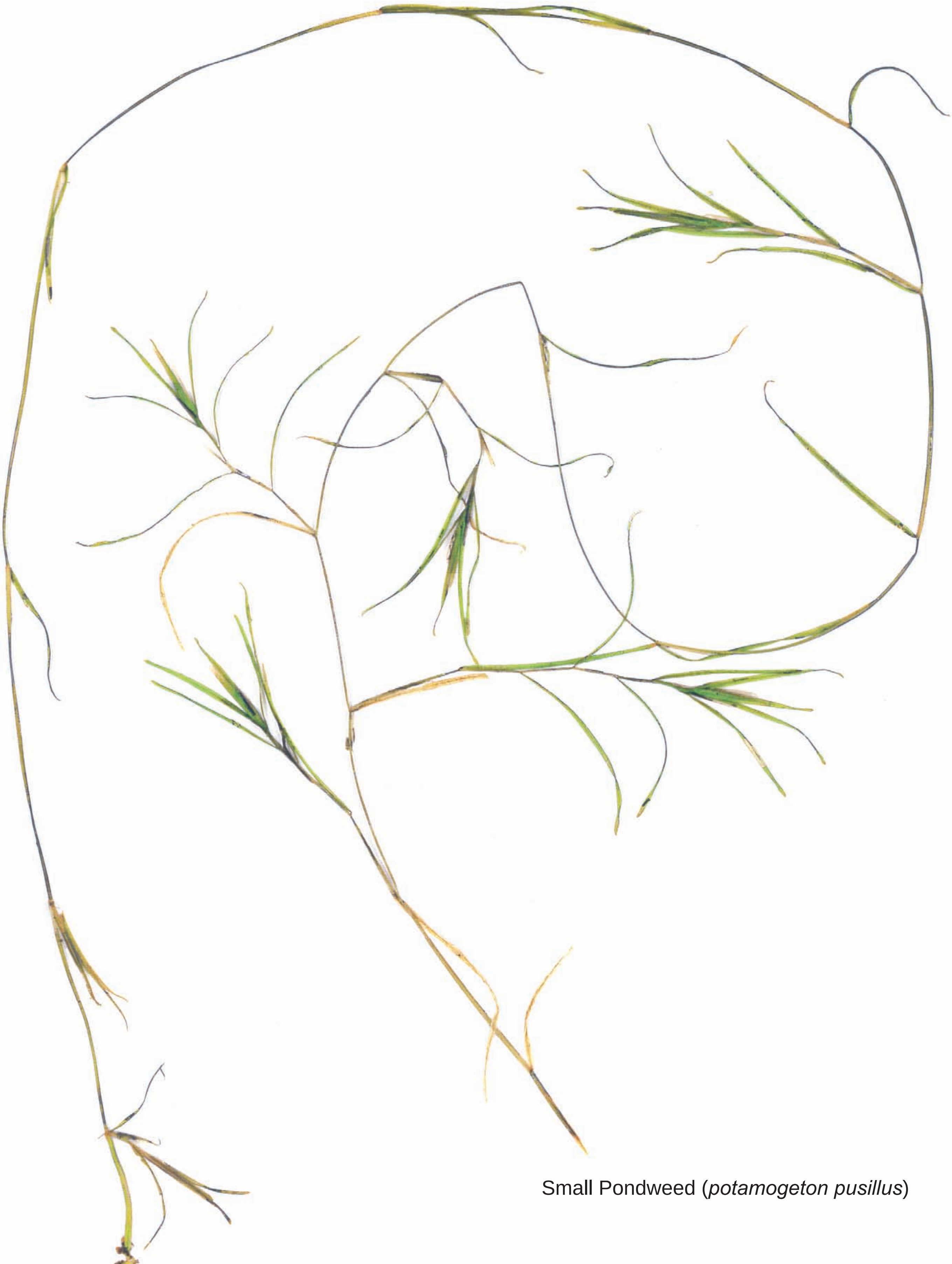
White Water Lily (*nymphaea odorata*)

Curly-Leaf Pondweed (*potamogeton crispus*)

Variable Pondweed (*potamogeton gramineus*)

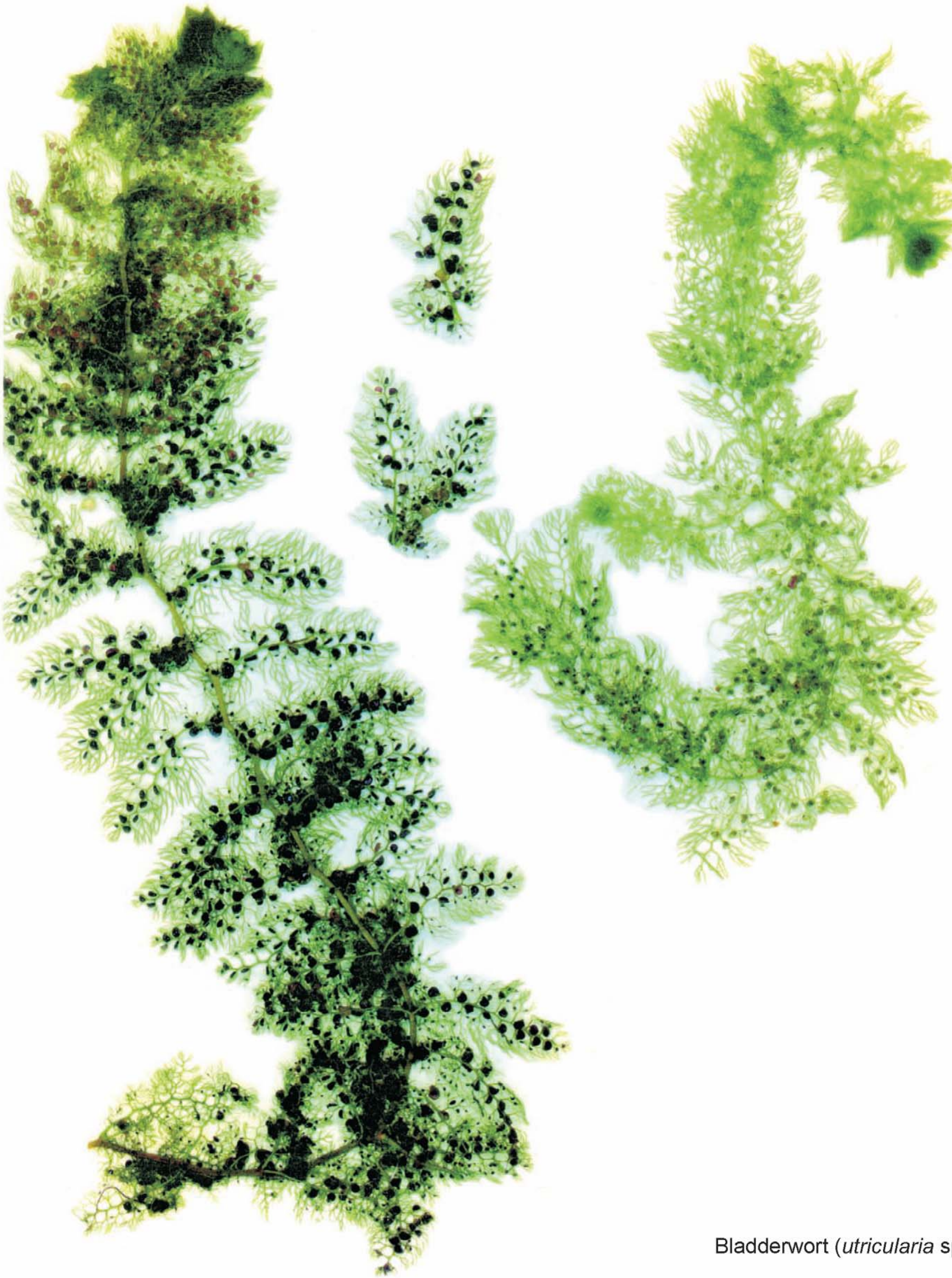
Illinois Pondweed (*potamogeton illinoensis*)

Sago Pondweed (*potamogeton pectinatus*)



Small Pondweed (*potamogeton pusillus*)

White Water Crowfoot (*ranunculus longirostris*)



Bladderwort (*utricularia* sp.)

(This page intentionally left blank)

Appendix B

BOATING ORDINANCE FOR GEORGE LAKE

(This page intentionally left blank)

I. GEORGE LAKE

6.01 GEORGE LAKE BOATING AND RECREATION REGULATIONS.

(a) Intent. The natural waters and adjacent beaches located in the Town of Bristol are valuable natural resources and those portions of such waters and beaches which are owned by the public are threatened by overuse and by misuse. This ordinance is intended to promote the health, safety and welfare of the public by placing reasonable regulations on the use of said waters and beaches to preserve their natural beauty and usefulness and to avoid conflicts of those members of the public enjoying said waters and beaches. This ordinance is intended to be consistent with Chapter 30 of the Wisconsin Statutes governing navigable waters harbors and navigation, and with all valid administrative rules of the Department of Natural Resources for the State of Wisconsin, and with all applicable zoning regulations of Kenosha County, to the end that all interest may enjoy the aquatic recreation consistent with public rights, interest and capability of the water resource.

(b) Applicability, Enforcement. The provisions of this ordinance shall apply to the waters of George Lake. The provision of this ordinance shall be enforced by law enforcement officers of the Town of Bristol, Kenosha County and State of Wisconsin.

(c) Patrol Boats. The provisions of this ordinance shall not apply to the operator of a duly authorized patrol boat when operated in the performance of duty, and sounding the required audible signal (siren) provided due regard is given to the safety of people in the vicinity.

6.02 STATE BOATING AND WATER SAFETY LAWS ADOPTED.

Sections 30.50 to 30.71, Wis. Stats., describing and defining regulations with respect to water traffic, boats, boating and related water activities and safety are hereby adopted by reference. In addition to the definitions incorporated from §30.50 to §30.71, Wis. Stats., the following definitions shall apply:

(a) "Shore zone" means all surface water within one hundred (100) feet of the shoreline.

(b) "Swimming zone" means an authorized area marked by regulatory markers to designate a swimming area.

(c) "Designated anchorage" means an area of water established and marked as an anchorage by lawful authority.

(d) "Public access" means any access to the water by means of public property.

(e) "Navigation lane" means an area designated by authorized aids to navigation.

(f) "Public boat ramp" means the gravel access ramp located on the north side of 106th Street approximately fourtenths (4/10) of a mile east of Highway 45.

6.03 ADDITIONAL REGULATION.

(a) Water Skiing Limited due to the shallow depth and limited acreage of George Lake (59 acres) with fully developed shoreline, fisherman and other recreational uses requiring slow moving boats, no person shall operate a motorboat towing a person on waterskis, aquaplane or similar device except during the hours of 12:00 noon until 6:00 p.m. daily.

(b) No person shall engage in waterskiing, aquaplaning or similar activity unless that person is wearing a Coast Guard approved Type 1, 2 or 3 personal flotation device.

6.04 SPEED RESTRICTIONS - SLOW-NO-WAKE.

No person shall operate a motorboat at a speed greater than slow-no-wake except during the hours of 12:00 noon until 6:00 p.m. daily.

6.05 SWIMMING.

(a) No person shall swim outside of the shore zone unless accompanied by a boat, attended by a competent observer.

(b) No person shall swim from any boat unless the boat is attended by a competent observer who is in the boat, and the swimmer shall stay within twenty-five (25) feet of the boat.

(c) The following described area is hereby declared the swimming area, and shall be buoyed accordingly. The north and south lines of the public beach at 101st Street extend into the water for a distance of two hundred (200) feet and the east and west lines of the public beach at 192nd Avenue extend into the water for a distance of two hundred (200) feet.

6.06 MOORING BUOYS, RAFTS AND PIERS.

(a) Mooring Buoys. The use of mooring buoys is prohibited.

(b) Swimming and Diving Rafts.

(1) No person shall place or maintain any raft or platform on George Lake more than one hundred (100) feet from the shoreline.

(2) Each raft shall have at least eighteen (18) inches above the water line and nor more than twelve (12) inches from each corner or projection attached thereto a red reflector of not less than three (3) inches in diameter.

(c) Piers.

(1) No person shall construct or maintain a pier or boat lift which extends more than fifty (50) feet from the shoreline nor shall any person maintain a swimming and diving raft more than one hundred (100) feet from the shoreline.

(d) Prohibited in Public Areas.

(1) No pier, swimming or diving raft shall be placed in waters of the extended boundaries of any street, fire lane or public park.

(e) Removal of Rafts and Piers.

(1) All piers, rafts or similar structures, and their supports, shall be removed from the waters on or before December 1, and remain out of the water until April 1 of the following year.

(2) In the event that such structures are not removed by December 1, the Town, after notice to the riparian owners, may remove the structure and the cost and expense of such removal shall be charged to the riparian owner. If such charges are not paid within thirty (30) days of the date of billing, a penalty of ten percent (10%) shall be added to such charges and the same shall constitute a lien on the property of the riparian owner and be inserted on the tax roll at the Town Office by the Town Clerk upon order by the Town Board.

6.07 MARKING ICE FISHING SHELTERS.

(a) No person shall place any ice fishing shanty, or similar structure, upon the ice of any lake, and leave it either unattended during hours of darkness, unless the shanty is marked with a bright orange reflectorized paint or tape at least three (3) inches wide, applied in a continued strip on all sides, no less than two (2) feet nor more than four (4) feet above the level of the ice.

6.08 LITTERING.

(a) No person shall place, throw or otherwise deposit any cans, bottles, debris, garage, refuse, waste, sewage or effluent into or on the waters, ice or shores of George Lake and any person who shall violate this section shall, upon conviction, pay the cost of removal in addition to any fine or forfeiture.

6.09 MOTOR VEHICLES ON THE ICE.

(a) No person shall operate any motor vehicle as (defined in Chapter 340.01, Wis. Stats.) on the ice of George Lake at any time, except that a vehicle equipped with snow plow may operate on the ice at their own risk for the purpose of snow plowing and such vehicle must be removed from the ice as soon as the vehicle has completed plowing the area.

6.10 PUBLIC BREACHES.

(a) There shall be two (2) public beaches on George Lake located at 101st Street, immediately north of 192nd Avenue, and the fire lane on 103rd Street. Said public beaches shall be closed at 10:00 p.m. each night and remain closed until sunrise of the following day.

(b) No person shall enter, or remain, on the property or the adjacent water area of a public beach during the period of time that the beach is closed.

(c) No person shall allow a pet to be on any public beach area at any time.

6.11 POWER LOADING.

No person shall engage in the act of powering a motorboat on or off a trailer at the Town boat launch site on Lake George with the engine being operated at a speed greater than idle speed. No person shall continue to operate the engine while engaged in the act of launching or retrieving a motorboat after the motorboat is at rest on the trailer. A sign shall be posted at the Town boat launch site advising of the requirements of this subsection as follows: "No driving onto trailers with motor operating above idle speed."

6.12 PENALTIES AND FORFEITURES.

(a) Any person convicted of violation of offenses listed in §6.01 through §6.11 and defined in §30.50 to §30.71, Wis. Stats., shall be subject to fines and forfeitures set forth in §30.80, Wis. Stats., with references to imprisonment deleted. Uniform deposit and bail schedule established by Wisconsin Judicial Conference shall be applicable to citations issued for violation of offenses adopted by this code and defined in §30.50 to §30.71, Wis. Stats.

(b) The penalties for violation of any other section of this ordinance shall, upon conviction, be subject to a fine or forfeiture of not less than Twenty-five ($25.00) Dollars or more than One Hundred ($100.00) Dollars for the first offense, and not less than Fifty ($50.00) Dollars or more than Two Hundred ($200.00) Dollars for a second offense within one (1) year of the first conviction. Deposits shall be as set forth in §3.06(j) of the Municipal Code of Bristol.

(This page intentionally left blank)

Appendix C

QUESTIONNAIRE SURVEY RESPONSES

The majority of respondents were year-round residents, which is what would be expected here in the southeastern Wisconsin. Most were long term residents. About one-half of respondents indicated that they used a number of other area lakes. Usually, responses to surveys of this nature suggest that folk stay pretty close to home when they live on a particular lake. Curiously, not all the lakes visited were “deep” lakes, which one might have expected given the limited depth of portions of George Lake; indeed, a majority of other lakes visited were smaller, shallow lakes in the Southeastern Wisconsin Region.

There is a somewhat higher percentage of anglers than has been found on many lakes. Most rate the fishing as fair. Panfish seem to be the favored fish, which is consistent with the rating of the fishery. From the improve/decline numbers, a majority of respondents suggested that the panfish population has increased, with a majority indicating that smallmouth bass and northern pike had declined. White sucker and yellow perch were fishes that most folk felt had remained the same over time. In terms of the other species caught, most were equally distributed between improve/decline responses, which would suggest that the fishery has remained somewhat constant. Curiously, the same spread is seen for carp, which would suggest that the carp problem is no worse, but no better. Slightly fewer respondents felt that the carp population had declined that has indicated that it had increased or has remained relatively constant over time.

Swimming was the favored active recreational pursuit, with bird watching being the favored passive recreational activity. Walking and picnicking were also highly favored passive recreational activities, while biking, fishing, hunting and cruising were additional favored active recreational activities. Nonmotorized watercraft were the dominant form of recreational watercraft, consistent with the indication that lake users favored less active uses of the lake. There was an indication that folk used the whole lake, although a large number of respondents did not indicate any location(s) on the map. Family activities were dominant. Lake use was rated as “light” during the week and “moderate” during the week end, by a majority of folk.

From a regulatory point of view, the plurality of folk were satisfied with law enforcement activity on the lake, although the majority of respondents indicated a range of levels of satisfaction from “not satisfied” through “no strong feeling” to “satisfied.” One respondent suggested that this was because there was very limited law enforcement presence on the Lake. In terms of stormwater regulations, folk were generally “satisfied” or had “no strong feeling.” Curiously, the plurality of respondents indicated strong dissatisfaction or dissatisfaction with zoning regulations and land use controls, citing concerns ranging from inappropriate county zoning to conversion of farmlands and too much development.

In terms of water quality, folk rated the lake as having poor water quality but good aesthetic qualities. The basis for their assessments were typically visual, with some consideration of olfactory and scientific indicators. Water clarity was a primary indicator, with a diverse aquatic flora and fauna being frequently mentioned as other indicators. These assessments were consistent with the indication that aquatic plants were a problem. There was good support for mechanical harvesting, restricted fertilizer use on the shoreline, and shoreline development controls. Dredging was the lake management measure preferred by the respondents. A plurality (about 40 percent) felt that the lake had deteriorated over time, but a large percentage (30 percent) felt that it had improved, which spread probably suggests that things have stayed the same.

The top five concerns reported by respondents were: 1) development around the lake, 2) numbers of water skiers/personal watercraft (PWCs)/waterfowl and wetland preservation, 3) shoreline erosion, 4) stormwater runoff, and 5) sedimentation. Power boating and waterskiing stood out as the activities to be restricted in certain areas; all watercraft activities were identified as activities to be restricted to certain hours, although comments provided suggested some disagreement amongst respondents regarding the nature of such restrictions, with some respondents wanting longer hours and other fewer hours for the pursuit of these activities.

Payment for improvements was fairly equally split between “yes” and “no” responses; no single activity for which folk would pay more was indicated, although several respondents mentioned aspects of aquatic plant management. The majority of folk (70 percent) felt that the District was doing a good job.

There were about 46 responses from a mailing of 224, or about a 20 percent response rate, which is considered good.

Appendix D

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 D-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 D-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 appendix.[1] These various individual nonpoint source control practices are summarized by group in Table D-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 D-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 D-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 D-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 D-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 in series 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 D-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 D-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.