COMMUNITY ASSISTANCE
PLANNING REPORT NO. 60
(2nd Edition)

A LAKE MANAGEMENT PLAN FOR GENEVA LAKE

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

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WALWORTH 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.

May 2008

$20.00

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Chapter I

INTRODUCTION

Geneva Lake,[1] is a 5,262-acre headwater lake located within U.S. Public Land Survey Township 2 North, Range 17 East, Town of Geneva; Township 1 North, Range 17 East, Town of Linn; and Township 1 North, Range 16 East, Town of Walworth, all in Walworth County.[2] The Lake offers a variety of water-based recreational opportunities and is the focus of the lake-oriented communities surrounding it. Proper management of the 18,307-acre tributary area to Geneva Lake will be required in order to maintain the Lake as a valuable recreational resource for the residents of the County and of the Region of which the County is an integral part.

The Geneva Lake community has a long history of efforts by the residents to protect and improve the Lake's utility. The very first lake organization in the State of Wisconsin was formed around Geneva Lake in 1898. Subsequently, other lake organizations were formed at Geneva Lake to manage lake levels and water quality as evidenced by the formation of such groups as the Geneva Lake Association in 1935, the Geneva Lake Level Corporation, the Geneva Lake Environmental Agency (GLEA) in 1971, and the Geneva Lake Conservancy in 1981.

The Lake has been the subject of numerous monitoring and planning studies involving various agencies and organizations including the U.S. Environmental Protection Agency (USEPA), the U.S. Geological Survey (USGS), the Wisconsin Department of Natural Resources (WDNR), the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and the GLEA. Previous studies related to lake water quality included participation in the WDNR Self-Help Monitoring Program and USGS Trophic State Index (TSI) monitoring program. The GLEA also historically participated in the WDNR Long-Term Trend monitoring program.

Initially, the Commission entered into a cooperative agreement with the GLEA during 1983 to prepare a water quality management plan for Geneva Lake. This study included the design and conduct of: a water quality sampling program to determine existing lake water quality conditions; inventories and analyses of pertinent tributary area characteristics affecting water quality conditions, including land use and management practices;

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[1]*The State of Wisconsin Geographic Names Council, pursuant to authorities granted under Section 23.25 of the* Wisconsin Statutes*, formally acted to confirm the official name of the Lake as Geneva Lake on May 22, 2003.*

[2]*In SEWRPC Planning Guide No. 5,* Floodland and Shoreland Development Guide*, 1969, the area of Geneva Lake was reported to be 5,262 acres, as measured from 1956 aerial photographs, which area is the lake surface area stated in the Wisconsin Department of Natural Resources inventory, published as Wisconsin Department of Natural Resources Publication No. PUB-FH-800 2005,* Wisconsin Lakes*, 2005. This surface area fluctuates with lake surface elevation and as a result of inter-annual variations in rainfall and runoff volumes. For example, based on 1980 aerial photographs, the area of Geneva Lake was estimated to be 5,425 acres. The difference in the two estimates is well within the limitations of the accuracy of the measurement techniques involved.*

identification of existing water uses; and, quantification and evaluation of sources of pollution. The GLEA collected data through 1985 and a final report, setting forth a recommended water quality management plan for Geneva Lake, was published in October 1985.[3]

Since that time, the location of Geneva Lake and its proximity to the greater metropolitan areas of Milwaukee and Chicago has contributed to a continued demand for more urban development in the vicinity of the Lake with concomitant demands for increased water-based recreational opportunities. As such urban growth is occurring in and around the City of Lake Geneva, the Villages of Fontana-on-Geneva Lake, Walworth, and Williams Bay, and the Towns of Geneva, Linn and Walworth, and their environs, the Geneva Lake community remains concerned about present and future impacts of continued urbanization within the lake tributary area on the Lake and its ecosystem. Because of the widespread and ongoing nature of these concerns, and given that the current lake management plan for Geneva Lake had reached its design lifespan, the GLEA requested the Regional Planning Commission to provide planning assistance in the development of a refined comprehensive lake management plan for the Lake.

Consequently, during 1997, a collaborative effort, involving the USGS, the WDNR, and the GLEA, was initiated to thoroughly describe the water quality of the Lake, as a prerequisite to the lake management planning process. Data from multiple water quality monitoring stations and from the analysis of surfacial sediment samples obtained from various areas of the Lake, together with historical water quality data and sediment core sample analyses, were used to determine the water quality of the Lake and assess the nature of the changes that have taken place in the Lake over the past 170 years. The results of these inventories and studies were published in 2002.[4]

These data and research investigations provide the background for the lake management planning program that has been implemented between 2002 and 2006. The resultant plan, which refines and extends the aforereferenced SEWRPC report, forms a logical complement to the 1985 report and documents the subsequent lake management actions that have been implemented in and around Geneva Lake, and represents an ongoing commitment by the GLEA to sound environmental planning.

This lake management plan was prepared by the Commission in cooperation with the GLEA, and other agencies, organizations and governmental units as appropriate. It incorporates the data and analyses developed in the aforementioned lake management-related studies. In addition, this plan also incorporates pertinent water quality and fishery data collected by the WDNR. This report presents feasible alternative in-lake measures for enhancing the water quality conditions and for providing opportunities for the safe and enjoyable use of the Lake. More specifically, this report discusses the physical, chemical, and biological characteristics of the Lake and the pertinent characteristics of its tributary area, as well as the feasibility of various water quality management alternatives which may enhance water quality conditions in the Lake. Specific management goals for Geneva Lake include achieving the recommended water quality standards in support of the objective of providing water quality suitable for maintaining a healthy fishery, and maintaining opportunities for water-based recreational activities. The recommended management plan for the Lake, presented herein, conforms to the requirements and standards set forth in the relevant *Wisconsin Administrative Codes*,[5] and, accordingly, should constitute a practical, as well as technically sound, guide for the management of Geneva Lake and its tributary basin.

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[3]*SEWRPC Community Assistance Planning Report No. 60,* A Water Quality Management Plan for Geneva Lake, Walworth County, Wisconsin, *October 1985.*

[4]*U.S. Geological Survey Water-Resources Investigations Report 02-4039,* Hydrology and Water Quality of Geneva Lake, Walworth County, Wisconsin, *2002.*

[5]*This plan has been prepared pursuant to the standards and requirements set forth in the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 103, "Water Quality Standards for Wetlands;" and 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 Geneva Lake, its tributary area, and on the climate and hydrology of the Geneva Lake tributary area. Subsequent chapters deal with the land use conditions, and the chemical and biological environments of the Lake.

WATERBODY CHARACTERISTICS

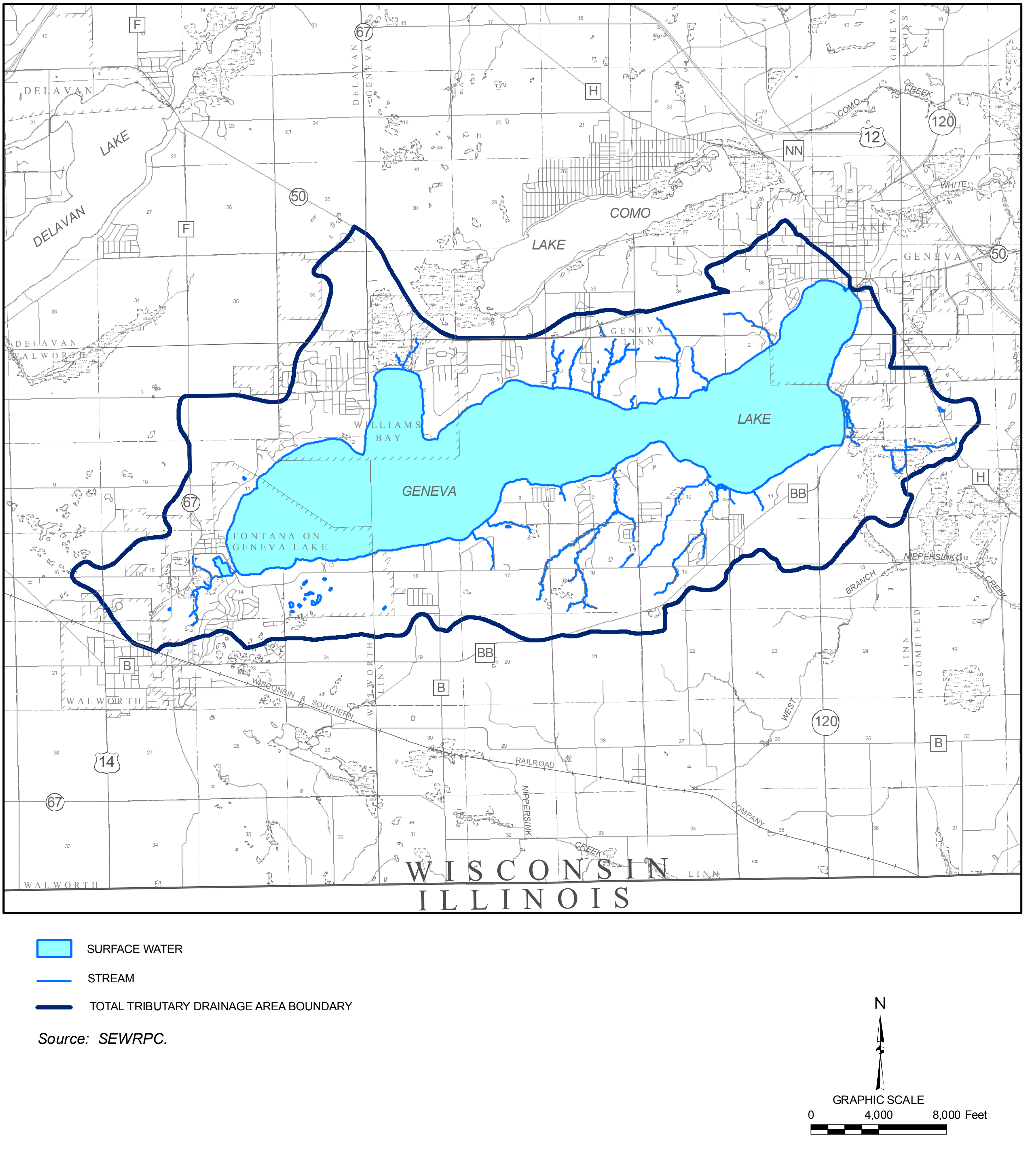
Geneva Lake is located in the City of Lake Geneva, the Villages of Fontana-on-Geneva Lake and Williams Bay, and Town of Walworth. The entire area tributary to Geneva Lake includes portions of the Towns of Bloomfield, Delavan, Geneva, Linn and Walworth; the City of Lake Geneva; and the Villages of Fontana-on-Geneva Lake, Walworth, and Williams Bay, as shown on Map 1. Geneva Lake is a headwater (or drained) lake which, although fed by numerous small tributary streams, depends principally on groundwater and rainfall onto the lake surface for its source of water. Geneva Lake, like all drained lakes, has an outlet, in this case the White River, which is a tributary stream system to the Illinois-Fox River system.

Geneva Lake lies in the pre-glacial Troy Valley, which originally drained to the southwest. During the later stages of the Wisconsin Glaciation, drainage to the southwest was blocked by the Delavan Glacial Lobe which created the Darien Moraine. This blocking of the original drainage, plus the increased elevation of the north and south slopes, raised the surface elevation of Geneva Lake to 14 feet above the elevation of neighboring Como Lake. The presence of an outwash terrace adjacent to the White River and the present depth of Geneva Lake suggest that an ice block broke off the receding glacier and that only this glacial fragment remained in the lake basin, thus limiting the volume of meltwater available for filling the Lake. Had the main body of the Delavan Lobe remained in the vicinity of the Lake, it is hypothesized that the Lake would have filled to a much higher elevation, and significantly increased lake depth.

As a result of the discharge of lake water through the hydrological feature now known as the White River, and the associated scouring of the river channel, the historic, post-glacial level of Geneva Lake dropped by approximately six feet by 1836, when the first dam was built on the White River at the lake outlet. This dam restored the lake depth to its historic level. Subsequent dam failures and reconstructions resulted in lake level fluctuations until 1894, when the Geneva Lake Level Corporation was established and the present dam and sluice gates were

Map 1

LOCATION MAP OF GENEVA LAKE



Source: SEWRPC.

constructed; a major upgrade of these 1894 structures was completed in 2002. The spillway crest was established at an elevation of 864.42 feet above the National Geodetic Vertical Datum of 1929 (NGVD-29).

Geneva Lake has a surface area of 5,262-acres, with a maximum depth of 140 feet and a mean depth of about 61 feet.[1] Approximately 11 percent of the lake area is less than 10 feet deep, 45 percent of the Lake has a water depth between 10 and 70 feet, and about 44 percent of the Lake has a water depth of more than 70 feet.[2] Geneva Lake is 7.6 miles long and 2.1 miles wide at its widest point. The major axis of the Lake lies in an east-west direction. The lake shoreline is 20.2 miles long, with a shoreline development factor of 2.03, indicating that the shoreline is about two times longer than a circular lake of the same area. The Lake has a total volume of approximately 320,948 acre-feet. The hydrographical and morphometric data is presented in Table 1 and the bathymetry of the Lake is shown on Map 2.

The shoreline of Geneva Lake is mostly developed for residential uses, with some scattered commercial uses comprised primarily of restaurants and businesses catering to lake users. As described in the initial report, the shorelands are comprised predominantly of: sand, 38.9 percent; rubble, 32.5 percent; gravel, 27.9 percent; and muck, 1.5 percent. The shoreland composition has been a major contributing factor to the historic good transparency of the water in Geneva Lake. Most of the developed shoreland of Geneva Lake has some form of shoreline protection. However, improperly installed and failing shoreline protection structures, and the erosion of natural shorelines on Geneva Lake, could be a limited cause for concern since 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 activity, ice movement, and motorized boat traffic. Few erosional areas were observed during the current study.

TRIBUTARY AREA CHARACTERISTICS

The area tributary to Geneva Lake—that is, the land area which drains directly into the Lake—totals about 18,307 acres, or about 28.6 square miles, in areal extent, as shown on Map 3. This area is coincident with the total area draining to the Lake. With a surface area of approximately 5,262 acres, or 8.2 square miles, the Lake has a very low watershed-to-lake surface area ratio of 2.5 to 1.0 and, consequently, has a relatively long residence time of 13.9 years. As mentioned, Geneva Lake is fed by direct precipitation, terrestrial springs, artesian wells, underwater springs, groundwater seepage, and numerous small perennial and intermittent streams. Numerous springs and artesian wells exist in the moraines surrounding the Lake, particularly along the southern and western shores,[3] and many of these are located within 100 feet of the Lake, as well as within the Lake itself. Groundwater flows are generally into the Lake from the north, west, and south, exiting the lake area to the east northeast.[4] The lake outlet is the White River, which flows approximately 20 miles in a northeasterly direction before joining the Fox River, a tributary of the Illinois River, at Burlington, Wisconsin.

Soil Types and Conditions

Land slope, vegetative cover, soil type and land use are important factors affecting the rate, amount and quality of stormwater runoff and, as such, are among the more important factors determining lake water quality. Land slopes

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[1]*Wisconsin Department of Natural Resources Publication No, PUB-FH-800 2005,* Wisconsin Lakes*, 2005.*

[2]*Wisconsin Department of Natural Resources Lake Use Report No. FX-1,* Lake Geneva, Walworth County, Wisconsin*, 1969.*

[3]*Wisconsin Geological and Natural History Survey Open-File Report No. 2006-02,* Groundwater Data Compilation for the Geneva Lake, Wisconsin, Area*, 2006. The authors note that the name of the Village of Fontana-on-Geneva Lake is derived from the Italian term for groundwater springs, or* fontana*, that testify to the prevalence of these features in the Geneva Lake area.*

[4]Ibid.

Table 1

HYDROLOGY AND MORPHOMETRY CHARACTERISTICS OF GENEVA LAKE

Parameter	Measurement
Size (total)	
Surface Area	5,262 acres
Total Tributary Area	18,307 acres
Volume	320,948 acre-feet
Residence Time[a]	13.9 years
Shape	
Maximum Length of Lake	7.6 miles
Length of Shoreline	20.2 miles
Maximum Width	2.1 miles
Shoreline Development Factor[b]	2.03
Depth	
Area of Lake Less than 10 Feet	11.0 percent
Area of Lake 10 to 70 Feet	45.0 percent
Area of Lake Greater than 70 Feet	44.0 percent
Mean Depth	61 feet
Maximum Depth	140 feet

NOTE: Minor differences between this and earlier reports concerning certain hydrologic and morphometric data are the result of refinements in the delineation of tributary area boundaries.

[a]*Residence Time: Time required for a volume equivalent to the full volume of the lake to enter the lake from the tributary area.*

[b]*Shoreline Development Factor: Ratio of shoreline length to that of a circular lake of the same area.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

are important determinants of stormwater runoff rates and of the susceptibility of soils to erosion, whereas vegetative cover can have a moderating effect on the erosivity of the runoff. Soil types, which are determined by soil texture and particle structure, influence the permeability, infiltration rate, and erodibility of soils and are discussed immediately below; land use is discussed in Chapter III of this report.

The major soil types present within the tributary area of Geneva Lake are: Casco silt loam, Calamus silt loam, Clyman silt loan, Dodge silt loam, Fox silt loam, Ehler silt loam, McHenry silt loam, Miami silt loam, Pistakee silt loam, Lapeer loam, Miami loam, and Houghton muck.

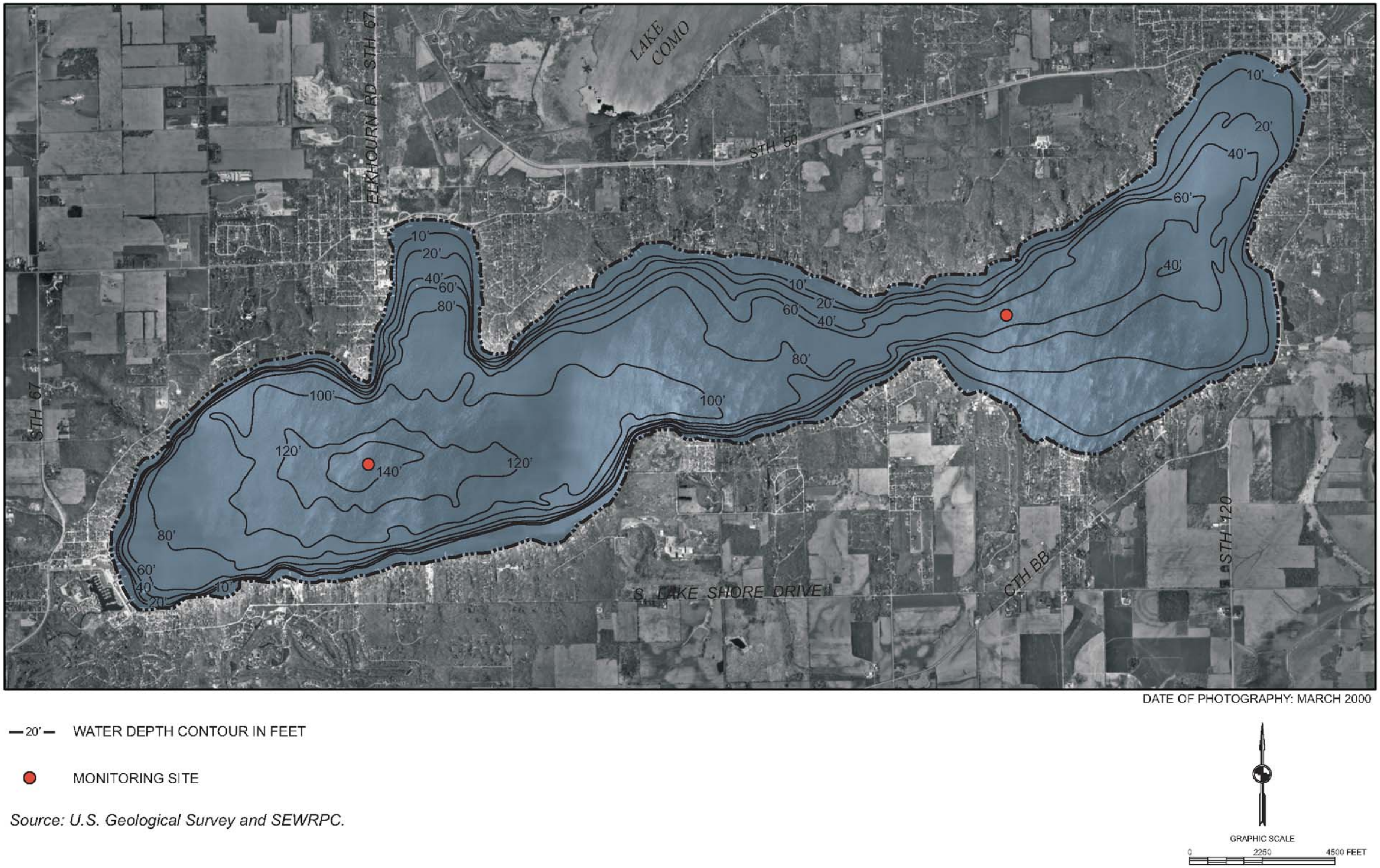
The U.S. Natural Resources Conservation Service (NRCS), formerly the U.S. Soil Conservation Service, under contract to the Southeastern Wisconsin Regional Planning Commission (SEWRPC), completed a detailed soil survey of the Geneva Lake area in 1966.[5] This soil survey contained interpretations for planning and engineering applications, as well as for agricultural applications. Using the regional soil survey, an assessment was made of hydrologic characteristics of the soils in the tributary area of Geneva Lake. Soils within the area tributary to Geneva Lake were categorized generally into four main hydrologic groups, as indicated in Table 2. Soils that could not be categorized were included in an "other" group. Well over one-half of the tributary area is covered by moderately drained soils, with the majority of the balance being covered by poorly drained and very poorly drained soils. The areal extent of these soils and their locations within the tributary area are shown on Map 4.

Although many homes in the Geneva Lake tributary area are serviced by public sewage systems, onsite sewage systems continue to be in use especially in homes located in areas away from shore. Data concerning the suitability of soils for onsite sewage systems and the interpretations associated with the soil survey are such that they continue to provide insights into the potential for land-based sources of pollution to affect the lake water quality either as a consequence of overland flows during storm events or through groundwater interflows into the Lake. These interpretations are based upon ratings that reflect 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 have effectively increased the area in which onsite sewage disposal systems may be utilized. Nevertheless, insofar as these ratings reflect the potential for the transport of contaminants into lakes through groundwater inflows, these assessments are presented herein as an index of the likelihood of groundwater-sourced contaminants entering Geneva Lake. The locations and suitability ratings of soils for conventional onsite sewage disposal systems, pursuant to the requirements of the pre-year 2000 Chapter

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

Map 2

BATHYMETRIC MAP OF GENEVA LAKE



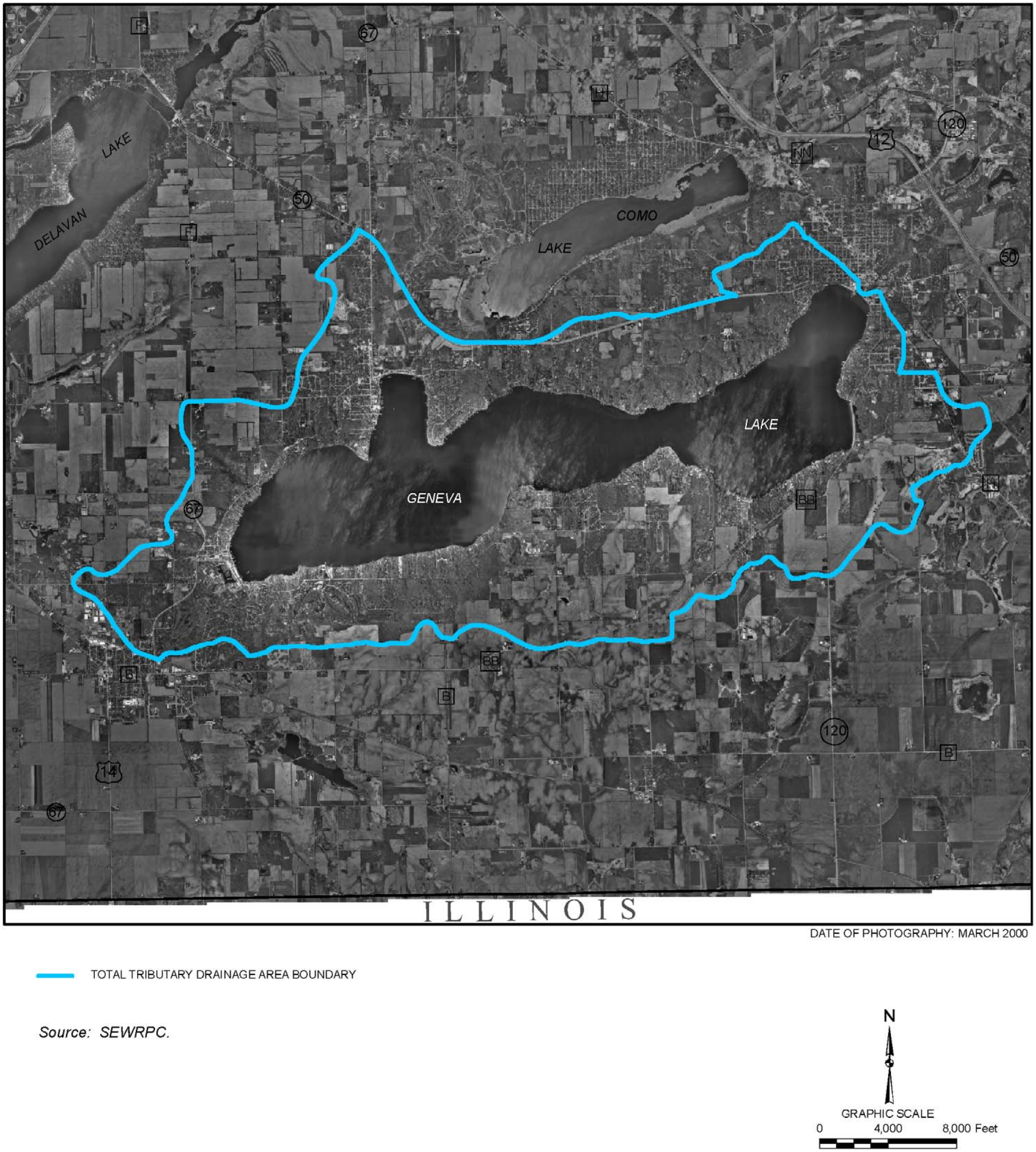
—20'— WATER DEPTH CONTOUR IN FEET

● MONITORING SITE

Source: U.S. Geological Survey and SEWRPC.

Map 3

TRIBUTARY AREA OF GENEVA LAKE



Source: SEWRPC.

Table 2

GENERAL HYDROLOGIC SOIL TYPES WITHIN THE AREA TRIBUTARY TO GENEVA LAKE

Group	Soil Characteristics	Direct Tributary Drainage Area (acres)	Percent of Land Total[a]
A	Well drained; very rapidly to rapid permeability; low shrink-swell potential	237	1.8
B	Moderately well drained; texture intermediate between coarse and fine; moderately rapid to moderate permeability; low to moderate shrink-swell potential	11,058	86.0
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	85	0.7
D	Very poorly drained; high water table for most of the year; organic or clay soils; clay soils having high shrink-swell potential	1,308	10.2
Other	Group not determined	164	1.3
Water	- -	5,455	- -
Total		18,307	100.0

[a]*Excludes water.*

Source: SEWRPC.

Comm 83 of the *Wisconsin Administrative Code*, are shown on Map 5. Based upon this analysis, it is useful to note that about one fifth of the lands within the area tributary to Geneva Lake are covered by soils that are categorized as having a potential sensitivity to disturbance and likelihood of being permeable to pollutants.

Land slopes within the area tributary to Geneva Lake range from less than 1 percent to greater than 20 percent, with the most steeply sloping lands being located along the western shorelands and in several confined locations along the north shore, as shown on Map 6. 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, more than half of the area tributary to Geneva Lake has slopes of less than 6 percent, while about one-fourth of the area has slopes of between 6 percent and 12 percent, as shown on Map 6. Only about 4 percent of the area tributary to Geneva Lake is considered to be steeply sloping, with slopes that exceed 20 percent.

Climate and Hydrology

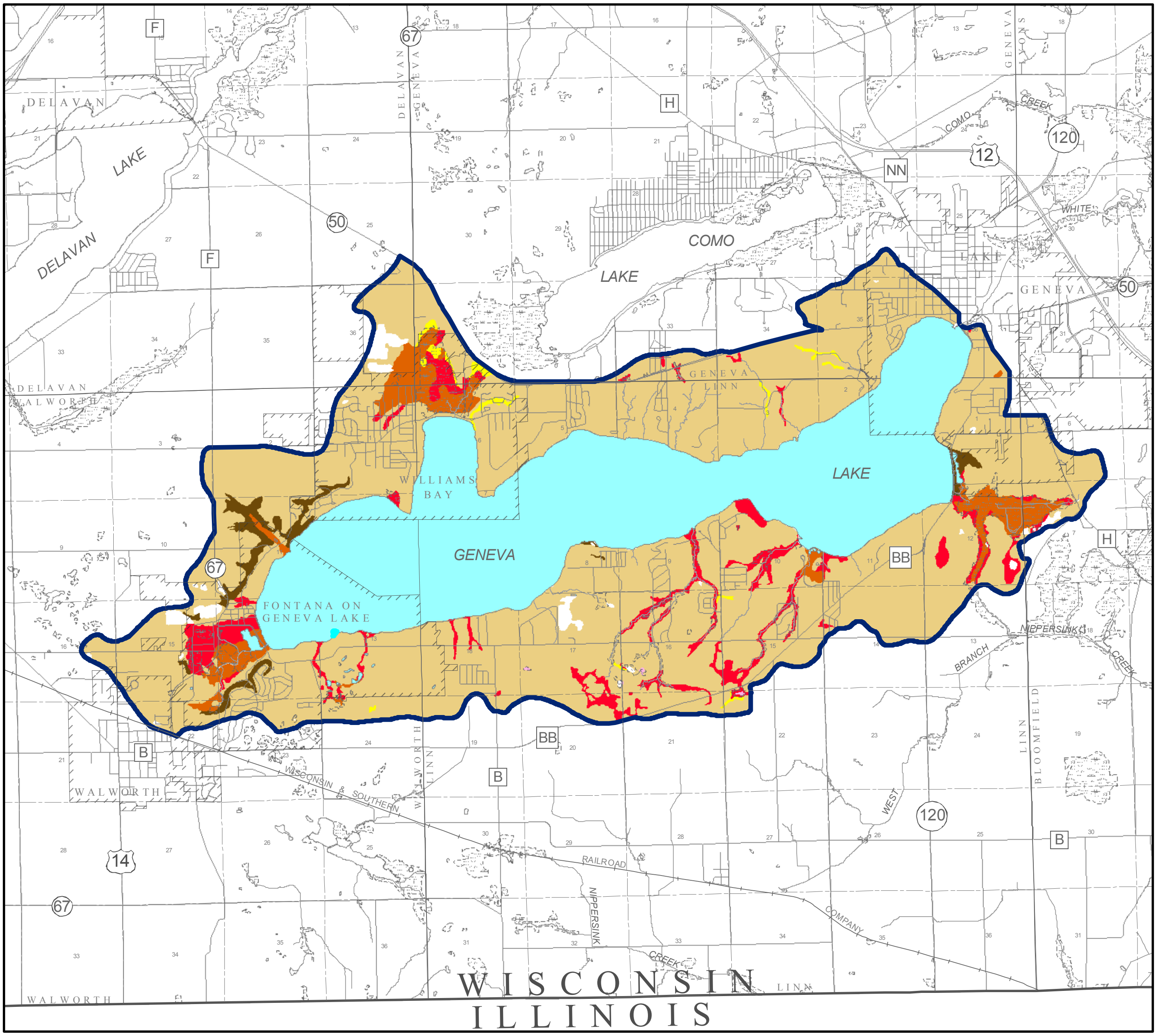
Long-term average monthly air temperature and precipitation values for the Geneva Lake area are set forth in Table 3. These averages were taken from official National Oceanic and Atmospheric Administration (NOAA) records for the weather recording station at Lake Geneva, Wisconsin. The records of this station may be considered typical of the lake area.

The mean annual temperature of 48.1°F at Lake Geneva is similar to that reported from other recording locations in southeastern Wisconsin. The 12-month period for calendar year 2001, as indicated in Table 3, was a period during which temperatures were generally above normal.

The mean annual precipitation at Lake Geneva is about 36.91 inches. Precipitation at Lake Geneva, during calendar year 2001, was about 39.24 inches, or about 6 percent above normal, with the greatest decrease from average, 2.07 inches, occurring during July, and the greatest increase above average, 3.12 inches, occurring during

Map 4

HYDROLOGIC SOIL GROUPS WITHIN THE AREA TRIBUTARY TO GENEVA LAKE



GROUP A: WELL-DRAINED SOIL

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

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

GROUP B: MODERATELY DRAINED SOIL

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

GROUP C: POORLY DRAINED SOIL

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

GROUP D: VERY POORLY DRAINED SOIL

SURFACE WATER

N

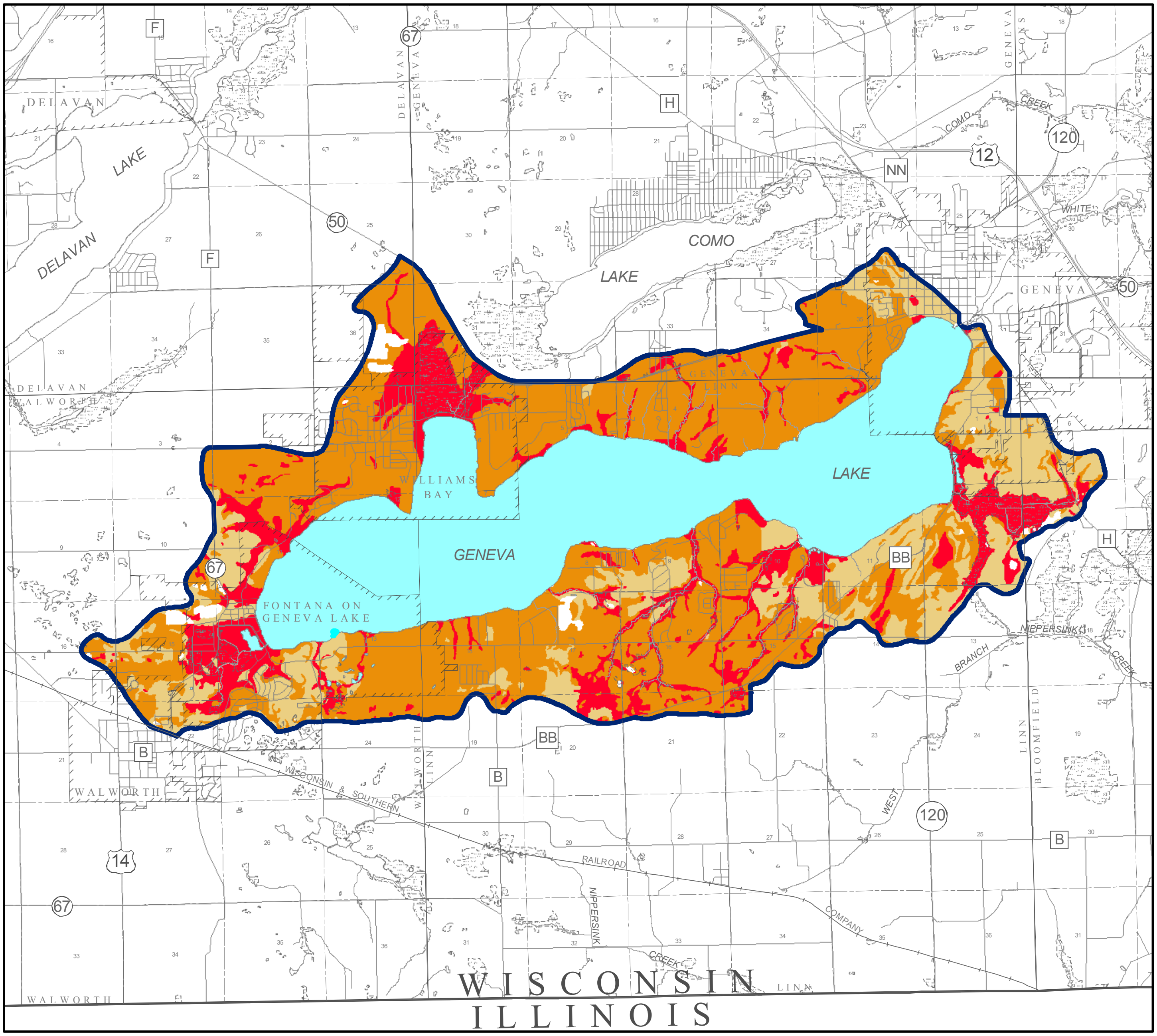
GRAPHIC SCALE

0 4,000 8,000 Feet

Source: Natural Resource Conservation Service and SEWRPC.

Map 5

GROUNDWATER CONTAMINATION POTENTIAL WITHIN THE AREA TRIBUTARY TO GENEVA LAKE



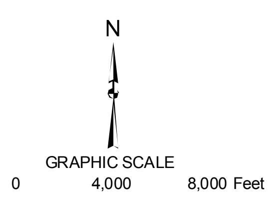
UNSUITABLE: Areas covered by soils which have a high probability of not meeting the June 2000 criteria of Chapter Comm 83 of the *Wisconsin Administrative Code* governing conventional onsite sewage disposal systems

UNDETERMINED: Areas covered by soils having a range of characteristics and or slopes which span the June 2000 criteria of Chapter Comm 83 of the *Wisconsin Administrative Code* governing conventional onsite sewage disposal systems so that no classification can be assigned

SUITABLE: Areas covered by soils having a high probability of meeting the June 2000 criteria of Chapter Comm 83 of the *Wisconsin Administrative Code* governing conventional onsite sewage disposal systems

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

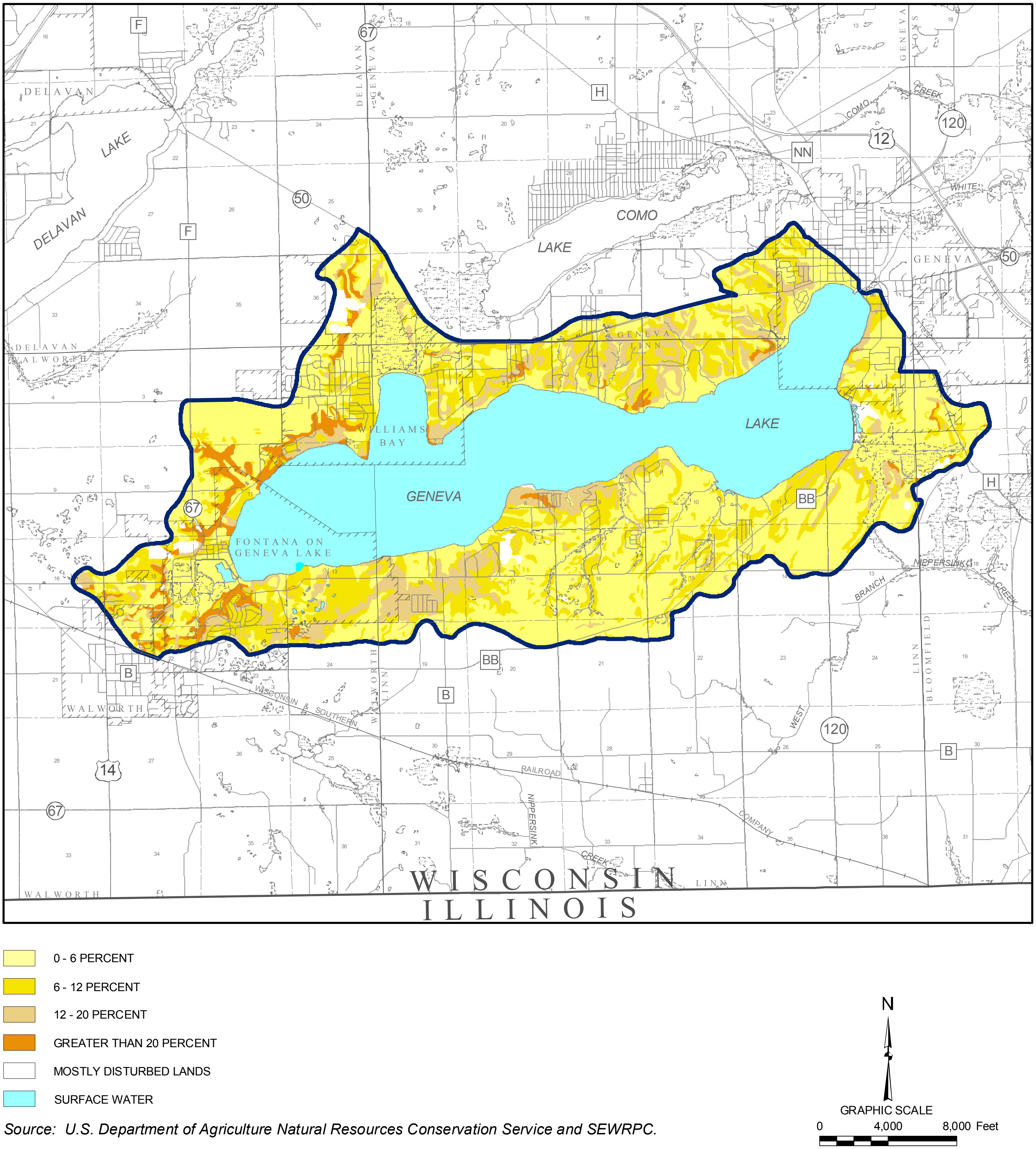
SURFACE WATER



Source: Natural Resources Conservation Service and SEWRPC.

Map 6

LAND SLOPES WITHIN THE AREA TRIBUTARY TO GENEVA LAKE



Source: U.S. Department of Agriculture Natural Resources Conservation Service and SEWRPC.

Table 3

LONG-TERM AND 2001 STUDY YEAR TEMPERATURE, PRECIPITATION, AND RUNOFF DATA FOR THE GENEVA LAKE AREA

Temperature													
Air Temperature Data (°F)	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Long-Term Mean Monthly	19.2	23.8	34.9	47.5	59.0	68.8	73.5	71.3	63.5	51.8	38.5	24.7	48.1
2001 Mean Monthly	23.4	23.3	33.4	52.4	60.4	68.2	75.6	73.8	62.3	52.1	48.3	33.7	50.6
Departure from Long-Term Mean	4.2	-0.5	-1.5	4.9	1.4	-0.6	2.1	2.5	-1.2	0.3	9.8	9.0	2.5

Precipitation														
Precipitation Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean	Total
Long-Term Mean Monthly	1.84	1.46	2.78	3.66	3.25	3.88	4.30	4.22	4.09	2.74	2.65	2.34	3.07	36.91
20-Year Average	1.79	1.38	2.08	3.08	4.37	4.23	2.96	3.40	3.40	2.34	2.89	1.42	2.78	33.34
2001 Mean Monthly	1.37	3.93	1.05	2.94	4.29	5.49	2.23	4.07	7.21	3.53	2.25	0.88	3.27	39.24
Departure from Long-Term Mean	-0.47	2.47	-1.73	-0.72	1.04	1.61	-2.07	0.15	3.12	0.79	-0.40	-1.46	0.21	2.33

Runoff													
Runoff Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Long-Term Mean Monthly	1.37	1.93	1.08	1.20	2.44	3.60	1.11	0.21	0.34	0.24	0.31	0.79	1.22
2001 Mean Monthly	2.04	2.28	2.48	0.44	1.31	2.93	0.43	0.43	1.03	0.76	0.83	1.47	1.37
Departure from Mean Monthly	0.67	0.35	1.40	-0.76	-1.13	-0.67	-0.68	0.22	0.69	0.52	0.52	0.68	0.15

NOTE: At time of press, data for water year 2004 was not yet available; data for water years 2002 and 2003 was incomplete.

Source: National Oceanic and Atmospheric Administration and U.S. Geological Survey; 20-year average precipitation from National Atmospheric Deposition Site WI99, Geneva Lake WI.

September. Six of the 12 months of the study period—February, May, June, August, September, and October—experienced above normal amounts of precipitation.

Table 3 also sets forth storm water runoff values derived from the U.S. Geological Survey (USGS) flow records for the White River gauging station located at Center Street in the City of Lake Geneva. Typically, more than half the normal yearly precipitation falls during the growing season, from May to September. Runoff rates are generally low during the last few months of this period (namely, in July, August and September), since evapotranspiration rates are high, vegetative cover is good, and soils are not frozen. As shown in Table 3, this pattern held true during the study year only for the month of July, whereas runoff rates in August and September were actually higher than normal, a pattern consistent with precipitation measurements during this same time period. Normally, about 20 percent of the summer precipitation is expressed as surface runoff, but intense summer storms occasionally produce higher runoff fractions. By contrast, approximately 45 percent of the annual precipitation occurs during the winter or early spring when the ground is frozen, and this may result in high surface runoff during those seasons.

Lake Stage

The water level of Geneva Lake is primarily determined by the dam located in the City of Lake Geneva at the outlet of the Lake to the White River. As described in the initial report, after prior dam failures and consequent lake level fluctuations, establishment, in 1894, of the Geneva Lake Level Corporation resulted in the construction

Table 4

COMPARISON OF WATER BUDGETS DEVELOPED FOR GENEVA LAKE

Year and Source	Water Input Percents			Water Output Percents		
	Precipitation	Surface Runoff	Groundwater	Evaporation	Outflow to White River	Groundwater
1985, SEWRPC	50	40	10	61	39	- -
1998, USGS.....................	48	44	8	43	57	- -
1999, USGS.....................	48	47	5	37	63	- -
Long-Term, SEWRPC......	50	43	7	40	60	- -

Source: U.S. Geological Survey and SEWRPC.

of the present dam and sluice gates with a spillway crest elevation of 864.42 feet above the National Geodetic Vertical Datum of 1929 (NGVD-29). This structure was extensively overhauled in 2002.

Water Budget

As shown in Table 4, water budgets for Geneva Lake have been developed as part of several studies since 1985. A water budget for Geneva Lake prepared for the earlier SEWRPC report estimated that water entering the Lake was comprised of 50 percent direct precipitation onto the lake surface, 40 percent surface runoff, and 10 percent groundwater inflow.[6] Of the water leaving the Lake, about 60 percent was the result of evaporation and about 40 percent was due to surface outflow to the White River.

The water budget computed from inflow and outflow data collected by USGS during 1998 and 1999 indicated that direct precipitation accounted for approximately 48 percent of the total input water to the Lake during both years.[7] Surface runoff accounted for about 44 percent of water flowing into the Lake in 1998 and about 47 percent in 1999; groundwater inflow made up about 8 percent of the input water in 1998 and about 5 percent in 1999. Of the total output water from the Lake, evaporation accounted for about 43 percent in 1998 and about 37 percent in 1999 of the water losses from the Lake; outflows to the White River accounted for about 57 percent in 1998 and about 63 percent in 1999.

For the current study, a long-term water budget was developed using data from the USGS and NOAA. This water budget estimates that, on a long-term basis, an average of about 32,187 acre-feet of water enters Lake Geneva each year. Over the long term, assuming that the lake level remains constant, the same volume of water leaves the Lake. Of the amount entering Lake Geneva on a long-term basis, about 50 percent comes from direct precipitation, 43 percent from surface runoff, and 7 percent from groundwater. The amount of water leaving Lake Geneva on a long-term basis is estimated to be comprised of 40 percent as a result of evaporation and 60 percent as a result of surface outflow to the White River. For the purposes of this study, it was assumed that no water was lost to ground water outflow. Data from this study is graphically shown in Figure 1.

As mentioned above, Geneva Lake has a relatively long hydraulic residence time of 13.9 years. The hydraulic residence time is important in determining the expected response time of a lake to increased or reduced nutrient and other pollutant loadings. Lakes having a long residence time typically respond slowly to changes in their tributary area since it takes a long time for a volume equivalent to the full volume of the lake to enter the lake from its tributary area.

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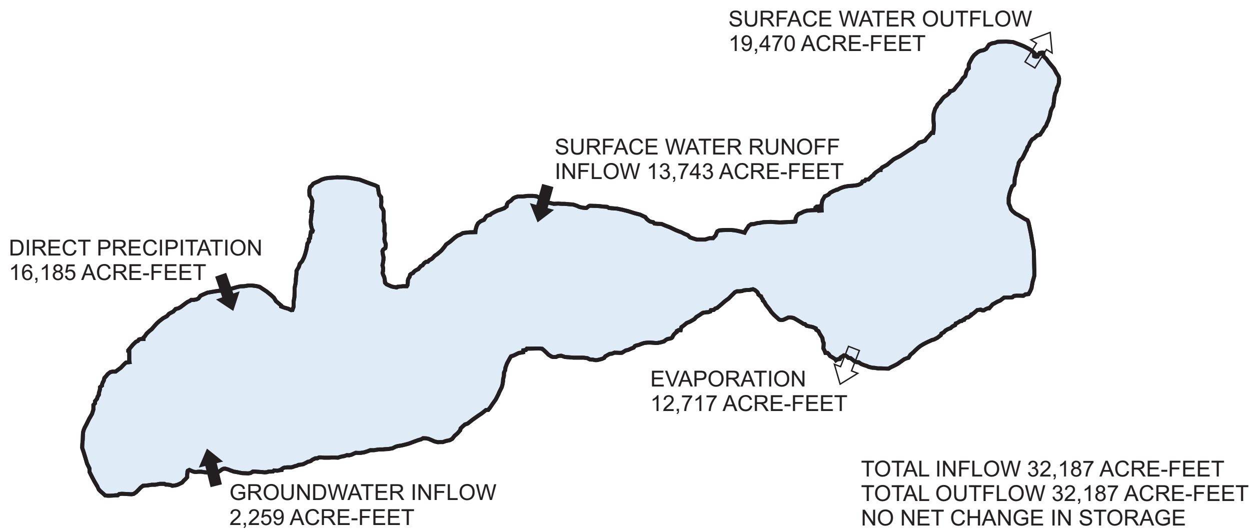
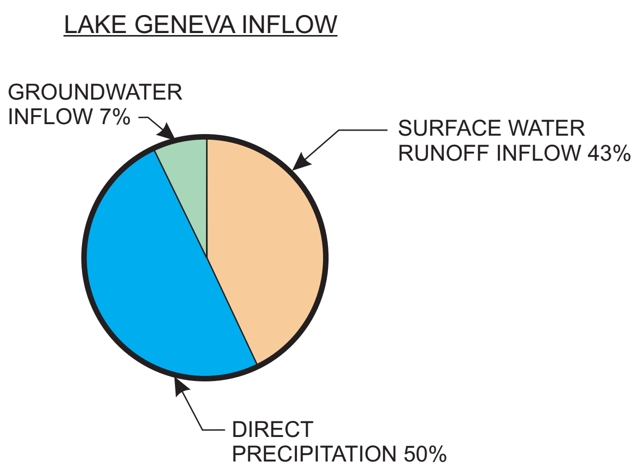
[6]*SEWRPC Community Assistance Planning Report No. 60,* A Water Quality Management Plan for Geneva Lake, Walworth County, Wisconsin, *October 1985.*

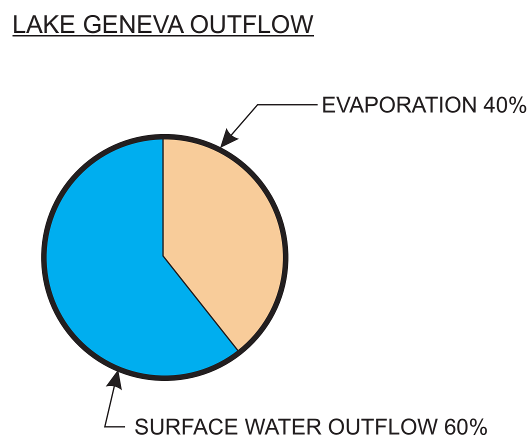
[7]*USGS Water-Resources Investigations Report 02-4039,* Hydrology and Water Quality of Geneva Lake, Walworth County, Wisconsin, *2002.*

Figure 1

LONG-TERM HYDROLOGIC BUDGET FOR GENEVA LAKE







Source: U.S. Geological Survey and SEWRPC.

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Chapter III

HISTORIC, EXISTING, AND FORECAST LAND USE AND POPULATION

INTRODUCTION

Water pollution problems, recreational use conflicts, and deterioration of the natural environment are all primarily a function of the human activities within the area tributary to a waterbody, as are the ultimate solutions to these problems. This is especially true with respect to lakes, which are highly susceptible to deterioration from human activities because of their relatively long pollutant retention times, and because of the variety of often conflicting uses to which lakes are subjected. Furthermore, urban development is often concentrated in the direct tributary areas, around the shorelines of lakes, where there are no intermediate stream segments to attenuate pollutant runoff and loadings. This type of lake degradation is more likely to interfere with desired water uses and is often more difficult and costly to correct than degradation arising from clearly identifiable point sources of pollution in the tributary area. Accordingly, the land uses and attendant population levels in the area directly tributary to a lake must be important considerations in any lake management planning effort. In the case of Geneva Lake, which is situated at the headwaters of a larger tributary system, the importance of nonpoint source pollutants in determining lake water quality and in influencing downstream water quality is paramount. For this reason, land usage and population distributions are summarized in this chapter, together with a review of jurisdictional issues relevant to water quality and lake management.

CIVIL DIVISIONS

The geographic extent and functional responsibilities of civil divisions and special-purpose units of government are important factors related to land use and management, since these local units of government provide the basic structure of the decision-making framework within which land use development and redevelopment must be addressed. Superimposed on the Geneva Lake tributary area are the local civil division boundaries shown on Map 7.

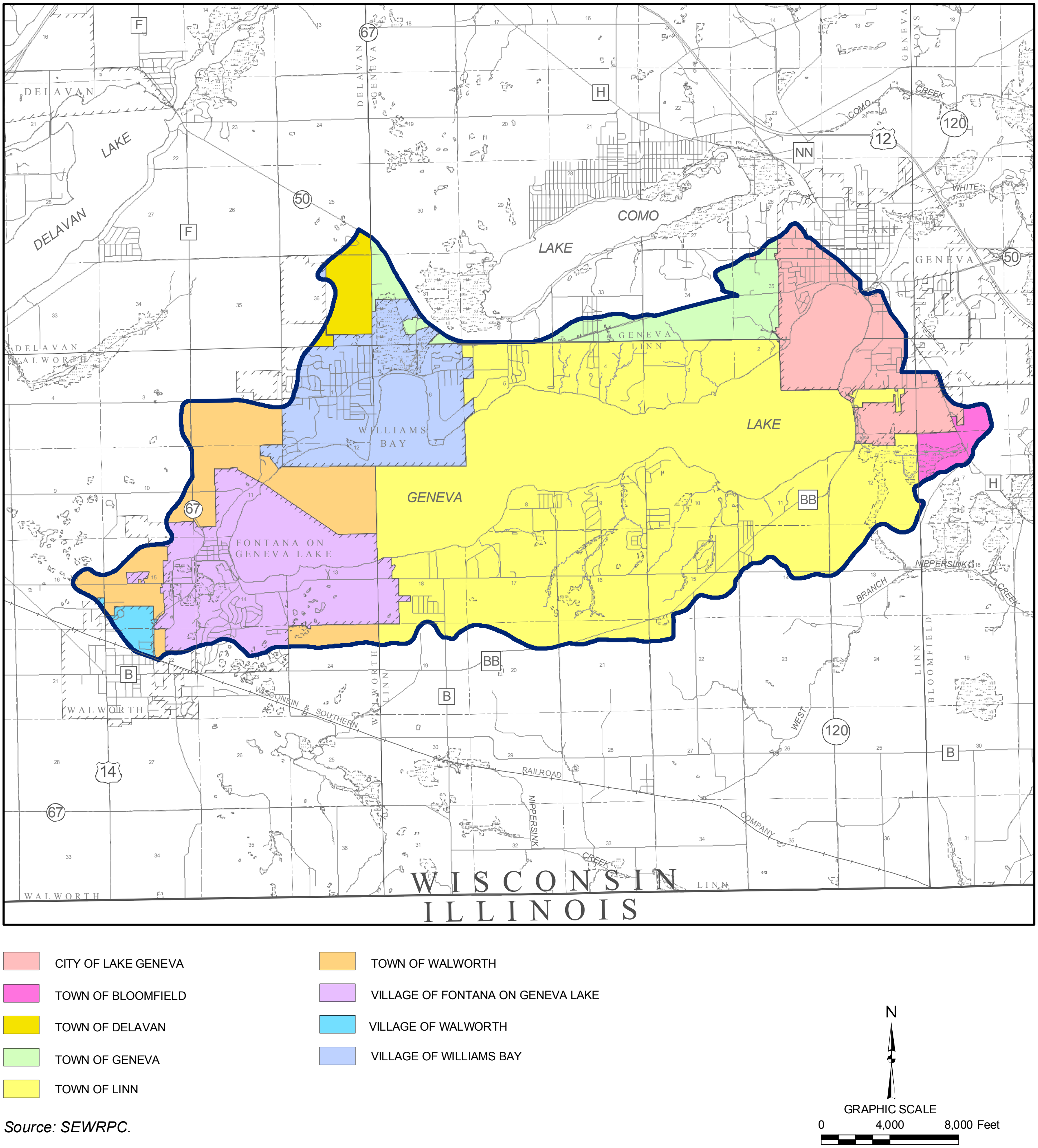
The area tributary to Geneva Lake includes portions of the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth; the Villages of Fontana-on-Geneva Lake, Walworth, and Williams Bay; and the City of Lake Geneva, all of which are located in Walworth County. The area and proportion of the tributary area lying within the jurisdiction of each civil division, as of January 1, 1985, are set forth in Table 5.

POPULATION

As indicated in Table 6, the resident population of the area tributary to Geneva Lake has increased greatly since 1963. In 1963, the resident population of the tributary area was 7,533 persons, which was more than two and a

Map 7

CIVIL DIVISION BOUNDARIES WITHIN THE AREA TRIBUTARY TO GENEVA LAKE: 2000



Source: SEWRPC.

Table 5

AREAL EXTENT OF CIVIL DIVISION BOUNDARIES WITHIN THE TOTAL TRIBUTARY AREA OF GENEVA LAKE

Civil Division	Civil Division Area within Total Tributary Area (acres)	Percent of Total Tributary Area within Civil Division
City of Lake Geneva	1,551	8
Town of Bloomfield	265	1
Town of Delavan	319	2
Town of Geneva	885	5
Town of Linn	9,447	52
Town of Walworth	1,569	9
Village of Fontana-on-Geneva Lake	2,299	12
Village of Walworth	132	1
Village of Williams Bay	1,840	10
Total	18,307	100

Source: SEWRPC.

Table 6

HISTORIC RESIDENT POPULATION AND HOUSEHOLD LEVELS WITHIN THE DRAINAGE AREA TRIBUTARY TO GENEVA LAKE: 1963-2000[a]

Year	Number of Residents	Number of Households
1963	7,533	2,256
1970	7,615	2,739
1980	8,668	3,368
1990	9,079	3,724
2000	10,698	4,492

[a]*Study area approximated using whole U.S. Public Land Survey one-quarter sections and U.S. Bureau of Census data.*

Source: SEWRPC.

half times the estimated 1950 population of 2,980. Population increases have been sporadic over the past 50 years. Following the rapid increase from 1950 to 1963, the 27 years after 1963 were witness to only a modest increase in population of about 1,600 persons. Then, during the next 10 years, from 1990 to 2000, the population advanced rapidly again, this time increasing by more than 1,600 persons in only one decade. Population growth may be expected to place a continued and increasing stress on the natural resource base of the Geneva Lake tributary area, and, as the populations of the Lake's tributary area, the County, and the Region continue to grow and change, 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 Geneva Lake are important determinants of lake water quality and recreational use demands. The current and planned land use patterns placed in the context of the historical development of the area are, therefore, important considerations in any lake management planning effort for Geneva Lake.

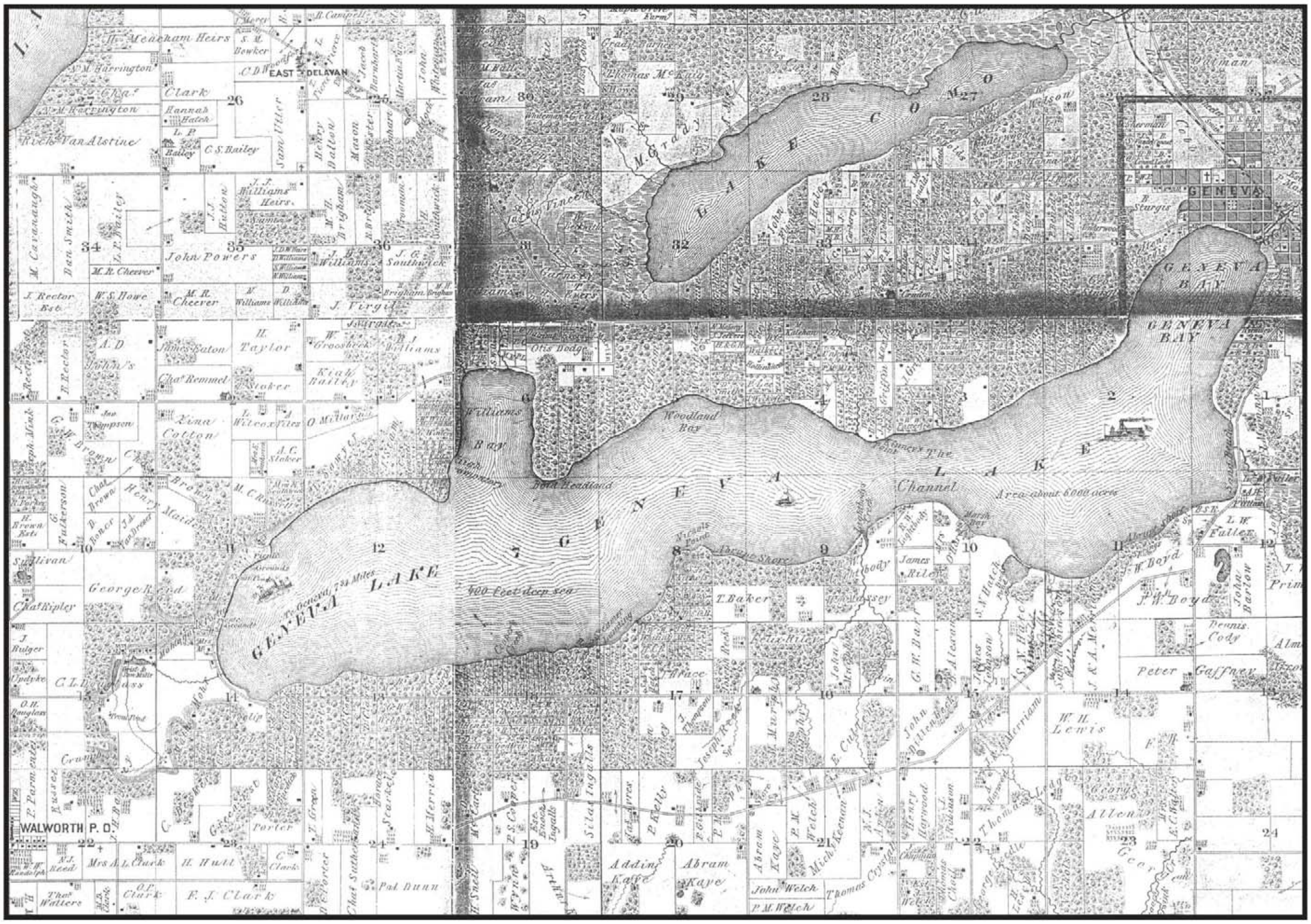
The movement of European settlers into the Southeastern Wisconsin Region began about 1830. Completion, within southeastern Wisconsin, of the U.S. Public Land Survey in 1836, and the subsequent sale of public lands in Wisconsin, brought a rapid influx of settlers into the area. Map 8 shows an 1873 plat of the U.S. Public Land Survey for the Geneva Lake area.

Significant urban development began to occur in the area tributary to Geneva Lake in the early 1900s. Table 7 and Map 9 indicate the historic urban growth patterns in the tributary area since 1850. The most significant urban development occurred from 1940 to 1963. During this period, almost 2,600 acres of the tributary area were converted from rural to urban land uses. Although the shoreline of the Lake is generally fully developed, the rate of urban development in the area tributary to Geneva Lake has continued to increase significantly in the last two decades, with much of this development occurring as redevelopment of large historic lakefront properties into smaller, more densely settled subdivisions.

The existing land use pattern in the Geneva Lake tributary area, as of 2000, is shown on Map 10 and is quantified in Table 8. As indicated in Table 8, as of 2000, about 5,124 acres, or 28 percent, of the area tributary to Geneva Lake were devoted to urban land uses. The dominant urban land use was residential, encompassing about 3,087 acres, or 60 percent of the area in urban use. As of 2000, about 13,183 acres, or 72 percent of the area tributary to

Map 8

HISTORIC PLAT MAP FOR THE GENEVA LAKE AREA: 1873



Source: Everts, Baskin, and Stewart, Chicago, Illinois.

Geneva Lake, were still devoted to rural land uses. About 4,529 acres, or about 34 percent of the rural area, were in agricultural land uses. Woodlands, wetlands, and surface waters, including the surface area of Geneva Lake, accounted for approximately 8,496 acres, or 64 percent, of the area in rural uses.

Under planned 2020 conditions, the trend toward more intense urban land usage is also expected to be reflected in the area tributary to the Lake.[1] As noted above, much of this development is expected to occur as agricultural lands are converted to urban lands, primarily for residential use, as shown on Map 11. However, some redevelopment of existing properties and the reconstruction of existing single-family homes may be expected, especially as the large lakeshore estates are converted to residential properties. By 2020, urban land uses within the area tributary to Geneva Lake are expected to increase in areal extent to about 6,738 acres, or about 37 percent of the area tributary to the Lake, as shown in Table 8. Urban residential uses are expected to increase from about

[1]*SEWRPC Planning Report No. 45,* A Regional Land Use Plan for southeastern Wisconsin: 2020, *December 1997; SEWRPC Community Assistance Planning Report No. 252,* A Land Use Plan for Walworth County, Wisconsin: 2020, *April 2001.*

Table 7

EXTENT OF URBAN GROWTH WITHIN THE AREA TRIBUTARY TO GENEVA LAKE: 1850-2000

Year	Direct Drainage Area	
	Extent of New Urban Development Occurring Since Previous Year (acres)[a]	Cumulative Extent of Urban Development (acres)[a]
1850	- -	- -
1880	48	48
1900	- -	- -
1920	331	379
1940	23	402
1950	1,478	1,880
1963	1,084	2,964
1970	205	3,169
1975	262	3,431
1980	250	3,681
1985	379	4,060
1990	366	4,426
1995	69	4,495
2000	60	4,555

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

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

3,087 acres, as of 2000, to about 3,983 acres in the year 2020. Agricultural lands in the tributary area, consequently, are expected to decrease in areal extent from about 4,529 acres, as of 2000, to about 2,976 acres in the year 2020.

Recent surveillance indicates that such changes in land usage appear to be due to large-lot residential development in the drainage area. If this trend continues, some of the open space areas remaining in the tributary 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]

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. Local zoning regulations include general, or comprehensive, zoning regulations and special-purpose regulations governing floodland and shoreland areas. General zoning and special-purpose zoning regulations may be adopted as a single ordinance or as separate ordinances; they may or may not be contained in the same document. Any analysis of locally proposed land uses must take into consideration the provisions of both general and special-purpose zoning. As already noted, the area tributary to Geneva Lake includes portions of the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth; the City of Lake Geneva; and the Villages of Fontana-on-Geneva Lake, Walworth, and Williams Bay. The ordinances administered by these units of government are summarized in Table 9.

General Zoning

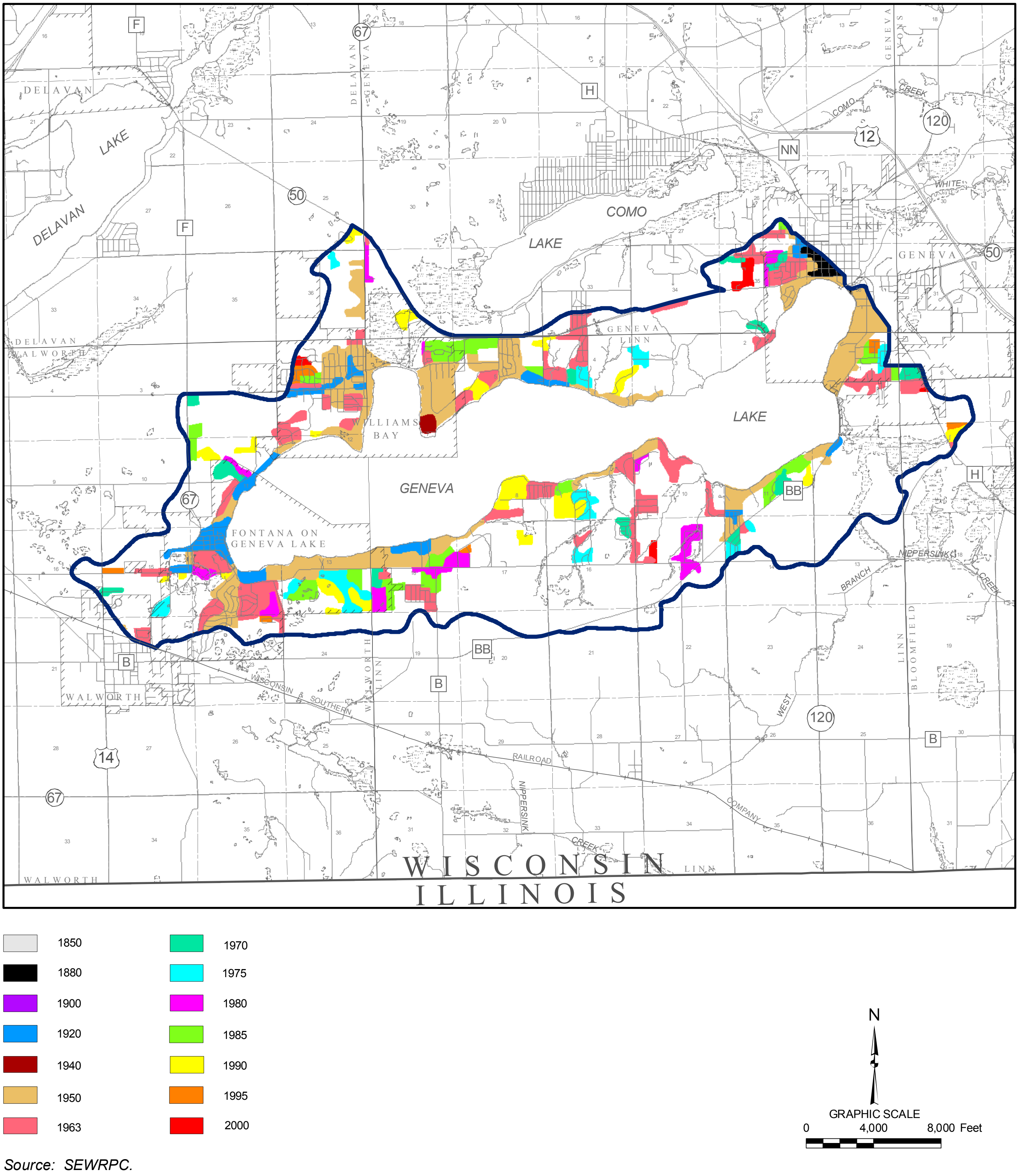
Cities in Wisconsin are granted comprehensive, or general, zoning powers under Section 62.23 of the *Wisconsin Statutes*. The same powers are granted to villages under Section 61.35, *Wisconsin Statutes*. Counties are granted general zoning powers within their unincorporated areas under Section 59.69 of the *Statutes*. However, a county zoning ordinance becomes effective only in those towns that ratify the county ordinance. 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.

General zoning is in effect in all communities in Walworth County. All five towns within the area tributary to Geneva Lake have adopted general county zoning ordinances.

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

Map 9

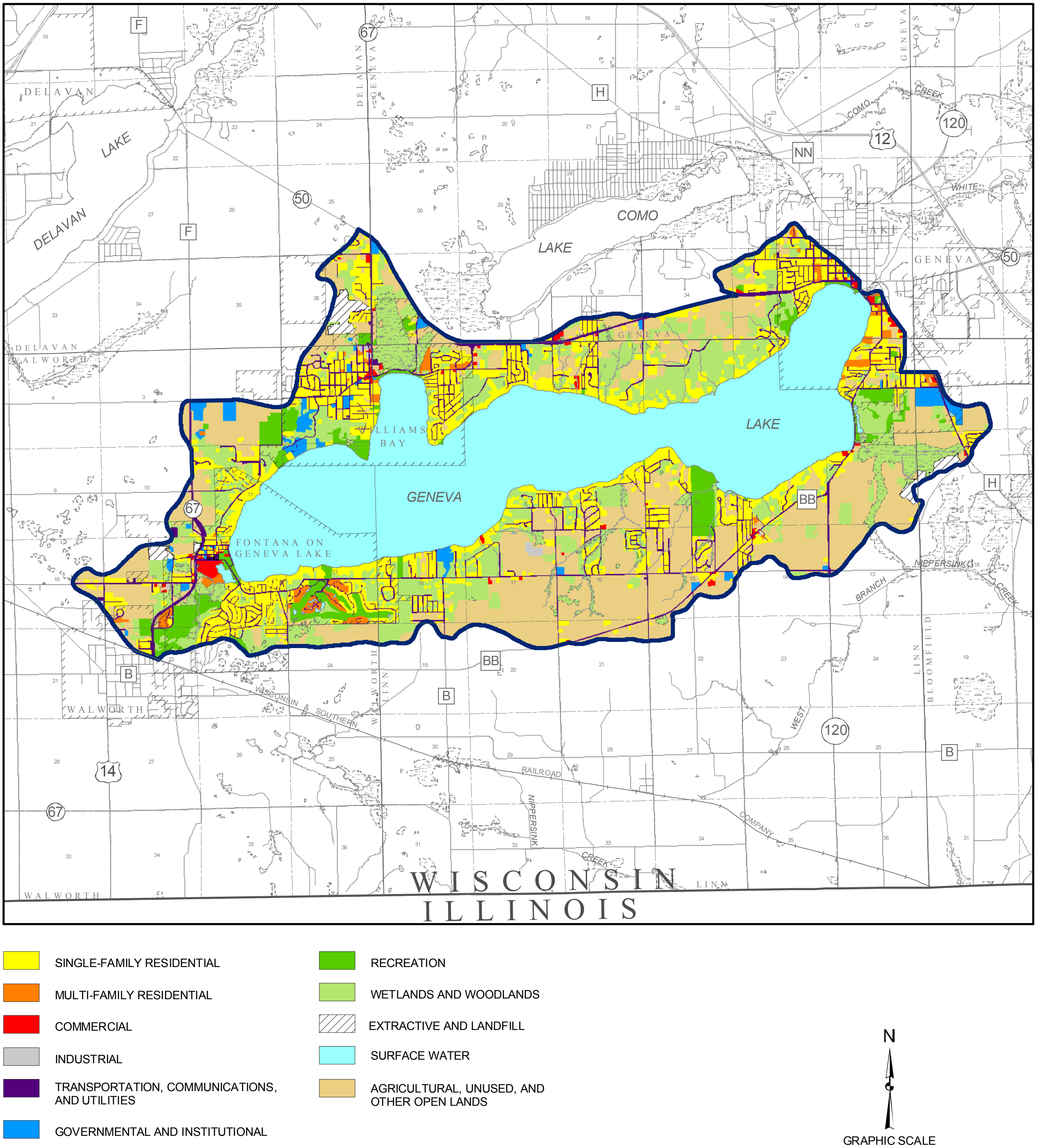
HISTORIC URBAN GROWTH WITHIN THE AREA TRIBUTARY TO GENEVA LAKE



Source: SEWRPC.

Map 10

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



Source: SEWRPC.

Table 8

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

Land Use Categories[a]	2000 Acres	2000 Percent of Direct Tributary Drainage Area	2020 Acres	2020 Percent of Direct Tributary Drainage Area
Urban				
Residential	3,087	16.9	3,983	21.7
Commercial	106	0.6	138	0.8
Industrial	26	0.1	61	0.3
Governmental and Institutional	227	1.2	484	2.6
Transportation, Communication, and Utilities	988	5.4	1,238	6.8
Recreation	690	3.8	834	4.6
Subtotal	5,124	28.0	6,738	36.8
Rural				
Agricultural	4,529	24.7	2,976	16.3
Wetlands	590	3.2	590	3.2
Woodlands	2,456	13.4	2,459	13.4
Water	5,450	29.8	5,450	29.8
Extractive	158	0.9	94	0.5
Subtotal	13,183	72.0	11,569	63.2
Total	18,307	100.0	18,307	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

Floodland Zoning

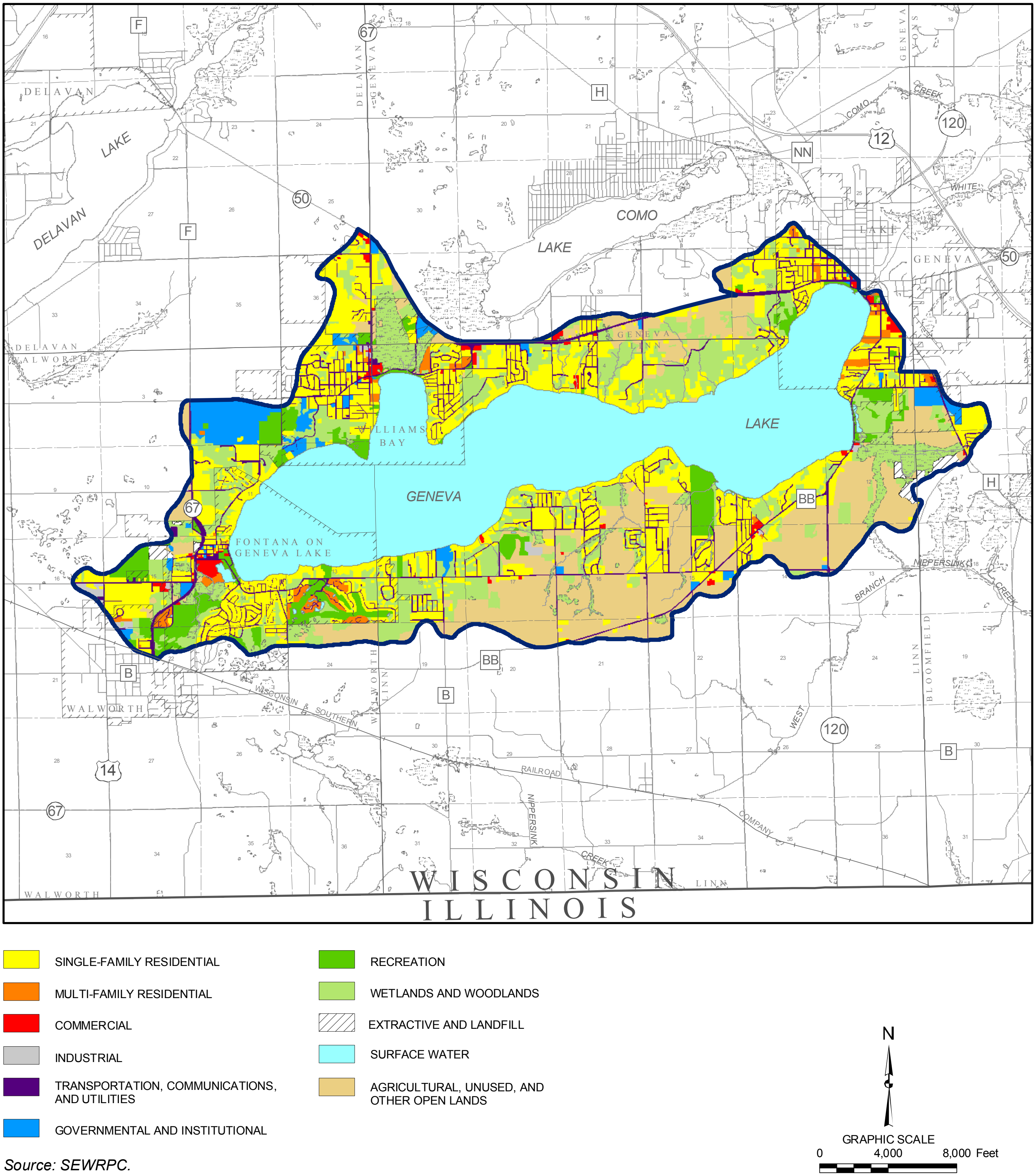
Section 87.30 of the *Wisconsin Statutes* requires that cities, villages, and counties, with respect to their unincorporated areas, adopt floodland zoning to preserve the floodwater conveyance and storage capacity of floodplain areas and to prevent the location of new flood damage-prone development in flood hazard areas. The minimum standards that such ordinances must meet are set forth in Chapter NR 116 of the *Wisconsin Administrative Code*. The required regulations govern filling and development within a regulatory floodplain, which is defined as the area subject to inundation by the 100-year recurrence interval flood event, the event which has a 1 percent probability of occurring in any given year. Under Chapter NR 116, local floodland zoning regulations must prohibit nearly all forms of development within the floodway, which is that portion of the floodplain required to convey the 100-year recurrence peak flood flow. Local regulations must also restrict filling and development within the flood fringe, which is that portion of the floodplain located outside the floodway that would be covered by floodwater during the 100-year recurrence flood. Filling and development of the flood fringe area can reduce the floodwater storage capacity of the natural floodplain, and may thereby increase downstream flood flows and stages. It should be noted that towns may enact floodland zoning regulations which may be more restrictive than those in the county shoreland and floodland protection zoning ordinances. Floodland zoning ordinances are in effect within all parts of the area tributary to Geneva Lake, with the exception of the Village of Walworth. All of the towns within the area tributary to Geneva Lake currently are regulated only by the county ordinance for floodplain zoning.

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

Map 11

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



Source: SEWRPC.

Table 9

LAND USE REGULATIONS WITHIN THE AREA TRIBUTARY TO GENEVA LAKE IN WALWORTH COUNTY BY COMMUNITY: 2003

Community	Type of Ordinance				
	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Erosion Control and Stormwater Management
Walworth County	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Adopted	Adopted
City of Lake Geneva	Adopted	Adopted	Adopted	Adopted	Adopted
Village of Fontana-on-Geneva Lake	Adopted[a]	Adopted	Adopted	Adopted	Adopted
Village of Walworth	Adopted	None	None	Adopted	None
Village of Williams Bay	Adopted[b]	Adopted	Adopted	Adopted	Adopted
Town of Bloomfield	County ordinance	County ordinance	County ordinance	County ordinance	County ordinance
Town of Delavan	County ordinance	County ordinance	County ordinance	County and Town ordinances	County ordinance
Town of Geneva	County ordinance	County ordinance	County ordinance	County ordinance	County ordinance
Town of Linn	County ordinance	County ordinance	County ordinance	County ordinance	County ordinance
Town of Walworth	County ordinance	County ordinance	County ordinance	County and Town ordinances	County ordinance

[a]*The Village of Fontana-on-Geneva Lake also exercises extraterritorial zoning in the Towns of Linn and Walworth.*

[b]*The Village of Williams Bay also exercises extraterritorial zoning in portions of the Towns of Geneva and Linn.*

Source: SEWRPC.

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 requires that counties place all wetlands five acres or larger and within the statutory shoreland zoning jurisdiction area into a wetland conservancy zoning district to ensure their preservation after completion of appropriate wetland inventories by the Wisconsin Department of Natural Resources (WDNR).

In 1982, the State Legislature extended shoreland-wetland zoning requirements to cities and villages in Wisconsin. Under Sections 62.231 and 61.351, respectively, of the *Wisconsin Statutes*, cities and villages in Wisconsin are required to place wetlands five acres or larger and located in statutory shorelands into a shoreland-wetland conservancy zoning district to ensure their preservation. Minimum standards for city and village shoreland-wetland zoning ordinances are set forth in Chapter NR 117 of the *Wisconsin Administrative Code*.

It should be noted that the basis for identification of wetlands to be protected under Chapters NR 115 and NR 117 is the Wisconsin Wetlands Inventory. Mandated by the State Legislature in 1978, the Wisconsin Wetlands Inventory resulted in the preparation of wetland maps covering each U.S. Public Land Survey township in the State. The inventory was completed for counties in southeastern Wisconsin in 1982, the wetlands being delineated by the Regional Planning Commission on its 1980, one inch equals 2,000 feet scale, ratioed and rectified aerial photographs as discussed in Chapter V.

County shoreland zoning ordinances are in effect in all unincorporated areas of Walworth County. All of the incorporated municipalities within the total drainage area tributary to Geneva Lake, except the Village of Walworth, have adopted shoreland-wetland zoning ordinances.

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.[3] 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. The City of Lake Geneva and the Villages of Fontana-on-Geneva Lake, Walworth, and Williams Bay, have each adopted their own set of subdivision ordinances. The Towns of Bloomfield, Geneva, and Linn have all adopted Walworth County ordinances. The Towns of Delavan and Walworth have adopted a set of subdivision ordinances that are a combination of their own provisions and those of Walworth County.

Construction Site Erosion Control and Stormwater Management Regulations

Section 62.23 of the *Wisconsin Statutes* grants authority to cities and villages in Wisconsin to adopt ordinances for the prevention of erosion from construction sites and the management of stormwater runoff from lands within their jurisdiction. Towns may adopt village powers and subsequently utilize the authority conferred on cities and villages under Section 62.23 to adopt their own erosion control and stormwater management ordinances, 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 with effect from August 1, 2004. Currently, none of the counties, cities, villages, and towns within the drainage area tributary to Geneva Lake are identified by the WDNR as being in urbanized areas that have been, or will be, required to obtain stormwater discharge permits.

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.[4] 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

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[3]*Under Section 236.02 of the* Wisconsin Statutes*, the extraterritorial plat approval jurisdiction is the area within three miles of the corporate limits of a first-, second-, or third-class city and within 1.5 miles of a fourth-class city or a village; the City of Lake Geneva is a city of the fourth-class.*

[4]*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.*

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
- 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.

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.

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.

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 Geneva Lake in 2003, except for the Village of Walworth. The City of Lake Geneva, and the Villages of Fontana-on-Geneva Lake and Williams Bay, have adopted their own ordinances with regards to both construction site erosion control and stormwater management. The Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth have adopted construction site erosion control and stormwater management ordinances by reference to the County ordinances.

Walworth County has adopted construction site erosion control and stormwater management ordinances. These ordinances apply to the unincorporated town lands in the County. The Walworth County construction site erosion control ordinance applies to all lands requiring a subdivision plat or certified survey, to sites upon which construction activities will disturb 4,000 square feet or more and/or 400 cubic yards or more of material, and to sites where pipeline placement operations disturb 300 linear feet or more of land surface. These ordinances 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*[5] 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.

The Walworth County stormwater management ordinance applies to residential lands of five acres or more in areal extent, residential lands where there is at least 1.5 acres of impervious surface, nonresidential lands of 2.0 acres in areal extent where there is at least 1.0 acre of impervious surface, or other lands on which development activities may result in stormwater runoff likely to harm public property or safety. The stormwater management ordinance establishes performance standards to manage both rate and volume of stormwater flows from regulated sites and water quality. Performance standards adopted in this ordinance and the resultant design of appropriate management practices are based on calculation procedures and principles set forth in *Urban Hydrology for Small Watersheds*.[6]

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

[6]*U.S. Department of Agriculture Technical Release 55,* Urban Hydrology of Small Watersheds*, June 1992.*

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Chapter IV

WATER QUALITY

INTRODUCTION

The earliest data on water quality conditions in many Wisconsin lakes date back to the early 1900s, when E.A. Birge and C. Juday, widely recognized pioneering lake researchers from the University of Wisconsin, collected basic information on Wisconsin lakes.[1] However, most water quality information for Geneva Lake is relatively recent, having been collected and recorded periodically from 1976 to the present. Data utilized for this report included Secchi disk readings, temperature-depth profiles, and dissolved oxygen, total phosphorus and chlorophyll-*a* concentration data for the period 1986 through 2000, as well as various other Wisconsin Department of Natural Resources (WDNR) reports and file data, U.S. Geological Survey (USGS) reports, Geneva Lake Environmental Agency (GLEA) reports, Geneva Lake Conservancy (GLC) reports and earlier Southeastern Regional Planning Commission (SEWRPC) reports.

EXISTING WATER QUALITY CONDITIONS

Water quality data gathered under the auspices of the WDNR monitoring programs and data collected by the USGS were used to assess lake water quality in Geneva Lake. For purposes of the initial water quality management plan for Geneva Lake,[2] data for the period from 1976 through 1977 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. These data have been supplemented with more recent data, collected during the period from 1986 through 2004, to determine and evaluate current water quality conditions in the Lake. In 1997, a three-year collaborative effort involving the USGS, the WDNR, and the GLEA, was initiated to determine the current water quality conditions of the Lake and its sediments, and to generate an understanding of long-term water quality conditions in Geneva Lake by comparing then-current water quality measurements with historic measurements and sediment core analyses.[3] Water quality samples during this collaborative study were generally taken seasonally from several sites located in the main basin and major bays of the Lake. These data indicated that

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[1]*E.A. Birge and C. Juday*, The Inland Lakes of Wisconsin, *1.* The Dissolved Gases and their Biological Significance, *Bulletin, Wisconsin Geological and Natural History Survey, Volume 22, 1911*.

[2]*SEWRPC Community Assistance Planning Report No. 60,* A Water Quality Management Plan for Geneva Lake, Walworth County, Wisconsin, *October 1985.*

[3]*U.S. Geological Survey Water-Resources Investigations Report 02-4039,* Hydrology and Water Quality of Geneva Lake, Walworth County, Wisconsin, *2002.*

water quality throughout Geneva Lake was relatively uniform horizontally. It, therefore, was recommended by USGS that an adequate long-term sampling strategy could be developed around samplings in the center of only the West and East Bays of Geneva Lake and, if financial constraints made it necessary, only of the West Bay. In keeping with this recommendation, since the time of the collaborative report, the GLEA, in cooperation with the USGS, has continued to monitor water quality conditions in Geneva Lake through samplings taken only at the West Bay sampling site. The discussion below is based primarily on water quality data from the West Bay and East Bay as shown in Tables 10, 11, and 12.

Tributary streams also can affect the water quality of a lake. Streams pick up materials as they flow over the land surface, and may also receive effluents from various sources such as roof eaves, sump pump drains, storm sewers and other sources and, therefore, can represent an important source of pollutants to a lake. Numerous intermittent and nine perennial streams flow into Geneva Lake. In the initial SEWRPC report, data for various water quality parameters were collected from streams tributary to Geneva Lake and are shown in Table 13.

Thermal Stratification

Thermal and dissolved oxygen profiles for Geneva Lake are shown in Figure 2. In the initial SEWRPC report, water temperatures in Geneva Lake ranged from a minimum of 32°F (0°C) during the winter to 75°F (24°C) during the summer. Between 1988 and 1993, water temperatures in Geneva Lake ranged from a minimum of 32°F (0°C) during the winter to 81.5°F (27.5°C) during the summer; between 1997 and 2004, water temperatures ranged from a minimum of 32°F (0°C) during the winter to 79°F (26°C) during the summer, as shown in Tables 10 and 11. These maximum summer temperatures during the current study period, while approximately 4°F warmer than those recorded during the initial study period, are, nonetheless, about 2°F lower than those recorded between 1988 and 1993. Elsewhere in the Southeastern Wisconsin Region, in Pewaukee Lake, for example, surface water temperatures approached 10°F warmer in recent years, compared with the 1976 and 1977 data.[4]

Geneva Lake is dimictic, which means that it mixes completely two times per year and is subject to thermal stratification during summer and winter. This process is illustrated diagrammatically in Figure 3. Thermal stratification is caused by the differential heating of the lake water. The resulting water temperature-density relationships at various depths within the lake cause layering, or stratification, of the water column. The development of summer thermal stratification begins in early summer, reaches its maximum in late summer, and disappears in the fall. Stratification may also occur during winter under ice cover. The annual thermal cycle within Geneva Lake is described below.

As summer begins, the Lake absorbs solar energy at the surface. Wind action and, to some extent, internal heat transfer mechanisms transmit this energy to the underlying portions of the waterbody. As the upper layer of water is heated by solar energy, a physical barrier, created by differing water densities between warmer and cooler water, begins to form between the warmer surface water and the colder, heavier bottom water, as shown in Figure 3. 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 (the epilimnion) from the cooler, heavier, lower layer (the hypolimnion), as shown in Figure 4. Although this barrier is readily crossed by fish, provided sufficient oxygen exists, it essentially prohibits the exchange of water between the two layers. This condition has a major impact on both the chemical and biological activity in a lake. In the initial SEWRPC report, the thermocline occupied a depth range of about 30 feet to 52 feet. Based on this data, it was estimated that 40 percent of the lake volume circulated during the summer stratification period, 24 percent was stagnant, and the remaining 36 percent was below the thermocline, but circulated to a limited extent. It was also reported that the hypolimnion of Geneva Lake remained at less than 16°C during the summer and provided suitable temperatures to support cold water fish species, such as trout and cisco.

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

Table 10

SEASONAL WATER QUALITY CONDITIONS IN WEST BAY OF GENEVA LAKE: 1997-2004

	Fall (mid-September to mid-December)		Winter (mid-December to mid-March)		Spring (mid-March to mid-June)		Summer (mid-June to mid-September)	
Parameter[a]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Physical Properties								
Alkalinity, as $CaCO_3$								
Range	- -	- -	- -	- -	180-192	179-193	- -	- -
Mean	- -	- -	- -	- -	184.63	184.75	- -	- -
Standard Deviation	- -	- -	- -	- -	4.21	4.65	- -	- -
Number of Samples	- -	- -	- -	- -	8	8	- -	- -
Hardness, as $CaCO_3$								
Range	- -	- -	- -	- -	217-227	220-223	- -	- -
Mean	- -	- -	- -	- -	220.67	220.67	- -	- -
Standard Deviation	- -	- -	- -	- -	3.33	1.21	- -	- -
Number of Samples	- -	- -	- -	- -	6	6	- -	- -
Color								
Range	- -	- -	- -	- -	5.0-17.0	5.0-15.0	- -	- -
Mean	- -	- -	- -	- -	8.14	7.5	- -	- -
Standard Deviation	- -	- -	- -	- -	4.56	4.189	- -	- -
Number of Samples	- -	- -	- -	- -	7	6	- -	- -
Dissolved Oxygen								
Range	8.2-11.2	0-10.6	11.7-15.2	6.0-13.2	8.9-13.9	7.1-13.2	8.2-10.1	0.0-7.0
Mean	9.34	1.48	13.63	10.25	12.02	10.67	8.99	2.30
Standard Deviation	0.86	3.33	1.45	3.37	1.59	2.03	0.51	2.37
Number of Samples	24	24	4	4	19	19	28	28
pH (units)								
Range	7.9-8.6	7.3-8.3	8.3-8.4	8.2-8.6	7.6-8.6	7.9-8.4	8.0-8.6	7.4-8.1
Mean	8.21	7.6	8.38	8.28	8.27	8.19	8.34	7.71
Standard Deviation	0.18	0.27	0.05	0.36	0.21	0.16	0.14	0.21
Number of Samples	24	24	4	4	19	19	28	28
Secchi Depth (feet)								
Range	11.2-22.0	- -	15.1-22.0	- -	5.58-26.9	- -	8.86-30.83	- -
Mean	16.6	- -	17.8	- -	15.31	- -	14.89	- -
Standard Deviation	3.1	- -	3.7	- -	5.87	- -	4.70	- -
Number of Samples	24	- -	3	- -	19	- -	28	- -
Specific Conductance (µS/cm)								
Range	475-523	490-540	480-516	499-549	483-528	502-529	471-513	498-540
Mean	495.92	519.04	499.25	518.50	506	513.79	493.54	525.5
Standard Deviation	11.40	14.21	15.04	22.35	11.29	7.61	12.25	9.04
Number of Samples	24	24	4	4	19	19	28	28
Temperature (°F)								
Range	45.3-73.0	44.1-47.8	33.8-36.5	35.1-37.9	36.1-70.7	36.3-48.2	67.1-78.1	43.9-47.3
Mean	60.05	45.70	34.88	36.59	50.37	42.50	73.49	45.51
Standard Deviation	9.50	1.07	1.15	1.18	10.87	2.89	3.27	1.16
Number of Samples	24	24	4	4	19	19	28	28
Turbidity (NTU)								
Range	- -	- -	- -	- -	0.4-1.6	0.5-1.7	- -	- -
Mean	- -	- -	- -	- -	0.98	1.03	- -	- -
Standard Deviation	- -	- -	- -	- -	0.5	0.45	- -	- -
Number of Samples	- -	- -	- -	- -	8	6	- -	- -
Metals/Salts								
Dissolved Calcium								
Range	- -	- -	- -	- -	34-35	34-35	- -	- -
Mean	- -	- -	- -	- -	34.19	34.24	- -	- -
Standard Deviation	- -	- -	- -	- -	0.36	0.37	- -	- -
Number of Samples	- -	- -	- -	- -	8	8	- -	- -
Dissolved Chloride								
Range	- -	- -	- -	- -	33.0-37.6	33.0-37.7	- -	- -
Mean	- -	- -	- -	- -	35.4	35.65	- -	- -
Standard Deviation	- -	- -	- -	- -	1.67	1.68	- -	- -
Number of Samples	- -	- -	- -	- -	8	8	- -	- -
Dissolved Iron (µg/l)								
Range	- -	- -	- -	- -	<10.0-<100.0	<10.0-<100.0	- -	- -
Mean	- -	- -	- -	- -	21.88	21.88	- -	- -
Standard Deviation	- -	- -	- -	- -	23.29	23.29	- -	- -
Number of Samples	- -	- -	- -	- -	8	8	- -	- -
Dissolved Magnesium								
Range	- -	- -	- -	- -	32.0-34.5	33.0-34.7	- -	- -
Mean	- -	- -	- -	- -	33.56	33.48	- -	- -
Standard Deviation	- -	- -	- -	- -	0.85	0.73	- -	- -
Number of Samples	- -	- -	- -	- -	8	8	- -	- -
Dissolved Manganese (µg/l)								
Range	- -	- -	- -	- -	<0.4-<1.0	<0.4-3.8	- -	- -
Mean	- -	- -	- -	- -	0.35	0.80	- -	- -
Standard Deviation	- -	- -	- -	- -	0.16	1.22	- -	- -
Number of Samples	- -	- -	- -	- -	8	8	- -	- -

Table 10 (continued)

Parameter[a]	Fall (mid-September to mid-December) Shallow[b]	Fall Deep[c]	Winter (mid-December to mid-March) Shallow[b]	Winter Deep[c]	Spring (mid-March to mid-June) Shallow[b]	Spring Deep[c]	Summer (mid-June to mid-September) Shallow[b]	Summer Deep[c]
Metals/Salts (continued)								
Dissolved Potassium								
Range	- -	- -	- -	- -	1.6-2.0	1.7-2.0	- -	- -
Mean	- -	- -	- -	- -	1.85	1.86	- -	- -
Standard Deviation	- -	- -	- -	- -	0.17	0.13	- -	- -
Number of Samples	- -	- -	- -	- -	8	8	- -	- -
Dissolved Silica								
Range	- -	- -	- -	- -	0.38-2.10	0.5-2.2	- -	- -
Mean	- -	- -	- -	- -	1.03	1.17	- -	- -
Standard Deviation	- -	- -	- -	- -	0.70	0.66	- -	- -
Number of Samples	- -	- -	- -	- -	7	7	- -	- -
Dissolved Sodium								
Range	- -	- -	- -	- -	16.0-18.4	16.0-18.7	- -	- -
Mean	- -	- -	- -	- -	17.03	17.01	- -	- -
Standard Deviation	- -	- -	- -	- -	0.78	0.84	- -	- -
Number of Samples	- -	- -	- -	- -	8	8	- -	- -
Dissolved Sulfate SO_4								
Range	- -	- -	- -	- -	30.0-31.6	30-32	- -	- -
Mean	- -	- -	- -	- -	30.88	31.29	- -	- -
Standard Deviation	- -	- -	- -	- -	0.55	0.79	- -	- -
Number of Samples	- -	- -	- -	- -	8	8	- -	- -
Nutrients								
Dissolved Nitrogen, Ammonia								
Range	<0.002-0.068	<0.01-0.438	<0.013-0.026	<0.013-0.123	0.001-0.048	0.019-0.169	0.003-0.038	<0.013-0.426
Mean	0.01	0.23	0.013	0.06	0.02	0.08	0.014	0.26
Standard Deviation	0.01	0.15	0.01	0.06	0.01	0.05	0.01	0.13
Number of Samples	24	17	4	4	19	12	28	14
Dissolved Nitrogen, NO_2+NO_3								
Range	<0.01-0.074	<0.01-0.19	0.026-0.084	<0.01-0.15	<0.01-0.11	0.05-0.12	<0.01-0.053	<0.01-0.33
Mean	0.02	0.03	0.06	0.07	0.06	0.07	0.009	0.11
Standard Deviation	0.02	0.05	0.02	0.06	0.03	0.02	0.009	0.12
Number of Samples	24	18	4	4	19	17	27	15
Total Nitrogen, Organic								
Range	0.22-0.62	0.49-1.20	0.36-0.60	0.30-0.81	0.31-0.92	0.34-1.23	0.28-1.51	0.48-1.04
Mean	0.46	0.76	0.47	0.51	0.49	0.55	0.51	0.78
Standard Deviation	0.09	0.24	0.11	0.22	0.15	0.22	0.23	0.17
Number of Samples	24	18	4	4	19	17	28	14
Dissolved Orthophosphorus								
Range	<0.002-0.005	<0.002-0.093	<0.002-0.003	<0.002-0.019	<0.002-0.003	<0.002-0.014	<0.002-0.004	0.003-0.108
Mean	0.002	0.04	0.002	0.007	0.001	0.003	0.002	0.05
Standard Deviation	0.001	0.03	0.001	0.009	0.0008	0.003	0.001	0.04
Number of Samples	24	18	4	4	19	17	19	15
Total Phosphorus								
Range	0.005-0.014	0.006-0.106	0.005-0.008	0.007-0.025	0.005-0.016	0.008-0.023	<0.005-0.015	0.011-0.118
Mean	0.009	0.052	0.007	0.015	0.010	0.013	0.008	0.055
Standard Deviation	0.003	0.029	0.001	0.008	0.003	0.004	0.003	0.032
Number of Samples	24	24	4	4	18	19	28	28
Biological								
Chlorophyll-*a* (μg/l)								
Range	- -	- -	0.4-3.0	- -	0.39-7.45	- -	<1.0-5.6	- -
Mean	- -	- -	2.4	- -	3.65	- -	2.75	- -
Standard Deviation	- -	- -	1.5	- -	2.22	- -	1.25	- -
Number of Samples	- -	- -	4	- -	16	- -	25	- -

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

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

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

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

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

From fall turnover until freeze-up, surface waters continue to cool in response to the continued decline in ambient air temperatures. Water is unique among liquids because it reaches its maximum density, or mass per unit of

Table 11

SEASONAL WATER QUALITY CONDITIONS IN EAST BAY OF GENEVA LAKE: 1997-2000

	Fall (mid-September to mid-December)		Winter (mid-December to mid-March)		Spring (mid-March to mid-June)		Summer (mid-June to mid-September)	
Parameter[a]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Physical Properties								
Alkalinity, as $CaCO_3$								
Range	- -	- -	- -	- -	185.0-189.0	189.0-192.0	- -	- -
Mean	- -	- -	- -	- -	187.25	190.5	- -	- -
Standard Deviation	- -	- -	- -	- -	2.06	2.12	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Hardness, as $CaCO_3$								
Range	- -	- -	- -	- -	220-220	220-220	- -	- -
Mean	- -	- -	- -	- -	220	220	- -	- -
Standard Deviation	- -	- -	- -	- -	0	0	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Color								
Range	- -	- -	- -	- -	<5.0-15.0	10.0-10.0	- -	- -
Mean	- -	- -	- -	- -	9.38	10	- -	- -
Standard Deviation	- -	- -	- -	- -	5.15	0	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Dissolved Oxygen								
Range	8.5-11.4	0.6-11.2	11.7-13.7	9.5-13.0	8.6-13.6	8.1-13.0	8.3-9.7	0.0-8.1
Mean	9.92	5.24	13.1	11.4	11.68	10.95	8.88	4.07
Standard Deviation	1.03	5.13	0.94	1.44	1.48	1.51	0.46	2.41
Number of Samples	11	11	4	4	13	13	13	13
pH (units)								
Range	8.2-8.6	7.4-8.5	8.2-8.6	8.3-8.6	8.2-8.7	8.1-8.4	8.3-8.6	7.5-8.1
Mean	8.38	7.86	8.38	8.37	8.46	8.29	8.45	7.75
Standard Deviation	0.15	0.43	0.17	0.15	0.13	0.11	0.11	0.21
Number of Samples	11	11	4	4	13	13	13	13
Secchi Depth (feet)								
Range	13.12-20.99	- -	14.4-21.3	- -	5.9-22.0	- -	9.8-23.6	- -
Mean	17.06	- -	17.3	- -	13.02	- -	13.55	- -
Standard Deviation	2.74	- -	3.44	- -	5.34	- -	3.87	- -
Number of Samples	11	- -	4	- -	13	- -	13	- -
Specific Conductance (µS/cm)								
Range	478-503	487-519	496-524	497-523	479-509	500-517	475-500	497-526
Mean	488.27	504.45	504	507.75	499.23	507.31	486.54	516.54
Standard Deviation	7.07	12.20	13.39	12.15	8.20	4.91	7.75	7.38
Number of Samples	11	11	4	4	13	13	13	13
Temperature (°F)								
Range	44.4-72.9	43.8-53.2	33.3-44.1	36.0-44.1	37.6-70.5	37.4-48.2	68.7-79.3	46.8-50.9
Mean	57.04	48.36	37.54	38.53	52.06	43.85	74.58	48.81
Standard Deviation	9.60	2.84	4.73	3.80	10.04	3.16	2.86	1.36
Number of Samples	11	11	4	4	13	13	13	13
Turbidity (NTU)								
Range	- -	- -	- -	- -	0.3-1.5	0.9-1.3	- -	- -
Mean	- -	- -	- -	- -	0.98	1.1	- -	- -
Standard Deviation	- -	- -	- -	- -	0.51	0.3	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Metals/Salts								
Dissolved Calcium								
Range	- -	- -	- -	- -	33.0-34.0	34.0-34.0	- -	- -
Mean	- -	- -	- -	- -	33.8	34.0	- -	- -
Standard Deviation	- -	- -	- -	- -	0.5	0	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Dissolved Chloride								
Range	- -	- -	- -	- -	32.0-36.8	33.0-34.0	- -	- -
Mean	- -	- -	- -	- -	34.45	33.5	- -	- -
Standard Deviation	- -	- -	- -	- -	2.00	0.7	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Dissolved Iron (µg/l)								
Range	- -	- -	- -	- -	<10.0-<10.0	<10.0-<10.0	- -	- -
Mean	- -	- -	- -	- -	<10.0	<10.0	- -	- -
Standard Deviation	- -	- -	- -	- -	0	0	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Dissolved Magnesium								
Range	- -	- -	- -	- -	32.0-33.0	33.0-34.0	- -	- -
Mean	- -	- -	- -	- -	32.8	33.5	- -	- -
Standard Deviation	- -	- -	- -	- -	0.5	0.7	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Dissolved Manganese (µg/l)								
Range	- -	- -	- -	- -	<0.4—0.5	<0.4-<0.4	- -	- -
Mean	- -	- -	- -	- -	0.35	<0.4	- -	- -
Standard Deviation	- -	- -	- -	- -	0.17	0	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -

Table 11 (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 Potassium								
Range	- -	- -	- -	- -	1.7-1.9	1.8-1.8	- -	- -
Mean	- -	- -	- -	- -	1.8	1.8	- -	- -
Standard Deviation	- -	- -	- -	- -	.08	0	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Dissolved Silica								
Range	- -	- -	- -	- -	0.27-0.60	0.55-0.63	- -	- -
Mean	- -	- -	- -	- -	0.425	0.59	- -	- -
Standard Deviation	- -	- -	- -	- -	0.165	0.57	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Dissolved Sodium								
Range	- -	- -	- -	- -	16.0-17.0	16.0-17.0	- -	- -
Mean	- -	- -	- -	- -	16.8	16.5	- -	- -
Standard Deviation	- -	- -	- -	- -	0.5	0.7	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Dissolved Sulfate SO_4								
Range	- -	- -	- -	- -	31.0-32.0	31.0-32.0	- -	- -
Mean	- -	- -	- -	- -	31.28	31.5	- -	- -
Standard Deviation	- -	- -	- -	- -	0.49	0.7	- -	- -
Number of Samples	- -	- -	- -	- -	4	2	- -	- -
Nutrients								
Dissolved Nitrogen, Ammonia								
Range	0.006-0.021	0.005-0.029	<0.013-0.026	<0.013-0.050	0.003-0.028	<0.013-0.069	0.004-0.015	<0.010-0.107
Mean	0.009	0.017	0.016	0.029	0.010	0.020	0.007	0.037
Standard Deviation	0.005	0.010	0.010	0.019	0.008	0.018	0.003	0.036
Number of Samples	11	11	4	3	13	13	13	13
Dissolved Nitrogen, NO_2+NO_3								
Range	<0.01-0.039	<0.01-0.19	0.016-0.052	0.030-0.085	<0.010-0.092	0.037-0.081	<0.005-0.010	<0.010-0.225
Mean	0.015	0.067	0.038	0.054	0.046	0.063	0.005	0.080
Standard Deviation	0.013	0.057	0.017	0.023	0.030	0.014	0.002	0.070
Number of Samples	11	11	4	4	13	13	13	13
Total Nitrogen, Organic								
Range	0.20-0.64	0.30-0.59	0.40-0.61	0.25-0.60	0.27-0.65	0.28-0.72	0.31-0.64	0.4-1.4
Mean	0.48	0.46	0.51	0.50	0.48	0.48	0.47	0.59
Standard Deviation	0.13	0.09	0.12	0.17	0.11	0.12	0.10	0.26
Number of Samples	11	11	4	4	13	13	13	13
Dissolved Orthophosphorus								
Range	<0.002-0.002	<0.002-0.003	<0.002-0.003	<0.002-0.003	<0.002-0.003	<0.002-0.003	<0.002-0.002	<0.002-0.007
Mean	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.002
Standard Deviation	0.0005	0.0008	0.001	0.001	0.001	0.001	0.001	0.002
Number of Samples	11	11	4	4	13	13	13	13
Total Phosphorus								
Range	<0.005-0.011	<0.005-0.015	<0.005-0.012	<0.005-0.026	<0.005-0.023	<0.005-0.015	<0.005-0.017	<0.005-0.019
Mean	0.007	0.009	0.008	0.013	0.011	0.010	0.008	0.010
Standard Deviation	0.002	0.004	0.004	0.010	0.005	0.004	0.005	0.004
Number of Samples	11	11	4	4	13	13	13	13
Biological								
Chlorophyll-*a* (μg/l)								
Range	0.8-4.1	- -	0.9-3.0	- -	<1.0-7.0	- -	0.6-7.0	- -
Mean	2.39	- -	2.27	- -	3.31	- -	2.76	- -
Standard Deviation	1.24	- -	0.94	- -	2.45	- -	1.78	- -
Number of Samples	11	- -	4	- -	13	- -	13	- -

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

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

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

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

volume, at about 39°F (4°C). Once the temperature of the water at the surface drops to this point of maximum water density, these waters will now have become more dense than the warmer waters below them. As a consequence of this density difference, the surface waters begin to "sink" to the bottom. Eventually, the entire water column is cooled to the point of maximum density. The surface waters continue to cool until they reach about 32°F, and are, once again, less dense than the waters below which remain at about 39°F. At 32°F, the lake surface may then become ice covered, isolating the lake water from the atmosphere for a period of up to four months. As shown in Figure 3, winter stratification occurs as the colder, lighter water and ice remains at the

Table 12

GENEVA LAKE WEST BAY SPRING OVERTURN WATER QUALITY: 1997-2004

Water Quality Parameter	April 21, 1997		April 14, 1998		April 13, 1999		April 12, 2000	
	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
Depth of Sample (feet)	1.6	141.0	1.6	134.5	1.6	141.0	1.6	142.7
Specific Conductance (μS/cm)	510	513	502	510	510	509	510	512
pH	8.4	8.4	8.3	8.4	8.2	8.3	8.2	8.3
Water Temperature (°F)	41.0	40.1	42.4	48.2	43.8	41.2	41.4	40.8
Color (platinum-cobalt scale)	10	10	10	5	5	5	17	15
Turbidity (Nephelometric turbidity units)	0.7	0.8	1.6	1.4	0.4	0.5	1.4	0.7
Secchi Disk (feet)	9.8		11.2		22.0		18.4	
Dissolved Oxygen	13.2	11.6	13.9	11.7	13.4	12.1	12.2	12.0
Hardness, as $CaCO_3$	220	220	217	221	220	220	220	220
Calcium	34	34	34	34	34	34	34	34
Magnesium	33	33	32	33	34	33	33	33
Sodium	16	16	16	16	17	17	17	17
Potassium	1.7	1.8	1.8	1.9	2.0	1.7	1.6	1.7
Alkalinity, as $CaCO_3$	192	193	189	189	185	185	185	186
Chloride	33	33	34	34	35	35	34.5	36.7
Sulfate	31	32	31	32	31	31	31.2	31.4
Dissolved Solids at 180°	268	270	278	276	272	274	290	304
Nitrate/Nitrite Nitrogen	0.053	0.066	0.074	0.073	0.083	0.079	0.070	0.068
Ammonia Nitrogen	<0.013	0.035	<0.013	<0.013	0.017	<0.013	0.044	0.043
Kdeldahl Nitrogen	0.6	0.5	0.44	0.54	.045	.049	0.92	0.51
Total Phosphorus	0.016	0.020	0.010	0.012	0.006	0.010	0.013	0.012
Orthophosphorus	0.003	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Iron (μg/l)	<10	<10	<10	<10	<10	<10	<10	<10
Manganese (μg/l)	<0.4	3.8	<0.4	<0.4	<0.4	<0.4	<1	<1
Chlorophyll-*a* (μg/l)	5.3	- -	4.2	- -	1.3	- -	2.2	- -

Water Quality Parameter	April 18, 2001		April 17, 2002		April 14, 2003		April 13,2004	
	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
Depth of Sample (feet)	1.6	134.5	1.6	141.0	1.6	139.4	1.6	141.0
Specific Conductance (μS/cm)	513	514	520	519	528	529	525	525
pH	8.2	8.2	8.4	8.4	8.6	8.1	8.2	8.2
Water Temperature (°F)	42.8	41.7	39.6	39.2	39.2	38.4	40.8	39.9
Color (platinum-cobalt scale)	5	5	5	<5	<5	<5	5	5
Turbidity (Nephelometric turbidity units)	1.5	1.1	1.2	1.7	<1.0	<1.0	<1.0	<1.0
Secchi Disk (feet)	19.4		19.0		17.1		17.4	
Dissolved Oxygen	12.6	12.1	13.4	13.2	13.6	13.0	13.5	13.1
Hardness, as $CaCO_3$	227	223	220	220	- -	- -	- -	- -
Calcium	35	35	34.1	34.1	34	34.2	34.4	34.6
Magnesium	34	33	33.6	33.6	34.4	34.5	34.5	34.7
Sodium	17	17	17.4	17.3	17.4	17.1	18.4	18.7
Potassium	1.7	1.8	2.0	2.0	2.0	2.0	2.0	2.0
Alkalinity, as $CaCO_3$	180	180	180	179	182	182	184	184
Chloride	35	34.8	36.6	36.9	37.6	37.1	37.5	37.7
Sulfate	30.1	30	31.6	32	30	30.3	31.1	31.6
Dissolved Solids at 180°	280	280	272	260	288	286	282	288
Nitrate/Nitrite Nitrogen	0.110	0.123	0.094	0.098	0.078	0.078	0.048	0.057
Ammonia Nitrogen	0.020	0.045	0.023	0.021	0.015	<0.013	0.025	0.135
Kdeldahl Nitrogen	0.35	0.37	0.52	0.44	0.37	0.34	0.38	0.38
Total Phosphorus	0.010	0.010	0.008	0.009	0.011	0.011	0.011	0.011
Orthophosphorus	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Iron (μg/l)	<10	<10	<100	<100	<100	<100	<100	<100
Manganese (μg/l)	<0.4	<0.4	<1	<1	<1	<1	<1	<1
Chlorophyll-*a* (μg/l)	<1	- -	1	- -	4.3	- -	3.9	- -

Source: Wisconsin Department of Natural Resources and SEWRPC.

surface, separated from the relatively warmer, heavier water near the bottom of the lake. The ice shuts the water column off from the atmospheric source of oxygen.

On Geneva Lake, ice cover typically exists from late December or early January until late March or early April, as shown in Table 14. Of particular note in Table 14 are data for the average number of days of ice cover for Geneva Lake for the period of 1862 to 2002. These ice-cover data are represented diagrammatically in Figure 5. As was noted in the aforereferenced collaborative report, the freeze dates for Geneva Lake showed no consistent pattern

Table 13

AVERAGE ANNUAL CONCENTRATIONS/VALUES OF SELECTED WATER QUALITY PARAMETERS FOR SEVERAL PERENNIAL STREAMS TRIBUTARY TO GENEVA LAKE: 1976-1977

Parameters[a]	Name of Stream								
	Birches	Southwick	Buttons Bay	Pottawatomie	Buena Vista	Gardens	Harris	Hillside	Trinke
Specific Conductance (μS/cm)	653	661	756	737	1,080	687	720	772	610
Chloride	15.6	28.5	47.8	39.4	168.0	21.3	19.3	48.4	14.9
pH (units)	7.7	8.1	7.4	8.0	8.4	8.0	7.6	7.9	7.6
Suspended Solids	6.9	17.9	6.4	9.9	12.5	5.1	9.8	17.2	7.8
Ammonia Nitrogen	0.124	0.096	1.220	0.047	0.353	0.026	0.069	0.226	0.471
Nitrate and Nitrite Nitrogen	0.130	0.46	0.68	0.49	1.34	4.73	0.38	0.24	0.32
Total Kjeldahl Nitrogen	0.350	0.389	5.570	0.340	0.992	0.194	0.339	0.556	1.090
Dissolved Phosphorus (filtered)	0.034	0.071	0.879	0.014	0.868	0.012	0.016	0.040	0.074
Total Phosphorus	0.048	0.083	1.430	0.036	0.935	0.024	0.032	0.078	0.112

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

Source: GLEA and SEWRPC.

of long-term change over the entire period of record, although the period from about 1905 to about 1940 did have unusually late freeze dates. In addition, the most recent ice breakup dates, along with the duration of ice cover, have exhibited trends consistent with those observed in lakes throughout the northern hemisphere. These trends are indicative of higher fall, winter, and spring air temperatures. Throughout most of the period since 1862, ice breakup has generally been around the beginning of April. In contrast, the most recent 10-year moving average indicates ice breakup around March 12, supporting a trend toward earlier breakup dates that began around 1980. Along with these earlier ice breakup dates, there has been a trend of decreasing ice cover duration, especially most recently, although there has been a degree of fluctuation in this regard when data for the entire period of record are examined. In 1862, ice covered Geneva Lake for a period of 110 days; this length of time had shortened to 65 days by the mid-1930s, then lengthened again to about 100 days by the mid-1960s. Most recently, the 10-year moving average has decreased again to around 70 days. Consequently, although most recent data are suggestive of a warming trend, examination of the data over the entire period of record indicates the present duration of ice cover is not much different to that observed around 1935.

Spring brings a reversal of the process of lake stratification. Once the surface ice has melted, the upper layer of water continues to warm until it reaches 39°F, the maximum density point of water and, coincidentally, the temperature of the deeper waters below it. At this point, the entire water column is, once again, the same temperature (and density) from surface to bottom and wind action results in a mixing of the entire lake. 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 continues to warm and become less dense, causing it to float above the colder, deeper water. Wind and resulting waves carry some of the energy of the warmer, lighter water to lower depths, but only to a limited extent. Thus begins the formation of the thermocline and another period of summer thermal stratification.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem since most organisms require oxygen to survive. As shown in Figure 2, during the current study period, dissolved oxygen levels were generally higher at the surface of Geneva Lake, where there was an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels were lowest on the bottom of the Lake, where decomposer organisms and chemical oxidation processes utilize oxygen in the decay process. When any lake becomes thermally stratified, as described above, the surface supply of dissolved oxygen to the hypolimnion is cut off. Gradually, if there is not enough dissolved oxygen to meet the total demands from the bottom dwelling aquatic life and decaying organic material, the dissolved oxygen levels in the bottom waters may be reduced, even to zero, a condition known as anoxia or

Figure 2

DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR GENEVA LAKE: 1997-2005

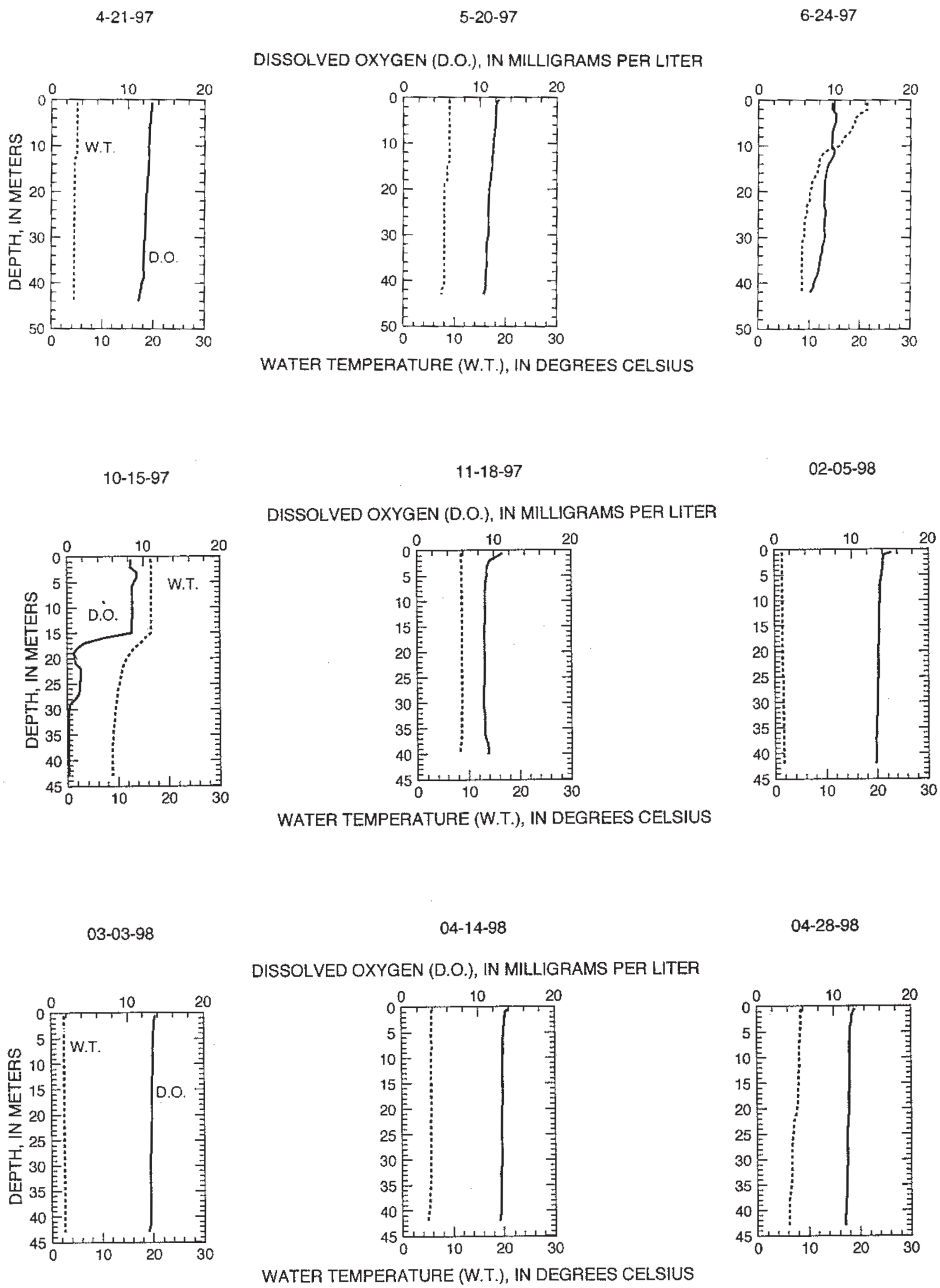


Figure 2 (continued)

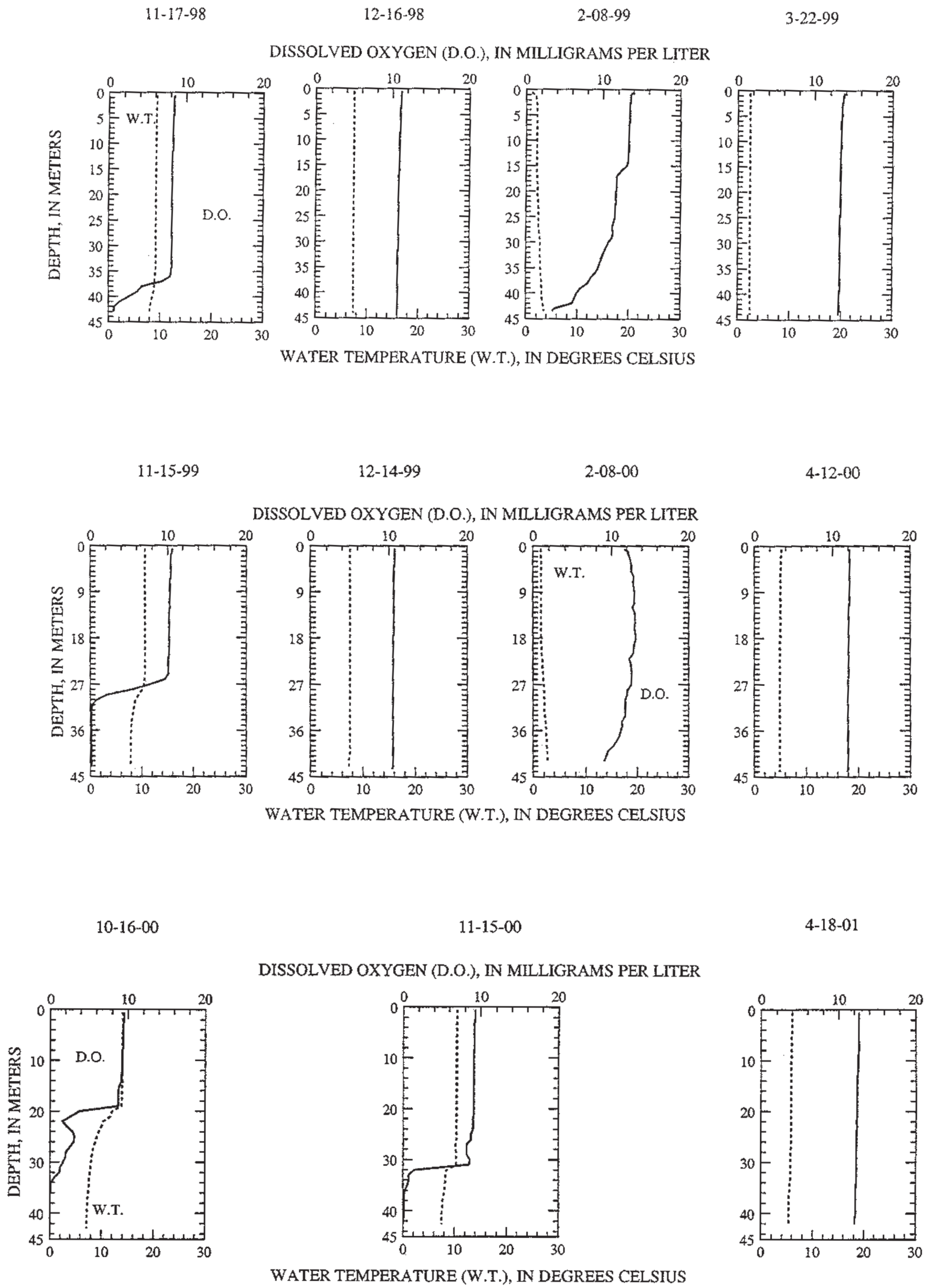


Figure 2 (continued)

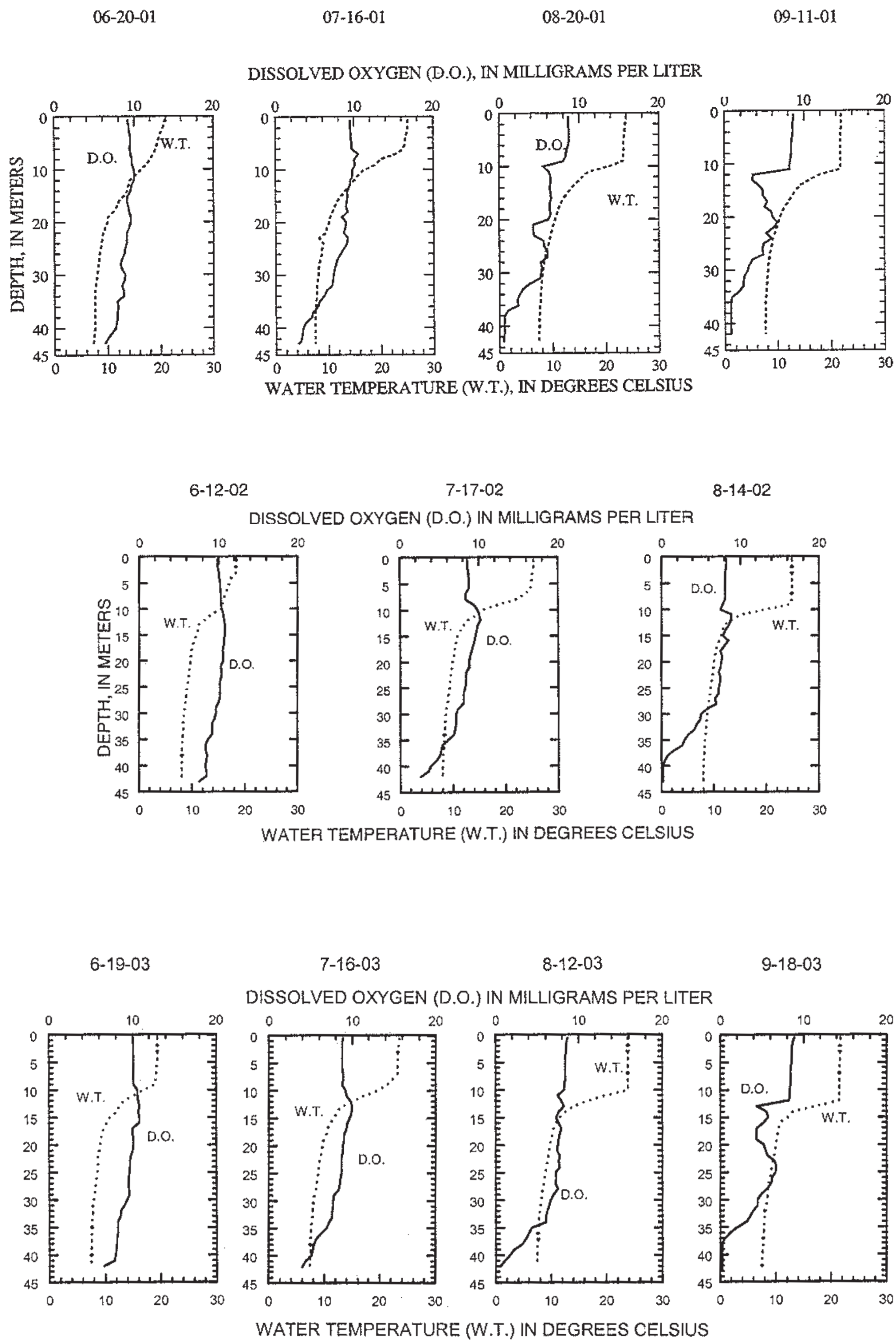
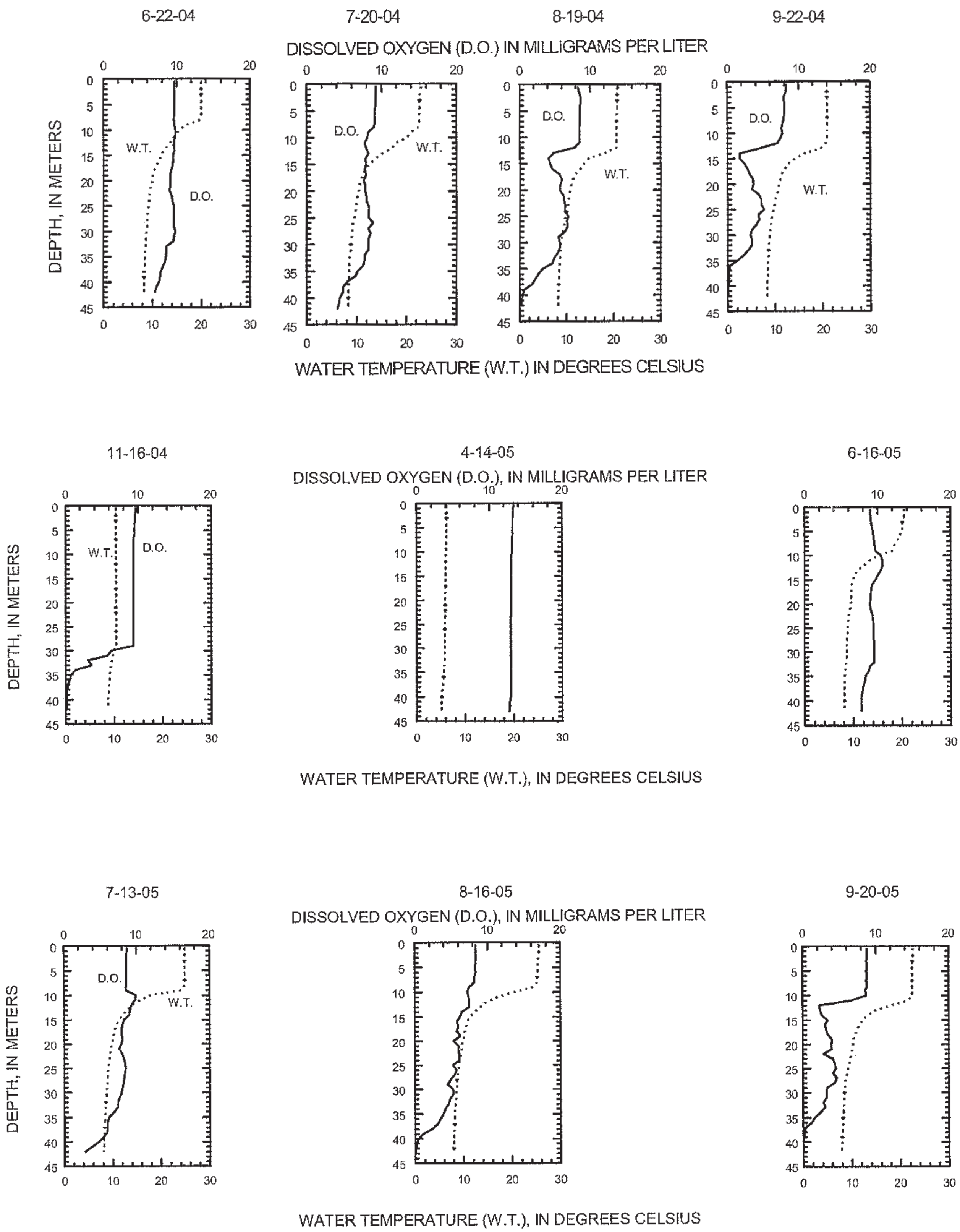


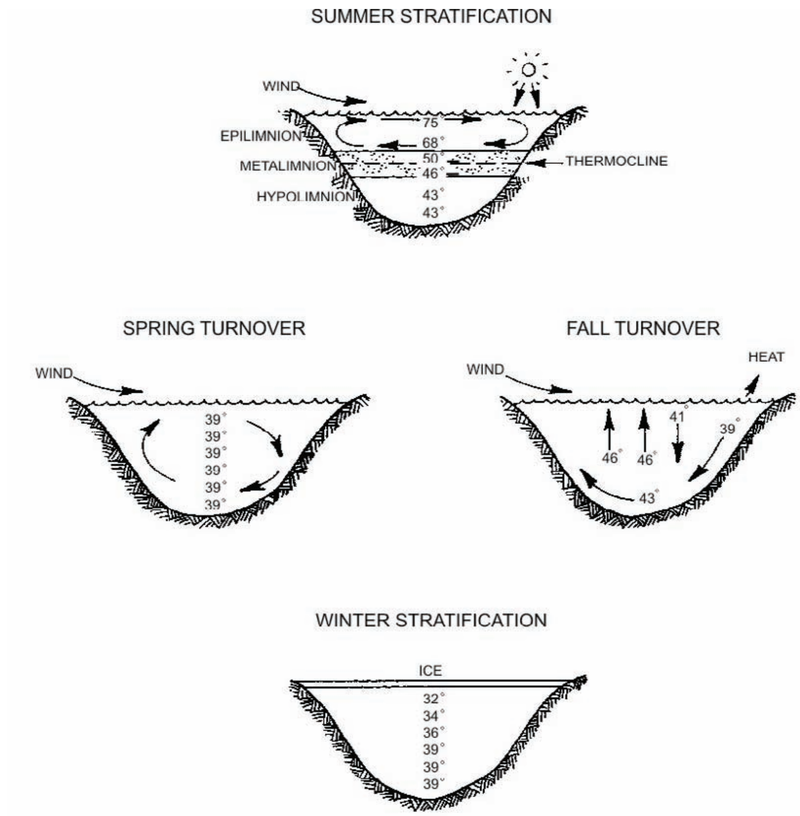
Figure 2 (continued)



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

Figure 3

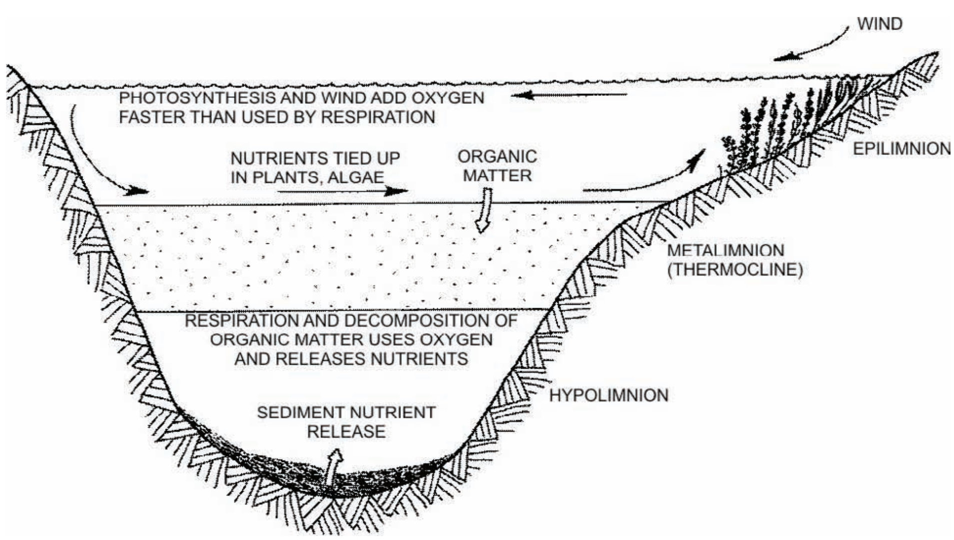
THERMAL STRATIFICATION OF LAKES



Source: University of Wisconsin-Extension and SEWRPC.

Figure 4

LAKE PROCESSES DURING SUMMER STRATIFICATION



Source: University of Wisconsin-Extension and SEWRPC.

Table 14

AVERAGE FREEZE AND BREAKUP DATES OF ICE ON GENEVA LAKE: 1862-2002

Years	Average Freeze Date	Average Breakup Date	Average Number of Days of Ice Cover
1862-1872	December 21	April 4	105
1872-1882	December 19	April 1	104
1882-1892	December 28	March 31	93
1892-1902	December 23	April 3	99
1902-1912	January 10	March 31	81
1912-1922	January 9	March 25	75
1922-1932	January 14	March 31	75
1932-1942	January 18	April 1	73
1942-1952	January 2	April 2	90
1952-1962	December 30	April 1	83
1962-1972	December 27	April 6	101
1972-1982	December 28	April 1	95
1982-1992	January 1	March 23	82
1992-2002	January 1	March 17	64

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

anaerobiasis, as shown in Figure 4. Periods of hypolimnetic oxygen depletion in Geneva Lake were reported during 1976 in the earlier SEWRPC report, and during 1988 and 1989 by the WDNR. Water quality data from the late summer-early fall of 1997 and 2000, collected as part of the aforementioned collaborative study,[5] indicate periods of total oxygen depletion in the hypolimnion of Geneva Lake, mostly in the deepest area of the west end sampling site, although during the late summer-early fall of 1997 the deepest areas in the east end and center sampling sites also exhibited a condition of total oxygen depletion.

Fall turnover, between September and October in most years, naturally restores the supply of oxygen to the bottom water, although hypolimnetic anoxia can be reestablished during the period of winter thermal stratification. Winter anoxia is more common during the years of heavy snowfall, when snow covers the ice, reducing the degree of light penetration and reducing algal photosynthesis that takes place under the ice. In some lakes in the Region, hypolimnetic anoxia does occur during winter stratification. Under these conditions, anoxia can contribute to the winter-kill of fish. At the end of winter, dissolved oxygen concentrations in the bottom waters of the lake are restored during the period of spring turnover, which generally occurs between March and May.

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

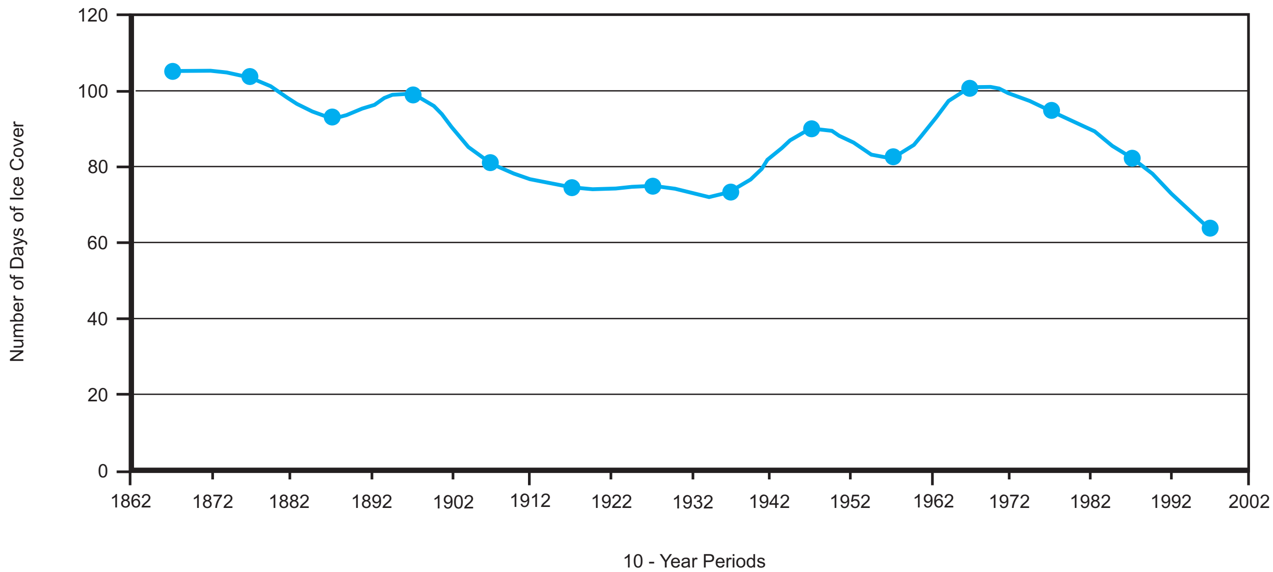
As reported in the initial SEWRPC report, winter concentrations of dissolved oxygen in Geneva Lake exceeded 5.0 milligrams per liter (mg/l)[6], a concentration level considered necessary to support aquatic life. However, during the summer stratification period, dissolved oxygen was depleted in the hypolimnion to below that

[5]Ibid.

[6]*Reported in the initial report as the equivalent unit of parts per million or ppm.*

Figure 5

AVERAGE NUMBER OF DAYS OF ICE COVER PER DECADE ON GENEVA LAKE: 1862-2002



Source: U.S. Geological Survey, Geneva Lake Environmental Agency, and SEWRPC.

threshold. Dissolved oxygen concentrations in the hypolimnion reached the critical level of 5.0 mg/l in late July, and it was estimated that the largest volume of poorly oxygenated water existed in early October, just prior to the fall turnover. During this latter period, lake water in Fontana Bay below 121 feet was completely devoid of oxygen and water below the 46-foot depth contained less than 5.0 mg/l. Consequently, during summer stratification, Geneva Lake had sufficient oxygen levels to support fish to a depth of about 50 feet, a volume representing about 60 percent of the total volume of the Lake. Both the Williams Bay and Geneva Bay sampling locations experienced low levels of dissolved oxygen at about the same depths as Fontana Bay, with dissolved oxygen levels reaching the critical level of 5.0 mg/l below 50 feet in both bays during summer stratification.

In addition to 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 release of phosphorus, or "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 importance of internal loading to the nutrient budget of Geneva Lake was examined during the aforementioned three-year collaborative study and 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.[7] Additionally, during periods of thermal stratification, specific conductance can increase at

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

the lake bottom due to an accumulation of dissolved materials in the hypolimnion. This is a consequence of the "internal loading" phenomenon noted above. As noted in the earlier SEWRPC report, specific conductance in the Lake, during the spring of 1976 through the winter of 1977, ranged from about 380 μS/cm to 430 μS/cm, which was somewhat lower than many other lakes in the Region. As shown in Table 10, specific conductance in the West Bay of the Lake, during the more recent period from 1997 to 2004, ranged from about 470 μS/cm to 550 μS/cm. Table 11 indicates a range for specific conductance of between about 475 μS/cm to 525 μS/cm in the East Bay of the Lake during the period from 1997 through 2000. As shown in Table 12, specific conductance during spring turnover in the West Bay of the Lake, between 1997 and 2004, ranged from about 500 μS/cm to 515 μS/cm. These specific conductance measurements for the areas sampled in Geneva Lake are within the normal range of values.

Specific conductance values for the nine perennial tributary streams during the initial study period, as shown in Table 13, ranged from about 610 μS/cm to 1,080 μS/cm, with the lowest value being found in Trinke Creek and the highest value in Buena Vista Creek. Values for a further six intermittent tributary streams during the initial study period ranged from about 595 μS/cm to 715 μS/cm. These ranges of values for the perennial and intermittent tributary streams were somewhat higher than the range of about 380 μS/cm to 430 μS/cm reported for the Lake during about the same time period, but are considered to be within the range of expected values for stream systems in southeastern Wisconsin.

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.[8] 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 the more populated and urban southeastern region averaged about 19 mg/l as contrasted with about 2.0 mg/l in the northeastern and northwestern regions of the State, about 4.0 mg/l in the central region, and about 7.0 mg/l in the southwestern region.[9]

During the initial SEWRPC study, chloride concentrations in Fontana Bay during the spring of 1976 through the winter of 1977 ranged from about 13 to 14 mg/l. Average chloride concentrations ranged: from about 35 to 36 mg/l in the West Bay during the period from 1997 through 2004, as shown in Table 10, and from about 33 to 35 mg/l in the East Bay during the period from 1997 through 2000, as shown in Table 11. As shown in Table 12, average spring overturn chloride concentrations in the West Bay ranged from about 33 to 37 mg/l. This trend toward increasing chloride concentrations is typical of many lakes in southeastern Wisconsin, as shown in Figure 6.

Average chloride concentrations for the nine perennial streams tributary to Geneva Lake during the initial study period are shown in Table 13. Although there is a substantial range in these values, from a low of about 15 mg/l in

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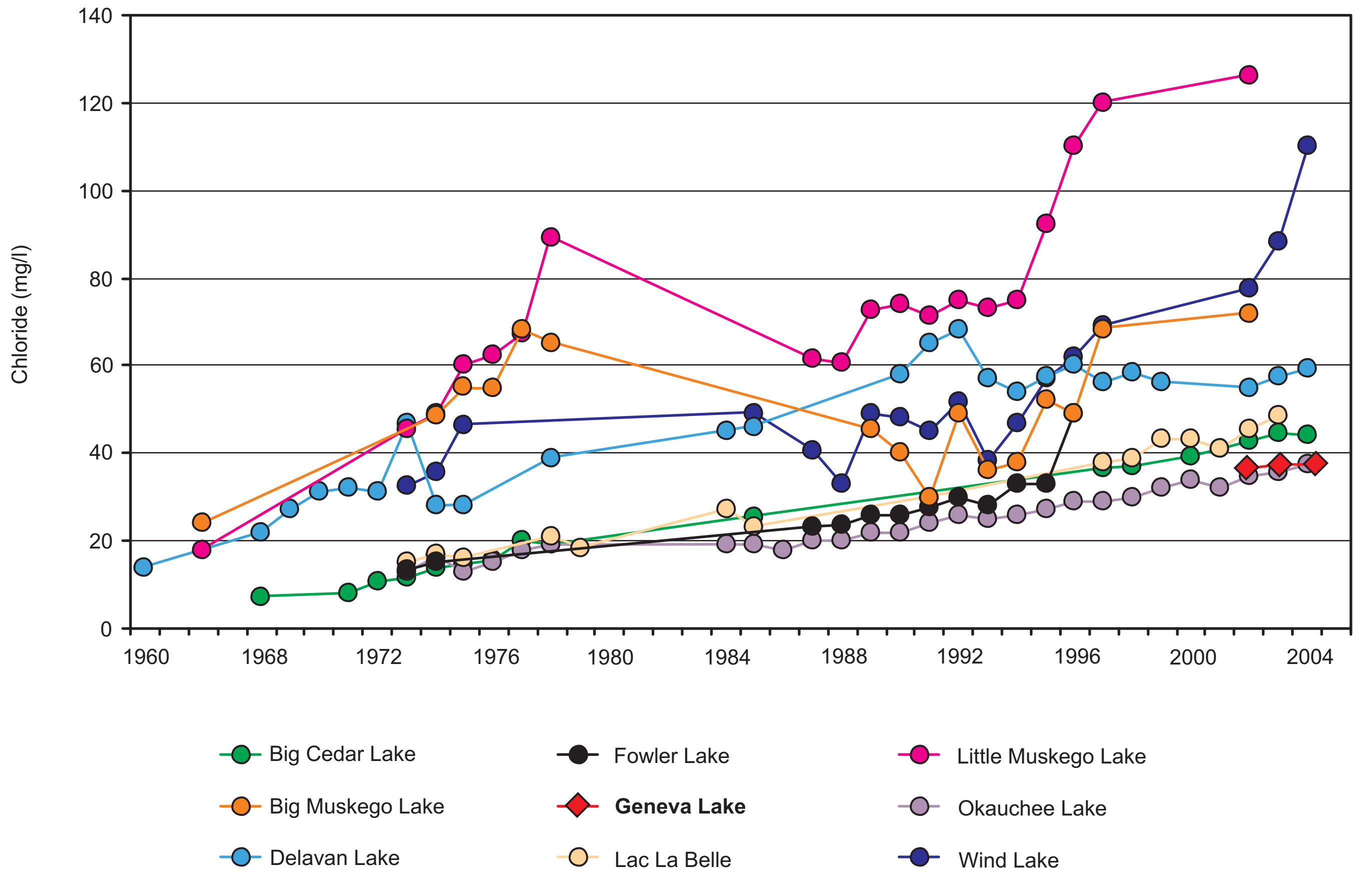
[8] *Frits van der Leeden, Fred L. Troise and David Keith Todd,* The Water Encyclopedia, Second Edition, *Lewis Publishers 1990.*

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

Figure 6

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



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

Trinke Creek to a high of about 168 mg/l in Buena Vista Creek, the three creeks with the largest tributary areas, Birches, Southwick, and Buttons Bay, had chloride concentrations of about 16, 28, and 48 mg/l, respectively.

The WDNR, as part of the National Atmospheric Deposition Program/National Trends Network, has operated a precipitation monitoring station at Geneva Lake since 1984, the purpose of which is to collect precipitation chemistry data in order to develop geographical and temporal long-term trends. A trend plot for samples collected at the Lake Geneva monitoring station indicates a gradually decreasing trend in chloride concentrations in precipitation from 1984 to the present.[10]

Alkalinity and Hardness

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 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

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

Wisconsin typically have a high alkalinity, with an average concentration of about 173 mg/l expressed as calcium carbonate.[11]

Wisconsin Department of Natural Resources data for Geneva Lake during the period from 1968 to 1975 show an average alkalinity of about 186 mg/l. As shown in Table 11, spring overturn measurements of alkalinity in the East Bay of Geneva Lake during the period from 1997 to 2000 averaged about 189 mg/l; Table 12 shows spring measurements of alkalinity in the West Bay for period from 1997 to 2004, which averaged about 189 mg/l. The alkalinity values for Geneva Lake are within the range of values commonly observed in lakes in southeastern Wisconsin.

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.[12] Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$). Although hardness measurements were not included in the initial SEWRPC report, WDNR data for the period from 1969 to 1972 indicated an average hardness of about 243 mg/l. As shown in Table 11, spring overturn measurements of hardness in the East Bay of Geneva Lake for the period from 1997 to 2000 averaged about 220 mg/l; Table 12 shows spring measurements of hardness in the West Bay for the period from 1997 to 2004 which also averaged about 220 mg/l.

Applying measurements of alkalinity and hardness to the study lake, Geneva Lake may be classified as a hard water-alkaline lake, which is typical of most lakes in southeastern Wisconsin.

Alkalinity and hardness were not measured in the streams tributary to Geneva Lake during either the initial or current study periods.

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.[13]

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.[14] 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

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

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

[13] Ibid.

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

about 6.9.[15] 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 Geneva Lake and other lakes in the Region.

In Geneva Lake, during the initial SEWRPC study, the pH in Fontana Bay was found to range between 8.0 and 8.2 standard units. As shown in Table 10, measurements of pH in the West Bay of Geneva Lake from 1997 to 2004 ranged from 7.3 to 8.6 with an average of about 8.1; Table 11 shows pH measurements in the East Bay from 1997 to 2000, which ranged from 7.4 to 8.7 with an average of about 8.2. Spring overturn measurements for the West Bay from 1997 to 2004, as shown in Table 12, indicated an average pH of about 8.3.

Measurements of pH for the perennial streams tributary to Geneva Lake are shown in Table 13. The pH ranged from 7.4 to 8.4, while the pH values for six intermittent streams ranged from 7.6 to 8.2. The pH values for Geneva Lake and its tributary streams all are within the range of values commonly observed in lakes in southeastern Wisconsin. Since Geneva Lake has a relatively high alkalinity or buffering capacity, and because the pH does fluctuate below 7, the Lake is considered to not be susceptible to the harmful effects of acidic deposition.

The pH of rain in the Southeastern Wisconsin Region is typically in the 4.4 range.[16] 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 recent years.[17]

Water Clarity

Water clarity, or transparency, is often used as an indication of overall water quality. In a 1999 survey of Geneva Lake users, 29 percent of respondents, the largest category, indicated that water clarity was the most important factor for them in determining water quality.[18] 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 typically 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. In the aforereferenced use survey, 70 percent of respondents felt that water clarity was best in Geneva Lake during the spring of the year. But, water clarity can also vary from region to region in the State 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.[19]

Secchi-disc depth measurements reported in the initial SEWRPC study for Geneva Lake ranged from a low of 9.6 feet in the summer of 1976 to a high of 18.0 feet in the winter of 1977, with an average of 12.1 feet. During the

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

[16]Ibid.

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

[18]*Geneva Lake Environmental Agency,* A Report on the Geneva Lake Use Survey, *October 1999.*

[19]Ibid.

current study period (1997-2004), Secchi-disc readings for the West Bay of Geneva Lake, as shown in Table 10, ranged from a minimum of 5.6 feet to a maximum of 30.8 feet, with an average of about 16.2 feet, well above the average for lakes in the Region. Secchi-disc readings during the current period for the East Bay of Geneva Lake, as shown in Table 11, also indicated above average clarity with readings ranging from a low of 5.9 feet to a high of 23.6 feet, with an average of 15.2 feet.

Seasonal variations in Secchi disk measurements, as shown in Tables 10 and 11, indicate a trend of gradually diminishing Secchi-disc depths as the seasons progress from winter, when Secchi-disc readings are typically highest, through spring and summer. This pattern is reinforced in Table 12 which shows Secchi-disc readings during the spring turnover periods from 1997 to 2004 for the West Bay of Geneva Lake. Lower Secchi-disc readings in spring are not unusual for lakes in the region, and reflect the growths of algae and zooplankton during the warmer months as well as the effects of surface runoff from the tributary area and inflows into the lakes. As shown in Figure 7, during the recent study period, average Secchi-disc readings indicate very good water quality in Geneva Lake.

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. Geneva Lake, during the current study period, consistently had low water color measurements with values generally below 10, far below the average of 46 for lakes in the Region, indicating that Geneva Lake has clearer water than most lakes in the southeastern Wisconsin.[20] This was reinforced by low turbidity measurements for Geneva Lake taken during the current study period. Measured values of turbidity in Geneva Lake were significantly lower than the average for lakes in the Southeastern Wisconsin Region, indicating clearer water than most of the lakes in the Region.

Historically, Geneva Lake has been known for its clear water; the original Pottawatomie Indian name for the Lake was "Kishwauketoe", which meant "clear water".[21] 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. This species was first observed in Geneva Lake in October of 1995 and its population in the Lake has been the subject of several GLEA surveys taken in 1996, 2000, and 2004,[22] the results of which will be discussed in Chapter V of this report.

The various water clarity parameters discussed above were not measured in the streams tributary to Geneva Lake during either the initial or current study periods.

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 μg/l.[23] In the initial study, chlorophyll-*a* concentrations from fall of

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

[21]*U.S. Geological Survey Water-Resources Investigations Report 02-4039,* op. cit.

[22]*Jennifer Church, Geneva Lake Environmental Agency,* 2004 Updated Status of *Dreissena polymorpha* and its Invasive Effects on the Littoral Macroinvertebrates in Geneva Lake, Wisconsin, *2004.*

[23]Ibid.

Figure 7

PRIMARY WATER QUALITY INDICATORS FOR GENEVA LAKE: 1969-2005

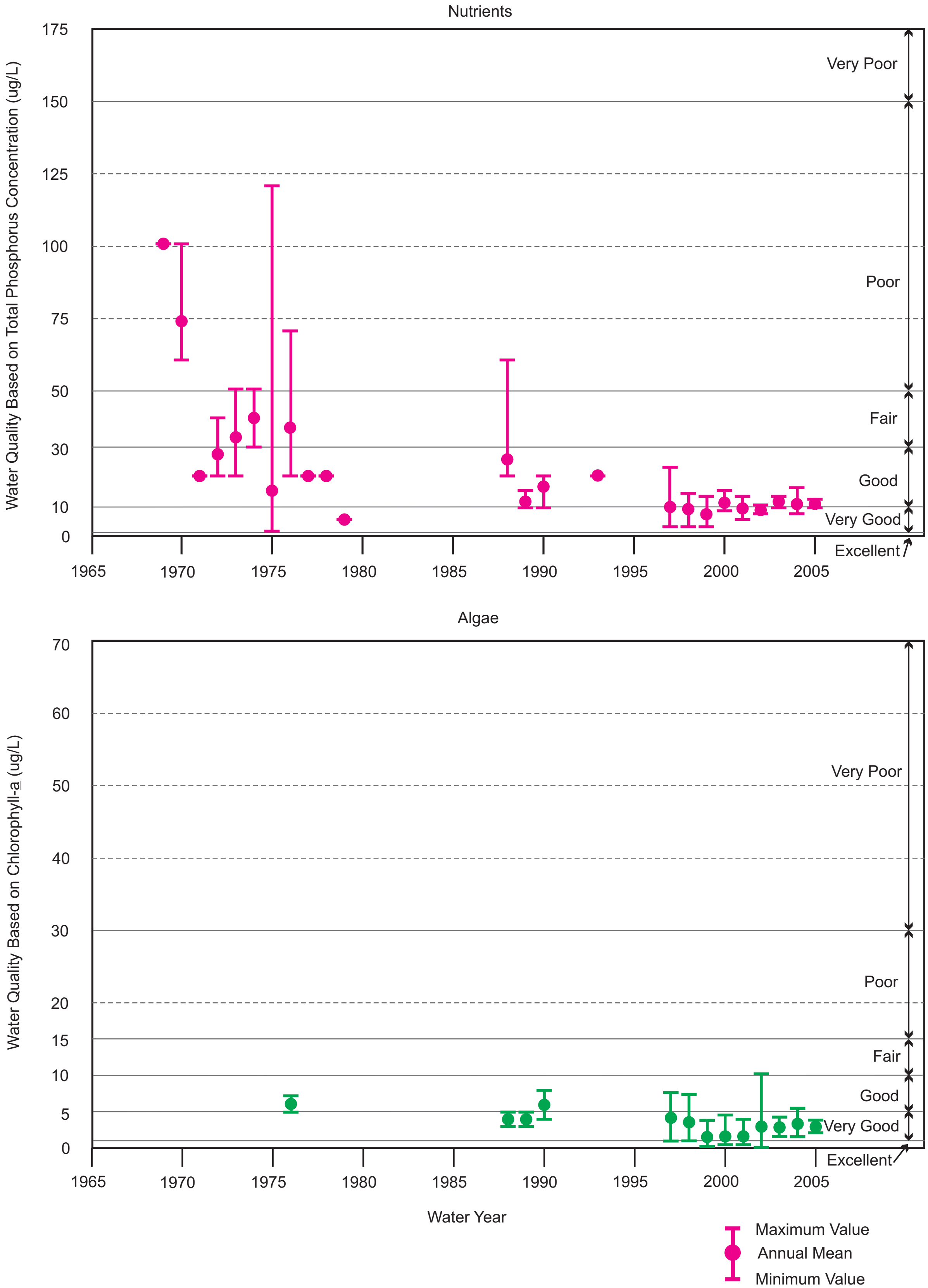
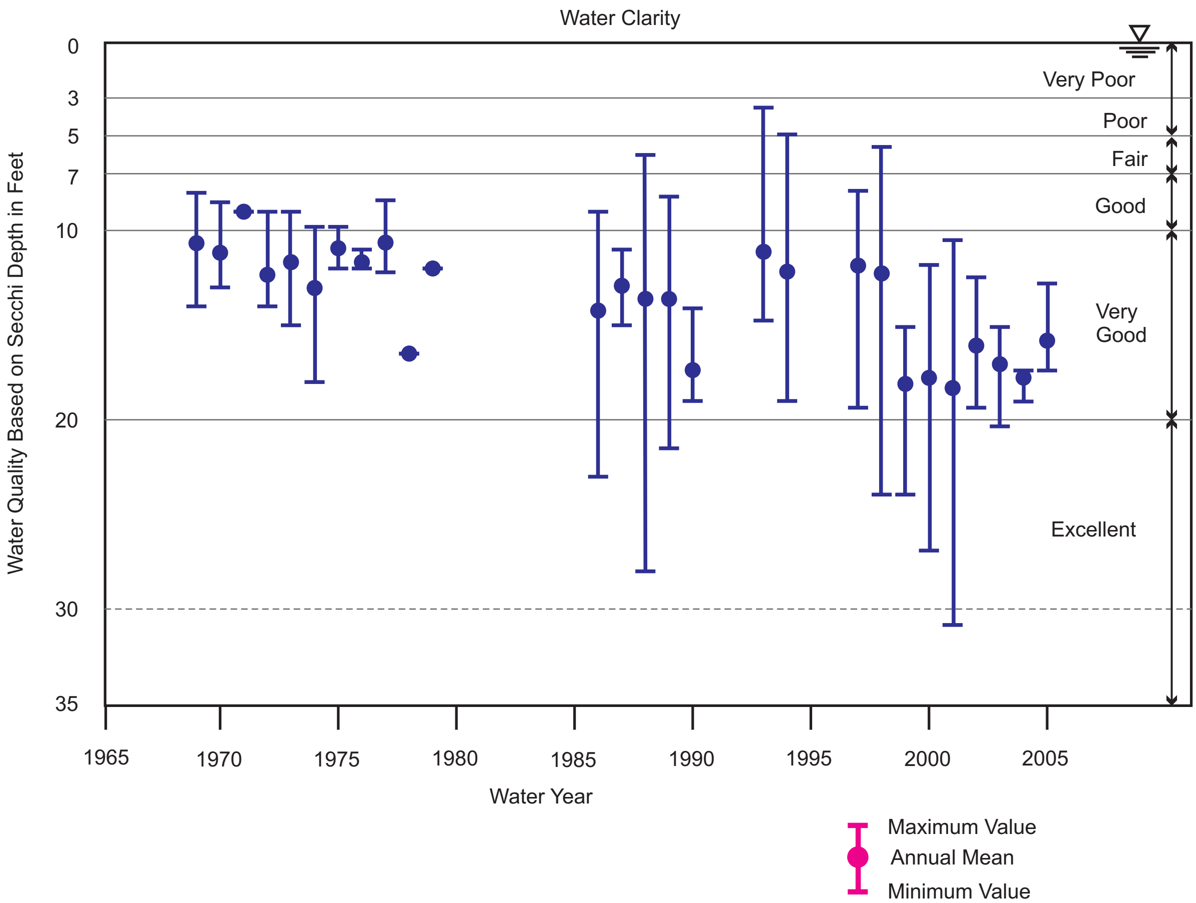


Figure 7 (continued)



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

1976 to spring of 1977 averaged 4.8 µg/l. During the aforementioned collaborative study, annual average chlorophyll-*a* concentrations gradually decreased from about 4.6 µg/l in 1997 to about 1.5 µg/l in 2000.[24] During the current study period, as shown in Tables 10 and 11, spring chlorophyll-*a* concentrations averaged about 3.6 µg/l in the West Bay of Geneva Lake and 3.3 µg/l in the East Bay. Table 12 shows an average chlorophyll-*a* concentration of about 2.8 µg/l during spring turnover in the West Bay. During the current study period, mean chlorophyll-*a* concentrations were generally below 10 µg/l. Chlorophyll-*a* levels above about 10 µg/l result in a green coloration of the water that may be severe enough to impair recreational activities such as swimming and waterskiing.[25] As shown in Table 10, seasonal variations of chlorophyll-*a* in the West Bay indicated a slight drop in average amount of chlorophyll-*a* from about 3.7 µg/l during the spring to about 2.8 µg/l during the summer. Table 11 shows a similar decrease in the East Bay. These values are within the range of chlorophyll-*a* concentrations recorded in other lakes in the Region[26] and indicate very good water quality, as illustrated in Figure 7.

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[24]*U.S. Geological Survey Water-Resources Investigations Report 02-4039,* op. cit.

[25]*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.*

[26]*Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

Chlorophyll-*a* concentrations were not measured in the streams tributary to Geneva Lake during either the initial or current study periods.

Nutrient Characteristics

Aquatic plants and algae require such nutrients as phosphorus and nitrogen for growth. In hard-water alkaline lakes, most of these nutrients are generally found in concentrations that exceed the needs of growing plants. However, in lakes where the supply of one or more of these nutrients is limited, plant growth can be limited by the amount of that nutrient available. The ratio of total nitrogen (N) to total phosphorus (P) in lake water indicates which nutrient is the factor most likely limiting aquatic plant growth in a lake.[27] 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. The nitrogen-to-phosphorus ratios in samples collected from Geneva Lake during the initial study period were mostly equal to or greater than 14:1, indicating that aquatic plant growth in Geneva Lake was most likely limited by phosphorus during the peak growing periods. During the current study period, as shown in Table 15, nitrogen-to-phosphorus ratios for the West Bay of Geneva Lake were nearly always well above the 14:1 ratio, indicating that during the current study period phosphorus was, again, the limiting factor during spring. Additionally, the summer N:P ratio for the West Bay during the current study period, as based on Table 10, was greater than 14:1, indicating that summer aquatic plant growth in Geneva Lake is also generally limited by phosphorus. Seasonal water quality data for the East Bay of Geneva Lake, as presented in Table 11, result in nitrogen-to-phosphorus ratios consistent with those discussed above for West Bay.

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 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 Geneva Lake, during the period 1976 through 1977, the mean concentration of total phosphorus near the surface was about 26 μg/l on an average annual basis, and about 40 μg/l on an average annual basis in the bottom waters. The combined average annual concentration of total phosphorus was about 31 μg/l. The current recommended water quality guideline for phosphorus in lakes, set forth in the adopted regional water quality management plan, is 20 μg/l of total phosphorus or less during spring turnover. This is the level considered in the regional plan as necessary to limit algal and aquatic plant growth to levels consistent with the requirements of full-body contact recreational and warmwater fishery and other aquatic life water use objectives. During the initial study period, Geneva Lake had total phosphorus levels in excess of these guidelines, indicating that there was sufficient phosphorus in the Lake to support periodic nuisance algal blooms.

During the current study period, as shown in Table 12, measurements of total phosphorus concentrations in both surface waters and bottom waters during the spring turnover in the West Bay of Geneva Lake generally fell within the recommended water quality guidelines for phosphorus and indicate very good water quality conditions. As shown in Table 10, average total phosphorus concentrations in the surface waters of West Bay of Geneva Lake dropped from an average of 10 μg/l during the spring to an average of about 8.0 μg/l during the summer. Total phosphorus concentrations then increased slightly in the fall to about 9.0 μg/l before dropping to about 7.0 μg/l during the winter. These values indicate generally very good to excellent water quality conditions in the surface waters of West Bay during the current study period. Total phosphorus concentrations were found to be higher in the bottom waters over these same periods, with a spring average of 13 μg/l, a summer average of 55 μg/l, an autumn average of 52 μg/l, and a winter average of 15 μg/l.

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[27]*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.*

Table 15

NITROGEN-PHOSPHORUS RATIOS FOR GENEVA LAKE WEST BAY: 1997-2004

Date	Nutrient Levels		
	Nitrogen (mg/l)	Phosphorus (mg/l)	N:P Ratio (mg/l)
April 21, 1997	0.55	0.018	30.6
April 14, 1998	0.49	0.011	44.5
April 13, 1999	0.05	0.008	6.3
April 12, 2000	0.71	0.013	54.6
April 18, 2001	0.36	0.010	36.0
April 17, 2002	0.48	0.009	53.3
April 14, 2003	0.36	0.011	32.7
April 13, 2004	0.38	0.011	34.5

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

In the East Bay, during the present study, as shown in Table 11, average total phosphorus concentrations in the surface waters dropped from 11.0 μg/l in spring to 8.0 μg/l in summer, and to 7.0 μg/l in autumn. Winter average total phosphorus concentrations were 8.0 μg/l. Total phosphorus concentrations in bottom waters in East Bay were generally somewhat higher than the surface concentrations over the same time periods with spring and summer averages of 10 μg/l, a fall average of 9.0 μg/l and a winter average of 13 μg/l. Total phosphorus concentrations in East Bay during the current study period indicate very good to excellent water quality conditions.

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 are decomposed 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. 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; a process known as "internal loading". This process also occurs under aerobic conditions, but generally at a slower rate than under anaerobic conditions. As the waters mix, this phosphorus may be widely dispersed throughout the lake waterbody and become available for algal growth, particularly if the rate of mixing is on the order of hours rather than days.[28] Dissolved oxygen data during the current study period tend to support the possibility of internal loading of phosphorus from the bottom sediments of Geneva Lake in the deeper West Bay. However, it was the conclusion of the collaborative study that internal loading of phosphorus does not contribute significant quantities of phosphorus to the Lake and, consequently, does not contribute to the productivity of the Lake.

Average annual concentrations of total phosphorus in the perennial streams tributary to Geneva Lake during the initial study period are presented in Table 13. Values range from 24 μg/l in Gardens Creek to 1,430 μg/l in Buttons Bay (Big Foot) Creek. These values, although generally somewhat higher than those in the main lake basin, are consistent with expected values, based, in part, on the nature of the lands and surface features that are drained by these creeks. Total phosphorus values during the initial study period for the six intermittent streams tributary to Geneva Lake are generally somewhat higher than those for the perennial counterparts, but this may be

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[28]*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.*

attributed to the fact that the intermittent streams flowed only during periods of heavy precipitation when large quantities of runoff carrying accumulated contaminants are introduced into the streams. During the initial study period, overall water quality in the intermittent streams was generally similar and was not considered a significant source of pollutants to Geneva Lake; water quality parameters for the intermittent streams was not measured during the current study period.

CHARACTERISTICS OF BOTTOM SEDIMENT

Sediment composition has an important effect on the biogeochemistry of a lake. Sediment particles serve as transport mechanisms for nutrients, especially phosphorus, as well as for a variety of pollutants, and play a key role in establishing benthic habitat and macrophyte substrate.

As part of the initial study, sediment transfer to Geneva Lake from its tributaries and storm sewers was measured, and atmospheric sediment loading was estimated. Shoreline erosion, although evident in some areas, was not considered to be of sufficient magnitude to warrant quantification. The initial study did not examine the chemical make-up of the bottom sediments of Geneva Lake, focusing instead on the estimated amounts of sediment being delivered annually to the Lake. Sediment loading will be discussed later in this chapter.

Between 1995 and 1997, sediment core and surfacial sediment samples were collected and analyzed by the WDNR and USGS. The results of the 1995 core sampling indicated that over the past 170 years there has been some deterioration of water quality, mostly assumed to be the result of urbanization.[29] The relationship between the rate of sedimentation and urbanization is suggested by the greater rate of sedimentation observed in Williams Bay and Geneva Bay relative to the rate of sedimentation in the main lake basin, although it should be noted that the rate of sedimentation in the two Bays was about average for 24 Wisconsin hard water lakes, has been much greater than the rate in the main lake basin. These increased sedimentation rates in Williams Bay and Geneva Bay are consistent with the historical urbanization trends in those areas, as earlier shown in Table 7 in Chapter III of this report. The results of the surfacial sediment analyses revealed the existence of elevated levels of some substances, particularly arsenic, copper, and zinc, and will be discussed in Chapter V of this report.

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. 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 drained lakes, like Geneva Lake, pollutant loadings transported across the land surface directly tributary to a lake, in the absence of identifiable or point source discharges from industries or wastewater treatment facilities, comprise the principal route by which contaminants enter the waterbody.[30] Currently, there are no significant point source discharges of pollutants to Geneva Lake or to the surface waters tributary to Geneva Lake. For this reason, the discussion that follows is based upon nonpoint source pollutant loadings to Geneva Lake.

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[29]*Paul J. Garrison, Wisconsin Department of Natural Resources Pub-SS-952 2000,* Paleoecological Study of Geneva Lake, Walworth County, *December 2000.*

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

Nonpoint sources of water pollution include urban sources, such as runoff from residential, commercial, transportation, construction, and recreational activities; and rural sources, such as runoff from agricultural lands and onsite sewage disposal systems. In the aforereferenced GLEA report on the survey of Geneva Lake users, of the top five sources that respondents felt contributed strongly to water pollution in Geneva Lake, four of them, fertilizers, stormwater, pesticides, and septic systems, were from nonpoint sources.

Atmospheric Loading

As part of the initial report, contributions of nitrogen and phosphorus as dry fallout in particulate matter from the atmosphere were measured. The results of these samplings indicated that, during the initial study period, the average atmospheric nutrient loading rates to Geneva Lake were similar to those reported from sites throughout southern Wisconsin, although the total nitrogen atmospheric loading rate appeared to be slightly lower than the regional average possibly as a result of the below average precipitation rate during the initial study period.

Storm Event and Snowmelt Runoff Loading

In the initial SEWRPC report, an evaluation of changes in the water quality of the tributary streams and storm sewers during spring snowmelt runoff and storm events was important in assessing the introduction of pollutants to Geneva Lake. Taking into account various factors such as the below average precipitation during the initial study year, the relatively small tributary area of Geneva Lake, the frozen or thawed condition of the ground during snowmelt and storm events, and the amount of vegetative cover in the tributary and subtributary areas, the results of tributary stream and storm sewer monitoring indicated that the level of pollutants in the storm sewer discharges exceeded the concentrations of pollutants transported by all water sources entering Geneva Lake. However, because of their continuous discharge, the perennial streams contributed a great mass of pollutants to Geneva Lake, even though none of the concentrations measured from the tributary streams were high enough to be considered serious sources of pollution. The intermittent streams, which exhibited low discharge rates, did not appear to be a major source of pollutants to the Lake. The primary contaminants transported to Geneva Lake by the tributary streams and storm sewers were nutrients, nitrogen and phosphorus, in various forms.

As reported in the initial study, rainfall events and snowmelt runoff both generally resulted in above normal concentrations of most contaminants entering Geneva Lake from the tributary streams and storm sewers:

- Rainfall runoff had higher levels of most contaminants, except for suspended solids and total dissolved solids (measured as specific conductance), than were present in the base flows of both perennial and intermittent streams.

- Stormwater discharges from storm sewers had higher levels of most contaminants, except for total dissolved solids, than were present in the base flows of both perennial streams.

- Snowmelt had higher levels of most contaminants, except for total dissolved solids, than were present in the base flows in perennial streams.

- Stormwater discharges from storm sewers had higher levels of all contaminants, except for suspended solids, total dissolved solids, and nitrate/nitrite-nitrogen, than were present in snowmelt.

- Snowmelt had higher levels of all contaminants than were present in rainfall events.

Nonpoint Source Pollution Loading

In 1994, the GLEA and the GLC, with the financial support of the WDNR through a Chapter NR 190 Lake Management Planning Grant, completed an assessment of nonpoint source pollution loadings to Geneva Lake.[31] Using the Agricultural Nonpoint Source Pollution (AGNPS) model, the model forecast water and pollutant

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[31] *Geneva Lake Environmental Agency,* The Use of the AGNPS Model Within the Geneva Lake Watershed, Walworth County, Wisconsin, *March 1994.*

loadings from the three major perennial tributary subwatersheds to Geneva Lake: Southwick, Birches, and Big Foot (Buttons Bay) Creeks. Stormwater runoff volumes for five different storm events, design storms, were modeled, as well as stormwater quality. Several standard water quality parameters were analyzed using the model. The model was able to correctly predict the consequences of the five design storm events in the Birches Creek subwatershed, the most agricultural of the three tributary areas, which contributed the highest soluble nutrient loadings to the Lake. The model also predicted the likelihood of a significant increase in sediment and nutrient loadings to Geneva Lake from the Birches Creek tributary area in the event that the then-undeveloped land in the tributary area was converted to urban residential or agricultural uses. The AGNPS analysis also suggested that the Southwick Creek tributary area, which included both urban and agricultural land uses, contributes the highest sediment, and related particulate nitrogen and phosphorus, loads to Geneva Lake. However, the AGNPS model was unable to accurately assess the effects of the retention/detention ponds in this tributary area. In the Big Foot Creek tributary area, the AGNPS model produced the greatest hydrologic response to the modeled storm events. It was not clear whether these results were due to the large size of the tributary area or to the way the computer utilized information regarding the extensive area of wetland within the tributary area. Further study of this topic was recommended.

Consequently, during the current study period, data on water quality and contaminant loadings from major tributaries to Geneva Lake, in particular Southwick Creek, Birches Creek, and Buttons Bay (Big Foot) Creek, were gathered during the collaborative study. Total phosphorus concentrations in Southwick Creek, which has a tributary area with mixed land uses, and Birches Creek, the largest of the Geneva Lake tributary areas and dominated by agriculture, were both strongly related to flow. Total phosphorus concentrations in Buttons Bay Creek, which has a tributary area containing significant amounts of wetlands, were more associated with seasonality. During base flow, phosphorus concentrations in Southwick and Birches creeks were both below 70 micrograms per liter (μg/l); during higher flows, concentrations in Southwick Creek ranged from 500 to 3,600 μg/l and in Birches Creek ranged from 500 to 9,000 μg/l. Seasonal variations of total phosphorus in Buttons Bay Creek ranged from 70 to 100 μg/l during fall, winter, and early spring, then increased in summer to about 1,200 to 1,500 μg/l before declining again in the fall.

In addition to Southwick, Birches, and Buttons Bay Creeks, 23 additional sites were sampled for flow and total phosphorus concentrations but on a much less frequent basis. Of note was the drop in levels of total phosphorus in Buena Vista Creek. Total phosphorus concentrations during the initial study period routinely as high as 1,500 μg/l, dropped to levels that, during the current study period, never rose above 50 μg/l.

As was determined for phosphorus, sediment loadings in Southwick and Birches creeks were closely related to flow. During base flow, suspended sediment concentrations in both streams were below 100 mg/l. During higher than base flows, concentrations of sediments increased dramatically in these two streams: in Southwick Creek during higher flows suspended sediment concentrations were commonly about 1,000 mg/l, but were as high as 5,600 mg/l; in Birches Creek during higher flows concentrations of suspended sediments were commonly about 500 mg/l, but were as high as 18,000 mg/l.

Nitrogen Loadings

In the initial SEWRPC report, of the approximately 122,200 pounds of nitrogen that entered Geneva Lake during the study year, about 70 percent was in the form of inorganic nitrogen, with the balance being in the form of organic nitrogen. Atmospheric dustfall and precipitation were the primary sources of nitrogen, accounting for approximately 60 percent of the total; perennial streams were the second most important source, contributing about 30 percent. The remaining nitrogen was contributed through the intermittent streams, groundwater seepage and stormwater discharges. It was estimated that 10 percent of the nitrogen entering the Lake was removed from the Lake through the White River outflow, with an undetermined amount of nitrogen being taken out of the water column by fish and aquatic plants, and by deposition into bottom sediments.

Of the perennial streams, Gardens Creek contributed the largest share, approximately 55 percent, of the nitrate nitrogen load to Geneva Lake; Buena Vista Creek supplied the largest amount of ammonia nitrogen, about 35 percent, and total Kjeldahl nitrogen, about 25 percent, of any perennial stream. These concentrations were attributed, at the time of the initial study, to seepage from the Fontana Sewage Treatment Plant infiltration ponds. Nitrogen loadings from the perennial and intermittent tributary streams of Geneva Lake were not measured during the current study period.

Phosphorus Loadings

Phosphorus has been identified in both initial and current study periods as the factor generally limiting aquatic plant growth in Geneva Lake. Excessive levels of phosphorus in the Lake could lead to conditions that interfere with the desired uses of the Lake. During the initial study, existing 1975 and forecast year 2000 phosphorus sources to the Lake were identified and quantified using SEWRPC 1975 land use inventory data; SEWRPC planned year 2000 land use data, derived from the adopted regional land use plan; and the SEWRPC water quality simulation model.

At the time of the initial study, dissolved phosphorus, which is the form directly available for use by plants, accounted for 5,300 pounds per year, about 55 percent, of the phosphorus entering the Lake. Perennial streams were the single most important source of dissolved phosphorus, contributing nearly 60 percent of that amount. The atmosphere was the second most important contributor, providing almost 30 percent of the phosphorus load. Of the perennial streams, over 80 percent of the dissolved phosphorus load entered the Lake from one creek, Buena Vista Creek. This was believed to be due to seepage from the infiltration ponds at the Fontana-on-Geneva Lake sewage treatment plant, a problem to be mitigated by the abandonment of this facility in 1984 as recommended in the regional water quality management plan.[32] The intermittent streams, groundwater seepage, and stormwater drains were minor contributors of phosphorus to the Lake at that time, with all three sources combined contributing about 10 percent of the dissolved and 12 percent of the total phosphorus entering the Lake.

During the initial study period, the atmosphere was the most important source of total phosphorus to the Lake, contributing over 4,700 pounds, or nearly 50 percent, of the total phosphorus load, with the perennial streams contributing about 40 percent. The percentage of total phosphorus contributed to the Lake by atmospheric fallout appeared high in comparison with the atmospheric loadings to other lakes in the Region, even though the average rate of phosphorus entering the Lake in this manner was comparable to the Regional average. This seeming contradiction can be explained by the very large surface area of Geneva Lake.

As reported in the initial SEWRPC report, the then-existing 1975 phosphorus load to Geneva Lake was estimated to be 13,270 pounds: contributions from atmospheric deposition and malfunctioning septic systems comprised about 20 percent and 15 percent, respectively, of that total, with overflows from the sewage ponds at the Fontana-on-Geneva Lake sewage treatment facility to Buena Vista Creek comprising a further 20 percent of the total load. Urban land uses accounted for 7,700 pounds, or about 60 percent, of the total amount, and rural land uses accounted for about 5,530 pounds, or 42 percent, of the total.

The Commission also estimated that under forecast year 2000 conditions, the phosphorus load to the Lake would be 8,930 pounds per year, or 30 percent less than the estimated 1975 loadings. As is noted below, this forecast is close to the observed actual 1998 phosphorus load to the Lake.[33] The decrease in the phosphorus load to Geneva Lake was predicated on the abandonment of the Fontana-on-Geneva Lake sewage treatment facility. Wastewater being treated at this facility at the time of writing of the initial plan was proposed in the regional water quality management plan to be diverted to a regional sewage treatment facility in the Town of Sharon and subsequently discharged to Picasaw Creek.

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

[33]*U.S. Geological Survey Water-Resources Investigations Report 02-4039,* op. cit.*; water years run from October through September.*

The total annual input of phosphorus to Geneva Lake during the current study period was estimated to be 7,000 pounds during water year 1998 and 18,700 pounds during water year 1999, the major sources of phosphorus being the tributaries which contributed an average of 85 percent of the total input during both years.[34] The year 1998 observed data are similar to the forecast year 2000 data calculated using the Wisconsin Lake Modeling Spreadsheet (WILMS),[35] set forth in Table 16, which suggests that, based upon long term runoff and precipitation data and land use area, that the most likely total phosphorus load to Geneva Lake would be approximately 6,975 pounds per year. Given this good agreement between predicted and observed phosphorus loadings to the Lake, the WILMS model was used to predict year 2020 phosphorus loadings based upon the same long term runoff and precipitation data and planned year 2020 land use.[36] Based upon planned land use, the anticipated year 2020 total phosphorus loading to Geneva Lake is expected to be about 6,600 pounds of phosphorus per year, which reduction in loading reflects the continuing decline of agriculture likely to occur in the Geneva Lake tributary area.

In terms of the outflow of phosphorus from Geneva Lake, during the initial study period it was estimated that small amounts of phosphorus, approximately 5 percent of the dissolved phosphorus and less than 10 percent of the total phosphorus entering the Lake, were lost through the White River outlet. The remainder of the phosphorus remained in the Lake and was utilized for biological production. In addition to losses through the lake outlet, phosphorus was estimated to be removed through chemical precipitation and/or particle absorption with subsequent deposition in the bottom sediments, and through removal of fish, plants, or other biological material from the Lake. At that time, the measured outflow of phosphorus in the White River was about 240 pounds per year of dissolved phosphorus and 600 pounds per year of total phosphorus. During the current study period, the outflow of phosphorus from the Lake was computed to be about 390 pounds for water year 1998 and 495 pounds for water year 1999.

Sediment Loadings

During the initial study period, sediment loading to Geneva Lake was estimated to total 1,714,400 pounds per year. The dominant sediment source to Geneva Lake was estimated to be atmospheric deposition and washout, which contributed 85 percent of the total during the initial study year. The remainder of the total was believed to come from the perennial and intermittent tributary streams and the storm sewers. In many lake systems, tributary streams are the major source of sediments, especially where large streams flow through the lake. However, Geneva Lake is a headwaters lake without large tributaries. The tributary area for Geneva Lake is quite small compared to the lake area and the numerous tributaries entering the lake are small, rarely exceeding one mile in length. In addition, the tributary area is generally well vegetated, soil erosion is not severe, and the volume of sediments transported to Geneva Lake by the tributary streams can be controlled, whereas atmospheric sources cannot. It was concluded during the initial study period that in general, the sediment loading to Geneva Lake was not considered excessive for a lake of its size.

Using Commission-generated unit area load relationships from the Regional water quality management planning program, year 2000 estimated sediment loads to Geneva Lake were calculated based upon then-existing land use conditions. These calculations, set forth in Table 17, indicated that approximately 3,450,000 pounds of sediment were mobilized from the land surface during that year. Based upon the hind cast 1980 sediment loading of approximately 3,575,640 pounds of sediment and the measured sediment load calculated during the initial study, a delivery rate of approximately 50 percent of the estimated load can be assumed. This would suggest that the actual delivered sediment load to Geneva Lake during the year 2000 was approximately 1,725,000 pounds.

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[34]*U.S. Geological Survey Water-Resources Investigations Report 02-4039,* Ibid.

[35]*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*, October 2003.*

[36]*Planned year 2020 land use is set forth in SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020*, December 1997.*

Table 16

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

Source	2000		2020	
	Pounds[a]	Percentage[a]	Pounds[a]	Percentage[a]
Urban				
High-Density (commercial and industrial uses)	1,323	18.9	1,922	29.2
Medium-Density (multi-family and institutional uses)	161	2.3	216	3.3
Low-Density (single-family and suburban-density residential uses)	274	3.9	355	5.4
Recreational Lands	185	2.7	223	3.4
Subtotal	1,943	27.8	2,716	41.7
Rural				
Mixed Agriculture	3,232	46.4	2,125	32.2
Row Crop Agriculture	141	2.0	84	1.3
Wetlands	53	0.8	53	0.8
Woodlands	196	2.8	197	3.0
Water	1,409	20.2	1,409	21.4
Subtotal	5,031	72.2	3,868	58.7
Total	6,974	100.0	6,584	100.0

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

Source: SEWRPC.

Using these same relationships but substituting year 2020 forecast land use data, the year 2020 sediment load to Geneva Lake can be estimated at 1,464,100 pounds of sediment. This estimate reflects the likely ongoing loss of agricultural lands in the tributary area of the Lake, and its conversion to urban land uses.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[37] Urban heavy metal loadings were not estimated as part of the initial report. However, using Commission-generated unit area load relationships from the Regional water quality management planning program, likely loadings of selected heavy metals can be estimated. These relationships attribute heavy metals in the aquatic environment only to urban land uses; rural lands are unlikely to generate such metals in southeastern Wisconsin as such metals are not naturally present in the underlying geological strata in any significant concentrations. The majority of these metals become associated with sediment particles, and is likely to be encapsulated in the bottom sediments of the Lake. [38]

Table 17 sets forth the estimated loadings of copper, zinc, and cadmium likely to be contributed to Geneva Lake from urban development surrounding the Lake under existing 2000 land use conditions. About 45 pounds of copper, 410 pounds of zinc, and 1.3 pounds of cadmium were estimated to be contributed annually to Geneva Lake from urban lands.

Under year 2020 conditions, as set forth in the adopted regional land use plan, the annual heavy metal loads to the Lake are anticipated to increase to approximately 80 pounds of copper, 725 pounds of zinc, and 2.0 pounds of cadmium.

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

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

Table 17

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

Land Use	2000					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	3,087	60,196	617.4	0.0	30.9	0.0
Commercial	106	83,104	127.2	23.3	157.9	1.0
Industrial	26	19,552	30.4	5.7	38.7	0.3
Communications, Transportation, and Utilities	988	9,386	108.7	0.0	0.0	0.0
Governmental	227	115,997	306.5	15.9	181.6	0.0
Recreational	690	16,560	186.3	- -	- -	- -
Water	5,450	1,024,600	708.5	- -	- -	- -
Extractive	227	71,100	135.9	- -	- -	- -
Wetlands	590	2,183	23.6	- -	- -	- -
Woodlands	2,456	9,087	98.2	- -	- -	- -
Agricultural	4,529	2,038,050	3,894.9	- -	- -	- -
Total	18,307	3,449,816	6,237.6	44.9	409.2	1.3

Land Use	2020					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	3,983	77,669	796.6	0.0	39.8	0.0
Commercial	138	108,192	165.6	30.4	205.6	1.4
Industrial	61	45,872	71.4	13.4	90.9	0.6
Communications, Transportation, and Utilities	1,238	11,761	136.2	0.0	0.0	0.0
Governmental	484	247,324	653.4	33.9	387.2	0.0
Recreational	834	20,016	225.2	- -	- -	- -
Water	5,450	1,024,600	708.5	- -	- -	- -
Extractive	94	42,300	80.8	- -	- -	- -
Wetlands	590	2,183	23.6	- -	- -	- -
Woodlands	2,459	9,098	98.4	- -	- -	- -
Agricultural	2,976	1,339,200	2,559.4	- -	- -	- -
Total	18,307	2,928,215	5,518.9	77.7	723.5	2.0

Source: SEWRPC.

Groundwater Quality

During the initial planning program, groundwater quality was monitored monthly in eight paired observation wells around Geneva Lake; the data from six of the permanent wells located in the "lowland" sites were reported in the initial report. It was noted at that time that the groundwater quality in these six permanent wells did not exhibit evidence of gross contamination, although four of the wells did have above-average levels of conductivity. In addition to the six permanent wells sampled, three pairs of wells were sampled on a rotating basis to evaluate the effects of septic tank leachate, urban development, and sewage infiltration ponds on groundwater. A comparison of the groundwater chemistry from the "upland" and "lowland" wells in each of these areas demonstrated no definite differences in groundwater quality. In addition, a comparison of average groundwater quality for all upland wells to that of all lowland wells indicated no significant differences in water quality. At that time, groundwater contributions of inorganic nitrogen ranged between 0.04 and 3.90 mg/l for both nitrite (NO_2) and nitrate (NO_3) nitrogen, and between 0.048 and 0.231 mg/l for ammonia nitrogen (NH_3); total Kjeldahl nitrogen values ranged between 0.225 and 0.753 mg/l. Total phosphorus values ranged from 0.058 to 0.378 mg/l.

During the current study period, as part of the collaborative study, phosphorus loading from groundwater was computed based on an estimated constant phosphorus concentration of 0.008 mg/l, this being the lowest concentration measured at Birches and Southwick Creeks during base-flow periods. Using estimated flows of groundwater as developed for the hydrologic budget of Geneva Lake as presented in that report, the annual phosphorus load to the Lake from groundwater sources was estimated to be 50 pounds during water year 1998 and 45 pounds during water year 1999; these values represented an estimated 0.5 percent of the phosphorus input to the Lake.

In-Lake Sinks

Of the annual phosphorus load entering Geneva Lake, it was estimated that 90 percent of the phosphorus load, or about 6,330 pounds of phosphorus during water year 1998 and 16,830 pounds during water year 1999, was retained within the Lake. These values are based on estimated retention percentages from other lakes in the Region, adjusted for Geneva Lake's long retention time of about 13.9 years. This mass of phosphorus is either used by the biomass within the Lake or deposited in the lake sediments.[39] The balance of the phosphorus entering the Lake, about 10 percent of the total load, is transported downstream. Of the phosphorus mass retained in the lake, a portion can potentially be removed by aquatic plant harvesting programs, which remove phosphorus from the Lake as a component of the aquatic plant biomass.[40]

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

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

[40]*T.M. Burton, D.L. King, and J.L. Ervin, U.S. Environmental Protection Agency Report No. EPA 440/5-79-OD1, "Aquatic Plant Harvesting As A Lake Restoration Technique,"* Proceedings of the U.S. Environmental Protection Agency National Lake Restoration Conference*, 1979; see also 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.*

trophic classification system,[41] and the Carlson Trophic State Index (TSI).[42] In addition, the Wisconsin Trophic State Index value (WTSI) is presented.[43] The WTSI is a refinement of the Carlson TSI designed to account for the greater humic acid content, brown water color, present in Wisconsin lakes, and has been adopted by the WDNR for use in lake management investigations.

Vollenweider Trophic State Classification
Using the Vollenweider trophic system and applying the data in Table 10, Geneva Lake would be classified as having about a 65 percent probability of being oligotrophic based upon phosphorus levels, as shown in Figure 8. The Lake would have about a 20 percent probability of being ultra-oligotrophic, and a 15 percent probability of being mesotrophic, based upon mean annual phosphorus concentrations. Based upon chlorophyll-*a* levels, the Lake would be classified as having a 50 percent probability of being oligotrophic, with about a 40 percent probability of being mesotrophic and about a 5 percent probability of being either ultra-oligotrophic or eutrophic, as shown in Figure 8. Based upon Secchi-disc readings, the Lake would be classified as having a 55 percent probability of being mesotrophic, with about a 20 percent probability of being either oligotrophic or mesotrophic, and a 2.5 percent probability of being either ultra-oligotrophic or hypertrophic, as shown in Figure 8.

While these indicators result in slightly differing lake trophic state classifications, it may be concluded that Geneva Lake should be classified as an oligo-mesotrophic lake, or a lake with good water quality for most uses.

Trophic State Index
The Trophic State Index (TSI) assigns a numerical trophic condition rating based on Secchi-disc transparency, and total phosphorus and chlorophyll-*a* concentrations. The original Trophic State Index developed by Carlson has been modified for Wisconsin lakes by the WDNR using data on 184 lakes throughout the State.[44] The Trophic State Index (TSI) ratings for Geneva Lake are shown in Figure 9 as a function of sampling date. Based on the Carlson Trophic State Index rating of between 28 and 44, Geneva Lake may be classified as oligotrophic.

As was stated earlier in this report, the zebra mussel, *Dreissena polymorpha,* was first observed in Geneva Lake in 1995. Due to the filter feeding proclivities of this organism, some lakes in which it has become established have experienced improved water clarity, or Secchi-disc transparency. In Geneva Lake, the population of this species has experienced some fluctuation since its introduction, as will be explained in more detail later in this report. Consequently, it is unclear at this time exactly what the impact of this species may be on the trophic status of the Lake. As shown in Figure 9, while chlorophyll-*a* appears to show a fairly steady rate of decrease since 1975, water clarity has been more or less constant since 1970 and total phosphorus concentrations, which showed a decline from 1970 through about 1995, leveled off before showing a slight increase from about 2000 through 2005. It has been suggested that since there appears to be a less direct relationship between total phosphorus and the other two major trophic state factors, namely water clarity and chlorophyll-*a*, this may be the result of grazing on phytoplankton by the mussels. Continued measuring of these factors along with monitoring of the zebra mussel population will be needed to better determine the exact nature of the interrelationships in this situation.

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

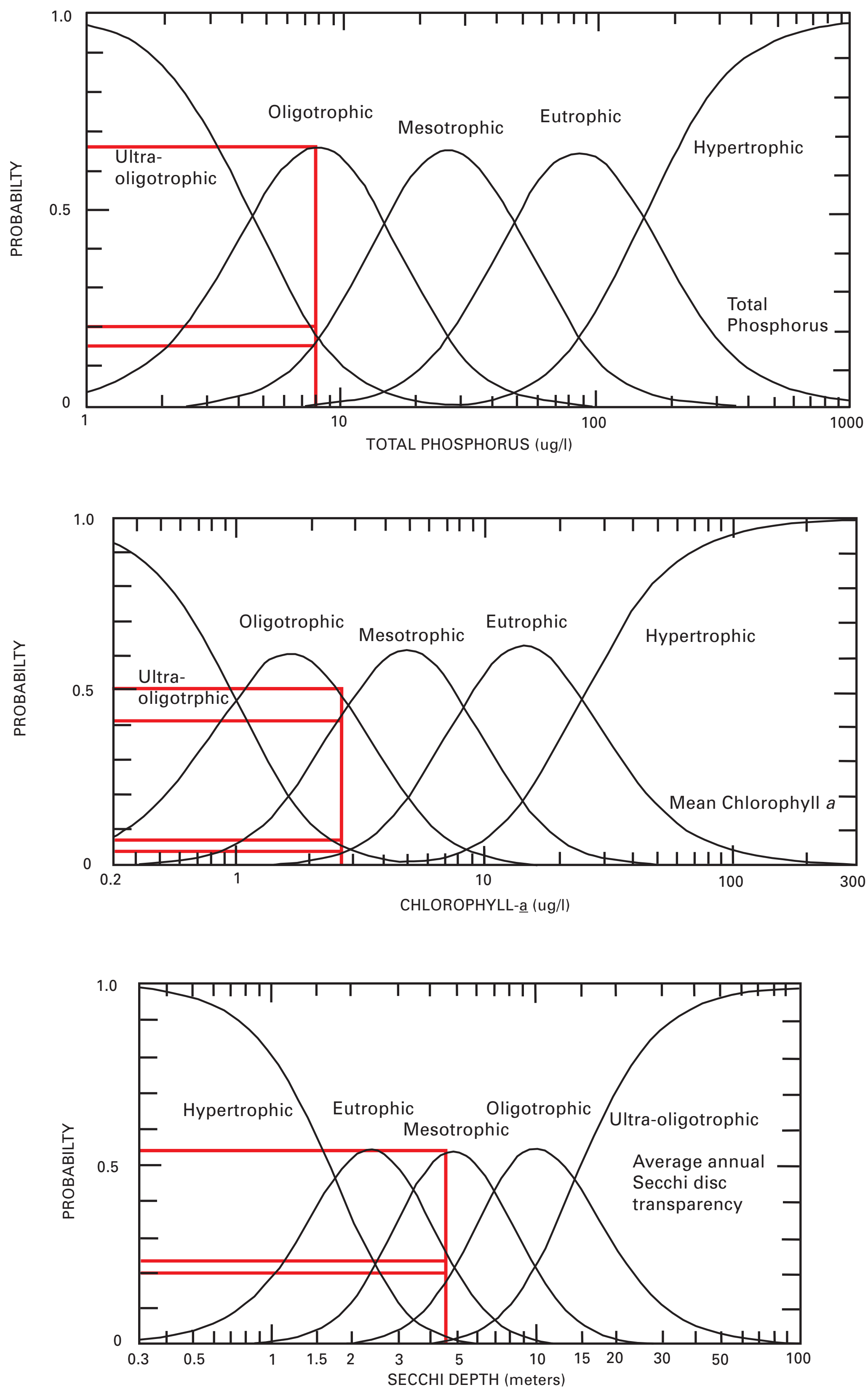
[42]*R.E. Carlson, "A Trophic State Index for Lakes,"* Limnology and Oceanography*, Vol. 22, No. 2, 1977.*

[43]*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.*

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

Figure 8

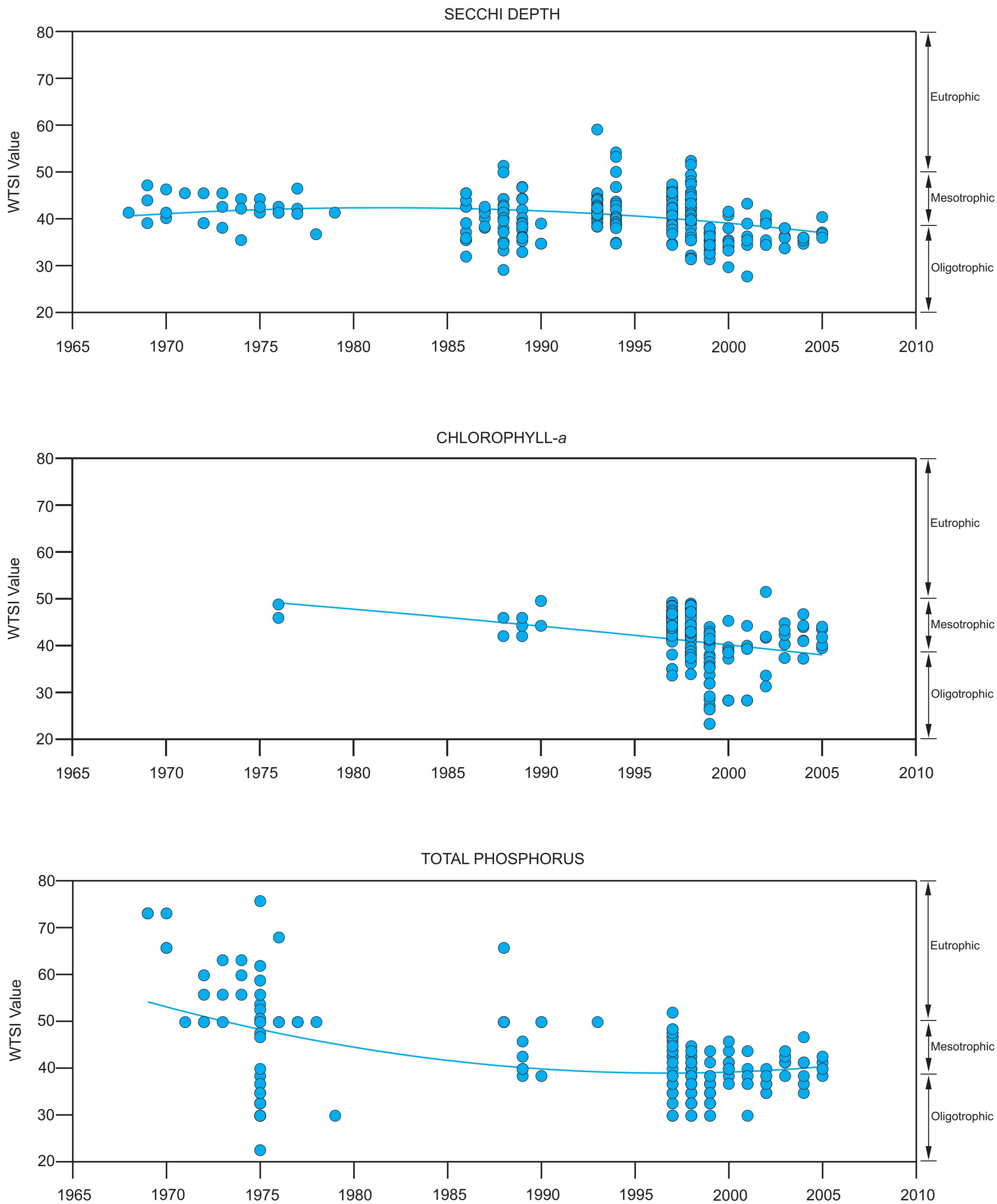
TROPHIC STATE CLASSIFICATION OF GENEVA LAKE BASED UPON THE VOLLENWEIDER MODEL: 2004



Source: U.S. Geological Survey and SEWRPC.

Figure 9

TROPHIC STATE INDICES FOR GENEVA LAKE: 1965-2005



Source: Wisconsin Department of Natural Resources and SEWRPC.

SUMMARY

Geneva Lake represents a typical hard-water, alkaline lake that is considered to have very good water quality. Water quality data collected as part of the collaborative study indicated that the Lake was between oligotrophic to mesotrophic, with average near-surface concentrations of total phosphorus equal to 8.0 μg/l, total nitrogen concentrations equal to 510 μg/l, and chlorophyll *a* concentration of 3..0 μg/l during the summer months. During the current study period, the average summer Secchi depth was about 15.0 feet and N:P ratios were always greater than 28:1 indicating that the limiting nutrient in the Lake was phosphorus.

There were no known point sources of pollutants in the tributary area of Geneva Lake. Historic, problematic seepage problems from the Fontana-on-Geneva Lake sewage treatment facility were mitigated during 1984 as a result of sewage being diverted for treatment to the regional sewage treatment facility in the Town of Sharon.

Nonpoint sources of pollution included stormwater runoff from urban and agricultural areas. Sediment and phosphorus loadings from the tributary area were estimated by both direct measurement at various points within the tributary area, and using the Wisconsin Lake Model Spreadsheet and unit area loads. These estimates suggested that about 7,000 pounds of phosphorus, 1,725,000 pounds of sediment, and about 45 pounds of copper, 410 pounds of zinc, and 1.3 pounds of cadmium were likely to enter the Lake annually. Where measured data were available, as in the case of phosphorus loadings, these estimates were noted to be not dissimilar. Consequently, the models were used to forecast future year 2020 conditions, which appear to be relatively unchanged, although slight reductions in phosphorus and sediment loads are anticipated as a result of conversion of agricultural lands to urban land uses and slight increases in heavy metals loads are anticipated as a result of increasing areas of urban land uses. Overall water quality conditions in Geneva Lake are expected to remain largely unchanged.

Chapter V

AQUATIC BIOTA AND ECOLOGICALLY VALUABLE AREAS

INTRODUCTION

Geneva Lake is an important element of the natural resource base of the City of Lake Geneva, the Villages of Fontana-on-Geneva Lake, Walworth, and Williams Bay, and the Towns of Geneva, Linn, and Walworth. The Lake, its biota, and the adjacent park and residential lands combine to contribute to the quality of life in the area. When located in urban settings, resource features such as lakes and wetlands are typically subject to extensive recreational use and high levels of pollutant discharges, common forms of stress to aquatic systems, and these may result in the deterioration of these natural resource features. For this reason, the formulation of sound management strategies must be based on a thorough knowledge of the pertinent characteristics of the individual resource features, as well as of the urban development in the area concerned. Accordingly, this chapter provides information concerning the natural resource features of the Geneva 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 Geneva Lake, a number of surveys were conducted as part of both the initial planning program and the current planning effort. For the current study, data on aquatic plant communities were collected through an aquatic plant survey conducted during the summer of 2001 by the Geneva Lake Environmental Agency (GLEA). Phytoplankton populations were sampled as part of a collaborative study carried out from April of 1997 to August of 1999.[1] These data are summarized below.

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[1]*U.S. Geological Survey Water-Resources Investigations Report 02-4039,* Hydrology and Water Quality of Geneva Lake, Walworth County, Wisconsin, *2002.*

Phytoplankton

Phytoplankton, or algae, are small, generally microscopic plants that are found in all lakes and streams. They occur in a wide variety of forms, in single cells or colonies, and can be either attached or free-floating. Phytoplankton abundance varies seasonally with fluctuations in solar irradiance, turbulence due to prevailing winds, water temperature, and nutrient availability. Typically, algal groups are determined on the basis of pigmentation as revealed in their color. Two algal groups especially important in aquatic ecosystems are the green algae and the blue-green algae.

Green algae (Chlorophyta) are the most important source of food for zooplankton, or microscopic animals, in the lakes of southeastern Wisconsin and are generally considered a more desirable form. They are generally smaller in size and tend to be more widely distributed throughout the water column than their blue-green counterparts. Blue-green algae or cyanobacteria (Cyanophyta), on the other hand, 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 of grazing by zooplankton.

Blooms of blue-green algae may reach nuisance proportions in fertile, or eutrophic, lakes, resulting in the accumulation of surface scums or slimes. In some cases, heavy concentrations of wind-blown algae accumulate along shorelines, where they die and decompose, causing noxious odors and unsightly conditions. The decay process consumes oxygen, sometimes depleting available supplies and resulting in fish kills. Also, certain species of blue-green algae may release toxic materials into the water. Algal blooms have not generally been perceived as a problem in Geneva Lake. Such growths are unlikely to occur in the future, in part, due to the presence of zebra mussels (*Dreissena polymorpha*) that feed on, *inter alia*, free-floating algae.

During the initial study period,[2] 40 different species of phytoplankton were identified in Geneva Lake. The dominant forms are shown in Table 18. However, the dominant forms of phytoplankton in a lake undergo seasonal variation. During spring turnover, nutrients from the bottom waters are circulated into the upper zone of the lake, bringing them into contact with sufficient sunlight for photosynthesis to occur. This normally results in an increase in the diversity of the algal populations. As summer progresses and the lake warms, becoming stratified, nutrients in the upper layer of a lake can become depleted, resulting in a loss of diversity in the algal populations. In fall, cooler temperatures and lower light conditions during fall turnover again favor a more diverse population of algae. This type of cyclical variation in phytoplankton populations has been observed in Geneva Lake.

In Geneva Lake during spring, the phytoplankton population demonstrated good diversity being comprised of about 48 percent blue-green algae, 49 percent green algae, and 3 percent diatoms.[3] Green algae and diatoms especially are best suited to the cooler water temperatures and less intense solar radiation characteristic of this season. As summer progressed, diversity waned as blue-green algae increased in abundance until they composed about 99 percent of the algae population. *Anacystis* sp. (= *Microcystis* sp.), a small, spherical, bloom-forming blue-green alga that occurs as a floating film on the water surface, was the most numerous species present from June through November.[4] This alga has the ability to utilize the atmospheric nitrogen and to store phosphorus

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[2]*SEWRPC Community Assistance Planning Report No. 60,* A Water Quality Management Plan for Geneva Lake, Walworth County, Wisconsin, *October 1985.*

[3]Ibid.

[4]Microcystis *spp. is known to develop microcystin, an alkaloid toxin that can cause skin irritations, gastro-enteric upsets, and, in extreme situations, mortality in mammalian populations, frequently, in wildlife or domestic animals that utilize the surface water for drinking: see Water Research Commission Report No. TT153/01,* Cyanobacteria in South Africa: A Review*, July 2001.*

Table 18

DOMINANT PHYTOPLANKTON IDENTIFIED IN GENEVA LAKE: 1976-1977

Blue-green	Diatoms	Green	Yellow-brown
Anabaena flos-aquae	*Dinobryon cylindricum*	*Oocystis borgie*	*Ceratium hirundenella*
Anacystis thermalis	*Fragilaria capucina*	- -	- -
Gomphosphaera wichurae	- -	- -	- -
Ocillatoria tenius	- -	- -	- -

Source: Geneva Lake Environmental Agency and SEWRPC.

within the cell, enabling it to outcompete other species, lacking this ability, when these primary growth nutrients are in short supply. In fall, the population became more diverse again being comprised of about 56 percent blue-green algae, 4 percent green algae, and 40 percent diatoms.[5] Diatoms are especially well-suited to the more turbulent surface water conditions typical of autumn.

It was noted in the earlier report that, based only on phytoplankton populations, Geneva Lake seemed to be exhibiting the characteristics of a slightly eutrophic lake during the late summer.[6] This was interpreted as suggesting a possible change in the trophic status of the Lake. Additional phytoplankton sampling at that time appeared to reinforce this idea. However, more recent observations of the algal community of Geneva Lake, made by the U.S. Geological Survey (USGS) as part of the aforereferenced collaborative study, do not support this idea.[7] These observations indicated the continued presence of diatoms and green and blue-green algae, as had been observed during the initial study in 1977. However, the green and blue-green algae were never very important to the total biovolume of phytoplankton in the Lake, whereas diatoms were the dominant phytoplankters especially during the spring and fall. Additionally, water quality data, collected as part of the collaborative study, indicated the trophic state of the Lake as remaining in the oligotrophic to mesotrophic range. No further mention was made of this possible shift in trophic status, to a more eutrophic state, and the relative abundance of blue-green algae probably reflects the ability of these plants to thrive over a range of environmental conditions.[8] Currently, phytoplankton samples are still being collected and analyzed six times per year.

Aquatic Macrophytes

Aquatic macrophytes, including emergent species such as rushes and cattails, floating-leaves species such as lily pads, and submergent species such as pondweeds, coontail and water milfoil, play an important role in the ecology of southeastern Wisconsin lakes. Depending on their types, distribution and abundance, they can be either beneficial or a nuisance. Macrophytes growing in reasonable densities in lakes are beneficial in maintaining lake fisheries and wildlife populations, providing habitat for a variety of aquatic organisms. They also may remove nutrients from the water that otherwise would contribute to excessive algal growth. Aquatic plants can become a nuisance when their densities become so great as to interfere with swimming and boating activities, when their growth forms limit habitat diversity, and when the plants reduce the aesthetic appeal of the resource. In the GLEA survey of Geneva Lake users,[9] about 45 percent of respondents felt there was just the right amount of aquatic

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[5]*SEWRPC Community Assistance Planning Report No. 60,* op. cit.

[6]Ibid.

[7]*U.S. Geological Survey Water-Resources Investigations Report 02-4039,* op. cit.

[8]*W. Rast, and J. A. Thornton, "Trends in Eutrophication Research and Control,"* Hydrological Processes*, Volume 10, Number 2, pages 295-313, 1996.*

[9]*Geneva Lake Environmental Agency,* A Report on the Geneva Lake Use Survey, *October 1999.*

plant growth for fish and wildlife, while approximately 30 percent reported feeling that aquatic plants limited their use of some parts of the Lake. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate, wave action, and type and size of fish populations present, determine the distribution and abundance of aquatic macrophytes in lakes. In southeastern Wisconsin, most lakes naturally support an abundant and diverse aquatic plant community. Illustrations of representative macrophyte species observed in Geneva Lake are set forth in Appendix A.

An aquatic plant survey of Geneva Lake was conducted during the summer of 1977 as part of the initial study. Aquatic plant surveys were also conducted in 1994 and 2001 by the GLEA. Table 19 presents a comparison of the aquatic macrophyte communities identified during these surveys. As shown in Table 19, of the three dominant species identified in the 2001 survey (muskgrass, *Chara* spp.; eel grass, *Vallisneria americana*; and Wigeon-grass, *Ruppia maritime*), only muskgrass was also dominant in the 1994 and 1976 surveys. Additionally, musk-grass was also reported as dominant in a 1967 survey conducted by the Wisconsin Department of Natural Resources (WDNR).[10] This consistency of species dominance would be expected in a fairly stable environment. Of note is the increase in dominance of the common bladderwort during the 1994 survey and its decline in dominance during the 2001 survey and the concomitant rise in dominance of wigeon-grass during the 2001 survey. Such short-term variations in species dominance can be attributed to a number of factors including, but not limited to, such things as: seasonal and inter-annual periodicity, inter-specific competition, human activities in the tributary area or the lake itself, changes in the substrate in which the plant grows, and the introduction of nonnative animal and plant species. Other common macrophytes observed during the 2001 survey included Illinois pondweed (*Potamogeton illinoensis*) and Eurasian water milfoil.

Eurasian water milfoil is one of eight milfoil species found in Wisconsin and the only one of these identified as exotic or nonnative pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can inhibit its growth under suitable conditions. The plant typically exhibits an "explosive" growth pattern in lakes with organic-rich sediments, or in lakes where the lake bottom has been disturbed. In such cases, the Eurasian water milfoil populations can displace native plant species, leading to loss of plant diversity, degradation of water quality, and reduction in habitat value for fish, invertebrates and wildlife, as well as to interference with the aesthetic and recreational use of the waterbodies.

Eurasian water milfoil reproduces by the rooting of plant fragments. Consequently, some recreational uses of lakes can contribute to the expansion of Eurasian water milfoil communities, especially when boat propellers fragment the plants. These fragments, as well as fragments that occur for other reasons, such as wind-induced turbulence or fragmentation of the plant by fishes, are able to generate new root systems, and allow the plants to colonize new sites. The fragments also can cling to boats, trailers, motors, and/or bait buckets, and can stay alive for weeks contributing to the transfer of Eurasian water milfoil to other lakes. The transfer of such plants between lakes is prohibited under Wisconsin law. For this reason, it is very important to remove all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies; pressure washing or drying being recommended measures.[11]

Curly-leaf pondweed (*Potamogeton crispus*), although present in all three surveys, was not present in significant numbers to be considered a problem. Like Eurasian water milfoil, curly-leaf pondweed is an invasive, nonnative plant that can outcompete important native aquatic plants, disrupting aquatic plant communities and leading to an array of negative effects on a lake's ecosystem.

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[10]*Wisconsin Department of Natural Resources Lake Use Report No. FX-1,* Lake Geneva, Walworth County, Wisconsin, *1969.*

[11]*See Wisconsin Department of Natural Resources Publication No. PUB-WT-782 2004,* Clean Boats, Clean Waters: Volunteer Watercraft Inspection Program*, 2004.*

Table 19

RELATIVE FREQUENCY OF OCCURRENCE OF SUBMERGENT PLANT SPECIES IN GENEVA LAKE: 1976, 1994, AND 2001

Common Name	Scientific Name	1976 Relative Frequency of Occurrence[a] (percent)	1994 Relative Frequency of Occurrence[a] (percent)	2001 Relative Frequency of Occurrence[a] (percent)
Big-Leaf Pondweed	*Potamogeton amplifolius*	0.8	0.3	1.3
Bushy Naiad	*Najas gracilllina*	3.6	- -	- -
Bushy Pondweed (slender naiad)	*Najas flexilis*	2.8	2.0	2.1
Clasping-Leaf Pondweed (red-head pondweed)	*Potamogeton richardsonii*	0.1	0.6	- -
Common Bladderwort	*Utricularia vulgaris*	0.6	13.0	3.8
Coontail	*Ceratophyllum demersum*	2.3	6.0	3.0
Curly-Leaf Pondweed	*Potamogeton crispus*	1.1	1.0	2.1
Eel Grass	*Vallisneria americana*	9.6	6.0	19.0
Elodea (waterweed)	*Elodea canadensis*	- -	3.1	- -
Elodea (waterweed)	*Elodea nuttallii*[b]	0.3	2.0	3.0
Eurasian Water Milfoil	*Myriophyllum spicatum*	5.1	2.0	7.2
Fern Pondweed	*Potamogeton robbinsii*	- -	- -	0.2
Flat-Stem Pondweed	*Potamogeton zosteriformis*	1.9	1.0	3.0
Floating-Leaf Pondweed	*Potamogeton natans*	0.2	2.0	1.3
Illinois Pondweed	*Potamogeton illinoensis*	- -	0.1	7.1
Leafy Pondweed	*Potamogeton foliosus*	0.1	0.1	- -
Long-Leaf Pondweed	*Potamogeton nodosus*	0.1	0.1	0.7
Muskgrass	*Chara* spp.	30.1	23.0	22.8
Northern (small) Bladderwort	*Utricularia minor*	0.1	- -	- -
Northern Water Milfoil	*Myriophyllum sibiricum*[c]	21.1	20.0	12.7
Sago Pondweed	*Potamogeton pectinatus*	12.0	14.0	10.1
Small Pondweed	*Potamogeton pusillus*	- -	- -	0.2
Spiny Naiad	*Najas marina*	0.1	- -	- -
Variable Pondweed	*Potamogeton gramineus*	3.6	3.0	- -
Water Stargrass	*Zosterella dubia*	- -	2.0	0.2
Water-Thread Pondweed	*Potamogeton diversifolius*	- -	- -	0.2
White-Stem Pondweed	*Potamogeton praelongus*	0.4	0.1	- -
White Water Buttercup	*Ranunculus longirostris*	1.2	0.3	- -
Wigeon-grass	*Ruppia maritime*	- -	- -	24.8

NOTE: There were 627 sampling sites located along 107 transects during the 1976 survey. During the 1994 survey, sampling was done along every other transect from the 1977 survey, a total of 55 transects, with approximately four sampling sites at each transect. During the 2001 survey, there were 135 sampling sites located along 27 transects.

[a]*The Relative Frequency of Occurrence is the frequency of occurrence of a species divided by the total frequency of all species. This statistic presents an indication of how the plants occur throughout a lake in relation to each other. In the initial (1985) SEWRPC report, these values were reported as Relative Abundance. In the GLEA 1994 report, "Geneva Lake's Submergent Macrophyte Community Diversity" by George Johnson, this value was reported as Percent Occurrence.*

[b]*Due to difficulty in differentiating Elodea occidentale, Elodea nuttallii, and Elodea canadensis, the 2001 GLEA report grouped the three species together; to be consistent with the 1977 report, the species are reported as E. nuttallii.*

[c]*Due to difficulty in differentiating Myriophyllum heterophyllum from Myriophyllum sibiricum (formerly known as M. exalbescens), the 2001 GLEA report grouped the two species together; to be consistent with the 1977 report, the species are reported as Myriophyllum sibiricum.*

Source: Geneva Lake Environmental Agency and SEWRPC.

The dominant submersed species observed during the 2001 survey was wigeon grass (*Ruppia maritima*), also known as ditch grass. This aquatic plant is a native species whose fruit and foliage provide an important food source for numerous species of waterfowl. More common in saltwater environs, the plant is found in only a few scattered locations in southeastern Wisconsin where it has a propensity for alkaline waters and can grow to depths of several meters.

Table 20 shows various statistical analyses of the Lake's aquatic plant community in 2001, whereas Map 12 shows the distribution of aquatic plant communities in Geneva Lake in 2001. The appearance of various

Table 20

STATISTICAL ANALYSIS OF AQUATIC PLANT COMMUNITY IN GENEVA LAKE: 2001

Common Name	Scientific Name	Sites Found	Relative Frequency of Occurrence[a] (percent)	Average Density[b]	Importance Value[c]
Big-Leaf Pondweed	*Potamogeton amplifolius*	3	1.0	2.0	2.0
Bushy Naiad	*Najas gracilllina*	- -	- -	- -	- -
Bushy Pondweed (slender naiad)	*Najas flexilis*	5	1.7	2.0	3.4
Clasping-Leaf (red-head) Pondweed	*Potamogeton richardsonii*	- -	- -	- -	- -
Common Bladderwort..............................	*Utricularia vulgaris*	10	3.1	2.0	6.2
Coontail	*Ceratophyllum demersum*	7	2.4	1.4	3.4
Curly-Leaf Pondweed..............................	*Potamogeton crispus*	5	1.7	1.8	3.1
Eel Grass..................................	*Vallisneria americana*	44	15.3	2.6	39.8
Elodea (waterweed)..................................	*Elodea canadensis*	- -	- -	- -	- -
Elodea (waterweed)..................................	*Elodea nuttallii*[d]	7	2.4	1.3	3.1
Eurasian water Milfoil	*Myriophyllum spicatum*	15	5.8	2.3	13.3
Fern Pondweed	*Potamogeton robbinsii*	1	0.2	1.0	0.2
Flat-Stem Pondweed..............................	*Potamogeton zosteriformis*	7	2.4	1.4	3.4
Floating-Leaf Pondweed..........................	*Potamogeton natans*	2	1.0	1.5	1.5
Illinois Pondweed..................................	*Potamogeton illinoensis*	17	5.8	1.6	9.3
Leafy Pondweed..................................	*Potamogeton foliosus*	- -	- -	- -	- -
Longleaf Pondweed..................................	*Potamogeton nodosus*	2	0.7	1.0	0.7
Muskgrass	*Chara* spp.	51	18.3	2.3	42.1
Northern (small) Bladderwort....................	*Utricularia minor*	- -	- -	- -	- -
Northern Water Milfoil..............................	*Myriophyllum sibiricum*[e]	29	10.2	1.4	14.3
Sago Pondweed	*Potamogeton pectinatus*	24	8.1	1.8	14.6
Small Pondweed..................................	*Potamogeton pusillus*	1	0.2	1.0	0.2
Spiny Naiad	*Najas marina*	- -	- -	- -	- -
Variable Pondweed	*Potamogeton gramineus*	- -	- -	- -	- -
Water Stargrass..................................	*Zosterella dubia*	1	0.2	4.0	0.8
Water-Thread Pondweed	*Potamogeton diversifolius*	1	0.2	2.0	0.4
White-Stem Pondweed..............................	*Potamogeton praelongus*	- -	- -	- -	- -
White Water Buttercup	*Ranunculus longirostris*	- -	- -	- -	- -
Wigeon Grass..................................	*Ruppia maritima*	55	19.7	3.1	61.1

NOTE: There were 135 sites sampled during the 2001 survey.

[a]*The relative frequency of occurrence is the frequency of occurrences of a species (from Table 19) divided by the total frequency of all species, expressed as a percent. This statistic presents an indication of how the plants occur throughout a lake in relation to each other.*

[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 was 5.0 and was estimated using the following criteria based on the degree of rake coverage by a species: no plants on the rake = density rating of 0; 1-20 percent rake coverage = 1.0; 21-40 percent coverage = 2.0; 41-60 percent coverage = 3.0; 61-80 percent coverage = 4.0; >80 percent coverage = 5.0. Average density is an indication of how abundant a particular plant is in those areas of a lake where it is found.*

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

[d]*Due to difficulty in differentiating Elodea occidentale, Elodea nuttallii, and Elodea canadensis, the 2001 GLEA report grouped the three species together; to be consistent with the 1977 report, the species are reported as E. nuttallii.*

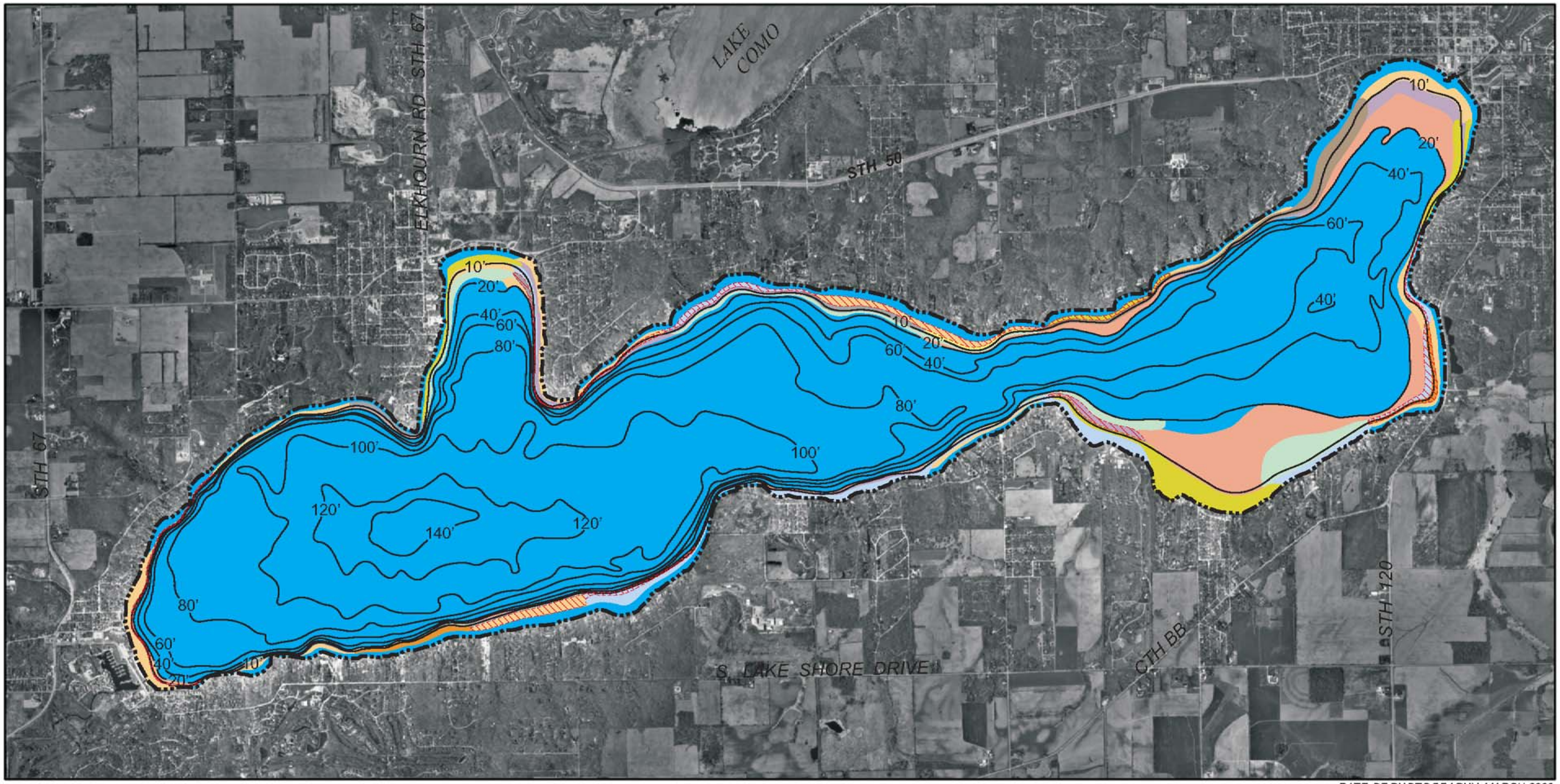
[e]*Due to difficulty in differentiating Myriophyllum heterophyllum from Myriophyllum sibiricum (formerly known as M. exalbescens), the 2001 GLEA report grouped the two species together; to be consistent with the 1977 report, the species are reported as Myriophyllum sibiricum.*

Source: Geneva Lake Environmental Agency and SEWRPC.

pondweed species such as clasping-leaf pondweed (*Potamogeton richardsonii*), Sago pondweed, Illinois pondweed, flat-stemmed pondweed (*Potamogeton zosteriformis*), variable pondweed (*Potamogeton gramineus*), and white-stem pondweed (*Potamogeton praelongus*) in the Lake is generally considered to be a positive sign as these are native aquatic plants that play important roles in area lakes. Table 21 presents the positive ecological importance of those aquatic plant species present in Geneva Lake during the 2001 survey.

Map 12

AQUATIC PLANT COMMUNITY DISTRIBUTION IN GENEVA LAKE: 2001



DATE OF PHOTOGRAPHY: MARCH 2000

- 20' — WATER DEPTH CONTOUR IN FEET
- OPEN WATER
- EURASIAN WATER MILFOIL
- MUSKGRASS
- NATIVE WATER MILFOIL, ILLINOIS PONDWEED, WILD CELERY, DITCH GRASS, WATERWEED, AND SAGO PONDWEED
- NATIVE WATER MILFOIL, WILD CELERY, DITCH GRASS, AND ROBINS PONDWEED
- NATIVE WATER MILFOIL, WILD CELERY, DITCH GRASS, AND MUSKGRASS
- NATIVE WATER MILFOIL, WILD CELERY, AND DITCH GRASS
- NATIVE WATER MILFOIL, ILLINOIS PONDWEED, WILD CELERY, DITCH GRASS, BLADDERWORT, SAGO PONDWEED, MUSKGRASS, AND SMALL PONDWEED
- NATIVE WATER MILFOIL, WILD CELERY, DITCH GRASS, SAGO PONDWEED, BUSHY PONDWEED, MUSKGRASS, AND VARIABLE PONDWEED
- NATIVE WATER MILFOIL, WILD CELERY, DITCH GRASS, MUSKGRASS, WATERWEED, SAGO PONDWEED, COONTAIL, FLAT-STEM PONDWEED, LARGE LEAF PONDWEED, FLOATING LEAF PONDWEED, AND CURLY-LEAF PONDWEED
- NATIVE WATER MILFOIL, WILD CELERY, DITCH GRASS, COONTAIL, MUSKGRASS, WATERWEED, FLAT-STEM PONDWEED, SAGO PONDWEED, WATER STAR GRASS, AND LARGE LEAF PONDWEED
- WILD CELERY, DITCH GRASS, MUSKGRASS, SAGO PONDWEED, COONTAIL, AND LONG LEAF PONDWEED

GRAPHIC SCALE
0 2250 4500 FEET

Source: SEWRPC.

Table 21

POSITIVE ECOLOGICAL SIGNIFICANCE OF AQUATIC PLANT SPECIES PRESENT IN GENEVA LAKE: 2001

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides shelter and food for young fish
Chara vulgaris (muskgrass)	Excellent producer of fish food, stabilizes bottom sediments, and has softening effect on the water
Elodea spp. (waterweed)[a]	Provides shelter and support for insects which are valuable as fish food
Myriophyllum sibiricum (northern water milfoil)[b]	Provides food for waterfowl, insect habitat and foraging opportunities for fish
Myriophyllum spicatum (Eurasian water milfoil)	None known
Najas flexilis (bushy pondweed)	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Potamogeton amplifolius (large-leaf pondweed)	Offers shade, shelter and foraging for fish; valuable food for waterfowl
Potamogeton crispus (curly-leaf pondweed)	Provides food, shelter and shade for some fish and food for wildfowl
Potamogeton diversifolius (water-thread pondweed)	Fruit an important food source for waterfowl; leaves and stems colonized by invertebrates and offer foraging for fish
Potamogeton illinoensis (Illinois pondweed)	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl
Potamogeton natans (floating-leaf pondweed)	Provides food for waterfowl, muskrat, beaver and deer; good fish habitat
Potamogeton nodosus (long-leaf pondweed)	Fruit is food source for ducks and geese; muskrat, beaver and deer eat other portions of the plant; invertebrate habitat and foraging opportunities for fish
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton pusillus (small pondweed)	Provides food for ducks, geese, muskrat, beaver, and deer, and provides food and shelter for fish
Potamogeton robinsii (fern pondweed)	Provides shelter and support for insects, which are valuable as food for waterfowl and fish (especially northern pike)
Potamogeton zosteriformis (flat-stem pondweed)	Provides some food for ducks
Ruppia maritime (wigeon-grass)	An excellent source of food and cover for fish and a popular food for many kinds of waterfowl
Utricularia vulgaris (bladderwort)	Provides cover and foraging for fish
Vallisneria americana (water celery/eelgrass)	Provides good shade and shelter, supports insects, and is valuable fish food
Zosterella dubia (water stargrass)	Provides food and shelter for fish, locally important food for waterfowl

[a]*Elodea occidentale, E. nuttallii, and E. canadensis were grouped together due to difficulty in identification.*

[b]*Myriophyllum heterophyllum and M. sibiricum (formerly M. exalbescens) were grouped together due to difficulty in identification.*

Source: Geneva Lake Environmental Agency and SEWRPC.

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 recorded efforts to manage the aquatic plants in Geneva Lake have taken place since 1950. Aquatic plant management activities in Geneva Lake can be categorized as chemical macrophyte and algal control,[12] with some limited, localized macrophyte harvesting. As reported in the initial study, no extensive harvesting has occurred on Geneva Lake. Currently, all forms of aquatic plant management, including harvesting, are subject to permitting by the WDNR pursuant to authorities granted the Department under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code.*

[12]*Through the late 1980s, Geneva Lake was treated regularly with molluscicides for the control of swimmer's itch. These control agents target the snails that act as intermediate host for the parasitic schistosomes.*

Chemical Controls

Perceived excessive macrophyte growths on Geneva Lake have historically resulted in the application of a chemical control program. Although the use of chemicals to control aquatic plants has been regulated in Wisconsin since 1941, records of aquatic herbicide applications have only been maintained by the WDNR beginning in 1950. Recorded herbicide treatments that have been applied to Geneva Lake from 1950 through 2003 are set forth in Table 22.

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 Geneva Lake, and years of application during the period 1950 through 1967, are listed in Table 22. The total amount of sodium arsenite applied over this 17-year period was about 40,550 pounds.

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

When it became apparent that arsenic was accumulating in the sediments of treated lakes and that the accumulations of arsenic were found to present potential health hazards both to humans and aquatic life, the use of sodium arsenite was discontinued in the State. This occurred in 1969. During 1996-1997, the USGS conducted analyses of surfacial sediment samples collected from that Lake basin that revealed the existence of elevated levels of some substances, particularly arsenic, copper, and zinc. Given that many of these elements occur in elevated concentrations as a consequence of human activities and urbanization with the watershed, there is a strong likelihood that, with continued inflows of heavy metals from developing areas in the tributary area, the sediment-linked metals could become problematic in the future.[13] Table 23 identifies the draft sediment-quality criteria for arsenic, copper, and zinc that have been developed by the WDNR to evaluate contamination in sediments. The levels of arsenic in the Lake sediments indicated in Table 23 can be compared to the historical records of sodium arsenite treatments for aquatic plant control presented in Table 22. It is of interest to note that concentrations of arsenic were highest in the main basin of Geneva Lake, even though sodium arsenite treatments would most likely have been performed in the shallower bays, an example of the phenomenon known as "sediment focusing" whereby flocculent materials are moved progressively offshore into the deeper water area of a lake.[14]

As shown in Table 22, the aquatic herbicides diquat, endothall, and 2,4-D also have been applied to Geneva 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, including 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. 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 the white and yellow water lilies (*Nymphaea tuberosa* and

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[13]*U.S. Geological Survey Fact Sheet FS-121-00,* Chemical Composition of Surficial Sediment in Geneva Lake, Wisconsin, *September 2000.*

[14]*Robert G. Wetzel,* Limnology*, Saunders, Philadelphia, 1975.*

Table 22

CHEMICAL CONTROL OF AQUATIC PLANTS IN GENEVA LAKE: 1950-2004

		Algae Control				Swimmer's Itch Control		Macrophyte Control				
Year	Total Acres Treated	Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine + (gallons)	AV-70 (gallons)	Copper Sulfate/ Copper Carbonate (pounds)	Copper Sulfate/ Lime (pounds)	Sodium Arsenite (pounds)	2, 4-D (gallons)	Diquat (gallons)	Endothal (gallons)	Aquathol (gallons)
1950-1967[a]	2,043	4,620	17,035	- -	- -	1,350/ 2,900	750/ 1,520	40,548	- -	7.0	- -	1,775 pounds/70 gallons
1968-1984[a]	792.4	1,507.5	214.7	- -	35.0 pounds/ 94.0 gallons	2,442/ 4,875	2,313.5/ 5,476	- -	190.7	269.8	4,620 pounds/ 165.8 gallons	6,820 pounds/ 339 gallons
1985[b]	25	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1986	4.57	- -	- -	- -	5.0	- -	130/45	- -	- -	- -	- -	8.5
1987	11.18	- -	- -	- -	18.0	- -	190/74	- -	0.5	6.0	- -	19.5
1988	2.66	- -	- -	- -	1.5	- -	12/6	- -	3.0	- -	- -	4.5
1989	4.3	- -	- -	3.0	- -	- -	- -	- -	4.0	3.0	- -	4.0
1990	25.1	- -	- -	5.0	- -	- -	- -	- -	15.5	- -	- -	5.0
1991	4.43	- -	- -	- -	3.0	- -	- -	- -	0.67	3.0	3.0	- -
1992	6.21	- -	- -	- -	3.0	- -	- -	- -	10.0	4.25	- -	- -
1993	10.92	- -	- -	- -	4.5	- -	- -	- -	31.5	3.5	- -	3.5
1994	6.36	- -	- -	- -	5.0	- -	- -	- -	15.75	2.5	- -	2.0
1995[c]	6.26	- -	- -	- -	5.0	- -	- -	- -	- -	5.0	- -	5.0
1996	8.1	- -	- -	- -	3.0	- -	- -	- -	12.0	3.0	- -	3.0
1997	8.91	- -	- -	- -	12.0	- -	- -	- -	- -	12.0	- -	7.0
1998	14.4	- -	- -	- -	25.0	- -	- -	- -	- -	15.0	- -	15.0
1999	9.93	- -	- -	- -	5.0[d]	- -	- -	- -	5.0	5.0	120 pounds/ 5 gallons	- -
2000	9.95	- -	- -	- -	10.1[d]	- -	- -	- -	- -	10.1	10.0	- -
2001	30	- -	- -	- -	18.0[d]	- -	- -	- -	- -	18.0	55 pounds/ 18 gallons	- -
2002	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2003	23.83	- -	- -	- -	15.5[d]	- -	- -	- -	- -	15.5	242.5 pounds/ 15.5 gallons	- -
Totals	- -	6,127.5	17,249.7	8.0	35.0 pounds/ 227.6 gallons	3,792/ 7,775	3,395.5/ 7,121	40,548	288.62	382.65	5,037.5 pounds/ 217.3 gallons	8,595 pounds/ 486 gallons

[a] *Application amounts reported in initial study.*

[b] *3,500 pounds of Clean-Flo Lake Cleanser applied.*

[c] *Additionally, 0.50 gallons of Sonar (fluridone) were applied.*

[d] *Wisconsin Department of Natural Resources APM Annual Summary uses the term "Copper Liquid," the amount applied is listed here as AV-70 for consistency with records from 1968-1997.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 23

SEDIMENT CONCENTRATIONS IN GENEVA LAKE AND DRAFT SEDIMENT QUALITY GUIDELINES

				Draft Guidelines (modified)		
Chemical	Main Basin (mg/kg)	Williams Bay (mg/kg)	Geneva Bay (mg/kg)	Lowest Effect Level	Medium Effect Level	Severe Effect Level
Arsenic	35.4	16.8	19.3	6	33	85
Copper	44.0	- -	- -	25	110	390
Zinc	158.0	232.0	241.0	120	270	820

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

Nuphar variegatum). The present restrictions on water use after application of these herbicides are given in Table 24.

In addition to the chemical herbicides used to control large aquatic plants, copper-based products (copper sulfate, Blue Vitriol, Cutrine, and AV-70) have also been used on Geneva Lake to control nuisance algae and swimmer's itch, as shown in Table 22. Like arsenic, copper 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.[15] Restrictions on water uses after application of copper sulfate are also given in Table 24.

Macrophyte Harvesting

Excessive macrophyte growth on Geneva Lake has historically resulted in a control program that relied primarily on chemical applications. The existing macrophyte control program has continued this practice. In the earlier SEWRPC report, initiation of a limited macrophyte harvesting program by individual property owners was recommended on a site-specific basis, rather than a comprehensive weed harvesting program using conventional weed harvesting equipment.[16] At the time of the current study, mechanical harvesting was not a significant component of the aquatic plant management plan, although there have been discussions in this regard with several riparian communities. Permits are required pursuant to Chapter NR 109 of the *Wisconsin Administrative Code* to cut vegetation in lakes. The harvested plant material must be removed from the water. Analysis of the feasibility of mechanical harvesting on Geneva Lake will be presented in Chapter VII of this report.

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 food web.

Zooplankton

Zooplankton are microscopic animals which inhabit the same environment as phytoplankton, the microscopic plants that constitute their primary food source. An important link in the food chain, zooplankton are, in turn, an important food source for fish. Due to their ability to move themselves through water, zooplankton typically occupy a much broader vertical distribution in the water column than do the more sessile phytoplankton. For the initial report, zooplankton populations were sampled with a 62-foot vertical tow. Twenty-two species of zooplankton belonging to two major zooplankton groups were identified. The dominant zooplankton species were *Cyclops thomasi*, *Daphnia longiremis*, *Eubosmina coregoni*, and *Tropocyclops prasinus*. Comparison of zooplankton populations collected during the initial study with those collected in earlier studies suggested changes in the water quality of Geneva Lake since 1900.[17] In particular, the presence of *Bosmina longirostis* in the initial study was considered to be an indication of possible increased nutrient enrichment. Although Geneva Lake continued to support zooplankton species characteristic of oligotrophic lakes, the presence of more tolerant forms was thought to be an indication of incipient eutrophication.

During the aforereferenced USGS collaborative study, zooplankton populations were surveyed in 1997, 1998 and 1999. Like the initial study, the collaborative study found significant seasonality in the density of zooplankton populations in Geneva Lake, with lowest population levels occurring during late fall through winter. Although no general conclusions were drawn in the collaborative study with respect to the possible nutrient enrichment of

[15] *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.*

[16] *SEWRPC Community Assistance Planning Report No. 60,* op. cit.

[17] Ibid.

Table 24

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

	Days after Application					
Use	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.

Geneva Lake, as reflected in the composition of the zooplankton community, it is noteworthy that *Bosmina longirostis*, present in the initial study and considered an indication of possible nutrient enrichment, was also detected during the collaborative study.

Benthic Invertebrates

The benthic, or bottom dwelling, faunal communities of lakes include such organisms as sludge worms, midges, and caddisfly larvae. These organisms are an important part of the food chain, acting as processors of organic material that accumulates on the lake bottom. Some benthic fauna are opportunistic in their feeding habits, while others are predaceous. The diversity of benthic faunal communities can be used as an indicator of lake trophic status. In general, a reduced or limited diversity of organisms present is indicative of a eutrophic lake; however, there is no single “indicator organism.” Rather, the entire community must be assessed to determine trophic status as populations can fluctuate widely through the year and between years as a consequence of season, climatic variability, and localized water quality changes.

In the initial report, the benthic fauna population of Geneva Lake was sampled with a Ponar® Dredge during summer stratification in September of 1976 and spring turnover of 1977.[18] Four sampling sites were in profundal zone locations west of “The Narrows” separating the east and west portions of the Lake, and one site was located in the littoral zone in Geneva Bay. The profundal zone is typified by low-light conditions, a finely divided organic layer of muck, and varying chemical conditions; the littoral zone generally has sufficient light for plant growth, a coarser, less-organic bottom, and more uniform chemical composition. Analysis of the samples of the benthic populations in these areas found species more tolerant of low oxygen conditions in the deeper profundal sites and species less tolerant of low oxygen condition in the littoral zone. The study indicated that benthic organisms persisted to moderate depths in the Lake, but at depths greater than 50 feet various physio-chemical conditions

[18]Ibid.

were such that the distribution of benthic organisms was restricted. Additionally, from the large number of empty snail shells observed and the numbers of snails collected during the sampling, it was concluded that the Lake had a high snail population which could, in part, explain the prevalence of swimmer's itch in the Lake. Snails serve as an intermediate host for the parasite responsible for swimmer's itch. The large number of empty snail shells would be consistent with the applications of copper sulfate and lime used to mitigate the swimmer's itch problem in the Lake, as discussed earlier in this chapter and documented in Table 22.

Benthic populations were not surveyed during the USGS collaborative study. However, in 2004, the GLEA updated the study on the zebra mussel population in the Lake.[19] The zebra mussel, *Dreissena polymorpha*, an invasive species with known negative impacts on native benthic populations, was first documented in Geneva Lake in 1995. In 1996, as the first in a planned series of surveys to monitor the population of zebra mussels every four years, the GLEA conducted a study to assess the veliger and adult populations of zebra mussels and their impact on the littoral-benthic macroinvertebrate community in the Lake. Subsequently, a second survey was conducted in 2000, followed by the most recent update in 2004.

The 1996 survey concluded that, although *D. polymorpha* had established a reproducing population, the effects of this population on the littoral-benthic macroinvertebrate community could not be determined given the recent date of their introduction into the Lake. Subsequently, the 2000 survey indicated an increase in the *D. polymorpha* population with concomitant changes in the littoral-benthic macroinvertebrate community, including increases in the amphipoid and chironomid populations. The results of the 2004 survey showed that, after exhibiting an increase in numbers between 1996 and 2000, zebra mussel populations had declined between 2000 and 2004. In 1996, *D. polymorpha* had comprised less than 5 percent of average total number of macroinvertebrates in the combined July and August samples; by 2000, this contribution of the total benthic community had increased to about 75 percent of the total. By 2004, the contribution of zebra mussels to the benthic community had dropped to about 60 percent of the total. The 2004 results also showed that, as zebra mussel populations have declined, diversity in the littoral-benthic community increased. The conclusions drawn from the 2004 survey were that *D. polymorpha* in Geneva Lake may be using up the available resources, including food and suitable hard substrate on which to attach themselves. Continued monitoring of this situation will be necessary to determine if this observed stabilization of population numbers, in fact, is occurring.

Fishes of Geneva Lake

Geneva Lake supports a large and diverse fish community. The size and depth of the Lake provide suitable habitat for both cold- and warm-water species, resulting in one of the most diverse fish populations of any lake in the Region.

During the initial SEWRPC study,[20] over 20 species of fish were sampled in Geneva Lake and its tributary streams, as set forth in Table 25. In 2004, seining surveys were conducted by the WDNR on numerous lakes in the southeastern region. These studies, part of a study to compare the current native, nongame fish populations with those that were in existence during the 1970s, used the same equipment and surveyed the same lakes as the earlier survey. The 2004 survey found an overall decrease in the number of native, nongame species, as shown in Table 26. Results similar to those in Table 26 were found for intolerant species of fish, such as the blacknose shiner, pugnose shiner, smallmouth bass, longear sunfish, and least darter, and for various rare species of fish, such as cisco, lake chubsucker, and killifish.

The general decline of the small nongame fish species observed during 2004 is of concern as fish community diversity is generally considered a sign of a healthy lake. A number of factors could be influencing this decline in diversity in Region lakes. These factors may not necessarily be the same factors, or combination of factors, for

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[19]*Jennifer Church, Geneva Lake Environmental Agency,* 2004 Updated Status of *Dreissena polymorpha* and Its Invasive Effects on the Littoral Macroinvertebrates in Geneva Lake, WI, *November 2004.*

[20]*SEWRPC Community Assistance Planning Report No. 60,* op. cit.

Table 25

SPECIES OF GAME FISH SAMPLED IN GENEVA LAKE AND THE STREAMS TRIBUTARY TO THE LAKE: 1976-1977

Species	Scientific Name
Rock Bass	*Ambloplites ruperstris*
Cisco	*Coregonus artedi*
Common Carp	*Cyprinus carpio*
Grass Pickerel	*Esox americanus vermiculatus*
Northern Pike	*Esox lucius*
Black Bullhead	*Ictalurus melas*
Yellow Bullhead	*Ictalurus natalis*
Brown Bullhead	*Ictalurus nebulosus*
Green Sunfish	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Smallmouth Bass	*Micropterus dolomieui*
Largemouth Bass	*Micropterus salmoides*
White Perch	*Morone americana*
Yellow Perch	*Perca flavescens*
Black Crappie	*Pomoxis nigromaculatus*
Rainbow Trout	*Salmo gairdneri*
Brook Trout	*Salmo trutta*
Brook Trout[a]	*Salvelinus fontinalis*
Lake Trout	*Salvelinus namaycush*
Sauger	*Stizotedion canadense*
Walleyed Pike	*Stizotedion vitreum vitreum*

[a]*Found only in the streams of the tributary area.*

Source: Geneva Lake Environmental Agency and SEWRPC.

Table 26

DECLINE OF NONGAME FISH SPECIES IN SELECTED LAKES IN SOUTHEASTERN WISCONSIN: 1978-2004

Lake	Number of Native Species		
	1970s	2004	Change
Beulah	23	14	-9
Big Cedar	12	9	-3
Camp	21	18	-3
Geneva	29	17	-12
Oconomowoc	22	14	-8
Okauchee	18	14	-4
Phantom, Lower	17	7	-10
Phantom, Upper	21	10	-11
Pike	11	14	-3
Rock	17	17	0

Source: Wisconsin Department of Natural Resources and SEWRPC.

every lake; however, one factor noted consistently in the WDNR survey reports was the change in shoreline habitat. Various human activities along the shoreline, clearing of downed trees, removal of aquatic plants, construction of more and larger piers, increasing numbers of moorings for boats and other watercraft, and the concomitant results of human activities, shading of aquatic plants due to the increased numbers of boat moorings, scouring of the lake bottom due to waves reflected off seawalls, increasing volumes of runoff from roofs and paved areas, contribute to changes over time in shoreline habitat that may be having a negative impact on aquatic life. Continued monitoring of fish populations in Geneva and other Regional lakes would be of benefit in further assessment of this possible trend in fish species diversity in southeastern Wisconsin.

During 1998, the WDNR published a report on the results of electrofishing surveys conducted on Geneva Lake between 1996 and 1998. Data on the populations of smallmouth bass, largemouth bass and walleye pike were collected in order to track changes in these populations over time.[21] Although it was felt that warmer water temperatures during the sampling period may have resulted in numbers of walleye that were atypical of the Geneva Lake population, catch rates and size structures of the smallmouth and largemouth bass populations were indicative of balanced, naturally reproducing populations. For both bass species, proportional population densities were within or above the recommended ranges for maintaining balanced populations.

Historically, numerous types of game fish have been stocked in Geneva Lake by the WDNR as well as by private individuals. The stocking record for the period from 1957 to 1985 was presented in the initial SEWRPC report. WDNR stocking records for the period of 1985 to 2005 are shown in Table 27. Historically, walleye have been the most frequently stocked fish in Geneva Lake.

At the time of the initial study, the coldwater fishery in the Lake included trout and cisco. The trout fishery in Geneva Lake was the result primarily of stocking both by the WDNR and private individuals. The

[21]*Douglas E. Welch and R. Dauffenbach,* Smallmouth Bass Survey Report for Geneva Lake, Walworth County, *Wisconsin Department of Natural Resources, 1998.*

Table 27

GAME FISH STOCKED IN GENEVA LAKE: 1985-2005

Year	Brown Trout	Lake Trout	Walleye	Seeforelen Brown Trout	Other
2005	- -	26,310	238,132	4,412	- -
2004	- -	50,500	- -	- -	- -
2003	- -	22,949	247,369	12,000	- -
2002	- -	18,084	- -	14,302	- -
2001	6,000	20,000	275,000	10,000	- -
2000	3,000	12,000	- -	- -	- -
1999	3,000	20,000	529,100	- -	- -
1998	3,000	20,000	3,755	- -	- -
1997	5,000	12,500	47,400	- -	- -
1996	3,000	25,914	- -	- -	- -
1995	3,000	19,925	110,185	- -	- -
1994	3,000	- -	- -	- -	Northern Pike: 819
1993	3,000	- -	93,904	- -	- -
1992	3,000	34,290	- -	- -	Northern Pike: 2,500 Splake: 20,000
1991	3,000	20,000	96,462	- -	- -
1990	3,000	- -	- -	- -	Rainbow Trout: 2,250
1989	- -	- -	54,400	- -	- -
1988	4,000	- -	- -	- -	- -
1987	6,000	1,050	- -	- -	- -
1986	- -	16,500	100,000	- -	- -
1985	2,000	20,000	- -	- -	Northern Pike: 2,500

Source: Wisconsin Department of Natural Resources and SEWRPC.

shallow water cisco fishery present in the Lake at that time was unique for southeastern Wisconsin and was considered to be the result of the exceptionally good water quality conditions in Geneva Lake.

The Lake has naturally reproducing populations of important predatory fish species, walleye, smallmouth bass, largemouth bass, and northern pike, as well as abundant panfish populations. “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. Panfish species known to exist in Geneva Lake include bluegill, pumpkinseed, and yellow perch. 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. While not considered to be an issue in Geneva Lake, panfish populations in some lakes within southeastern Wisconsin have been noted to be stunted, or slow-growing, because their numbers are not controlled by predator fishes. Panfish frequently feed on the fry of predator fish and, if the panfish population is overabundant, they may quickly deplete the predator fry population. Figure 10 illustrates the importance of a balanced predator-prey relationship, using walleyed pike and perch as an example.

“Rough fish” is a broad term applied to species such as carp that do not readily bite on hook and line, but feed on game fish, destroy habitat needed by more desirable species, and are commonly considered in southeastern Wisconsin to be undesirable for human consumption. Rough fish species which have been found in Geneva Lake include carp, lake chubsucker, white sucker, and bowfin. Of these, the lake chubsucker is a State-listed species of special concern.

The Geneva Lake fishery is currently passively managed through current state fishing regulations. The 2006-2007 regulations governing the harvest of fishes from Geneva Lake are summarized in Table 28.[22]

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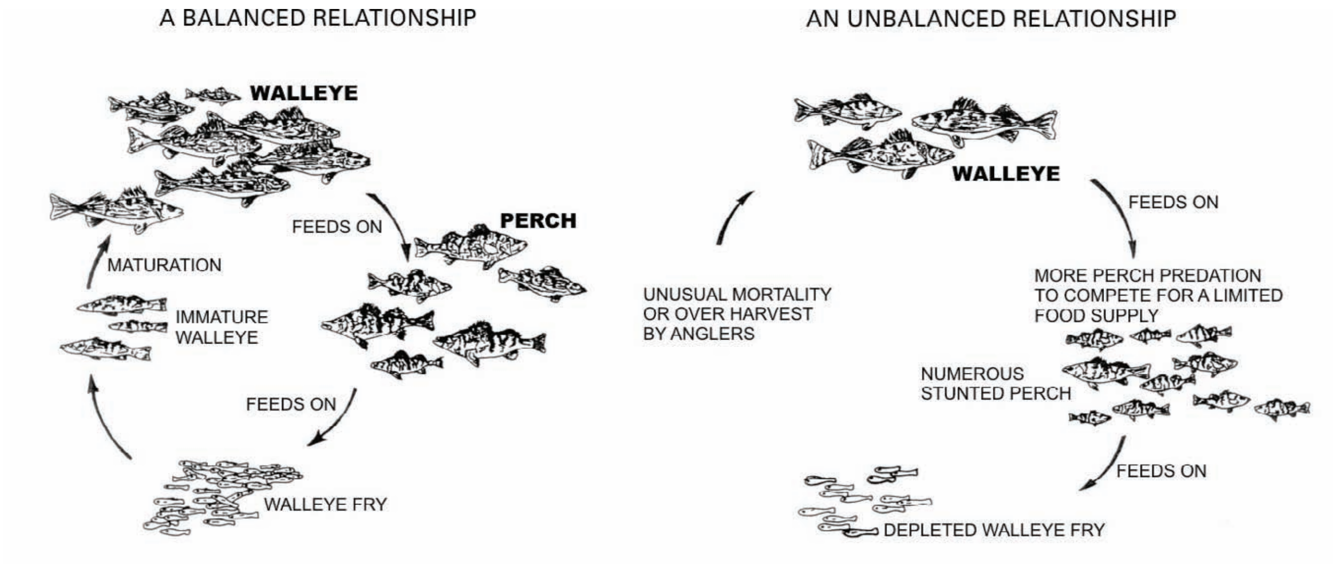
[22]*Wisconsin Department of Natural Resources Publication No. PUB-FH-301 2006,* Guide to Wisconsin Hook and Line Fishing Regulations: 2006-2007*, 2006.*

Figure 10

THE PREDATOR-PREY RELATIONSHIP



Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 28

WISCONSIN STATE FISHING REGULATIONS APPLICABLE TO GENEVA LAKE: 2006-2007

Species	Open Season	Daily Limit	Minimum Size
Northern Pike	May 6 to March 4	1	32 inches
Walleyed Pike	May 6 to March 4	5	15 inches
Muskellunge	May 6 to November 30	1	34 inches
Largemouth and Smallmouth Bass	May 6 to March 4	5	14 inches
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. PUB-FH-301 2006*, Guide to Wisconsin Hook and Line Fishing Regulations 2006-2007, *2006, and SEWRPC.*

Other Wildlife

Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the current study, it is possible, by polling naturalists and wildlife managers familiar with the area, to complete a list of amphibians, reptiles, birds, and mammals that 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 Geneva Lake area; associating these lists with the historic and remaining habitat areas in the Geneva Lake tributary area as inventoried; and projecting the appropriate amphibian, reptile, bird, and mammal species into the Geneva Lake area. The net result of the application of this technique is a listing 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 tributary area.

Mammals

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 Geneva Lake tributary 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 29 lists 37 mammals whose ranges are known to extend into the area.

Birds

A large number of birds, ranging in size from large game birds to small songbirds, also are expected to be found in the Geneva Lake tributary area. Table 30 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 Geneva Lake tributary area supports a significant population of waterfowl. Mallards, wood ducks, blue-winged teal and Canada geese are the most numerous waterfowl and are known to nest in the area. In the aforementioned GLEA survey of Geneva Lake users, just under one-half of respondents, about 45 percent, indicated that they felt the waterfowl populations added to the aesthetics of the Lake, while about one-quarter suggested that waste products from waterfowl hurt the Lake. Many game birds, songbirds, waders, and raptors also reside or visit the Lake and its environs. Osprey 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 species of birds. Hawks and owls function as major rodent predators within the ecosystem. Swallows, whippoorwills, woodpeckers, nuthatches, and flycatchers, as well as several other species, serve as major insect predators. In addition to their ecological roles, birds such as robins, red-winged blackbirds, orioles, cardinals, kingfishers, and mourning doves serve as subjects for bird watchers and photographers. Threatened species migrating in the vicinity of Geneva Lake include the cerulean warbler, Acadian flycatcher, great egret, and osprey. Endangered species migrating in the vicinity of Geneva Lake include the common tern, Caspian tern, Forster’s tern, and loggerhead shrike.

Amphibians and Reptiles

Amphibians and reptiles are vital components of the ecosystem in an environmental unit like the Geneva 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 Geneva Lake area. Table 31 lists the 11 amphibian and 17 reptile species normally expected to be present in the Geneva 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.

WILDLIFE HABITAT AND RESOURCES

The complete spectrum of wildlife species originally native to Walworth County has, along with its habitat, undergone significant change in terms of diversity and population size since the European settlement of the area. This change is a direct result of the conversion of land by the settlers from its natural state to agricultural and urban uses, beginning with the clearing of the forest and prairies, the draining of wetlands, and ending with the development of extensive urban areas. Successive cultural uses and attendant management practices, both rural and urban, have been superimposed on these 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 salts for snow and ice control; the presence of heavy motor vehicle traffic that produces disruptive levels of noise, air pollution, and nonpoint source water pollution; and the introduction of domestic pets.

Table 29

MAMMALS OF THE GENEVA LAKE AREA

Scientific (family) and Common Name	Scientific Name
Didelphidae	
Virginia Opossum	*Didelphis virginiana*
Soricidae	
Cinereous Shrew	*Sorex cinereus*
Short-Tailed Shrew	*Blarina brevicauda*
Vespertilionidae	
Little Brown Bat	*Myotis lucifugus*
Silver-Haired Bat	*Lasionycteris octivagans*
Big Brown Bat	*Eptesicus fuscus*
Red Bat	*Lasiurus borealus*
Hoary Bat	*Lasiurus cinereus*
Leporidae	
Eastern Cottontail Rabbit	*Sylvilgus floridanus*
Sciuridae	
Southern Woodchuck	*Marmota monax*
Thirteen-Lined Ground Squirrel (gopher)	*Spermophilus tridecemlineatus*
Eastern Chipmunk	*Tamias striatus*
Grey Squirrel	*Sciurus carolinensis*
Western Fox Squirrel	*Sciurus niger*
Southern Flying Squirrel	*Glaucomys volans*
Castoridae	
American Beaver	*Castor canadensis*
Cricetidae	
Woodland Deer Mouse	*Peromyscus maniculatus gracilis*
Prairie Deer Mouse	*Peromyscus maniculatus bairdii*
White-Footed Mouse	*Peromyscus leucopus*
Meadow Vole	*Microtus pennsylvanicus*
Prairie 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 (ermine)	*Mustela erminea*
Long-Tailed Weasel	*Mustela frenata*
Mink	*Mustela vison*
Badger	*Taxidea taxus*
Striped Skunk	*Mephitis mephitis*
Otter (occasional visitor)	*Lontra canadensis*
Cervidae	
White-Tailed Deer	*Odecoileus virginianus*

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

Wildlife habitat areas remaining in the Region were inventoried by SEWRPC in cooperation with the WDNR during 1985. The five major criteria used to determine the value of these wildlife habitat areas are listed below:

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

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

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 maintains its proximity to other wildlife habitat areas.

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

On the basis of these five criteria, the wildlife habitat areas in the Geneva 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.

Table 30

BIRDS KNOWN OR LIKELY TO OCCUR IN THE GENEVA LAKE AREA

Scientific (family) and Common Name	Scientific Name	Breeding	Wintering	Migrant
Gaviidae				
Common Loon[a]	*Gavia immer*	- -	- -	X
Podicipedidae				
Pied-Billed Grebe	*Podylimbos podiceps*	X	- -	X
Horned Grebe	*Podiceps auritus*	- -	- -	X
Ardeidae				
American Bittern[a]	*Botaurus lentiginosus*	X	- -	X
Least Bittern[a]	*Ixobrychus exilis*	X	- -	X
Great Blue Heron[a]	*Ardea herodias*	X	R	X
Great Egret[b]	*Casmerodius albus*	- -	- -	X
Cattle Egret[c]	*Bulbulcus ibis*	- -	- -	R
Green-Backed Heron	*Butrodes striatus*	X	- -	X
Black-Crowned Night Heron[a]	*Nycticorax nycticorax*	- -	- -	X
Gruidae				
Sandhill Crane	*Grus canadensis*	X	- -	X
Anatidae				
Tundra Swan	*Cygnus columbianus*	- -	- -	X
Mute Swan[c]	*Cygnus olor*	X	X	X
Snow Goose	*Chen caerulescens*	- -	- -	X
Canada Goose	*Branta canadensis*	X	X	X
Wood Duck	*Aix sponsa*	X	- -	X
Green-Winged Teal	*Anas crecca*	- -	- -	X
American Black Duck[a]	*Anas rubripes*	- -	X	X
Mallard	*Anas platyrhynchos*	X	X	X
Northern Pintail[a]	*Anas acuta*	- -	- -	X
Blue-Winged Teal[a]	*Anas discors*	X	- -	X
Northern Shoveler	*Anas clypeata*	- -	- -	X
Gadwall	*Anas strepera*	- -	- -	X
American Wigeon[a]	*Anas americana*	- -	- -	X
Canvasback[a]	*Aythya valisineria*	- -	- -	X
Redhead[a]	*Aythya americana*	- -	- -	X
Ring-Necked Duck	*Aythya collaris*	- -	- -	X
Lesser Scaup[a]	*Aythya affins*	- -	- -	X
Common Goldeneye[a]	*Bucephala clangula*	- -	X	X
Bufflehead	*Bucephala albeola*	- -	- -	X
Hooded Merganser	*Lophodytes cucullatus*	R	- -	X
Common Merganser[a]	*Mergus merganser*	- -	- -	X
Red-Breasted Merganser[a]	*Mergus serrator*	- -	- -	X
Ruddy Duck	*Oxyura jamaicensis*	- -	- -	X
Cathartidae				
Turkey Vulture	*Cathartes aura*	X	- -	X
Accipitridae				
Osprey[b]	*Pandion haliaetus*	- -	- -	X
Bald Eagle[b,d]	*Haliaeetus leucocephalus*	- -	- -	R
Northern Goshawk[a]	*Accipiter gentilis*	- -	R	R
Cooper's Hawk[a]	*Accipiter cooperi*	X	X	X
Sharp-Shinned Hawk	*Accipiter striatus*	- -	X	X
Northern Harrier[a]	*Circus cyaneus*	X	X	X
Red-Shouldered Hawk[b]	*Buteo lineatus*	R	- -	X
Broad-Winged Hawk	*Buteo platypteris*	- -	- -	X
Red-Tailed Hawk	*Buteo jamaicensis*	X	X	X
Rough-Legged Hawk	*Buteo lagopus*	- -	X	X
Falconidae				
American Kestrel	*Falco sparverius*	X	X	X
Merlin[a]	*Falco columbarius*	- -	- -	X

Table 30 (continued)

Scientific (family) and Common Name	Scientific Name	Breeding	Wintering	Migrant
Phasianidae				
Gray Partridge[c]	*Perdix perdix*	R	R	- -
Ring-Necked Pheasant[c]	*Phasianus colchicus*	X	X	- -
Wild Turkey	*Meleagris galloparvo*	X	X	- -
Northern Bobwhite[e]	*Corlinus virginianus*	X	- -	- -
Rallidae				
Virginia Rail	*Rallus limicola*	X	- -	X
Sora	*Porzana carolina*	X	- -	X
Common Moorhen	*Gallinula chlorapus*	X	- -	X
American Coot	*Fulca americana*	X	R	X
Charadriidae				
Black-Bellied Plover	*Pluvialis squatarola*	- -	- -	X
Lesser Golden Plover	*Pluvialis dominica*	- -	- -	X
Killdeer	*Charadrius vociferus*	X	- -	X
Scolopacidae				
Greater Yellowlegs	*Tringa melanolueca*	- -	- -	X
Lesser Yellowlegs	*Tringa flavipes*	- -	- -	X
Solitary Sandpiper	*Tringa solitaria*	- -	- -	X
Spotted Sandpiper	*Actitis macularia*	X	- -	X
Upland Sandpiper[a]	*Bartramia longicauda*	R	- -	X
Pectoral Sandpiper	*Calidria melantos*	- -	- -	X
Common Snipe	*Capella gallinago*	R	R	X
American Woodcock	*Philohela minor*	X	- -	X
Wilson's Phalarope	*Steganopus tricolor*	- -	- -	X
Laridae				
Bonaparte's Gull[a]	*Larus philadelphia*	- -	- -	X
Ring-Billed Gull	*Larus delawarensis*	- -	- -	X
Herring Gull	*Larus argentatus*	- -	X	X
Common Tern[†]	*Sterna hirunda*	- -	- -	R
Forster's Tern[†]	*Sterna forsteri*	R	- -	X
Black Tern	*Chlidonias niger*	X	- -	X
Columbidae				
Rock Dove[c]	*Columba livia*	X	X	- -
Mourning Dove	*Zenaida macroura*	X	X	X
Cuculidae				
Black-Billed Cuckoo	*Coccyzus erythropthalmus*	X	- -	X
Yellow-Billed Cuckoo[a]	*Coccyzus americanus*	X	- -	X
Strigidae				
Eastern Screech Owl	*Otus asio*	X	X	- -
Great Horned Owl	*Bubo virginianus*	X	X	- -
Snowy Owl	*Nyctea scandiaca*	- -	R	X
Barred Owl	*Strix varia*	X	X	- -
Long-Eared Owl[a]	*Asio otus*	R	R	X
Short-Eared Owl[a]	*Asio flammeus*	- -	R	X
Northern Saw-Whet Owl	*Aegolius acadicus*	- -	- -	X
Caprimulgidae				
Common Nighthawk	*Chordeiles minor*	X	- -	X
Apodidae				
Chimney Swift	*Chaetura pelagica*	X	- -	X
Trochilidae				
Ruby-Throated Hummingbird	*Archilocus colubris*	X	- -	X
Alcedinidae				
Belted Kingfisher	*Megaceryle alcyon*	X	X	X

Table 30 (continued)

Scientific (family) and Common Name	Scientific Name	Breeding	Wintering	Migrant
Picidae				
Red Bellied Woodpecker	*Melanerpes carolinus*	X	X	- -
Red-Headed Woodpecker[a]	*Melanerpes erythrocephalus*	X	R	X
Yellow-Bellied Sapsucker	*Sphyrapicus varius*	- -	R	X
Downy Woodpecker	*Picoides pubescens*	X	X	- -
Hairy Woodpecker	*Picoides villosus*	X	X	- -
Northern Flicker	*Colaptes auratus*	X	R	X
Tyrannidae				
Olive-Sided Flycatcher	*Nuttallornis borealis*	- -	- -	X
Eastern Wood-Pewee	*Contopus virens*	X	- -	X
Yellow-Bellied Flycatcher[a]	*Empidonax flaviventris*	- -	- -	X
Acadian Flycatcher[b]	*Empidonax virescens*	X	- -	X
Alder Flycatcher	*Empidonax alnorum*	R	- -	X
Willow Flycatcher	*Empidonax traillii*	X	- -	X
Least Flycatcher	*Empidonax minimus*	X	- -	X
Eastern Phoebe	*Sayornia phoebe*	X	- -	X
Great Crested Flycatcher	*Myiarchus crinitus*	X	- -	X
Eastern Kingbird	*Tyrannus tyrannus*	X	- -	X
Alaudidae				
Horned Lark	*Eremophila alpestris*	X	X	X
Hirundinidae				
Purple Martin[a]	*Progne subris*	X	- -	X
Tree Swallow	*Iridoprocne bicolor*	X	- -	X
Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*	X	- -	X
Bank Swallow	*Riparia riparia*	X	- -	X
Cliff Swallow	*Pertocheliden pyrrhonota*	X	- -	X
Barn Swallow	*Hirundo rustica*	X	- -	X
Corvidae				
Blue Jay	*Cyanocitta cristata*	X	X	X
American Crow	*Corvus brachyrhynchos*	X	X	X
Paridae				
Black-Capped Chickadee	*Parus atricapillus*	X	X	X
Sittidae				
Red-Breasted Nuthatch	*Sitta canadensis*	- -	X	X
White-Breasted Nuthatch	*Sitta carolinensis*	X	X	- -
Certhiidae				
Brown Creeper	*Certha familiaris*	- -	X	X
Troglodytidae				
House Wren	*Troglodytes aedon*	X	- -	X
Winter Wren	*Troglodytes troglodytes*	- -	- -	X
Sedge Wren	*Cistothorus platensis*	X	- -	X
Marsh Wren	*Cistothorus palustrus*	X	- -	X
Regulidae				
Golden-Crowned Kinglet	*Regulus satrapa*	- -	X	X
Ruby-Crowned Kinglet[a]	*Regulus calendula*	- -	- -	X
Sylviidae				
Blue-Gray Gnatcatcher	*Polioptila caerulea*	X	- -	X
Turidae				
Eastern Bluebird	*Sialia sialis*	X	- -	X
Veery[a]	*Catharus fuscenscens*	X	- -	X
Gray-Cheeked Thrush	*Catharus minimus*	- -	- -	X
Swainson's Thrush[a]	*Catharus ustulatus*	- -	- -	X
Hermit Thrush	*Catharus guttatus*	- -	- -	X
Wood Thrush[a]	*Hylocichla mustelina*	X	- -	X
American Robin	*Turdus migratorius*	X	X	X

Table 30 (continued)

Scientific (family) and Common Name	Scientific Name	Breeding	Wintering	Migrant
Mimidae				
Gray Catbird	*Dumetalla carolinensis*	X	- -	X
Brown Thrasher	*Toxostoma rufum*	X	- -	X
Motacillidae				
American Pipit	*Anthus spinoletta*	- -	- -	X
Bombycillidae				
Bohemian Waxwing	*Bombycilla garrulus*	- -	R	- -
Cedar Waxwing	*Bombycilla cedorum*	X	X	X
Lanniidae				
Northern Shrike	*Lanius excubitor*	- -	X	X
Loggerhead Shrike[t]	*Lanius ludovicianus*	- -	- -	R
Sturnidae				
European Starling[c]	*Sturnus vulgaris*	X	X	X
Vireonidae				
White-Eyed Vireo[a]	*Vireo griseus*	- -	- -	X
Solitary Vireo	*Vireo solitarius*	- -	- -	X
Yellow-Throated Vireo	*Vireo flavifrons*	X	- -	X
Warbling Vireo	*Vireo gilvus*	X	- -	X
Red-Eyed Vireo	*Vireo olivaceus*	X	- -	X
Parulidae				
Blue-Winged Warbler	*Vermivora pinus*	X	- -	X
Golden-Winged Warbler[a]	*Vermivora chrysoptera*	- -	- -	X
Tennessee Warbler[a]	*Vermivora peregrina*	- -	- -	X
Orange-Crowned Warbler	*Vermivora celata*	- -	- -	X
Nashville Warbler[a]	*Vermivora ruficapilla*	- -	- -	X
Northern Parula	*Parula americana*	- -	- -	X
Yellow Warbler	*Dendroica patechia*	X	- -	X
Chestnut-Sided Warbler	*Dendroica pensylvanica*	- -	- -	X
Magnolia Warbler	*Dendroica magnolia*	- -	- -	X
Cape May Warbler[a]	*Dendroica tigrina*	- -	- -	X
Black-Throated Blue Warbler	*Dendroica caerulescens*	- -	- -	X
Yellow-Rumped Warbler	*Dendroica coronata*	- -	X	X
Black-Throated Green Warbler	*Dendroica virens*	- -	- -	X
Blackburnian Warbler	*Dendroica fusca*	- -	- -	X
Pine Warbler	*Dendroica pinus*	- -	- -	R
Prairie Warbler	*Dendroica discolor*	- -	- -	X
Palm Warbler	*Dendroica palmarum*	- -	- -	X
Bay-Breasted Warbler	*Dendroica castanea*	- -	- -	X
Blackpoll Warbler	*Dendroica striata*	- -	- -	X
Cerulean Warbler[b]	*Dendroica cerulea*	R	- -	R
Black-and-White Warbler	*Mniotilta varia*	- -	- -	X
American Redstart	*Setophaga ruticilla*	X	- -	X
Prothonotary Warbler[a]	*Protonotaria citrea*	- -	- -	R
Ovenbird	*Seiurus aurocapillus*	X	- -	X
Northern Waterthrush	*Seiurus noveboracensis*	- -	- -	X
Louisiana Waterthrush[a]	*Seiurus motacilla*	- -	- -	X
Common Yellowthroat	*Geothlypis trichas*	X	- -	X
Connecticut Warbler[a]	*Oporonis agilis*	- -	- -	X
Wilson's Warbler[a]	*Wilsonia pusilla*	- -	- -	X
Mourning Warbler	*Oporonis philadelphia*	R	- -	X
Canada Warbler	*Wilsonia canadensis*	- -	- -	X
Yellow-Breasted Chat[a]	*Icteria virens*	R	- -	R
Thraupidae				
Scarlet Tanager	*Piranga rubra*	X	- -	X

Table 30 (continued)

Scientific (family) and Common Name	Scientific Name	Breeding	Wintering	Migrant
Cardinalidae				
Northern Cardinal	*Cardinalis cardinalis*	X	X	- -
Rose-Breasted Grosbeak	*Pheucticus ludovicianus*	X	- -	X
Indigo Bunting	*Passerina cyanea*	X	- -	X
Emberizidae				
Dickcissel[a]	*Spiza americana*	R	- -	X
Rufous-Sided Towhee	*Pipilo erythrophthalmus*	X	- -	X
American Tree Sparrow	*Spizella arborea*	- -	X	X
Chipping Sparrow	*Spizella passerina*	X	- -	X
Field Sparrow[a]	*Spizella pusilla*	X	- -	X
Vesper Sparrow[a]	*Pooecetes graminues*	X	- -	X
Lark Sparrow	*Chondestes grammacus*	- -	- -	R
Savannah Sparrow[a]	*Passerculus sandwichensis*	X	- -	X
Grasshopper Sparrow[a]	*Ammodramus savannarum*	X	- -	X
Henslow's Sparrow[b]	*Ammodramus henslowii*	R	- -	X
Fox Sparrow	*Passerella iliaca*	- -	R	X
Song Sparrow	*Melospiza melodia*	X	X	X
Lincoln's Sparrow	*Melospiza lincolnii*	- -	- -	X
Swamp Sparrow	*Melospiza georgiana*	X	X	X
White-Throated Sparrow	*Zonotrichia albicollis*	- -	R	X
White-Crowned Sparrow	*Zonotrichia leucophrys*	- -	- -	X
Dark-Eyed Junco	*Junco hymealis*	- -	X	X
Lapland Longspur	*Calcarius lapponicus*	- -	X	X
Snow Bunting	*Plectrophenax nivalis*	- -	X	X
Icteridae				
Bobolink[a]	*Dolichonyx oryzivorus*	X	- -	X
Red-Winged Blackbird	*Agelius phoeniceus*	X	X	X
Eastern Meadowlark[a]	*Sturnella magna*	X	R	X
Western Meadowlark[a]	*Sturnella neglecta*	R	- -	X
Yellow-Headed Blackbird	*Xanthocephalus xanthocephalus*	X	- -	X
Rusty Blackbird	*Euphagus carolinus*	- -	R	X
Common Grackle	*Quiscalus quiscula*	X	X	X
Brown-Headed Cowbird	*Molothrus ater*	X	R	X
Orchard Oriole[a]	*Icterus spurius*	R	- -	X
Northern Oriole	*Icterus galbula*	X	- -	X
Fringillidae				
Purple Finch	*Carpodacus purpureus*	- -	X	X
House Finch	*Carpodacus mexicanus*	X	X	X
Common Redpoll	*Carduelis flammea*	- -	X	X
Pine Siskin[a]	*Carduelis pinus*	- -	X	X
American Goldfinch	*Carduelis tristis*	X	X	X
Evening Grosbeak	*Hesperiphona vespertina*	- -	X	X
Passeridae				
House Sparrow[c]	*Passer domesticus*	X	X	- -

NOTE: Total number of bird species: 216
Number of alien, or nonnative, bird species: 6 (3 percent)

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

X - Present, not rare
R - Rare

Table 30 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]*Occurs in the lake study area as escapes from managed hunt programs.*

[f]*State-designated endangered species.*

Source: John E. Bielefeldt, Racine County Naturalist, and SEWRPC.

As shown on Map 13, about 4,187 acres, or about 23 percent of the area tributary to Geneva Lake, were classified in the 1985 inventory as wildlife habitat. This area is somewhat larger than the area reported in the initial planning study, which indicated about 2,116 acres of the area tributary to Geneva Lake to be wildlife habitat. This increase reflects, in part, the results of the wetland acquisition and restoration program of the Geneva Lake Conservancy and others as well as continued refinement of wildlife habitat boundaries. Of the current area of wildlife habitat, about 1,097 acres, or about 6 percent of the tributary area, were classified as Class I habitat; 1,948 acres, or 10 percent, were classified as Class II habitat; and, 1,142 acres, or 6 percent, were classified as Class III habitat.

NATURAL AREAS AND CRITICAL SPECIES HABITAT

The Geneva Lake area contains natural areas of regional and statewide importance, due to its richness of natural habitat and biota and contains four specially designated natural areas as defined in the adopted Regional Natural Areas and Critical Species Habitat plan.[23] The locations of these four natural areas are shown in the following order, from west to east, on Map 14:

1. Fontana Prairie and Fen: This 10-acre moderate-quality calcerous fen and wet-mesic prairie complex is located near the west end of Geneva Lake. It contains several uncommon species, including the State-designated threatened beaked spike-rush (*Eleocharis rostellata*). In addition to its listing by the WDNR as a Rare Species Habitat, Fontana Prairie and Fen has received an NA-3 designation identifying it as a natural area of local significance.

2. Williams Bay Lowlands: Under the ownership of the Village of Williams Bay, this eight-acre parcel of Rare Species Habitat has been given an NA-3 designation identifying it as a natural area of local significance. It is a moderate-quality complex of sedge meadow, shrub-carr, shallow marsh, wet prairie, and lowland hardwoods containing the white lady's-slipper orchid (*Cypripedium candidum*), a State-designated threatened species.

3. Peninsula Woods: This 39-acre parcel, under private ownership, consists of a dry-mesic hardwood stand on the north side of Geneva Lake. It contains a valuable plant species, the American gromwell (*Lithospermum latifolium*), a State-designated species of special concern and, as a Rare Species Habitat, has received the designation of NA-3 identifying it as a natural area of local significance.

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

Table 31

AMPHIBIANS AND REPTILES OF THE GENEVA 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
Eastern Tiger Salamander	*Ambystoma tigrinum tigrinum*	X	- -
Salamandridae			
Central Newt	*Notophthalmus viridescens louisianenis*	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
Cope's Gray Tree Frog	*Hyla chrysocelis*	- -	X
Ranidae			
Green Frog	*Rana clamitans melanota*	X	- -
Northern Leopard Frog	*Rana pipiens*	- -	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[c]	*Emydoidea blandingii*	- -	X
Trionychidea			
Eastern Spiny Softshell	*Trionyx spiniferus spiniferus*	X	- -
Colubridae			
Northern Water Snake	*Nerodia sipedon sipedon*	X	- -
Queen Snake[b]	*Regina septemvittata*	- -	X
Midland Brown Snake	*Storeria delcayi wrightorum*	X	- -
Northern Redbelly Snake	*Storeia occipitormaculata occipitormaculata*	X	- -
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*	X	- -
Chicago Garter Snake	*Thamnophis sirtalis semifasciata*	X	- -
Eastern Plaines Garter Snake	*Thamnophis radix radix*	X	- -
Eastern Hognose Snake	*Heterodon platyrhinos*	- -	X
Eastern Smooth Green Snake	*Opheodrys vernalis vernalis*	- -	X
Eastern Milk Snake	*Lampropeltis triangulum triangulum*	- -	X
Viperidae			
Eastern Massasaga Rattlesnake[b]	*Sistrurus catenatus catenatus*	- -	X

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

[b]*Identified as endangered in Wisconsin.*

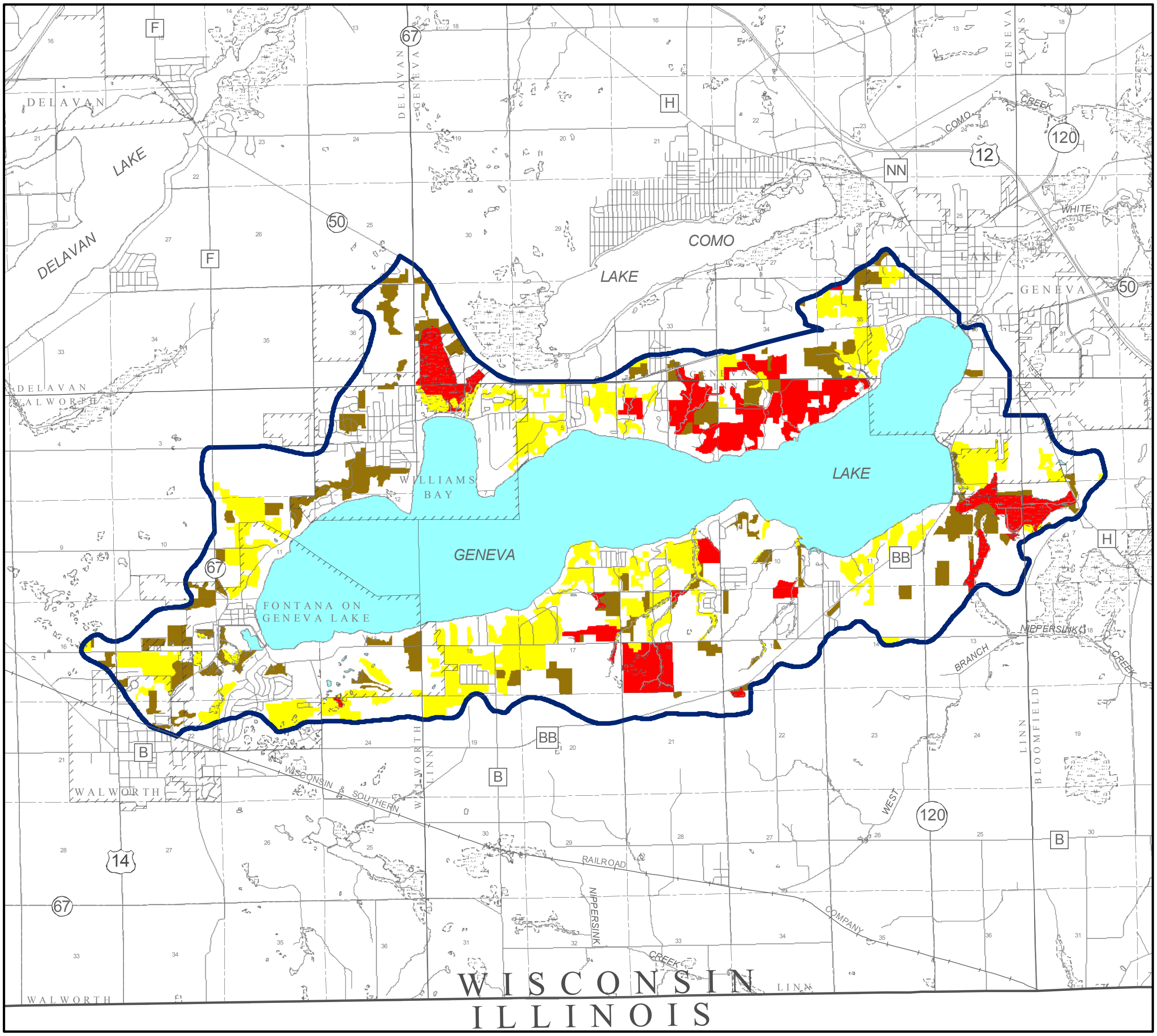
[c]*Identified as threatened in Wisconsin.*

Source: Gary S. Casper, Geographical Distribution of the Amphibians and Reptiles of Wisconsin*, 1996, Wisconsin Department of Natural Resources, R.C. Vogt,* Natural History of the Amphibians and Reptiles of Wisconsin*, 1981, U.S. Department of Agriculture Integrated Taxonomic Information System, and SEWRPC.*

4. Wychwood: This 226-acre parcel, under private ownership, is comprised of a large tract of dry-mesic hardwoods occupying a terminal moraine on the north side of Geneva Lake. An area of generally good quality throughout, it is identified as an area of local significance and, as such, has been given a designation of NA-3.

Map 13

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



CLASS I, HIGH-VALUE HABITAT

CLASS II, MEDIUM-VALUE HABITAT

CLASS III, GOOD-VALUE HABITAT

SURFACE WATER

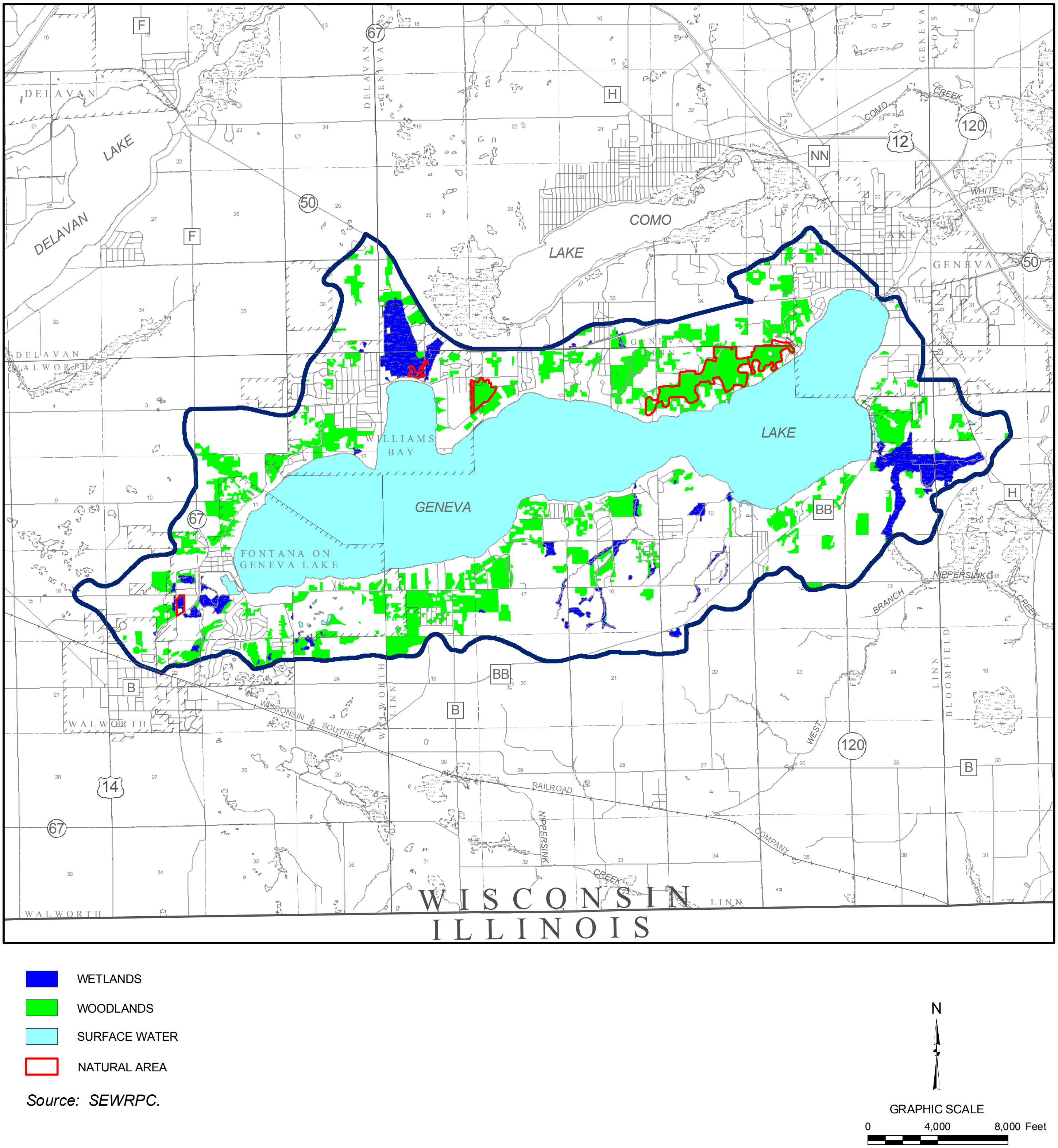
Source: SEWRPC.

GRAPHIC SCALE

0 4,000 8,000 Feet

Map 14

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



Source: SEWRPC.

Geneva Lake, the White River, Potawatomi Creek, Van Slyke Creek, and Southwick Creek have all been assigned a rating of AQ-2 identifying them as aquatic areas of countywide or regional significance. Additionally, Potawatomi and Van Slyke Creeks are rated as Class I trout streams containing high-quality trout habitat, requiring no stocked or hatchery trout. Southwick Creek is rated as a Class II trout stream containing adequate food sources and living space, but not enough natural reproduction to utilize available resources. Table 32 presents a summary of the endangered, threatened, rare or special concern species in the Geneva Lake area.

In 2003, the GLC published a Priority Areas Inventory and Protection Plan for the Geneva Lake area.[24] The mission of the GLC is to promote responsible growth and development in the region while protecting natural resources and historical sites. As a part of the aforementioned GLC-project, a geographic information system (GIS)-based inventory of natural and agricultural areas recommended for protection was developed.

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).[25]

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 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.[26]

As a practical matter, experience has shown that application of the WDNR, the USEPA and USCOE, and the 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 a provision in the Federal wetland delineation manual that allows for the application of professional judgment in cases where the satisfaction of the three criteria for wetland identification is unclear.

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[24] *Geneva Lake Conservancy Executive Summary,* Priority Areas Inventory and Protection Plan, *June 2003.*

[25] *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.*

[26] *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.*

Table 32

ENDANGERED, THREATENED, RARE, SPECIAL CONCERN, AND UNCOMMON SPECIES IN THE GENEVA LAKE AREA: 1997

Species of Concern	Location	Species Status
Plants		
American Gromwell	Peninsula Woods	Special concern
Beaked Spike-Rush	Fontana Prairie and Fen	Uncommon
White Lady's-Slipper Orchid	Williams Bay Lowlands	Threatened
Fish		
Lake Herring	Geneva Lake	Special concern
Least Darter	Geneva Lake, White River	Special concern
Longear Sunfish	White River	Threatened
River Redhorse	White River	Threatened
Birds		
Alder Flycatcher	Bloomfield Tamaracks	Uncommon
Black Tern	Bloomfield Tamaracks, Como Lake, Section Five Marsh and Pond, Swift	Rare
Veery	Bloomfield Tamaracks	Uncommon

Source: SEWRPC.

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

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

Table 33 characterizes the wetland plant species typically found in the tributary area. As shown on Map 14, in 2000, wetlands covered about 590 acres, or 3 percent, of the area tributary to Geneva Lake. This is somewhat greater than the 492 acres in existence at the time of the initial report, the increase being due to the wetland acquisition and restoration programs of the GLC and others as well as to the continued refinement of wetland boundaries. Major wetland communities located in the area tributary to Geneva Lake include deep- and shallow-water marsh, sedge meadow, fresh (wet) meadow, shrub carr, southern wet to wet-mesic hardwoods, and fens. The amount and distribution of wetlands in the area should remain relatively constant if the recommendations contained in the adopted regional land use plan are followed. Of special note are the large areas of wetland in Williams Bay, the Kishwauketoe Nature Conservancy (KNC) area, and in the vicinity of the Big Foot Beach State Park, and the remnants of a much larger wetland in the Village of Fontana-on-Geneva Lake.

Table 33

EMERGENT WETLAND PLANT SPECIES IN THE AREA TRIBUTARY TO GENEVA LAKE

Scientific Name — Family, Genus, and Species	Common Name
Polypodiaceae	
Thelypteris palustris	Marsh fern
Cypressaceae	
Thuja occidentalis	White cedar
Typhaceae	
Typha latifolia	Broadleaf cat-tail
Typha angustifolia	Narrowleaf cat-tail
Sparganiaceae	
Sparganium eurycarpum	Bur-reed
Alismataceae	
Alisma plantago-aquatica	Water plantain
Sagittaria latifolia	Arrow-head
Gramineae	
Bromus ciliatus	Ciliated brome grass
Glyceria striata	Fowl manna grass
Phramites communis	Reed grass
Calamagrostis canadensis	Canada bluojoint grass
Agrostis stolonifera[a]	Redtop grass
Muhlenbergia glomerata[b]	Muhly grass
Muhlenbergia mexicana-racemosa[b]	Muhly grass
Spartina pectinata	Prairie cord grass
Phalaris arundinacea[a]	Reed canary grass
Leersia oryzoides	Cut grass
Andropogon gerardi[b]	Big Bluestem grass
Cyperaceae	
Eleocharis rostellata[a,b]	Beaked spike rush
Scirpus validus	Softstem bulrush
Scirpus acutus	Hardstem bulrush
Scirpus fluviatilis	River bulrush
Scirpus atrovirens	Green bulrush
Eriophorum sp.	Cotton grass
Carex sterilis[b]	Sedge
Carex stricta	Tussock sedge
Carex lacustris	Lake sedge
Carex spp.	Sedges
Araceae	
Sumplocarpus foetidus	Skunk cabbage
Acorus calamus	Sweet flag
Amaryllidaceae	
Hypoxix hirsuta	Star-grass
Iridaceae	
Iris versicolor	Blue flag
Orchidaceae	
Habenaria hyperborea	Northern fringed orchid
Salicaceae	
Populus deltoides	Cottonwood
Salix serissima	Autumn willow
Salix candida	Sage-leaved willow
Salix nigra	Black willow
Salix interior	Sandbar willow
Salix discolor	Pussy willow
Betulaceae	
Betula papyrifera	Paper birch
Betula pumila	Bog birch
Ulmaceae	
Ulmus americana	American elm
Urticaceae	
Urtica dioica	Stinging nettle
Polygonaceae	
Rumex orbiculatus	Water dock
Polygonum natans	Smartweed
Ranunculaceae	
Caltha palustris	Marsh marigold
Thailictrum dasycarpum	Meadow rue
Aquifoliaceae	
Ilex verticillata	Winterberry
Aceraceae	
Acer negundo	Boxelder
Balsaminaceae	
Impatiens biflora	Jewel weed
Rhamnaceae	
Rhamnus cathartica[a]	Common buckthorn
Rhamnus alnifolius[b]	Alderleaf buckthorn
Hypericaceae	
Triadenum fraseri	Marsh St. John's wort
Lythraceae	
Decodon verticillatus	Water-willow
Lythrum salicaria[a]	Purple loosestrife
Onagraceae	
Epilobium coloratum	Willow-herb
Umbelliferae	
Zizia aurea	Golden alexanders
Cicuta bulbifera	Water-hemlock
Angelica atropurpurea	Angelica
Oxypolis rigidior	Cowbane
Cornaceae	
Cornsus amomum	Silky dogwood
Cornsus stolonifera	Red osier dogwood
Oleaceae	
Fraxinus pennsylvanic	Green ash
Gentianaceae	
Gentiana procera[b,d]	Lesser fringed gentian
Asclepiadaceae	
Asclipias incarnata	Marsh milkweed
Verbenaceae	
Verbena hastata	Blue vervain
Labiatae	
Pycnanthemum virginianum	Mountain mint
Lycopus virginicus	Bugle weed
Lycopus americanus	Common water horehound
Mentha arvensis	Wild mint
Mentha piperita[a]	Peppermint
Scrophulariaceae	
Chelone glabra	Turtlehead
Pedicularis lanceolata	Swamp lousewort
Caprifoliceae	
Viburnum trilobum	Highbush cranberry
Viburnum lentago	Nannyberry
Sambucus canadensis	Elderberry
Cucurbitaceae	
Echinocystis lobata	Wild cucumber
Valerianaceae	
Valeriana edulis	Marsh valerlan
Lobeliaceae	
Lobelia siphilitica	Great blue lobelia
Lobelia kalmii[b]	Brook lobelia
Compositae	
Helenium autumnale	Sneezeveed
Bidens cernua	Bur marigold
Bidens frondosa	Beggar's ticks
Ambrosia trifida	Giant ragweed
Solidago uliginosa	Bog goldenrod
Solidago patula	Swamp goldenrod
Solidago gigantea	Giant goldenrod
Solidago ohioensis[b,d]	Ohio goldenrod
Solidago riddellii[b]	Riddell's goldenrod
Solidago graminifolia	grass-leaved goldenrod
Aster novae-angliae	New England aster

Table 33 (continued)

Scientific Name Family, Genus, and Species	Common Name
Cruciferae	
Cardamine bulbosa	Bitter cress
Nasturtium officinale[a]	Water-cress
Saxifragaceae	
Parnassia glauca[b]	Grass of Parnassus
Ribes hirtellum	Northern gooseberry
Rosaceae	
Physocarpus opulifolius	Ninebark
Potentilla fruticosa	Shrubby cinquefoil
Potentilla palustris	Bog cicquefoil

Scientific Name Family, Genus, and Species	Common Name
Compositae (continued)	
Aster puniceus	Redstem aster
Aster ludiculus	Swamp aster
Aster junciformis	Rush aster
Aster umbellatus	Flat-top aster
Aster Simplex	Marsh aster
Eupatorium maculatum	Joe-pys weed
Eupatorium perfoliatum	Boneset
Liatris pycnostachya	Gayfeather
Cirsium miticum[b]	Swamp thistle

NOTE: This table is presented in taxonomic order.

[a] *Alien or nonnative plant species.*

[b] *Plant species located in the fen.*

[c] *Identified as a Wisconsin endangered plant species in Wisconsin Department of Natural Resources Technical Bulletin No. 92, Endangered and Threatened Vascular Plants in Wisconsin, by Robert H. Reed.*

[d] *Identified as a Wisconsin threatened plant species, Ibid.*

Source: SEWRPC.

Deep and shallow marsh plant communities are dominated by cattails (*Typha* spp.). Other emergent plant species commonly occurring in the deep and shallow marshes within the Geneva Lake tributary area include bur-reed (*Sparganium eurycarpum*), arrow-head (*Sagittaria latifolia*), reed grass (*Phragmites communis*), bulrush (*Scirpus* spp.), lake sedge (*Carex lacustris*), and water-willow (*Decodon verticillatus*). A shallow marsh is associated with the fen located north of Williams Bay.

Sedge meadows are considered to be 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 willow (*Salix* spp.) and red osier dogwood (*Cornus stolonifera*). In extremely disturbed shrub carrs, the willow, 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 meadows which are dominated by forbes such as the marsh (*Aster simplex*), swamp (*Aster lucidulus*), and New England (*Aster novae-angliae*) asters, and the giant goldenrod (*Solidago gigantea*). As reported in the initial study, a fresh meadow is associated with the sedge meadow and shrub-carr complex located immediately south of the Big Foot State Park.

Fens are very rare and specialized plant communities growing on water-logged organic soils associated with alkaline springs and seepages. In the initial study, several small fen communities were noted within wetland complexes located in the Villages of Fontana-on-Geneva Lake and Williams Bay. Characteristic plants include shrubby cinquefoil (*Potentilla fruticosa*), Riddell's goldenrod (*Solidago riddellii*), and other species known as calciphiles or calcium tolerant plants.

WOODLANDS

Woodlands are defined by SEWRPC as those areas containing a minimum of 17 trees per acre with a diameter of at least four inches at breast height (4.5 feet above the ground).[27] The woodlands are classified as dry, dry-mesic, mesic, wet-mesic, wet hardwood, and conifer swamp forests; the last three of which are also considered wetlands. SEWRPC maintains an inventory of woodlands within the Region which is updated every five years. In the area tributary to Geneva Lake, approximately 2,515 acres of woodland were inventoried in 1980 as part of the initial report; during the current study, woodlands comprised about 2,443 acres, or about 15 percent of the area tributary to the Lake.

Specifically, the woodlands in the Geneva Lake tributary area, shown on Map 14, include: southern dry-mesic hardwood forests characterized by northern red oak (*Quercus borealis*), shagbark hickory (*Carya ovata*), and white ash (*Fraxinus americana*); southern mesic hardwood forests dominated by sugar maple (*Acer saccharum*) and basswood (*Tilia americana*); and, southern wet to wet-mesic hardwood forests characterized by black willow (*Salix nigra*), cottonwood (*Populus deltoides*), and American elm (*Ulmus americana*). As reported in the initial study, lowland woods in the Geneva Lake tributary area are generally associated with the wetland complexes at the northern end of Williams Bay and the western end of Geneva Lake in the Village of Fontana-on-Geneva Lake. Isolated stands of wet to wet-mesic hardwoods also occur in the Big Foot State Park and at the Big Foot Country Club, located in the Towns of Linn and Walworth, respectively. A high-quality mesic woodland worthy of inclusion in the state scientific area preservation program is located on the northeastern side of the Lake in proximity to the Wychwood Estate.

The amount and distribution of woodlands in the tributary area should also remain relatively stable if the recommendations contained in the regional land use plan are followed. However, if urban development continues within the tributary area much of the remaining woodland cover may be expected to be lost.

ENVIRONMENTAL CORRIDORS

One of the most important tasks undertaken by SEWRPC as part of its regional planning effort was the identification and delineation of those areas of the Region having high concentrations of natural, recreational, historic, aesthetic, and scenic resources and which, therefore, 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 that are essential for 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 at least 400 acres in size, two miles in length, and 200 feet in width. The primary environmental corridors identified in the area tributary to Geneva Lake are contiguous with the environmental corridors and adjacent to the isolated natural resource areas lying outside the Lake area boundary, and, consequently, meet these size and natural resource element criteria.

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[27]*Bruce P. Rubin and Gerald H. Emmerich, Jr., "Refining the Delineation of Environmental Corridors in Southeastern Wisconsin,"* SEWRPC Technical Record*, Vol. 4, No. 2, March 1981.*

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 any one element of the total environment may lead to a chain reaction of deterioration and destruction among the others. The loss of wetlands, for example, may have far-reaching effects, since such loss may lead to the destruction of fish spawning grounds, wildlife habitat, groundwater recharge areas, and the natural filtration and floodwater storage areas of interconnected lake and stream hydrological 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 the destruction of wildlife habitat. Although the effects of any one of these environmental changes may not in and of itself be overwhelming, the combined effects may lead eventually to the deterioration of the underlying and supporting natural resource base, and of the overall quality of the environment for life. The need to protect and preserve the remaining environmental corridors within the area tributary to Geneva Lake thus becomes apparent.

In the area tributary to Geneva Lake, the riverbanks and lakeshores located within the environmental corridors should be candidates for immediate protection through proper zoning or through public ownership. Of the areas not already publicly owned, the remaining areas of natural shoreline, and riparian wetland areas, are perhaps the most sensitive areas in need of greatest protection. In this regard, the regional natural areas and critical species habitat protection and management plan recommends public acquisition of specific lands.[28] Within the area tributary to Geneva Lake, the Fontana Prairie and Fen natural area and the Williams Bay Lowlands natural area, are both already under public ownership by the Village of Fontana-on-Geneva Lake and the Village of Williams Bay, respectively. The Peninsula Woods natural area, totaling 39 acres in areal extent and supporting a State-designated plant species of special concern, and the Wychwood natural area, totaling 226 acres, are recommended for acquisition by private conservancy organizations. Table 34 summarizes the proposed acquisition of the selected natural area sites described above.

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, related undeveloped floodlands, and shorelands. During the initial planning period, the primary environmental corridors in the area tributary to Geneva Lake encompassed about 3,470 acres, or 27 percent of the tributary area in 1980. These corridors have been subject to urban encroachment because of their desirable natural resource amenities. Consequently, as of 2000, about 2,840 acres, or 22 percent of the area tributary to the Lake, remained as primary environmental corridor, as shown on Map 15. Unplanned or poorly planned intrusions of urban development into these corridors, however, not only tend to destroy the very resources and related amenities sought by the development, but also tend to create severe environmental and development problems as well. The preservation of these corridors, thus, is one of the major ways in which the water quality of Geneva Lake can be maintained and perhaps improved.

Secondary Environmental Corridors
The secondary environmental corridors in the Geneva Lake tributary area are located generally along intermittent streams or serve as links between segments of primary environmental corridors. These 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. Secondary environmental corridors facilitate movements of surface water, 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. Such corridors, while not as important as the primary environmental corridors, should be preserved in essentially

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

Table 34

LAND ACQUISITION OF SELECTED NATURAL AREA SITES IN THE GENEVA LAKE TRIBUTARY AREA

Site	Natural Area Class	Total Acres of Site	Acres Already Under Protective Ownership	Acres Proposed to Be Acquired	Proposed Acquisition Agency
Fontana Prairie and Fen......	NA-3	10	10	- -	Village of Fontana-on-Geneva Lake
Williams Bay Lowlands........	NA-3	8	8	- -	Village of Williams Bay
Peninsula Woods................	NA-3	39	- -	39	Private conservancy organization
Wychwood	NA-3	226	- -	226	Private conservancy organization

Source: SEWRPC.

natural, open space uses as urban development proceeds within the tributary area, particularly when the opportunity is presented to incorporate the corridors into urban stormwater detention areas, associated drainage ways, and neighborhood parks. During the initial planning period, as of 1980, secondary environmental corridors encompassed about 40 acres, or less than 1 percent of the area tributary to Geneva Lake. As of 2000, the area identified as secondary environmental corridor was essentially unchanged from 1980, as shown on Map 15.

Isolated Natural Resource Areas

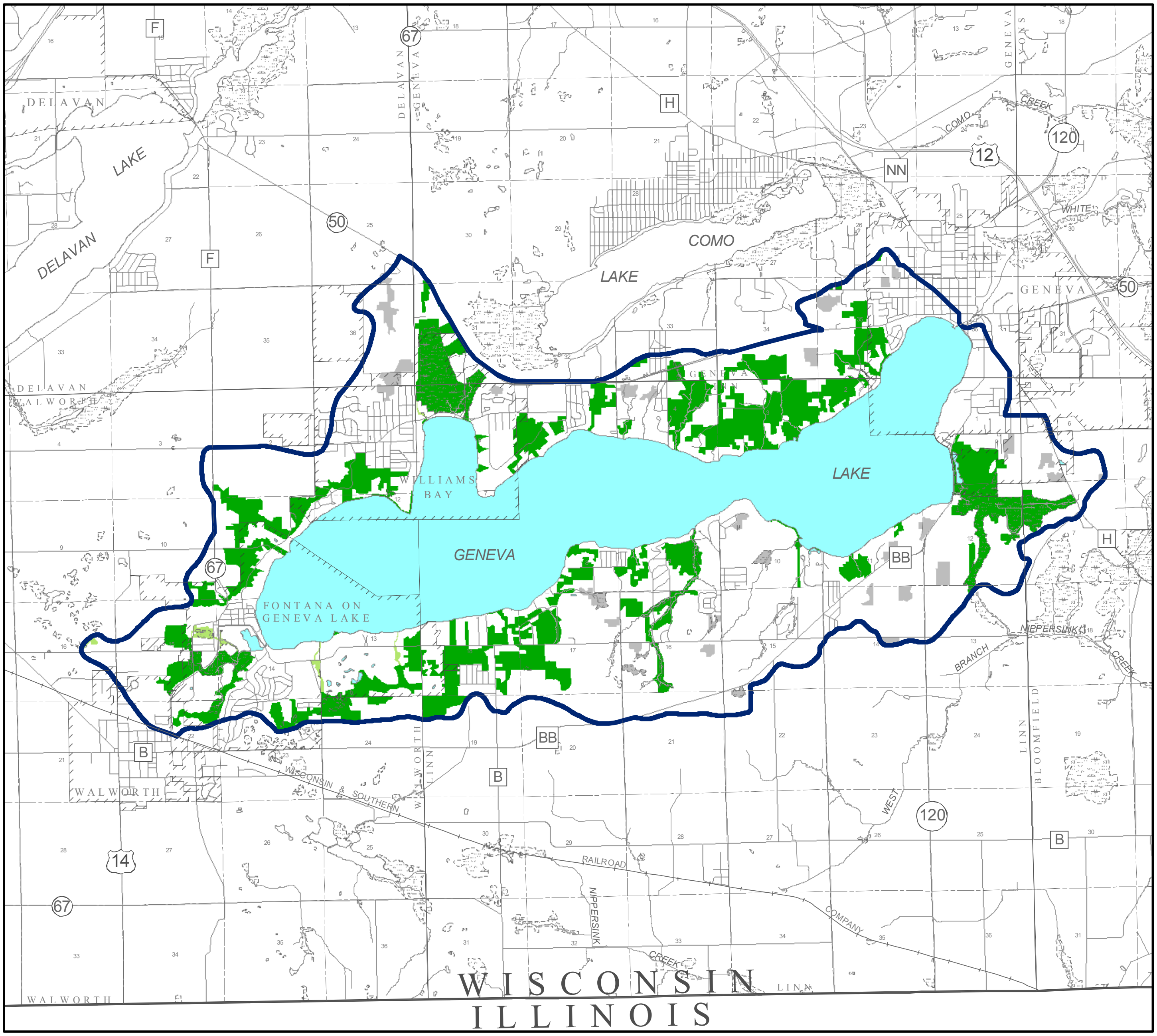
In addition to the environmental corridors, other, small concentrations of natural resource base elements exist within the area tributary to Geneva Lake. These resource base elements are isolated from the environmental corridors by urban development or agricultural uses and, although separated from the environmental corridor network, have important natural values. Isolated natural resource areas may provide the only available wildlife habitat in an area, provide good locations for local parks and nature study areas, and lend an aesthetic character or natural diversity to an area. Important isolated natural resource features within southeastern Wisconsin include a geographically well-distributed variety of isolated wetlands, woodlands, and wildlife habitat. These isolated natural resource features should be protected and preserved in a natural state whenever possible. Such isolated areas, five or more acres in areal extent within the area tributary to Geneva Lake, totaled about 300 acres, or 2 percent of the tributary area as of 1980. As of 2000, isolated natural resource features totaled about 335 acres, or about 2 percent of the area, as shown on Map 15.

SUMMARY

Geneva Lake and its tributary area represent a significant part of the natural resource base of the Region. The Lake, its biota, and the natural areas, woodlands, wetlands, and environmental corridors that comprise this area combine to offer a high quality natural setting that contributes to the quality of life in the area. In recent years, urban development, increased recreational use and introduction of nonnative invasive plant and animal species have resulted in a degradation of the Lake and its tributary area. For this reason, it is important that sound management strategies be developed and implemented to preserve the natural features of Geneva Lake and its tributary area.

Map 15

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



PRIMARY ENVIRONMENTAL CORRIDOR

SECONDARY ENVIRONMENTAL CORRIDOR

ISOLATED NATURAL RESOURCE AREA

SURFACE WATER

Source: SEWRPC.

N

GRAPHIC SCALE
0 4,000 8,000 Feet

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Chapter VI

CURRENT WATER USES AND WATER USE OBJECTIVES

INTRODUCTION

Nearly all major lakes in the Southeastern Wisconsin Region serve multiple purposes, ranging from recreation to receiving waters for stormwater runoff. Recreational uses range from noncontact, passive 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 developed and adopted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC), and are 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 Geneva Lake, are discussed in this chapter.

RECREATIONAL USES AND FACILITIES

Geneva Lake is located within about a one hour drive from much of the metropolitan Milwaukee area as well as the northern suburban communities of the Chicago metropolitan area. Indeed, in a 1999 survey of Geneva Lake users conducted jointly by the Geneva Lake Environmental Agency (GLEA), the University of Wisconsin-Extension (UWEX), and the Wisconsin Department of Natural Resources (WDNR), 80 percent of seasonal residents of the Geneva Lake area reported being from the Chicago metropolitan area.[2] A further 10 percent of seasonally resident respondents reported being from other areas in Illinois.

Geneva Lake is the largest lake in southeastern Wisconsin and the fourth deepest named lake in the State. Its location, many access sites, and degree of shoreline development contribute to a more intensive recreational usage than is found on many other lakes in the Region. The Lake supports a full range of lake uses. These uses include aesthetic viewing, angling, both during the summer and winter fishing seasons, recreational boating, 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.*

[2]*Geneva Lake Environmental Agency,* A Report on the Geneva Lake Use Survey, *October 1999.*

swimming. Winter recreational uses of Geneva Lake also include cross-country skiing, ice boating, ice skating, and snowmobiling. The scope of these recreational uses engaged in on Geneva Lake is sufficiently broad to be consistent with the recommended water 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.

Aesthetic Viewing
The great natural beauty of the Geneva Lake area, with its steeply sloping, wooded northern and southern shores, together with the water clarity of Geneva Lake itself, has been acclaimed since the time of original settlement. In addition, the area's natural beauty has been enhanced through the professional landscaping and architectural design features associated with the large estates established around the Lake beginning in the mid-1870s. The planning and building of these estates, and such institutions as the Yerkes Observatory, demonstrated great care and respect for the natural features of the area, providing visual enjoyment to thousands of visitors who annually view these structures and their grounds from public excursion boats or witness their aesthetic qualities first-hand through the use of the continuous footpath around the Lake. This footpath is accessible to and utilized by the public, and is a feature unique to the Geneva Lake community. The beauty of the Geneva Lake area, both natural and constructed, has been the subject of numerous books and publications, and annually attracts thousands of visitors who participate in the numerous seasonal events and activities the area has to offer. In the 1999 GLEA recreational user survey, "enjoying the view" was among the most popular reported recreational uses of Geneva Lake.[3]

Angling
In 1969, estimates of fishing pressure and fish harvesting on Geneva Lake indicated that, at that time, there were 25 person-hours per acre of water surface devoted to angling during a year.[4] This level of effort was considered to be "light" when compared to other lakes in the area. Nevertheless, given the large size of the Lake, this level of effort would result in a large number of fishing boats. The harvest was estimated at 23 fish per acre with Geneva Lake anglers catching approximately 0.92 fish per hour, compared to a harvest rate of 0.81 fish per hour for other lakes in the area. In the aforereferenced 1999 GLEA survey of Geneva Lake users, nearly half of all respondents reported fishing on Geneva Lake, 78 percent of whom considered their fishing experience to be good to excellent with 71 percent rating the places on the lake from which to fish as good to excellent.

The Geneva Lake fishery has been supported by WDNR stocking programs. As discussed in Chapter V, fisheries surveys indicate that the Lake supports an excellent panfish stock, as well as self-reproducing populations of smallmouth and largemouth bass. Evidence of the good fishing is provided by the number of ice fishing shelters that occur on the ice during the winter months, and by the relatively large numbers of fishing boats and shoreline anglers using the Lake during the summer.

It was reported in the initial SEWRPC report that, due to increasing conflicts between fishermen and power boaters especially on weekends and holidays, little fishing was done during the middle of the day when power boats were most active on the Lake.

Recreational Boating
Due to its size, depth, water quality, aesthetics, and proximity to the metropolitan centers of Milwaukee and Chicago, Geneva Lake is one of the most visited recreational spots in the Region, especially for recreational boating. In an intensive statewide survey of boating pressure on Wisconsin's lakes and rivers conducted in 1989 by the WDNR, Geneva Lake was reported to be the fourth most-visited inland waterbody in the State and the

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[3]Ibid.

[4]*Wisconsin Department of Natural Resources Lake Use Report No. FX-1,* Lake Geneva, Walworth County, Wisconsin, *1969.*

most-visited site in the then-WDNR Southeast District.[5] Not surprisingly, when, in that same survey, respondents were asked about the degree of crowding on the water, they reported feeling the highest level of crowding in the State. In the aforementioned 1999 GLEA survey, respondents reported that recreational boating was among the three most popular recreational uses of Geneva Lake. Additionally, 76 percent of respondents believed that the numbers of boats on the Lake should be restricted; 60 percent indicated they had changed their plans or not used the Lake on the weekends because of the intensity of boat traffic; 89 percent felt that boats were a major contributor to pollution of the Lake waters; 81 percent felt that there needed to be more control over the number of intoxicated boaters; and, 63 percent believed their lake experience had been slightly to considerably degraded as a consequence of crowding. Complementary to these perceptions, respondents indicated that better management of boats on the Lake was the primary response needed to enhance the recreational use of the Lake.[6]

One way to determine the degree of recreational boating use of a lake is through estimates of the numbers of boats launched. In the aforementioned 1999 GLEA user survey, over one-half of the respondents, approximately 55 percent, felt that public access contributed to overcrowding and user conflicts on the Lake. Table 35 contains the estimated launch totals from the four municipal launch sites on the Lake for the period from 2001 to 2003. As shown in the table, the combined total number of launches from these four sites increased from about 16,000 launches in 2001 to about 24,000 launches in 2003. Since accurate launch records have not been kept for all of the public access sites on Geneva Lake, the data in Table 35 are likely to be significantly lower than the actual numbers of boats launched. Nevertheless, these data are of value in assessing and determining trends in the degree of recreational boat usage on Geneva Lake.

An indirect method for 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 2 to 5 percent of the total number of watercraft docked and moored. Counts of boats docked or moored on Geneva Lake based on surveys conducted in 1998, 1999, 2001, 2002, and 2003 are shown in Table 36. As the data show, there is a fairly consistent upward trend in the numbers of boats over time during the period between 1998 to 2003, with approximately 5,000 watercraft currently docked or moored on Geneva Lake. Also, except for 2002, there has been a trend for sail boat numbers to decrease in years when power boat numbers increased. Additionally, personal watercraft (PWC) numbers increased during each year until 2003, when the number of PWCs actually decreased somewhat. Based on the abovementioned estimate of between 2 percent and 5 percent of the total numbers of watercraft being in active use on the Lake at any given time, between approximately 95 and 238 boats could be expected to be in operation during 1998, while between about 105 to 261 boats could be expected to be in operation during 2002. These estimates, however, are generally lower than the numbers of watercraft observed in operation based upon the observed numbers of boats in use at the time of the over flights in 1977, 1988, and 2003.

Direct counts are the most accurate way to determine the numbers 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. The numbers of watercraft per acre are an indication of the intensity of recreational boating use. Table 37 shows boat counts made by the Geneva Lake Water Safety Patrol, the Geneva Lake Environmental Agency and the WDNR on specific dates, including holidays, weekend days and week days, during 1977, 1988, and 2003 based on aerial flyovers, and the concomitant boating densities. During 1977, the average boat count was 494 vessels, resulting in a boating density of one boat per 11 acres of open water; during 1988, the average boat count was 647, resulting in a boating density of one boat per eight acres of water; and, during 2003, the average boat count was 394, resulting in a boating density of one boat per 13 acres of water. These data appear to reflect similar trends to those indicated by the launch totals from municipal boat launch sites.

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[5]*Wisconsin Department of Natural Resources, http://digital.library.wisc.edu/1711.dl/EcoNatRes.DNRBull174*; *the WDNR Southeast District encompassed Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan, Walworth, Washington, and Waukesha Counties. This same region now forms the WDNR Southeast Region.*

[6]*Geneva Lake Environmental Agency,* op. cit.

Table 35

ESTIMATED LAUNCHES AT MUNICIPAL SITES ON GENEVA LAKE: 2001-2003

Year	Fontana-on-Geneva Lake	City of Lake Geneva	Williams Bay	Linn	Total
2001	4,795	3,659	7,666	N/A	16,120
2002	6,211	3,523	8,367	N/A	18,101
2003	5,895	2,378	8,647	7,084	24,004

NOTE: The above numbers are calculated based upon dollar figures, not actual counted launches.

Source: Geneva Lake Environmental Agency, Villages of Fontana-on-Geneva Lake and Williams Bay, City of Lake Geneva, and Town of Linn.

Table 36

DOCKED AND MOORED WATERCRAFT ON GENEVA LAKE: 1998-1999 AND 2001-2003

Year	Power Boats	Sail Boats	PWC	Other	Total
1998	2,926	611	- -[a]	1,227	4,764
1999	3,412	575	430	396	4,813
2001	3,070	605	559	668	4,902
2002	3,230	620	665	710	5,225
2003	3,473	408	490	686	5,057

[a]*Prior to 1999, PWC (personal water craft) were counted as "Other."*

Source: Geneva Lake Environmental Agency and Water Safety Patrol.

Table 37

BOATS IN USE AND BOATING DENSITIES ON GENEVA LAKE: 1977, 1988, AND 2003

	1977				1988				2003		
Survey Dates	July 3	July 4	July 16	July 17	July 3	July 4	July 23	September 3	July 4	August 2	August 5
Boats in Use	500	650	325	500	865	1,120	367	236	512	459	211
Boating Density........	10.5	8.1	16.2	10.5	6.1	4.7	14.3	22.3	10.3	11.5	24.9

NOTE: Boating densities are calculated as acres per boat, based on a surface area for Geneva Lake of 5,262 acres.

Source: Wisconsin Department of Natural Resources, Water Safety Patrol, and SEWRPC; 2003 data collected by Geneva Lake Environmental Agency.

There is a range of opinions on the issue of what constitutes optimal boating density on a lake. In the initial SEWRPC report, 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. Using this criterion, a total of about 330 watercraft would be the maximum number of boats that should be in use on Geneva Lake at any given time. In a 2003 GLEA report, discussing trends in boating use on Geneva Lake, one boat per 10 to 15 acres of lake surface was considered to be a conservative density for all types of boating activities, although it was felt this acreage would need to be larger for high-powered boating and water skiing.[7] Even so, the 2003 GLEA report concluded that the numbers of boats

[7]*Geneva Lake Environmental Agency,* Trends in Boating Use on Geneva Lake, *Summer 2003.*

in operation on the Lake were generally within, yet very close to exceeding, this recommended range of boating densities.

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. Such boating densities as described above for Geneva Lake generally appear to exceed these guidelines. This would be consistent with public perceptions that the Lake is heavily used, especially on weekends. However, it should be noted that the counts of boats in use on Geneva Lake as presented in Table 37 do not distinguish high-speed powerboats from sailboats, smaller fishing boats, and other watercraft that may not require as large an area for safe operation.

In the abovereferenced 2003 GLEA report on recreational boating use of Geneva Lake, several boating trends were identified: based on launch records from the municipal launch sites, the total number of boats launched has decreased slightly over the past 10 years, although earlier launch data showed a more than 200 percent increase during the 1980s; the numbers of boats docked or moored on Geneva Lake have shown a gradual increase over time; and, the numbers of sailboats has decreased during three of the last five years of record. As reported in the initial SEWRPC study, the combined totals of boats moored and in use recorded by the Geneva Lake Safety Patrol and the GLEA reflect about a 20 percent increase from 1973 to 1985; data gathered by the GLEA and the Water Safety Patrol show a continued increase of about 10 percent during the period from 1985 to 1999.

As the abovementioned surveys of Lake users and counts of boats and launches seem to indicate, Geneva Lake experiences high levels of recreational boating use, which, at times, lead to recreational water use conflicts. Currently, boating activities on the Lake are regulated by the State boating and water safety laws, and by a joint uniform lake ordinance, adopted by the riparian municipalities, which sets forth specific regulations for the operation of watercraft on Geneva Lake. These ordinances are summarized in Appendix B.

Swimming
As described in the initial SEWRPC report, swimming is a primary recreational activity at the six public beaches on the Lake. At the time of the initial report, the six public beaches on the Lake comprised a combined total of 4,300 linear feet of Lake frontage on 6.4 acres of shoreland property. In addition to these public beaches, many of the subdivisions surrounding the Lake had private beaches and swimming piers.

A popular swimming-related recreational activity at Geneva Lake is scuba diving. The high level of water clarity, large size, deep water and numerous steep drop offs make Geneva Lake a popular destination for many scuba enthusiasts.

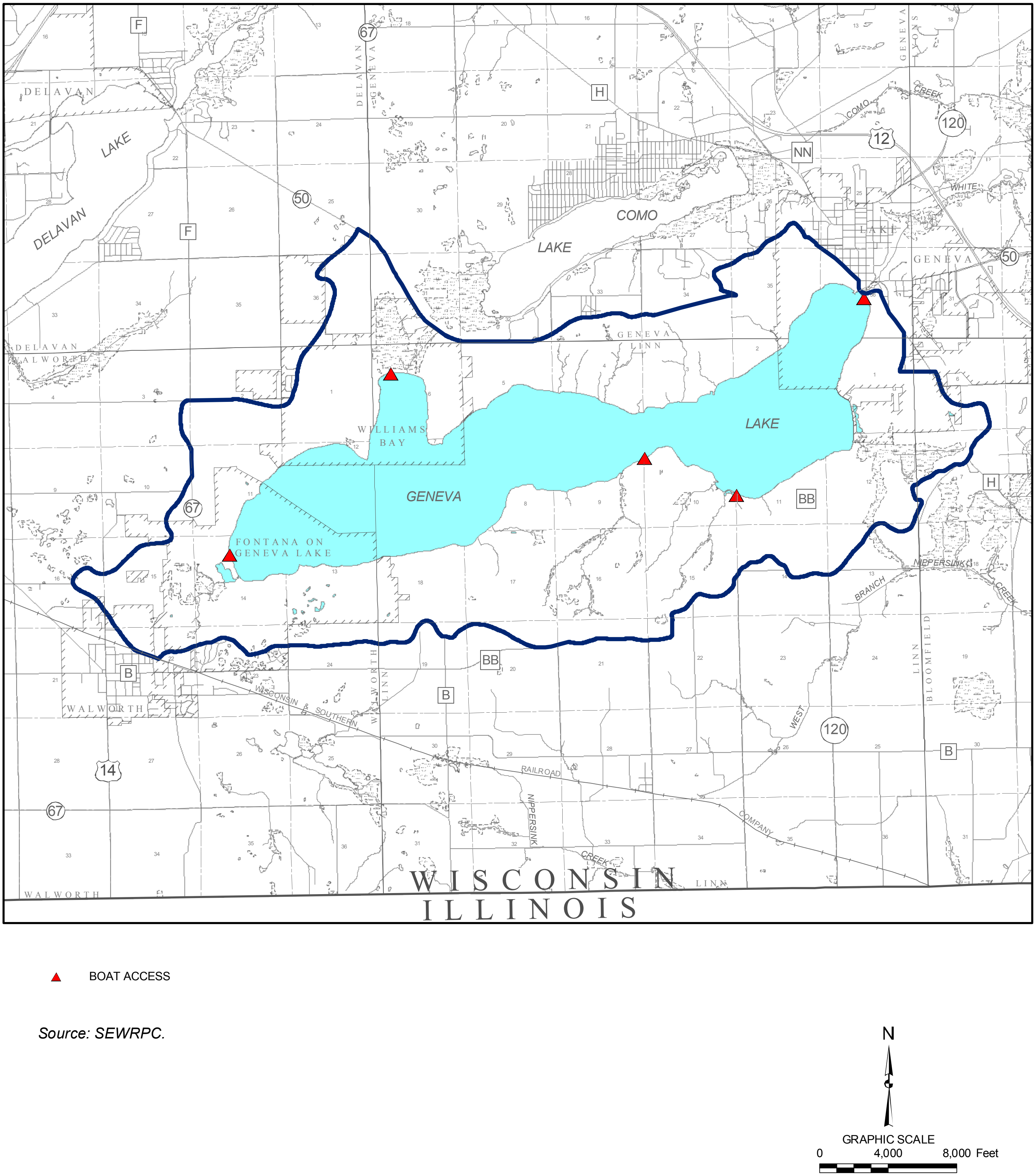
Park and Open Space Sites
Geneva Lake provides an ideal setting for the provision of park and open space sites and facilities, and there are numerous access sites on the Lake, both public and private. In the original SEWRPC plan, 24 such access sites were recorded as being in use at that time.

Public Access Sites
As of 2005, public access included: five public boat launch sites, each with parking; several smaller nonboating access sites, with access only to the public footpath that extends along the shoreline of the Lake; and, the State-owned Big Foot Beach State Park.

As shown on Map 16, there are five public boating access sites on Geneva Lake that are also access sites to the public shoreline footpath. In the Village of Williams Bay, the Williams Bay Lakefront Park, owned and operated by the Village, contains a multiple ramp with four launching stations side-by-side and car-trailer parking immediately adjacent to the ramp. Lakefront Park also maintains a swimming beach, pier, and Lakefront walkway. A shoreline restoration project featuring a vegetative buffer strip to reduce shoreline erosion was executed at Lakefront Park. The Park is located along E. Geneva Street in Williams Bay, across from the Kishwauketoe Nature Conservancy area. The primary municipal boating access site in the Village of Fontana-on-Geneva Lake is found on Lake Street between 3rd Street and Bay View Avenue. The municipal launch site at

Map 16

PUBLIC BOAT ACCESS SITES ON GENEVA LAKE: 2006



Source: SEWRPC.

Fontana-on-Geneva Lake is a double, side by side ramp structure with parking for cars and trailers located in the nearby Village parking lot. The municipal launch site in the City of Lake Geneva is also a multiple, side-by-side ramp structure with parking for cars with trailers located in a nearby municipal lot. The Town of Linn owns and operates two public boating access sites: the Hillside site, a single ramp located on the southern shore of the Lake between Buttons Bay and the Narrows, which includes a small swim area with a lifeguard station, onsite single car parking with handicapped parking space, and an adjacent area to temporarily park detached boat trailers; and the Linn Pier site, a single ramp located along the southern shore of the Lake at the Narrows, which includes a small swim area, spaces for single car parking, handicapped parking, and car-trailer parking.

There are several smaller public access sites that only provide access to the public shoreline footpath; they have no boat launching facilities and no parking. The Shadow Lane site, which is located along the southern shore of the Lake, is a small "pocket park" recently constructed by the Town of Linn. The Town of Linn also owns the Chapin road site located on the north shore of the Lake. The Village of Fontana-on-Geneva Lake owns and operates the Mohr Road access site located along the southern shore at the western end of the Lake.

There is one State-owned park on Geneva Lake. Big Foot Beach State Park, owned and operated by the State of Wisconsin, is a 271-acre site just south of the City of Lake Geneva on the eastern shore of the Lake. This Park offers a wide variety of recreational facilities including wooded campsites, a sand beach, picnic areas, and numerous hiking and cross-country ski trails. There currently are no WDNR-owned boat launch facilities on Geneva Lake, although the master plan for Big Foot Beach State Park, developed in 1996, proposes two concrete launch ramps serving 100-car/trailer parking spaces. Construction of this site has not yet been started. As of 1998, Geneva Lake was considered to have adequate public boating access.[8]

It is important to note that the provision of park and open space sites within the area tributary to Geneva Lake should continue to be guided by the recommendations contained in the Walworth County park and open space plan.[9] The purpose of that plan, in part, is to guide the preservation, acquisition, and development of land for park, outdoor recreation, and related open space purposes and to protect and enhance the underlying and sustaining natural resource base of the tributary area. With respect to the Geneva Lake tributary area, the plan recommends the maintenance of existing park and open space sites in the area. In addition, the plan recommends that the undeveloped lands in the primary environmental corridor tributary to Geneva Lake be retained and maintained as natural open space. These lands include the Fontana Prairie and Fen, Williams Bay Lowlands, Peninsula Woods and Wychwood, as discussed previously in Chapter V.

Private Access Sites

In addition to the abovementioned public access sites, there are several privately owned and operated sites with boat access and mooring facilities located around Geneva Lake, including: Gage Marine, Abbey Springs, the Lake Geneva Yacht Club, the Abbey Resort, Lake Geneva Marine, and Gordy's Marine. As mentioned above, numerous private subdivisions around the Lake have their own private access sites, such as the Shady Lane subdivision on the north side of the Lake and the Wooddale subdivision on the south side of the Lake.

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[8]*Douglas E. Welch and Rick Dauffenbach, Wisconsin Department of Natural Resources,* Smallmouth Bass Survey Report for Geneva Lake, Walworth County (WBIC 0758300), *1998.*

[9]*SEWRPC Community Assistance Planning Report No. 135, 2nd Edition,* A Park and Open Space Plan for Walworth County*, September 2000; see also Community Assistance Planning Report No. 148,* A Park and Open Space Plan for the Village of Walworth, Walworth County, Wisconsin*, November 1986, and Community Assistance Planning Report No. 242,* A Park and Open Space Plan for the City of Lake Geneva, Walworth County, Wisconsin*, April 1999.*

Wisconsin Department of Natural Resources Recreational Rating
In general, Geneva Lake provides a variety of outdoor recreational opportunities. Based upon the outdoor recreation rating system developed by the WDNR, Geneva Lake received 68 of a possible 72 points, as shown in Table 38. This rating indicates that the Lake provides a range of recreational opportunities, including a highly productive fishery, water quality conducive to swimming and boating, an adequate number of boat launch sites, water depth and surface area conditions conducive to boating, and a varied landscape that enhances the natural aesthetics of the Lake. The only feature that was considered to detract from the recreational rating was a lack of significant stretches of natural shoreline around the Lake.

WATER USE OBJECTIVES

The regional water quality management plan recommended the adoption of full recreational and coldwater sport fisheries objectives for Geneva Lake. The findings of the inventories of the natural resource base, set forth in Chapters III through V of this report, indicate that the existing uses of the Lake and the natural resources of the drainage area are generally supportive of such objectives, although it is expected that some minor remedial measures may be required if the Lake is to continue to fully meet these objectives.

WATER QUALITY STANDARDS

The water quality standards supporting the warmwater fishery and full recreational use objectives as established for planning purposes in the adopted regional water quality management plan are set forth in Table 39. These standards are similar to those set forth in Chapters NR 102 and 104 of the *Wisconsin Administrative Code*, but have been refined for planning purposes in terms of their application. Standards and guidelines are recommended for temperature, pH, and dissolved oxygen, fecal coliform, and total phosphorus concentrations. These standards apply to the epilimnia of lakes and to streams. The total phosphorus guideline applies to spring turnover concentrations measured in the surface waters of lakes. In addition, such contaminants as oil, debris, and surface scums; odor, taste, and color-producing substances; and toxins are not permitted in concentrations harmful to the aquatic life pursuant to the standards set forth in Chapter NR 102 of the *Wisconsin Administrative Code*.

The adoption of these standards and 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 and full-body contact recreation, in these waters.

Table 38

WISCONSIN DEPARTMENT OF NATURAL RESOURCES RECREATIONAL RATING OF GENEVA LAKE: 1969

Space: Total Area = 5,262 acres			Total Shore Length = 20.2 miles		
Quality (18 maximum points for each item)					
Fish:					
X 9	High production	__ 6	Medium production	__ 3	Low production
__ 9	No problems	__ 6	Modest problems, such as infrequent winterkill, small rough fish problems	__ 3	Frequent and overbearing problems, such as winterkill, carp, excessive fertility
Swimming:					
X 6	Extensive sand or gravel substrate (75 percent or more)	__ 4	Moderate sand or gravel substrate (25 to 50 percent)	__ 2	Minor sand or gravel substrate (less than 25 percent)
X 6	Clean water	__ 4	Moderately clean water	__ 2	Turbid or darkly stained water
X 6	No algal or weed problems	__ 4	Moderate algal or weed problems	__ 2	Frequent or severe algal or weed problems
Boating:					
X 6	Adequate water depths (75 percent of basin more than five feet deep)	__ 4	Marginally adequate water depths (50 to 75 percent of basin more than five feet deep)	__ 2	Inadequate depths (less than 50 percent of basin more than five feet deep)
X 6	Adequate size for extended boating (more than 1,000 acres)	__ 4	Adequate size for some boating (200 to 1,000 acres)	__ 2	Limit of boating challenge and space (less than 200 acres)
X 6	Good water quality	__ 4	Some inhibiting factors, such as weedy bays, algal blooms, etc.	__ 2	Overwhelming inhibiting factors, such as weed beds throughout
Aesthetics:					
__ 6	Existence of 25 percent or more wild shore	__ 4	Less than 25 percent wild shore	X 2	No wild shore
X 6	Varied landscape	__ 4	Moderately varied	__ 2	Unvaried landscape
X 6	Few nuisances, such as excessive algae carp, etc.	__ 4	Moderate nuisance conditions	__ 2	High nuisance condition
Total Quality Rating: 68 out of a possible 72					

Source: Wisconsin Department of Natural Resources.

Table 39

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.

Chapter VII

ALTERNATIVE LAKE MANAGEMENT MEASURES

INTRODUCTION

Based upon review of the inventories and analyses set forth in Chapters II through VI, five 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. The management measures considered herein are focused primarily on those measures which are applicable to the Geneva Lake Environmental Agency (GLEA), Walworth County, and the City of Lake Geneva, the Villages of Fontana-on-Geneva Lake, Walworth, and Williams Bay, and the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth.

TRIBUTARY AREA MANAGEMENT ALTERNATIVES

Land Use Management and Zoning

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

Development in the Shoreland Zone

Existing 2000 and planned buildout land use patterns and existing zoning regulations in the tributary area to Geneva Lake have been described in Chapter II. If the recommendations set forth in the adopted regional land use plan are followed, under buildout conditions, some additional urban residential development within the area tributary to Geneva Lake would occur.[1] While much of this residential development is likely to occur on agricultural lands, the redevelopment and reconstruction of existing single-family homes and commercial structures on lakefront estate properties may be expected to occur, in addition to infilling of existing platted lots and some backlot development. 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 Geneva Lake and within the area tributary to the Lake should be evaluated for potential impacts on the Lake, as such proposals are advanced.

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

Recent studies of the potential impact of riparian landscaping activities on the nutrient loading 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.[2] 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 have enacted lawn care or fertilizer application control ordinances in addition to conducting public informational programming as discussed below. The Town of Delavan was one of the first communities in Wisconsin to adopt an ordinance eliminating the application of fertilizers containing phosphorus to urban residential lands. Many other communities have adopted similar ordinances. 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.

Lawn care or turf management ordinances typically include a limitation on the application of phosphorus to urban lands. As noted in Chapter IV of this plan, phosphorus is the principal nutrient triggering the growths of aquatic plants and algae in Geneva Lake: the greater the mass of phosphorus entering the Lake, the greater the likely response by the in-lake plant community. Limiting the use of phosphorus fertilizers, therefore, reduces the potential for this element to be washed off the land surface into the Lake. Typical ordinance requirements limit this potential by specifying that either the fertilizers applied to urban lawns contain no phosphorus or, alternatively, not more than 3 percent phosphorus, this latter provision allowing for the application of compost-based fertilizers such as Milorganite®, the sludge-based product distributed by the Metropolitan Milwaukee Sewerage District (MMSD). Most ordinances that adopt the 0 percent phosphorus requirement do allow for the use of compost-based products, and both types of ordinances allow for the application of phosphorus-containing fertilizer should such a soil amendment be indicated by a soil test. Property owners and householders can obtain a soil test through the county University of Wisconsin-Extension (UWEX) offices. Turf management ordinances do not apply to agricultural lands, which are governed less formally through guidelines prepared and distributed by the U.S. Natural Resources Conservation Service (NRCS, formerly the U.S. Soil Conservation Service).

In addition to limiting the inputs of nutrients at their source, the preservation, restoration, and maintenance of appropriate shoreline vegetative buffers can intercept nutrients carried by overland flows and stormwater runoff prior to these flows entering the Lake.[3] The benefit of such features is recognized in the Wisconsin Department of Natural Resources (WDNR) Technical Standards for land management of nutrients in both rural and urban environments.[4] The Nutrient Management Standard specifically indicates the application of vegetative buffers as one approach when nutrients are applied within a surface water quality management area, which area is defined as 1,000 feet from the ordinary high water mark (OHWM) of a lake or 300 feet from the OHWM of a navigable river or stream, excluding those areas within this zone that do not drain to the waterbody. The Turf Nutrient Management Standard recommends a buffer width of 20 feet adjacent to a waterway or to the OHWM of a waterway. This latter standard also sets forth recommendations for appropriate management of high traffic areas and recreational areas, including golf courses. Establishment of riparian vegetative buffers around lakes, streams, and wetlands is a goal of the Walworth County land and water resource management plan.[5]

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[2] *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.*

[3] *See University of Wisconsin-Extension Publication No. GWQ044,* Protecting Your Waterfront Investment*, May 2005.*

[4] *Wisconsin Department of Natural Resources, Technical Standard No. 590,* Nutrient Management*, September 2005; Wisconsin Department of Natural Resources, Technical Standard No. 1100,* Turf Nutrient Management*, January 2006.*

[5] *Walworth County Land Department,* Walworth County Land & Water Resource Management Plan, *February 1999.*

Given the increasing importance of urban land uses within the riparian area of Geneva Lake, and within its tributary area, consideration of a comprehensive program to regulate urban and agricultural practices appears to be warranted.

Development in the Tributary Area

The level of development envisioned in the aforereferenced regional land use plan for the area tributary to Geneva Lake indicates continuing urban development, generally on suburban-density lots. Implementation of the recommended regional land use plan provisions for the Geneva Lake drainage area is endorsed in the County land and water resource management plan.[6]

In addition to implementing appropriate land use development plans, careful review of applicable zoning ordinances to incorporate levels and patterns of development that are consistent with the plan within the area tributary to Geneva Lake is recommended. Changes in the zoning ordinances could be considered to better reflect the land use patterns recommended in the regional land use 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.[7] Further, where lands are converted to urban use from rural open space and rural agricultural uses, application of appropriate land division, land development, and land management ordinances is recommended.[8] To this end, the Walworth County land and water resource management plan recommends the ongoing administration and continued enforcement of the County land disturbance, erosion control, mine restoration, and stormwater management ordinance where applicable. In addition, the plan suggests that the County staff meet with their counterparts in the incorporated municipalities to share lessons learned with respect to the County ordinance, and encourage these municipalities to adopt similar ordinance provisions.

Given the changing land uses within the tributary area to Geneva Lake, consideration of a comprehensive planning and zoning program to regulate urban development appears to be warranted.

Stormwater Management on Development Site

With respect to stormwater management on development sites, as of 2003, Walworth County, the City of Lake Geneva, and the Villages of Fontana-on-Geneva Lake and Williams Bay 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. The Towns of Bloomfield, Delavan, Geneva, Linn and Walworth have adopted the Walworth County stormwater management ordinance, while the Village of Walworth, as of 2003, had not enacted its own nor adopted the county stormwater management ordinance. 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. In particular, the ordinances should be reviewed for concurrency with Chapter NR 151 of the *Wisconsin Administrative Code*.

Where local ordinances and State law require the use of stormwater management facilities that include wet detention basins, appropriate shorescaping can enhance both the water quality benefits to be derived from the

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[6]Ibid.

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

[8]*Walworth County Land Department,* op. cit.

application of this technology as well as the aesthetics and wildlife habitat value. Guidance with respect to such shorescaping is set forth in a recent UWEX publication on the design and management of such basins.[9]

Given the increasing importance of urban land uses within the riparian area of Geneva Lake, and its tributary area, consideration of a comprehensive stormwater planning and management program to regulate, primarily, urban runoff quantity and quality, and agricultural runoff where applicable, appears to be warranted.

Protection of Environmentally Sensitive Lands

Environmentally sensitive lands within the area tributary to Geneva Lake include wetlands, woodlands, and wildlife habitat areas. Nearly all of these areas within the Geneva Lake tributary area are included in the environmental corridors and isolated natural resource features delineated by the Regional Planning Commission. Protection of these lands is explicitly recognized in the County land and water resource management plan. In addition, upland areas, woodlands, and wildlife habitat areas, currently, are protected primarily through local land use regulations. Wetlands enjoy a wider range of protections additionally set forth in applicable 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. Wetland areas are currently protected to a degree by current zoning and regulatory programs administered by the U.S. Army Corps of Engineers, WDNR, Walworth County, and local municipal authorities under one or more of the Federal, State, County, and local regulations and ordinances.

Some of the wetland, woodland, and wildlife habitat areas within the area tributary to Geneva Lake have been recommended for public acquisition in the adopted regional natural areas and critical species habitat management and protection plan.[10] These lands include the 39-acre Peninsula Woods and the 226-acre Wychwood, as set forth in the regional natural areas and critical species habitat and management plan. Public acquisition of these lands, including acquisition by not-for-profit conservation organizations, is recommended. The County land and water resource management plan recommends that the County support the creation of a countywide land conservancy as one vehicle for acquiring and managing sensitive lands within the County.[11]

Given the increasing importance of urban land uses within the tributary area of Geneva Lake, consideration of a comprehensive program to protect and preserve wetlands and critical habitat areas appears to be warranted.

Pollution Abatement and Stormwater Management

All human activities upon the land surface result in some degree of mobilization of contaminants and modification of surface runoff patterns that can affect lakes and streams, their quality, and biotic condition. Many human activities can be mitigated to a large extent by the implementation of sound planning, 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

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[9]*University of Wisconsin-Extension Publication No. GWQ045,* Storm Water Basins: Using natural landscaping for water quality & esthetics [sic]—A Primer on Planting and Managing Native Landscaping for Storm Water Basins*, June 2005.*

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

[11]*Walworth County Land Department,* op. cit.

and streams. The commitment of Walworth County to these principles is set forth in the County land and water resource management plan.[12]

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 the principles of sound land use planning. Beyond such actions, specific interventions may be required to control the mass of contaminants, generated by various types of land use activity, 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 corridor, 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,[13] and in the Walworth County land and water resource management plan.[14]

The regional water quality management plan recommends that the nonpoint source pollutant loadings from the areas tributary to Geneva Lake be reduced by up to 50 percent in urban areas and by up to 75 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 urban and urbanizing lands within the area tributary to the Lake. These loadings constituted about 20 percent of the total phosphorus loading and about 10 percent of the sediment loading to Geneva Lake, and 100 percent of the heavy metals loadings, based upon year 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 and sediment from urban lands are expected to increase to about 35 percent and 20 percent of the total loadings, respectively, as agricultural lands are progressively converted to urban uses. The contribution of heavy metals from urban lands, by definition, is expected to remain at 100 percent of the total loading.

While some proportion of these contaminant loads may be attenuated as a consequence of the passage of runoff and sheet flows across the land surface and through wetland areas, the ability of these land surfaces and 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 and the loss of ground cover, diminishing their ability to capture contaminants, or creating contaminant loads of such magnitude that the wetlands are overloaded. In extreme cases, the surface flows across the land can increase contaminant loadings to the waterbody as a result of soil erosion and related phenomena. 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.

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

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[12]Ibid.

[13]*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.*

[14]*Walworth County Land Department*, op. cit.

below. Consideration of a comprehensive program of nonpoint source pollution abatement to regulate urban and agricultural runoff quality appears to be warranted.

Rural Nonpoint Source Controls
Upland erosion from agricultural and other rural lands is a contributor of sediment to streams and lakes. Estimated phosphorus and sediment loadings from croplands, woodlots, pastures, and grasslands in the area tributary to Geneva Lake are 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 Geneva Lake.

Based upon the pollutant loading analysis set forth in Chapter IV, a total annual phosphorus load of about 6,240 pounds is estimated to be contributed to Geneva Lake during the year 2000. Of that mass, it is estimated that 4,150 pounds per year, or 65 percent of the total loading, were contributed by runoff from rural land. In addition, it is estimated that 2,110,000 pounds of sediment, or 60 percent of the total sediment load to Geneva Lake, were contributed annually from agricultural lands in the area tributary to the Lake. As of the year 2000, such lands comprised about 4,700 acres, or about 25 percent of the area tributary to Geneva Lake, which area is anticipated to diminish to about 3,100 acres, or about 15 percent, of the tributary area by the year 2020.

While agricultural land uses are anticipated to be a declining form of land usage within the area tributary to Geneva Lake, the agricultural operations that remain within the tributary area will continue to contribute a significant proportion of the sediment load to the waterbody. Table 16 in Chapter IV of this report suggests that, based upon estimated contaminant loadings, agricultural land uses will continue to contribute 50 percent of the total sediment load, or 1,381,500 pounds of sediment annually, to Geneva 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 NRCS or County Land Department, 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 9,880 acres, or about 50 percent, of the total area tributary to Geneva Lake. The annual phosphorus loading from these urban lands was estimated to be 1,200 pounds, or 20 percent of the total load of phosphorus to the Lake. This is anticipated to increase to about 35 percent of the total load of phosphorus under buildout conditions. Those urban-source pollutant loadings that are most controllable include runoff from the residential lands adjacent to the Lake, and urban runoff from areas with a high proportion of impervious surface. The potential also exists within the Geneva 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 City of Lake Geneva, and the Villages of Fontana-on-Geneva Lake and Williams Bay, 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 suburban-density development is currently taking place in the area tributary to Geneva 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.[15] 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, Walworth County has adopted a construction site erosion control ordinance which is administered and enforced by the County in both the shoreland and nonshoreland areas of the unincorporated areas of the lands tributary to Geneva 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. In the City of Lake Geneva, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the Towns of Bloomfield, Delavan, Geneva, Linn, and Walworth, this function is performed by the respective Cities, Villages, and Towns. Because of the potential for development, some of it albeit unplanned, in the area tributary to Geneva 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 initial study, about 60 percent of the resident population and 30 percent of the land area tributary to Geneva Lake received public sanitary sewer service from systems operated by either the City of Lake

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

Geneva or the Villages of Fontana-on-Geneva Lake and Williams Bay. Concentrations of urban development located along the shoreline of Geneva Lake have been included within public sanitary sewer service areas serving the urban centers located around the Lake, as recommended in the adopted regional water quality management plan, as amended.[16] However, lands lying outside this area, but identified as having a density of development equivalent to an urban concentration, would continue to be provided with sewage disposal through the use of onsite sewage disposal systems. Even so, the regional plan also recommends that sewerage needs in such areas be periodically reevaluated in light of changing conditions.

Onsite Sewage Disposal System Management

At the time of the initial report, 43 percent of the population residing in the area tributary to Geneva Lake utilized onsite systems for treatment of sanitary and household wastewaters. While much of the urban-density development in the vicinity of the immediate lakeshore is sewered, portions of the area tributary to Geneva Lake continue to be served by onsite sewage disposal systems. Phosphorus loadings to the Lake from these remaining onsite sewage disposal systems are estimated to contribute only a minor proportion of the total phosphorus load to the Lake, which proportion is anticipated to decline as public sanitary sewerage services are extended within the tributary area pursuant to the adopted regional water quality management plan[17] and sewer service area plans.[18] In addition to lake water quality considerations, sewage disposal options in the area have implications for groundwater quality and property values. Thus, onsite sewage disposal is an important consideration in the portions of the tributary area not within the planned public sanitary sewer service area. Two basic alternatives are available for abatement of pollution from onsite sewage disposal systems: continued reliance on, and management of, the onsite sewage disposal systems, and, alternatively, the expansion of the existing public sanitary sewer system.

Where onsite sewage disposal systems remain the primary wastewater treatment method, it is recommended that an onsite sewage disposal system management program be carried out, including the conduct of an ongoing informational and educational effort. Homeowners in areas served by onsite systems should be advised of the rules, regulations, and system limitations governing onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs. Walworth County currently has such a program in place, pursuant to Chapter Comm 83 of the *Wisconsin Administrative Code* for onsite sewage disposal systems installed after 1983, and consideration is currently being given by the Wisconsin Legislature to extending this inspection program to all onsite sewage disposal systems.

The Linn Sanitary District has an active private onsite sanitary waste treatment system (POWTS) management program. Between 2002 and 2006, over 1,300 POWTS were inspected by Linn Sanitary District inspectors. The District is now working with Walworth County to include most of these systems into the county's preventive maintenance program.

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[16]*SEWRPC Community Assistance Planning Report No. 56, 2nd Edition,* Sanitary Sewer Service Area for the Walworth County Metropolitan Sewerage District, Walworth County, Wisconsin*, November 1991, as amended; SEWRPC Community Assistance Planning Report No. 203,* Sanitary Sewer Service Area for the City of Lake Geneva and Environs, Walworth County, Wisconsin*, December 1992, as amended; and SEWRPC Community Assistance Planning Report No. 219,* Sanitary Sewer Service Area for the Villages of Fontana and Walworth and Environs, Walworth County, Wisconsin*, June 1995, as amended.*

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

[18]*SEWRPC Community Assistance Planning Report No. 56, 2nd Edition, as amended,* op. cit.*; SEWRPC Community Assistance Planning Report No. 203, as amended,* op. cit.*; and SEWRPC Community Assistance Planning Report No. 219, as amended,* op. cit.

IN-LAKE MANAGEMENT ALTERNATIVES

The reduction of external nutrient loadings to Geneva 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 lakes, the nutrients previously delivered to, and retained in, such lakes can result in increased macrophyte growth, which can result in restricted water use potentials, even after the implementation of tributary area-based management measures. Given that Geneva Lake falls within the oligo-mesotrophic range, consideration of in-lake rehabilitation techniques may be of value.

The applicability of specific in-lake rehabilitation techniques is highly dependent on the lake-specific characteristics of individual waterbodies. 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 in 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. Application of most of these measures requires a regulatory permit to be issued by the WDNR; certain management measures may also require Federal or local regulatory permits in addition to the State permit(s).

Water Quality Monitoring and Management Measures

As discussed in Chapter IV, water quality information for Geneva Lake has been compiled during the current study period mainly through the collaborative study involving the USGS, WDNR and GLEA. Since that time, monitoring of water quality parameters has continued through services provided by the GLEA. The WDNR offers a volunteer 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 are added to the WDNR-sponsored data base containing lake water quality information for many of the lakes in Wisconsin and are accessible on-line through the WDNR website. In addition, the GLEA regularly publishes reports on the water quality of Geneva Lake, which can be viewed on the Agency’s website at http://www.genevaonline.com/~glea/dataA.html.

The WDNR also offers an Expanded Self-help Monitoring Program that involves the collection of additional 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 (SLOH). 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 (UWSP). This program requires volunteers to obtain and transmit the water quality samples to the laboratory. In both cases, the WDNR administers a Small Grant funding program under the auspices of the Chapter NR 190 Lake Management Planning Grant Program that can be applied for to defray the costs of laboratory analysis and sampling equipment.

The USGS offers an extensive water quality monitoring program, within which Federal field personnel conduct a series of approximately five samplings annually, 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 specialist services, including groundwater modeling and monitoring.

Ongoing water quality monitoring by the GLEA, supplemented periodically by more detailed water quality monitoring conducted under the auspices of the USGS Trophic State Index (TSI) Monitoring program, is considered to be a viable option for Geneva 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 the fishery are separately considered below.

Phosphorus Precipitation and Inactivation
Nutrient inactivation is a restoration measure that is designed to limit the biological availability of phosphorus by chemically binding the element within 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 Geneva 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 rerelease of nutrients into the environment. While some limited deepening of specific areas within the Lake basin may be warranted for navigational purposes, the widespread use of in-lake nutrient load reduction measures is not warranted in Geneva 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 observed phosphorus concentration in the Lake water column. Consequently, the application of external nutrient reduction programs provides a strong likelihood of being an effective means of controlling in-lake water quality conditions. Application of in-lake management measures, therefore, does not appear to be warranted.

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

OUTLET CONTROL OPERATIONS
Outflow control refers to the ability of lake managers to artificially manipulate lake levels to achieve a specific outcome within the waterbody. Decreasing water levels periodically can provide opportunities to consolidate flocculent sediments, desiccate (drying out) undesirable aquatic plants and certain aquatic animals, and enhance the export of nutrient-rich waters as a means of improving water quality. 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. Such manipulation requires the presence of a permanent or temporary control structure.

The outflow from Geneva Lake is controlled by a dam located at the White River outlet on the eastern end of the Lake in the City of Lake Geneva. The outlet structure, as described earlier in this report, consists of a dam and sluice gates whose crest was established at an elevation of 864.42 feet National Geodetic Vertical Datum of 1929 (NGVD-29). The outlet is currently operated to ensure a relatively stable water level within Geneva Lake, while, pursuant to the requirements of Chapter 30 of the *Wisconsin Statutes*, providing a minimum outflow to the White River. While the presence of this control structure provides the opportunity to vary water levels within the Lake, such manipulation does not appear to be warranted at this time.

DRAWDOWN

Drawdown refers to 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 growths of some shoreland plants by exposing the plants to climatic extremes, while the growths of other plants are unaffected or enhanced. Both desirable and undesirable plants can be 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 affect the lake fisheries both indirectly, by reducing the numbers of food organisms, and directly, by reducing available habitat and desiccating eggs and spawning habitat. Costs are associated primarily 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 reflooding, loss of use of the lake during the drawdown, changes in species composition, and a reduction in the density of benthic organisms following drawdown and reflooding. In some drawdown projects, it has been found that several years after reflooding, flocculent sediments began to reappear because of algae and macrophyte sedimentation. Therefore, to maintain the benefits of a drawdown project, the lake may have to be drawn down every five to 10 years to recompact any new sediment.

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 Geneva Lake.

Water Level Stabilization

Water level fluctuation does not appear to be a significant concern of Geneva Lake users. In the aforementioned GLEA report on the Geneva Lake user survey, only 1 percent of respondents regarded water level stabilization as one of three most important actions that needed to be taken to address their concerns about the Lake. While water level management in a lake is a common technique for managing fish and aquatic macrophytes, the consequences of manipulating lake water levels can be both beneficial and deleterious. The major impacts from the riparian owner standpoint are that the fluctuating water levels affect shoreline erosion and 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 Geneva 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 cutterhead 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 Geneva 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 Geneva 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 Geneva 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 Geneva Lake comes from both urban and agricultural lands within the area tributary to Geneva 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 U.S. Army Corps of Engineers (USCOE) 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 Geneva 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; similar analysis may also be in order in regards to copper concentrations as a result of the various copper compounds used in past years to treat algae and swimmer's itch in the Lake.

Because of the considerations noted above, extensive dredging of Geneva Lake is not considered a viable alternative at this time.

Aquatic Plant and Fisheries Management

Fisheries Management Measures

Geneva Lake provides a quality habitat for a healthy, warmwater fishery. Currently, adequate water quality, dissolved oxygen levels, sand and gravel shorelines, and diverse plant community exist for the maintenance of a sportfish population in the Lake. Winterkill is currently not a problem. The Lake supports a good smallmouth and largemouth bass fishery, along with a wide range of sportfish and panfish. In addition, the pugnose shiner, a State Threatened Species, and the lake chubsucker, a State Special Concern species, have been reported being present in the Lake.

Habitat Protection

Habitat protection refers to a range of conservation measures designed to maintain existing fish spawning habitat, including measures such as restricting recreational use and other intrusions into gravel-bottomed shoreline areas during the spawning season. For bass 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. The environmentally valuable areas identified within the Lake and its tributary area are the most important areas to be protected. In addition, limiting or restricting certain activities in sensitive areas of the Lake will prevent significant disturbance of fish nests and aquatic plant beds. The WDNR has authority, granted under Chapter NR 107 of the *Wisconsin Administrative Code*, to demarcate environmentally sensitive areas within Geneva Lake. Within these areas, aquatic plant management measures can be restricted, and dredging, filling, and the construction of piers and docks can be managed. Water level fluctuations, other than those consequent to natural climatic variability, and water quality conditions, which can affect fish habitat and the breeding success of fishes, also can be managed to benefit any environmentally sensitive areas. 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. Any such measures identified pursuant to the delineation of Chapter NR 107 environmentally sensitive areas are determined on a site-specific basis and are regulated by the State under various statutory authorities, primarily under Chapter 30 of the *Wisconsin Statutes*.

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 Geneva Lake is protected by some type of structural measure. Four shoreline erosion control techniques were in use in 2000: vegetative buffer strips, rock revetments, wooden and concrete bulkheads, and beach. Maintenance of a vegetated buffer strip immediately adjacent to the Lake is the simplest, least costly, and most natural method of reducing shoreline erosion. This technique employs natural vegetation, rather than maintained lawns, within five to 10 feet of the lakeshore and the establishment of emergent aquatic vegetation from two to six feet lakeward of the shoreline.

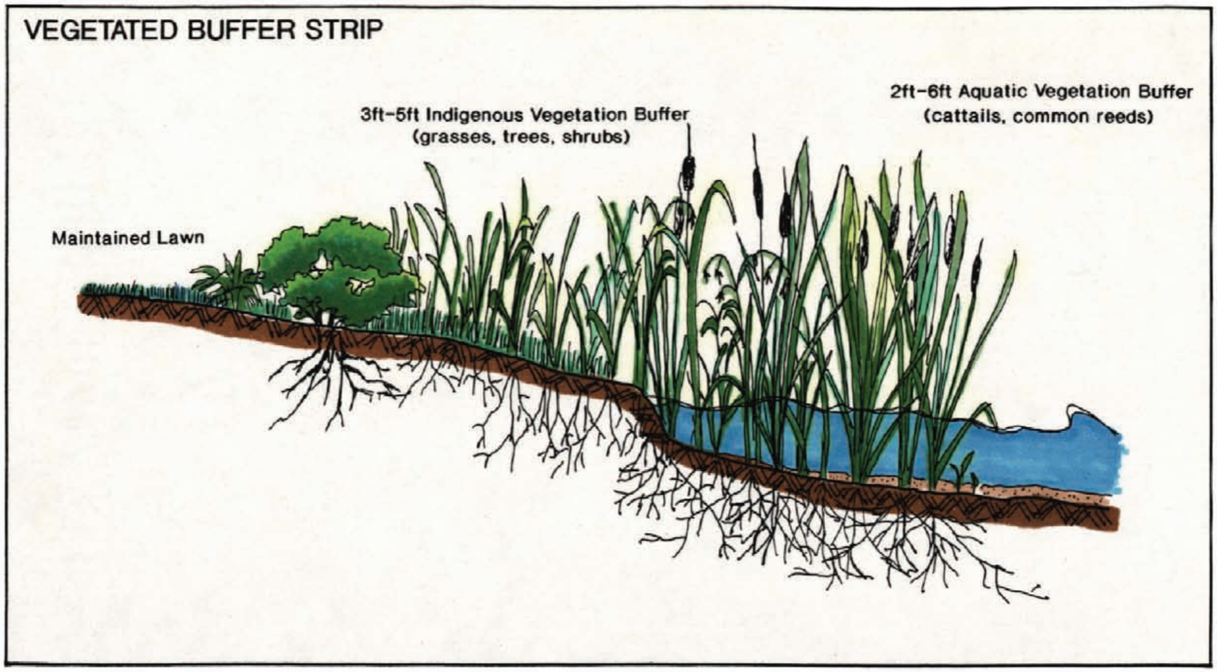
Desirable plant species that may be expected and encouraged to invade a buffer strip, or which could be planted, include arrowhead (*Sagittaria latifolia*), cattail (*Typha* spp.), common reed (*Phragmites communis*), water plantain (*Alisma plantago-aquatica*), bur-reed (*Sparganium eurycarpum*), and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

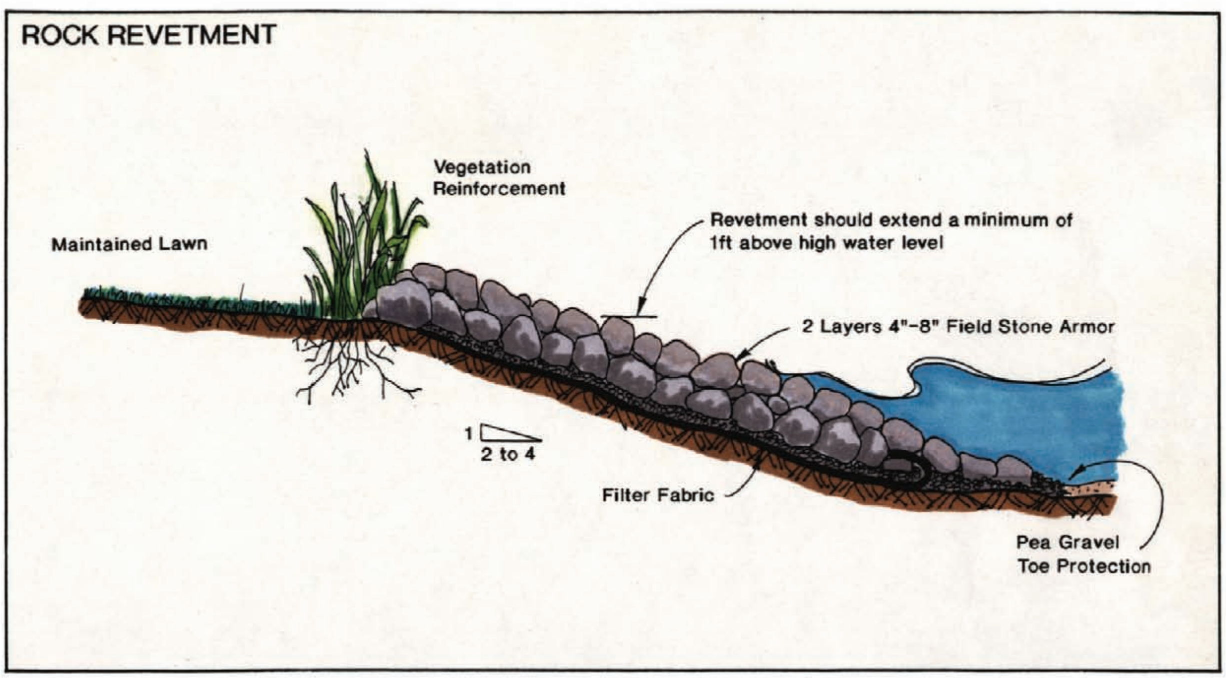
Rock revetments, or riprap, are a highly effective method of shoreline erosion control applicable to many types of erosion problems, especially in areas of low banks and shallow water. Many of these structures are already in place at Geneva Lake. The technique involves the shaping of the shoreline slope,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

The use of vegetated buffer strips and riprap, as shown in Figure 11, 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

Figure 11

PLAN ALTERNATIVES FOR SHORELINE EROSION CONTROL





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

Source: SEWRPC.

selection of appropriate shoreland protection structures is subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*, which limit the use of structural management measures to moderate- and high-energy shorelines as defined in the *Wisconsin Administrative Code*.

Modification of Species Composition
Species composition management refers to a group of conservation and restoration measures that include selective harvesting of undesirable fish species and stocking of desirable species designed to enhance the angling resource value of a lake. These measures also include water level manipulation both to aid in the breeding of desirable species, for example, increasing water levels in spring to provide additional breeding habitat for pike, and to disadvantage undesirable species, for example, drawing a lake down to concentrate forage fish and increase predation success and also to strand juveniles and desiccate the eggs of undesirable species. Costs, as with water level management above, are primarily associated with loss of use; effectiveness is good, but by no means certain; and side effects include collateral damage to desirable fish populations.

More extreme measures include organized fishing events and selective cropping of certain fish species, poisoning, and enhancement of predation by stocking. In lakes with an unbalanced fishery, dominated by carp and other rough fish, chemical eradication has been used to manage the fishery. Lake drawdown is often used along with chemical treatments to expose spawning areas and eggs and concentrate fish in shallow pools, thereby increasing their availability to anglers, commercial harvesters, or chemical eradication treatments. Fish barriers are usually used to prevent reintroduction of undesirable species from up- or downstream, and the habitat thus created will benefit the desired gamefish populations. Chemical eradication is a drastic, costly measure and the end result may be highly unpredictable. Although effectiveness is generally good, such extreme measures are not considered viable for Geneva Lake.

As noted in Chapter V, Geneva 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 Geneva 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 Geneva Lake are given in Table 28 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 three groups: physical measures, which include lake bottom coverings and water level management; mechanical removal measures, which include harvesting and manual removal; and chemical measures, which include using aquatic herbicides and biological control measures, which in turn include the use of various organisms, including insects. Of these, chemical and biological measures are stringently regulated and require a State permit.

Costs of aquatic plant management measures range from minimal, for manual removal of plants using rakes and hand-pulling, to upwards of $100,000, for the purchase of a mechanical plant harvester and ancillary equipment, the operational costs for which can approach $10,000 to $20,000 per year depending on staffing and operating policies. Harvesting is probably the measure best applicable to larger areas while chemical controls may be best suited to use in confined areas and for initial control of invasive plants. Planting of native plant species is largely experimental in lakes, but can be considered a specialized shoreland management zone at the water's edge where such a measure is frequently employed. Physical controls and mechanical harvesting may have side effects in the expansion of plant habitat and the spread of reproductive vegetative fragments.

Aquatic Herbicides
Chemical treatment with aquatic herbicides is a short-term method of controlling heavy growths of aquatic macrophytes and algae. Chemicals are applied to the growing plants in either liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophyte growth are the relative ease, speed, and convenience of application. Herbicides also offer a degree of selectivity, targeting specific types of aquatic plants. However, the disadvantages associated with chemical control include the following:

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

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

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

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

5. Adverse impacts on other aquatic organisms may be expected. At the concentrations used for macrophyte control, Diquat has been known to kill the zooplankton *Daphnia* and *Hyalella*, both important fish foods. *Daphnia* is the primary food for the young of nearly all fish species found in the Region's lakes.[19]

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.[20]

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

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

[20]*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.*

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*. Limited financial assistance for chemical control programs may be available pursuant to the aquatic invasive species grant program as set forth under Chapter NR 198 of the *Wisconsin Administrative Code*, or through the Wisconsin Waterways Commission as authorized under Chapter NR 7 of the *Wisconsin Administrative Code*.

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

Aquatic Plant Harvesting

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

1. Harvesting removes the plants from the lake. The removal of this plant biomass decreases the rate of accumulation of organic sediment. A typical harvest of submerged macrophytes from eutrophic lakes in southeastern Wisconsin can yield between 140 and 1,100 pounds of biomass per acre per year.[21]

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.[22]

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

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[21]*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.*

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

The disadvantages of macrophyte harvesting include the following:

1. Harvesting is most effective in water depths greater than two feet. Large harvesters cannot operate in shallow water or around docks and buoys. Operation of harvesting equipment in shallow waters can result in significant increases in turbidity and disruption of the lake bottom and lake bottom-dwelling fauna.

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

3. Fish, especially young-of-the-year bluegills and largemouth bass, as well as fish-food organisms, are frequently caught in the harvester. As much as 5 percent of the juvenile fish population can be removed by harvesting. A WDNR study found that four pounds of fish were removed per ton of plants harvested.[23]

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.[24] 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 Geneva Lake could be conducted through cooperative agreements among various municipalities in the tributary area or be contracted to a private company. These costs are largely staff costs and operating costs such as fuel, oil, and maintenance. The cost of new harvesting equipment, when needed, would be about $282,500.

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.[25] 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

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

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

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

be the case if a less directed harvesting program was followed. “Clear cutting” of aquatic plants and denuding the lake bottom of flora should be avoided. However, top cutting of plants, such as Eurasian water milfoil, as shown in Figure 12, is suggested.

Water depth, the numbers and arrangement of docks and moorings, and nature of bottom substrate are important factors when considering the application of mechanical harvesting. Most harvesting equipment is large and not well-suited for close operation around docks and moorings where precise control of movement is needed. Areas of shallow depth, two to three feet or less, containing muck or other soft or flocculent bottom materials also are generally not considered to be well-suited to the use of harvesting as the equipment tends to churn up these bottom materials, creating turbid water conditions, affecting established benthic communities, and fragmenting rooted aquatic macrophytes. Additionally, plants such as Eurasian water milfoil, which propagate through the spread of plant fragments, may actually be given a reproductive advantage as a result of the chopping action of harvesting equipment, although many of the newer machines can capture up to 90 percent of the plant fragments. Mechanical harvesting is best suited to large open areas, free of docks, moorings, and 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 harvesting 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.[26] 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 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.[27]

Because of the demonstrated need for control of aquatic plants, harvesting is considered a viable option in the areas of Geneva Lake that are conducive to this method of management. Mechanical harvesting of aquatic plants must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*.

Manual Harvesting

Due to water depth limitations imposed by the size and maneuverability of the harvesters, it is not always possible for harvesters to reach the shoreline of every property. Likewise, because of the cost and other concerns relating to the use of chemical herbicides, alternative measures for the control of aquatic plant growth in specific areas of the Lake should be considered. A number of specially designed rakes are available from commercial outlets to assist lakefront homeowners in manually removing aquatic plants from the shoreline area. The advantages of these rakes are that they are easy and quick to use, and result in an immediate result, in contrast to chemical treatments that involve a waiting period. This method also removes the plants from the lake avoiding the accumulation of organic matter on the lake bottom. Unfortunately, manual harvesting is feasible in only very limited areas and is not practical for large-scale use. Nevertheless, manual harvesting does offer a reasonable level of aquatic plant control in the vicinity of docks and piers, and is therefore considered a viable option. Manual harvesting beyond a 30-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

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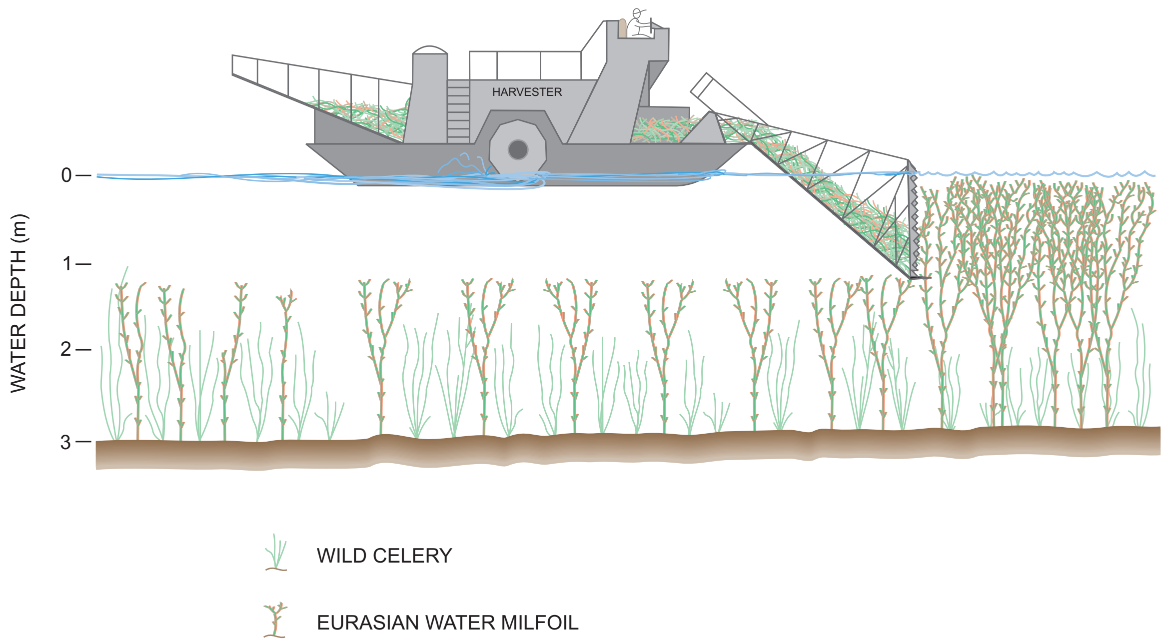
[26]*Wisconsin Department of Natural Resources,* Eurasian Water Milfoil in Wisconsin: A Report to the Legislature*, 1992.*

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

Figure 12

PLANT CANOPY REMOVAL WITH AN AQUATIC PLANT HARVESTER



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

Source: Wisconsin Department of Natural Resources and SEWRPC.

provision of this Chapter, piers and other recreational areas must be placed within the 30-foot-wide recreational corridor.

Biological Controls

Another alternative approach to controlling nuisance weed conditions, in this particular case Eurasian water milfoil, is biological control. Classical biological control has been successfully used to control both weeds and herbivorous insects.[28] 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.[29] 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:

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[28]*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.*

[29]*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.*

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

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

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

The potential disadvantages of using *Eurhychiopsis lecontei* include:

1. The studies done on *Eurhychiopsis* are very recent and more tests are necessary to determine if there are significant adverse effects.[30]

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

Relatively few studies 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 Geneva Lake at this time. Use of biological control agents must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*.

Biological control agents are regularly used to control infestations of purple loosestrife in wetlands and along shorelands. Where there are adequate densities of this invasive plant, the loosestrife beetles have proven to be extremely beneficial. The use of these control agents—*Hylobius transversovittatus*, *Galerucella pusilla*, *Galerucella calmariensis*, *Nanophyes brevis*, and *Nanophyes marmoratus*—is recommended where appropriate.

The use of other biological control agents is prohibited in Wisconsin; the use of the grass carp, *Ctenopharyn-godon idella*, for aquatic plant control is expressly prohibited.

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

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.

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[30]*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.*

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 WDNR 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 Geneva 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 21 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 Geneva 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 UWEX. The aquatic plant species lists provided in Chapter V, and the illustrations of common aquatic plants present in Geneva 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 Geneva 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 and into new areas of the Lake.

To prevent unwanted introductions of plants and invasive aquatic animals into lakes, boaters should remove all plant fragments from their boats and trailers when exiting a lake, and allow wet wells, engine water jackets, and bilges to dry thoroughly for up to one week. Alternatively, boaters can run their vessels through a car wash, where high-pressure, high-temperature water sprays can remove and destroy organisms, such as the zebra mussel juveniles (veligers).[31] Providing the opportunity for the removal of plant fragments at the boat landing on Geneva 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 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, personal watercraft are restricted to slow-no-wake speeds within 200 feet of shore, other motorized water craft are restricted to slow-no-wake speeds within 100 feet of pierheads. These areas typically coincide with water depths of less than five feet in depth. Demarcation of WDNR-delineated sensitive areas, Eurasian water milfoil control areas, and similar environmentally valuable or sensitive areas of the Lake is recommended. It is also recommended that the governmental bodies surrounding Geneva Lake continue to enforce the 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 the UWEX, the WDNR, and Walworth 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 GLEA and GLC regularly present 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. The GLEA has also produced a series of informational bulletins, or "Summary Sheets," that present specific topics to educate and inform their readers of various lake management topics. The information gained at first hand by the public during participation in these programs and through the newsletters increases the credibility of the proposed changes in the nature and intensity of use to which the Lake is subjected.

In addition to the 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

[31]*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.*

level and at the high school level. Such programming as Project WET is available from and supported by UWEX, and provides youth the opportunity to experience "hands on" the aquatic environment and become better informed about current and future lake issues and concerns. Currently, numerous outdoor education-based youth programs and camps for middle school age and older children are conducted annually through Aurora University at its George Williams Campus near Williams Bay. Consideration of the continuation of activities of this type, with the potential for additional programming under the auspices of programs such as Project WET or Adopt-a-Lake, should be supported through agreements involving local Lake organizations, municipalities, and school districts. Public information and education programming is considered a viable option.

Finally, reporting of USGS and GLEA water quality sampling results to the public should be continued.

ANCILLARY LAKE MANAGEMENT MEASURES

Institutional Development
While lake management activities fall under the general powers of municipalities, with the management and control of navigable waters being established pursuant to Sections 62.11(5) and 61.34(1), *Wisconsin Statutes*, other public and private organizational alternatives for the management of lakes in the State of Wisconsin exist.[32]

Private lake organizations have the option to be incorporated, generally as nonstock, not-for-profit corporations under Chapter 181, *Wisconsin Statutes*. Public lake organizations include special-purpose units of government that are created as public inland lake protection and rehabilitation districts under Chapter 33, *Wisconsin Statutes*, utility districts created pursuant to the municipal statutes, and town sanitary districts created under Chapter 60, *Wisconsin Statutes*. The specific type (or types) of organization created is based upon the decision of the community.

In the case of Geneva Lake, general oversight of lake management activities currently is provided by the GLEA, and inter-governmental agency established pursuant to Section 66.0301, *Wisconsin Statutes*, with the advisory input from the City of Lake Geneva, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the Towns of Linn and Walworth. While no change in this organizational arrangement is anticipated, this section outlines those options that are available to the Geneva Lake community with respect to lake management activities.

Private Lake Organizations
Private lake organizations are voluntary. Such organizations have the advantage that there are few restrictions imposed upon the types of activities in which they engage, subject to relevant permits and laws. Incorporated associations generally have a somewhat greater number of restrictions imposed upon them, but may be considered qualified associations for purposes of obtained State cost-share grants. Because of their voluntary nature, membership levels, and, therefore, income levels, of associations often fluctuate from year-to-year. Even so, a number of property owner associations exist around Geneva Lake. Membership in these organizations may be required under deed covenants as these organizations are generally associated with subdivisions. Thus, while these organizations tend to be geographically confined, many have broader mandates than solely lake issues, although these issues may be important to the association memberships.

Private lake and lake-oriented organizations serving the Geneva Lake community currently include the Geneva Lake Level Corporation, founded in 1894, with responsibility for dam operations; the Lake Geneva Water Safety Patrol, founded in 1927, with responsibility for enhancing the safe use of the waters of Geneva Lake; the Geneva Lake Association, a lakewide property owners association whose purpose is the promotion of, and engagement in, community improvements in the Geneva Lake area; the Environmental Education Foundation, whose purpose is to promote environmental education through the awarding of grants and scholarships to Geneva Lake area

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[32]*See University of Wisconsin-Extension Publication No. G3216,* The Lake in Your Community*, 1986; and University of Wisconsin-Extension Publication No. G3818,* People of the Lakes: A Guide for Wisconsin Lake Organizations: Lake Associations & Lake Districts, 11th edition, *2006*.

students and schools for the advancement of environmental education; and, the Geneva Lake Land Conservancy, founded in 1982, with responsibility for the acquisition and management of critical lands in the vicinity of Geneva Lake. In addition to these entities, several property owner associations also exist around the Lake, serving specific lakeside communities.

Public Lake Organizations

Public inland lake protection and rehabilitation districts, or lake management districts, are public governmental units formed under Chapter 33, *Wisconsin Statutes*, for the specific purpose of managing and protecting lake water quality. Inclusion in the district, once the district is created, is mandatory, and registered voters and persons owning property within the district become the electors of the district for purposes of governance. Lake management districts have the capability of raising public funds subject to majority approval of the district budget at the annual meeting of the district. For this reason, lake management districts can provide a more stable financial base from which to undertake lake management activities. Often, lake associations and lake districts operate in harmony around lakes throughout Wisconsin. Town sanitary districts, formed pursuant to Subchapter IX of Chapter 60, *Wisconsin Statutes*, can adopt a lake focus. Such districts are known as lake sanitary districts and perform many or all of the same functions as lake protection and rehabilitation or management districts.

Although creation of a lake management district around Geneva Lake has been discussed on a number of occasions, it has generally been felt by the community that the GLEA, as an inter-governmental organization, is an effective means of addressing lake management concerns. The GLEA is created pursuant to Chapter 66, *Wisconsin Statutes*, by the municipalities surrounding Geneva Lake, for the purpose of maintaining the resources of Geneva Lake by protecting, preserving and enhancing a desirable lake and watershed quality. Since 1975, the Agency has operated under a Uniform Resolution and By-Laws signed by the sponsoring units of government. The Resolution calls for the Agency to: (1) study the 5,462-acre Geneva Lake and its 12,800-acre watershed, with regard to its physical, chemical and biological characteristics; water quality; lake and land use; protective measures; and recreation- and resource-related problems; and, (2) make recommendations to protect its resources and improve living conditions to accomplish these recommendations.

Creation of a Chapter 33, *Wisconsin Statutes*, public inland lake protection and rehabilitation district is an unlikely option at this time. Consideration of the creation of such a district in the future should be contingent upon need.

SUMMARY

This chapter has described options that could be employed in managing the types of problems recorded as occurring in Geneva 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 40.

The evaluation of the potential management measures for improving the Geneva Lake water quality was carried out on the basis of the effectiveness, cost, and technical feasibility of the measures. Those alternative measures not considered further at this time include: phosphorus precipitation and inactivation, drawdown by water level control modifications, dredging, biological control of aquatic plants, lake bottom covering, 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 40

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR GENEVA 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, Upper Fox River priority tributary area plan, and county land and water resource management plan recommendations within tributary area	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 USGS Water Quality Monitoring Program; consider participation in WDNR Expanded Self-help program or University of Wisconsin-Stevens Point Environmental Task Force TSI 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 40 (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
		Enforce size and catch limit regulations	Yes
	Aquatic plant management	Use (limited) 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
		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
In-Lake Management Alternatives	Public Informational and Educational Programming	Conduct public informational programming utilizing seminars and distribution of informational materials	Yes
		Support participation of schools in Project WET, Adopt-A-Lake, etc.	Yes
		Conduct public informational and educational programming on aquatic plants and options for their management	Yes
		Encourage methods of preventing unwanted intrusions of invasive biota at public recreational boat access	Yes
Ancillary Management Measures	Institutional development	Create a lake association for Geneva Lake	No[c]
		Create a public inland lake protection and rehabilitation district serving Geneva Lake	No[c]

[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.*

[c]*Several environmental and lake-protection-oriented organizations, as well as property owner associations, exist around Geneva Lake; these organizations and associations are expected to continue to operate and form valuable systems for delivery of informational programming to lake residents.*

Source: SEWRPC.

Chapter VIII

RECOMMENDED MANAGEMENT PLAN FOR GENEVA LAKE

INTRODUCTION

This chapter presents a recommended management plan for Geneva 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 Geneva Lake, the physical and biological quality of the waters of the Lake, recreational use and population forecasts set forth in Chapters II through VI, and an evaluation of alternative lake management measures set forth in Chapter VII. 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 40, 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 Geneva 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, 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 Geneva 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,[1] the regional land use plan,[2] and the Walworth County land and water resource management plan.[3]

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[1]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume Three,* Recommended Plan*, June 1979; SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995.*

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

[3]*Walworth County Land Department,* Walworth County Land & Water Resource Management Plan, *February 1999.*

The recommended management measures for Geneva Lake are graphically summarized on Map 17, and are listed in Table 41. The recommended plan measures are more fully described in the following paragraphs. It should be noted that recreational use management and institutional development measures were also considered in developing this management plan, but were not included within the recommended management plan at this time. The recommended management agency responsibilities for tributary area land management also are set forth in Table 41.

TRIBUTARY AREA MANAGEMENT MEASURES

Land Use Control and Management

A fundamental element of a sound management plan and program for Geneva 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 Geneva Lake under buildout 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).[4] The recommended land use plan envisions that urban land use development within the area tributary to Geneva 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. Notwithstanding, such development in the shoreland zone is likely to represent a significant densification of urban density development along the shores of the Lake, as very large estates are converted to subdivision-type developments, as discussed below.

Development in the Shoreland Zone

A major land use issue which has the potential to affect Geneva 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 the magnitudes of pollutant loadings into the Lake, and 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 Geneva Lake to the maximum extent practical is recommended; where such circumstances are not practicable, implementation of structural stormwater management measures and vegetative shoreline protection measures is strongly recommended.

It is further recommended that lakefront developments, as well as setback and landscaping provisions, be carefully reviewed by the Towns of Geneva, Linn, and Walworth, the Villages of Fontana-on-Geneva Lake and Williams Bay, the City of Lake Geneva, Walworth County, and the Wisconsin Department of Natural Resources (WDNR). Such review would address specific shoreland zoning requirements, and could consider the stormwater and urban nonpoint source pollution abatement practices proposed to be included in shoreland development activities. 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.

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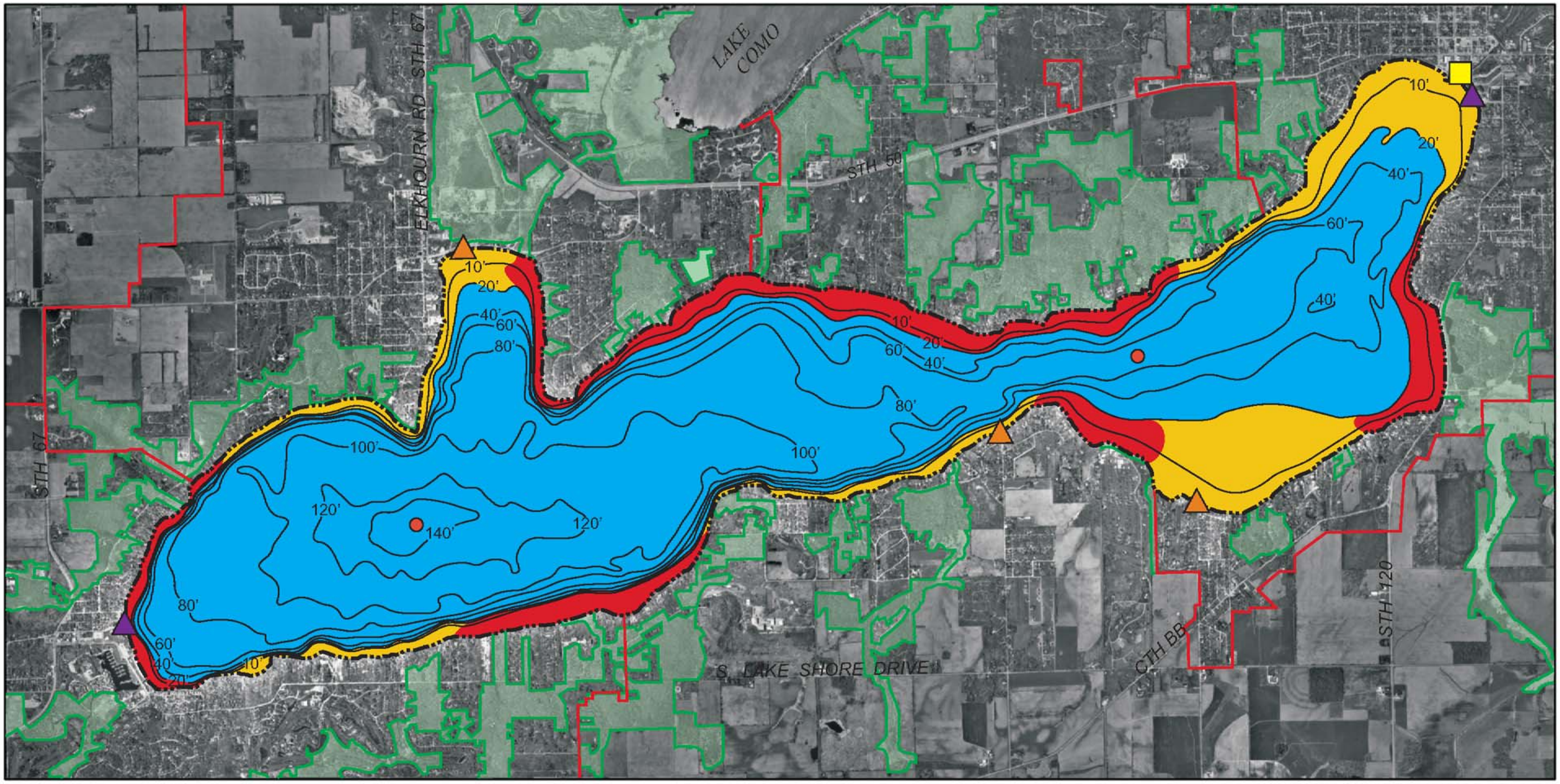
[4]*SEWRPC Planning Report No. 45,* op. cit.

Map 17

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR GENEVA LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

20' WATER DEPTH CONTOUR IN FEET

WATER LEVEL CONTROL STRUCTURE

PUBLIC ACCESS SITE

DEVELOP FUEL SPILL RESPONSE PLAN FOR MARINAS

LAND MANAGEMENT

PROTECT ENVIRONMENTAL CORRIDOR LANDS

- OBSERVE GUIDELINES SET FORTH IN REGIONAL, COUNTY, AND LOCAL LAND USE PLANS
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS

REFINE SANITARY SEWER SERVICE AREAS AS NECESSARY; MAINTAIN PUBLIC SANITARY SEWERAGE SERVICES

WATER QUALITY MANAGEMENT

CONTINUE WATER QUALITY MONITORING

AQUATIC PLANT MANAGEMENT

OPEN WATER: DEPTH GREATER THAN 20 FEET-NO MANAGEMENT MEASURES REQUIRED

EURASIAN WATER MILFOIL: WATCH AND CONTROL AREA

CONTINUE TO MONITOR AQUATIC PLANTS

RECREATIONAL USE MANAGEMENT

- CONTINUE TO ENFORCE BOATING REGULATIONS
- MAINTAIN PUBLIC ACCESS SITES

FISHERIES MANAGEMENT

- PROTECT AND ENHANCE FISH HABITAT
- MONITOR FOR NONNATIVE SPECIES
- CONTINUE TO ENFORCE FISH AND WILD LIFE REGULATIONS

PUBLIC INFORMATION PROGRAM

- CONTINUE PUBLIC AWARENESS AND EDUCATIONAL PROGRAMS

GRAPHIC SCALE

0 2250 4500 FEET

Source: U.S. Geological Survey and SEWRPC.

Table 41

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR GENEVA 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 Walworth County development plan	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay; City of Lake Geneva; and Geneva Lake Conservancy and Geneva Lake Association
		Lakeshore areas	Maintain historic lake front residential dwelling densities to extent practical and continue to enforce setback requirements; consider conservation development principles	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay; City of Lake Geneva; and Geneva Lake Conservancy and Geneva Lake Association
		Entire tributary area	Develop and implement consistent stormwater management ordinances in all riparian communities, especially development areas; periodic review of stormwater ordinances	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay; City of Lake Geneva; and Geneva Lake Conservancy and Geneva Lake Association
	Protecting environmentally sensitive lands	Fontana Prairie and Fen, Peninsula Woods, Williams Bay Lowlands, Wychwood	Implement regional natural areas and critical species habitat protection and management plan recommendations within tributary area; consider public or private acquisition of features of local or greater significance	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay; City of Lake Geneva; the Geneva Lake Conservancy and Geneva Lake Association; and GLEA
Pollution Abatement	General nonpoint source pollution abatement	Entire tributary area	Implement recommendations made in the regional and county land and water resource management plans	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay, and City of Lake Geneva
	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, Walworth County
	Urban nonpoint source controls	Entire tributary area	Promote urban housekeeping and yard care practices through public educational programming	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay, and City of Lake Geneva; GLEA
			Implement various urban nonpoint source controls, including storm water management	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay, and City of Lake Geneva; GLEA
	Developing Area nonpoint source controls	Entire tributary area	Develop and enforce construction site erosion control and stormwater management ordinances; review ordinances for concurrence with NR 152	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay, and City of Lake Geneva; GLEA

Table 41 (continued)

Plan Element	Subelement	Location	Management Measure	Management Responsibility
Pollution Abatement (continued)	Public sanitary sewerage system management	Sewered portions and urbanizing portions of the tributary area	Conduct periodic review and refinement of sewer service area needs within sewered areas of the tributary area	Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay, and City of Lake Geneva; GLEA
	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	Walworth County; Towns of Geneva, Linn, and Walworth; Linn Sanitary district; GLEA; private landowners
Water Quality	Water quality monitoring	Main lake basin (west bay)	Continue participation in USGS Water Quality Monitoring Program; consider participation in WDNR Expanded Self-help program or University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program	USGS, WDNR, UW-SP, GLEA
Aquatic Biota	Fisheries management	Entire lake	Protect fish habitat	WDNR, GLEA, private sports organizations
			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, GLEA, private shoreline property owners
			Continue stocking of selected game fish species and monitor rough fish populations Enforce size and catch limit regulations	WDNR, GLEA, private sports organizations
	Aquatic plant management	Entire lake	Conduct periodic reconnaissance surveys of aquatic plant communities Update aquatic plant management plan every three to five years Provide and conduct programming on aquatic plants and various management measures	WDNR, GLEA
		Selected areas of the Lake	Use (limited) aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife[a]	WDNR, GLEA
		Selected areas of the Lake	Mechanically harvest aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants[b] Manually harvest aquatic plants from around docks and piers where feasible	WDNR, GLEA
		Lakeshore areas	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	WDNR, GLEA, private lakefront property owners

Table 41 (continued)

Plan Element	Subelement	Location	Management Measure	Management Responsibility
Aquatic Biota (continued)	Invasive species	Entire lake	Continue to monitor population size, make-up, and distribution of invasive species such as zebra mussel, purple loosestrife, Eurasian water milfoil	WDNR, GLEA
Water Use	Recreational use management	Entire lake	Enforce 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	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay, and City of Lake Geneva; WDNR, GLEA, Water Safety Patrol
Ancillary Management Measures	Public Informational and Educational Programming	Entire tributary area	Conduct public informational programming utilizing seminars and distribution of informational materials	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay, and City of Lake Geneva; WDNR, GLEA, Water Safety Patrol, Geneva Lake Conservancy, Geneva Lake Association, and Environmental Education Foundation
			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.	Walworth County; Towns of Geneva, Linn, and Walworth; Villages of Fontana-on-Geneva Lake and Williams Bay, and City of Lake Geneva; WDNR, GLEA, Water Safety Patrol, Geneva Lake Conservancy, Geneva Lake Association, and Environmental Education Foundation
			Encourage methods of preventing unwanted intrusions of invasive biota at public recreational boat access	

[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.

Development in the Tributary Area

Another land use issue which has the potential to affect the Lake is the potential development for urban uses of the agricultural and other open space lands in the tributary 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. 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 full buildout condition envisioned under the regional land use plan, a significant portion of the undeveloped lands, outside of the environmental corridors and other environmentally sensitive areas, could potentially be developed for low- to medium-density urban uses.

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 within 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 Geneva 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.

Stormwater Management

It is recommended that the Towns of Geneva, Linn, and Walworth, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the City of Lake Geneva 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 programs 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, and to ensure that there is harmony between the ordinances governing urban density development in each of the municipalities draining to Geneva Lake. Adoption by all riparian municipalities of common stormwater management ordinance provisions is strongly recommended.

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 Geneva 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 (USCOE) permit program, State shoreland zoning requirements, and local zoning ordinances. Nearly all wetland areas in the Geneva 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.

Nevertheless, some wetland and woodland areas have been identified for acquisition in the adopted regional natural areas and critical species habitat protection and management plan, including Peninsula Woods and Wychwood.[5] Public acquisition or acquisition by private conservation organizations of these lands is recommended. In this regard, implementation of the recommendations of the adopted park and open space plan for Walworth 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 of nonpoint sources of pollution within the tributary area on Geneva Lake. These measures are set forth in the aforereferenced regional water quality management plan and the Walworth 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 rural and urban nonpoint sources, and onsite sewage disposal systems in the tributary area. About 60 percent of the lakeshore areas tributary to Geneva Lake is served by onsite sewerage systems; the balance of the lakefront area is served by public water-borne sanitary sewerage services.

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

[6]*SEWRPC Community Assistance Planning Report No. 135, 2nd Edition,* A Park and Open Space Plan for Walworth County*, September 2000, as amended.*

Nonpoint source control measures should be considered for the areas tributary to Geneva Lake. The regional water quality management plan recommended a reduction of about 50 percent in urban, and of up to 75 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 Geneva Lake. These nonpoint source pollution abatement goals are recommended to be achieved through a combination of rural agricultural nonpoint controls, urban stormwater management, and construction erosion controls implemented in the tributary area to Geneva Lake. 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 aforereferenced Walworth 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 Geneva, Linn, and Walworth, the Villages of Fontana-on-Geneva Lake, and Williams Bay, the City of Lake Geneva, Walworth 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 Walworth County. As discussed previously, it is recommended that the Towns of Geneva, Linn, and Walworth, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the City of Lake Geneva, in coordination with the WDNR, Walworth County, and the special purpose 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 Geneva Lake include conservation tillage, integrated nutrient and pesticide management, and pasture management. In addition, it is recommended consideration be given to cropping patterns and crop rotation cycles, with attention to the specific topography, hydrology, and soil characteristics for each farm. A reduction of about 25 percent in the nonpoint source loading from rural lands could provide up to about a 15 percent reduction in total phosphorus loading to Geneva Lake. Implementation of the recommendations and work planning activities set forth in the Walworth 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 for management measures implemented under the Targeted Runoff Management (TRM) and Urban Nonpoint Source Management grant programs.

Urban Nonpoint Source Pollution Controls

The development of urban nonpoint source pollution abatement measures for the Geneva Lake areas should be the primary responsibility of the Towns of Geneva, Linn, and Walworth, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the City of Lake Geneva. 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 GLEA, in cooperation with the

City, the Villages and the Towns, take the lead in sponsoring such programming for the Geneva Lake community through regular public informational meetings and mailings. The agency should also ensure that relevant literature, available through the University of Wisconsin-Extension (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 fact sheets, within the GLEA "Summary Information Sheets" series, be prepared to identify specific residential land management measures beneficial to the water quality of Geneva Lake and distributed to property owners. These fact sheets could be distributed by the GLEA and the riparian municipalities, with the assistance of UWEX and Walworth 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 5 percent reduction in total phosphorus loadings to the Lake.

Developing Areas and Construction Site Erosion Control

It is recommended that Walworth County, the Towns of Geneva, Linn, and Walworth, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the City of Lake Geneva continue efforts to control soil erosion attendant to construction activities in accordance with existing ordinances. As noted in Chapter III, Walworth County has adopted construction erosion control ordinances. Enforcement of the ordinances by the County is generally considered effective. The provisions of these ordinances apply to all development except single- and two-family residential construction. The single- and two-family construction erosion control is to be carried out as part of the building permit process. In the City and Villages, 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 Geneva 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 Geneva Lake, it is important that adequate construction erosion control programs be in place.

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

Onsite and Public Sewage Disposal System Management

The lakeshore areas and areas tributary to Geneva Lake are served by both onsite and public sanitary sewerage systems. While onsite systems are estimated to be a minor contributor to the total phosphorus load to the Lake, current County ordinance provisions requiring the regular inspection and maintenance of onsite sewage disposal systems should be enforced to minimize potential phosphorus loadings from this source. It also is recommended that Walworth County, in cooperation with the Linn Sanitary District, the Towns of Geneva, Linn, and Walworth, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the City of Lake Geneva, assume the lead in providing the public informational and educational programs necessary to encourage affected property owners to have existing onsite systems inspected and any needed remedial measures undertaken, as appropriate. Homeowners should be advised of the rules and regulations governing, and the limitations of onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs, especially of those older systems not yet subject to the inspection requirements of the County ordinance.

Typical costs for a basic inspection and maintenance service range from about $100 to $200 per year, although more extensive programs could be more expensive. The costs of the informational programming typically have been included within the operating budget of the County.

For those portions of the area tributary to Geneva Lake served by public sanitary sewerage systems, it is recommended that the GLEA, in cooperation with the Towns of Geneva, Linn, and Walworth, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the City of Lake Geneva, assume the lead in providing public informational and educational programs to encourage affected property owners to use their sewerage systems appropriately and wisely. In an analogous recommendation, stenciling of storm drains and related informational programming encourages Lake residents to dispose of waste products safely, avoiding discharge directly to the surface waters or indirectly through the wastewater treatment works to the environment. Periodic review of the sewer service areas, pursuant to the guidelines set forth in the regional water quality management plan, should be undertaken within each of the sanitary sewer service areas delineated around the Lake to ensure adequate capacity exists and service is provided to those urban density areas within the unrefined service area as development occurs in the drainage area tributary to Geneva Lake.

IN-LAKE MANAGEMENT MEASURES

The recommended in-lake management measures for Geneva Lake are summarized in Table 41 and are graphically summarized on Map 17. The major recommendations include: water quality and quantity monitoring; fisheries management and habitat protection; nonpoint-source pollution prevention; shoreland protection; aquatic plant management; recreational use management; and, informational and educational programming.

Surface Water Quality Management

Continued water quality monitoring of Geneva Lake is recommended. Ongoing Lake sampling, conducted under the auspices of the current GLEA program, is recommended with water samples being collected and various water quality parameters being measured several times a year at a central station in the deepest portion of the lake basin. The recommended sampling site is in the central portion of the western lobe of the Lake.[7] It is also recommended that the results of such monitoring be posted on the GLEA website and distributed as appropriate through the GLEA "Summary Information Sheets" series.

Water Quantity and Lake Level Management

As indicated in Chapter II, outflow from Geneva Lake is controlled by a dam and sluice gates located on the eastern end of the Lake in the City of Lake Geneva. The present actual operating regime of the dam is intended to maintain the lake level at an elevation of about 864.42 feet above the National Geodetic Vertical Datum of 1929 (NGVD-29). The Geneva Lake Level Corporation built the original permanent dam and sluice gates in 1894 and an improvement project upgrading the structure was completed in 2002.

Although Lake levels were not a major concern among Lake users, as reported in the lake use survey, it is worth noting that fluctuations in lake levels can contribute to various concerns. The placement of shoreline protection structures can be more or less effective depending upon the magnitude and frequency of variations in water levels. These variations also affect availability and quality of fish and aquatic life habitat, with extreme fluctuations potentially being disadvantageous to mollusks and other less mobile life forms. Large fluctuations in lake levels can affect downstream landowners who may be affected by velocity and volume of waters discharged through the Geneva Lake outlet to the White River. Outflows of water at the White River outlet are measured by a USGS owned and operated monitoring gauge, data from which are available through the USGS.[8]

No changes in the operating regime of the impoundment are recommended.

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[7] *U.S. Geological Survey Water-Resources Investigations Report No. 02–4039,* Hydrology and water quality of Geneva Lake, Walworth County, Wisconsin*, 2002.*

[8] *Data are collected from the U.S. Geological Survey gauging station number 055451345 on the White River at Center Street in the City of Lake Geneva, Wisconsin. Real time stream flow data can be viewed on the U.S. Geological Survey website at:*
http://waterdata.usgs.gov/wi/nwis/uv/?site_no=055451345&PARAmeter_cd=00065,00060.

Fisheries Management
Periodic fishery surveys are recommended to be conducted by the WDNR. Such surveys 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 known factors such 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 by the WDNR of northern pike, walleyed pike, and/or other game fish species, as appropriate, in order to maintain a continuing, viable sport fishery.

These actions should provide a sound basis for 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 Geneva Lake are designed to provide for habitat protection by avoiding disturbances to fish breeding areas during spring and autumn, managing aquatic plant communities, and maintaining stands of native aquatic plants. In particular, this recommendation extends to, and includes, any WDNR-delineated, Chapter NR 107 sensitive areas that may be located in the lake, although at the time of the printing of this document there were no State-designated sensitive areas in Geneva Lake. In addition, it is recommended that environmentally sensitive lands, including wetlands along the lakeshore and in the tributary area be preserved, as recommended, in part, in the regional natural areas and critical species habitat protection and management plan.[9]

Shoreland Protection
Most of the Geneva Lake shoreline is protected and no major areas of erosion, which would require additional protection against wind, wave, and/or 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 shorelines, or combinations thereof, 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 implementation on the landward side of the shoreline, where practical. Guidance provided in Chapter NR 328 of the *Wisconsin Administrative Code* sets forth the methodology for determining appropriate shoreline protection structures for inland lakes based upon wind wave action and fetch,

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

substrate, and likely boat wake action. Utilization of the "long-form" of the erosion intensity (EI) worksheet, set forth in Table 1 of Section NR 328.08(2), is recommended.[10]

In addition to the foregoing measures, it is also recommended that the City of Lake Geneva, the Towns of Geneva, Linn, and Walworth, and the Villages of Fontana-on-Geneva Lake and Williams Bay continue to enforce existing shoreland setback requirements and construction site erosion control and stormwater management ordinances. Provision of informational materials to shoreland property owners is recommended, as set forth in the informational and educational programming element of this plan. Review and refinement of the existing local governmental ordinances for concurrency with the Chapter NR 151 suite of administrative codes is recommended.

Aquatic Plant Management

The aquatic plant management strategy set forth below recognizes the importance of recreational uses of Geneva Lake. Integral to the aquatic plant management strategy is the protection and preservation of fish breeding habitat. In addition, this strategy recognizes the ecosystem values and functions provided within Geneva 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. The aquatic macrophyte control recommendations set forth below are consistent with Chapters NR 103, NR 107, and NR 109 of the *Wisconsin Administrative Code*.

Alternative Methods for Aquatic Plant Control

Various aquatic plant management techniques: manual, mechanical, and chemical, are potentially applicable on Geneva Lake, as noted in Chapter VII. A number of these methods have been employed with varying success on Geneva Lake in the past, although use of chemical herbicides has been the major control measure utilized throughout the Lake in recent years.

Chemical Controls

Chemical controls, in the form of herbicides and algicides, have been the primary means of aquatic plant control on Geneva Lake. As noted in Chapter V of this report, the aquatic herbicides diquat, endothal, sodium arsenite, and 2,4-D have been applied to Geneva Lake to control aquatic macrophyte growth; copper sulfate compounds have been used to control swimmer's itch and algal growth.

Diquat is a nonselective herbicide that also will kill many nontarget species of aquatic plants, including such native species 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. Systemic herbicides such as 2,4-D and fluridone are considered to be more selective and are generally used to control Eurasian water milfoil. However, 2,4-D also will kill high-value, native aquatic plant species such as water lilies. Fluridone will also affect coontail and elodea, both native species providing good habitat and having good food value for fish and wildlife, as noted in Chapter V.

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 that may be given effect as either additional macrophyte growths or algal blooms. 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.

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[10]*An automated "short form" for the calculation of erosion intensity is available on the WDNR website at: http://dnr.wi.gov/org/water/fhp/waterway/erosioncalculator.shtml. This form is based solely on wind fetch and does not include consideration of boat wake effects.*

Selective use of chemical control is likely to be the most suitable technique for the control of infestations of Eurasian water milfoil and other nuisance species, especially in nearshore and confined 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 Controls

Manual methods of aquatic plant control, such as raking or hand-pulling, are generally environmentally sound. Manual control methods are very effective for small-scale application; for example, in and around docks and piers. However, manual techniques are generally not practical for large-scale plant control methods. Manual means are recommended for use on Geneva Lake to control nearshore plant growths, especially around individual piers and docks.

Mechanical Controls

Based on previous experience with the use of mechanical harvesting technologies in lakes in southeastern Wisconsin, mechanical harvesting of aquatic plants on Geneva Lake could be, in certain areas of the Lake, a viable method of controlling plant growth and associated filamentous algae. The most significant impact of mechanical harvesting is the removal of the organic plant biomass, decreasing nutrient inputs to the Lake. Potential negative impacts of mechanical harvesting, as outlined by the USEPA,[11] include: the removal of small fish, lack of selectivity in plant species harvested, limited depths of operation, potential for the propagation of plant fragments especially of species whose natural reproduction is through auto-fragmentation, including Eurasian water milfoil, and time needed to treat specific areas of a waterbody. Additionally, on a waterbody the size of Geneva Lake, running time from shoreline off-loading locations to areas of treatment may be of such length as to significantly reduce the cost-effectiveness of operating the equipment. However, mechanical harvesting does offer temporary relief from nuisance aquatic plant growths over large areas of lake surface, especially when conducted in accordance with a management plan designed to optimize benefits and minimize adverse impacts.

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

While mechanical harvesting has been determined to be a viable alternative for aquatic plant management in Geneva Lake, the limited areas of concern and relative paucity of nuisance aquatic plants growths in the Lake would suggest that the introduction of widespread mechanical aquatic plant management measures may be premature except in specific locations, such as the larger marinas located around the lakeshore.

Shoreline Cleanup Crew

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 as it decomposes, 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. Given that a significant number of lake homeowners may be seasonal or elderly, it is not always feasible for the riparian owners to clean their shoreline when needed. To alleviate this problem, shoreline municipalities and riparian

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[11]*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.*

owners could institute a comprehensive program of shoreline cleanup to remove as much floating vegetation from the shoreline area as possible. Such a program has the advantage of removing vegetative fragments generated by other aquatic plant management techniques, as well as those generated by recreational boating traffic and auto-fragmentation. Implementation of this recommendation could be coordinated by the GLEA. However, investments in staff and equipment would be required. Acquisition of an appropriate barge and motor could cost up to $50,000, with staffing costs of between $10,000 and $20,000 per year, depending upon staffing and operating policies.

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. The "Clean Boats, Clean Waters" volunteer watercraft inspection program is an opportunity for citizens to take an active role in limiting the spread of aquatic invasive species. Through the "Clean Boats, Clean Waters" program, volunteers are trained to organize and conduct boater education programs in their community. Adult and youth teams inform boaters on how and where invasive species are most likely to hitch a ride into waterbodies, perform boat and trailer checks for invasive species, distribute informational brochures and collect, and report any new waterbody infestations. 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. This type of program could be implemented through the GLEA or through the Lake Geneva Water Safety Patrol.

A parallel informational program could 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. This latter program would be best implemented by the GLEA and Geneva Lake Land Conservancy.

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 Geneva Lake community has consistently supported informational and educational programming within their community. Efforts by the GLEA through its Summary Information Sheets and citizen-oriented informational programming, have encouraged environmentally sound behaviors within the Lake, and have contributed to shoreland restoration efforts and lake monitoring as well. Thus, ongoing informational and educational programming is recommended. In implementing these recommendations, the GLEA should work cooperatively with the governmental and nongovernmental organizations serving the Geneva Lake community.

Recommended Aquatic Plant Management Measures
It is recommended that aquatic macrophyte surveys continue to 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: data collected should include descriptions of: major areas of nuisance plant growth; areas chemically treated and/or harvested; and, if 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. It is further recommended that if mechanical harvesting takes place, 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.

1. It is recommended that the use of chemical herbicides be limited to controlling nuisance growth of exotic species in shallow water around docks and piers where the harvester is unable to reach. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners. It is recommended that chemical applications, if required, be made by licensed applicators in early spring subject to State permitting requirements to maximize their effectiveness on nonnative plant species, while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions. Such use should be evaluated annually and the herbicide applied only on an as needed basis. Only herbicides that selectively control milfoil, such as 2,4-D, should be used. Algicides, such as Cutrine Plus, are not recommended because there are few significant, recurring filamentous algal or planktonic algal problems in the Geneva Lake and valuable macroscopic algae, such as *Chara* and *Nitella* are killed by this product.

2. The control of rooted vegetation between adjacent piers is recommended to be left to the riparian owners concerned. GLEA 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.

3. It is further recommended that the GLEA conduct a public informational program on the types of aquatic plants in Geneva 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.

The recommended aquatic plant control areas are shown on Map 17. 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 GLEA and municipalities. Implementation of this plan would not entail significant capital costs. Annual operation and maintenance costs of $2,000 are estimated to be incurred by the GLEA for the conduct of this program. Should individual homeowners wish to purchase any of the specialty rakes that are available for the manual harvesting of aquatic plants around piers and docks, such a rake can be obtained for about $100.

OTHER LAKE MANAGEMENT MEASURES

Recreational Use Management
Public Recreational Boating
The level of public recreational boating access to Geneva Lake is consistent with statewide standards as set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. Municipalities should maintain adequate public recreational boating access to ensure continuing eligibility for State lake enhancement services, such as fish stocking programs, grants for access improvements, and cost-share grants for lake protection activities.

With respect to boating ordinances applicable to Geneva Lake, it is recommended that current levels of enforcement be maintained. Recreational boating ordinances should be reviewed periodically for concurrency with applicable State regulations.

Recreational boating access users should be made aware of the presence of exotic invasive species within Geneva Lake, including zebra mussel and Eurasian water milfoil. 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 the various municipalities make disposal bins available at their public recreational boating access sites for disposal of plant materials and other refuse removed from watercraft using the public recreational boating access sites.[12] As noted above, the lake community may wish to participate in, among others, the "Clean Boats, Clean Waters" program.

Spill Response Preparedness

Geneva Lake is the site of several large marinas with shoreline or on-lake fueling facilities, located in the City of Lake Geneva, the Village of Williams Bay, and the Village of Fontana-on-Geneva Lake. Two such facilities are located in the latter Village. The Federal Emergency Planning and Community Right to Know Act (EPCRA) program requires communities to prepare for hazardous chemical releases through emergency planning and by maintaining hazardous chemical information that is submitted to them by the facilities covered under the law. EPCRA, also known as Title III of the Superfund Amendments and Reauthorization Act (SARA), brings industry, government, and the general public together to address emergency planning for accidental chemical releases. The emergency planning aspect requires communities to prepare for hazardous chemical releases, and provides essential information for emergency responders. The community right-to-know aspect increases public awareness of chemical hazards in their community and allows the public and local governments to obtain information about these chemical hazards.

Wisconsin Emergency Management (WEM) is responsible for implementing EPCRA at the State and local levels. WEM is responsible for administering: the Emergency Planning Grant that provides funding on a formula basis to county Local Emergency Planning Committees (LEPCs) for local planning and program administration, and the Equipment Grant that provides matching funding for computer equipment and hazardous materials response equipment.

Walworth County has a LEPC set up in accordance with the Federal Legislation, which is responsible for implementing EPCRA requirements at the county level. The County emergency management director is a member of the LEPC to ensure continuity and coordination of emergency response planning. It is recommended that the GLEA consult with the Walworth County LEPC regarding recommended spill response planning, and act as liaison with the municipalities in which the dockside fueling facilities are located to ensure conformance with the EPCRA requirements.

Public Informational and Educational Programs

It is recommended that the GLEA assumes the lead in the development of a public informational and educational program. Participation by the City of Lake Geneva, the Towns of Geneva, Linn, and Walworth, and the Villages of Fontana-on-Geneva Lake and Williams Bay 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 the UWEX. Additionally, *The Geneva Lake Book*, a publication of the GLEA, presents a high quality overview of the various aspects and issues confronting the Geneva Lake community and is recommended to continue to be made available.[13] These topics covered in the *Geneva Lake Book* include beneficial lawn care practices and household chemical use.

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[12] *The City of Lake Geneva, the Towns of Geneva, Linn, and Walworth, and the Villages of Fontana-on-Geneva Lake and Williams Bay should continue to monitor experience with the use of high pressure washing stations for the control of zebra mussel currently being gained within the Laurentian Great Lakes Basin and consider adoption of those measures proven to be successful in limiting the spread of zebra mussel within the Region. The U.S.-Canadian International Joint Commission regularly provides informational materials on this and related subjects.*

[13] *George W. Johnson, Resource Manager Geneva Lake Environmental Agency,* The Geneva Lake Book, *1997.*

Informational materials, such as brochures and pamphlets 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.

Given the extent of public interest in Geneva Lake, it is recommended that the GLEA and the local municipalities continue 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.[14]

The GLEA 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.

Institutional Development

In the case of Geneva Lake, general oversight of lake management activities currently is provided by the GLEA, with the advisory input from the City of Lake Geneva, the Towns of Geneva, Linn and Walworth, and the Villages of Fontana-on-Geneva Lake and Williams Bay. Consideration of other lake organization alternatives, including the creation of a Chapter 33 public inland lake protection and rehabilitation district, has been initiated periodically; however, it is generally agreed that the GLEA is an appropriate and effective vehicle to coordinate and implement lake management measures on Geneva Lake. No changes in this relationship are recommended; it is recommended that the GLEA continue to be the lead agency for the identification and implementation of lake management activities affecting Geneva Lake and its watershed. Continued funding of the GLEA at an appropriate level by the participating municipalities is recommended.

In addition, the important roles of other civic organizations, including the Geneva Lake Association, Geneva Lake Conservancy, Geneva Lake Level Corporation, and Lake Geneva Water Safety Patrol, as well as of the individual riparian municipalities, are noted, and endorsed.

PLAN IMPLEMENTATION AND COSTS

The actions recommended in this plan largely represent an extension of ongoing actions being carried out by the GLEA, the City of Lake Geneva, the Towns of Geneva, Linn, and Walworth, and the Villages of Fontana-on-Geneva Lake and Williams Bay, 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 GLEA and local municipalities are recommended to be continued with refinements as proposed herein. Some aspects of these programs lend themselves to citizen involvement through participation in the UWEX “Clean Boats, Clean Waters” Program, and identification with environmentally sound owner-based land management activities. It is recommended that the GLEA, in cooperation with the local municipalities,

[14]*Because the GLEA is not a public inland lake protection and rehabilitation district, there is not a statutory requirement that the District hold an annual meeting. However, the Agency could work with the local municipalities and other civic organizations to develop a regular series of informational programs that would benefit not only the Lake residents, but also the community at large. The GLEA has previously conducted a number of such programs.*

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, UWEX, and SEWRPC.

Some of the capital costs of continuing to implement an active program of lake monitoring and management could be offset with grants from the Wisconsin Waterways Commission under Chapter NR 7 Recreational Boating Facilities Grant Program, including 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, and/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 41, and the estimated costs of these elements, linked to possible funding sources where such are available, are summarized in Table 42. In general, it is recommended that the GLEA continue to provide a coordinating role for community-based lake management actions, in cooperation with the appropriate local government units.

CONCLUDING REMARKS

Geneva 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 Geneva Lake, based upon the recommendations set forth herein, will provide the water quality protection needed to maintain conditions in Geneva Lake suitable for all forms of recreational use and for fish and other aquatic life.

Table 42

ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR GENEVA 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, City, Villages
	Density management in the shoreland zone	- -	- -	County, Towns, City, Villages
	Stormwater management plan development	- -	- -	County, Towns, City, Villages
	Protection of environmentally sensitive lands and environmental corridors	- -	- -	WDNR Lake Protection Grant and Stewardship Grant Programs, Geneva Lake Conservancy, GLEA
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 storm water management ordinances	- -[c]	$250-$500/acre[c]	Municipalities, county, private firms, individuals
	Public sanitary sewer system management	- -	- -	County, Towns, City, Villages, local sanitary districts
	Onsite sewage system management	- -[c]	$100-$200[c]	County, Towns, City, Villages, local sanitary districts
Water Quality	Continue participation in USGS Water Quality Monitoring Program annual sampling program in West Bay and flow gauge at White River outlet; consider participation in WDNR Expanded Self-help program or University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program	- -	$16,000[d]	GLEA, USGS, WDNR
Aquatic Biota	Protect fish habitat	- -	- -	WDNR, GLEA, GLC, private sports organizations, individuals
	Maintain shoreline and littoral zone fish habitat	- -	- -	County, municipalities, private sports organizations, GLEA, individuals, WDNR, GLC
	Continue stocking of selected game fish	- -	- -	WDNR, private sporting groups
	Enforce size and catch limit regulations	- -	- -	WDNR
	Conduct periodic reconnaissance surveys of aquatic plant communities	- -	$1,500[e]	WDNR Lake Management Planning Grant Program, GLEA
	Update aquatic plant management plan every three to five years	- -	$1,500[e]	WDNR Lake Management Planning Grant Program, GLEA
	Provide and conduct programming on aquatic plants and various management measures	--	--	WDNR Lake Management Planning Grant Program, GLEA
	Use (limited) aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife	- -	$1,000/acre[g]	GLEA, individuals

Table 42 (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)	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, GLEA
	Manually harvest aquatic plants from around docks and piers where feasible	$100	$100	GLEA, individuals
	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	- -	- -	GLEA, individuals
	Continue to monitor zebra mussel population in Lake	--	$1,200	GLEA, WDNR
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, City, Villages, GLEA, WDNR
Ancillary Management Measures	Public informational and educational programming: seminars, programs, Project WET, Adopt-A-Lake	- -	$1,200	GLEA, UWEX/ WDNR/WAL Lakes Partnership, school districts
	Explore the possibilities and cost-effectiveness of purchasing hazardous spill equipment as it relates to the large numbers of moored watercraft concentrated in some areas	- -	- -	Towns, City, Villages, GLEA, WDNR
Total	- -	303,600	181,600	- -

[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 Walworth County, City is the City of Lake Geneva, Villages are the Villages of Fontana-on-Geneva Lake and Walworth, Towns are the Towns of Geneva, Linn, and Walworth, UWEX is the University of Wisconsin-Extension, and WAL is the Wisconsin Association of Lakes, GLEA is the Geneva Lake Environmental Agency, WSP is the Water Safety Patrol and GLC is the Geneva Lake Conservancy.*

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

[d]*USGS water quality and flow-gauge services are operated on a cost-share basis with GLEA in conjunction with the City of Lake Geneva, the Villages of Fontana-on-Geneva Lake and Williams Bay, and the Towns of Geneva, Linn and Walworth. 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.

APPENDICES

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Appendix A

ILLUSTRATIONS OF COMMON AQUATIC PLANTS FOUND IN GENEVA LAKE

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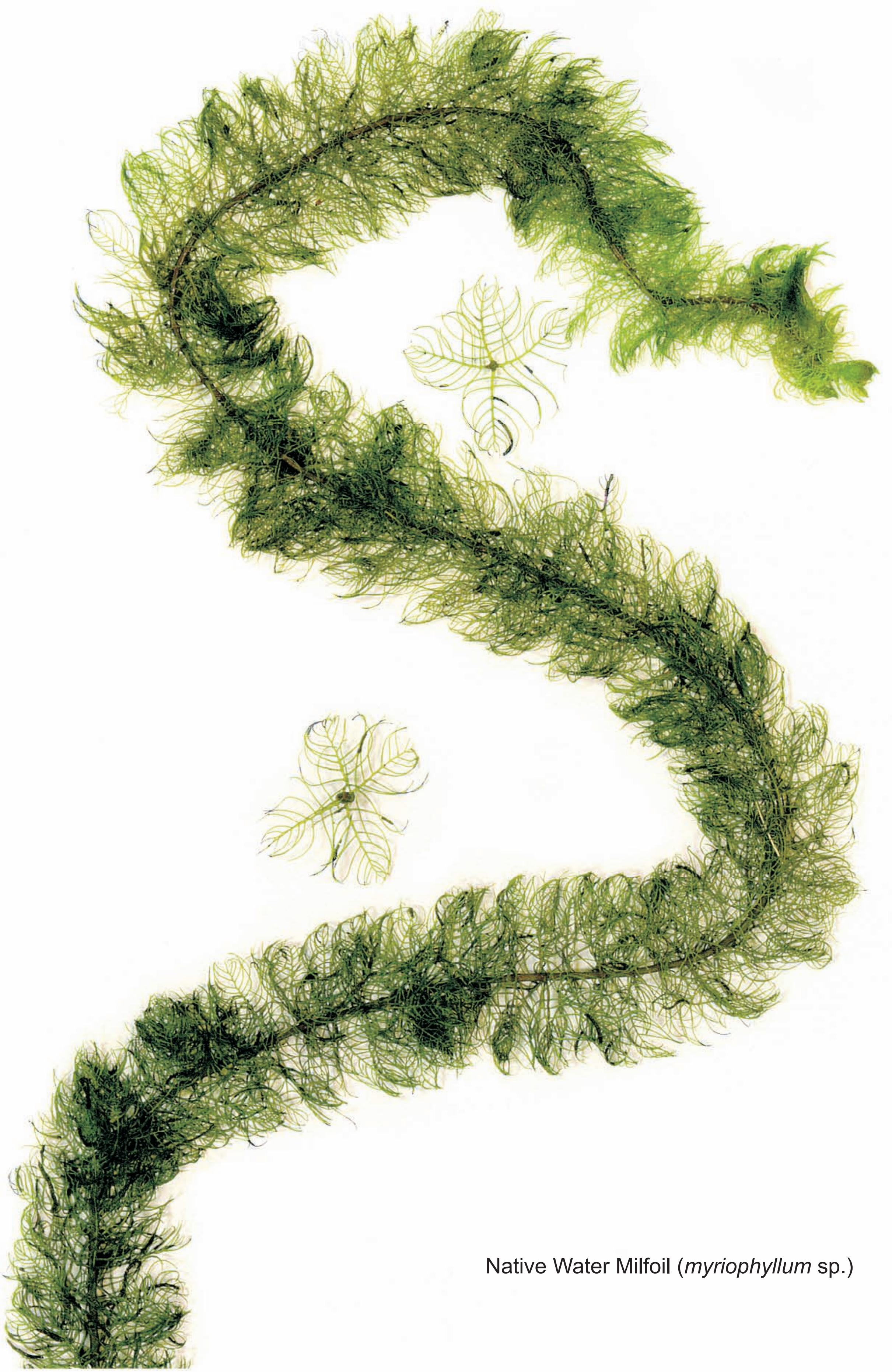
Coontail (*ceratophyllum demersum*)

Muskgrass (*chara vulgaris*)

Waterweed (*elodea canadensis*)



Native Water Milfoil (*myriophyllum* sp.)

Eurasian Water Milfoil (*myriophyllum spicatum*)
Exotic Species (nonnative)

Bushy Pondweed (*najas flexilis*)

Large-Leaf Pondweed (*potamogeton amplifolius*)

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

Illinois Pondweed (*potamogeton illinoensis*)

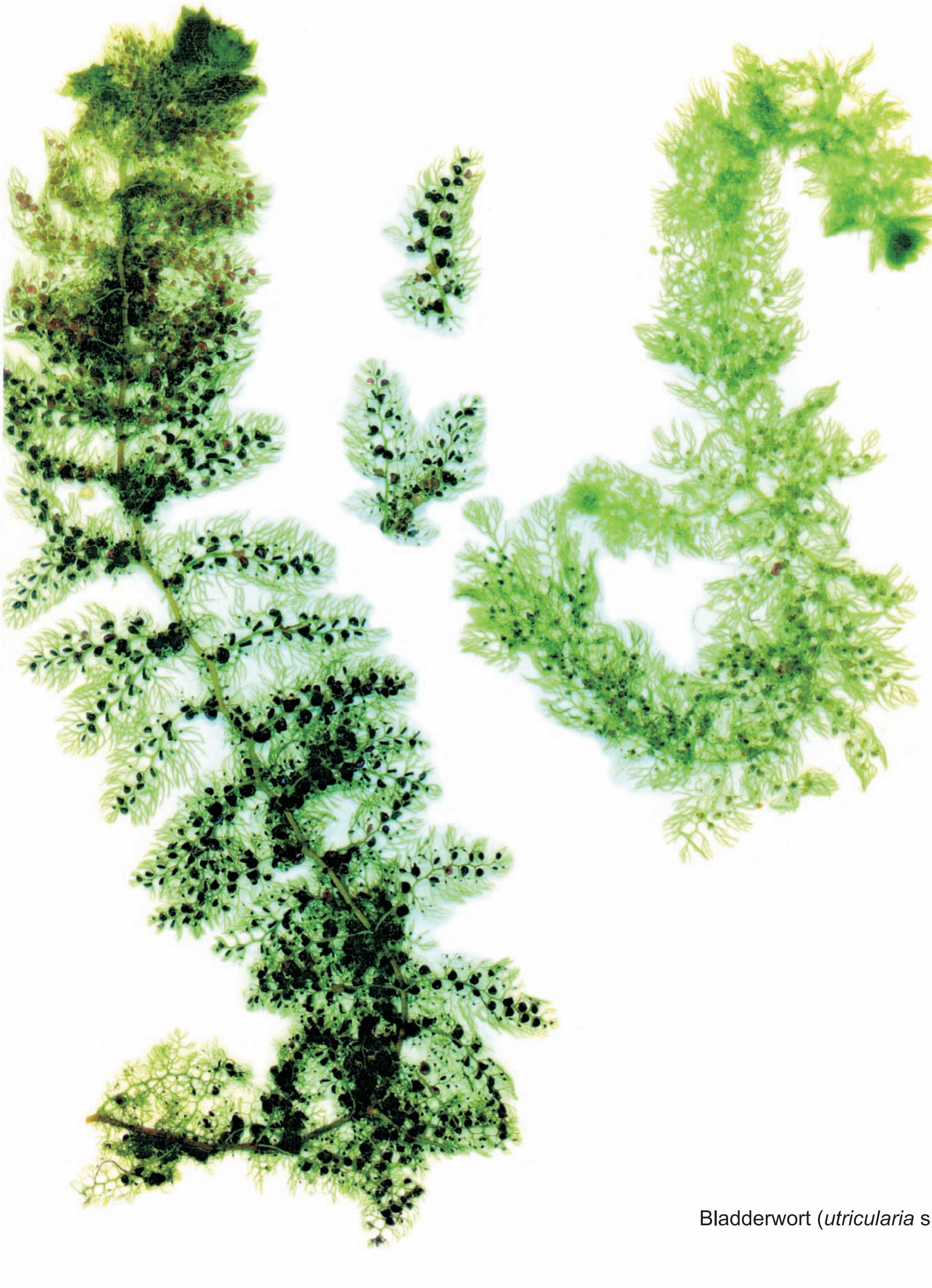
Floating-Leaf Pondweed (*potamogeton natans*)

Long Leaved Pondweed
(*potamogeton nodosus*)

Sago Pondweed (*potamogeton pectinatus*)

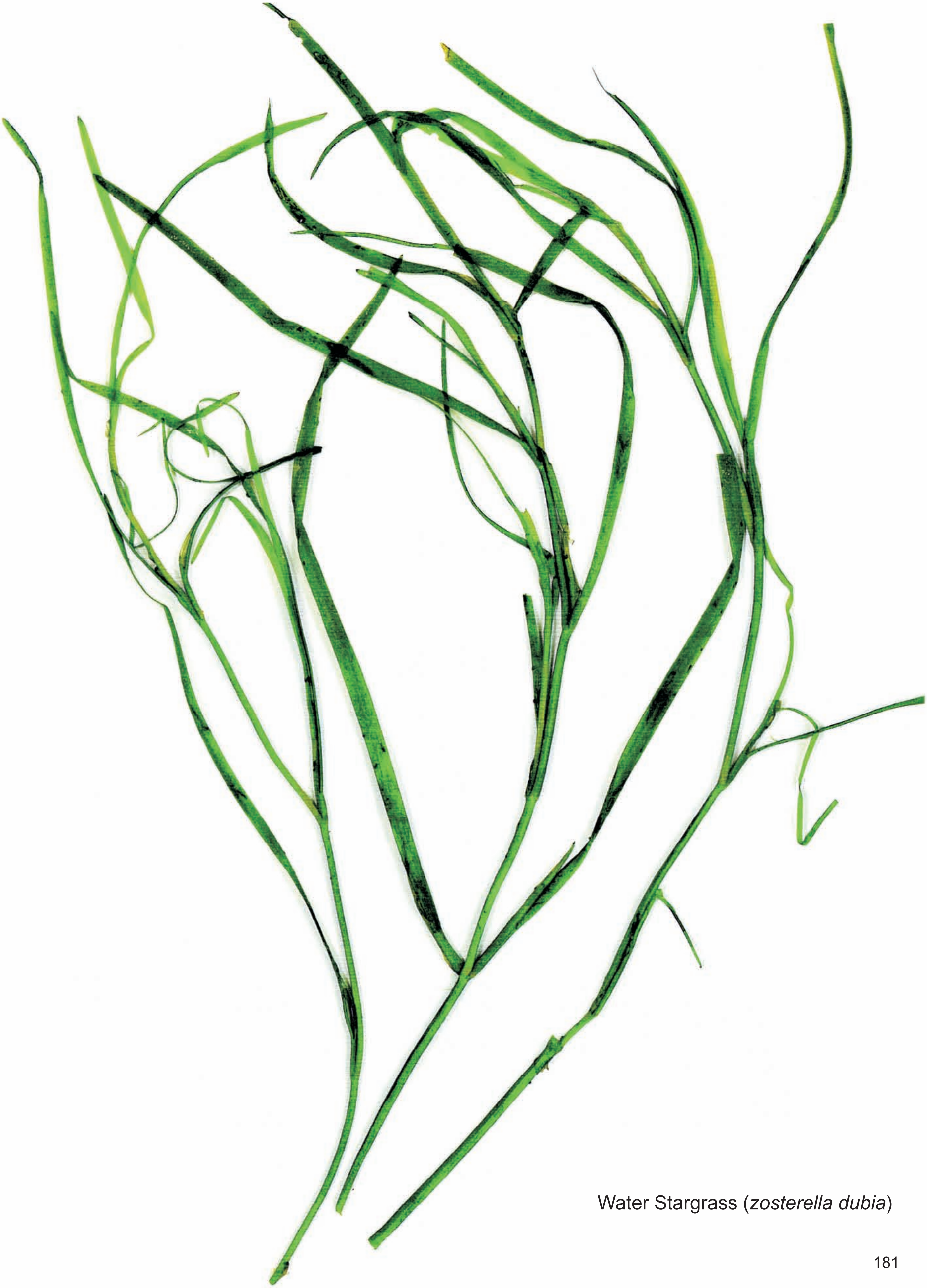
Small Pondweed (*potamogeton pusillus*)

Flat-Stem Pondweed (*potamogeton zosteriformis*)



Bladderwort (*utricularia* sp.)

Eel Grass / Wild Celery (*valisneria americana*)



Water Stargrass (*zosterella dubia*)

Ditch-Grass (*ruppia maritima*)

Appendix B

BOATING ORDINANCE FOR GENEVA LAKE

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ADOPTED 1971
AMENDED 1990
JUNE 2002

JOINT UNIFORM LAKE LAW ORDINANCE

Geneva Lake Walworth County Wisconsin

Emergency Number 911

Non-Emergency Numbers
Geneva Lake
Law Enforcement Agency
248-3132
Williams Bay Police Dept.
245-2710
Lake Geneva Police Dept.
248-3132
Fontana Police Dept.
275-2135
Linn Police Dept.
248-6900
Water Safety Patrol
245-6577
Dept. of National Resources
Conservation Warden
245-6037

(Official Publication)
Village of Fontana-on-Geneva Lake, WI
Village of Williams Bay, WI
Town of Walworth, WI
ORDINANCE NO. 3-90
An Ordinance Amending Joint Uniform Lake Law Ordinance Of Geneva Lake, Walworth County, Wisconsin.

The Common Council of the City of Lake Geneva, the Village Boards of the Village of Williams Bay and the Village of Fontana-on-Geneva Lake, and the Town Boards of the Town of Linn and the Town of Walworth, Walworth County, Wisconsin, do ordain jointly and identically, in conformity with secs. 30.77 and 30.81 of the Wisconsin Statutes, as follows:

SECTION 1.

The Uniform Lake Law Ordinance of Geneva Lake, Walworth County, Wisconsin, be and the same is hereby repealed and recreated to read as follows:

Section I. (a) **Applicability.** The provisions of this ordinance are adopted in the interest of public health and safety and shall apply to persons, boats and other objects upon, in and under the waters and ice of Geneva Lake within the jurisdictions of the city, villages and towns above-named, which are all such municipalities surrounding, riparian to and having jurisdiction over said lake.

(b) **Enforcement.** This ordinance shall be enforced by the officers, employees and agents of the Geneva Lake Law Enforcement Agency, and by the properly designated and authorized officers and agents of said municipalities.

(c) **Water Safety Patrol.** The Geneva Lake Water Safety Committee, Inc., through its Water Safety Patrol shall:

1. Promote water safety upon Geneva Lake in Walworth County, Wisconsin, including water rescue, promulgating and encouraging practices conducive to the safety of persons and property incident to the use and enjoyment of water traffic, pleasure and sports.
2. Educate in promoting water safety in all of its aspects.

Section II. State Boating and Water Safety Laws and Administrative Orders and Rules Adopted.

(a) The statutory provisions describing and defining regulations with respect to water and ice traffic, boats, boating and related water and ice activities in the following enumerated sections of the Wisconsin Statutes, exclusive of any provisions therein relating to the penalties to be imposed or the punishment for violation of said statues, are hereby adopted and by reference made a part of this ordinance as if fully set forth herein. Any act required to be performed or prohibited by any statute incorporated by reference herein is required or prohibited by this ordinance:

30.50 (Definitions)

30.501 (Capacity plates on boats)

30.51 (Operation of unnumbered boats prohibited; exemptions)

30.52 (Certificate of number; applications; issuance; renewals; fees)

30.523 (Certification of registration card to be on board; display of stickers or decals and identification numbers)

30.53 (Certification of origin; requirements; contents)

30.531 (Certificate of title, requirements; exemptions)

30.533 (Application for certificate of title; hull and engine identification numbers)

30.539 (Contents of certificate of title)

30.54 (Lost, stolen or mutilated certificates)

30.541 (Transfers of boat titles)

30.543 (Report of stolen or abandoned boats)

30.544 (Inspection of boats purchased out-of-state)

30.549 (Transfer of ownership of boats with a certificate of title, certificate of number or registration)

30.55 (Notice if abandonment or destruction of boat or change of address)

30.60 (Classification of motor boats)

30.61 (Lighting equipment)

30.62 (Other equipment)

30.63 (Use of certain outboard motors restricted)

30.64 (Patrol boats exempt from certain traffic regulations)

30.65 (Traffic rules)

30.66 (Speed restrictions)

30.67 (Accidents and accident reports)

30.675 (Distress signal flag)

30.68 (Prohibited operation)

30.681 (Intoxicated boating)

30.682 (Preliminary breath screening test)

30.683 (Implied contest)

30.684 (Chemical tests)

30.686 (Report arrest to department)

30.687 (Officers actions after arrest for violating intoxicated boating law)

30.69 (Water skiing)

30.70 (Skin diving)

30.71 (Boats equipped with toilets)

(b) All rules and orders created by the Wisconsin Department of Natural Resources designated Chapter NR 5 of the Wisconsin Administrative Code, modifying or supplementing the foregoing provisions of the state law or which may be adopted or made in the future are hereby incorporated in and made a part of this ordinance by reference to the same as if they are or were to be set out herein verbatim.

(c) All deletions, additions and amendments which may be made to the sections of the State laws enumerated under Section II. (a) above are hereby adopted and incorporated herein by reference as of the time of their respective effective dates, as if they were to be set out herein verbatim.

(d) **Speed limits**

1. No person shall operate any boat powered by an engine, or any other boat, in or upon the waters of Geneva Lake at a speed in excess of 35 miles per hour between sunrise and sunset nor at a speed in excess of 15 miles per hour between sunset and sunrise, from 12:01 p.m. Friday to midnight Sunday, from May 15th to September 30th of each year, and from 12:01 a.m. to midnight on Memorial Day, 4th of July, and Labor Day of each year. At all other times during the year, no person shall operate any boat powered by an engine, or any other boat, in or upon the waters of Geneva Lake at a speed in excess of 45 miles per hour between sunrise and sunset nor at a speed in excess of 15 miles per hour between sunset and sunrise.

2. The speed limit set forth in subsection II. (d) **1.** shall not apply to Police Patrol Boats in situations involving emergencies, or while engaged in law enforcement, nor to boats participating in a duly authorized race, regatta or water ski meet duly authorized by a permit while operating in the designated area authorized by said permit. The speed limit set forth in subsection II. (d) 1. shall not apply to Water Safety Patrol Boats in situations involving emergencies.

Section III. Zones, Lanes and Restrictions.

(a) **Zones and lanes defined.**

1. All areas marked by buoys and/or regulatory markers as swimming zones are so designated as swimming zones.

2. Traffic lanes for boats shall be those areas designated as such by identifying buoys or other aids to navigation.

3. Where the traffic lane is not so identified, a traffic lane is hereby established and shall be the greater distance between the shoreline and a line parallel to and 200 feet distant from it, and 100 feet from any dock, raft, pier, structure, mooring area or buoyed restricted area.

(b) **Restrictions.**

1. Traffic lights. Any municipality may install and operated boat traffic lights and when so installed and operating they must be obeyed by all boat or other watercraft operators using such traffic lane.

2. No water traffic outside the traffic lane shall exceed the "slow-no-wake" speed limit.

Section IV. Additional Safety Regulations and Rules.

(a) **Right-of-Way at Docks, Piers and Wharves.** Boats leaving or departing from a pier, dock or wharf shall have the right-of-way over all other boats approaching such dock, pier or wharf.

(b) **Right-of-Way of Sailboats over Rowboats.** Boats propelled entirely by muscular power shall yield the right-of-way to sailboats when necessary to avoid risk of collision.

(c) **Mooring Lights.** No person shall moor or anchor any boat, raft, buoy or other floating object or permit the same to drift in the traffic lane above described between sunset and sunrise unless there is prominently displayed thereon a white light of sufficient size and brightness to be visible from any direction for a distance of two miles on a dark night with clear atmosphere. This provision shall not apply to authorized structures within the pierhead line nor to boats or objects moored or anchored in mooring areas.

(d) **Rafts and Platforms.** No person shall place or maintain any raft or platform more than 50 feet from the shore unless it is so anchored that it has at least 6 inches of free board above the water line and has attached thereto not less than 12 inches from each corner or projection a red reflector not less than 3 inches in diameter.

(e) **Swimming Regulations.**

1. **Swimming From Boats.** No person shall swim from any boat unless such boat is anchored or the boat is manned by a competent person.

2. **Swimming in Traffic Lane.** No person shall swim in the traffic lane unless accompanied by a boat manned by a competent person. Such boat shall stay within 50 feet of and guard such swimmer. This paragraph is subject to the provisions set forth in paragraph 3., below.

3. **Hours Limited.** No person shall swim in the traffic lane from sunset to sunrise.

(f.) **Water Skiing.**

1. All water skiing is forbidden outside the traffic lane.

2. No watercraft which shall have in tow a person or persons on water skis, surfboards, or similar devices shall be operated upon Geneva Lake unless such watercraft shall be occupied by at least 2 competent persons. One person shall operate the boat and observe boat traffic at all times and the second shall observe the towed person.

3. The drivers or operators of all watercraft by means of which aquaplanes, water skis, or similar devices are being towed, and the riders of such devices, must conform to the same rules and clearance as provided in this ordinance for motor boats.

4. Any person using water skis, an aquaplane or a similar device, or any person who is towed in any manner by a watercraft or other means shall wear or have on his or her

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Linn Police Dept.
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Dept. of National Resources
Conservation Warden
245-6037

(Official Publication)
Village of Fontana-on-Geneva Lake, WI
Village of Williams Bay, WI
Town of Walworth, WI
ORDINANCE NO. 3-90
An Ordinance Amending Joint Uniform Lake Law Ordinance Of Geneva Lake, Walworth County, Wisconsin.

The Common Council of the City of Lake Geneva, the Village Boards of the Village of Williams Bay and the Village of Fontana-on-Geneva Lake, and the Town Boards of the Town of Linn and the Town of Walworth, Walworth County, Wisconsin, do ordain jointly and identically, in conformity with secs. 30.77 and 30.81 of the Wisconsin Statutes, as follows:

SECTION 1.

The Uniform Lake Law Ordinance of Geneva Lake, Walworth County, Wisconsin, be and the same is hereby repealed and recreated to read as follows:

Section I. (a) **Applicability.** The provisions of this ordinance are adopted in the interest of public health and safety and shall apply to persons, boats and other objects upon, in and under the waters and ice of Geneva Lake within the jurisdictions of the city, villages and towns above-named, which are all such municipalities surrounding, riparian to and having jurisdiction over said lake.

(b) **Enforcement.** This ordinance shall be enforced by the officers, employees and agents of the Geneva Lake Law Enforcement Agency, and by the properly designated and authorized officers and agents of said municipalities.

(c) **Water Safety Patrol.** The Geneva Lake Water Safety Committee, Inc., through its Water Safety Patrol shall:

1. Promote water safety upon Geneva Lake in Walworth County, Wisconsin, including water rescue, promulgating and encouraging practices conducive to the safety of persons and property incident to the use and enjoyment of water traffic, pleasure and sports.

2. Educate in promoting water safety in all of its aspects.

Section II. State Boating and Water Safety Laws and Administrative Orders and Rules Adopted.

Board of Trustees of Williams Bay deems the area comprising Geneva Lake north of a line drawn from the most southerly point of Conference Point on the West and the most southerly point of Cedar Point on the east, and the Board of Trustees of Fontana-on-Geneva Lake deems the area comprising said lake west of a line drawn from the north line of Belvidere Park on the north shore and the eastern edge of the public road east of Club Unique Subdivision on the south shore in the Village, and the Common Council of Lake Geneva deems the area of Geneva Bay from Geneva Bay Estates east to the lakefront of the Somerset Condominium Association, as being highly congested and hazardous for all kinds of water traffic, especially motorpowered watercraft of all kinds, sailboats, water skiers and fishermen, and that subsurface activities are especially dangerous in said areas because persons engaged in such activities cannot be seen by observers on the surface of the water. Therefore, the said Boards deem it expedient, proper and necessary to ordain as follows:

All skin and other underwater diving and swimming used or performed with self-contained, underwater breathing apparatus (SCUBA diving) or similar devices are hereby forbidden during the period from May 20 to September 15 of each year within the above-described area, except to recover personal property, bodies, and to examine bottom of the lake for some public authority, and then only after making application for and receiving permission from the Water Safety Patrol in writing.

(b) No person shall engage in underwater diving and swimming with self-contained underwater breathing apparatus without first having registered and been issued a permit card provided by the Water Safety Patrol.

(c) It shall be unlawful to SCUBA dive underwater when unassisted. When assisted it must be so done that each diver shall have another with him who is a competent, properly equipped SCUBA diver.

(d) A SCUBA diver shall be accompanied when in the water by a boat equipped with an approved dive flag as provided in sec. 30.70, Stats. The boat must be anchored and must be manned by a competent person.

(e) There shall be no SCUBA diving at any of the public beaches, nor shall SCUBA diving be done in such a way as to interfere with fishermen and their lines, or with boats and their anchors.

(f) Restricted areas on the lake other than those above designated may be out of bounds for SCUBA divers as determined by the Water Safety Patrol. These areas shall be properly marked and designated.

(g) All SCUBA divers and all other users of Geneva Lake who find articles of any value on the bottom of the lake shall deliver them to the Water Safety Patrol for return to their proper owners, and if such owners cannot be found, then for disposal according to law.

(h) SCUBA diving is forbidden between the hours of sunset and sunrise unless for some emergency and then only if properly authorized as above provided.

Section VIII. Repeal of Conflicting Ordinances.

Any ordinance conflicting with the provisions of this ordinance or any part thereof

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2. Educate in promoting water safety in all of its aspects.

Section II. State Boating and Water Safety Laws and Administrative Orders and Rules Adopted.

conviction thereof, forfeit not more than One Hundred ($100.00) Dollars for the first offense and not more than Two Hundred ($200.00) Dollars upon conviction of the same offense a second and subsequent time within one (1) year, together with the costs of prosecution and penalty assessment, and in default of payment of such forfeiture and costs, shall be imprisoned in the county jail not exceeding six (6) months.

5. Any person who shall violate any provisions of this ordinance set forth in Section II thorough VII, inclusive, except as specified in paragraphs X (a) 1. thru 4. of this subsection, shall, upon conviction thereof, forfeit not more than Fifty ($50.00) Dollars for the first offense and not more than One Hundred ($100.00) Dollars upon the conviction of the same offense a second and subsequent time within one (1) year.

SECTION 2. Effective Date. This ordinance shall be in full force and effect upon and from its passage, approval and publication as required by law.

PASSED AND ADOPTED by the Common Council of the City of Lake Geneva, the Village Boards of the Village of Williams Bay and the Village of Fontana-on-Geneva Lake, and the Town Boards of the Town of Linn and the Town of Walworth, Walworth County, Wisconsin, on the dates set forth below.

Dated 6/26/06

Richard Chroust
Chairman, Lake Use Committee

Appendix C

NONPOINT SOURCE POLLUTION CONTROL MEASURES

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

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

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

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

Table C-1

GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF NONPOINT SOURCE WATER POLLUTION ABATEMENT

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

Table C-1 (continued)

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

Table C-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Rural	Conservation practices	Includes such practices as strip cropping, contour plowing, crop rotation, pasture management, critical area protection, grading and terracing, grassed waterways, diversions, woodlot management, fertilization and pesticide management, and chisel tillage	Up to 50	Cost for Natural Resources Conservation Service (NRCS) recommended practices are applied to agricultural and related rural land; the distribution and extent of the various practices were determined from an examination of 56 existing farm plan designs within the Region. The capital cost of conservation practices ranges from $3,000 to $5,000 per acre of rural land, with an average annual operation and maintenance cost of from $5.00 to $10 per rural acre
	Animal waste control system	Construct streambank fencing and crossovers to prevent access of all livestock to waterways; construct a runoff control system or a manure storage facility, as needed, for major livestock operations; prevent improper applications of manure on frozen ground, near surface drainageways, and on steep slopes; incorporate manure into soil	50 to 75	Cost estimated per animal unit; animal waste storage (liquid and slurry tank for costing purposes) facilities are recommended for all major animal operations within 500 feet of surface water and located in areas identified as having relatively high potential for severe pollution problems. Runoff control systems recommended for all other major animal operations. It is recognized that dry manure stacking facilities are significantly less expensive than liquid and slurry storage tanks and may be adequate waste storage systems in many instances. The estimated capital cost and average operation and maintenance cost of a runoff control system is $100 per animal unit and $25 per animal unit, respectively. The capital cost of a liquid and slurry storage facility is about $1,000 per animal unit, with an annual operation and maintenance cost of about $75 per unit. An animal unit is the weight equivalent of a 1,000-pound cow
	Base-of-slope detention storage	Store runoff from agricultural land to allow solids to settle out and reduce peak runoff rates. Berms could be constructed parallel to streams	50 to 75	Construct a low earthen berm at the base of agricultural fields, along the edge of a floodplain, wetland, or other sensitive area, design for 24-hour, 10-year recurrence interval storm; berm height about four feet. Apply where needed in addition to basic conservation practices; repair berm every 10 years and remove sediment and spread on land. The estimated capital cost of base-of-slope detention storage would be $500 per tributary acre, with an annual operation and maintenance cost of $25 per acre
	Bench terraces	Construct bench terraces, thereby reducing the need for many other conservation practices on sloping agricultural land	75 to 90	Apply to all appropriate agricultural lands for a maximum level of pollution control. Utilization of this practice would exclude installation of many basic conservation practices and base-of-slope detention storage. The capital cost of bench terraces is estimated at $1,500 per acre, with an annual operation and maintenance cost of $100 per acre
Urban and Rural	Public education programs	Conduct regional and county-level public education programs to inform the public and provide technical information on the need for proper land management practices on private land, the recommendations for management programs, and the effects of implemented measures; develop local awareness programs for citizens and public works officials; develop local contract and education efforts	Indeterminate	For first 10 years, includes cost of one person, materials, and support for each 25,000 population. Thereafter, the same cost can be applied for every 50,000 population. The cost of one person, materials, and support is estimated at $55,000 per year

Table C-1 (continued)

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

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

[b]*The approximate effectiveness refers to the estimated amount of pollution produced by the contributing category (urban or rural) that could be expected to be reduced by the implementation of the practice. The effectiveness rates would vary greatly depending on the characteristics of the watershed and individual diffuse sources. It should be further noted that practices can have only a "sequential" effect, since the percent pollution reduction of a second practice can only be applied against the residual pollutant load which is not controlled by the first practice. For example. two practices of 50 percent effectiveness 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 C-2, not all practices are needed, applicable, or cost-effective for all watersheds, due to variations in pollutant loadings and land use and natural conditions among the watersheds. Therefore, it is recommended that the practices indicated as needed for nonpoint source pollutant control be refined by local level nonpoint source control practices planning, which would be analogous to sewerage facilities planning for point source pollution abatement. A locally prepared plan for nonpoint abatement measures should be better able to blend knowledge of current problems and practices with a quickly evolving technology to achieve a suitable, site-specific approach to pollution abatement.

Table C-2

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

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

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

[b]*The provision of bench terraces would exclude most basic conservation 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.