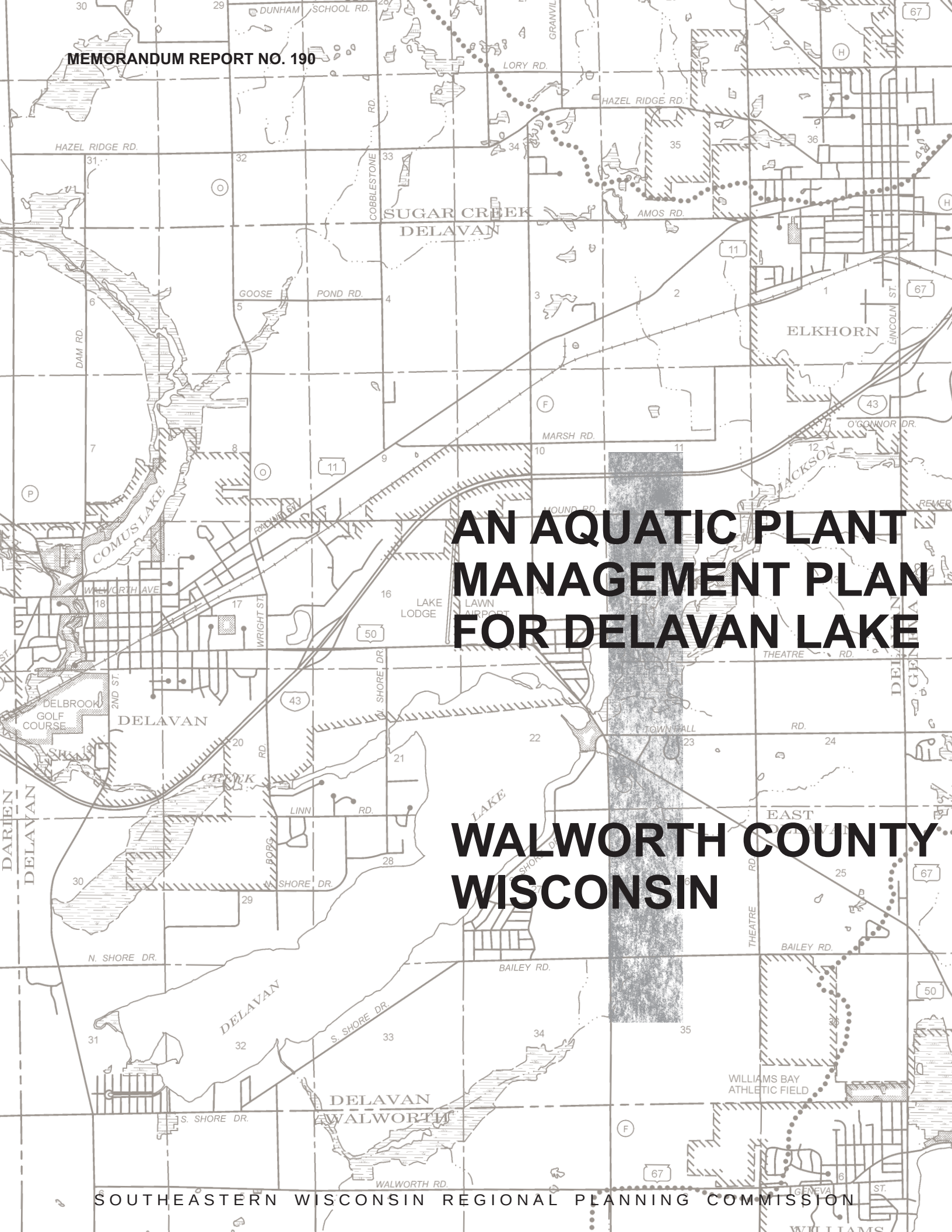
MEMORANDUM REPORT NO. 190



AN AQUATIC PLANT MANAGEMENT PLAN FOR DELAVAN LAKE

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Special acknowledgment is due to Dr. Jeffrey A. Thornton, CLM, PH, and Dr. Thomas M. Slawski, SEWRPC Principal Planners; Mr. Edward J. Schmidt, SEWRPC GIS Planning Specialist; Mr. Aaron Owens, SEWRPC Research Analyst; and, Mr. Michael A. Borst, SEWRPC Research Aide, for their contributions to the conduct of this study and the preparation of this report.

MEMORANDUM REPORT
NUMBER 190

AN AQUATIC PLANT MANAGEMENT PLAN FOR DELAVAN LAKE

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

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May 2011

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Chapter I

INTRODUCTION

Delavan Lake, located in the City and Town of Delavan, Walworth County, Wisconsin, is a 2,072-acre drainage, or flow-through, lake system lying within the Turtle Creek subwatershed of the Lower Rock River watershed.[1] The Lake is located in U.S. Public Land Survey Sections 13, 14, 20 through 23, 27 through 29, and 31 through 33, Township 2 North, Range 16 East, in central Walworth County.

The location of Delavan Lake, situated within easy reach of both the greater Milwaukee and Chicago metropolitan areas, makes it a popular destination for weekend recreational users, as well as year-round residents. The Lake is a valuable natural resource offering a variety of recreational and related opportunities to the resident community and its visitors. As may be expected, the size and location of the Lake contribute to a continuing demand for urban-density residential development in the vicinity of the Lake, especially in areas adjacent to the incorporated municipalities in the watershed, with concomitant demands for water-based recreational opportunities.

Seeking to keep pace with this demand for both residential development and lake-related recreation, the Delavan Lake community, through the Town and City of Delavan and in cooperation with the Delavan Lake Sanitary District (DLSD), a Chapter 60 *Wisconsin Statutes* town sanitary district, continues to undertake an annual program of lake and aquatic plant management to improve the usability and prevent the deterioration of the Lake and its natural resource potential.

This report represents a refined aquatic plant management plan for Delavan Lake, provides information on the condition of the aquatic plant communities in Delavan Lake through 2009, and provides the basis for the ongoing implementation of an aquatic plant management program within the Lake.

BACKGROUND

The Delavan Lake community has initiated and conducted numerous actions to protect and improve the water quality of Delavan Lake. These actions have been summarized in, and integrated into, the adopted lake

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[1]*SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995; see also SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, *Volume Two,* Alternative Plans, *February 1979.*

management plan for Delavan Lake.[2] This plan continues to be implemented by the City and Town of Delavan, and Walworth County, among others. The DLSD, as a Chapter 60, *Wisconsin Statutes*, town sanitary district with powers to act as public inland lake protection and rehabilitation district, continues to implement the aquatic plant management program on the Lake under an agreement with the Town of Delavan.

Pursuant to the plan recommendations, it was recommended that the aquatic plant management plan element of the lake management plan be reviewed and refined at approximately five-year intervals. Consequently, in response to this recommendation, the DLSD entered into an agreement with the Southeastern Wisconsin Regional Planning Commission (SEWRPC) during 2008, under which SEWRPC would prepare an updated aquatic plant management plan for Delavan Lake.

Specifically, this report represents part of the ongoing commitment of the Delavan Lake community, through the Town of Delavan, to sound planning with respect to the Lake. The report sets forth inventories of the aquatic plant communities present within the Lake. Those inventories were prepared by Aron & Associates in cooperation with, and funded by, the DLSD, and include the results of field surveys conducted by Aron & Associates during the summer of 2009. The aquatic plant surveys were conducted by Aron & Associates using the modified Jesson and Lound[3] transect method, enhanced with position data for each sampling location as determined by a global positioning system. The planning program was funded in part through a Chapter NR 190 Lake Management Planning Grant awarded to the DLSD during 2008 and administered by the Wisconsin Department of Natural Resources (WDNR).

The scope of this report is limited to a consideration of the aquatic plant communities present within the Delavan Lake, the documentation of changes in the aquatic plant communities based upon existing and historic data and information, and the refinement of those management measures which can be effective in the control of nuisance and nonnative aquatic plant growths as defined in Chapters NR 40, NR 107, and NR 109 of the *Wisconsin Administrative Code*. The recommendations made focus primarily on the aquatic plant management program of the DLSD, informational programming by the DLSD and Delavan Lake Improvement Association (DLIA), and the lake and land management actions of the Town and City of Delavan, among others.

AQUATIC PLANT MANAGEMENT PROGRAM GOALS AND OBJECTIVES

The lake use goals and objectives for Delavan Lake were developed initially in consultation with the Town of Delavan during the lake management planning program.[4] The agreed goals and objectives are to:

1. Protect and maintain public health, and promote public comfort, convenience, necessity and welfare, in concert with the natural resource, through the environmentally sound management of native vegetation, fishes, and wildlife populations in and around Delavan Lake;

2. Effectively control the quantity and density of aquatic plant growths in portions of the Delavan Lake basin to better facilitate the conduct of water-related recreation, improve the aesthetic value of the resource to the community, and enhance the resource value of the waterbody;

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

[3]*R. Jesson, and R. Lound, Minnesota Department of Conservation Game Investigational Report No. 6,* An Evaluation of a Survey Technique for Submerged Aquatic Plants, *1962.*

[4]*SEWRPC Community Assistance Planning Report No. 253,* op. cit.

3. Effectively maintain the water quality of Delavan Lake to better facilitate the conduct of water-related recreation, improve the aesthetic value of the resource to the community, and enhance the resource value of the waterbody; and

4. Promote a quality, water-based experience for residents and visitors to Delavan Lake consistent with the policies and objectives of the WDNR as set forth in the regional water quality management plan.[5]

The inventory and aquatic plant management plan elements presented in this report conform to the requirements and standards set forth in the relevant *Wisconsin Administrative Codes.*[6] Implementation of the recommended actions set forth herein should continue to serve as an important step in achieving the stated lake use objectives over time.

[5]*SEWRPC Planning Report No. 30,* op. cit.*, as amended; see also SEWRPC Memorandum Report No. 93,* op. cit.

[6]*This plan has been prepared pursuant to the standards and requirements set forth in the following chapters of the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 103, "Water Quality Standards for Wetlands;" Chapter NR 107, "Aquatic Plant Management;" and Chapter NR 109, "Aquatic Plants Introduction, Manual Removal and Mechanical Control Regulations."*

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Chapter II

INVENTORY FINDINGS

INTRODUCTION

Delavan Lake is located in the City and Town of Delavan, Walworth County, Wisconsin, as shown on Map 1. The Lake has a surface area of 2,072 acres. As a through-flow or drainage lake system, Delavan Lake has both a defined inlet and outlet. The principle inflow is through Jackson Creek, which enters the Lake at its northern end, and the principle outflow is through Swan Creek, a tributary to Turtle Creek in the Lower Rock River basin, draining the Lake toward the west. Additional inflow to Delavan Lake is through an unnamed tributary at the southwestern end of the Lake.

Delavan Lake has been the subject of numerous studies and plans, including a University of Wisconsin-Madison concept plan,[1] several U.S. Geological Survey (USGS) reports,[2] an aquatic plant management plan,[3] numerous annual aquatic plant survey reports,[4] and a lake management plan.[5] This plan further refines the aquatic plant management element of the 2002 comprehensive lake management plan based upon observed year 2009 in-lake conditions.

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[1]*University of Wisconsin-Madison,* Delavan Lake: A Recovery and Management Study*, Institute for Environmental Studies, 1986.*

[2]*U.S. Geological Survey Water-Resources Investigations Report No. 87-4168,* Hydrology and Water Quality of Delavan Lake in Southeastern Wisconsin, *1988; U.S. Geological Survey Water-Resources Investigations Report No. 96-4160,* Phosphorus Dynamics in Delavan Lake Inlet, Southeastern Wisconsin, *1996; U.S. Geological Survey Water-Resources Investigations Report No. 97-4014,* Retention of Sediments and Nutrients in Jackson Creek Wetland near Delavan Lake, Wisconsin, 1993-1995, *1997; U.S. Geological Survey Fact Sheet FS-232-96,* Sediment and Nutrient Trapping Efficiency of a Constructed Wetland near Delavan Lake, Wisconsin, 1993-1995, *1996.*

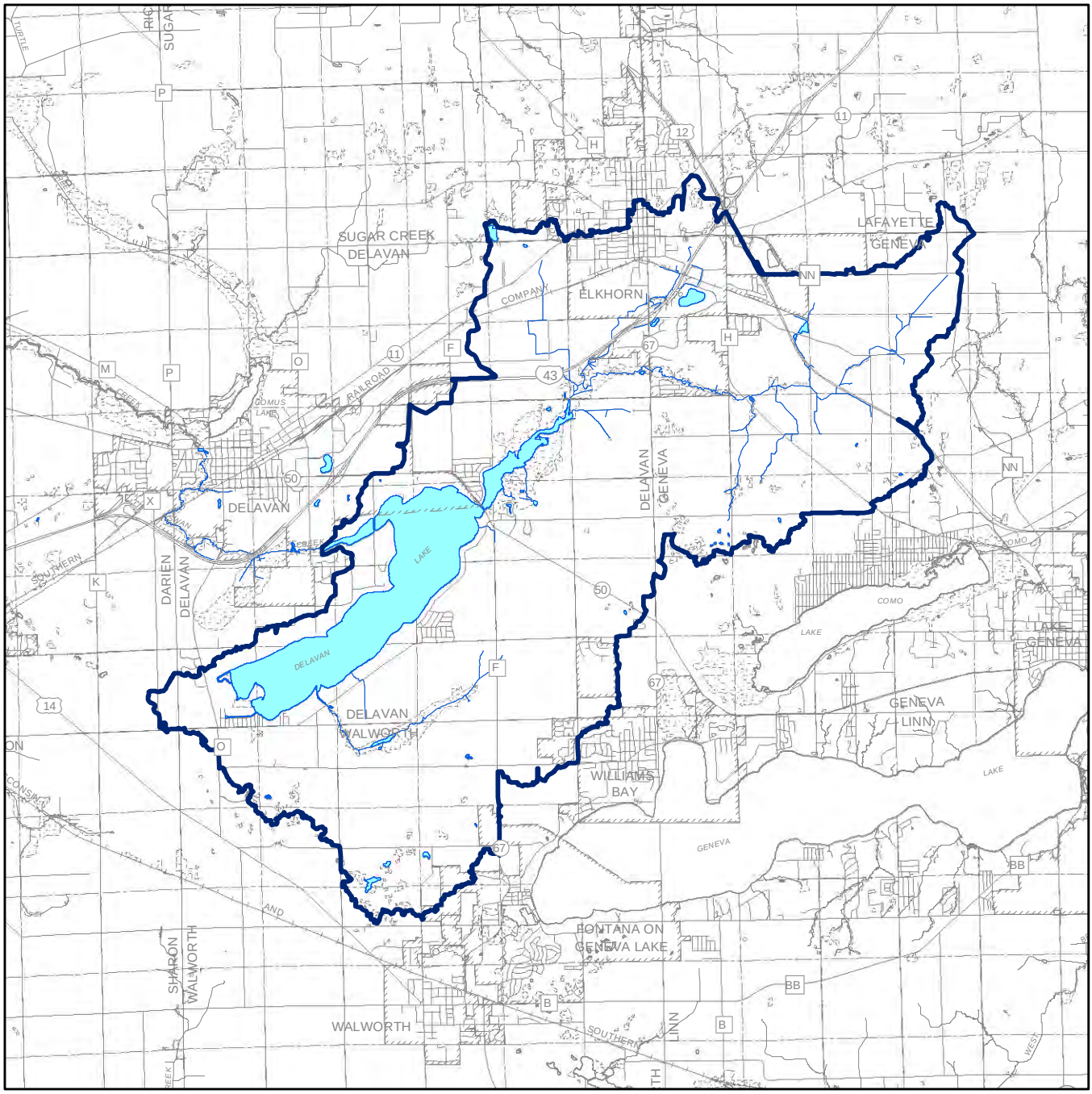
[3]*Aron & Associates,* Delavan Lake Plant Management Plan, *September 1993.*

[4]*Aron & Associates,* Delavan Lake Aquatic Plant Survey Report, *1992, and similar for subsequent years.*

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

Map 1

LOCATION MAP OF DELAVAN LAKE



Total Tributary Area Boundary

Surface Water

Source: SEWRPC.

N

0 5,000 10,000 Feet

Table 1

HYDROLOGY AND MORPHOMETRY OF DELAVAN LAKE

Parameter	Delavan Lake
Size	
Surface Area of Lake	2,072 acres
Total Tributary Area[a]	26,180 acres
Lake Volume	44,800 acre-feet
Residence Time[b]	2.0 years
Shape	
Length of Lake	3.9 miles
Width of Lake	1.0 mile
Length of Shoreline	13.0 miles
Shoreline Development Factor[c]	2.2
General Lake Orientation	NE-SW
Depth	
Mean Depth	21 feet
Maximum Depth	56 feet
Portion of Lake less than 10 feet	29 percent
Between 10 and 20 feet	14 percent
Between 20 and 30 feet	15 percent
Between 30 and 40 feet	17 percent
Between 40 and 50 feet	22 percent
Greater than 50 feet	3 percent

[a]*The total tributary area for Delavan Lake was recorded in the previous SEWRPC report as 26,115 acres based upon U.S. Geological Survey 10-feet contour interval topographic mapping. The current measurement is based on elevation refinements made possible through the updated SEWRPC digital terrain modeling analysis with a contour interval of two feet.*

[b]*Residence time is estimated as the time period required for a volume of water equivalent to the volume of the lake to enter the lake during years of normal precipitation.*

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

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

WATERBODY CHARACTERISTICS

The hydrographical characteristics of Delavan Lake are set forth in Table 1. The Lake is aligned in an approximately northeast-southwest orientation, with a maximum depth of approximately 56 feet and a mean depth of about 21 feet. The bathymetry of the Lake is shown on Map 2. Delavan Lake has a surface area of 2,072 acres, a total volume of 44,800 acre-feet and a shoreline of approximately 13.0 miles in total length. The system has a shoreline development factor of about 2.2, indicating that, due to the irregularities of its shoreline, the perimeter of the Lake is a little more than twice as long as the perimeter of a perfectly circular lake of the same area. By contrast, Pleasant Lake, to the north, has a development factor of about 1.6, reflecting that Lake's nearly circular shape, while the nearby Lauderdale Lakes system, also to the north, has a shoreline development factor of 3.6, reflecting the many irregularities and bays of that Lake. The shoreline development factor often is related to the level of biological activity in a lake: the greater a lake's shoreline development factor (due to greater shoreline contour irregularity), the greater is the likelihood that the lake contains shallow, nearshore areas—the places usually containing habitat more suitable for plant and animal life—and, therefore, the greater the biological productivity of the lake. With a development factor of 2.2, Delavan Lake would be expected to have a moderate level of biological productivity compared to other lakes in the area.

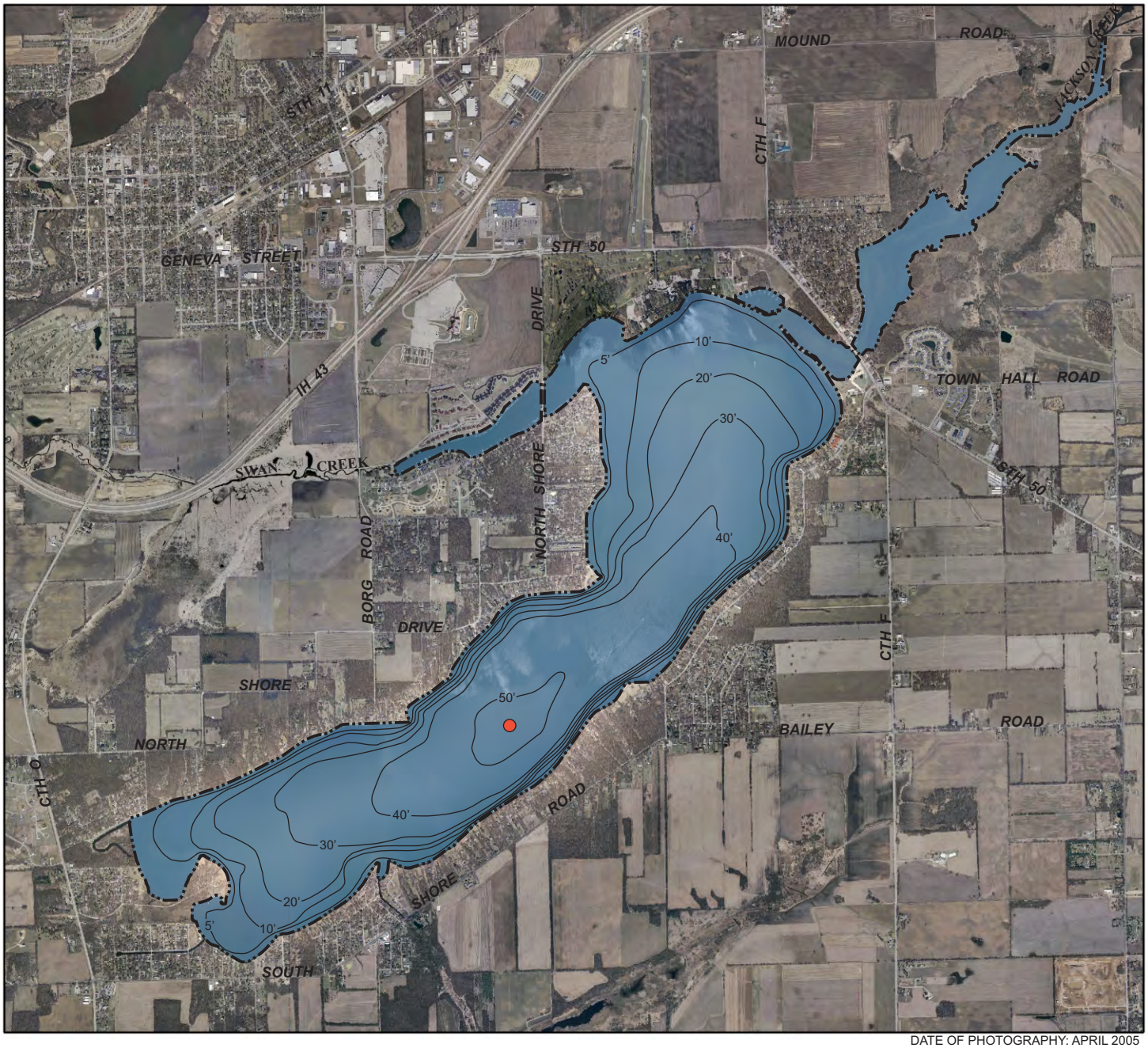
Biological activity in a lake also can be influenced by other physical factors, such as bottom sediment composition and lake-basin contours. In Delavan Lake, the littoral, or nearshore, zone would extend from the ordinary high water mark out to a depth of about 10 feet.[6] As shown in Table 1, nearly 30 percent of Delavan Lake has a water depth of 10 feet or less. Map 2 reveals most of the areas in the Lake with relatively flat lake bottom contours of 10 feet or less are located in the two bays at the southwestern end of the Lake, in the bay at the northwestern end of the Lake leading to the outlet, and in the bay at the northern end of the Lake, including the inlet. A survey of the lake bottom, conducted by the USGS,[7] revealed that, of the surveyed bottom sediments, about 73 percent of the lake bottom was covered by muck and silt, and about 15 percent was covered by sand and gravel; the remaining portion of the lake bottom, about 12 percent

[6]Ibid.

[7]*U.S. Geological Survey Water-Resources Investigations Report 87-4168,* op. cit.

Map 2

BATHYMETRIC MAP OF DELAVAN LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

MONITORING SITE

GRAPHIC SCALE

0 1750 3500 FEET

Source: U.S. Geological Survey and SEWRPC.

of the Lake, was covered by rock. A preponderance of soft bottom sediments and the flatness of bottom contours are conditions consistent with lakes having high biological productivity. In Delavan Lake, these areas are limited to the embayments noted which may limit the productivity of the Lake overall.

TRIBUTARY AREA AND LAND USE CHARACTERISTICS

As shown on Map 3, the area tributary to Delavan Lake is situated mostly within the Town of Delavan, with other portions of the tributary area extending into the Cities of Delavan and Elkhorn, the Villages of Fontana-on-Geneva Lake and Williams Bay; and the Towns of Darien, Geneva, LaFayette, Sharon, Sugar Creek, and Walworth, all in Walworth County. This area is approximately 26,180 acres, or about 40.9 square miles, in areal extent. The Lake and its tributary area are situated in the south central portion of Walworth County.

The drainage area tributary to Delavan Lake was re-evaluated as part of this planning program. The initial drainage area tributary to the Lake was delineated using U.S. Geological Survey 7.5 minute quadrangle topographic mapping with 10 feet contour intervals. Subsequently, the topographic mapping has been enhanced with the result that topographic mapping is currently available with contour intervals of two feet, which make the definition of watershed boundaries more precise than was possible using the 10 feet contour intervals topography. Based upon the more detailed topographic mapping, the drainage area tributary to Delavan Lake has been refined, and the refined drainage area utilized in this report.

Population

The population and the numbers of households and housing units within the Delavan Lake system tributary area have all generally increased since 1960, as documented in Table 2. The greatest increase in the numbers of households occurred between 1970 and 1980 when the numbers of households increased nearly 26 percent, increasing from 2,041 to 2,562 households. Subsequently, the greatest increases in population and the numbers of households occurred between 1990 and 2000, when the number of people living in the drainage area increased from 7,122 persons to 8,461 persons, an increase of nearly 19 percent. In contrast, the numbers of housing units, also shown in Table 2, indicated a fairly steady rate of increase from 1960 to 2000, with the largest increase, about 24 percent, occurring between 1970 and 1980.

Land Uses

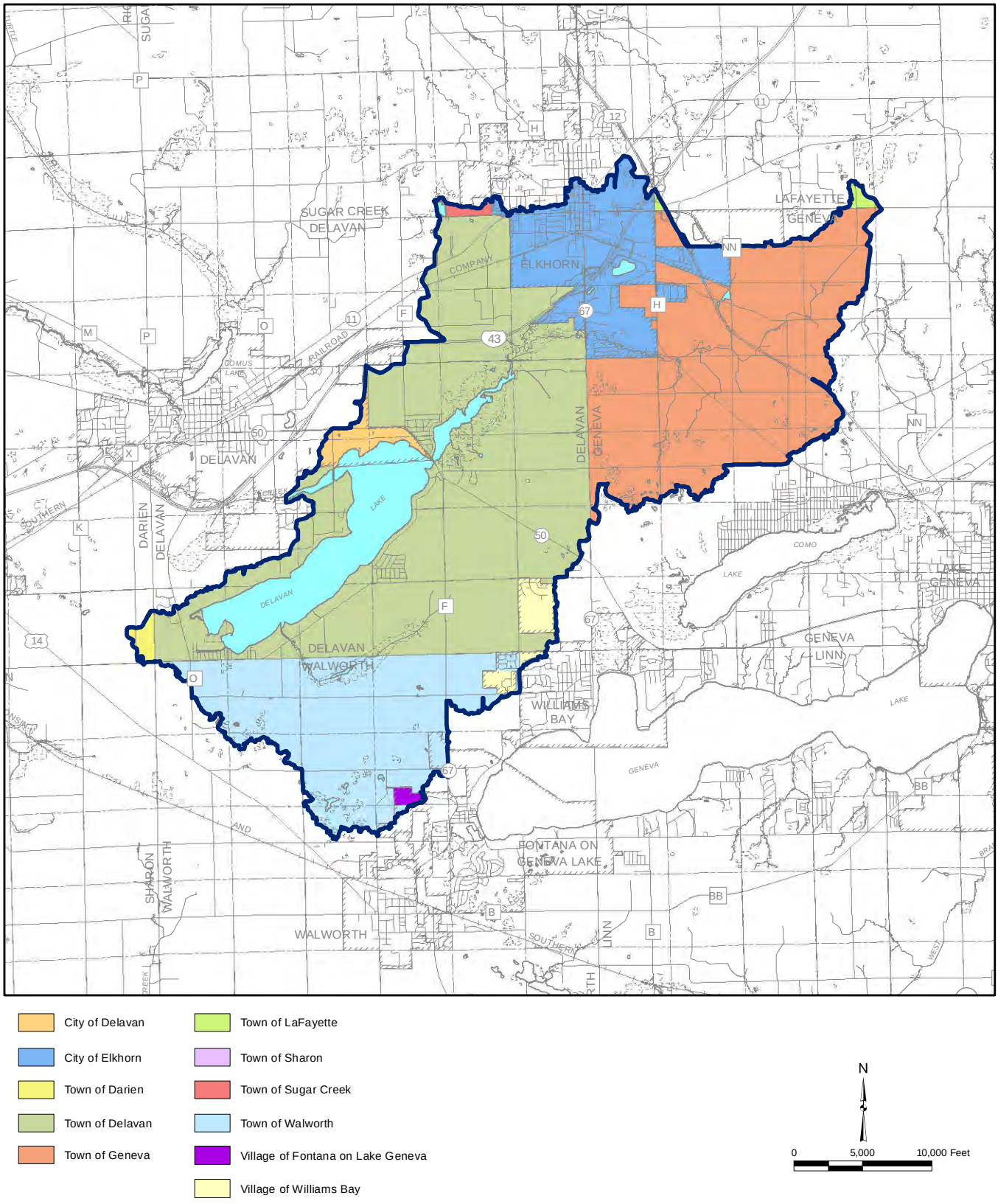
The land uses within the total area tributary to Delavan Lake are primarily rural, with agricultural uses being the dominant rural land use; the dominant urban land use is residential. Map 4 shows the existing land uses within the tributary area as of 2000 which are summarized in Table 3.

As shown on Map 4, single-family residential uses dominate the shoreland areas of Delavan Lake while agricultural uses dominate the greater portion of the tributary area away from the Lake. There are a few fairly large woodland tracts within the tributary area: one directly south of the Lake, another directly east of the Lake, and a third along Jackson Creek, which flows into Delavan Lake at the Lake's northern end.

Future changes in land use within the area tributary to the Lake system are expected to include limited further urban development especially in the areas contiguous to existing urban lands within the incorporated municipalities, infilling of already platted lots, and possible redevelopment of existing properties. Under proposed year 2035 conditions, as shown on Map 5 and summarized in Table 3, overall urban land uses are expected to increase, from about 16 percent of the land coverage in 2000 to nearly 34 percent of the land coverage in 2035. Among the rural land uses, agricultural uses are anticipated to decrease from about 68 percent of the land coverage in the year 2000, to about 51 percent of the land coverage under planned year 2035 conditions. As discussed further below, these land use changes have the potential to modify the nature and delivery of nonpoint source contaminants to the system, with concomitant impacts on the aquatic plant communities within the waterbody.

Map 3

CIVIL DIVISION BOUNDARIES WITHIN THE AREA TRIBUTARY TO DELAVAN LAKE



Source: SEWRPC.

Table 2

POPULATION, HOUSEHOLDS, AND HOUSING UNITS WITHIN THE AREA TRIBUTARY TO DELAVAN LAKE: 1960-2000

Year	Population	Households	Total Housing Units
1960	5,814	1,733	2,604
1970	6,733	2,041	3,039
1980	6,904	2,562	3,776
1990	7,122	2,804	4,102
2000	8,461	3,400	4,844

NOTE: Households include year-round occupied housing units. Total housing units include vacant units either for sale, for rent, occupied only seasonally, or otherwise vacant. In 2000, 84 percent of the vacant housing units were for seasonal use. Population is only counted in households.

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

SHORELINE PROTECTION STRUCTURES

Erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with lake access and use. Wind-wave erosion, ice movement, and motorized boat traffic usually cause such erosion. Nearly all the shoreline of Delavan Lake is developed for residential use with only a few small isolated stretches in a natural state. During the 2009 shoreline protection survey conducted by Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff, shoreline protection techniques observed along the Delavan Lake shoreline included riprap, bulkheads, revetments, beaches, and areas of natural shoreline, as shown on Map 6. There were no severe shoreline erosion-related problems observed during the 2009 survey. Other than a few small stretches of shoreline where riprap had been used to replace some bulkhead and natural shoreline, there were few differences between the structures observed during the previous SEWRPC survey in 2002 and the 2009 survey.

WATER QUALITY

The earliest, definitive data on water quality conditions in Delavan Lake were collected by the Wisconsin Department of Natural Resources (WDNR) in 1960.[8] Other sources of information on the historical water quality of Delavan Lake include the results of monitoring studies conducted by Limnetics, Inc.,[9] and the U.S. Environmental Protection Agency.[10]

In 1983, the Town of Delavan, Delavan Lake Sanitary District (DLSD), and the USGS initiated a joint program of investigation into the water quality of Delavan Lake. [11] Beginning shortly thereafter, in 1986, data also were acquired under the auspices of the WDNR Self-Help Monitoring Program which was later supplanted by the University of Wisconsin-Extension (UWEX) Citizen Lake Monitoring Network (CLMN). Under the CLMN program, volunteers collect basic water quality data and report them to a central data base, the WDNR Surface Water Information Management Systems, or SWIMS.

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[8] *Wisconsin Conservation Department,* Surface Water Resources of Walworth County, *1961.*

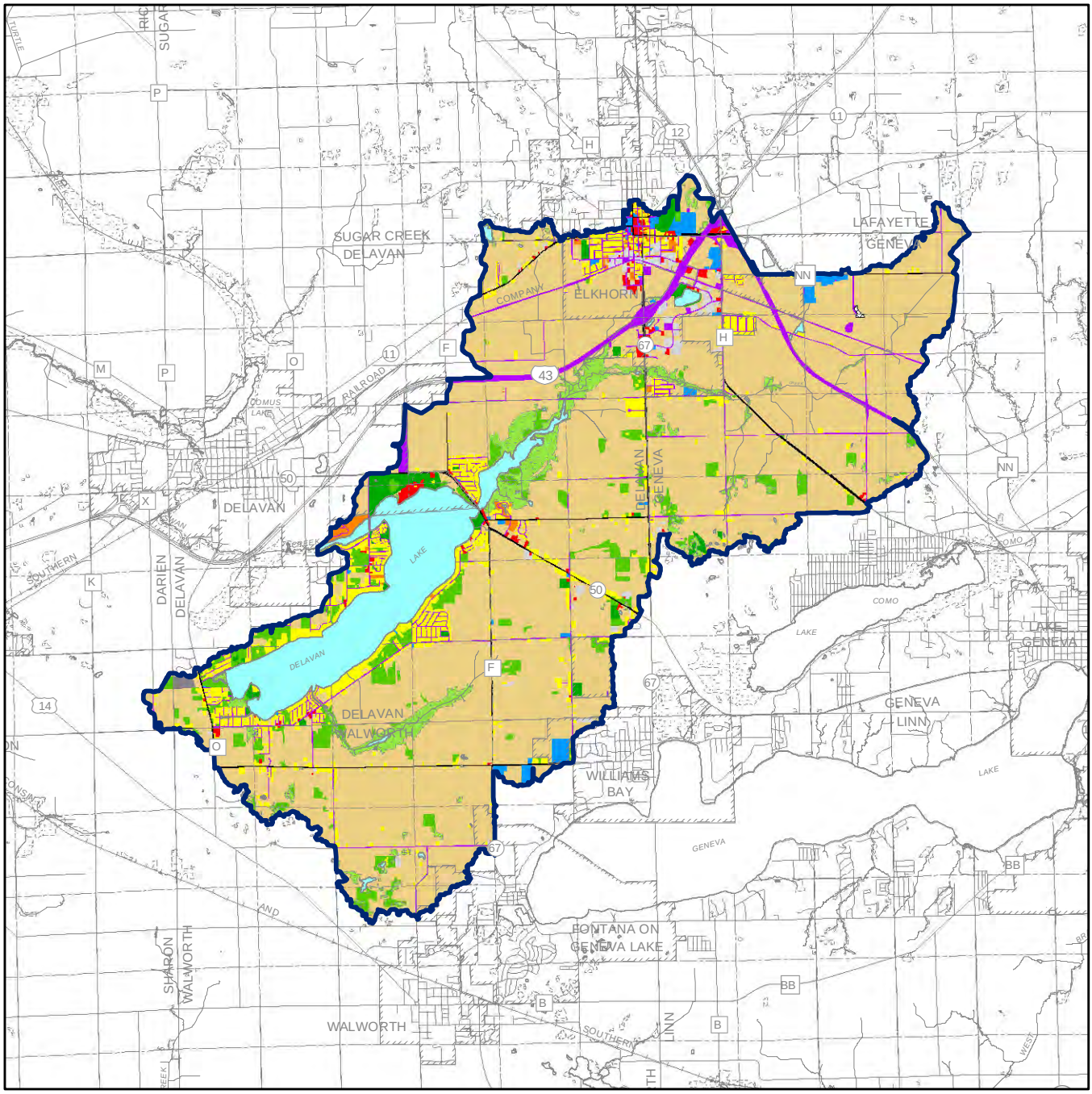
[9] *Limnetics, Inc.,* Lake Delavan Limnological Survey, Wisconsin, *1968.*

[10] *U.S. Environmental Protection Agency,* Report on Delavan Lake, Walworth County, Wisconsin, *National Eutrophication Survey Working Paper No. 36.*

[11] *Data acquired pursuant to these studies are compiled in U.S. Geological Survey Open-File Report 95–190,* Water-Quality Stage Data for Wisconsin Lakes, Water Year 1994, *1995, and published annually; data for the period from 1984 were included in U.S. Geological Survey Water-Data Report WI-84-1,* Water Resources Data, Wisconsin, Water Year 1984, *1985, and published annually through 1993.*

Map 4

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



Source: SEWRPC.

Table 3

EXISTING AND PLANNED LAND USE WITHIN THE TOTAL AREA TRIBUTARY TO DELAVAN LAKE: 2000 AND 2035

Land Use Categories[a]	2000		2035	
	Acres	Percent of Tributary Area	Acres	Percent of Tributary Area
Urban				
Residential	1,765	6.7	3,563	13.6
Commercial	188	0.7	1,078	4.1
Industrial	242	0.9	791	3.0
Governmental and Institutional	239	0.9	502	1.9
Transportation, Communication, and Utilities	1,417	5.4	2,291	8.8
Recreational	336	1.3	544	2.1
Subtotal	4,187	15.9	8,769	33.5
Rural				
Agricultural and Other Open Lands	17,767	68.0	13,222	50.5
Wetlands	972	3.7	972	3.7
Woodlands	1,163	4.4	1,150	4.4
Surface Water	2,057	7.9	2,057	7.9
Extractive	29	0.1	5	<0.1
Landfill	5	<0.1	5	<0.1
Subtotal	21,993	84.1	17,411	66.5
Total	26,180	100.0	26,180	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

For the comprehensive lake management plan,[12] water quality data collected primarily by the USGS were used to determine water quality conditions in the Lake at that time.[13] Water quality data utilized in the current report include the foregoing data as well as additional data collected by the USGS during the period since 2000. These data, collected with funding provided by the DLSD and USGS, are summarized in Table 4 and shown in Figure 1. Sampling locations used for data collection are shown on Map 2.

Water Clarity

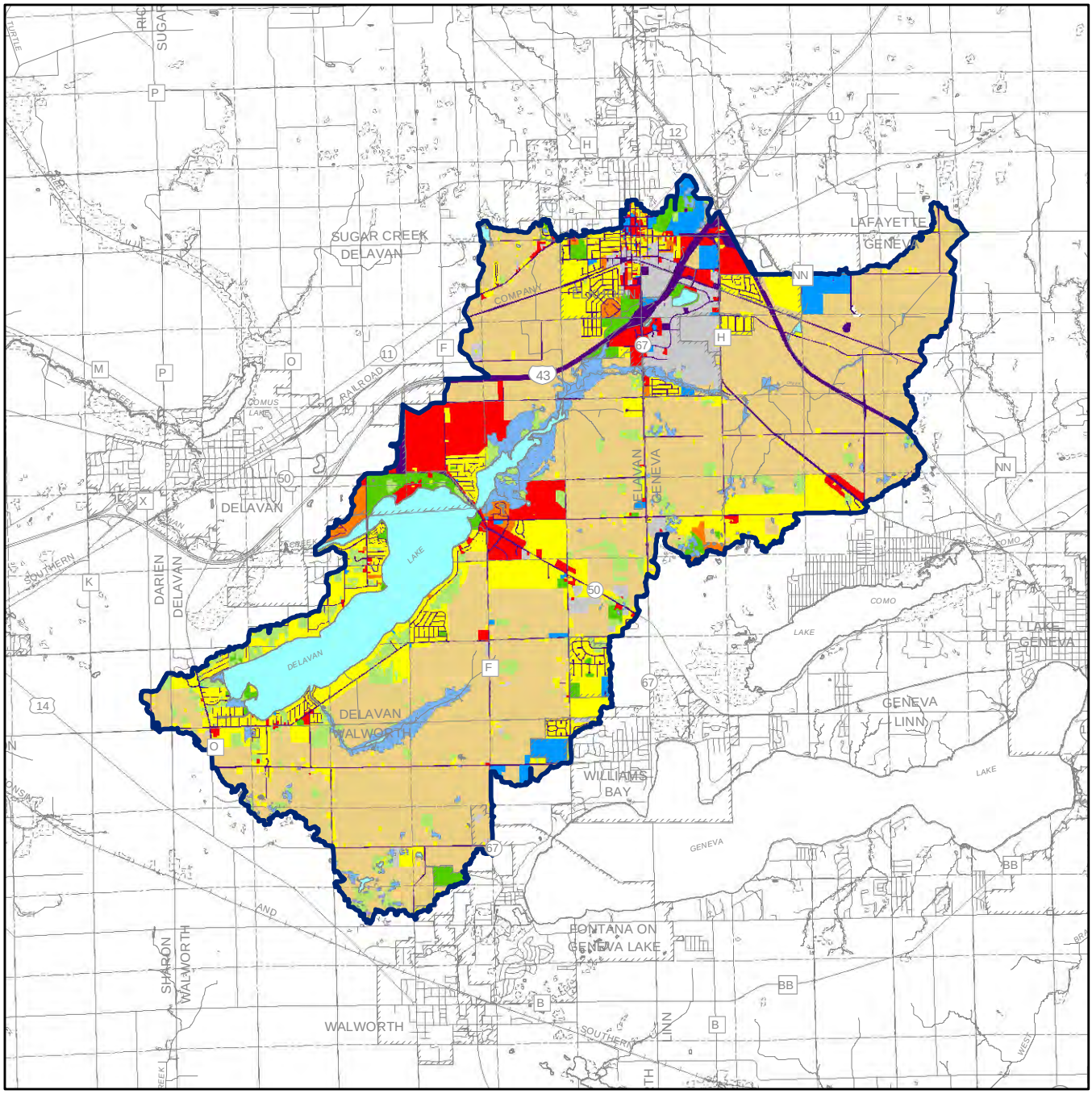
Water clarity, or transparency, is often used as an indicator of water quality. Transparency can be affected by physical factors, such as water color and suspended particulates, and by various biological factors, including seasonal variations in planktonic algal populations living in the lake. Water clarity typically is measured with a Secchi disk, a black-and-white, eight-inch-diameter disk, which is lowered into the water until a depth is reached at which the disk is no longer visible. This depth is known as the "Secchi-disk reading." Such measurements comprise an important part of the aforementioned CLMN program in which citizen volunteers assist in lake water quality monitoring efforts.

[12]*SEWRPC Community Assistance Planning Report No. 253,* op. cit.

[13]*See Dale M. Robertson, Gerald L. Goddard, Daniel R. Helsel, and Kevin L. MacKinnon, "Rehabilitation of Delavan Lake, Wisconsin,"* Lake and Reservoir Management, *Volume 16, Number 3, pages 155-176, 2000.*

Map 5

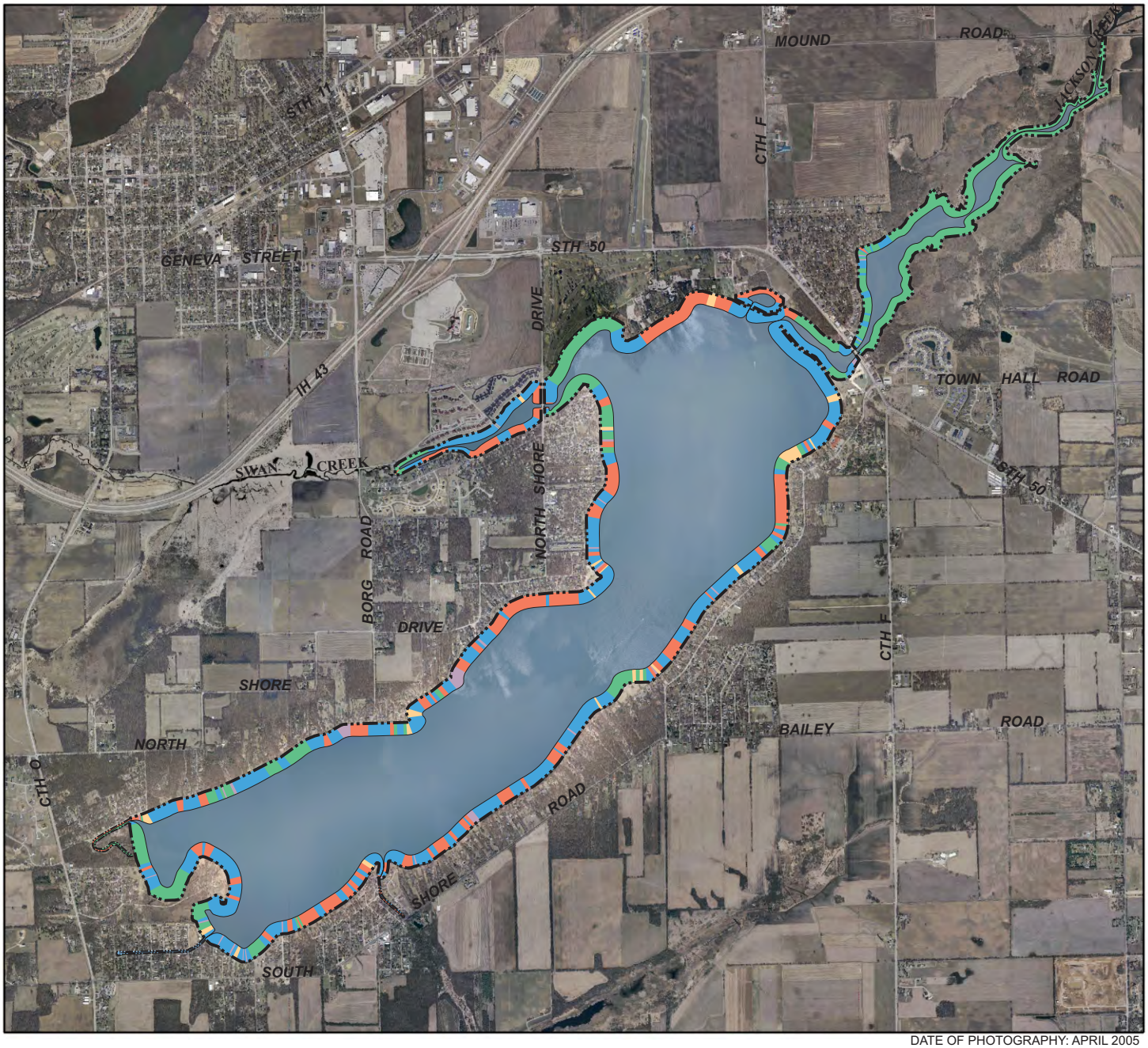
PLANNED LAND USE WITHIN THE AREA TRIBUTARY TO DELAVAN LAKE: 2035



Source: SEWRPC.

Map 6

SHORELINE PROTECTION STRUCTURES ON DELAVAN LAKE: 2009



DATE OF PHOTOGRAPHY: APRIL 2005

RIPRAP

BEACH

NATURAL

BULKHEAD

REVETMENT

GRAPHIC SCALE

0 1750 3500 FEET

Source: SEWRPC.

Table 4

SEASONAL SURFACE WATER QUALITY DATA FOR DELAVAN LAKE

Time Period	Season	Data Parameter	Total Phosphorus (mg/l)	Chlorophyll-*a* (µg/l)	Secchi Depth (feet)
1983-1991	Fall (mid-September to mid-December)	Range Mean Number	0.041-0.470 0.154 20	0.2-24.0 10.0 19	1.6-13.8 5.9 20
	Winter (mid-December to mid-March)	Range Mean Number	0.064-0.332 0.144 15	0.1-120.0 17.4 14	1.6-24.6 12.5 10
	Spring (mid-March to mid-June)	Range Mean Number	0.041-0.160 0.99 24	0.1-31.0 8.2 24	2.6-18.0 8.2 23
	Summer (mid-June to mid-September)	Range Mean Number	0.018-0.136 0.068 33	1.7-300.0 39.0 32	1.6-8.6 4.2 34
1991-1999	Fall (mid-September to mid-December)	Range Mean Number	0.009-0.126 0.077 26	0.4-6.2 1.9 10	5.5-22.0 13.1 30
	Winter (mid-December to mid-March)	Range Mean Number	0.011-0.577 0.138 8	0.1-24.0 5.1 8	2.0-24.9 12.1 8
	Spring (mid-March to mid-June)	Range Mean Number	0.013-0.150 0.061 43	0.1-6.4 1.1 26	2.6-35.1 19.7 45
	Summer (mid-June to mid-September)	Range Mean Number	0.007-0.170 0.042 68	0.5-37.6 7.0 25	4.6-21.9 9.8 69
2000-2007	Fall (mid-September to mid-December)	Range Mean Number	0.050-0.102 0.094 10	6.6 6.6 1	5.6-18.4 9.3 10
	Winter (mid-December to mid-March)	Range Mean Number	0.049-0.089 0.074 9	0.6-9.0 4.3 7	4.6-21.6 14.3 9
	Spring (mid-March to mid-June)	Range Mean Number	0.018-0.087 47.4 64	0.3-15.9 5.8 20	3.9-35.4 16.7 64
	Summer (mid-June to mid-September)	Range Mean Number	0.016-0.210 0.050 100	1.9-30.3 10.7 21	3.9-17.4 8.6 98

Source: U.S. Geological Survey and SEWRPC.

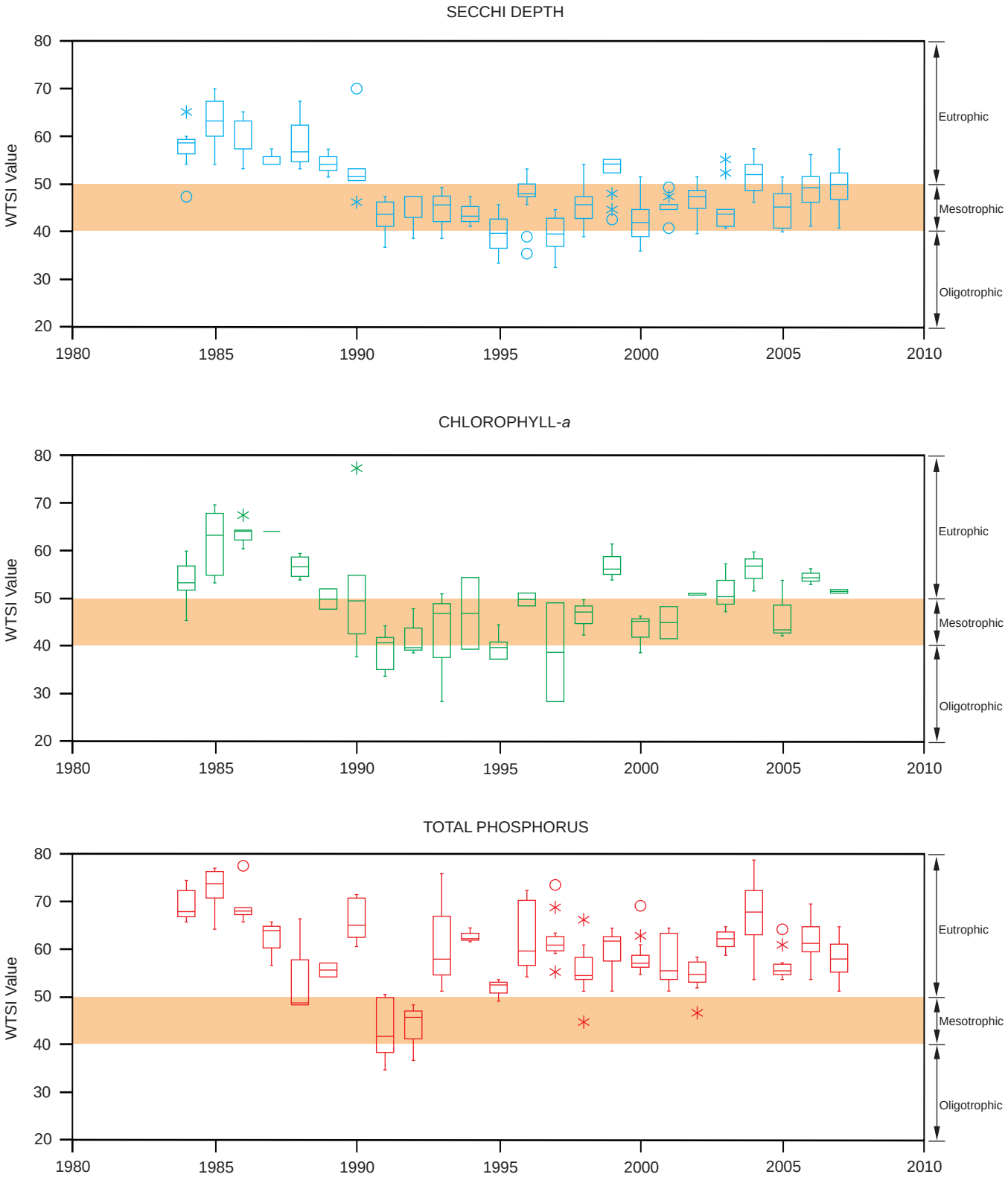
DLSD staff members have monitored water clarity at several locations around Delavan Lake since 1983. As noted in the comprehensive lake management plan,[14] water clarity prior to the alum treatment in 1991 averaged about eight feet, indicative of fair to good water quality; after the alum treatment, the annual average value was about 14 feet, indicative of very good water quality.

During the current study period, the average Secchi-disk transparency ranged from a minimum annual average value of about nine feet during 2004 to a maximum annual average value of about 17 feet in 2000, with the annual average Secchi-disk transparency being about 10 feet during the other years of record. While this range of values

[14]*SEWRPC Community Assistance Planning Report No. 253,* op. cit.

Figure 1

WISCONSIN TROPHIC STATE INDICES FOR DELAVAN LAKE: 1980-2007



NOTE: Box plot shows the median (horizontal line), the range (ends of the whiskers), and the upper (75th) and lower (25th) quartiles (edges of box) of the data in each group.

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

spans the range of values previously reported from Delavan Lake, the recent data do indicate a reduction in annual average water clarity from the 14 feet reported following the alum treatment to about 10 feet during the current reporting period. Such a change is consistent with the diminution of effectivity of the alum in capturing phosphorus entering the Lake during the growing season, which would lead to increased algal growths and organic turbidities, reducing water clarity.

Zebra Mussel Impacts on Water Clarity

Delavan Lake is listed by the WDNR as having had an established population of zebra mussels (*Dreissena polymorpha*) since 1999. Zebra mussels, a nonnative species of shellfish with known negative impacts on native benthic organism populations, are having a varied impact on the inland lakes of the Upper Midwest, disrupting the food chain by removing significant amounts of bacteria and smaller phytoplankton which serve as food for a variety of other aquatic organisms, including larval and juvenile fishes and many forms of zooplankton. As a result of the filter feeding proclivities of these animals, many lakes have experienced improved water clarity. This improved water clarity, in turn, has led to increased growths of rooted aquatic plants, including Eurasian water milfoil. Curiously, within the Southeastern Wisconsin Region, zebra mussels have been observed attaching themselves to the stalks of the Eurasian water milfoil plants, dragging the stems out of the zone of light penetration due to the weight of the zebra mussel shells, and interfering with the competitive strategy of the Eurasian water milfoil plants. This has contributed to improved growths of native aquatic plants in some cases, and to the growths of filamentous algae too large to be ingested by the zebra mussels in others. Regardless as to the seeming beneficial impacts of these animals, the overall effect is that, as zebra mussels and other invasive species spread to inland lakes and rivers, so do the environmental, aesthetic, and economic costs to water users. Since 1992, the DLSD has participated in a zebra mussel monitoring program conducted in cooperation with the WDNR and the Zebra Mussel Watch of the University of Wisconsin Sea Grant. Additionally, Delavan Lake is one of four Wisconsin lakes included in a research study being conducted by the WDNR in cooperation with staff from the University of Wisconsin-Madison and the Stephen F. Austin University in Texas to determine the impact of zebra mussels on Wisconsin lakes.[15]

Remote Sensing of Water Clarity

In addition to in-lake direct measurements of water clarity using a Secchi-disk, transparency of many Wisconsin lakes has been measured using remote sensing technology. The Environmental Remote Sensing Center (ERSC), established in 1970 on the University of Wisconsin-Madison campus, was one of the first remote sensing facilities in the United States. Using data gathered by satellite remote sensing over a three-year period, the ERSC generated a map based on a mosaic of satellite images showing the estimated water clarity of the largest 8,000 lakes in Wisconsin. The WDNR, through its volunteer Self-Help Monitoring Program (now the CLMN) was able to gather water clarity measurements from about 800 lakes, or about 10 percent of Wisconsin's largest lakes. Of these, the satellite remote sensing technology utilized by ERSC was able to accurately estimate water clarity, providing a basis for extrapolating water clarity estimates to the remaining 90 percent of lakes included in the ERSC study. Measurements collected through ERSC remote sensing program estimated the average water clarity of Delavan Lake to be nine feet, a value indicative of moderately enriched nutrient conditions and generally good water quality. Such data are essentially consistent with, but slightly less than, the USGS Secchi-disk measurements.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. Generally, dissolved oxygen levels are higher at the surface of a lake, where there is an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels are usually lowest near the bottom of a lake, where decomposer organisms and chemical oxidation processes utilize oxygen in the decay process.

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[15]*Delavan Lake Sanitary District of the Towns of Delavan and Walworth,* Delavan Lake, Wisconsin Lake Water Quality Report 2007, *April 2008.*

When a lake becomes stratified—that is, when a thermal gradient (called a "thermocline") or chemical gradient ("chemocline") of sufficient intensity produces a barrier separating the upper waters, called the epilimnion, from the lower waters, known as the hypolimnion—the surface supply of oxygen to the hypolimnion is cut off. Eventually, if there is not enough dissolved oxygen to meet the demands from the bottom dwelling aquatic life and decaying organic material, the dissolved oxygen levels in the bottom waters may be reduced to zero, a condition known as anoxia or anaerobiasis.

Where oxygen levels are depleted in the hypolimnion, fish and other motile aquatic organisms tend to move upward, nearer to the surface of the lake, where higher dissolved oxygen concentrations exist. This migration, when combined with temperature, can select against some 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, fish and other aquatic organisms are susceptible to summerkills, or, alternatively, are driven into the warmer water portions of the lake where their condition and competitive success may be severely impaired. Additionally, this condition, common to many shallow lakes in Wisconsin, can lead to winter fish kills if the oxygen stored in the waters beneath an ice layer is not sufficient to meet the total demand.

Dissolved oxygen levels presented in the comprehensive lake management plan showed that, before the alum treatment, dissolved oxygen levels at or near the bottom of Delavan Lake commonly fell to zero or near zero during the summer months; similar conditions were observed during much of the period from 1991 through 1999, following the alum treatment. By mid-June 1999, for example, dissolved oxygen concentrations dropped to below five milligrams per liter (mg/l) or the minimum level necessary to support many species of fish, at a depth of approximately 26 feet, with concentrations decreasing to near zero at about 42 feet.

Similar in-lake dissolved oxygen concentration profiles were observed during the current study period, with summer oxygen depletion being observed below about 23 feet of depth.

In addition to these biological consequences, the lack of dissolved oxygen at depth can enhance the development of chemoclines, or chemical gradients, with an inverse relationship to the dissolved oxygen concentration. For example, the sediment-water exchange of elements, such as phosphorus, iron, and manganese, is increased under anaerobic conditions, resulting in increased hypolimnetic concentrations of these elements. Under anaerobic conditions, changes in iron and manganese oxidation states enable the release of phosphorus from the iron and manganese complexes to which they were bound under aerobic conditions. This "internal loading" can affect water quality significantly if these nutrients and salts are mixed into the epilimnion, especially during early summer, when these nutrients can become available for algal and rooted aquatic plant growth. Water quality data presented in the comprehensive lake management plan, in particular the pH and specific conductance profiles for Delavan Lake, seemed to indicate the presence of this internal loading phenomenon.

Chlorophyll-*a*

Chlorophyll-*a* is the major photosynthetic ("green") pigment present in algae. The amount of chlorophyll-*a* present in the water, therefore, is an indication of the amount or biomass of algae in the water. The mean chlorophyll-*a* concentration for lakes in the Region is about 43.3 micrograms per liter (μg/l), with a median concentration of about 9.9 μg/l.[16] Chlorophyll-*a* levels above about 10 μg/l generally result in a green coloration of the water that, as chlorophyll-*a* levels increase, may become severe enough to impair recreational activities, such as swimming or waterskiing.[17]

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

[17]*J.R. Vallentyne, "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.*

As related in the comprehensive lake management plan, chlorophyll-*a* values prior to the 1991 alum treatment averaged annually about 20 μg/l, indicative of generally poor water quality, although seasonal values varied widely from a low below 0.1 μg/l to a high of 300 μg/l. After the alum treatment, concentrations averaged annually about 4.0 μg/l, indicative of very good water quality.

During the current study period, annual average chlorophyll-*a* values generally increased from about 3.5 μg/l during 2000 and 2001, to almost 15 μg/l during 2004, after which the annual average chlorophyll-*a* concentrations oscillated between about 6.5 μg/l and 7.0 μg/l reported during 2005 and 2007, and 11.6 μg/l and 14.7 μg/l in 2004 and 2006. These more recent data suggest that, while the Lake may not be experiencing regular problem levels of chlorophyll-*a*, there are increasing incidences of chlorophyll-*a* concentrations exceeding the threshold value of about 10 μg/l, above which the Lake may develop a green coloration. This trend, as noted above, is consistent with reduced water clarity due to increased algal growths and organic turbidities.

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 such as Delavan Lake where the supply of one or more of these nutrients is less than that needed by growing plants, plant growth is limited by the amount of the nutrient that is available in the least quantity relative to all of the others. The ratio of total nitrogen (N) to total phosphorus (P) in lake water indicates which nutrient is the factor most likely to be limiting aquatic plant growth in a lake.[18] 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.

During the period preceding the preparation of the comprehensive lake management plan, the nitrogen-to-phosphorus (N:P) ratios indicated that, between 1984 and 1999, plant production historically was sometimes limited by nitrogen and sometimes by phosphorus. During the first year following the 1991 alum treatment, with the removal of phosphorus from the water column, phosphorus became the limiting factor, but, by the following year, N:P levels declined to levels similar to those seen prior to the alum treatment. However, phosphorus would appear to remain the aquatic plant growth limiting factor in the Lake.

Total phosphorus concentrations include 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, and is, therefore, usually considered a good indicator of nutrient status in a lake. For lakes, the guideline value set forth in the adopted regional water quality management plan is 0.020 mg/l (20 μg/l) of total phosphorus or less during spring turnover. This is the level considered as necessary to limit algal and aquatic plant growths to levels consistent with recreational water use objectives, as well as with water use objectives for maintaining a warm water fishery and other aquatic life. Following the alum treatment, the average total phosphorus concentration in the surface waters of Delavan Lake was about 0.060 mg/l, or significantly reduced from the pre-alum treatment concentrations of 0.100 mg/l. During the current study period, these average surface water total phosphorus concentrations remained unchanged, averaging about 0.060 mg/l. However, average surface water total phosphorus concentrations during specific years from 2000 onwards ranged from a low of about 0.040 mg/l to a high of 0.080 mg/l. In each of the study years, the spring turnover total phosphorus concentration exceeded the Regional guideline value of 0.020 mg/l, above which algal blooms and a visible “green” coloration of the lake water can be anticipated.

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

Seasonal gradients of phosphorus concentration between the epilimnion and hypolimnion of a lake reflect the biogeochemistry of this growth element. When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed. Phosphorus from these organisms is then either stored in the bottom sediments or rereleased into the water column. Because phosphorus is not highly soluble in water, it readily forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions and accumulates, predominantly, in the lake sediments. As aforestated, if the bottom waters become depleted of oxygen during stratification, certain chemical changes occur, including the change in the oxidation state of iron from the insoluble Fe^{3+} state to the more soluble Fe^{2+} state. The effect of these chemical changes is that phosphorus becomes soluble and is more readily released from the sediments, in 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.

During the previous SEWRPC study, the 1991 through 1999 data indicated that there was internal loading of phosphorus from the bottom sediments of Delavan Lake. In addition, at certain times of the year, phosphorus appeared to be released from the sediments in the inlet, while at other times the inlet sediments may have acted as a store for phosphorus. It was believed that the movement of phosphorus from the inlet sediments, as a consequence of both chemical and biological processes, would contribute phosphorus to the Lake during the summer months. The mass of phosphorus thus mobilized during the summer months was estimated to be sufficient to form a significant portion of the phosphorus load entering Delavan Lake through the Jackson Creek inlet.[19] It was estimated that this internal loading contributed about 11,000 pounds, or more than one-half of the total phosphorus load to Delavan Lake, during 1998. Thus, the potential contribution of phosphorus to the water column from the bottom waters of Delavan Lake may be considered significant in terms of the total phosphorus load. However, under "normal" conditions, the majority of the phosphorus released from the lake sediments is likely to be returned to the lake sediments, as noted above, when the iron is oxidized (to Fe^{+3}) at the time of the autumnal turnover.

As such loading occurs, the magnitude of the release and its subsequent effects in contributing to algal growth in the surface waters of the Lake may be moderated by a number of circumstances, including the rates of mixing during the spring and fall overturn events. Slow mixing generally results in any phosphorus released into the bottom waters of the Lake being reprecipitated and unavailable to aquatic plants.[20]

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 directly as surface runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Pollutants transported by streams also enter a lake as surface water inflows.

In flow-through lakes, like Delavan Lake, pollutant loads transported by inflowing streams, by precipitation falling directly onto the Lake surface, and by runoff from the tributary area immediately surrounding the Lake, in the absence of identifiable or point source discharges from industries or wastewater treatment facilities, comprise

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[19]*D.M. Robertson, S.J. Field, J.F. Elder, G.L. Goddard and W.F. James,* Phosphorus Dynamics in Delavan Lake Inlet, Southeastern Wisconsin, 1994, *U.S. Geological Survey Water-Resources Report 96-4160,* op. cit.

[20]*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),"* Hydrobiologia*, Volume 97, 1982, pp. 209-224.*

the principal routes by which contaminants enter the waterbody.[21] Currently, there are no significant point source discharges of pollutants into Delavan Lake.[22] For this reason, the discussion that follows is based upon nonpoint source pollutant loadings to the system.

Nonpoint sources of water pollution include urban sources, such as stormwater runoff from residential, commercial, transportation, construction, and recreational activities, and rural sources, such as runoff from agricultural lands.

Nonpoint source phosphorus, suspended solids, and urban-derived metals inputs to Delavan Lake were estimated using the Wisconsin Lake Model Spreadsheet (WILMS version 3.0),[23] and the unit area load-based models developed for use within the Southeastern Wisconsin Region.[24]

Phosphorus Loadings

The USGS first constructed a phosphorus budget for Delavan Lake during 1984. At that time, the annual phosphorus load contributed to Delavan Lake by external sources was calculated to be about 20,000 pounds of phosphorus. With the exception of 1996, external loadings of phosphorus to Delavan Lake have generally been calculated to range from about 12,000 pounds to 18,000 pounds of phosphorus. These calculated phosphorus loads were compared to estimated phosphorus loads generated on the basis of the WILMS model. The model's estimates were slightly greater than the actual field measurements reported by the USGS.[25] The differences between the predicted and observed phosphorus loads were attributed, at the time, to the fact that the model did not take into account the effects of phosphorus retention within the Mound Road wetland. It was felt that during some periods of the year, the wetland might remove phosphorus that ultimately would otherwise enter the Lake from the water, or the wetland might possibly delay the delivery of the phosphorus to the Lake during the growing season, thereby moderating the biological effects of the phosphorus load.[26] Although wide fluctuations in year-to-year phosphorus loadings make it difficult to accurately confirm a reduction in phosphorus loadings using linear regression analysis, it was felt that phosphorus loadings to Delavan Lake through Jackson Creek and the Delavan

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[21]*Sven-Olof Ryding and Walter Rast,* The Control of Eutrophication of Lakes and Reservoirs*, Unesco Man and the Biosphere Series, Volume 1, Parthenon Press, Carnforth, 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.*

[22]*See 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.*

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

[24]*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.*

[25]*D.M. Robertson, G.L. Goddard, D.R. Helsel, and K.L. MacKinnon, "Rehabilitation of Delavan Lake, Wisconsin,"* Lake and Reservoir Management, *Volume 20, No. 3, pages 155-176, 2000.*

[26]*D.M. Robertson, J.F. Elder, G.L. Goddard, and W.F. James, "Dynamics in Phosphorus Retention in Wetlands Upstream of Delavan Lake, Wisconsin,"* Lakes and Reservoir Management, *Volume 14, No. 4, pages 466-477, 1998.*

Lake inlet were likely to be decreasing. Such a trend would be consistent with the effects of the diversion of treated wastewater from the tributary area and the implementation of watershed management measures, such as the construction of the Mound Road wetland, during the period between 1980 and 2000.

During the current study, as shown in Table 5, existing year 2000 phosphorus loads to Delavan Lake were identified and quantified using SEWRPC land use inventory data.[27] It was estimated that, under year 2000 conditions, the total phosphorus load to Delavan Lake was 17,100 pounds. Of the annual total phosphorus load, it was estimated that 15,400 pounds per year, or about 90 percent of the total loading, were contributed by runoff from rural lands, mostly agricultural, and 1,430 pounds per year, or about 8 percent, were contributed by runoff from urban lands, mostly from residential sources. About 270 pounds, or about 2 percent, were contributed by direct precipitation onto the lake surface.

Under 2035 conditions, as set forth in the adopted regional land use plan,[28] the annual total phosphorus load to the Lake is anticipated to continue to diminish as agricultural activities within the area tributary to Delavan Lake are replaced by urban residential land uses. Table 6 shows the estimated phosphorus loads to Delavan Lake under planned year 2035 conditions. The most likely annual total phosphorus load to the Lake under the planned conditions is estimated to be 15,765 pounds. Of this total annual forecast phosphorus load to Delavan Lake, approximately 11,470 pounds per year, or about 73 percent of the total loading, are estimated to be contributed by runoff from rural land, and 4,010 pounds per year, or about 25 percent, from urban land. About 265 pounds, or about 2 percent, are expected to be contributed by direct precipitation onto the lake surface. This represents an ongoing change in the distribution of the sources of the phosphorus load to the Lake, with urban sources of phosphorus becoming increasingly important in the total phosphorus load forecast for 2035.

The comprehensive lake management plan for Delavan Lake notes that most of the tributary area has been provided with public sanitary sewer service by the DLSD with wastewater treatment being provided by the Walworth County Metropolitan Sewerage District (WalCoMet).[29] Consequently, those few onsite sewage systems that remained were almost exclusively in rural areas and whatever contribution of phosphorus to the Lake made by them was considered insignificant.

While an increasing utilization of agro-chemicals in urban landscaping may offset some of the benefits achieved through introduction of integrated agricultural nutrient and pest management practices,[30] the stormwater management requirements set forth in Chapter NR 151 of the *Wisconsin Administrative Code*, and the limits established by the Wisconsin Legislature on the use and sale of fertilizer containing phosphorus in turf fertilizers to be used in urban areas, pursuant to 2009 Wisconsin Act 9, and on the amount of phosphorus in certain cleaning agents, pursuant to 2009 Wisconsin Act 63, may be expected to further decrease the phosphorus loads to Delavan Lake. With regard to achieving the stormwater management requirements set forth in Chapter NR 151, adoption of an integrated regional approach has been proposed within the community. This approach has considerable merit as it anticipated an integrated and coordinate approach to effectively reducing contaminant loads from urban nonpoint sources.

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[27]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

[28]Ibid.

[29]*SEWRPC Community Assistance Planning Report No. 56, 2nd Edition,* op. cit.

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

Table 5

ESTIMATED ANNUAL POLLUTANT LOADINGS TO DELAVAN LAKE BY LAND USE CATEGORY: 2000

Land Use Category	Pollutant Loads			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential	17.2	353.0	0.0	17.6
Commercial	73.6	225.6	41.4	280.1
Industrial	91.0	283.1	53.2	360.6
Governmental	61.0	322.6	16.7	191.2
Transportation	6.7	155.8	0.0	0.0
Recreational	4.0	90.7	0.0	0.0
Subtotal	253.5	1,430.8	111.3	849.5
Rural				
Agricultural	3,997.5	15,279.6	- -	- -
Wetlands	3.6	38.9	- -	- -
Woodlands	1.8	46.5	- -	- -
Water	193.3	267.4	- -	- -
Extractive	7.6	29.2	- -	- -
Subtotal	4,203.8	15,661.6	- -	- -
Total	4,457.3	17,092.4	111.3	849.5

Source: SEWRPC.

Table 6

ESTIMATED ANNUAL POLLUTANT LOADINGS TO DELAVAN LAKE BY LAND USE CATEGORY: 2035

Land Use Category	Pollutant Loads			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential	34.7	712.6	0.0	35.6
Commercial	422.5	1,293.6	237.1	1,606.2
Industrial	297.4	925.4	174.2	1,178.6
Governmental	128.2	677.7	35.1	401.6
Transportation	10.9	252.0	0.0	0.0
Recreational	6.5	146.8	0.0	0.0
Subtotal	900.2	4,008.1	446.3	3,222.0
Rural				
Agricultural	2,974.9	11,370.9	- -	- -
Wetlands	1.8	38.9	- -	- -
Woodlands	2.1	46.0	- -	- -
Water	143.3	267.4	- -	- -
Extractive	2.2	8.6	- -	- -
Subtotal	3,124.3	11,731.8	- -	- -
Total	4,024.5	15,739.9	446.3	3,222.0

Source: SEWRPC.

Effects of the Mound Road Wetland Complex

As reported in the comprehensive lake management plan, differences between the phosphorus loads entering the constructed wetland from the Jackson Creek tributary area and leaving the wetland at Mound Road during 1994 and 1995 indicated that, at times, the wetland acted as both a phosphorus source and a phosphorus sink.[31] The principal beneficial function of the wetland, therefore, was to *modify the timing of the delivery of the phosphorus load* to the Lake such that the phosphorus did not enter Delavan Lake during the summer growing season, thereby *moderating the biological response* to the annual load to phosphorus to the Lake, regardless of whether the wetland is acting as a source or a sink for phosphorus.[32]

Additionally, comparing phosphorus loads exiting the wetland at Mound Road with the phosphorus loads entering Delavan Lake at STH 50 suggested that processes associated with the inlet, such as phosphorus releases from sediments or phosphorus loading from sites other than Jackson Creek, may be occurring and contributing to the phosphorus loading of the Lake. The impacts of these phosphorus loading routes are immediate and not subject to the influence of the Mound Road wetland. To this end, comprehensive stormwater management, using an integrated regional approach, would be indicated as a basis for more effectively moderating the phosphorus loads from the total area draining to Delavan Lake.[33] Regardless, periodic maintenance of the Mound Road wetlands and its associated ponds appears to be providing benefit to Delavan Lake.

Role of the Lake Sediments

During the period between 1995 and 1998, about 80 percent of the total phosphorus loading to the Lake was estimated by USGS[34] to have been used by the biomass within the Lake or deposited in the Lake sediments each year.[35] Further, a portion of the phosphorus mass retained in the Lake was typically removed through the aquatic plant harvesting program of DLSD, which removes phosphorus from the Lake[36] as a component of the aquatic plant biomass. As noted above, it is possible that a portion of this bound phosphorus could be released back in to the water column of the Lake as a consequence of the phenomenon known as "internal loading." During the

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[31]*D.M. Robertson, J.F. Elder, G.L. Goddard, and W.F. James,* op. cit.

[32]*Phosphorus entering the Mound Road wetland complex during the spring runoff period is likely to be retained within the wetland either as particulate phosphorus attached to sediment particles that are retained in the sedimentation ponds or as plant material; in the autumn, some of the phosphorus contained within plant biomass may be released back into the water upon the senescence of the plants, with a further small percentage being incorporated into the wetland sediments. Phosphorus exiting the wetland complex during the autumn and winter would not contribute to aquatic plant growth in Delavan Lake during the preceding summer recreational season.*

[33]*For example, the application of flocculent chemicals at a point upstream of the Mound Road wetland has been mooted as a means of enhancing the effectiveness of the wetland treatment system. Such an approach could enhance the effectiveness of the wetlands in removing nutrients being transported by Jackson Creek to Delavan Lake; however, chemical dosing involves considerable operational costs and invokes the need for increased retention in the depositional area to permit flocculation of the alumino-phosphates.*

[34]*U.S. Geological Survey Water-Resources Investigations Report 87-4168,* op. cit.

[35]*D.P. Larsen and H.T. Mercier, "Phosphorus Retention Capacity of Lakes,"* Journal of the Fisheries Research Board of Canada, *Volume 33, pages 1742-1750, 1976.*

[36]*T.M. Burton, D.L. King, and J.L. Ervin, "Aquatic Plant Harvesting As A Lake Restoration Technique,"* Proceedings of the U.S. Environmental Protection Agency National Lake Restoration Conference, *EPA 440/5-79-od1, 1979. See also, U.S. Environmental Protection Agency Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition, *August 1990.*

previous SEWRPC study, the USGS estimated that, for the period from 1995 through 1998, the amount of internal loading of phosphorus ranged from 5,000 pounds to 10,500 pounds per year.[37] This would represent from about 35 percent to about 60 percent of the total phosphorus load to Delavan Lake. Typically, these loads would not be expected to significantly influence surface water phosphorus concentrations, except when the overturn event is sudden and accomplished within hours.[38] During "normal" years, overturn occurs gradually as the surface waters warm and cool, allowing the sediment phosphorus to be largely reabsorbed and returned to the sediments. That there is some contribution of the sediment bound phosphorus to the water column of Delavan Lake can be verified through the application of the Organization for Economic Cooperation and Development (OECD) phosphorus load-response model to the Delavan Lake phosphorus loading data. Based upon the results of this modeling, it is estimated that the annual average in-lake phosphorus concentration in Delavan Lake should be 0.030 mg/l; the observed annual average total phosphorus concentration under year 2000 conditions was 0.050 mg/l.

Sediment Loadings

In the comprehensive lake management plan, the average annual sediment loading to the inlet was about 600 tons of sediment. During the period between 1994 and 1995, data suggested that between 40 and 70 percent of the total sediment load generated from the Jackson Creek area may be expected to be deposited in the inlet, with the remainder being conveyed into the Lake. During 1990 and 1991, sediment export from the Lake amounted to between about 30 to 50 percent of the sediment load entering the Lake at STH 50. During the period from 1990 through 1995, the amount of sediment loading downstream of STH 50 declined, and during 1994 and 1995, the wetland complex served as a net depositional area. These trends were supported by the observation that the eastern and northern sedimentation basins located within the Mound Road wetland complex had accumulated about two to three feet and about one foot of retained sediment, respectively.

As a consequence of these observations, the Town of Delavan undertook the restoration of the two ponds during the mid-2000s. This restoration not only created new capacity within the ponds, but also modified the pond designs to better retain sediments. This redesign included the elimination of the channels that had been initially included in the pond design as a potential mechanism for promoting sheet flow through the wetland complex. As noted in the comprehensive lake management plan, these channels were not successful in achieving their design objective, leading instead to the creation of channelized flow through the wetland system. With the improvements undertaken during the restoration process, these channels were filled and a more typical berm was proved on the down gradient side of the ponds to promote sheet flow.

For the current study period, the estimated sediment loadings to Delavan Lake under existing year 2000 are shown in Table 5. A total annual sediment loading of about 4,460 tons was estimated to be contributed to Delavan Lake, as shown in Table 5. Of the likely annual sediment load, it was estimated that 4,110 tons per year, or about 90 percent of the total loading, were contributed by runoff from rural lands, mostly from agricultural sources, and 255 tons, or about 6 percent, contributed by urban lands. Approximately 195 tons, or about 4 percent of the annual sediment load, were contributed by atmospheric deposition onto the lake surface.

Under 2035 conditions, as set forth in the adopted regional land use plan and as shown in Table 6, the annual sediment load to the Lake is anticipated to diminish. The most likely annual sediment load to the Lake under buildout conditions is estimated to be 4,025 tons. Of the forecast sediment load anticipated for Delavan Lake, about 2,980 tons of sediment was estimated to be contributed to the Lake from rural sources and 900 tons from urban sources. Approximately 145 tons of sediment per year was estimated to continue to be contributed by direct precipitation onto the lake surface.

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[37] *U.S. Geological Survey Water-Resources Investigations Report 87-4168,* op. cit.

[38] *R.D. Robarts, P.J. Ashton, J.A. Thornton. H.J. Taussig, and L.M. Sephton,* op. cit.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[39] The majority of these metals become associated with sediment particles,[40] and, consequently, are likely to be encapsulated into the bottom sediments of a lake.

The estimated loadings of copper and zinc likely to be contributed to Delavan Lake under existing year 2000 and forecast year 2035 land use conditions are shown in Tables 5 and 6, respectively. In 2000, about 110 pounds of copper and 850 pounds of zinc were estimated to be contributed annually to Delavan Lake, all from urban lands. Under planned year 2035 conditions, as set forth in the adopted regional land use plan,[41] the annual zinc load and the annual load of copper to Delavan Lake is forecast to increase about four-fold to about 3,220 pounds and 445 pounds per year, respectively.

TROPHIC STATUS

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 that 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. Although some eutrophic lakes are present in the Region, severely eutrophic lakes are rare, especially since the regionwide implementation of recommendations put forth in the regional water quality management plan. Severely enriched lakes are sometimes referred to as being hypertrophic.

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

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

[41] *SEWRPC Planning Report No. 48,* op. cit.

trophic classification system,[42] and the Carlson Trophic State Index (TSI),[43] with a variation known as the Wisconsin Trophic State Index value (WTSI).[44] The WTSI is a refinement of the Carlson TSI and is designed to account for the greater humic acid content—brown water color—present in Wisconsin lakes; it has been adopted by the WDNR for use in lake management investigations.

Applying total phosphorus data for Delavan Lake from the time of the previous SEWRPC report, the empirical relationships developed through the Vollenweider-OECD open-boundary trophic classification system predicted that Delavan Lake, at that time, had about a 60 percent probability of being eutrophic and about a 35 percent probability of being mesotrophic; predictions based on mean chlorophyll-*a* concentrations and Secchi-disk readings were consistent with those based on total phosphorus. Thus, Delavan Lake at the time of the previous SEWRPC report was considered to be classified as meso-eutrophic, or having water quality that would be considered impaired for some uses.

WTSI ratings for Delavan Lake at the time of the previous SEWRPC report also classified Delavan Lake as meso-eutrophic.[45] Secchi-disk derived WTSI values ranged from 25 to 65 during the period of record assessed during the initial study, with a median value of about 40. This was consistent with the TSI value derived from the aforementioned ERSC satellite remote sensing study, which was estimated to be 46, a value associated with mesotrophic lakes. During the current study period, Secchi-disk-derived TSI values ranged from a low of 38 during 2000 to a high of 48 during 2004. The mean value of the Secchi-disk TSI during the study period was 43, which suggests that Delavan Lake remains a mesotrophic waterbody. This determination is consistent with the available water quality data obtained for Delavan Lake and with the aforementioned physical factors of the Lake.

AQUATIC PLANTS: DISTRIBUTION AND MANAGEMENT AREAS

Past and Present Aquatic Plant Communities in Delavan Lake

Surveys of aquatic plants in Delavan Lake have been conducted by various public and private organizations since 1948. From the 1950s to the time of the lake rehabilitation project in 1989-1990, the number of aquatic plant species in the Lake had been in a state of decline. From as many as 25 species observed during the 1950s, the number of species had decreased to only seven species by the time of the 1960s, with this number declining to only four species by 1968. By the mid-1970s, white water lily was considered the dominant plant species in the Lake, and, by 1972, all major "weed" beds in the Lake were reported to have disappeared, with only single plants and scattered patches of plants being reported in the Lake. During the 1980s, two additional aquatic plant surveys were conducted, prior to the major lake rehabilitation project. During these surveys, only three species of aquatic macrophytes were identified with the dominant plant being curly-leaf pondweed (*Potamogeton crispus*), an invasive nonnative plant, along with white water lily and another, unidentified pondweed.

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[42]*Organization for Economic Cooperation and Development-OECD,* Eutrophication of Waters: Monitoring, Assessment and Control*, OECD, Paris, 1982; H. Olem and G. Flock, U.S. Environmental Protection Agency Report EPA-440/4-90-006,* op. cit.

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

[44]*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.*

[45]*A value above 50 is generally indicative of the enriched conditions associated with eutrophic lakes.*

As a result of increased water clarity and a decrease in rough fish populations brought about by the afore-mentioned lake rehabilitation project during 1989-1990, significant changes occurred in the aquatic plant communities in the Lake. In the surveys conducted between 1990 and 1994, as well as in those conducted between 1996 and 1999, 29 species of aquatic macrophytes, including the two emergent species—cattail (*Typha latifolia*) and bulrush (*Scirpus* sp.)—were reported to occur in Delavan Lake.[46]

In the 2002 comprehensive lake management plan, the results of the 1999 aquatic plant survey were used to assess and evaluate the aquatic plant community in Delavan Lake. At that time, 13 species of aquatic macrophytes were identified, not including species of bulrush (*Scirpus* sp.) and cattail (*Typha* sp.) associated with the wetland complexes along the inlet channel and the southwestern bay. These emergent macrophytes, although present during the survey, were not considered part of the submergent plant community. Eurasian water milfoil (*Myriophyllum spicatum*) was the dominant species in many areas of the Lake, as it had been since 1996. Curly-leaf pondweed was also abundant during this period and was reported to be at nuisance levels. Sago pondweed (*Potamogeton pectinatus*), muskgrass (*Chara vulgaris*), and coontail (*Ceratophyllum demersum*), respectively, were the next most common species in the Lake, and wild celery (*Vallisneria americana*) appeared to be spreading in the Lake, at least locally near the small tributary inlet at the southeastern end of the Lake.

For the current study, data from aquatic plant surveys conducted on Delavan Lake during July of 2009 and 2010 have been used to formulate and support modifications to the aquatic plant management program being conducted on Delavan Lake. The results of the 2009 survey are shown in Table 7 and depicted on Map 7.[47] During these surveys, a preliminary general reconnaissance of the Lake was made by boat, followed by a detailed survey utilizing a methodology similar to that employed by the WDNR, which involved sampling at pre-determined depths along transect lines located at intervals around the entire shoreline of Delavan Lake. Of the 16 aquatic plant species observed during the transect survey in 2009, the dominant species in the Lake was coontail, although Eurasian water milfoil and star duckweed (*Lemna trisulca*) were also present in significant amounts. Other species observed during either the reconnaissance or the transect survey, included Sago pondweed, muskgrass, duckweed, slender naiad/bushy pondweed (*Najas flexilis*), white water lily (*Nymphaea* sp.), curly-leaf pondweed, flat-stem pondweed (*Potamogeton zosteriformes*), wild celery, watermeal (*Wolffia* sp.), and water stargrass (*Zosterella dubia*). During 2010, 14 species were observed, as some of the pondweed species (*Potamogeton* spp.) were not reported during the 2010 survey.[48] The maximum rooting depth observed was 17 feet.

Variations in the occurrence of pondweed species in lakes are not unusual. Such variations are frequently reported and reflect anticipated inter-annual variability within the lakes. Such variability is related to weather conditions, insolation or the availability of sunlight, and related climatic factors, as well as to sampling effort. With regard to the latter, rare species may be under-sampled. Consequently, variations in occurrences of pondweed species, in particular, rarely reflect long term changes in a lake ecosystem.

Comments on the ecological significance of each plant identified during the 2009 aquatic plant survey are set forth in Table 8. Representative illustrations of these aquatic plants can be found in Appendix A.

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[46]*Aron & Associates,* Delavan Lake Aquatic Plant Survey, *1992; Aron & Associates,* Delavan Lake Aquatic Plant Survey, *1993; Aron & Associates,* Delavan Lake Aquatic Plant Management Plan, *September 1993; Aron & Associates,* Delavan Lake Aquatic Plant Survey, *1994; Aron & Associates,* Delavan Lake Aquatic Plant Survey, *1996; Aron & Associates,* Delavan Lake Aquatic Plant Survey, *1997; Aron & Associates,* Delavan Lake Aquatic Plant Survey, *1998; Aron & Associates,* Delavan Lake Aquatic Plant Survey, *1999.*

[47]*Aron & Associates,* Delavan Lake Aquatic Plant Survey, *2009.*

[48]*Aron & Associates,* Delavan Lake Aquatic Plant Survey, *2010.*

Table 7

AQUATIC PLANT SPECIES OBSERVED IN DELAVAN LAKE: JULY 2009 AND 2010

Aquatic Plant Species	2009 Frequency of Occurrence[a]	2010 Frequency of Occurrence[a]
Ceratophyllum demersum (coontail)	63	54
Chara vulgaris (muskgrass)	3	3
Elodea canadensis (waterweed)	3	2
Lemna minor (duckweed)	1[b]	2
Lemna trisulca (star duckweed)	30	12
Myriophyllum spicatum (Eurasian water milfoil)	33	35
Najas flexilis (bushy pondweed/slender naiad)	- -[b]	- -[b]
Nymphaea sp. (white water lily)	- -[b]	- -[b]
Potamogeton crispus (curly-leaf pondweed)	7	2
Potamogeton foliosis (leafy pondweed)	1	0
Potamogeton natans (floating-leaf pondweed)	0	1
Potamogeton pectinatus (Sago pondweed)[c]	18	23
Potamogeton zosteriformis (flat-stem pondweed)	2	0
Vallisneria americana (wild celery/eel-grass)	8	23
Wolffia sp. (watermeal)	1[b]	1
Zannichellia pulastris (horned pondweed)	1	0
Zosterella dubia (water stargrass)	7	12

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

[b]*Found only in the general survey.*

[c]*Sago pondweed has been reclassified as* Stuckenia pectinata*.*

Source: Aron & Associates, and SEWRPC.

Aquatic Plant Diversity in the Delavan Lake System

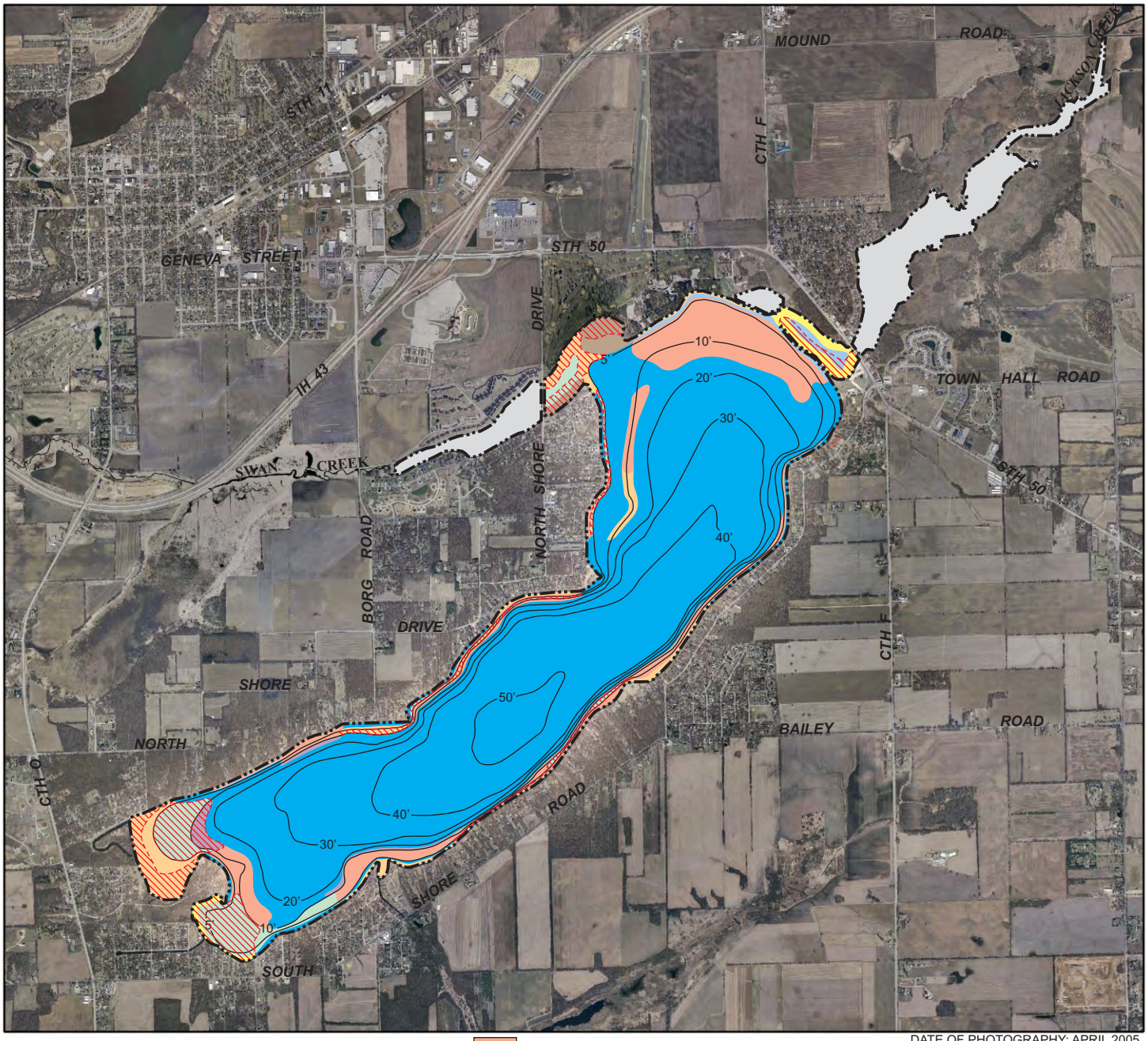
A critical key to the ability of an ecosystem, such as a lake, to maintain its ecological integrity is through *biological diversity*. Conserving the biological diversity, or biodiversity, of an ecosystem helps not only to sustain the system, but preserves a spectrum of options for future decisions regarding the management of that system. During 2009, the aquatic plant communities in the Delavan Lake system demonstrated the greatest diversity of species in the shallow water areas where water was three feet or less in depth.[49] A planktonic algal bloom was reported in the north half of the Lake, with the entire littoral zone, including the associated aquatic plants, being covered with a heavy growth of filamentous algae. Aron & Associates reported that the inlet channel north of the STH 50 bridge was dominated by water stargrass, Eurasian water milfoil, and coontail, and the floating-leaved aquatic plant, duckweed. The western shoreline had few plants, while the eastern shoreline of the inlet channel contained coontail, Eurasian water milfoil, and flat-stem pondweed, with water lilies, duckweed, and watermeal.

From STH 50 to the main lake basin, only fringing vegetation was observed, outside of the harvested navigational channel, but these fringe areas were heavily vegetated with coontail, water stargrass, elodea, Eurasian water milfoil, and star duckweed. The "golf-course bay" was dominated by Eurasian water milfoil, coontail, and Sago

[49]Ibid.

Map 7

AQUATIC PLANT COMMUNITY DISTRIBUTION IN DELAVAN LAKE: 2008



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

OPEN WATER

AREA NOT SURVEYED

EURASIAN WATER MILFOIL

COONTAIL, WATER STAR GRASS, AND CURLY-LEAF PONDWEED

COONTAIL AND MUSKGRASS

COONTAIL, SAGO PONDWEED, WILD CELERY, WHITE WATER CROWFOOT, CURLY-LEAF PONDWEED, FLAT-STEM PONDWEED, AND HORNED PONDWEED

COONTAIL AND CURLY-LEAF PONDWEED

COONTAIL

COONTAIL, WHITE WATER CROWFOOT, AND WATERWEED

SAGO PONDWEED, WILD CELERY, WHITE WATER CROWFOOT, CURLY-LEAF PONDWEED, FLAT-STEM PONDWEED, AND HORNED PONDWEED

GRAPHIC SCALE

0 1750 3500 FEET

Source: Aron & Associates and SEWRPC.

Table 8

POSITIVE ECOLOGICAL SIGNIFICANCE OF AQUATIC PLANT SPECIES PRESENT IN DELAVAN LAKE: 2008

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides good shelter for young fish; supports insects valuable as food for fish and ducklings; native
Chara vulgaris (muskgrass)	Excellent producer of fish food, especially for young trout, bluegills, small and largemouth bass; stabilizes bottom sediments; has softening effect on the water by removing lime and carbon dioxide; native
Elodea canadensis (waterweed)	Provides shelter and support for insects which are valuable as fish food; native
Lemna minor (duckweed)	A very nutritious food source for waterfowl; extensive mats can interfere with mosquito breeding; can remove large amounts of nutrients from the water (has been used for wastewater treatment); native
Lemna trisulca (star duckweed)	A good food source for ducks and geese; provides cover for small fish and invertebrates; native
Myriophyllum spicatum (Eurasian water milfoil)	None known; nonnative
Najas flexilis (bushy pondweed)	Stems, foliage, and seeds important wildfowl food; produces good food and shelter for fish; native
Nymphaea sp. (white water lily)	Seeds are used as food by waterfowl; leaves offer shade and shelter for fish; native
Potamogeton crispus (curly-leaf pondweed)	Provides habitat for fish in winter and spring before other plants are actively growing; nonnative
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish; native
Potamogeton zosteriformis (flat-stem pondweed)	Provides some food for ducks; native
Ranunculus longirostris (white water buttercup)	Fruit and foliage are food for waterfowl; stems and leaves provide cover for invertebrates; native
Vallisneria americana (wild celery/eel-grass)	Provides good shade and shelter; supports insects; valuable fish food; native
Wolffia sp. (watermeal)	Food for waterfowl, muskrat, and some fish; native
Zannichellia palustris (horned pondweed)	Fruit and foliage provide food for waterfowl and trout; native
Zosterella dubia (water stargrass)	Provides food and shelter for fish; locally important food for waterfowl; native

NOTE: Information obtained from *A Manual of Aquatic Plants* by Norman C. Fassett, University of Wisconsin Press; *Guide to Wisconsin Aquatic Plants*, Wisconsin Department of Natural Resources; and, *Through the Looking Glass...A Field Guide to Aquatic Plants*, Wisconsin Lakes Partnership, University of Wisconsin-Extension.

Source: Aron & Associates, and SEWRPC.

pondweed, with some water stargrass also present. The aquatic plant community of the outlet was similar to that of the inlet, with occasional vegetation consisting of coontail, Eurasian water milfoil, Sago pondweed, and water stargrass. The two bays at the southern end of the Lake had moderate vegetation in 2009, with the eastern-most bay being dominated by Eurasian water milfoil and coontail in the deeper water. The western-most bay was also dominated by coontail, Eurasian water milfoil, Sago pondweed, water stargrass, and water lilies.

During the 2009 survey, Aron & Associates reported that the native aquatic plants appeared to be very stressed, especially the Sago pondweed which was covered by filamentous algae. Coontail dominated all depth contours in 2009, especially in the areas just outside of the pier lines along the eastern and western shorelines of the Lake. Many aquatic plants were weighted down with zebra mussels, although the zebra mussels did not appear to be stressing the coontail. Wild celery appeared to be slowly increasing its range in the nearshore areas of Delavan Lake, especially the areas between the piers, although Eurasian water milfoil also had increased in these nearshore zones between the piers. Similar conditions prevailed during 2010.

Aquatic Plant Species of Special Significance

Beneficial Native Aquatic Plants

There was one native plant species observed in the 2009 and 2010 surveys of Delavan Lake that is of high ecological value: muskgrass. Muskgrass is a favorite waterfowl food source and, as an effective bottom sediment stabilizer, benefits water quality. Its prevalence in the plant communities of a lake may be a significant contributing factor to establishing and maintaining good water quality of a lake and, consequently, in establishing water quality conditions that assist native plant species to successfully compete with nonnative species.

Deleterious Nonnative Species

During the 2009 aquatic plant survey of Delavan Lake, two nonnative aquatic plant species of special significance were observed: Eurasian water milfoil and curly-leaf pondweed. These species are considered detrimental to the ecological health of the Lakes and are declared nuisance species identified in Chapters NR 40 and NR 109 of the *Wisconsin Administrative Code*. The sacred lotus (*Nelumbo nucifera*) has recently been reported from the Lake outlet, and yellow floating heart (*Nymphoides peltata*), designated as a prohibited species in Section NR 40.04 of the *Wisconsin Administrative Code*, has been reported from ponds located in the vicinity of Delavan Lake. These latter species should be monitored, and appropriate measures as required for the control of prohibited species listed in Chapter NR 40 applied.

Eurasian water milfoil is one of eight milfoil species found in Wisconsin and the only one known to be exotic or nonnative. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can inhibit its growth, which can be explosive under suitable conditions. The plant exhibits this characteristic growth pattern in lakes with organic-rich sediments, or where the lake bottom has been disturbed. It frequently has been reported as a colonizing species following dredging, unless its growth is anticipated and controlled. Eurasian water milfoil populations can displace native plant species and interfere with the aesthetic and recreational use of the waterbodies. This plant has been known to cause severe recreational use problems in lakes within the South-eastern Wisconsin Region.

Eurasian water milfoil reproduces by the rooting of plant fragments. Consequently, some recreational uses of lakes can result in the expansion of Eurasian water milfoil communities, especially when boat propellers fragment Eurasian water milfoil 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, allowing the plant 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 milfoil to other lakes. 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. Pursuant to Section NR 40.07 of the *Wisconsin Administrative Code*, all aquatic plant fragments must be removed from vessels, vehicles, and trailers prior to launching a boat and after retrieving a boat and before transporting the boat on the public highways. In acknowledgment of this, the WDNR encourages the conduct of its Clean Boats-Clean Waters Program. In use on many lakes within the Region, this program enlists the help of volunteers to maintain a presence at public boat launch sites during peak periods of use to perform boat and trailer checks and to distribute informational materials to educate boaters on how to prevent the spread of aquatic invasive species such as Eurasian water milfoil.

Curly-leaf pondweed is a plant that thrives in cool water and exhibits a peculiar split-season growth cycle that helps give it a competitive advantage over native plants and makes management of this species difficult. In late

summer, the plant produces specialized over-wintering structures, or "turions." In late summer, the main body of the plant dies off and drops to the bottom where the turions lie dormant until the cooler fall water temperatures trigger the turions to germinate. Over the winter, the turions produce winter foliage that thrives under the ice. In spring, when water temperatures begin to rise again, the plant has a head start on the growth of native plants and quickly grows to full size, producing flowers and fruit earlier than its native competitors. Because it can grow in more turbid waters than many native plants, protecting or improving water quality is an effective method of control of this species; clearer waters in a Lake can help native plants compete more effectively with curly-leaf pondweed.

Changes in the Delavan Lake Aquatic Plant Community

Aquatic plant communities do undergo cyclical and periodic changes, which reflect, in part, changing climatic conditions on an interannual scale as well as the evolution of the aquatic plant community in response to such factors as changes in long term nutrient loading, sedimentation rates, and recreational use patterns. The former, interannual, changes occur over a period of three to seven years and may be temporary; the latter, evolutionary changes occur over a decadal period or longer and are longer-lasting. For example, the change in the Eurasian water milfoil population in a lake may reflect the results of aquatic management practices and/or may be a reflection of a periodicity the species naturally experiences. Such periodicity, especially in Eurasian water milfoil populations, has been observed elsewhere in Southeastern Wisconsin, and potentially reflects the influences of a combination of stressors. These stressors include biological factors, such as the activities of naturally occurring Eurasian water milfoil weevils, as well as climatic and limnological factors, such as insolation, water temperature, and lake circulation patterns. Also, some species, such as the pondweeds, exhibit distinct seasonality, with individual species having well-defined growing periods that reflect water temperature, insolation, and other factors.

To determine the nature of changes occurring in aquatic plant communities, successive surveys, utilizing similar methods, need to be conducted every three to five years. The modified Jesson and Lound transect method, as promulgated by the WDNR and used during the conduct of the 2009 and 2010 surveys, when utilized in successive aquatic plant surveys, will allow the statistical evaluation of changes in the aquatic plant community within the Lake.[50] For example, the ebb and flow of aquatic plant populations in Delavan Lake is reflected, to some degree, in comparisons of annual total mean density values of the observed aquatic plant species from 2001 through 2009,[51] as shown in Table 9. These data indicate the complexity of the interactions between aquatic plant species in this system. Because all of the data were collected by the same observer, observer-related effects on the data set can be considered as minimal. That said, it is noteworthy that the pondweeds, particularly flat-stem pondweed and Sago pondweed—which were of importance to the aquatic plant community in the Lake during the first half of the decade—between 2001 and 2004/2005—diminished in importance during recent years. During this latter period, coontail and Eurasian water milfoil shared a dominant position in the aquatic plant community of the Lake, although the dominance of Eurasian water milfoil appears to have declined during 2008 and 2009. Such periodicity in Eurasian water milfoil populations is well-known and has been ascribed variously to: heavy winter snow cover during the year prior, which limits the ability of the plant to grow under the ice; climatic variability, which either favors or disadvantages Eurasian water milfoil growth in the spring, especially during those years in which a "cold snap" occurs at the end of a warm early spring season; or the presence of the Eurasian water milfoil weevil, whose populations periodically overtake the Eurasian water milfoil population which sustains and supports the weevil population, causing a "crash" in the milfoil population. Late season harvesting or herbicide treatment in the year preceding the decline in dominance also have been identified as

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[50]*Memo from Stan Nichols, to J. Bode, J. Leverence, S. Borman, S. Engel, D., Helsel, entitled "Analysis of Macrophyte Data for Ambient Lakes-Dutch Hollow and Redstone Lakes example," Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, February 4, 1994.*

[51]*Aron & Associates,* Delavan Lake Aquatic Plant Survey, op. cit.

Table 9

TOTAL MEAN DENSITIES FOR AQUATIC PLANT SPECIES OBSERVED IN DELAVAN LAKE: 2001-2010

Aquatic Plant Species	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Ceratophyllum demersum (coontail)	3.00	0.69	2.03	2.16	1.89	2.69	2.16	1.24	1.25	1.11
Chara vulgaris (muskgrass)	0.03	0.25	0.53	0.02	0.03	0.01	0.07	0.00	0.04	0.07
Elodea canadensis (waterweed)	0.06	0.06	0.16	0.06	0.00	0.02	0.05	0.00	0.04	0.02
Lemna minor (duckweed)	0.02	0.05	0.00	0.00	0.00	0.13	0.05	0.00	0.00	0.02
Lemna trisulca (star duckweed)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.44	0.15
Myriophyllum spicatum (Eurasian water milfoil)	0.96	2.31	2.98	1.78	2.44	1.71	1.45	0.34	0.40	0.54
Potamogeton crispus (curly-leaf pondweed)	0.17	0.44	0.57	0.04	0.21	0.00	0.08	0.10	0.07	0.02
Potamogeton foliosis (leafy pondweed)	0.06	0.04	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.23
Potamogeton pectinatus (Sago pondweed)	1.66	0.74	0.88	0.66	0.58	0.34	0.51	0.19	0.17	0.01
Potamogeton zosteriformis (flat-stem pondweed)	1.37	0.74	0.88	0.66	0.00	0.03	0.00	0.01	0.02	- -
Vallisneria americana (wild celery/eel-grass)	0.08	0.01	0.11	0.12	0.12	0.12	0.20	0.09	0.16	0.33
Zannichellia palustris (horned pondweed)	0.03	0.05	0.01	0.01	0.01	0.01	0.02	0.00	0.02	- -
Zosterella dubia (water stargrass)	0.18	0.10	0.08	0.09	0.08	0.27	0.16	0.14	0.10	0.14

Source: Aron & Associates, and SEWRPC.

potential contributing factors in some lakes to decreased success or abundance of Eurasian water milfoil populations. Recently, more frequent observations of zebra mussel growths on the Eurasian water milfoil stems have been observed. The weight of these animals can lead to the collapse of the milfoil stems, which would disadvantage the plants whose survival strategy is to dominate the higher levels of the water column and reduce their success in a lake. The specific factor or factors that have affected the density of the Eurasian water milfoil populations in Delavan Lake, however, remain unclear at this time. The data set forth in Table 9 would suggest continuation of the present aquatic plant management practices and population monitoring as a basis for evaluating future interventions.

Past and Present Aquatic Plant Management Practices

All forms of aquatic plant management currently 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.* Aquatic plant management practices include manual and mechanical measures, chemical herbicides, physical barriers, and biological interventions. The use of chemicals to control aquatic plants and algae in Wisconsin has been regulated since 1941, even though records of aquatic herbicide applications have only been maintained by the WDNR since 1950. Prior to 1950, aquatic plant management interventions, while likely, were not recorded.

Historically, through 1996, aquatic plant management efforts on Delavan Lake can be characterized as being primarily chemical. A cumulative summary of chemical applications of a range of aquatic herbicides have been used at intervals through 2008 and are summarized in Table 10. As shown in Table 10, between 1950 and 1969, approximately 10,396 pounds of sodium arsenite were applied to Delavan Lake. 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 in 1969.

An aquatic plant management plan for Delavan Lake was first developed in 1993.[52] This plan recommended a combination approach of chemical treatment and mechanical harvesting as a means to aquatic plant management in the Lake. A comprehensive lake management plan for Delavan Lake and its watershed was subsequently

[52]*Aron & Associates,* Delavan Lake Aquatic Plant Management Plan, op. cit.

Table 10

CHEMICAL CONTROL OF AQUATIC PLANTS IN DELAVAN LAKE: 1950-2008

Year	Total Acres Treated	Algae Control				Macrophyte Control					
		Copper Sulfate (pounds)	Copper Sulfate (gallons)	AV-70 (gallons)	Cutrine or Cutrine Plus (gallons)	Sodium Arsenite (pounds)	2,4-D (pounds)	2,4-D (gallons)	Diquat (gallons)	Glyphosate (gallons)	Endothall/ Aquathol (gallons)
1950-1969	- -	81,113	- -	- -	- -	10,396	- -	- -	- -	- -	- -
1970	- -	4,095	- -	- -	- -	- -	- -	- -	- -	- -	- -
1971	- -	9,200	- -	- -	- -	- -	- -	- -	- -	- -	- -
1972	- -	7,000	- -	- -	- -	- -	- -	- -	- -	- -	- -
1973	- -	2,433	- -	- -	- -	- -	- -	- -	- -	- -	- -
1974	- -	2,667	- -	- -	- -	- -	- -	- -	- -	- -	- -
1975	- -	2,595	- -	865	- -	- -	- -	- -	- -	- -	- -
1976	- -	- -	- -	1,130	- -	- -	- -	- -	- -	- -	- -
1977	- -	700	- -	875	- -	- -	- -	- -	- -	- -	- -
1978	- -	115	- -	566	- -	- -	- -	- -	- -	- -	- -
1979	- -	20	- -	627	- -	- -	- -	- -	- -	- -	- -
1980	- -	- -	- -	660	- -	- -	- -	- -	- -	- -	- -
1981	- -	- -	- -	67	- -	- -	- -	- -	- -	- -	- -
1982	- -	- -	- -	213	- -	- -	- -	- -	- -	- -	- -
1983	- -	- -	- -	884	- -	- -	- -	- -	- -	- -	- -
1984	- -	- -	- -	915	- -	- -	- -	- -	- -	- -	- -
1985	- -	- -	- -	508	- -	- -	- -	- -	- -	- -	- -
1986	- -	15	- -	723	- -	- -	- -	- -	- -	- -	- -
1987	- -	5	- -	10	- -	- -	- -	- -	- -	- -	- -
1988-1989	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1990	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.2	- -
1991	- -	- -	- -	10	2.0	- -	- -	- -	10.0	1.3	- -
1992	- -	- -	- -	4	1.5	- -	- -	- -	1.5	- -	- -
1993	- -	- -	- -	- -	33.7	- -	- -	- -	19.0	- -	- -
1994	- -	- -	- -	- -	27.5	- -	- -	- -	25.1	- -	- -
1995	- -	- -	- -	- -	79.3	- -	- -	- -	37.5	- -	40.5
1996	- -	2,595	- -	- -	11.0	- -	- -	57.5	11.0	- -	15.0
1997	- -	- -	- -	- -	134.5	- -	2,339.0	- -	23.5	- -	25.7
1998	- -	- -	- -	- -	123.8	- -	900.0	- -	6.7	- -	8.3
1999	- -	- -	- -	- -	- -	- -	2,930.0	32.5	31.3	- -	47.2
2000	127.5	- -	192.2	- -	- -	- -	- -	- -	51.8	- -	38.0
2001	19.2	- -	17.0	- -	- -	- -	- -	- -	12.0	- -	31.5
2002	32.3	- -	22.0	- -	- -	- -	902.9	- -	28.5	- -	31.0
2003	229.1	- -	347.0	- -	- -	- -	2,381.8	56.0	37.5	- -	31.0
2004	11.4	- -	- -	- -	- -	- -	1,250.1	- -	- -	- -	- -
2005	19.7	- -	11.5	- -	- -	- -	854.5	12.7	17.0	- -	- -
2006	28.5	- -	26.8	- -	- -	- -	504.7	26.3	32.8	- -	26.3
2007	20.1	- -	10.0	- -	- -	- -	859.3	- -	10.7	<0.1	10.7
2008	21.1	- -	23.0	- -	- -	- -	- -	- -	10.0	- -	12.0
Total	- -	109,938	649.5	8,057	413.3	10,396	12,922.3	185.0	355.9	1.6	317.2

NOTE: In 2007, 1,332 cubic yards of Eurasian water milfoil, curly-leaf pondweed, and algae were mechanically harvested from Delavan Lake.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 11

AQUATIC PLANT HARVESTING ON DELAVAN LAKE: 1997-2010

Year	Cubic Yards Harvested
1997	3,835
1998	1,430
1999	1,765
2000	4,155
2001	2,869
2002	5,026
2003	5,949
2004	2,288
2005	4,177
2006	2,749
2007[a]	1,332
2008	1,385
2009	1,746
2010	2,392

[a]Lake Lawn Lodge, operating under a one-year permit issued in 2007 for 12 acres, harvested 1,606 cubic yards of Eurasian water milfoil, curly-leaf pondweed, Sago pondweed, and algae.

Source: Delavan Lake Sanitary District, and SEWRPC.

developed in 2002 by SEWRPC.[53] This plan also recommended that a combination of chemical treatment and mechanical harvesting be employed on the Lake with mechanical harvesting being the primary management method, emphasizing the cutting of shared access lanes, rather than the clear-cutting of large open areas, and the surface harvesting of nonnative aquatic plants, such as Eurasian water milfoil, to provide a competitive advantage to the low-growing native plants present in the Lake. The 2002 SEWRPC report recommended that chemical treatments, if necessary, be made in early spring to maximize their effectiveness on nonnative plant species and that such treatments be limited to controlling nuisance growths of exotic species in shallow water around docks and piers, where the harvester is unable to reach. Harvesting records have been maintained by DLSD and amounts of plant material harvested from the Lake since 1997 are presented in Table 11.

FISHERIES AND WILDLIFE

Fishes of Delavan Lake

The fish community in Delavan Lake has undergone significant changes since the time of the 1948 fish survey. At that time, largemouth bass were found to be the dominant gamefish with yellow perch and black crappie being the dominant panfish. By 1959, largemouth bass were reported to be less common,[54] and by 1966, an electrofishing survey found that smallmouth bass had become the most commonly encountered fish in the Lake[55] with largemouth bass reported to be scarce. In 1972,[56] a fish survey conducted on Delavan Lake found walleye had become the principal gamefish in the Lake, northern pike were scarce and largemouth bass were nearly absent. By the 1980s, two undesirable species, carp and bigmouth buffalo, were reported to be dominating the Lake fishery. After the lake rehabilitation project and rotenone treatment in 1989 to 1990, restocking of the Lake fishery by the WDNR was begun in 1990 with the intent on establishing a diverse fish community in Delavan Lake dominated by predator fish. Stocking of Delavan Lake since 1990 is documented in Table 12.

At the time of the previous SEWRPC report, walleye were the most abundant gamefish in Delavan Lake although the population appeared to be in a state of decline. Muskellunge and smallmouth bass populations were small, due in part, it was felt, to intense competition for food with the large population of walleye. In contrast to the

[53]*SEWRPC Community Assistance Planning Report No. 253*, op. cit.

[54]*W.R. Byam*, Fyke Net Survey of Delavan Lake, Walworth County, *Wisconsin Conservation Department Intradepartmental Memo, 1960.*

[55]*D. Mraz*, Electrofishing Survey, September 23, 1966, *Wisconsin Conservation Department Intradepartmental Memo, 1960.*

[56]*R. Piening*, F-1D2 Report with Fisheries Management Recommendations for Delavan Lake, Walworth County, *Wisconsin Department of Natural Resources Intradepartmental Memo, 1973.*

Table 12

FISH STOCKED INTO DELAVAN LAKE

Year	Species Stocked	Number	Average Fish Length (inches) or Age Class
1990	Muskellunge Northern pike Largemouth bass Smallmouth bass Walleye	100,000 400,000/4,914 1,039 241 2,000,000	1.00 1.00/7.50 Adults Adults 1.00
1991	Muskellunge Northern pike Walleye	17,800/2,500 4,000 2,150,000	2.00/10.00 8.00 Fry
1992	Muskellunge Northern pike	2,850/383 3,160	Fingerlings/yearlings 8.00
1993	Muskellunge Northern pike Smallmouth bass	2,670/398 2,500 17,920	11.00/yearlings 8.00 2.00
1994	Muskellunge Northern pike	2,505 2,500	9.90 7.00
1997	Muskellunge Northern pike	2,500 1,181	10.00 7.70
1998	Muskellunge Walleye Smallmouth bass	1,135 1,350,000/213,500 75,500	8.00 Fry/2.30 Fingerlings
1999	Muskellunge Walleye Smallmouth bass	2,500 400,000 69,861	Fingerlings Fry Fingerlings
2000	Walleye Muskellunge	900,000/60,567 250	Fry/fingerlings 9.20
2001	Muskellunge Walleye	4,072 200,000/121,100	10.60 Fry/fingerlings
2002	Muskellunge Walleye	4,136 171,021	10.40 2.00
2003	Muskellunge Walleye	4,144 1,615,000	11.25 Fry
2004	Muskellunge Walleye	2,500 1,200,000/100,709	10.90 Fry/fingerlings
2005	Muskellunge Walleye	2,500 1,300,000/100,866	11.60 Fry/fingerlings
2006	Muskellunge Walleye	1,373 2,118,190/86,132	12.40 Fry/fingerlings
2007	Muskellunge Walleye	1,667 1,000,000	13.00 Fry
2008	Muskellunge Walleye	2,267 72,520	9.80 1.60

NOTE: As part of the restocking of Delavan Lake after the 1989 drawdown and rotenone treatment of the Lake, additional stockings between 1990 and 1993 included a total of 264,341 bluegill, 244,324 yellow perch, 6,484 black crappie, 7,295 pounds of mimic shiners, and 1,325 pounds of fathead minnows.

Source: Wisconsin Department of Natural Resources and SEWRPC.

declining population of walleye, the proportions of largemouth bass and northern pike in the gamefish population of Delavan Lake had been increasing.

Since the restocking of Delavan Lake in 1990, the WDNR initially worked toward achieving a unique balance within the food web of Delavan Lake by seeking to maintain a very large population of walleye in the Lake that would serve to utilize food-chain dynamics to promote water clarity in the Lake. At the time of the previous SEWRPC report, it was felt that the effects of such biomanipulation were beginning to show signs of declining effectiveness that might continue to become more pronounced through the year 2005 as the large 1990 year-class of walleye reach the end of their natural life spans and disappear from the fish community. Currently, the WDNR appears to have moved away from the biomanipulation of fishes in the Lake and moving more toward managing the Lake for largemouth bass and northern pike.

The Lake is considered to have a moderately diverse fish population[57] and the WDNR lists walleye and panfish as "abundant" in Delavan Lake, northern pike as "common," and Muskie, largemouth and smallmouth bass as "present."[58]

Wildlife in the Delavan Lake Area

With respect to wildlife, and given the urbanization of land uses present around the shorelands of Delavan Lake, most of the wildlife remaining would be expected to be urban-tolerant species: smaller animals and waterfowl would be expected to inhabit the lakeshore areas; muskrats, beaver, grey and fox squirrels, and cottontail rabbits are likely the most abundant and widely distributed fur-bearing mammals in the immediate riparian areas; and, larger mammals, such as the whitetail deer, are likely to be confined to the larger wooded areas and the open meadows found within the tributary area of the Lake. The remaining undeveloped areas provide the best-quality cover for many wildlife species.

The Delavan Lake tributary area supports a significant population of waterfowl including mallards, wood duck, and blue-winged teal, as well as an abundance of a Canada goose species that has increased to nuisance levels in recent years throughout the Region. During the migration seasons a greater variety of waterfowl may be present and in greater numbers. To manage the resident Canada goose concern, the Delavan Lake community has sought the assistance of the U.S. Fish and Wildlife Service in controlling the nonmigratory goose population around the Lake, and undertook a successful goose control program during 2010.

Amphibians and reptiles are vital components of the Delavan Lake ecosystem, and include frogs, toads, salamanders, and turtles and snakes, respectively. About 14 species of amphibians and 16 species of reptiles would normally be expected to be present in the Delavan Lake area.

WDNR-Designated Sensitive Areas and Critical Species Habitat

Within or immediately adjacent to bodies of water, the WDNR identifies sites that have special importance biologically, historically, geologically, ecologically, or even archaeologically. Such areas are defined as "areas of aquatic vegetation identified by the Department as offering critical or unique fish and wildlife habitat, including seasonal or life-stage requirements, or offering water quality or erosion control benefits of the body of water" and, after comprehensive examination and study is completed by WDNR staff from many different disciplines and fields of study, are identified as Sensitive Areas pursuant to Chapter NR 107 of the *Wisconsin Administrative Code*. In an effort to protect and maintain these Sensitive Areas, Chapter NR 107 authorizes the Department of

[57]*Wisconsin Department of Natural Resources,* Delavan Lake (Walworth County, Wisconsin) Integrated Sensitive Area Report, *2007.*

[58]*Wisconsin Department of Natural Resources Publication No. PUBL-FM-800-2005,* Wisconsin Lakes, *2005*.

Natural Resources to undertake various management measures, such as: restricting chemical treatment of aquatic plants in Sensitive Areas on lakes and requiring that alternatives to chemical treatment of aquatic plants be evaluated.

In 2005, the WDNR designated five sensitive areas in Delavan Lake; the complete Integrated Sensitive Area Report, containing specific management recommendations for each area,[59] is appended hereto as Appendix B. As described in the WDNR Sensitive Areas report for Delavan Lake, for example, Areas 4 and 5 at the southwestern end of the Lake in Highland's Bay, View Crest, and Ravenswood areas, provide valuable habitat utilized by many fish species for spawning, nursery areas, protective cover, and feeding areas; consequently, recommendations for management of Areas 4 and 5 include the harvesting of "cruising lanes" for fish.[60] Sensitive Areas 1 and 2 in the inlet region at the northeast end of the Lake have been observed to be especially rich in bird species, including State-designated special-concern species black tern and least bittern and State-designated endangered species, Forester tern.[61] Areas 1 and 2 are also of particular importance due to their containing nearly all of the remaining undeveloped shoreline of Delavan Lake, thereby providing the last remaining areas of high-quality wildlife habitat in Delavan Lake.

SEWRPC also has identified natural areas and critical species habitat areas within the Southeastern Wisconsin Region.[62] Map 8 shows those natural areas and critical species habitat sites within the area tributary to Delavan Lake. The Lake Lawn Wetland Complex, a 276-acre wetland complex along Jackson Creek at the north end of Delavan Lake, has received a rating of NA-3 designating it as a Natural Area of local significance. The Elkhorn Railroad Prairie Remnant contains the threatened plant species Prairie milkweed, *Asclepias sullivantii*. Additionally, in the Delavan Lake tributary area, the lakeshore areas located within the environmental corridors, as shown on Map 9, should be candidates for immediate protection through proper zoning or through public ownership.

RECREATIONAL USES AND FACILITIES

As set forth in the regional water quality management plan, Delavan Lake is a multi-purpose waterbody recommended for the maintenance of a warmwater sportfishery and full recreational use in addition to serving year-round as a visual amenity.[63] Active recreational uses include boating, waterskiing, swimming, and fishing during the summer months; and cross-country skiing, snowmobiling, and ice-fishing during the winter. Popular passive recreational uses include walking, bird watching, and picnicking. The Lake experiences intense recreational boating use during open-water periods, especially on weekends and holidays. Indeed, in an intensive

[59]*Wisconsin Department of Natural Resources,* Integrated Sensitive Areas Report, op. cit.

[60]*See Wisconsin Department of Natural Resources Publication No. PUB-WT-781 2004,* The Facts on Eurasian Water-Milfoil, *2004.*

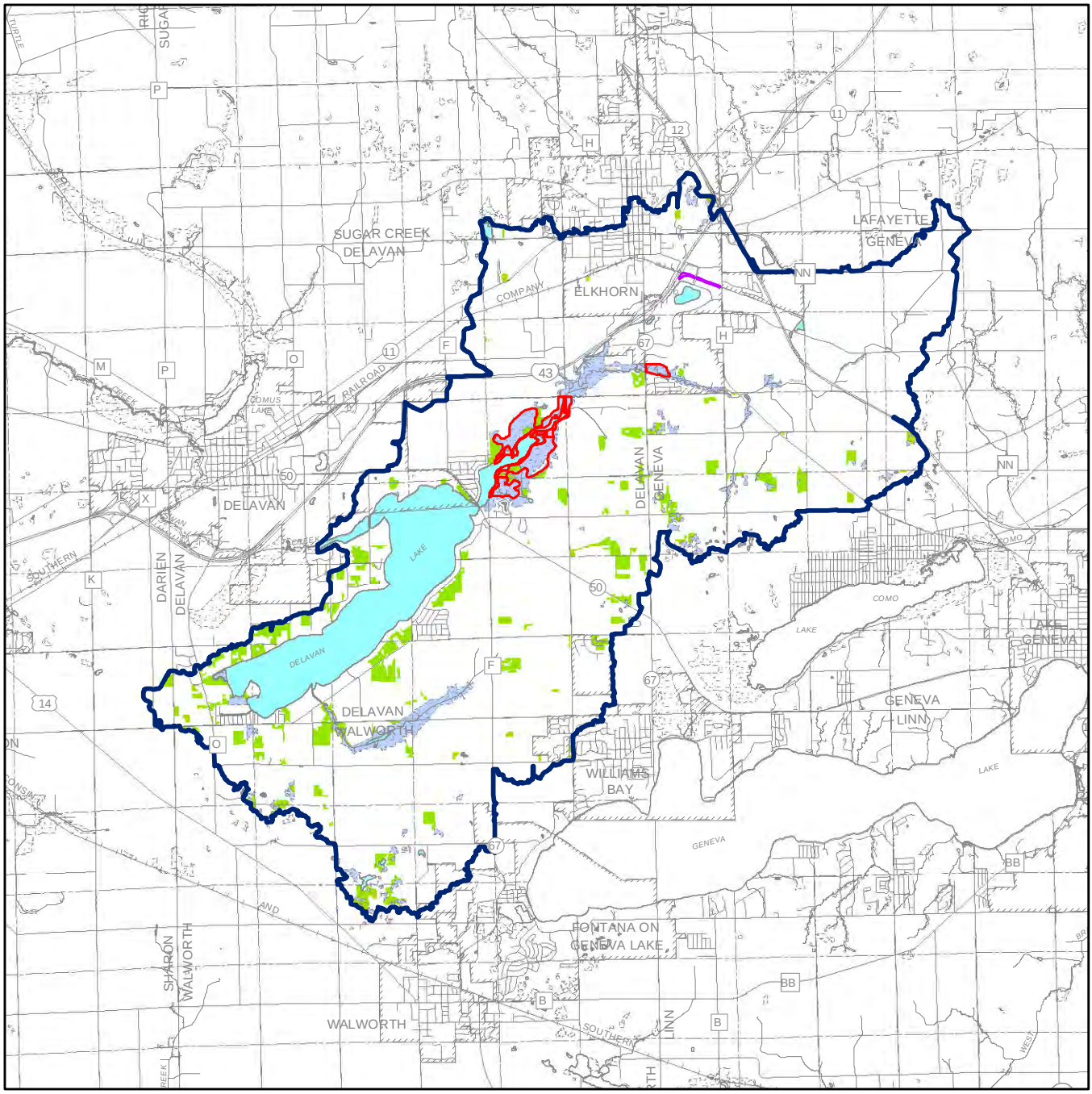
[61]Ibid.

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

[63]*SEWRPC Planning Report No. 30,* op. cit. *See also SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

Map 8

NATURAL AREAS AND CRITICAL SPECIES HABITAT WITHIN THE AREA TRIBUTARY TO DELAVAN LAKE



Natural Area

Critical Species Habitat Site

Woodlands

Wetlands

Surface Water

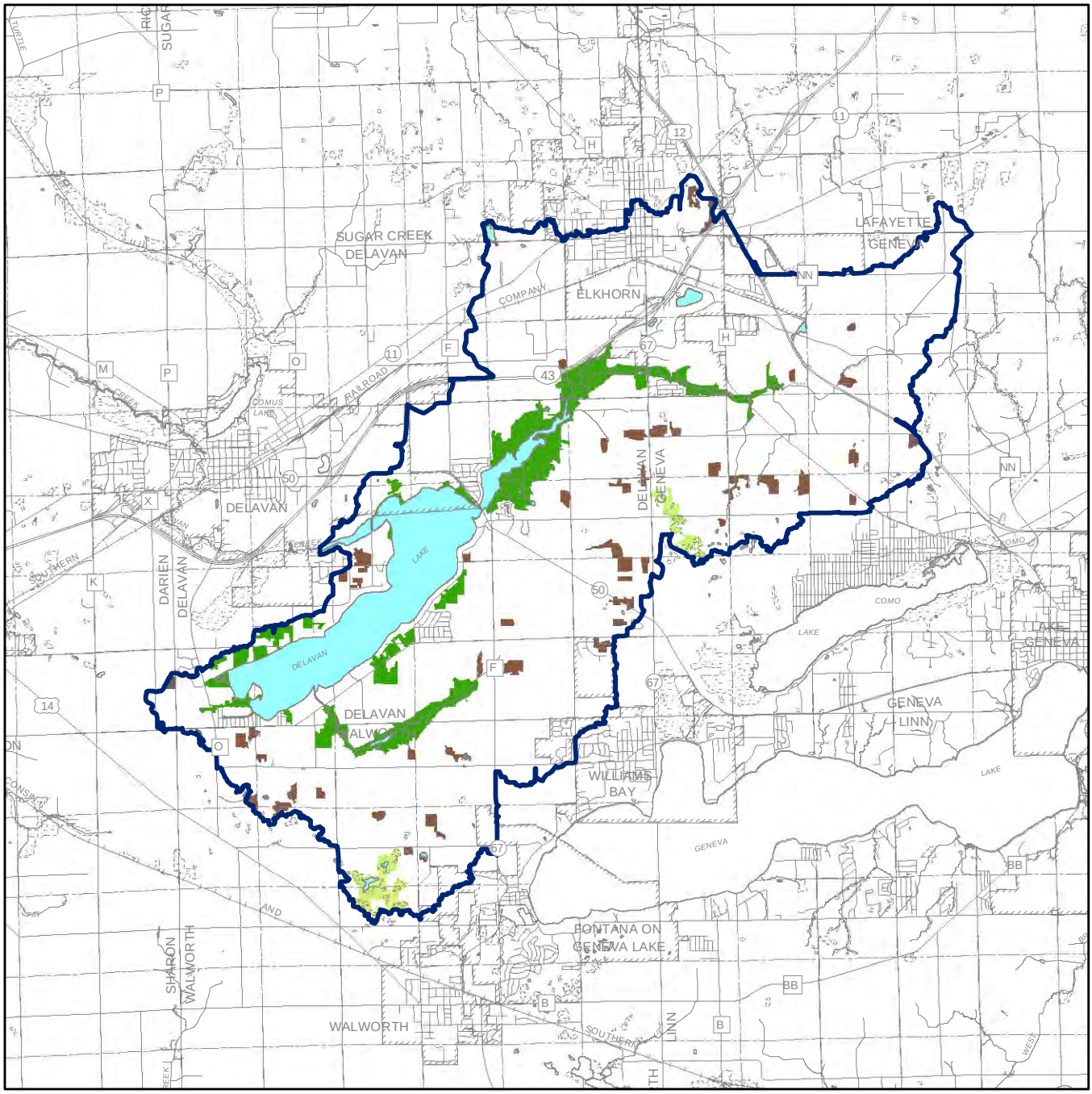
Source: SEWRPC.

N

0 5,000 10,000 Feet

Map 9

PRIMARY ENVIRONMENTAL CORRIDORS WITHIN THE AREA TRIBUTARY TO DELAVAN LAKE: 2005



Primary Environmental Corridor

Secondary Environmental Corridor

Isolated Natural Resource Area

Surface Water

Source: SEWRPC.

statewide survey of boating pressure on Wisconsin's lakes and rivers conducted in 1989 by the WDNR, Delavan Lake was reported to be the sixth most-visited site in the then-WDNR Southeast District.[64]

Parks and Public Access

Delavan Lake is served by a number of parks, both privately owned and public, providing access to the Lake, as shown on Map 10. The Lake is deemed to have adequate public access as defined in Chapter NR 1 of the *Wisconsin Administrative Code,* which establishes quantitative standards for determining the adequacy of public recreation boating access, setting maximum and minimum standards based upon available parking facilities for car-top and car-trailer units.

The major public access site is the Town of Delavan Park, located at the northeast end of the Lake near STH 50, as shown on Map 10. This site provides a paved boat ramp with two docks and paved parking area for more than 100 vehicles with trailers, a picnic area, swimming beach, pavilion, bank fishing and playground areas.

Recreational Use

Delavan Lake plays host to a variety of water-based outdoor recreational activities. The Town of Delavan keeps records of the usage at the Town Park on Delavan Lake; their records indicate that, for the Town Park in 2007, there were 2,729 season pass users, 802 beach users, 940 bank fishers, and 4,592 people who engaged in general park activities. Because of Delavan Lake's size, boating and boating-related (such as angling and scenic viewing) usage is the major recreational component on the Lake. Records of boats launched from the Town Park public access, shown in Table 13, indicate that the number of boats launched has increased nearly eight-fold since 1988. Records for other launch sites around the Lake were not available.

The Delavan Lake Sanitary District has conducted annual riparian watercraft surveys since 1987. The results of these surveys, as shown in Table 14, indicate that about 1,982 watercraft were moored on the Lake or stored on shore in 1999 compared to about 2,104 in 2008. The types of watercraft docked or moored on a lake, as well as the relative proportion of nonmotorized to motorized watercraft, reflect the attitudes of the primary users of the lake, the lake residents. The 2008 riparian watercraft survey on Delavan Lake showed motorized watercraft capable of high speed accounted for at least 70 percent of all types of watercraft, with motorboats comprising the single largest category. The term "motorboat" is general and can include power ("ski") boats, as well as fishing boats. For purposes of this report, it was assumed that approximately 75 percent of boats classified as "motor-boats" would be capable of high speed. Such a high percentage of high-speed boats would indicate that recreational high-speed boating is a major active recreational use on Delavan Lake.

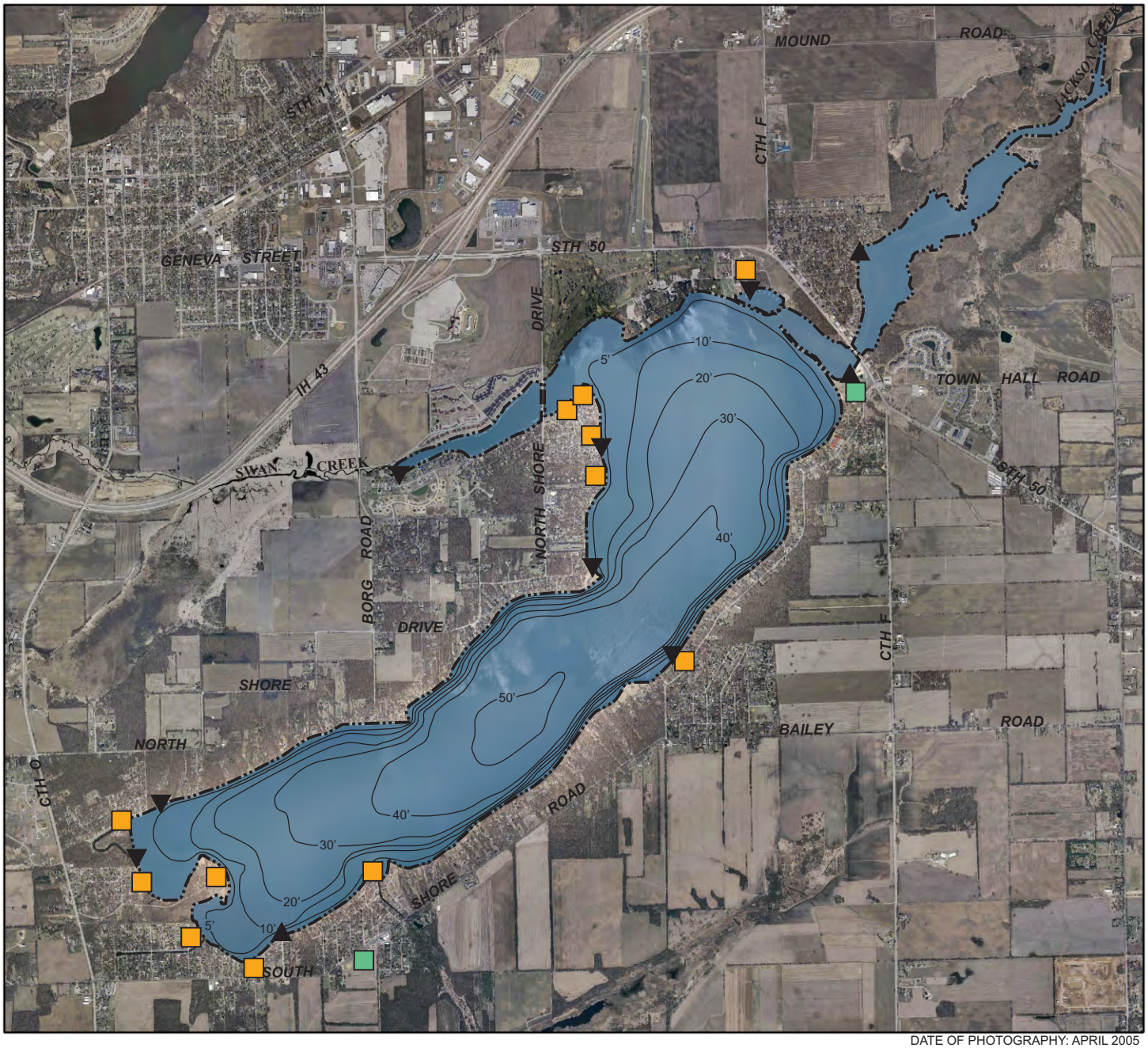
To assess the degree of recreational boat use on a lake, it has been estimated that, in the Southeastern Wisconsin Region, the number of watercraft operating on a lake at any given time is between about 2 percent and 5 percent of the total number of watercraft docked and moored. On Delavan Lake, this would amount to somewhere between 42 and 105 watercraft of all kinds, about 70 percent of which would be motorized and capable of high-speed operation.

There is a range of opinions on the issue of what constitutes optimal boating density, or number of acres of open water available in which to operate a boat on a lake. In this regard, during the mid-1980s, an average area of about 16 acres per powerboat or sailboat was, at that time, considered suitable for the safe and enjoyable use of a boat on a lake. Over time, motorized watercrafts of all kinds have steadily increased in power and speed. For safe waterskiing and fast boating, the regional park and open space plan suggested an area of 40 acres per boat as the

[64]*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.*

Map 10

RECREATIONAL FACILITIES IN THE VICINITY OF DELAVAN LAKE: 2009



DATE OF PHOTOGRAPHY: APRIL 2005

▲ PUBLIC BOAT ACCESS

▼ PRIVATE BOAT ACCESS

■ PUBLIC OUTDOOR RECREATIONAL AND OPEN SPACE SITE

■ PRIVATE OUTDOOR RECREATIONAL AND OPEN SPACE SITE

GRAPHIC SCALE

0 1750 3500 FEET

Source: SEWRPC.

Table 13

BOATS LAUNCHED FROM TOWN PARK ACCESS TO DELAVAN LAKE: 1988-2008

Year	Total Number of Boats Launched
1988	2,412
1989	2,331
1991	2,569
1992	6,467
1993	7,860
1994	8,644
1995	8,471
1996	12,336
1997	9,584
1998	8,146
1999	7,899
2000	11,823
2001	12,580
2002	12,872
2003	14,658
2004	16,756
2005	15,768
2006	13,225
2007	13,918
2008	18,210

NOTE: No records were available for the 1990 season due to low lake levels produced during the lake rehabilitation project.

Source: Delavan Lake Sanitary District and SEWRPC.

minimum area necessary for safe operations.[65] Using these guidelines, estimates of the density of boats capable of high speeds on Delavan Lake, based on the counts of riparian watercraft docked or moored around the Lake, would produce boating densities between about one boat per 28 acres to about one boat per 69 acres.

Another way to assess the degree of recreational boat use on a lake is through direct counts of boats actually in use on a lake at a given time. During 2009, surveys to assess the types of watercraft in use on a typical summer weekday and a typical summer weekend day were conducted by SEWRPC staff. The results of these surveys are shown in Table 15. As shown in the table, fishing boats were the most popular watercraft in use on the Lake during weekdays and weekends. Fishing boats represented over 70 percent of all types of boats in use on weekdays and nearly 50 percent of all types of boats in use on weekends. Based on counts of boats actually in use, the density of high-speed watercraft on the Lake on weekdays ranged from 59 acres per boat in the morning to 122 acres per boat in the afternoon; on weekends, the range was from 38 acres per boat in the afternoon to 83 acres per boat in the morning. In general, mornings were the busiest times on weekdays mornings, mainly fishing boats; on weekends, afternoons were the busiest times with powerboats, fishing boats and pontoon boats being in use the most. These densities on weekdays and weekends are generally within those considered appropriate for the conduct of safe high-speed boating activities. It is noted, however, that the higher degree of boating activity that often occurs on regional lakes during holiday weekends may produce high-speed boating densities that temporarily exceed the guideline values.

Table 16 shows how people were using Delavan Lake recreationally during a typical summer weekday and a typical summer weekend in 2009. The most popular recreational activity, both on weekdays and weekends, was fishing from boats; other popular activities were going to parks and pleasure boating. Other recreational activities on the Lake included swimming, waterskiing/tubing, pleasure boating, fishing from shore, operating personal watercraft, sailing, and canoeing/paddle boating.

Recreational boating activities on Delavan Lake are currently regulated through Town ordinances as appended hereto in Appendix C.

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

Table 14

WATERCRAFT DOCKED OR MOORED ON DELAVAN LAKE[a]

Year	Motorboat	Pontoon Boat	Sail Boat	Personal Watercraft	Canoes and Others	Total
1999	1,035	369	160	283	135	1,982
2008	1,023	424	114	307	236	2,104

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

Source: Delavan Lake Sanitary District and SEWRPC.

Table 15

WATERCRAFT IN USE ON DELAVAN LAKE: JULY 2009

Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Tuesday, June 30									
9:30 a.m. to 11:30 a.m.	3	5	50	2	5	0	0	0	65
12:00 p.m. to 2:00 p.m.	4	3	20	0	5	0	0	0	32
Saturday, August 22									
9:00 a.m. to 10:00 a.m.	4	2	37	0	18	0	0	0	61
1:30 p.m. to 2:30 p.m.	21	14	28	5	1	3	1	0	73

Source: SEWRPC.

Table 16

RECREATIONAL USE IN/ON DELAVAN LAKE: JULY 2009

Date and Time	Weekday Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Tuesday, June 30										
9:30 a.m. to 11:30 a.m.	5	10	0	5	0	2	80	0	25	127
12:00 p.m. to 2:00 p.m.	2	8	6	0	0	0	67	0	2	55
Total for the Day	7	18	6	5	0	2	147	0	27	212
Percent	3	8	3	2	0	1	70	0	13	100

Date and Time	Weekend Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Saturday, August 22										
9:00 a.m. to 10:00 a.m.	2	14	0	20	0	0	88	0	50	174
1:30 p.m. to 2:30 p.m.	7	80	18	2	6	8	73	6	104	304
Total for the Day	9	94	18	22	6	8	161	6	154	478
Percent	2	20	4	5	1	2	34	1	31	100

Source: SEWRPC.

LOCAL ORDINANCES

As shown in Table 17, the Towns of Darien, Delavan, Geneva, Lafayette, Sharon, Sugar Creek, and Walworth have adopted the Walworth County ordinances in regard to general zoning, floodland zoning, shoreland or shoreland-wetland zoning, and subdivision control. The Towns of Darien, Delavan, Lafayette, Sugar Creek, and Walworth have also adopted Town ordinances in regards to subdivision control. The Towns of Lafayette, Sharon, Sugar Creek, and Walworth have each adopted the county ordinances in regards to construction site erosion control/stormwater management. The Villages of Fontana and Williams Bay have each adopted their own village ordinances in regards to general zoning, floodland zoning, shoreland or shoreland-wetland zoning, subdivision control, and construction site erosion control and stormwater management. The Cities of Delavan and Elkhorn have each adopted their own city ordinances in regards to general zoning, subdivision control and construction site erosion control and stormwater management. The City of Delavan has its own ordinances in regards to floodland zoning and shoreland or shoreland-wetland zoning. Walworth County has adopted ordinances regarding general zoning, floodland zoning, shoreland or shoreland-wetland zoning, subdivision control (floodland and shoreland only), and construction site erosion control and stormwater management.

Table 17

LAND USE REGULATIONS WITHIN THE AREA TRIBUTARY TO DELAVAN LAKE IN WALWORTH COUNTY BY CIVIL DIVISION

Community	Type of Ordinance				
	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
Walworth County	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Floodland and shoreland only	Adopted
City of Delavan	City ordinance	City ordinance	City ordinance	City ordinance	City ordinance
City of Elkhorn	City ordinance	- -	- -	City ordinance	City ordinance
Village of Fontana-on-Geneva-Lake	Village ordinance	Village ordinance	Village ordinance	Village ordinance	Village ordinance
Village of Williams Bay	Village ordinance	Village ordinance	Village ordinance	Village ordinance	Village ordinance
Town of Darien	County ordinance	County ordinance	County ordinance	County and town ordinances	- -[a]
Town of Delavan	County ordinance and ETZ[b]	County ordinance	County ordinance	County and town ordinances	- -[a]
Town of Geneva	County ordinance and ETZ[b]	County ordinance	County ordinance	County ordinance	- -[a]
Town of Lafayette	County ordinance and ETZ[b]	County ordinance	County ordinance	County and town ordinances	County
Town of Sharon	County ordinance	County ordinance	County ordinance	County ordinance	County
Town of Sugar Creek	County ordinance	County ordinance	County ordinance	County and town ordinances	County
Town of Walworth	County ordinance and ETZ[b]	County ordinance	County ordinance	County and town ordinances	County

[a]*The Towns of Darien, Delavan, and Geneva administer one- and two-family erosion control regulations locally, other than within shoreland areas, where the County is responsible for enforcement.*

[b]*Cities and villages are granted certain extraterritorial zoning (ETZ) authority within town areas under Section 62.23(7a) of the* Wisconsin Statutes*. For first, second, and third class cities (population of at least 10,000), the ETZ jurisdiction area may extend up to three miles from their corporate limits; for fourth class cities (population less than 10,000) and for villages, the ETZ jurisdiction area may extend up to 1.5 miles from their corporate limits. Under the* Statutes*, cities and villages may, of their own accord, adopt interim zoning to preserve existing land uses within extraterritorial zoning areas for a period of two years. In most other respects, extraterritorial zoning is a joint venture between the city or village and the concerned town. Other than for the initial adoption of the interim zoning, the governing body of the city or village may adopt or amend zoning within the extraterritorial area only upon the approval by a majority of an extraterritorial zoning committee, comprised of three members of the city or village plan commission and three members appointed by the concerned town board. The initial interim zoning may be extended up to one year by the governing body of the city or village, but only upon the recommendation of the joint extraterritorial zoning committee. The prescribed composition of the joint extraterritorial zoning committee places towns on equal footing with cities and villages in extraterritorial zoning matters, other than for the initial adoption of the interim extraterritorial zoning. When extraterritorial zoning is enacted, the county government retains zoning authority within statutory shoreland areas.*

Source: SEWRPC.

Chapter III

ALTERNATIVE AND RECOMMENDED AQUATIC PLANT MANAGEMENT PRACTICES

INTRODUCTION

Delavan Lake generally contains a robust, if not overly diverse, aquatic plant community capable of supporting a warmwater fishery, albeit with some areas that suffer impairment of recreational boating opportunities and other lake-oriented activities due to an overabundance of aquatic macrophytes. For example, in those areas of the Lake where Eurasian water milfoil (*Myriophyllum spicatum*) is abundant, certain recreational uses are limited, the aesthetic quality of the Lake is impaired, and in-lake habitat degraded. Eurasian water milfoil is listed as a nonnative invasive species.[1] The plant primarily interferes with recreational boating activities by encumbering propellers, clogging cooling water intakes, snagging paddles, and slowing sailboats by wrapping around keels and control surfaces. The plant also causes concern among swimmers who find the plant stalks distasteful. Thus, without control measures, these areas can become problematic to navigation, fishing, and swimming. Native aquatic plants, generally found at slightly deeper depths, pose fewer potential problems for navigation, swimming, and fisheries, and generally have attributes that sustain a healthy fishery. Many native aquatic plants provide fish habitat and food resources, and offer shelter for juvenile fishes and young-of-the-year fish.

In this chapter, alternative and recommended actions for the management of aquatic plants in Delavan Lake are presented. These measures are focused primarily on those measures which can be implemented by the Town of Delavan and the Delavan Lake Sanitary District (DLSD),[2] in cooperation with the Delavan Lake Improvement Association (DLIA), Kettle Moraine Land Trust (KMLT), and Delavan Lake Watershed Initiative Network

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[1]*See Chapter NR 109 of the* Wisconsin Administrative Code. *Section NR 109.07 (2) states that "The following aquatic plants are designated as invasive aquatic plants statewide: Eurasian water milfoil, curly leaf pondweed and purple loosestrife."*

[2]*Delavan Lake is "central" to the strategic plan of the Delavan Lake Sanitary District, forming the second of three strategic goals of the District, which include the following: Strategy One, deliver timely and cost effective maintenance, upgrades and expansion of the collection system;* ***Strategy Two, create and maintain long term cooperative alliances with qualified entities involved in lake management activities within the Delavan Lake watershed****; and, Strategy Three, develop and sustain an effective, professional business culture with a focus on excellence in performance and in all aspects of communication and customer service.*

(Delavan Lake WIN), with lesser emphasis given to those measures which are applicable to other agencies and organizations having jurisdiction or interests within the area tributary to the Lake. Collectively, these five entities represent a progression of focus from an in-lake and lakeshore focus on the part of the Town, DLSD, and DLIA, to the larger watershed focus of the KMLT and Delavan Lake WIN.

AQUATIC PLANT MANAGEMENT

As stated in Chapter II of this report, recent aquatic plant management activities in Delavan Lake can be categorized as a combination approach, utilizing mechanical harvesting and chemical herbicide treatment to manage nuisance levels of aquatic plant growth in the Lake. In addition, individual householders on Delavan Lake are known to have engaged in manual harvesting and chemical control of aquatic plants in the vicinities of their piers and docks.

The shoreland and aquatic macrophyte management elements of this plan consider alternative management measures consistent with the provisions of Chapters NR 103, NR 107, and NR 109 of the *Wisconsin Administrative Code*. Further, the alternative aquatic plant management measures are consistent with the requirements of Chapter NR 7 of the *Wisconsin Administrative Code*, and with the public recreational boating access requirements relating to the eligibility under the State cost-share grant programs, set forth under Chapter NR 1 of the *Wisconsin Administrative Code*.

ARRAY OF AQUATIC PLANT MANAGEMENT MEASURES

Aquatic plant management measures can be classed into four groups: ***physical measures***, which include lake bottom coverings and water level management; ***biological measures***, which include the use of various organisms, including herbivorous insects and plantings of aquatic plants; ***manual*** and ***mechanical measures***, which include harvesting and removal of aquatic plants; and, ***chemical measures***, which include the use of aquatic herbicides. All control measures are stringently regulated and require a State of Wisconsin permit; chemical controls are regulated under Chapter NR 107 of the *Wisconsin Administrative Code*, and all other aquatic plant management practices are regulated under Chapter NR 109 of the *Wisconsin Administrative Code*. Placement of bottom covers, a physical measure, also requires a Wisconsin Department of Natural Resources (WDNR) permit under Chapter 30 of the *Wisconsin Statutes*. Costs range from minimal for manual removal of plants using rakes and hand-pulling, to upwards of $75,000 for the purchase of a mechanical plant harvester, for which the operational costs can approach $2,500 to $25,000 per year, depending on staffing and operation policies.

Physical Measures

Lake bottom covers and light screens provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. They have been used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motorboating. Sand and gravel are usually widely 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. However, such materials, known as bottom screens or barriers, generally have to be placed and removed annually. Such barriers also are susceptible to disturbance by watercraft propellers or the build-up of gasses from decaying plant biomass trapped under the barriers. In the case of Delavan Lake, the need to encourage native aquatic plant growth while simultaneously controlling the growth of Eurasian water milfoil, suggests that the placement of lake bottom covers as a method to control aquatic plant growth does not appear to be warranted. Thus, such measures are not considered viable for Delavan Lake.

Biological Measures

Biological controls offer an alternative approach to controlling nuisance plants. Classical biological control techniques have been successfully used to control nuisance plants with herbivorous insects.[3] However, the few studies of Eurasian water milfoil control utilizing *Eurhychiopsis lecontei*, an aquatic weevil species, have resulted in variable levels of control, with little control being achieved on those lakes having extensive motorized boating traffic. Thus, the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control is not considered a viable option for use on Delavan Lake at this time.

The use of grass carp, *Ctenopharyngodon idella*, an alternative biological control used elsewhere in the United States, is not permitted in Wisconsin. This voracious herbivore has been shown to denude lakes and ponds of aquatic vegetation, exposing lake bottom sediments to wind erosion and increasing turbidity in lakes and ponds, and enhancing the likelihood of occurrence of nuisance algal blooms.[4]

A variation on the theme of biological control is the introduction of aquatic plants into a waterbody as a means of encouraging or stimulating the growth of desirable native aquatic plant species in a lake. While few projects of this nature have been undertaken in the Southeastern Wisconsin Region, the Lac La Belle Management District, in partnership with the WDNR and University of Wisconsin-Milwaukee, did attempt to supplement the aquatic plant community of that Lake by selectively planting pondweeds (*Potamogeton* spp.).[5] Several hundred pondweeds were transplanted into Lac La Belle, and, while there is some evidence that a few of these transplants were successful, the net outcome of the project was disappointing. Few of the introduced plants were observed in subsequent years.[6] Given the apparent low success rate, supplemental plantings are not considered to be a viable aquatic plant management option for Delavan Lake at this time.

Manual and Mechanical Measures

The physical removal of specific types of vegetation by selective harvesting of plants provides a highly selective means of controlling the growths of nuisance aquatic plant species, including Eurasian water milfoil. Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, manual harvesting of aquatic plants within a 30-foot-wide corridor along a 100-foot length of shoreline would be allowed without a WDNR permit, provided the plant material is removed from the Lake. Harvested aquatic plant material can be used as compost, providing a source of moisture for the composting process, but adding relatively little organic material to the compost. Any other manual harvesting would require a State permit, unless employed in the control of designated nonnative invasive species, such as Eurasian water milfoil or curly-leaf pondweed.

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[3]*B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control,"* LakeLine, *Vol. 17, No. 3, September 1997, pp. 20-21, 34-3; see also, 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; and C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology, *John Wiley, New York, New York, USA.*

[4]*C. Holdren, W. Jones and J. Taggart,* Managing Lakes and Reservoirs, *Third Edition, North American Lake Management Society, Terrene Institute, and U.S. Environmental Protection Agency, 2001.*

[5]*Donald H. Les and Glenn Guntenpergen, "Laboratory Growth Experiments for Selected Aquatic Plants, Final Report, July 1989 – June 1990 (Year 1)," Report to the Wisconsin Department of Natural Resources, June 1990; Wisconsin Department of Natural Resources,* Environmental Assessment: Improvement of the Water Quality and Fisheries Habitat of LacLaBelle [sic] and the Lower Oconomowoc River, *s.d.*

[6]*At the 2003 annual meeting of the Lac La Belle Management District, a citizen reported observing a herbicide application in the vicinity of the planted area of the Lake. Such an application might explain the observed lack of success of this management measure. See SEWRPC Community Assistance Planning Report No. 47, 2nd Edition,* A Water Quality Management Plan for Lac La Belle, Waukesha County, Wisconsin, *May 2007.*

Aquatic macrophytes also may be harvested mechanically with specialized equipment consisting of a cutting apparatus, which cuts up to about five feet below the water surface, and a conveyor system that picks up the cut plants. Mechanical harvesting can be a practical and efficient means of controlling plant growth as it removes the plant biomass and nutrients from a lake. Mechanical harvesting is particularly effective as a measure to control large-scale growths of aquatic plants. Narrow channels can be harvested to provide navigational access and "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish. The harvesting of water lilies and other emergent native plants should be avoided.

"Clear cutting" aquatic plants and denuding the lake bottom of flora, using either manual or mechanical harvesting, should be avoided. However, top cutting of plants, such as Eurasian water milfoil, using mechanical harvesters, as shown in Figure 2, has proven to be beneficial in some lakes as a means of minimizing the competitive advantage of the Eurasian water milfoil plant and encouraging native aquatic plant growths.[7]

In the nearshore area, specially designed rakes are available to assist in the manual removal of nuisance aquatic plants, such as Eurasian water milfoil. The use of such rakes also provides a safe and convenient method of controlling aquatic plants in deeper nearshore waters around piers and docks. The advantage of the rakes is that they are relatively inexpensive—costing between $100 and $150 to purchase from various suppliers, easy and quick to use, and immediately remove the plant material from the lake, without a waiting period. Removal of the plants from the lake avoids the accumulation of organic matter on the lake bottom, which adds to the nutrient pool that favors further plant growth. State permitting requirements for manual aquatic plant harvesting mandate that the harvested material be removed from the lake. Should the DLSD acquire a number of these specially designed rakes, they could be made available for the riparian owners to use on a trial basis to test their operability before purchasing them.

Hand-pulling of stems, where they occur in isolated stands, provides an alternative means of controlling plants, such as Eurasian water milfoil, in the Lake. Because this is a more selective measure, the rakes being nonselective in their harvesting, manual removal of Eurasian water milfoil is considered a viable option in Delavan Lake, where practicable and feasible.

An advantage of mechanical aquatic plant harvesting is that the harvester typically leaves enough plant material in the lake to provide shelter for fish and other aquatic organisms, and to stabilize the lake bottom sediments. Aquatic plant harvesting also has been shown to facilitate the growth of native aquatic plants in harvested areas by allowing light penetration to the lakebed. Many native aquatic plants are low-growing species that are less likely to interfere with human recreational and aesthetic uses of a lake. A disadvantage of mechanical harvesting is that the harvesting operation may cause fragmentation of plants and, thus, unintentionally facilitate the spread of some plants that utilize fragmentation as a means of propagation, namely Eurasian water milfoil. Harvesting may also disturb bottom sediments in shallower areas where such sediments are only loosely consolidated, thereby increasing turbidity and resulting in deleterious effects, including the smothering of fish breeding habitat and nesting sites. Disrupting the bottom sediments also could increase the risk that an exotic species, such as Eurasian water milfoil, may colonize the disturbed area since this is a species that tends to thrive under disturbed bottom conditions. To this end, most WDNR-issued permits do not allow harvesting in areas having a water depth of less than three feet, which would limit the utility of this alternative in some littoral areas of the Lake and, especially, in the inlet and outlet. Harvesting in the inlet is particularly problematic given the inability of the harvester to navigate under the STH 50 bridge. Nevertheless, if done correctly and carefully, harvesting has been shown to be of benefit in ultimately reducing the regrowth of nuisance plants when used under conditions suitable for this method of control.

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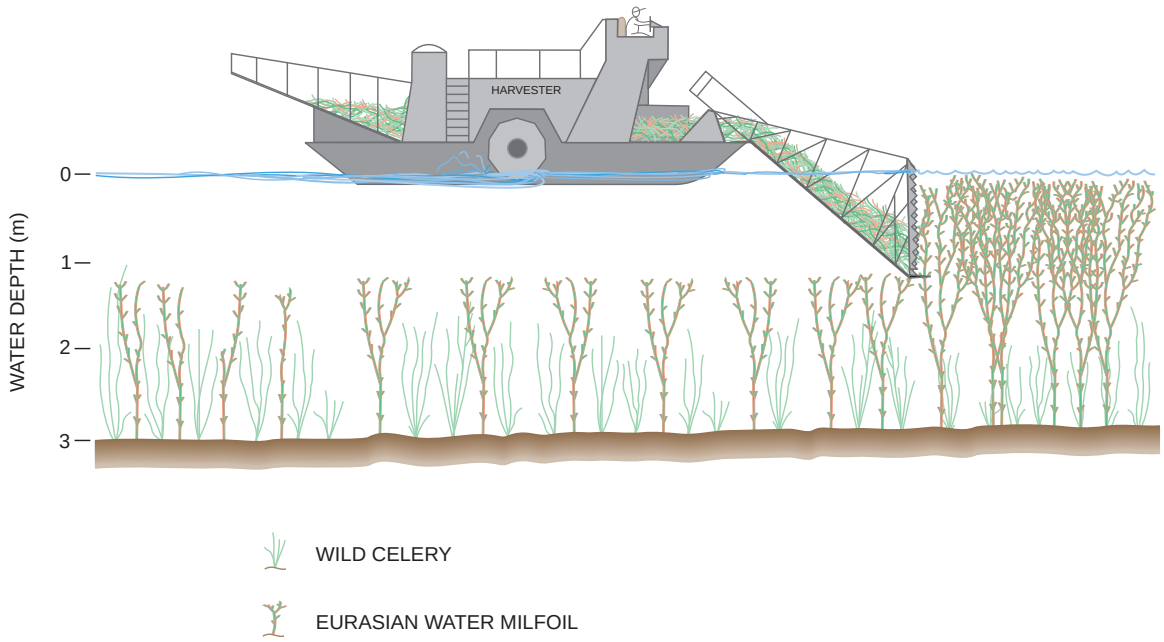
[7]*See SEWRPC Memorandum Report No. 143*, An Aquatic Plant Management Plan for the Lauderdale Lakes, Walworth County, Wisconsin, *August 2001*.

Figure 2

PLANT CANOPY REMOVAL WITH AN AQUATIC PLANT HARVESTER



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

Source: Wisconsin Department of Natural Resources and SEWRPC.

Given the extent of areas needing aquatic plant management, the nature of the bottom sediments and species composition in these areas, mechanical harvesting continues to be considered a viable management option as a control of aquatic plants in areas of Delavan Lake, subject to permit requirements and provisions.

Chemical Measures

Chemical treatment with herbicides is a short-term method of controlling heavy growths of nuisance aquatic plants. Chemicals are generally applied to the growing plants in either a liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophytes growth are the relatively low-cost and the ease, speed, and convenience of application. The disadvantages associated with chemical control include unknown long-term effects on fish, fish food sources, and humans; a risk of increased algal blooms due to the eradication of macrophyte competitors; an increase in organic matter in the sediments, possibly leading to increased plant growth, as well as anoxic conditions which can cause fishkills; adverse effects on desirable aquatic organisms; loss of desirable fish habitat and food sources; and, finally, a need to repeat the treatment the following summer due to existing seed banks and/or plant fragments. Widespread chemical treatments can also provide an advantage to less desirable, invasive, introduced plant species to the extent that such treatments may produce conditions in which nonnative species can outcompete the more beneficial, native aquatic plant species. Hence, this is seldom a feasible management option to be used on a large scale. Widespread chemical treatment, therefore, is not considered a viable option for Delavan Lake, although limited chemical control is often a viable technique for the control of the relatively small-scale infestations of aquatic plants, such as Eurasian water milfoil.

To minimize the possible impacts of deoxygenation, loss of desirable plant species, and contribution of organic matter to the sediments, early spring or late fall applications should be considered.[8] Such applications also minimize the concentration and amount of chemicals used due to the facts that colder water temperatures enhance the herbicidal effects, while the application of chemical herbicides during periods when most native aquatic plants species are dormant limit the potential for collateral damage. Use of chemical herbicides in aquatic environments is stringently regulated and requires a WDNR permit and WDNR staff oversight during applications.

Use of early spring chemical controls, especially in those shoreline areas where mechanical harvesting would not be deemed viable, targeting growths of Eurasian water milfoil or other invasive nuisance aquatic plants in and around the Lake, is considered a viable option for Delavan Lake, subject to permit requirements and provisions.

In general, the use of chemical algicides is not recommended. However, such use may be warranted in advance of peak use periods, such as the mid-summer Independence Day holiday. Limited use of copper-based algicides during such periods may be warranted to limit human exposure to algal excretory products, especially those released by blue-green algae (cyanobacteria). Blue-green algae have the ability to produce a range of biological toxins, encompassing hepato- and neuro-toxic secondary metabolites that are most commonly known from the cyanobacterial genera *Anabaena*, *Aphanizomenon*, *Cylindrospermopsis*, *Microcystis*, *Nodularia*, *Nostoc*, and *Oscillatoria*. The majority of poisoning incidents, which largely affect domestic animals, are the result of acute or sub-acute liver toxicity caused by microcystins, although there are reported cases of human toxicity arising from prolonged exposure to blue-green algal toxins. The toxins, however, are produced in a random and unpredictable fashion—the mere presence of the algal genera does not indicate the presence of toxic forms. In order to reliably determine potential algal toxicity, monitoring algal toxins using an ELISA technique has proven robust and useful for standardized screening of blue-green algal-rich samples. The WDNR has been experimenting with such monitoring in recent years.[9]

RECOMMENDED AQUATIC PLANT MANAGEMENT MEASURES

The most-effective plans for managing aquatic plants rely on a combination of methods and techniques, such as those described above. Therefore, to enhance the recreational uses of Delavan Lake, while maintaining the quality and diversity of the biological communities, the following recommendations are made:

- Manual harvesting around piers and docks by riparian owners is the recommended means of controlling nonnative nuisance species of plants in those areas. In this regard, the DLSD could consider purchasing several specialty rakes designed for the removal of vegetation from shoreline property and make these available to riparian owners. This would allow the riparian owners to use the rakes on a trial basis before purchasing their own. Although the rakes do not require a permit for use along a 30-foot-wide length of shoreline, State requirements for manual aquatic plant harvesting mandate that the harvested material be removed from the lake. Where feasible and practicable, hand-pulling of stems, where they occur in isolated stands, is also recommended as an alternative means of controlling Eurasian water milfoil. Manual control should target nonnative species.

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[8]*It should be noted that, at the time of writing, late fall herbicide treatments are considered to be experimental in Wisconsin and will not typically be permitted by the WDNR at this time, pending further research into the use of such treatments. It also is noted that many aquatic plants become dormant during the late fall and winter, die back, and do not meet the nuisance standards established pursuant to Chapter NR 107 of the* Wisconsin Administrative Code *as the basis for the application of aquatic herbicides. Consequently, late fall applications of herbicides are not recommended.*

[9]*See C.J. Hedman, W.R. Krick, D.A. Perkins, E.A. Harrahy, W.C. Sonzogni, "New Measurements of Cyano-bacterial Toxins in Wisconsin Water,"* Journal of Environmental Quality, *Volume 37, Number 5, 2008, pages 1817-1824.*

- It is recommended that the use of chemical herbicides be limited to controlling nuisance growths of exotic species, in particular Eurasian water milfoil and curly-leaf pondweed. It is recommended that chemical applications, if required, be made by licensed applicators in early spring or late fall, 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 somewhat selectively control Eurasian water milfoil and curly-leaf pondweed, such as 2,4-D and endothall,[10] should be used.

- Due to the significant, recurring filamentous algae problem in Delavan Lake, the use of algicides, such as Cutrine Plus, is recommended.[11] Care should be taken in the use of this algicide since valuable macroscopic algae, such as *Chara* and *Nitella*, are killed by this product. Indeed, the 2008 aquatic plant survey conducted by Aron & Associates, noted the continued decline of *Chara* in the Lake. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners: property owners and visitors should be advised to avoid contact with water that looks like "pea soup," shower after coming into contact with any surface water (whether or not a blue-green algae bloom appears to be present; surface waters may contain other species of potentially harmful bacteria and viruses), and avoid treating such waters with algicides as toxins may be released into the water when blue-green algal cells die off.

- Mechanical harvesting, used in concert with an annual herbicide treatment, should be continued as a method of aquatic plant management in Delavan Lake in those areas where depth of water and bottom sediment types are conducive to mechanical harvesting; in those areas of the Lake, its inlet, and outlet which are of insufficient water depth and preclude mechanical harvesting, manual harvesting in concert with an annual herbicide treatment is recommended.

- Few lakes in southeastern Wisconsin lack aquatic plant growth, and Delavan Lake is no exception. However, some areas of the Lake could benefit from a greater diversity of native aquatic plants, especially where low-growing plants, such as muskgrass, which provide food and shelter for fish and waterfowl occur. Because of their low-growing height, these species are often outcompeted by the nonnative Eurasian water milfoil. Eurasian water milfoil grows rapidly to the lake surface, capturing the available sunlight and shading out the native species. Thus, control of the Eurasian water milfoil, using manual and chemical means as noted above, is one means of promoting the growth of native plants, and is considered a viable option for Delavan Lake.

- Through informational programming, riparian owners should be encouraged to monitor their shoreline areas, as well as open-water areas of the Lake, for new growths of nonnative nuisance plants and report such growths immediately to the Town of Delavan, DLSD, and WDNR so that a timely and effective response can be executed. The “May Day at the Lake” or similar awareness event should be continued to encourage the involvement of stakeholders at all levels in the lake management process.

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[10]*See Wisconsin Department of Natural Resources PUBL-WR-236 90,* Chemical Fact Sheet: 2,4-D, *May 1990; see also Wisconsin Department of Natural Resources PUBL-WR-237 90,* Chemical Fact Sheet: Endothall, *May 1990.*

[11]*See Wisconsin Department of Natural Resources PUBL-WR-238 90,* Chemical Fact Sheet: Copper Compounds, *May 1990.*

- Maintenance of the shoreline demonstration project at the Town of Delavan Community Park public recreational boating access site at STH 50 and South Shore Drive is recommended to encourage other lakefront property owners to diversify the shoreland environment, providing greater habitat value and making it more resistant to disturbance.[12] Incorporation of natural shoreland management practices into the landscaping of riparian properties also can provide a varying visual amenity for homeowners which changes with changing season. Use of native plants in this role can help these plant communities compete with nonnative, invasive species.

- It is recommended that the DLSD continue to conduct in-lake aquatic plant surveys, annually as at present or at not less than about three- to five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of major areas of nuisance plant growth and areas chemically treated—to this end, aquatic plant harvester staff should be trained to identify the major aquatic plant species present in the Lake and keep records of the most abundant species harvested.

- Additional periodic monitoring of the aquatic plant community—by the DLSD harvester staff, Town of Delavan staff, Walworth County staff, Kettle Moraine Land Trust (KMLT) staff, or Delavan Lake Improvement Association (DLIA) members, for example—is recommended for the early detection and control of future-designated nonnative species that may occur. Early control could be effected with the assistance of funds provided through the Chapter NR 198, aquatic invasive species control grant program, and should be undertaken as soon as possible once the presence of a nonnative, invasive species is observed and confirmed, reducing the risk of spreading these species and restoring native aquatic communities.

- Control of currently designated invasive species, designated pursuant to Chapters NR 40 and NR 109 of the *Wisconsin Administrative Code*, by the Town of Delavan using appropriate control measures,[13] is recommended throughout the Lake.

ARRAY OF SHORELINE PROTECTION MEASURES

Shoreline protection measures refer to a group of management measures designed to reduce and minimize shoreline loss due to erosion by waves, ice, or related action of the water. Currently, most of the shoreline of Delavan Lake is in a developed state. To the extent practicable, continued use of vegetative shoreline protection is recommended. Where structural management measures were installed, most of the observed shoreline protection measures were in a good state of repair and no severe erosion-related problems were observed. Monitoring and ongoing maintenance of shoreline protection structures by property owners is recommended.

Five shoreline erosion control techniques are commonly used: vegetative buffer strips, riprap, rock revetments, wooden and concrete bulkheads, and beach. Factors affecting the choice of method include: cost; the shoreline bank height, vegetation, stability and composition; the shoreline geometry and geographic orientation; the lake bottom contour and vegetation immediately adjacent to the stretch of shoreline under consideration; the proximity

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[12]*See, for example, SEWRPC publication entitled "Managing the Water's Edge: Making Natural Connections":* http://www.sewrpc.org/SEWRPCFiles/Environment/RecentPublications/ManagingtheWatersEdge-brochure.pdf.

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

to boat channels; possible influence of adjacent structures in producing flank erosion; and, the amount of open water (or "fetch") over which wind can act to produce wave action directly into the shoreline under consideration. A worksheet is provided within Section NR 328.08 Table 1 as a means of assisting property owners who wish to install or modify existing shoreline protection structures.

Maintenance of a vegetated buffer strip immediately adjacent to the Lake is the simplest, least costly, and most natural method of reducing shoreline erosion. Along developed shorelines, this technique employs natural vegetation, rather than maintained lawns, in the first five to 10 feet back from the waterline and the establishment of emergent aquatic vegetation from the waterline out to two to six feet lakeward. The use of such natural shorescaping techniques is generally required pursuant to Chapter NR 328 of the *Wisconsin Administrative Code*, except in moderate- to high-energy shorelines where more-robust structural approaches may be required. Along undeveloped shorelines, the WDNR recommends shoreland buffers extend from the water's edge onto land at least 35 to 50 feet, contain three layers of flora—herbaceous, shrub, and tree—found in natural Wisconsin lakeshores, and not be mowed except for a viewing access corridor.[14]

Desirable plant species that may be expected and encouraged to form an effective 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 lawn grass and the above-ground portion of the plants will protect the soil against the erosive forces of rainfall and wave action. A narrow path to the Lake could 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 riprap is a highly effective method of shoreline erosion control applicable to many types of erosion problems, especially in areas of low banks and shallow water and is already in place along portions of the shoreline of Delavan Lake. As shown in Figure 3, this method 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 riprap structures 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 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, they may fail because of washout of the filter material.

Vertical bulkheads, which form barriers to wildlife and amphibians, are not recommended. Beaches, and the use of sand blankets for the control of aquatic plants within the shoreland zone, also are not recommended, although maintenance of existing beach areas is warranted, given the current intensity of use of these areas by the community.

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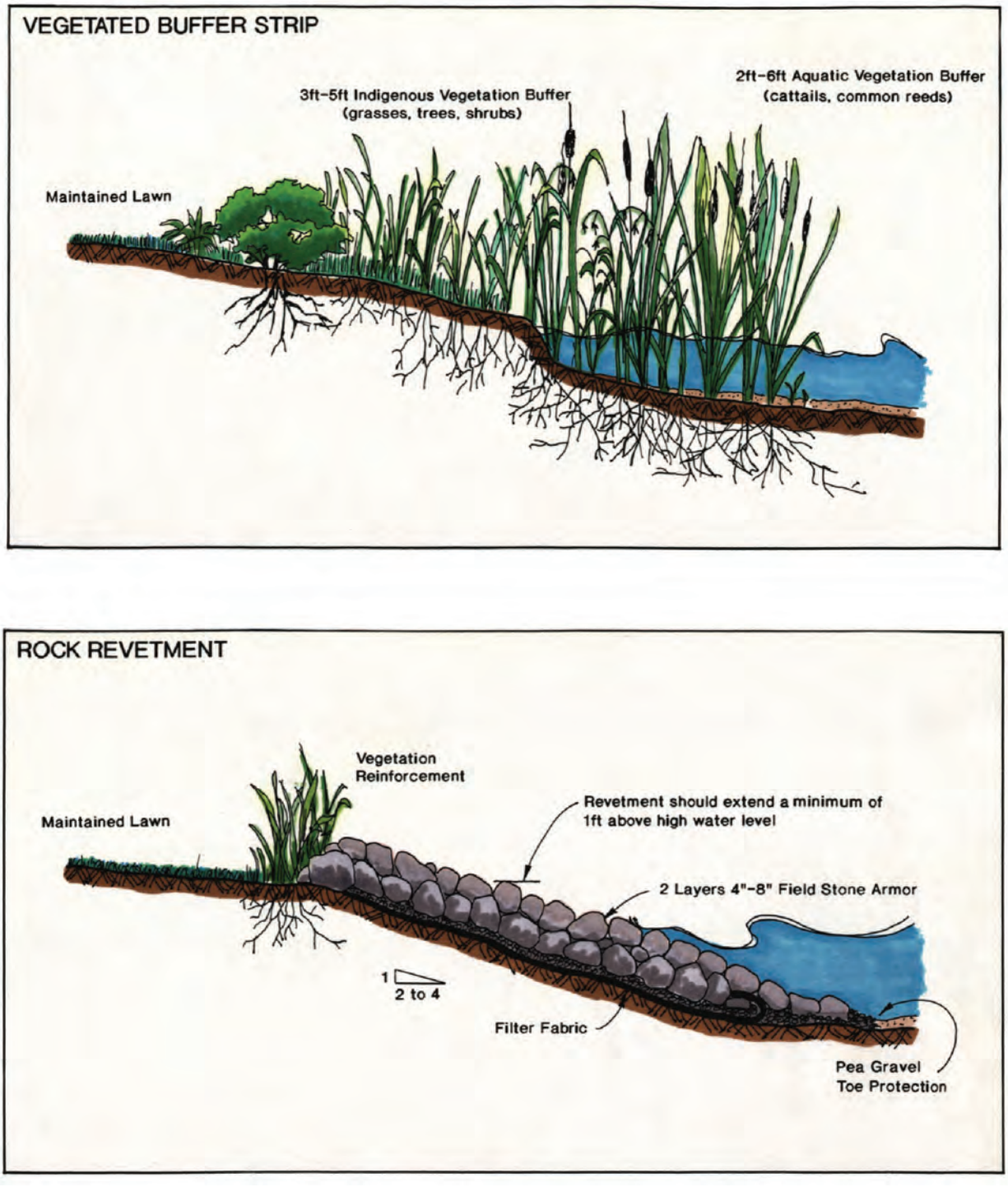
[14]*Wisconsin Department of Natural Resources*, Delavan Lake (Walworth County, Wisconsin) Integrated Sensitive Area Report, 2007.

Figure 3

RECOMMENDED ALTERNATIVES FOR SHORELINE EROSION CONTROL



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

Source: SEWRPC.

RECOMMENDED SHORELINE MANAGEMENT MEASURES

Vegetative buffer strips and riprap are the recommended methods of shoreline protection. These alternatives were selected because they can be constructed, at least partially, by local residents; because most of the construction materials involved are readily available; because the measures would, in most cases, enable the continued use of the immediate shoreline; and because the measures are visually "natural" or "semi-natural" and should not significantly affect the aesthetic qualities of the lake shoreline. Vegetative buffer strips are most effective in low- to moderate-energy shoreline conditions and have the added advantage of producing a more natural, aesthetically pleasing appearance while also providing enhanced shoreland habitat supportive of native plant and animal species, both terrestrial and aquatic. In those portions of the Lake subject to direct action of wind waves and ice scour, a more robust form of shoreline protection capable of tolerating more high-energy conditions may be appropriate.

It should be noted that the selection of appropriate shoreland protection structures is subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*.

Conduct of informational and educational field days, workshops, and demonstration projects is encouraged as part of the outreach effort to promote sound shoreland management. Maintenance of the shoreland buffer established at the Town of Delavan Community Park is recommended.

SUMMARY

This chapter documents the recommendations arising from a study of the aquatic plant community of Delavan Lake, requested by the DLSD and conducted by Aron & Associates and SEWRPC staff. Existing and anticipated conditions, potential aquatic plant management problems, and recreational use problems on the Lake are considered. The plan sets forth recommended actions and management measures for the resolution of those problems. The recommended plan is summarized in Table 18 and shown on Map 11. Maps 12 and 13 provide details of the recommended aquatic plant management plan elements for the northern-most and southern-most portions of Delavan Lake, respectively.

The shoreland protection and aquatic plant management elements of this plan recommend actions be taken that would reduce human impacts on ecologically valuable areas in and adjacent to the Lake, encourage a biologically diverse community of native aquatic plants, and limit the spread of nonnative invasive plant species. The plan recommends the use of mechanical harvesting of nuisance plants in those areas where depth of water and bottom substrate are sufficient to support such activity, limited use of chemical herbicides mainly in areas where nuisance levels of nonnative invasive species are present, manual harvesting aquatic plants around piers and docks with subsequent removal of cut material from the Lake, and monitoring of invasive species populations. The plan further recommends periodic in-lake aquatic plant surveys every three to five years to monitor changes in the aquatic plant community and assess effectiveness of aquatic plant management techniques.

The Town and City of Delavan should promote appropriate shoreline management practices, including the use of riprap and vegetative buffer strips, where applicable. For example, additional options regarding shoreland protection and maintenance should be made available to riparian property owners, thereby providing riparian residents with alternatives to traditional activities. Using more natural shorescaping practices, such as those employed in the shoreline demonstration project at the Town of Delavan Community Park public recreational boating access site at STH 50 and South Shore Drive, will encourage other lakefront property owners to diversify the shoreland environment, providing greater habitat value and making it more resistant to disturbance. To this end, provision of appropriate informational books and pamphlets at the DLSD offices and in the Delavan Public Library would contribute to achieving this objective, while the DLSD website (*http://www.dlsd.org/*), DLIA website (*http://www.delavan-lake.org/*), and KMLT website (*http://kmlandtrust.org/*), among others, offer additional opportunities for information sharing within the community.

Table 18

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR DELAVAN LAKE

Plan Element	Subelement	Management Measures	Management Responsibility
Aquatic Plant Management Measures	Proactive measures	Conduct periodic in-lake reconnaissance surveys of aquatic plant communities and update aquatic plant management plan at least every three to five years[a]	DLSD
		Monitor shorelines and open water areas for new growths of nonnative invasive species and immediately report any new growths to the DLSD	DLSD and private landowners
		Additional periodic monitoring of the aquatic plant community for the early detection and control of future-designated nonnative species that may occur	WDNR, DLSD, and private landowners
	Management actions	Manually harvest around piers and docks as necessary[b]	Private landowners
		Encourage growth of native plants in Delavan Lake through use of vegetated buffer strips and control of Eurasian water milfoil	WDNR, Town of Delavan, DLSD, private landowners, and Delavan Lake WIN
		Mechanically harvest nuisance plants in those areas where species, depth of water, and type of bottom sediment are supportive, and manually harvest around piers and docks, in order to: • maintain boating access—cut access lanes with minimum dimensions of 50 feet wide and five feet deep • enhance angling opportunities—cut "cruising lanes" within aquatic plant bed with approximate dimensions of 10 feet wide and five feet deep to increase opportunities for predation of forage fishes by game fishes • encourage native plant growth and biodiversity—minimize treatments during fish breeding seasons to those essential for providing boating access and/or public safety; harvest only as necessary for boating access • promote public safety—maintain areas, especially around beaches, to minimize algal scums; encourage shoreland buffers and promote low- or no- agrochemical applications within 20 feet of the shoreline Limited use of aquatic herbicides for control of nuisance nonnative aquatic plant growth where necessary; specifically target Eurasian water milfoil[c] Limited use of algicides for the control of nuisance algal blooms, especially in swimming areas	WDNR and DLSD
		Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and deposition of organic materials into Lake	Private landowners
Ancillary Management Measures	Shoreline Protection Management	Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Walworth County, Town of Delavan, City of Delavan, WDNR, and private landowners
	Water Quality Monitoring	Continue participation in UWEX CLMN program; consider participation in WDNR Expanded Self-Help program, periodic participation in U.S. Geological Survey TSI or similar programs	WDNR, USGS, DLSD, and Town of Delavan
	Natural Resource Protection	Protect primary environmental corridors to maintain the area's environmental quality, natural beauty, and provide quality recreational opportunities	Walworth County, Town of Delavan, City of Delavan, WDNR, and private landowners

Table 18 (continued)

Plan Element	Subelement	Management Measures	Management Responsibility
Ancillary Management Measures (continued)	Recreational Use Management	Maintain adequate public recreational boating access from the public access site pursuant to Chapter NR 7 guidelines	WDNR, Town of Delavan
		Maintain signage at public access sites regarding invasive species and WDNR Clean Boats-Clean Waters Program; provide disposal containers for disposal of plant material removed from watercraft at boat launch sites	WDNR, Town of Delavan, DLSD, and DLIA
	Public informational and educational programming	Continue to provide informational material and pamphlets on lake-related topics, especially the importance of aquatic plants and the protection of ecologically significant areas; consider offering public informational programming on topics of lake-oriented interest and education	Town of Delavan, DLSD, WDNR, DLIA, and UWEX
		Encourage inclusion of lake studies in environmental curricula (e.g., Pontoon Classroom, Project WET, Adopt-A-Lake)	Area school districts, UWEX, WDNR, Town and City of Delavan, DLIA, KMLT, Delavan Lake WIN, and DLSD
		Encourage riparian owners to monitor their shoreline areas, as well as open-water areas of the Lake, for new growths of nonnative plants and report same immediately to WDNR	DLIA, KMLT, and private shoreline property owners
	DLSD continuing education	Maintain awareness of current developments in the area of lake management through informative publications such as “Lake Tides” (available free through the Wisconsin Lakes Partnership) and attendance at lake education conventions, workshops, and seminars	UWEX, DLIA, KMLT. Delavan Lake WIN, WDNR,DLSD, and Wisconsin Lakes

NOTE: Delavan Lake WIN = Delavan Lake Watershed Initiative Network
DLSD = Delavan Lake Sanitary District
DLIA = Delavan Lake Improvement Association
WDNR = Wisconsin Department of Natural Resources
UWEX = University of Wisconsin-Extension
USGS = U.S. Geological Survey
KMLT = Kettle Moraine Land Trust
CLMN = UWEX Citizen Lake Monitoring Network
TSI = Trophic State Index monitoring protocol based on measurements of Secchi disc transparency and total phosphorus and chlorophyll-*a* concentrations
Project WET = Water Education Training

[a]*The aquatic plant surveys are currently conducted annually on behalf of the Delavan Lake Sanitary District.*

[b]*Manual harvesting beyond a 30-linear-foot width of shoreline is subject to WDNR individual permitting pursuant to Chapter NR 109 of the* Wisconsin Administrative Code*.*

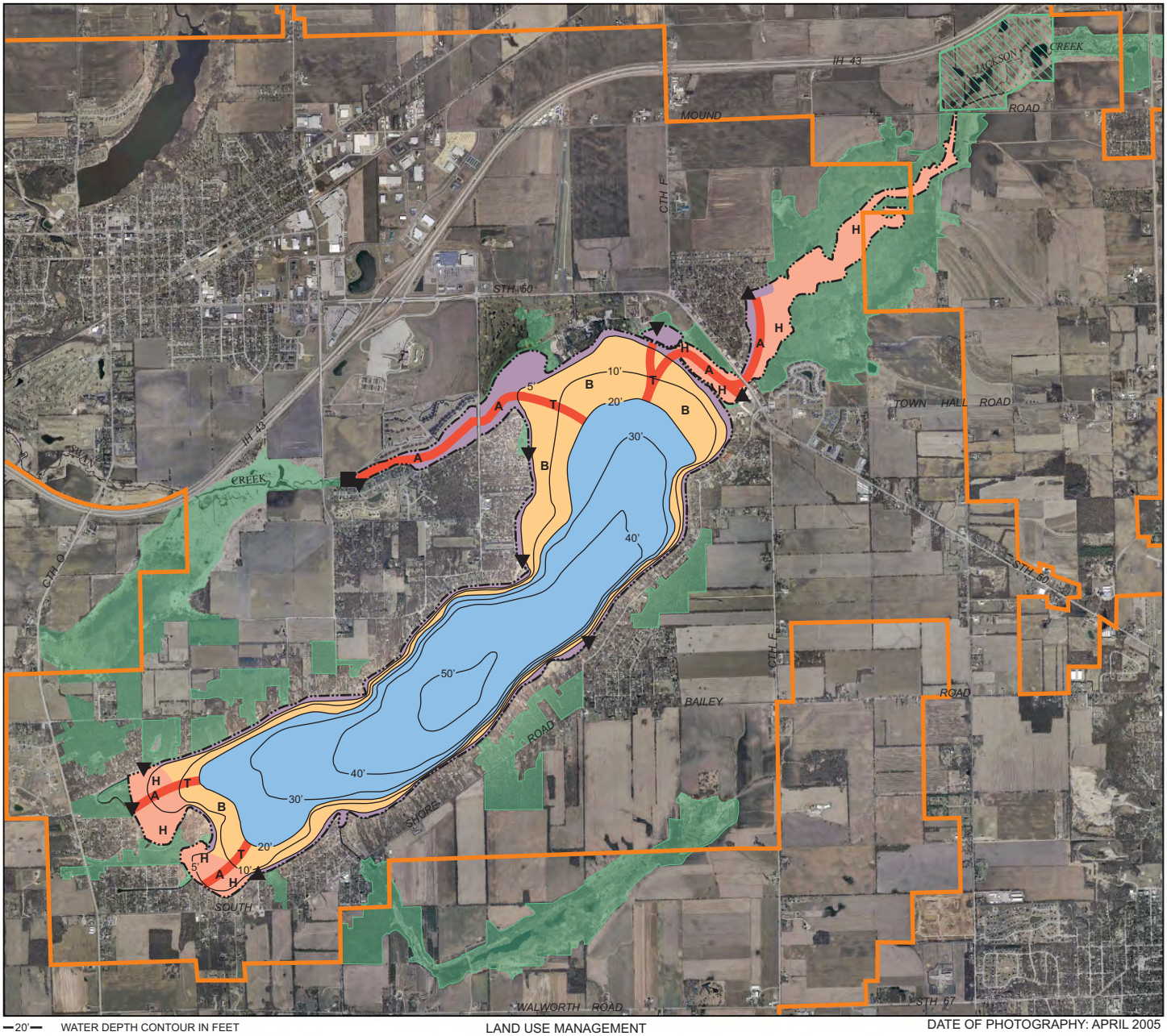
[c]*Use of aquatic herbicides requires a WDNR permit pursuant to Chapter NR 107 of the* Wisconsin Administrative Code*.*

Source: SEWRPC.

Adherence to the recommendations contained in this plan should provide the basis for a set of management actions that are: aligned with the goals and objectives set forth in Chapter I of this report; reflective of the ongoing commitment by the Delavan Lake community, through the various municipalities and communities within the tributary area of the Lake, to sound planning with respect to the Lake; and, sensitive to current needs, as well as those in the immediate future.

Map 11

RECOMMENDED MANAGEMENT PLAN FOR DELAVAN LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

■ WATER LEVEL CONTROL STRUCTURE

▲ PUBLIC ACCESS SITE AND HARVESTER OFF-LOAD AREA

▼ PRIVATE ACCESS SITE

AQUATIC PLANT MANAGEMENT

A ACCESS: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

T TRANSIT LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

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

H HABITAT: ECOLOGICALLY-VALUABLE AREAS - NO AQUATIC PLANT MANAGEMENT MEASURES RECOMMENDED DURING FISH BREEDING SEASON

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

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

LAND USE MANAGEMENT

PROTECT ENVIRONMENTAL CORRIDOR LANDS

MANAGE AND MAINTAIN THE MOUND ROAD WETLAND

- OBSERVE GUIDELINES SET FORTH IN THE REGIONAL LAND USE PLAN, MAINTAIN HISTORIC LAKEFRONT RESIDENTIAL DWELLING DENSITIES
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS

BOUNDARY OF SANITARY SEWER SERVICE AREA: WALWORTH COUNTY METROPOLITAN SEWERAGE DISTRICT - PROVIDE PUBLIC SANITARY SEWERAGE SERVICES, REFINE AS NECESSARY

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES SELF-HELP MONITORING PROGRAM

FISHERIES MANAGEMENT

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

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

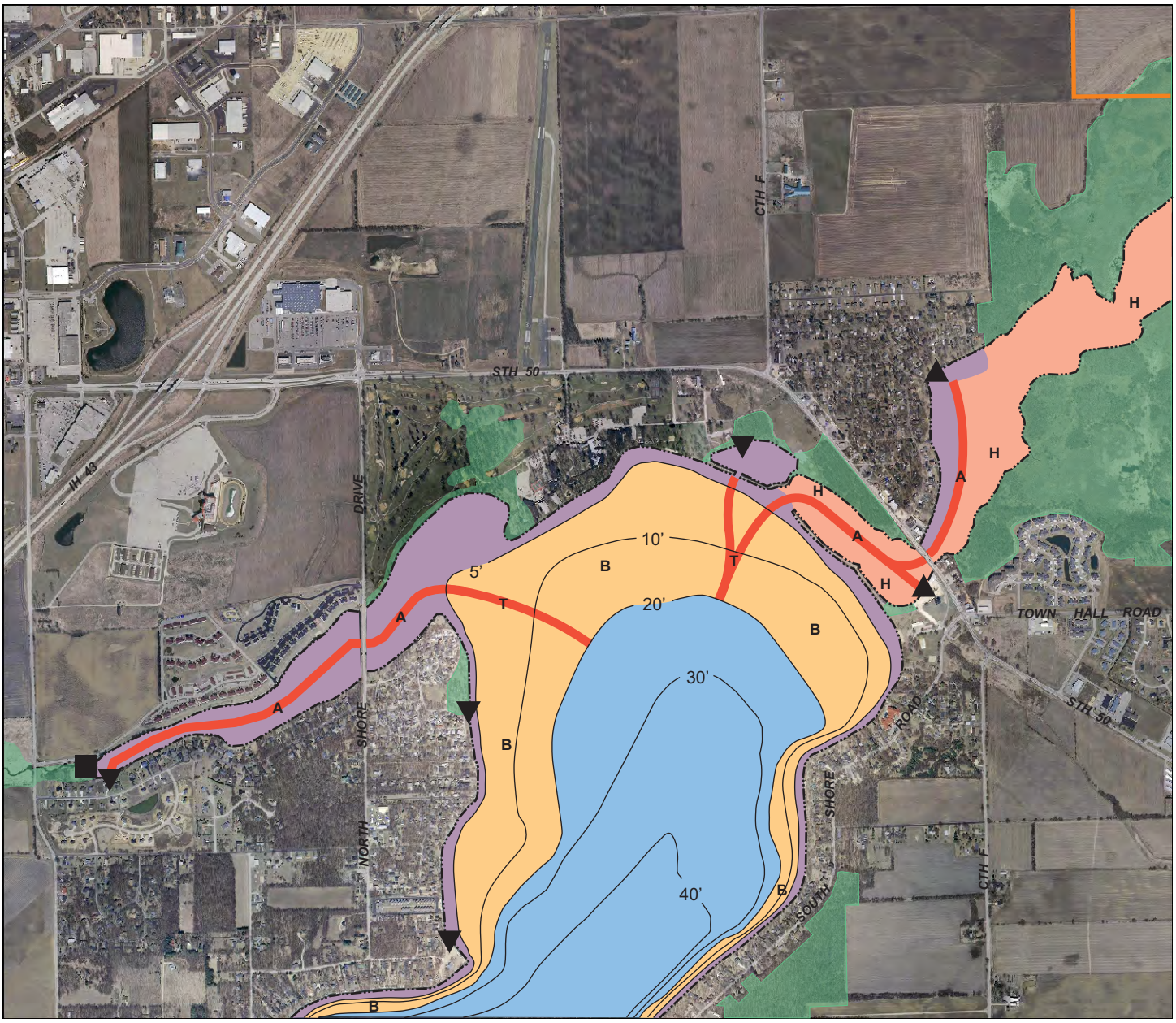
GRAPHIC SCALE

0 1500 3000 FEET

Source: SEWRPC.

Map 12

DETAIL OF RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR THE NORTHERN PORTION OF DELAVAN LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

■ WATER LEVEL CONTROL STRUCTURE

▲ PUBLIC ACCESS SITE AND HARVESTER OFF-LOAD AREA

▼ PRIVATE ACCESS SITE

AQUATIC PLANT MANAGEMENT

A ACCESS: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

T TRANSIT LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

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

H HABITAT: ECOLOGICALLY-VALUABLE AREAS - NO AQUATIC PLANT MANAGEMENT MEASURES RECOMMENDED DURING FISH BREEDING SEASON

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

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

LAND USE MANAGEMENT

PROTECT ENVIRONMENTAL CORRIDOR LANDS

- OBSERVE GUIDELINES SET FORTH IN THE REGIONAL LAND USE PLAN, MAINTAIN HISTORIC LAKEFRONT RESIDENTIAL DWELLING DENSITIES
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS

BOUNDARY OF SANITARY SEWER SERVICE AREA: WALWORTH COUNTY METROPOLITAN SEWERAGE DISTRICT - PROVIDE PUBLIC SANITARY SEWERAGE SERVICES, REFINE AS NECESSARY

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES SELF-HELP MONITORING PROGRAM

FISHERIES MANAGEMENT

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

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

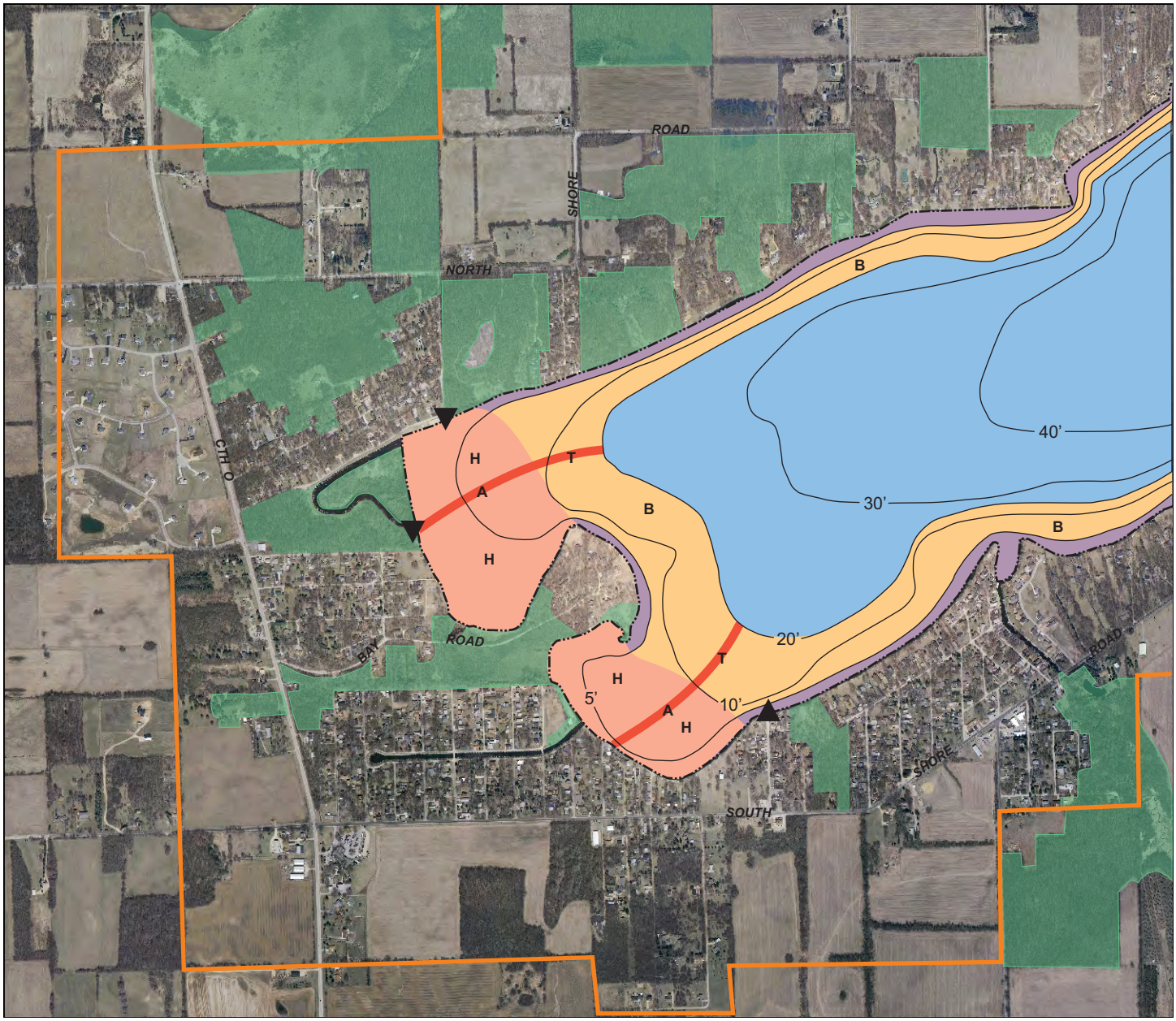
GRAPHIC SCALE

0 1000 2000 FEET

Source: SEWRPC.

Map 13

DETAIL OF RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR SOUTHERN PORTION OF DELAVAN LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

■ WATER LEVEL CONTROL STRUCTURE

▲ PUBLIC ACCESS SITE AND HARVESTER OFF-LOAD AREA

▼ PRIVATE ACCESS SITE

AQUATIC PLANT MANAGEMENT

A — ACCESS: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

T — TRANSIT LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

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

H — HABITAT: ECOLOGICALLY-VALUABLE AREAS - NO AQUATIC PLANT MANAGEMENT MEASURES RECOMMENDED DURING FISH BREEDING SEASON

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

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

LAND USE MANAGEMENT

PROTECT ENVIRONMENTAL CORRIDOR LANDS

- OBSERVE GUIDELINES SET FORTH IN THE REGIONAL LAND USE PLAN, MAINTAIN HISTORIC LAKEFRONT RESIDENTIAL DWELLING DENSITIES
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS

BOUNDARY OF SANITARY SEWER SERVICE AREA: WALWORTH COUNTY METROPOLITAN SEWERAGE DISTRICT - PROVIDE PUBLIC SANITARY SEWERAGE SERVICES, REFINE AS NECESSARY

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES SELF-HELP MONITORING PROGRAM

FISHERIES MANAGEMENT

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

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

GRAPHIC SCALE

0 750 1500 FEET

Source: SEWRPC.

Chapter IV

ANCILLARY RECOMMENDATIONS AND A RECOMMENDED WATER QUALITY MONITORING PROGRAM FOR DELAVAN LAKE

INTRODUCTION

The Delavan Lake community is actively engaged with the waterbody that forms the centerpiece of their community. The Lake serves not only as a shared backyard for the community, but also provides a range of recreational and aesthetic enjoyment opportunities for visitors and residents alike.

This active engagement of the community and its stakeholders has resulted in the conduct of an initial diagnostic study of the lake environment in the mid-1980s by the University of Wisconsin-Madison and sustained the active program of lake and wastewater management that was undertaken in the early 1990s by a host of agencies including local, State, and Federal government entities.[1] This engagement continues to underpin the interest and investment of the community in the management of Delavan Lake. In these efforts, the community has acted not only individually, but also collectively under the auspices of the Town of Delavan, the Delavan Lake Improvement Association (DLIA), a Chapter 181 *Wisconsin Statutes* nonstock not-for-profit corporation, and the Delavan Lake Sanitary District (DLSD), a Chapter 60 *Wisconsin Statutes* town sanitary district created by the Town of Delavan. With the support of the City of Delavan, Walworth County, and various State-level entities such as the Wisconsin Department of Natural Resources (WDNR) and the University of Wisconsin-Extension (UWEX), the community has played a leading role in lake rehabilitation not only in Wisconsin but across the United States.[2]

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[1]*University of Wisconsin-Madison, "Delavan Lake: A Recovery and Management Study," Institute for Environmental Studies, 1986; D. Helsel and K. MacKinnon. "Final Report for the Delavan Lake Rehabilitation Project, Town of Delavan, Walworth County, Wisconsin," prepared by the Wisconsin Department of Natural Resources and Delavan Lake Sanitary District for the Clean Lakes Grant Program, in fulfillment of the requirements of Grants #X995781-01 and #Soo5954-01-1. U.S. Environmental Protection Agency, Region V, 1995.*

[2]*See D.M. Robertson, G.L. Goddard, D.R. Helsel, and K.L. MacKinnon, "Rehabilitation of Delavan Lake, Wisconsin,"* Lake and Reservoir Management*, Volume 20, No. 3, pages 155-176, 2000.*

In this chapter, recommended actions for the monitoring and management of water quality in Delavan Lake are presented, including recommended actions relating to community-based informational programming, continuing education, and natural resources protection. These measures are focused primarily on those measures which can be implemented by the Town of Delavan and the DLSD, with lesser emphasis given to those measures which are applicable to other agencies and organizations having jurisdiction within the area tributary to the Lake.

WATER QUALITY MANAGEMENT

Water quality—typically defined in terms of in-lake phosphorus concentrations, Secchi-disk water clarity, and chlorophyll-*a* concentrations—is one of the key measures used to determine the overall health of a waterbody. The importance of good water quality can hardly be underestimated, as it impacts nearly every facet of the natural balances and relationships that exist in a lake between the myriad of abiotic and biotic elements present. Because of the importance water quality plays in the functioning of a lake ecosystem, careful monitoring of this lake element represents a fundamental management tool.

An extensive body of knowledge about the water quality of Delavan Lake has been accumulated, principally by the U.S. Geological Survey (USGS) with the active participation and financial support of the DLSD. These data are reported annually between 1983 and 2009 by the USGS in their U.S. Geological Survey Open-File Report series entitled *Water-Quality and Lake-Stage Data for Wisconsin Lakes*.[3] In addition to the data, numerous professional papers and articles have also been prepared by Federal, State, and local partners, and the Delavan Lake experience has attracted worldwide attention.[4]

Nevertheless, this acquisition of knowledge has come at a cost, and despite significant financial support from the Federal government—through the USGS and U.S. Environmental Protection Agency (US EPA)—and the State of Wisconsin—through the Chapter NR 190 "Lake Management Planning Grant Program" and Chapter NR 191 "Lake Protection Grant Program" and initial support through the Chapter NR 120 "Nonpoint Source Pollution Abatement Program," Turtle Creek Priority Watershed Project—the Town of Delavan and DLSD have made substantial investments of both public funds and staff time. These investments have been supplemented by additional voluntary investments by the DLIA. While all of these investments have been made by the various organizations and individuals with due recognition that the knowledge gained from the studies would immediately benefit the local community, there also was recognition of the ultimate contribution of the studies to the greater good. This ability of the Delavan Lake community to support data acquisition and development of scientific knowledge for the greater good was severely impaired as a consequence of the global financial downturn of 2009, with the consequence that the available funding for lake management was required by the tax-paying community to be more locally focused. Consequently, the DLSD requested SEWRPC to review the then-current monitoring and research program portfolio with a view toward more narrowly focusing the data and knowledge acquisition program on the specific needs of Delavan Lake, and reducing the level of funding required to a minimum. In

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[3]*Beginning in October 1985 through September 1994, data were reported annually in the U.S. Geological Survey Water Data Report series,* Water Resources Data, Wisconsin*; since October 1994, data have been reported annually in the U.S. Geological Survey Open-File Report series,* Water-Quality and Lake-Stage Data for Wisconsin Lakes. *Data for the period between October 1983 and September 1985 in the U.S. Geological Survey Water-Resources Investigations Report series as U.S. Geological Survey Water-Resources Investigations Report No. 87-4168,* Hydrology and Water Quality of Delavan Lake in Southeastern Wisconsin*, 1988.*

[4]*See, for example, United Nations Environment Programme Contribution to the United Nations World Water Assessment Programme (WWAP),* Water Security and Ecosystem Services: The Critical Connection, Ecosystem Management Case Studies*, pages 17-20, May 2005.*
http://www.unep.org/Themes/Freshwater/PDF/EMP_case%20studies_webR.pdf

response to this request, the Array of Management Measures set forth below has been structured such that the water quality management measures represent a hierarchy of investment options ranging from a minimum recommended level of effort to the continuation of the recent high level of effort.

Array of Management Measures

A basic level of data gathering on lakes is provided under the auspices of the University of Wisconsin-Extension (UWEX) Citizen Lake Monitoring Network (CLMN), formerly the WDNR Self-Help Monitoring Program. Volunteers enrolled in Level 1 of this program gather data at regular intervals on water clarity through the use of a Secchi disk.[5] Because the presence of contaminants in water tends to reduce water clarity, Secchi-disk measurements are generally considered one of the key parameters in determining the overall health of a lake. Loss of clarity is typically caused by the presence of inorganic materials such as silts and clays or organic materials such as algae. Where the loss of clarity is related to the presence of algae, water clarity can be a measure of a lake's trophic status, or level of enrichment with plant nutrients. Secchi-disk measurement data collected under the aupices of the CLMN program are added to the WDNR-sponsored data base, the Surface Water Integrated Monitoring System (SWIMS), which contains lake water quality information for many lakes in Wisconsin. The data are accessible on-line through the WDNR website at *http://dnr.wi.gov/org/water/swims/.*

The UWEX also offers an Expanded Citizen Lake Monitoring Network program (Level 2) that involves collecting data on several other key physical and chemical parameters, in addition to the Secchi-disk measurements.[6] Under this program, samples of lake water are collected by volunteers at regular intervals and analyzed by the State Laboratory of Hygiene (SLOH) for total phosphorus and chlorophyll-*a* concentrations. Collection of water samples for these additional analyses is more extensive and, consequently, places more of a burden on the volunteer(s). These data also are added to the SWIMS data base. Knowledge of total phosphorus and chlorophyll-*a* concentrations and Secchi-disk transparency allows the observer to calculate the Trophic State Index (TSI) value for a lake,[7] and classify the waterbody according to either a national ranking scale or Wisconsin-based ranking scale (WTSI),[8] the latter accounting for the humic coloration of Wisconsin's lakes.

With respect to stream monitoring, the UWEX hosts the Water Action Volunteers (WAV) program that is analogous in many ways to the CLMN program. The WAV Level 1 stream monitoring program involves the collection of data on water temperature, dissolved oxygen concentrations, stream flows, and water transparency at monthly intervals between April and October. Volunteers also annually assess the aquatic and streamside habitat and, twice annually during spring and autumn, the stream's macroinvertebrate community, using a biotic index. Under the Level 2 program, volunteers measure dissolved oxygen concentrations, pH, and transparency at monthly intervals between April and October on pre-determined dates, and temperature measurements are made using continuous temperature monitoring devices, called thermistors. Data are compiled in an on-line database and are accessible through the UWEX website at *http://watermonitoring.uwex.edu/wav/monitoring/databaseResults.html.*

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[5] http://watermonitoring.uwex.edu/level1/monitoring.html.

[6] http://watermonitoring.uwex.edu/level2/index.html.

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

[8] *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.*

The basic UWEX CLMN program is available at no charge, but does require volunteers to be committed to taking Secchi-disk measurements at regular intervals throughout the spring, summer, and fall. The Expanded CLMN program requires additional commitment by volunteers to take a more-extensive array of measurements and samples for analysis, also on a regular basis. As with any volunteer-collected data, despite the implementation of standardized field protocols, individual variations in levels of expertise due to background and experiential differences, can lead to variations in data and measurements from lake-to-lake and from year-to-year for the same lake, especially when volunteer participation changes.

In addition to the UWEX volunteer-based CLMN and WAV programs, the University of Wisconsin-Stevens Point (UWSP) Water and Environmental Analysis Laboratory (WEAL) offers several volunteer-conducted water quality sampling programs for both lakes and rivers. Under these latter programs, volunteers collect water samples and send them to the UWSP for analysis. The lake monitoring program is recommended to be carried out during spring and fall, when the lake is well-mixed. Two standard analytical regimes are offered: Package A which includes analysis of alkalinity, total hardness, calcium hardness, color, conductivity, ammonium nitrogen, nitrate plus nitrite nitrogen, and total Kjeldahl nitrogen, total phosphorus, reactive phosphorus, turbidity, chloride, sulfate, potassium, sodium, and pH; and Package B which includes analysis of conductivity, ammonium nitrogen, nitrate plus nitrite nitrogen, total Kjeldahl nitrogen, total phosphorus, reactive phosphorus, and chloride. The river monitoring program includes analysis of water samples for ammonium nitrogen, nitrate plus nitrite nitrogen, total Kjeldahl nitrogen, total phosphorus, reactive phosphorus, chloride, and total suspended solids. It is recommended that this program be linked to stream flow, with samples being acquired under both low or base flow conditions and high flow conditions to fully characterize the stream water quality. WEAL provides technical support to both lake and stream monitors with respect to sampling site selection, lake level and stream flow measurements, study design, and data interpretation, and can offer additional specialized services. These latter extend to groundwater sampling and analysis.

The WEAL turnover sampling program requires only a twice-a-year sampling, thereby requiring a smaller time commitment by the volunteers, but, there is a modest charge for the laboratory analysis, and, because sampling is performed by volunteers, is subject to those variations identified above. Additionally, since samples need to be taken as closely as possible to the actual turnover period, which occurs only during a relatively short window of time, volunteers need to monitor lake conditions as closely as possible to be able to determine when the turnover period is occurring.

The USGS offers an extensive water quality monitoring program under their Trophic State Index (TSI) monitoring program. USGS field personnel conduct a series of approximately five monthly samplings beginning with the spring turnover. Samples are analyzed by the SLOH for an extensive array of physical and chemical parameters. The USGS program does not require volunteer sampling. All sampling and analysis is provided by USGS personnel using standardized field techniques and protocols. As a result, a more standardized set of data and measurements may be expected. However, the cost of the USGS program is significantly higher than the CLMN or WEAL programs, even with State cost-share availability.

Finally, the USGS offers a variety of specialized monitoring programs that include targeted research studies, similar to those carried out on Delavan Lake during the 1980s and 1990s, as well as modeling studies, toxicity assessments, and geomorphic analyses.[9] Lake surface elevation gauging and stream flow gauging could be considered.

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[9]*See U.S. Geological Survey, Wisconsin Water Science Center,* Capabilities Summaries. http://wi.water.usgs.gov/about/docs/wwsc_capabilities.pdf.

Recommended Management Measures

The data gathered and knowledge obtained through the numerous studies carried out on Delavan Lake have had a major influence on the practice of lake management, not only in Wisconsin, but also globally, as has been noted. The investment of the Delavan Lake community in generating this knowledge is both recognized and appreciated by water resources management practitioners. While due recognition must be given to the ability of any single community or government to support such an extensive program of data acquisition and knowledge development, the SEWRPC staff note the scarcity of long-term data sets, such as that which has been accumulated for Delavan Lake, not only at the State level but also globally.

To this end, the recommended water quality management measures set forth below are presented in a tiered fashion to include not only the cost considerations but also their incremental contributions to the creation of knowledge and formulation of an effective lake management program. Beginning with a minimal level of effort, necessary to provide baseline data on the lake environment and provide warning of any major changes in lake water quality, the tiered program incrementally considers additional levels of effort that would ultimately culminate in the level of effort represented by the year 2009 data and knowledge acquisition program.

To this end, it is recommended that the Town and City of Delavan, perhaps in partnership with the DLSD and/or DLIA and/or Kettle Moraine Land Trust (KLMT) and/or Delavan Lake Watershed Initiative Network (Delavan Lake WIN), seek to achieve the highest tier practicable within the current economic climate, and review the feasibility of additional investments as economic conditions warrant:

- Tier 1. Continue to participate in the CLMN Level 1 program, with water clarity measurements being obtained from a single, centrally-located lake monitoring station near the deepest part of the Lake. This would be the minimum level of effort that should be considered.

- Tier 2. Continue to participate in the CLMN Level 2 program, with samples being obtained from a single, centrally-located lake monitoring station near the deepest part of the Lake. Alternatively, the Delavan Lake community could consider participating in the USGS TSI monitoring program, with samples being obtained from this central site.

- Tier 3. Increase the number of sampling stations to include northern and southern sites as well as the central, deep hole station; under this tier, sampling at the northern and southern sites would follow the CLMN Level 1 protocol, and sampling at the central site would follow the CLMN Level 2 protocol.

- Tier 4. Sample all three in-lake sites using the CLMN Level 2 protocol.

- Tier 5. Continue to sample all three in-lake sites using the CLMN Level 2 protocol; increase the sampling frequency at the centrally-located site to include monthly sampling with surface water and bottom water samples being analyzed for nutrient concentrations (WEAL Package B).

- Tier 6. Continue to sample the central lake station at spring and autumn overturn and monthly during the summer with surface water and bottom water samples being analyzed for nutrient and mineral concentrations (WEAL Package A); consider adding one or two mid-depth samples to be analyzed for nutrient and mineral concentrations at this site, especially during the summer months when the Lake is stratified. Continue to sample the northern and southern sites with surface water and bottom water samples being analyzed for nutrient concentrations (WEAL Package B).

- Tier 7. As Tier 2, but with participation in the WAV Level 1 monitoring program at stations located on Jackson Creek at Mound Road and Turtle Creek at Borg Road immediately downstream of the dam.

- Tier 8. As Tier 2, but with participation in the WAV Level 2 monitoring program at stations located on Jackson Creek at Mound Road and Turtle Creek at Borg Road immediately downstream of the dam.

- Tier 9. As Tier 4 (CLMN Level 2 monitoring program), but with participation in the WAV Level 2 monitoring program at stations located on Jackson Creek at Mound Road and Turtle Creek at Borg Road immediately downstream of the dam.

- Tier 10. As Tier 6 (WEAL Package A with samples obtained from four depths at the central sampling site and WEAL Package B with surface water and bottom water samples obtained from the northern and southern sites), plus the WAV Level 2 monitoring program at stations located on Jackson Creek at Mound Road and Turtle Creek at Borg Road immediately downstream of the dam. Alternatively, the Delavan Lake community could consider participating in the USGS TSI monitoring program, with samples being obtained from the three in-lake sites and from stations located on Jackson Creek at Mound Road and Turtle Creek at Borg Road immediately downstream of the dam. Consideration should also be given to sampling Jackson Creek upstream of the Mound Road Wetland complex in order to be able to evaluate the effectiveness of this system in modifying the nutrient loads to the Lake.

The WDNR offers Small Grant cost-share funding within the Chapter NR 190 Lake Management Planning Grant Program that can be applied for to defray the costs of laboratory analysis and sampling equipment.

WATER QUANTITY MONITORING AND MANAGEMENT

In addition to the water quality monitoring alternatives, it is recommended that water quantity monitoring also be continued.[10] At a minimum, maintenance of the USGS Delavan Lake Mound Road gauge station would be recommended. This should be combined with at least daily measurements of lake stage or lake surface elevation; this task could be undertaken by Town staff, DLSD staff, or a citizen volunteer. A second level of effort in this regard would be to maintain the USGS automated lake level recorder.

The alternative level of water quantity monitoring effort would be to continue the USGS Delavan Lake outlet gauge station and maintain the USGS gauging station on Jackson Creek upstream of Mound Road. Monitoring of flow in Jackson Creek upstream of the Mound Road Wetland complex and at the Mound Road site would enable the calculation of mass balances to evaluate the effectiveness of the Mound Road wetland system in modifying the nutrient loads to the Lake.[11]

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[10]*The Town of Delavan, as the owner of record of the Delavan Lake dam, must maintain the structure pursuant to their obligation as the owner of the dam in accordance with Section 31.18 of the* Wisconsin Statutes, *and subject to the requirements of the WDNR as set forth in Chapter 305 of the* Wisconsin Administrative Code.

[11]*The Kettle Moraine Land Trust (KMLT) received a Mississippi River Basin Initiative (MBRI) grant from the U.S. Natural Resources Conservation Service (NRCS) during mid-2010 for an edge-of-field program for monitoring the effectivity of grassed waterways; based upon continuing discussions between the KMLT, NRCS, and U.S. Geological Survey (USGS), the KMLT was investigating potential funding mechanisms relating to the Jackson Creek and Mound Road flow gauging stations as a basis for documenting probably water quality improvements associated with the agricultural best management practice. The Delavan Lake WIN is one potential mechanism for promoting, implementing, and documenting such management practices.*

NATURAL RESOURCE PROTECTION

Ecological balance and natural beauty are important determinants of the ability of an area to provide a pleasant and habitable environment for all forms of life and to maintain its social and economic well being. Preservation of the most significant aspects of the natural resource base is therefore essential to the well being of an area.

One of the most important tasks completed under the regional planning program for southeastern Wisconsin has been the identification and delineation of those areas in the Region in which concentrations of the best remaining elements of the natural resource base occur.[12] The protection and preservation of such areas in essentially natural, open uses is crucial in maintaining both the ecological balance and natural beauty of the Region and the planning area.

The delineation of these natural resource and resource-related elements on a map results in an essentially linear pattern of relatively narrow, elongated areas which have been termed "environmental corridors" by the Regional Planning Commission. Primary environmental corridors include a wide variety of the important natural resource and resource-related elements. Map 9 in Chapter III of this report shows the locations of the primary environmental corridors in the area tributary to Delavan Lake.

In any consideration of environmental corridors, it is important to note that the preservation of such resources can assist in flood flow attenuation, water pollution abatement, and favorable climate modification. In addition, because of the many interacting relationships between living organisms and their environment, the destruction or deterioration of any one element of the natural resource base may lead to a chain reaction of deterioration and destruction of other elements. The draining and filling of wetlands, for example, may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and the natural filtration action and flood water storage functions of interconnecting stream systems. The resulting deterioration of surface water quality may, in turn, lead to deterioration of the quality of groundwater, which serves as a source of domestic, municipal, and industrial water supply and on which low flows in rivers and streams may depend. Similarly, the destruction of woodland cover may result in soil erosion and stream siltation, more rapid stormwater runoff and attendant increased flood flows and stages, and 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 will eventually create serious environmental and developmental problems. These problems include flooding, water pollution, deterioration and destruction of wildlife habitat, loss of groundwater recharge areas, and destruction of the unique natural beauty of the area. The need to maintain the integrity of the remaining environmental corridors thus becomes apparent.

The primary environmental corridors include the best remaining woodlands, wetlands, and wildlife habitat areas, and are, in effect, composites of the best remaining residual elements of the natural resource base of the planning area. These corridors have truly immeasurable environmental and recreational value. The protection of the primary environmental corridors from intrusion by incompatible rural and urban uses, and thereby from degradation and destruction, will serve to maintain a high level of environmental quality in the planning area, protect its natural beauty, and provide valuable recreation opportunities and is, therefore, recommended. To this end, it is recommended that the Delavan Lake community through the Delavan Lake WIN among other alternatives seek appropriate opportunities for collaboration with land conservancies, land development entities, and land owners in formulating future land management practices—such as the use of conservation subdivisions, for example—that would protect and preserve these environmental corridors and maintain the ambience of the Delavan Lake area.

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[12]*See, for example, SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006; see also, SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin*, September 1997.*

STORMWATER MANAGEMENT

Ongoing urban density development planned for the drainage area tributary to Delavan Lake has been documented in the adopted comprehensive land use plan for Walworth County. Such development will shift the dominant nonpoint source of pollution loads to the Lake from the rural landscape to the developing urban landscape. The principle means of transferring these nonpoint source pollution loads to Delavan Lake is via the stormwater conveyance systems. With the promulgation of Chapters NR 151, "Runoff Management," and NR 216, "Storm Water Discharge Permits," of the *Wisconsin Administrative Code*, practices to moderate the delivery of sediment and other contaminants are required for new urban density development. To this end, consideration should be given to the establishment of a regional stormwater management system. The initial step toward evaluating such a system would entail the development of a regional stormwater management plan. In addition, consideration should be given to the possible establishment of an intergovernmental entity or utility district charged with preparing and implementing a regional level stormwater management plan. Addressing stormwater management at the regional level would help to better integrate actions by individual municipalities and potentially generate economic efficiencies through minimizing duplication or facilities, designing and siting stormwater facilities so that multiple developments and urban areas can be served through communal facilities, and ensuring appropriate inspection and maintenance of any infrastructure required to meet, or exceed, State standards.

RECREATIONAL USE MANAGEMENT

Current public recreational boating standards as set forth in Sections NR 1.91(4) and NR 1.91(5) of the *Wisconsin Administrative Code*, establish minimum and maximum standards for public boating access development, respectively, to qualify waters for resource enhancement services provided by the WDNR. As noted in Chapter II, the public recreational boating access site for Delavan Lake is located at the north end of the Lake in the Town of Delavan Community Park. At present, the Delavan Lake public access conforms to current State public recreational boating access standards.[13]

It is recommended that appropriate signage continue to be maintained at the public recreational boating access site in the Town of Delavan Community Park to alert users of Eurasian water milfoil, zebra mussels, and other nonnative invasive species. Such information should also be included in the community's informational programming, consistent with the aquatic plant management measures set forth in this plan. Walworth County and the Town of Delavan also should continue participating in the WDNR-UWEX Clean Boats-Clean Waters Program.[14]

INFORMATION AND EDUCATION

Public Informational Programming

As part of the overall citizen informational and educational programming being conducted in the Delavan Lake community, residents and visitors in the vicinity of the Lake should continue to be made aware of the value of the

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[13]*Maintenance of the public recreational boating access to Delavan Lake may include maintenance of navigability and navigation channels. Dredging of a channel of a waterway is limited to the degree necessary to accommodate recreational watercraft generally used on the waterway. Typical dimensions of inland lake navigation channels would be a channel 50 feet wide and to the five feet depth contour adjacent to the public recreational boating access site. Cost share funding for dredging such a channel in a waterway may be available through the Chapter NR 7, "Recreational Boating Facilities Grant Program," administered by the Wisconsin Waterways Commission.*

[14]*Wisconsin Department of Natural Resources Publication No. PUB-WT-782 2008,* Clean Boats, Clean Waters Volunteer Watercraft Inspection Program*, 2008; see also,* www.uwsp.edu/cnr/uwexlakes/CBCW.

ecologically significant areas in the overall structure and functioning of the ecosystems of the Lake. Specifically, informational programming related to the protection of ecologically valuable areas in and around the Lake should focus on the need to minimize the spread of nuisance aquatic invasive species, such as hydrilla and Eurasian water milfoil. Delavan Lake benefits greatly from the coordination and commitment of local Lake-oriented organizations, as well as the efforts of the many various private riparian subdivisions and communities in existence around the Lake.

With respect to aquatic plants, distribution of posters and pamphlets, available from the UWEX and the WDNR, that provide information and illustrations of aquatic plants, their importance in providing habitat and food resources in aquatic environments, and the need to control the spread of undesirable and nuisance plant species is recommended. Currently, many lake residents seem to view all aquatic plants as "weeds" and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impact. Continued inclusion of specific public informational and educational programming within the activities of the various municipalities and organizations within the Lake's tributary area, is recommended. These programs should focus on the value and 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. These programs 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.

Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the lake management program, are available from the UWEX, the WDNR, the Walworth County Offices, the DLSD, and many Federal government agencies. These brochures could be provided to homeowners through local media, direct distribution, local Lake-oriented association meetings, and targeted library/civic center displays. Alternately, they could be incorporated into the newsletters produced and distributed within the Delavan Lake community. Many of the ideas contained in these publications can be integrated into ongoing, larger-scale activities, such as anti-littering campaigns, recycling drives, and similar pro-environment activities.

Educational Programming

Classroom-based educational programming support is offered by the WDNR, Walworth County, and the UWEX Lakes Program, through programs such as the Project WET (Water Education Training) curriculum. These programs can contribute to an informed public, actively involved in the protection of ecologically valuable areas within the area tributary to Delavan Lake. The Delavan-Darien and/or Elkhorn School Districts, for example, in partnership with various civic organizations, could consider the conduct an annual Pontoon Classroom program on the Lake. In general, citizen monitoring and awareness of the positive value of native aquatic plant communities are important opportunities for public informational programming and continued participation in such are recommended for the Lake.

Continuing Education

As part of their commitment to the effective managing of Delavan Lake, the Town of Delavan, DLSD, and DLIA board members, and interested citizens and civic organizations, should continue to avail themselves of opportunities to learn about current developments and issues involving lake management. There are numerous publications, newsletters, seminars and conventions available through governmental, educational and other organizations and agencies dealing with the subject of lake management. Walworth County, UWEX, the Wisconsin Lakes (WAL), the North American Lake Management Society (NALMS), and WDNR all produce written material and conduct meetings and seminars dealing with lake management issues. Publications, such as *Lake Tides*, published by the Wisconsin Lakes Partnership and available from UWEX, are also readily available and deal with a wide range of lake-related topics. Additionally, the statewide Lakes Convention, held annually (in Green Bay, Wisconsin), provides valuable opportunities to learn about important and timely developments in lake management and learn about lake issues from experts in their fields. Participation in activities that will further understanding of lake management issues is deemed an important part of the lake management experience.

SUMMARY

This plan documents the ancillary recommendations arising from a study of the aquatic plant community of Delavan Lake, requested by the DLSD, and examines existing and anticipated conditions, potential water quality management problems, and recreational use problems on the Lake. The plan sets forth recommended actions and management measures for the resolution of those problems. The recommended plan is summarized in Chapter III, in Table 18 and shown on Map 11.

Delavan Lake was found to be slightly eutrophic and of marginally below average water quality. Preservation of environmental corridor lands, and especially within the shoreland areas situated immediately adjacent to the Lake, is recommended. Walworth County, the Towns of Darien, Delavan, Geneva, LaFayette, Sharon, Sugar Creek, and Walworth, the Cities of Delavan and Elkhorn, the Villages of Fontana and Williams Bay, together with the Delavan Lake community, should support appropriate land management practices designed to reduce nonpoint source pollutant discharges in stormwater runoff into the Lake. Further, the Town and City of Delavan should promote appropriate shoreline management practices, including the use of vegetative buffer strips where applicable.

The plan recommends regular participation in the UWEX CLMN Level 1 volunteer water quality monitoring program as the minimum level of effort associated with water quality monitoring and management. Consideration of participation in the UWEX CLMN Level 2 volunteer water quality monitoring program of participation in the USGS TSI monitoring program, or equivalent, is also recommended. Recognizing the importance and value of the long-term data set that has been acquired on Delavan Lake, it is recommended that the Town and City of Delavan maintain as comprehensive a data collection effort as possible, with due regard for the economic demands that such a program will place on the Delavan Lake community, especially during the current period of global economic downturn. Further, continuation of the water quantity monitoring effort at the Delavan Lake dam was recommended as a minimum level of monitoring effort, with maintenance of the water quantity monitoring upstream and downstream of the Mound Road wetland system to the extent possible as a secondary level of investment, possibly associated with the activities of the KMLT and/or Delavan Lake WIN within the context of their Mississippi River Basin Initiative agricultural runoff management program.

With regard to recreational uses of Delavan Lake, the plan recommends maintaining the public access site in a manner consistent with Chapter NR 1 standards and Chapter NR 7 guidelines, as well as maintaining signage regarding aquatic and other invasive species.

Finally, the recommended plan includes continuation of an ongoing program of public information and education, focusing on providing riparian residents and lake users with an improved understanding of the lake ecosystem. For example, additional options regarding household chemical use, lawn and garden care, shoreland protection and maintenance, and recreational use of the Lake should be made available to riparian property owners, thereby providing riparian residents with alternatives to traditional activities. Additionally, Town of Delavan, DLSD, and DLIA Board members, and Delavan Lake community members generally, are encouraged to maintain and broaden their awareness of current developments in the area of lake management through participation in meetings, seminars, conventions and other lake management-related events, and educational opportunities.

As noted in Chapter III, adherence to the recommendations contained in this plan should provide the basis for a set of management actions that are: aligned with the goals and objectives set forth in Chapter I of this report; reflective of the ongoing commitment by the Delavan Lake community, through the various municipalities and communities within the tributary area of the Lake, to sound planning with respect to the Lake; and, sensitive to current needs, as well as those in the immediate future.

APPENDICES

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Appendix A

REPRESENTATIVE ILLUSTRATIONS OF AQUATIC PLANTS FOUND IN DELAVAN LAKE

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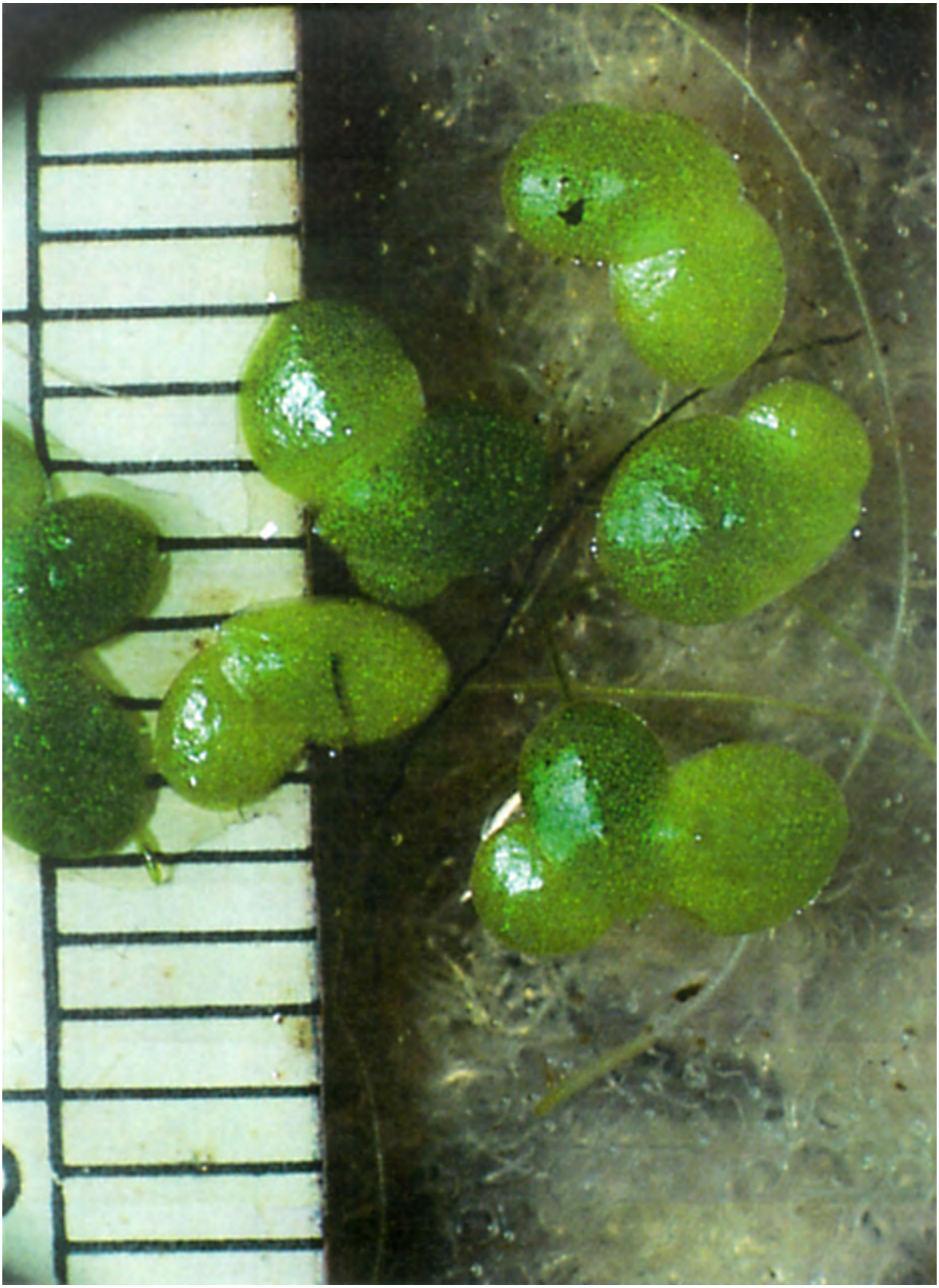
Bushy Pondweed (*najas flexilis*)

Coontail (*ceratophyllum demersum*)

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

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

Flat-Stem Pondweed (*potamogeton zosteriformis*)



Lesser Duckweed (*lemna minor*)

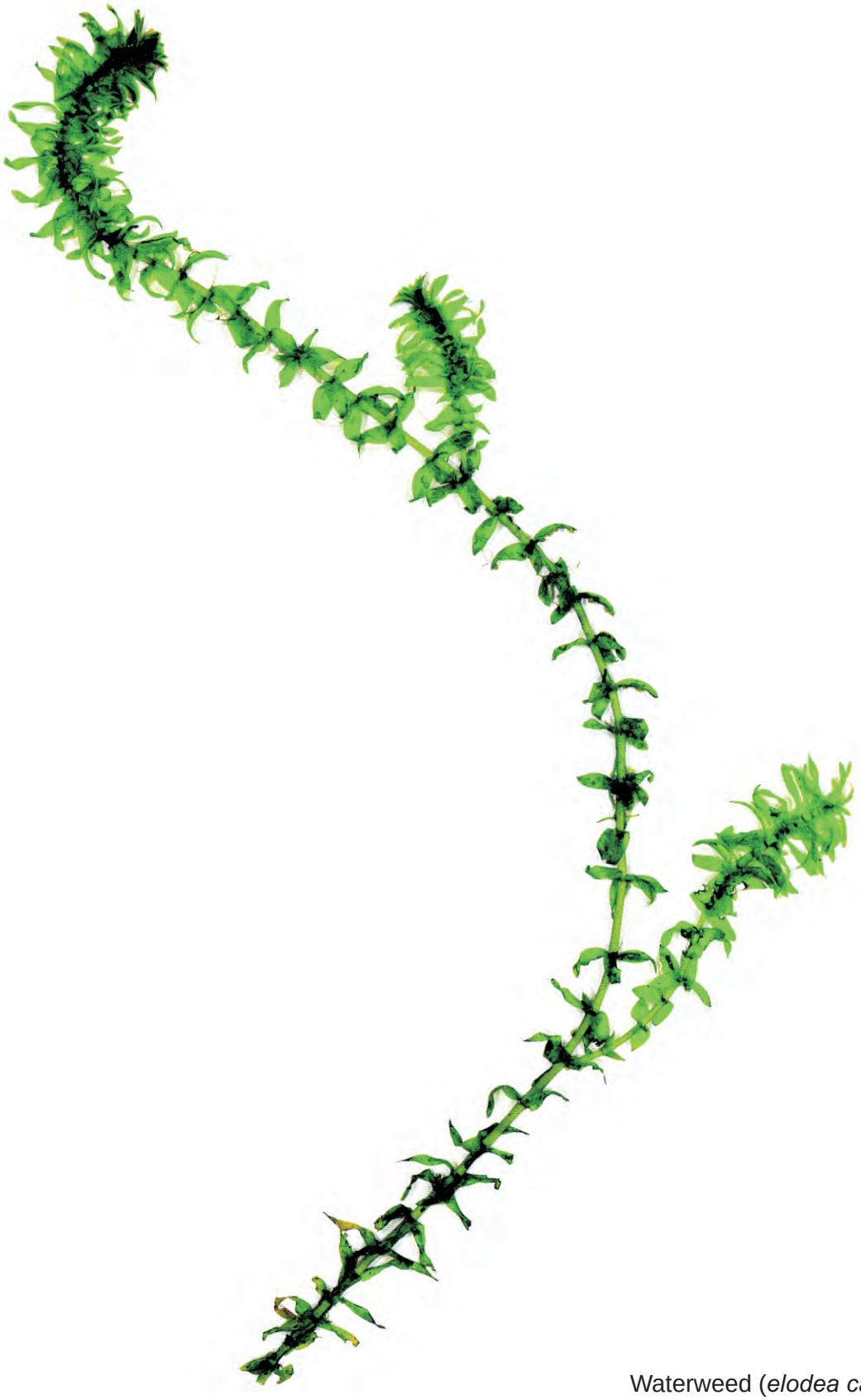
NOTE: Plant species in photograph are not shown proportionate to actual size

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

Muskgrass (*chara vulgaris*)

Sago Pondweed (*potamogeton pectinatus*)

Water Stargrass (*zosterella dubia*)



Waterweed (*elodea canadensis*)

White Water Lily (*nymphaea odorata*)

Eel-Grass / Wild Celery (*valisneria americana*)

Appendix B

WISCONSIN DEPARTMENT OF NATURAL RESOURCES CHAPTER NR 107 SENSITIVE AREA DELINEATIONS FOR DELAVAN LAKE

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Final – January 22nd, 2007

Delavan Lake (Walworth County, Wisconsin)
Integrated Sensitive Area Report

Assessment Dates:	June 23, 2005 - Areas 1-3 July 8, 2005 – Areas 1 - 2 July 27, 2005 - Areas 4-5
Number of Sensitive Areas Surveyed:	5
Site Evaluators:	Doug Welch, Fisheries Biologist Jim Jackley, Wildlife Biologist Jenny Herrmann, Wildlife Technician Kevin MacKinnon, Delavan Lake Sanitary District Heidi Bunk, Lakes Biologist Pam Schense, Water Management Specialist Mike Hemmingsen, Water Resources Specialist
Authors:	Mike Hemmingsen, Water Resources Specialist Heidi Bunk, Lakes Biologist

General Lake Information

Delavan Lake is located in the city and town of Delavan in Walworth County. The lake is fed and drained by Jackson Creek, a tributary of Turtle Creek that drains to the Lower Rock River. A dam at the lake's outlet is used to control water levels. The lake has a surface area of approximately 2,072 acres, a maximum depth of about 56 feet, a volume of approximately 44,800 acre-feet, and a mean depth of about 21 feet. (SEWRPC 2002) Delavan Lake has a shoreline length of about 13 miles, which is almost entirely developed for residential uses with the exception of a few wetland areas, most of which are discussed in this report.

Delavan Lake has a watershed (drainage area) of about 26,000 acres or 40.8 square miles. As of 1995, approximately 85 percent of the watershed consisted of rural land uses, and 15 percent of urban land uses. Major land uses included: 70 percent agriculture, 8 percent woodlands, wetlands or open lands, 7 percent residential, and 8 percent commercial, industrial, transportation, and recreational. Under planned 2020 conditions, the Walworth County development plan and regional land use plan forecast 6200 acres (24 percent of total area) of development within the watershed. (SEWRPC 2002)

In 1989 a major restoration project was begun on Delavan Lake to fix the severely deteriorated lake ecosystem. The lake was temporarily lowered 10 feet and a complete

fishery eradication was conducted. Modifications were made at the dam, an in-lake barrier was constructed to allow for short-circuiting of lake inflows, and a sediment control channel was built at the inlet. Sediments in the deeper portions of the lake received an alum treatment, and numerous non-point source pollution controls were conducted in the watershed. The lake's fishery was then restocked and previously farmed wetlands were reestablished. As one of the largest lake restoration projects in North America, this project has given Delavan Lake international attention in the area of lake rehabilitation. The Delavan Lake project was awarded Wisconsin's top prize for lake stewardship, and the North American Lake Management Society's 1991 Technical Excellence Award in recognition of outstanding efforts in lake restoration, protection, and management. (SEWRPC 2002)

Due to restoration efforts, Delavan Lake now has multiple recreational uses including the seasonal activities of fishing, water skiing, swimming, small craft sailing, ice fishing, cross-country skiing, ice-skating, and hunting. The lake also provides natural scenic beauty throughout the year, and opportunities for walking, jogging, bird watching, and picnicking.

Delavan Lake supports a moderately diverse fish population. Wisconsin Department of Natural Resources fish surveys conducted between 1990 and 1999 reported the presence of 16 fish species including: Walleyed pike, yellow perch, northern pike, muskellunge, largemouth bass, smallmouth bass, bluegill, pumpkinseed, green sunfish, black crappie, rock bass, black bullhead, white sucker, mimic shiner, fathead minnow, and common carp.

Exotic Species

Exotic species, most notably zebra mussels, Eurasian watermilfoil, and purple loosestrife have invaded southeastern Wisconsin lakes. Boaters traveling from lake to lake often facilitate the propagation of exotic species. The introduction of exotic species into a lake ecosystem can lead to a decline in the native plant population and cause problems with nutrient loading. In addition, the disturbance of lake bottoms from human activity (boating, plant harvesting, chemical treatments, etc.) enhances the colonization and/or expansion of exotic species. Two simple steps to prevent the spread of exotic species include 1) Removing aquatic plants, animals, and mud from trailers and boats before leaving the boat access; and 2) Draining water from boats, motors, bilges, live wells, and bait containers before leaving the water access.

Eurasian watermilfoil can be found in four of the sensitive areas on Delavan Lake. Eurasian watermilfoil is one of eight milfoil species currently found in Wisconsin. It is often misidentified as one of its seven native cousins, and vice versa. In many areas within the lake, this non-native milfoil has established large monocultures and has out competed many native plants. These dense beds of milfoil not only impede the growth of native plant species but also inhibit fish movement and create navigational problems for boaters.

The regenerative ability of Eurasian watermilfoil is another obstacle when attempting to control this species. Fragments of Eurasian watermilfoil detached by harvesting, boating, and other recreational activities can float to non-colonized areas of the lake or downstream to additional lakes in the drainage system and create new colonies. Therefore, when controlling Eurasian watermilfoil, selective chemicals and harvesting, coupled with skimming, often produces the best results. In some lakes, biological agents such as the milfoil weevil have helped suppress milfoil populations. However, the most effective "treatment" of exotic milfoil is prevention through public education.

Curly-leaf pondweed is another submerged, exotic species found in Delavan Lake. Like Eurasian watermilfoil, curly-leaf often grows into large, homogenous stands. It can crowd out native vegetation, create navigational problems, and limit fish movement. Curly-leaf pondweed dies off in mid-summer, increasing nutrient availability in the water column. This often contributes to summer algal blooms and decreasing water quality.

The unusual life cycle of curly-leaf pondweed makes management difficult. The plant germinates as temperatures decrease in fall. Curly-leaf is highly tolerant of cold temperatures and reduced sunlight, continuing to grow under lake ice and snow cover. With ice-off and increasing water temperatures in the spring, the plant produces fruit, flowers, and buds (turions). Turions are the main reproductive mechanism of curly-leaf. To control the species in lakes, the plant must be combated before turions become viable. Most plant harvesters have not started cutting when curly-leaf is most susceptible and a small window of opportunity exists for chemical treatment. Therefore, prevention through public education is once again very important.

Purple loosestrife, a hardy perennial native to Europe, is another exotic species common to Wisconsin. Since its introduction to North America in the early 1800s, purple loosestrife has become common in gardens and wetlands, and around lakes, rivers, and roadways. The species is highly invasive and thrives in disturbed areas. Purple loosestrife plants often out compete native plants, resulting in the destruction of food, cover, and nesting sites for wildlife and fish.

Purple loosestrife most often spreads when seeds adhere to animals. Humans should be aware of picking up seeds on clothing and equipment when in the vicinity of the plant. Loosestrife can be controlled manually, biologically, or with a broad-leaf herbicide. Young plants can be pulled, but adult plants have large root structures and must be excavated with a garden fork. Biological control is most effective on large stands of purple loosestrife. Five different insects are known to feed on this plant. Four of those have been used as control agents in the United States. Of the five species, *Galerucella pusilla* and *G. calmariensis* are leaf-eating beetles; *Nanophyes brevis* and *N. marmoratus* are flower-eating beetles; and *Hylobius trasversovittatus* is a root-boring weevil. Only *N. brevis* has not been released in the United States (WDNR 2003). Lastly and most importantly, prevention through public education plays an important role in the management of this species.

Shoreland Management

Wisconsin's Shoreland Management Program, a partnership between state and local governments, works to protect clean water, habitat for fish and wildlife, and natural scenic beauty. The program establishes minimum standards for lot sizes, structural setbacks, shoreland buffers, vegetation removal, and other activities within the shoreland zone. The shoreland zone includes land within 1000 feet of lakes, 300 feet of rivers, and floodplains. Current research shows that present standards are probably inadequate for the protection of water resources (Woodford and Meyer 2003, Garn 2002). Therefore, many communities have chosen to go beyond minimum standards to ensure protection of our natural resources. This report provides management guidelines for activities within the lake and in the immediate shoreland areas. Before any recommendations in this report are completed, please check with the Department of Natural Resources and local units of government for required approvals.

A vital step in protecting our water resources is to maintain effective vegetative buffers. A shoreland buffer should extend from the water onto the land at least 35 to 50 feet. Studies have shown that buffers less than 35 feet are not effective in reducing nutrient loading. Wider buffers of 50 feet or more can help provide important wildlife habitat for songbirds, turtles, frogs, and other animals, as well as filter pollutants from runoff. In general, no mowing should occur in the buffer area, except perhaps in a viewing access corridor. The plant composition of a buffer should match the flora found in natural Wisconsin lakeshores. A buffer should include three layers - herbaceous, shrub, and tree.

In addition, citizens living on Delavan Lake and the community at large should investigate other innovative ways to reduce the impacts of runoff flowing into the lake while improving critical shoreline habitat (Greene 2003). This may include the use of phosphorus-free fertilizers, installing rain gardens, setting the lawnmower at a higher mower height, decreasing the area of impervious surfaces, or restoring aquatic plant communities.

Introduction

Department personnel conducted Delavan Lake sensitive area designation surveys on June 23, 2005, July 8, 2005 and July 27, 2005, following the Wisconsin Department of Natural Resources' sensitive area survey protocol. This study utilized an integrated team of DNR resource managers with input from multiple disciplines: water regulation, fisheries, lake biology, and wildlife. Kevin MacKinnon from the Delavan Lake Sanitary District accompanied DNR staff on June 23, 2005 and July 27, 2005. A bird list was compiled for the inlet area on July 8, 2005 by Jim Jackley and Jenny Herrmann (DNR wildlife). The wildlife biologist and wildlife technician canoed the inlet from 5:20 AM to 7:00 AM that morning.

Sensitive areas are defined in Wisconsin Administrative Code NR 107.05 (3)(i)(1) as *areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or life stage requirements, or offering water quality or erosion control benefits to the body of water*. Department resource managers determined that five areas on Delavan Lake met this definition.

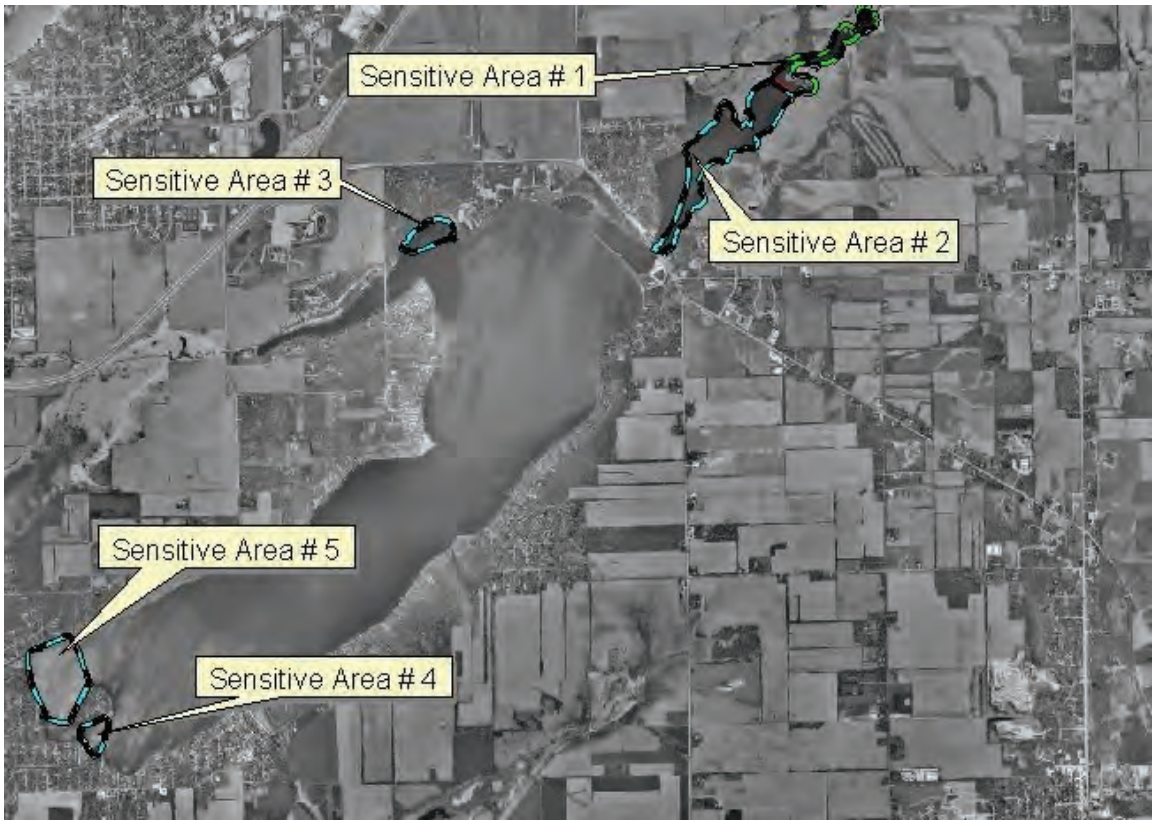
Overview of Sensitive Area Designations

Sensitive areas often have aquatic or wetland vegetation, terrestrial vegetation, gravel or rubble lake substrate, or areas that contain large woody cover (fallen trees or logs). These areas provide water quality benefits to the lake, reduce shoreline erosion, and provide habitat necessary for seasonal and/or life stage requirements of fish, invertebrates, and wildlife. A designated sensitive area alerts interested parties (i.e., DNR personnel, county zoning personnel, lake associations, lake districts, towns, etc.) that the area contains critical habitat vital to sustaining a healthy lake ecosystem, or may feature an endangered plant or animal. Information presented in a sensitive area report may discourage certain permits from being approved within these sites.

Whole Lake Recommendations:

Several recommendations from Department staff pertain to Delavan Lake as a whole rather than to individual sensitive areas:

1. The aquatic plant community in Delavan Lake is not highly diverse outside of the sensitive areas. Native aquatic plant beds should be protected and maintained.
2. Prevent the spread of exotic species through sign postings, education, etc. and control exotic species where established. Post "Exotics Alert" sign at boat landing. (Already Present)
3. Comply with state and local shoreland zoning standards by maintaining no-cut buffers and setbacks, removing non-conforming structures, and limiting impervious surfaces.
4. Create shoreland buffers and maintain existing buffers, especially in areas not currently developed.
5. Continue to monitor water quality for early detection of changes and possible degradation. This monitoring has been conducted since 1983 by the United States Geological Survey and the Delavan Lake Sanitary District.
6. Implement recommendations of the SEWRPC (Southeastern Wisconsin Regional Planning Commission) lake management plan.


Sensitive Area # 1
Sensitive Area # 3
Sensitive Area # 2
Sensitive Area # 5
Sensitive Area # 4

Resource Value of Sensitive Area Site 1 – Delavan Lake

Sensitive Area 1 is located in the upper inlet of Delavan Lake (see Map 1). The inlet is part of Delavan Lake, but is also considered by many as a part of Jackson Creek. This sensitive area, with its rich ecological diversity, serves as 1) a nutrient buffer reducing algae blooms; 2) a biological buffer reducing the likelihood of exotic invasions; 3) a physical buffer against shoreline erosion; 4) a micro-habitat increasing biodiversity, and 5) allows for sediment stabilization. The entire inlet area is classified as Class I or Class II Wildlife Habitat Areas by the Southeastern Regional Planning Commission (SEWRPC 2002, page 124). See Appendix 1 for a complete list of aquatic plants found in sensitive areas of Delavan Lake, and Appendix 2 for fish information.

The substrate (lake bottom) in Sensitive Area 1 consists primarily of muck but also contains some silt and detritus. The water depth ranges between 1 and 1.75 ft with sensitive area habitat located along the shoreline, near-shore terrestrial, and littoral zones (i.e. the entire upper portion of the inlet is sensitive). The shoreland buffer in this sensitive area is made up of approximately 90 percent wetland and 10 percent wooded area. The wetland consists of deep marsh, shallow marsh, and sedge meadow. Large woody cover is present at the rate of approximately 1-2 pieces per 30-meter width of shoreline. Herbaceous plants are dominant, covering 76-100 percent of the buffer zone, while shrubs are present covering 1-25 percent of the buffer zone, and trees are common covering 26-50 percent of the buffer zone. This area has unique aesthetics and has undergone very little human influence or shoreline development; therefore the natural scenic beauty (NSB) rating of this sensitive area is outstanding.

The extensive development of Delavan Lake has reduced available wildlife habitat. However, this portion of the lake provides excellent shelter, nesting areas, and feeding areas for upland wildlife, muskrat, mink, geese, song birds, bitterns, rails, black terns, foresters terns, yellow headed blackbirds, frogs, toads, turtles, and snakes for the majority of the year. Emergent vegetation is the most important habitat component of this site. Table 1 displays all plants found in the sensitive area and their level of abundance.

Table 1. Plants observed in Sensitive Area 1.

	Emergent	**Submergent**	**Free-floating**	**Exotic**
PRESENT (0-25% Cover)	*Scirpus* (bulrush) *Carex* (sedges) Calamagrostis (Can. BJ) Sparganium (bur reed) Verbena (blue vervain) Asclepias (marsh milkweed) Salix (willow) Sagittaria (arrowhead)	*Ceratophyllum* (coontail)	Filamentous (algae)	*Myriophyllum spicatum* (Eurasian watermilfoil) *P. crispus* (curly-leaf pondweed)
COMMON (26-50% Cover)	Cornus (dogwood)		*Lemna* (duckweed) *Wolffia* (watermeal)	
ABUNDANT (51-75% Cover)		Potamogeton nodosus (long leaf pondweed)		
DOMINANT (76-100% Cover)	*Typha* (cattail)	*Potamogeton pectinatus* (sago pondweed)		

Many wildlife species were personally observed by the site evaluators during the sensitive area survey. Dozens of leopard and green frogs were leaping out of the water. Hundreds of damselflies were flying around and sitting on aquatic plant vegetation. Damselflies are an important food source for many fish and wildlife species. Birds observed on the afternoon of June 23, 2005 include forester terns (2 adults and 2 juveniles), great blue herons (2), green herons, black terns (2), and red wing blackbirds. Forester terns are a state listed endangered species.

Great blue herons often congregate in this sensitive area. During a boat count conducted on August 3, 2005, between 100 and 150 great blue herons were observed (Kevin MacKinnon, personal observation). The trees behind the wetland areas in this sensitive area may potentially provide a heron rookery.

A large amount of plant biomass was present in this sensitive area. However, the water was often quite turbid. Bays and lakes that have a large amount of plants typically exhibit clear water. The turbidity in the water is likely caused by carp. Several dozen carp were observed in Sensitive Area # 1.

<u>Management Recommendations for Sensitive Area #1</u>

1. Attempt the planting of wild rice to help with nutrient management and sediment loading. Wild rice is also a good source of food for wildlife.

2. No alteration of the littoral zone unless to improve spawning habitat.

3. Create a seasonal fish refuge area by not allowing motorized boats in the spring during fish spawning.

4. Maintain the current level of snags, cavity trees, perch trees, shrub and herbaceous cover, as well as aquatic vegetation.

5. Increase wildlife corridor by purchasing farmland in the watershed and turning it into grassland. This action will also reduce runoff into Jackson Creek and its tributaries.

6. A no wake zone is strongly recommended for this area (currently in place) to protect emergent aquatic vegetation. No aquatic plant removal should be allowed.

7. Boardwalks will be allowed on a case by case basis to provide open water access only for a riparian landowner. Watercraft moored at the boardwalk must be able to navigate the water without any additional dredging. The number of moorings allowed will be less than "reasonable use" as defined by state law.

8. Do not remove fallen trees along shoreline, except where navigation is impaired. If navigation is impaired by a fallen tree, cut into smaller pieces and place outside of boating lane.

9. Recommendations regarding **local and county zoning**:
    - Strictly enforce shoreland and wetland ordinances
    - New development should comply with the Walworth County Land Use Plan and the Town of Delavan master plan.
    - Require a buffer/"no touch" zone for grading projects. This buffer/"no touch" zone should be at least 100 feet from the edge of the wetland back into the (landward) upland portion of parcels.
    - Require a buffer/"no touch" zone for grading projects located along steep slopes. The zone should extend at least 100 feet from the edge of a steep slope towards the landward side of the parcel.
    - Grading proposals should be strictly examined for superior erosion control and nutrient management plans.

10. A DNR permit should not be issued for any of the following:

Dredging	Pea gravel/sand blankets
Filling of wetlands	Rip Rap
Aquatic plant screens	New Piers *
Boat Ramps	Sea Walls/Retaining Walls
Recreational floating devices	

*Boardwalks only. See Recommendation # 7.

11. No chemical treatment allowed except to target an infestation of an exotic species such as purple loosestrife, eurasian watermilfoil or curly leaf pondweed. Biological controls such as the purple loosestrife beetle and the milfoil weevil should be considered where appropriate.

12. No mechanical harvesting should be conducted in this sensitive area.

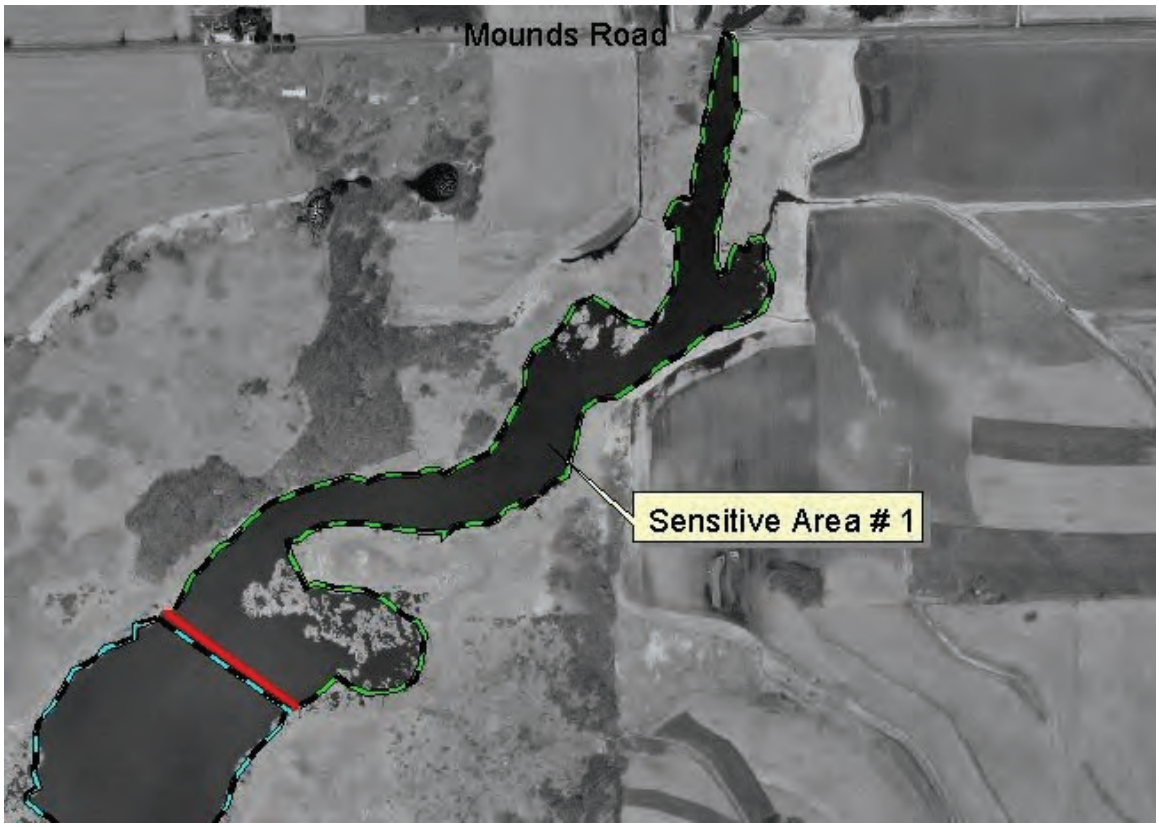
In summary, the ecological community of Sensitive Area 1 has distinctly unique features when compared to the waterbody as a whole. This site provides a visual and audible buffer from shoreline structures, roads, and boat traffic. Aquatic plants in the sensitive area include emergents, algae, potamogetons, exotics, free floating, floating leaf and submergents. Wet edge plants include herbs, sedges, shrubs, and grasses. Game fish and forage fish are present in the sensitive area, and bass and pike use the area for spawning. **The undeveloped shoreline is extremely valuable for wildlife**. Wildlife present in the sensitive area include furbearers, songbirds, swallows, waterfowl, shore birds, and amphibians. State listed special concern species present within this site include black terns and least bitterns. This site could be used to educate citizens about wetlands and sensitive areas.

Resource Value of Sensitive Area Site 2 – Delavan Lake

Sensitive area 2 in the lower inlet of Delavan Lake serves as a fish and wildlife refuge and has diverse aquatic vegetation, terrestrial vegetation and wildlife populations. The site acts as a nutrient buffer reducing algae blooms, a biological buffer reducing the likelihood of exotic invasions, a physical buffer against shoreline erosion, a micro-habitat increasing biodiversity, and allows for sediment stabilization. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of Delavan Lake, and Appendix 2 for fish information.

The average water depth in Sensitive Area 2 is between one and two feet. The sensitive area habitat includes near-shore terrestrial, shoreline, and littoral zones. The bottom substrate consists of silt, clay, muck and detritus. The heavy plant cover shaded the water below, causing the temperature of the water at 2 feet to be approximately 10 - 15 degrees Fahrenheit cooler than the water at the surface.

The shoreland buffer consists of approximately 70 percent wetland and 30 percent wooded area. The wetland consists of deep marsh, shallow marsh, and shrub carr. Large woody cover is present at the rate of approximately 1-2 pieces every 30 meters of shoreline. Herbaceous plants are dominant, covering 76-100 percent of the buffer zone, while shrubs and trees are common covering 26-50 percent of the buffer zone. This area has unique aesthetics and has undergone no human influence, therefore the natural scenic beauty rating (NSB) of this area is outstanding. The developed shoreline in the lower inlet is excluded from the sensitive area designation.


Mounds Road
Sensitive Area # 1

The extensive development of Delavan Lake has reduced available wildlife habitat. However, this portion of the lake provides suitable shelter, nesting area, and feeding area for upland wildlife, beaver, muskrat, mink, duck, goose, songbird, tern, yellow headed blackbird, frogs, toads, several species of turtle, and snakes. Emergent vegetation and snag trees are the most important habitat components at this site. Table 2 displays all plants found in the sensitive area and their level of abundance.

Table 2. Plants observed in Sensitive Area 2.

	Emergent	**Submergent**	**Free-floating**	**Exotic**
PRESENT (0-25% Cover)	Calamagrostis (Can. BG) *Scirpus* (bulrush) *Carex* (sedges) Jancus (rush) Iris (yellow) Asclepias (marsh milkweed) Eupatorium (joe pye weed) Salix (willow) Cornus (dogwood) Sagittaria (arrowhead) Sparganium (bur reed) Eupatorium (boneset)	*Potamogeton nodosus* (longleaf pondweed) *Ceratophyllum* (coontail) *Elodea* (waterweed) *Ranunculus trichophyllus* (water crow foot)		*Potamogeton crispus* (Curly leaf pondweed)
COMMON (26-50% Cover)		*Potamogeton pectinatus* (sago pondweed)	Filamentous (algae)	
ABUNDANT (51-75% Cover)			*Lemna* (duckweed) *Wolffia* (watermeal)	
DOMINANT (76-100% Cover)	*Typha* (cattail)	*P. zosteriformis* (flat-stemmed pondweed) *Myriophyllum sibiricum* (northern watermilfoil)		*Myriophyllum spicatum* (Eurasian watermilfoil)

Management Recommendations for Sensitive Area # 2

1. No alteration of the littoral zone unless to improve spawning habitat.

2. A no wake zone is strongly recommended for this area (currently in place) to protect emergent aquatic vegetation.

3. Create a seasonal fish refuge area by not allowing motorized boats in the spring during fish spawning.

4. Harvest exotic species (mainly curly leaf pondweed and Eurasian water milfoil) on the western edge of the sensitive area to improve habitat and improve the boat access lane.

5. A DNR permit should not be issued for any of the following:

Dredging	Pea gravel/sand blankets
Filling of wetlands	Rip Rap
Aquatic plant screens	Recreational floating devices
Boat Ramps	Sea Walls/Retaining Walls

6. Boardwalks and piers will be allowed on a case by case basis to provide open water access only for a riparian landowner. Watercraft moored at the boardwalk or pier must be able to navigate the water without any additional dredging. The number of moorings allowed will be less than "reasonable use" as defined by state law.

7. No chemical treatment allowed except to target an infestation of an exotic species such as purple loosestrife, eurasian watermilfoil or curly leaf pondweed. Biological controls such as the purple loosestrife beetle and the milfoil weevil should be considered where appropriate.

8. Maintain the current level of snags, cavity trees, perch trees, shrub and herbaceous cover, as well as aquatic vegetation.

9. Increase wildlife corridor by purchasing farmland in the watershed and turning it into grassland. This action will also reduce runoff into Jackson Creek and its tributaries.

10. Do not remove fallen trees along shoreline, except where navigation is impaired. If navigation is impaired by a fallen tree, cut into smaller pieces and place outside of boating lane.

11. Recommendations regarding **local and county zoning**:
    - Strictly enforce shoreland and wetland ordinances
    - New development should comply with the Walworth County Land Use Plan and the Town of Delavan master plan.
    - Require a buffer/"no touch" zone for grading projects. This buffer/"no touch" zone should be at least 100 feet from the edge of the wetland back into the (landward) upland portion of parcels.
    - Require a buffer/"no touch" zone for grading projects located along steep slopes. The zone should extend at least 100 feet from the edge of a steep slope towards the landward side of the parcel.
    - Grading proposals should be strictly examined for superior erosion control and nutrient management plans.

In summary, the ecological community of Sensitive Area 2 has distinctly unique features when compared to the waterbody as a whole including its undeveloped shoreline. This site provides a visual buffer from shoreline structures. Aquatic plants in the sensitive area include emergents, algae, potamogetons, exotics, free floating, floating leaf, and submergents. Wet edge plants include herbs, sedges, rushes, shrubs, and grasses. Game fish, panfish, young of the year fry and forage fish are present in the sensitive area. Wildlife present include furbearers, waterfowl, shore birds (including wood ducks and brood), amphibians, and reptiles. **The undeveloped shoreline is extremely valuable for wildlife.** This site could be used to educate citizens about wetlands and sensitive areas, possibly by canoe.

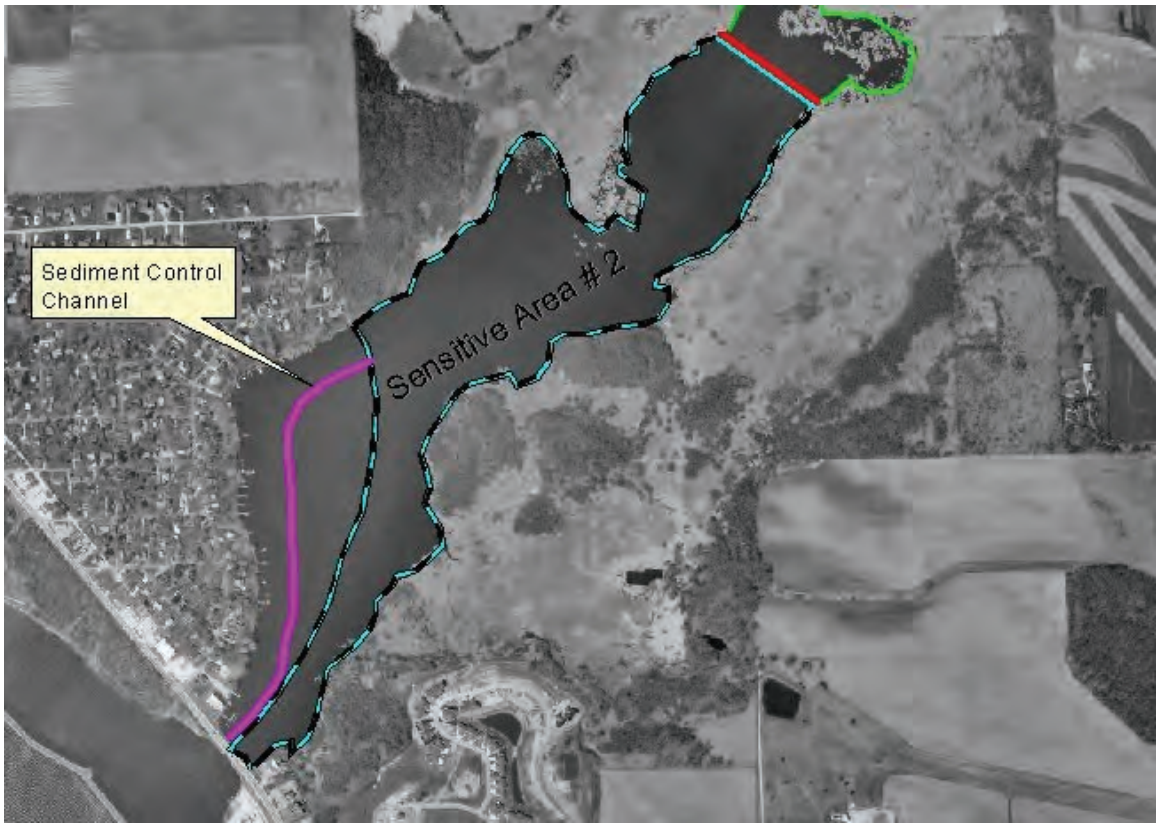
On July 8, 2005, a Department wildlife biologist and wildlife technician conducted a bird survey of the Delavan Lake inlet which is made up of Sensitive Areas 1 and 2. A canoe was used to conduct the bird survey which begun at 5:20 am at the Mound Road crossing of the inlet. The survey ended at 7 AM at the public boat launch.

The following species were seen or heard in the northern section of the inlet between 5:20 and 5:50 am: green heron (2), great blue heron (2), song sparrow (2), swamp sparrow (6), red-winged blackbird (17), common yellowthroat (6), wood duck (3 adults with 5 young), marsh wren (12), bank swallow (14), barn swallow (3).

The following species were seen or heard in the middle section of the inlet between 5:50 and 6:15 am: swamp sparrow (2), red-winged blackbird (4), marsh wren (13), song sparrow (1), common yellowthroat (2), killdeer (1), semi-palmated plover (2), sand hill crane (2), willow flycatcher (1), blue jay (2), American robin (1), American gold finch (1).

The following species were seen or heard in the south end of the inlet between 6:15 and 7:00am: killdeer (1), wood duck (9 adults 33 young), least bittern (3 adults, 1 young), marsh wren (17), common yellowthroat (10), green heron (1), yellow warbler (1), yellow headed blackbird (12), ring-billed gull (5), black tern (2).

Final – January 22nd, 2007



Resource Value of Sensitive Area Site 3 – Delavan Lake

Sensitive Area 3 in Lake Lawn Bay of Delavan Lake serves as a fish and wildlife refuge and has a diverse wildlife population. The area acts as a nutrient buffer to reduce algae blooms, a biological buffer reducing the likelihood of exotic invasions, a physical buffer against shoreline erosion, a micro-habitat that increases biodiversity, and allows for sediment stabilization. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of Delavan Lake, and Appendix 2 for fish information.

The average water depth in Sensitive Area 3 is about two feet. The sensitive area habitat includes the near-shore terrestrial land, shoreline, and littoral zones. The bottom substrate consists primarily of sand and gravel. The shoreland buffer consists of approximately 50 percent wetland and 50 percent wooded area. Herbaceous plants are dominant, covering 76-100 percent of the buffer zone, while shrubs and trees are common covering 26-50 percent of the buffer zone. The wetland consists of shallow marsh, deep marsh, and shrub carr. Willow and ash trees along with dogwood shrubs are common along the shore. Silver maple was also noted. Large woody cover is present at the rate of approximately 1-2 pieces every 30 meters of shoreline. This area has undergone minimal human influence, therefore the natural scenic beauty (NSB) of this area is considered to be average.

This area is an important fish nursery. The sand and gravel substrate provide spawning habitat for bass, bluegill, pumpkinseed and crappie. Northern pike, musky and yellow perch deposit eggs on the chara and other available submergent vegetation. Walleye deposit their eggs on the rock and gravel. Young of the year of all of the fish species mentioned utilize the area for feeding and shelter.

The extensive development of Delavan Lake has reduced available wildlife habitat. However, this portion of the lake provides suitable shelter, nesting area, and feeding area for muskrat, mink, duck, goose, songbird, osprey, frogs, toads, several species of turtle, and snakes. A painted turtle was observed during the survey conducted on June 23, 2005. This small area provides habitat for many species and provides an important shelter away from active boating and shoreline development. Emergent vegetation and snag trees are the most important habitat components at this site. Table 3 displays all plants found in the sensitive area and their level of abundance.

Table 3. Plants observed in Sensitive Area 3.

	Emergents	**Submergents**	**Exotics**	**Algae**
PRESENT (0-25% Cover)	Polygonum (smartweed)	*Potamogeton pectinatus* (sago pondweed)	*P. crispus* (curly-leaf pondweed)	
COMMON (26-50% Cover)	Salix (willow) Cornus (dogwood)			Chara (muskgrass)
ABUNDANT (51-75% Cover)				
DOMINANT (76-100% Cover)	*Typha* (cattail)			

Management Recommendations for Sensitive Area # 3

1. Maintain the current level of snags, cavity trees, perch trees, shrub and herbaceous cover, as well as aquatic vegetation.

2. Do not remove fallen trees along shoreline, except where navigation is impaired. If navigation is impaired by a fallen tree, cut into smaller pieces and place outside of boating lane.

3. No alteration of the littoral zone unless to improve spawning habitat.

4. A no wake zone is strongly recommended for this area (currently in place) to protect emergent aquatic vegetation.

5. Create a seasonal fish refuge area by not allowing motorized boats in the spring during fish spawning.

6. No chemical treatment allowed except to target an infestation of an exotic species such as purple loosestrife, eurasian watermilfoil or curly leaf pondweed. Biological controls such as the purple loosestrife beetle and the milfoil weevil should be considered where appropriate.

7. No mechanical harvesting should be conducted.

8. A DNR permit should not be issued for any of the following:

Dredging
Filling of wetlands
Aquatic plant screens
Boat Ramps
Pea gravel/sand blankets
Rip Rap
Recreational floating devices
Sea Walls/Retaining Walls

9. Boardwalks and piers will be allowed on a case by case basis to provide open water access only for a riparian landowner. Watercraft moored at the boardwalk or pier must be able to navigate the water without any additional dredging. The number of moorings allowed will be less than "reasonable use" as defined by state law.

In summary, Sensitive Area # 3 is very important as a refuge for fish and wildlife, away from active boating lanes. Important habitat components at this site include gravel bottom, submerged vegetation, and over-hanging vegetation. This area offers a spawning area, nursery area, feeding area, and protective cover to walleye, northern pike, musky, small mouth bass, large mouth bass, centrarchid, perch, sucker, and minnows. Many bird species utilize the complex of trees and shrubs and would not be present on Delavan Lake without this refuge.

Resource Value of Sensitive Area Site 4 – Delavan Lake

Sensitive Area 4, located in Highland's Bay of Delavan Lake, serves as an important fish nursery and has a diverse wildlife population. The area also acts as a physical buffer against shoreline erosion. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of Delavan Lake, and Appendix 2 for fish information.

The average water depth in sensitive area 4 is between four and five feet. Sediment depth is 1.5 to 2 feet. The sensitive area habitat includes near-shore terrestrial, shoreline, and littoral zones. The shoreland buffer zone consists of approximately 40 percent wetland, 50 percent wooded area, and 10 percent developed land. Herbaceous plants and trees are abundant, covering 51-75 percent of the shoreland buffer zone, while shrubs and lawns are present covering 1-25 percent of the shoreland buffer zone. The wetland consists of deep marsh and shrub carr. Large woody cover is present at the rate of approximately 1-2 pieces every 30 meters of shoreline. 90 percent of this sensitive area has undergone minimal human influence, having a natural scenic beauty (NSB) rating of good, while the remaining 10 percent has undergone human disturbance, and has an NSB rating of average.

The extensive development of Delavan Lake has reduced available wildlife habitat. However, this portion of the lake provides suitable shelter, nesting area, and feeding area for frogs and toads. Ducks and turtles use this area for shelter, cover and feeding. Important habitat components at this location include emergent vegetation, submergent vegetation, floating leaf vegetation, shrubs, brush and snag trees. Table 4 displays all plants found in the Sensitive Area and their level of abundance.

Table 4. Plants observed in Sensitive Area 4.

	Emergents	**Submergents**	**Floating Leaf**	**Free-floating**
PRESENT (0-25% Cover)		*Ranunculus trichophyllus* (water crow foot) *Vallisneria* (wild celery) *Myriophyllum sibiricum* (northern watermilfoil)		*Spirodela* (large duckweed)
COMMON (26-50% Cover)	Salix (willow)	*Ceratophyllum* (coontail)		
ABUNDANT (51-75% Cover)		*Stuckenia pectinata* (sago pondweed)	*Nymphaea odorata* (white water lily)	*Wolffia* (watermeal)
DOMINANT (76-100% Cover)	*Typha* (cattail)	*Myriophyllum spicatum* (Eurasian watermilfoil)		Filamentous (algae)

Management Recommendations for Sensitive Area # 4

1. Harvest cruising lanes for fish.

2. Harvest access lane for boats up to the edge of the cattails.

3. A no wake zone is strongly recommended for this area (currently in place) to protect emergent aquatic vegetation (especially water lilies).

4. Do not remove fallen trees along shoreline, except where navigation is impaired. If navigation is impaired by a fallen tree, cut into smaller pieces and place outside of boating lane.

5. No chemical treatment allowed except to target an infestation of an exotic species such as purple loosestrife, eurasian watermilfoil or curly leaf pondweed. Biological controls such as the purple loosestrife beetle and the milfoil weevil should be considered where appropriate.

6. A DNR permit should not be issued for any of the following along the undeveloped shoreline:

   Dredging
   Filling of wetlands
   Aquatic plant screens
   Sea Walls/Retaining Walls
   Pea gravel/sand blankets
   Rip Rap
   Recreational floating devices

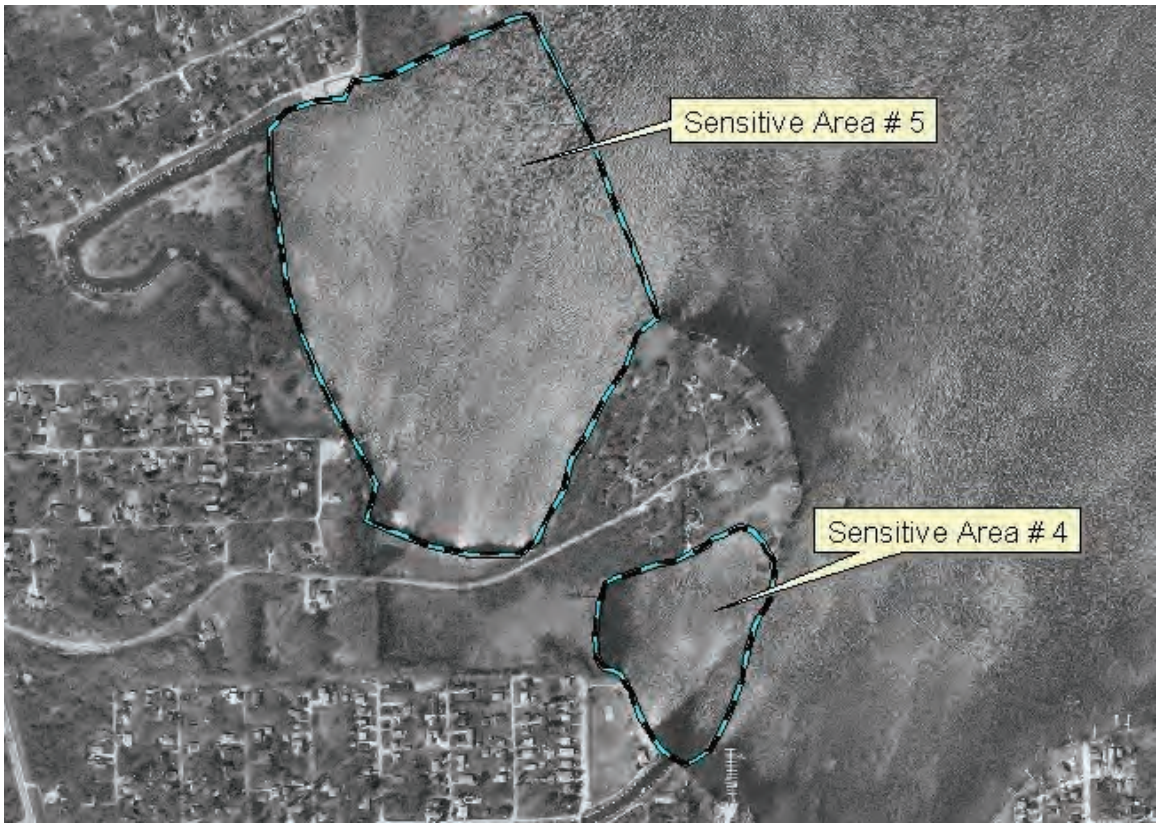
7. New piers along the currently developed shoreline will be permitted. The number of moorings allowed will be equal to "reasonable use" as defined by state law.

8. Restrict pier, boardwalk and ramp construction along the currently undeveloped shoreline. If condos or a subdivision are built, a single shared boat ramp would be less destructive to the sensitive area than piers.

9. Sediment in this area is deep. This sensitive area is not a good place for humans to swim or wade. Homeowners should not expect a permit to be granted for dredging in order to create swimming areas.

In summary, this site provides a visual and audio buffer from shoreline structures, roads, and boat traffic. Aquatic plants in the sensitive area include emergents, algae, potamogetons, exotics, free floating, floating leaf, and submergents. Wet edge plants include herbs and shrubs. Game fish, panfish, and forage fish are present in the sensitive area. Wildlife species present include furbearers, song birds, waterfowl, shore birds, amphibians, and reptiles. This site could be used to educate citizens about wetlands and sensitive areas.

White water lilies patches are limited in number on Delavan Lake. The lily pads in this bay are important to the survival of many fish species. Walleye, northern pike, musky, small mouth bass, large mouth bass, centrarchid, perch, suckers, and minnows utilize this sensitive area for feeding, protective cover, and as a nursery. Additionally, northern pike, musky, perch, and minnows (various forage fish) will use this area for spawning.


Sensitive Area # 5
Sensitive Area # 4

Resource Value of Sensitive Area Site 5 – Delavan Lake

Sensitive Area 5, located along the View Crest and Ravenswood sections of Delavan Lake, serves as an important fish nursery, has a diverse wildlife population, aquatic vegetation, terrestrial vegetation, and provides natural scenic beauty. The area also acts as a physical buffer against shoreline erosion. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of Delavan Lake, and Appendix 2 for fish information.

The average water depth in Sensitive Area 5 is approximately four feet. The sensitive area habitat includes near-shore terrestrial, shoreline, and littoral zones. The shoreland buffer zone consists of approximately 50 percent wetland, 40 percent wooded area, and 10 percent developed land. Herbaceous plants and trees are dominant, covering 76-100 percent of the shoreland buffer zone, while shrubs and lawns are present covering 1-25 percent of the shoreland buffer zone. The wetland consists of a deep marsh and shrub carr. Large woody cover is present at the rate of approximately 1-2 pieces every 30 meters of shoreline. A small part of this sensitive area has undergone human influence, having a natural scenic beauty (NSB) rating of average, while the remaining area has undergone minimal human disturbance, and has a good NSB rating.

Walleye, northern pike, musky, small mouth bass, large mouth bass, centrarchid (pan fish), perch, suckers, and minnows utilize this sensitive area for feeding, protective cover, and as a nursery. Additionally, northern pike, musky, perch, and minnows will use this area for spawning.

The extensive development of Delavan Lake has reduced available wildlife habitat. However, this portion of the lake provides suitable shelter, nesting area, and feeding area for muskrat, duck, songbirds, sandhill cranes (observed), kingbirds, kingfishers, frogs, toads, and turtles. Ducks and turtles use this area for shelter, cover and feeding. Emergent vegetation, floating leaf vegetation, shrubs, brush, and snag trees are important habitat components present at this location. Damselflies and dragonflies are abundant. Table 5 displays all plants found in the sensitive area and their level of abundance.

Table 5. Plants observed in Sensitive Area 5.

	Emergents	**Submergents**	**Free-floating**	**Algae**
PRESENT (0-25% Cover)	*Eupatorium maculatum* (joe pye weed) *Phragmites australis* (giant reed grass)	*Myriophyllum sibiricum* (northern watermilfoil) *Stuckenia pectinata* (sago pondweed)	*Wolffia* (watermeal) *Spirodela* (large duckweed) *Nymphaea odorata* (white water lily)	
COMMON (26-50% Cover)	*Typha* (cattail)			
ABUNDANT (51-75% Cover)		*Ceratophyllum* (coontail)		
DOMINANT (76-100% Cover)		*Vallisneria* (wild celery)	**Exotics** *Myriophyllum spicatum* (Eurasian watermilfoil)	Filamentous (algae)

Management Recommendations for Sensitive Area # 5

1. Create a shoreline buffer along the developed shoreline using native plants. Biologs should be utilized where appropriate.

2. Protect and restore emergent aquatic plants.

3. Harvest cruising lanes for fish.

4. Harvest two access lanes for boats, one for the Ravenswood subdivision and one for the View Crest subdivision.

5. A no wake zone is strongly recommended for this area (currently in place) to protect emergent aquatic vegetation (especially water lilies).

6. Do not remove fallen trees along shoreline, except where navigation is impaired. If navigation is impaired by a fallen tree, cut into smaller pieces and place outside of boating lane.

7. No chemical treatment allowed except to target an infestation of an exotic species such as purple loosestrife, eurasian watermilfoil or curly leaf pondweed. Biological controls such as the purple loosestrife beetle and the milfoil weevil should be considered where appropriate.

8. A DNR permit should not be issued for any of the following along the undeveloped shoreline:

Dredging	Pea gravel/sand blankets
Filling of wetlands	Rip Rap
Aquatic plant screens	Recreational floating devices
Sea Walls/Retaining Walls	

9. New piers along the currently developed shoreline will be permitted. The number of moorings allowed will be equal to "reasonable use" as defined by state law.

10. Restrict pier, boardwalk and ramp construction along the currently undeveloped shoreline. If condos or a subdivision are built, a single shared boat ramp would be less destructive to the sensitive area than piers.

In summary, the ecological community of Sensitive Area 5 provides a visual buffer from shoreline structures, roads, and boat traffic. Aquatic plants in the sensitive area include emergents, algae, potamogetons, exotics, free floating, floating leaf, and submergents. Wet edge plants include herbs and shrubs. Game fish, panfish, and forage fish are present in the sensitive area. Wildlife present in the area includes upland species, furbearers, songbirds, waterfowl / shore birds, amphibians, and reptiles. This site could be used to educate citizens about wetlands and sensitive areas.

Conclusion

Five sensitive areas have been designated on Delavan Lake, and development along the shoreline of each of the five sensitive areas should be carefully studied to prevent any further loss of habitat. This report identifies the biological components of each sensitive area, identifies sensitive area characteristics, and poses management recommendations for each of the five areas.

Wisconsin lakes attract many users, all of whom are affected by water quality. Delavan Lake attracts a diverse group of patrons, inevitably creating conflict between conservationists and recreational users. Therefore, the objective must be to create and maintain a balance between recreational use and preservation of habitat. This is essential to the lakes' health. An integrated approach to lake management that includes the public and all of the lakes' governing units will help to maintain this balance. Improving or at least maintaining water quality in Wisconsin lakes is critical. By protecting and restoring lake habitat, Delavan Lake will continue to sustain healthy ecosystems and responsible recreational opportunities for years to come.

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APPENDIX 1 - Aquatic plants within sensitive areas of Delavan Lake

Emergent	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**
Sparganium (bur reed)	X	X			
Zizania (wild rice)					
Typha (cattail)	X	X	X	X	X
Jancus (rush)		X			
Scirpus (bulrush)	X	X			
Eleocharis (spike-rush)					
Carex (sedges)	X				
Decodon (water-willow)					
Alisma (water plantain)					
Sagittaria (arrowhead)	X	X			
Acorus (sweet flag)					
Aster (aster)					
Thelypteris (marsh fern)					
Glyceria (mannagrass)					
Calamagrostis (Can. BG)	X	X			
Bidens (Beggar Tick)					
Lobelia (great blue)					
Iris (Blue Flag)		X			
Eupatorium (joe pye weed)		X			X
Eupatorium (boneset)		X			
Polygonum (smartweed)			X		
Arundo (giant reed)					X
Iris		X			
Mentha (mint)					
Asclepias (marsh milkweed)	X	X			
Verbena (blue vervain)	X				
Coreopsis (tick seed)					
Impatiens (jewelweed)					
Rumex (marsh dock)					
Cornus (dogwood)	X	X	X		
Salix (willow)	X	X	X	X	
Solidago (goldenrod)					

Final – January 22nd, 2007

Submergent	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**
Myriophyllum sibiricum (northern watermilfoil)		X		X	X
Chara (muskgrass)					
Potamogeton amplifolius (large-leaf pondweed)					
Potamogeton nodosus (longleaf pondweed)		X			
Elodea (waterweed)		X			
Utricularia (bladderwort)					
Ceratophyllum (coontail)	X	X		X	X
Stuckenia pectinata (sago pondweed)	X	X		X	X
Ranunculus trichophyllus (water crow foot)		X		X	
Vallisneria (wild celery)				X	
P. zosteriformis (flat-stemmed pondweed)		X			
P. illinoensis (Illinois pondweed)					
Najas flexilis (slender naiad)					
P. praelongus (white-stemmed pondweed)					
P. richardsonii (clasping-leaf pondweed)		X			

Free-floating					
Nuphar advena (yellow water lily)					
Nymphaea odorata (white water lily)				X	X
Wolffia (watermeal)	X	X		X	X
P. natans (floating-leaf pondweed)					
Lemna (duckweed)		X			
Spirodela (large duckweed)	X			X	X

Exotic					
Myriophyllum spicatum (Eurasian watermilfoil)	X	X		X	X
P. crispus (curly-leaf pondweed)	X		X		
Lythrum (purple loosestrife)					

Algae					
Chara (muskgrass)			X		
filamentous	X	X			X

APPENDIX 2 – Fish Species in Delavan Lake

Doug Welch, Fisheries Biologist

Walleyed pike, yellow perch, northern pike, muskellunge, largemouth bass, smallmouth bass, bluegill, pumpkinseed, green sunfish, black crappie, rock bass, black bullhead, white sucker, mimic shiner, fathead minnow, and common carp can all be found in Delavan Lake.

The shoreline of Delavan Lake is highly developed, and the sensitive areas give the fish population a natural area to sustain themselves. Walleye, northern pike, musky, smallmouth bass, largemouth bass, perch, suckers, and minnows use the sensitive areas on Delavan Lake as nurseries, feeding areas and for protective cover. The sensitive areas are also used by fish for spawning, especially the sensitive areas with sand and gravel bottoms.

The sand and gravel bottom of Sensitive Area 3 provides a spawning habitat for bass, bluegill, pumpkinseed, and crappie. Northern pike will deposit their eggs on the chara, and other submergent vegetation. Walleye will deposit their eggs on the rock and rubble. All the above mentioned fish use this site as a nursery and feeding area.

Lilly pads are limited on Delavan Lake. The lilly pads in Sensitive Area 4 (Highlands Bay) provide shade and cover habitat for many species of fish. Fish feed on invertebrates attached to lilly pads and submergent aquatic vegetation in this bay. The bay is used for feeding and protection and as a nursery by walleye, musky, bass, northern pike, bluegill, pumpkinseed, crappie, yellow perch, suckers, and minnows. This bay is used for spawning by northern pike, yellow perch, and various minnows.

Submergent and floating leaf aquatic vegetation in Sensitive Area 5 (Ravenswood and View Crest) provides spawning habitat for northern pike, musky, yellow perch, and minnows. Bass, bluegill, and pumpkinseed will construct nests in areas where silt is not too deep. Bass, bluegill pumpkinseed, yellow perch, crappie, walleye, northern pike, musky, and minnows use this site as a nursery and feeding area.

Appendix C

BOATING ORDINANCE
APPLICABLE TO DELAVAN LAKE

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CHAPTER 19
MUTUAL AND IDENTICAL REGULATIONS FOR BOATING ON DELAVAN LAKE AND LAKE COMUS FOR THE CITY AND TOWN OF DELAVAN

19.01 PURPOSE. The regulations set forth in this Chapter are adopted pursuant to 30.77(3)(a), Stats, permitting cities, villages, and towns in the interest of public health, safety or welfare to adopt local regulations, which are consistent with Sec. 30, Stats., and are applicable to the waters of Delavan Lake and Lake Comus, being within the state and located only in the jurisdictions of the City and Town of Delavan, such regulations including those relating to the equipment, use or operation of boats or any activity regulated by ss 30.61 to 30.71, thereby requiring identical local regulations enacted by all towns, cities and villages having jurisdiction. These regulations hereinafter set forth are accordingly substantively identical for the Town and City.

Established April 17, 2002, Ordinance No. 229

19.02 INTENT. The intent of this chapter is to provide access to Delavan Lake and Lake Comus for all users and further provide safe and healthful conditions for the enjoyment of aquatic recreation consistent with public needs and the capacity of the water resource, recognizing the intensity of their recreational use. This chapter is deemed necessary in the interest of public health, safety and welfare.

Established April 17, 2002, Ordinance No. 229

19.03 APPLICABILITY AND ENFORCEMENT. The provisions of this chapter apply to the waters of Delavan Lake and Lake Comus and that portion of the inlet and outlet lying wholly within the City of Delavan and Town of Delavan, Walworth County, Wisconsin. The provisions of this chapter shall be enforced by the authorized law enforcement officers of the City of Delavan and Town of Delavan police departments, inclusive of the Water Safety Patrol.

Established April 17, 2002, Ordinance No. 229

19.04 STATE BOATING AND WATER SAFETY ADOPTED. The statutory provisions describing and defining regulations with respect to water traffic, boats, boating and related water activities in the following enumerated sections or subsections of the Wisconsin Statutes, exclusive of any provisions therein relating to the penalties to be imposed for the punishment for violation of such statutes, together with any future amendments, modifications, revisions, additions or deletions of the Wisconsin Statutes incorporated herein, shall be incorporated herein and made a part

of this Code in order to secure uniform regulations of lake use; are hereby adopted and by reference made a part of this section, as if fully set forth herein:

(1)	30.50	Definitions.
(2)	30.501	Capacity plates on boats.
(3)	30.51	Certificate of number and registration; requirements; exemptions.
(4)	30.52	Certificate of number and registration; application; certification and registration period; fees; issuance.
(5)	30.523	Certification or registration card to be on board; display of stickers or decals and identification number.
(6)	30.531	Certificate of title; requirements; exemptions.
(7)	30.54	Lost, stolen or mutilated certificates.
(8)	30.541	Transfers of boat titles.
(9)	30.543	Report of stolen or abandoned boats.
(10)	30.544	Inspection of boats purchased out-of-state.
(11)	30.549	Transfer of ownership of boats with a certificate of title, certificate of number or registration.
(12)	30.55	Notice of abandonment or destruction of boat or change of address.
(13)	30.60	Classification of motorboats.
(14)	30.61	Lighting equipment.
(15)	30.62	Other equipment.
(16)	30.63	Sale and use of certain outboard motors restricted.
(17)	30.64	Patrol boats.
(18)	30.65	Traffic rules.
(19)	30.66	Speed restrictions.
(20)	30.67	Accidents and accident reports.
(21)	30.675	Distress signal flag.
(22)	30.68	Prohibited operation.
(23)	30.681(1)	Intoxicated boating.
(24)	30.682	Preliminary breath screening test.
(25)	30.683	Implied consent.
(26)	30.684	Chemical tests.
(27)	30.686	Report arrest to department.
(28)	30.678	Officer’s action after arrest for violating intoxicated boating law.
(29)	30.69	Water skiing.
(30)	30.70	Skin diving.
(31)	30.71	Boats equipped with toilets.

Established April 17, 2002, Ordinance No. 229

19.05 DEFINITIONS.

(1) TRAFFIC LANE. The traffic lane of Delavan Lake embraces the entire surface thereof, excepting therefrom those areas designated, "shore zone" or "swimming zone" as defined herein and identified on the map marked Exhibit "A" on file in the City Clerk's and Town Clerk's office, or areas defined as "slow no wake" by marker buoys registered and approved by the State of Wisconsin Department of Natural Resources and the Town of Delavan. No traffic lane is designated for Lake Comus. (See definition of "Shore Zone" as it pertains to Lake Comus.)

(2) SHORE ZONE. On Delavan Lake, the water area within 200 feet of any shore. On Lake Comus, the shore zone shall be deemed to embrace the whole surface thereof.

(3) SWIMMING AREA. An authorized area within 200 feet from shore marked by official buoys to designate a swimming area.

(4) CHANNEL. A waterway less than 400 feet wide.

(5) PUBLIC LANDING. A marina or landing facility and the adjoining public shore line under the ownership or operation of the State, County, City or Town.

(6) DESIGNATED ANCHORAGE. That area of water established and marked as an anchorage by lawful authority.

(7) WATER SAFETY PATROL OFFICER. Any duly authorized law enforcement officer, including City and Town police officers and Walworth County sheriff's deputies.

(8) PERSON. "Person" includes any individual, firm, partnership, corporation, company, association, or body politic, except the United States and the State of Wisconsin, and includes any agent, trustee, personal representative, receiver, assignee or other similar representative thereof.

(9) SAILBOAT. Any water craft propelled by sail which is designed and constructed to be used as a boat for transportation of a person or persons. When a sailboat is propelled by machinery instead of by sail, it shall be deemed to be a motorboat.

(10) SLOW-NO-WAKE. That speed at which a boat moves as slowly as possible while still maintaining steerage control.

Established April 17, 2002, Ordinance No. 229

19.06 SPEED RESTRICTIONS.

(1) No person shall at any time operate a boat at a speed in excess of slow-no-wake within the shore zone, or within 200 feet of any swimmer, marked swimming area, diving flag, canoe, rowboat, sailboat, non-operating motor boat, bridge, public landing, anchorage, or areas defined as slow-no-wake by marker buoys registered and approved by the State of Wisconsin Department of Natural Resources and the Town of Delavan.

(2) No person shall operate a boat in excess of 15 miles per hour within the traffic lane between sunset and sunrise, except for water safety patrol or emergency water craft.

(3) Notwithstanding other provisions to the contrary appearing herein or adopted by reference, on Lake Comus no person shall operate a boat in excess of slow-no-wake except for emergency water craft.

(4) No person shall operate a boat in excess of slow-no-wake in the west bay area of Lake Delavan as defined by "slow-no-wake" buoys placed in a line starting 200 feet from the Chicago Club stairs to the lakeshore on the north shore of the lake to within 200 feet of Blue Gill Road on the south shore of the lake. In addition, no person shall operate a boat in excess of slow-no-wake in the inlet of Lake Delavan, defined as that area north of the Highway 50 bridge across Lake Delavan, and in the outlet of Lake Delavan, defined as the area west of the North Shore Bridge, on North Shore Drive of Lake Delavan.

Established April 17, 2002, Ordinance No. 229

19.07 OPERATION OF MOTOR VEHICLES ON ICE.

(1) No person shall operate an automobile, farm truck, motor bus, motor truck, truck tractor or any other motor vehicle with a shipping weight of more that 1,000 pounds on the frozen waters of Delavan Lake or Lake Comus.

(2) This section shall not apply to authorized emergency vehicles or other vehicles operating with the specific authorization of the City of Delavan Police Department or Town of Delavan Police Department.

(3) The statutory definitions contained in Sec. 340.01, Wisconsin Stats., are hereby adopted and by reference made a part of this section as if fully set forth herein.

Established April 17, 2002, Ordinance No. 229

19.08 CAPACITY.

(1) RESTRICTIONS. No person shall operate or own, rent or permit a boat to leave the place where it is customarily kept for operation on the waters covered by this chapter with passengers or cargo in excess of the capacity recommended by the manufacturer's rating.

(2) HORSEPOWER CAPACITY. No person shall operate or loan, rent or permit a boat to leave the place where it is customarily kept for operation on the waters covered by this chapter, powered by a motor with horsepower in excess of the capacity recommended by the manufacturer of said boat.

Established April 17, 2002, Ordinance No. 229

19.09 ADDITIONAL TRAFFIC RULE(S).

(1) In addition to the traffic rules in Sec. 30.65, Wis. Stats., the following rule shall apply to boats using the waters covered by this chapter:

(a) Right-of-Way at Docks, Piers and Wharfs. All boats leaving or departing from a pier, dock or wharf have the right-of-way over all other water craft approaching such dock, pier or wharf.

Established April 17, 2002, Ordinance No. 229

19.10 INTOXICATION AND INTOXICATING LIQUORS. Intoxicated Persons Not to Ride in Boats. In addition to Subsec. 30.681(1) Wis. Stats., no person shall permit any person who is so intoxicated as to be unable to provide for his own safety or the safety of others to ride as a passenger in any boat operated by him.

Established April 17, 2002, Ordinance No. 229

19.11 SAFE OPERATION REQUIRED. No person shall operate, direct or handle a boat in such manner as to unreasonably annoy, unnecessarily frighten or endanger the occupants of his or other boats. In addition, no person shall operate, direct or handle a boat in a negligent manner or in any other manner that could endanger the life, property or person of another. Continued violations of this section by a minor could subject the parent, guardian, lessor or owner to arrest and persecution for contributing to the delinquency of a minor.

Established April 17, 2002, Ordinance No. 229

19.12 WATER SKIING. In addition to Sec. 30.69, Wis. Stats., the following other restrictions shall apply:

(1) Any boat engaged in starting, towing, dropping, or releasing a person on water skis, aquaplane or similar device must conform to all sections of this chapter, and in addition, must operate only in the traffic lane.

(2) There shall be no more than 2 tow lines per boat and no more than one person using each tow line as a means of water skiing or similar sport. The persons being towed shall be equipped with a coast guard approved personal flotation device.

Established April 17, 2002, Ordinance No. 229

19.13 SWIMMING REGULATIONS.

(1) SWIMMING FROM BOATS PROHIBITED. No person shall swim, snorkel or skin dive in the shore zone from any boat unless such boat is anchored and unless the swimmers, snorkelers and skin divers stay within 25 feet of the boat.

(2) SWIMMING IN TRAFFIC LANE; DISTANCE SWIMMING. No person in Delavan Lake shall swim, snorkel or skin dive in the traffic lane (more than 200 feet from shore). No person in Delavan Lake or Lake Comus shall do any distance swimming, snorkeling or skin diving unless the person is accompanied by a boat carrying a ring buoy and containing a competent observer. For this type of swimming, if there be more than one swimmer, snorkeler or skin diver, each shall be accompanied by a boat.

Established April 17, 2002, Ordinance No. 229

19.14 POLLUTING AND LITTERING WATERS PROHIBITED.

(1) No person shall deposit, place or throw, or allow or cause to be deposited, placed or thrown from the shore or from any boat, raft, pier platform or similar structure any cans, paper, bottles, debris, refuse, garbage, solid or liquid waste into the water of the lake or on the ice of the lake.

(2) No person shall discharge or cause or allow to be discharged any solid or liquid waste from his residence onto the grounds or shore land so that waste could either artificially or naturally flow into the water of the lake or upon the ice of the lake.

Established April 17, 2002, Ordinance No. 229

19.15 OVERNIGHT MOORING PROHIBITED. The anchoring, drifting or mooring of boats on open water, upon which people are living, sleeping or camping is prohibited between 10:00 p.m. and 4:00 a.m.

Established April 17, 2002, Ordinance No. 229

19.16 BUOYS MARKING RACE COURSES. Such buoys may be set without lighting and no permit is required from the Water Safety Patrol. Such buoys shall be of a bright color and made of materials which will not damage a boat if struck. Authorization shall be obtained from the City of Delavan or the Town of Delavan for any buoy marking race courses between sunset and sunrise.

Established April 17, 2002, Ordinance No. 229

19.17 STATIONARY ARTIFICIAL STRUCTURES.

(1) DECLARATION OF PURPOSE. The purpose of this section is to promote the public health, safety and welfare of all persons using the navigable waters of the Town. It is recognized that the indiscriminate location of stationary artificial structures within and upon such waters, without any municipal supervision or regulation thereof, constitutes a danger and hazard to the healthful and safe enjoyment of the rights of such waters.

(a) This section is not intended to interfere with the riparian rights of riparian owners.

(2) PERMIT TO ESTABLISH STATIONARY ARTIFICIAL STRUCTURES NECESSARY.

(a) Required. No person shall establish by anchor, pilings, or other type of construction, an artificial stationary structure, raft or buoy other than a wharf or pier, within the shore zone or a contrivance used or designed for navigation on water, within or upon the navigable waters of the Town, without first obtaining a permit from the Town Board, to erect such a structure.

(i) The section shall not apply to those structures regulated by the Public Service Commission under Section. 30.12, Wis Stats.

(b) Application. Application for such permit shall be made on forms furnished by the Town Clerk, and shall state the name of the applicant, the proposed location of the structure, its design and dimensions, including, but not limited to the height above and below the water line, lighting and reflection equipment to be installed, nature of anchorage to water bed, permanency of structure, purpose for which it will be used, together with such additional pertinent information as the Town Board may require.

(c) Requirements. Pursuant to Secs. 30.13 and 30.772, Wis Stats., the Town of Delavan does hereby enact local regulations and restrictions upon the granting and issuance of permits for establishing artificial stationary structures in the navigable waters in Delavan Lake.

(i) Buoys. No permit for the placement of a mooring buoy in the navigable waters of Delavan Lake may be granted unless all of the following criteria are satisfied:

(A) Only riparian property owners shall be permitted to place mooring buoys for use by said owner

(B) For purposes of this ordinance the location of any mooring buoy shall include the distance from the center of the mooring buoy outward in any direction, in a radius of thirty feet. Placement of the mooring buoys shall be within the pierhead line established Sec. 19.18(2) of this Municipal Code and also be within the setback requirement of Sec. 19.18(3)(e)(i) of this Municipal Code. Further, no mooring buoy may extend beyond the riparian owner's pier.

(C) The placement of any mooring buoy within the limitations set forth herein shall not be permitted if any other pier, wharf, mooring, or other permanent structure exists within the area where the mooring buoy is to be placed.

(D) No stationary mooring buoy may be placed within ninety feet of a location ordinarily used as a swimming or fishing area, boat launch nor any other area that may interfere with navigation on any waterway.

(E) This section applies to mooring buoys only and not to aids to navigation that require a permit from the Department of Natural Resources.

(F) No mooring buoys may be placed under this ordinance more than two hundred (200) feet from the nearest ordinary high-water shoreline mark, unless a permit for same is obtained from the State of Wisconsin Department of Natural Resources.

(G) No mooring buoy may be placed or used in any navigable waters if:

i. The mooring buoy obstructs or interferes with public rights or interest in the navigable waters.

ii. The riparian owner does not give written permission for the placement and use of the mooring buoy.

iii. The mooring buoy or use of the mooring buoy interferes with the rights of other riparian owners.

iv. The mooring buoy or use of the mooring buoy adversely affects critical or significant fish or wildlife habitat.

v. The mooring buoy violates any other rules of the Department of Natural Resources or the placement or use of the mooring buoy violates a condition or restriction on a permit issued by the Department of Natural Resources.

vi. The mooring buoy anchor is placed more than two hundred (200) feet from the ordinary high-water mark unless one of the following applies:

a. A permit is obtained from the Town of Delavan and approved by the Department of Natural Resources.

b. A permit is obtained from the Department of Natural Resources.

c. The mooring buoy is properly within a designated mooring buoy area.

(ii) Rafts. No permit for the placement of any permanent raft in the navigable waters of Delavan Lake may be granted unless all of the following criteria are satisfied:

(A) Rafts may not be used to secure permanent attachments for boats or personal water craft.

(B) All rafts shall have a minimum of twenty-four square inches of reflective material on each side that is plainly visible to boat traffic.

(C) Rafts shall have the permit number of the riparian owner affixed to said raft, which is clearly visible for purposes of identification.

(D) All rafts shall be no more than 100 feet from shore.

(E) All rafts shall have an elevation of at least twelve inches above the water line at flat water.

(d) Determination by Town Board. Within 10 days after receipt of the application, the Town Board, or its designated agent, shall personally inspect the structure and area of its designated agent, shall personally inspect the structure and area of its location for which a permit is requested, and shall make a determination as to whether the erection of the proposed structure will be detrimental

to the health, safety and welfare of the users of the navigable waters of the Town, or whether it will constitute an unreasonable obstruction or interference with the free navigation of such waters. The determination shall be made on the bases of the information contained in the application, and a personal inspection of the structure and its proposed location by the members of the Town Board, or its designated agent. The following considerations shall be included in those weighted by the Board in reaching its determination:

(i) The proposed location of the structure;

(ii) The length of time it is to be established in such location;

(iii) Dimensions of the structure;

(iv) Composition and design of the structure;

(v) Warning lights and reflector lights on the structure;

(vi) Heights above and depth below the water line at the proposed locations;

(vii) Use or uses to be made of the structure;

(viii) Existing uses made of the waters in which the structure is to be established;

(ix) Effect of structure on free navigation of such waters;

(x) Effect of structure on health, safety and welfare of all users of such waters.

(A) The Town Board shall thereupon grant or deny the permit in accordance with such determination.

(e) Issuance of Permits. If satisfied that the proposed structure will not be a danger or hazard to the health and safe enjoyment, and the free navigation of the navigable waters of Delavan lake by all users thereof, and upon payment of a permit fee of $10.00, the Town Board shall issue a permit to establish such structure, signed by the Town Chairman and the Town Clerk, which permit shall specify the conditions under which the structure may be established and used. Such permit may be revoked or suspended for cause, by the Town Board upon written, verified complaint. Prior to revocation or suspension of such permit, the Town Board. Such written notice of hearing, containing the alleged reasons for the proposed action, shall be served upon the permittee at least 10 days prior to the date set for the hearing. These requirements

shall be in addition to the requirements of the State, as presently enforced by the Town. All permits issued pursuant to this section shall be effective for 3 years from the date of issuance.

(f) Penalties and Remedies. If any structure is established in violation of this chapter, the following remedies and penalties may be imposed:

(i) After structure permit is issued, the Town may revoke the permit if the structure subsequently violates any provision of this chapter or state law.

(ii) A structure violating any provision of this chapter or state law shall constitute a nuisance pursuant to Sec. 30.294, Stats., punishable by a forfeiture not to exceed $50.00 for each such violation. Under this subsection, each day constitutes a separate offense.

(iii) The unlawful structure may, additionally, or as an alternative remedy, to sub. (ii), be removed by town officials pursuant to the procedures of Sec. 66.0495, Stats.

(g) Retrospective Operation. Because this chapter is enacted under the power of the Town Board to enact regulations for the health, safety and welfare of its citizens, its terms shall operate retroactively upon existing structures that come within its scope, where the persons establishing such structures have no vested rights in them. No vested rights shall be considered to exist where the person establishing the structure was or should have been aware of the intention of the Town Board to regulate such establishments, prior to the expenditure by such person of substantial moneys in the establishment of such structure.

(h) Mooring or Anchoring in Swimming Areas. No person shall moor or anchor any boat, at any time, other than an emergency craft, in marked swimming areas.

(i) Public Landings. No person shall moor or anchor any boat at public beaches, parks or landings other than at piers as designated by the controlling government agency.

(j) Procedures. The procedures and provisions of Chapter 68, Wis. Stats., shall apply to the grant, denial or revocation of a structure permit by the Town.

Established April 17, 2002, Ordinance No. 229

19.18 ESTABLISHMENT OF PIERHEAD LINE AND WHARF REGULATIONS.

(1) DEFINITIONS. The definitions as set forth in Sec. 30.01, Stats., are hereby adopted and incorporated herein by reference, the same as if set forth at length herein. Any future amendments, revisions or modifications of the state statutes incorporated herein are intended to be made a part of this subsection. In this ordinance:

(a) PIER shall mean any structure extending channel ward from the shore with water on both sides, built or maintained for the purpose of providing a berthing or mooring place for watercraft or for loading or unloading cargo or passengers onto or from watercraft including temporary boat hoists without roof or walls.

(b) WHARF shall mean any structure extending along the shore and generally connected with the uplands throughout its length, built or maintained for the purpose of providing a berthing or mooring place for watercraft or for loading or unloading cargo or passengers onto or from watercraft.

(c) PIERHEAD LINE shall mean as established in para. (2)(a) below, is a line established in the water of Delavan Lake adjacent to and roughly parallel to the shoreline for the purpose of creating uniformity in the length of piers extending from the shoreline into the waterway.

(2) ESTABLISHMENT OF PIERHEAD LINE

(a) Pursuant to Secs. 30.13(3) and 30.11, Stats., and in the interest of the preservation and protection of the public's rights in the waters of Delavan Lake, the Town of Delavan, within its respective boundaries, does hereby establish a pierhead line on Delavan Lake, which shall be at a distance of 80 feet waterward from the shoreline, except in areas where wetland extend 45 feet or more channelward from the shoreline, in which case, the pierhead line is established at a distance of 35 feet channelward into open water from the channelward edge of the wetland. The shoreline, for the purpose of this subsection, shall be at the elevation of 94.75 (feet) WDNR datum (or 927.91 MSL), commonly referred to as the "summer level," which is 36 ½ inches below the brass bench mark (elevation 97.79 (feet) WDNR datum (or 930.95 MSL), located on the cement bank on the north side of the dam. The pierhead line shall run parallel to the shoreline. "Wetland" is defined as an area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, has soils indicative of wet conditions, but is not open water.

(3) PIER PLANNER

(a) All piers, accessories, and other nearshore construction as referenced in the Pier Planner WZ-017 (3/96 revision) published by the WDNR are hereby incorporated herein by reference as guidelines that must be followed by waterfront property owners on Delavan Lake

(b) Extension Beyond Pierhead Line; Exception.

(i) No wharf or pier shall extend beyond the pierhead line which has been established under para. (2)(a) above. A wharf or pier which extends into navigable waters beyond the pierhead line established under para. (2)(a) constitutes an unlawful obstruction of navigable waters unless authorization for the wharf or pier is granted, pursuant to subsec. (3)(c) of this Ordinance, or unless it is a permissible preexisting wharf or pier that existed prior to the establishment of the pierhead line on November 15, 1998.

(3)(c) VARIANCE POWER. The Town of Delavan shall have the power to hear and grant requests for variances to the provisions of para. (2)(a), above, relating to the pierhead line. Such variances shall be so conditioned that the spirit and purpose of this Ordinance shall be observed and the public health, safety and welfare preserved and substantial justice done.

(i) No such variance shall be granted unless there are exceptional, extraordinary or unusual circumstances or conditions applying to the lot or parcel in question that do not apply generally to other properties on Delavan Lake.

(ii) No such variance shall be granted that will create substantial detriment to adjacent property or that will materially impair or be contrary to the purpose and spirit of this Ordinance.

(d) VARIANCE PROCEDURES. Application for a variance shall be made to the Town of Delavan Plan Commission. Said application shall state, with reasonable specificity, the location of the property, ownership of the property, what type of variance is being sought, and the reasons of the applicant for seeking the variance. The applicant may request and the Plan Commission shall grant, if requested, a hearing on the proposed variance. The Plan Commission shall make a determination within ten days from the date of hearing (exclusive of the date of hearing) on the variance, unless waived by the applicant. The Plan Commission shall, in writing, cause to be filed with the Town Clerk, its findings and reasons for the granting or denial of the variance.

(e) APPEAL. Any person aggrieved by the determination of the Plan Commission may, within ten days of the filing of the Plan Commission determination with the Town Clerk, file written notice of appeal with the Town Clerk. Said notice shall specify the reasons for appeal. Any notice of appeal not filed within the time specified herein shall be deemed to have been waived. The Town Board shall promptly review a properly filed appeal. Review of a Town Board determination shall be in accordance with Chapter 68, Wis. Stats.

(4) REMOVAL OF UNLAWFUL OBSTRUCTIONS. The Town of Delavan may remove or cause to be removed a wharf or pier which constitutes an unlawful obstruction of navigable waters as set forth in subsection (3) above, as provided under Sec. 66.0495, Stats.

(5) DILAPIDATED STRUCTURES IN NAVIGABLE WATERS PROHIBITED.

(a) Any wharf or pier in navigable waters which is so old, dilapidated or in need of repair that it is dangerous, unsafe or unfit for use, may be proceeded against by the Town of Delavan, in the manner and pursuant to the procedure provided in Sec. 66.0495 Stats.

(b) Any wharf or pier in navigable waters which is declared so old, dilapidated or in need of repair that it is dangerous, unsafe or unfit for use under Sec. 66.0495(1)(b), Stats., or repair is determined unreasonable under that section, is a public nuisance and may be proceeded against under ch. 823, Stats. or under Chapter 10 of this Municipal Code.

(6) MARINAS AND LAGOONS. No marina or lagoon shall be constructed or expanded unless a permit for the same has been obtained from the Wisconsin Department of Natural Resources as provided by law. At the time an application is filed with the Department of Natural Resources, a copy of such application shall be filed with the Town of Delavan.

(7) FIRE NUMBERS REQUIRED. The Town Board shall require the owners of all wharves and piers, including owners of all permissible preexisting wharves and piers, to install fire number signs on those piers of a design specified by the Town Board. Subdivisions and Associations shall have the name of the Association or Subdivision installed upon its piers in lieu of or in addition to fire numbers. All piers shall be registered with the Town Clerk.

(8) PENALTIES. Any person who shall violate any of the provisions of any section of this ordinance, shall, upon conviction thereof, be subject to the penalties as set forth in Section 19.18(1) of the Municipal Ordinances of the Town of Delavan.

(9) LAKE AND STREAM ACCESS. It is not intended by this ordinance to repeal, abrogate, or annul, provisions of Section 19.09(10) of this municipal code.

Established April 17, 2002, Ordinance No. 229; Revised February 18, 2003,Ordinance No. 240, Revised September 16, 2003.

19.19 MOORING OR ANCHORING IN SWIMMING AREAS. No person shall moor or anchor any boat, at any time, other than an emergency craft, in marked swimming areas.

Established April 17, 2002, Ordinance No. 229

19.20 PUBLIC LANDINGS. No person shall moor or anchor any boat at public beaches, park or landings other than at piers as designated by the controlling government agency.

Established April 17, 2002, Ordinance No. 229

19.21 ENFORCEMENT.

(1) POWERS. An officer patrolling the waters may stop and board any boat for the purpose of enforcing Secs. 30.50 to 30.80, Wis Stats., or any rules or ordinances enacted pursuant thereto, if he has reasonable cause to believe there is a violation of such sections, rules or ordinances, or if the stopping and boarding of any boat is essential to conduct a search and rescue operation.

(2) ARREST FOR VIOLATION. Any person violating any provision of this chapter shall be subject to arrest, whether at the time of arrest he is on the waterways or upon shore and any water patrol officer may pursue the offender ashore to enforce the terms hereof.

(3) PROCEDURE ON ARREST. Whenever a person is arrested for violation of this chapter, the Water Safety Patrol officers may permit such person to make a money deposit. Such deposit shall be made to the Town or City of Delavan or to the Municipal Judge of the Town or City in an amount not to exceed the amount of the maximum forfeiture which may be imposed after the accused is found guilty, or other such amount as may be fixed by that particular Court in the setting up of a bail bond schedule.

(4) FAILURE OF DEFENDANT TO APPEAR. If the person so arrested and released fails to appear personally or by an authorized attorney or agent before the Court at the time fixed for hearing, the money deposit by the accused, pursuant to the previous subsection, shall be retained and used for the payment of the forfeiture, which forfeiture may be imposed either with or without costs as determined by the Court after an ex parte hearing upon the accused. The excess, if any, shall be returned to the person who makes the deposit upon his making application for the same. If the accused is found not guilty, the entire amount of the deposit shall be refunded to the depositor upon his making application for the same.

Established April 17, 2002, Ordinance No. 229

19.22 MARKERS AND NAVIGATION AIDS: POSTING CHAPTER.

(1) DUTY OF CHIEF. The Chief of the Water Safety Patrol shall place and maintain or have placed and maintained suitable markers, navigation aids and signs in such water areas as shall be appropriate to advise the public of the provisions of this chapter and post and maintain a copy of this chapter at all public access points within the jurisdiction of the Town.

(2) STANDARD MARKERS. All markers placed by the Chief or any other person upon the waters of the lake shall comply with the regulations of the State Department of Natural Resources and/or any State statutory provision.

(3) INTERFERENCE WITH MARKERS PROHIBITED. (Am. #86) No person shall, without authority, remove, damage or destroy or moor or attach any water craft to any buoy (except mooring buoys when authorized), beacon or marker placed in the waters of the lake by the authority of the United States, State, Village or Town or by any private person pursuant to the provisions of this chapter.

(4) ENFORCEMENT POWERS. An officer patrolling the waters as a part of a water safety patrol unit may stop and board any boat or any rules or ordinances enacted pursuant thereto, if they have reasonable cause to believe there is a violation of such section, rules or ordinances.

Established April 17, 2002, Ordinance No. 229

19.23 PENALTIES. The penalties set forth in Sec. 30.80, Stats., are hereby incorporated by reference.

Established April 17, 2002, Ordinance No. 229

19.24 REPEAL OF CONFLICTING ORDINANCES. All ordinances regulating traffic, boats, boating or water sports upon the waters covered by this chapter and all ordinances or parts of ordinances in conflict with this chapter heretofore enacted are hereby repealed.

(1) It is contemplated hereby, and the adoption of this ordinance is conditioned upon, the Common Council of the City of Delavan similarly adopting the foregoing regulations contained therein as a part of its municipal code.

(2) This ordinance shall be effective the day following the publication of the last to be published of the ordinance or its counterpart City of Delavan ordinance adopting the same regulations, both being published subsequent to their respective adoptions.

Established April 17, 2002, Ordinance No. 229