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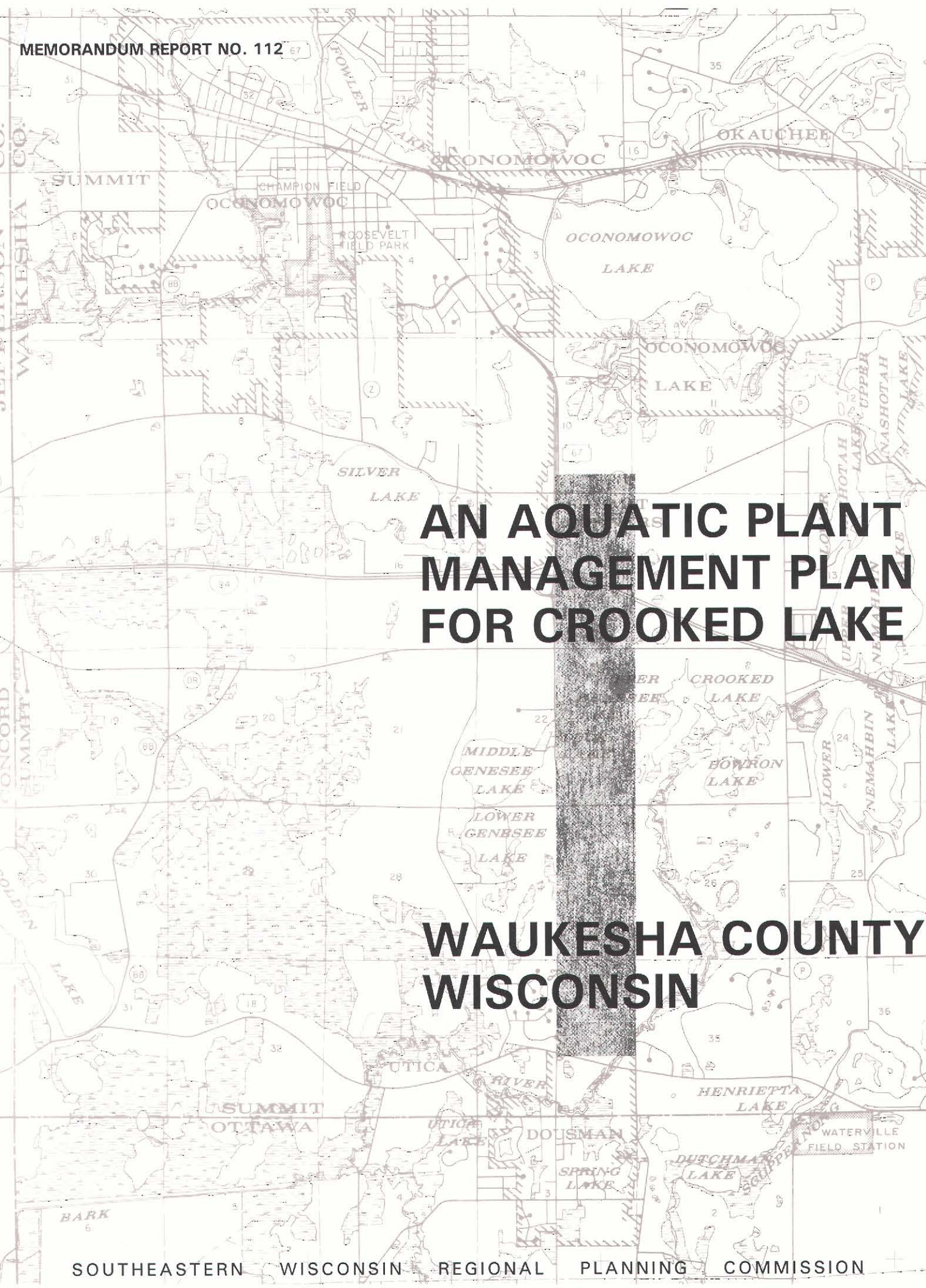

AN AQUATIC PLANT MANAGEMENT PLAN FOR CROOKED LAKE

WAUKESHA COUNTY WISCONSIN

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MEMORANDUM REPORT
NUMBER 112

AN AQUATIC PLANT MANAGEMENT PLAN FOR CROOKED LAKE

WAUKESHA COUNTY, WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
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Chapter I

INTRODUCTION

Crooked Lake, located on the Bark River in the Town of Summit, Waukesha County, Wisconsin, is a valuable natural resource offering a unique setting and variety of recreational and related-use opportunities to the small residential community and visitors using the Lake and the Bark River. However, there is a perception that inappropriate recreational uses of the Lake adversely affect the recreational and visual values of the resource, contributing to excessive aquatic plant growth within the Lake. During 1997, the Crooked Lake Property Owners' Association voiced these concerns to the Town of Summit, which subsequently requested the assistance of the Southeastern Wisconsin Regional Planning Commission in compiling an aquatic plant management plan for Crooked Lake. The planning program, conducted in association with the Wisconsin Department of Natural Resources and Crooked Lake Property Owners' Association, was designed to provide inventory information on the aquatic plant communities, water quality, and recreational usage of Crooked Lake as the initial step in formulating a lake protection and rehabilitation program for the Lake.

This report, therefore, sets forth the recreation use inventory and inventory of aquatic plant communities present within Crooked Lake, and represents part of the ongoing commitment of the Town and Property Owners' Association to sound planning with respect to the Lake. These inventories were prepared by the Southeastern Wisconsin Regional Planning Commission during 1998 and 1999, and include the results of field surveys conducted by the Commission during July 1997 and August 1998.

The aquatic plant survey of Crooked Lake was conducted by Commission staff using the modified Jesson and Lound[1] transect method employed by the Wisconsin Department of Natural Resources for aquatic plant surveys throughout the State. In addition, the Commission staff, in association with the Crooked Lake Property Owners' Association, conducted a mail-drop questionnaire survey of lakeshore residents to identify community concerns regarding recreational use of the Lake and water quality. Water quality data, gathered under the auspices of the Wisconsin Department of Natural Resources Self-Help Monitoring Program by the Crooked Lake Property Owners' Association, are also incorporated into this plan. This planning program was funded in part by a Wisconsin Department of Natural Resources Lake Management Planning Grant awarded to the Town of Summit under the Chapter NR 190 Lake Management Planning Grant Program.

The scope of this report is limited to consideration of the factors affecting aquatic plant communities present within Crooked Lake and the recreational uses of the Lake. However, this plan forms an integral part of any future comprehensive lake management plan for Crooked Lake. The preparation of a comprehensive lake management plan for Crooked Lake will require additional water quality and biological data collection and analysis.

The recreational lake use goals and objectives for Crooked Lake were developed in consultation with the Town of Summit. The goals and objectives are:

1. To protect and maintain public health, and to promote public comfort, convenience, necessity, and welfare, through the environmentally sound management of the vegetation, fishery, and wildlife populations in and around Crooked Lake;

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

2. To provide for high-quality, water-oriented recreational and aesthetic opportunities for residents and visitors to Crooked Lake, and manage the aquatic plant communities in the Lake in an environmentally sound manner; and,

3. To effectively manage the water quality of Crooked Lake to maintain an healthy aquatic plant community and, thereby, 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.

This inventory, which conforms to the requirements and standards set forth in the relevant *Wisconsin Administrative Codes*,[2] should serve as an initial step in achieving these objectives over time.

[2]*This plan has been prepared pursuant to the standards and requirements set forth in three chapters of the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 103, "Water Quality Standards for Wetlands;" and Chapter NR 107, "Aquatic Plant Management."*

Chapter II

INVENTORY FINDINGS

INTRODUCTION

Crooked Lake is a 58-acre drainage Lake located in the Town of Summit, Waukesha County, Wisconsin, as shown on Map 1. Crooked Lake is a small natural lake, occupying a shallow depression in outwash deposits in the course of the Bark River, just downstream from Lower Nemahbin Lake. The outlet of the Lake to the Bark River, at the southeastern end of Crooked Lake, is controlled by a low head control structure of about three feet in elevation. The Bark River, after leaving Crooked Lake, drains south and west to the Rock River system at Fort Atkinson in Jefferson County.

The direct drainage area tributary to Crooked Lake is 533 acres in areal extent, while the total tributary drainage area of Crooked Lake is 33,850 acres. Historically, the lakeshore of Crooked Lake was part of a large farm. Currently the shoreline is partially developed with the eastern shoreline covered largely with marshy wetland. The surrounding land uses in the area are primarily agricultural and open lands, with the remainder comprised of single-family residential, wetland and woodland, and institutional land uses. Lake-oriented residential lands are the principal urban features of the drainage area directly tributary to Crooked Lake.

WATERBODY CHARACTERISTICS

Crooked Lake is a 58-acre waterbody, the hydrographical characteristics of which are set forth in Table 1. The Lake is a drainage lake, with the Bark River entering the Lake through two inlets on the eastern shoreline of the Lake, and draining out through an outlet located almost directly adjacent to the southeastern inflow. The inlet on the northeastern shore is a constructed canal connecting the Bark River to the Lake via wetlands. This latter inflow, constructed during the 1920s or 1930s, is intermittent in character, flowing during high flow periods only. Nevertheless, Crooked Lake has an extremely high flushing rate.

The Lake is roughly elongate in shape, with several bays. The waterbody has a maximum depth of 16 feet, a mean depth of seven feet, and a volume of 406 acre-feet. The bathymetry of the Lake is shown on Map 2.

CIVIL DIVISIONS

The geographic extent and functional responsibilities of civil divisions and special-purpose units of government are important factors related to land use and management. Local units of government provide the basic structure of the decision-making framework within which land use development and redevelopment must be addressed. Crooked Lake and the drainage area directly tributary to the Lake are totally encompassed by the Town of Summit. However, the total land area draining to Crooked Lake, including those areas draining to the Lake through of upstream waterbodies, includes portions of the Town of Richfield, in Washington County, and the City of Delafield, the Villages of Chenequa, Hartland, Merton, Nashotah, and Oconomowoc Lake, and the Towns of Delafield, Lisbon, Merton, Richfield and Summit, in Waukesha County, as shown on Map 3.

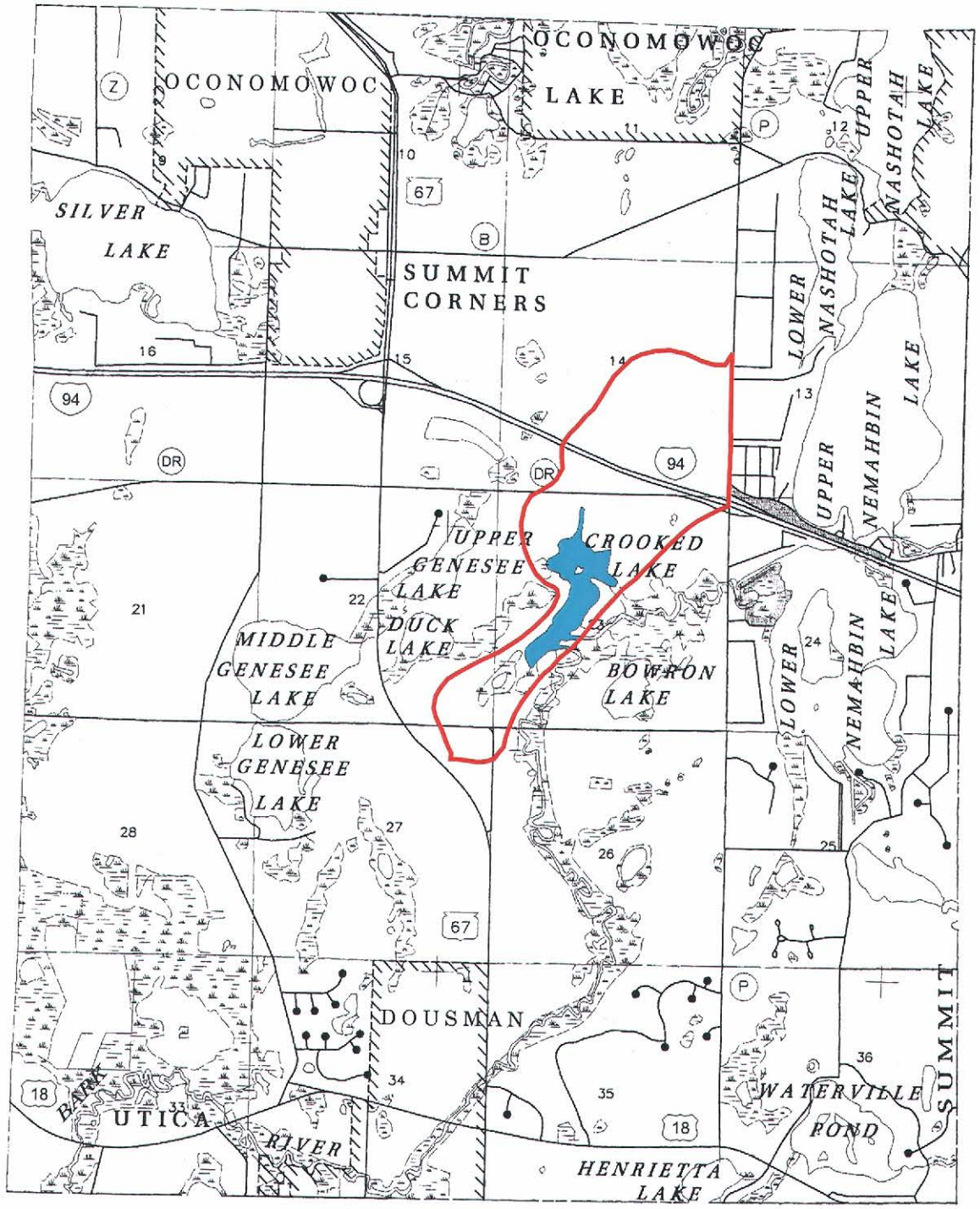
LAND USE AND SHORELINE DEVELOPMENT

Population

In 1990, there were approximately 35 persons residing in 17 housing units within the drainage area directly tributary to Crooked Lake. According to the results of a 1997 survey of Lake Residents, two households were reported to be seasonally occupied. The riparian residential lands are located primarily on the northern and

Map 1

LOCATION MAP OF CROOKED LAKE



Source: SEWRPC.

Table 1

HYDROGRAPHIC CHARACTERISTICS OF CROOKED LAKE

Parameter	Measurement
Surface Area	58 acres
Volume	406 acre-feet
Shoreline Length	2.3 miles
Maximum Depth	16 feet
Mean Depth	7.0 feet
Tributary Drainage Area	33,850 acres

Source: SEWRPC.

western shores of Crooked Lake. As of 1995, no new lots or developments had been provided for within the drainage area directly tributary to Crooked Lake.

Land Use

Woodlands and wetlands occupied almost all of the shorelands of Crooked Lake with the exception of a few residential stands. Public access to the lake is possible only through the Bark River inlet, on the eastern shore. The existing 1990 land use pattern in the drainage area directly tributary to Crooked Lake is shown on Map 4 and is quantified in Table 2.

About 50 acres, or about 10 percent, of the drainage area directly tributary to Crooked Lake were devoted to urban land uses. The dominant urban land use was transportation and utilities, encompassing 27 acres, or about 5 percent of the area in urban land use. About 482 acres, or 90 percent of the Crooked Lake drainage area, were still devoted to rural land uses. About 342 acres, or about 64 percent of the rural area, were in agricultural uses. Woodlands, wetlands, and surface waters, including the surface area of Crooked Lake, accounted for approximately 140 acres, or about 26 percent of the rural land uses.

Under year 2010 conditions, only limited conversion of rural land to rural-density residential land uses within the drainage area tributary to Crooked Lake is envisioned in the regional land use and County development plans,[1] as shown on Map 5. However, a significant amount of the agricultural land in the northern half of the drainage area directly tributary to Crooked Lake is expected to be converted to urban land uses as part of the proposed Pabst Farms, Inc., development currently being planned. These lands are anticipated to be converted to mixed office/ commercial land uses adjacent to IH 94 and to medium-density urban residential uses in the long-term buildout projections. The Pabst Farms, Inc., development will be subject to stormwater management measures set forth in a site-specific stormwater management plan being prepared pursuant to the County ordinance requirements. Limited infilling of existing platted lots and additional low-density, single-family residential development within the southern portion of the drainage area directly tributary to the Lake may occur as existing large lots are further subdivided over time.

WATER QUALITY

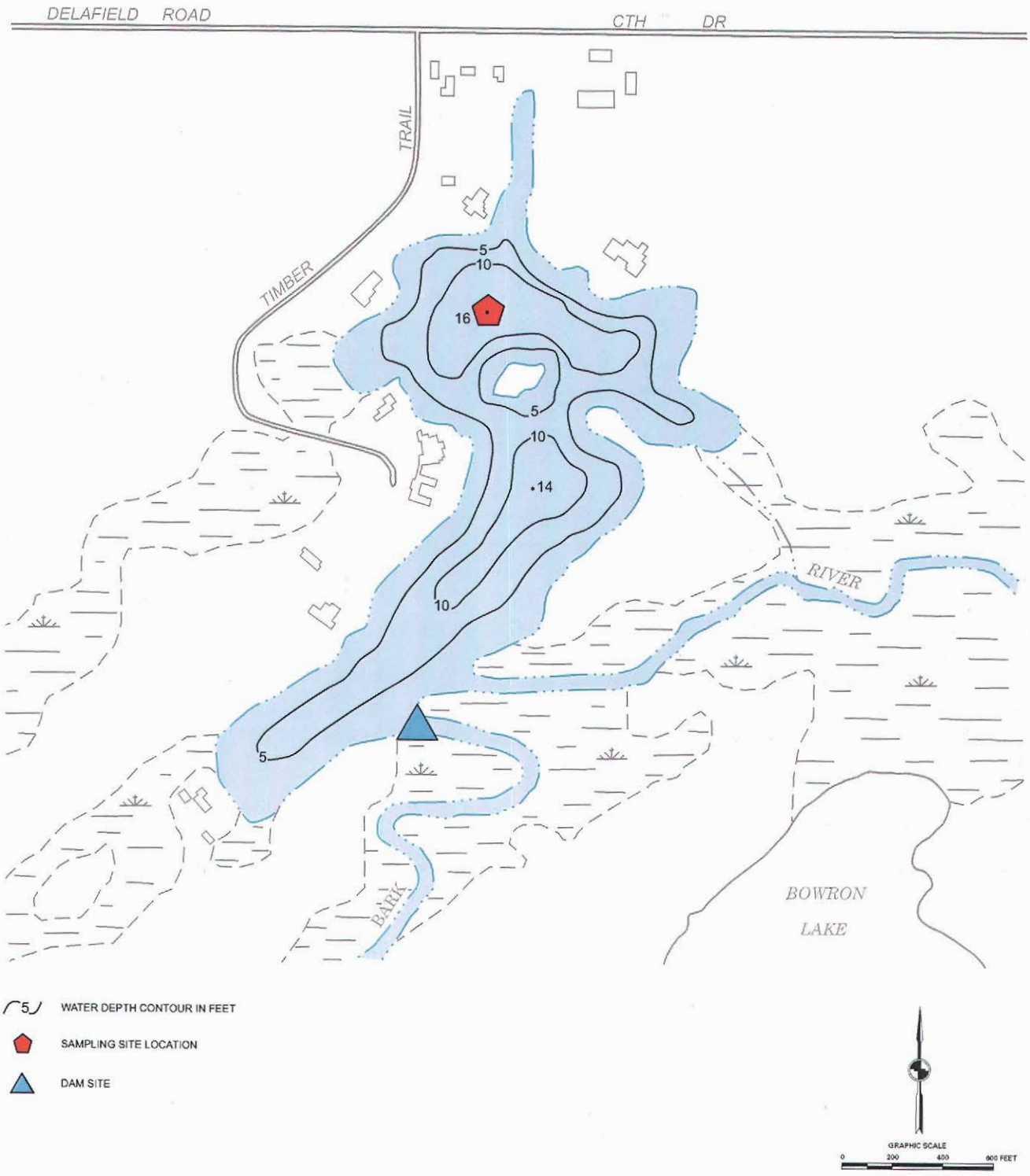
Based on Secchi-disk transparency measurements obtained by the Crook Lake Property Owners' Association under the auspices of the Wisconsin Department of Natural Resources Self-Help Monitoring Program, Crooked Lake has a good to very good water quality. Secchi-disk readings, obtained from October 22, 1994 through July 12, 1997, ranged between five feet and 12.5 feet, with an average reading of 8.8 feet. The Lake has a Wisconsin Trophic State Index value of about 44, indicating that the Lake is a mesotrophic waterbody, as shown in Figure 1.[2] Mesotrophic lakes are moderately fertile lakes that support abundant aquatic plant growth and may

[1] *SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997; SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

[2] *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.*

Map 2

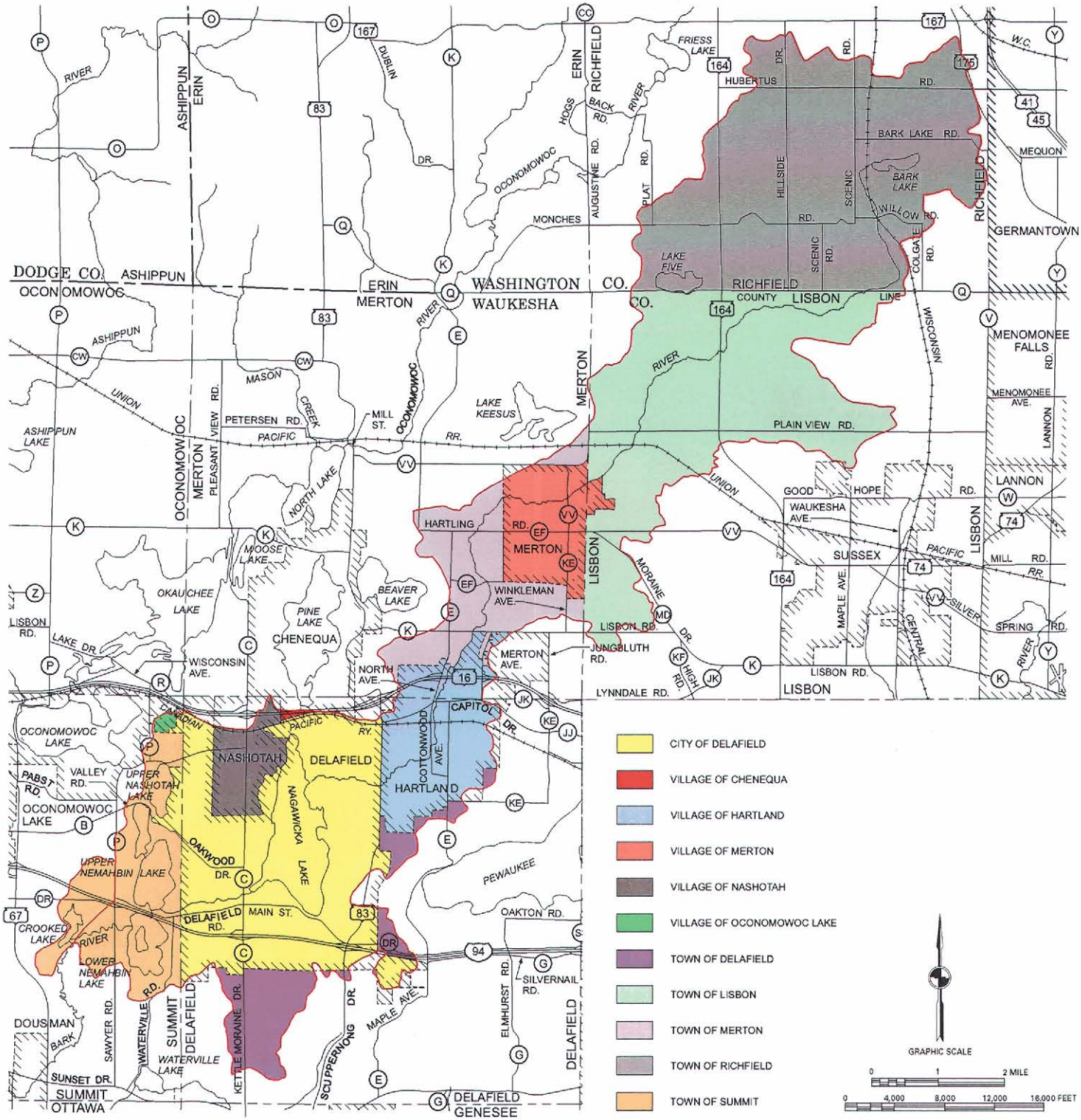
BATHYMETRIC MAP OF CROOKED LAKE



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 3

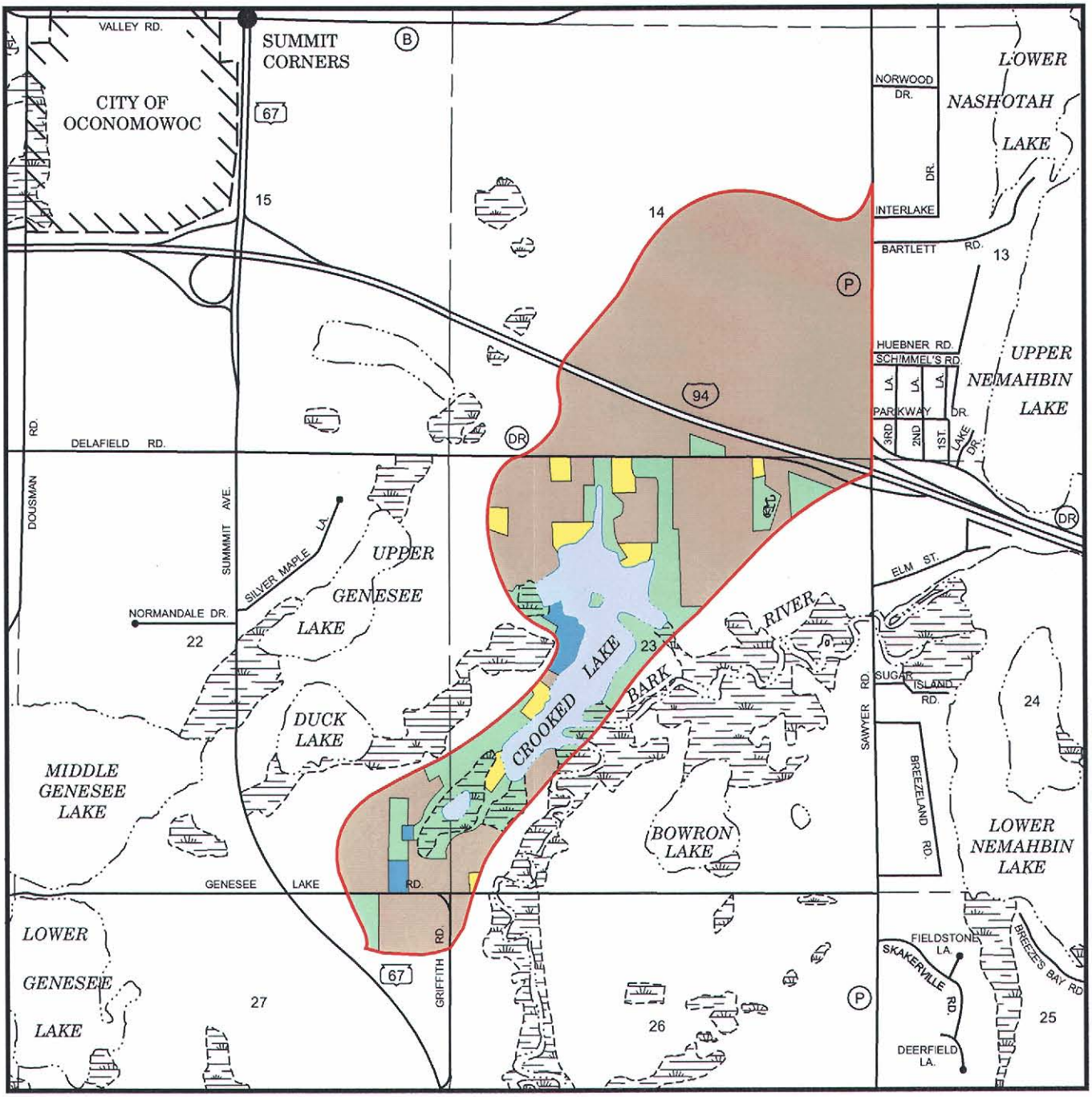
CIVIL DIVISIONS WITHIN THE TOTAL TRIBUTARY DRAINAGE AREA TO CROOKED LAKE: 1990



Source: SEWRPC.

Map 4

GENERALIZED LAND USE WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO CROOKED LAKE: 1990



- SINGLE - FAMILY RESIDENTIAL
- GOVERNMENT AND INSTITUTIONAL
- WETLANDS AND WOODLANDS
- SURFACE WATER
- AGRICULTURAL, UNUSED, AND OTHER OPEN LANDS

GRAPHIC SCALE

0 1/8 1/4 MILE

0 1000 2000 FEET

Source: SEWRPC.

Table 2

EXISTING AND RECOMMENDED LAND USE WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO CROOKED LAKE

Land Use Categories	1990		Buildout	
	Acres	Percent of Drainage Area	Acres	Percent of Drainage Area
Urban				
Residential	16	3.0	169	31.7
Commercial	--	--	158	29.6
Governmental	8	1.5	8	1.5
Transportation and Utilities	27	5.1	27	5.1
Recreational	--	--	36	6.8
Subtotal	51	9.6	398	74.7
Rural				
Agricultural	342	64.2	--	--
Wetlands	19	3.5	19	3.5
Woodlands	61	11.4	56	10.5
Water	59	11.1	59	11.1
Other Open Land	1	0.2	1	0.2
Subtotal	482	90.4	135	25.3
Total	533	100.0	533	100.0

Source: SEWRPC.

support productive fisheries. Nuisance growths of algae and plants are usually not exhibited by mesotrophic lakes. Many of the cleaner lakes in southeastern Wisconsin are classified as mesotrophic.[3]

Because of the limited amount of field data available, estimates of long-term annual average phosphorus and chlorophyll-a concentrations were calculated from Secchi-disk transparency values using the regression relationships, or the Vollenweider suite of trophic state equations, developed by the Organization for Economic Co-Operation and Development (OECD).[4] An annual average phosphorus concentration of 60 micrograms per liter (µg/l), and an annual average chlorophyll-a concentration of 12 µg/l, was calculated. While these concentrations suggest that Crooked Lake may be eutrophic, or highly enriched, compared with other lakes in southeastern Wisconsin,[5] the full impact of the relatively high pollutant loadings, set forth below, experienced by Crooked Lake as a consequence of the large upstream watershed, is likely to be moderated by the rapid throughflow of water in the system. Crooked Lake has a residence time of 0.01 year. Lakes with water residence times of less than 0.1 year are unlikely to experience the same detrimental consequences of eutrophication as

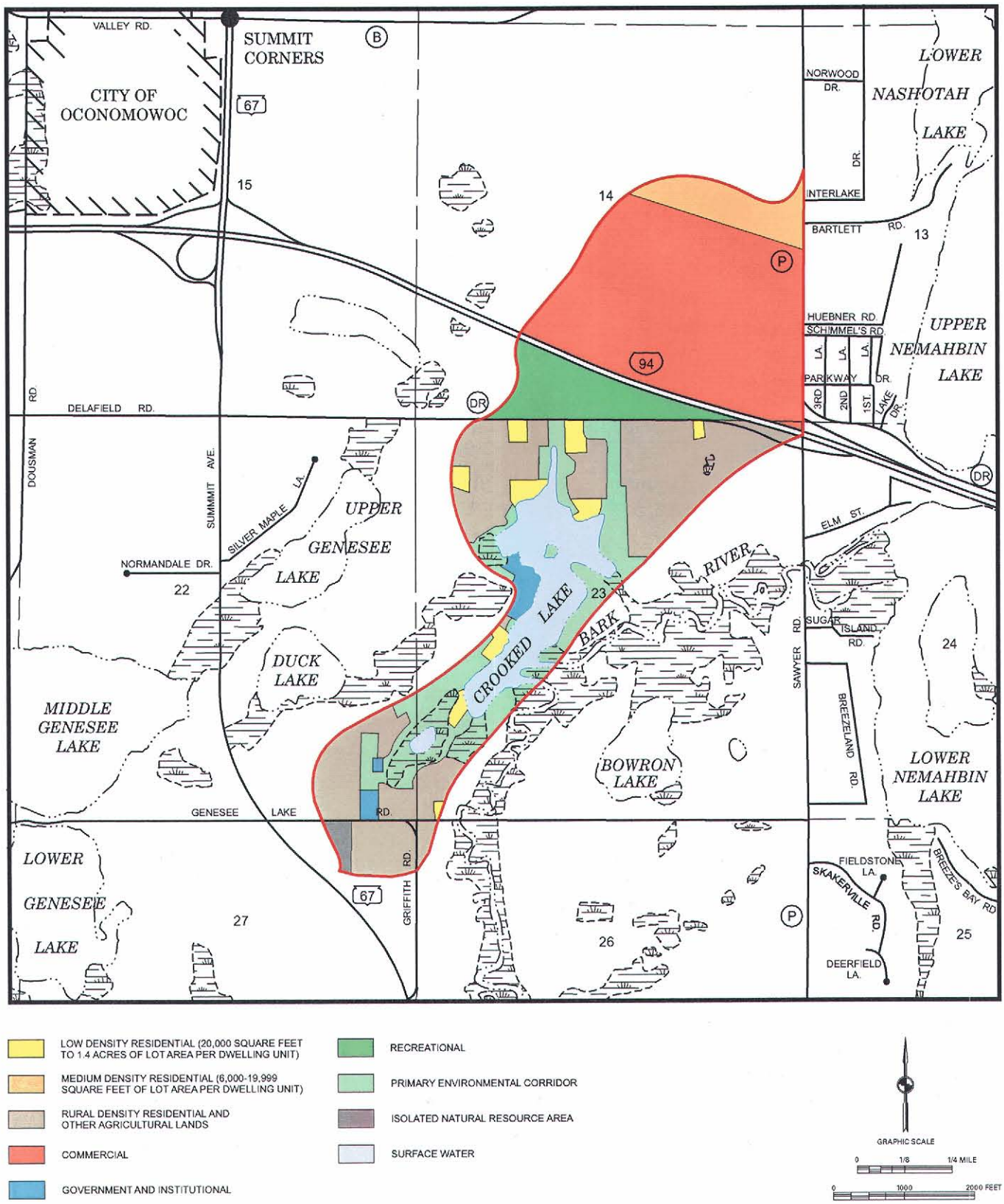
[3]*See R.A. Lillie, and J.W. Mason,* Limnological Characteristics of Wisconsin Lakes, *Wisconsin Department of Natural Resources Technical Bulletin No. 138, 1983; also see SEWRPC Memorandum Report No. 93,* A Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[4]*Organization for Economic Co-Operation and Development,* Eutrophication of Waters Monitoring, Assessment and Control, *Paris 1982.*

[5]*Lillie and Mason, op. cit.*

Map 5

RECOMMENDED LAND USE WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO CROOKED LAKE: 1990



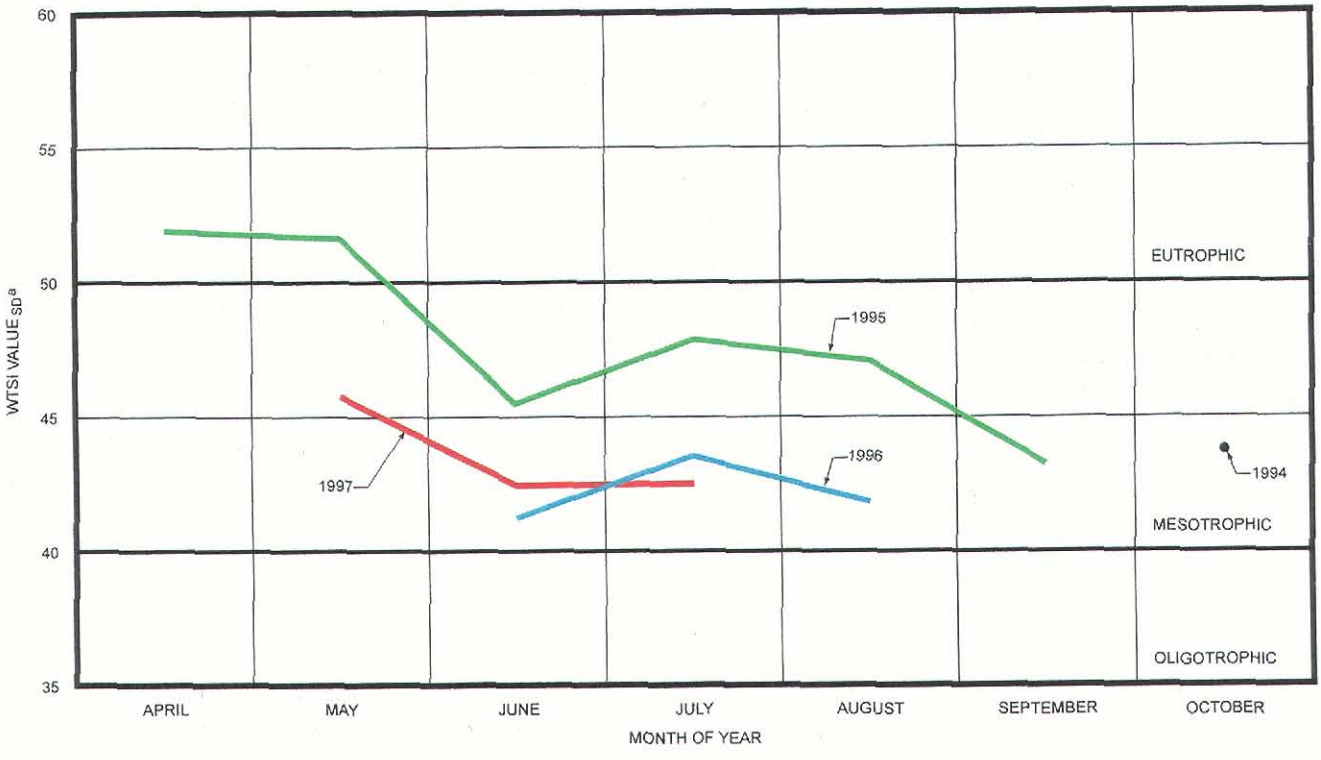
- LOW DENSITY RESIDENTIAL (20,000 SQUARE FEET TO 1.4 ACRES OF LOT AREA PER DWELLING UNIT)
- MEDIUM DENSITY RESIDENTIAL (6,000-19,999 SQUARE FEET OF LOT AREA PER DWELLING UNIT)
- RURAL DENSITY RESIDENTIAL AND OTHER AGRICULTURAL LANDS
- COMMERCIAL
- GOVERNMENT AND INSTITUTIONAL
- RECREATIONAL
- PRIMARY ENVIRONMENTAL CORRIDOR
- ISOLATED NATURAL RESOURCE AREA
- SURFACE WATER

GRAPHIC SCALE
0 1/8 1/4 MILE
0 1000 2000 FEET

Source: SEWRPC.

Figure 1

TROPHIC STATE INDEX FOR CROOKED LAKE: 1994-1997



Note: SD = Secchi-disk depth, 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.

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

lakes with longer residence times, rather they are dominated by the quality of the inflowing river.[6] In addition, the forecast concentrations are consistent with the range of phosphorus and chlorophyll-a concentrations measured in the upstream Upper Nemahbin and Nagawicka Lakes.[7]

POLLUTANT LOADINGS

Pollutant loads to a lake are generated by various natural processes and human activities that take place in the drainage area tributary to a lake. These loads are transported to the lake through the atmosphere, across the land surface enter the lake as direct runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Pollutants transported by streams enter a lake as surface water inflows. In drainage, or through-flow lakes, like Crooked Lake, pollutants loadings transported by inflowing streams and across the land surface directly tributary to a lake, in the absence of identifiable or point source discharges from industries or

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[6] *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.*

[7] *SEWRPC Memorandum Report No. 101,* Upper Nemahbin Lake Watershed Inventory Findings, Waukesha County, Wisconsin, *May 1995; SEWRPC Memorandum Report No. 130,* A Lake and Watershed Inventory for Nagawicka Lake, Waukesha County, Wisconsin, *draft, January 1999.*

wastewater treatment facilities, comprise the principal routes by which contaminants enter a waterbody.[8,9] For this reason, the discussion that follows is based upon nonpoint source pollutant loadings or pollutant loadings transported to Crooked Lake by inflowing streams.

The nonpoint source pollutant loads to Crooked Lake were estimated on the basis of land use inventory data and unit load coefficients determined for southeastern Wisconsin.[10] Annual contaminant loads entering Crooked Lake were calculated to be approximately 5,075 tons of sediment, approximately 20,275 pounds of phosphorus, approximately 290 pounds of copper, and approximately 2,150 pounds of zinc, respectively, as shown in Table 3. Copper and zinc were used in this analysis as surrogates for metals and other pollutants that are contributed primarily from urban sources.

To validate the estimated contaminant loads to Crooked Lake, Commission staff applied the estimated phosphorus load of 20,275 pounds in the aforereferenced Vollenweider-type OECD phosphorus budget model to estimate an in-lake total phosphorus concentration. This calculation resulted in an estimated annual average phosphorus concentration of about 110 µg/l. No data are available from which to assess the magnitude of loading to Crooked Lake from internal or groundwater sources. However, due to relatively small surface area of the Lake, and small size of the riparian residential community, phosphorus inputs from atmospheric and onsite sewage disposal system sources are estimated to be insignificant, especially in comparison with the phosphorus loadings from the extremely large tributary drainage area to the Lake.

Under buildout conditions, significant urban development, largely in the form of residential development at overall low densities, is expected to occur within the total drainage area tributary to Crooked Lake.[11] While little of this development is expected to occur in the portion of the drainage area directly tributary to the Lake,[12] this more intense development within the total drainage area tributary has the potential to increase the pollutant loadings to the Lake from the Bark River. Such loadings from the total tributary watershed could be minimized by the use of residential development clusters on smaller lots, preserving the majority of the open spaces, and by the use of stormwater management and construction site erosion controls.

SOIL TYPES AND CONDITIONS

Soil type, land slope, and land use and management practices are among the more important factors determining Lake Water quality conditions. Soil type, land slope, and vegetative cover are also important factors affecting the rate, amount, and quality of stormwater runoff. The soil texture and soil particle structures influence the permeability, infiltration rate, and erodibility of soils. Land slopes are also important determinants of stormwater runoff rates and of susceptibility to erosion.

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[8]*Ryding and Rast, op. cit.*

[9]*The regional water quality management plan recommended construction of a new sewage treatment plant to serve the Delafield-Hartland area and abandonment of the then existing Hartland sewage treatment plant. Full implementation of this plan recommendation resulted in the diversion of treated sewage effluents to a discharge point on the Bark River below Crooked Lake, with concomitant benefits for water quality within the lower Bark River system.*

[10]*See SEWRPC Memorandum Report No. 101,* Upper Nemahbin Lake Watershed Inventory Findings, Waukesha County, Wisconsin, *May 1995, for a description of the methodology employed.*

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

[12]*Ibid.; also SEWRPC Community Assistance Planning Report No. 209, op. cit.*

Table 3

ESTIMATED ANNUAL POLLUTANT LOADINGS TO CROOKED LAKE BY LAND USE CATEGORY: 1990

Land Use Category	Pollutant Loads			
	Sediment (tons)	Phosphorus[a] (pounds)	Copper (pounds)	Zinc (pounds)
Urban Land				
Residential	615.0	3,368.1	114.0	829.1
Commercial	230.5	744.2	95.3	762.1
Industrial	57.9	181.9	27.6	183.0
Transportation	114.1	523.7	54.4	381.2
Recreational	2.1	14.8	0.0	3.5
Subtotal	1,019.6	4,832.7	291.3	2,158.9
Rural Land				
Agricultural	3,152.9	12,235.1	--	--
Wetlands	5.5	120.6	--	--
Woodlands	6.9	151.7	--	--
Water	205.6	290.8	--	--
Extractive	163.6	635.0	--	--
Other Open Lands	518.2	2,011.0	--	--
Subtotal	4,052.7	15,444.2	--	--
Total	5,072.3	20,276.9	291.3	2,158.9

[a]*Due to the limited surface area and small residential population of Crooked Lake, phosphorus inputs from atmospheric and onsite sewage disposal system sources are not significant in comparison to riverine inputs from the tributary drainage area.*

Source: SEWRPC.

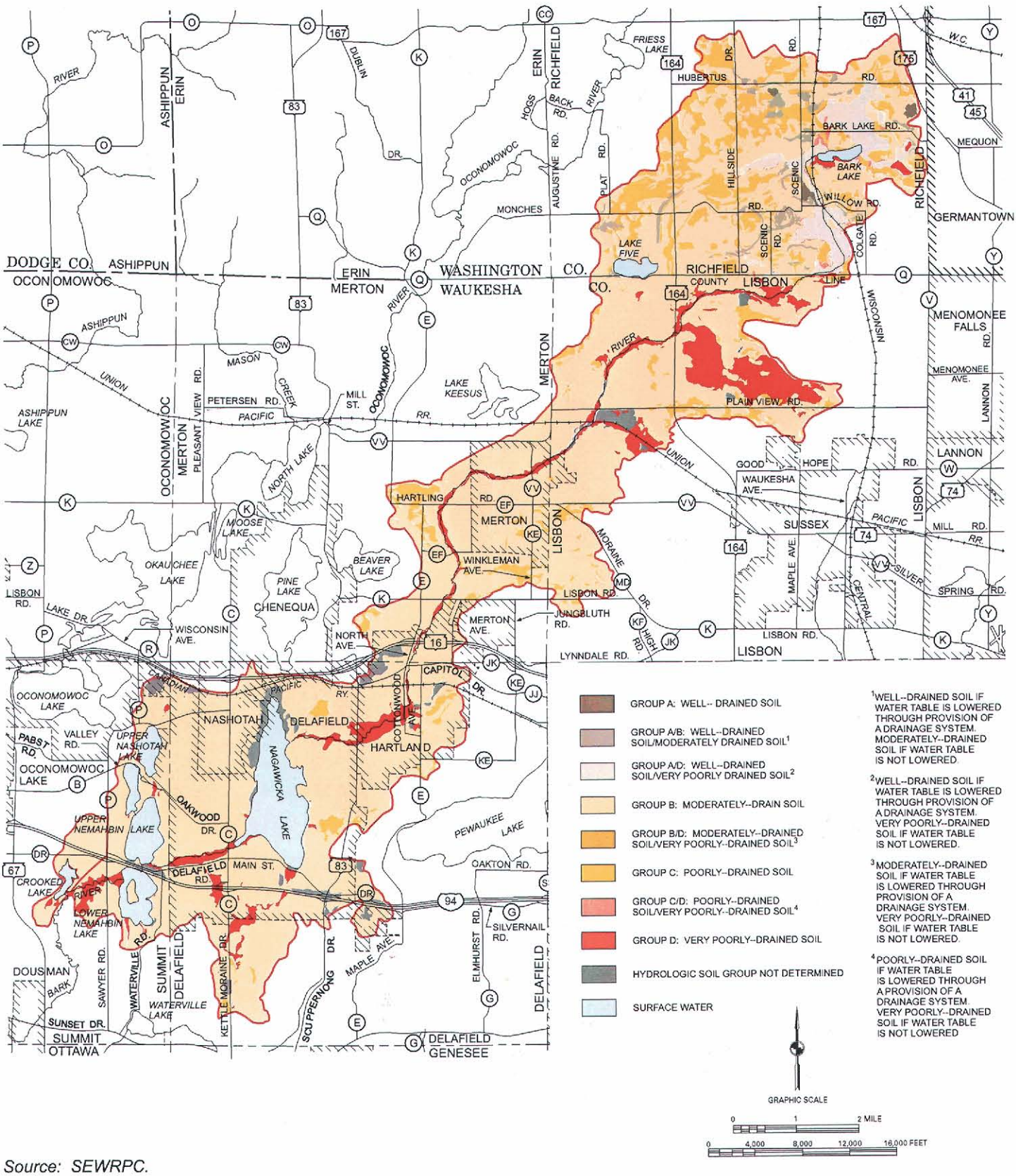
The U.S. Natural Resources Conservation Service, under contract to the Southeastern Wisconsin Regional Planning Commission, completed a detailed soil survey of the Crooked Lake area in 1966.[13] Using the regional soil survey, an assessment was made of the hydrologic characteristics of the soils in the tributary drainage area to Crooked Lake. Soils within the total and direct tributary area to Crooked Lake were categorized into four main hydrologic soil groups, as well as an "other" category, as indicated on Maps 6 and 7. Approximately 68 percent of the of the total tributary drainage area is covered by moderately drained soils, about 23 percent of the tributary drainage area by very poorly drained soils, and one percent with well-drained soils, with the remaining areas of the watershed being surface water, as shown on Map 6. About 87 percent of the drainage area directly tributary to the Lake is covered by moderately drained soils, approximately three percent by very poorly drained soils, with the remaining areas of the direct watershed being surface water, as shown on Map 7.

The regional soil survey also contained interpretations for planning and engineering applications. The suitability of the soils for urban residential development was assessed using three common development scenarios: development with conventional onsite sewage disposal systems; development with alternative onsite sewage disposal systems; and development with public sanitary sewers. At present, all residential lands in the drainage area tributary to Crooked Lake are served by private onsite sewage disposal systems. The soil suitability interpretations for the use of such systems were updated by the Regional Planning Commission based upon the

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

Map 6

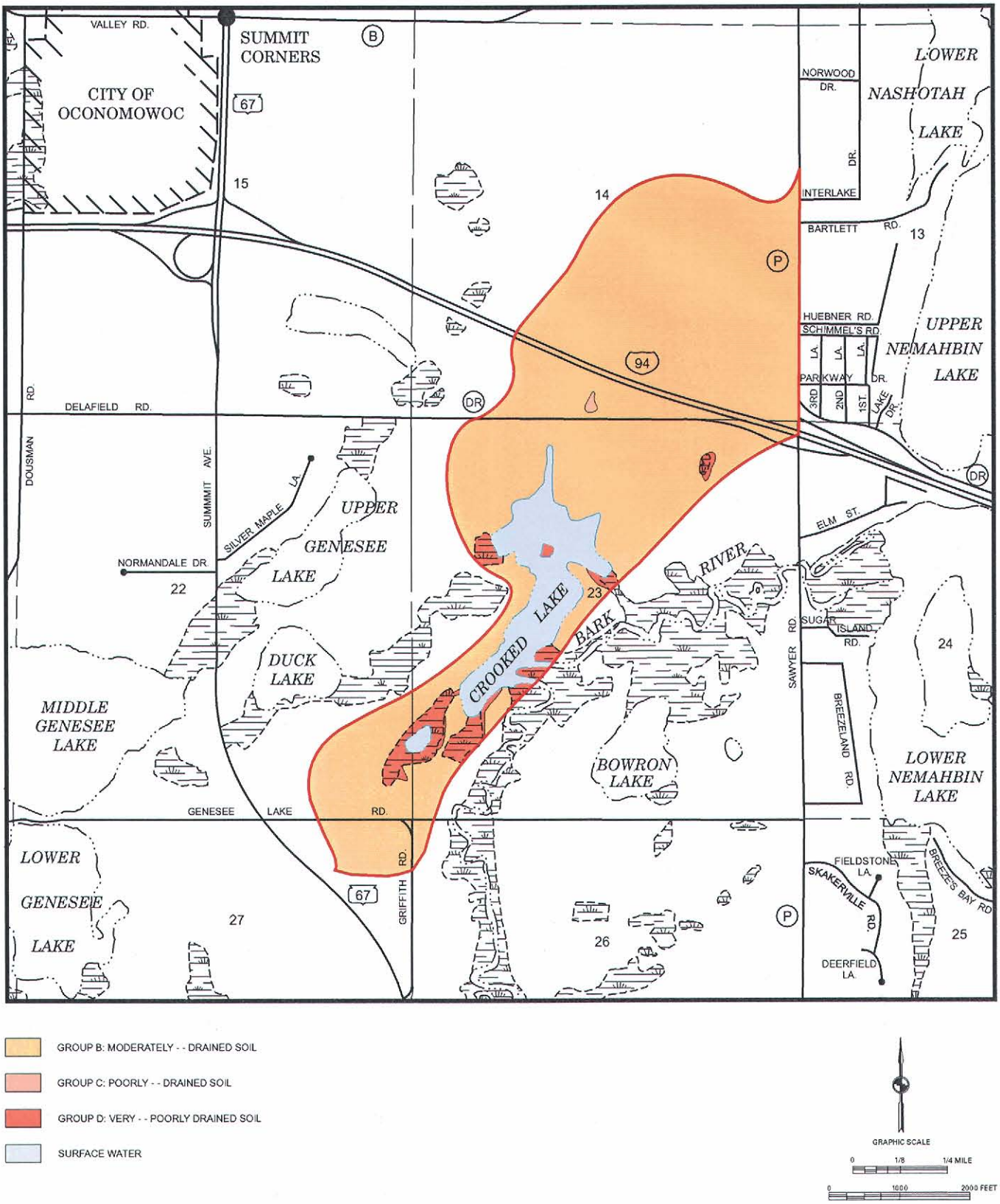
HYDROLOGIC SOIL GROUPS WITHIN THE TOTAL TRIBUTARY DRAINAGE AREA TO CROOKED LAKE



Source: SEWRPC.

Map 7

HYDROLOGIC SOIL GROUPS WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO CROOKED LAKE



GROUP B: MODERATELY - - DRAINED SOIL

GROUP C: POORLY - - DRAINED SOIL

GROUP D: VERY - - POORLY DRAINED SOIL

SURFACE WATER

GRAPHIC SCALE

0 1/8 1/4 MILE

0 1000 2000 FEET

Source: SEWRPC.

soil characteristics provided by the detailed soil surveys and the field experience of County and State technicians responsible for overseeing the location and design of such systems. The classifications reflect the current soil and site specifications set forth in Chapter Comm 83 of the *Wisconsin Administrative Code*. As shown on Map 7, the drainage area directly tributary to Crooked Lake is covered by moderately well-drained soils. These soils are generally considered suitable for residential development using both conventional and alternative onsite sewage disposal systems, as well as public sanitary sewer service.

AQUATIC PLANTS, DISTRIBUTION, AND MANAGEMENT AREAS

Commission staff conducted a survey of aquatic plant species in the Lake basin during July of 1997. The results of this survey are presented in Table 4 and graphically depicted on Map 8. These plant distributions were verified by field reconnaissance during August of 1998. Illustrations of the common aquatic plants found in Crooked Lake are included in Appendix A.

Sixteen aquatic plant species were found in Crooked Lake. While the Lake had high flora diversity, only Eurasian water milfoil was widespread throughout the Lake. The other plant species were sparsely scattered throughout the Lake, and only coontail, *Ceretophyllum demersum*; muskgrass, *Chara* sp.; Sago pondweed, *Potamogeton pectinatus*; and bladderwort, *Utricularia* sp., appeared with any significant density. The dominance of Eurasian water milfoil, as shown in Table 5, is cause for concern, as it is an exotic, or nonnative species that can exhibit "explosive" growth under suitable conditions, such as the presence of organic-rich sediments, as at the inflows and outflow of Crooked Lake. It reproduces by the rooting of plant fragments, and has been known to cause severe recreational use problems in lakes in southeastern Wisconsin. It often outcompetes the native aquatic vegetation of lakes in southeastern Wisconsin, reduces the biodiversity of the lakes, and degrades the quality of fish and wildlife habitats.[14] A reconnaissance mission conducted by Commission staff in August of 1998 discovered that while Eurasian water milfoil remained dominant and widespread throughout the Lake basin, it was not as abundant as the previous summer, with fewer plants growing to the surface of the water and impeding recreational uses.

Purple loosestrife, *Lythrum salicaria,* another nonnative nuisance plant, was also present in the wetlands and riparian areas surrounding the Lake. Like Eurasian water milfoil, purple loosestrife is known to spread profusely, outcompeting native plant growth and reducing the quality of fish and wildlife habitat while adding little ecological benefit. Purple loosestrife is a declared weed in the State of Wisconsin and is subject to an ongoing eradication program. The distributions of both these plants should be monitored as part of the proposed aquatic plant-monitoring program within the Wisconsin Department of Natural Resources Self-Help Monitoring Program.

FISHERIES

The Wisconsin Department of Natural Resources Publication No. FM-800-95REV, *Wisconsin Lakes*, 1995, indicates that northern pike are present, and largemouth bass and panfish are common. Based on a 1975 lake inventory conducted by the Wisconsin Department of Natural Resources,[15] the fish community was comprised of bluegill, yellow perch, green sunfish, pumpkinseed, blackstripe topminnow, largemouth bass, Iowa darter, northern pike, least darter, johnny darter, tadpole madtom, grass pickeral, banded killifish, and unspecified minnows and carp. Areas along the less steeply sloping shores of the Lake present suitable habitats for the spawning of bass and northern pike. Spawning takes place in the spring, between the time of the spring thaw and

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[14] *Wisconsin Department of Natural Resources,* Eurasian Water Milfoil in Wisconsin: A Report to the Legislature, *1993.*

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

Table 4

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

Aquatic Plant Species Present	Abundance[a]	Ecological Significance[b]
Ceratophyllum demersum (coontail)	Common	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara Vulgaris (muskgrass)	Abundant	Excellent producer of fish food, especially for young trout, bluegills, small and largemouth bass, stabilizes bottom sediments, and has softening effect on the water by removing lime and carbon dioxide
Myriophyllum sp. (native milfoil)	Scarce	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	Common	None known
Najas flexilis (bushy pondweed)	Scarce	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	Scarce	Provides good food and shelter for fish and food for ducks
Nuphar sp. (yellow water lily)	- -[c]	Leaves, stems, and flowers are eaten by deer; roots eaten by beaver and porcupine; seeds eaten by wildfowl; leaves provide harbor to insects, in addition to shade and shelter for fish
Nymphaea tuberosa (white water lily)	- -[c]	Provides shade and shelter for fish; seeds eaten by wildfowl; rootstocks and stalks eaten by muskrat; roots eaten by beaver, deer, moose, and porcupine
Potamogeton crispus (crispy-leaf pondweed)	Scarce	Provides food, shelter, and shade for some fish and food for wildfowl
Potamogeton gramineus (variable pondweed)	Common	Provides habitat for fish and food for waterfowl, in addition to muskrat, beaver, deer, and moose
Potamogeton nodosus (long-leaved pondweed)	Scarce	Provides support for insects eaten by fish; sometimes important for wildfowl
Potamogeton pectinatus (sago pondweed)	Common	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton zosteriformis (flat-stemmed pondweed)	Scarce	Provides some food for ducks
Typha latifolia (cattail)	Common	Supports insects; stalks and roots important food for muskrats and beavers; attracts marsh birds, wildfowl, and songbirds, in addition to being used as spawning grounds by sunfish and shelter for young fish
Utricularia sp. (bladderwort)	Common	Provides good food and cover for fish
Vallisneria americana (water celery)	Abundant	Provides good shade and shelter, supports insects, and is valuable fish food

[a]Species mean density for all sample points, including sample points where a particular species did not occur in Crooked Lake: Abundant (density rating = 4 to 5). Common (Density rating = 2 to 3), Scarce (density rating = 1).

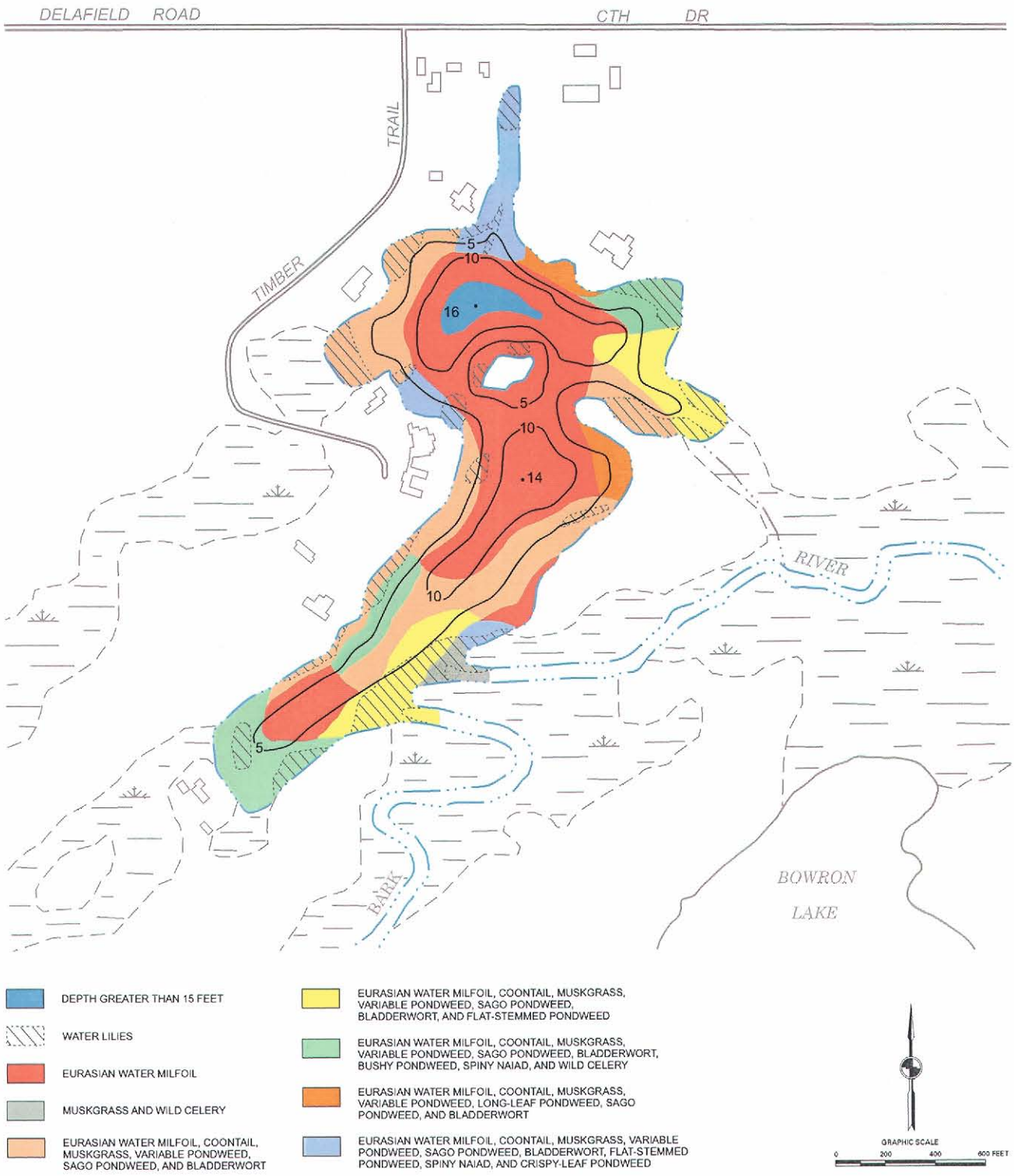
[b]Information obtained from A Manual of Aquatic Plants by Norman C. Fassett and Guide to Wisconsin Aquatic Plants, Wisconsin Department of Natural Resources.

[c]Not measurable using the Jesson and Lound Survey Technique for Submerged Aquatic Plants.

Source: SEWRPC.

Map 8

AQUATIC PLANT COMMUNITY DISTRIBUTION IN CROOKED LAKE: 1997



Source: SEWRPC.

Table 5

FREQUENCY OF OCCURRENCE AND DENSITY RATINGS OF SUBMERGENT PLANT SPECIES IN CROOKED LAKE: JULY 1997

Plant Species	Sites Found	Frequency of Occurrence (percent)	Density at Sites Found	Density in Whole Lake
Ceratophyllum demersum (coontail)	32	47.06	1.72	0.81
Chara vulgaris (muskgrass)	24	35.29	2.21	0.78
Myriophyllum sp. (native milfoil)	1	1.47	1.00	0.01
Myriophyllum spicatum (Eurasian water milfoil)	65	95.59	3.60	3.44
Najas flexilis (bushy pondweed)	4	5.88	1.25	0.07
Najas marina (spiny naiad)	2	2.94	2.00	0.06
Potamogeton crispus (crispy-leaf pondweed)	3	4.41	1.00	0.04
Potamogeton gramineus (variable pondweed)	15	22.10	1.53	0.34
Potamogeton nodosus (long-leaved pondweed)	2	2.94	1.00	0.03
Potamogeton pectinatus (sago pondweed)	16	23.53	2.19	0.51
Potamogeton zosterformis (flat-stemmed pondweed)	6	8.82	1.83	0.16
Utricularia sp. (bladderwort)	27	39.91	1.56	0.62
Vallisneria americana (water celery)	3	4.41	2.67	0.12

NOTE: There were 68 sampling points.

Source: SEWRPC.

mid-June. The carp population of Crooked Lake currently presents no serious threat to the lake ecosystem, probably due to more conductive habitat elsewhere in the Bark River drainage area, but should continue to be monitored.

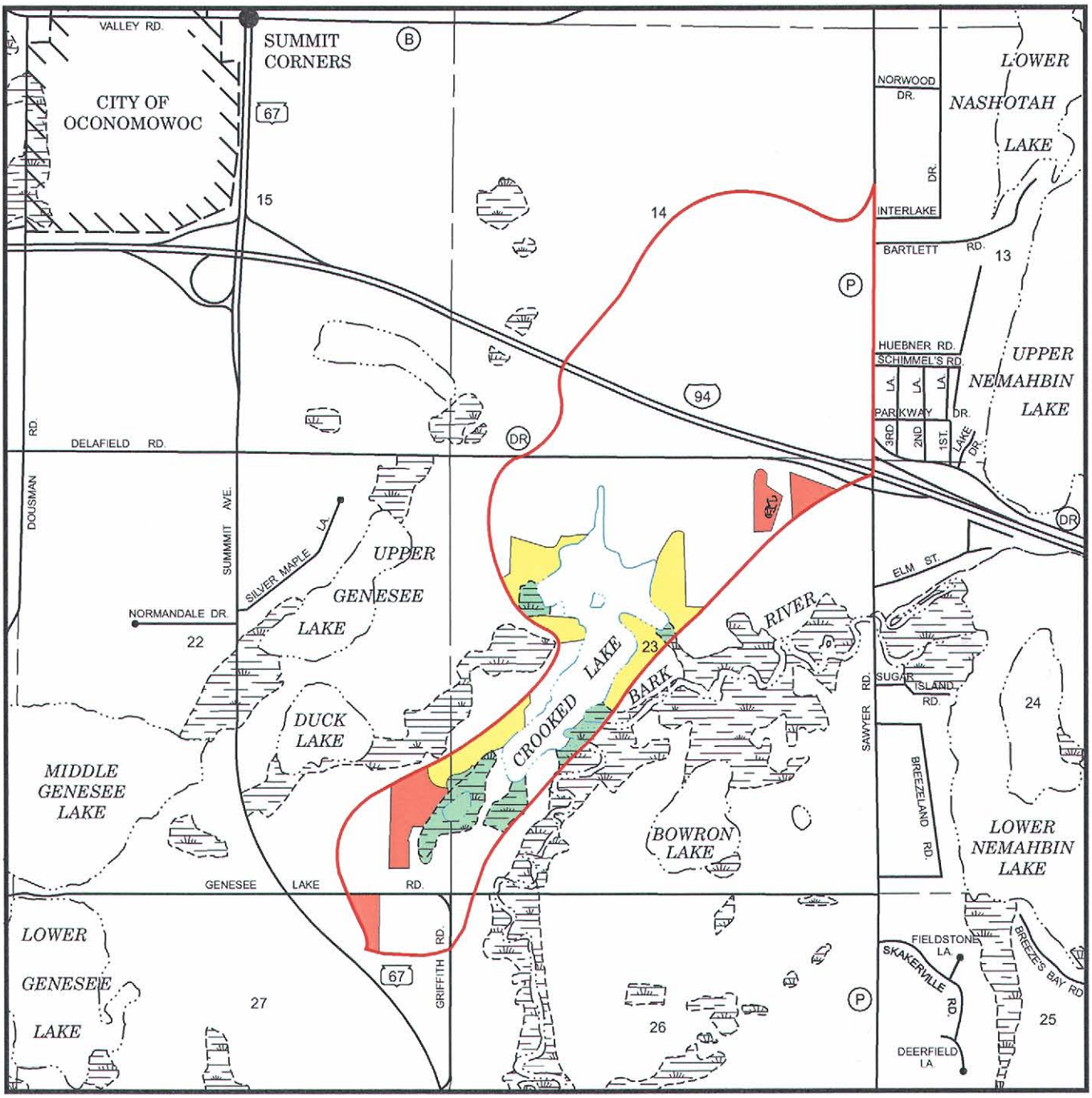
WILDLIFE AND WATERFOWL

Given the extremely low-density, single-family residential nature of much of the Lake's shoreline, and the surrounding woodlands and wetlands in the vicinity, it is likely that the wildlife community is comprised of small upland game animals, such as rabbit and squirrel; predators, such as fox and raccoon; game birds, such as pheasant; marsh furbearers, such as muskrat; migratory and resident songbirds; marsh birds, such as redwinged blackbirds and great blue herons; and waterfowl. The character of wildlife species, along with the nature of the habitat present in the planning area has undergone significant change since the time of European settlement and the subsequent clearing of forests, plowing of the prairie, and filling or draining of wetlands for agricultural purposes. Modern practices that adversely affect wildlife and wildlife habitat include: the excessive use of fertilizers and pesticides, road salting, heavy traffic, the introduction of domestic animals, and the fragmentation and isolation of remaining habitat areas for urban and agricultural uses.

As shown on Map 9, wildlife habitat areas in the drainage area directly tributary to Crooked Lake generally occur in association with existing surface water, wetland, and woodland resources, shown on Map 10, located around

Map 9

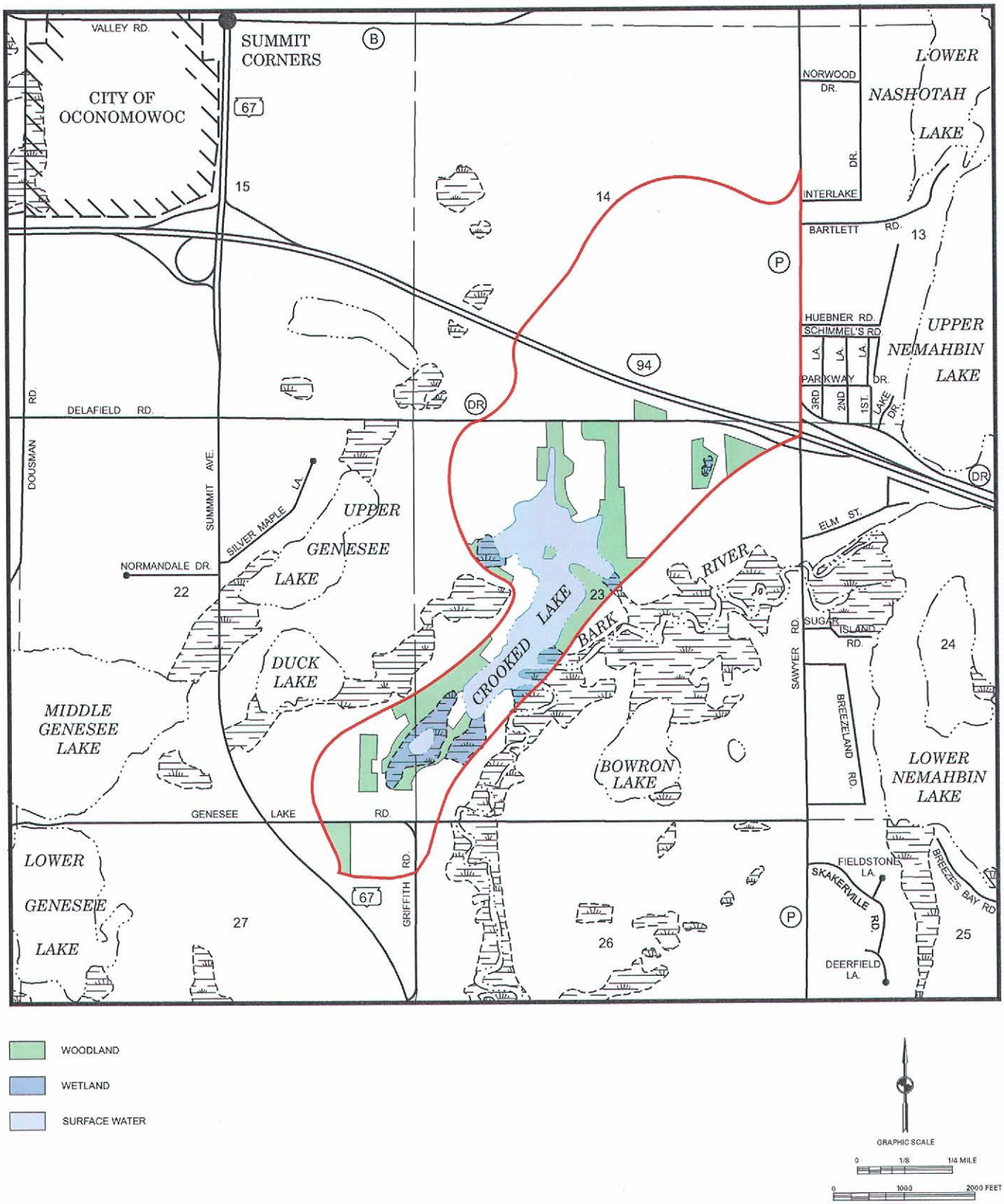
WILDLIFE HABITAT AREAS WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO CROOKED LAKE: 1990



Source: SEWRPC.

Map 10

WOODLANDS AND WETLANDS WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO CROOKED LAKE: 1990



WOODLAND

WETLAND

SURFACE WATER

GRAPHIC SCALE

0 1/8 1/4 MILE

0 1000 2000 FEET

Source: SEWRPC.

Crooked Lake and the Bark River. Such areas covered about 80 acres, or about 15 percent of the drainage area. Of this total habitat acreage, about 24 acres, or about 5 percent were rated as Class I habitat; about 34 acres, or about 6 percent were rated as Class II habitat; and about 22 acres, or about 4 percent were rated as Class III habitat.[16]

The habitat areas shown on Map 9 are largely coincident with Commission-delineated environmental corridors in this watershed, as shown on Map 11. Primary environmental corridors extend over 144 acres, or about 27 percent of the drainage area tributary to Crooked Lake. Isolated natural resource features cover four acres, or about 1 percent of the drainage area. The Commission recommends that, to the extent practicable, primary environmental corridor lands should be maintained in essentially natural, open uses.[17]

RECREATIONAL USES AND FACILITIES

Crooked Lake is a multi-purpose use waterbody serving all forms of recreation, including swimming, boating, and fishing in the summer months, and ice-skating, cross-country skiing, and ice fishing in the winter months. The Lake is used year-round as a visual amenity—walking and jogging, bird watching, and picnicking being popular passive recreational uses of the waterbody.

A boat survey conducted in July of 1997 indicated that 22 boats were either moored in the water or stored on land adjacent to the Lake. The types of boats included: canoes, fishing boats, paddleboats, pontoons, and a kayak. None of these watercraft were in operation at the time of the survey, and residents generally report light usage, except on holiday weekends when the Lake is perceived to be heavily used by both powered and nonpowered watercraft.

Recreational boating access to Crooked Lake is possible only through the Bark River inlet, which the Lake residents must use as well. The Bark River inlet allows access to Crooked Lake by canoes and rowboats, as well as by motorized boats and personal watercraft. Should the Bark River access be managed in the future to moderate the perceived deleterious influences of motorized watercraft, or should the Lake require enhancement services provided by the Wisconsin Department of Natural Resources, public access needs and provision of adequate public recreational boating access would have to be considered. Crooked Lake currently does not have adequate public recreational boating access as set forth in Chapter NR 1 of the *Wisconsin Administrative Code*.

SHORELINE PROTECTION STRUCTURES

Erosion of shorelines results in the loss of land, damage to shoreland infrastructure, and interference with Lake access and use. Wind-wave erosion, ice movement, and motorized boat traffic usually cause such erosion. A survey of the Crooked Lake shoreline, conducted by Commission staff in July of 1997, identified the shoreline as existing in an almost 100 percent natural state, with only three small areas consisting of riprap, bulkhead, or beach, as shown on Map 12. At present, shoreland erosion is not a problem on Crooked Lake.

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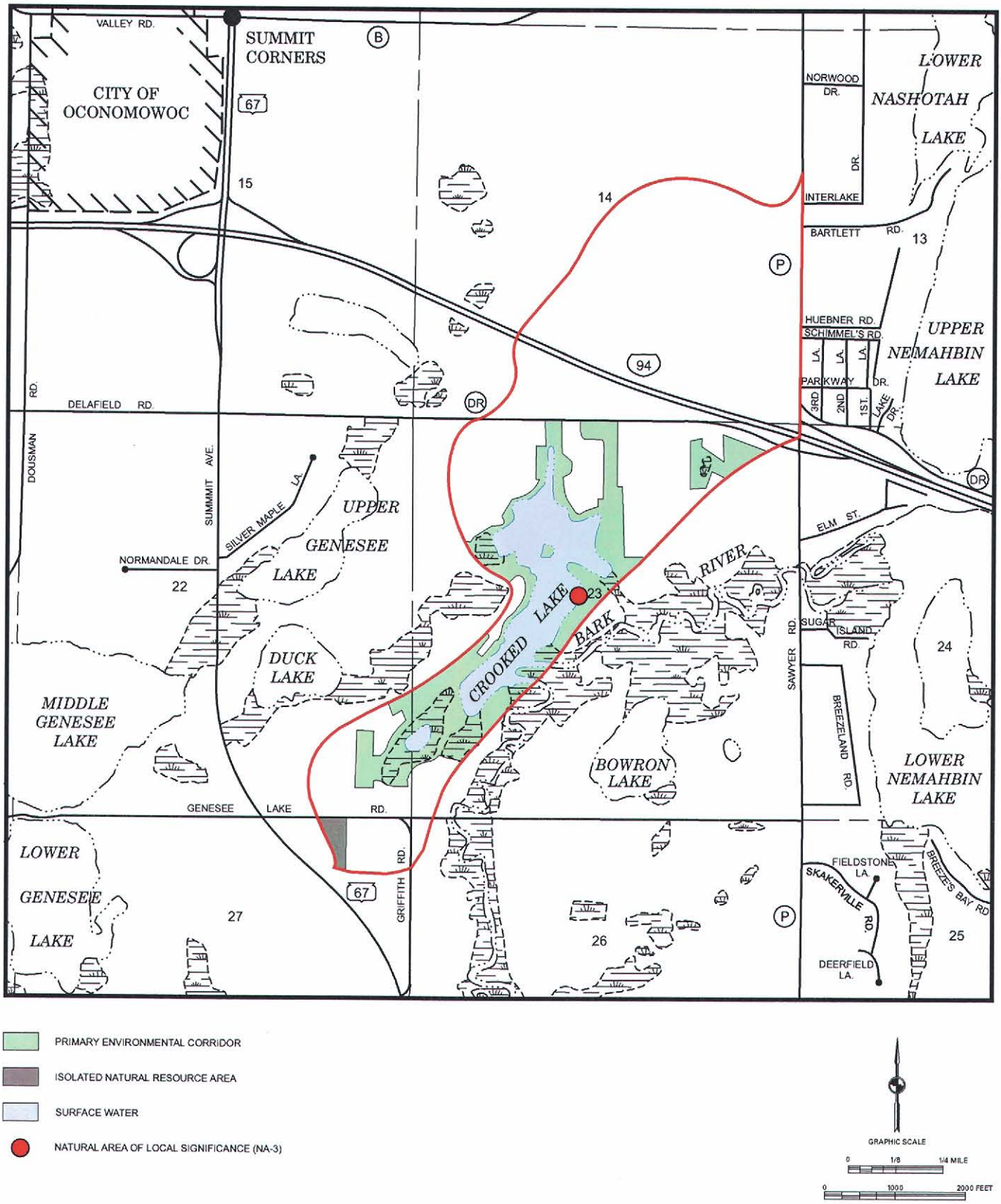
[16]*For details on these classifications, see SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin—2010, *January 1992.*

[17]*SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin—2010, *January 1992, p.438.*

Map 11

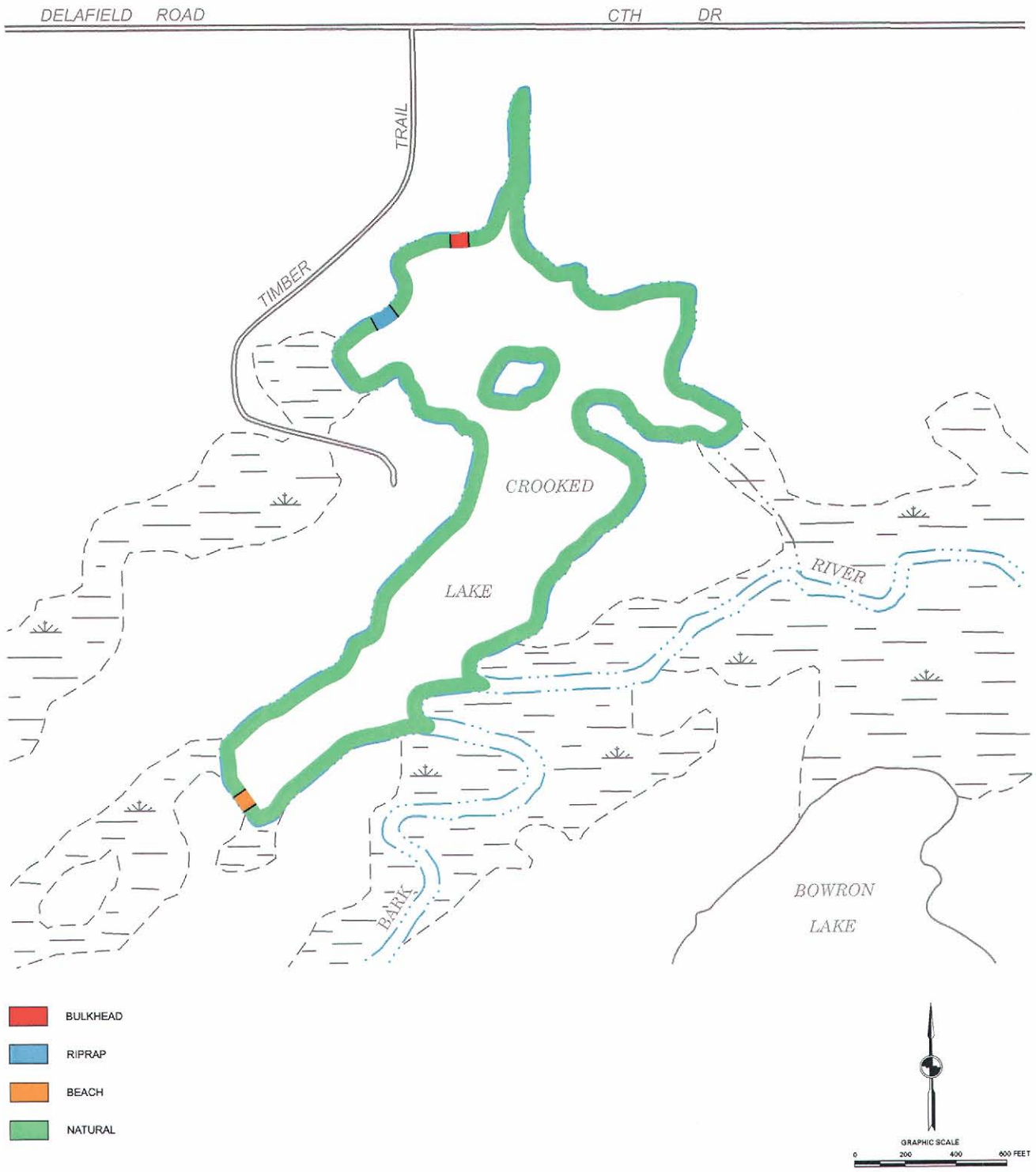
ENVIRONMENTAL CORRIDORS AND NATURAL AREAS WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO CROOKED LAKE: 1990



Source: SEWRPC.

Map 12

SHORELINE PROTECTION CONDITIONS ON CROOKED LAKE: 1997



Source: SEWRPC.

LOCAL ORDINANCES

Crooked Lake is subject to a boating ordinance promulgated by the Town of Summit. This ordinance provides generally applicable rules for all waters within the jurisdiction of the District, as set forth in Appendix B. These rules limit the times during which boats may operate on Crooked Lake and allow for the enactment and enforcement of boating restrictions and limitations. This ordinance requires powerboats to operate at slow-no-wake speeds between sunset and sunrise. Also, the operation of any motor vehicles, including snowmobiles, is not permitted on any icebound inland lakes within Town of Summit. The ordinance conforms to State of Wisconsin boating and water safety laws pursuant to Chapter 30, *Wisconsin Statutes*.

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Chapter III

LAKE USE PROBLEMS AND ISSUES

INTRODUCTION

Although Crooked Lake is of a relatively high quality, capable of supporting a wide variety of water uses, there are a number of existing and potential future problems and issues, which should be addressed in this aquatic plant management plan. These issues of concern include physical aspects of the Lake's morphology and water level; potential changes in ecologically valuable areas and aquatic plant species composition; construction site erosion and nonpoint source pollution; water quality; and public recreational uses and boating access to the Lake.

LAKE MORPHOLOGY AND WATER LEVELS

Crooked Lake, as set forth in Chapter II, is relatively small, shallow lake situated in the terminal position within Southeastern Wisconsin Region on the Bark River chain of lakes. The upstream lakes—comprising Bark Lake and Lake Five in Washington County, Merton Millpond, Nagawicka Lake, and Upper and Lower Nemahbin Lakes in Waukesha County—provide some benefit to Crooked Lake as basins within which contaminants are retained by the hydrological processes occurring within the lake basins. However, the relatively large areal extent of the total tributary drainage area to the Lake indicates that the Bark River delivers substantial quantities of suspended and dissolved materials into Crooked Lake. While the relatively small volume of the Lake and concomitant rapid through-flow rate suggest that much of this material is carried through the Lake by the river, observations by community residents, summarized in Appendix C, indicate that substantial deposition of suspended materials occurs in the vicinities of the inflow areas to the Lake. This siltation has resulted in the significant accumulations of muck, and the presence of Eurasian water milfoil beds, in the vicinity of the inflows. The Eurasian water milfoil conditions may be due, at least in part, to the rooting of plant fragments carried into the Lake in the inflow. Such evidence contrasts with the more diverse plant communities observed in other portions of the Lake and downstream reaches of the Bark River, areas having a sandy lake bottom substrate,[1] and suggests that lake morphology is an important issue to be considered.

In addition to the physical features of the Lake system that encourage deposition of suspended and dissolved materials within the lake basin, the physical characteristics of the Crooked Lake basin naturally introduce recreational use constraints. These constraints are enumerated in the analysis of recreational use issues set forth below. Notwithstanding, human interventions within the drainage area directly tributary to Crooked Lake, which included the construction of the northernmost inlet to the lake reported by residents to have occurred in the 1920s or 1930s, also may contribute to the extent and severity of in-lake impacts associated with the inflow and circulation of river water within Crooked Lake. For this reason, modification of the drainage patterns within the drainage area directly tributary to Crooked Lake is an important issue to be considered.

A further consideration related to the morphology of the Lake, but beyond the scope of this report, is the reported flooding experienced along the Bark River upstream of its confluence with the mainstem of the Rock River outside of the Southeastern Wisconsin Region. Public concerns have been raised regarding increased flooding along the Bark River downstream of Nagawicka Lake as a result.

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[1] *Wisconsin Department of Natural Resources,* Impacts of Phosphorus on Streams, *"Final Report of the Phosphorus and High-Flow Field Studies," U.S. Environmental Protection Agency, Region V, Project No. P0055420-01, April 1984.*

ECOLOGICALLY VALUABLE AREAS AND AQUATIC PLANTS

The ecologically valuable areas within the drainage area tributary to Crooked Lake, as documented in Chapter II, include wetlands and woodlands and wildlife habitat. Most of these areas are included in the lands designated as primary environmental corridor. Critical sites within the Lake include prime fish spawning habitat, macrophyte beds, especially those containing a diverse native flora, and the shoreline areas supporting the more productive aquatic habitat, as described in Chapter II. Protection of these areas is an important issue that should be considered.

The presence of Eurasian water milfoil throughout the lake basin, but especially in those areas where flocculent sediments are being deposited as noted above, and the presence of purple loosestrife in the wetlands adjoining the Lake, especially in the Bark River marsh, represent other important issues which should be considered. These plants often outcompete native aquatic plants, dominating the plant communities in lakes and wetlands in southeastern Wisconsin. This occurs to the detriment of fish and wildlife habitat and native species of plants. The dominance of Eurasian water milfoil and purple loosestrife in aquatic ecosystems in southeastern Wisconsin degrades the natural resource base and interferes with human recreational and aesthetic use of the natural resources.

As shown on Map 9, the drainage area directly tributary to Crooked Lake remains in a largely natural state, surrounded by woodlands and wetlands. The wetlands physically connected to the Lake provide valuable fish spawning habitat, especially during the early spring. In addition to providing habitat, these areas also contribute to the scenic vistas that characterize the drainage area directly tributary to Crooked Lake. The environmental corridors in the Crooked Lake tributary drainage area, as shown on Map 9, contain almost all of the best remaining woodlands, wetlands, and wildlife habitat. The Bark River Marsh, situated immediately upstream of Crooked Lake, downstream of Lower Nemahbin Lake, has been designated as a natural area of local significance in the regional natural areas and critical species habitat protection and management plan.[2] This 158-acre deep and shallow water cattail marsh is currently in private ownership. The protection of these resources from intrusion by incompatible land uses which degrade and destroy their environmental values, and the preservation of the corridors in an essentially open and natural state, is an important issue to be considered.

WATER QUALITY

As of 1997, surface water quality in Crooked Lake was reported to be fair to good based upon Secchi disk transparencies recorded by the Crooked Lake Property Owners' Association under the auspices of the Wisconsin Department of Natural Resources Self-Help Monitoring Program. As describe in Chapter II, the Lake may be considered to be a mesotrophic or moderately productive lake, capable of supporting abundant aquatic plant growths and productive fisheries. Nuisance growths of algae and plants are usually not exhibited by mesotrophic lakes. Many of the cleaner lakes in southeastern Wisconsin are classified as mesotrophic. Nevertheless, lake residents have expressed concerns, summarized in Appendix C, regarding the perceived degradation in water quality, principally related to nuisance levels of aquatic plants and the presence and accumulation of silt and organic litter from the two Bark River inlets on the eastern shore. For these reasons, surface water quality is an important issue to be considered.

Excessive aquatic plant growths have consistently impaired recreational uses of the Lake in recent years. Senescent or dying, and decomposing, plants are perceived to be one cause of unpleasant odors, while epiphytic, or attached algal, growths and the abundance of plant material are perceived as decreasing water clarity.

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

Lake residents also frequently expressed concern over siltation in the eastern and southern embayments of the Lake. They report that the Lake, historically, had a sand and sandy gravel bottom, and note that the only portion of the Lake that continues to have a sand bottom is the portion north of the Bark River inlets. This would indicate that at least one source of the severe sedimentation and siltation problems is the two Bark River inlets.

The highly organic, fine silt that characterizes the material deposited in the Lake is not only the preferred rooting habitat of Eurasian water milfoil, perhaps contributing to the abundance of Eurasian milfoil in Crooked Lake, but also reduces the depth of the Lake in some areas to only a few inches of standing water. A reconnaissance conducted by Commission staff during August 1998 in the northeastern embayment of the Lake, where the Bark River traverses the wetlands to enter the Lake, found the flocculent sediment to be a minimum of four feet in depth. Riparian owners expressed concern over the dangers inherent in swimming in these areas, as well as over the loss of usable lake area. In addition, the odorous sediment had a moss growing on the surface. The sediment could be the result of a combination of factors, including: runoff from development of properties upstream from the Lake; deposition and decay of organic material, such as leaves from the shoreland areas and aquatic plants; and sediment loadings from tributary areas.

Though many of the residents expressed a desire to see the water quality of the Lake improved by aquatic plant harvesting and dredging, there was also a fear of the potential damage such in-lake management measures might have on the lake-wetland ecosystem. Many of the residents wished to have studies done on various aspects of the Lake and its ecosystem, including sediment loads from the Bark River and the affect of upstream construction on siltation within the Lake, before any lake management decisions were made. All were uniformly in support of helping to support lake management measures, provided that such measures would not detrimentally affect the integrity of the Lake ecosystem.

CONSTRUCTION SITE EROSION AND NONPOINT SOURCE POLLUTION

Erosion during construction and nonpoint source pollutants associated with new urban development in the total drainage area tributary to Crooked Lake represents a potentially significant threat to the Lake's water quality.[3] Based upon recommendations set forth in the regional land use plan and Waukesha County development plan, future development of the open lands in the drainage area tributary to Crooked Lake is expected to occur, especially in those areas adjacent to existing urban areas where additional residential and commercial development is anticipated. Unplanned development, both on the Lake and within the drainage area tributary to the Lake, could also take place. Unless appropriate construction site erosion control and stormwater and nonpoint source pollution control measures are implemented,[4] impacts on the lake water quality could potentially result. Thus, the control of construction site erosion and stormwater nonpoint source pollution remains an important issue to be considered.

PUBLIC RECREATIONAL USE AND BOATING ACCESS

Recreational boating opportunities on Crooked Lake are limited due to the lack of adequate public access. Current requirements contained in Sections NR 1.91(4) and NR 1.91(5), respectively, of the *Wisconsin Administrative*

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[3]*See the pollutant loading analyses set forth in SEWRPC Memorandum Report No. 101,* Upper Nemahbin Lake Watershed Inventory Findings, Waukesha County, Wisconsin, *May 1995, and SEWRPC Memorandum Report No. 130,* A Lake and Watershed Inventory for Nagawicka Lake, Waukesha County, Wisconsin, *draft, January 1999.*

[4]*As documented in SEWRPC Memorandum Report No. 130,* A Lake and Watershed Inventory for Nagawicka Lake, Waukesha County, Wisconsin, *draft, January 1999, governmental units within the drainage area tributary to Crooked Lake have adopted construction site erosion control and stormwater management ordinance provisions.*

Code, mandate standards for adequate public boating access development to Crooked Lake such that, at a minimum, public access sites accommodate vehicle and car-trailer units totaling five units, and, at a maximum, five car-trailer units. In addition, one handicapped-accessible unit would be provided in each case. Alternatively, Section NR 1.91(6) of the *Wisconsin Administrative Code* provides procedures for determining alternative public access standards which may differ from the minimum and maximum standards set forth in Sections NR 1.91(4) and NR 1.91(5), on a site specific basis, in cases where unusual environmental or developmental factors preclude provision of access within the standards. The lack of adequate public recreational boating access may limit the ability of the Crooked Lake Property Owners' Association and Town of Summit to access State funding for lake enhancement services.

Currently, public recreational boating access to Crooked Lake is gained from the Nemahbin Lakes public recreational boating access site on CTH DR, through Lower Nemahbin Lake and the Bark River, to Crooked Lake. The Bark River downstream of Lower Nemahbin Lake is a popular canoe route with Crooked Lake being part of that route. Riparian owners considered the Lake to be moderately to heavily used for recreational boating purposes, and few felt that additional or further access opportunities were warranted. All the riparian owners expressed concerns, summarized in Appendix C, over the inappropriate use of motorized vessels, in particular personal watercraft, and their detrimental effects on Crooked Lake. Many residents felt that the Lake was too small to support personal watercraft, and that the increased wave action and turbidity was damaging to the many natural areas ringing the Lake. The excessive noise, the inappropriate use of the personal watercraft in shallow water areas and other sensitive areas of the Lake, the excessive speeds of the watercraft, and the subsequent lack of law enforcement, as well as their potential damage to the rich wildlife and wildlife habitat in the shorelands, were noted by all the lake residents. Hence, public recreational boating access on Crooked Lake is an important issue to be considered.

Chapter IV

ALTERNATIVE AND RECOMMENDED LAKE PROTECTION MEASURES

INTRODUCTION

Chapter III described five issues of concern to be considered as part of this aquatic plant management plan. These issues are related to: physical aspects of the Lake's morphology and siltation, potential changes in ecologically valuable areas and aquatic plant species composition, construction site erosion and nonpoint source pollution, water quality, public recreational uses and boating access to the Lake. Following a brief summary of the ongoing lake management program activities, alternatives and recommended measures to address each of these issues and concerns are described in this chapter. The alternatives and recommendations set forth herein are focused primarily on those measures which are applicable to the Crooked Lake Association and the Town of Summit, with lesser emphasis given to measures which are applicable to others with jurisdiction within the drainage area tributary to Crooked Lake.

PAST AND PRESENT LAKE MANAGEMENT ACTIONS

The residents of Crooked Lake, in conjunction with the Town of Summit, have recognized the importance of informed and timely action in the management of Crooked Lake. The initial action in this regard was the formation of the Crooked Lake Association, which provides the forum for many of the lake management activities of the Lake's residents.

The Association is currently enrolled in the water quality-monitoring program conducted under the auspices of the Wisconsin Department of Natural Resources Self-Help Monitoring Program. The Town of Summit, on behalf of the Crooked Lake Association, holds this Phase I Lake Management Planning Grant to conduct a study of the aquatic plant communities in Crooked Lake, and to assess possible water quality impacts that might affect the Lake in the future. This study is one element of a comprehensive lake management plan for Crooked Lake.

Information gathered through the water quality monitoring program and the aquatic plant study will be regularly reported to the community through the annual Association meeting and the local media as part of an ongoing citizen education and involvement program related to Lake Management activities.

LAKE MORPHOLOGY AND WATER LEVELS

The surface area, volume, and location of Crooked Lake within the Bark River watershed results in the Lake having an extremely large drainage basin that delivers water and pollutants to the Lake. The hydrologic and hydraulic conditions throughout the Bark River drainage basin are such that, during extreme rainfall events like those that occurred during the summers of 1997 and 1998, flooding occurs at numerous locations along the waterway. While this flooding does create some degree of concern for the residents of the Crooked Lake community, the systemwide nature of the concern indicates that an analysis be conducted of the entire Bark River system through to its confluence with the mainstem of the Rock River. Thus, while the Crooked Lake Property Owners' Association and Town of Summit could participate in such a study, resolution of the immediate flooding and related water quality concerns of the Crooked Lake residents is beyond the scope of this investigation.

Notwithstanding, the human intervention in the drainage patterns of the Bark River adjacent to Crooked Lake would suggest that restoration of historic river flow patterns might provide some measure of water quality protection for Crooked Lake. Specifically, consideration of the closure of the northernmost inlet channel to Crooked Lake from the Bark River, as well as consideration of the feasibility and desirability of constructing a

high- or low-flow bypass across the narrow neck of land between the Bark River inflow and outflow reaches in the vicinity of Crooked Lake, should form part of the proposed hydrologic and hydraulic study of the Bark River system.

As discussed in Chapter III, the deposition of sediments from the Bark River drainage area, leading to a reduction in the depth of Crooked Lake, affects the recreational boating use of the Lake. In addition, concerns have been expressed regarding the impact of such sedimentation on the aquatic plant communities in Crooked Lake.

Options Considered

Three options were considered regarding the potential control of sediment deposition and water levels in Crooked Lake. Under the first option, no specific actions would be undertaken and the lake levels would be the result of natural fluctuations. Under the second option, the Lake would be selectively deepened, specifically to remove accumulated flocculent sediments at the Bark River inflows to the Lake. The third option involves the redirection of the Bark River inlet to flow around Crooked Lake.

Natural Fluctuations

Under the first option considered, the variations in year-to-year rainfall amounts and the distribution of rainfall and associated runoff within the Bark River watershed would continue to result in lake level fluctuations as currently occurs. Additional sedimentation and deposition of decaying aquatic plant and other vegetative material may increase the shallow water problems in selected areas.

Water Level Augmentation

Under the second option considered, the selective deepening of Crooked Lake would mitigate the shallow lake water levels. Specifically, this option would include the removal of soft, flocculent sediments that have been deposited in the vicinity of the Bark River inflows to the Lake. Given the potential cost of removing these sediments, and the potential for redeposition of further amounts of sediment from upstream sources, removal of accumulated sediments should be considered only after upstream sources of sediment have been controlled, or other measures implemented to by-pass additional sediment loads around the Lake.

Sediment Reduction Measures

The third option incorporates the investigation of redirecting/diverting the Bark River channel inlet to flow around Crooked Lake. This option should only be considered as part of a hydrologic and hydraulic analysis for the entire Bark River basin.

Other actions that could be considered under the general water level augmentation measures heading, namely the deepening of the Lake by raising the low head overflow outflow structure, are not considered to be feasible, given the concerns raised by residents and upstream management units regarding flooding during periods of high rainfall-runoff. Increasing the storage volume of Crooked Lake under these circumstances could exacerbate flooding problems within the Bark River basin. This option should be considered as part of a hydrologic and hydraulic analysis has been completed for the Bark River basin.

Recommended Control Measures

The preparation of a comprehensive watershed plan for the Bark River system, including a detailed hydraulic and hydrologic analysis, is recommended. No specific action on the part of the Crooked Lake Property Owners' Association or Town of Summit is recommended prior to the determination of appropriate systemwide management measures. Consideration of a high-flow/low-flow bypass and of the restoration of the natural river patterns in the vicinity of Crooked Lake should be included in the aforementioned study as possible alternatives to be considered in this portion of the Bark River basin. Such a comprehensive planning study should be initiated by Waukesha and Washington Counties and prepared by the Southeastern Wisconsin regional Planning Commission in cooperation with the Wisconsin Department of Natural Resources and relevant partner agencies. It should be noted that the recommended measures to reduce sediment loading and decaying vegetation as described in subsequent sections may mitigate the increases in the sediment-related shallow water problems.

ECOLOGICALLY VALUABLE AREAS AND AQUATIC PLANTS

Crooked Lake and its tributary drainage area contain relatively large tracts of ecologically valuable areas, including significant areas of diverse, native aquatic vegetation suitable for fish spawning which are located within, and immediately adjacent to, the Lake. As described in Chapter III, the potential problems associated with ecologically valuable areas in and near Crooked Lake include the potential loss of wetlands and other ecologically valuable areas due to urbanization or other encroachments; the degradation of wetlands and aquatic habitat due to the presence of invasive species, including Eurasian water milfoil and purple loosestrife; and disturbances associated with recreational boating.

Options Considered

Four measures to protect and maintain the biodiversity of Crooked Lake and its tributary drainage area have been identified as being potentially viable. Under the first option, protection of ecologically valuable areas would be provided through control of boating usage of the Lake, effected through local boating ordinances. Under the second option, protection of ecologically valuable areas could be accomplished through land use control measures. Under the third option, in-lake management measures could be used to moderate deleterious changes in the aquatic plant and animal communities that comprise the ecologically valuable areas within the Lake basin. Under the fourth option, citizen informational and educational programming could encourage actions on the part of riparian residents and residents within the drainage area tributary to Crooked Lake that would benefit maintenance of ecologically valuable areas within the Lake.

Boating Ordinances

The promulgation of more stringent controls on the use of powered watercraft within Crooked Lake is one means of regulating the conduct of boat traffic, which could be harmful to the most important ecologically valuable areas in the Lake. These areas include the western portions of the lake basin where the greatest diversity of native aquatic plant species occur. In addition, boat traffic within the remainder of the basin should be restricted to necessary boat traffic only to prevent the further colonization and proliferation of Eurasian water milfoil. Controls on boat traffic could be put in place using the following three options:

1. Provide for slow-no-wake boating only within a specified distance of the shoreline, such as in the "shore zone," within 100 feet of pierheads or 200 feet of the shoreline in the case of personal watercraft, as defined in the Wisconsin Department of Natural Resources boating ordinance guidelines;[1]

2. Limit boating activity within specific areas of the Lake such as in "boat excluded areas" or "motorboat prohibition zones", and/or define specific traffic lanes within the Lake to minimize the disturbance and propagation of nuisance plant species by the operation of watercraft;

3. Limit the speeds at which boat traffic travels in specific areas of the Lake such as in "slow-no-wake" areas or by some other form of "speed restriction."

Boat excluded areas and traffic lanes must be designated by approved regulatory markers. These areas are preferable to motorboat prohibition areas as the latter can lead to legal challenges based on the right of free use of navigable waters. Similarly, slow-no-wake restrictions are preferable to speed limits designated in miles per hour terms owing to implementation and enforcement considerations. Placement of regulatory markers must conform to Section NR 5.09 of the *Wisconsin Administrative Code*, and all restrictions placed on the use of the waters of the State must be predicated upon the protection of public health, safety, or welfare. Boating ordinances, enacted

[1] *Wisconsin Department of Natural Resources,* Guidelines: Ordinance Writing and Buoy Placement for Wisconsin Waters, *s.d.*

in conformity with State law, must be clearly posted at public landings in accordance with the requirements of Section 30.77(4) of the *Wisconsin Statutes*.

Buoyage has the advantage of being visible to recreational boaters but can be expensive to obtain, install, and maintain. Affected areas can be clearly demarcated. Two general options exist regarding the use of buoyage: the establishment of regulated areas using regulatory buoys, such as slow-no-wake or exclusionary areas, or the enhancement of public awareness using informational buoys. Establishment of additional slow-no-wake areas within Crooked Lake, outside of the statutory slow-no-wake shoreland zone, will require amendment of the Town of Summit boating ordinance, Ordinance 183, and a Wisconsin Department of Natural Resources permit. Only regulatory markers are enforceable.

Buoys placed within the waters of the State of Wisconsin are subject to the requirements set forth in Chapter 30, *Wisconsin Statutes*. Such buoys are white in color, cylindrical in shape, seven or more inches in diameter, and extend 36 or more inches above the water line. Regulatory buoys include buoys used to demarcate restricted areas, prohibit boating or types of boating activities in specific areas, and control the movements of watercraft. Buoys used to demarcate regulated areas display their instructions in black lettering. Prohibition buoys display an orange diamond with an orange cross inside. Control buoys display an orange circle. Local authorities having jurisdiction over the waters involved may place danger buoys or informational buoys without an ordinance, although a Wisconsin Department of Natural Resources permit is still required. Informational buoys are similar in construction to the regulatory buoys, but contain an orange square on the white background. Informational buoys are not enforceable.

Land Management Measures

The recommended future condition land use plan for the drainage area tributary to Crooked Lake is set forth in the regional land use and Waukesha County development plans.[2] Those plans recommend the preservation of primary environmental corridor lands in essentially natural, open space use. Most of the wetlands and other ecologically valuable lands adjacent to Crooked Lake and within the drainage area directly tributary to Crooked Lake are included within these primary environmental corridors. The plan recommends that such protection be afforded through the placement of these lands in appropriate zoning districts, depending upon the type and character of the natural resource features to be preserved and protected.

All lakes, rivers, streams, wetlands, and associated undeveloped floodlands and shorelands are recommended to be placed in lowland conservancy or floodplain protection districts. The existing Town of Summit zoning for the lands in the vicinity of Crooked Lake and in the drainage area directly tributary to Crooked Lake is generally consistent with the recommended future land use pattern set forth in the regional land use plan and Waukesha County development plan. The Town zoning for the drainage area directly tributary to Crooked Lake generally provides for conservancy zoning of wetland portions of the primary environmental corridors. The upland portions of the drainage area are included in the R-1 zoning district, which provides for low-density, single-family residential development.

The purchase of specific critical properties or the acquisition of conservation easements, as a means of protecting them from encroachment or further degradation, or as a means of facilitating their rehabilitation and restoration, is possible through the Chapters NR 50/51 of the *Wisconsin Administrative Code*, the Stewardship Grant Program, and Chapter NR 191, the Lake Protection Grant Program. Outright purchase, or the purchase of conservation easements, are both possible options. Lands proposed for purchase must be appraised using standard governmental land acquisition procedures as established by the Wisconsin Department of Natural Resources, and must be subject to a land management plan setting forth the processes and procedures for their long-term

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[2]*SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997; SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

maintenance and development. The Chapter NR 191 grant program provides State cost-share funding for the purchase up to a maximum State share of $200,000 at up to a 75 percent State cost-share. The Chapter NR 50/51 grant program provides State cost-share funding up to a maximum State share of $100,000 at up to a 50 percent cost-share.

In-Lake Management Measures

Various potential in-lake management actions may be considered for purposes of control of aquatic plants. These actions include harvesting, chemical treatment, biological controls, lake drawdown, and lake bottom covering. Because of the extent of the current aquatic plant problems on Crooked Lake, as described in Chapters II and III, chemical and biological in-lake measures are considered applicable. Aquatic plant harvesting is often not viable on smaller lakes or shallow lakes,[3] while the use of drawdown is limited by the extremely low head of the outlet control structure situated on the Bark River outflow from Crooked Lake. Measures, such as the use of bottom coverings, require permits from the Wisconsin Department of Natural Resources and are difficult to apply on steeply sloped shorelines or in extensive applications, such as would be required at Crooked Lake. The only in-lake measures related to aquatic plant management considered viable are manual harvesting of selected nuisance species, such as Eurasian water milfoil and purple loosestrife, limited chemical treatment of these two species in situations where extensive infestations occur, and maintenance of natural shorelines to promote the survival of naturally occurring populations of the Eurasian water milfoil weevil, *Euhrychiopsis lecontei*, which have been observed in the Lake by Regional Planning Commission and Wisconsin Department of Natural Resources staff during field inspections in 1997 and 1998.

Citizen Information and Education

As part of the overall citizen informational and educational programming to be conducted in the Crooked Lake community, residents and visitors in the vicinity of Crooked Lake should be made aware of the value of the ecologically significant areas in the overall structure and functioning of the ecosystems of Crooked Lake. Specifically, informational programming related to the protection of ecologically valuable areas in and around Crooked Lake should focus on need to minimize the spread of nuisance aquatic species, such as purple loosestrife in the wetlands and Eurasian water milfoil in the Lake. Citizens participating in water-based recreation on Crooked Lake and along the Bark River should also be encouraged to participate in boater education programs. Other informational programming offered by the Wisconsin Department of Natural Resources, University of Wisconsin and University of Wisconsin-Extension (UWEX), and other agencies can contribute to an informed public, actively involved in the protection of ecologically valuable areas within the drainage area tributary to, and lake basin of, Crooked Lake.

Recommended Protection Measures

Recommended actions for the management of ecologically valuable areas and aquatic plants should be effected by the Town of Summit through its existing boating ordinance and amendment thereof. It is recommended that the Town continue to limit boat speeds 100 feet from pierheads, and personal watercraft speeds 200 feet from shore, to slow-no-wake as defined in Chapter 30 of the *Wisconsin Statutes*; reduce motorized boat traffic within the Eurasian water milfoil control areas shown on Map 13 to essential traffic only; and define watercraft transit speeds and lanes consistent with the milfoil control areas and established patterns of recreational boating usage on the Lake. Such regulation may require buoyage depending on the sufficiency of the signage and notices provided to lake users and the level of compliance achieved. Copies of such an ordinance must be placed at the Nemahbin Lakes public access site as set forth in Section 30.77(4) of the *Wisconsin Statutes*.

In addition, the Crooked Lake Property Owners' Association, in cooperation with the Town of Summit, should support the preservation of the primary environmental corridor lands in the drainage area tributary to Crooked Lake in essentially natural, open-space uses, primarily through public land use controls. Such preservation should

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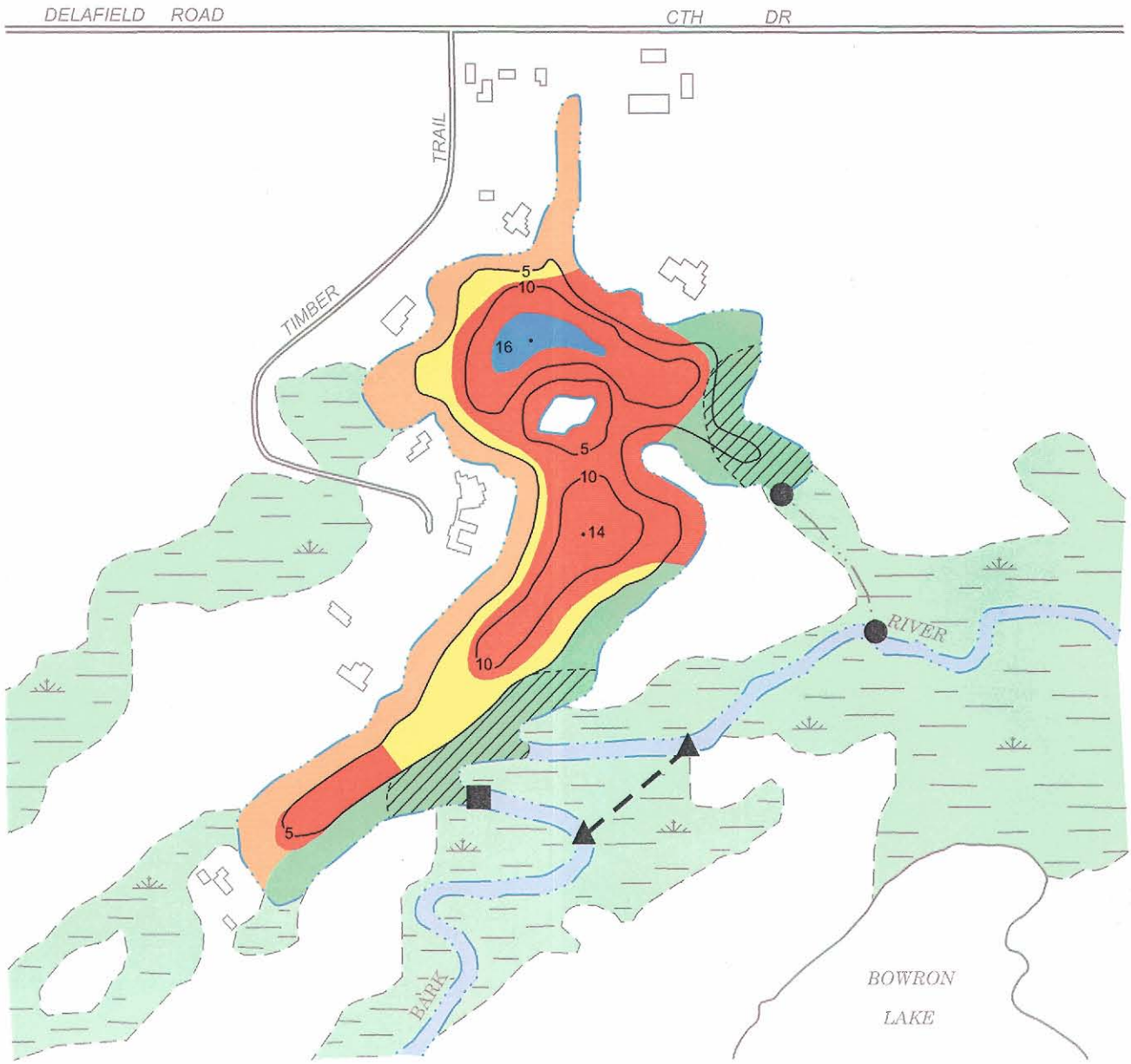
[3]*Wisconsin Department of Natural Resources Publication No. FH-205-97,* Your Aquatic Plant Harvesting Program: A How-To Field Manual, *1997.*

Map 13

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR CROOKED LAKE



Source: SEWRPC.

be promoted through the enforcement of existing regulations intended to protect such natural resources. At present, the current Town zoning protects the wetland and riparian portions of the primary environmental corridor lands in conservancy districts.

The Town of Summit and the Crooked Lake Property Owners' Association should also support acquisition and preservation of the Bark River marsh immediately upstream of the Lake by Waukesha County. If considered necessary, the Town and/or Association also should consider supporting future management actions that may be necessary to ensure the habitat quality of the wetlands—actions such as the control of purple loosestrife or other invasive plants which might degrade the habitat quality of the wetlands- and protect critical species habitat areas as set forth in SEWRPC Planning Report No. 42, *A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin*, September 1997.

The Crooked Lake Property Owners' Association and the Wisconsin Department of Natural Resources should work with private property owners to promote and encourage limited, manual control of aquatic plants within the lake basin. Selected manual harvesting of these plant species is recommended in areas where this level of control is appropriate to the abundance of plants. Such control measures encourage the resurgence of native plant species and enhance the value of the habitat areas within the Lake. Further, should more aggressive actions be warranted, the Crooked Lake Property Owners' Association and the Wisconsin Department of Natural Resources could develop a reasonable herbicide usage policy to control the expansion of purple loosestrife and Eurasian water milfoil growths in the Lake. Early spring treatment to control Eurasian water milfoil growth in the Lake has proven effective in other lakes in Southeastern Wisconsin and is recommended. Early spring herbicide treatments result in a reduced biomass subject to decomposition and limit the accumulation of organic materials on the lake bottom.

The Town of Summit and the Crooked Lake Property Owners' Association, through a joint educational and informational program, should discourage human disturbances in ecologically valuable areas, except as may be necessary to provide riparian residents with a reasonable level of access to the main body of the Lake, and limit boating and other water sports in the ecologically valuable areas. Lake residents and visitors should be made aware of the invasive nature of species such as purple loosestrife and Eurasian water milfoil, and be encouraged to participate in citizen-based control programs coordinated by the Wisconsin Department of Natural Resources and University of Wisconsin-Extension.

WATER QUALITY

Crooked Lake, as a mesotrophic waterbody, may be considered a relatively unpolluted lake in the context of Southeastern Wisconsin.[4] Nevertheless, accumulations of organic material in the eastern and southern portions of the lake basin have created concern amongst the lakeshore residents.

Protection of the surface water quality of Crooked Lake can be accomplished through the protection of ecologically valuable areas, adoption of good housekeeping practices within the drainage area tributary to Crooked Lake, and through installation and maintenance of appropriate shoreline protection. Specific public informational programming, with an emphasis on composting of leaves, would complement riparian good housekeeping practices, and potentially reduce the rate at which terrestrial leaf litter accumulates within the lake basin.

Continued participation in the Wisconsin Department of Natural Resources Self-Help programs is also recommended as a means of assessing the health of Crooked Lake on a regular basis. These programs can provide an early warning of undesirable changes in lake water quality and aquatic species composition and initiate

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

appropriate responses in a timely manner. Further, as part of the lower Rock River basin water quality management plan, Crooked Lake and the Bark River chain of lakes are candidate waterbodies to be considered for a nonpoint source priority watershed program lakes cluster project.[5]

CONSTRUCTION SITE EROSION AND NONPOINT SOURCE POLLUTION CONTROLS

As described in Chapter II, the primary sources of pollutant loadings to Crooked Lake are nonpoint sources generated in the drainage area tributary to the Lake. In addition to the existing rural and urban sources of water pollution, the Waukesha County development plan provides for significant levels of new development, including infilling of existing platted lots, within the total drainage area tributary to Crooked Lake. Although moderated to a degree by the upstream lakes, such development could result in a potential increase in the loads of some pollutants associated with urban development being transported into Crooked Lake from nonpoint sources and construction sites. Nonpoint source pollutant loadings from existing and future urban areas, and from rural areas, represent one controllable source of pollution to the Lake.

Options Considered

Watershed management measures may be used to reduce nonpoint source pollutant loadings from such rural sources as runoff from cropland and pastureland; from such urban sources as runoff from residential, commercial, transportation, and recreational land uses; and from construction activities. The alternative, nonpoint source pollution control measures considered in this report are based upon the recommendations set forth in the regional water quality management plan,[6] the County soil erosion control plans,[7] and information presented by the U.S. Environmental Protection Agency.[8]

Two options to control nonpoint source pollution to Crooked Lake and its tributary drainage area have been identified as being potentially viable. Under the first option, urban nonpoint source controls could be used to moderate contaminant loadings to the Lake from upstream, urbanized areas. Under the second option, rural nonpoint source controls could be used to moderate contaminant loadings from upstream agricultural areas and areas of open lands.

Urban Nonpoint Source Controls

The regional water quality management plan recommends that the nonpoint source pollutant loadings from the urban areas tributary to Crooked Lake be reduced by about 25 percent in addition to reductions from urban construction erosion control, onsite sewage disposal system management, and streambank and shoreline erosion control measures.

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[5]*Wisconsin Department of Natural Resources Publication No. PUBL-WT-280-98-REV,* Lower Rock River Basin Water Quality Management Plan: a Five-Year Plan to Protect and Enhance our Water Resources, *October 1998.*

[6]*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, as refined by SEWRPC Memorandum Report No. 93, op. cit.*

[7]*SEWRPC Community Assistance Planning Report No. 159,* Waukesha County Agricultural Soil Erosion Control Plan, *June 1988; SEWRPC Community Assistance Planning Report No. 170,* Washington County Agricultural Soil Erosion Control Plan, *March 1989.*

[8]*U.S. Environmental Protection Agency, Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, *2nd Edition, August 1990; and its technical supplement, U.S. Environmental Protection Agency, Report No. EPA-841/R-93-002,* Fish and Fisheries Management in Lakes and Reservoirs: Technical Supplement to the Lake and Reservoirs Restoration Guidance Manual, *May 1993.*

Potentially applicable urban nonpoint source control measures include wet detention basins, grassed swales, and good urban "housekeeping" practices. Generally, the application of low-cost urban housekeeping practices may be expected to reduce nonpoint source loadings from urban lands by about 25 percent.

Public educational programs can be developed to encourage such good urban housekeeping practices, to promote the selection of building and construction materials which reduce the runoff contribution of metals and other toxic pollutants, and to promote the acceptance and understanding of the proposed pollution abatement measures and the importance of lake water quality protection. Urban housekeeping practices and source controls include restricted use of fertilizers and pesticides; improved pet waste and litter control; the substitution of plastic for galvanized steel and copper roofing material and gutters; proper disposal of motor vehicle fluids; increased leaf collection; and reduced use of street deicing salt.

Proper design and application of urban nonpoint source control measures, such as grassed swales and detention basins, requires the preparation of a detailed stormwater management system plan that addresses stormwater drainage problems and controls nonpoint sources of pollution. Based on preliminary evaluation, however, it is estimated that few practices would be effective in the areas within the immediate vicinity of Crooked Lake. More effective measures would be those applied upstream of Crooked Lake by neighboring municipalities. Those municipalities immediately upstream of Crooked Lake along the Bark River, namely the City of Delafield and Village of Hartland, have recently adopted stormwater management and construction site erosion control ordinances that could potentially benefit Crooked Lake. Management measures that can be applied within the Town of Summit in the immediate vicinity of Crooked Lake are limited largely to good urban housekeeping practices and grassed swales. However, structural measures could be considered for installation as part of the development process in urbanizing areas within the total drainage area.

Rural Nonpoint Source Controls

Upland erosion from agricultural and other rural lands is a contributor of sediment to streams and lakes in the drainage area to Crooked Lake. Estimated phosphorus and sediment loadings from croplands, woodlots, pastures, and grasslands in the Crooked Lake drainage area are set forth in Table 3. These loadings are recommended to be reduced to the target level of agricultural soil erosion control of three tons per acre per year identified in the County agricultural soil erosion control plans as the tolerable levels, which can be sustained without impairing productivity. Implementation of these recommendations is considered to be important water quality management measures for Crooked Lake.

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

Recommended Control Measures

Recommended actions for the management of nonpoint source pollution sources include strict enforcement of the stormwater and construction site erosion control ordinances to reduce sediment and contaminant loadings from the urbanizing areas in the Crooked Lake drainage area, especially in those areas nearest to the Lake.

The Crooked Lake Property Owners' Association, in conjunction with the Town of Summit, should assume the lead in the development of a public educational and informational program for the residents around and in the immediate vicinity of Crooked Lake, which encourage the institution of good urban housekeeping practices including, pesticide and fertilizer use management, improved pet waste and litter control, and yard waste management, as well as other lake management-related topics. It is recommended that informational programming related to nonpoint source pollution abatement and other lake management topics be included at the annual meetings of the Crooked Lake Property Owners' Association.

PUBLIC RECREATIONAL USE AND BOATING ACCESS

Crooked Lake provides opportunities for high-quality, water-based recreation. As described in Chapter III, potential problems associated with increased recreational boating use of Crooked Lake include the lack of adequate public recreational boating access as defined in Chapter NR 1 of the *Wisconsin Administrative Code*, and potential environmental damage arising from intrusion of boats and personal watercraft into ecologically valuable areas as well as perceived recreational use conflicts.

Options Considered

Two options to provide public recreational boating access to Crooked Lake have been identified. Under the first option, provision of a level of access fully consistent with the standards set forth in Chapter NR 1 of the *Wisconsin Administrative Code* could be considered. Under the second option, provision of a level of access that differs from the standards set forth in Chapter NR 1 could be considered. Recommendations for public recreational boating restrictions are described earlier under the section relating to ecologically valuable area protection and aquatic plants.

Access Standards

Determination of the amount of access that should be accommodated at Crooked Lake is dependent on the areal extent of the open water lake surface. Crooked Lake, with a surface area of 58 acres, falls in the 50- to 99-acre category for recreational use lakes established in Section NR 1.91 of the *Wisconsin Administrative Code*. As previously noted, the minimum number of car-trailer units that could be accommodated at Crooked Lake, in a manner consistent with the Section NR 1.91 guidelines, would be a combination of five vehicle and car-trailer units, plus a handicapped accessible unit, for a total of six units. The maximum number of car-trailer units would be five car-trailer units, plus a handicapped accessible unit, for a total of six units. Furthermore, standards set forth in the regional and county park and open space plans indicate that the fast or high-speed boating capacity of the Lake is limited to about three boats, with the safe use capacity likely to be achieved with consideration of only riparian-owned boat usage. At present, there are approximately 22 watercraft moored or trailered at Crooked Lake. Assuming 5 percent of these watercraft, to be in operation as fast or high-speed boats, this would indicate no car-trailer parking spaces suitable for fast boat transportation would be warranted. Observations by Commission staff, conducted during July 1997, indicated that, indeed, between one and nine watercraft were in operation during both weekdays and weekend days on Crooked Lake.

Recommended Boating Access

There are currently no suitable sites for the provision of public access directly to Crooked Lake. Given the relatively small surface area of the Lake, and its surrounding land form that significantly limits the siting of a traditional public recreational boating access, and given that the Lake appears to be adequately served by existing public access sites located both upstream and downstream on the Bark River, it is recommended that the existing public recreational boating access to Crooked Lake be considered adequate pursuant to guidelines set forth in Section NR 1.91(6) of the *Wisconsin Administrative Code*. Therefore, it is recommended that the public access to Crooked Lake continue to be served from the Nemahbin Lakes public access site or through rights-of-way adjacent to stream-crossing sites upstream and downstream of the Lake. However, should on-lake public access be provided in the future, the facilities to be provided should conform to the guidance on accessibility contained in Wisconsin Department of Natural Resources Publication No. CA-003-88, *Handbook for Accessibility...A Reference to Help Develop Outdoor Recreation Areas to Include People with Disabilities*.

It is also recommended that provision be made at the access sites for the posting of such boating regulations, applicable to Crooked Lake, as may be adopted by the Town of Summit and other notices as necessary.

SUMMARY

This plan, which documents the findings and recommendations of a study requested by the Crooked Lake Property Owners' Association, examines existing and anticipated conditions and potential aquatic plant

Table 6

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN ELEMENTS FOR CROOKED LAKE

Issue	Plan Element	Subelement	Location	Management Measures[a]	Management Responsibility
Ecologically Valuable Areas and Aquatic Plants	Land use management	Land use plan implementation	Entire watershed	Support implementation set forth in the regional land use plan for Washington County and in the development plan for Waukesha County	Town of Summit
	Watershed land management	Construction site erosion control	Entire watershed	Continue to enforce existing erosion control and water quality protection ordinances; refine ordinances where necessary	Washington County, Waukesha County, and Town of Summit
		Urban nonpoint source controls	Direct drainage area	Implement and maintain recommended good urban housekeeping practices	Crooked Lake Property Owners' Association, Town of Summit
		Rural nonpoint source controls	Entire watershed	Support implementation and maintenance of rural land best management practices	Crooked Lake Property Owners' Association, Town of Summit
		Environmentally sensitive lands protection	Entire watershed	Support preservation of environmental corridor lands	Crooked Lake Property Owners' Association, Town of Summit
				Acquire and protect the Bark River marsh	Waukesha County
	Aquatic plant management	Manual harvesting	Areas of nuisance growth in Crooked Lake	Harvest nuisance aquatic plants, including Eurasian water milfoil, as required around docks and piers	Crooked Lake Property Owners' Association
		Chemical controls	Areas of nuisance growth in Crooked Lake	Treat nuisance plants, including Eurasian water milfoil, as required – early spring treatment recommended, if necessary	Crooked Lake Property Owners' Association, Wisconsin Department of Natural Resources
		Nuisance species monitoring program	Entire watershed	Monitor lakes and surrounding wetlands for the presence or spread of nuisance species, including Eurasian water milfoil and purple loosestrife; consider establishing Eurasian water milfoil control areas	Crooked Lake Property Owners' Association, Wisconsin Department of Natural Resources
		Biological controls	Crooked Lake	Monitor lakes for the presence or spread of the aquatic weevil (Eurhychiopsis lecontei)	Crooked Lake Property Owners' Association, Wisconsin Department of Natural Resources
Surface Water Quality and Quantity Management	Water quality management	Water quality monitoring	Entire lake	Continue to participate in the DNR Self-Help Monitoring Program	Crooked Lake Property Owners' Association
	Water quantity management	Comprehensive watershed plan	Bark River system	Conduct systemwide comprehensive watershed planning, including hydrologic and hydraulic study to determine causes, consequences, and correctives of water level fluctuations	Washington County, Waukesha County, Wisconsin Department of Natural Resources; Regional Planning Commission

Issue	Plan Element	Subelement	Location	Management Measures[a]	Management Responsibility
Public Recreation and Boating Access	Recreational use management	Public access	Crooked Lake	Provide adequate public access as necessary Continue enforcement of existing boating ordinance Review and refine boating ordinance to limit high speed boating traffic, especially in Eurasian water milfoil control areas	Town of Summit, Wisconsin Department of Natural Resources
Informational Programming	Informational program	Public informational programming	Entire watershed	Continue public awareness and information programming Encourage householders to adopt environmentally sustainable land management practices	Crooked Lake Property Owners' Association, Town of Summit

[a]*Costs to be determined.*

Source: SEWRPC.

management problems of the Crooked Lake and presents a recommended plan for the resolution of these problems. The recommended plan is summarized in Table 6 and shown on Map 13.

Crooked Lake was found to be mesotrophic lake of average quality located in close proximity to the Milwaukee metropolitan area and within an increasingly urban part of Waukesha County. Crooked Lake's water quality is dominated by that of the Bark River and its extensive tributary drainage area. Surveys indicated that the Lake and its tributary drainage area contain significant areas of ecological value, including numerous wetlands and high-quality wildlife habitat surrounding the Lake. Preservation of environmental corridor lands, and especially of the Bark River marsh situated immediately upstream of Crooked Lake, is recommended. The Town of Summit and Crooked Lake Property Owners' Association should support the acquisition of the Bark River marsh by Waukesha County as recommended in the regional natural areas and critical species habitat protection and management plan.

The Crooked Lake aquatic plant management plan recommends actions be taken to reduce further human impacts on the in-lake macrophyte beds, especially those beds dominated by Eurasian water milfoil, and reduce human impacts on the ecologically valuable areas adjacent to the Lake. In this regard, consideration should be given to refining the Town of Summit boating ordinance to limit boating traffic within those areas of the Lake where Eurasian water milfoil is prevalent, as shown on Map 13. The plan also recommends limited aquatic plant management measures, including selected manual removal and surveillance activities at this time, mainly in the cases where purple loosestrife and Eurasian water milfoil are present. The limited use of chemical treatment only to treat such invasive species as purple loosestrife and Eurasian water milfoil could be considered if necessary.

Consideration of existing public recreational boating access to the Lake from sites both upstream and downstream of the Lake as adequate pursuant to Section NR 1.91(6) of the *Wisconsin Administrative Code* is recommended, subject to the provisions of the refined boating ordinance described above. Posting of such boating regulations as may be adopted by the Town of Summit relating to Crooked Lake at the public access sites is recommended.

The recommended plan includes continuation of an ongoing program of public information and education providing riparian residents and lake users. For example, additional options regarding household chemical usage, lawn and garden care, shoreland protection and maintenance, and recreational usage of the Lake should be made available to riparian householders, thereby providing riparian residents with alternatives to traditional alternatives and activities. Continued participation by the Crooked Lake Property Owners' Association in the Wisconsin Department of Natural Resources Self-Help Monitoring Program is also recommended.

Because of the river dominance of the Lake water quality and its potential impact of aquatic plant growth in the Lake, the plan recommends the conduct of a comprehensive watershed plan, including a hydraulic and hydrologic analysis. Such an analysis should examine the entire Bark River system from the aspect of flooding and water level management as well as watershedwide land use, water quality, and open space plan development. In addition, the study should specifically consider the feasibility and consequences of an high flow or low flow bypass to route river water, and its contaminant loads, past Crooked Lake during storm events. Control of both urban and rural nonpoint sources of water pollution should be considered as an element of this basinwide planning project. The Crooked Lake Property Owners' Association should encourage strict enforcement of existing stormwater and construction site erosion control ordinances, especially within those areas of the drainage basin directly tributary to Crooked Lake.

The recommended plan seeks to balance the demand for high-quality residential and recreational opportunities at the Crooked Lake with the requirements for environmental protection.

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APPENDICES

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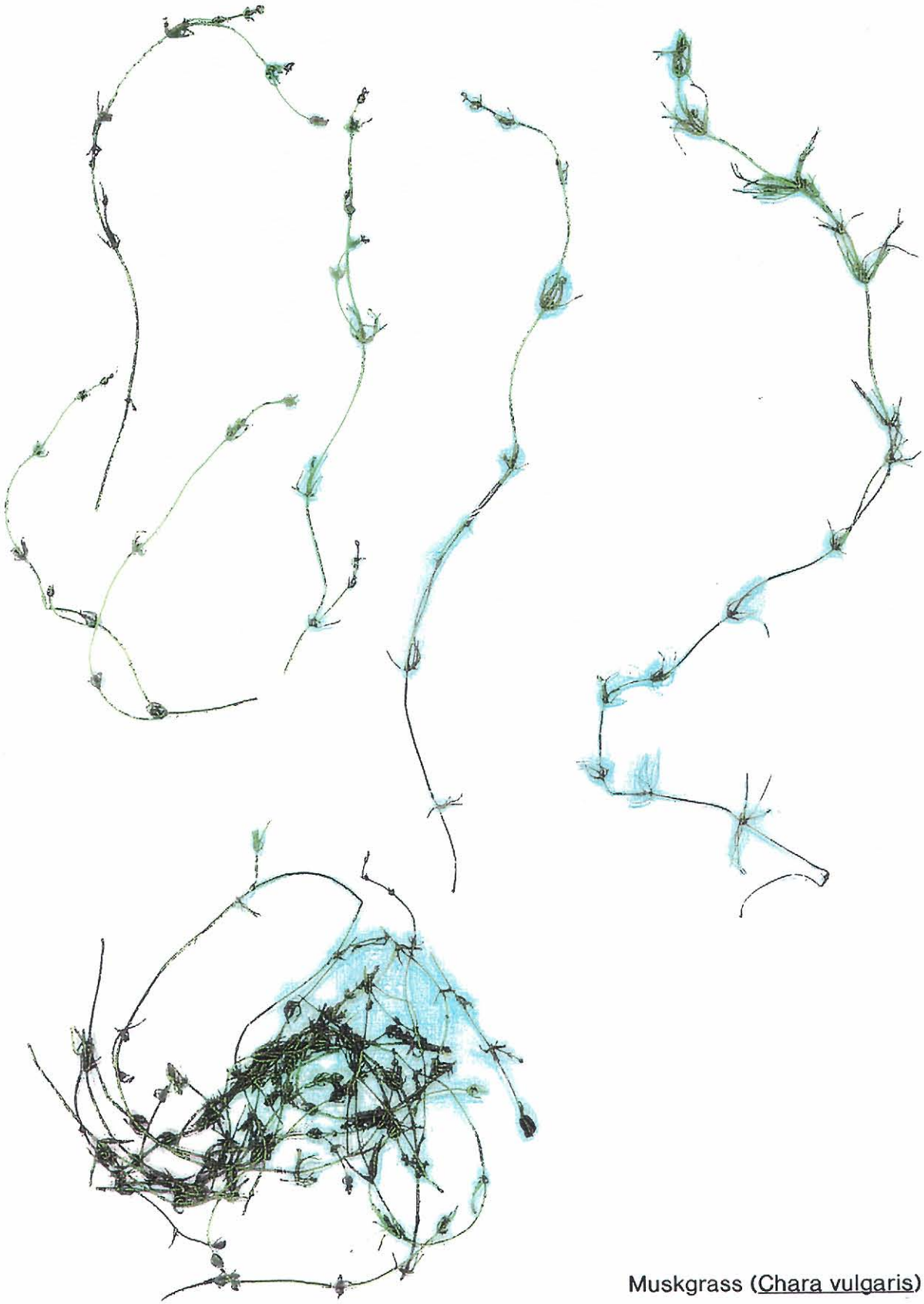
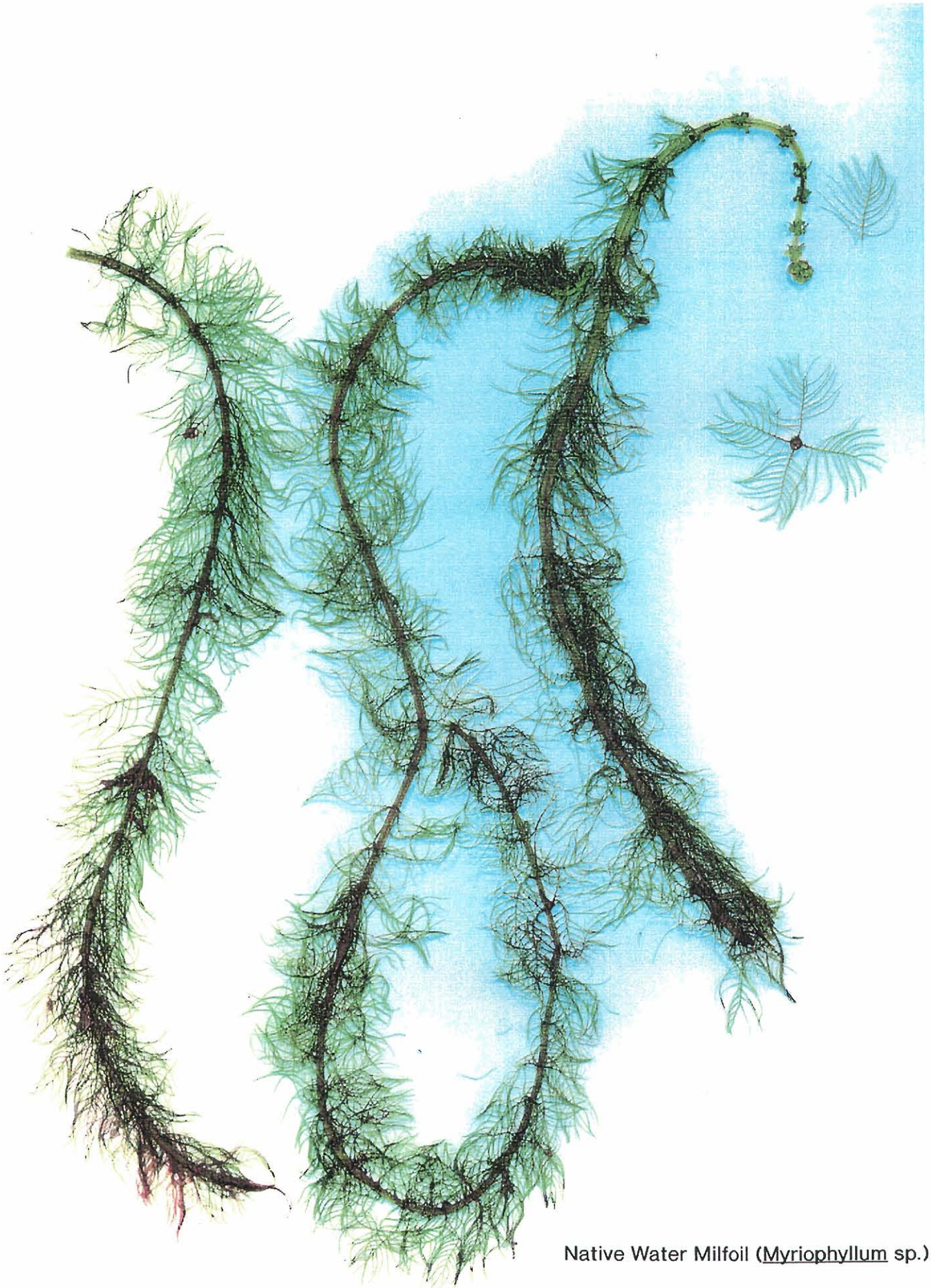
Appendix A

REPRESENTATIVE ILLUSTRATIONS OF AQUATIC PLANTS FOUND IN CROOKED LAKE

Coontail (Ceratophyllum demersum)

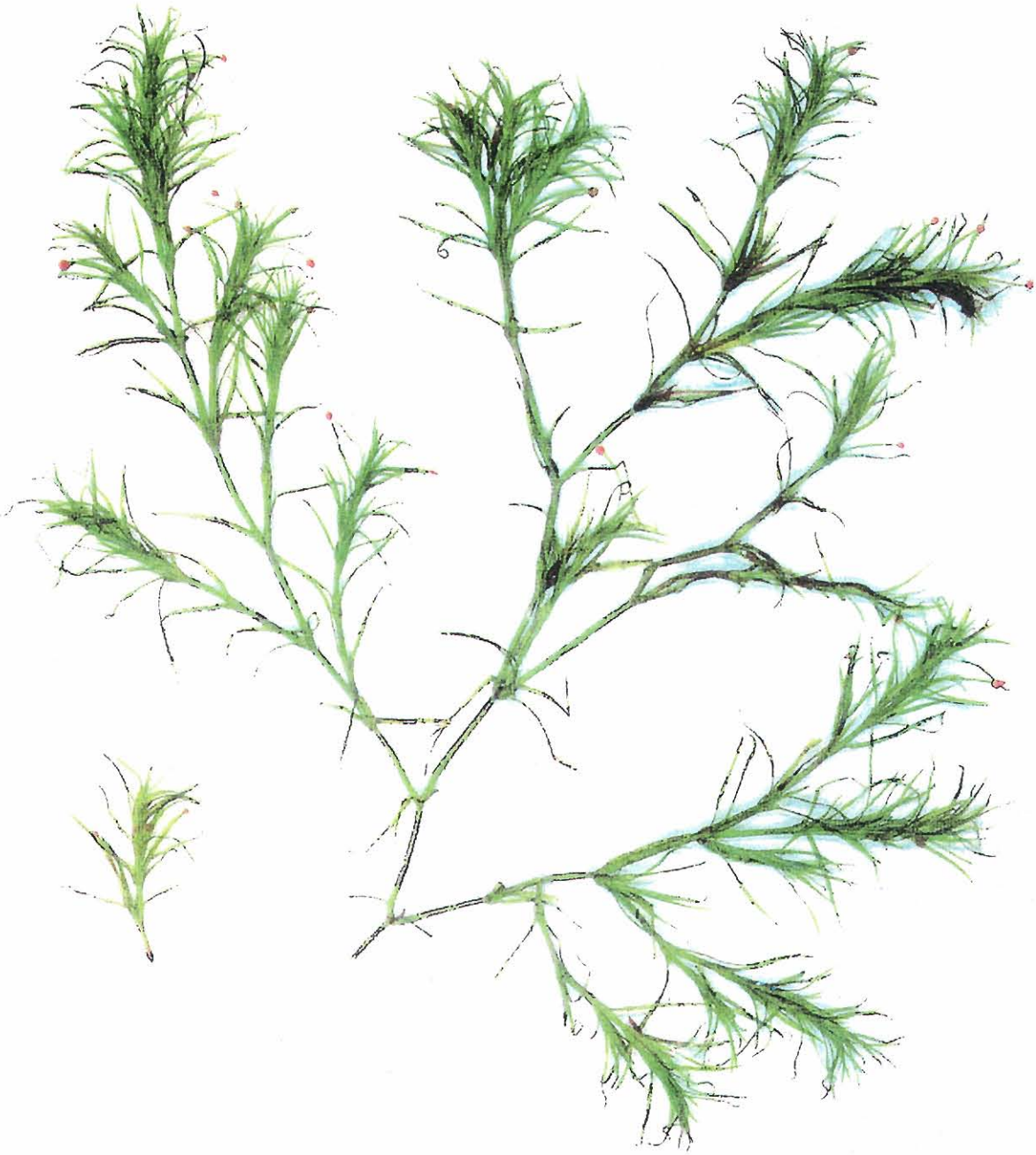


Muskgrass (Chara vulgaris)



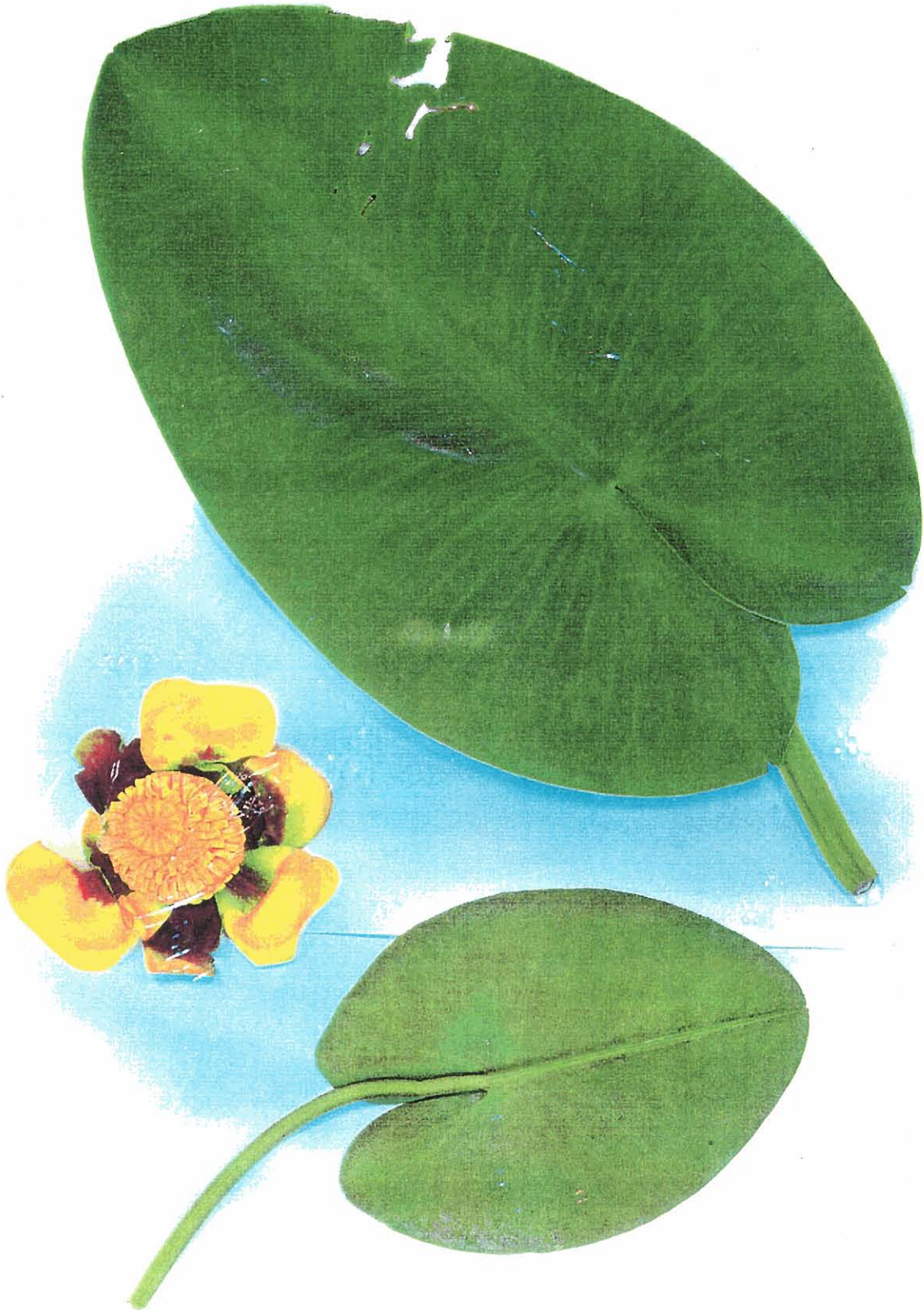
Native Water Milfoil (Myriophyllum sp.)

Eurasian Water Milfoil (Myriophyllum spicatum)

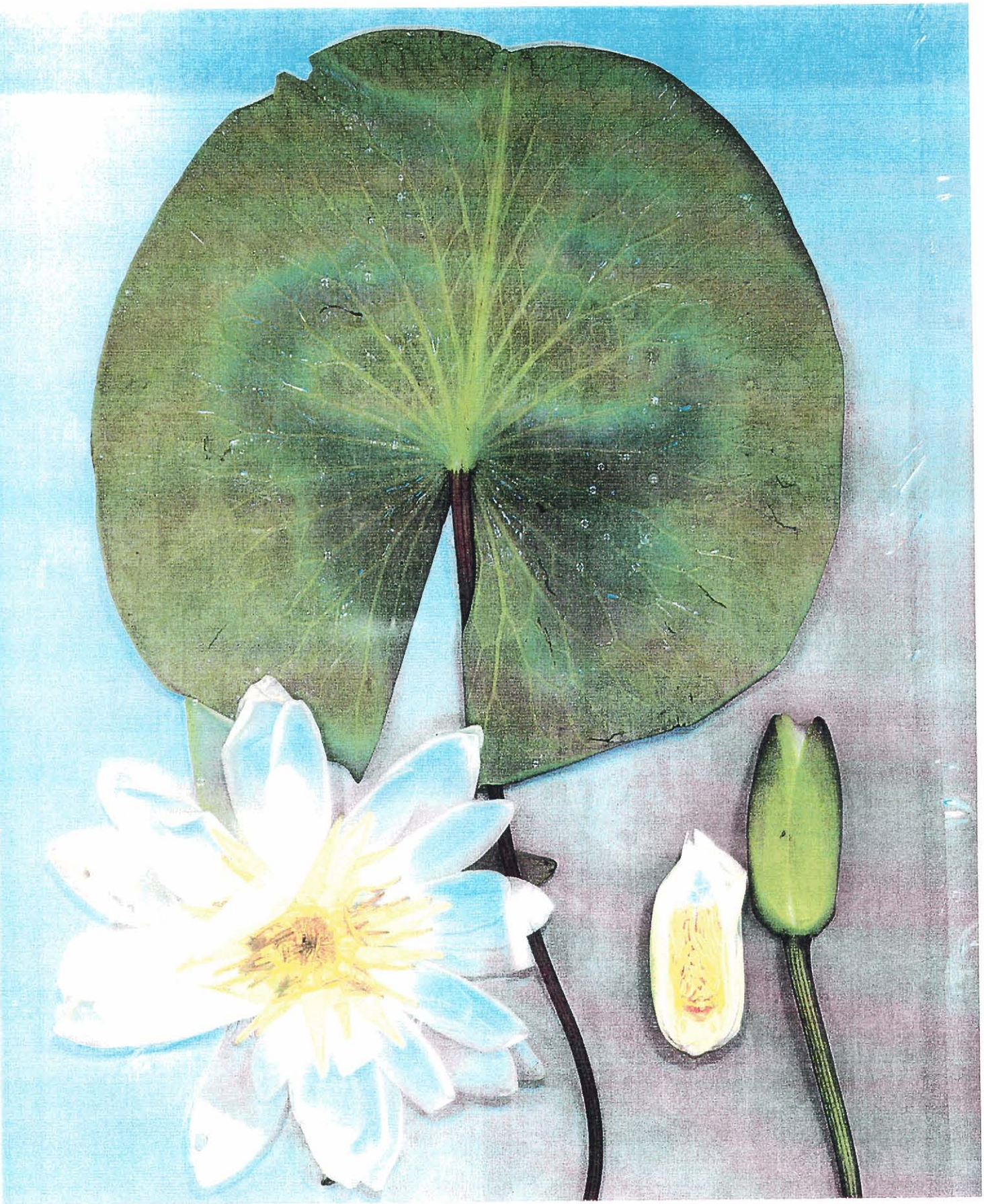


Bushy Pondweed (Najas flexilis)

Spiney Naiad (Najas marina)



Yellow Water Lilly (Nuphar variegatum)

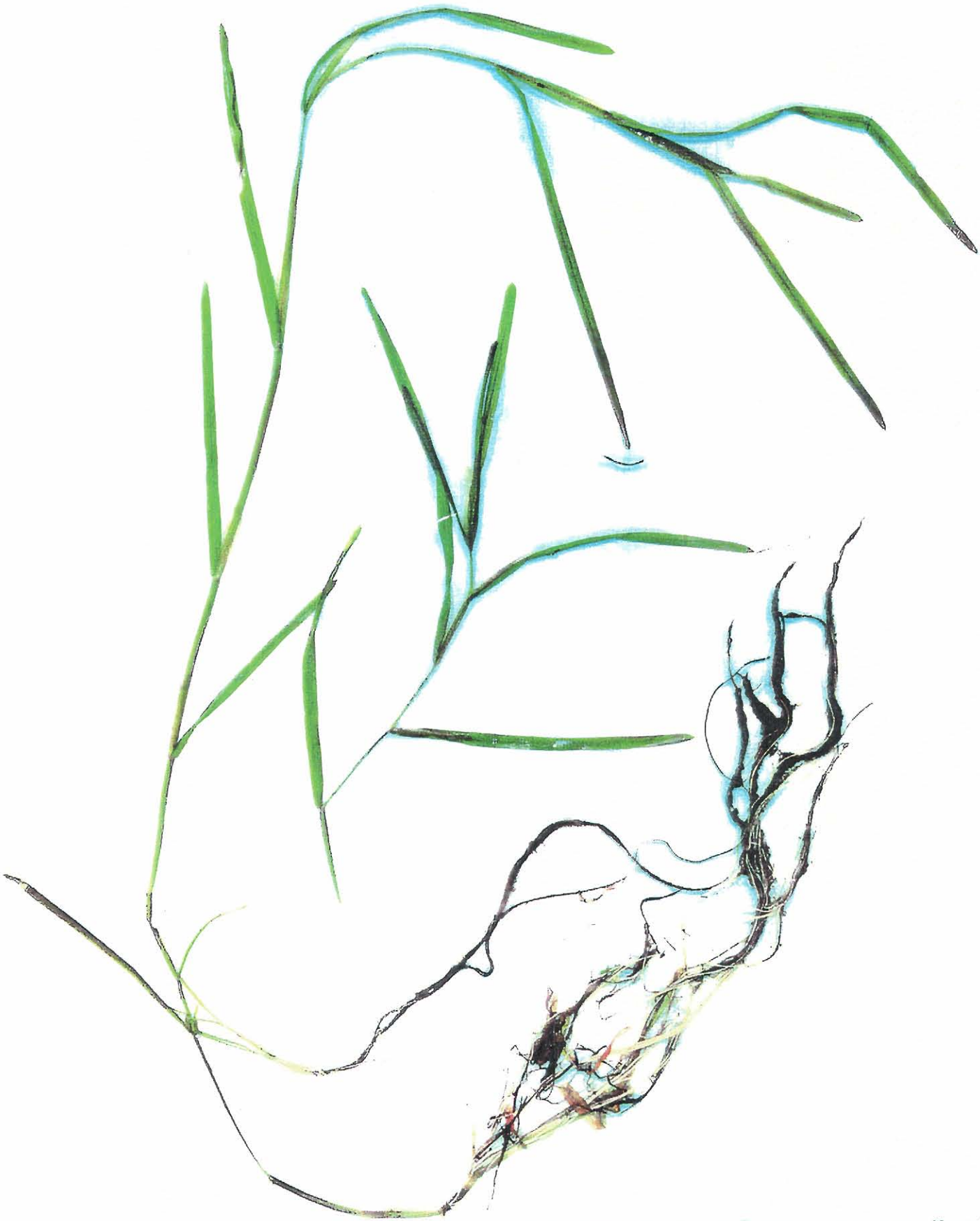


White Water Lilly (Nymphaea tuberosa)

Curly Leaf Pondweed (Potamogeton crispus)

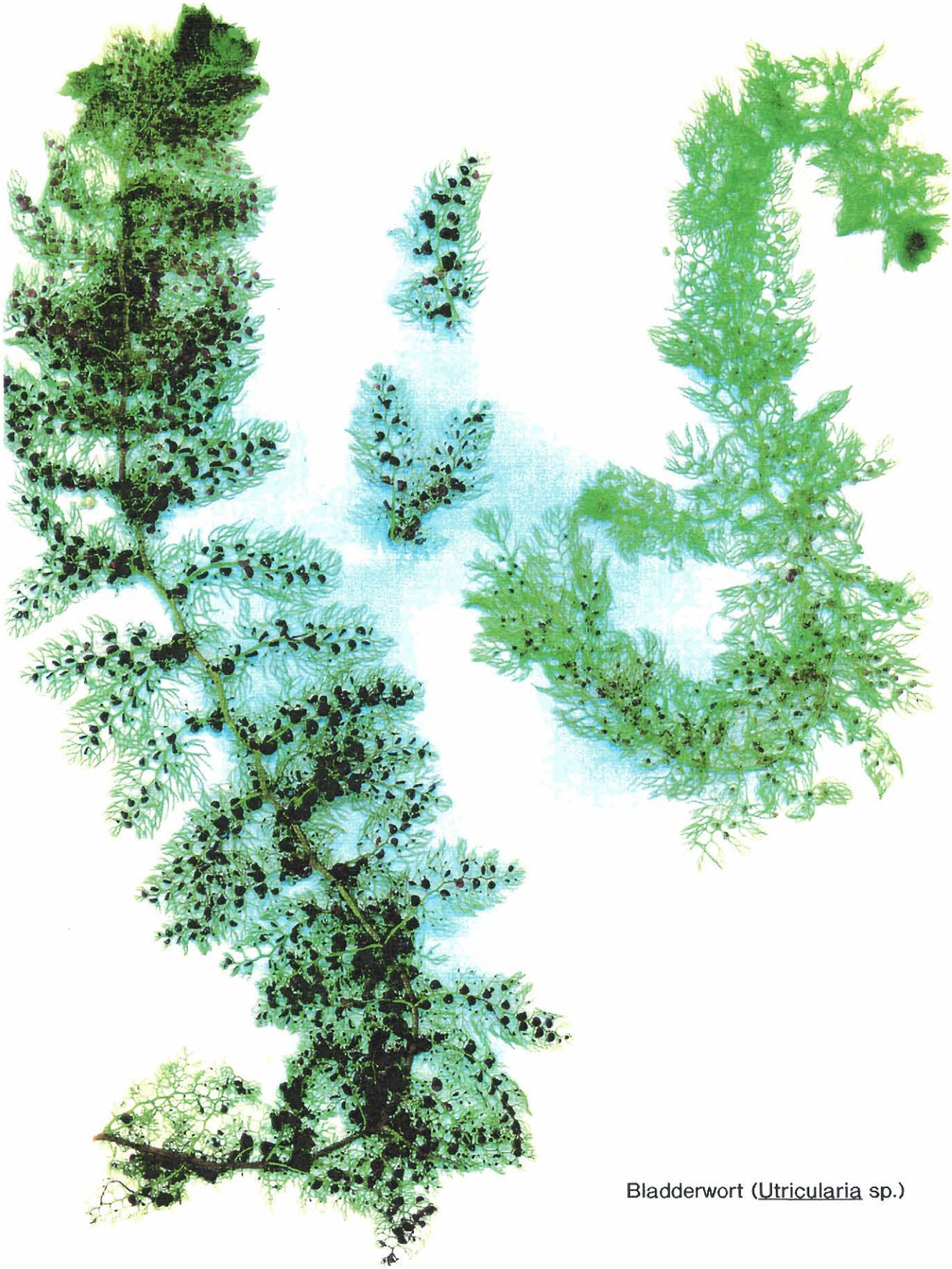
Variable Pondweed (Potamogeton gramineus)

Sago Pondweed (Potamogeton pectinatus)

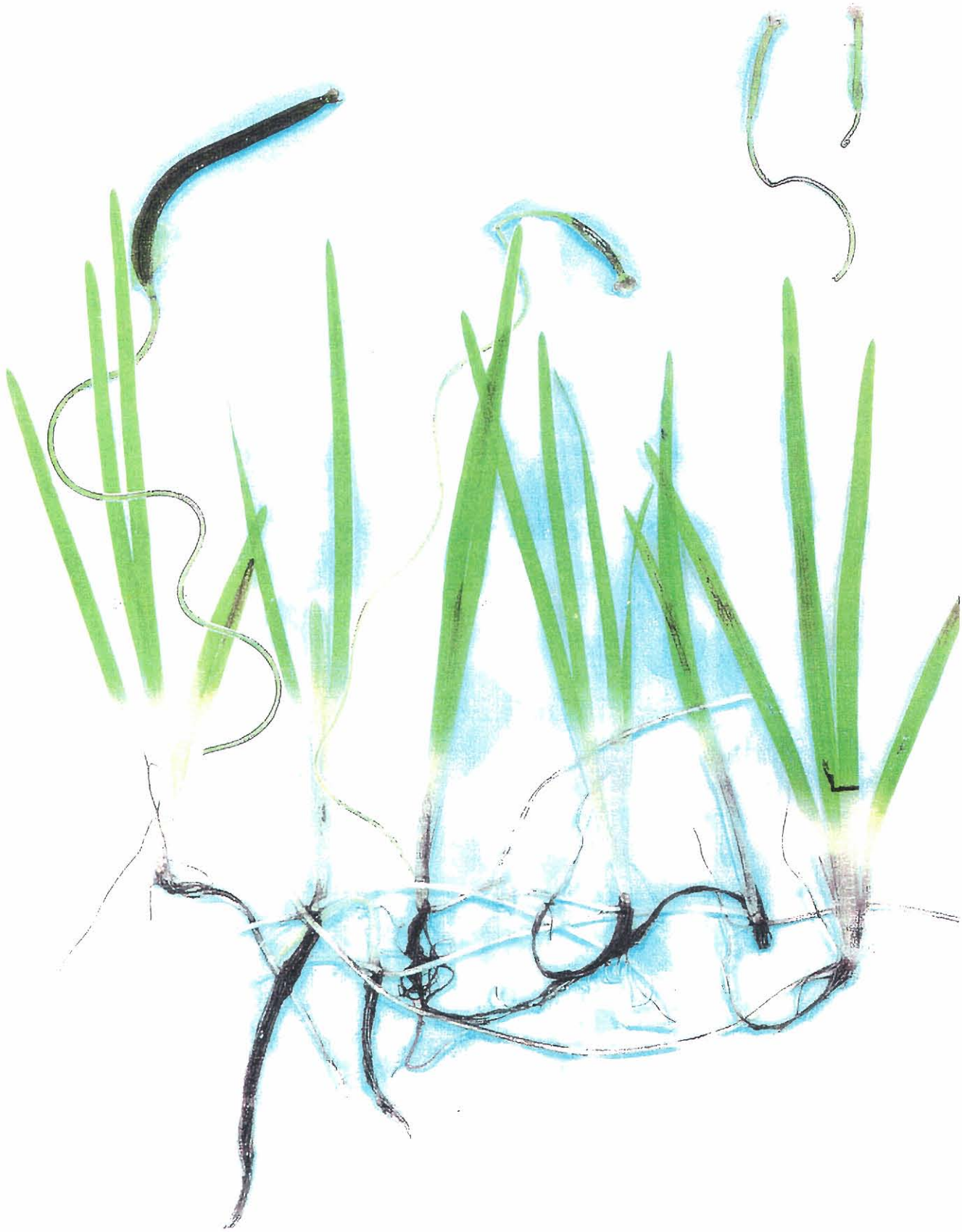


Flat-stem Pondweed (Potamogeton zosteriformis)

Cattail (Typha augustifolia)



Bladderwort (Utricularia sp.)



Eel Grass/ Wild Celery (Vallisneria americana)

Appendix B

BOATING ORDINANCE APPLICABLE TO CROOKED LAKE

Fourth Draft

STATE OF WISCONSIN TOWN OF SUMMIT WAUKESHA COUNTY

ORDINANCE NO. 183

AN ORDINANCE REGULATING THE
USE AND OPERATION OF MOTOR BOATS
ON THE WATERS OF THE
FOLLOWING DESCRIBED LAKES
IN THE TOWN OF SUMMIT

WHEREAS, the Town Board of the Town of Summit, Waukesha County, Wisconsin deems it necessary to regulate the use and operation of motor operated boats for the protection of life, person and property on the following lakes: Upper Nemahbin, Lower Nemahbin, Lower Genesee, Middle Genesee, Crooked Lake, Duck Lake, Waterville Lake, Lake Laura, Bowron Lake and Egg Lake; and

WHEREAS, the Town Board of the Town of Summit, Waukesha County, Wisconsin intends by this ordinance to provide safe and healthful conditions for the enjoyment of aquatic recreation consistent with public rights and interests and the capability of the water resource,

NOW, THEREFORE, the Town Board of the Town of Summit, Waukesha County, Wisconsin DOES ORDAIN AS FOLLOWS:

SECTION 1: An ordinance to regulate the use and operation of motor boats, and to regulate water sports upon and under the water of the aforementioned lakes is hereby created to read as follows:

1. APPLICATION: The provisions of this ordinance shall apply to the waters of Upper Nemahbin, Lower Nemahbin, Lower Genesee, Middle Genesee, Crooked Lake, Duck Lake, Waterville Lake, Lake Laura, Bowron Lake and Egg Lake, within the jurisdiction of the Town of Summit. The provisions of this ordinance shall be enforced by the officers of the Water Safety Patrol Unit and police of the jurisdiction of the Town of Summit.

2. STATE BOATING AND WATER SAFETY LAWS ADOPTED:

   A. Except as otherwise specifically provided in this ordinance, the current and future statutory provisions describing and defining regulations with respect to water traffic, boats, boating, and relating water activities in §§30.50 up to and including 30.71, of the Wisconsin Statutes, exclusive of any provisions therein

relating to the penalties to be imposed or the punishment for violation of said statutes, are hereby adopted and by reference made a part of this ordinance as if fully set forth herein. Any act required to be performed or prohibited by any current or future statute incorporated herein by reference is required or prohibited by this ordinance. Any further additions, amendments, revisions or modifications of the statute incorporated herein are intended to be made part of this ordinance in order to secure uniform state-wide regulation of the waterways of the State.

B. All rules and orders created by the Wisconsin Department of Natural Resources, modifying or supplementing the foregoing provisions of State Law or which may be adopted or made in the future, are hereby incorporated in and made a part of this ordinance by deferring to the same as if they are or were to be set out herein verbatim.

3. OPERATION OF MOTOR BOATS:

A. No motor boat shall be operated on Lake Laura, Egg Lake, or Duck Lake at any time at a speed in excess of slow no wake.

B. No motor boat shall be operated on Upper Nemahbin, Lower Nemahbin, Lower Genesee, Middle Genesee, Crooked Lake, Waterville Lake or Bowron Lake from sunset until sunrise at a speed in excess of slow no wake.

4. SWIMMING REGULATIONS: No person, unless said person is engaging in activities and subject to the provisions of §30.70, Wisconsin Statutes, entitled Skin Diving, shall:

A. Swim from any unmanned boat, unless such boat is anchored, or

B. Swim more than 150 feet from the shoreline unless is a designated swimming zone or unless accompanied by a competent person in a boat, or

C. Swim more than 150 feet from the shoreline between sunset and sunrise.

5. LOCAL REGULATION ON ICEBOUND INLAND WATERS.

A. No person shall operate or park or permit, authorize, direct or control the operation or parking of or ride as a passenger on any motorized vehicle or motor-driven vehicle, including but not limited to motor vehicles, snowmobiles, or all-terrain vehicles on the ice on any portion of the aforementioned lakes.

B. The Chief of Police of the Town of Summit, upon application to him and payment of a license fee established by the Town Board, being satisfied that ice conditions do and will permit operation of a motorized vehicle or motor-driven vehicle upon a designated portion of the lake without material risk or hazard, may issue a written permit expiring within 24 hours after issuance authorizing operation of a motorized vehicle or motor-driven vehicle on the lake for particular purposes to be specified in such permit. Said particular purposes shall be limited to: snowplowing of a portion of the lake for an ice skating rink, transporting of property to an island or conducting official lake studies. No such permit shall authorize speed or acrobatic contests, exhibitions or performances; racing; fishing; nor shall any such permit authorize joyriding, sightseeing or any other activity not deemed necessary by the Chief of Police.

6. PENALTY:

A. STATE BOATING AND WATER SAFETY LAWS AND ALL OTHER VIOLATIONS AS SET FORTH IN §2 OF THIS ORDINANCE.

Any forfeiture for violation of the State statute, rule or order adopted by reference in §2 of this ordinance shall conform to the forfeiture permitted to be imposed for violation of such statutes as set forth in the Uniform Wisconsin Deposit and Bail Schedule for Conservation, Boating, Snowmobile, and ATV Violations, including any variations or increases for subsequent offenses, which schedule is adopted by reference.

B. LOCAL BOATING LAWS AS SET FORTH IN §§3, 4, AND 5 OF THIS ORDINANCE.

Any person 16 years or older violating the provisions of this ordinance shall be subject to a forfeiture of not more than $500 plus court costs and penalty assessment. Failure to pay any forfeiture hereunder shall subject the violator to imprisonment in the County Jail or loss of license.

Any person 14 or 15 years of age shall be subject to a forfeiture of not less than $10 nor more than $25 plus court costs and penalty assessment per each offense or referred to the proper authorities as provided in Chapter 48, Wisconsin Statutes. Failure to pay any forfeiture hereunder shall subject the violator to the provisions of §48.17(2), Wisconsin Statutes.

Any person under the age of 14 shall be referred to the proper authorities as provided in Chapter 48, Wisconsin Statutes.

7. ENFORCEMENT.

A. ENFORCEMENT PROCEDURE. The statutory provisions of §§66.115, 66.119, 66.12, 30.29, 30.50 to 30.71, and Chapter 799, Wisconsin Statutes, are adopted and by reference made a part of this ordinance as if fully set herein. Any act required to be performed or prohibited by any statute incorporated herein by reference is required or prohibited by this ordinance. Any future additions, amendments, revisions or modifications of the statutes incorporated herein are intended to be made part of this ordinance in order to secure uniform state-wide regulation and enforcement of boating ordinance violations. Further, the Town of Summit specifically elects to use the citation method of enforcement.

B. DEPOSITS.

1. Schedule of Deposits. The schedule of cash deposits shall be as follows:

   §2: Applicable sections of Uniform Wisconsin Deposit and Bail Schedule for Conservation, Boating, Snowmobile and ATV Violations plus current assessment fees and current court costs if applicable.

   §§3, 4 and 5: $50 plus court costs and assessments plus current assessment fees and current court costs if applicable.

2. Deposit for Repeat Offenses. Any person found guilty of violating this ordinance or any part thereof who was previously convicted of the same section within the last year shall forfeit twice the deposit delineated above plus court costs and penalty assessment.

3. Non-Scheduled Deposit. If a deposit schedule has not been established for a specific violation, the arresting officer shall require the alleged offender to deposit not less than the maximum forfeiture permitted hereunder.

4. Depository. Deposits should be made in cash, money order, or certified check to the Clerk of Municipal Court, who shall issue a receipt therefore as required by Wisconsin Statute. If the deposit is mailed, the signed statement required by Wisconsin Statute shall be mailed with the deposit.

C. NONEXCLUSIVITY.

1. Other Ordinances. Adoption of this ordinance does not preclude the Town Board from adopting any other ordinance or providing for the enforcement of any other law or ordinance relating to the same or other matter.

2. Other Remedies. The issuance of a citation hereunder shall not preclude the Town Board or any authorized office from proceedings under any other ordinance of law or by any other enforcement method to enforce any ordinance, regulation or order.

SECTION 2: SEVERABILITY.

The several sections of this ordinance are declared to be severable. If any section or portion thereof shall be declared by a court of competent jurisdiction to be invalid, unlawful or unenforceable, such decision shall apply only to the specific section or portion thereof directly specified in the decision, and shall not affect the validity of any other provisions, sections or portions thereof of the ordinance. The remainder of the ordinance shall remain in full force and effect. Any other ordinances whose terms are in conflict with the provisions of this ordinance are hereby repealed as to those terms that conflict.

SECTION 3. EFFECTIVE DATE.

This ordinance shall take effect immediately upon passage and posting or publication as provided by law.

This ordinance passed this 3rd day of Dec, 1992.

BY ORDER OF THE TOWN BOARD OF THE TOWN OF SUMMIT, WAUKESHA COUNTY, WISCONSIN

Edwin H. Rohloff

EDWIN H. ROHLOFF, TOWN CHAIRMAN

ATTEST:

Elizabeth L. Dow

ELIZABETH L. DOW, TOWN CLERK

Published or posted on the 14 day of May, 1993.

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Appendix C

PUBLIC OPINION OF WATER USE AND QUALITY IN CROOKED LAKE, WAUKESHA COUNTY, WISCONSIN

SUMMARY OF STATISTICAL DATA AND RESULTS

I. METHODOLOGY

A. Questionnaire survey using a mail-back survey conducted during summer 1997.

B. Analysis based upon nine responses out of 10 possible.

II. RESPONDENT PROFILE

A. Majority of respondents (56 percent) were year-round residents.

B. Majority of respondents (67 percent) had used Crooked Lake for more than 10 years.

C. Majority of respondents (67 percent) used the Lake with family and friends.

III. LAKE USE

A. Categories of Use

1. Walking/jogging was the most important use (rated 1.1 on a five-point scale, where 1.0 is the most important use), followed by bird watching and swimming/diving (both rated 1.5), rowing/canoeing and paddle boating (both rated 1.75), and cross-country skiing (rated 1.8). Picnicking/barbecuing was the fifth most important use (rated 1.9) followed by fishing (rated 2.1).

2. Jet-skiing, waterskiing, and snowmobiling were the least important uses (all rated 5.0 on a five-point scale, where 5.0 was the least important use). Sailing (rated 4.2) was the nest least important use.

B. Intensity of Use

1. Moderate (67 percent) use.

C. Frequency of Use

1. On an annual basis, bird watching was the most frequently engaged-in activity (averaging 216 days per year). Walking/jogging was the second most frequently engaged-in activity (averaging 131 days per year).

2. During spring and summer, walking/jogging was the most frequently engaged-in activity (averaging 95 days), followed by fishing (51 days).

3. During autumn and winter, fishing was the most frequently engaged-in activity (averaging 32 days), closely followed by cross-country skiing (24 days).

4. On average, respondents spent 51 days per year fishing during open water periods, and eight days ice fishing.

D. Use of Lake

1. Use of the Lake was generally lakewide, although the southern lobe of the Lake seemed to be used more extensively than other sites within the basin.

2. Majority of respondents (67 percent) did not feel that additional public access opportunities were necessary for Crooked Lake, primarily due to the small size of the Lake.

E. Levels of Satisfaction

1. Majority of respondents (67 percent) were not dissatisfied with the general level of law enforcement on the Lake; 44 percent were satisfied with law enforcement.

2. Majority of respondents (67 percent) were not dissatisfied with the level of land use regulation in the watershed; 33 percent were satisfied with current regulations.

IV. WATER QUALITY

A. Assessment

1. Based upon water clarity and chemistry, the largest number of respondents (44 percent) rated the Lake as having poor water quality.

2. Based upon aquatic plant growth, the largest number of respondents (44 percent) rated the Lake as having good water quality, although 33 percent rated the lake as having poor water quality using the same indicators.

3. Based upon biological conditions, the majority of respondents (56 percent) rated the Lake as having good water quality.

4. Many respondents (44 percent) rated water quality using aquatic plant abundance or types as indicators; 33 percent rated water quality based upon recreational uses, specifically the ability to swim safely in the Lake.

5. The majority of respondents (78 percent) perceived a decline in water quality over time; none of the respondents felt that the Lake had remained the same or improved.

B. Management

1. The majority of respondents (78 percent) indicated that the Lake had excessive aquatic plant growth.

2. The greatest number of respondents (44 percent) preferred dredging as a means of controlling this excessive aquatic plant growth, with equal numbers (33 percent) indicating mechanical harvesting of aquatic plants from within the Lake, and limiting fertilizer use and placing additional development control on all properties within the watershed; use of aquatic chemicals as a means of controlling the excessive aquatic plant growth was the least preferred technique.

3. The majority of respondents (89 percent) were willing to pay more for lake-related improvements, with the largest number (44 percent) suggesting that additional funds be used to harvest aquatic plants and dredge the Lake.

4. Some respondents (about 44 percent of those commenting) felt that funds could be raised through taxation or assessments, with most (33 percent) suggesting a State and local partnership as an equitable approach.

C. Concerns

1. The majority of respondents (78 percent) were concerned about the number of jet-skiers; 67 percent of respondents also expressed significant concern about general water quality and sedimentation and the presence of shallow areas within the Lake basin; and 56 percent of respondents expressed concern about the speed of boats on the Lake, fluctuating water levels, and the need to preserve wetlands riparian to the Lake.

2. Several respondents (22 percent) expressed concern regarding the impact or influence of IH 94 on the hydrology and water quality of the Lake, suggesting that this influence be investigated further.