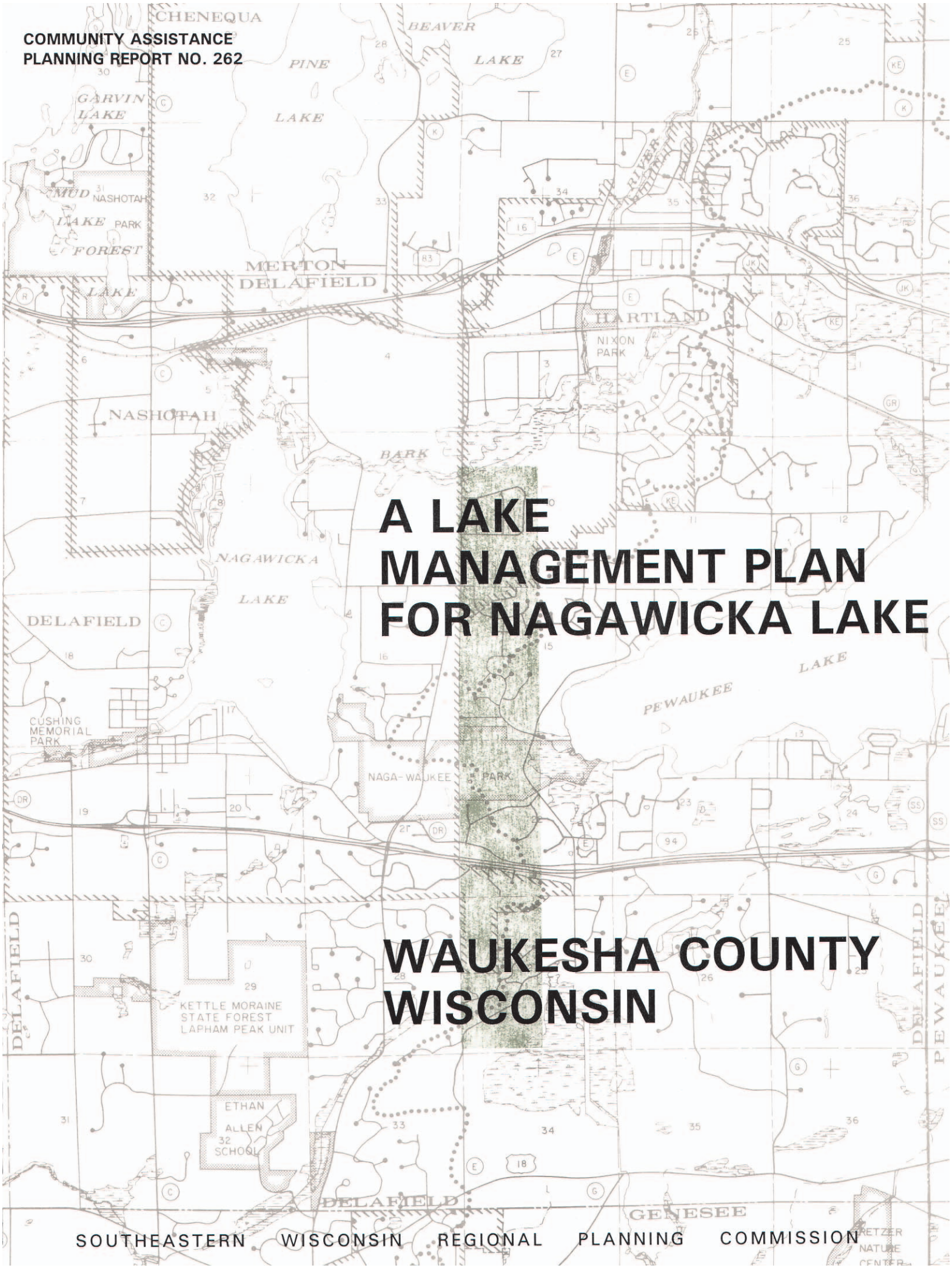
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 262




# A LAKE MANAGEMENT PLAN FOR NAGAWICKA LAKE

# WAUKESHA COUNTY WISCONSIN

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COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 262

# A LAKE MANAGEMENT PLAN FOR NAGAWICKA LAKE

# WAUKESHA COUNTY, WISCONSIN

Prepared by the

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# Chapter I

# INTRODUCTION

Nagawicka Lake is a 917-acre drainage lake located on the Bark River within U.S. Public Land Survey Sections 5, 8, 9, 16, 17, 20, and 21, Township 7 North, Range 18 East, City of Delafield and Village of Nashotah, Waukesha County. The Lake offers a variety of water-based recreational opportunities and is the focus of the communities surrounding the Lake. Portions of the lakeshore, particularly in the vicinity of the Naga-Waukee County Park and adjacent to the northernmost embayment known as the "Kettle," present a rural character among changing land uses in an urbanizing area. Elsewhere, the shoreline is well developed primarily for residential uses. Portions of the City of Delafield downtown overlook the southwestern portions of the Lake.

Nagawicka Lake is heavily used and is a popular destination for recreational users. Notwithstanding, the Lake has experienced various management problems during recent years, including surface water use conflicts, siltation, and abundant aquatic plant growths in the shallower portions of the lake basin. In addition, present and future residential and commercial growth within the drainage area directly tributary to Nagawicka Lake is perceived to have impacted the Lake and its ecosystem. Other issues raised by lake residents and users include concerns over variable water quality conditions, contamination of lake waters by nonpoint source pollution, loss of riparian wetlands, and modifications of the shoreland. These issues have been quantified to the extent possible and documented in a lake and watershed inventory for Nagawicka Lake.[1]

Based upon the documented issues identified in the aforereferenced inventory, this plan sets forth alternative and recommended management actions for the Lake and its watershed. In addition, this plan presents and evaluates issues raised by attendees present at a public informational meeting convened by the City of Delafield Lake Welfare Committee in the City of Delafield during May 2000, and sets forth additional alternative and recommended management measures that address these concerns.

This report represents an ongoing commitment of the City of Delafield and its Lake Welfare Committee, in cooperation with the Village of Nashotah, to sound environmental planning with respect to the Lake. This report describes both watershed management and in-lake management measures that may be applied to enhance the water quality conditions, biological communities, and recreational opportunities in the Lake.

This plan is intended to provide the recommended means to: 1) contribute to the overall conservation and wise use of Nagawicka Lake through the environmentally sound management of vegetation, fishes, and wildlife populations in and around the Lake; 2) provide the potential for high-quality, water-based recreational experiences by residents and visitors to the Lake; and 3) effectively control the severity of nuisances resulting from the recurring excessive aquatic macrophyte and algal growths in portions of the Nagawicka Lake basin to facilitate the conduct of water-based recreational activities, to improve the aesthetic value of the Lake, and to enhance its resource value. This plan should serve as a practical guide over time for achieving these objectives in a technically sound manner.

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[1] *SEWRPC Memorandum Report No. 130,* A Lake and Watershed Inventory for Nagawicka Lake, Waukesha County, Wisconsin, *March 1999.*

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# Chapter II

# BACKGROUND AND SUMMARY OF INVENTORY FINDINGS

## INTRODUCTION

Nagawicka Lake is located in the west central portion of Waukesha County, encompassed within the City of Delafield and the Village of Nashotah, as shown on Map 1. The Lake is a drainage lake on the Bark River, with a clearly defined inflow entering the Lake on the northeastern shore, and a defined outlet draining the southwestern embayment of the Lake. Nagawicka Lake is located in the central portion of the Bark River watershed, downstream of Bark Lake, and upstream of a chain of lakes that include Upper and Lower Nemahbin and Crooked Lakes. Inventory data on Nagawicka Lake and its watershed are presented in detail in SEWRPC Memorandum Report No. 130, *A Lake and Watershed Inventory for Nagawicka Lake, Waukesha County, Wisconsin*, published in March 1999. This chapter summarizes the relevant inventory data set forth in that report, and includes additional data gathered during the latter part of 1999 through mid-2000, in response to comments made by the public at an informational meeting convened by the City of Delafield Lake Welfare Committee during May 2000. Issues of concern are identified. Alternative and recommended lake management measures to address the issues of concern are described in subsequent chapters of this report.

## LAND USE

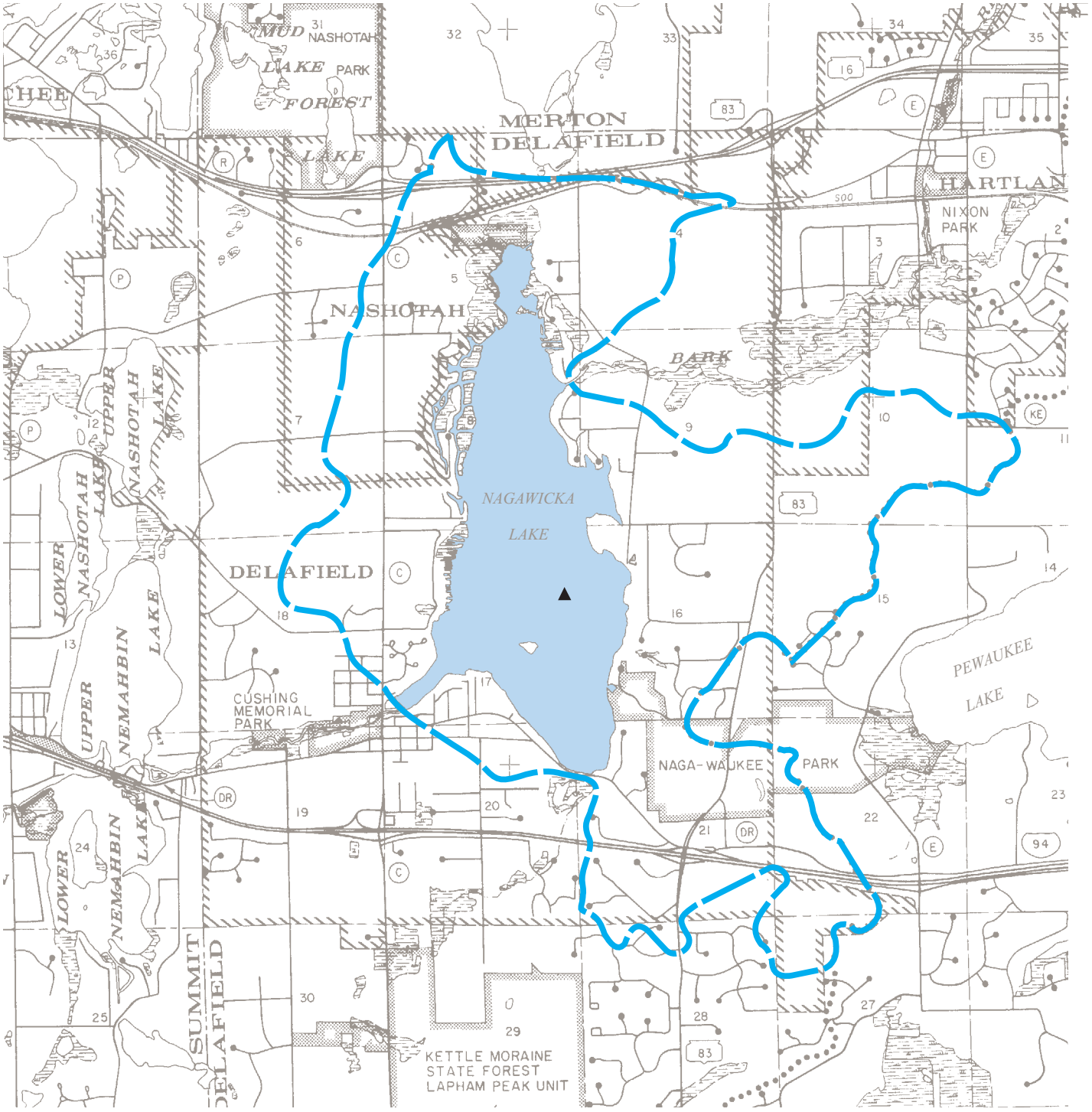
The Lake's total tributary drainage area is about 45 square miles in areal extent, as shown on Map 2. As of 1995, approximately 68 percent of the total tributary drainage area to the Lake remained in rural land uses, with the dominant land usage being agricultural. Agricultural lands comprised about 37 percent of the total tributary drainage area. Woodlands, wetlands, and other open lands comprised a further 17 percent of the total tributary drainage area to the Lake. About 32 percent of the tributary drainage area was in urban land uses. Residential land usage comprised about 19 percent of the total tributary drainage area. Commercial, industrial, and recreational land uses comprised a further 3 percent of the total tributary drainage area to the Lake.

Under buildout conditions, the Waukesha County development plan and regional land use plan forecast about 4,700 acres of additional urban development within the drainage area tributary to the Lake. About 4,000 acres of this development is anticipated to be for residential uses. Thus, a significant portion of the rural lands outside of the environmental corridors, environmentally sensitive areas, and prime agricultural lands would be in residential or other urban usage under full buildout conditions, particularly in that portion of the drainage basin directly tributary to Nagawicka Lake.

Woodlands and wetlands within the total drainage area tributary to Nagawicka Lake each comprised about 10 percent of the land area, or approximately 5,600 acres in total. A total of about 7,900 acres of the drainage area were identified as wildlife habitat, about one-half of which was considered to be Class I wildlife habitat. Much of this area was encompassed within environmental corridors or isolated natural features identified by the Regional Planning Commission in the adopted regional land use plan. The majority of the environmental corridors were considered to be primary environmental corridors.

Map 1

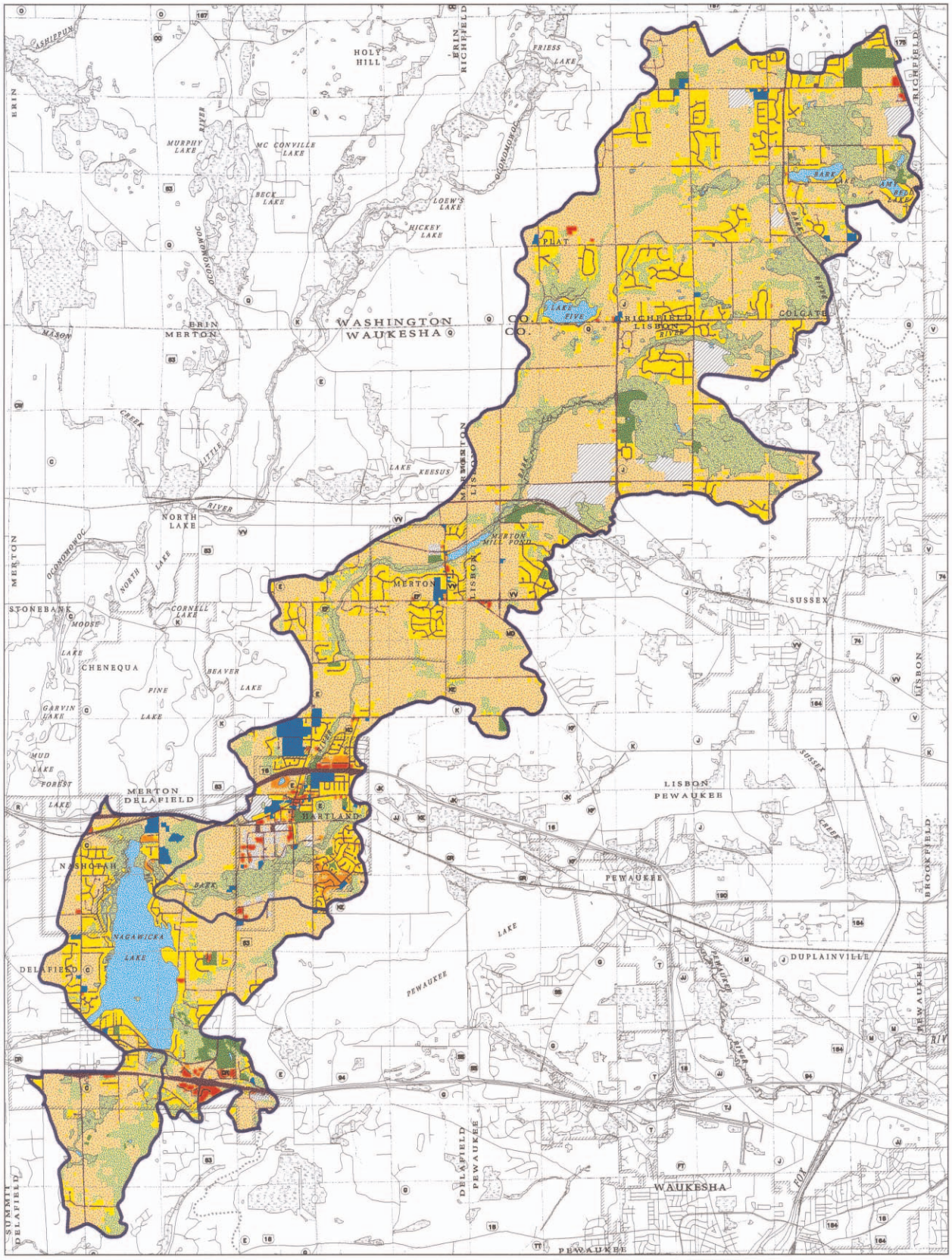
LOCATION MAP OF NAGAWICKA LAKE




*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Map 2

## GENERALIZED LAND USE WITHIN THE TOTAL TRIBUTARY DRAINAGE AREA TO NAGAWICKA LAKE: 1995




- Single–family residential
- Multi–family residential
- Commercial
- Industrial
- Transportation, communications and utilities
- Government and institutional
- Recreation
- Surface water
- Wetlands and woodlands
- Agricultural, unused and other open lands
- Extractive and landfill
- Total Tributary Drainage Area

0 1 2
Scale in miles

*Source: SEWRPC.*

Public recreational access to Nagawicka Lake was afforded by two public recreational boating access sites and the Naga-Waukee County Park operated by the Waukesha County Parks System. Two privately owned recreational boating access sites are also situated on the lakeshore. Over 1,000 watercraft were observed to be moored or trailered in the vicinity of the Lake, about 30 of which were in operation during a typical week day and about 60 during a typical, off-peak weekend day. Nagawicka Lake received a recreational rating of 63, of a possible 72 points, using the Wisconsin Department of Natural Resources (WDNR) recreational use rating system, indicating relatively diverse and high-quality recreational opportunities are afforded by the Lake.

Given the changing land usage within the drainage area tributary to Nagawicka Lake, and the likelihood of continued and increased demand for water-based recreational opportunities on and around Nagawicka Lake, the protection of the natural resource base through sound land use planning, the preservation of environmental corridors and natural resource features, and the management of existing and potential recreational use conflicts are issues of concern that should be considered.

## WATER BUDGET

Nagawicka Lake has a volume of about 46,000 acre-feet. Water flow through the Lake, as well as lake level, is controlled by two outlet structures, a gated dam and a mill race, located on the Bark River on the southwestern shore of the Lake. The outlet structures have variable discharge elevations that maintain a mean depth of 36 feet in the Lake. Nagawicka Lake is a drainage lake with a discrete inflow and outflow. Inflow and outflow is provided through the Bark River. About 29,000 acre-feet of water enter the Lake annually by way of the River, which discharges a similar volume downstream during a typical year. Rainfall and evaporation each account for about 10 percent of the water budget of the Lake. The water residence time in the Lake is about 1.6 years.

While Nagawicka Lake provides substantial storage capacity within the Middle Bark River, concerns have been expressed to the City of Delafield Lake Welfare Committee by the Upper Nemahbin Lake Management District Board of Commissioners regarding the hydrologic operating regime of the Nagawicka Lake dam. These concerns have arisen as a result of periodic flooding of homes and businesses located on the southern shore of Upper Nemahbin Lake, along CTH DR and adjacent to IH 94. Similar concerns have been expressed by the Crooked Lake Property Owners Association relative to flooding experienced along the Bark River upstream of its confluence with the mainstem of the Rock River.[1] As noted in the aquatic plant management plan prepared for Crooked Lake by the Regional Planning Commission, these concerns are largely beyond the scope of a lake management planning program and are best addressed in the context of a comprehensive hydraulic and hydrologic study for the Bark River watershed. In part, a comprehensive study should address the operating regimes for all the impoundments located on the Bark River, especially those impoundments having maximum and minimum operating levels established by the WDNR pursuant to authorities granted under Chapter 31, *Wisconsin Statutes*, of which Nagawicka Lake is one.

Notwithstanding, in a lake management planning effort endorsed by the City of Delafield Lake Welfare Committee, the Upper Nemahbin Lake Management District has undertaken a limited scope hydrologic and wetland study of the portion of the Bark River downstream of Nagawicka Lake and upstream of Upper Nemahbin Lake. The objective of this study is to identify options for the attenuation of flood flows and pollutant loads in this portion of the watershed. As of late-2000, this study was underway.

Given public concerns regarding the operation of the dam at Nagawicka Lake, the hydraulic and hydrologic management of water flow through Nagawicka Lake is an important issue that should be considered.

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[1] *SEWRPC Memorandum Report No. 112,* An Aquatic Plant Management Plan for Crooked Lake, Waukesha County, Wisconsin, *April 2000.*

## WATER QUALITY

Nagawicka Lake is a deep water, dimictic, meso-eutrophic lake with a water quality varying from poor to good, depending upon the indicators considered. The Lake has a relatively slow through-flow of water, as noted above, with an hydraulic residence time of about 1.6 years. This residence time implies that contaminants entering Nagawicka Lake have adequate time to interact with the flora and fauna of the Lake, with a consequent impact on the biological response to be expected from external nutrient and pollutant loads. In addition, the in-lake total phosphorus concentration is at the Regional Planning Commission-recommended threshold value of 0.02 milligrams per liter (mg/l) at the time of spring turnover, consistent with the meso-eutrophic, or moderately enriched, status of the Lake. Above the 0.02 mg/l level, indicates that water quality problems may be expected to occur. Given existing water quality conditions and the extent of proposed changes in land usage within the drainage area tributary to Nagawicka Lake, whence the major portion of the external nutrient load to the Lake is generated through human activities on the land surface, water quality degradation is an important issue that should be considered.

### Point Sources of Water Pollution

There are no known point sources of water pollution discharging to Nagawicka Lake. Wastewater from that portion of the drainage area directly tributary to the Lake is treated and disposed of through a public sanitary sewerage system operated by the City of Delafield and Villages of Nashotah and Hartland, and connected to the Delafield-Hartland Water Pollution Control Commission (Dela-Hart) sewerage system for treatment purposes. Elsewhere in the drainage area tributary to the Lake, onsite sewage disposal systems are generally used for wastewater treatment.

### Nonpoint Sources of Water Pollution

Based upon 1990 land use conditions in the total drainage area tributary to Nagawicka Lake, approximately 13,000 pounds of phosphorus entered the Lake on an annual basis. The principal source of this nutrient load was human activities within the watershed. The major portion of this load entered the Lake through the Bark River. About 90 percent of the influent phosphorus load was estimated to remain within the Lake, contributing to the productivity of the system, although internal loading was estimated to be minimal.

Specific concern was expressed by the City of Delafield Lake Welfare Committee with respect to ongoing commercial and industrial development in the drainage area tributary to the Lake, especially in the vicinities of the STH 83 intersections with IH 94 south of the Lake and STH 16 north of the Lake. Pollution loads from within these subbasins were modeled under existing 1990 and forecast buildout land use conditions. The results of the modeling suggested that, without stormwater management measures being put into place, substantial increases in heavy metals loadings from those lands could occur as a consequence of continued urban development. These subbasins also were estimated to contribute about 10 percent of the phosphorus load to the Lake.

In addition to the concerns expressed by the City of Delafield Lake Welfare Committee, further concern was expressed by the citizens in attendance at the May 2000 public meeting over pollutant loading from residential development northwest of the Lake. As a consequence, further modeling of specific subbasins was undertaken. The forecast 1990 and buildout contaminant loads from the urban residential development areas in question, located adjacent to CTH C, largely in the Village of Nashotah, are shown in Table 1. Although the forecast sediment loads suggested a decrease in mass of sediment delivered to the Lake from this area, field survey data obtained during the summer of 2000 indicated that a significant volume of sediment being delivered to the Lake. Map 3 shows the measured change in sediment depth within the constructed channels at the stormwater outlet point on the northwestern shore of the Lake. These measurements indicated a change in sediment depth at the outlet from about 10 to 16 inches of silt in 1999 to about 26 to 30 inches of silt in 2000. Field inspections also conducted during the summer of 2000, found that provision for stormwater treatment from the area in question in the detention basin located in the Village of Nashotah between Range Woods Drive and Nagawicka Avenue north of their intersections with Mission Avenue had been removed. This modification to the stormwater basin had been reported by the citizens attending the public informational meeting convened by the Lake Welfare Committee.

**Table 1**

**ESTIMATED POLLUTANT LOADS TO NAGAWICKA LAKE FROM URBAN DEVELOPMENT WITHIN SUBBASIN BR-26**

| Land Use | 1990 | | | | | | Buildout | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area (acres) | Sediment (pounds) | Phosphorus (pounds) | Copper (pounds) | Zinc (pounds) | Cadmium (pounds) | Area (acres) | Sediment (pounds) | Phosphorus (pounds) | Copper (pounds) | Zinc (pounds) | Cadmium (pounds) |
| Multi-Family Residential | 21 | 5,040 | 18 | 3 | 17 | 0.2 | 85 | 20,400 | 72 | 10 | 69 | 0.9 |
| Single-Family Residential | 262 | 5,109 | 52 | 0 | 3 | 0.0 | 622 | 12,129 | 124 | 0 | 6 | 0.0 |
| Commercial | 7 | 5,488 | 8 | 2 | 10 | 0.1 | 12 | 9,408 | 14 | 3 | 18 | 0.1 |
| Industrial | 1 | 752 | 1 | <1 | 1 | <0.1 | 0 | - - | - - | - - | - - | - - |
| Government and Institutional | 35 | 17,885 | 47 | 2 | 28 | 0.0 | 75 | 38,325 | 101 | 5 | 60 | 0.0 |
| Woodlands and Wetland | 328 | 1,214 | 13 | 0 | 0 | 0.0 | 328 | 1,214 | 13 | 0 | 0 | 0.0 |
| Recreational | 4 | 96 | 1 | 0 | 0 | 0.0 | 2 | 48 | <1 | 0 | 0 | 0.0 |
| Agricultural | 506 | 227,700 | 435 | 0 | 0 | 0.0 | 39 | 17,550 | 34 | 0 | 0 | 0.0 |
| Total | 1,163 | 263,284 | 575 | 7 | 59 | 0.3 | 1,163 | 99,074 | 359 | 18 | 153 | 1.0 |

*Source: SEWRPC.*

The Lake Welfare Committee, upon further investigation, determined that the WDNR Chapter 30, *Wisconsin Statutes*, permit required water quality treatment only during the construction phase of the subdivision. Notwithstanding, it would appear from the field data that consideration of stormwater management measures should be considered.

The deposition of sediment within the Lake, and particularly in the northern and western portions of the lake basin, was a major concern among the citizens attending the May 2000 informational meeting. During the course of this meeting, the citizens expressed a clear desire that their recreational boating access to the Lake be maintained. This viewpoint was consistent with the concerns expressed by the Lake Welfare Committee. A review of the available sediment quality data, set forth in the aforereferenced inventory report, suggested that the lake sediments were generally within the guideline concentrations established by the Wisconsin Department of Natural Resources, except in the case of ammonia-nitrogen which exceeded the recommended lowest effect level (LEL) concentration for that form of nitrogen. This suggests that sediment removal could be an option to be considered in the maintenance of riparian boating access to the Lake. However, implementation of such an option has important implications for the environmentally sensitive areas delineated within the Nagawicka Lake basin by the WDNR pursuant to authority granted the Department in Chapter NR 107 of the *Wisconsin Administrative Code*.

Given the results of the lake sediment surveys conducted by Commission staff during 1999 and 2000, and public concerns regarding the impacts of siltation on recreational and other uses of Nagawicka Lake, sediment accumulation within Nagawicka Lake is an important issue that should be considered.

## OTHER ISSUES

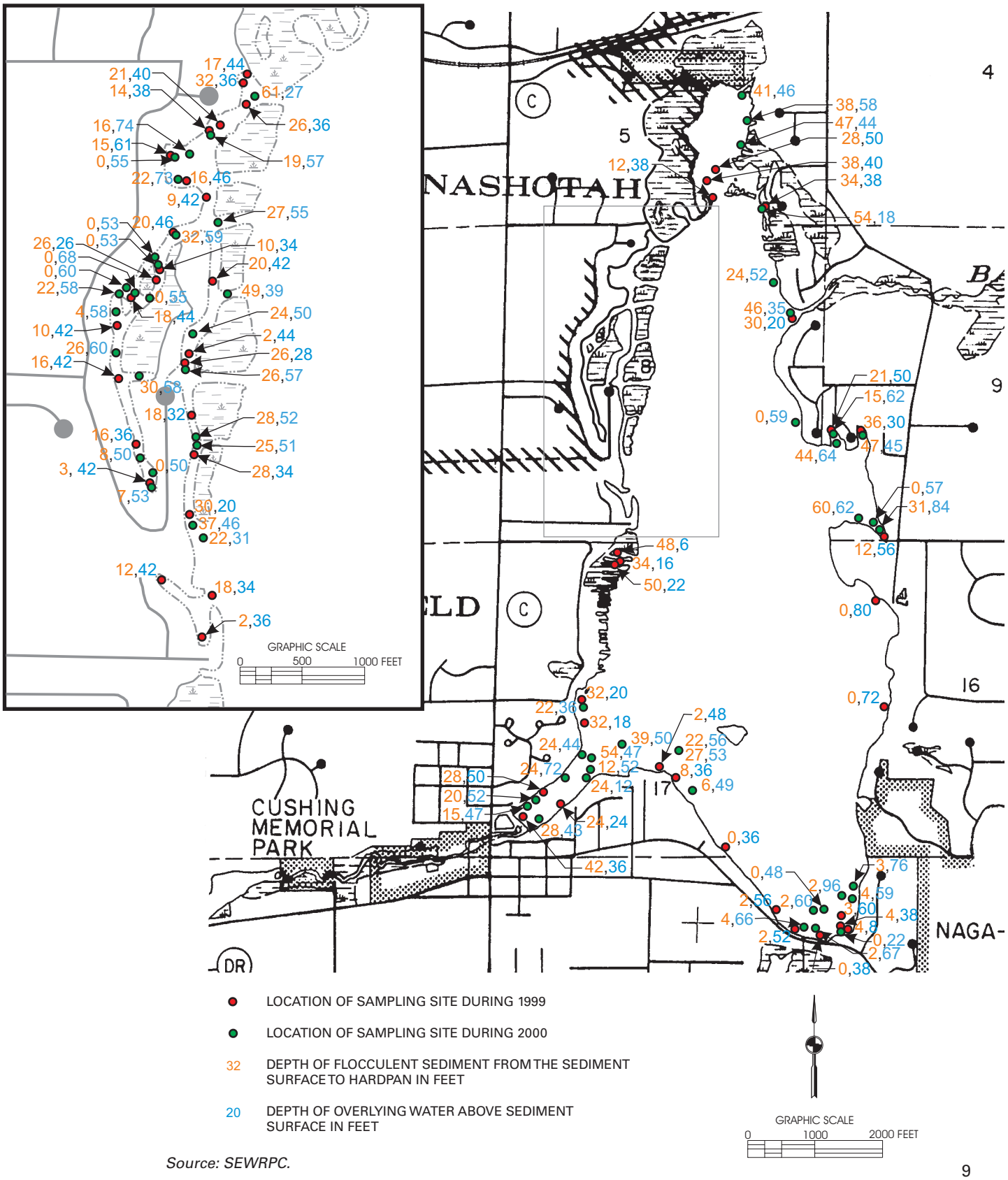
Citizens attending the public informational meeting in May 2000 identified a number of additional issues to be addressed in the context of the lake management planning program for Nagawicka Lake. These issues included concern over the lake fishery, the management of aquatic plants, the role of the City of Delafield Lake Welfare Committee as an effective organization for lake management within the City of Delafield administrative structure, and the desire for more information on the Lake and its management.

### Fisheries and Aquatic Plant Management

Concerns were expressed by those in attendance at the public informational meeting convened by the City of Delafield Lake Welfare Committee during May 2000 regarding the presence of zebra mussel, *Dreissena*

Map 3

FLOCCULENT SEDIMENT ACCUMULATIONS IN SHORELAND AREAS WITHIN NAGAWICKA LAKE: 1999 AND 2000




*Source: SEWRPC.*

*polymorpha*, its impact on fishes, and the changing fish habitat within the Lake. In part, the latter concerns also related to sedimentation within the lake basin, which has been identified previously as a water quality issue of concern. While public perceptions of the lake fishery were mixed, there was agreement regarding the perceived loss of habitat due to siltation in areas of the Lake that were previously observed to have sandy substrates. A number of citizens noted the increase in organic sediments within the Lake; a perception that coincided with the perceived increase in rooted aquatic plants in portions of the lake basin. Both of these issues were also related to the diminution of recreational boating access opportunities for riparian owners. For these reasons, fisheries and aquatic plant management, and the redelineation of ecologically valuable areas within the Lake, were identified as issues of concern that should be considered.

**Institutional Development**
Of particular concern to the citizens attending the May 2000 informational meeting was the administration of the City's shoreland and stormwater ordinances. The relationship between the City of Delafield Lake Welfare Committee and the Village of Nashotah, the other riparian governmental unit, was also raised, as was the relationship between the City of Delafield and the Village of Hartland, the governmental unit located immediately upstream of the Lake.

Citizens of the City and Village living in proximity to the Lake have, from time to time, considered the formation of a public inland lake protection and rehabilitation district, or lake management district, for the Lake, pursuant to the provisions of Chapter 33, *Wisconsin Statutes*. Such a district would have the advantage of including both the City and Village lands within the jurisdiction of a single, special-purpose governmental unit, provided that such municipalities agree to the inclusion of their territory within the proposed lake management district as provided in Section 33.24.

Given the need for specialized knowledge of shoreland zoning requirements and the location of the Lake within two incorporated municipalities and adjacent to a third, organizational issues relating to lake management are important issues that should be considered.

**Informational Programming**
The City of Delafield Lake Welfare Committee, consequent to the public informational meeting of May 2000, determined that there was a need within the Nagawicka Lake community for regular informational programming. Hence, such programming is an important issue that should be considered.

# Chapter III

# ALTERNATIVE LAKE MANAGEMENT MEASURES

## WATER USE OBJECTIVES

The regional water quality management plan recommended the adoption of full recreational and warmwater sport fisheries objectives for Nagawicka Lake. The inventory findings set forth herein and in the lake and watershed inventory for Nagawicka Lake indicate that the uses of the Lake and the resources of the drainage area are generally supportive of such objectives.[1]

The full recreational use objective is supported by the large numbers of recreational users observed on and around the Lake during recreational use surveys conducted by the Regional Planning Commission during June and July of 1997. Of the approximately 140 weekday users, and 325 weekend users, about one-fifth were engaged in boating activities, while the balance were engaged in nonboating uses such as picnicking, swimming, or angling from shore. The recommended warmwater sport fishery objective is supported in Nagawicka Lake by a sport fishery based largely on largemouth bass and panfish. These fishes have traditionally been sought after in Nagawicka Lake.

Notwithstanding, it is expected that remedial measures will be required if the Lake is to fully meet the foregoing water use objectives. Based upon discussions with the City of Delafield Lake Welfare Committee, the outcome of the May 2000 public informational meeting, and a review of the inventory findings, the following issues were identified as requiring consideration in the formulation of alternative and recommended lake management measures: 1) land use management, 2) protection of environmentally sensitive lands, 3) water quality improvement and stormwater management, 4) hydraulic and hydrologic management of water flow, 5) fisheries and aquatic plant management, 6) recreational use management, 7) public informational programming, and 8) institutional development.

Potentially effective measures to address these concerns include watershed management measures, such as land use planning and zoning and in-lake rehabilitation techniques. Watershed management and land use planning and zoning measures can serve to protect the Lake by promoting and maintaining a sound land use pattern in the area; protecting groundwater recharge areas; and reducing pollutant runoff to the Lake, thus, improving water quality and fish and habitat conditions. In-lake rehabilitation techniques can treat directly identified water quality problems and lake use conflicts.

This chapter reviews lake and watershed management alternatives that address both of these approaches, and identifies feasible measures for the management of Nagawicka Lake that address the issues of concern identified in Chapter II and in the lake and watershed inventory.

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[1] *SEWRPC Memorandum Report No. 130,* A Lake and Watershed Inventory for Nagawicka Lake, Waukesha County, Wisconsin, *March 1999.*

## WATERSHED MANAGEMENT ALTERNATIVES

### Land Use Management

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

#### *Development in the Direct Drainage Area and Shoreland Zone*

Existing 1990 and planned buildout land use patterns and existing zoning regulations in the tributary area to Nagawicka Lake have been described in the lake and watershed inventory report, and are summarized in Chapter II. If the recommendations set forth in the adopted Waukesha County development plan and regional land use plan are followed, under buildout conditions, significant additional urban residential development within the drainage area tributary to Nagawicka Lake would occur. Much of this residential development is likely to occur on agricultural lands. Infilling of existing platted lots and some backlot development, as well as the redevelopment and reconstruction of existing single-family homes and commercial structures on lakefront properties, also may be expected to occur. Recent surveillance indicates that this type of development is currently occurring. Accordingly, given the potential impact of lakeshore development on the lake resources, land use development or redevelopment proposals around the shoreline of Nagawicka Lake and within the drainage area directly tributary to the Lake should be evaluated for potential impacts on the Lake, as such proposals are advanced.

#### *Development in the Tributary Drainage Area*

The level of development envisioned in the Waukesha County development plan for the Waukesha County portion of the drainage basin tributary to Nagawicka Lake indicates continuing urban development, generally on large suburban-density lots. Careful review of applicable zoning ordinances to incorporate levels and patterns of development consistent with the plan within the drainage area tributary to Nagawicka Lake is recommended. Changes in the zoning ordinances could be considered to better reflect the land use patterns recommended in the County development plan within the portion of the drainage area within Waukesha County and those recommended in the regional land use plan within the portion of the drainage area within Washington County. Consideration should be given to minimizing the areal extent of development by providing specific provisions and incentives to cluster residential development on smaller lots while preserving portions of the open space on each property or group of properties considered for development.

#### *Stormwater Management on Development Sites*

With respect to stormwater management on development sites, as of 1999, both the City of Delafield and the Village of Hartland had adopted stormwater management ordinances that are similar in content. These ordinances reflect current best practices insofar as the determination of stormwater flows, mitigation of flooding potential, and the control of contaminants from land use activities are concerned. The Lake Welfare Committee, during 2000, recommended that the City of Delafield work toward a similar end with the Village of Nashotah to encourage consistency in stormwater management throughout the drainage area directly tributary to Nagawicka Lake.

### Protection of Environmentally Sensitive Lands

Environmentally sensitive lands within the drainage area tributary to Nagawicka Lake include wetlands, woodlands, and wild life habitat areas. Nearly all of these areas within the Nagawicka Lake drainage area are included in the environmental corridors and isolated natural features delineated by the Regional Planning Commission.

Wetland protection can be accomplished through land use regulation and, in cases where land use regulations may not offer an adequate degree of protection, through public acquisition of sensitive sites. These wetland areas are currently protected to a degree by current zoning and regulatory programs administered by the U.S. Army Corps of Engineers, Wisconsin Department of Natural Resources (WDNR), and County and municipal authorities under

one or more of the Federal, State, County, and local regulations. Notwithstanding, some of the wetland areas within the drainage area tributary to Nagawicka Lake have been recommended for acquisition in the adopted regional natural areas and critical species habitat management and protection plan, including the Nagawicka Bog and Oak Woods Natural Area, and the Bark River School Sedge Meadow.[2]

Upland areas, woodlands and wildlife habitat areas, currently are protected only through local land use regulation. The Nagawicka Oak Woods is recommended for acquisition in the adopted regional natural areas and critical species habitat protection and management plan.

**Water Quality Improvement and Stormwater Management**

Watershed management measures may be used to reduce nonpoint source pollutant loadings from such rural sources as runoff from crop and pasture lands and from livestock wastes; from such urban sources as runoff from residential, commercial, industrial, transportation, and recreational land uses; from construction activities; and from onsite sewage disposal systems. The alternative, watershed-based nonpoint source pollution control measures considered in this report are based upon the recommendations set forth in the adopted regional water quality management plan,[3] the Waukesha County soil erosion control plan,[4] the County land and water resource management plans,[5] and information presented by the U.S. Environmental Protection Agency.[6]

Nonpoint sources of pollutants in the drainage area tributary to Nagawicka Lake include runoff from both urban and rural sources, as summarized in Table 2. Under current land use conditions, urban land uses contribute about one-fifth, or 21 percent, of the external nonpoint source phosphorus load to the Lake. This is expected to increase under buildout conditions to about two-fifths, or 41 percent, of the external phosphorus load. Urban sources of nonpoint pollutants also contribute virtually all the metal load to the Lake. As urban land uses expand within the drainage area, nonpoint-sourced loads of metals to the Lake are likely to increase as well. While some proportion of these contaminant loads may be attenuated as a consequence of the extensive wetland areas along the Bark River upstream of Nagawicka Lake, the ability of these wetlands to assimilate pollutants is wholly dependent upon the maintenance of their structure and function within their ecosystems. These features can be overwhelmed by inappropriate land uses that result in the degradation of the wetlands, diminishing their ability to capture contaminants, or creating contaminant loads of such magnitude that the wetlands are overloaded. Thus, the control of nonpoint sources of water pollution at their sources is an important consideration. Properly applied, such controls can reduce the pollutant loadings to a lake by about 25 percent or more. The adopted regional water

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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.*

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

[4] *SEWRPC Community Assistance Planning Report No. 159,* Waukesha County Agricultural Soil Erosion Control Plan, *June 1988.*

[5] *Waukesha County,* Land and Water Resource Management Plan: 1999-2002, *December 1998; and Washington County,* Land and Water Resource Management Plan: 2000-2005, *August 2000.*

[6] *U.S. Environmental Protection Agency, Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second 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.*

Table 2

ESTIMATED CONTAMINANT LOADS TO NAGAWICKA LAKE: 1995 AND BUILDOUT

| Land Use | 1995 | | | | | | Buildout | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area (acres) | Sediment (tons) | Phosphorus (pounds) | Copper (pounds) | Zinc (pounds) | Cadmium (pounds) | Area (acres) | Sediment (tons) | Phosphorus (pounds) | Copper (pounds) | Zinc (pounds) | Cadmium (pounds) |
| Residential | 4,971 | 248.6 | 1,342 | 99 | 696 | - - | 8,890 | 444.5 | 2,400 | 178 | 1,245 | - - |
| Commercial | 199 | 78.0 | 239 | 44 | 297 | 2 | 669 | 262.3 | 803 | 147 | 997 | 7 |
| Industrial | 818 | 307.6 | 957 | 180 | 1,219 | 8 | 1,646 | 618.9 | 1,926 | 362 | 2,453 | 16 |
| Communications and Utilities | 344 | 1.6 | 38 | - - | - - | - - | 344 | 1.6 | 38 | - - | - - | - - |
| Governmental | 347 | 88.7 | 468 | 24 | 278 | - - | 372 | 95.1 | 502 | 26 | 298 | - - |
| Recreational | 276 | 3.3 | 75 | - - | - - | - - | 395 | 4.7 | 107 | - - | - - | - - |
| Water | 1,364 | 128.2 | 177 | - - | - - | - - | 1,364 | 128.2 | 177 | - - | - - | - - |
| Wetlands | 2,774 | 5.1 | 111 | - - | - - | - - | 2,774 | 5.1 | 111 | - - | - - | - - |
| Woodlands | 2,998 | 5.6 | 120 | - - | - - | - - | 2,900 | 5.4 | 116 | - - | - - | - - |
| Open Lands | 2,051 | 9.7 | 226 | - - | - - | - - | 454 | 2.2 | 50 | - - | - - | - - |
| Agricultural | 12,810 | 2,882.2 | 11,016 | - - | - - | - - | 9,144 | 2,057.4 | 7,864 | - - | - - | - - |
| Total | 28,952 | 3,758.6 | 14,769 | 347 | 2,490 | 10 | 28,952 | 3,625.4 | 14,094 | 713 | 4,993 | 23 |

*Source: SEWRPC.*

quality management plan recommends the application of urban and rural land management practices to achieve about a 25 percent reduction in nonpoint source loads in this watershed.

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

***Rural Nonpoint Source Controls***

Upland erosion from agricultural and other rural lands is a contributor of sediment to streams and lakes in the Bark River watershed and to Nagawicka Lake. Estimated phosphorus and sediment loadings from croplands, woodlots, pastures, and grasslands in the drainage area tributary to Nagawicka Lake were presented in the lake and watershed inventory. These data were utilized in determining the pollutant load reduction that could be achieved, the types of practices needed, and the extent of the areas to which the practices need to be applied within the drainage area tributary to Nagawicka Lake.

Based upon the pollutant loading analysis set forth in Table 2, a total annual phosphorus loading of 15,000 pounds is estimated to be contributed to Nagawicka Lake. Of that mass, it is estimated that 12,000 pounds per year, or 79 percent of the total loading, were contributed by runoff from rural land. Of the balance, about 3,000 pounds per year, or 21 percent, were contributed by runoff from urban land. In addition, as set forth in the pollutant loading analysis presented in Chapter IV of the lake and watershed inventory, about 160 pounds of phosphorus from onsite sewage disposal systems and about 80 pounds of phosphorus from precipitation were estimated to be contributed to Nagawicka Lake. Similarly, based upon the pollutant loading analysis set forth in Table 2, it is estimated that 2,900 tons of sediment, or about 77 percent of the total sediment load to Nagawicka Lake, are contributed annually from agricultural lands in the drainage area tributary to Nagawicka Lake. As of 1995, such lands comprised about 12,800 acres, or about 44 percent of the drainage area tributary to Nagawicka Lake.

The regional water quality management plan recommends measures be taken to provide about a 25 percent reduction in nonpoint source pollutant loading from rural lands in the watershed. Implementation of these recommendations is considered to be adequate for water quality management purposes related to Nagawicka Lake.

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

***Urban Nonpoint Source Controls***

As of 1995, established urban land uses comprised about 7,000 acres, or about 24 percent, of the total drainage area tributary to Nagawicka Lake. The annual phosphorus loading from these urban lands is estimated to be 3,000 pounds, or about 21 percent of the total load of phosphorus to the Lake. This is anticipated to increase to about 41 percent of the total load of phosphorus under buildout conditions. The regional water quality management plan recommends that the nonpoint source pollutant loadings from the urban areas tributary to Nagawicka 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. For this reason, consideration should be given to reducing the pollutant loadings from the controllable urban nonpoint sources to the extent practicable in order to minimize the negative results of nutrient loadings on the Lake.

Those pollutant loadings that are most controllable include runoff from the residential lands adjacent to the Lake, urban runoff from areas with an high proportion of impervious surface, and poorly maintained agricultural lands. The potential also exists within the Nagawicka Lake watershed for significant construction site erosion impacts if development continues in the tributary drainage area as has been the recent trend.

Potentially applicable urban nonpoint source control measures include stormwater management measures, wet detention basins, grassed swales, and good urban "housekeeping" practices. Generally, the application of low-cost urban housekeeping practices may be expected to reduce nonpoint source loadings from urban lands by about 25 percent. Public educational programs can be developed to encourage good urban housekeeping practices, to promote the selection of building and construction materials which reduce the runoff contribution of metals and other toxic pollutants, and to promote the acceptance and understanding of the proposed pollution abatement measures and the importance of lake water quality protection. Urban housekeeping practices and source controls include restricted use of fertilizers and pesticides, improved pet waste and litter control, the substitution of plastic for galvanized steel and copper roofing materials and gutters, proper disposal of motor vehicle fluids, increased leaf collection, and continued use of reduced quantities of street deicing salt.

Particular attention should be given to reducing pollutant loadings from high pollutant loading areas, such as commercial sites, parking lots, and material storage areas. To the extent practicable, parking lot stormwater runoff should be diverted to areas covered by pervious soils and appropriate vegetation, rather than being directly discharged to surface waters. Material storage areas may be enclosed or periodically cleaned, and diversion of stormwater away from these sites may further reduce pollutant loadings.

As has been noted above, the City of Delafield and the Village of Hartland have adopted stringent stormwater management ordinances applicable to new development, since 1999, within the areas under their jurisdiction. While these measures limit the potential impacts of new development, they do not address impacts from existing land uses nor do they address the cumulative impacts of past development. Therefore, additional measures to reduce nonpoint source pollution from existing development would appear to be warranted. This is especially true for those subbasins directly tributary to the Lake in which significant development has occurred. These include nonpoint loads generated by commercial development within subbasin BR-28 in the vicinity of the STH 83 and IH 94 intersection south of the Lake, industrial development within subbasin BR-24 in the vicinity of the STH 83 and STH 16 northeast of the Lake, and urban residential development within subbasin BR-26 adjacent to CTH C northwest of the Lake.

Proper design and application of structural urban nonpoint source control measures, such as grassed swales and detention basins, requires the preparation of a detailed stormwater management system plan that addresses stormwater drainage problems and controls nonpoint sources of pollution. As of 2001, the City of Delafield had contracted for the preparation of a detailed stormwater management plan that would address these issues insofar as they relate to the urban development in the vicinity of the STH 83 and IH 94 intersection.

***Developing Areas***

Developing areas can generate significantly higher pollutant loadings than established areas of similar size. Developing areas include a wide array of activities, including urban renewal projects, individual site development within the existing urban area, and new land subdivision development. The regional land use plan envisions only limited new urban development within the drainage area. As previously noted, however, large-lot suburban-density development is currently taking place in the drainage area tributary to Nagawicka Lake at rates which exceed the levels envisioned in the adopted regional land use plan. In addition, higher-density development is occurring within the City of Delafield on the southern shore of the Lake and adjacent to the Bark River downstream of the Lake.

Construction sites, especially, may be expected to produce suspended solids and phosphorus loadings at rates several times higher than established urban land uses. Control of sediment loss from construction sites can be provided by measures set forth in the model ordinance developed by the Wisconsin Department of Natural Resources in cooperation with the Wisconsin League of Municipalities.[7] These controls are temporary measures taken to reduce pollutant loadings from construction sites during stormwater runoff events. Construction erosion controls may be expected to reduce pollutant loadings from construction sites by about 75 percent. Such practices are expected to have only a minimal impact on the total pollutant loading to the Lake due to the relatively small amount of land proposed to be developed. However, such controls are important pollution control measures that can abate localized short-term loadings of phosphorus and sediment from the drainage area and the upstream tributary area. The control measures include such revegetation practices as temporary seeding, mulching, and sodding, and such runoff control measures as filter fabric fences, straw bale barriers, storm sewer inlet protection devices, diversion swales, sediment traps, and sedimentation basins.

At the present time Waukesha County has adopted construction site erosion control ordinances which are administered and enforced by the County concerned in both the shoreland and nonshoreland areas of the unincorporated areas of the drainage area tributary to Nagawicka Lake. The provision of these ordinances apply to all development except single- and two-family residential construction. Single- and two-family construction erosion control measures are to specified as part of the building permit process. In the City of Delafield, the Villages of Chenequa, Hartland, and Nashotah, and the Town of Delafield in Waukesha County, this function is performed by the City, Villages, and Town. Because of the potential for development, albeit unplanned, in the Waukesha County portion of the drainage area tributary to Nagawicka Lake, it is important that adequate construction erosion control programs, including enforcement, be in place.

***Onsite Sewage Disposal System Management***

While the immediate lakeshore is sewered, much of the drainage area tributary to Nagawicka Lake continues to be served by onsite sewage disposal systems. As reported in lake and watershed inventory, onsite sewage disposal systems are estimated to contribute about 1 percent of the total phosphorus loading in 1995, and about 2 percent total phosphorus loading to Nagawicka Lake under buildout conditions.[8] In addition to lake water quality considerations, sewage disposal options in the area have implications for groundwater quality and property

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

[8]*Wisconsin Department of Natural Resources,* Wisconsin Lake Model Spreadsheet Version 2.00, *June 1994.*

values. Thus, onsite sewage disposal is an important consideration in the entire drainage area. Two basic alternatives are available for abatement of pollution from onsite sewage disposal systems: continued reliance on, and management of, the onsite sewage disposal systems, and, alternatively, the expansion of the existing public sanitary sewer system.

As noted, the concentrations of urban development located along the shoreline of Nagawicka Lake have been included within a public sanitary sewer service area, as recommended in the adopted regional water quality management plan. However, lands lying outside this area, but identified as having a density of development equivalent to an urban concentration, would continue to be provided with sewage disposal through the use of onsite sewage disposal systems. Notwithstanding, the regional plan also recommended that sewerage needs in such areas be periodically reevaluated in light of changing conditions. Such an evaluation was recently completed[9] and included specific recommendations to extend the existing public sanitary sewerage service to selected areas within the drainage area tributary to Nagawicka Lake, as shown on Map 4.

Where onsite sewage disposal systems remain the primary wastewater treatment method, it is recommended that an onsite sewage disposal system management program be carried out, including the conduct of an ongoing informational and educational effort. Homeowners in areas served by onsite systems should be advised of the rules, regulations, and system limitations governing onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs. Generally, it is recommended that these efforts be undertaken by, or with the assistance of, the County sanitarians in Waukesha and Washington Counties. These counties currently have such programs in place.

## IN-LAKE MANAGEMENT ALTERNATIVES

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

The applicability of specific in-lake rehabilitation techniques is highly dependent on lake-specific characteristics. The success of any lake rehabilitation technique can seldom be guaranteed, and because of the relatively high cost of applying most techniques, a cautious approach to implementing in-lake rehabilitation techniques is generally recommended. Certain in-lake rehabilitation techniques should be applied only to lakes in which: 1) nutrient inputs have been reduced below the critical level; 2) there is a high probability of success in applications of the particular technology to lakes of similar size, shape, and quality; and 3) the possibility of adverse environmental impacts is minimal. Finally, it should be noted that some in-lake rehabilitation techniques require the issuance of permits from appropriate State and Federal agencies prior to implementation.

Alternative lake rehabilitation measures include in-lake water quality management, water level management, and aquatic plant and fish management measures. Each of these groups of management measures.

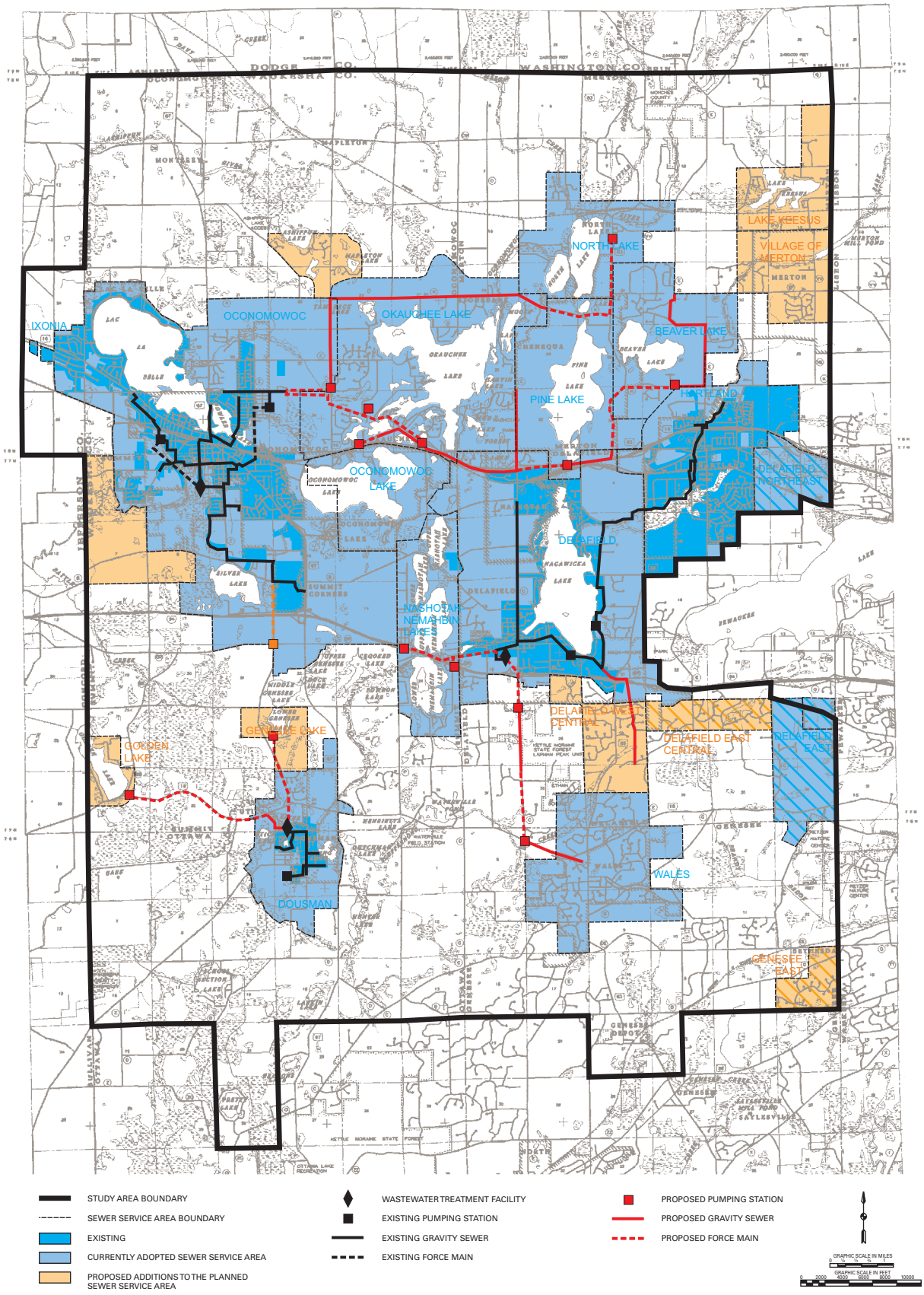
### Water Quality Improvement

This group of in-lake management practices includes a variety of measures designed to directly modify the magnitude of either a water quality determinant or biological response. Specific measures aimed at managing aquatic plants and the fishery are separately considered below.

[9] *Black & Veatch,* Sanitary Sewerage System Plan for the Northwestern Waukesha County Area*, April 2000.*

Map 4

POST-PUBLIC HEARING RECOMMENDED MODIFICATIONS TO THE REGIONAL WATER QUALITY MANAGEMENT PLAN BASED UPON THE NORTHWESTERN WAUKESHA COUNTY SEWERAGE SYSTEM PLAN STUDY AREA




NOTE: Hatched areas are assumed to be served by Fox River Watershed System.

*Source: SEWRPC.*

***Phosphorus Precipitation and Inactivation***

Nutrient inactivation is a restoration measure that is designed to limit the biological availability of phosphorus by chemically binding the element in the lake sediments using a variety of divalent or trivalent cations, highly positively charged elements. Aluminum sulphate (alum), ferric chloride, and ferric sulphate are commonly used cation sources. The use of these techniques to remove phosphorus from nutrient-rich lake waters is an extension of common water supply and wastewater treatment processes. Costs depend on the lake volume and type and dosage of chemical used. Approximately 100 tons of alum, costing about $150 per ton, can treat a lake area of about 40 acres. Effectiveness depends, in part, on the ability of the alum flocculent to form a stable "blanket" on the lakebed, to wit, on flushing time, turbulence, lake water acidity (pH) and rate of continued sedimentation. Impacts can include the release of toxic quantities of free aluminum into the water. The resulting improved water clarity can also encourage the spread of rooted aquatic plants.

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

***Nutrient Load Reduction***

Nutrient diversion is a restoration measure, which is designed to reduce the trophic state or degree of over-feeding of a waterbody and thereby control the growth response of the aquatic plants in the system. Control of nutrients in surface water runoff in the watershed is generally preferable to attempting such control within a lake. Many of the techniques presented in the watershed management section above are designed for this purpose.

In-lake control of nutrients generally involves removal of contaminated sediments or encapsulation of nutrients by chemical binding. Costs are generally high, involving an engineered design and usually some form of pumping or excavation. Effectiveness is variable. Impacts include the rerelease of nutrients into the environment.

While limited sediment removal for recreational boating access and related aesthetic purposes is recommended for portions of Nagawicka Lake, this measure is not recommended as a means of nutrient load reduction.

**Hydraulic and Hydrologic Management**

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

***Outlet Control Operations***

The outflow from Nagawicka Lake is controlled by an outlet structure and a mill race, both located on the southwest side of the Lake in the vicinity of CTH C. In addition, a hydraulic connection between the Lake and the former fish rearing ponds located at the former fish hatchery on CTH DR, adjacent to the Bark River downstream of the Lake, has been reported. The outlet structure has a variable discharge elevation that maintains an operating level, relative to the datum established by the Wisconsin Public Service Commission,[10] of between 98.2 feet in winter and 98.7 feet based on local datum in summer, resulting in a mean depth of about 36 feet in the Lake. The variable level discharge potentially provides an opportunity to manage the lake levels so as to moderate flood flows through the system, given the concerns raised by residents downstream with regard to flooding along the southern shore of Upper Nemahbin Lake. However, in order to best develop an hydraulic and hydrologic operating regime that provides optimal benefit to both residents and lake users, as well as to the environment in the Lake and downstream in the Bark River, such a management program should be based upon a thorough understanding the hydrology of the Bark River system.

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[10]*Established pursuant to the Order of the Wisconsin Department of Natural Resources dated June 10, 1993, case number 3-SE-92-530.*

Therefore, the preparation of an hydraulic and hydrologic analysis of the Bark River system, as part of a comprehensive watershed plan for the Bark River system, is recommended. No specific action on the part of the City of Delafield is recommended prior to the determination of appropriate systemwide management measures. Notwithstanding, it is recommended that the City, in concert with other riparian municipalities; Jefferson, Washington and Waukesha Counties; and the Wisconsin Department of Natural Resources work to promote the conduct of a comprehensive watershed planning program for the Bark River. Consideration of modifications of operation of Nagawicka Lake and of the restoration of the natural river patterns in the upstream of Upper Nemahbin Lake and Nagawicka Lake should be included in the aforementioned study as possible alternatives to be considered in this portion of the Bark River basin.

***Drawdown***

Drawdown refers to a the manipulation of lake water levels, especially in man-made lakes, in order to change or create specific types of habitat and thereby manage species composition within a waterbody. Drawdown may be used to control aquatic plant growth and to manage fisheries. With regard to aquatic plant management, periodic drawdowns can reduce the growth of some shoreland plants by exposing the plants to climatic extremes, while the growth of others is unaffected or enhanced. Both desirable and undesirable plants are affected by such actions. Costs are primarily associated with loss of use of the waterbody surface area during drawdown, provided there is a means of controlling water level in place, such as a dam or other outlet control structure. Effectiveness is variable with the most significant side effect being the potential for increased plant growth.

Drawdown can also affect the lake fisheries both indirectly, by reducing the numbers of food organisms, and directly, by reducing available habitat and desiccating (drying out) eggs and spawning habitat. In contrast, increasing water levels, especially during spring, can provide enhanced fish breeding habitat for some species, such as pike and muskellunge, and increase the food supply for opportunistic feeders, such as bass, by providing access to terrestrial insects, for example. Costs are primarily associated with loss of use. Effectiveness is better than for aquatic plant control, but the potential for side effects remains high given that undesirable fish species may also benefit from water level changes.

Sediment exposure and desiccation by means of lake drawdown has been used as a means of stabilizing bottom sediments, retarding nutrient release, reducing macrophyte growth, and reducing the volume of bottom sediments. During the period of drawdown, the exposed sediments are allowed to oxidize and consolidate. It is believed that by reducing the sediment oxygen demand and increasing the oxidation state of the surface layer of the sediments, drawdown may retard the subsequent movement of phosphorus from the sediments. Sediment exposure may also curb sediment nutrient release by physically stabilizing the upper flocculent, sediment-water interface, zone of the sediments which plays an important role in the exchange reaction and mixing of the sediments with the overlying water. Drawdown may thus deepen the lake by dewatering and compacting the bottom sediments. The amount of compaction depends upon the organic content of the sediment, the thickness of sediment exposed above the water table, and the timing and duration of the drawdown.

Possible improvements resulting from a lake drawdown include reduced turbidity from wind action, improved game fishing, an opportunity to collect fish more effectively in fish removal programs, an opportunity to improve docks and dams, and an opportunity to clean and repair shorelines and deepen areas using conventional earth-moving equipment.

In contrast, depending on the timing and duration of the drawdown, drawbacks include loss of fish breeding habitat, loss of benthic food organisms, and disruption of waterfowl feeding and roosting patterns. Increased turbidity and unpleasant odors from rotting organic matter may occur during the period of the drawdown. Other adverse impacts of lake drawdown include algal blooms after reflooding, loss of use of the lake during the drawdown, changes in species composition, and a reduction in the density of benthic organisms following drawdown and reflooding. In some drawdown projects, it has been found that several years after reflooding, flocculent sediments began to reappear because of algae and macrophyte sedimentation. Therefore, to maintain the benefits of a drawdown project, the lake may have to be drawn down every five to 10 years to recompact any new sediments.

As noted above, the water level of Nagawicka Lake is controlled by an hydraulic control structure located on the southwestern shore of the Lake. A drawdown of up to about four feet could be obtained by opening the gate on the flume. A total breaching of the dam would allow a drawdown of approximately eight feet, exposing about 35 percent of the lake bottom. However, because of the unpredictability of the results, the impairment of recreational uses, and the temporary nature of the beneficial effects of a drawdown, drawdown is not recommended for Nagawicka Lake.

***Dredging***

Sediment removal is a restoration measure that is carried out using a variety of techniques, both land-based and water-based, depending on the extent and nature of the sediment removal to be carried out. For large-scale applications, a barge-mounted hydraulic or cutter-head dredge is generally used. For smaller-scale operations a shore-based drag-line system is typically employed. Both methods are expensive, especially if a suitable disposal site is not located close to the dredge site. Costs for removal and disposal begin at between $10 and $15 per cubic yard, with the cost of sediment removal alone beginning at between $3.00 and $5.00 per cubic yard. Effectiveness of dredging varies with the effectiveness of watershed controls in reducing or minimizing the sediment sources. Federal and State permits are required for use of this option. A recommended checklist provided by the Wisconsin Department of Natural Resources is included as Appendix B.

Dredging is the only restoration technique that directly removes the accumulated products of degradation and sediment from a lake system and can return a lake to a younger "age." If carried to the extreme, dredging can be used, in effect, to construct a new lake with a size and depth to suit the management objectives. Dredging has been used in other lakes to increase water depth; remove toxic materials; decrease sediment oxygen demand, prevent fish winterkills and nutrient recycling; restore fish breeding habitat; and decrease macrophyte growth. The objective of a dredging program at Nagawicka Lake would be to increase water depth to maintain recreational boating access and increased public safety.

Dredging may have serious, though generally short-term, adverse effects on the Lake. These adverse effects could include increased turbidity caused by sediment resuspension, toxicity from dissolved constituents released by the dredging, oxygen depletion as organic sediments mix with the overlying water, water temperature alterations, and destruction of benthic habitats. There may also be impacts at upland spoil disposal sites, such as odor problems, restricted use of the site, and disturbances associated with heavy truck traffic. In the longer term, disruption of the lake ecosystem by dredging can encourage the colonization of disturbed portions of the lakebed by less desirable species of aquatic plants and animals, including Eurasian water milfoil, which is present in Nagawicka Lake.

While dredging results in an immediate increase in lake depth, such increases may be short-lived if the sources of sediment being deposited in the lake are not controlled within the drainage area tributary to the lake. The sediment load reaching Nagawicka Lake comes primarily from urban and agricultural lands tributary to the Bark River and Nagawicka Lake. Further sediment may be generated from streambank erosion. Many of these sources can be effectively controlled through the adoption, implementation, and maintenance of recommended control measures within the watershed. Such practices should be implemented in concert with any sediment removal projects for maintenance of navigation channels in the Lake.

Dredging of lakebed material from navigable waters of the State requires a Wisconsin Department of Natural Resources Chapter 30 permit and a U.S. Army Corps of Engineers Chapter 404 permit. In addition, current solid waste disposal regulations define dredge material as a solid waste. Chapter NR 180 of the *Wisconsin Administrative Code* requires that any dredging project of over 3,000 cubic yards submit preliminary disposal plans to the Department of Natural Resources for review and potential solid waste licensing of the disposal site. Because sodium arsenite was applied to Nagawicka Lake in the 1950s and 1960s, sediment samples may need to be analyzed to determine the extent and severity of any residual arsenic contamination. However, based upon the sediment data set forth in the lake and watershed inventory, the sediments would not be considered too "heavily polluted," with only sediment concentrations of ammonia-nitrogen exceeding the Wisconsin Department of Natural Resources quality standards at some locations.

Dredging Nagawicka Lake could be accomplished with several different types of equipment, including a hydraulic cutterhead dredge mounted on a floating barge; or bulldozer and backhoe equipment if part of the Lake were drained; or a clamshell, or bucket, dragline dredge from the shoreline.

While the use of conventional earth-moving equipment and shore-based draglines has some advantages over hydraulic dredging, particularly since these methods would not require large disposal and dewatering sites in close proximity to the project area, these methods would benefit from the drawdown of the Lake. Reducing the water level in the Lake would be advantageous for dragline dredging because it would not require the removal of shoreland trees, resulting in less disturbance of the shoreline to provide access for trucks and equipment. Likewise, reduced water levels would allow conventional construction equipment access to the littoral portions of the waterbody. Nevertheless, given the potential recreational use impacts of a drawdown during the summer recreation season, use of these methods is not recommended.

Hydraulic cutterhead dredging is the most commonly employed method in the United States. The dredge is typically a rotating auger or cutterhead on the end of an arm that is lowered to the sediment-water interface. Sediment excavated by the cutterhead is pumped as a slurry of 10 to 20 percent solids by a centrifugal pump to the disposal site. This pumping usually limits the distance between the lake and disposal site to less than a mile, even using intermediate booster pumps. Because of the large volume of slurry produced, a relatively large disposal site is typically required. Water returned from the disposal site, whether returned to the lake or a stream, would have to meet effluent water quality standards of the State and would be subject to State permitting. Limiting the ability to dispose of dredge spoils in the Nagawicka Lake watershed is a 1997 resolution by the City of Delafield Common Council that established a five-year moratorium on disposal of dredge spoils within the Mission Avenue area of the City.

Notwithstanding, portions of the Lake are subject to siltation that limits recreational boating access to and from portions of the Lake. Assuming that a dredging project would seek to maintain recreational boating access to Nagawicka Lake in three defined areas of the Lake, the constructed channels located along the northwestern and northeastern shorelines of the Lake, in portions of Zastrow Bay, and in portions of St. John's Bay in the vicinity of the Bleeker Street public recreational boating access site, an estimated 65,000 cubic yards of material would potentially have to be removed. At a cost of between $5.00 and $15 per cubic yard, such a project would have a cost of between $325,000 and $975,000.

Because of the considerations noted above, extensive dredging of Nagawicka Lake is not considered a viable alternative at this time. However, some limited deepening of the navigational lanes noted above to permit the free flow of boating traffic is considered a viable alternative. Portions of the constructed channels adjacent to the northwestern shore of the Lake were dredged during 1998, as shown on Map 5.

**Fisheries and Aquatic Plant Management**

***Fisheries Management Measures***

Nagawicka Lake provides a quality habitat for a healthy, warmwater fishery. Currently adequate water quality, dissolved oxygen levels, sand and gravel shorelines, and diverse plant community exist for the maintenance of a

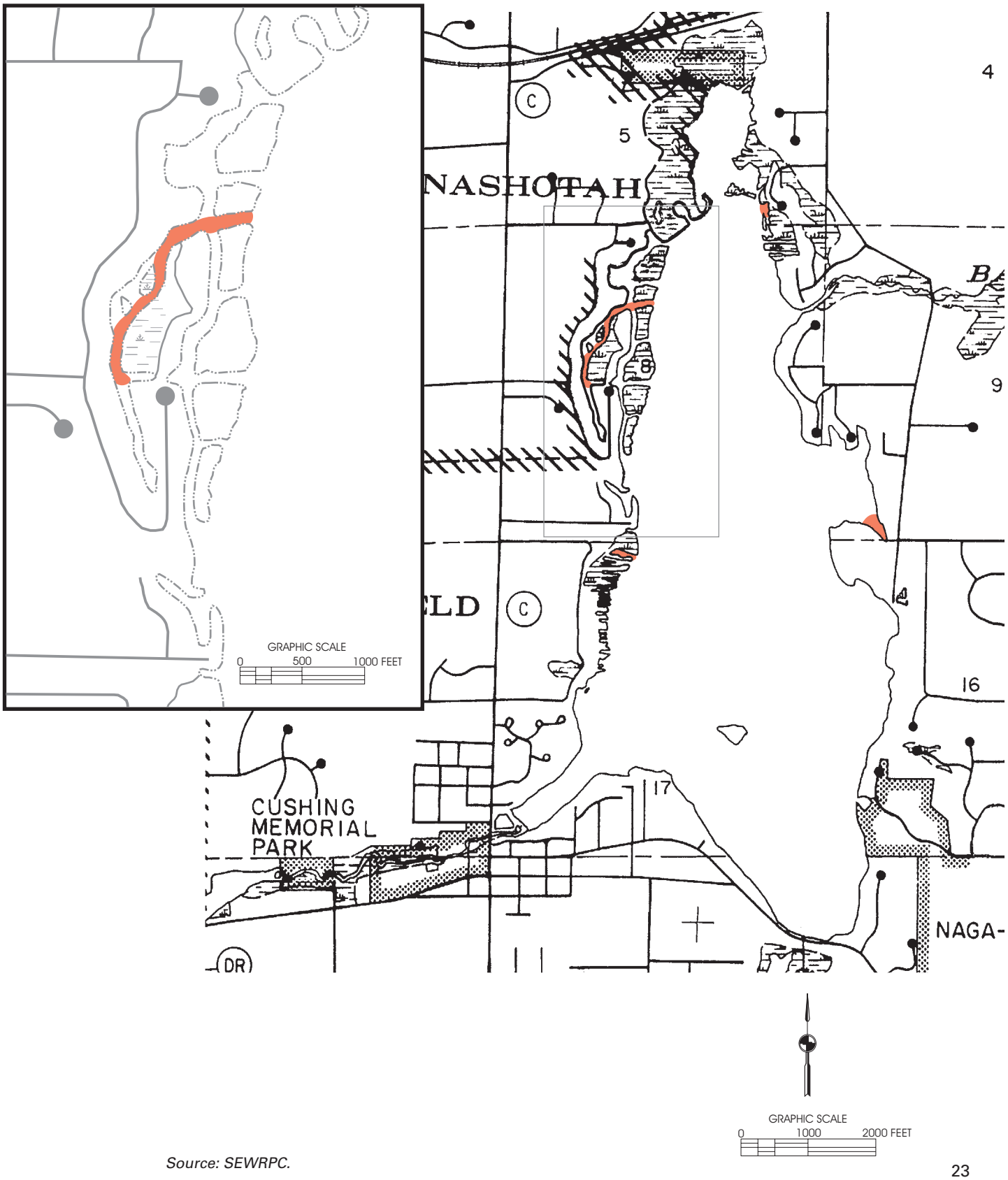
sportfish population in the Lake. Winterkill is not a problem. The Lake supports a good largemouth bass fishery, along with a wide range of sport and panfish. The pugnose shiner, a State Threatened Species, has been reported from the Lake.

*Habitat Protection*

Habitat protection refers to a range of conservation measures designed to maintain existing fish spawning habitat, including measures such as restricting recreational and other intrusions into gravel-bottomed shoreline areas during the spawning season. For bass this is mid-April to mid-June. Use of natural vegetation in shoreland management zones and other "soft" shoreline protection options aid in habitat protection. Costs are generally low, unless the habitat is already degraded. Modification of aquatic plant harvesting operations may be considered to

Map 5

SITES OF RECENT DREDGING PROJECTS CONDUCTED IN NAGAWICKA LAKE




*Source: SEWRPC.*

support restoration and protection of native aquatic plant beds and maintenance of fish breeding habitat during the early summer period. Effectiveness is variable depending in part on community acceptance and enforcement. Generally, it is more effective to maintain a good habitat than to restore a habitat after it is degraded.

Loss of habitat should be a primary concern of any fisheries management program. The environmentally valuable areas identified in the lake and watershed inventory are the most important areas to be protected. In addition, limiting or restricting certain activities in sensitive areas of the Lake will prevent significant disturbance of fish nests and aquatic plant beds. The areas are designated by the WDNR pursuant to authorities granted under Chapter NR 107 of the *Wisconsin Administrative Code*, and are shown on Map 6. Within these areas, aquatic plant controls measures are restricted and dredging, filling, and the construction of piers and docks is discouraged.

It should be noted that water level fluctuations can also alter fish habitat. The potential effects of any proposed perturbations in water levels on the fishery should be well-studied before considering implementation. Also, the importance of maintaining good water quality cannot be overemphasized as a fish habitat protection measure.

*Shoreline Maintenance*

Shoreline maintenance refers to a group of measures designed to reduce and minimize shoreline loss due to erosion by waves, ice, or related actions of the water. Currently, about 42 percent of the shoreline of Nagawicka Lake is protected by some type of structural measure. Four shoreline erosion control techniques were in use in 1997: vegetative buffer strips, rock revetments, wooden and concrete bulkheads, and beach. Maintenance of a vegetated buffer strip immediately adjacent to the Lake is the simplest, least costly, and most natural method of reducing shoreline erosion. This technique employs natural vegetation, rather than maintained lawns, within five to 10 feet of the lakeshore and the establishment of emergent aquatic vegetation from two to six feet lakeward of the shoreline.

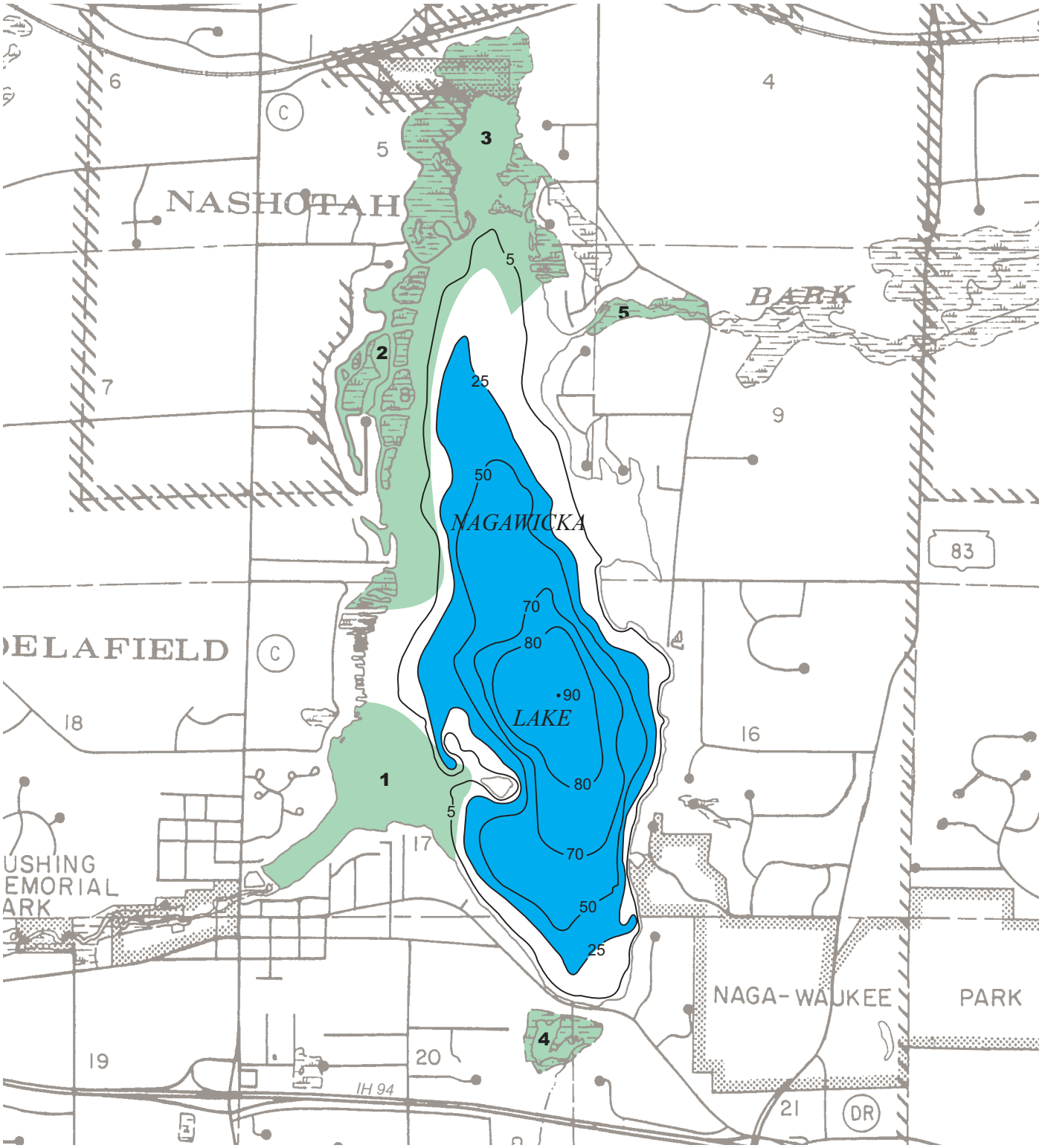
Desirable plant species which may be expected and encouraged to invade a buffer strip, or which could be planted, include arrowhead (*Sagittaria latifolia*), cattail (*Typha* spp.), common reed (*Phragmites communis*), water plantain (*Alisma plantago-aquatica*), bur-reed (*Sparganium eurycarpum*), and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

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

Wooden bulkheads prevent landslides or slope failures, and provide protection against wave action and, to a lesser extent, ice action. A series of horizontal boards are bolted to a series of vertical posts sunk into the soil at the

Map 6

WISCONSIN DEPARTMENT OF NATURAL RESOURCES-DELINEATED SENSITIVE AREAS IN NAGAWICKA LAKE




2 WISCONSIN DEPARTMENT OF NATURAL RESOURCES-DELINEATED SENSITIVE AREAS

—20′— WATER DEPTH CONTOUR IN FEET

DEPTH GREATER THAN 25 FEET

GRAPHIC SCALE
0 1000 2000 FEET

*Source: Wisconsin Department of Natural Resources.*

waterline. Alternatively, a close-set series of vertical poles three to six inches in diameter can be erected. A stone toe is usually provided on the lakeward side to protect against undercutting. A sunken cable tieback to an anchored "deadman" may be used to prevent the bulkhead from slipping towards the lake. Advantages of wooden bulkheads are that they provide substantial protection and maintain the shoreline in a fixed position. They are generally constructed of materials that are readily available. Nevertheless, bulkheads, depending on their type, may be less visually appealing than rock revetments, less flexible and more susceptible to ice damage, more difficult and expensive to repair, and a greater barrier to amphibians within the shoreland area than other shoreland stabilization structures. Wooden bulkhead involve a total capital cost of about $10 per linear foot. Use of wooden bulkheads is discouraged by the Wisconsin Department of Natural Resources.

Gabions are steel wire-mesh basket filled with rock. Gabions are commercially available in a variety of sizes and are constructed and filled with rocks at the site of placement. An underlying filter cloth prevents the erosion of finer particles from below and behind the gabion, while a rock "toe" may also be provided to prevent undercutting. The advantages of gabions are that they are flexible, relatively easy to construct, and are effective against ice movement. Gabions often become covered with vegetation, which adds to their visual appeal. The disadvantages of gabions are their relatively high cost, the potential for damage and breakage of the wire-mesh basket, and the considerable excavation needed to implant them. Gabions cost about $30 to $40 per linear foot.

Of these measures, the use of vegetated buffer strips and riprap is recommended. In those portions of the Lake subject to direct action of wind waves and ice scour, the use of riprap would provide a more robust means of stabilizing shorelines.

*Modification of Species Composition*

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

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

Nevertheless, consideration should be given to monitoring and surveying the current fishery. Based upon the data collected, recommendations for modification of the species composition of the fish community in the Lake may be found to be needed. Fish stocking is not recommended on Nagawicka Lake at this time.

*Regulations and Public Information*

To reduce the risk of overharvest, the Wisconsin Department of Natural Resources has placed restrictions on the number and size of certain fish species caught by anglers. The open season, size limits, and bag limits for the fish species of Nagawicka Lake are given in Table 3. Enforcement of these regulations is critical to the success of any sound fish management program.

Table 3

WISCONSIN STATE FISHING REGULATIONS: 2000-2001

| Species | Open Season | Daily Limit | Minimum Size |
|---|---|---|---|
| Northern Pike | May 6 to March 1 | 2 | 26 inches |
| Walleyed Pike | May 6 to March 1 | 5 | 15 inches |
| Largemouth and Smallmouth Bass | May 6 to March 1 | 5 | 14 inches |
| Bluegill, Pumpkinseed (sunfish), Crappie, and Yellow Perch | Open all year | 25 | None |
| Bullhead and Rough Fish | Open all year | None | None |

*Source: Wisconsin Department of Natural Resources Publication No. PUB-FH-301 00REV,* Guide to Wisconsin Hook and Line Fishing Regulations 2000-2001, *January 2000, and SEWRPC.*

***Aquatic Plant Management Measures***

Aquatic plant management refers to a group of management and restoration measures aimed at both removal of nuisance vegetation and manipulation of species composition in order to enhance and provide for recreational water use. Generally, aquatic plant management measures are classed into three groups: physical measures, which include lake bottom coverings and water level management; mechanical removal measures, which include harvesting and manual removal; and chemical measures, which include using aquatic herbicides and biological control measures, which include the use of various organisms, including insects. Of these, chemical and biological measures are stringently regulated and requires a State permit.

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

*Aquatic Herbicides*

Chemical treatment with aquatic herbicides is a short-term method of controlling heavy growths of aquatic macrophytes and algae. Chemicals are applied to the growing plants in either liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophyte growth are the relatively low cost and the ease, speed, and convenience of application. However, the disadvantages associated with chemical control include the following:

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

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

3. Since much of the dead plant materials are left to decay in the lake, nutrients contained in them are rapidly released into the water and fuel the growth of algae. The decomposition of the dead plant material also consumes dissolved oxygen and increases the potential for fish kills. Accretion of

additional organic matter in the sediments as a result of decomposition also increases the organic content of the soils and predisposes the sediments toward reintroduction of other (or the same) nuisance plant species. Long-term deposition of plant material may result in the need for other management measures, such as dredging.

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

5. Adverse impacts on other aquatic organisms may be expected. At the concentrations used for macrophyte control, Diquat has been known to kill the zooplankton *Daphnia* and *Hyalella*, both important fish foods. *Daphnia* is the primary food for the young of nearly all fish species found in the Region's lakes.[11]

6. Areas must be treated again in the following season and weedbeds may need to be treated more than once in a summer.

7. Many of the chemicals available are nonselective, often affecting nontarget, desirable species as well as the "weeds."

The advantages and disadvantages of chemical macrophyte control also apply to the chemical control of algae. Copper, the active ingredient in algicides, may accumulate in the bottom sediments, where excessive amounts are toxic to fish and benthic animals. Fortunately, copper is rapidly eliminated from human systems and few cases of copper sensitivity among humans are known.[12]

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

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

*Aquatic Plant Harvesting*

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

1. Harvesting removes the plants from the lake. The removal of this plant biomass decreases the rate of accumulation of organic sediment. A typical harvest of submerged macrophytes from eutrophic lakes in Southeastern Wisconsin can yield between 140 and 1,100 pounds of biomass per acre per year.[13]

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

[12] *J.A. Thornton, and W. Rast, "The Use of Copper and Copper Compounds as an Algicide,"* Copper Compounds Applications Handbook, *H.W. Richardson, ed., Marcel Dekker, New York, 1997.*

[13] *James E. Breck, Richard T. Prentki, and Orie L. Loucks, editors,* Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting, *Proceedings of Conference at Madison, Wisconsin, February 14-16, 1979.*

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

3. Repeated macrophyte harvesting may reduce the regrowth of certain aquatic macrophytes. The regrowth of milfoil has been reported to have decreased as harvesting frequency was increased.

4. Where dense growths of filamentous algae are closely associated with macrophyte stands, they may be harvested simultaneously.

5. The macrophyte stalks remaining after harvesting provide cover for fish and fish-food organisms, and stabilize the bottom sediment against wind erosion.

6. Selective macrophyte harvesting may reduce stunted populations of panfish in lakes where excessive cover has adversely influenced predator-prey relationships. By allowing an increase in predation on young panfish, both gamefish and the remaining panfish may show increased growth.[14]

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

The disadvantages of macrophyte harvesting include the following:

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

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

3. Fish, especially young-of-the-year bluegills and largemouth bass, as well as fish-food organisms, are frequently caught in the harvester. As much as 5 percent of the juvenile fish population can be removed by harvesting. A Wisconsin Department of Natural Resources study found that four pounds of fish were removed per ton of plants harvested.[15]

4. The reduction in aquatic macrophyte biomass by harvesting or chemical control can reduce the diversity and productivity of macroinvertebrate fish-food organisms feeding on the epibiota.[16] Bluegills generally move into the shoreline area after sunset, where they consume these macroinvertebrates. After sunrise they migrate to open water, where they graze, primarily on

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

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

[16] *Breck et al., op. cit.*

zooplankton.[17] If harvesting or chemical control shifts the dominance of the littoral macroinvertebrate fauna to sediment dwellers, the macroinvertebrate component of the bluegill diet could be restricted. This would increase predation pressure on zooplankton and reduce the growth rate of the panfish; it could eventually lead to undesirable ramifications throughout the food web in a lake.

5. Macrophyte harvesting may influence the community structure of macrophytes by favoring such plants as milfoil (*Myriophyllum* spp.) that propagate from cut fractions. This may allow these plants to spread into new areas through the rerooting of the cut fractions.

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

7. The efficiency of macrophyte harvesting is greatly reduced around piers, rafts, and buoys because of the difficulty in maneuvering the harvesting equipment in those restricted areas. Manual methods have to be used in these areas.

8. High capital and labor costs may be associated with harvesting programs. Macrophyte harvesting on Nagawicka Lake could be continued by the City of Delafield staff or be contracted to a private company. These costs are largely staff costs and operating costs such as fuel, oil, and maintenance. The cost of new harvesting equipment, when needed, would be about $100,000.

Various types of harvesters and harvesting practices are available to address the many issues encountered on Nagawicka Lake. The City of Delafield currently operates an aquatic plant harvester, primarily in St. John's Bay near the outlet of the Lake.

A harvesting program should be designed to provide optimal benefits and minimal adverse impacts. Small fish are common in dense macrophyte beds, but larger fish, such as largemouth bass, do no utilize these dense beds.[18] Narrow channels may be harvested to provide navigational access and "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish. "Shared access" lanes may also be cut, allowing several residents to use the same lane. Increased use of these lanes should keep them open for longer periods than would be the case if a less directed harvesting program was followed. "Clear cutting" of aquatic plants and denuding the lake bottom of flora should be avoided. Top cutting of plans such as Eurasian water milfoil, as shown in Figure 1, is suggested. The harvest of water lilies and other emergent native plants, however, should be avoided.

Protecting native aquatic plant communities from disturbances can help prevent Eurasian water milfoil from spreading within a lake. Recent studies show that native plants can effectively compete with Eurasian water milfoil. However, the exotic tends to out compete native plants when the lake's ecosystem is stressed. Stress can be brought on by watershed pollution, shoreline development, changing water levels, boating activity, carp, and aquatic nuisance controls.[19] This maintenance of a healthy aquatic plant community has been found to be the most efficient way of managing aquatic plants, as opposed to other means of managing problems once they occur. Furthermore, native aquatic plant communities contribute most effectively to the maintenance of good water

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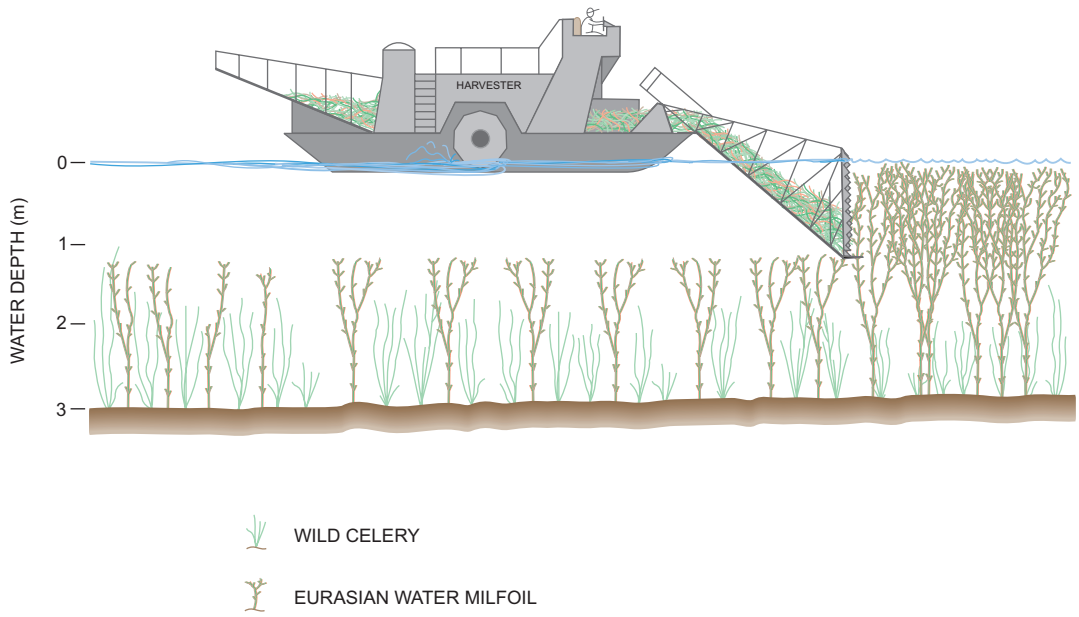
[17] *Breck et al., op. cit.*

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

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

**Figure 1**

**PLANT CANOPY REMOVAL WITH AN AQUATIC PLANT HARVESTER**




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

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

quality by providing suitable habitat for desirable fish and other aquatic organisms which promote stable or increased property values and quality of life.[20]

Because of the demonstrated need for control of aquatic plants in Nagawicka Lake, harvesting is considered a viable continued management option.

*Manual Harvesting*

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

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

*Biological Controls*

Another alternative approach to controlling nuisance weed conditions, in this particular case Eurasian water milfoil, is biological control. Classical biological control has been successfully used to control both weeds and herbivorous insects.[21] Recent documentation states that *Eurhychiopsis lecontei*, an aquatic weevil species, has the potential as a biological control agent for Eurasian water milfoil. In 1989, the weevil was discovered during a study investigating a decline of Eurasian water milfoil growth in a Vermont pond. *Eurhychiopsis* proved to have significant negative effects on Eurasian water milfoil in the field and in the lab. The adult weevil feeds on the milfoil causing lesions which make the plant more susceptible to pathogens, such as bacteria or fungi, while the weevil larvae burrows in the stem of the plant causing enough tissue damage for the plant to lose buoyancy and collapse.[22] The few studies that have been done since that time have indicated the following potential advantages to use of this weevil as a means of Eurasian water milfoil control:

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

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

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

The potential disadvantages of using *Eurhychiopsis lecontei* include:

1. The studies done on *Eurhychiopsis* are very recent and more tests are necessary to determine if there are significant adverse effects.[23]

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

Relatively few studies have been completed using *Eurhychiopsis lecontei* as a means of aquatic plant management control. These have resulted in variable levels of control, and, while priced competitively with aquatic herbicides, is not recommended as being practical for Nagawicka Lake at this time.

*Lake Bottom Covering*

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

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[21]*C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities, *1984, pp. 659-696; C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology, *John Wiley, New York, New York, USA.*

[22]*Sally P. Sheldon, "The Potential for Biological Control of Eurasian Water Milfoil (*Myriophyllum spicatum*) 1990-1995 Final Report," Department of Biology Middlebury College, February 1995.*

[23]*The use of Eurhychiopsis on an experimental basis to control Eurasian water milfoil is being monitored in selected Wisconsin lakes by the Wisconsin Department of Natural Resources and the University of Wisconsin-Stevens Point from 1995 through 1998.*

The advantages of bottom covers and screens are that control can be confined to specific areas, the covers and screens are usually unobtrusive and create no disturbance on shore, and the covers are relatively easy to install over small areas. The disadvantages of bottom covers and screens are that they do not reduce eutrophication of the lake, they are expensive, they are difficult to spread and anchor over large areas or obstructions, they can slip on steep grades or float to the surface after trapping gases beneath them, and they may be difficult to remove or relocate.

Screens and covers should not be used in areas of strong surfs, heavy angling, or shallow waters where motorboating occurs. They should also not be used where aquatic vegetation is desired for fish and wildlife habitat. To minimize interference with fish spawning, screens should be placed before or after spawning. A permit from the Wisconsin Department of Natural Resources is required for use of sediment covers and light screens. Permits require inspection by the Department staff during the first two years, with subsequent permits issued for three-year periods.

The estimated cost of lake bottom covers that would control plant growth along a typical shoreline property, an area of about 700 square feet, ranges from $100 for burlap to $300 for aquascreen. Because of the limitations involved, lake bottom covers as a method to control aquatic plant growth are not recommended for Nagawicka Lake.

*Public Informational Programming*

Aquatic plant management usually centers on the eradication of nuisance aquatic plants for the improvement of recreational lake use. The majority of the public views all aquatic plants as “weeds” and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impacts. Thus, public information is an important component of an aquatic plant management program and should include information and education on:

1. The types of aquatic plants in Nagawicka Lake and their value to water quality, fish, and wildlife.

2. The preservation of existing stands of desirable plant species.

3. The identification of nuisance species and the methods of preventing their spread.

4. Alternative methods for controlling existing nuisance plants including the positive and negative aspects of each method.

An organized aquatic plant identification/education day is one method of providing hands-on education to lake residents. Such an event was organized by Cushing Elementary School in the City of Delafield during 1998 as part of the School’s Lake A’Fair. Other sources of information and technical assistance include the Wisconsin Department of Natural Resources and the University of Wisconsin-Extension Service. The aquatic plant species list provided in Chapter V of the lake and watershed inventory may serve as a checklist for individuals interested in identifying the plants near their residences. Residents can observe and record changes in the abundance and types of plants in their part of a lake on an annual basis.

Of the submerged floating and free-floating aquatic plant species found in Nagawicka Lake, Eurasian water milfoil is one of the few species likely to cause lake-use problems. Eurasian water milfoil, unlike most aquatic plants, can reproduce from fragments and often forms dense, monotypical beds with little habitat value for fish or waterfowl. Residents should be encouraged to collect fragments that wash ashore after storms, from weekend boat traffic, and after harvesting. The plant fragments can be used as mulch on flower gardens or ornamental planting areas. Likewise, lake users should be encouraged to inspect boats and trailers both prior to launch and following recover as Eurasian water milfoil and other aquatic plants can be transported between lakes as fragments on boats and boat trailers. To prevent unwanted introductions of plants into lakes, boaters should remove all plant fragments from their boats and trailers when exiting the lake. Providing the opportunity for the removal of plant fragments at the boat landing on Nagawicka Lake, and provision of signage at the boat landing, including

provision of disposal containers at the boat landing, may help motivate boaters to utilize this practice. Posters and pamphlets are available from the Wisconsin Department of Natural Resources and University of Wisconsin-Extension Service that provide information and illustrations of milfoil, discuss the importance of removing plant fragments from boats, and remind boaters of their duty in this regard.

**Recreational Use Management**

Regulatory measures provide a basis for controlling lake use and use of the shorelands around a waterbody. On land, shoreland zoning, requiring set backs and shoreland buffers can protect and preserve views both from the water and from the land, control development around a lake to minimize its environmental impacts and manage public and private access to a waterbody. On water, recreational use zoning can provide for safe and multiple-purpose use of lakes by various groups of lake users and protect environmentally sensitive areas of a lake. Use zoning can take the form of allocating times of use, such as the annual fishing season established by the State. A key issue in zoning a waterbody for use is equity; the same rules must apply to both riparian owners/residents and off-lake users. This condition is usually met in situations where use zoning is motivated by the protection of fish habitat, for example, as both on- and off-lake users would appreciate an enhanced fishery. Costs are relatively low, associated with creating and posting the ordinance, and effectiveness can be good with regular/consistent enforcement. Costs increase for measures requiring buoyage.

Although Nagawicka Lake is currently subjected to intensive recreational pressures at times, the use of recreational zoning is not considered a viable management measure at this time.

**Public Informational Programming**

Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the recreational use and shoreland zoning regulations, are available from the University of Wisconsin-Extension Service, the Wisconsin Department of Natural Resources, and the Waukesha County Department of Parks and Land Use. These latter cover topics, such as beneficial lawn care practices and household chemical use guidelines. These brochures could be provided to homeowners through local media, direct distribution or targeted school displays. Other Waukesha County lake organizations, in cooperation with the Waukesha County Department of Parks and Land Use, have compiled and distributed information packets to landowners on water quality protection measures and residential "good housekeeping" practices. A lake fair, such as that held by the Cushing Elementary School in the City of Delafield during 1998, could provide a venue for the distribution of materials of an environmental nature. Such activities could also raise public interest in the activities of the City of Delafield Lake Welfare Committee. Many of the foregoing ideas can be integrated into ongoing, larger-scale municipal activities such as anti-littering campaigns, recycling drives, and similar pro-environment activities.

Finally, the participation of Nagawicka Lake in the Wisconsin Department of Natural Resources Ambient Lakes Monitoring Program should be continued. In addition, the data acquired under this program could be supplemented by volunteer monitoring under the auspices of the WDNR "Self-Help Monitoring Program," which involves citizens in taking Secchi-disk transparency readings in the Lake at regular intervals. The Lake Coordinator of the Wisconsin Department of Natural Resources-Southeast Region could assist in enlisting volunteers in this program. The information gained at first hand by the public during participation in this program increases the credibility of the proposed changes in the nature and intensity of use to which the Lake is subjected.

**Institutional Development**

While lake management activities fall under the general powers of municipalities, in the case of the City of Delafield, management and control of navigable waters is established pursuant to Section 62.11(5), *Wisconsin Statutes*, and, in the case of the Village of Nashotah, pursuant to Section 61.34(1), *Wisconsin Statutes*, other public and private organizational alternatives for the management of lakes in the State of Wisconsin exist.[24] Private lake organizations have the option to be incorporated, generally as nonstock, not-for-profit corporations

[24]*See University of Wisconsin-Extension Publication No. G3216,* The Lake in Your Community*, 1986.*

under Chapter 181, *Wisconsin Statutes*. Public lake organizations include special-purpose units of government that are created generally as public inland lake protection and rehabilitation districts under Chapter 33, *Wisconsin Statutes*, although some sanitary districts and utility districts created pursuant to the municipal statutes also engage in lake management activities. The specific type of organizations created is based upon the decision of the community.

In the case of Nagawicka Lake, general oversight of lake management activities is provided by the City with the advisory input from the City of Delafield Lake Welfare Committee. Created by the City of Delafield by Resolution No. 87.12, the City of Delafield Lake Welfare Committee is tasked with the study of "problems and issues relating to Nagawicka Lake and/or the Bark River within the City limits." The Committee was formed of aldermanic and citizen members, appointed by the Mayor with the approval of the City Council. Citizens from the Village of Nashotah have been invited by the Committee Chairman to serve on this Committee in an *ex officio* capacity.

***Private Lake Organizations***

Private lake organizations are voluntary. Such organizations have the advantage that there are few restrictions imposed upon the types of activities in which they engage, subject to relevant permits and laws. Incorporated associations generally have a somewhat greater number of restrictions imposed upon them, but may be considered qualified associations for purposes of obtained State cost-share grants. Because of their voluntary nature, membership levels, and, therefore, income levels, of associations often fluctuate from year-to-year. Notwithstanding, a number of private associations with interests in lake management exist around Nagawicka Lake. These organizations are generally associated with subdivisions and have broader mandates than solely lake issues, although these may be important to the association memberships.

***Public Lake Organizations***

Public inland lake protection and rehabilitation districts, or lake districts, are public governmental units formed for the specific purpose of managing and protecting lake water quality. Inclusion in the district, once the district is created, is mandatory; registered voters and persons owning property within the district become the electors of the district for purposes of governance. Lake management districts have the capability of raising public funds subject to majority approval of the district budget at the annual meeting of the district. For this reason, lake management districts can provide a more stable financial base from which to undertake lake management activities. Often, lake associations and lake districts operate in harmony around lakes throughout Wisconsin. Although creation of a lake management district around Nagawicka Lake has been discussed on a number of occasions, it has generally been felt by the community that the Lake Welfare Committee is an effective means of addressing lake management concerns within the City of Delafield.

Nevertheless, given that Nagawicka Lake lies within two municipal jurisdictions, concerns have arisen with regard to the degree to which the City of Delafield Lake Welfare Committee can effectively operate on a lakewide basis. To date, this operation is effected through the inclusion of citizens from the Village of Nashotah within the Committee structure, and through negotiation between the City of Delafield and Village of Nashotah both at the level of municipal staff and at the level of the City Council and Village Board.

Section 33.25, *Wisconsin Statutes*, provides for the formation of public inland lake protection and rehabilitation districts by petition. In the case of the Nagawicka Lake community, such a petition would be directed to Waukesha County, as the Lake falls within multiple municipalities. This petition would have to identify a name for the proposed district, define the boundaries of the district, and contain the signatures 51 percent of the land owners or those of the owners of 51 percent of the land within the proposed district. In addition, the petition should set forth the necessity for the district, the basis upon which a district is being formed and the reason why a district is necessary, and the purpose that the district will serve, that the district will promote the public health,

convenience, necessity, or public welfare and benefit the lands being included within the district.[25] In the case of Nagawicka Lake, an additional requirement applicable to the formation of a district, set forth in Section 33.24, *Wisconsin Statutes*, would be that approvals have to be obtained from the City of Delafield and Village of Nashotah for inclusion of their territory within the proposed district prior to the petition to form a lake management district being submitted to Waukesha County for consideration.

Another consideration relating to the definition of a lake management district boundary are the extent to which the drainage area tributary to a lake is included in a district. It is rarely practical to include a lake's total tributary drainage area within a lake management district, and, in the case of Nagawicka Lake, not feasible, given the extent of the total drainage area tributary to the Lake. Guidance provided by the University of Wisconsin-Extension recommends that consideration be given to district boundaries, including the entire lakeshore, all riparian property, areas directly affecting the lake and/or which are included in planned service areas, and entire parcels be included.[26] Pursuant to this guidance, therefore, should a lake management district be considered around Nagawicka Lake, one option would be to include riparian properties and subdivisions surrounding the Lake within the proposed district. In general, these properties lie within a boundary demarcated by CTH DR to the south, STH 83 to the east, STH 16 to the north, and CTH C to the west, as shown on Map 7.[27]

Alternatively, a district boundary could be drawn to more closely follow the lakeshore. Such a boundary could be demarcated by Milwaukee Street in the south; Golf Road in the southeast; STH 83 (Hartland Road), and Nagawicka Road in the east; Rasmus Road in the north; and CTH C (Lakeland Drive), Nashotah Avenue, Nagawicka Avenue, Mission Avenue, Lakeland Drive, West Shore Drive, and Lakeland Drive in the west, as shown on Map 8.

Consideration of the creation of a public inland lake protection and rehabilitation district is recommended. Nevertheless, creation of such a district would be contingent upon need. Such a need does not currently exist, and may not arise, especially should the City of Delafield provide a substantive role for the Lake Welfare Committee in the management of development within the direct drainage area and shoreland zone as indicated above.

***Other Organizational Options***

As noted above, some sanitary districts and/or utility districts within Wisconsin have become involved in lake management activities. The Nagawicka Lake community is served by a sanitary sewerage system operated by the City of Delafield and connected to the Delafield-Hartland Water Pollution Control Commission sewerage system for treatment purposes. This Commission is solely responsible for the conveyance and treatment of wastewaters conveyed to their facilities by participating municipalities. Unlike other special-purpose units of government within lake-oriented communities, such as the Lake Pewaukee Sanitary District and Delavan Lake Sanitary District, the Delafield-Hartland Water Pollution Control Commission has not previously taken an active role in lake management. A future role for the Commission, outside of its current wastewater conveyance and treatment mandate, is unlikely.

Notwithstanding, the City of Delafield has expressed some interest in the creation of utility district to operate stormwater management and conveyance systems within specific subbasins located within the City. In particular,

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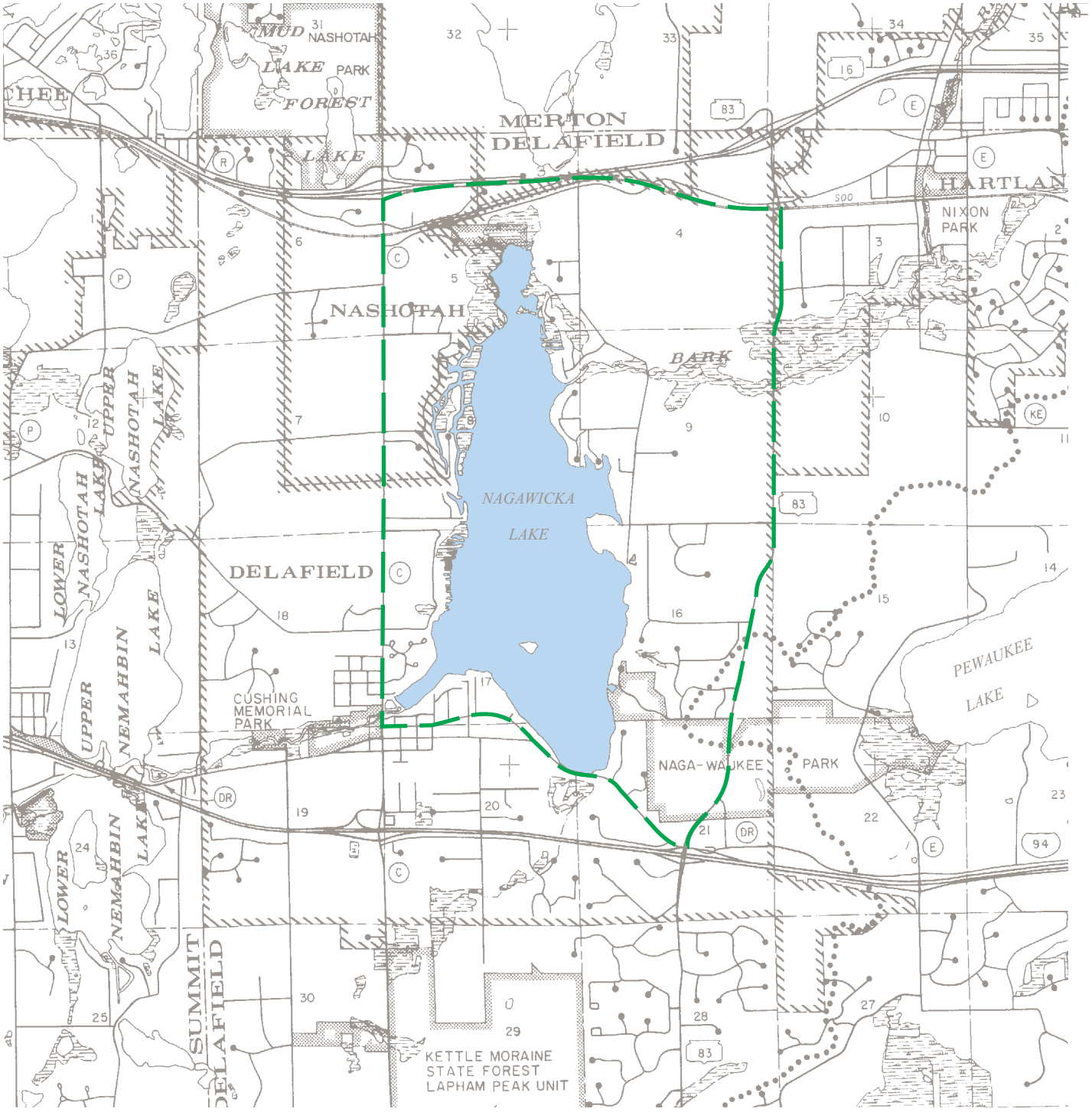
[25]*Benefit has been defined in terms of the benefit to the district of having particular lands included within the district boundaries, rather than the benefit to the individual landowner. See University of Wisconsin-Extension,* Guide to Wisconsin's Lake Management Law, Tenth Edition, *1996.*

[26]*University of Wisconsin-Extension,* Guide to Wisconsin's Lake Management Law, Tenth Edition, *1996.*

[27]*Use of these major highways to demarcate the District boundaries would include portions of the Village of Hartland and the Village of Chenequa.*

Map 7

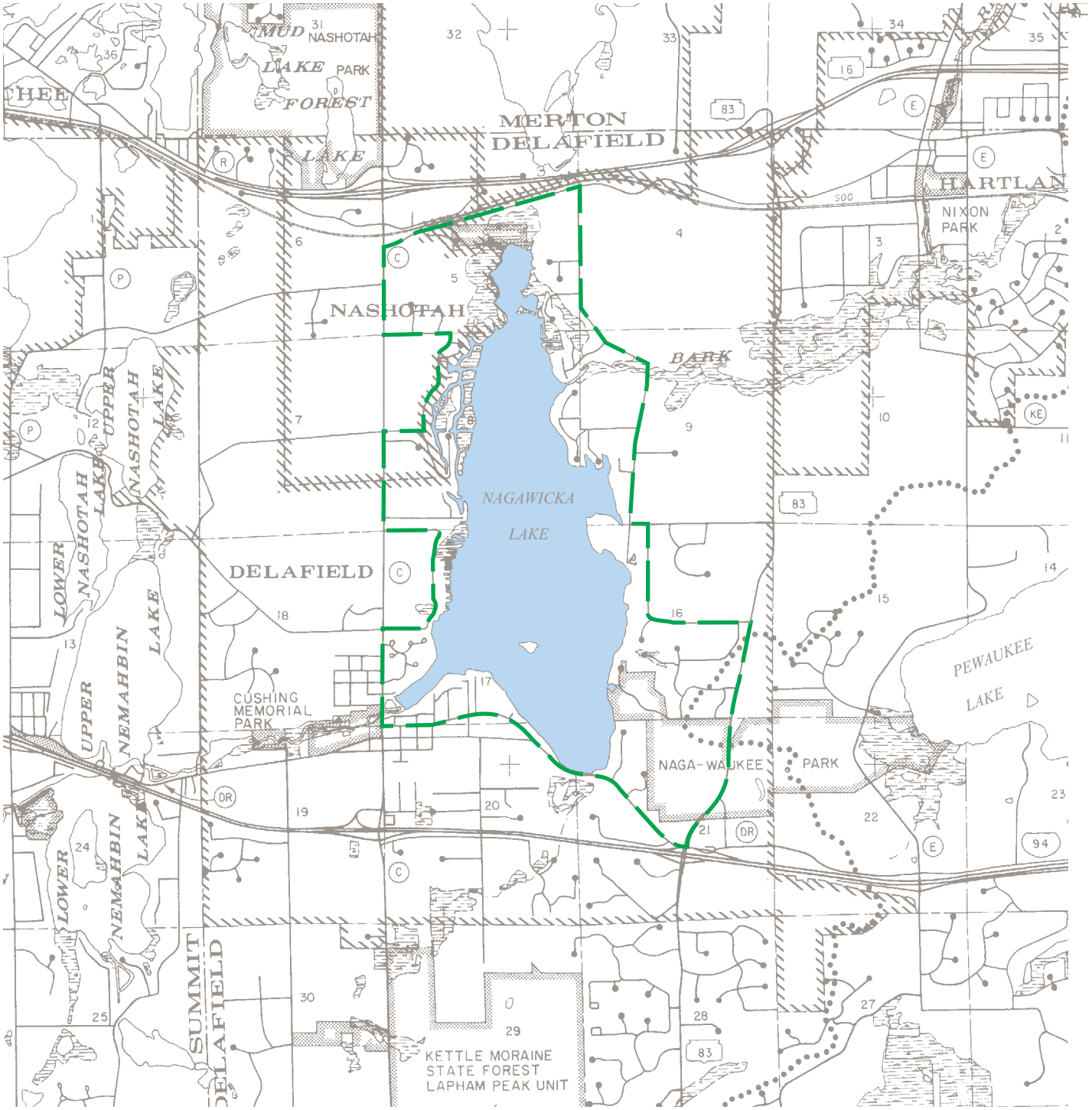
POTENTIAL LAKE MANAGEMENT DISTRICT BOUNDARY FOR NAGAWICKA LAKE




*Source: SEWRPC.*

Map 8

ALTERNATIVE LAKE MANAGEMENT DISTRICT BOUNDARY FOR NAGAWICKA LAKE




*Source: SEWRPC.*

the concept of creation a stormwater utility to operate and maintain stormwater conveyance and pollution control facilities in the vicinity of the STH 83 and IH 94 interchange, within the subbasin designated BR-28 in the regional water quality management plan, has been mooted. As of early 2001, this alternative was under consideration by the City of Delafield Public Works Committee as one element in the preparation of a stormwater management plan for this subbasin. While such a special-purpose district is may be created for the purpose of controlling stormwater runoff and quality in critical subbasins, stormwater utility districts are unlikely to have the capacity to engage in lake management activities.

## SUMMARY

This chapter has described options that could be employed in managing the types of problems recorded as occurring in Nagawicka Lake and which could, singly or in combination, assist in achieving and maintaining the water quality and water use objectives set forth in Chapter VI of the lake and watershed inventory. Selected characteristics of these measures are summarized in Table 4.

An evaluation of the potential management measures for improving the Nagawicka Lake water quality was carried out on the basis of the effectiveness, cost, and technical feasibility of the measures. Those alternative measures not considered further at this time are: phosphorus precipitation and inactivation, in-lake nutrient load reduction by dredging, drawdown by water level control modifications, biological control of aquatic plants, lake bottom covering, fish stocking, and recreational use zoning. The remaining measures were recommended to be considered further for incorporation in the recommended plan described in Chapter IV.

## Table 4

## SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR NAGAWICKA LAKE

| Alternative Measure | Description | Estimated Costs: 2000 | | Considered Viable for Inclusion in Recommended Lake Management Plan |
|---|---|---|---|---|
| | | Capital | Operation and Maintenance | |
| Land Use Management | Implement regional land use and county development plan within watershed | - - | - - | Yes |
| | Maintain existing density management in lakeshore areas | - - | - - | Yes |
| | Develop and implement consistent stormwater management ordinances in all riparian communities | - - | - - | Yes |
| Protection of Environmentally Sensitive Lands | Implement regional natural areas and critical species habitat protection and management plan recommendations within watershed | - - | - - | Yes |
| Rural Nonpoint Source Pollution Control | Encourage conservation tillage, contour farming, contour strip cropping, crop rotation, grassed waterways, and pasture and streambank management in agricultural areas of the watershed | - -[a] | - -[a] | Yes |
| Urban Nonpoint Source Pollution Control | Promote urban housekeeping practices, public educational programming, and grassed swales | - -[a] | - -[a] | Yes |
| Construction Site Erosion Control | Enforce construction site erosion control ordinances requiring soil stabilization, surface roughening, barriers, diversion swales, sediment traps and basins | $250 per acre | $25 per acre | Yes |
| Sanitary Sewerage System Management | Implement onsite sewage disposal system management, including inspection and maintenance | - - | $100[b] | Yes |
| Water Quality Improvement | Conduct alum treatment to achieve phosphorus inactivation in lake sediments | - - | $115,000 | No |
| | Promote nutrient load reduction within the Lake basin through sediment management | - - | Variable | No |
| Hydraulic and Hydrologic Management | Modify outlet control operations | - - | - - | No[c] |
| | Drawdown | - - | - - | No |
| | Dredging | - -[c] | $325,000 to $975,000 | Yes[e] |

**Table 4 (continued)**

| Alternative Measure | Description | Estimated Costs: 2000 | | Considered Viable for Inclusion in Recommended Lake Management Plan |
|---|---|---|---|---|
| | | Capital | Operation and Maintenance | |
| Fisheries Management | Protect fish habitat | - - | - - | Yes |
| | Maintain shorelines and littoral zone fish habitat | - - | - - | Yes |
| | Modify species composition through stocking or selective removal of fishes | - - | - - | No |
| | Enforce size and catch limit regulations | - - | $1,200 | Yes |
| Aquatic Plant Management | Use aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife | - - | Variable | Yes[f] |
| | Harvest aquatic plants to provide boating access lanes and fish lanes; remove Eurasian water milfoil canopy to promote growth of native plants | $100,000 | $22,000 | Yes[g] |
| | Manual harvesting of aquatic plants from around docks and piers | $100 | - - | Yes |
| | Employ biological controls using inocula of Eurasian water milfoil weevils | - - | Variable | No |
| | Use sediment covers to shade out aquatic plant growth around piers and docks | - - | $40 to $220 per 700 square feet | No |
| | Conduct public information and education programming on aquatic plants and options for their management | - - | $100 to $300 | Yes |
| Recreational Use Management | Enforce boating regulations to maximize public safety; improve signage | - - | $1,000[h] | Yes |
| | Develop time and/or space zoning schemes to limit surface use conflicts | - - | - - | No |
| Public Informational and Educational Programming | Public informational and educational programming | - - | $1,200 | Yes |
| Institutional Development | Create a lake association for Nagawicka Lake residents | - - | - - | No[i] |
| | Create a public inland lake protection and rehabilitation district serving Nagawicka Lake | - - | - - | No |
| | Consider other organizational options such as utility districts or a lake management role for the sanitary district | - - | - - | No |
| | Continue an advisory role for the City of Delafield Lake Welfare Committee within the City | - - | - - | Yes |

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

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

**Table 4 (continued)**

[c]*While no change to the current operational regime of the Nagawicka Lake dam is suggested, a review and evaluation of the operational regime is recommended to be conducted as part of an hydraulic and hydrologic study of the entire Bark River system.*

[d]*Capital costs would be incurred should the City if Delafield determine to purchase an hydraulic dredge to be operated by City staff: capital costs would be about $200,000, depending on the size of the equipment obtained.*

[e]*To be determined on a case-by-case basis, on a small-scale basis, no general dredging of Nagawicka Lake is anticipated; maintenance of constructed channels and recreational boating access from public launch sites is recommended.*

[f]*In limited areas when found necessary to supplement harvesting and control exotic, invasive species.*

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

[h]*Cost for improved signage.*

[i]*Several property owner associations exist around Nagawicka Lake; these associations are expected to continue to operate and form valuable systems for delivery of informational programming to lake residents.*

*Source: SEWRPC.*

# Chapter IV

# RECOMMENDED MANAGEMENT PLAN FOR NAGAWICKA LAKE

## INTRODUCTION

This chapter presents a recommended management plan, for Nagawicka Lake. The plan is based upon inventories and analyses of land use and land and water management practices, pollution sources in the drainage area tributary to Nagawicka Lake, the physical and biological quality of the waters of the Lake, land use and population forecasts, and an evaluation of alternative lake management measures. The recommended plan sets forth means for: 1) providing water quality conditions suitable for full-body contact recreational use and the maintenance of healthy communities of warmwater fish and other aquatic life, 2) reducing the severity of existing or perceived problems which constrain or preclude desired water uses, 3) improving opportunities for water-based recreational activities, and 4) protecting environmentally sensitive areas. The elements of the recommended plan were selected from among the alternatives described in Chapter III, and evaluated on the basis of which of the feasible alternatives may be expected to best meet lake management objectives.

Analyses of water quality and biological conditions indicate that the general condition of the water of Nagawicka Lake is good. There appear to be few impediments to water-based recreation, although access by recreational watercraft is limited in some portions of the Lake by water depths and growths of aquatic macrophytes. Nevertheless, based upon a review of the inventory findings and consideration of planned developments within the drainage area tributary to the Lake, as set forth in the adopted Waukesha County development plan, measures will be required to protect and maintain the high quality of the Lake for future lake users. Therefore, this plan sets forth recommendations for: land use management in the drainage area tributary to Nagawicka Lake, protection of environmentally sensitive lands, water quality improvement, hydraulic and hydrologic management, fisheries and aquatic plant management, and informational programming. These measures complement and refine the watershedwide land use controls and management measures recommended in the adopted regional water quality management plan[1] and the Washington and Waukesha Counties land and water resource management plans.[2]

The recommended management measures for Nagawicka Lake are graphically summarized on Map 9, and are listed in Table 5. The recommended plan measures are more fully described in the following paragraphs. It should be noted that recreational use management and institutional development measures were also considered in developing this management plan, but were not included within the recommended management plan at this time. The recommended management agency responsibilities for watershed land management also are set forth in Table 5.

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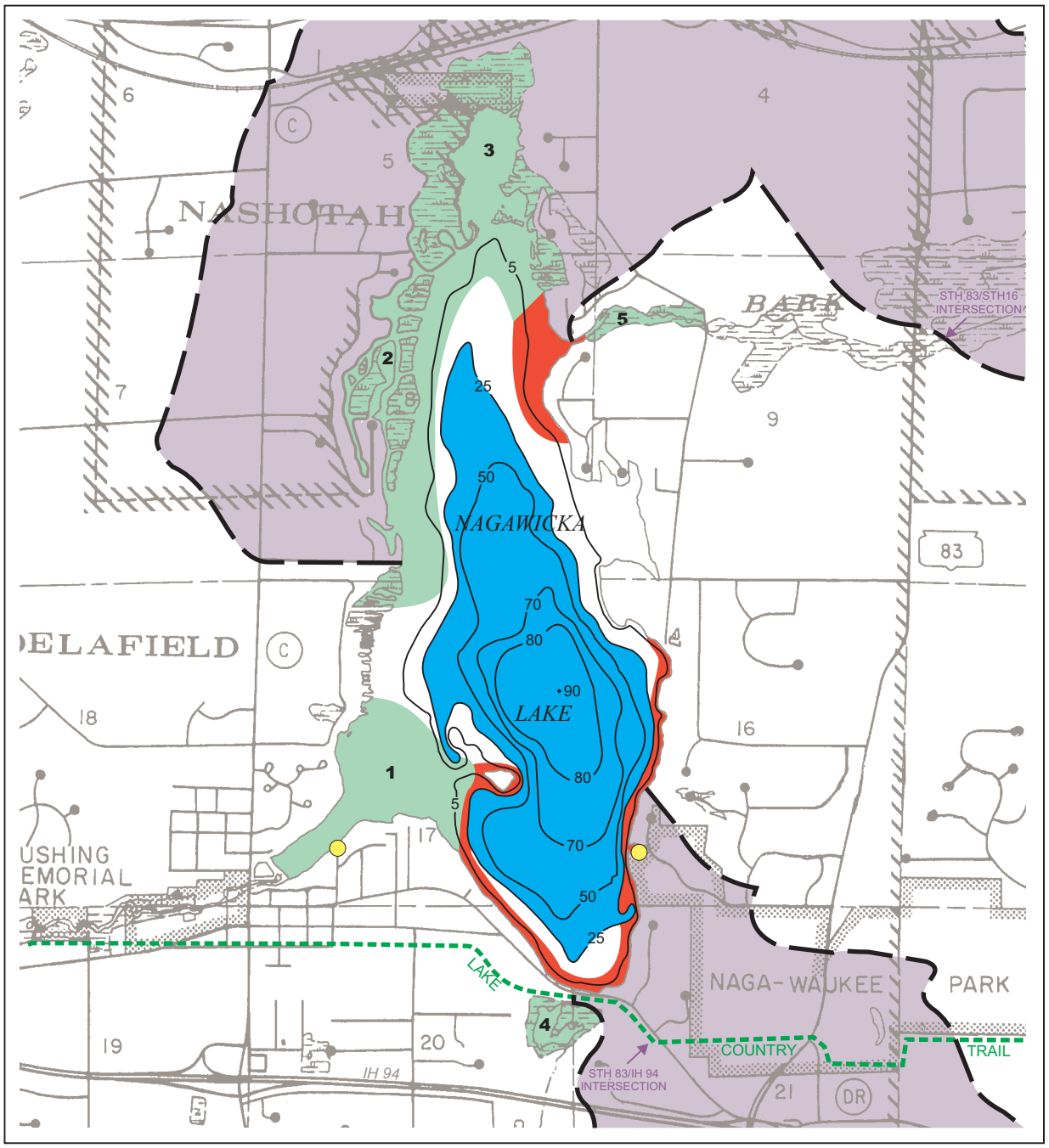
[1] *SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume Three,* Recommended Plan, *June 1979.*

[2] *Waukesha County,* Land and Water Resource Management Plan: 1999-2002, *December 1998; and Washington County,* Land and Water Resource Management Plan: 2000-2005, *August 2000.*

Map 9

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR NAGAWICKA LAKE




—5— WATER DEPTH CONTOUR IN FEET

AQUATIC PLANT MANAGEMENT

2 WISCONSIN DEPARTMENT OF NATURAL RESOURCES-DELINEATED SENSITIVE AREAS: RECOMMENDED TO BE RE-EVALUATED AND REFINED IN SELECTED AREAS

NUISANCE AQUATIC PLANT MANAGEMENT CONTROL RECOMMENDED IN THESE AREAS

OPEN WATER, DEPTH GREATER THAN 25 FEET

LAND USE MANAGEMENT

STORMWATER MANAGEMENT, DRAINAGE AND POLLUTANT REDUCTION RECOMMENDED TO BE DEVELOPED AS PART OF DETAILED STORMWATER MANAGEMENT PLANS IN THESE AREAS

- PROTECT ENVIRONMENTALLY VALUABLE AREAS
- MAINTAIN EXISTING SHORELINE STRUCTURES
- IMPLEMENT WAUKESHA COUNTY DEVELOPMENT PLAN AND REGIONAL LAND USE PLAN IN WASHINGTON COUNTY AND PROMOTE GOOD HOUSEKEEPING PRACTICES IN DRAINAGE AREA

MONITORING PROGRAM

- CONDUCT FISH SURVEY
- CONTINUE WATER QUALITY MONITORING
- REFINE AQUATIC PLANT SURVEY AT THREE- TO FIVE-YEAR INTERVALS

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

RECREATIONAL BOATING ACCESS

- PUBLIC BOAT ACCESS
- MAINTAIN NAVIGATION CHANNELS AS NECESSARY, SUBJECT TO WISCONSIN DEPARTMENT OF NATURAL RESOURCES PERMITS

WATER LEVEL MANAGEMENT

- SUPPORT BARK RIVER BASIN HYDRAULIC AND HYDROLOGIC STUDY; MAINTAIN EXISTING LAKE LEVELS

GRAPHIC SCALE
0 1000 2000 FEET

 *Source: SEWRPC.*

Table 5

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR NAGAWICKA LAKE

| Plan Element | Subelement | Location | Management Measures | Management Responsibility |
|---|---|---|---|---|
| Land Use Control and Management | Land use development planning | Entire watershed | Observe guidelines set forth in the regional land use plan and Waukesha County development plan | Washington County Waukesha County, City of Delafield, Village of Hartland, Village of Nashotah, Town of Delafield |
| | Density management | Lakeshore areas | Maintain historic lake front residential dwelling densities to extent practicable | City of Delafield, Village of Nashotah |
| | Shoreland development | Lakeshore areas | Review of shoreland development proposals by the City of Delafield and the City Plan Commission with advice from the City Lake Committee | City of Delafield |
| | Stormwater management plan development | STH 83 and IH 94 intersection | Consider practices to moderate flooding upstream of Lake Country Trail and reduce contaminant inputs to Lake from urban development around the STH 83 and IH 94 intersection area | City of Delafield, Town of Delafield |
| | | Mission Avenue extended stormwater outfall | Consider practices to reduce the sediment loads into Nagawicka Lake from the Mission Avenue extended stormwater outfall by reviewing and updating stormwater management practices | Village of Nashotah |
| | | STH 83 and STH 16 intersection | Consider practices to reduce contaminant loads to Nagawicka Lake from urban development upstream of the STH 83 and STH 16 intersection | City of Delafield, Village of Hartland |
| | Environmentally sensitive lands | Bark River wetlands and The Kettle | Establish adequate protection of wetlands and shorelands as set forth in the regional natural areas and critical species habitat protection and management plan | Waukesha County, City of Delafield, Village of Hartland, Village of Nashotah |
| Surface Water Quality and Quantity Management | Water quality monitoring | Entire Lake | Continue participation in WDNR Programs | WDNR, City of Delafield, |
| | Water quantity monitoring, analysis, and planning | 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, SEWRPC, WDNR |
| Nonpoint Source Pollution Control | Rural nonpoint source controls | Entire watershed | Promote sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans | USDA, WDATCP, Washington County, Waukesha County |
| | Urban nonpoint source controls | Entire watershed | Promote sound urban housekeeping and yard care practices through informational programming | City of Delafield, Village of Hartland, Village of Nashotah |
| | | Entire watershed | Consider development of lawn care management and shoreland protection ordinance | City of Delafield, Village of Nashotah |

**Table 5 (continued)**

| Plan Element | Subelement | Location | Management Measures | Management Responsibility |
|---|---|---|---|---|
| Nonpoint Source Pollution Control (continued) | Construction site erosion control and stormwater management ordinance | Entire watershed | Develop and enforce construction site erosion control and stormwater management ordinance pursuant to Waukesha County model ordinance | Waukesha County, City of Delafield, Village of Hartland, Village of Nashotah |
| | Onsite sewage disposal system management | Unsewered portions of the watershed | Inspect and maintain onsite sewage disposal systems | Waukesha County, Washington County, private landowners |
| Fish Management | Fish survey | Selected areas of Lake | Conduct fish survey to determine stocking needs; conduct periodic creel census | WDNR |
| Shoreland Protection | Maintain structures | Entire lake | Maintain existing shoreline structures and repair as necessary | City of Delafield, Village of Nashotah |
| | Minimize shoreland impacts on lake water quality and habitat | Lake shoreline | Restrict pollutant loading from stormwater discharges to the Lake through implementation of stormwater management practices | Waukesha County, City of Delafield, Village of Hartland, Village of Nashotah, WDNR |
| | | Lake shoreline | Enforce adequate setbacks in shoreland areas | Waukesha County, City of Delafield, Village of Nashotah, WDNR |
| | | Lake shoreline | Install construction site erosion control measures as required by local ordinance; enforce construction site erosion control and stormwater ordinance provisions | Waukesha County, City of Delafield, Village of Hartland, Village of Nashotah, WDNR |
| | | Lake shoreline | Encourage shoreline restoration projects and creation of buffer strips, and promote consistency in application of landscaping practices in sensitive shoreland areas, through informational programming and demonstration sites | Waukesha County, City of Delafield, Village of Nashotah, WDNR, UWEX |
| Habitat Protection and Lake Use Management | WDNR-delineated sensitive areas | Selected areas of Lake | Limit chemical treatments and harvesting pursuant to Chapter NR 107 requirements | WDNR |
| | | Selected areas of Lake | Conduct a reassessment of the NR 107 delineated sensitive areas within Nagawicka Lake, especially along the western shoreline of the Lake | WDNR |
| Aquatic Plant Management | Comprehensive plan refinement | Entire Lake | Update aquatic plant management plan every three to five years | City of Delafield |
| | Boating channel harvesting | Selected areas of Lake | Harvest aquatic plants as required to facilitate recreational boating access | City of Delafield |
| | Chemical treatment | Selected areas of Lake | Limited to control of nuisance aquatic plant growth where necessary; specifically target Eurasian water milfoil and purple loosestrife infestations | City of Delafield |

Table 5 (continued)

| Plan Element | Subelement | Location | Management Measures | Management Responsibility |
|---|---|---|---|---|
| Boating Access | Dredging | Public access sites | Maintain recreational boating access from the public access sites based upon a minimum channel depth of 6 feet and width of 50 feet pursuant to Chapter NR 7 guidelines | City of Delafield, WDNR |
| | | Selected near-shore areas | Maintain recreational boating access within constructed waterways where necessary | City of Delafield, private landowners, WDNR |
| | | WDNR-delineated sensitive areas | Maintain recreational boating access areas where necessary, based upon site specific conditions and dependent upon results of a reassessment of WDNR-delineated Sensitive Areas #1 and #2 [Note: No dredging in the Kettle, Sensitive Area #3] | WDNR, City of Delafield, private landowners |
| | | Selected nearshore areas | Conduct detailed sediment survey to prepare engineering designs for the maintenance of recreational boating access | City of Delafield, WDNR |
| Informational and Educational Program | Public informational and educational programming | Entire watershed | Continue public awareness and informational programming | City of Delafield, WDNR, UWEX |
| | | Entire Lake | Encourage inclusion of lake studies in environmental curricula (e.g., Project WET, Adopt-A-Lake) | Kettle Moraine School District, Cushing School, UWEX |

*Source: SEWRPC.*

## WATERSHED MANAGEMENT MEASURES

### Land Use Control and Management

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

The recommended land use plan for the drainage area tributary to Nagawicka Lake under buildout conditions is described in Chapter II. The framework for the plan is the regional land use plan as prepared and adopted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC), and refined through the Waukesha County development plan.[3] The recommended land use plan envisions that urban land use development within the drainage area tributary to Nagawicka Lake will occur primarily at low densities and only in areas which are covered by soils suitable for the intended use. Urban land use development should be permitted to occur only in areas which are covered by soils suitable for the intended use; which are not subject to special hazards such as

[3]*SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

flooding; and which are not environmentally sensitive, that is, not encompassed within the Regional Planning Commission-delineated environmental corridors described in Chapter V of the lake and watershed inventory report.

***Development in the Direct Drainage Area and Shoreland Zone***

A major land use issue which has the potential to affect Nagawicka Lake is the redevelopment of existing lakefront properties, replacing lower-density uses with higher-density, multi-family dwellings with potential for increased roof areas, parking areas, and other areas of impervious surfaces. Replacement of a pervious land surface with an impervious surface will increase the rate of stormwater runoff to the Lake, increase pollutant loadings on the Lake, and will reduce groundwater recharge. While these effects can be moderated to some extent through structural stormwater management measures, there is likely to be an adverse impact on the Lake from significant redevelopment in the drainage area tributary to the Lake involving conversion to higher-density land uses. For this reason, maintenance of the historic low- and medium-density residential character of the shoreline of Nagawicka Lake to the maximum extent practical is recommended.

It is further recommended that lakefront developments, as well as setback and landscaping provisions, be carefully reviewed by the City Plan Commission with advice from the City Lake Welfare Committee. Such review would address specific shoreland zoning requirements, and could consider the stormwater and urban nonpoint source pollution abatement practices proposed to be included in shoreland development activities.

***Development in the Tributary Drainage Area***

Another land use issue which has the potential to affect the Lake is the potential development for urban uses of the agricultural and other open space lands in the tributary drainage area. As previously noted, large-lot residential development is occurring in areas of the lake watershed in which such development was not envisioned in the adopted regional land use plan. If this trend continues, much of the open space areas remaining in the drainage area will be replaced over time with large-lot urban development. This may significantly increase the pollutant loadings to the Lake and increase the pressures for recreational use of the Lake. Under the full buildout condition envisioned under the Waukesha County development plan,[4] a significant portion of the undeveloped lands outside the environmental corridors and other environmentally sensitive areas, could potentially be developed for low-density urban uses.

The existing zoning in the Waukesha County portion of the drainage basin permits development, generally on large suburban-density lots, over much of the remaining open lands other than the environmental corridors. Control of shoreland redevelopment, and the related intensification of use, is not specifically addressed in the existing zoning codes. It is recommended that the impact of future land use development on Nagawicka Lake be minimized through review and modification of the applicable zoning ordinance regulations and zoning district maps to address the concerns noted. Changes in zoning ordinances are recommended to minimize the areal extent of development by providing specific provisions and incentives for the clustering of residential development on smaller lots while preserving significant portions of the open space on each property or group of properties considered for development.

***Stormwater Management***

It is recommended that the City of Delafield, through its Lake Welfare and Public Works Committees, take an active role in promoting urban nonpoint source pollution abatement. Actions to promote urban nonpoint source pollution abatement would include the conduct of specific stormwater management planning within the portion of

[4]Ibid.

the direct drainage area located within the City.[5] Such a planning program would include a review of the City's stormwater management ordinance, similar provisions of which have been adopted by the Village of Hartland as the Village's stormwater management ordinance. It is recommended that the City continue to share its experience in developing appropriate ordinance language to mitigate and control urban nonpoint sources of water pollution with the Village of Hartland. Further, it is recommended that the City encourage the Village of Nashotah to adopt similar ordinance provisions, thereby contributing to the adoption of consistent stormwater management ordinance provisions throughout the drainage area directly tributary to the Lake. In this regard, it is recommended that the City of Delafield and Village of Nashotah review and consider the use of the Waukesha County model construction site and stormwater management ordinance,[6] incorporating local refinement as needed. Adoption by all riparian municipalities of common stormwater management ordinance provisions is strongly recommended.

**Management of Environmentally Sensitive Lands**

Wetland, woodland, and groundwater recharge area protection can be accomplished through land use regulation and public land acquisition of critical lands. Both measures are recommended for the drainage area tributary to Nagawicka Lake. The wetland areas within the drainage area tributary to the Lake are currently largely protected through the existing regulatory framework provided by the U.S. Army Corps of Engineers permit program, State shoreland zoning requirements, and local zoning ordinances. Nearly all wetland areas in the Nagawicka Lake drainage area are included in the environmental corridors delineated by the Regional Planning Commission and protected under one or more of the existing Federal, State, County, and local regulations.

Notwithstanding, some wetland and woodland areas have been identified for acquisition in the adopted regional natural areas and critical species habitat protection and management plan, including the Nagawicka Bog and Oak Woods Natural Area, and the Nagawicka Lake Critical Species Habitat.[7] Public acquisition of these lands is recommended. In this regard, implementation of the recommendations of the adopted park and open space plan for Waukesha County[8] would complement the protection and preservation of these environmentally sensitive lands.

**Water Quality Improvement**

The recommended watershed land management measures are specifically aimed at reducing the water quality impacts on Nagawicka Lake of nonpoint sources of pollution within the tributary drainage area. These measures are set forth in the aforereferenced regional water quality management plan and the Washington and Waukesha Counties land and water resource management plans. As indicated in the lake and watershed inventory, the only significant sources of phosphorus loading to the Lake that are subject to potential controls are rural and urban nonpoint sources and, outside of portions of the drainage area directly tributary to Nagawicka Lake, onsite sewage

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[5]*As of early 2001, the City of Delafield had engaged an engineering consulting firm to review the stormwater management measures installed within subbasin BR-28, within which the IH 94 and STH 83 intersection and associated development is located, and recommend refinements to the City's stormwater management ordinance based upon their findings. Likewise, as of early 2001, the City had engaged the Village of Nashotah in a dialogue with respect to the Village's stormwater management requirements with a view toward ensuring consistent ordinance language within the drainage area directly tributary to Nagawicka Lake.*

[6]*Waukesha County, "Construction Site Erosion Control and Stormwater Management Ordinance," March 1998.*

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

[8]*SEWRPC Community Assistance Planning Report No. 137,* A Park and Open Space Plan for Waukesha County, *December 1989.*

disposal systems in the drainage area. The area directly tributary to Nagawicka Lake is largely served by a public sanitary sewerage system.

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

Nonpoint source pollution abatement controls in the drainage area are recommended to be achieved through a combination of rural agricultural nonpoint controls, urban stormwater management, and construction erosion controls. The implementation of the land management practices described below may be expected to result in a reduction of total phosphorus loadings to Nagawicka Lake of about 25 percent, a reduction considered to be the maximum practicable given the findings of the inventories and analyses conducted under the planning effort. The measures recommended are generally consistent with the recommendations set forth in the Washington and Waukesha Counties land and water resource management plans.

***Rural Nonpoint Source Pollution Control***

The implementation of nonpoint source pollution controls in rural areas requires the cooperative efforts of the City of Delafield and Village of Nashotah, Waukesha County, and private landowners. Technical assistance can be provided by the U.S. Department of Agriculture Natural Resources Conservation Service; the Wisconsin Department of Agriculture, Trade and Consumer Protection; the Washington County Land Conservation Department; and the Waukesha County Department of Parks and Land Use. As discussed previously, it is recommended that the City of Delafield Lake Welfare Committee, in coordination with the Wisconsin Department of Natural Resources (WDNR), Waukesha County, and the local units of government involved, develop a strategy to address nonpoint source pollution. State and Federal soil erosion control and water quality management programs, individually or in combination, can be used to achieve pollutant reduction goals. Such programs include the U.S. Department of Agriculture Environmental Quality Incentive Program (EQIP), the Wisconsin Department of Natural Resources runoff management and lake protection programs,[9] and various local land acquisition initiatives.

Highly localized, detailed, and site-specific measures are required to effectively reduce soil loss and contaminant runoff in rural areas. These measures are best defined and implemented at the local level through the preparation of detailed farm conservation plans. Practices which are considered most applicable within the total drainage area tributary to Nagawicka Lake include conservation tillage, integrated nutrient and pesticide management, and pasture management. In addition, it is recommended consideration be given to cropping patterns and crop rotation cycles, with attention to the specific topography, hydrology, and soil characteristics for each farm. A reduction of about 25 percent in the nonpoint source loading from rural lands, could provide up to about a 15 percent reduction in total phosphorus loading to Nagawicka Lake. Implementation of the recommendations and work planning activities set forth in the Washington and Waukesha Counties land and water resource management plans would constitute a major step toward implementation of these lake management recommendations.

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[9]*While the Bark River has been identified in the adopted regional water quality management plan as being an high-priority watershed for inclusion in the priority watershed planning program, changes to Chapter NR 120 of the* Wisconsin Administrative Code *have modified priority watershed funding such that funds are now available under the Targeted Runoff Management (TRM) program for specific projects within priority watersheds. In addition, proposed grant programs identified in Chapters NR 153 and 154 of the* Wisconsin Administrative Code, *currently being drafted, could potentially provide funds for implementation of rural best management practices. The Chapter NR 191 Lake Protection Grant Program provides cost-share funding for land acquisition, wetland restoration, and ordinance development.*

The cost of the needed measures will vary depending upon the details of the recommended farm conservation plans. These costs may be expected to be incurred to a large extent for purposes of agricultural land erosion control in any case. As noted above, pending promulgation of Chapters NR 153 and NR 154 of the *Wisconsin Administrative Code*, cost-share funding might be available to encourage installation of appropriate land management measures.

***Urban Nonpoint Source Pollution Control***

The development of urban nonpoint source pollution abatement measures for the Nagawicka Lake areas should be the primary responsibility of the City of Delafield and the Villages of Hartland and Nashotah in Waukesha County. As set forth in the lake and watershed inventory, and in Chapter II, each of these municipalities includes a water quality area of concern, within which nonpoint source pollution control measures would be anticipated to result in a reduction of the controllable nonpoint source pollution load to the Lake.

In addition to the adoption of stormwater management ordinances, the most viable measures to control urban nonpoint sources of pollution appear to be good urban land management and urban housekeeping practices. Such practices consist of fertilizer and pesticide use management, litter and pet waste controls, and managing leaf and yard waste. The promotion of these measures requires an ongoing public informational program. It is recommended that the City of Delafield Lake Welfare Committee, in cooperation with the City and the two Villages involved, take the lead in sponsoring such programming for the Nagawicka Lake community through regular public informational meetings and mailings. The Committee should also ensure that relevant literature, available through the University of Wisconsin-Extension Service and the Wisconsin Department of Natural Resources is made available at these meetings and at the Delafield Public Library. Such low-cost measures complement the City of Delafield street sweeping program and litter collection activities.

As an initial step in carrying out the recommended urban practices, it is recommended that a fact sheet identifying specific residential land management measures beneficial to the water quality of Nagawicka Lake be prepared and distributed to property owners. This fact sheet could be distributed by the City of Delafield with the assistance of the University of Wisconsin-Extension Service and Waukesha County Department of Parks and Land Use offices. The recommended measures may be expected to provide about a 25 percent reduction in urban nonpoint source pollution runoff and up to about a 5 percent reduction in total phosphorus loadings to the Lake.

Within the identified water quality areas of concern, comprised of the commercial development in the City of Delafield at the intersection of IH 94 and STH 83, the industrial development within the Village of Hartland Industrial Park near the intersection of STH 16 and STH 83, and the residential development adjacent to Mission Road in the Village of Nashotah, specific stormwater management plans are recommended to be prepared in order to determine the best stormwater management practices.[10]

With respect to the area of concern centered on the IH 94 and STH 83 intersection, the City and Town of Delafield should consider practices to moderate drainage and flooding upstream of the Lake Country Trail at Milwaukee Street, City of Delafield. That evaluation is recommended to consider the drainage and flooding problems, as well as address the quality of the runoff, especially with respect to nutrients and heavy metals likely to be conveyed in the runoff from the impervious surfaces associated with the commercial developments.

With respect to the area of concern centered in the vicinity of the STH 16 and STH 83 intersection, the Village of Hartland should consider practices to address the quality of the runoff, especially with respect to nutrients, heavy metals, and macro-pollutants, including litter and debris likely to be conveyed in the runoff from the impervious surfaces associated with the industrial developments.

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[10]*As of 2000, the City of Delafield had engaged an engineering firm to, inter alia, prepare a stormwater management plan for the IH 94 and STH 83 intersection.*

With respect to the area of concern adjacent to Mission Road, the Village of Nashotah should consider practices to minimize the throughflow of sediments and solids being conveyed from the residential and agricultural areas into Nagawicka Lake. Restoration of water quality management practices within the dry detention basin located within the Lake Country Estates Subdivision should be considered.[11] The Village of Nashotah should also consider adopting a stormwater management ordinance containing similar provisions to those adopted by the City of Delafield and the Village of Hartland to ensure future water quality protection for Nagawicka Lake.

***Developing Areas and Construction Site Erosion Control***

It is recommended that Washington and Waukesha Counties and the City of Delafield and the Villages of Hartland and Nashotah continue efforts to control soil erosion attendant to construction activities in accordance with existing ordinances. As noted in Chapter III, Washington and Waukesha Counties have adopted construction erosion control ordinances. Enforcement of the ordinances by the Counties is generally considered effective. The provision of these ordinances apply to all development except single- and two-family residential construction. The single- and two-family construction erosion control is to be carried out as part of the building permit process. In the City of Delafield and the Villages of Hartland and Nashotah in Waukesha County, this function is performed by the City and Village Building Inspection staff.

Construction site erosion controls may include the use of silt fences, sedimentation basins, rapid revegetation of disturbed areas; the control of "tracking" from the site; and careful planning of the construction sequence to minimize the areas disturbed. Construction site erosion control is particularly important in minimizing the more severe localized short-term nutrient and sediment loadings to Nagawicka Lake that can result from uncontrolled construction sites. Consideration should be given to incorporating construction site erosion control measures into a formal stormwater management system serving larger developments following construction.

Construction site erosion control measures may be expected to reduce the phosphorus loading from that source by about 75 percent. Because of the potential for development in the Waukesha County portion of the area tributary to Nagawicka Lake, it is important that adequate construction erosion control programs be in place.

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

***Onsite Sewage Disposal System Management***

Although the lakeshore areas tributary to Nagawicka Lake are served by public sanitary sewerage systems, portions of the total drainage area to the Lake continue to be served by onsite sewage disposal systems. Such systems have been estimated to contribute less than one percent of the total phosphorus load to the Lake, although further urban density large lot development within the drainage area is anticipated to increase loadings from this source. Notwithstanding, current County ordinance provisions requiring the regular inspection and maintenance of onsite sewage disposal systems should be enforced to minimize phosphorus loadings from this source.

Typical costs for a basic inspection and maintenance service range from about $100 to $200 per year, although more extensive programs could be more expensive.

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[11]*The City of Delafield Lake Welfare Committee has reported that a standpipe designed to provide water quality benefit within the detention basin was removed in accordance with WDNR permit conditions following completion of major construction activities within the Lake Country Estates Subdivision. Notwithstanding, subsequent landscaping and other activities within the catchment area of the detention basin appear to have generated significant transport of sediment into Nagawicka Lake, as documented by the in-lake sediment accumulation surveys conducted between 1999 and 2000 and reported in Chapter III of this plan. Thus, while water quality benefits are not required by the WDNR pursuant to their Chapter 30,* Wisconsin Statutes, *permitting authority, there would appear to be a clear need for ongoing water quality treatment in this subbasin.*

## IN-LAKE MANAGEMENT MEASURES

The recommended in-lake management measures for Nagawicka Lake are summarized in Table 5 and are graphically summarized on Map 9. The major recommendations include water quality monitoring, hydrologic management, fisheries management, habitat protection, shoreline protection, and aquatic plant management.

### Water Quality Monitoring

Continued water quality monitoring of Nagawicka Lake is recommended. Enrollment of one or more lake residents as Wisconsin Department of Natural Resources Self-Help Monitoring Program volunteers is recommended. Such enrollment can be accomplished through the Southeast Region Office of the Wisconsin Department of Natural Resources. A firm commitment of time is required of the volunteers. In addition, participation in the trophic status index (TSI) Self-Help Monitoring Program, measuring nutrients, chlorophyll-*a*, and temperature, is recommended. Such monitoring should be conducted five times a year at a central station in the deepest portion of the lake basin. Monitoring programs are facilitated by the Wisconsin Department of Natural Resources through the expanded Self-Help Monitoring Program and by the University of Wisconsin-Stevens Point Environmental Task Force Laboratory through their lake monitoring programs.

### Hydraulic and Hydrologic Management

Concerns have been raised by residents regarding water levels being too low or too high. As indicated in the lake and watershed inventory, outflow from Nagawicka Lake is controlled by two outlet structures, a dam and a small former mill race, both located on the western side of the Lake just east of CTH C. The northerly outlet is controlled by a dam, while the southerly outlet consists of a 3.25-foot-wide mill race. In practice, only the northerly outlet structure is adjusted to control the lake level.

The present actual operating regime of the dam is intended to maintain the lake level at an elevation which registers between 98.2 and 98.7 feet, Public Service Commission datum.[12] The lake elevation is controlled by manual adjustment of the dam operating gate which adjustment is made periodically by a member of the City of Delafield Public Works Department based upon the observed lake levels. Any change in this operating regime would require a petition from the City of Delafield to the Wisconsin Department of Natural Resources. Given the size and type of lake involved, it is considered reasonable to have an operating water level range of no less than 0.5 foot. Since such a range can be maintained with the existing operating system, no additional operational controls are deemed necessary. However, the existing gate operating system for the dam gate will need to be periodically maintained and repaired to keep it functional.

Notwithstanding, 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 City of Delafield is recommended prior to the determination of appropriate systemwide management measures. 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.

### Fisheries and Aquatic Plant Management

#### *Fisheries Monitoring and Management*

*Habitat Protection*

The habitat protection measures recommended for Nagawicka Lake are, in part, provided by the recommended aquatic plant management program set forth below. The aquatic plant management plan is designed to provide for habitat protection by avoiding disturbances in fish breeding areas during spring and autumn; reducing the use of aquatic plant herbicides; and maintaining stands of native aquatic plants especially in the inlet area.

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[12] *These operating levels were established pursuant to an application of the City of Delafield through WDNR permit number 3-SE-92-530 dated June 10, 1993.*

In addition, it is recommended that environmentally sensitive lands, including wetlands along the western lakeshore, the Bog and adjacent wetlands on the northern shore and the influent River be preserved. In particular, this recommendation extends to the maintenance of the wetlands located in the western portions of the lake basin and the ecological integrity of Nagawicka Bog, as shown on Map 9.

Notwithstanding, it is recommended that the Wisconsin Department of Natural Resources review the NR 107 sensitive area delineations in the vicinities of the constructed channels located along the western and northern shorelines of the Lake. Such a review is predicated upon the proposed maintenance of the navigational channels serving riparian properties in these areas of the Lake. The conduct of maintenance dredging, as recommended under recreational boating access below, requires that these currently designated sensitive areas, identified as Sensitive Areas #1 and #2 in the WDNR letter report dated May 15, 1990, be reviewed as dredging is currently not permitted in Sensitive Area #1 and restricted in Sensitive Area #2. These areas are shown on Map 10. It is recommended that the descriptions of these areas be refined to distinguish between the natural areas of lake shoreland wetland and littoral habitat and the constructed channels, allowing the latter to be maintained for purposes of recreational boating access.

*Shoreline Protection*

Most of the Nagawicka Lake shoreline is protected and no major areas of erosion, which require additional protection against wind, wave, and wake erosion, were identified in the planning effort. Various protection options are described in Chapter III for consideration in the repair or replacement of existing protection structures. Adoption of the vegetated buffer strip method is recommended to be used in lakeshore areas and on the tributary Bark River wherever practical in order to maintain habitat value and the natural ambience of the lakeshore. Continued maintenance of existing revetments and other protection structures is also recommended. Conversion of bulkheads to revetments or natural vegetated shoreline or combinations is recommended to be considered where potentially viable at such time as major repairs are found necessary. Natural vegetated buffer strips should also be considered for shorelines, where practical.

In addition to the foregoing measures, it is also recommended that the City of Delafield and the Village of Nashotah continue to enforce existing shoreland setback requirements, and construction site and stormwater management ordinances. To this end, it is recommended that the City of Delafield Plan Commission request the City of Delafield Lake Welfare Committee to review, on an advisory basis, plans submitted to the Plan Commission for proposed developments within the shoreland zone, as provided under institutional development below.

*Management of Species Composition*

Three specific actions are recommended with respect to fisheries management: the conduct of a fishery survey, the assessment of angling pressures, and the formulation of refined stocking and size and bag limitations. The fishery survey should be conducted by the Wisconsin Department of Natural Resources at the request of the City of Delafield and should have the following objectives:

1. To identify changes in fish species composition that may have taken place in the Lake since the previous surveys, in 1982 and 1995;

2. To permit any changes in fish populations, species composition and condition factors to be related to such known interventions as stocking programs, water pollution control activities, and aquatic plant management programs;

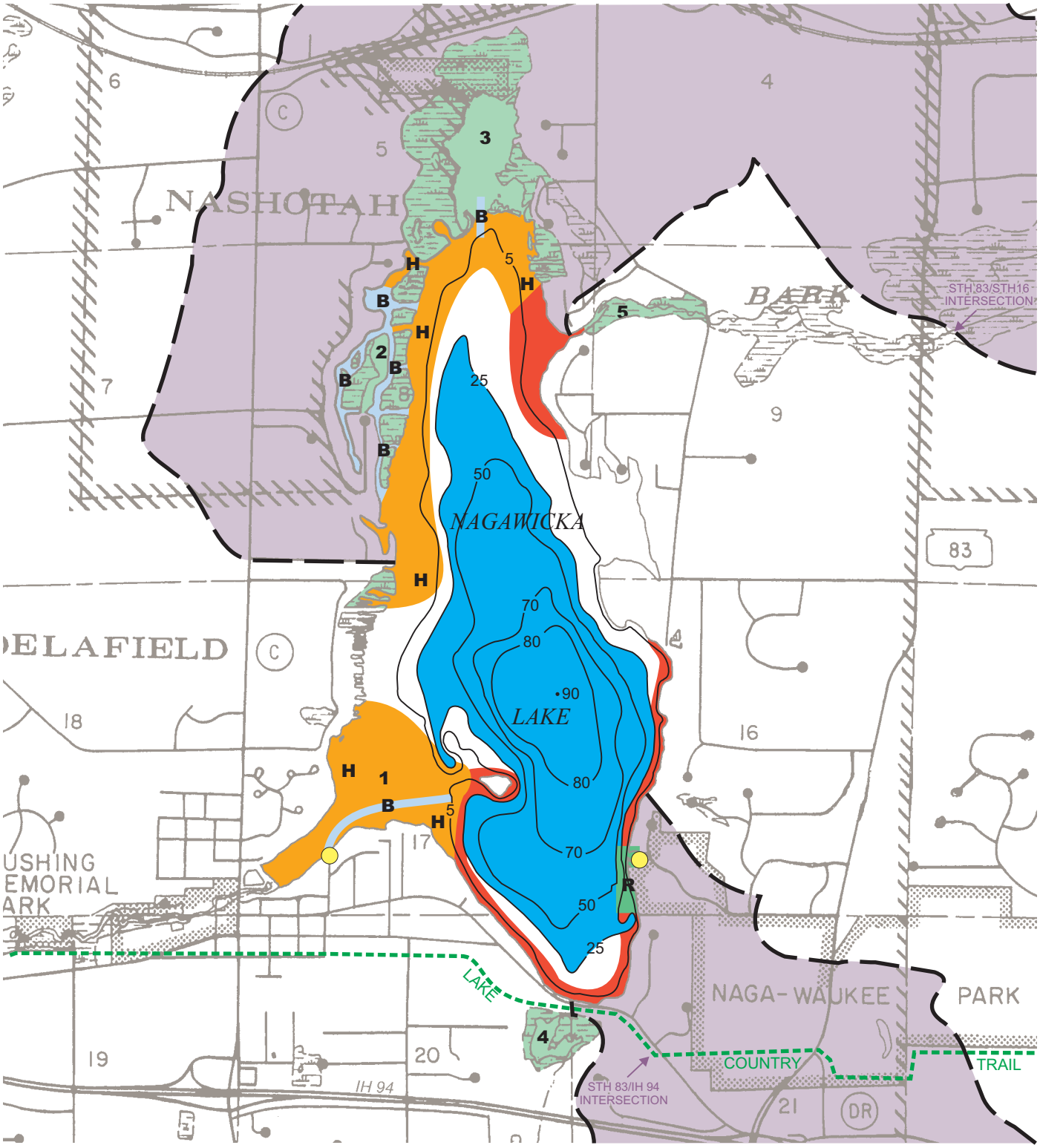
3. To refine and update information on fish spawning areas, breeding success, and survival rates; and,

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

Given the fishing pressures on the Lake, it would be desirable to also conduct a one-time analysis of fish tissues for metal and toxic contamination at the time the fisheries survey was conducted.

Map 10

AQUATIC PLANT MANAGEMENT PLAN FOR NAGAWICKA LAKE




*Source: SEWRPC.*

The second recommended action relative to a fishery management program is an assessment of angling pressures on the Lake. This assessment should:

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

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

These two actions are recommended to provide a sound basis for the District and the Wisconsin Department of Natural Resources to consider developing a stocking program and to revise, as may be found necessary, the current fishing regulations regarding the size and number of fish to be taken seasonally.

The cost of the recommended comprehensive fish survey is estimated to be $16,000.

***Aquatic Plant Management***

The aquatic plant management strategy set forth below recognizes the importance of fishing as a recreational use of Nagawicka Lake. Integral to the aquatic plant management strategy is the protection and preservation of fish breeding habitat.

An aquatic macrophyte control plan consistent with Chapters NR 103 and NR 107 of the *Wisconsin Administrative Code* is included in Appendix C of this report. The plan recommends that continued aquatic macrophyte surveys be conducted at about five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of: major areas of nuisance plant growth; areas harvested and/or chemically treated, species harvested and amounts of plant material removed from lake, and species and approximate numbers of fish caught in the harvest.

A daily harvester log, containing this information, should be maintained. This information, in conjunction with the conduct of the recommended aquatic macrophyte surveys, will allow evaluation of the effectiveness of the aquatic plant control program over time and allow adjustments to be made in the program to maximize its benefit.

Modifications of the existing aquatic plant management program are recommended to enhance the use of Nagawicka Lake while maintaining the quality and diversity of the biological communities. The following recommendations are made:

1. Mechanical harvesting is recommended as the primary management method. As indicated in Chapter III, this will, in the long-term, help to maintain good water quality conditions by removing plant materials which are currently contributing to an accumulation of decomposing vegetation and associated nutrient recycling. The harvesting should be carried out by the City of Delafield using its existing harvester and transport equipment.

2. It is recommended that shared-access channels be harvested to minimize the potential detrimental effects on the fish and invertebrate communities. Directing boat traffic through these common channels would help to delay the regrowth of vegetation in these areas.

3. Surface harvesting is recommended, cutting to a depth of approximately two feet to remove the surface canopy of nonnative aquatic plants, such as the Eurasian water milfoil. This should provide a competitive advantage to the low-growing native plants present in the Lake. By not disturbing the low-growing species which generally grow within one to two feet of the lake bottom and in relatively low densities, leaving the root stocks and stems of all cut plants in place, the resuspension of sediments in Nagawicka Lake will be minimized, and some degree of cover will continue to be provided for panfish populations which support the bass population in the Lake. Further, cutting should not be broad-based, but focused on boating channels and selected navigation areas.

4. It is recommended that the use of chemical herbicides be limited to controlling nuisance growth of exotic species in shallow water around docks and piers where the harvester is unable to reach. Such use should be evaluated annually and the herbicide applied only on an as needed basis. Only herbicides that selectively control milfoil, such as 2,4-D, should be used. Algicides, such as Cutrine Plus, are not recommended because there are no significant filamentous algae or planktonic algae problems in the Nagawicka Lake and valuable macroscopic algae, such as *Chara* and *Nitella* are killed by this product.

5. It is recommended that chemical applications, if required, be made in early spring to maximize their effectiveness on nonnative plant species, while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions.

6. The control of rooted vegetation between adjacent piers is recommended to be left to the riparian owners concerned, as it is time consuming and costly for a mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. The City of Delafield Lake Welfare Committee may wish to obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to inform residents of the control options available.

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

8. It is further recommended that the City of Delafield Lake Welfare Committee conduct a public informational program on the types of aquatic plants in Nagawicka Lake; on the value of and the impacts of these plants on water quality, fish, and on wildlife; and on alternative methods for controlling existing nuisance plants including the positive and negative aspects of each method. This program can be incorporated into the comprehensive informational and educational programs which also would include information on related topics, such as water quality, recreational use, fisheries, and onsite sewage disposal systems.

The recommended aquatic plant control areas are shown on Map 9. The control measures in each area are designed to optimize desired recreational opportunities and to protect the aquatic resources.

The recommended aquatic plant management plan represents a continuation of the current aquatic plant management program conducted by the City of Delafield. Implementation of this plan would entail a capital cost of about $100,000, the majority of which would be required for the eventual replacement of equipment, and an annual operation and maintenance cost of about $22,000. Aquatic herbicide treatments, or biological controls of Eurasian water milfoil, within the Eurasian water milfoil control areas may be expected to cost about $1,000 per acre treated.

## OTHER LAKE MANAGEMENT MEASURES

### Recreational Use Management

#### *Public Recreational Boating Access*

Dredging is recommended to be used only for the maintenance of recreational boating access to the Lake and to provide or enhance boating access opportunities for riparian householders and the public. The associated environmental impacts of such projects should be identified and evaluated on a case-by-case basis, as is required by the *Wisconsin Administrative Code* for the issuance of permits under the authority of Chapter 30, *Wisconsin Statutes*. The dredging projects which were undertaken during 1995 and 1999, enhanced boating access in the southern portions of Zastrow Bay, and the northwestern and northeastern portions of the Lake within the constructed channels providing recreational boating access to riparian residences. Lakewide dredging, as noted in Chapter III, is not required or recommended.

The future dredging projects that are recommended in this plan are limited to the maintenance of the constructed access channels originally constructed for purposes of establishing recreational boating access along the northwestern and northeastern shores of Nagawicka Lake. In addition, given the reported increase in siltation in St. John's Bay in recent years, in the vicinity of the outlet to Nagawicka Lake, maintenance of the public recreational boating channel from the Bleeker Street public recreational boating access site may be required. In this case, the provision of an access channel of approximately 50 feet in width and six feet in depth to the appropriate depth contour, defined by the long-term average water depth reported by the WDNR[13] to be 98.15 Public Service Commission datum, in the main Lake basin would be recommended, as currently indicated in Wisconsin Department of Natural Resources guidance for public recreational boating access channels.[14]

Based upon the current depth of accumulated sediments within these areas, shown on Map 2, the estimated volume of soft sediments that could be considered for removal from Nagawicka Lake is 65,000 cubic yards, this volume being comprised of approximately 10,500 cubic yards of material within the public recreational boating access channel proposed to serve the Bleeker Street public recreational boating access site, approximately 9,000 cubic yards of material in Zastrow Bay in the vicinity of the fire lane and water access point, and approximately 45,900 cubic yards of material within the constructed channels on the northwestern and northeastern shorelines of the Lake.

The cost for maintenance of boating access channels will vary depending upon the amount of sediment to be removed, the proximity of the dredge spoil disposal site(s), and the dredging method used. However, based upon a range in cost from about $5.00 per cubic yard to $15 per cubic yard, typical costs to remove the total volume of accumulated sediment would be between about $325,000 and $975,000. With the possible exception of the provision of a public recreational boating access channel serving the Bleeker Street public access, dredging costs must be borne by the community; some State cost-share funding may be available to offset the costs of providing public recreational boating access through the Wisconsin Waterways Commission Recreational Boating Facility grant program.[15] These latter funds are administered by the Wisconsin Department of Natural Resources, and are awarded subject to application and availability of funds. All dredging projects are subject to permitting by the Wisconsin Department of Natural Resources under authorities granted the Department under Chapter 30, *Wisconsin Statutes*.

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[13]*Wisconsin Department of Natural Resources permit No. 3-SE-92-530, op. cit.*

[14]*It should be noted that the dimensions of the public recreational boating channel set forth for a public recreational boating access channel serving the Bleeker Street public recreational boating access site in the City of Delafield relate only to that site. Channel maintenance within the constructed channels located on the north-western and northeastern shorelines of Nagawicka Lake should conform to the current channel dimensions as constructed, and not exceed the design width and depth of these waterways. Recommendations for maintenance dredging do not imply deepening or modifying the design dimensions of constructed waterways, nor indicate construction of new artificial waterways along the lakeshore. Further, the plan recommends no dredging within the "Kettle" area of Nagawicka Lake, which area has been identified in the regional natural areas and critical species habitat protection and management plan as an area of exceptional ecological value.*

[15]*Communities within the Southeastern Wisconsin Region that have engaged in significant dredging projects have used a variety of funding mechanisms, including, in most cases, a cost-share arrangement whereby the project cost is shared by the municipal governmental unit, the riparian landowner, and other governmental or nongovernmental organization. Cost sharing is generally based upon an agreed formula, appropriate to the community and considered by the community to be an equitable distribution of the relative benefits that accrue to each participating organization or individual, typically, the landowner receives benefit in improved navigational access to the waterway, the community receives benefit in improved navigational access and, often, aesthetic appeal, and other potential participants receive benefit from increased revenues due to higher property values, greater utilization of riparian and other facilities, such as fuel outlets and sport suppliers, etc.*

Dredging on Nagawicka Lake is further complicated by the fact that the City of Delafield enacted a five-year moratorium on the disposal of dredge spoils within the Mission Avenue area of the City during 1997. The result of this moratorium is that there would be a need to transport any dredged materials removed from the Lake in the vicinity of Mission Avenue away from the Lake, for disposal elsewhere. The transportation costs associated with such haulage would suggest that the higher cost estimates would be a more reasonable estimate of the probable cost of dredging, at least along the northwestern portions of the lakeshore, under these circumstances.

With respect to boating ordinances applicable to Nagawicka Lake, it is recommended that current levels of enforcement be maintained. In addition, recreational boating access users should be made aware of the presence of exotic invasive species within Nagawicka Lake, including zebra mussel and Eurasian water milfoil. Appropriate signage should be placed at the public recreational boating sites, and supplemental materials on the control of invasive species should be made available to the public. These materials could be provided to riparian householders by means of mail drops or distribution of informational materials at public buildings, such as the Delafield Public Library, and to nonriparian users through informational materials provided by the County at the entrance to Naga-waukee County Park or available at the Bleeker Street access site. In addition, it is recommended that the City of Delafield and Waukesha County make disposal bins available at their public recreational boating access sites for disposal of plant materials and other refuse removed from watercraft using the public recreational boating access sites.[16]

**Public Informational and Educational Programs**

It is recommended that the City of Delafield Lake Welfare Committee assume the lead in the development of a public informational and educational program. This program should deal with various lake management-related topics, including onsite sewage disposal system management, water quality management, land management, groundwater protection, aquatic plant management, fishery management, and recreational use. Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the recreational use and shoreland zoning regulations, are available from the Wisconsin Department of Natural Resources and the University of Wisconsin-Extension Service. These cover topics such as beneficial lawn care practices and household chemical use. Such brochures should be provided to homeowners through local media, direct distribution or targeted library and civic center displays. Such distribution can also be integrated into ongoing, larger-scale activities, such as lakeside litter collections, which can reinforce anti-littering campaigns, recycling drives, and similar environmental protection activities.

Given the extent of public interest in Nagawicka Lake, it is recommended that the City of Delafield Lake Welfare Committee consider offering regular informational programs on the Lake and issues related thereto. Such programming can provide a mechanism to raise awareness of the Lake issues, and provide a focal point from which to distribute the informational materials referred to above.[17]

The City of Delafield Lake Welfare Committee is also encouraged to take an active role in encouraging the Kettle Moraine School District to adopt and utilize lake-related educational programs, such as Adopt-A-Lake and Project WET, as means of more closely linking students to the lake environment. The Committee should also include

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

[17]*Because the City of Delafield Lake Welfare Committee is not a public inland lake protection and rehabilitation district, there is not statutory requirement that the Committee hold an annual meeting. However, the Committee could work with the City to develop a regular series of informational programs that would benefit not only the Lake, but also the community at large.*

St. John's-Northwestern Military Academy within the scope of their educational programming. Student-based programs can also complement or supplement the citizen-based monitoring activities recommended above.

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

**Institutional Development**

Given the pressures facing the inland waters of the Southeastern Wisconsin Region, the continued focus of the City of Delafield Lake Welfare Committee on Nagawicka Lake is commendable and appropriate. It is recommended that the Committee continue to perform its defined functions and that consideration be given to broadening its advisory role with regard to lakefront development and redevelopment, shoreline setbacks, and the provision of shoreline landscaping. This would enhance the Committee's functions by best utilizing the specialized knowledge[18] of the Committee members in a manner consistent with the resolution creating the Committee—the text of which is appended hereto as Appendix D. To this end, the following recommendations are set forth at the request of the City of Delafield Lake Welfare Committee, pursuant to their review of the draft lake management plan and in response to the unanimous adoption, at their meeting on March 29, 2001, of a motion to instruct the Commission staff to provide such recommendations within the recommended plan.

Because of the specialized nature of shoreland zoning requirements, and given the specific knowledge of such requirements available to the City of Delafield through its Lake Welfare Committee, it is recommended that lakefront developments or redevelopments be referred to the Lake Welfare Committee by the City Plan Commission for review and advice, where the Plan Commission deems such advice appropriate. Such review would address specific shoreland zoning requirements, and could consider the stormwater and urban nonpoint source pollution abatement practices proposed to be included in shoreland development activities. In addition, the Lake Welfare Committee should review and comment on the shoreland setbacks and landscaping provisions to minimize shoreland impacts on water quality and habitat, and encourage shoreline restoration practices as recommended herein. It is recognized that such review and comment would be at the request of, and advisory to, the City Plan Commission pursuant to the statutory authority conferred upon city plan commissions under Section 62.25, *Wisconsin Statutes*. To facilitate such review and comment, it is suggested that a member of the City Plan Commission also serve on the City of Delafield Lake Welfare Committee. Therefore, it is recommended that the City of Delafield consider the following actions to provide a more substantive role for the Lake Welfare Committee:

1. Appoint a representative jointly to both the Lake Welfare Committee and the City Plan Commission. Ideally, this individual should serve as the chairperson of the Lake Welfare Committee and as a citizen or aldermanic appointee to the City Plan Commission;

2. Provide notice of matters relating to the shorelands of the Lake within the City of Delafield to the Lake Welfare Committee, where deemed appropriate, for consideration and formulation of an appropriate referral to the City Plan Commission;

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[18]*City of Delafield Lake Welfare Committee members have regularly attended the Wisconsin Lakes Partnership annual lakes convention, sponsored by the University of Wisconsin-Extension, the Wisconsin Department of Natural Resources, and the Wisconsin Association of Lakes, Inc., where issues relating to lake management within the State have been discussed, and information presented to persons engaged in the practice of lake management. Attendees include elected officials, commissioners of public inland lake protection and rehabilitation districts, board members of lake associations, and other interested persons. Subjects presented have included shoreland zoning and administration of lake organizations—at the 2001 convention, wetlands and shorelands—at the 2000 convention, and related subject matter. In addition, Committee members have also attended informational and educational programming in the Region, including the 2001 southeastern Wisconsin lake convention, where the subject matter included management of aquatic exotics, control of geese in shoreland areas, and Wisconsin's boating laws and their enforcement.*

3. Encourage the Lake Welfare Committee to schedule their meetings in advance of those of the City Plan Commission to allow sufficient time for the formulation of appropriate referrals on an advisory basis;

4. Continue to include participation of representatives from the Village of Nashotah with the Lake Welfare Committee in an *ex officio* capacity;

5. Invite representatives from the Village of Hartland to participate with the Lake Welfare Committee in an *ex officio* capacity; and,

6. Assist the Lake Welfare Committee in their liaison with the Village of Nashotah and the Village of Hartland to encourage a coordinated approach to the management of Nagawicka Lake.

While there have been a number of approaches to both the Wisconsin Department of Natural Resources and SEWRPC staff with respect to the formation of a public inland lake protection and rehabilitation district around Nagawicka Lake, pursuant to the provisions of Chapter 33, *Wisconsin Statutes*, it would appear that the creation of such a governmental unit would be premature. It is recommended that the existing City of Delafield Lake Welfare Committee be strengthened as set forth above prior to further consideration being given to alternative lake organizational alternatives.

Future development of the Lake Welfare Committee, which currently includes representation from the Village of Nashotah in an *ex officio* capacity, could include the conclusion of a more formal Section 66.30, *Wisconsin Statutes*, agreement between the riparian municipalities, such as has formed the Geneva Lake Environmental Agency around Lake Geneva in Walworth County. However, such an action should be predicated upon the Committee assuming a more active role in the conduct of recommended lake management activities. It is not recommended at this time. Should such action be contemplated, based upon the future situations within the drainage area directly tributary to Nagawicka Lake, it is suggested that consideration be given, rather, to the formation of a public inland lake protection and rehabilitation district pursuant to Chapter 33, *Wisconsin Statutes*, as discussed in Chapter III.

It should be noted, relative to organizational development relevant to Nagawicka Lake and its tributary drainage area, that the creation of utility districts for the provision of stormwater management services has been mooted for those subbasins identified as water quality areas of concern. This alternative is currently being considered by the city of Delafield within the context of a stormwater management plan being prepared for the development at the intersection of IH 94 and STH 83 within the City. If such a special-purpose unit of government is formed, the recommendations relating to the creation of linkages between the Lake Welfare Committee and City of Delafield Plan Commission would also be applicable to the formation of linkages between a utility district commission and the Lake Welfare Committee.

The cost of modifying the institutional arrangements for the conduct of lake management activities on Nagawicka Lake is considered to be nominal, and relate primarily to providing staff support as required to meet the City's obligations under Wisconsin's open meetings and open records law. Costs for informational programming were set forth above, with respect to the recommended program of public information and education.

## PLAN IMPLEMENTATION AND COSTS

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

Generally, fisheries and aquatic plant management practices, such as monitoring, harvesting, and public awareness campaigns currently implemented by the City of Delafield, in part through the Lake Welfare Committee, are recommended to continue with refinements proposed herein. Some aspects of these programs lend themselves to citizen involvement through volunteer-based creel surveys, participation in the Wisconsin Department of Natural Resources Self-Help Monitoring Program, and identification with environmentally sound owner-based land management activities. It is recommended that the City assume the lead in the promotion of such citizen actions, with a view toward building community commitment and involvement. Assistance is generally available from agencies such as the Wisconsin Department of Natural Resources, the County University of Wisconsin-Extension Service office, and the Southeastern Wisconsin Regional Planning Commission. The City of Delafield Lake Welfare Committee would be an appropriate focal point within the City administration to coordinate and host public awareness programming.

A major cost element in the plan relates to the eventual replacement of harvesting equipment. Implementation of the recommended plan would entail a capital expenditure of about $100,000 and an annual operation and maintenance expenditure of about $22,000, including existing expenditures, over the next 10 years. The City's current budget for annual operation and maintenance of the harvesters is appropriate to cover this level of future investment. When it is necessary to replace the existing harvesting equipment, some of the capital costs could be met with grants from the Wisconsin Waterways Commission under Chapters NR 103 and NR 107 of the *Wisconsin Administrative Code*, while additional cost share assistance may be available from the Wisconsin Waterways Commission for the conduct of Eurasian water milfoil control programs using chemical herbicides.

The most significant new cost associated with the recommendations set forth herein, estimated at $1 million, relates to the conduct of maintenance dredging, and the provision of ongoing public recreational boating access to the main lake basin from the Bleeker Street public access site. As noted above, the latter, with an estimated cost of $160,000, may be eligible for cost-share assistance through the Recreational Boating Facilities program of the Wisconsin Waterways Commission, administered by the Wisconsin Department of Natural Resources. The remaining costs would have to be borne by the riparian residents, potentially with assistance from the riparian municipalities and other interested parties. To this end, should the recommended review of the Chapter NR 107 sensitive areas be conducted by the Wisconsin Department of Natural Resources, and the terms of the delineations modified to reflect the constructed nature of the boating channels and permit maintenance dredging, the City of Delafield may wish to consider the purchase of dredging equipment as a means of reducing future maintenance dredging costs. Such an approach was adopted by the School Section Lake Protection and Rehabilitation District to good effect in the major dredging project completed by that District within Waukesha County during the late 1990s. Should it be possible to implement the maintenance dredging recommendations, it is suggested that this alternative be considered as part of a detailed engineering study to prepare the dredging project implementation plan.

The suggested lead agency or agencies for initiating program-related activities, by plan element, are set forth in Table 5, and the estimated costs of these elements, linked to possible funding sources where such are available, are summarized in Table 6.

Nagawicka Lake is a valuable natural resource in the Southeastern Wisconsin Region. Increases in population, urbanization, income, leisure time, and individual mobility forecast for the Region may be expected to result in additional pressure for development in the drainage area tributary to the Lake and for water-based recreation on the Lake. Adoption and administration of an effective lake management program for Nagawicka Lake, based upon the recommendations set forth herein, will provide the water quality protection needed to maintain conditions in Nagawicka Lake suitable for recreational use and for fish and other aquatic life.

## Table 6

## ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR NAGAWICKA LAKE

| Plan Element | Subelement | Estimated Cost 2000-2020[a] | | Potential Funding Sources[b] |
|---|---|---|---|---|
| | | Capital | Annual Operation and Maintenance | |
| Land Use Control and Management | Land use development planning | - - | - - | County, City, Villages |
| | Density management in the shoreland zone | - - | - - | - - |
| | Shoreland development | - - | - - | - - |
| | Stormwater management plan development | - - | - - | County, City, Villages |
| | Environmentally sensitive lands | - - | - - | WDNR Lake Protection Grant and Stewardship Grant Programs |
| Surface Water Quality and Quantity Management | Water quality monitoring | - - | - -[c] | USGS, City, WDNR Self-Help and Ambient Lakes Monitoring Programs |
| | Water quantity monitoring | - - | - -[d] | City, USGS, WDNR |
| Nonpoint Source Pollution Control | Rural nonpoint source controls | - -[e] | - -[e] | County, USDA EQIP, WDNR/WDATCP Runoff Management Program |
| | Urban nonpoint source controls | - -[e] | - -[e] | County, WDNR/WDATCP Runoff Management Program |
| | Construction site erosion control | - -[e] | - -[e] | County, private firms, individuals |
| | Onsite sewage disposal system management | - -[e] | - -[e] | County Private firms, individuals |
| Fish Management | Fish survey | $16,000[f] | - -[f] | WDNR |
| Shoreland Protection | Maintenance of structures | - - | - - | Private firms, individuals |
| | Minimize shoreland impacts on lake water quality and habitat | - - | - - | Private firms, individuals |
| Habitat Protection and Lake Use Management | WDNR-delineated sensitive areas | - - | - - | City, WDNR |
| Aquatic Plant Management | Comprehensive plan refinement | - - | $1,500 | City, WDNR Lake Management Planning Grant Program |
| | Major/minor boating channel harvesting | $100,000[g] | $22,000 | City, Wisconsin Waterways Commission |
| | Chemical treatment | - - | $1,000/acre | Wisconsin Waterways Commission |
| Boating Access | Dredging | - -[h] | $48,750 | Wisconsin Waterways Commission |
| Informational and Educational Program | Public informational and educational programming | - - | $1,200 | UWEX/ WDNR/WAL Lakes Partnership |
| Total | - - | $116,000 | $73,450[i] | - - |

[a] *All costs expressed in January 2001 dollars.*

[b] *Unless otherwise specified, USDA is the U.S. Department of Agriculture, USGS is the U.S. Geological Survey, WDNR is the Wisconsin Department of Natural Resources, WDATCP is the Wisconsin Department of Agriculture, Trade and Consumer Protection, County is Washington and Waukesha Counties, City is the City of Delafield and its Lake Welfare Committee, Village is the Village of Nashotah, UWEX is the University of Wisconsin-Extension, and WAL is the Wisconsin Association of Lakes.*

**Table 6 (continued)**

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

*[c]Water quantity monitoring should be conducted in conjunction with an hydraulic and hydrologic analysis of the entire Bark River system; USGS hydrological monitoring at their station in Jefferson County should be maintained.*

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

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

*[g]Costs are based on the assumption that the existing harvester and ancillary equipment may eventually need replacement; cost-share assistance for harvester purchase may be available from the Wisconsin Waterways Commission Recreational Boating Facilities Grant Program. Planning costs assume that plan revisions will be completed at a cost of $6,000 every four years.*

*[h]Capital costs may be incurred if the City of Delafield purchases an hydraulic dredge to undertake this work using City staff; cost-share assistance may be available from the Wisconsin Waterways Commission Recreational Boating Facilities Grant Program. The annual cost of dredging is estimated at 1/20th the total estimated cost of $975,000.*

*[i]Costs exclude the costs to the City of Delafield and Village of Nashotah related to land use planning and zoning, and exclude costs related to herbicide treatments.*

*Source: SEWRPC.*

# APPENDICES

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# Appendix A

# NONPOINT SOURCE POLLUTION CONTROL MEASURES

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

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

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

Of the sets of practices recommended for various levels of diffuse source pollution control presented in Table A-2, not all practices are needed, applicable, or cost-effective for all watersheds, due to variations in pollutant loadings and land use and natural conditions among the watersheds. Therefore, it is recommended that the practices indicated as needed for nonpoint source pollutant control be refined by local level nonpoint source control practices planning, which would be analogous to sewerage facilities planning for point source pollution abatement. A locally prepared plan for nonpoint abatement measures should be better able to blend knowledge of current problems and practices with a quickly evolving technology to achieve a suitable, site specific approach to pollution abatement.

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

## Table A-1

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

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

## Table A-1 (continued)

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

## Table A-1 (continued)

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

## Table A-1 (continued)

| Applicable Land Use | Control Measures[a] | Summary Description | Approximate Percent Reduction of Released Pollutants[b] | Assumptions for Costing Purposes |
|---|---|---|---|---|
| Urban and Rural | Public education programs | Conduct regional and county-level public education programs to inform the public and provide technical information on the need for proper land management practices on private land, the recommendations for management programs, and the effects of implemented measures; develop local awareness programs for citizens and public works officials; develop local contract and education efforts | Indeterminate | For first 10 years, includes cost of one person, materials, and support for each 25,000 population. Thereafter, the same cost can be applied for every 50,000 population. The cost of one person, materials, and support is estimated at $55,000 per year |
| | Construction erosion control practices | Construct temporary sediment basins; install straw bale dikes; use fiber mats, mulching, and seeding; install slope drains to stabilize steep slopes; construct temporary diversion swales or berms upslope from the project | 20 to 40 | Assume acreage under construction is the average annual incremental increase in urban acreage; apply costs for a typical erosion control program for a construction site. The estimated capital cost and operation and maintenance cost for construction erosion control is $250 to $5,500 and $250 to $1,500 per acre under construction, respectively |
| | Materials storage and runoff control facilities | Enclose industrial storage sites with diversion; divert runoff to acceptable outlet or storage facility; enclose salt piles and other large storage sites in crib and dome structures | 5 to 10 | Assume 40 percent of industrial areas are used for storage and to be enclosed by diversions; assume existing salt storage piles enclosed by cribs and dome structures. The estimated capital cost of industrial runoff control is $2,500 per acre of industrial land. Material storage control costs are estimated at $75 per ton of material |
| | Stream protection measures | Provide vegetative buffer zones along streams to filter direct pollutant runoff to the stream; construct streambank protection measures, such as rock riprap, brush mats, tree revetment, jacks, and jetted willow poles, where needed | 5 to 10 | Apply a 50-foot-wide vegetative buffer zone on each side of 15 percent of the stream length; apply streambank protection measures to 5 percent of the stream length. Vegetative buffer zones are estimated to cost $21,200 per mile of stream and streambank protection measures cost about $37,000 per stream mile |
| | Pesticide and fertilizer application restrictions | Match application rate to need; eliminate excessive applications and applications near or into surface water drainageways | 0 to 3 | Cost included in public education program |
| | Critical area protection | Emphasize control of areas bordering lakes and streams; correct obvious erosion and other pollution source problems | Indeterminate | Indeterminate |

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

*[b]The approximate effectiveness refers to the estimated amount of pollution produced by the contributing category (urban or rural) that could be expected to be reduced by the implementation of the practice. The effectiveness rates would vary greatly depending on the characteristics of the watershed and individual diffuse sources. It should be further noted that practices can have only a "sequential" effect, since the percent pollution reduction of a second practice can only be applied against the residual pollutant load which is not controlled by the first practice. For example. two practices of 50 percent effectiveness would achieve a theoretical total effectiveness of only 75 percent control of the initial load. Further, the general levels of effectiveness reported in the table are not necessarily the same for all pollutants associated with each source. Some pollutants are transported by dissolving in water and others by attaching to solids in the water; the methods summarized here reflect typical pollutant removal levels.*

*[c]For highly urbanized areas which require retrofitting of facilities into developed areas, the costs can range from $400,000 to $1,000,000 per acre of storage.*

*Source: SEWRPC.*

## Table A-2

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

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

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

*[b]The provision of bench terraces would exclude most basic conversation practices and base-of-slope detention storage facilities.*

*[c]In addition to diffuse source control measures, lake rehabilitation techniques may be required to satisfy lake water quality standards.*

*Source: SEWRPC.*

## Appendix B

# WISCONSIN DEPARTMENT OF NATURAL RESOURCES LAKE DREDGING GUIDANCE

State of Wisconsin
Department of Natural Resources

**APPLICATION FOR LAKE DREDGING**
Form 3500-53I (R 6/2000)

The Wisconsin Department of Natural Resources helps protect your rights in public waters as well as public safety, by ensuring adequate planning and design of projects affecting fish and wildlife habitat, water quality and natural scenic beauty. This is done through permit and plan approval requirements for individual water projects.Chapters 30 and 31 of the Wisconsin Statutes require written permits for certain activities on or near a waterway: for example, to place any material below the ordinary high water mark (such as rock riprap, fish cribs, culverts, fords, etc.); to construct a bridge, dredge material from a lake or stream; create a pond; or to construct, operate, or maintain a dam. A single pier or wharf can generally be placed without a permit, provided state standards are met; more extensive piers or marinas require a permit.

**Before submitting this application for a lake dredging permit please contact your county, city or village zoning department to find out if your project site is in either a mapped wetland orfloodplain and if local zoning restrictions could affect your project. Please see the Wetland Information topic (found in the Waterway and Wetland Permits Web Page) or request Wetland Packet #20 in addition to this packet for details.**

**A complete application with detailed drawings will help us make a decision about your application for a permit. The following information is necessary for a complete application**

**To help us make a decision in the shortest time possible, please submit the following information:**

1. **A copy of your deed or similar proof of ownership** (e.g. land contract, current property tax receipt).

2. **Good photographs that clearly show the existing project area.** Remember, too much snow cover or vegetation may obscure important details. If possible, have another person stand near the project area for size reference.

3. **Five (5) copies of a completed application Form 3500-53 including applicant information page and project plans.** When completing your application,**please use a ballpoint pen with black ink.** The site location sketch and plan drawings (see Sample Drawing) should be clear and to scale and have enough detail to find the site and understand the project proposal. **Please follow the sample drawing and information requirements pages attached. Also, make sure your phone number (both business and home) and property address or fire number is on the application. Plans may be submitted on a separate page(s), but please submit five (5) copies.**

4. **Five (5) copies of a narrative description of your proposal**, on a separate blank page. Please state:
   - what the project is,
   - how you intend to carry out the project, including methods, materials and equipment,
   - your proposed construction schedule and sequence of work,
   - what temporary and permanent erosion control measures will be used, and
   - the location of any disposal area for dredged or excavated materials.

5. **Five (5) copies of site maps.** Provide copies of relevant maps (when possible), such as USGS topographic map, Wisconsin Wetland Inventory map, FEMA floodplain maps, soil or zoning maps, with the project location clearly identified.

6. **The appropriate application fee (complete Form 3500-53A – attached).**

If you have questions or problems in filling out or completing the application requirements, please call or contact the Water Management Specialist for the county where your project is located.

When you are finished compiling your application materials, remember to check your application for completeness. Then make copies of all materials so that you can submit**five copies** of the requested information to the Department. We also recommend that you keep a complete copy for your own records.Remember, incomplete applications may cause a delay in processing.

**NOTE:** Depending upon the type, complexity, and location of your proposed project**processing can take 60 working days (3 months) or longer to complete a review, public notice and any required environmental analysis if your application is completed in detail.**

**Thank you for contacting the Wisconsin Department of Natural Resources.**
Enclosed are the project application materials you have requested.

## Lake Dredging Information Requirements

All applications to remove material from alakebed require the following information, on the application form and plan drawing sheet supplied or additional sheets if necessary.

1. In the **"proposed materials"** box, indicate what equipment and method of excavation will be used. The application must contain a description of the sequence of construction events including the installation of temporary and permanent erosion control measures and final landscaping and stabilization measures for the spoil disposal area.

2. In the **"location sketch"** box, sketch or trace a map that clearly indicates the location of the project. Recommended scale is 1" = 2000'. The map should enable the Department investigator to locate the project site.

3. The **top view** should include the following information:

   a. The location of the shoreline and the location of the cross section.
   b. The proposed dredge area.
   c. The spoil disposal area. NOTE: If spoils are to be hauled from the site for disposal, provide a map showing where disposal will occur.
   d. Floodplain and wetland boundary.
   e. Depth contours up to the limit of the proposed dredging.
   f. The scale of the top view and a north arrow.

**Note: Spoil disposal is not allowed in wetlands or floodplains.**

4. The **cross-section view** of the project should be selected approximately perpendicular to the lake and include the following:

   a. The normal water level in the lake.
   b. A profile of the existing bottom and the proposed dredged bottom.
   c. The scale or dimensions of the drawing.

5. Proper erosion control measures, including the use of staked hay bales and silt fencing, must be used and maintained during and after the construction of this project. Allerodible areas must be immediately seeded and mulched with a fast growing grass mixture. This grass seed mixture must become established and stabilize allerodible areas. These erosion control measures must adequately protect the waterway and wetlands from erosion and run-off.

Please select the scale of the drawing carefully to fit all the necessary information on the application form. If necessary, use additional sheets. Be sure to draw all the plans as accurately as possible. The Department may require additional information to evaluate the project.

**Please send the completed application to the Water Management Specialist for the county where your project is located. (a complete listing of addresses by county can be found on the Waterway and Wetland Permits web page link below)**
http://www.dnr.state.wi.us/org/water/fhp/waterway/wmscoun.htm


Click here for DNR Regional Office / Service Center Office addresses, phone numbers

DRAWINGS OF PROPOSED ACTIVITY SHOULD BE PREPARED IN ACCORDANCE WITH SAMPLE DRAWING

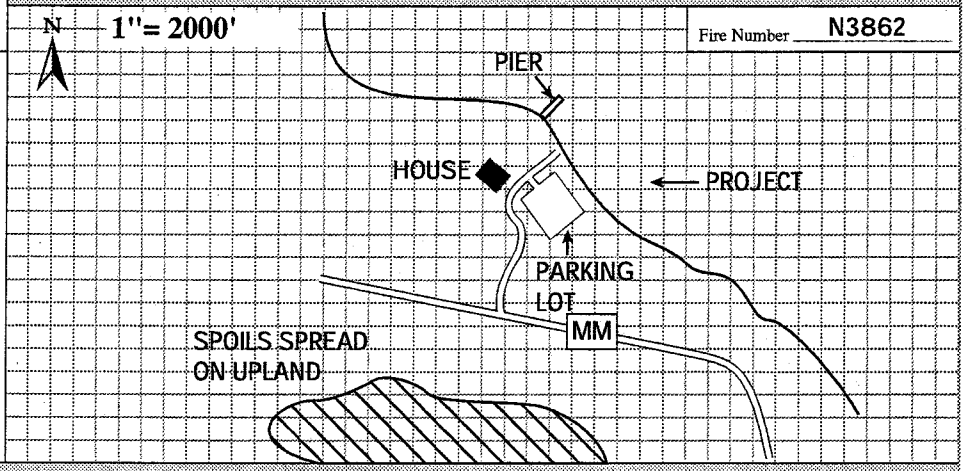
Location Sketch (Indicate scale.) Show route to project site, include nearest main road and crossroad.

LAKE DREDGING SAMPLE DRAWING

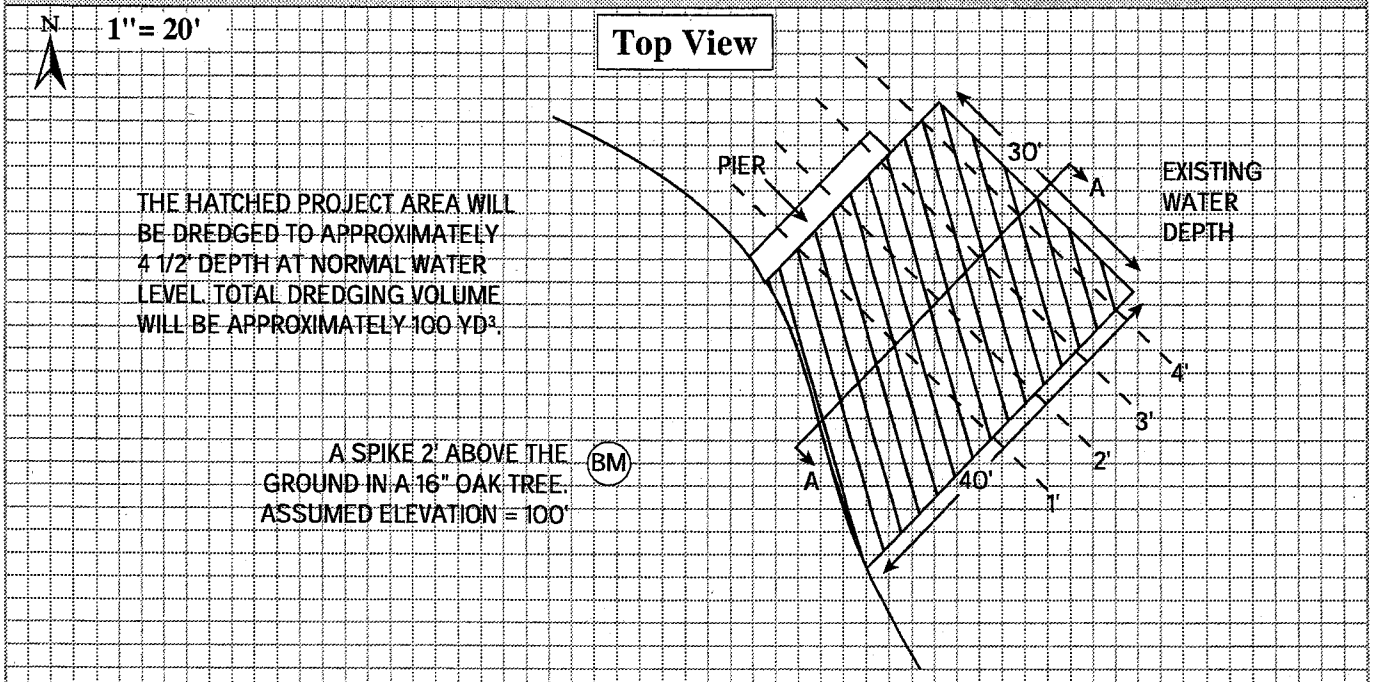
Fire Number N3862

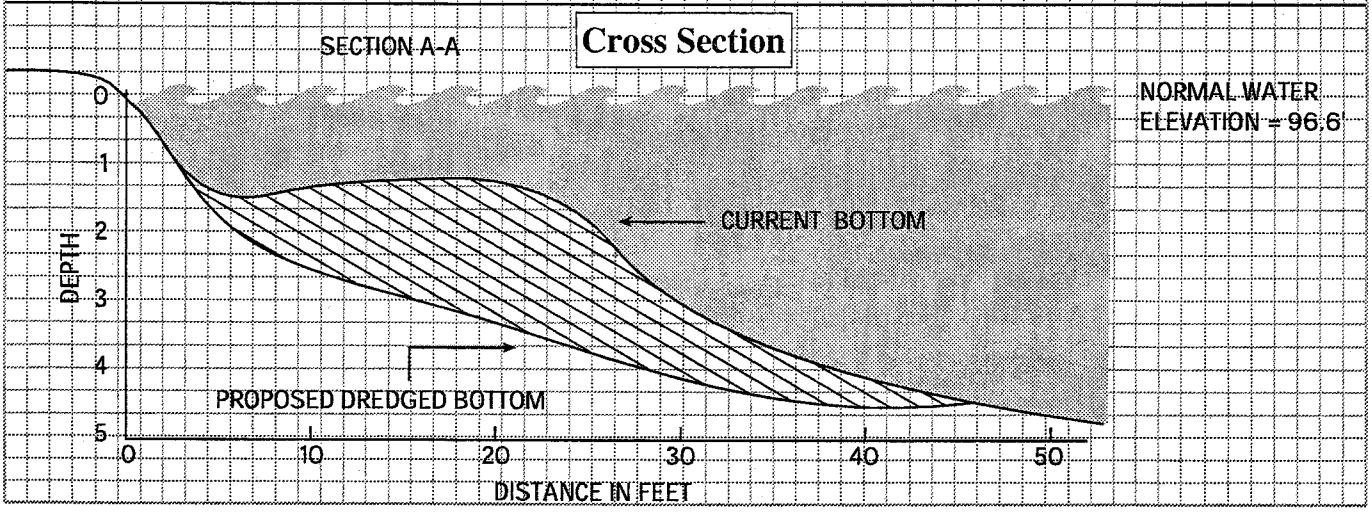
Proposed Materials

Excavation will be by clamshell dredge. Spoils will be hauled off site to an upland location. Totaldredge volume is approximately 100 cubic yards.




Project Plans. (Include top view and typical cross sections. Clearly identify features and dimensions or indicate scale.) Use additional sheets if necessary.



State of Wisconsin
Department of Natural Resources
(Return to appropriate DNR Regional/Service Center Office)

# State / Federal Application for Water Regulatory Permits and Approvals

Form 3500-053 (R 11/00)



PLEASE COMPLETE BOTH PAGES 1 & 2 OF THIS APPLICATION. PRINT OR TYPE. The Department requires use of this form for any application filed pursuant to Chapter 30, Wis. Stats. The Department will not consider your application unless you complete and submit this application form. Personally identifiable information on this form will not be used for any other purpose, but it must be made available to requesters under Wisconsin's open records law [s. 19.31-19.39, Wis. Stats.].

1. Applicant (Individual or corporate name)

Address

City, State, Zip Code | Fire Number

Telephone No. (Include area code) | Tax Parcel Number

2. Agent/Contractor (firm name)

Address

City, State, Zip Code

Telephone No. (Include area code)

3. If applicant is not owner of the property where the proposed activity will be conducted, provide name and address of owner and include letter of authorization from owner. Owner must be the applicant or co-applicant for structure, diversion and stream realignment activities.

Owner's Name | Address | City, State, Zip Code

4. Is the applicant a business? ☐ Yes ☐ No

If YES, is the permit or approval you are applying for necessary for you to conduct this business in the State of Wisconsin?

☐ Yes ☐ No

If YES, please explain why (attach additional sheets if necessary):

5. Project Location

Address _____

Village/City/Town _____

Fire Number _____ Tax Parcel Number _____

Waterway _____

County _____

Govt. Lot _____ OR ____1/4, ____1/4, of Section ____,

Township ____North, Range ____ (East) (West)

6. Adjoining Riparian (Neighboring Waterfront Property Owner) Information

Name of Riparian #1 | Address | City, State, Zip Code

Name of Riparian #2 | Address | City, State, Zip Code

7. Project Information (Attach additional sheets if necessary)

(a) Describe proposed activity (include how this project will be constructed)

(b) Purpose, need and intended use of project

(c) I have applied for or received permits from the following agencies: (Check all that apply)

☐ Municipal ☐ County ☐ Wis. DNR ☐ Corps of Engineers

(d) Date activity will begin if permit is issued _____; be completed: _____.

(e) Is any portion of the requested project now complete? ☐ Yes ☐ No

If yes, identify the completed portion on the enclosed drawings and indicate here the date activity was completed:

I hereby certify that the information contained herein is true and accurate. I also certify that I am entitled to apply for a permit, or that I am the duly authorized representative or agent of an applicant who is entitled to apply for a permit. Any inaccurate information submitted may result in permit revocation, the imposition of a forfeiture(s) and requirement of restoration.

☐ Withhold personal identifiers collected on this form from disclosure on any list of 10 or more individuals that the DNR is requested to provide to another person [s. 23.45, Wis. Stats.].

Signature of Applicant(s) or Duly Authorized Agent | Date Signed

| LEAVE BLANK - FOR RECEIVING AGENCY USE ONLY | | |
|---|---|---|
| Corps of Engineers Process No. | Wisconsin DNR File No. | |
| Received By | Date Received | Date Application Was Complete |

# State / Federal Application for Water Regulatory Permits and Approvals

Form 3500-053 (R 11/00)



Drawings of proposed activity should be prepared in accordance with sample drawing.

Proposed Materials

**Location Sketch** (Indicate scale)
Show route to project site: include nearest main road and crossroad.

N 1" = _____ ft.

Fire Number _____

**Project Plans** (Include top view and typical cross sections. Clearly identify features and dimensions or indicate scale.)
Use additional sheets if necessary.

N 1" = _____ ft.

**Top View**

**Cross Section**

State of Wisconsin
Department of Natural Resources

# Fee for Decisions on Applications to Alter Lakes, Streams or Wetlands

Form 3500-053A (R 11/00) 

*** PLEASE SEE PAGE 2 OF THIS FORM FOR APPLICABLE FEE ***

State law requires that we charge a fee for processing your request to make changes to surface waters and wetlands. Each application or request requires the correct fee in order for review to begin. **If your project includes several regulated activities you need to include payment only for the most costly activity.** If you have questions regarding the appropriate fee, please contact your local Water Management Specialist.

Applications are reviewed on a first in - first out basis (information on current average decision times is available on request). We do our utmost to deliver a decision promptly. **Expedited decision making is available for a supplemental fee of $2000.** It guarantees a decision within 90 days for most activities, 150 days for activities requiring a public notice or environmental assessment (EA), or 210 days for activities requiring both public notice and EA. Please submit a letter with your application describing the time frame that will meet your needs along with a check for $2000. (The supplemental fee funds permit reviewers specifically designated for expedited decision making). Within twenty days we will respond in writing, specifying any additional information needed for an expedited decision on your proposal and the time within which we can make a decision once the application is completed.

**Refunds** of standard fees are made only if the refund is requested before we determine that the application is complete. Supplemental fees will be refunded if a decision is not made within the standard decision time.

**Applications for permits or approvals submitted after work has been commenced or completed require twice the usual fee.** Projects started or completed without obtaining the appropriate permits are subject to potential enforcement actions (e.g., monetary forfeitures, required abatement).

Personally identifiable information on this form will not be used for any other purpose, but it must be made available to requesters under Wisconsin's open records law [s. 19.31-19.39, Wis. Stats.].

**TO BE COMPLETED BY APPLICANT:**

_____ _____

Permit/Approval Applied for With Highest Fee (see listing on page 2) | Amount Enclosed

_____ _____

Signature of Applicant | Date Signed

| LEAVE BLANK – DEPARTMENT OF NATURAL RESOURCES USE ONLY | | |
|---|---|---|
| Fee Received $_____ | ☐ Check | ☐ Money Order |
| Received by _____ | | |

**The Following Projects Do Not Require Fees:**
Standard riprap, shore and/or biostabilization protection
Fish cribs and similar structures for improving fish habitat
Nesting platforms and similar structures for improving wildlife habitat
Waterway projects funded in whole or in part by any federal or state agency
Dam or wetland projects conducted by state or federal agencies
Activities regulated by the Corps of Engineers that do not require state notification

The list below shows the fee that will be charged for many of the waterway and wetland permits, approvals, and determinations made by the Department of Natural Resources. **Please contact your local Water Management Specialist if your activity is not listed to determine the correct fee or if you have questions regarding which category best fits your project.**

**These Activities Require a $50.00 Fee:**
Boat ramp
Temporary bridge, culvert or ford on streams or wetlands less than 35 feet wide
Dry fire hydrant
Pile cluster
Ponds not connected to a waterway (unconnected pond)
Ponds not located in a wetland or floodplain
Sand (pea gravel) blanket
Single utility crossing of waterway or wetland by vibratory plow method
Boathouse repair certification

**These Activities Require a $300.00 Fee:**
Culvert or bridge on streams or wetlands less than 35 feet wide
Dredging less than 3,000 cubic yards
Permanent boat shelter
Flowage drawdowns
Grading more than 10,000 square feet
Pond connected to a waterway by a non-navigable connection (ultimately connected pond)
Pond located in a wetland
Private piers (requiring a permit)
Retaining wall on inland waters
Single family residential wetland fills, including yard fills and access paths
Single utility crossing by trenching in waterway or wetland
Small dam construction or alteration on non-navigable stream
Structure on bed of stream/lake not otherwise listed
Wetlands projects not otherwise listed that requires written submittal to DNR (see your Corps of Engineers letter)

**These Activities Require a $500 Fee:**
Barge fleeting
Breakwaters, revetments, groins, jetties, seawalls and solid piers on Lakes Michigan and Superior
Bridge, culvert on streams greater than 35 feet wide
Channel change
Commercial or public multi-slip pier
Consolidated utility crossing permit (non-trench methods)
Cranberry production activities affecting more than two acres of wetlands
Dam abandonment
Dam construction or alteration other than small dams on nonnavigable streams
Dam transfer of ownership
Diversion for agricultural/irrigation purposes
Dredging more than 3,000 cubic yards
Multi-unit residential, commercial or industrial wetland fills
Municipal bulkhead line approval
Municipal lakebed grants (review of legislation and use agreements)
Municipal waterway enclosure
Non-metallic mining (e.g., gravel extraction)
Pond connected to a waterway by a navigable connection (connected enlargement)
Waterway enlargement
Water level or flow decisions related to dams

**Supplemental Fee for Expedited Decisions** **$2000** (See page 1 for procedure)

**NOTES: Activities not identified on this list will have a fee of $300.**

# Appendix C

# AN AQUATIC PLANT MANAGEMENT PLAN FOR NAGAWICKA LAKE, WAUKESHA COUNTY, WISCONSIN

## INTRODUCTION

This aquatic plant management plan is an integral part of the lake management plan for Nagawicka Lake and represents an important element of the ongoing commitment of the City of Delafield and Village of Nashotah to sound environmental management with respect to the Lake. The aquatic plant management portion of the lake management plan was prepared during 2000 by the Regional Planning Commission, and is based on field surveys conducted by the Commission staff during June 1997[1] and subsequent surveillance during 1999 and 2000. The plan follows the format adopted by the Wisconsin Department of Natural Resources (WDNR) for aquatic plant management plans pursuant to Chapters NR 103 and NR 107 of the *Wisconsin Administrative Code*. Its scope is limited to those management measures which can be effective in the control of aquatic plant growth; those measures which can be readily undertaken by the City of Delafield concerned in concert with the riparian residents; and those measures which will directly affect the uses of Nagawicka Lake. The aquatic plant management plan for the Nagawicka Lake is comprised of seven elements:

1. A set of aquatic plant management objectives;

2. A brief description of the Lake and its watershed;

3. A statement of the current use restrictions and the need for aquatic plant management in the Nagawicka Lake;

4. An evaluation of alternative means of aquatic plant management and a recommended plan for such management;

5. A description of the recommended plan;

6. A description of the equipment needs for the recommended plan; and

7. A recommended means of monitoring and evaluating the efficacy of the plan.

## STATEMENT OF AQUATIC PLANT MANAGEMENT OBJECTIVES

The aquatic plant management program objectives for the Nagawicka Lake were developed in consultation with the City of Delafield Lake Welfare Committee, which Committee included representation from Village of Nashotah. The objectives are to:

---

[1]*The inventory data upon which this aquatic plant management plan is based are set forth in SEWRPC Memorandum Report No. 130,* A Lake and Watershed Inventory for Nagawicka Lake, Waukesha County, Wisconsin, *March 1999.*

1. Effectively control the quantity and density of aquatic plant growths in the Nagawicka Lake to enhance water-related recreational activities; to improve the aesthetic character of the resource; and to preserve and enhance the overall value of the waterbody;

2. Contribute to the overall conservation and wise use of the Nagawicka Lake through the environmentally sound management of vegetation, fishes and wildlife populations in and around the Lake; and,

3. Promote a high-quality, water-based recreational experience for residents and visitors to the Nagawicka Lake.

## NAGAWICKA LAKE AND ITS WATERSHED CHARACTERISTICS

Nagawicka Lake is located in the west central portion of Waukesha County, encompassed within the City of Delafield and the Village of Nashotah, as shown on Map C-1. The Lake is a drainage lake on the Bark River, with a clearly defined inflow entering the Lake on the northeastern shore, and a defined outlet draining the southwestern embayment of the Lake. Nagawicka Lake is located in the central portion of the Bark River watershed, downstream of Bark Lake, and upstream of a chain of lakes that include Upper and Lower Nemahbin and Crooked Lakes. Inventory data on Nagawicka Lake and its watershed are presented in detail in SEWRPC Memorandum Report No. 130, *A Lake and Watershed Inventory for Nagawicka Lake, Waukesha County, Wisconsin*, published in March 1999.

Nagawicka Lake is a 917-acre drainage lake located on the Bark River within U.S. Public Land Survey Sections 5, 8, 9, 16, 17, 20, and 21, Township 7 North, Range 18 East, City of Delafield and Village of Nashotah, Waukesha County. The Lake offers a variety of water-based recreational opportunities and is the focus of the communities surrounding the Lake. Portions of the lakeshore, particularly in the vicinity of the Naga-Waukee County Park and adjacent to the northernmost embayment known as the "Kettle," present a rural character among changing land uses in an urbanizing area. Elsewhere, the shoreline is well developed primarily for residential uses. Portions of the City of Delafield downtown overlook the southwestern portions of the Lake.

### Land Use and Shoreline Development

The Lake's total tributary drainage area is about 45 square miles in areal extent. As of 1990, approximately 78 percent of the total tributary drainage area to the Lake remained in rural land uses, with the dominant land usage being agricultural. Agricultural lands comprised about 44 percent of the total tributary drainage area. Woodlands, wetlands, and other open lands comprised a further 27 percent of the total tributary drainage area to the Lake. About 22 percent of the tributary drainage area was in urban land uses. Residential land usage comprised about 17 percent of the total tributary drainage area. Commercial, industrial, and recreational land uses comprised a further 4 percent of the total tributary drainage area to the Lake.

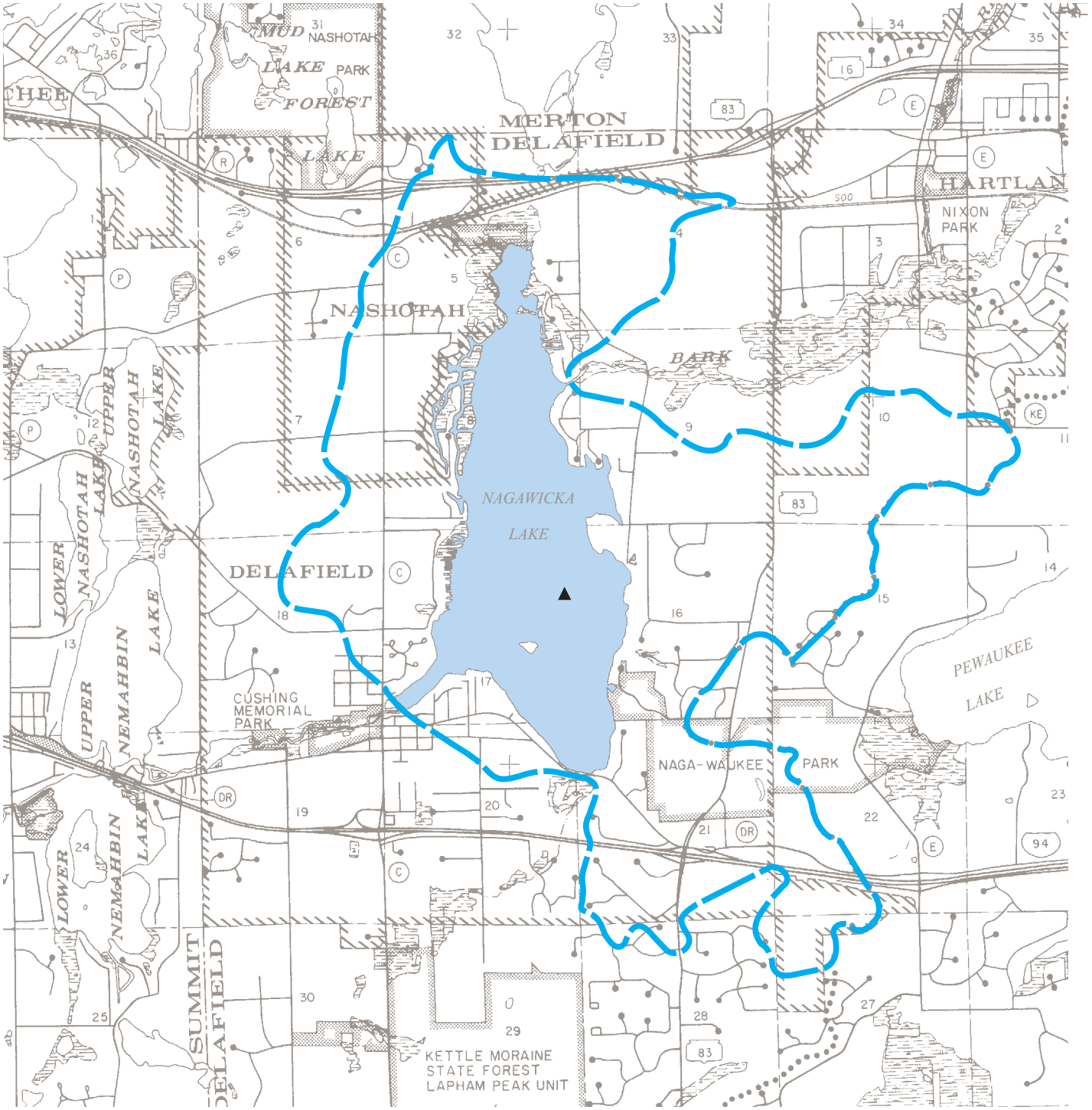
Under buildout conditions, the Waukesha County development plan and regional land use plan forecast about 4,700 acres of additional urban development within the drainage area tributary to the Lake. About 4,000 acres of this development is anticipated to be for residential uses. Thus, a significant portion of the rural lands outside of the environmental corridors, environmentally sensitive areas, and prime agricultural lands would be in residential or other urban usage under full buildout conditions, particularly in that portion of the drainage basin directly tributary to Nagawicka Lake.

### Aquatic Plants, Distribution, and Management Areas

A June 1997 macrophyte survey conducted by the Commission staff identified 12 different species of plants in Nagawicka Lake. The greatest diversity of plants in Nagawicka Lake was found to be present in the shallower portions of the basin of the Lake surrounding the area of deepest water. Coontail, muskgrass, curly-leaf pondweed, and water celery, in addition to both native and Eurasian water milfoil, were found in these areas of the Lake, as shown on Map C-2. Muskgrass, water celery, and native water milfoil appeared to be dominant in many areas of the main lake basin, while other portions of the lake basin were dominated by Eurasian water

Map C-1

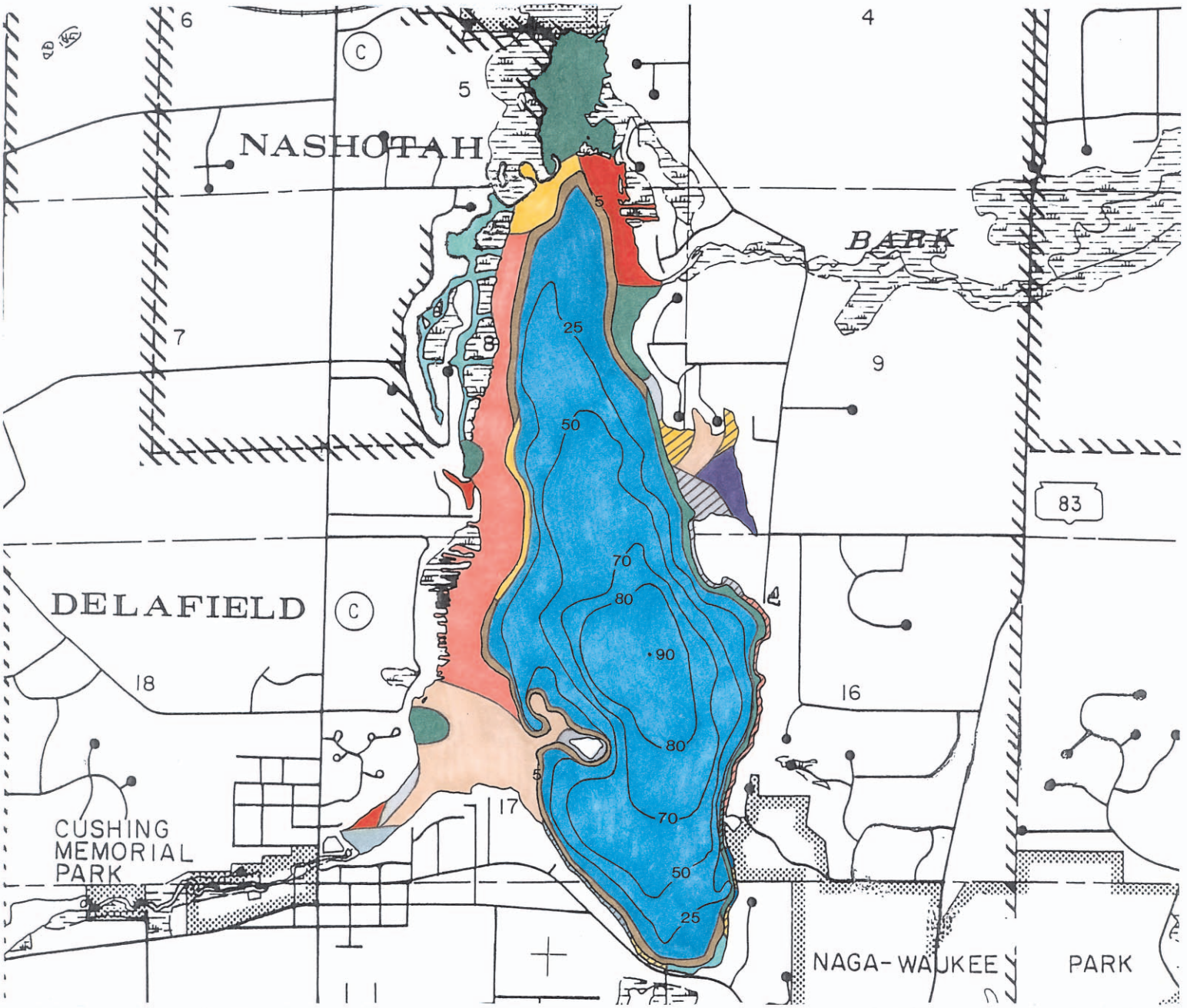
LOCATION MAP OF NAGAWICKA LAKE




*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Map C-2

## AQUATIC PLANT COMMUNITY DISTRIBUTION IN NAGAWICKA LAKE: 1997




LEGEND

- MUSKGRASS
- SPARSE
- NATIVE MILFOIL, MUSKGRASS, COONTAIL, AND EURASIAN WATER MILFOIL
- NATIVE MILFOIL, MUSKGRASS, PONDWEEDS, WATER CELERY, AND EURASIAN WATER MILFOIL
- NATIVE MILFOIL, COONTAIL, CURLY-LEAF PONDWEED, SAGO PONDWEED, FLAT-STEMMED PONDWEED, WATER CELERY, AND EURASIAN WATER MILFOIL
- NATIVE MILFOIL, MUSKGRASS, PONDWEEDS, AND WATER CELERY
- MUSKGRASS, PONDWEEDS, WATER CELERY, AND ELODEA
- NATIVE MILFOIL, MUSKGRASS, AND EURASIAN WATER MILFOIL
- NATIVE MILFOIL, MUSKGRASS, AND WATER CELERY
- NATIVE MILFOIL, COONTAIL, CURLY-LEAF PONDWEED, FLAT-STEMMED PONDWEED, WATER CELERY, ELODEA, AND EURASIAN WATER MILFOIL
- NATIVE MILFOIL AND PONDWEEDS
- NATIVE MILFOIL, CURLY-LEAF PONDWEED, FLAT-STEMMED PONDWEED, SAGO PONDWEED, MUSKGRASS, WATER CELERY, AND EURASIAN WATER MILFOIL

GRAPHIC SCALE

0 2000 4000 FEET



*Source: SEWRPC.*

milfoil, coontail, and curly-leaf pondweed. A species list, compiled from the results of the Regional Planning Commission aquatic plant survey, is set forth in Table C-1 along with comments on the ecological significance of each plant on the list. Representative illustrations of these aquatic plants can be found in Appendix B of the aforereferenced lake and watershed inventory report.

Eurasian water milfoil is an exotic aquatic plant species, not native to North America, which proliferates excessively creating thick beds of vegetation. In shallower depths of water, such as are present over much of Nagawicka Lake, Eurasian water milfoil is able to grow to the surface making certain recreational uses less enjoyable, if not dangerous, and impairing the aesthetic quality of the waterbodies. In addition to interfering with recreational activities, Eurasian water milfoil disrupts the ecosystem of the Lake. This particular species of milfoil has been known to become the dominant plant present in Lake with its ability to regenerate, to replace native vegetation, and to reduce the quality of fish and wildlife habitat. Further, when Eurasian water milfoil is fragmented by boat propellers, or any other means, the torn shoots are able to sprout new roots, colonizing new sites. These shoots can also cling to boats, trailers, motor props, or bait buckets; and can stay alive for weeks facilitating transfer to other lakes. For this reason it very important to remove all vegetation from boats and trailers after removing them from the water.[2]

Five areas on Nagawicka Lake were designated as environmentally sensitive areas by the Wisconsin Department of Natural Resources during 1990 because of the importance of these areas to the maintenance of good water quality conditions in, and the biological integrity of, the Lake. These areas are shown on Map C-3.

**Fisheries, Wildlife, and Waterfowl**

Nagawicka Lake supports a relatively large and diverse fish community. The Wisconsin Department of Natural Resources reports more than 30 species of fish, including the pugnose shiner, a State Threatened Species.[3] The most prevalent predator fishes in the Lake include northern pike, walleyed pike, smallmouth bass, and largemouth bass. Panfish species present in the Lake include bluegills, pumpkinseeds, green sunfish, and black crappies.

Given the land uses present around the shorelands of the Lake, only smaller animals and waterfowl generally inhabit the Lakeshore. Muskrats, beaver, grey and fox squirrels, and cottontail rabbits are probably the most abundant and widely distributed fur-bearing mammals in the immediate riparian areas. Larger mammals, such as the whitetail deer, are generally confined to the larger wooded areas and the open meadows found in the park and open space lands within the drainage areas of the Lake. The Nagawicka Lake drainage areas support a significant population of waterfowl including mallards, wood duck, and blue-winged teal. During the migration seasons a greater variety of waterfowl may be present and in greater numbers.

Amphibians and reptiles are vital components of the Nagawicka Lake ecosystem, and include frogs, toads, and salamanders, and turtles and snakes, respectively. About 14 species of amphibians and 16 species of reptiles would normally be expected to be present in the Nagawicka Lake area, at least one, Blanding's turtle, is considered a State Threatened Species.

**Recreation**

Nagawicka Lake is a multi-purpose waterbody serving all forms of recreation, including boating, swimming, and year-round fishing. Because of its size, Nagawicka Lake receives a significant amount of powerboat and sailboat use. Maximum boater use of lakes in Southeastern Wisconsin generally occurs between the hours of 10:00 a.m.

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

[3] *Wisconsin Department of Natural Resources Fish Management Report No. 131,* Creel Survey on Pewaukee and Nagawicka Lakes, Waukesha County, Summer 1982, *February 1987.*

Table C-1

AQUATIC PLANT SPECIES OBSERVED IN NAGAWICKA LAKE AND THEIR ECOLOGICAL SIGNIFICANCE

| Aquatic Plant Species Present | Ecological Significance[a] |
|---|---|
| *Ceratophyllum demersum* (coontail) | Provides good shelter for young fish and supports insects valuable as food for fish and ducklings |
| *Chara vulgaris* (muskgrass) | Excellent producer of fish food, especially for young trout, bluegills, small and largemouth bass; stabilizes bottom sediments; and has softening effect on the water by removing lime and carbon dioxide |
| *Elodea canadensis* (waterweed) | Provides shelter and support for insects valuable as fish food |
| *Myriophyllum spicatum* (Eurasian water milfoil) | None known |
| *Myriophyllum* sp. (native milfoils) | Provides shelter and is a valuable food producer, supporting many insects eaten by fish; fruits eaten by many wildfowl; a few wildfowl eat foliage; sparingly eaten by muskrats and moose |
| *Najas flexilis* (bushy pondweed) | Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish |
| *Nuphar* sp. (yellow water lily) | Leaves, stems, and flowers are eaten by deer; roots eaten by beavers and porcupines; seeds eaten by wildfowl; leaves provide harbor to insects, in addition to shade and shelter for fish |
| *Nymphaea* sp. (white water lily) | Provides shade and shelter for fish; seeds eaten by wildfowl; rootstocks and stalks eaten by muskrats; roots eaten by beaver, deer, moose, and porcupine |
| *Potamogeton amplifolius* (large-leaf pondweed) | Provides support for insects and produces good food supply for fish and ducks |
| *Potamogeton crispus* (curly-leaf pondweed) | Provides food, shelter, and shade for some fish and food for wildfowl |
| *Potamogeton pectinatus* (sago pondweed) | This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish |
| *Potamogeton praelongus* (white-stemmed pondweed) | Provides feeding grounds for muskellunge; also good food producers for trout; good food producer for ducks |
| *Potamogeton zosteriformis* (flat-stemmed pondweed) | Provides some food for ducks |
| *Vallisneria americana* (water celery) | Provides good shade and shelter, supports insects, and is valuable fish food |

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

*Source: SEWRPC.*

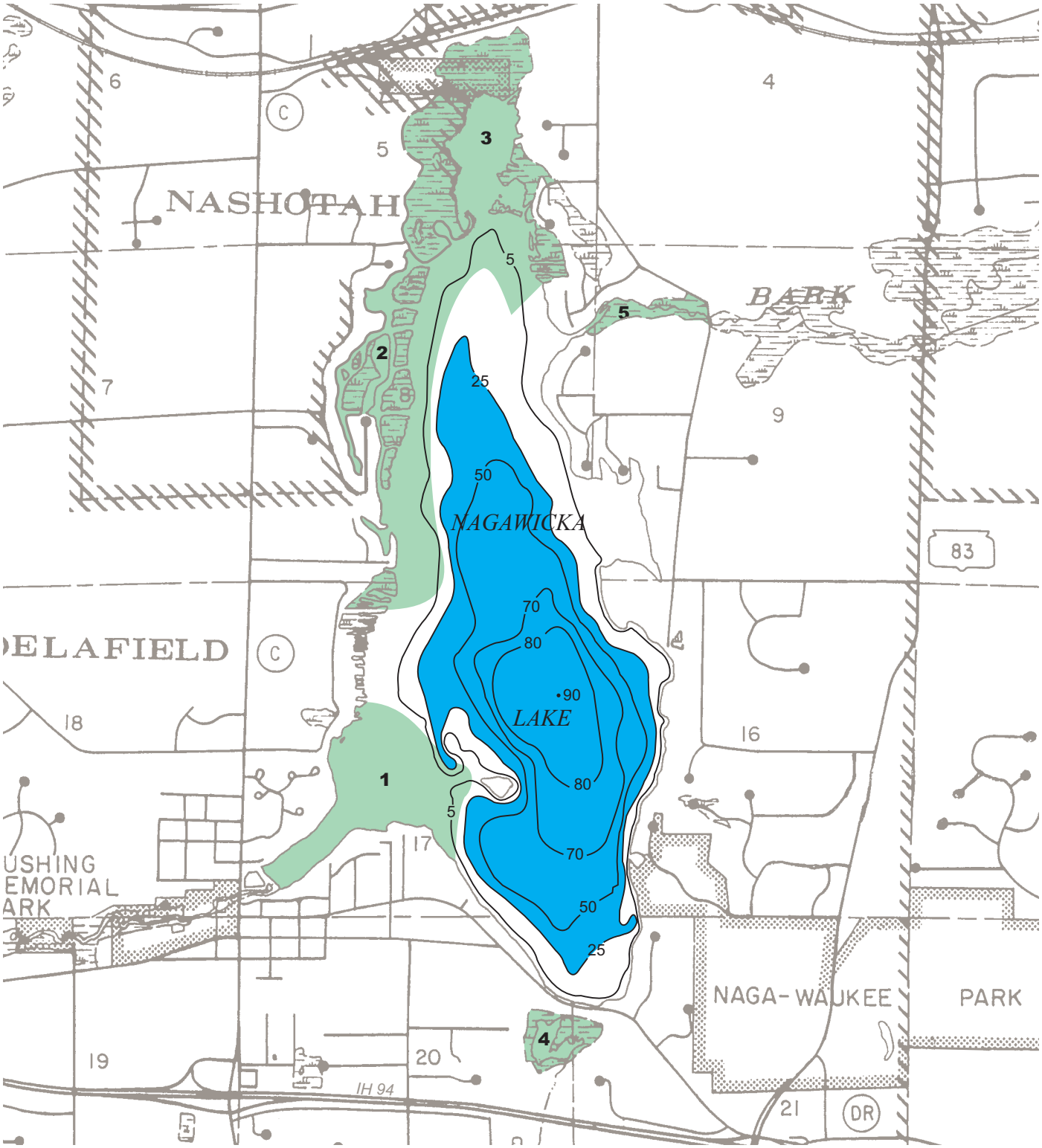
and 2:00 p.m. A boat survey conducted by the Commission staff on June 26 and July 19, 1997, between these hours indicated that a total of 54 and 121 watercraft of all descriptions were typically in use on the Lake during the summer at one time. Swimming facilities are provided at the Naga-Waukee County Park, located on the southeastern shoreline of the Lake. This park also provides picnicking and camping facilities for Waukesha County residents and visitors who enjoy lakeside vistas and the natural ambience of the Park.

## USE RESTRICTIONS IMPOSED BY AQUATIC PLANTS

Excessive plant growth on both Nagawicka Lake impedes boat traffic, making some areas of the Lake impassable without aquatic plant control. The dense plant growths generally occur in the southwestern portion of the Lake

Map C-3

WISCONSIN DEPARTMENT OF NATURAL RESOURCES-DELINEATED SENSITIVE AREAS IN NAGAWICKA LAKE




2 WISCONSIN DEPARTMENT OF NATURAL RESOURCES-DELINEATED SENSITIVE AREAS

—20′— WATER DEPTH CONTOUR IN FEET

DEPTH GREATER THAN 25 FEET

GRAPHIC SCALE
0 1000 2000 FEET

*Source: Wisconsin Department of Natural Resources.*

basin, known as St. John's Bay, and along portions of the western shoreline of the Lake, severely restricting boating and shoreline angling and swimming, and even impairing the aesthetic enjoyment of the waterbody. The littoral areas of the northern embayment, known as the "Kettle," are also subject to abundant plant growths which impede boating access to and from the "Kettle" to the main lake basin. The plant growth limits recreational use of the Lake and shoreline, and results in public complaints throughout the summer season. Failure to remove floating vegetation which is left behind by the plant harvesters, or cut by boat propellers, leads to a buildup of vegetation along the shoreline. During the summer months, these beds of vegetation can become foul smelling and unsightly. The excessive plant growth also contributes to the accumulation of organic sediment on the bottom of the Lake.

## PAST AND PRESENT AQUATIC PLANT MANAGEMENT PRACTICES

Aquatic herbicides have been used on both Nagawicka Lake under permits issued by the Wisconsin Department of Natural Resources since the 1950s, when records of such control programs began to be kept. The aquatic plant control measures initially involved the use of sodium arsenite. Nagawicka Lake is noted as being one of the 10 most heavily treated waterbodies in Wisconsin, receiving more than 43 tons of sodium arsenite during the approximately 20-year period from 1950 through 1967. Applications of sodium arsenite were discontinued in 1967 after arsenic accumulations were found in the lake sediments and concerns were expressed over possible human health impacts. More recent chemical treatments have made use of more specific systemic herbicides such as 2,4-D, as set forth in Table C-2. All current chemical treatments of Nagawicka Lake are applied by State-licensed personnel and conform to the requirements of permits issued under Chapter NR 107 of the *Wisconsin Administrative Code*. Chemical applications are normally made in late spring and early summer as the plants begin to grow, with occasional follow-up treatments being applied in mid-summer.

Aquatic plant harvesting has been used in concert with a herbicide treatment to control aquatic plant growth in Nagawicka Lake. The City of Delafield has purchased and currently operates an aquatic plant harvester and associated conveying and transport equipment on the Lake. One of the objectives of the aquatic plant management program for Nagawicka Lake that aquatic herbicide use be minimized and synchronized with the aquatic plant harvesting operation to maximize impacts. Herbicide application should be confined to nearshore areas to control nuisance plants, such as milfoil and coontail, which are difficult to control in any other way.

## ALTERNATIVE METHODS FOR AQUATIC PLANT CONTROL

### Background

Various aquatic plant management techniques, manual, mechanical, physical and chemical, are potentially applicable to the Nagawicka Lake.[4] A number of these methods have been employed with varying success on the Nagawicka Lake in the past.

### Physical Controls

One physical method of aquatic plant control involves the drawing down of a waterbody in order to change or create specific types of habitat and thereby manage species composition within the waterbody. Such drawdown was not considered to be practicable on Nagawicka Lake due to the heavy recreational demands placed on the Lake throughout the year.

Other physical controls, such as the placement of bottom barriers and use of shoreline protection structures, such as riprap, may be practicable. Bottom barriers provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. Barriers should not be used in areas of strong surf, heavy angling, or shallow water where motorboating occurs.

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[4]*The various methods referred to in the text are described in more detail in U.S. Environmental Protection Agency Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, *August 1990.*

Table C-2

HISTORIC CHEMICAL CONTROLS ON NAGAWICKA LAKE: 1950-1994

| Year[a] | Macrophyte Control | | | | Algal Control | |
|---|---|---|---|---|---|---|
| | Sodium Arsenite (pounds) | Diquat (gallons) | Aquathol K (gallons) | 2,4-D (pounds) | Copper Sulfate (pounds) | Cutrine-Plus (gallons) |
| 1950 | 300 | 0.00 | 0.0 | 0.00 | 20 | 0.00 |
| 1951 | 200 | 0.00 | 0.0 | 0.00 | 15 | 0.00 |
| 1952 | 0 | 0.00 | 0.0 | 0.00 | 0 | 0.00 |
| 1953 | 200 | 0.00 | 0.0 | 0.00 | 0 | 0.00 |
| 1954 | 2,560 | 0.00 | 0.0 | 0.00 | 0 | 0.00 |
| 1955 | 2,980 | 0.00 | 0.0 | 0.00 | 0 | 0.00 |
| 1956 | 2,760 | 0.00 | 0.0 | 0.00 | 0 | 0.00 |
| 1957 | 3,216 | 0.00 | 0.0 | 0.00 | 0 | 0.00 |
| 1958 | 5,216 | 0.00 | 0.0 | 0.00 | 0 | 0.00 |
| 1959 | 2,860 | 0.00 | 0.0 | 0.00 | 200 | 0.00 |
| 1960 | 2,100 | 0.00 | 0.0 | 0.00 | 250 | 0.00 |
| 1961 | 6,520 | 0.00 | 0.0 | 0.00 | 300 | 0.00 |
| 1962 | 5,130 | 0.00 | 0.0 | 0.00 | 400 | 0.00 |
| 1963 | 12,240 | 0.00 | 0.0 | 0.00 | 1,400 | 0.00 |
| 1964 | 11,340 | 0.00 | 0.0 | 0.00 | 2,200 | 0.00 |
| 1965 | 11,700 | 0.00 | 0.0 | 0.00 | 1,400 | 0.00 |
| 1966 | 9,702 | 0.00 | 0.0 | 0.00 | 1,440 | 0.00 |
| 1967 | 8,190 | 0.00 | 0.0 | 0.00 | 1,150 | 0.00 |
| 1969 | 0 | 0.00 | 0.0 | 0.00 | 405 | 0.00 |
| 1970 | 0 | 0.00 | 0.0 | 0.00 | 1,930 | 0.00 |
| 1980 | 0 | 0.00 | 6.0 | 0.00 | 0 | 9.00 |
| 1982 | 0 | 17.00 | 15.0 | 0.00 | 0 | 20.00 |
| 1985 | 0 | 10.00 | 20.5 | 3.00 | 0 | 33.00 |
| 1986 | 0 | 19.00 | 21.5 | 9.00 | 0 | 38.50 |
| 1987 | 0 | 17.25 | 22.5 | 0.00 | 0 | 21.75 |
| 1988 | 0 | 0.00 | 0.0 | 20.00 | 0 | 38.00 |
| 1989 | 0 | 0.00 | 3.0 | 31.25 | 350 | 2.25 |
| 1991 | 0 | 0.00 | 0.0 | 8.25 | 0 | 0.75 |
| 1992 | 0 | 1.75 | 0.0 | 7.00 | 0 | 1.75 |
| Total | 87,214 | 65.00 | 88.5 | 78.50 | 11,460 | 165.00 |

[a]*During years not included, no chemical controls were used.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Extensive use has been made of shoreline protection structures along the developed areas of the Nagawicka Lake shoreline, as shown on Map C-4. Because of the uniqueness of each shoreline situation these control methods are recommended for Nagawicka Lake only for installation by homeowners on a site-specific basis.

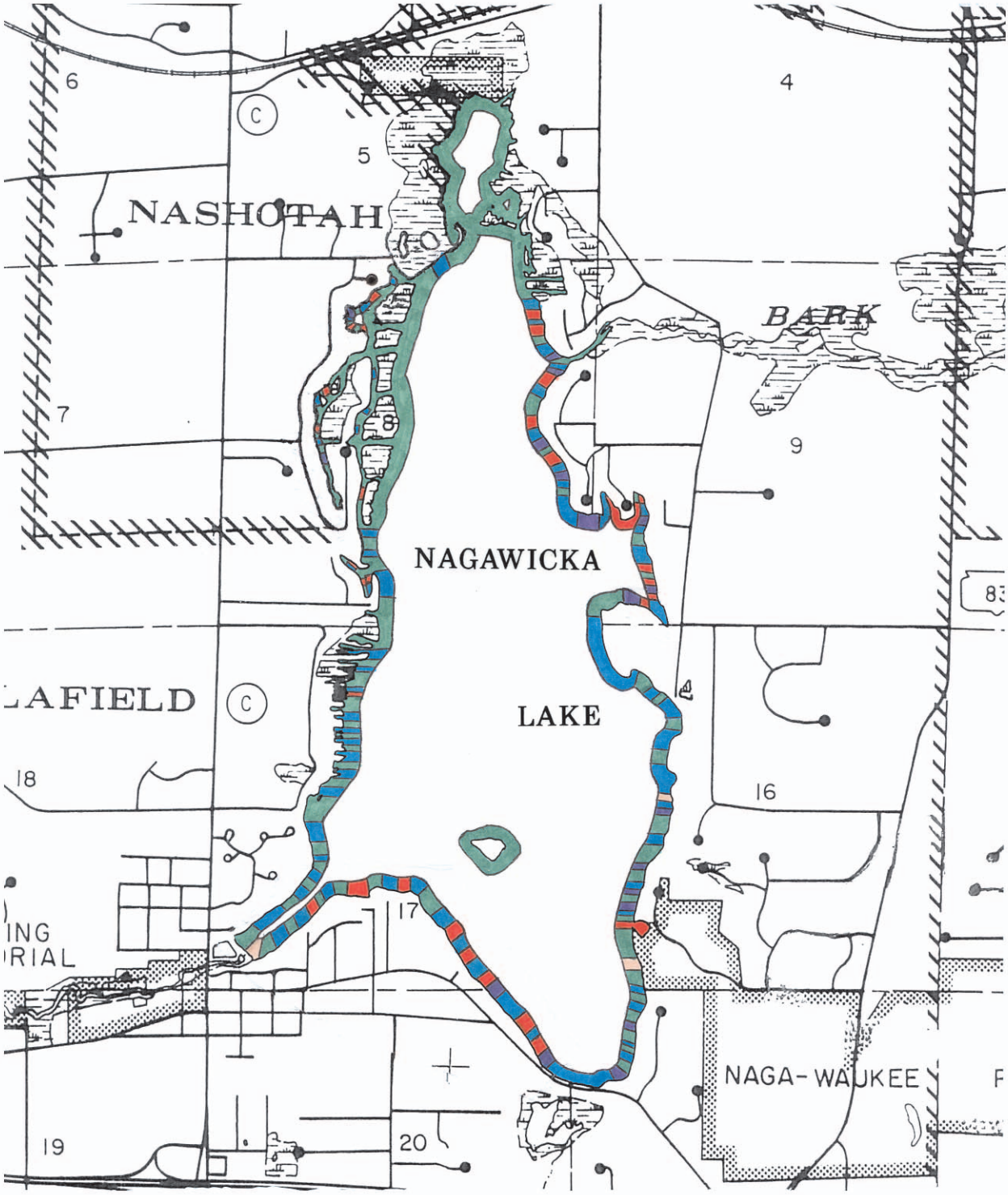
Both types of controls require permits from the Wisconsin Department of Natural Resources.

**Chemical Controls**

Chemical control measures are viewed by the community as having uncertain long-term environmental impacts, as well as possible consequences for human health. While the herbicides recently used on the Nagawicka Lake have met applicable U.S. Environmental Protection Agency standards and are applied by licensed personnel, the use of chemical control measures can contribute to an ongoing aquatic plant problem by augmenting the natural rates of accumulation of decayed organic matter in the lake sediments, releasing the nutrients contained in the

Map C-4

SHORELINE PROTECTION CONDITIONS ON NAGAWICKA LAKE




Source: SEWRPC.

plants back into the water column where they can be reused in new plant, including algal, biomass production. The use of chemical control measures may also damage or destroy nontarget plant species that provide needed habitat for fish and other aquatic life. Accordingly, chemical control measures should not be relied upon to fully control the infestations of aquatic plants in Nagawicka Lake.

However, chemical control measures are recommended for the control of the nuisance conditions over relatively small areas of the Lake. If considered necessary, chemical applications should be made in accordance with current Wisconsin Department of Natural Resources rules, under the authority of a State permit, by a licensed applicator working under the supervision of State staff. Records accurately delineating treated areas and the type and amount of herbicide used in each area, should be carefully recorded and used as a reference in applying for permits in the following year. A recommended checklist is provided as Figure C-1.

**Manual Controls**

Manual methods of aquatic plant control, such as raking or hand-pulling, while environmentally sound, are difficult to employ on a large-scale. Although very effective in small-scale applications, for example, in and around docks and piers, manual techniques are generally not practicable for large-scale plant control methods. Manual means are considered a viable option on the Nagawicka Lake to control nearshore plant growths, and for removal of rooted vegetation along shorelines and around docks by individual riparian land owners. The advantage of these manual control methods, as opposed to chemical treatment, is that the response is immediate, no permits are required, and potential long-term affects of chemicals are not a concern.

**Mechanical Controls**

Based on previous experience employing mechanical harvester technologies on the Nagawicka Lake, mechanical harvesting of aquatic plants appears to be a practicable and efficient primary means of controlling plant growth in the Lake in an environmentally sensitive manner. Harvesting removes the plant biomass, and nutrients from the Lake. While mechanical harvesting can potentially impact fish and other aquatic life caught up by the machine, disturb loosely consolidated lake bottom sediments, and result in the fragmentation and spread of some aquatic plants, it has also been shown to have some benefit in ultimately reducing the regrowth of other plants and removing phosphorus from the Lake.[5] Harvesting also removes attached, epiphytic algal growths with the harvested plant material, and leaves sufficient plant material in the Lake to continue to provide forage and shelter for fish and other aquatic life, while stabilizing the lake sediments to prevent increased turbidity due to wave resuspension.

Of the various types of harvesters available, one alternative would be to purchase a smaller harvester, with about a seven-foot removable cutter bar which could then also be operated for cleanup of floating aquatic plants. The removal of the cutting bar would allow the harvester to operate in somewhat shallower water, such as in the constructed channels located on the northeastern and northwestern shores of the Lake. This type of harvester has the ability to cut and hold about 8,500 pounds of vegetation and to operate in areas as shallow as three feet. Options exist which could allow for the replacement of the paddlewheels with an hydraulically powered propeller system decreasing the width of the machine. This particular system can be operated with diesel fuel which is more economical than the standard paddlewheel option and is compatible with a transporter.

Accessory equipment needed to accompany a new harvester would include a trailer to move the harvester and a shore conveyor to unload the plants, if the new and currently owned harvesters are to work simultaneously. The options exist to buy each piece of equipment separately or to purchase one piece of equipment which is designed for both needs.

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[5]*Environmental Protection Agency*, The Lake and Reservoir Restoration Guidance Manual, *2nd Edition, August 1990, p. 146.*

**Figure C-1**

**DISTRICT CHECKLIST FOR HERBICIDE APPLICATION**

- ☐ Nuisance report completed defining areas of potential treatment
- ☐ Permit filed with the Wisconsin Department of Natural Resources
- ☐ Certified applicator hired[a]
- ☐ Required public notice in the newspaper
- ☐ Public informational meeting (required if five or more parties request a meeting)
- ☐ Posting of areas to be treated in accordance with regulations (discussed previously in report)
- ☐ Weather conditions cooperating
  - — Wind direction and velocity
  - — Temperature

*[a]A licensed applicator will determine the amount of herbicide to be used, based upon discussions with appropriate staff from the Wisconsin Department of Natural Resources, and will keep records of the amount applied.*

*Source: SEWRPC.*

A harvesting program should be designed to provide optimal benefits and minimal adverse impacts. Small fish are common in dense macrophyte beds, but larger fish, such as largemouth bass, do not normally utilize these dense beds. Narrow channels may be harvested to provide navigational access and "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish. Shared access lanes may also be cut, allowing several residents to use the same lane. Increased use of these lanes should keep them open for longer periods than would be the case if a less directed harvesting program was followed. Because of the demonstrated need for control of aquatic plants in Nagawicka Lake and because the current lake management decisions have indicated a need for aquatic plant harvesting, harvesting is considered a viable management option which should be continued by the City of Delafield.

**Biological Controls**

Another alternative approach to controlling nuisance aquatic plant conditions, in this particular case Eurasian water milfoil, is biological control. Classical biological control has been successfully used to control both weeds and herbivorous insects.[6] Recent documentation states that *Euhrychiopsis lecontei*, an aquatic weevil species, has the potential as a biological control agent for Eurasian water milfoil. In 1989, the weevil was discovered during a study investigating a decline of Eurasian water milfoil growth in a Vermont pond. *Euhrychiopsis* proved to have

[6]*C.B. Huffacker, D.L. Dahlsen, D.H. Janzen and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities, *1984, pp. 659-696; C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology, *Kohl Wiley, New York, New York, USA.*

significant effects on Eurasian water milfoil in the field and in the laboratory. The adult weevil feeds on the milfoil causing lesions which make the plant more susceptible to pathogens, such as bacteria or fungi, while the weevil burrows in the stem of the plant causing enough tissue damage for the plant to lose buoyancy and collapse.[7] Although studies thus far indicate that the weevil has the potential to be a biological control for Eurasian water milfoil, at present there is not enough supporting evidence and actual exposure to warrant recommending this type of control on Nagawicka Lake except on an experimental basis.

**Information and Education**

In addition to these in-lake rehabilitation methods, an ongoing campaign of community information would help to support the aquatic plant management program by encouraging the use of shoreland buffer strips, responsible use of household and garden chemicals, and environmentally friendly household and garden practices to minimize the input of nutrients from these riparian areas. This information program would also remind riparian residents of the habitat and other benefits, such as shoreline stabilization, provided by the aquatic flora of the Lake, and promote the preservation of an healthy aquatic flora in Nagawicka Lake.

## RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

The recommended aquatic plant management plan consists of integrated used of mechanical and manual harvesting and chemical treatment designed to minimize the negative impacts on the ecologically valuable areas of the Lake, while providing the control needed to achieve the desired recreational uses of the Lake.

In order to implement the recommended aquatic plant management program the following management actions are recommended:

1. Mechanical harvesting is recommended as the primary management method. As indicated in Chapter III of the lake management plan, this will, in the long-term, help to maintain good water quality conditions by removing plant materials which are currently contributing to an accumulation of decomposing vegetation and associated nutrient recycling. The harvesting should be carried out by the City of Delafield using its existing harvester and transport equipment.

2. It is recommended that shared-access channels be harvested to minimize the potential detrimental effects on the fish and invertebrate communities. Directing boat traffic through these common channels would help to delay the regrowth of vegetation in these areas.

3. Surface harvesting is recommended, cutting to a depth of approximately two feet to remove the surface canopy of nonnative aquatic plants, such as the Eurasian water milfoil, this should provide a competitive advantage to the low-growing native plants present in the Lake. By not disturbing the low-growing species which generally grow within one to two feet of the lake bottom and in relatively low densities, leaving the root stocks and stems of all cut plants in place, the resuspension of sediments in Nagawicka Lake will be minimized, and some degree of cover will continue to be provided for panfish populations which support the bass population in the Lake. Further, cutting should not be general, but focused on boating channels.

4. It is recommended that the use of chemical herbicides be limited to controlling nuisance growth of exotic species in shallow water around docks and piers where the harvester is unable to reach. Such use should be evaluated annually and the herbicide applied only on an as needed basis. Only herbicides that selectively control milfoil, such as 2,4-D, should be used. Algicides, such as Cutrine Plus, are not recommended because there are no significant filamentous algae or planktonic algae

[7] *Sally P. Sheldon, "The Potential for Biological Control of Eurasian Water Milfoil (*Myriophyllum spicatum*) 1990-1995 Final Report," Department of Biology Middlebury College, February 1995.*

problems in the Nagawicka Lake and valuable macroscopic algae, such as *Chara* and *Nitella* are killed by this product.

5. It is recommended that chemical applications, if required, be made in early spring to maximize their effectiveness on nonnative plant species, while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions.

6. The control of rooted vegetation between adjacent piers is recommended to be left to the riparian owners concerned, as it is time consuming and costly for a mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. The City of Delafield Lake Welfare Committee may wish to obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to inform residents of the control options available.

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

8. It is further recommended that the City of Delafield Lake Welfare Committee conduct a public informational program on the types of aquatic plants in Nagawicka Lake; on the value of and the impacts of these plants on water quality, on fish, and on wildlife; and on alternative methods for controlling existing nuisance plants including the positive and negative aspects of each method. This program can be incorporated into the comprehensive informational and educational programs which also would include information on related topics, such as water quality, recreational use, fisheries, and onsite sewage disposal systems.

**Harvesting Plan**

The recommended aquatic plant management plan for the Nagawicka Lake is graphically summarized on Map C-5. As indicated on the map, it is proposed that aquatic plant management activities be restricted in certain ecologically valuable areas of the Lake. For this reason, aquatic plant management activities should be confined to zones related to recreational boating access (Zone A), open water (Zone O), and recreational uses (Zone R). Further, aquatic plant management operations will be concentrated in the areas identified for Eurasian water milfoil control, and targeted on Zone A (especially near the boating access ramps and in the principal boating use areas). A majority of the lake basin is comprised of deep water habitat requiring no aquatic plant management intervention, about 65 percent of the Lake being greater than five-feet in depth.

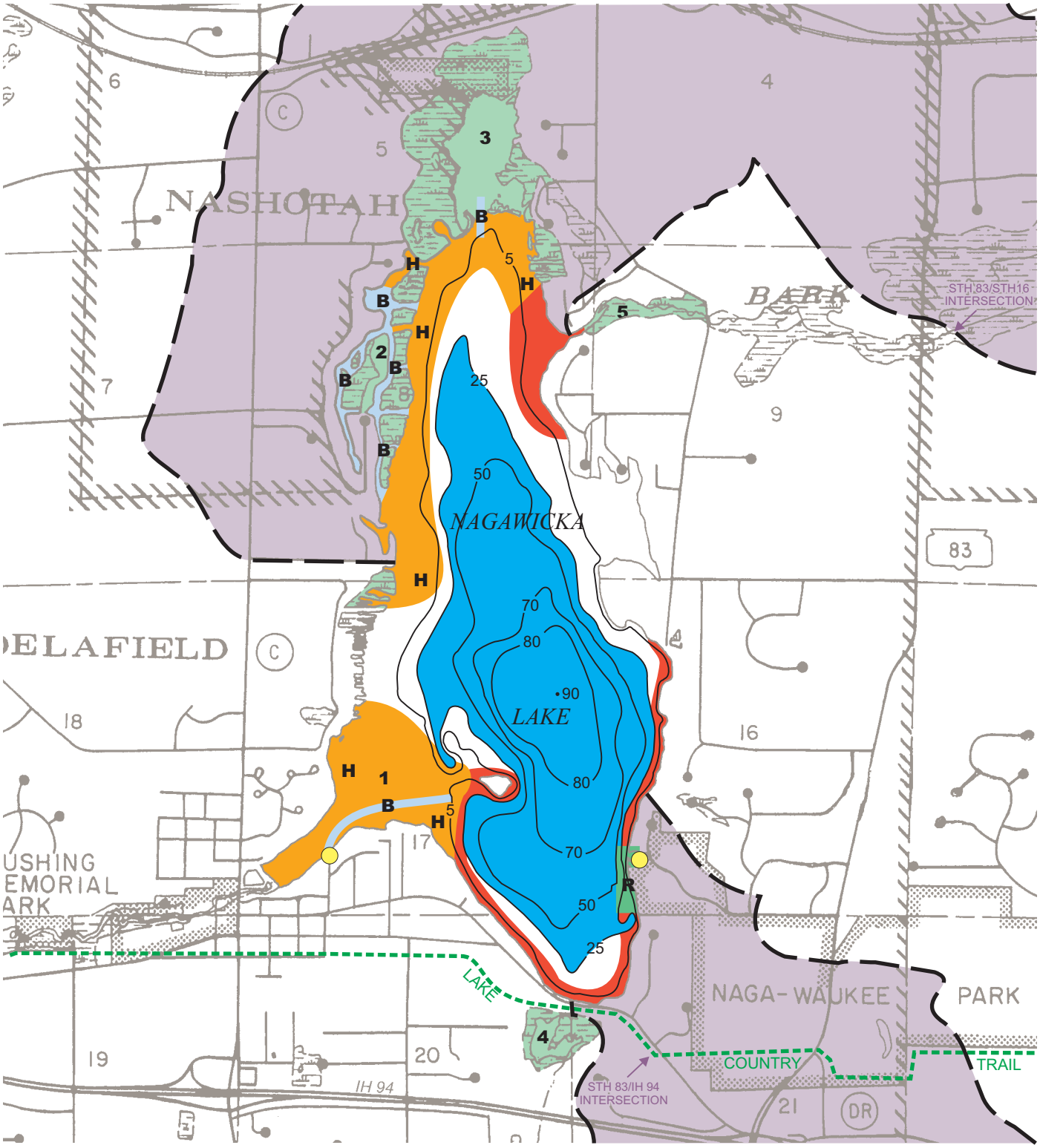
The environmentally sensitive areas, as identified by the Wisconsin Department of Natural Resources in 1990, should be reviewed as recommended in the lake management plan. However, existing controls applied within these areas limit harvesting, and restrict chemical applications in the five areas. In general, harvesting, if permitted within the sensitive areas as currently delineated, should not take place in shallow waters, generally five feet or less, to avoid disturbance of fish spawning areas and beds of native aquatic plants. Special care should be taken to avoid disturbing major spawning and habitat areas of bass in the Nagawicka Lake during the spring spawning season, May 1 to June 30, annually.

The primary objective of the management program is to accommodate the multiple recreational uses of the Lake, and to enhance the public perception of the Lake without inflicting irreparable damage on the structure and functioning of the lake ecosystem. To accomplish this objective, only specified control measures should be applied in each of the various lake zones identified on Map C-5. The recommended sequence of the harvester operations on Nagawicka Lake is portrayed in Figure C-2. The recommended aquatic plant management treatments that should be applied in each of the three lake zones are shown in Table C-3.

It is envisioned that the harvesting crew will be required to spend about 25 to 35 hours per week on Nagawicka Lake to accomplish the stated goals.

Map C-5

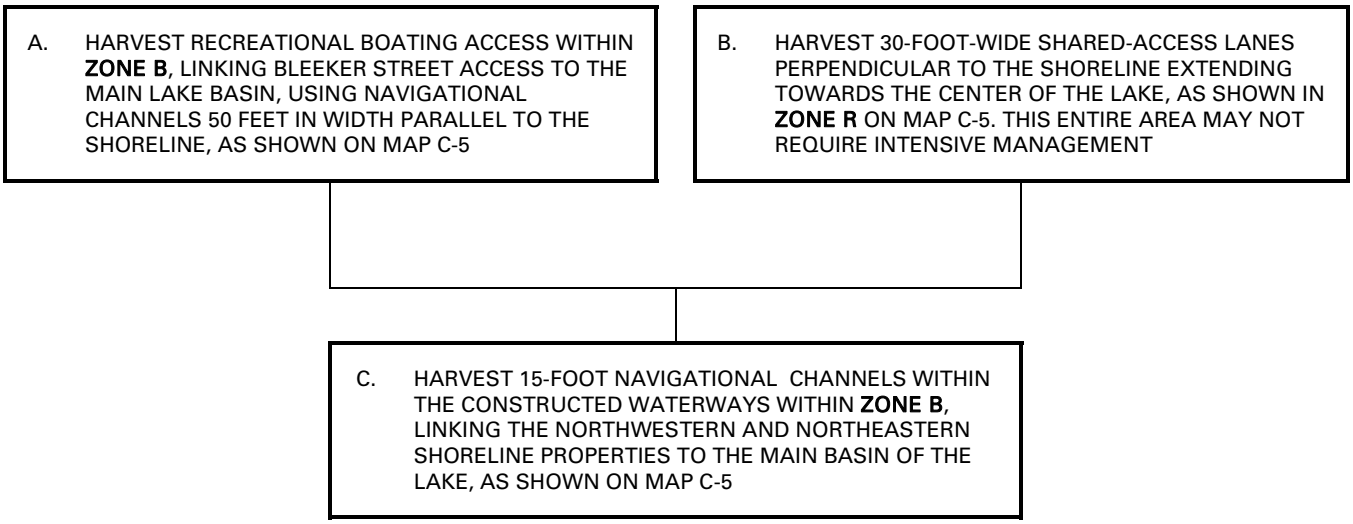
AQUATIC PLANT MANAGEMENT PLAN FOR NAGAWICKA LAKE




*Source: SEWRPC.*

Figure C-2

HARVESTING SEQUENCE FOR NAGAWICKA LAKE[a]




NOTE: Sequence A and B could be done concurrently in one area of the Lake as a time-saving measure.

[a]*No harvesting would be conducted in Zone H or within 100 feet of the island areas.*

*Source: SEWRPC.*

**Depth of Harvesting and Treatment of Fragments**

The harvesting equipment proposed to be used has a maximum cutting depth of five feet. While this may exceed the actual water depth in some areas it is not the intention of the owners or operators of the equipment to denude the Lake of aquatic plants given the heavy angling use of the waterbody, its morphology (which is not conducive to extensive motorized boat traffic), and the program goals. All plant cuttings and fragments will be collected *in situ* by the harvester. Those fragments accumulating along the shoreland areas will be collected by the riparian homeowners. Fragments can be used by the homeowners as garden mulch.

**Buoyage**

Temporary marker buoys may be used to direct harvesting operations in the lake basin by marking the areas to be cut. However, the size of the Lake generally precludes the need for such buoys, except insofar as they are required for the control of boating traffic on the Lake. The harvester operators will be provided with a laminated copy of the harvesting plan and made familiar with the plan and local landmarks to the degree necessary to carry out the plan without the use of buoyage.

**Harvested Plant Material Transfer Site(s)**

Plant material will be removed from the harvester at the off-loading area adjacent to the Bleeker Street public recreational boating access site, where it will be transferred to a dump truck using a conveyor and transported to disposal sites identified by the City of Delafield. Plant material will be collected and disposed of daily to avoid leaching of nutrients back into the Lake and to minimize the visual degradation of the environment near the boat launching site. The operators will stringently police the off-loading site to ensure minimal disruption of boaters and of the people using the riparian areas of the Lake.

Table C-3

RECOMMENDED AQUATIC PLANT MANAGEMENT TREATMENTS FOR NAGAWICKA LAKE

| Zone and Priority | Recommended Aquatic Plant Management Treatment |
|---|---|
| Zone B (Boating)<br>Moderate-Priority Harvesting | Harvesting limited to maintaining 15-foot-wide navigational channels around the northeastern and northwestern perimeter of the Lake, and 50-foot-wide recreational boating access lane from Bleeker Street public recreational boating access site, to allow boat access to the open water area of the Lake<br>Limited late season harvesting, late August to early September, may be necessary to maintain adequate open water areas to the central portion of the Lake |
| Zone H (Habitat)<br>Low-Priority Harvesting | It is recommended that selected areas of the Lake, designated as WDNR sensitive areas, be preserved as high-quality habitat area, subject to review by the WDNR as recommended in the lake management plan<br>This zone and adjacent lands should be managed for fish habitat<br>Limited harvesting and no in-lake chemical application should be permitted, except in special instances where selective herbicide application may be allowed for the control of nuisance species<br>Debris and litter cleanup would be needed in some adjacent areas; the immediate shoreline should be preserved in natural, open use to the extent possible |
| Zone R (Recreational Access)<br>High-Priority Harvesting | The entire area may not require intensive plant management[a]<br>Nuisance aquatic macrophyte growth within 150 feet of shoreline should be harvested to provide maximum opportunities for boating, fishing, and swimming<br>Areas between piers should not be harvested due to potential liability and maneuverability problems. Residents should be encouraged to manually harvest aquatic plants in these areas<br>Chemical use, if required, should be restricted to pier and dock areas and should not extend more than 100 feet from shore, subject to permit requirements, to control of nuisance species |

[a]*Excludes areas greater than 15 feet which require no harvesting.*

*Source: SEWRPC.*

**Disposal of Harvested Plant Material**

Harvested plant material will be land-spread on area farms or disposed of by land disposal. Harvested plant material will be used as compost.

**Precautions to Protect Wildlife and Ecologically Valuable Areas**

Operators will be provided with a laminated copy of the approved harvesting plan map as set forth in Map C-5, showing the limits of harvesting operations. A copy of the map will be kept on the harvester at all times. Operations should normally not be carried out in those areas with less than three feet of depth to protect bass habitat and spawning areas. Harvesting operations in the areas identified as suitable for bass spawning will be restricted until mid-June to permit undisturbed spawning.

**Public Information**

It is the policy of the City of Delafield Lake Welfare Committee to maintain an active dialogue with the community. This dialogue is carried out through the medium of the public press and in public fora through various public meetings and other scheduled hearings.

**Harvesting Schedule**
The harvesting season will begin no earlier than May 15th and will end about September 30th of each year. Actual harvesting time, not including unloading, maintenance, and downtime, will average 30 to 35 hours per week over a five-day week on average, depending on weather conditions and plant growth, to minimize recreational conflicts. During peak-growth periods, this time requirement may be increased somewhat. Further, harvesting will be confined to daylight hours to minimize public disturbances resulting from harvester and plant removal operations. As provided for above, the harvesting operations will also be modified to protect fish spawning areas and other ecologically valuable areas of the lake as set forth on Map C-5.

## EQUIPMENT NEEDS AND OPERATION

### Equipment Needs and Total Costs

***Manufacturer***: Aquarius Systems, D&D Products, Inc., North Prairie, Wisconsin, or other manufacturer with comparable equipment.

### Existing Equipment Requiring Replacement

***Harvester***: Aquarius Systems model HM-420 or equivalent.

| | | |
|---|---|---|
| ***Costs***: | HM-420 Aquatic Plant Harvester or equivalent | $ 65,000 |
| | TR 12 trailer | 5,000 |
| | Shore conveyor (for Nagawicka Lake) | 15,000 |
| ***Shore Barge***: | | |
| ***Costs***: Shore Barge with conveyor | | $ 15,000 |
| ***Total Cost*** | | $100,000 |

**Maintenance Schedule, Storage, and Related Costs**
Routine maintenance will be performed by the City of Delafield in accordance with the manufacturer's recommended maintenance schedule. Maintenance costs will be borne by the City. Winter storage of the harvesting equipment will be the responsibility of the City of Delafield. The harvesting equipment will be stored in the City of Delafield Department of Public Works shed located about one-half mile west of the Delafield City Hall.

**Insurance Coverage**
Insurance coverage on the harvesting equipment will be incorporated into the policy held by the City of Delafield on all capital equipment. Liability insurance for the operation of the harvesting equipment will also be borne by the City. The relevant certificates of insurance will be held by the City of Delafield.

**Operators, Training, and Supervision**
The harvesting equipment will be owned and operated by the City of Delafield, who will be responsible for day-to-day operations of the equipment. The City will provide operator training as required. City staff have extensive experience in the operation of this type of machinery. Initial training will be provided by the manufacturers on delivery of the machinery.

Day-to-day supervision will be by the City staff.

## EVALUATION AND MONITORING

**Daily Record-Keeping Relating to the Harvesting Operation**
Daily harvesting activities will be recorded by the operators of the harvesting equipment in an operations log. An annual summary of the harvesting program will be submitted to the City of Delafield City Council (or designated Committee thereof), and made available to the public at that time.

It is the intention of the City of Delafield to undertake a periodic, formal review of the harvesting program as set forth in the management plan for Nagawicka Lake, a copy of which has been lodged with the Department's Southeast Region Office.

**Daily Record-Keeping Relating to the Harvester**
Daily maintenance and service records showing engine hours, fuel consumed and oil used, will be recorded in a harvester operations log.

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## Appendix D

# CITY OF DELAFIELD RESOLUTION NO. 87.12 TO CREATE A LAKE WELFARE COMMITTEE FOR THE CITY OF DELAFIELD, WISCONSIN

RESOLUTION NO. 87.12

A RESOLUTION TO CREATE A LAKE WELFARE COMMITTEE
FOR THE CITY OF DELAFIELD, WISCONSIN

WHEREAS, the Common Council of the City of Delafield recognizes that the City has as one of its natural resources Lake Nagawicka, and

WHEREAS, the City is responsible for the day to day management of said lake, and is dedicated to providing quality use thereof, and

WHEREAS, several issues and concerns have arisen concerning the lake, which should be investigated with recommendations to the Common Council,

NOW THEREFORE BE IT RESOLVED, that the LAKE WELFARE COMMITTEE of the City of Delafield is hereby created.

BE IT FURTHER RESOLVED that the charge to the Committee is to study all problems and issues relating to Nagawicka Lake and/or the Bark River within the City limits, and make recommendations to the Common Council concerning solutions thereto.

BE IT FURTHER RESOLVED, that the Committee shall be comprised of one member of the City Council serving a one year term, renewable annually, and one citizen member from each aldermanic district. Those citizens from odd-numbered aldermanic districts are to serve terms to expire in odd-numbered years, and those citizens from even-numbered aldermanic districts are to serve terms to expire in even-numbered years. Initial terms shall be for one and two years as indicated above, with terms thereafter being for two years. Members shall be appointed by the Mayor with approval of the City Council.

Dated this 20 day of July, 198

CITY OF DELAFIELD

Robert M. Savrnoch

Robert M. Savrnoch, Mayor

ATTEST:

Lois Jensen

Lois Jensen, City Clerk