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SEWRPC Staff Memorandum

AN AQUATIC PLANT MANAGEMENT PLAN UPDATE FOR NAGAWICKA LAKE, WAUKESHA COUNTY, WISCONSIN: 2011

June 15, 2012

INTRODUCTION

Nagawicka Lake has been the subject of both a lake and watershed inventory,[1] and a comprehensive lake management plan prepared by the Southeastern Wisconsin Regional Planning Commission (SEWRPC).[2] The comprehensive lake management plan included an aquatic plant management plan element that has been adopted by the City of Delafield Lake Welfare Committee. In 2006, pursuant to the recommendations set forth in the comprehensive lake management plan, SEWRPC prepared an updated aquatic plant management plan to refine the aquatic plant element of the comprehensive lake plan.[3] The aquatic plant management plan update, set forth in this SEWRPC Staff Memorandum, is intended to be an integral part of the comprehensive lake management plan, and a refinement and update of the 2006 aquatic plant management plan. This update represents an important element of the ongoing commitment of the City of Delafield and its Lake Welfare Committee, in cooperation with the Village of Nashotah, to sound environmental management of the Lake.

The 2006 aquatic plant management plan was prepared by SEWRPC based upon field surveys conducted by SEWRPC staff during June 2004. The aquatic plant survey was conducted by SEWRPC staff using the modified Jesson and Lound transect method employed by the Wisconsin Department of Natural Resources (WDNR) at that time.[4] The current 2011 survey, also conducted by SEWRPC staff, employed a grid-based

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

[2]*SEWRPC Community Assistance Planning Report No. 262,* A Lake Management Plan for Nagawicka Lake, Waukesha County, Wisconsin*, March 2001.*

[3]*SEWRPC Memorandum Report No. 161,* An Aquatic Plant Management Plan for Nagawicka Lake, Waukesha County, Wisconsin*, March 2006.*

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

survey method currently endorsed by the WDNR.[5] This SEWRPC Staff Memorandum further refines the aquatic plant management plan element of the comprehensive lake management plan for Nagawicka Lake based upon the results of the aquatic plant survey conducted during 2011.

This SEWRPC Staff Memorandum follows the format adopted by the 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 in Nagawicka Lake, those measures which can be readily undertaken by the City of Delafield Lake Welfare Committee in concert with the riparian residents and the Village of Nashotah, and those measures which will directly affect the use of Nagawicka Lake.

This SEWRPC Staff Memorandum is comprised of seven main sections: 1) a statement of planning goals and objectives; 2) a brief description of the Lake and its watershed; 3) descriptions of past and current aquatic plant communities based on aquatic plant surveys, including a comparison of the compositions of past aquatic plant communities with those currently reported to be present in Nagawicka Lake; 4) a statement of the current use restrictions and the need for aquatic plant management in Nagawicka Lake; 5) a description of past and present aquatic plant management practices utilized on Nagawicka Lake; 6) a review and evaluation of alternative methods of aquatic plant management; and 7) a description of the recommended plan.

STATEMENT OF AQUATIC PLANT MANAGEMENT GOALS AND OBJECTIVES

The goals and objectives for Nagawicka Lake were developed in consultation with the City of Delafield Lake Welfare Committee. The goals and objectives are to:

- Control effectively the quantity and density of aquatic plant growths in portions of Nagawicka Lake to improve the water-related recreation opportunities, to improve the aesthetic value of the resource to the community, and to enhance the resource value of the waterbody;

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

- Protect and maintain public health and to promote public comfort, convenience, and welfare in concert with the natural resource through the environmentally sound management of native vegetation, fishes, and wildlife in and around Nagawicka Lake; and

- Promote a quality water-based experience for residents and visitors to Nagawicka Lake consistent with the policies and practices of the WDNR, as set forth in the regional water quality management plan, SEWRPC Planning Report No. 30, *A Regional Water Quality Management Plan for Southeastern Wisconsin—2000*, as amended.[6]

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[5]*J. Hauxwell, S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky, and S. Chase. Wisconsin Department of Natural Resources, Bureau of Science Services, Publication No. PUB-SS-1068 201,* Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry and Analysis, and Applications, *March 2010.*

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

NAGAWICKA LAKE AND ITS WATERSHED CHARACTERISTICS

Nagawicka Lake is located within the City of Delafield and Village of Nashotah, both in Waukesha County, as shown on Map 1. The Lake is a drainage, or through-flow, lake being both fed and drained by the Bark River. The Lake is a 917-acre waterbody with a single, deep basin. The total drainage area tributary to Nagawicka Lake is about 45 square miles in areal extent,[7] with portions of the tributary area extending into southern Washington County, wherein lies the headwaters of the Bark River system. The direct tributary area of Nagawicka Lake, or that area which drains directly to the Lake without passing through any upstream waterbody, is about 7.5 square miles in areal extent, and is situated wholly within Waukesha County.

AQUATIC PLANT COMMUNITIES

Prior to the formulation of the 2006 SEWRPC aquatic plant management plan, two previous surveys of the aquatic plant communities in Nagawicka Lake had been conducted. The first of these surveys was that of Aron & Associates, conducted during August 1993.[8] Subsequently, SEWRPC staff conducted an aquatic plant species reconnaissance survey of the lake basin during 1997 as part of the lake and watershed inventory then being compiled.[9] This latter reconnaissance survey was incorporated into the comprehensive lake management plan for Nagawicka Lake.[10] More recently, aquatic plant surveys of the Lake were undertaken by SEWRPC staff during 2004 and 2011 as part of the 2006 aquatic plant management plan formulation and this refinement, respectively.[11] Key aspects of each of the four surveys are summarized chronologically below.

1993 Survey
The 1993 survey identified 12 species of aquatic plants, many of which were reported to be common to abundant.[12] Muskgrass (*Chara vulgaris*); water celery, or eel-grass, (*Vallisneria americana*); and native milfoil (*Myriophyllum sibiricum*) were the most abundant aquatic plants in many areas of the main lake basin. Healthy populations of pondweeds (*Potamogeton* spp.) appeared to be scattered throughout the Lake, and were most commonly found at depths of between five and 10 feet. Eurasian water milfoil, (*Myriophyllum spicatum*) was scattered throughout the Lake, but largely confined to areas of the Lake with depths of between 10 and 15 feet.

1997 Survey
During the 1997 survey,[13] 12 species of submergent plants were identified in Nagawicka Lake. Several species known to interfere with the recreational and aesthetic use of the Lake were reported, including Eurasian water milfoil, coontail (*Ceratophyllum demersum*), and curly-leaf pondweed (*Potamogeton crispus*). Eurasian water

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[7]*Note: Refined topographic mapping of Waukesha County shows the areas tributary to Beaver and Pine Lakes to be part of the Oconomowoc River subbasin and hydrologically distinct from that of the Bark River.*

[8]*Aron & Associates,* Nagawicka Lake Plant Management Plan*, August 1993.*

[9]*SEWRPC Memorandum Report No. 130,* op. cit.

[10]*SEWRPC Community Assistance Planning Report No. 262,* op. cit.

[11]*SEWRPC Memorandum Report No. 161,* op. cit.

[12]*SEWRPC Memorandum Report No. 130,* op. cit.

[13]*SEWRPC Community Assistance Planning Report No. 262,* op. cit.

milfoil and curly-leaf pondweed are designated nonnative invasive species pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*. Aquatic plant growth occurred in waters of up to 15 feet in depth, with the exception of the southeastern and southwestern portions of the Lake where growth was sparse, perhaps due to the steeply sloping lake bottom in these areas. Musk grass, eel-grass (wild celery), and native milfoil (*Myriophyllum* spp.) were dominant in portions of the lake basin, while healthy populations of pondweeds (*Potamogeton* spp.) were scattered throughout the Lake, generally in the five-to-10 foot depth range. Eurasian water milfoil was also scattered throughout the Lake, but was more commonly found at depths of between 10 feet and 15 feet.

2004 Survey
During 2004, 16 species of submerged aquatic plants were identified, including both native and nonnative species. The number of species suggests a more diverse and abundant aquatic plant community than previously recorded in the Lake. Both Eurasian water milfoil and curly-leaf pondweed again were noted as present in the Lake. However, these species appeared to be present in significantly reduced abundances from the densities observed during the 1997 reconnaissance. Such periodicity, especially in Eurasian water milfoil populations, has been observed elsewhere in southeastern Wisconsin, and potentially reflects the influences of a combination of stressors. These stressors include biological factors, such as the activities of Eurasian water milfoil weevils,[14] as well as climatic and limnological factors, such as insolation, water temperature, and current circulation patterns. Map 2 shows the distribution of aquatic plant species in Nagawicka Lake in 2004.

2011 Survey
During the 2011 reconnaissance, 19 species of submerged aquatic plants were observed. The distribution of these aquatic plant species is shown on Map 3. The most common species in the Lake in 2011 included muskgrass, floating-leaf pondweed, eel-grass, and water star-grass (*Zosterella dubia*).

Changes in the Observed Aquatic Plant Communities
Results of the 2004 and 2011 aquatic plant surveys conducted in Nagawicka Lake are summarized in Tables 1 and 2. There was little change observed in the aquatic plant community from the time of the 1993 survey to the time of the 1997 survey, with about the same 12 species reported in each survey and little change in the dominant species. During the 2004 survey, 24 species of aquatic plants were identified: 16 species were submergent, four were floating-leaved species, and one was an emergent plant. The increase in submergent species reported in the 2004 survey suggests a more diverse and abundant aquatic plant community than previously observed during the earlier two surveys. This increase in the number of species observed could reflect a more rigorous sampling protocol in the 2004 survey, or it could reflect seasonal variations in plant community composition, rather than a major change in the plant community of the Lake from 1997 to 2004. Several of the additional species observed during the 2004 survey that were not previously reported in Nagawicka Lake were comprised of various species of pondweeds, including Sago pondweed (*Potamogeton pectinatus*) and small pondweed (*Potamogeton pusillus*). The appearance of pondweeds in a lake is generally considered to be a positive sign. Table 3 describes the positive ecological significance of all aquatic species found in Nagawicka Lake during the course of the surveys conducted from 1993 through 2011.

While such changes in species composition may reflect sampling protocols and/or seasonality within the macrophyte community in a given lake, the loss of a particular plant species also may indicate changes in the underlying ecosystem. For example, the apparent loss of species in a lake may be related to an increase in abundance of Eurasian water milfoil, with shifts in the abundance of several native species, including coontail,

[14] *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.*

several varieties of pondweed, and native water milfoil, appearing to coincide with an increase in abundance of Eurasian water milfoil.

In contrast, the loss of a particular plant species may indicate changes in weather and climate. Aquatic plant communities undergo cyclical and periodic changes, which, in part, reflect changing climatic conditions on an interannual scale and, in part, the evolution of the aquatic plant community in response to changing hydroclimate conditions in a lake—these latter including factors, such as changes in long-term nutrient loading, sedimentation rates, and recreational use patterns.

Interannual changes in the aquatic plant communities of a lake occur over a period of three to seven years and may be temporary. Evolutionary changes occur over a decadal or longer period, and are longer-lasting. Some species, such as pondweeds, exhibit distinct seasonality, with individual species having well-defined growing periods that reflect water temperature, insolation, and other factors. Variations in the occurrence of pondweed species in lakes are not unusual. Such variations are frequently reported and reflect anticipated interannual variability within a lake. Such variability is related to weather conditions, insolation or the availability of sunlight, and related climatic factors, as well as sampling effort (rare species may be under-sampled). Consequently, variations in occurrences of pondweed species, in particular, rarely reflect long-term changes in a lake ecosystem. Similarly, changes in the Eurasian water milfoil population in a lake may reflect the results of aquatic management practices and/or may be a reflection of a periodicity the species naturally experiences. Such periodicity, especially in Eurasian water milfoil populations, has been observed elsewhere in southeastern Wisconsin, and potentially reflects the influences of a combination of stressors. These stressors include biological factors, such as the activities of naturally occurring Eurasian water milfoil weevils, as well as climatic and limnological factors, such as insolation, water temperature, and lake circulation patterns.

Comparison of the Transect- and Grid-Based Methodologies

To determine the nature of changes occurring in aquatic plant communities, successive surveys, utilizing similar methods, should to be conducted every three to five years. The modified Jesson and Lound transect method, as promulgated by the WDNR and widely used throughout the Southeastern Wisconsin Region by SEWRPC staff prior to 2010, allows the statistical evaluation of changes in the aquatic plant community within a lake when utilized in successive aquatic plant surveys.[15] In 2010, the WDNR reverted to a grid-based sampling methodology,[16] and, consequently, the 2011 SEWRPC-conducted survey was accomplished using this methodology. In future years, as successive surveys are conducted at these same sampling points on the Nagawicka Lake grid, more meaningful comparisons of empirical data may be possible.

That the two methodologies provide somewhat differing levels of information about the aquatic plant community should be anticipated. The transect method, adapted from terrestrial ecology and adopted to overcome the limitations inherent in a grid-based system, uses four aquatic plant samples collected at each sampling point to determine if a plant species is "present" or "absent" in each sample. This methodology provides an objective means of determining the abundance of a plant species; subsequently, the various other statistical measures—relative density, frequency of occurrence, and importance value—can be used in analyzing aquatic plant communities, since they are based on this initial objective observation. The method provides a fairly reliable and objective assessment of plant community composition. Further, since the "present" or "absent" determination is objectively made, the accuracy of this method is unlikely to be affected

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

[16]*J. Hauxwell, S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky, and S. Chase,* op. cit.

by different observers. Quite simply, the species is either in the sample, or it is not, and any errors made are due to either misidentification or inadvertently overlooking a small fragment of a species present in the sample.

The grid-based methodology, in which only one sample is collected at each sampling point and field staff make subjective evaluations as to the abundance of each species using a five-point scale without the benefit of objective descriptors for assigning these values, objectively notes only presence or absence data. Other data, such as relative density, importance value, and the like, are less objective since they are dependent on the initial subjective field assessment of abundance. Simply put, different observers may assign differing scores for density. The WDNR staff, themselves, note that "the presence/absence data cannot be used to estimate biomass or percent cover, [and] it is less sensitive to interannual or seasonal variations in plant abundance."[17] The WDNR staff also note that "the method is relatively rapid and cost-effective and can be used on the large scale to collect baseline data and statistically compare communities over time,"[18] which seems to be its principal attribute when compared with the transect-based methodology.

In 2010, a comparative study of the transect-based and grid-based methodologies was conducted on Powers Lake in Kenosha County, Wisconsin.[19] Results of this study suggested that both the grid-based and transect-based methodologies provided essentially the same information with regard to the numbers and types of aquatic plant species observed in Powers Lake during that year. Both sampling methods resulted in muskgrass being identified as the dominant aquatic plant species in that lake, with bladderwort being the next most frequently encountered species. The two methodologies, however, differed in terms of identifying the third most frequently encountered species, with the transect method identifying coontail, while the grid method identified eel-grass (wild celery). Both aquatic plants are considered to be of high value for fishes and other aquatic organisms, so these differences were not considered to be significant for purposes of aquatic plant management in Powers Lake. Other minor differences in the aquatic plant data produced by the two methodologies, such as frequency of occurrence and pattern of distribution, from the point of view of aquatic plant management, were not considered to be significant in the Powers Lake study.

The agreement with respect to the dominant aquatic plant species and their relative areas of distribution indicated by both methodologies is important. An important objective of aquatic plant management practices is to address recreational and other use impairments that arise as a result of certain aquatic plants being dominant in a lake to the point where their abundance reaches nuisance levels.[20] This is especially significant when the plants that dominate are nonnative species, such as Eurasian water milfoil, as oftentimes the nonnative species flourish at the expense of native species. As a consequence, whole ecosystems within a lake can be disrupted as native plant species, which normally provide the food, shelter, and other factors which native aquatic animal

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[17] *See also J.D. Madsen, "Point Intercept and Line Intercept Methods for Aquatic Plant Management," U.S. Army Corps of Engineers Waterways Experiment Station Aquatic Plant Control Technical Note No. MI-02, 1999; and L. Dodd-Williams, G.O. Dick, R.M. Smart, and C.S. Owens, "Point Intercept and Surface Observation GPS (SOG): A Comparison of Survey Methods—Lake Gaston, NC/VA," U.S. Army Corps of Engineers Research and Development Center Report No. ERDC/TN APCRP-EA-19, 2008.*

[18] *Wisconsin Department of Natural Resources, Publication No. PUB-SS-1068 2010,* op. cit.

[19] *SEWRPC Memorandum Report No. 193,* A Lake Protection Plan for Powers Lake, Kenosha and Walworth Counties, Wisconsin*, November 2011.*

[20] *The presence of "nuisance" is an important determinant in the issuance of permits for the application of chemical herbicides in lakes, as stated in Section NR 107.05(3)(c) of the* Wisconsin Administrative Code.

life are adapted to and depend upon for survival, become replaced with nonnative species that do not fulfill these same requirements. Aquatic plant management works to develop strategies aimed at restoring the balance between desirable native aquatic plant species and other species as a basis for supporting and sustaining a wide range of lake uses that include recreational activities, such as swimming, fishing, and recreational boating, among others.

Aquatic Plant Diversity in Nagawicka Lake

A critical key to the ability of an ecosystem, such as a lake, to maintain its ecological integrity is through *biological diversity*. Conserving the biological diversity, or biodiversity, of an ecosystem helps, not only to sustain the system, but preserves a spectrum of options for future decisions regarding the management of that system. Generally, Nagawicka Lake has exhibited good biodiversity in its aquatic plant communities, especially since 2004, although the modest increase in the reported number of aquatic plant species during this time period may be a function of more rigorous surveying methodology, rather than any significant changes in the communities themselves.

Aquatic Plant Species of Special Significance

Native Aquatic Plants

There have been several native plant species observed in various surveys of Nagawicka Lake that are of exceptionally high-ecological value: muskgrass (*Chara* spp.) and large-leaf pondweed (*Potamogeton amplifolius*). Muskgrass is a favorite waterfowl food source and, as an effective bottom sediment stabilizer, benefits water quality. Its prevalence in the plant communities of a lake may be a significant contributing factor to establishing and maintaining good water quality of a lake and, consequently, in establishing water quality conditions that assist native plant species to successfully compete with nonnative species. Muskgrass has been a species reported as common to abundant in the Lake since the 1993 survey. Large-leaf pondweed, also known as musky weed or bass weed, is another native species of high value in natural communities that was observed in earlier surveys, but was not observed in the 2011 survey, possibly as the result of the plant's seasonality and the timing of the various aquatic plant surveys. This plant, as fishermen well know, enjoys a reputation as a highly valuable provider of fish habitat. [21]

Nonnative Species

During the 2011 and earlier aquatic plant surveys of Nagawicka Lake, nonnative aquatic plant species of special significance were also observed. Two of these species, Eurasian water milfoil (*Myriophyllum* spicatum) and curly-leaf pondweed (*Potamogeton crispus*), are considered detrimental to the ecological health of the Lake and are declared nuisance species identified in Chapter NR 109 of the *Wisconsin Administrative Code*.

Eurasian water milfoil is one of eight milfoil species found in Wisconsin and the only one known to be exotic or nonnative. This plant has been known to cause severe recreational-use problems in lakes within the Southeastern Wisconsin Region. Eurasian water milfoil populations can displace native plant species and interfere with the aesthetic and recreational use of the waterbodies. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can inhibit its growth, which can be explosive under suitable conditions. The plant exhibits this characteristic growth pattern in lakes with organic-rich sediments, or where the lake bottom has been disturbed. It frequently has been reported as a colonizing species following dredging, unless its growth is anticipated and controlled. While the re-introduction of native species of pondweeds has been attempted,[22] "top-chopping" or removal of the Eurasian water milfoil canopy has been

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[21] *Wisconsin Lakes Partnership,* Through the Looking Glass…A Field Guide to Aquatic Plants*, Wisconsin Lakes Partnership, University of Wisconsin-Extension, 1999.*

[22] *Wisconsin Lakes Partnership,* op. cit.

shown to provide a competitive advantage to native plants which can allow native plants to outcompete the Eurasian water milfoil.[23]

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

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

USE RESTRICTIONS IMPOSED BY AQUATIC PLANTS

Excessive plant growth in a lake can negatively impact a variety of recreational uses in a waterbody. For example, heavy aquatic plant growth can impede boat traffic, making some areas of a lake impassable without aquatic plant control. In Nagawicka Lake, dense plant growths generally occur near the outlet in the portion of the lake basin known as "St. John's Bay," along portions of the western shoreline of the Lake, and in the vicinity of the point of entry of the Bark River into 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," also are subject to abundant plant growths that impede boating access between the "Kettle" and the main lake basin. The plant growth limits recreational use of the Lake and shoreline, and results in public complaints throughout the summer season.

In addition, floating vegetation that is left behind by the plant harvesters or cut by boat propellers can lead 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. Consequently, the City of Delafield has maintained a policy of collecting these "floaters," whether generated by recreational boating activities or aquatic plant harvesting, when they appear in the open waters of the Lake. Plant fragments that accumulate in shallow water of less than three feet depth and along the lakeshores should be collected and removed by the riparian homeowners, as indicated in the comprehensive lake management plan.

Another issue of concern is the occurrence of Eurasian water milfoil and curly-leaf pondweed in Nagawicka Lake. These plants are identified in Chapter NR 109 of the *Wisconsin Administrative Code* as a nonnative

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[23]*See Appendix D of SEWRPC Memorandum Report No. 143, 2nd Edition,* An Aquatic Plan Management Plan for the Lauderdale Lakes, Walworth County, Wisconsin*, July 2010.*

invasive aquatic plants, and designated for specific control within aquatic plant management programs, as noted above.

PAST AND PRESENT AQUATIC PLANT MANAGEMENT PRACTICES

A WDNR-approved aquatic plant control program has been undertaken on Nagawicka Lake since the 1950s, when records of such control programs began to be kept by the WDNR. However, aquatic plant control programs on Nagawicka Lake probably predate the WDNR recordkeeping system. Prior to 1950, aquatic plant management interventions are likely, but were not recorded. The early aquatic plant control program conducted on Nagawicka Lake can be categorized as primarily a chemical control program designed to minimize nuisance growths of aquatic macrophytes and algae. Table 4 contains a list based on WDNR records of chemical herbicides used on Nagawicka Lake to control nuisance plants. Between 1950 and 1970, 87,214 pounds of sodium arsenite and 11,110 pounds of copper sulphate (11,460 pounds, totaled over all years) were applied to Nagawicka Lake to control perceived nuisance growths of these plants.[24] However, since the late-1960s, the aquatic plant control program conducted on Nagawicka Lake has shifted toward aquatic plant harvesting as the major element of the aquatic plant management strategy in the Lake. Table 5 shows the amounts of aquatic plant material harvested from Nagawicka Lake since 2004. In addition, individual riparians and some property owner associations manually harvest aquatic plants around piers and docks and along their shorelines, and some have treated specific areas of the Lake with chemical herbicides. Where harvested materials are deposited on piers, the City of Delafield collects the accumulated plant materials as part of their harvesting program.

Aquatic plants within Nagawicka Lake are an important component of the Lake ecosystem, providing habitat and food for a variety of aquatic and other organisms including fish and waterfowl. In turn, these organisms support a large part of the recreational industry associated with Nagawicka Lake and its surrounding community. Thus, the presence of aquatic plants is a key element not only in the biological economy of the Lake but also the human economy of the surrounding landscape. The presence of aquatic plants is natural and part of a healthy lake system.

Nevertheless, when aquatic plants occur in abundance, they can be perceived of as a problem, interfering with recreational uses and the aesthetic enjoyment of the Lake. Aquatic plant surveys conducted on Nagawicka Lake within the last 10 years indicate a relatively balanced and stable aquatic plant community, with few changes in species composition and abundance being apparent during this period. The Lake generally supports a healthy and diverse aquatic macrophyte community, although extensive stands of Eurasian water milfoil (*Myriophyllum spicatum*) can occur throughout the waterbody. For this reason, aquatic plant management of Nagawicka Lake has focused on minimizing the abundance of nonnative, invasive species such as Eurasian water milfoil while promoting the growth of native plants necessary to maintain a healthy lake environment.

ALTERNATIVE METHODS FOR AQUATIC PLANT CONTROL

Background

Various aquatic plant management techniques, manual, mechanical, physical, and chemical, are potentially viable on Nagawicka Lake.[25] Consideration has been given to each of these techniques, and a number of these methods have been employed with varying success on Nagawicka Lake in the past. **All aquatic plant**

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[24] *Wisconsin Department of Natural Resources Technical Bulletin No. 57,* op. cit.

[25] *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.*

management measures are regulated by the State of Wisconsin, and most management measures require State permits which are issued by the WDNR pursuant to authorities granted under Chapter 30 of the *Wisconsin Statutes*, and Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*, among others.

Physical Controls

Physical methods, such as drawdown, are not feasible because of the heavy recreational demands placed on the Lake throughout the year. The impact upon recreation and the uncertainty surrounding its effects, combined with the limited duration of such effectiveness, necessitating frequent repeat treatments, makes this type of control expensive and problematic, and, hence, not feasible for use on Nagawicka Lake. Drawdown can also encourage the growth of some plant species. For these reasons, drawdown is not a recommended technique for Nagawicka Lake at this time.

Other physical controls, such as the placement of bottom barriers and use of shoreline protection structures, such as riprap, may be more practicable for Nagawicka Lake. 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. However, these structures must be placed and removed annually. Barriers should not be used in areas of strong surf, heavy angling, or shallow water where motorboating occurs. Because of the limitations involved, lake bottom covering as a method to control aquatic plant growth is not recommended for Nagawicka Lake.

Map 4 shows the various shoreline protection methods in use on Nagawicka Lake in 2011. These structures have been installed primarily to control erosion of the shoreline. 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. Nevertheless, use of natural vegetation at the water's edge provides significant benefit not only in terms of water quality protection, limiting shoreline erosion and runoff of contaminants into the waterway from the land surface, but also additional benefit in terms of habitat for fishes, aquatic organisms, amphibians, and birds.[26]

Chemical Controls

Chemical treatment with aquatic herbicides is a short-term method of controlling heavy growths of aquatic macrophytes and algae. The use of chemical controls can be viewed by the community as having uncertain long-term environmental impacts, as well as possible consequences for human health. While all the herbicides used on Nagawicka Lake have met applicable U.S. Environmental Protection Agency standards and are applied by registered applicators,[27] the use of chemical control techniques can contribute to an ongoing aquatic plant problem by augmenting the natural rates of accumulation of decaying organic matter in the Lake. Contributing to the oxygen demand may cause anoxia. The use of herbicides can also potentially damage or destroy nontarget plant species that provide needed habitat for fish and other aquatic life. As a result, less-

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[26] *SEWRPC,* Managing the Water's Edge: Making Natural Connections*, May 2010.*

[27] *See, for example, Wisconsin Department of Natural Resources PUBL-WR-236 90,* Chemical Fact Sheet: 2,4-D, *May 1990; see also Wisconsin Department of Natural Resources PUBL-WR-237 90,* Chemical Fact Sheet: Endothall, *May 1990; Wisconsin Department of Natural Resources PUBL-WR-239 90,* Chemical Fact Sheet: Glyphosate, *May 1990; and, Wisconsin Department of Natural Resources PUBL-WR-238 90,* Chemical Fact Sheet: Copper Compounds*, May 1990.*

desirable, invasive, introduced plant species may outcompete the more beneficial, native species. Hence the use of chemical herbicides is not a feasible option to be used on a large scale in Nagawicka Lake.

However, chemical control is often a viable technique for the control of Eurasian water milfoil and certain other plants, such as curly-leaf pondweed and purple loosestrife. Chemicals can be applied to the growing plants in either liquid or granular form. Chemical treatment can be administered at a relatively low cost and has been utilized by individual landowners within the portions of the lake basin, especially the embayment along the eastern shore of the Lake, known locally as Zastrow (or Zastrow's) Bay. Consequently, the use of aquatic herbicides is considered a viable option for use in selected areas of Nagawicka Lake, although, within the environmentally sensitive areas delineated by the WDNR pursuant to authorities granted under Chapter NR 107 of the *Wisconsin Administrative Code*, the use of chemical herbicides may be limited or restricted. Chemical applications, if used, should be conducted under the authority of the appropriate permit by a licensed applicator working under the supervision of WDNR staff.

Biological Controls

An alternative approach to controlling nuisance plants, particularly Eurasian water milfoil, is biological control. Classical biological control techniques have been successfully used to control both nuisance plants and herbivorous insects. Recent evidence shows that *Galerucella pucilla* and *Galerucella calmariensis*, beetle species, and *Hylobius transversovittatus* and *Nanophyes brevis*, weevil species, have potential as biological control agents for purple loosestrife. Extensive field trials conducted by the WDNR in the Southeastern Wisconsin Region since 1999 have indicated that these insects can provide effective management of large infestations of purple loosestrife.[28]

In contrast, recent studies of *Eurhychiopsis lecontei*, an aquatic weevil, have resulted in widely differing experiences of its potential as a biological control agent for Eurasian water milfoil.[29] Consequently, as very few studies have been completed using *Eurhychiopsis lecontei* as a means of aquatic plant management control,[30] it is not recommended for use in the Lake at this time. Use of biological control agents, with the exception of grass carp, is subject to State permitting requirements pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*. The use of grass carp, *Ctenopharyngodon idella*, an alternative biological control used elsewhere in the United States, is not permitted in Wisconsin. Grass carp are a designated invasive species pursuant to Chapter NR 40 of the *Wisconsin Administrative Code*.

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[28]*B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control,"* LakeLine*, Vol. 17, No. 3, September 1997, pp. 20-21, 34-3; see also, C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities*, 1984, pp. 659-696; and C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology*, John Wiley, New York, New York, USA.*

[29]*Sally P. Sheldon,* op. cit.

[30]*Contrast the experiences, for example, reported on Whitewater Lake in SEWRPC Memorandum Report No. 177,* An Aquatic Plant Management Plan for Whitewater and Rice Lakes, Walworth County, Wisconsin*, March 2010, with those reported on Spring Lake in SEWRPC Memorandum Report No. 149,* A Lake Protection Plan for Spring Lake and Willow Spring Lake, Waukesha County, Wisconsin*, August 2004, which yielded widely differing results: Spring Lake, with limited motorized watercraft traffic, achieved a significant level of control as a result of a naturally occurring weevil population, although this control was several years in the making.*

Manual Controls
Manual methods, such as raking or hand-pulling, are difficult to employ on a large scale. Although very effective for small-scale application, for example, in and around docks and piers, manual techniques are generally the least efficient of the aquatic plant control methods. While manual means will be needed to control nearshore plant growths and collect floating plant material from mechanical harvesting operations, this method is too inefficient and time-consuming to employ on the scale needed to manage aquatic plant problems over the entire basin of Nagawicka Lake.

In the nearshore area, specially designed rakes are available to assist in the manual removal of nuisance aquatic plants, such as Eurasian water milfoil. The use of such rakes also provides a safe and convenient method of controlling aquatic plants in deeper nearshore waters around piers and docks. The advantage of the rakes is that they are relatively inexpensive, easy and quick to use, and immediately remove the plant material from a lake, without a waiting period. Hand-pulling of stems, where they occur in isolated stands, provides an alternative means of controlling plants, such as Eurasian water milfoil, in a lake, and purple loosestrife, on a lakeshore. Harvested material must be removed from a lake. Removal of the plants from a lake avoids the accumulation of organic matter on a lake bottom, which adds to the nutrient pool that favors further plant growth. State permitting requirements for manual aquatic plant harvesting pursuant to Chapter NR 109 of the *Wisconsin Administrative Code* apply, although individual landowners are allowed to clear 30 feet along the shoreline as a viewing and access corridor without a permit.

In the shoreland area, where purple loosestrife may be expected to occur, bagging and cutting loosestrife plants prior to the application of chemical herbicides to the cut ends of the stems, can be an effective control measure for small infestations of this plant. Loosestrife management programs, however, should be followed by an annual monitoring and control program for up to 10 years following the initial control program to manage the regrowth of the plant from seeds. Manual removal of such plants is recommended for isolated stands of purple loosestrife when and where they occur.

Mechanical Controls
On the basis of previous use of mechanical harvester technologies on Nagawicka Lake, mechanical harvesting of aquatic plants appears to be a practicable and efficient means of controlling plant growth in an environmentally sensitive manner. Harvesting removes the plant biomass and nutrients from a lake. While mechanical harvesting can potentially impact fish and other aquatic life, disturb loosely consolidated lake bottom sediments, and result in the fragmentation and spread of some aquatic plants, it has been shown to benefit in ultimately reducing the regrowth of other plants. Harvesting also removes attached, epiphytic algal growths with the harvested plant material, and leaves sufficient plant material in a lake to provide forage and shelter for fish and other aquatic life and to stabilize sediments. Mechanical harvesting is the recommended method for control of aquatic plants in Nagawicka Lake. Use of mechanical harvesting should be undertaken outside of the environmentally sensitive areas delineated by the WDNR pursuant to authorities granted under Chapter NR 107 of the *Wisconsin Administrative Code*, and within the environmentally sensitive areas subject to the limitations stated in the assessment summaries applicable to environmentally sensitive areas designated as Area #1 through Area #3. These limitations noted in the WDNR sensitive areas assessment appended hereto as Exhibit 1.

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

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

Harvesting Plan

The recommended aquatic plant management plan for Nagawicka Lake is set forth in Map 5. As indicated, it is proposed that aquatic plant management activities be restricted in certain ecologically valuable areas of the Lake. Aquatic plant management operations will be concentrated in the main basin of the Lake and near the boating access ramps, as well as in the principal boating and fishing areas. As noted above, the goal of the management program is to accommodate recreational uses of the impoundment as much as possible without inflicting irreparable damage on the ecosystem of the Lake, its structure and functioning. To accomplish this goal, specific control measures will be applied in the various lake zones identified on Map 5. Generally, harvesting will not take place in waters less than three feet deep to avoid the disturbance of fish spawning and nursery areas and beds of native aquatic plants, and special efforts will be made to avoid disturbing major spawning and habitat areas of sportfish in Nagawicka Lake during the spawning season, after July 1st annually.

In addition, there are five identified environmentally sensitive areas in the Lake, shown on Map 6, that have been delineated by the WDNR pursuant to authorities granted the Department under Section NR 107.05(3)(i) of the *Wisconsin Administrative Code*. These include: Sensitive Area No. 1—the northern shoreline and nearshore waters of St. John's Bay; Sensitive Area No. 2—the nearshore waters and constructed channels along the western shores of Nagawicka Lake; Sensitive Area No. 3—the northern extreme of the Lake known as the "Kettle," Sensitive Area No. 4—the pond located immediately south of Milwaukee Street; and Sensitive Area No. 5—the debouchment of the Bark River and adjacent waters of the Lake. Specific management measures, such as use of chemical herbicides and dredging of sediments within these areas, are limited or prohibited. As noted above, the WDNR Sensitive Area Assessment Summary is appended hereto as Exhibit 1.

Within these guidelines, aquatic plant management treatments, required to promote specific lake uses and functions, are proposed to be applied for the following purposes:

- Access Channels and Boating Transit Areas: Narrow channels, approximately 10 feet to 20 feet,[31] or two to four harvester widths, wide will be harvested to provide boating access to the main body of the Lake; chemical herbicide use is proposed to be restricted to pier and dock areas within 50 feet of the shore, although chemical treatment of Eurasian water milfoil within the channel from the Bleeker Street public recreational boating access site and the main basin of Nagawicka Lake may be allowed prior to July 1st annually with appropriate WDNR permits.

- Fishing and Recreational Areas: Narrow channels, approximately 10 feet, or two harvester widths wide, will be harvested perpendicular to the shore of the main basin of the Lake at approximately 100-foot intervals; chemical herbicide use is recommended to be limited to milfoil and purple loosestrife control at and adjacent to the public access sites. In addition, broad bands of macrophytes within 150 feet of the shore will be harvested in the heavily used recreational areas of the Lake in order to facilitate access to the open water areas through approximately 20-foot-wide shared-access channels. Chemical use will be restricted to pier and dock areas within 50 feet of the shore.

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[31] *The dimensions of the harvested channels noted herein are advisory only; the actual harvested channel dimensions and locations are stated in the Chapter NR 109 aquatic plant harvesting permit issued by the Wisconsin Department of Natural Resources, and are subject to change, pursuant to their regulatory authority set forth in Chapter 23 of the* Wisconsin Statutes.

- Habitat Areas: Areas of the Lake having a predominantly wetland-like character will be preserved from any intervention, except where necessary to control purple loosestrife infestations. Additional litter collection efforts may be required in these areas to maintain their aesthetic appeal. Chemical herbicide use is generally to be prohibited, especially in the WDNR-delineated environmentally sensitive areas, shown on Map 6.

- Open Water Areas: Deep-water areas of the Lake would be linked to boating access areas by approximately 50-foot-wide channels in this largely plant-free area; no chemical herbicides are proposed to be used in this area.

- Eurasian water milfoil Control Areas: Intensive harvesting and/or chemical herbicide use is recommended to minimize the spread of Eurasian water milfoil, especially in the vicinity of the debouchement of the Bark River, as shown on Map 5, where increasingly widespread stands of Eurasian water milfoil have been developing since the initial aquatic plant survey. Where permitted by the WDNR, an emphasis on Eurasian water milfoil control in the western embayment of the Lake locally known as St. John's Bay also is recommended.

Application of aquatic plant management measures in each of these areas, as has been noted above, is subject to State of Wisconsin permitting requirement pursuant to Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*, and the specific recommendations set forth in this SEWRPC Staff Memorandum.

Depth of Harvesting and Treatment of Fragments
The Aquarius HM-420-VS Series aquatic plant harvesters have a maximum cutting depth of five feet. While this exceeds the actual water depth of about one-third of the Lake, 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. The majority (95 percent or more) of plant cuttings and fragments will be collected by the harvester on the site. Those fragments accumulating along the shore will be collected by the riparian homeowners. Fragments can be used by the homeowners as garden mulch, or piled on pier-heads for regularly-scheduled pickups by the City.

Buoys
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 and the presence of numerous shoreline landmarks generally preclude the need for such buoys, except as may be 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 buoys. Harvesting operations are regularly supervised by City staff.

Harvested Plant Material Transfer Site(s)
Plant material will be removed from the harvester at the primary off-loading site located at Ridley Road on the eastern shores of the Lake in the area known as Zastrow Bay, as shown on Map 5. A secondary off-loading site is located in the area adjacent to the Bleeker Street public recreational boating access site, which site is used only when the harvesting operations are concentrated in the southern portions of the Lake. Harvested plant material 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 offloading site to ensure minimal disruption of boaters and of the people using the riparian areas of the Lake.

Disposal of Harvested Plant Material
Harvested plant material will be landspread on area farms, used as compost, or used by area residents and contractors as a soil amendment.

Precautions to Protect Wildlife, Fisheries, and Ecologically Valuable Areas
Operators will be provided with a laminated copy of the approved harvesting plan map (Map 5), showing the limits of harvesting operations. A copy of this map will be kept on the harvester at all times. Operations will be forbidden in the upper reaches of the Lake, within WDNR-delineated Sensitive Areas #2 and #3, except for the harvesting of navigation channels in these areas as described in the WDNR Sensitive Area Assessment Summary appended hereto as Exhibit 1, to prevent disturbance of the wetland areas. In addition, harvesting will be forbidden in those areas of three feet or less in depth to protect sportfish habitat and spawning areas. Harvesting operations in the areas identified as suitable for sportfish spawning and designated as environmentally sensitive areas by the WDNR pursuant to its authority granted under Chapter NR 107 of the *Wisconsin Administrative Code* (Exhibit 1) will be restricted after July 1st to permit undisturbed spawning. The harvesting season will begin no earlier than May 15 and will end no later than October 15 of each year.

Public Information
It is the policy of the City of Delafield to maintain an active dialogue with the community. This dialogue is carried out through the medium of the public press and through various City Committees and Departments, specifically public works, public meetings, and other scheduled hearings. In addition, the City of Delafield Lake Welfare Committee holds regular public meetings. Where necessary, personal contacts with homeowners should be made.

Harvesting Schedule
Harvesting will average 30 to 35 hours per week over a five-day week between May 15th and October 15th of each year, depending on weather conditions and plant growth, to minimize recreational conflicts. In addition, harvesting will be confined to daylight hours to minimize public disturbances resulting from harvester and plant removal operations. As described above, harvesting operations will also be modified to protect fish spawning areas and other ecologically valuable areas of the Lake as set forth on Map 6.

Equipment Needs and Capital Costs
The City of Delafield currently owns and operates an Aquarius model HM-420-VS harvester, with 10-year anticipated life span. Replacement of this harvester when necessary may be expected to cost about $63,850.

Harvester: Aquarius model HM-420-VS harvester or equivalent

Manufacturer: Aquarius Systems, a Division of D&D Products, Inc., North Prairie, Wisconsin

Costs:	(1) HM-420-VS Aquatic Plant Harvester or equivalent	$140,000
	(1) Harvester Trailer (double axle)	18,000
	(1) T-12 Transport Barge or equivalent	140,000
	(1) TR-34 Transport Barge Trailer (tri-axle) or equivalent	19,500
	(1) M/SC-23 Shore Conveyor or equivalent	49,000
	(1) Ford F-550, 4x4, 1-ton Dump Truck or equivalent	30,000*
	Total	$396,500

*Note: The Dump Truck is used for multiple applications. The cost shown is for that portion of the vehicle price applicable to the percentage of use for transporting harvested aquatic plant material. The total cost of the vehicle is about $80,000, and the percentage of use for aquatic plant management purposes is 37.5 percent.

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 of Delafield. Winter storage of the harvesting equipment will be the responsibility of the City of Delafield. The harvester will be stored at the municipal garage.

Insurance Coverage
Insurance coverage on the harvester will be incorporated into the policy held by the City of Delafield on all capital equipment. Liability insurance for the operation of the harvester 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 harvester will be owned and operated by the City of Delafield, which 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 Aquamarine on delivery of the machinery.

Day-to-day supervision will be by the City staff, with oversight by the Director of Public Works.

Daily Recordkeeping Relating to the Harvesting Operations
A record of daily harvesting activities will be recorded by the operator in a harvester operations log. An annual summary of the harvesting program will be submitted to the WDNR as required, 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 comprehensive lake management plan for Nagawicka Lake, as refined in this SEWRPC Staff Memorandum, a copy of which has been provided to the WDNR Southeast Region Office.

Daily Recordkeeping 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.

SUMMARY

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 comprehensive 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 growths of exotic species—specifically, Eurasian water milfoil, purple loosestrife, and curly-leaf pondweed, if the latter is required to manage nuisance populations—especially 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, subject to the limitations stated within the environmentally sensitive assessment for the five sensitive areas delineated by the WDNR pursuant to Chapter NR 107 of the *Wisconsin Administrative Code*. Only herbicides that selectively control Eurasian water milfoil, such as 2,4-D, should be used, subject to WDNR permitting. 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—prior to July 1st annually—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. Should use of chemical herbicides be considered for the control of Eurasian water milfoil in the vicinity of the debouchement of the Bark River, consideration should be given to the use of granular formulations of 2,4-D and an autumn application to maximize the herbicide contact time within this hydrologically-active area and minimize the drift of the chemical into the adjacent environmentally sensitive areas (Sensitive Area #3 to the north, and Sensitive Area #5 immediately upstream of the debouchement in the Bark River). Use of chemical herbicides in these two areas is not permitted pursuant to WDNR Chapter NR 107 guidance.

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.

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. Pursuant to WDNR guidance relating to aquatic plant management within the environmentally sensitive areas delineated pursuant to Chapter NR 107, both mechanical harvesting and use of aquatic herbicide use in the navigational channel between the Bleeker Street public recreational boating access site and the main basin of Nagawicka Lake (Sensitive Area #1) must be completed by July 1st annually. Mechanical harvesting in the navigational channels along the northwestern shores of Nagawicka Lake (Sensitive Area #2) is likewise restricted to the centers of the channels, while mechanical harvesting in the "Kettle" (Sensitive Area #3) is similarly limited to provision of recreational boating access. Use of chemical herbicides in both of the latter areas is not allowed in these designated environmentally sensitive areas.

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. The City of Delafield Lake Welfare Committee may wish to obtain informational brochures regarding shoreline maintenance, for example, to inform residents of the management options available.

A summary of the recommended aquatic plant management actions, compiled by the City of Delafield, is presented as Exhibit 2 and appended hereto.

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SEWRPC Staff Memorandum

AN AQUATIC PLANT MANAGEMENT PLAN UPDATE FOR NAGAWICKA LAKE, WAUKESHA COUNTY, WISCONSIN: 2011

TABLES

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Table 1

AQUATIC PLANT SPECIES OBSERVED IN NAGAWICKA LAKE: 2004-2011

Aquatic Plant Species	2004	2011
Ceratophyllum demersum (coontail)	Present	Present
Chara spp. (muskgrass)	Present	Common
Elodea canadensis (waterweed)	Present	Present
Myriophyllum exalbescens (northern water milfoil)	Present	Present
Myriophyllum spicatum (Eurasian water milfoil)	Present	Scarce
Najas flexilis (bushy pondweed)	Scarce	Present
Najas marina (spiny naiad)	Scarce	Present
Potamogeton amplifolius (large-leaf pondweed)	Present	- -
Potamogeton crispus (curly-leaf pondweed)	Scarce	Present
Potamogeton foliosus (leafy pondweed)	- -	Scarce
Potamogeton gramineus (variable pondweed)	- -	Scarce
Potamogeton illinoensis (Illinois pondweed)	Scarce	Scarce
Potamogeton pectinatus (Sago pondweed)	Scarce	Present
Potamogeton natans (floating-leaf pondweed)	- -	Common
Potamogeton nodosus (long-leaf pondweed)	- -	Scarce
Potamogeton richardsonii (clasping-leaf pondweed)	Present	Scarce
Potamogeton zosteriformis (flat-stem pondweed)	Present	Scarce
Utricularia vulgaris (bladderwort)	Scarce	Scarce
Vallisneria americana (eel-grass/wild celery)	Present	Common
Zosterella dubia (water stargrass)	Common	Common

NOTE: In the 2004 survey, species identified as “abundant” had a density value of 3.5 to 4.0; “common” had a density value of 2.5 to 3.4; “present” had a density value of 1.5 to 2.4; and, “scarce” had a density value of less than 1.5. The density value is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake. Such determination is made possible through the Jesson-Lound transect method where four samples are taken at each pre-determined depth along each transect line. In 2010, the WDNR revised the methodology for aquatic plant surveys to a grid-based point-intercept method. The 2011 survey was conducted by SEWRPC staff using the point-intercept method utilizing 639 sample sites. For purposes of comparison, the following descriptors were used for the 2011 survey based on the relative density of each species: “abundant” had a relative density of 4.0 to 5.0; “common” had a density value of 3.0 to 3.9; “present” refers to a density value of 2.0 to 2.9; “scarce” refers to a density of 1.0 to 1.9; “very scarce” refers to a density of 0.1 to 0.9.

Source: SEWRPC.

Table 2

FREQUENCY OF OCCURRENCE, RELATIVE DENSITY, AND IMPORTANCE VALUE OF AQUATIC PLANT SPECIES OBSERVED IN NAGAWICKA LAKE: 2004-2011

Aquatic Plant Species	2004			2011		
	FREQ	ADEN	IV	FREQ	ADEN	IV
Ceratophyllum demersum (coontail)	34.5	2.08	72	39.6	2.26	89
Chara spp. (muskgrass)	57.6	2.39	137	47.9	3.45	165
Elodea canadensis (waterweed)	8.6	1.83	16	5.6	2.00	11
Myriophyllum exalbescens (northern water milfoil)	46.8	2.28	106	27.7	2.49	69
Myriophyllum spicatum (Eurasian water milfoil)	28.1	2.10	59	3.6	1.26	4
Najas flexilis (bushy pondweed)	3.6	1.00	4	15.3	2.14	32
Najas marina (spiny naiad)	0.7	1.00	1	11.9	2.91	34
Potamogeton amplifolius (large-leaf pondweed)	2.9	2.00	6	- -	- -	- -
Potamogeton crispus (curly-leaf pondweed)	15.8	1.36	22	0.9	2.17	2
Potamogeton foliosus (leafy pondweed)	- -	- -	- -	2.0	1.46	2
Potamogeton gramineus (variable pondweed)	- -	- -	- -	5.8	1.54	8
Potamogeton illinoensis (Illinois pondweed)	14.4	1.40	20	9.1	1.71	15
Potamogeton natans (floating-leaf pondweed)	- -	- -	- -	0.3	3.50	1
Potamogeton pectinatus (Sago pondweed)	7.2	1.40	10	6.3	2.53	15
Potamogeton nodosus (long-leaf pondweed)	- -	- -	- -	0.8	1.00	1
Potamogeton pusillus (small pondweed)	- -	- -	- -	1.1	1.14	1
Potamogeton richardsonii (clasping-leaf pondweed)	10.8	1.53	17	6.3	1.75	10
Potamogeton zosteriformis (flat-stem pondweed)	38.1	1.85	71	2.0	1.92	3
Utricularia vulgaris (bladderwort)	0.7	1.00	1	3.9	1.28	5
Vallisneria americana (eel-grass/wild celery)	54.7	2.41	132	46.2	3.15	145
Zosterella dubia (water stargrass)	0.7	3.00	2	7.7	3.14	24

FREQ = Frequency of Occurrence = the number of occurrences of a species divided by the number of samples with vegetation, expressed as a percentage.

ADEN = Average (or Relative) Density = the sum of the density ratings for a species divided by the number of sampling points with vegetation.

IV = Importance Value = the product of the relative frequency and the average density, expressed as a percentage.

Source: SEWRPC.

Table 3

POSITIVE ECOLOGICAL SIGNIFICANCE OF AQUATIC PLANT SPECIES PRESENT IN NAGAWICKA LAKE

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides good shelter for young fish; supports insects valuable as food for fish and ducklings; native
Chara spp. (muskgrass)	A favorite waterfowl food and fish habitat, especially for young fish; native
Elodea canadensis (waterweed)	Provides shelter and support for insects which are valuable as fish food; native
Myriophyllum sibiricum (northern water milfoil)	Leaves and fruit provide food for waterfowl and shelter and foraging for fish
Myriophyllum spicatum (Eurasian water milfoil)	None known; nonnative
Najas flexilis (bushy pondweed)	Important food source for waterfowl, marsh birds, and muskrats; provides food and shelter for fish; native
Najas marina (spiny naiad)	Important food source for waterfowl, marsh birds, and muskrats; provides food and shelter for fish; native
Nitella spp. (stonewort)	Sometimes grazed by waterfowl; forage for fish; native
Potamogeton amplifolius (large-leaf pondweed)	Also known as bass-weed or musky-weed, this plant is highly prized by fishers as prime fish habitat; provides excellent shelter for small fish and foraging opportunities for predator fish; valuable waterfowl food; native
Potamogeton crispus (curly-leaf pondweed)	Nonnative
Potamogeton foliosus (leafy pondweed)	The fruit is an important food source for many waterfowl; also provides food for muskrat, deer, and beaver; native
Potamogeton gramineus (variable pondweed)	The fruit is an important food source for many waterfowl; also provides food for muskrat, deer, and beaver; native
Potamogeton illinoensis (Illinois pondweed)	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl; native
Potamogeton natans (floating-leaf pondweed)	The late-forming fruit provides important food source for ducks; provides good fish habitat due to its shade and foraging opportunities; native
Potamogeton nodosus (long-leaf pondweed)	Fruit grazed by waterfowl; provides food for muskrat, beaver, and deer; habitat for invertebrates and forage opportunities for fish; native
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish; native
Potamogeton richardsonii (clasping-leaf pondweed)	The fruit is an important food source for waterfowl; the stem and leaves supply food for muskrat, beaver, deer, and moose and provide forage and cover for fish; native
Potamogeton zosteriformis (flat-stem pondweed)	Provides some food for ducks; native
Ranunculus longirostris (white water crowfoot)	Fruit and foliage good food sources for waterfowl; native
Utricularia vulgaris (bladderwort)	Stems provide food and cover for fish; native
Vallisneria americana (eel-grass/wild celery)	Provides good shade and shelter, supports insects, and is valuable fish food; native
Zosterella dubia (water stargrass)	Locally important food source for waterfowl and forage for fish; native

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

Source: SEWRPC.

Table 4

CHEMICAL CONTROLS ON NAGAWICKA LAKE: 1950-2009

Year	Algae Control		Macrophyte Control					
	Cutrine-Plus (gallons)	Copper Sulphate (pounds)	Sodium Arsenite (pounds)	2,4-D		Diquat (gallons)	Glyphosate (gallons)	Endothall/ Aquathol (gallons)
				(gallons)	(pounds)			
1950-1970	0.00	11,110	87,214	0.00	0.00	0.00	0.00	0.0
1971-1979[a]	- -	- -	- -	- -	- -	- -	- -	- -
1980	9.00	0	0	0.00	0.00	0.00	0.00	6.0
1981	0.00	0	0	0.00	0.00	0.00	0.00	0.0
1982	20.00	0	0	0.00	0.00	17.00	0.00	15.0
1983-1984	0.00	0	0	0.00	0.00	0.00	0.00	0.0
1985	33.00	0	0	0.00	3.00	10.00	0.00	20.5
1986	38.50	0	0	0.00	9.00	19.00	0.00	21.5
1987	21.75	0	0	0.00	0.00	17.25	0.00	22.5
1988	38.00	0	0	0.00	20.00	0.00	0.00	0.0
1989	2.25	350	0	0.00	31.25	0.00	0.00	3.0
1990	0.00	0	0	0.00	0.00	0.00	0.00	0.0
1991	0.75	0	0	0.00	8.25	0.00	0.00	0.0
1992	1.75	0	0	0.00	7.00	1.75	0.00	0.0
1993	7.00	0	0	0.00	0.00	2.75	0.00	0.0
1994	1.00	0	0	2.50	0.00	1.00	0.00	0.0
1995	1.10	0	0	3.25	0.00	1.25	0.00	1.0
1996	0.00	0	0	8.75	0.00	0.00	0.00	0.0
1997	0.00	0	0	0.00	0.00	0.00	0.00	0.0
1998[b]	- -	- -	- -	- -	- -	- -	- -	- -
1999	0.00	0	0	0.00	0.00	0.00	0.00	0.0
2000	0.00	0	0	0.00	0.00	0.00	0.00	0.0
2001	0.00	0	0	0.00	0.00	0.00	0.25	0.25 lbs.
2002	0.00	0	0	0.00	0.00	0.00	0.00	0.0
2003	0.00	0	0	0.00	0.00	0.00	0.00	0.0
2004-2009[a]	- -	- -	- -	- -	- -	- -	- -	- -
2010-2011[c]	- -	- -	- -	- -	- -	- -	- -	- -
Total	174.10	11,460	87,214	14.50	78.50	70.00	0.25	89.50 + 0.25 lbs.

[a] *Chemical records no chemical controls used during these years.*

[b] *No records available for these years.*

[c] *Records not available at time of printing.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 5

AMOUNT OF AQUATIC PLANT MATERIAL HARVESTED FROM NAGAWICKA LAKE

Year	Plant Material Removed (cubic yards)
2003	1,650
2004	1,755
2005	2,110
2006	1,790
2007	2,250
2008	1,280
2009	2,140
2010	2,550
2011	2,080

Source: Wisconsin Department of Natural Resources and SEWRPC.

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SEWRPC Staff Memorandum

AN AQUATIC PLANT MANAGEMENT PLAN UPDATE FOR NAGAWICKA LAKE, WAUKESHA COUNTY, WISCONSIN: 2011

MAPS

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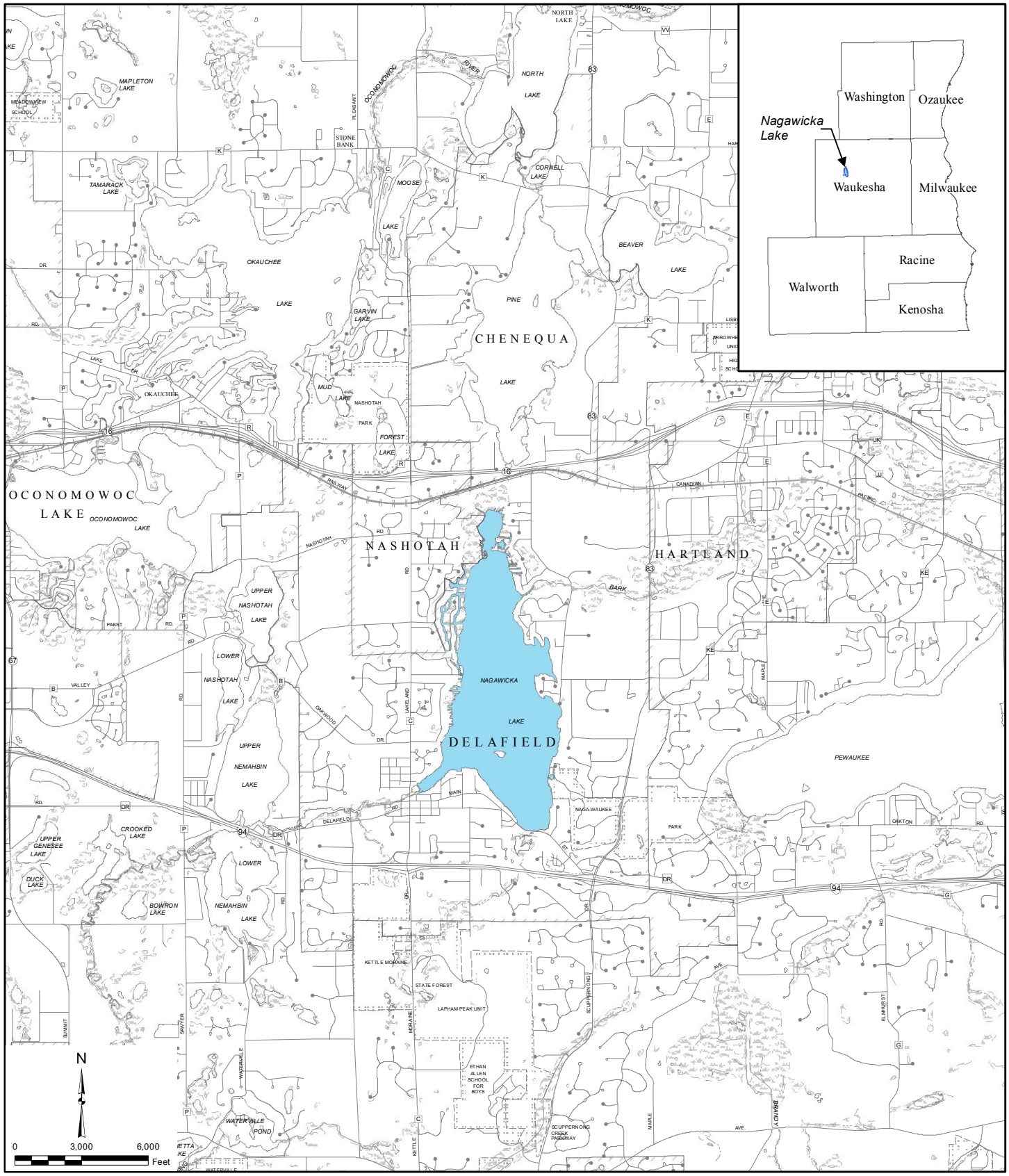
Map 1

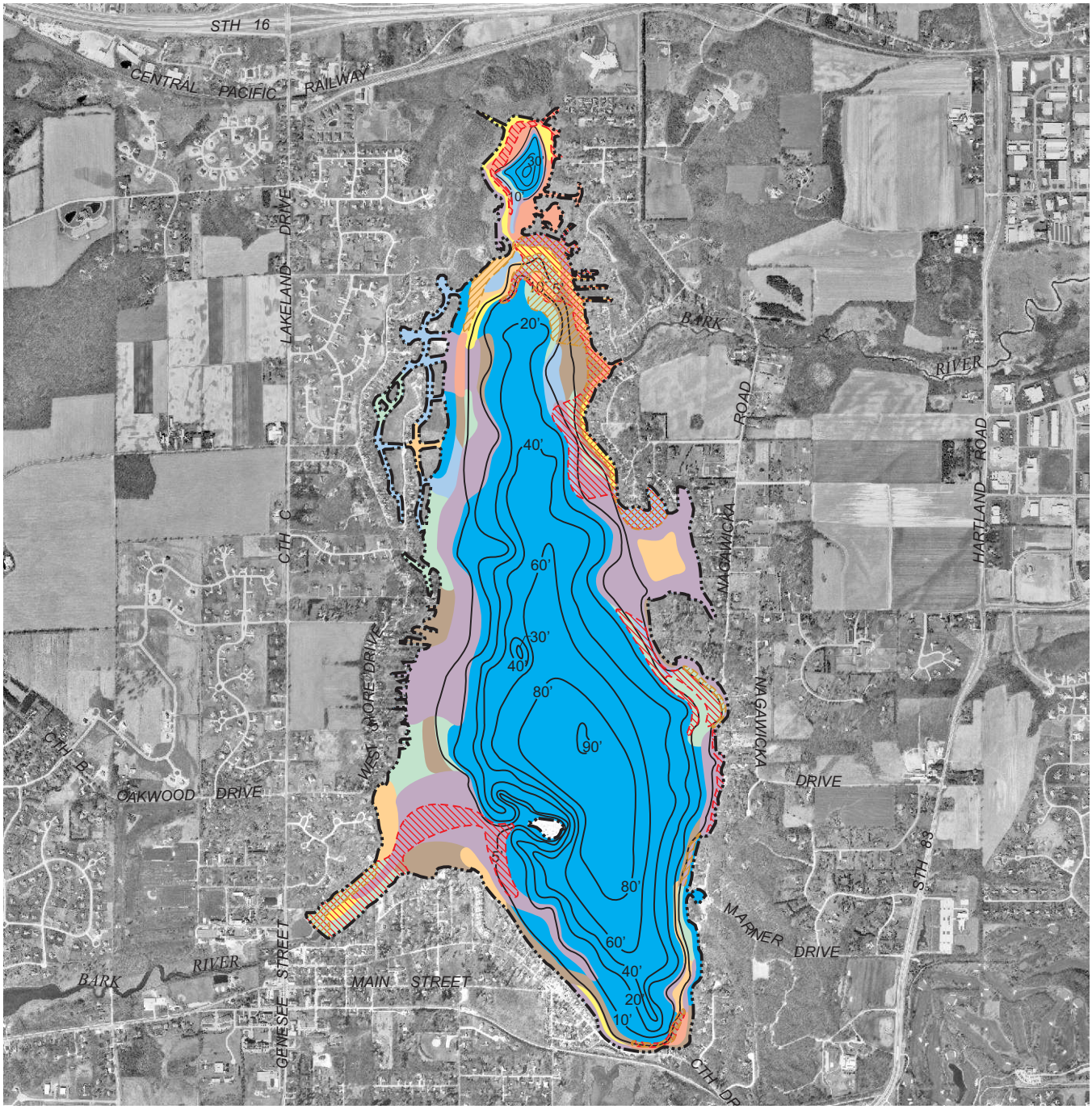
LOCATION OF NAGAWICKA LAKE



Source: SEWRPC.

Map 2

AQUATIC PLANT COMMUNITY DISTRIBUTION IN NAGAWICKA LAKE: 2004



DATE OF PHOTOGRAPHY: MARCH 2000

— 20' — WATER DEPTH CONTOUR IN FEET

OPEN WATER

CURLY LEAF PONDWEED

EURASIAN WATER MILFOIL

WILD CELERY, FLAT STEM PONDWEED, MUSKGRASS, AND COONTAIL (NATIVE WATER MILFOIL, ILLINOIS PONDWEED, CLASPING PONDWEED, AND SAGO PONDWEED)

WILD CELERY, MUSKGRASS, NATIVE WATER MILFOIL, FLAT STEM PONDWEED, CLASPING LEAF PONDWEED (COONTAIL, ILLINOIS PONDWEED, WATERWEED, SAGO PONDWEED, AND BUSHY PONDWEED)

MUSKGRASS (WILD CELERY, NATIVE WATER MILFOIL, FLAT STEM PONDWEED, COONTAIL, ILLINOIS PONDWEED, SAGO PONDWEED, CLASPING LEAF PONDWEED, LARGE LEAF PONDWEED, WATER STAR GRASS, AND BUSHY PONDWEED)

ILLINOIS PONDWEED, MUSKGRASS, AND NATIVE WATER MILFOIL (FLAT STEM PONDWEED, COONTAIL, LARGE LEAF PONDWEED, SAGO PONDWEED, WATERWEED, WILD CELERY, AND BLADDERWORT)

WILD CELERY, NATIVE WATER MILFOIL, COONTAIL, AND FLAT STEM PONDWEED (MUSKGRASS, WATERWEED, AND ILLINOIS PONDWEED)

COONTAIL (MUSKGRASS, WILD CELERY, NATIVE WATER MILFOIL, FLAT STEM PONDWEED, WATERWEED, CLASPING LEAF PONDWEED, BUSHY PONDWEED, AND LARGE LEAF PONDWEED)

WILD CELERY, NATIVE WATER MILFOIL (MUSKGRASS, FLAT STEM PONDWEED, ILLINOIS PONDWEED, CLASPING LEAF PONDWEED, LARGE LEAF PONDWEED, WATERWEED, AND COONTAIL)

NOTE: ( ) INDICATES SPECIES FOUND IN LESS THAN 50 PERCENT OF THE SITE..

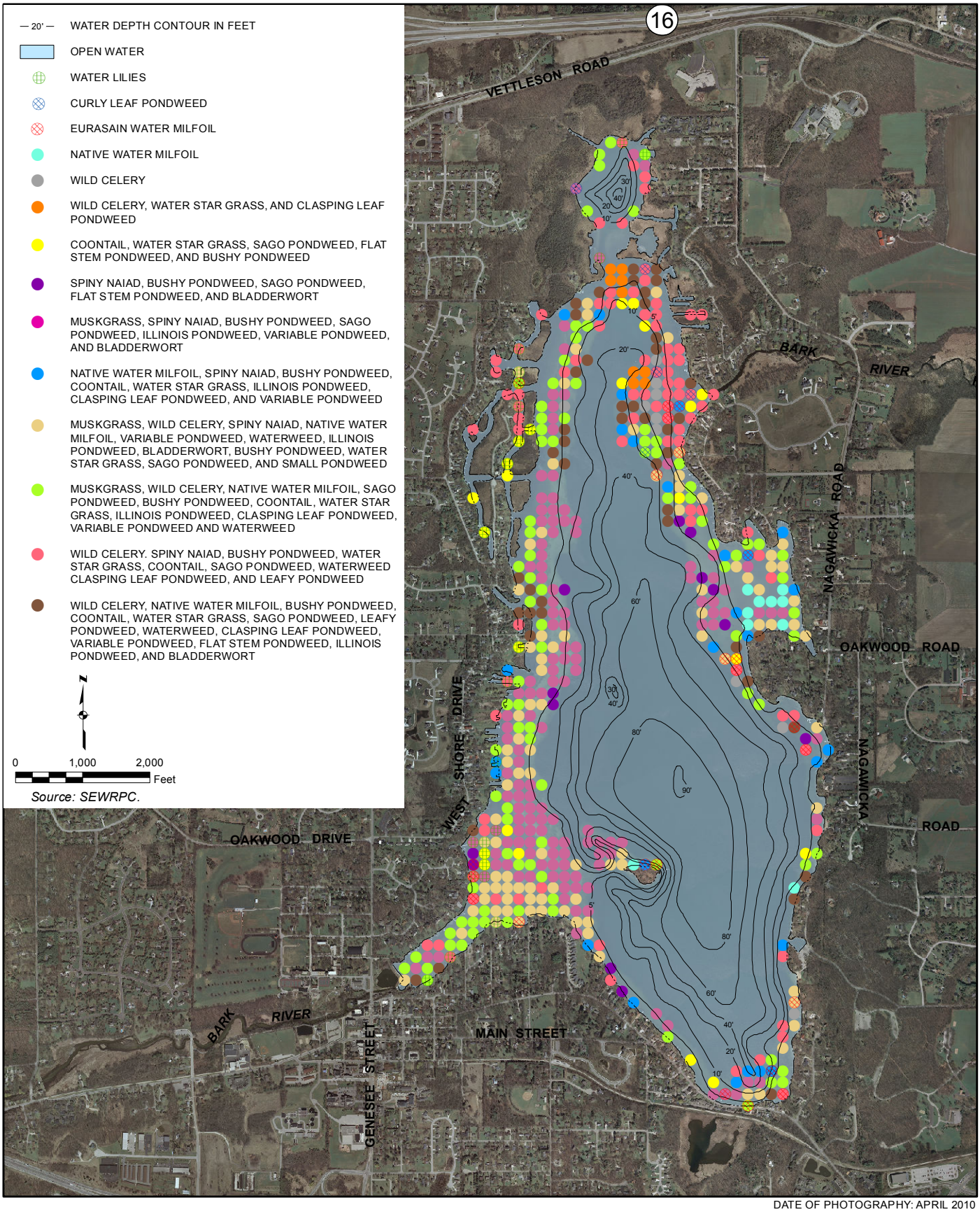
GRAPHIC SCALE

0 1200 2400 FEET

Source: SEWRPC.

Map 3

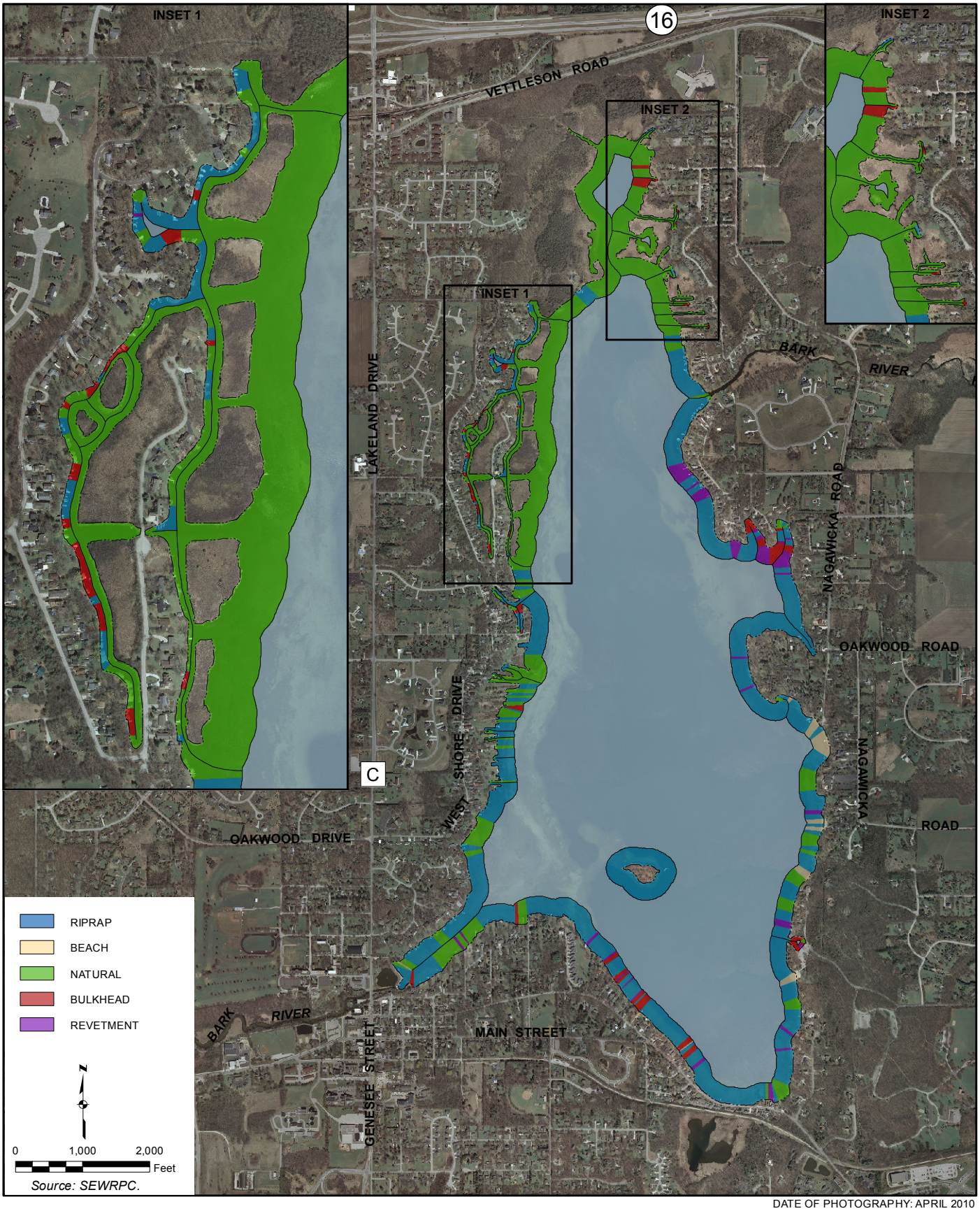
AQUATIC PLANT COMMUNITY DISTRIBUTION IN NAGAWICKA LAKE: 2011



DATE OF PHOTOGRAPHY: APRIL 2010

Map 4

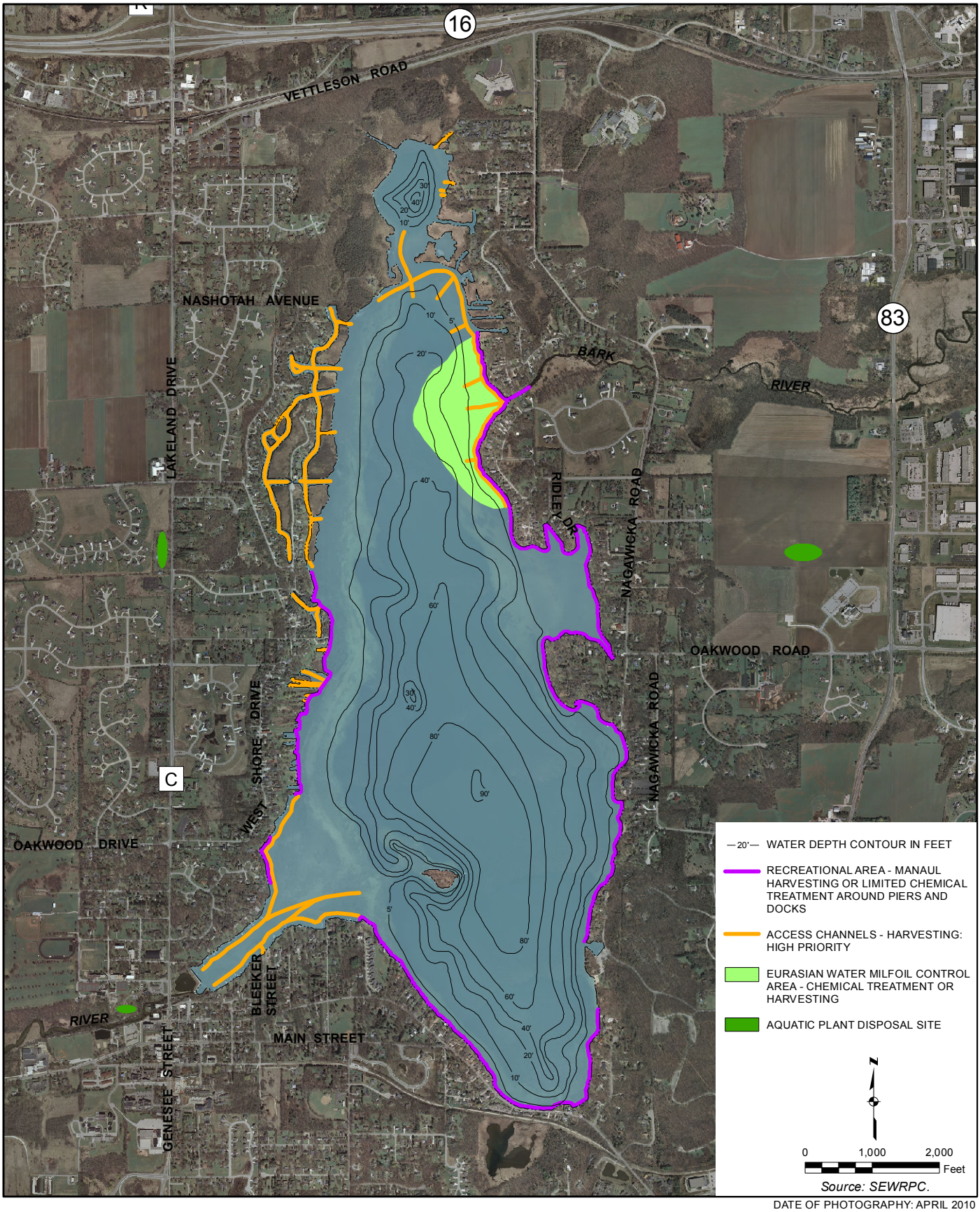
SHORELINE PROTECTION STRUCTURES ON NAGAWICKA LAKE



DATE OF PHOTOGRAPHY: APRIL 2010

Map 5

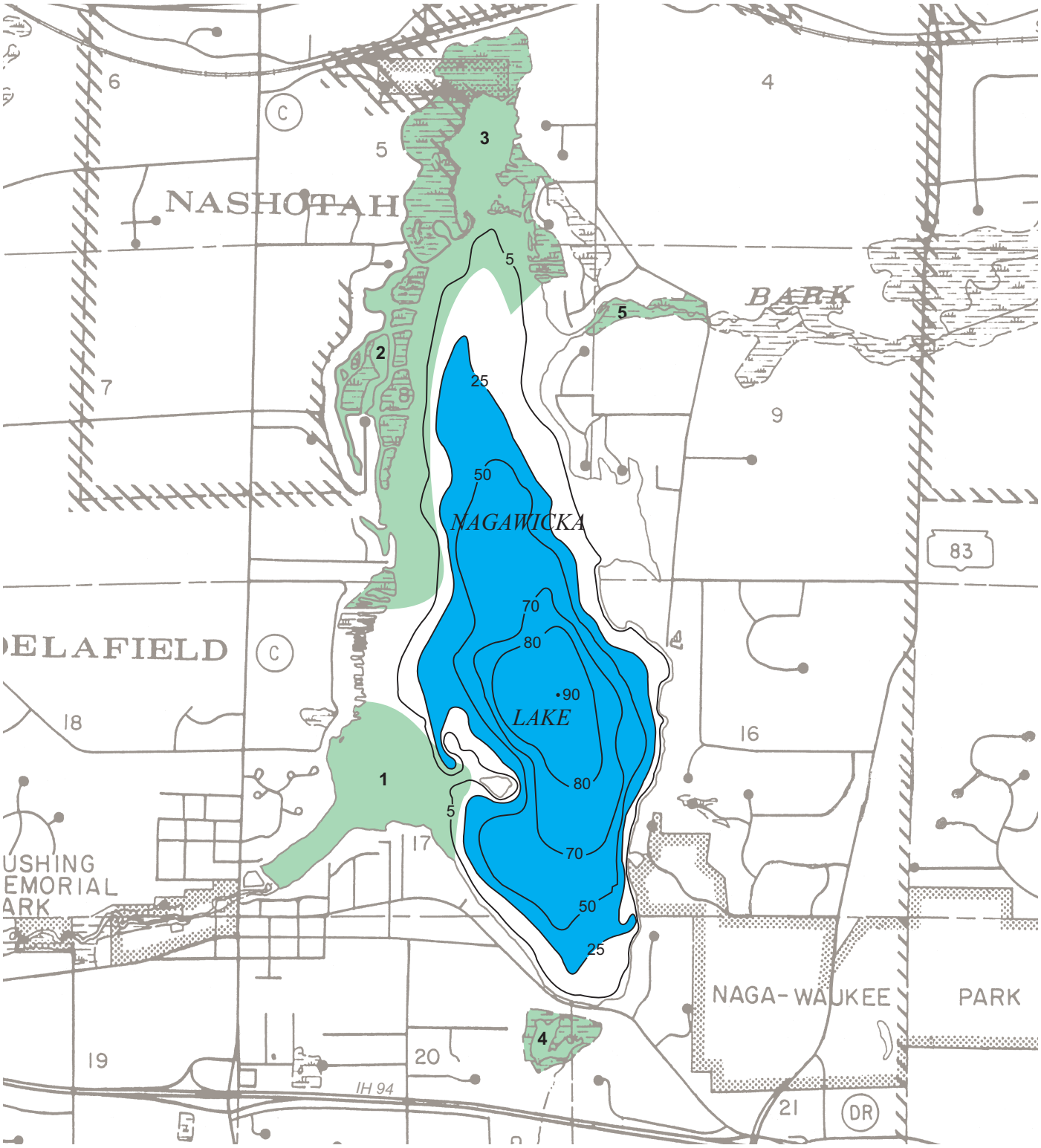
AQUATIC PLANT MANAGEMENT PLAN FOR NAGAWICKA LAKE



DATE OF PHOTOGRAPHY: APRIL 2010

Map 6

ENVIRONMENTALLY SENSITIVE AREAS OF 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.

SEWRPC Staff Memorandum

AN AQUATIC PLANT MANAGEMENT PLAN UPDATE FOR NAGAWICKA LAKE, WAUKESHA COUNTY, WISCONSIN: 2011

Exhibit 1

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

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State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

AQUATIC PLANT MANAGEMENT

SENSITIVE AREA ASSESSMENT SUMMARY

File Ref:

LAKE: NAGAWICKA COUNTY: WAUKESHA

DATE OF ASSESSMENT: JUNE 8, 1989 NUMBER OF SENSITIVE AREAS: 5

RESOURCE VALUE OF AREA #1

The area is commonly known as St. John's Bay. This area's most important function is that of spawning habitat for northern pike. The Department Fish Manager has determined through creel census that the northern pike population in the lake is diminishing, so it is important to protect and enhance northern's natural spawning habitat. St. John's Bay is the primary northern spawning area on the lake. The vegetation here is not very diverse but does provide nursery and feeding habitat year round for bass and panfish, as well as the northerns. It is important to end chemical treatments of this area by July 1 so that there will be sufficient regrowth of vegetation by spring for the northerns.

The banks in St. John's Bay provide muskrat with shelter. Raccoons, geese and mallards feed and rear their young in this area. The area just west of the island is primarily sand and gravel bottom and is a popular swimming area.

Vegetation in St. John's Bay helps stabilize the soft sediments. The plants also support an abundant amount of larger sized invertebrates. St. John's Bay also acts as a nutrient and sediment trap for the lake.

MANAGEMENT RECOMMENDATIONS FOR AREA #1

1. Mechanical treatment allowed with restrictions: Harvesting should end by July 1st and should be restricted to channels 25 feet from piers and extending out into open water. Minimal hand control allowed around piers & beaches.

2. Chemical treatment for Eurasian milfoil and purple loosestrife allowed only in navigational channels before July 1st.

3. None of the following inlake activities allowed:
   a. dredging
   b. filling
   c. boardwalks
   d. mechanical harvesting of vegetation in the area located northeast of St. John's Bay.

4. The following activities allowed with conditions:
   a. pea gravel/sand blankets in compliance with DNR provisions.
   b. aquascreen limited to area inside of navigational channel.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

File Ref:

AQUATIC PLANT MANAGEMENT

SENSITIVE AREA ASSESSMENT SUMMARY

LAKE: NAGAWICKA COUNTY: WAUKESHA

DATE OF ASSESSMENT: JUNE 8, 1989 NUMBER OF SENSITIVE AREAS: 5

RESOURCE VALUE OF AREA #2

This area of Nagawicka Lake has an unusually large amount of shoreline, and is therefore extremely valuable to fish and wildlife. The shoreline gravel provides spawning beds for bass and is heavily used by bluegills. The area is also an important spawning area for northern pike. The vegetation is fairly diverse and includes pondweeds, Yellow & White Water Lilies, Milfoil, Chara, sedges and Arrow Head. This vegetation is not only an excellent habitat, but also provides a food base. The vegetation and stumps, deadfalls, and other woody vegetation are important nursery and feeding areas for fish.

The songbirds, shorebirds and waterfowl use the area for feeding, rearing their young, and nesting. Use during migration is especially high. Muskrat and raccoon also feed and rear their young here.

This area acts as a nutrient and sediment trap for the lake and the aquatic vegetation helps prevent shoreline erosion. Protection of the existing native plants is an important method of helping diminish invasions of Purple Loosestrife and Eurasian milfoil.

MANAGEMENT RECOMMENDATIONS FOR AREA #2

1. Chemical treatment not allowed.

2. Mechanical treatment restricted to center of channels.

3. None of the following inlake activities allowed:
   a. filling
   b. pea gravel/sand blanket

4. The following activities allowed with conditions:
   a. dredging restricted to 25 ft center of channel.
   b. private piers for riparians' use only.
   c. boardwalks allowed for educational purposes only.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

AQUATIC PLANT MANAGEMENT

Carroll D. Besadny
Secretary

SENSITIVE AREA ASSESSMENT SUMMARY

LAKE: NAGAWICKA COUNTY: File Ref: WAUKESHA

DATE OF ASSESSMENT: JUNE 8, 1989 NUMBER OF SENSITIVE AREAS: 5

RESOURCE VALUE OF AREA #3

This area is called "the kettle" and is at the extreme north end of Nagawicka. The water depth drops off very quickly here to over 40 feet. Vegetation in this area includes Tamarack, sedges, cattails, pondweeds, water lilies, Purple Loosestrife and a variety of other emergent wetland vegetation.

The sedge and cattail fringe area is a good northern spawning area. The interconnecting channel between this area and the lake contains substantial amounts of tree stumps which provide cover, as well as a feeding and nursery area for bass and bluegill. The vegetation and substrate in the kettle provides nursery habitat, spawning beds, and feeding areas for bass, bluegill, crappie and northerns.

The kettle is used during migration by shorebirds, songbirds and waterfowl. Muskrat, opossum and raccoon feed and rear their young here. Wading birds feed in the area from spring until late fall.

The kettle acts as a nutrient and sediment trap for the lake and the aquatic vegetation helps prevent shoreline erosion. Protection of the existing native plants is an important method of helping diminish invasions of Purple Loosestrife and Eurasian milfoil.

MANAGEMENT RECOMMENDATIONS FOR AREA #3

1. Chemical treatment not allowed.

2. Mechanical treatment restricted to the existing NE channel to provide access to the kettle

3. None of the following inlake activities allowed:
   a. dredging, including stumps and vegetation
   b. pea gravel/sand blanket
   c. aquascreen
   d. filling

4. The following activities allowed with conditions:
   a. private piers for riparians' use only.
   b. boardwalks for educational purposes.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

AQUATIC PLANT MANAGEMENT

Carroll D. Besadny
Secretary

SENSITIVE AREA ASSESSMENT SUMMARY

LAKE: NAGAWICKA COUNTY: File Ref: WAUKESHA

DATE OF ASSESSMENT: JUNE 8, 1989 NUMBER OF SENSITIVE AREAS: 5

RESOURCE VALUE OF AREA #4

The wetland area, also known as Charlie's pond, is regulated by the Army Corp of Engineers, the City of Delafield, and the Department of Natural Resources. This is an extremely valuable wetland complex which drains the south end of Nagawicka Lake. The wetland acts as a sediment and nutrient trap and the aquatic vegetation helps prevent shoreline erosion.

Although the water is rather shallow most of the year, the wetland maintains a small population of most fish species that are found in Nagawicka Lake. The Department's Fish Manager uses the excellent spawning habitat in the wetland to propagate northern pike. The area is also a very good nursery area for most pan fish.

The wetland is considered a quality feeding area for wading birds, especially during migration. Migrating song birds frequent the area to nest, feed and rear their young. Muskrats, raccoons and waterfowl also frequent the area. Protection of the existing native plants is an important method of helping diminish invasions of Purple Loosestrife and Eurasian milfoil.

MANAGEMENT RECOMMENDATIONS FOR AREA #4

1. Chemical treatment not allowed.

2. Mechanical treatment limited to minimal hand control by piers.

3. None of the following inlake activities allowed:
   a. dredging
   b. pea gravel/sand blanket
   c. filling

4. The following activities allowed with conditions:
   a. aquascreen can be used, but only on riparians immediate shoreline-remove annually.
   b. piers for riparians' use only.
   c. boardwalks for educational and aesthetic purposes only, and not to provide boat access.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

AQUATIC PLANT MANAGEMENT

SENSITIVE AREA ASSESSMENT SUMMARY File Ref:

LAKE: NAGAWICKA COUNTY: WAUKESHA

DATE OF ASSESSMENT: JUNE 8, 1989 NUMBER OF SENSITIVE AREAS: 5

RESOURCE VALUE OF AREA #5

This area is the Bark River area leading into Nagawicka Lake. It provides an estuary habitat that is used by northerns and a variety of wildlife. The river provides white suckers with very good gravel areas which are used for spawning.

The river supports a variety of plant species. Emergent plants include cattails, sedges, Purple Loosestrife. Submergent plants include milfoil, pondweeds, and Yellow Water Lily.

Waterfowl nest and feed in the area, and it provides excellent habitat during migration. Muskrat and raccoon feed in the area.

This river acts as a nutrient and sediment trap for the lake and the aquatic vegetation helps prevent shoreline erosion. Protection of the existing native plants is an important method of helping diminish invasions of Purple Loosestrife and Eurasian Milfoil.

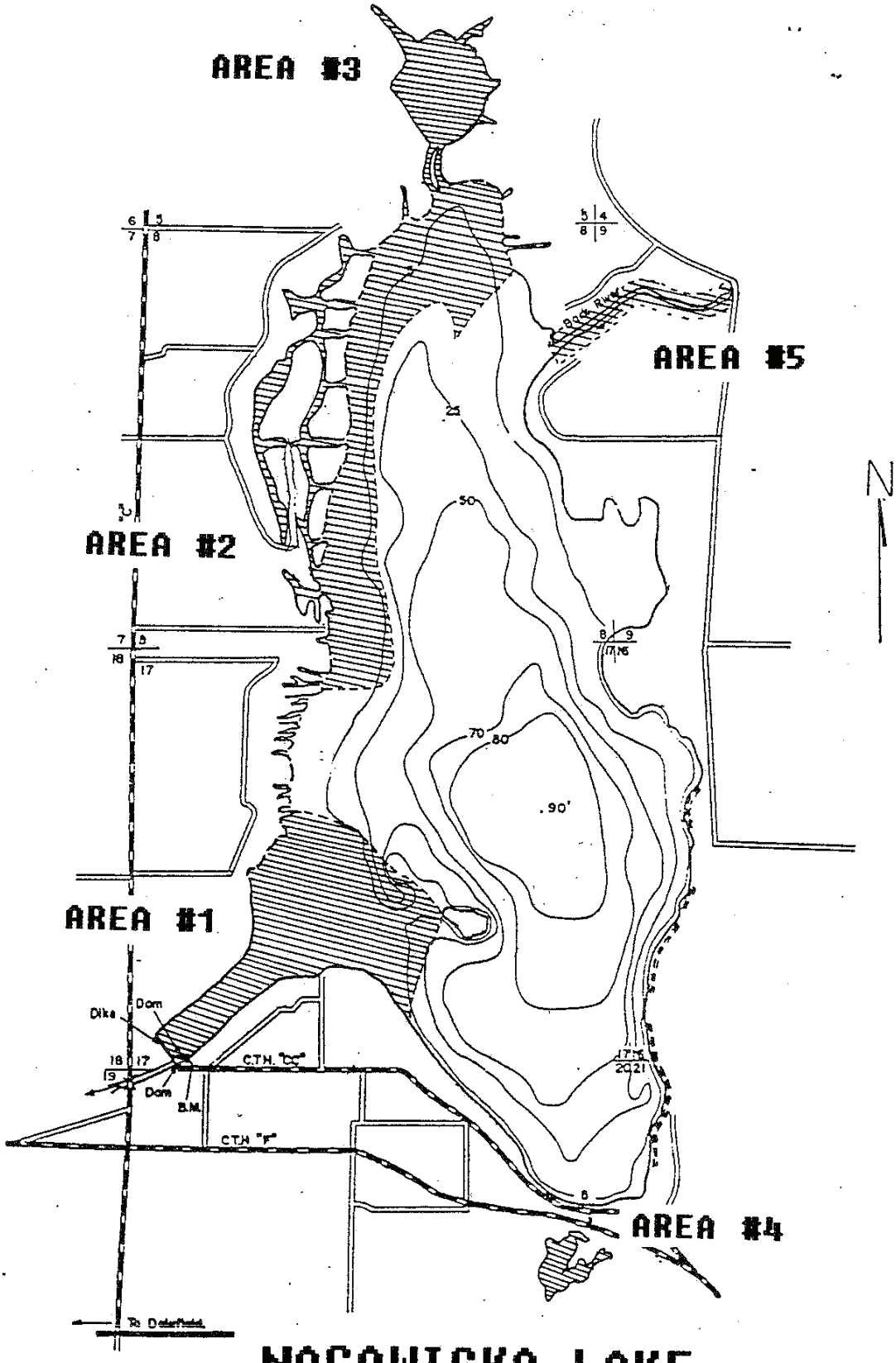
MANAGEMENT RECOMMENDATIONS FOR AREA #5

1. Chemical treatment not allowed.

2. Mechanical treatment limited to hand control for navigation.

3. None of the following inlake activities allowed:
   a. dredging
   b. pea gravel/sand blanket
   c. aquascreen
   d. boardwalks

4. The following activities allowed with conditions:
   a. private piers for riparians' use only.



NAGAWICKA LAKE
SENSITIVE AREAS

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SEWRPC Staff Memorandum

AN AQUATIC PLANT MANAGEMENT PLAN UPDATE FOR NAGAWICKA LAKE, WAUKESHA COUNTY, WISCONSIN: 2011

Exhibit 2

CITY OF DELAFIELD AQUATIC PLANT HARVESTING PLAN SUMMARY

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CITY OF DELAFIELD

AQUATIC PLANT HARVESTING PLAN
NAGAWICKA LAKE: 2012-2017

SHORELINE HARVESTING

The City performs shoreline harvesting along the shorelines highlighted in MAP 1. Shoreline harvesting is performed to provide navigational and recreational access for boaters and swimmers respectively. Shoreline harvesting is conducted from the pier line out to a maximum of 300 feet from shore. The actual distance out from shore varies significantly around the lake and in most areas of shoreline harvesting, the distance that we harvest is significantly less than 300 feet from shore. In some locations it can be as little as 25 to 50 feet out from shore. In some locations, where the piers are spaced far enough apart and the water depth is deep enough, we do perform some harvesting between piers. The piers need to be spaced far enough apart so that the harvester operator is confident that he can navigate the area without risk of injury or property damage to the harvester, piers, boats or other private property on the water. The water depth must also be deep enough such that the harvester does not hit or upset the bottom sediment in the lake and that after cutting, a minimum of 1-foot of plant material is left in place at the bottom.

CHANNEL HARVESTING

The City performs channel harvesting as highlighted in MAP 2 to provide access for boaters. The depth of harvesting for the channels is a maximum of 5 feet, with a typical depth of approximately 3 feet.

In the Northwest Channels (Sensitive Area 2) mechanical harvesting is restricted to the center of the channels. Depending on the overall width of the various channels, the width of the navigational lane harvested in the center is typically ten to twenty feet. The edges of many of these channels include significant growths of native pond weeds, which are not disturbed by our operations.

In the Kettle area (Sensitive Area 3) harvesting is restricted to channels that provide access to the Kettle. Many years we do not perform any harvesting in the Kettle. The City has been permitted to harvest an access channel between the Kettle and the main body of the lake. However, we have never had to perform harvesting in this area. We have a well-defined boating lane established with buoys and the regular boat traffic seems to keep the access lane open without the need for harvesting. The City has kept this lane on the channel harvesting map in case harvesting becomes necessary in the future to keep it open for access. On occasion (not every year) the City will need to harvest very short access channels as shown in the northeast portion of the Kettle to provide access to the Kettle for riparians in that area. When we do have to go into this area, it is typically for one single cutting in a given year and is typically necessary in late July or August.

In the northeast shore area of the lake, near the entrance of the Bark River into the lake, the City limits its harvesting to navigational channels until June 15 due to fish spawning activity. These channels are typically about 20 feet in width.

In St. John's Bay (Sensitive Area 1) the City limits its harvesting to access channels located approximately 25 feet from piers and extending out into open water.

TOP CUTTING

In the northeast shore area of the lake, near the entrance of the Bark River, (also known as "The Patch") the City performs top cutting after June 15 as highlighted in MAP 3. The City concentrates its efforts on removing the thick Eurasian water milfoil and Curly-leaf pondweed canopy from this area.

AQUATIC PLANT DISPOSAL SITES

The City's primary aquatic plant disposal sites are shown on MAP 4. The majority of the plant material is taken to site #1 on the map, which is Oakwood Park. This is an approximately 40 acre parcel owned by the City and currently used as a passive use park. The park is immediately adjacent to farm fields. The aquatic plants are typically dewatered on the City property and then spread on the adjacent farm field.

Site #2 is the City's old brush drop-off site located behind the Post Office off of CTH "C". This site is typically utilized when recent rain makes access into the Oakwood Park site problematic or when the crew is harvesting and unloading on the south end of the lake.

Site #3 is a local nursery/garden center located in Nashotah. The owner uses the plants for fertilizer/compost/soil amendment in his gardens.

In addition to the three sites specifically identified, the City also delivers plant material to various residents, landscape contractors and farmers as requested for use as compost/fertilizer/soil amendment.