MEMORANDUM REPORT NO. 161
(2ND EDITION)

# AQUATIC PLANT MANAGEMENT PLAN FOR NAGAWICKA LAKE

# WAUKESHA COUNTY, WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due to Danielle Matuszak MS, Specialist-Biologist; Justin Poinsatte, PhD, Principal Specialist-Biologist; Hanna Helker, Intern Biologist; Thomas Slawski, PhD, Chief Biologist; Megan Deau, Principal Graphic Designer; Morgan Goff, former Intern Biologist for their contributions to the conduct of this study and the preparation of this report. Acknowledgement is also extended to Tom Hafner – Noxious Weed Commissioner at the City of Delafield, for his contributions to the report. Acknowledgement is also extended to the lake monitoring volunteers for their time, efforts, and equipment. Volunteers included Mike Hausman (Lake Welfare Committee, Chairman) and Jim Ellsworth (Lake Welfare Committee, Member).

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Prepared by the
Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin 53187-1607
www.sewrpc.org

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# INTRODUCTION 1

*Credit: Commission Staff*

The Southeastern Wisconsin Planning Commission (Commission) completed this aquatic plant inventory and management study of Nagawicka Lake (Lake) on behalf of the City of Delafield (City). This memorandum report is the Commission's fourth aquatic plant management plan for Nagawicka Lake.[1,2] The Wisconsin Department of Natural Resources (WDNR) will use data and conclusions generated as part of the Commission's study to evaluate the Lake's aquatic plant community and draft an updated Aquatic Plant Control permit.

## 1.1 PROJECT SETTING, BACKGROUND, SCOPE, AND INTENT

Nagawicka Lake is a 981-acre two-story lake located in the City of Delafield in Waukesha County (Map 1.1).[3] Public access to the Lake is provided through a boat launch off Mariner Drive, which is administrated by Waukesha County. Additionally, the City has an improved public access launch at Bleeker Street, as well as several unimproved public access sites at Oak Street Park, St. Johns Park, and Lois Jensen Nature Preserve. The Lake is fed and drained by the Bark River and its water elevation is controlled by an outlet dam. Attaining a maximum depth of 90 feet, the deepest portions of the Lake are likely not capable of supporting an aquatic plant community, but previous surveys have indicated that the shallow nearshore areas support abundant growth of rooted aquatic plants. The previous aquatic survey conducted by the Commission in 2016 observed 32 species, including several beneficial native species like muskgrass (*Chara* spp.), Sago pondweed (*Stuckenia pectinata*), eelgrass (*Vallisneria americana*), and Illinois pondweed (*Potamogeton illinoensis*). Invasive aquatic plant species, including Eurasian watermilfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*), and spiny naiad (*Najas marina*) were also observed in the Lake at this

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

[2] *The Commission prepared an aquatic plant management plan for the lake in 2017 in SEWRPC Staff Memorandum,* Preliminary Findings and Recommendations, Nagawicka Lake Aquatic Plant Survey, Waukesha County, Wisconsin*, April 2017. Elements of this aquatic plant management plan were also referenced in SEWRPC Community Assistance Planning Report No. 262 (2nd Edition),* A Lake Management Plan for Nagawicka Lake, Waukesha County, Wisconsin*, 2021.*

[3] *While the entirely of the Lake's surface is within the City of Delafield, portions of the northwestern shoreline are in the Village of Nashotah.*

## Map 1.1
## Bathymetry and Local Location Names of Nagawicka Lake


DATE OF PHOTOGRAPHY: 2022

—5'— 5 FOOT WATER DEPTH CONTOUR

DEEP HOLE MONITORING SITE

PUBLIC BOAT LAUNCH

PRIVATE BOAT LAUNCH

DAM

N

0 1,000 2,000 Feet

*Source: SEWRPC*

time. The aquatic plant survey conducted for this update was conducted in July 2024 where Commission staff utilized the recommended baseline monitoring protocol employed by the WDNR.[4] There are four WDNR-designated Sensitive Areas on the Lake (see Map 1.2);[5] these areas are particularly important for sustaining elements of the lake's ecology, such as providing fish spawning and rearing habitat, and consequently intensive management is limited in these areas.

The City manages aquatic plant growth on the Lake to enhance navigation and recreational opportunities, primarily through mechanical harvesting and chemical treatments for invasive species control. Aquatic plant management is regulated by the WDNR and requires a permit. The City is required to reevaluate the aquatic plant community, update the aquatic plant management plan (APM), and renew the aquatic plant management harvesting permit every five years.

This updated APM plan summarizes information and recommendations needed to best manage the aquatic plant community of the Lake. The plan covers four main topics:

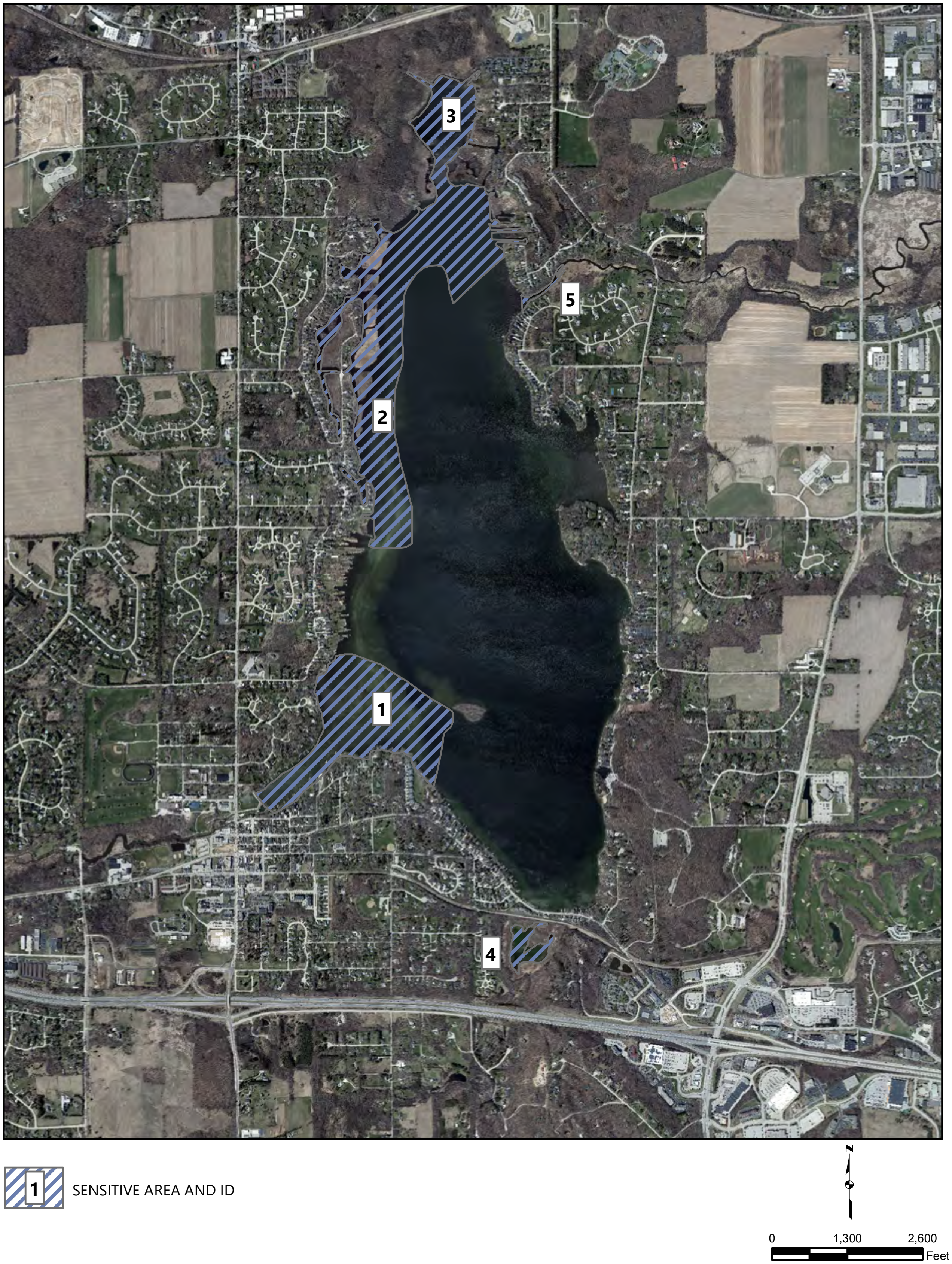
- APM Goals and Objectives
- Aquatic Plant Community Changes and Quality
- Aquatic Plant Control Alternatives
- Recommended Aquatic Plant Management Plan

This memorandum focuses on approaches to monitor and control actively growing nuisance populations of aquatic plants and presents a range of alternatives that could potentially be used to achieve desired APM goals and provides specific recommendations related to each alternative. These data and suggestions can be valuable resources when developing requisite APM permit applications and implementing future aquatic plant management efforts.

[4] *Hauxwell, J., S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky and S. Chase, "Recommended baseline monitoring of aquatic plants in Wisconsin: sampling design, field and laboratory procedures, data entry and analysis, and applications,"* Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068*, 2010.*

[5] *Sensitive Areas 5 covers the Bark River delta into Nagawicka Lake, which is considered by WDNR to be part of the Lake.*

**Map 1.2**
**Sensitive Areas on Nagawicka Lake**




*Source: SEWRPC, WDNR*

# INVENTORY FINDINGS AND RELEVANCE TO RESOURCE MANAGEMENT 2

*Credit: Commission Staff*

## 2.1 AQUATIC PLANT MANAGEMENT GOALS AND OBJECTIVES

Aquatic plant management (APM) programs are designed to further a variety of lake user and riparian landowner goals and desires. For example, most APM programs aim to improve lake navigability. However, APM programs must also be sensitive to other lake uses and must maintain or enhance a lake's ecological integrity. Consequently, APM program objectives are commonly developed in close consultation with many interested parties. The Nagawicka Lake (Lake) APM plan considered input from City of Delafield Lake Welfare Committee (City), Wisconsin Department of Natural Resources (WDNR), and the public. Objectives of the Nagawicka Lake APM program include the following.

- Effectively control the quantity and density of nuisance aquatic plant growth in well-targeted portions of Nagawicka Lake. This objective helps:
  - Enhance water-based recreational opportunities,
  - Allow opportunities for native and beneficial plant growth,
  - Improve community-perceived aesthetic values, and
  - Maintain or enhance the Lake's natural resource value.
- Manage the Lake in an environmentally sensitive manner in conformance with *Wisconsin Administrative Code* standards and requirements under Chapters NR 103 "Water Quality Standards for Wetlands," NR 107 "Aquatic Plant Management," and NR 109 "Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations." Following these rules helps the City preserve and enhance the Lake's water quality, biotic communities, habitat value, and essential structure and relative function in relation to adjacent areas.
- Protect and maintain public health and promote public comfort, convenience, and welfare while safeguarding the Lake's ecological health through environmentally sound management of vegetation, wildlife, fish, and other aquatic/semi-aquatic organisms in and around the Lake.

- Promote a high-quality water-based experience for residents and visitors to the Lake consistent with the policies and practices of the WDNR, as described in the regional water quality management plan, as amended.[6]

To meet these objectives, the City executed an agreement with the Commission to investigate the characteristics of the Lake and to update the aquatic plant management plan. As part of this planning process, surveys of the aquatic plant community and comparison to results of previous surveys were conducted. This chapter presents the results of each of these inventories.

## 2.2 AQUATIC PLANT COMMUNITY COMPOSITION, CHANGE, AND QUALITY

All healthy lakes have plants and native aquatic plants form a foundational part of a lake ecosystem. Aquatic plants form an integral part of the aquatic food web, converting sediments and inorganic nutrients present in the water into organic compounds that are directly available as food to other aquatic organisms. Through photosynthesis, plants utilize energy from sunlight and release the oxygen required by many other aquatic life forms into the water. Aquatic plants also serve several other valuable functions in a lake ecosystem, including:

- Improving water quality by filtering excess nutrients from the water
- Providing habitat for invertebrates and fish
- Stabilizing lake bottom substrates
- Supplying food for waterfowl and various lake-dwelling animals

Even though aquatic plants may hinder human use and/or access to a lake, aquatic plants should not necessarily be eliminated or even significantly reduced in abundance because they often support many other beneficial functions. For example, water lilies play a significant role in providing shade, habitat, and food for fish and other important aquatic organisms. They also help prevent damage to the lakeshore by dampening the power of waves that could otherwise erode the shoreline. Additionally, the shade that these plants provide helps reduce the growth of undesirable plants because it limits the amount of sunlight reaching the lake bottom. Given these benefits, large-scale removal of native plants that may be perceived as a nuisance should be avoided when developing plans for aquatic plant management.

**Aquatic Plant Surveys**

Aquatic plant inventories of Nagawicka Lake have been completed several times in the past to support aquatic plant management permit applications. Commission staff surveyed the Lake's aquatic plants in 1997, 2004, 2011, and 2016.[7] To establish long-term management goals and permitted management of the Lake, the City has decided to evaluate the Lake's aquatic plant community and prepare an aquatic plant management plan for the Lake. The 2016 and 2024 surveys both used the same point-intercept grid and methodology.[8,9] In this method, sampling sites are based on predetermined global positioning system (GPS) location points that are arranged in a grid pattern across the entire surface of a lake.

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

[7] *The 1993 aquatic plant survey was conducted by Aron & Associates, Nagawicka Lake Plant Management Plan, August 1993.*

[8] *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; as refined in the Memo from S. 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*

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

The grid pattern of Nagawicka Lake consists of 1,451 points (provided by WDNR staff) that allows the types and abundance of aquatic plants to be directly contrasted to prior point-intercept surveys (see Figure 2.1). At each grid point sampling site, a single rake haul is taken and a qualitative assessment of the rake fullness, on a scale of zero to three (see Figure 2.2), is made for each species identified. The same points were sampled using the same techniques in 2016 and 2024. This consistency enables more detailed evaluation of aquatic plant abundance and distribution change than has been possible in the past.

Commission staff conducted the 2024 survey on July 8th through the 11th with the assistance of volunteers from the City. Conditions during the survey were excellent, with sunny to partly sunny skies, low wind speeds, and minimal boat traffic. The Lake's water clarity was adequate, which enhanced visual observations of aquatic plant species within six feet of the sampling location. In general, the aquatic plant specimens were mature, and several species were in flower (e.g., white water lily (*Nymphaea odorata*) and spatterdock (*Nuphar variegata*)). In addition to the aquatic plants, Commission staff observed waterfowl, fish, whitetail deer, muskrats, and turtles during the survey.

While Commission staff strived to survey as much of the Lake as feasible, certain areas of the Lake were not surveyed in 2024. These areas included the central portion of the main Lake body, which was determined to be too deep for vascular aquatic plants to grow. Other points that were not surveyed were either due to obstacles such as docks or points that were deemed to be on shore. Ultimately of the 1,451 points on the Lake, 607 site were sampled, of which 499 had aquatic plants present.

### Aquatic Plant Survey Metrics

Each aquatic plant species has preferred habitat conditions in which that species thrives, as well as conditions that limit or completely inhibit its growth. For example, water conditions (e.g., depth, clarity, source, alkalinity, and nutrient concentrations), substrate composition, the presence of or absence of water movement, and pressure from herbivory and/or competition all can influence the type of aquatic plants found in a water body. All other factors being equal, water bodies with a diverse array of habitat variables are more likely to host a diverse aquatic plant community. For similar reasons, some areas of a particular lake may contain plant communities with low diversity, while other areas of the same lake may exhibit higher diversity. Historically, human manipulation has often favored certain plants and reduced biological diversity (biodiversity). Thoughtful aquatic plant management can help maintain, or even enhance, aquatic plant biodiversity.

Several metrics are useful to describe aquatic plant community condition and design management strategies. These metrics include total rake fullness, maximum depth of colonization, species richness, biodiversity, evaluation of sensitive species, and relative species abundance. Metrics derived from the 2016 and 2024 point-intercept surveys are described below.

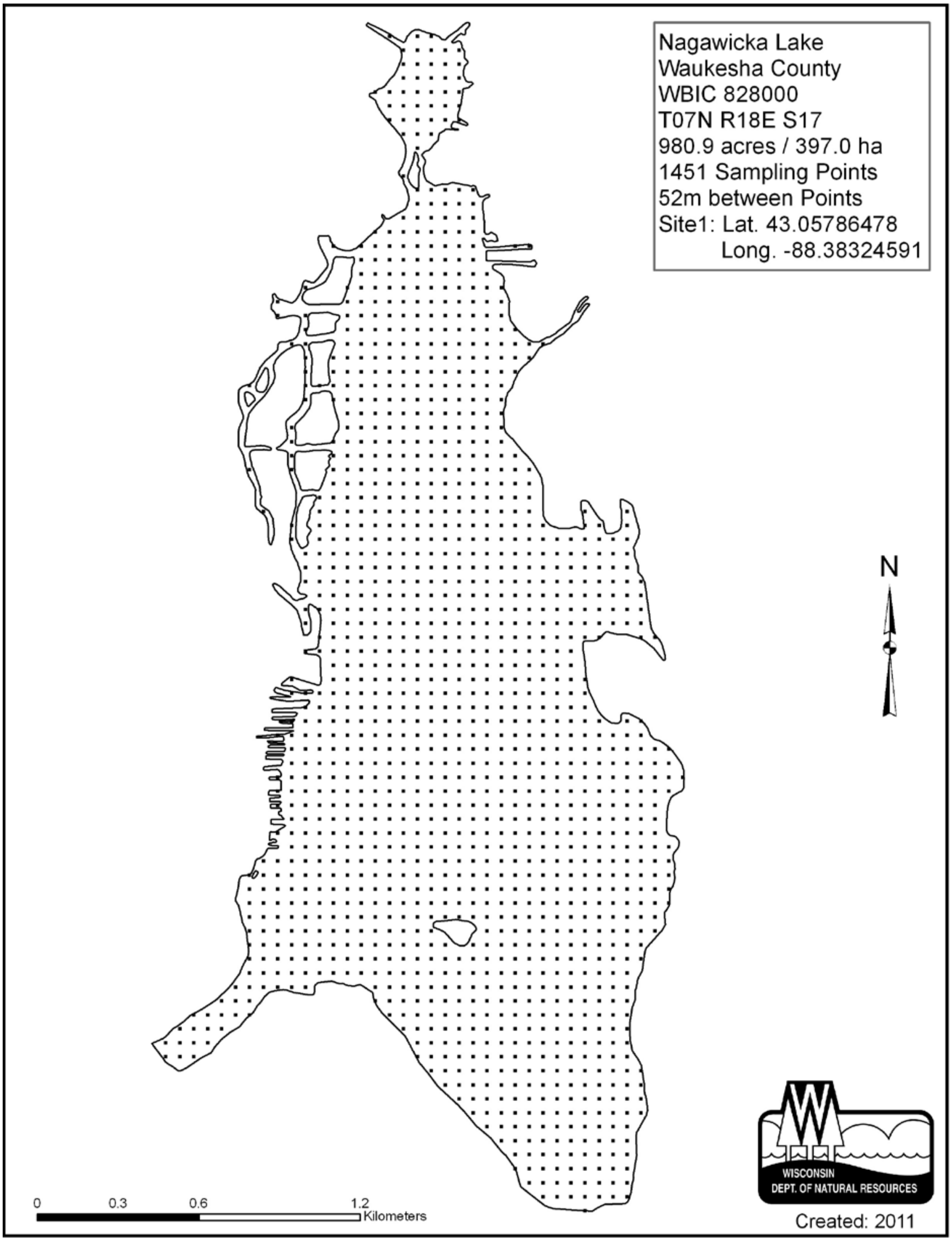
#### *Total Rake Fullness*

As described earlier in this section, Commission staff qualitatively rated the plant abundance at each survey point by how much of the sampling rake was covered by all aquatic plant species.[10] This rating, called total rake fullness, can be a useful metric evaluating general abundance of aquatic plants as part of the point-intercept survey. As shown in Figure 2.3, total rake fullness across all surveyed points in Nagawicka Lake averaged 1.29 in 2024 which is down from 2016 where the average rake fullness was 1.97. Of the 496 points that had aquatic plants present, 64 had a rake fullness of 3 (see Figure 2.4), 148 had a rake fullness of 2, and 291 had a rake fullness of 1.

The most abundant areas of plant growth were the nearshore areas, particularly in Saint John's Bay and the northeastern portion of the Lake. These areas were generally shallower allowing for denser plant growth. The eastern shoreline of the southern half of the lake, as well as portions of the southwestern shoreline, are not conducive to extensive aquatic plant growth, as this area quickly drops into depths that are light-limiting for aquatic plants at the current water clarity levels.

[10] *This method follows the standard WDNR protocol.*

**Figure 2.1**
**Aquatic Plant Point-Intercept Survey Grid for Nagawicka Lake**




*Source: WDNR and SEWRPC*

***Maximum Depth of Colonization***

Maximum depth of colonization (MDC) can be a useful indicator of water quality, as turbid and/or eutrophic (nutrient-rich) lakes generally have shallower MDC than lakes with clear water.[11] It is important to note that for surveys using the point-intercept protocol, the protocol allows sampling to be discontinued at depths greater than the maximum depth of colonization for vascular plants. However, aquatic moss and macroalgae, such as muskgrass and nitella, frequently colonize deeper than vascular plants and thus may be under-sampled in some lakes. For example, *Chara globularis* and *Nitella flexilis* have been found growing as deep as 37 and 35 feet, respectively, in Silver Lake, in Washington County. In 2024 the MDC in Nagawicka Lake was 16 feet, a half-foot deeper than the 2016 survey. Muskgrass (*Chara* spp.) was the most common species observed at 16 feet deep.

**Figure 2.2**
**WDNR Rake Fullness Rating**

| Fullness Rating | Coverage | Description |
|---|---|---|
| 1 |  | Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer. |
| 2 |  | There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines. |
| 3 |  | The rake is completely covered and tines are not visible |

*Source: WDNR*

***Species Richness***

The number of distinct types of aquatic plants present in a lake is referred to as the species richness of the lake. Larger lakes with diverse lake basin morphology, less human disturbance, and/or healthier, more resilient lake ecosystems have greater species richness. Aquatic plants provide a wide variety of benefits to lakes, examples of which are briefly described in Table 2.1. The species richness observed in the 2024 survey was 32 plant species, similar to the number of species found in 2016 (see Figure 2.5 and Table 2.2). In 1993 only 12 species of aquatic plants were found in Nagawicka Lake and has increased nearly every survey since. While this is a good trend to see, it should be noted that over the years methodology for plant surveys and taxonomy identification has improved, which may have contributed to the increase in known species.

***Biodiversity and Species Distribution***

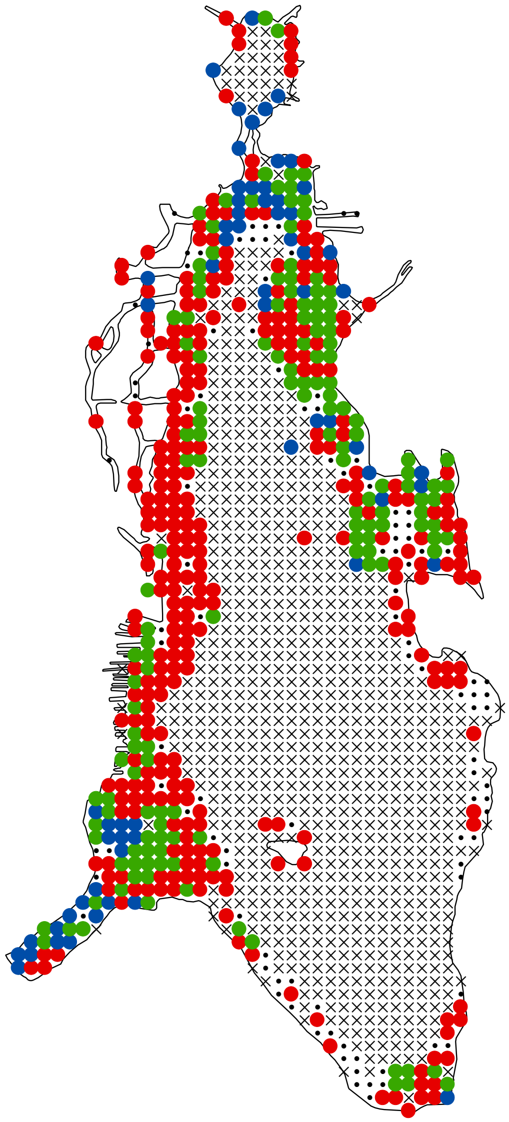
Species richness is often incorrectly used as a synonym for biodiversity. The difference in meaning between these terms is both subtle and significant. Biodiversity is based on the number of species present in a habitat along with the abundance of each species. For the purposes of this study, abundance was determined as the percentage of observations of each species compared to the total number of observations made. Aquatic plant biodiversity can be measured with the Simpson Diversity Index (SDI).[12] Using this measure, a community dominated by one or two species would be considered less diverse than one in which several different species have similar abundance. In general, more diverse biological communities are better able to maintain ecological integrity in response to environmental stresses. Promoting biodiversity not only helps sustain an ecosystem but preserves the spectrum of options useful for future management decisions.

Nagawicka Lake has good biodiversity with an SDI of 0.80 in 2024, same as it was in 2016. Between zero and ten species were found at any single sampling point across the Lake, with higher richness of species being found particularly in nearshore areas (see Figure 2.5). Actions that conserve and promote aquatic plant biodiversity are critical to the long term health of the Lake. Such actions not only help sustain and increase the robustness and resilience of the existing ecosystem, but also promote efficient and effective future aquatic plant management.

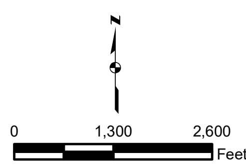
[11] *D.E. Canfield Jr, L. Langeland, and W.T. Haller, "Relations Between Water Transparency and Maximum Depth of Macrophyte Colonization in Lakes," Journal of Aquatic Plant Management 23, 1985.*

[12] *The SDI expresses values on a zero to one scale where 0 equates to no diversity and 1 equates to infinite diversity.*

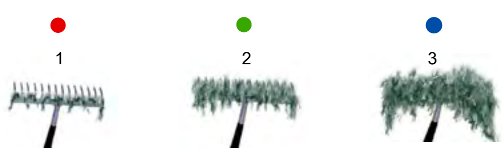
## Figure 2.3
## Total Rake Fullness in Nagawicka Lake: July 2024



NOTE: Survey was conducted on Nagawicka Lake from July 8th-11th, 2024.




**RAKE FULLNESS RATING**




VISIBLE NEARBY

• NO AQUATIC PLANTS FOUND × NOT SAMPLED

*Source: WDNR and SEWRPC*

***Sensitive Species***

Aquatic plants metrics such as species richness and disturbance tolerance are often used as indicators of the ecological health of lake due to aquatic plants' varying sensitivity to human activity. In hard water lakes, such as those common in Southeastern Wisconsin, species richness generally increases with water quality and decreases with nutrient enrichment.[13] In 2017, a new method of tying aquatic plants to lake health was developed that utilized human disturbance variables and found that as those variables increased, the abundance of sensitive aquatic plant species decreased, with tolerant species becoming more prevalent.[14] Three sensitive species, as identified in this 2017 publication, were found during the 2024 survey: slender naiad (*Najas flexilis)*, large-leaf pondweed (*Potamogeton amplifolius)*, and variable-leaf pondweed (*Potamogeton gramineus)* (see Figure 2.6).

**Figure 2.4**
**Rake Fullness of "3" of *Chara* sp. in Nagawicka Lake: July 2024**

*Source: SEWRPC*

***Relative Species Abundance***

Based on the 2024 point-intercept survey, the five most abundant submerged aquatic plant species in the Lake were, in decreasing order of abundance: 1) muskgrass, 2) eelgrass (*Vallisneria americana*), 3) water star grass (*Heteranthera dubia*), 4) sago pondweed (*Stuckenia pectinata*), (5) elodea (*Elodea canadensis*) (see Maps A.1 through A.5 in Appendix A, respectively). Much of the submergent plant community consisted of dense intermixed beds of muskgrass and eelgrass. Water star grass was found in the greatest abundance in the northeastern portion of the lake. It had occasional occurrences in the kettle, along the western shoreline and in the southernmost tip of the Lake. Sago pondweed was found primarily near Saint Johns Bay and along the western shoreline with several points along the eastern shoreline and on the southern end of the Lake. While aquatic plants were found along nearly the entire shoreline of Nagawicka Lake, due to the deep drop off in depth on the southeastern shoreline, very few plants were observed at sampling points in that area.

**Invasive Species**

This subsection will discuss invasive species observations in Nagawicka Lake, as these are often the focus of aquatic plant management efforts.

***Eurasian Watermilfoil***

Eurasian Watermilfoil (EWM) is one of eight milfoil species found in Wisconsin and is the only exotic or nonnative milfoil species. EWM favors mesotrophic to moderately eutrophic waters, fine organic-rich lake-

[13] *Vestergaard, O. and Sand-Jensen, K. "Alkalinity and Trophic State Regulate Aquatic Plant Distribution in Danish Lakes," Aquatic Botany 67, 2000.*

[14] *Mikulyuk, Alison, Martha Barton, Jennifer Hauxwell, Catherine Hein, Ellen Kujawa, Kristi Minahan, Michelle E. Nault, Daniel L. Oele, and Kelly I. Wagner, "A macrophyte bioassessment approach linking taxon-specific tolerance and abundance in north temperate lakes,"* Journal of environmental management *199): 172-180, 2017.*

**Table 2.1**
**Examples of Positive Ecological Qualities Associated with a Subset of the Aquatic Plant Species Present in Nagawicka Lake**

| | |
|---|---|
| *Ceratophyllum demersum* (coontail) | Provides good shelter for young fish; supports insects valuable as food for fish and ducklings; native |
| *Chara* spp. (muskgrasses) | A favorite waterfowl food and fish habitat, especially for young fish; native |
| *Elodea canadensis* (common waterweed) | Provides shelter and support for insects which are valuable as fish food; native |
| *Heteranthera dubia* (water stargrass) | Locally important food source for waterfowl and forage for fish; native |
| *Myriophyllum spicatum* (Eurasian watermilfoil) | None known. Invasive nonnative. Hinders navigation, outcompetes desirable aquatic plants, reduces water circulation, depresses oxygen levels, and reduces fish/invertebrate populations |
| *Najas flexilis* (slender naiad) | 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; naturalized nonnative |
| *Potamogeton crispus* (curly-leaf pondweed) | Adapted to cold water; mid-summer die-off can impair water quality; invasive nonnative |
| *Potamogeton gramineus* (variable pondweed) | The fruit is an important food source for many waterfowl; also provides food for muskrat, deer, and beaver; 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 zosteriformis* (flat-stem pondweed) | Provides some food for ducks; native |
| *Stuckenia pectinata* (Sago pondweed) | This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish; native |
| *Utricularia* spp. (bladderworts) | Stems provide food and cover for fish; native |
| *Vallisneria americana* (eelgrass/water celery) | Provides good shade and shelter, supports insects, and is valuable fish food; 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*

bottom sediment, warmer water with moderate clarity and high alkalinity, and tolerates a wide range of pH and salinity.[15,16] In Southeastern Wisconsin, EWM can grow rapidly and has few natural enemies to inhibit its growth. Furthermore, it can grow explosively following major environmental disruptions, as small fragments of EWM can grow into entirely new plants.[17] For reasons such as these, EWM can grow to dominate an aquatic plant community in as little as two years.[18,19] In such cases, EWM can displace native plant species and interfere with the aesthetic and recreational use of waterbodies. However, established populations may rapidly decline after approximately ten to 15 years.[20]

Human-produced EWM fragments (e.g., created by boating through EWM), as well as fragments generated from natural processes (e.g., wind-induced turbulence, animal feeding/disturbance) readily colonize disturbed sites, contributing to EWM spread. EWM fragments can remain buoyant for two to three days in summer and

[15] *U.S. Forest Service, Pacific Islands Ecosystems at Risk (PIER), 2019.: hear/org/pier/species/myriophyllum_spicatum.htm.*

[16] *S.A. Nichols and B. H. Shaw, "Ecological Life Histories of the Three Aquatic Nuisance Plants: Myriophyllum spicatum, Potamogeton crispus, and Elodea canadensis," Hydrobiologia 131(1), 1986.*

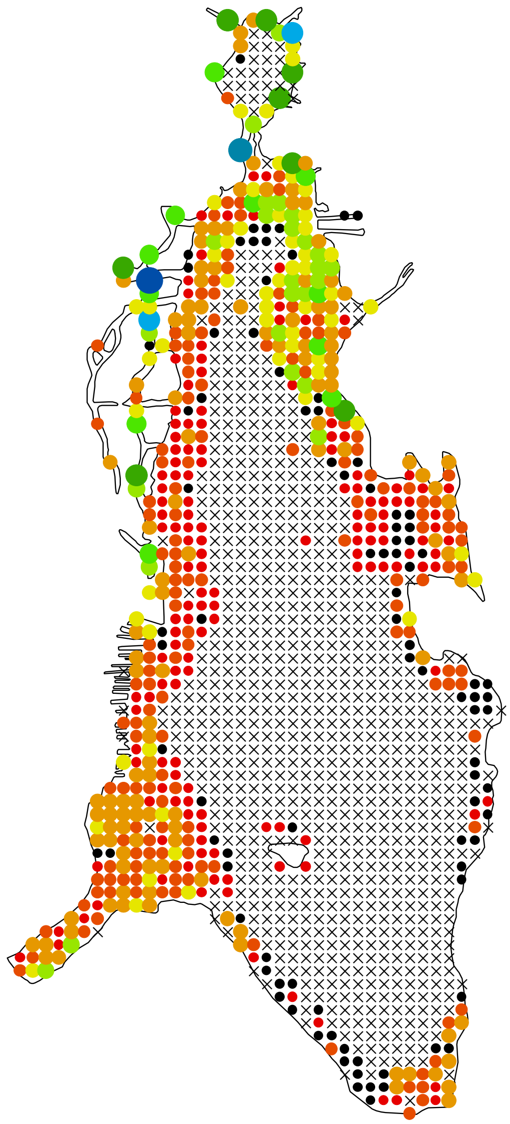
[17] Ibid.

[18] *S.R. Carpenter, "The Decline of Myriophyllum spicatum in Eutrophic Wisconsin (USA) Lake," Canadian Journal of Botany 58(5), 1980.*

[19] *Les, D. H., and L. J. Mehrhoff, "Introduction of Nonindigenous Vascular Plants in Southern New England: a Historical Perspective," Biological Invasions 1:284-300, 1999.*

[20] *S.R. Carpenter, 1980, op. cit.*

## Figure 2.5
## Species Richness in Nagawicka Lake: July 2024



NOTE: Survey was conducted between July 8th-11th, 2024. Species Richness values include nearby visual sightings of aquatic plants and nonnative aquatic plant species.

**SPECIES RICHNESS**

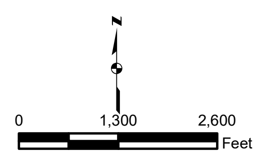
1   6   × NOT SAMPLED

2   7   • NO AQUATIC PLANTS FOUND

3   8

4   9

5   10




*Source: WDNR and SEWRPC*

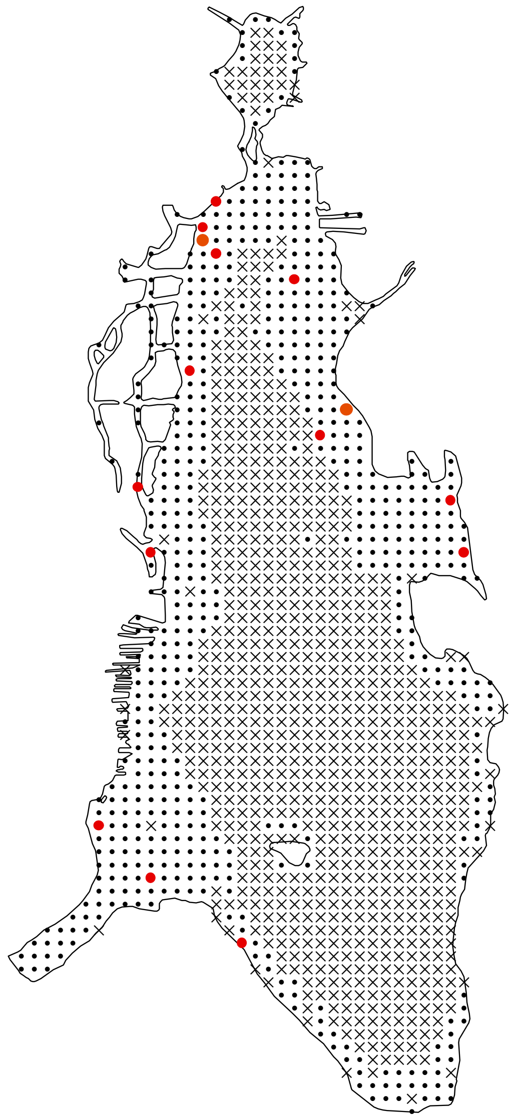
## Table 2.2
## Aquatic Plant Species Observed in Nagawicka Lake: 1993-2024

| Aquatic Plant Species | Native or Invasive | 1993 | 1997 | 2004 | 2011 | 2016 | 2024 |
|---|---|---|---|---|---|---|---|
| *Ceratophyllum demersum* | Native | X | X | X | X | X | X |
| *Chara* spp. | Native | X | X | X | X | X | X |
| *Eleocharis acicularis* | Native | -- | -- | -- | X | -- | X |
| *Elodea canadensis* | Native | -- | -- | X | X | X | X |
| *Heteranthera dubia* | Native | -- | -- | X | X | X | X |
| *Lemna minor* | Native | -- | -- | -- | -- | X | X |
| *Lemna trisulca* | Native | -- | -- | -- | -- | X | X |
| *Myriophyllum heterophyllum* | Native | X | X | X | X | X | -- |
| *Myriophyllum spicatum* | Invasive | X | X | X | X | X | X |
| *Myriophyllum verticillatum* | Native | -- | -- | -- | -- | -- | X |
| *Najas flexilis* | Native | X | X | X | X | X | X |
| *Najas marina* | Naturalized | X | X | X | X | X | X |
| *Nitella* sp. | Native | X | -- | -- | -- | -- | -- |
| *Nuphar variegata* | Native | -- | -- | -- | X | X | X |
| *Nymphaea odorata* | Native | -- | -- | -- | X | X | X |
| *Potamogeton amplifolius* | Native | X | X | X | -- | -- | X |
| *Potamogeton crispus* | Invasive | X | X | X | X | X | X |
| *Potamogeton foliosus* | Native | -- | -- | -- | X | -- | -- |
| *Potamogeton friesii* | Native | -- | -- | -- | -- | X | X |
| *Potamogeton gramineus* | Native | -- | -- | -- | X | X | X |
| *Potamogeton illinoensis* | Native | -- | -- | X | X | X | X |
| *Potamogeton illunoensis x natans* | Native | -- | -- | -- | -- | -- | X |
| *Potamogeton natans* | Native | -- | -- | -- | X | X | -- |
| *Potamogeton nodosus* | Native | -- | -- | -- | X | -- | -- |
| *Potamogeton praelongus* | Native | -- | -- | -- | -- | X | X |
| *Potamogeton pusilis* | Native | -- | -- | -- | X | -- | -- |
| *Potamogeton richardsonii* | Native | X | X | X | X | X | X |
| *Potamogeton strictifolius* | Native | -- | -- | -- | -- | X | -- |
| *Potamogeton zosteriformis* | Native | X | X | X | X | X | X |
| *Ranunculus aquatilis* | Native | -- | -- | -- | -- | X | X |
| *Riccia Fluitans* | Native | -- | -- | -- | -- | -- | X |
| *Sagittaria latifolia* | Native | -- | -- | -- | X | -- | -- |
| *Sagittaria* sp. | Native | -- | -- | -- | -- | X | X |
| *Sparganium eurycarpum* | Native | -- | -- | -- | -- | X | -- |
| *Sparganium sp.* | Native | -- | -- | -- | -- | -- | X |
| *Spirodela polyrhiza* | Native | -- | -- | -- | -- | X | X |
| *Stuckenia pectinata* | Native | -- | -- | X | X | X | X |
| *Typha sp.* | Native | -- | -- | -- | -- | X | X |
| *Utricularia vulgaris* | Native | -- | -- | X | X | X | X |
| *Vallisneria americana* | Native | X | X | X | X | X | X |
| *Wolffia borealis* | Native | -- | -- | -- | -- | X | -- |
| *Wolffia columbiana* | Native | -- | -- | -- | -- | X | -- |
| *Wolffia sp.* | Native | -- | -- | -- | -- | -- | X |
| Species Total | | 12 | 11 | 16 | 24 | 31 | 32 |

Note: Red text indicates nonnative and/or invasive species.

*Source: SEWRPC*

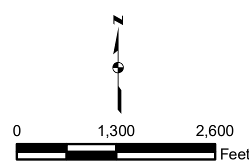
**Figure 2.6**
**Sensitive Species - Species Richness in Nagawicka Lake: July 2024**



NOTE: Survey was conducted between July 8th-11th, 2024. Species Richness values include nearby visual sightings of aquatic plants.

**SENSITIVE SPECIES RICHNESS**

- ● 1
- ● 2
- ● 3
- × NOT SAMPLED
- • NO AQUATIC PLANTS FOUND




*Source: WDNR and SEWRPC*

two to six days in fall, with larger fragments remaining buoyant longer than smaller ones.[21] The fragments can also cling to boats, trailers, motors, and/or bait buckets where they can remain alive for weeks contributing to transfer of milfoil to other lakes. For these reasons, it is especially important to remove all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies.

In the 2024 survey, EWM was found on the rake at 16 points across the Lake and seen nearby an additional 11 points. These populations were primarily on the north basin of the Lake and the western shoreline (see Map A.6 in Appendix A). EWM was most commonly observed with a rake fullness of one or as a visual near the survey point. In 2016, EWM was observed on the rake at 11 points with a rake fullness of two and three at one point each and was observed as a visual at 8 additional points (see Figure 2.7).

***Curly-Leaf Pondweed***

Curly-leaf pondweed (CLP) (*Potamogeton crispus*) continues to be present in Nagawicka Lake. This plant, like EWM, is identified in Chapter NR 109 of the *Wisconsin Administrative Code* as a nonnative invasive aquatic plant. Although survey data suggests it presently is only a relatively minor species in terms of dominance, and, as such, is less likely to interfere with recreational boating activities, the plant can grow in dense strands that exclude other high value aquatic plants. For this reason, CLP must continue to be monitored and managed as an invasive member of the aquatic community. Lastly, it must be remembered that CLP senesces by midsummer, and therefore may be underrepresented in the inventory data presented in this report.

On Nagawicka Lake, CLP was found on the rake at 14 points, each of which had a rake fullness of one, as well as one additional site as a visual in the northern kettle(see Map A.7 in Appendix A). Comparatively, CLP was only found on the rake at 3 points in 2016 with 2 additional visual sightings (see Figure 2.8).

***Spiny Naiad***

Spiny Naiad (*Najas marina*) is classified as a restricted species in Wisconsin. Spiny naiad can form dense mats of vegetation on the bottoms of waterbodies that can subsequently smother native aquatic plant species. Waterfowl will often consume the seeds, which germinate by digestion; consequently, waterfowl are considered a primary vector for the spread of this species.[22]

In 2016, spiny naiad was found at 44 points but was only found at 4 points in 2024 (see Figure 2.9). Additionally, there were 3 visual sitings in 2016 and 2 sightings in 2024. In 2024, 5 of the 6 points where spiny naiad was found were located near the entrance to Saint John's Bay (see Map A.8 in Appendix A). The remaining point was located near Sylvester Drive south of Price Road.

***Future Invasive Aquatic Plant Species Threats***

Although starry stonewort (*Nitellopsis obtusa*) was not found in Nagawicka Lake during the 2016 nor the most recent 2024 aquatic plant inventory, the WDNR first observed this invasive aquatic plant in Southeastern Wisconsin lakes in 2014. Some of these lakes, including Pewaukee Lake, Upper Nemahbin and Okauchee Lake are near Nagawicka Lake and had verified populations of starry stonewort in 2019.[23] This is a major concern since starry stonewort has been spreading to other nearby lakes in Southeastern Wisconsin and no management methods have yet been found to successfully manage its growth. This species can form extremely dense vegetative mats that may affect aquatic plant community species richness and can impede recreational use. Dense growth of starry stonewort can also interfere with life-cycle critical functions of fish and other animals, including fish spawning.[24] The best control is to prevent its introduction to Nagawicka Lake (see more details in Chapter 3).

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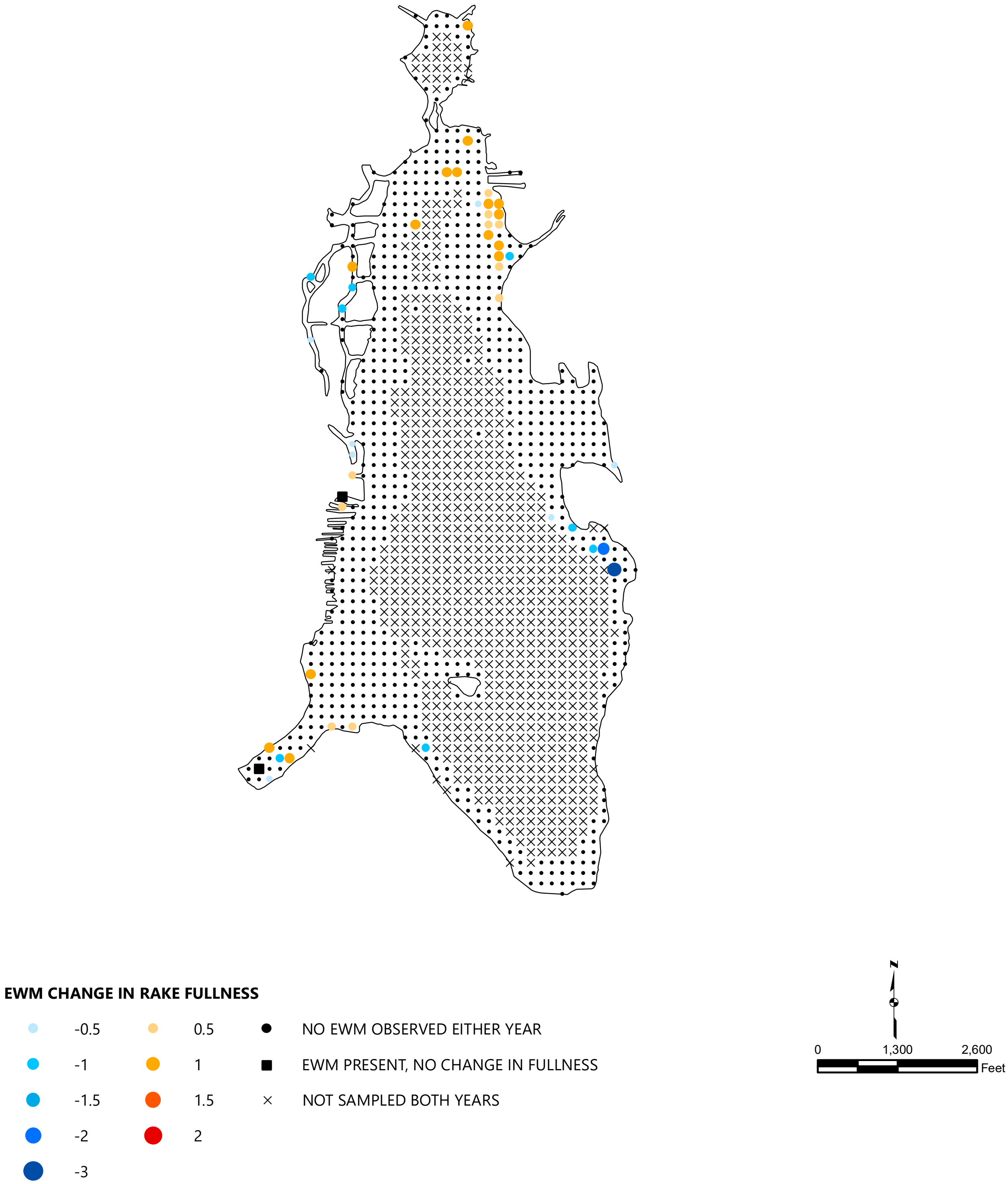
[21] *J.D. Wood and M. D. Netherland, "How Long Do Shoot Fragments of Hydrilla (Hydrilla verticullata) and Eurasian Watermilfoil (Myriophyllum spicatum) Remain Buoyant?', Journal of Aquatic Plant Management 55: 76-82, 2017.*

[22] *dnr.wisconsin.gov/topic/Invasives/fact/SpinyNaiad.*

[23] *apps.dnr.wi.gov/lakes/invasives/AISLists.aspx?species=STARRY_STONEW&status+%3c%3e+OBSERVED&groupBy=County.*

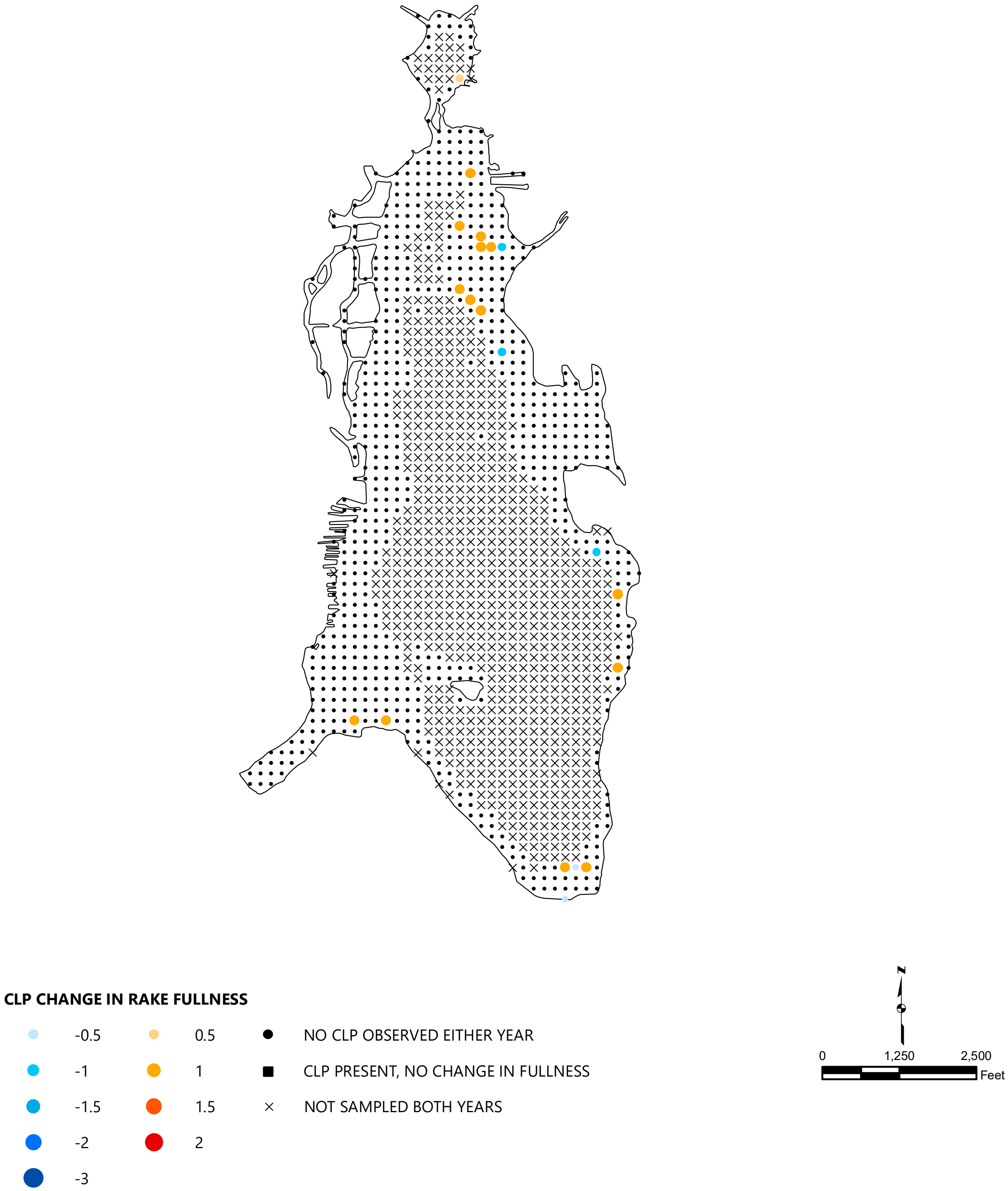
[24] *"Aquatic Invasive Species Quick Guide: Starry Stonewort (Nitellopsis obtusa L.)", Golden Sands Resource Conservation and Development Council, Inc. Visit www.goldensandsrcd.org/aquatic-invasive-species to download this series of handouts. Developed by Golden Sands Resource Conservation & Development Council, Inc. as part of an aquatic invasive species education program, supported by a grant from the Wisconsin Department of Natural Resources. Maintained and updated by the Wisconsin Citizen Lake Monitoring Network.*

## Figure 2.7
## Change in 2016-2024 in Eurasian Watermilfoil Rake Fullness in Nagawicka Lake



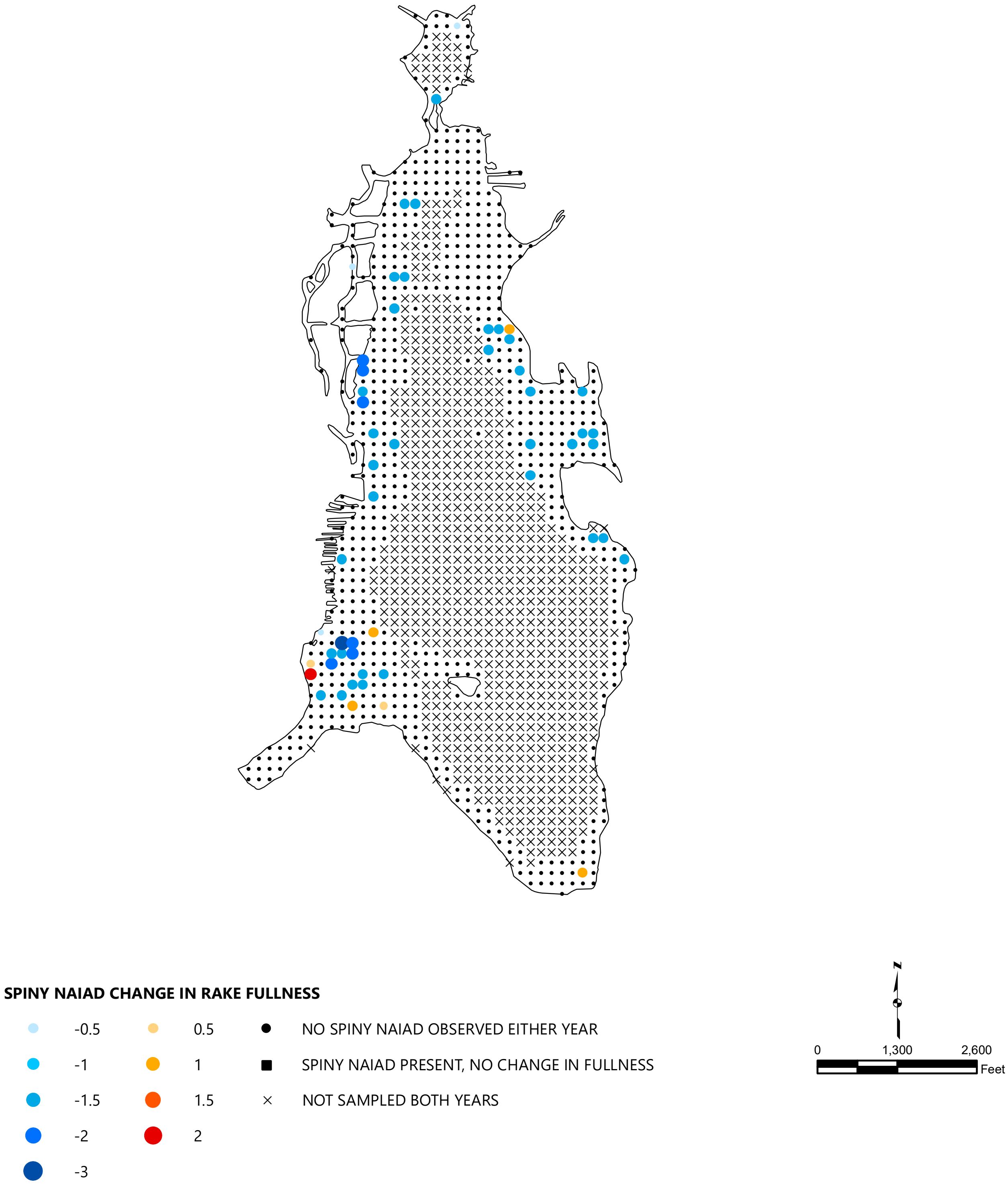

*Source: WDNR and SEWRPC*

## Figure 2.8
## Change in 2016-2024 in Curly-Leaf Pondweed Rake Fullness in Nagawicka Lake




*Source: WDNR and SEWRPC*

**Figure 2.9**
**Change from 2016-2024 Spiny Naiad Rake Fullness in Nagawicka Lake**




*Source: WDNR and SEWRPC*

**Apparent Changes in Observed Aquatic Plant Communities: 2016 Versus 2024**

The 2024 aquatic plant survey identified a total of 32 different plant species including visuals, similar to the 31 species found in the 2016 aquatic plant survey. Thus, it is evident that Nagawicka Lake has a highly diverse aquatic plant community. Overall, the plant species found in the Lake remain largely the same.

In addition to the number of different aquatic plant species detected in the Lake, several other comparisons can be drawn between the 2016 and 2024 aquatic plant survey results, as examined below.

- The total littoral vegetated frequency of occurrence decreased by 3.8 from 2016 to 2024. It was 84.35 in 2024 compared to 88.15 in 2016 (see Table 2.3).

- The MDC in Nagawicka Lake during the 2024 survey was 16 feet, a half a foot deeper than the 2016 survey, where the MDC was 15.5 feet (see Table 2.3).

- The composition and order of the five most common species Changed from 2016 to 2024. Three of the 5 top most common species remained the same but the other two most common species changed. In 2024 the five were 1) muskgrass, 2) eelgrass, 3) water star grass, 4) coontail, 5) Elodea. In 2016 the five most common species were 1) muskgrass, 2) eelgrass, 3) various-leaved water-milfoil (*Myriophyllum heterophyllum*), 4) coontail, 5) white water-lily.

- EWM occurrence increased slightly between 2016 and 2024. It was found at 11 points in 2016 and 16 sites in 2024 with an additional 8 visual sightings in 2016 and 11 in 2024 (see Table 2.4 and Figure 2.7).

- CLP occurrence increased slightly with it being found at 14 points in 2024 compared to the 3 in 2016. There were 2 additional visual sightings in 2016 and only one sighting in 2024 (see Table 2.4 and Figure 2.8).

- Spiny naiad occurrence decreased greatly from 2016 where it was found at 44 points. It was found at 4 points in 2024, with only 2 additional visual sightings as compared to the 3 visual sighting in 2016 (see Table 2.4 and Figure 2.9).

- Several native aquatic plant species have small populations within Nagawicka Lake including forked duckweed (*Lemna trisulca*), spatterdock, common bladderwort (*Utricularia vulgaris)*, and several pondweeds (*P. gramineus*, *illinoensis, and amplifolius*). All of which were found at less than 5 points across the Lake.

As was described earlier, sensitive aquatic plant species are the most vulnerable to human disturbance. Therefore, changes in sensitive species abundance can indicate the general magnitude of human disturbance derived stress on a waterbody's ecosystem. The number of sensitive species at each sample point during 2016 and 2024 were contrasted (see Figure 2.10). Overall, the sensitive species richness decreased between 2016 and 2024. A few significant observations were noted:

- The most common sensitive "species" in the Lake in both the 2016 and 2024 surveys was muskgrass.[25] The least-found sensitive species was large-leaf pondweed (*Potamogeton amplifolius*) which was found at only a single site in 2024.

- Sensitive species were distributed throughout the Lake; however they were only found at 13 of the 499 surveyed points (2.6 percent) (see Figure 2.6).

- Gains and losses in the number of sensitive species at each survey point were distributed throughout the Lake, with more points losing sensitive species numbers than gaining them (see Figure 2.10).

[25] *Commission staff did not identify muskgrass to species at each point in the plant survey, so all references to muskgrass are to the genus (*Chara *spp.). All species of muskgrass are currently identified as sensitive species*

**Table 2.3**
**Aquatic Plants Summary Statistics: PI Survey 2024**

| | |
|---|---|
| Total number of sites visited | 607 |
| Total number of sites with vegetation | 496 |
| Total number of sites shallower than maximum depth of plants | 588 |
| Frequency of occurrence at sites shallower than maximum depth of plants | 84.35 |
| Simpson Diversity Index | 0.80 |
| Maximum depth of plants (feet) | 16.00 |
| Number of sites sampled using rake on Rope (R) | 123 |
| Number of sites sampled using rake on Pole (P) | 484 |
| Average number of all species per site (shallower than max depth) | 1.77 |
| Average number of all species per site (veg. sites only) | 2.10 |
| Average number of native species per site (shallower than max depth) | 1.71 |
| Average number of native species per site (veg. sites only) | 2.03 |
| Species Richness | 29 |
| Species Richness (including visuals) | 31 |

*Source: SEWRPC*

## 2.3 PAST AND PRESENT AQUATIC PLANT MANAGEMENT PRACTICES

Aquatic plants have been managed in some form on Nagawicka Lake since the late 1950s when sodium arsenite was used to control aquatic plants in the lake (see Table 2.5). This, alongside copper sulfate for algal control was used up until the mid-1970s. By the late 1980s, Diquat and 2, 4-D became the main chemical elements to control aquatic plants. At the same time, Cutrine-Plus and Aquathol K became the standard for algal growth control in the Lake. In the last twenty years, chemical use for controlling aquatic plants and algal growth has been used in the Lake.

Aquatic plant harvesting has been used to manage aquatic plants in Nagawicka Lake since the 1960s. However, starting in 2003, harvesting of aquatic plants became the main form of aquatic plant control on the Lake. Since 2003, 38,550 cubic yards of aquatic plants have been removed from the Lake (see Table 2.6). In 2024 the City was permitted to harvest 60 acres on the Lake. Harvesting operation are carried out by the City's Public Works Department staff, with 1,695 cubic yards of aquatic plants being removed in 2024.

A benefit of harvesting versus chemical treatment is that harvesting physically removes plant mass and the nutrients contained therein. The Commission calculated the pounds of total phosphorus removed through harvesting in Nagawicka Lake by multiplying the annual mass of aquatic plants removed by the phosphorus concentration of those aquatic plants, with the following notes and assumptions:

- The density of the wet harvested plants was assumed to be approximately 300 pounds per cubic yard.

- The amount of phosphorus contained by aquatic plants varies by species, lake, and time. The phosphorus content of harvested plants used estimates from the Wisconsin Lutheran College (WLC) on Pewaukee Lake, the U.S. Geological Survey on Whitewater and Rice lakes (Whitewater-Rice), and a study conducted on a eutrophic lake in Minnesota (Minnesota). The WLC study assumed that plant dry weight is 6.7 percent of wet weight and that total phosphorus constitutes 0.2 percent of the total dry weight of the plant. The Whitewater-Rice and Minnesota studies assumed that dry weight is 15 and 7 percent of the wet weight, respectively, and phosphorus constituted 0.31 and 0.30 percent of the dry plant weight, respectively. Assumed values for the percent of dry weight to wet weight and the total phosphorus concentrations are similar to those found in other studies.[26,27,28]

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[26] *A.M. Ebeling, D.D. Ebeling, and F.A. Rwatambuga, "Analysis of Total Phosphorus in Harvested Aquatic Plants from Pewaukee Lake, WI,"* Wisconsin Lutheran College Biology Department Technical Bulletin 014*, 2011.*

[27] *G.L. Goddard and S.J. Field, Hydrology and Water Quality of Whitewater and Rice Lakes in Southeastern Wisconsin, 1990-91,* U.S. Geological Survey Water-Resources Investigations Report 94-4101*, 1994.*

[28] *S.A. Peterson, W.L. Smith, and K.L. Malueg, "Full-scale harvest of aquatic plants: nutrient removal from a eutrophic lake,"* Journal of Water Pollution Control Federation 46(4): 697-707*, 1974.*

**Table 2.4**
**Nagawicka Lake Aquatic Plant Survey Summary: July 2016 Versus July 2024**

| Aquatic Plant Species | Native or Invasive | Number of Sites Found[a] (2016/2024) | Frequency of Occurrence Within Vegetated Areas[b] (2016/2024) | Average Rake Fullness[c] (2016/2024) | Relative Frequency of Occurrence[d] (2016/2024) | Visual Sightings[e] (2016/2024) |
|---|---|---|---|---|---|---|
| *Ceratophyllum demersum* (coontail) | Native | 47/53 | 8.66/10.69 | 1.40/1.15 | 4.2/5.1 | 1/3 |
| *Chara spp.* (muskgrass) | Native | 385/375 | 70.90/75.60 | 1.94/1.49 | 34.5/5.9 | 6/12 |
| *Eleocharis acicularis* (needle spikerush) | Native | --/1 | --/0.20 | --/1.00 | --/0.20 | --/0 |
| *Elodea canadensis* (waterweed) | Native | 36/50 | 6.63/10.08 | 1.25/1.18 | 3.2/4.8 | 1/6 |
| *Heteranthera dubia* (water stargrass) | Native | 10/70 | 1.84/14.11 | 1.40/1.23 | 0.9/6.7 | 0/6 |
| *Lemna minor* (duckweed) | Native | 0/11 | 0/2.22 | 0/1.00 | 0/1.1 | 20/23 |
| *Lemna trisulca* (forked duckweed) | Native | 3/2 | 0.55/0.40 | 1.00/1.00 | 0.3/0.2 | 0/7 |
| *Myriophyllum heterophyllum* (various-leafed watermilfoil) | Native | 126/-- | 23.20/-- | 1.44/-- | 11.3/-- | 33/-- |
| *Myriophyllum spicatum* (Eurasian watermilfoil) | Invasive | 11/16 | 2.03/3.23 | 1.27/1.00 | 1.0/1.5 | 8/11 |
| *Myriophyllum verticillatum* | Native | --/2 | --/0.40 | --/1.00 | --/0.2 | --/0 |
| *Najas flexilis* (slender naiad) | Native | 34/12 | 6.26/2.42 | 1.09/1.00 | 3.0/1.1 | 1/1 |
| *Najas marina* (spiny naiad)[f] | Naturalized | 44/4 | 8.10/0.81 | 1.18/1.25 | 3.9/0.4 | 3/2 |
| *Nuphar variegata* (spatterdock)[g] | Native | 1/1 | 0.18/0.20 | 1.00/1.00 | 0.1/0.1 | 9/2 |
| *Nymphaea odorata* (white water lily) | Native | 2/9 | 0.37/1.81 | 1.00/1.00 | 0.2/0.9 | 53/16 |
| *Potamogeton amplifolius* (large-leaf pondweed)[h] | Native | --/1 | --/0.20 | --/1.00 | --/0.17 | --/0 |
| *Potamogeton crispus* (curly-leaf pondweed) | Invasive | 3/14 | 0.55/2.82 | 1.00/1.00 | 0.3/1.3 | 2/1 |
| *Potamogeton friesii* (Fries' pondweed) | Native | 7/20 | 1.29/4.03 | 1.29/1.00 | 0.6/1.9 | 0/0 |
| *Potamogeton gramineus* (variable pondweed) | Native | 18/3 | 3.31/0.60 | 1.00/1.00 | 1.6/0.3 | 6/0 |
| *Potamogeton illinoensis x natans* | Native | --/31 | --/6.25 | --/1.00 | --/3.0 | --/9 |
| *Potamogeton illinoensis (Illinois pondweed)h* | Native | 33/4 | 6.08/0.68 | 1.09/1.00 | 3.0/0.4 | 5/0 |
| *Potamogeton natans (floating-leaf pondweed)* | Native | 1/-- | 0.18/-- | 2.00/-- | 0.68/-- | 2/-- |
| *Potamogeton praelongus* (white-stem pondwed) | Native | 2/7 | 0.37/1.41 | 1.00/1.00 | 0.2/0.7 | 0/2 |
| *Potamogeton richardsonii* (clasping-leaf pondweed)[h] | Native | 25/14 | 4.60/2.82 | 1.24/1.00 | 2.2/1.3 | 5/6 |
| *Potamogeton stricifolius* (stiff pondweed) | Native | 3/-- | 0.55/-- | 1.00/-- | 0.3/-- | 0/-- |
| *Potamogeton zosteriformis* (flat-stem pondweed) | Native | 14/9 | 2.58/1.81 | 1.07/1.00 | 1.3/0.9 | 2/1 |
| *Ranunculus aquatilis* (white water crowfoot) | Native | 2/8 | 0.37/1.61 | 1.00/1.00 | 0.2/0.8 | 0/2 |
| *Riccia Fluitans* (slender Riccia) | Native | 0/1 | 0.20 | 1.00 | NA | 0/0 |
| *Sagittaria sp.* (arrowhead) | Native | 0/18 | 0/3.63 | 0/1.06 | 0/1.7 | 1/8 |
| *Sparganium sp.* (bur-reed) | Native | 0/0 | 0/0 | 0/0 | 0/0 | 1/2 |
| *Spirodela polyrhiza* (large duckweed) | Native | 0/2 | 0/0.40 | 0/1.00 | 0/0.2 | 20/7 |
| *Stuckenia pectinata* (Sago pondweed)[h] | Native | 37/50 | 6.81/10.08 | 1.24/1.10 | 3.3/4.8 | 8/25 |
| *Typha sp.* (cattail) | Native | 0/0 | 0/0 | 0/0 | 0/0 | 3/2 |
| *Utricularia vulgaris* (bladderwort) | Native | 5/4 | 0.92/0.81 | 1.20/1.00 | 0.4/0.4 | 0/4 |
| *Vallisneria americana* (eel-grass/wild celery)[h] | Native | 268/25 | 19.36/50.40 | 1.39/1.15 | 24.0/23.9 | 16/38 |
| *Wolffia borealis* (Northern watermeal) | Native | 0/0 | 0/0 | 0/0 | 0/0 | 19/0 |
| *Wolffia columbiana (common watermeal)* | Native | 0/0 | 0/0 | 0/0 | 0/0 | 39/0 |
| *Wolffia sp.* (watermeal) | Native | 0/3 | 0/6.25 | 0/1.00 | 0/3.0 | 0/11 |

**Table continued on next page.**

**Table 2.4 (Continued)**

Note: Red text indicates non-native and/or invasive species. See Appendix A for distribution maps and identifying features

[a] *Number of Sites refers to the number of sites at which the species was retrieved and identified on the rake during sampling.*

[b] *Frequency of Occurrence, expressed as a percent, is the percentage of times a particular species occurred when there was aquatic vegetation present at the sampling site.*

[c] *Average rake fullness is the average amount, on a scale of 0 to 3, of a particular species at each site where that species was retrieved by the rake.*

[d] *Relative Frequency of Occurrence, expressed as a percent, is the frequency of that particular species compared to the frequencies of all species present.*

[e] *Visual Sightings is the number of sites where that particular species was visually observed within six feet of the actual rake haul location but was not actually retrieved on the rake and was not, therefore, assigned a rake fullness measurement for that site. At sites where this occurred, the species was simply marked as "present" at that site. Recording the number of visual sightings helps give a better picture of species distribution throughout the lake.*

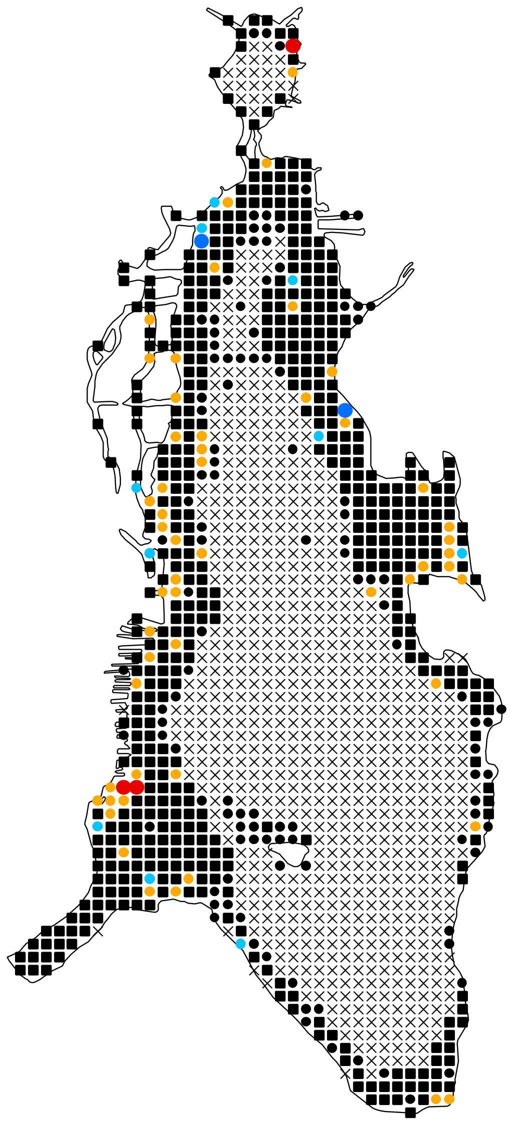
[f] *Spiny naiad was added to the NR 40 list as a restricted species in 2015, meaning it is not allowed to be transported, transferred, or introduced without a permit. Because the species is not native to Wisconsin and can become quite abundant, especially in lakes of poor water quality with hard water, it is currently considered a "naturalized" native species that can provide good habitat and food for fish and macroinvertebrates. Paul M. Skawinski,* Aquatic Plants of the Upper Midwest, 2nd Edition, *2014;* Through the Looking Glass: A Field Guide to Aquatic Plants, 2nd Edition, *2013.*

[g] *Although* Nuphar variegata *was not observed at a survey point in 2023, this species was recorded as a boat survey species near point 1104 and was observed at several other locations around the lake, always in sheltered bays.*

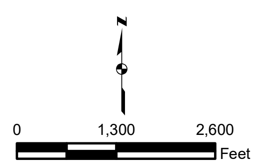
[h] *Considered a high-value aquatic plant species known to offer important values in specific aquatic ecosystems under Section NR 107.08 (4) of the* Wisconsin Administrative Code.

*Source: Wisconsin Department of Natural Resources and SEWRPC*

## Figure 2.10
## Change in Sensitive Species Richness in Nagawicka Lake: 2016-2024



NOTE: Survey was conducted between July 8th-11th, 2024. Species Richness values include nearby visual sightings of aquatic plants.




**CHANGE IN SPECIES RICHNESS OF SENSITIVE SPECIES**

- -1
- -2
- 1
- 2
- NO SENSITIVE AQUATIC PLANTS FOUND
- NO CHANGE IN SENSTIVE AQUATIC PLANTS FOUND
- NOT SAMPLED

*Source: WDNR and SEWRPC*

## Table 2.5
## Aquatic Plant Chemical Control Agents Applied to Nagawicka Lake: 1959-2024

| Year | Rodeo (gallons) | Sodium Arsenite (pounds) | Diquat (gallons | Endothall | | 2, 4-D | | Cutrine-Plus (gallons) | Copper Sulfate (pounds) | AV-70 (gallons) | Aquathol K (gallons) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Gallons | Pounds | Gallons | Pounds | | | | |
| 1959 | -- | 2,860 | -- | -- | -- | -- | -- | -- | 200 | -- | -- |
| 1960 | -- | 2,100 | -- | -- | -- | -- | -- | -- | 250 | -- | -- |
| 1961 | -- | 6,520 | -- | -- | -- | -- | -- | -- | 300 | -- | -- |
| 1962 | -- | 5,130 | -- | -- | -- | -- | -- | -- | 400 | -- | -- |
| 1963 | -- | 12,240 | -- | -- | -- | -- | -- | -- | 1400 | -- | -- |
| 1964 | -- | 11,340 | -- | -- | -- | -- | -- | -- | 2200 | -- | -- |
| 1965 | -- | 11,700 | -- | -- | -- | -- | -- | -- | 1400 | -- | -- |
| 1966 | -- | 9,702 | -- | -- | -- | -- | -- | -- | 1440 | -- | -- |
| 1967 | -- | 8,190 | -- | -- | -- | -- | -- | -- | 1150 | -- | -- |
| 1968 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1969 | -- | -- | -- | -- | -- | -- | -- | -- | 405 | -- | -- |
| 1970 | -- | -- | -- | -- | -- | -- | -- | -- | 1930 | -- | -- |
| 1971-1973[a] | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1974 | -- | 165 | -- | -- | 50 | -- | -- | -- | 165 | -- | -- |
| 1975 | -- | -- | -- | 20 | -- | -- | -- | -- | 2,200 | 35 | -- |
| 1976 | -- | -- | -- | -- | -- | -- | -- | -- | 1,400 | 8 | 10 |
| 1977 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 12 | 10 |
| 1978 | -- | -- | -- | -- | -- | -- | -- | 5.5 | -- | -- | 3 |
| 1979 | -- | -- | -- | -- | -- | -- | -- | 9 | -- | -- | 6 |
| 1980 | -- | -- | -- | -- | -- | -- | 17 | 20 | -- | -- | 15 |
| 1981 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1982-1983 | -- | -- | 3 | -- | -- | 28 | -- | 63 | -- | -- | 14 |
| 1984 | -- | -- | 24 | -- | -- | 3 | -- | 33 | -- | -- | 20.5 |
| 1985 | -- | -- | 14 | -- | -- | 9 | -- | 38.5 | -- | -- | 21.5 |
| 1986 | -- | -- | 17.25 | -- | -- | -- | -- | 18.75 | -- | -- | 22.5 |
| 1987 | 3.1 | -- | 20 | -- | -- | -- | -- | 48 | -- | -- | -- |
| 1988 | -- | -- | -- | -- | -- | 31.25 | -- | 2.25 | -- | -- | 3 |
| 1989 | -- | -- | 2.5 | -- | -- | 20.5 | -- | 5.5 | -- | -- | 6 |
| 1990 | -- | -- | .75 | -- | -- | 8.25 | -- | .75 | -- | -- | -- |
| 1991 | -- | -- | 1.75 | -- | -- | 7 | -- | 1.75 | -- | -- | -- |
| 1992 | -- | -- | 2.75 | -- | -- | -- | -- | 7 | -- | -- | -- |
| 1993 | -- | -- | 1 | -- | -- | -- | 2.5 | 1 | -- | -- | -- |
| 1994 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1995 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

**Table continued on next page.**

**Table 2.5 (Continued)**

| Year | Rodeo (gallons) | Sodium Arsenite (pounds) | Diquat (gallons | Endothall | | 2, 4-D | | Cutrine-Plus (gallons) | Copper Sulfate (pounds) | AV-70 (gallons) | Aquathol K (gallons) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Gallons | Pounds | Gallons | Pounds | | | | |
| 1996 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1997-2009 | 17.28 | -- | -- | 2.0 | -- | -- | -- | -- | -- | -- | -- |
| 2015 | -- | -- | -- | -- | -- | 16.3 | -- | -- | -- | -- | 2.0 |
| 2016-2019 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2020 | -- | -- | -- | -- | -- | 2.58 | -- | -- | -- | -- | 36.12 |
| 2021 | -- | -- | -- | -- | -- | 24.38 | -- | -- | -- | -- | 48.245 |
| 2022 | -- | -- | -- | -- | -- | 1.5 | -- | -- | -- | -- | 3.25 |
| 2023 | -- | -- | -- | -- | -- | 8.88 | -- | -- | -- | -- | 26.67 |
| 2024 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Total | 20.38 | 69,947 | 6.75 | 22.0 | 50.0 | 160.64 | 19.5 | 251.0 | 14,840.0 | 55.0 | 247.785 |

Note: 2024 chemical application reports were not available at the time of this report.

*Source: Wisconsin Department of Natural Resources, City of Delafield, and SEWRPC*

Using these methods, the Commission estimates that aquatic plant harvesting has removed approximately 9,356 pounds of phosphorus from the Lake during the 22 years for which plant harvest records are available (see Figure 2.11). The City's harvesting removes an average of 425 pounds of phosphorus from the Lake each year. The WDNR's Presto-Lite tool estimates that the average total annual phosphorus load to the Lake ranges between 1,738 to 6,718 lbs. per year. Therefore, aquatic plant harvesting may remove up to 24 percent of the total phosphorus contributed annually by surface runoff and tributary streams.

**Table 2.6**
**Aquatic Plants Harvested in Nagawicka Lake: 2003-2024**

| 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 |
| 2012 | 1,930 |
| 2013 | 1,490 |
| 2014 | 1,465 |
| 2015 | 1,560 |
| 2016 | 1,955 |
| 2017 | 1,835 |
| 2018 | 1,660 |
| 2019 | 1,460 |
| 2020 | 1,755 |
| 2021 | 1,395 |
| 2022 | 1,075 |
| 2023 | 1,670 |
| 2024 | 1,695 |
| Total | 38,550 |
| Annual Mean | 1,752 |

*Source: City of Delafield and SEWRPC*

## 2.4 POTENTIAL AQUATIC PLANT CONTROL METHODOLOGIES

Aquatic plant management techniques can be classified into six categories.

- *Physical measures* include lake bottom coverings
- *Biological measures* include the use of organisms such as herbivorous insects
- *Manual measures* involve physically removing plants by hand or using hand-held tools such as rakes
- *Mechanical measures* rely on artificial power sources and remove aquatic plants with a machine known as a harvester or by suction harvesting
- *Chemical measures* use aquatic herbicides to kill nuisance and nonnative plants *in-situ*
- *Water level manipulation measures* utilize fluctuations in water levels to reduce aquatic plant abundance and promote growth of specific native species

All aquatic plant control measures are stringently regulated and most require a State of Wisconsin permit. Chemical controls, for example, require a permit and are regulated under *Wisconsin Administrative Code* Chapter NR 107, "Aquatic Plant Management", while placing bottom covers (a physical measure) requires a WDNR permit under Chapter 30 of the *Wisconsin Statutes*. All other aquatic plant management practices are regulated under *Wisconsin Administrative Code* Chapter NR 109, "Aquatic Plants: Introduction, Manual Removal and Mechanical Control Regulations." Furthermore, the aquatic plant management measures described in this plan are consistent with the requirements of Chapter NR 7, "Recreational Boating Facilities Program," and with the public recreational boating access requirements relating to eligibility under the State cost-share grant programs set forth in *Wisconsin Administrative Code* Chapter NR 1, "Natural Resources Board Policies." Water level manipulations require a permit and are regulated under *Wisconsin Statutes* 30.18 and 31.02.[29,30] More details about each aquatic plant management category are discussed in the following sections, while recommendations are provided later in this document.

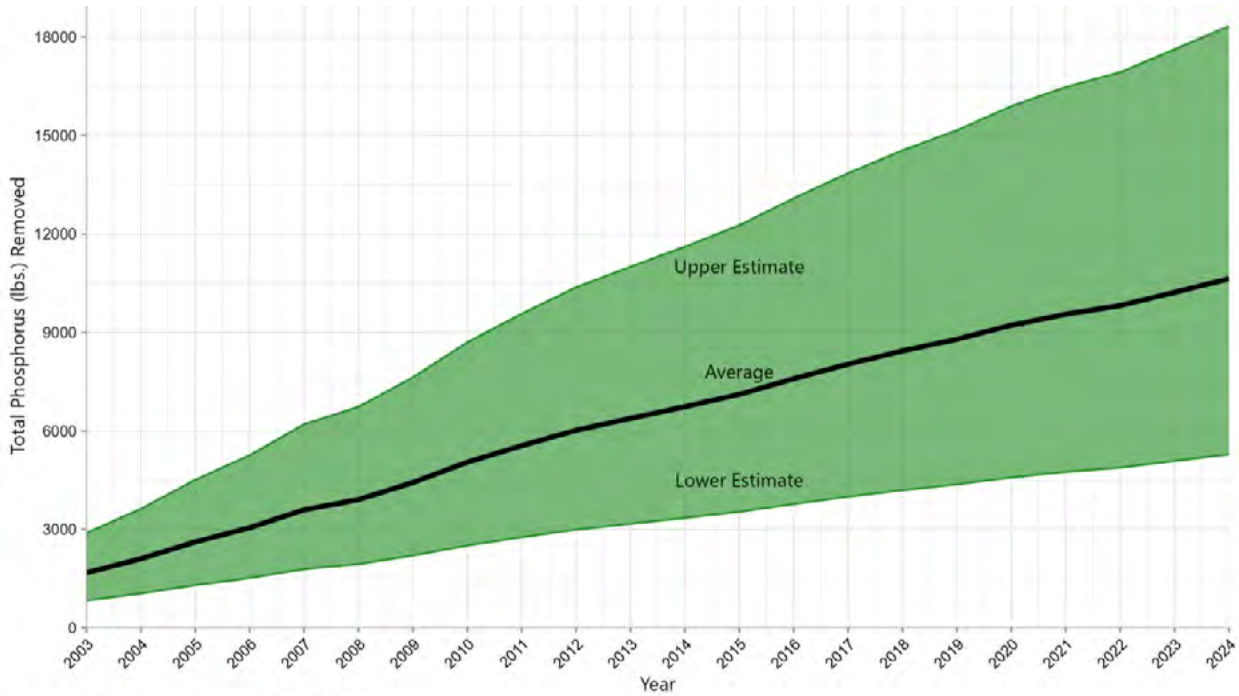
Non-compliance with aquatic plant management permit requirements is an enforceable violation of Wisconsin law and may lead to fines and/or complete permit revocation. The information and recommendations provided in this memorandum help frame permit requirements. Permits can cover up to a five-year period.[31] At the end of that period, the aquatic plant management plan must be updated. The updated plan must

[29] *docs.legis.wisconsin.gov/statutes/statutes/30/ii/18.*

[30] *docs.legis.wisconsin.gov/statutes/statutes/31/02.*

[31] *Five-year permits allow a consistent aquatic plant management plan to be implemented over a significant length of time. This process allows the selected aquatic plant management measures to be evaluated at the end of the permit cycle.*

**Figure 2.11**
**Nagawicka Lake Phosphorus Removal by Harvesting: 2003-2024**




Source: City of Delafield and SEWRPC

consider the results of a new aquatic plant survey and should evaluate the success, failure, and effects of earlier plant management activities that have occurred on the lake.[32] These plans and plan execution are reviewed and overseen by the WDNR regional lakes and aquatic invasive species coordinators.[33]

**Physical Measures**

Lake-bottom covers and light screens provide limited control of rooted plants by creating a physical barrier that reduces or eliminates plant-available sunlight. Various materials such as pea gravel or synthetics like polyethylene, polypropylene, fiberglass, and nylon can be used as covers. The longevity, effectiveness, and overall value of some physical measures is questionable. The WDNR does not permit these kinds of controls. Consequently, lake-bottom covers are not a viable aquatic plant control strategy for the Lake.

**Biological Measures**

Biological control offers an alternative to direct human intervention to manage nuisance or exotic plants. Biological control techniques traditionally use herbivorous insects that feed upon nuisance plants. This approach has been effective in some southeastern Wisconsin lakes.[34] For example, milfoil weevils (*Eurhychiopsis lecontei)* have been used to control EWM. Milfoil weevils do best in waterbodies with balanced panfish populations,[35] where dense EWM beds reach the surface close to shore, where natural shoreline areas include leaf litter that provides habitat for over-wintering weevils, and where there is comparatively little boat traffic. This technique is not presently commercially available, making the use of milfoil weevils non-viable.

[32] *Aquatic plant harvesters must report harvesting activities as one of the permit requirements.*

[33] *Information on the current aquatic invasive species coordinator is found on the WDNR website.*

[34] *B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control," LakeLine 17(3): 20-21, 34-37, September 1997; 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, pp. 659-696, 1984; and C.B. Huffacker and R.L. Rabb, editors, Ecological Entomology, John Wiley, New York, New York, USA.*

[35] *Panfish such as bluegill and pumpkinseed are predators of herbivorous insects. High populations of panfish lead to excess predation of milfoil weevils.*

**Manual Measures**

Manually removing specific types of vegetation is a highly selective means of controlling nuisance aquatic plant growth, including invasive species such as EWM. Two commonly employed methods include hand raking and hand pulling. Both physically remove target plants from a lake. Since the vast majority of plant stems, leaves, roots, and seeds are actively removed from the lake, the reproductive potential and nutrients contained by pulled/raked plants material is also removed. These plants, seeds, and nutrients would otherwise re-enter the lake's water column or be deposited on the lake bottom. Hence, this aquatic plant management technique helps incrementally maintain water depth, improves water quality, and can help decrease the spread of nuisance/exotic plants. Hand raking and hand pulling are readily allowed by WDNR and are practical methods to control riparian landowner scale problems.

Raking with specially designed hand tools is particularly useful in shallow nearshore areas. This method allows nonnative plants to be removed and provides a safe and convenient aquatic plant control method in deeper nearshore waters around piers and docks. Advantages of this method include:

- Tools are inexpensive ($100 to $150 each)
- The method is easy to learn and use
- It may be employed by riparian landowners without a permit if certain conditions are met
- Results are immediately apparent
- Plant material is immediately removed from a lake (including seeds)[36]

The second manual control method, hand-pulling whole plants (stems, roots, leaves, seeds) where they occur in isolated stands, is a simple means to control nuisance and invasive plants in shallow nearshore areas that may not support large-scale initiatives. This method is particularly helpful when attempting to target nonnative plants (e.g., EWM, curly-leaf pondweed) during the high growth season when native and nonnative species often mix. Hand pulling is more selective than raking, mechanical removal, and chemical treatments, and, if carefully applied, is less damaging to native plant communities. Recommendations regarding hand-pulling, hand-cutting, and raking are discussed later in this document.

**Mechanical Measures**

Two methods of mechanical harvesting are currently employed in Wisconsin—mechanical harvesting and suction harvesting. Both are regulated by WDNR and require a permit.[37]

***Mechanical Harvesting***

Aquatic plants can be mechanically gathered using specialized equipment commonly referred to as harvesters. Harvesters use an adjustable depth cutting apparatus that can cut and remove plants from the water surface to up to about five feet below the water surface. The harvester gathers cut plants with a conveyor, basket, or other device. Mechanical harvesting is often a very practical and efficient means to control nuisance plant growth and is widely employed in Southeastern Wisconsin.

In addition to controlling plant growth, gathering and removing plant material from a lake reduces in-lake nutrient recycling, sedimentation, and targets plant reproductive potential. In other words, harvesting removes plant biomass, which would otherwise decompose and release nutrients, sediment, and seeds or other reproductive structures (e.g., turions, bulbils, plant fragments) into a lake. Mechanical harvesting is particularly effective and popular for large-scale open-water projects. However, small harvesters are also produced that are particularly suited to working around obstacles such as piers and docks in shallow nearshore areas.

[36] *Most of the material is removed during raking, however fragmentation/local spread from raking can occur in addition to fragmentation/local spread from wave action/other mechanical disruption.*

[37] *Mechanical control permit conditions depend upon harvesting equipment type and specific equipment specifications.*

An advantage of mechanical harvesting is that the harvester, when properly operated, "mows" aquatic plants and, therefore, typically leaves enough living plant material in place to provide shelter for aquatic wildlife and stabilize lake-bottom sediment. Harvesting, when done properly, does not kill aquatic plants, it simply trims plants back. Aside from residual plant mass remaining because of imperfect treatment strategy execution, none of the other aquatic plant management methods purposely leave living plant material in place after treatment. Aquatic plant harvesting has been shown to allow light to penetrate to the lakebed and stimulate regrowth of suppressed native plants. This is particularly effective when controlling invasive plant species that commonly grow quickly early in the season (e.g., EWM, curly-leaf pondweed) when native plants have not yet emerged or appreciably grown.

A disadvantage of mechanical harvesting is that the harvesting process may fragment plants and thereby unintentionally propagate EWM and curly-leaf pondweed. EWM fragments are particularly successful in establishing themselves in areas where plant roots have been removed. This underscores the need to avoid harvesting or otherwise disrupting native plant roots. Harvesting may also agitate bottom sediments in shallow areas, thereby increasing turbidity and resulting in deleterious effects such as smothering fish breeding habitat and nesting sites. To this end, most WDNR-issued permits do not allow deep-cut harvesting in water less than three feet deep,[38] which limits the utility of this alternative in many littoral and shoal areas. Nevertheless, if employed correctly and carefully under suitable conditions, harvesting can benefit navigation lane maintenance and can reduce regrowth of nuisance plants while maintaining, or even enhancing, native plant communities.

Cut plant fragments commonly escape the harvester's collection system and form mats or accumulate on shorelines. In addition, boating activity can fragment aquatic plants and also contribute to accumulations of cut plant fragments in the lake or along the shoreline. To compensate for this, most harvesting programs include a plant pickup program. Some plant pickup programs use a harvester to gather and collect significant accumulations of floating plant debris as well as sponsor regularly scheduled aquatic plant pick up from lakefront property owner docks. Property owners are encouraged to actively rake plant debris along their shorelines and place these piles on their docks for collection. This kind of program, when applied systematically, can reduce plant propagation from plant fragments and can help alleviate the negative aesthetic consequences of plant debris accumulating on shorelines. Nevertheless, it is important to remember that normal boating activity (particularly during summer weekends) often creates far more plant fragments than generated from mechanical harvesting. Therefore, a plant pickup program is often essential to protect a lake's health and aesthetics, even in areas where harvesting has not recently occurred.

#### *Suction Harvesting, DASH, and Diver-Assisted Hand Pulling*

Another mechanical plant harvesting method uses suction to remove aquatic plants from a lake. Suction harvesting removes sediment, aquatic plants, plant roots, and anything else from the lake bottom and disposes this material outside the lake. Since bottom material is removed from the lake, this technique also requires a dredging permit in addition to the aquatic plant management permit.

First permitted in 2014, DASH is a mechanical process where divers identify and pull select aquatic plants and roots from the lakebed and then insert the entire plant into a suction hose that transports the plant to the surface for collection and disposal. The process is a mechanically assisted method for hand-pulling aquatic plants. Such labor-intensive work by skilled professional divers is, at present, a costly undertaking and long-term monitoring will need to evaluate the efficacy of the technique. If the City or individual property owners choose to employ DASH, a NR 109 permit is required. Nevertheless, many apparent advantages are associated with this method including: 1) lower potential to release plant fragments when compared to mechanical harvesting, raking, and hand-pulling, thereby reducing spread and growth of invasive plants like EWM; 2) increased selectivity of plant removal when compared to mechanical harvesting which in turn reduces native plant loss; and 3) lower potential for disturbing fish habitat.

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[38] *Deep-cut harvesting is harvesting to within one foot of the lake bottom. This is not allowed in shallow water because it is challenging to ensure that the harvester avoids lake-bottom contact in such areas.*

**Water Level Manipulation Measures**

Manipulating water levels can also be an effective method for controlling aquatic plant growth and restoring native aquatic plant species, particularly emergent species such as bulrush and wild rice.[39] In Wisconsin, water level manipulation is considered to be most effective by using winter lake drawdowns, which expose lake sediment to freezing temperatures while avoiding conflict with summer recreational uses. One to two months of lake sediment exposure can damage or kill aquatic plant roots, seeds, and turions through freezing and/or desiccation. As large areas of lake sediment need to remain exposed for extended periods, water level manipulation is most cost effective in lakes with operable dam gates that can provide fine levels of control of water elevations within the lake. In lakes without dams, high capacity water pumping can be used to reduce lake levels at much greater cost.

While water level manipulation affects all aquatic plants within the drawdown zone, not all plants are equally susceptible to drawdown effects. Abundance of water lilies and milfoils (*Myriophyllum* spp.) can be greatly reduced by winter drawdowns while other species, such as duckweeds, may increase in abundance.[40] Two studies from Price County, Wisconsin show reduced abundance of invasive EWM and curly-leaf pondweed and increased abundance of native plant species following winter drawdowns.[41,42] Thus, drawdowns can be used to dramatically alter the composition of a lake's aquatic plant community. Many emergent species rely upon the natural fluctuations of water levels within a lake. Conducting summer and early fall drawdowns have effectively been used to stimulate the growth of desired emergent vegetation species, such as bulrush, burreeds, and wild rice, in the exposed lake sediments, which subsequently provide food and habitat for fish and wildlife. However, undesired emergent species, such as invasive cattails and phragmites, can also colonize exposed sediment, so measures should be taken to curtail their growth during a drawdown.[43]

Water level manipulation can also have unintended impacts on water chemistry and lake fauna.[44,45] Decreased water clarity and dissolved oxygen concentrations as well as increased nutrient concentrations and algal abundance have all been reported following lake drawdowns. Rapid drawdowns can leave lake macroinvertebrates and mussels stranded in exposed lake sediment, increasing their mortality, and subsequently reducing prey availability for fish and waterfowl. Similarly, drawdowns can disrupt the habitat and food sources of mammals, birds, and herptiles, particularly when nests are flooded as water levels are raised in the spring. Therefore, thoughtful consideration of drawdown timing, rates, and elevation, as well as the life history of aquatic plants and fauna within the lake is highly recommended. Mimicking the natural water level regime of the lake as closely as possible may be the best approach to achieve the desired drawdown effects and minimize unintended and detrimental consequences.

As discussed above, water level manipulation is a large-scale, permitted operation that can have major effects on lake ecology. Consequently, detailed information on the Lake's hydrology, including groundwater, should be compiled before undertaking such an operation. The WDNR would likely require and consider the following during review of the drawdown permit application:

- Existing lake bottom contours should be reevaluated (see Map 1.1) with any changes mapped to develop updated bathymetric information.

- Lake volume needs to be accurately determined for each foot of depth contour.

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[39] *For detailed literature reviews on water level manipulation as an aquatic plant control measure, see C. Blanke, A. Mikulyuk, M. Nault, et al., Strategic Analysis of Aquatic Plant Management in Wisconsin, Wisconsin Department of Natural Resources, pp. 167-171, 2019 as well as J.R. Carmignani and A.H. Roy, "Ecological Impacts of Winter Water Level Drawdowns on Lake Littoral Zones: A Review," Aquatic Sciences 79: 803-824, 2017.*

[40] *G.D. Cooke, "Lake Level Drawdown as a Macrophyte Control Technique," Water Resources Bulletin 16(2): 317-322, 1980.*

[41] *Onterra, LLC, Lac Sault Dore, Price County, Wisconsin: Comprehensive Management Plan, 2013.*

[42] *Onterra, LLC, Musser Lake Drawdown Monitoring Report, Price County, Wisconsin, 2016.*

[43] *Blanke et al., 2019,* op. cit.

[44] Ibid.

[45] *Cooke,* op. cit.

- Lake bottom acreage exposed during various intervals of the drawdown must be determined.
- Knowledge of the drawdown and refill times for the Lake would guide proper timing of drawdown to maximize effectiveness and minimize impacts to Lake users.
- A safe drawdown discharge rate would need to be calculated to prevent downstream flooding and erosion.
- Effects on the lake drawdown to the structural integrity of outlet dams should be examined.
- A WDNR permit and WDNR staff supervision are required to draw down a lake. Additionally, lakeshore property owners need to be informed of the drawdown and permit conditions before the technique is implemented. Targeted invasive species populations should be monitored before and after refill is complete to assess efficacy and guide future management.

# MANAGEMENT RECOMMENDATIONS AND PLAN IMPLEMENTATION 3

*Credit: Commission Staff*

This Chapter summarizes the information and recommendations needed to manage aquatic plants in Nagawicka Lake, particularly the nonnative species of Eurasian watermilfoil (EWM), curly-leaf pondweed (CLP), and spiny naiad. Accordingly, it presents a range of alternatives that could potentially be used, and provides specific recommendations related to each alternative. The measures discussed focus on those that can be implemented by the City of Delafield (City) Lake Welfare Committee (LWC) in collaboration with the Wisconsin Department of Natural Resources (WDNR) and Lake residents. The aquatic plant management recommendations contained in this chapter are limited to approaches that monitor and control nuisance level aquatic plant growth in the Lake after the growth has already occurred.

The individual recommendations presented below, and which collectively constitute the recommended aquatic plant management plan, balance three major goals:

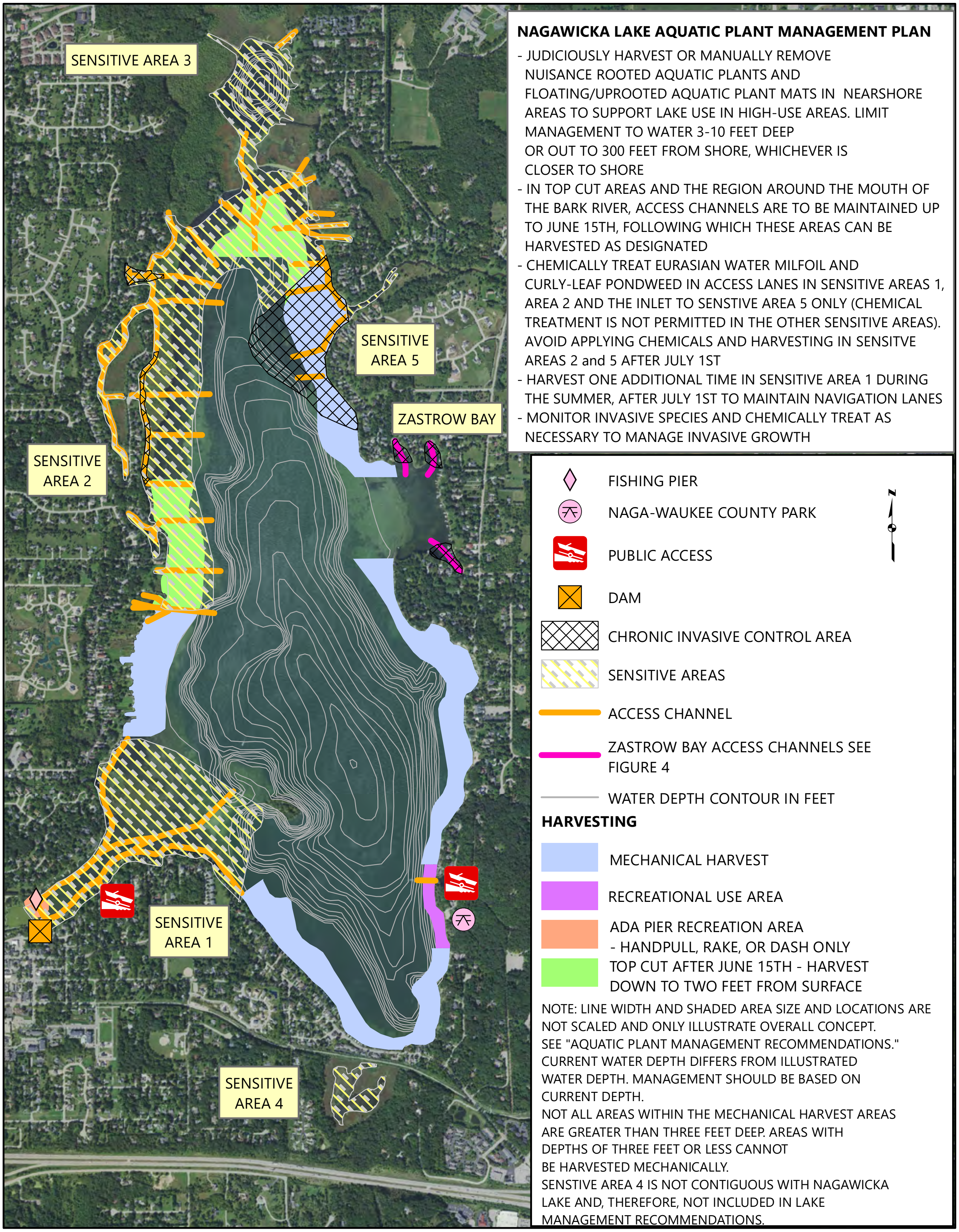
- Improving navigational access within the Lake
- Protecting the native aquatic plant community
- Controlling CLP, EWM, and hybrid watermilfoil populations

Plan provisions also ensure that current recreational uses of the Lake (e.g., swimming, boating, fishing) are maintained or promoted. The plan recommendations described below consider common, State-approved, aquatic plant management alternatives including manual, biological, physical, chemical, and mechanical measures.

## 3.1 RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

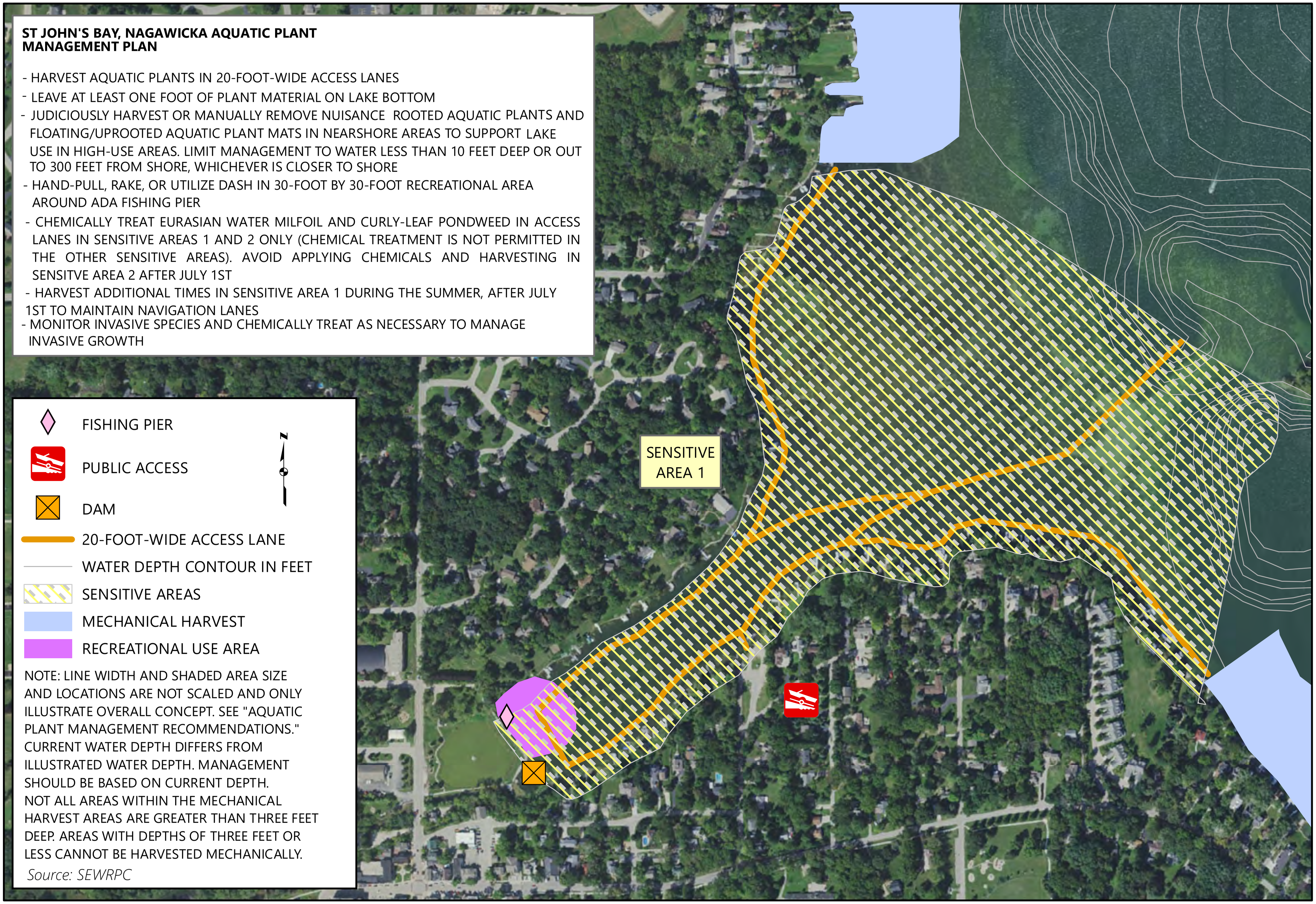
The most effective plans to manage nuisance and invasive aquatic plant growth rely on a combination of methods and techniques as well as consideration of when and where these techniques should be applied. The recommended aquatic plant management plan is presented in Figures 3.1 through 3.4 and briefly summarized in the following paragraphs. These management techniques were discussed with both the City and the WDNR.

**Figure 3.1**
**Aquatic Plant Management Plan for Nagawicka Lake: 2017-2021**



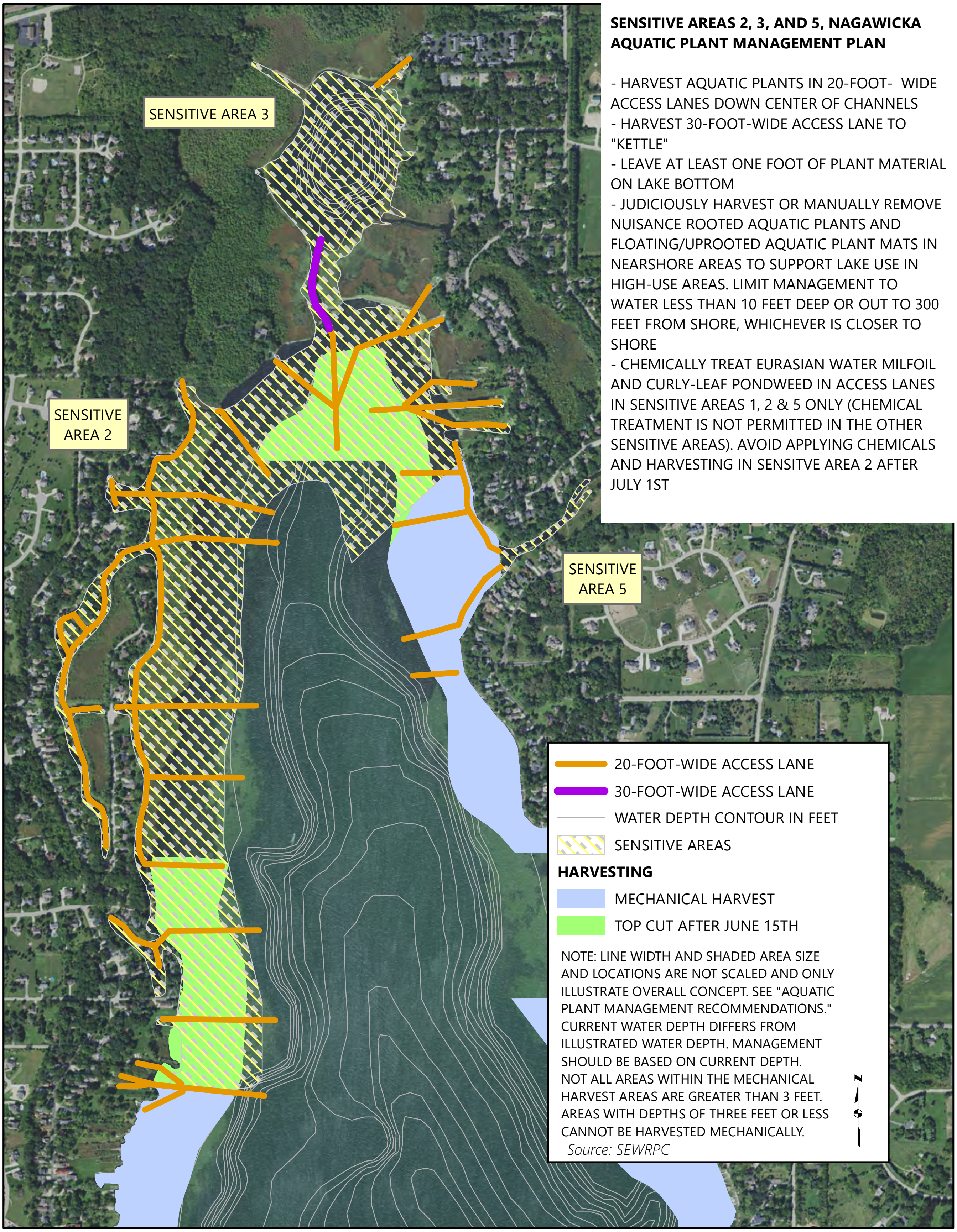

*Source: SEWRPC*

**Figure 3.2**
**Aquatic Plant Management Plan for St. John's Bay, Nagawicka Lake: 2025-2029**



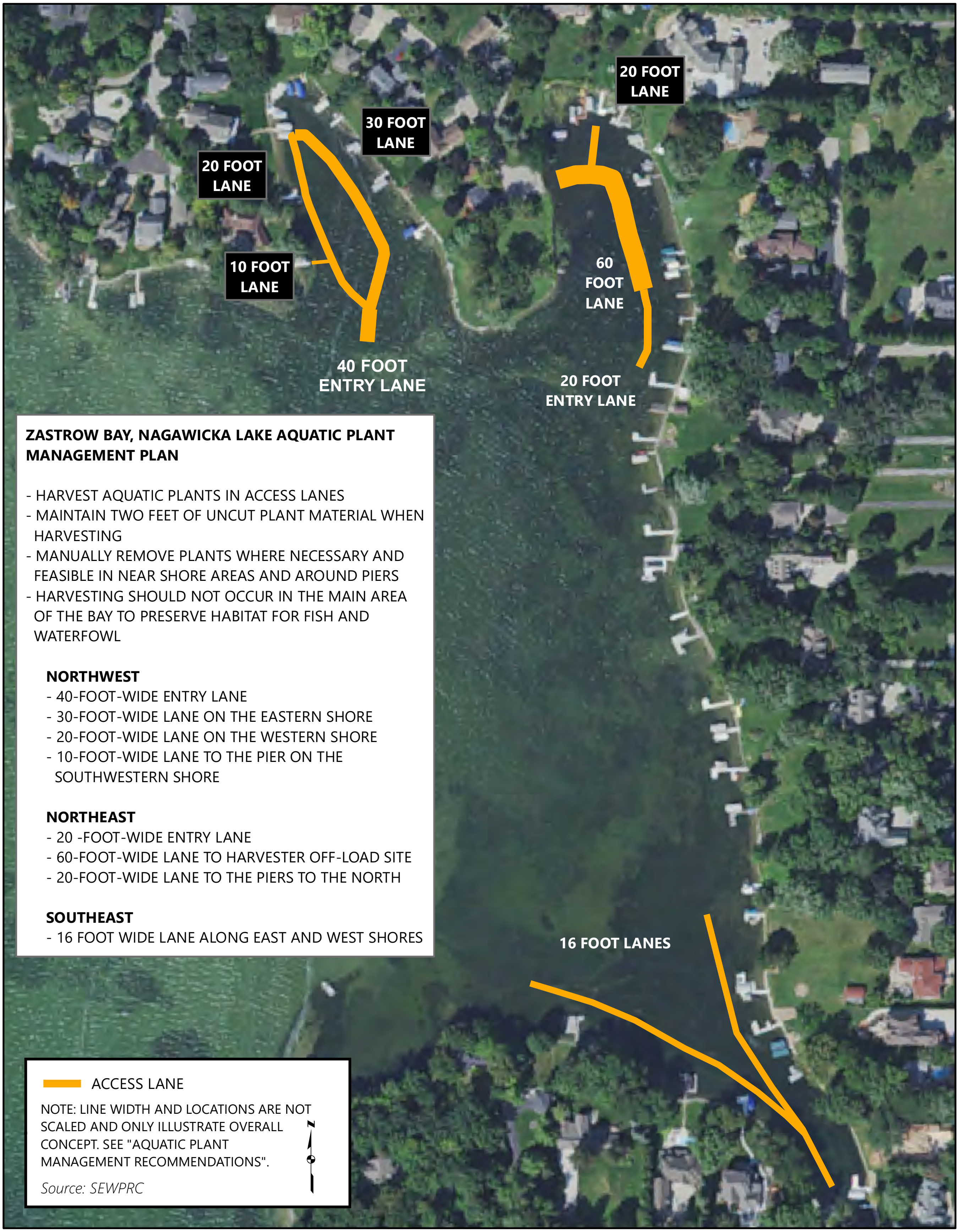
*Source: SEWRPC*

## Figure 3.3
## Aquatic Plant Management Plan for Sensitive Areas 2, 3, and 5, Nagawicka Lake: 2017-2021




*Source: SEWRPC*

**Figure 3.4**
**Aquatic Plant Management Plan for Zastrow Bay, Nagawicka Lake: 2025-2029**



**Aquatic Plant Management Recommendations**

A "silver bullet" single-minded strategy rarely produces the most efficient, most reliable, or best overall result. Using multiple strategies often yields the best results when managing an aquatic plant community. Several factors complicate aquatic plant management in Nagawicka Lake. These factors include:

- Portions of WDNR-designated sensitive areas are located along highly developed shorelines.

- The sole handicapped fishing pier on the Lake is located in a WDNR-designated sensitive area.

- Uncertain water depths.[46] Unmapped shallow water areas that extend well into the Lake near the mouth of the Bark River are prone to nuisance aquatic plant growth and impede navigation near the center of the Lake.[47]

- Offshore plant beds near the mouth of the Bark River have consistently contained large populations of Eurasian water milfoil and curly-leaf pondweed.

These factors must be considered to produce an aquatic plant management program that fully addresses Lake-user needs to enhance access to, and the health of, Nagawicka Lake. This plan recommends three primary aquatic plant management techniques, each of which has custom adaptation for the conditions present in certain portions of the Lake. The menu of recommended management options includes:

- Aquatic Plant Harvesting (Deep Cut, Top Cut, and DASH)
  - Access Lanes
  - Recreational Areas
  - Nearshore Areas
  - High-Use Sensitive Areas
  - Invasive Plant Control
  - Bark River Delta
  - End of Season

- Manual Removal (Raking and Hand Pulling)
  - Individual Property Owners
  - Collective Manual Removal Programs

- Early Spring Chemical Treatment
  - Invasive Plant Control
  - Navigation Lanes in Sensitive Area 1

These methods are combined to form the recommended Nagawicka Lake aquatic plant management program. The elements of this program are listed below.

1. **Aquatic plant harvesting to create access lanes** should be considered a <u>high priority</u>. As can be seen on Figure 3.1, harvesting is recommended to create access channels in areas of the Lake that host dense aquatic plant growth, impeding boat access to and within the main body of the Lake. The lanes should, extend into open water (about 10 feet in water depth). Harvesting in Sensitive Areas 1, 2, and 3 must leave a minimum of one foot of growing plant material at the Lake bottom (see Figures 3.2 and 3.3). Access lanes in Sensitive Area 1 are to be located at least 25 feet from piers and are restricted to a maximum width of 20 feet. As requested by the City and a change from the previous APM Plan, harvesting lanes illustrated in Figure 3.2 in Sensitive Area 1 can be harvested

[46] *Due to outdated bathymetric information combined with implementation of dredging projects throughout Nagawicka Lake, actual water depths observed in the field must take precedence over mapped water depths when making real-time decisions. It is also important to note that the location and extent of dredging projects must be consistent with the WDNR approved Chapter 30 Permit Application (Project I.D. 06D006), revised May 2008 for the City of Delafield, prepared by Foth Infrastructure & Environment, LLC.*

[47] *It should be noted that the City of Delafield dredged 9,500 cubic yards of sediment out of the Bark River Delta in Nagawicka Lake in November and December 2024; Communication between Commission Staff and Tom Hafner, City of Delafield.*

multiple times during the open water growing season.[48] Harvesting in Sensitive Area 2 is restricted to access channels no greater than 20 feet wide down the center of the navigation channels. Harvesting in Sensitive Area 3 is restricted to a 30-foot-wide access lane to the "Kettle" and 20-foot maximum width access channels cut near the northeast and eastern shorelines.

A more specific harvesting plan is proposed for Zastrow Bay on the Lake's east-central shoreline (see Figure 3.4). Zastrow Bay may be harvested in three locations: the northwest, northeast, and southeast fingers of the Bay. Harvesting in each finger of the Bay is limited to four passes of the harvester where management is needed most. These areas must preserve at least two feet of uncut living plant material at the Lake bottom.

2. **Recreational use harvesting.** Broad bands of nuisance aquatic plant growth may be harvested within 150 feet of Naga-Waukee County Park and the same distance extending in all directions of the handicapped fishing pier in St. Johns Bay to facilitate recreational use (see Figure 3.2). At least one foot of living plant material must remain after harvest at the Lake bottom. Chemicals may be used in the early spring in areas too shallow to utilize the harvester. This recommendation should be considered a high priority.

3. **Nearshore nuisance plant harvesting.** Aquatic plants should be controlled to support desired Lake uses in high-use shoreline areas. Management should be limited to water depths less than 10 feet and areas less than 50-feet wide. Top-cut harvesting should be used in water depths between three and 10 feet. Should the need arise, shallower areas may be manually harvested (discussed below) or mechanically harvested with a small, maneuverable, shallow-draft harvester (e.g., Inland Lakes ILH5x4–1—"Mini" Series or similar). However, the majority of 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. This recommendation should be considered a medium priority.

4. **Deep-cut harvesting at the end of the season in areas prone to siltation** (medium priority). This method may be employed in the northwest channels, access channels, and areas around the Lake that have been dredged. Harvest leaving at least one foot of rooted aquatic vegetation at the Lake bottom during the last harvest of the season (typically September)

5. **Early spring chemical treatment in access channels only in Sensitive Area 1 and 2, if nuisance plant growth impedes Lake access.** Sensitive Areas 1 and 2 are the only sensitive areas where chemicals may be used to control aquatic plants. Treatment should be limited to Eurasian water milfoil and curly-leaf pondweed infested areas in navigation lanes. If chemical treatment is used in Sensitive Area 1 or 2, it should only occur in the early spring when human contact and risks to native plants are most limited, and not after July 1st. A WDNR permit and WDNR staff supervision are required to implement this alternative. Lakeshore property owners must be notified of planned chemical treatment schedules and permit conditions before chemicals are applied to the lake. This recommendation should be considered a low priority.

6. **Invasive species plant control.** While the 2024 aquatic plant survey did not reveal a need to actively control Eurasian water milfoil or curly-leaf pondweed, these plants should still be monitored. As aquatic plant community species change, the need for management changes. This is particularly true around the mouth of the Bark River where Eurasian water milfoil and curly-leaf are known to be dense, and in heavily used shallow areas. Populations should be controlled with top-cut harvesting and early spring chemical treatments. This recommendation should be considered a high priority.

7. **Manual removal of nuisance plant growth in near-shore areas and Eurasian water milfoil** should be considered in areas too shallow, inaccessible, or otherwise unsuitable for other plant control methods. "Manual removal" is defined as control of aquatic plants by hand or using hand-held non-powered tools. Given what is known of plant distribution, this option is given a medium priority.

[48] *Personal communication via email between Commission Staff (Danielle Matuszak) and WDNR Staff (Heidi Bunk) on December 17, 2024.*

Riparian landowners need not obtain a permit for manually removing aquatic plants if they confine this activity to a 30-foot width of shoreline (including the recreational use area such as a pier) that does not extend more than 100 feet into the Lake and they remove all resulting plant materials from the Lake.[49] A permit is required if the property owner lives adjacent to a sensitive area or if the Lake Welfare Committee or other group actively engages in such work.[50] Prior to the "raking/hand-pulling" season, an educational campaign should be actively conducted to help assure that shoreline residents appreciate the value of native plants, understand the relationship between algae and plants (i.e., more algae will grow if fewer plants remain), know the basics of plant identification, and the specifics about the actions they are allowed to legally take to "clean up" their shorelines.[51]

8. **Expand participation in the Clean Boats Clean Waters program to at least all public launches.** Participation in this program proactively encourages lake users to clean boats and equipment before launching and using them in Nagawicka Lake.[52] This will help lower the probability of invasive species entering and leaving the lakes. The County maintains the aquatic invasive species removal sign and a removal station at the Naga-Waukee Park boat launch. The City maintains the signage and removal station at the Bleeker Street boat launch, in addition to participating in Clean Boat Clean Waters program.

9. **Stay abreast of best management practices to address invasive species.** The City should regularly communicate with the Waukesha County AIS Coordinator and WDNR staff about the most effective treatment options for invasive species as novel techniques and/or chemical products that may more effectively target these species become available.

***Harvesting Conditions***

Figure 3.1 illustrates the overall aquatic plant recommendations for Nagawicka Lake.[53] To assure sustainable recreational use and the long-term health of the Lake, the following conditions must be added to all aquatic plant harvesting practices.

1. **Maintain and operate harvesting equipment in conformance with manufacturer's recommendations.** For example, never operate the harvester in water shallower than the maximum draft range of the harvester (e.g., 20 inches for the ILH7-450 Aquatic Weed Harvester) and never operate with the cutter head or paddle wheels at or near the lake bottom.

2. **Inspect all cut plants for live animals.** Immediately return live animals to the water. When feasible, a second staff person equipped with a net could accompany and assist the harvester operator. Animals can be caught in the harvester and harvested plants, particularly when cutting larger plant mats. Consequently, carefully examine cut materials to avoid inadvertent harvest of fish, crustaceans, amphibians, turtles, and other animals.

3. **Harvesting should not occur in the early spring** to avoid disturbing fish spawning. Studies suggest that harvesting activities can significantly disturb the many fish species that spawn in early spring. Thus, avoiding harvesting during this time can benefit the Lake's fishery. The City has begun harvesting in previous years the day after Memorial Day.[54]

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[49] *The manual removal area limitation for nearshore aquatic plants applies to shorelines where native plants are present. The removal area limitation does not apply to areas populated solely with nonnative and invasive plants.*

[50] *If a lake district or other group wants to remove invasive species along the shoreline, a permit is necessary under Chapter NR 109, "Aquatic Plants: Introduction, Manual Removal and Mechanical Control Regulations," of the* Wisconsin Administrative Code, *as the removal of aquatic plants is not being completed by an individual property owner along his or her property.*

[51] *Commission and WDNR staff could help review documents developed for this purpose*

[52] *Further information about Clean Boats Clean Waters can be found on the WDNR website at: dnr.wi.gov/lakes/cbcw.*

[53] *Line width and locations are not scaled and only illustrate overall concept. The actual size, orientation, and depth of plant management activities depend upon sensitive area restrictions and permit conditions and site-specific factors. Site-specific factors include the composition of the plant community, water depth, shoreline configuration and obstacles, and other factors.*

[54] *Email communication between Commission staff and Tom Hafner, City of Delafield.*

4. **All harvester operators must successfully complete WDNR training to help assure adherence to harvesting permit specifications and limitations.** The regional WDNR aquatic invasive species coordinator and/or the City of Delafield's Public Works Department should provide training. At a minimum, training should cover 1) "deep-cut" versus "shallow-cut" techniques and when to employ each in accordance with this plan, 2) review of the aquatic plant management plan and associated permits with special emphasis focused on the need to restrict cutting in shallow areas, 3) identifying the boundaries of WDNR-designated Sensitive Areas and being familiar with regulations pertaining to these areas, and 4) plant identification to encourage preservation of native plant communities. Additionally, this training course should reaffirm that all harvester operators are obligated to record their work for inclusion in annual reports that are required under harvesting permits.

5. Harvesting can fragment plants and recreational boating can also fragment plants, especially on the weekends. Plant fragments may float in the Lake, accumulate on shorelines, and help spread undesirable plants. The harvesting program should include a comprehensive plant pickup program that all residents can use. This helps ensure that harvesting and recreational boating does not create Recreational Boating Facilities Grant Program through the WDNR and Wisconsin Waterways Commission a nuisance for Lake residents. The program typically includes residents raking plants, placing them in a convenient location accessible to the harvester (e.g., the end of a pier), and regularly scheduled pickup of cut plants by the harvester operators. This effort should be as collaborative as practical.

6. All plant debris collected from harvesting activities must be collected and disposed of at the designated disposal sites, as shown on Map 2. No aquatic plant material may be deposited within identified floodplain and wetland areas.

**Future Funding**

Current efforts pursued by the City have been effective at maintaining a healthy and diverse aquatic plant community while suppressing aquatic invasive species populations. The City should continue to utilize WDNR Surface Water Grants to further their efforts in monitoring the Lake, inspecting watercraft at boat launches, and targeting areas for management. Key grant programs to fund these efforts are as follows:

- **Clean Boats, Clean Waters** – this grant program covers up to 75 percent of up to $24,000 to conduct watercraft inspections, collect data, educate boaters about invasive species, and reporting invasive species to the WDNR.

- **Aquatic Invasive Species Prevention** – this grant program covers up to 75 percent of either $4,000 or $24,000 for projects that help prevent the spread of AIS species. Eligible costs include the acquisition of decontamination equipment at public boat launches as well as targeted management at boat launches or other access points. All lakes are eligible for at least $4,000 in funding but lakes that are designated as high priorities for AIS spread statewide, due to large amounts of boat traffic and/or the presence of particular invasive species, are eligible for $24,000. Due to the presence of the invasive starry stonewort (*Nitellopsis obtusa*) in nearby lakes, Nagawicka Lake is eligible for up to $24,000 via this grant program. The City must continue to participate in the Clean Boats, Clean Waters program to maintain eligibility for this grant program.

- **Aquatic Invasive Species Control** – this grant program covers up to 75 percent of up to $50,000 for small-scale projects and $150,000 for large-scale projects that suppress or reduce an AIS population within a lake. Given the current limited spread of EWM and CLP within the lakes, the small-scale project is more appropriate at this time. The large-scale projects should be considered if the populations of these species increase or a novel invasive species, such as starry stonewort, is observed within the lake. Aquatic Invasive Species Control grants fund projects that utilize integrated pest management and are designed to cause multi-season suppression of the target species. An approved aquatic plant management plan is a requirement to participate in this program and only approved recommendations from the plan are eligible projects for funding through this program.

- **Recreational Boating Facilities Grant Program**[55] – this grant program covers up to 50% of $250,00 for a recreational boating facility project. These projects can include aquatic plant harvesting equipment, rehabilitation of facilities, trash skimming equipment, improvement or repair of locks, construction projects such as ramps or dredging for safe water depths. The City has received grants from this program in the past to assist with the funding of projects.

The City should consider applying for these grant programs whenever feasible to support the monitoring, communication, watercraft inspection, and targeted management recommended in this aquatic plant management plan.

## 3.2 SUMMARY AND CONCLUSIONS

As requested by the City, the Commission worked with the City to develop a scope of work and secure funding to provide information needed to renew the City's aquatic plant management permit. This report, which documents the findings and recommendations of the study, examines existing and anticipated conditions, potential aquatic plant management problems, and lake use. Conformant with the study's intent, the plan includes recommended actions and management measures as well as options for future funding. Figures 3.1 through 3.4 summarize and locate where aquatic plant management recommendations should be implemented.

Successfully implementing this plan will require cooperative engagement from the City, State and regional agencies, Waukesha County, municipalities, and residents/users of the Lake. The recommended measures help foster conditions sustaining and enhancing the natural beauty and ambience of Nagawicka Lake while promoting a wide array of water-based recreational activities suitable for the Lake's intrinsic characteristics.

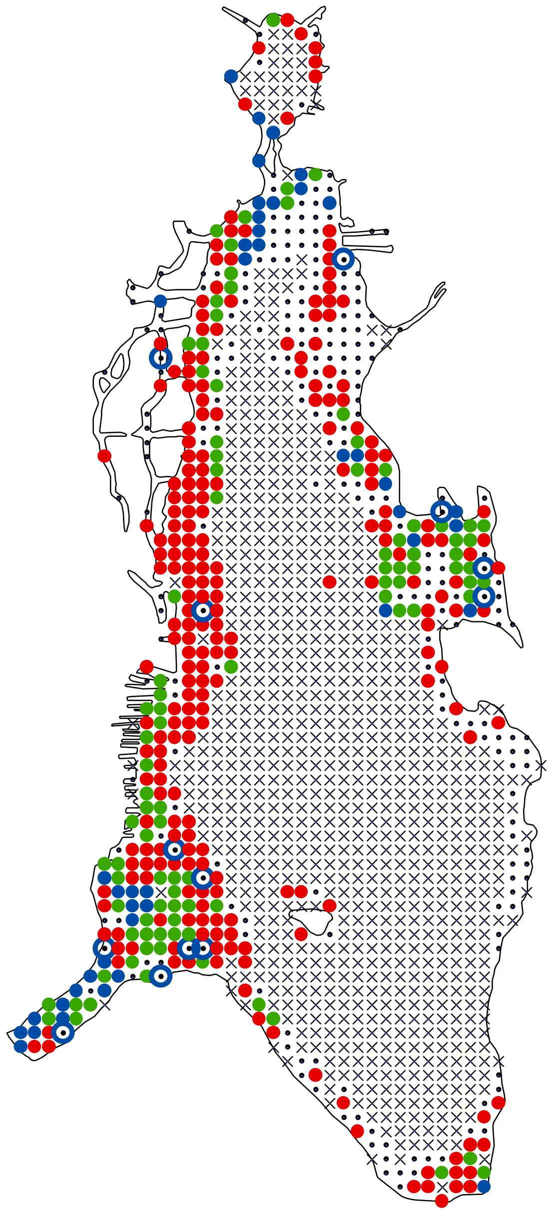
[55] *dnr.wisconsin.gov/aid/RBF.html.*

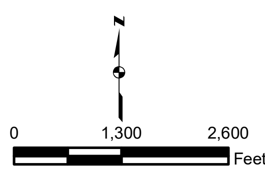
# APPENDICES

# NAGAWICKA LAKE AQUATIC PLANT SPECIES DETAILS

# APPENDIX A

## Figure A.1
## Muskgrass Rake Fullness in Nagawicka Lake: July 2024






NOTE: Survey was conducted on Nagawicka Lake from July 8th-11th, 2024.

**RAKE FULLNESS RATING**

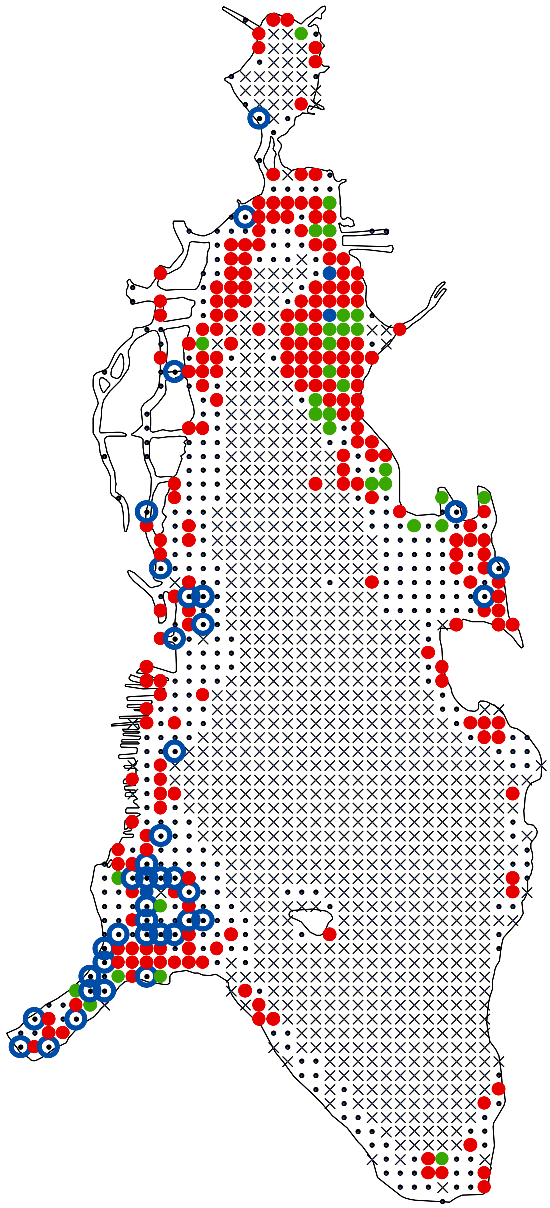
1 2 3

VISIBLE NEARBY

• NO AQUATIC PLANTS FOUND × NOT SAMPLED

*Source: WDNR and SEWRPC*

## Figure A.2
## Eelgrass Rake Fullness in Nagawicka Lake: July 2024



NOTE: Survey was conducted on Nagawicka Lake from July 8th-11th, 2024.

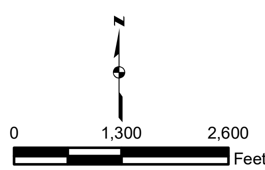
**RAKE FULLNESS RATING**

1 2 3

VISIBLE NEARBY

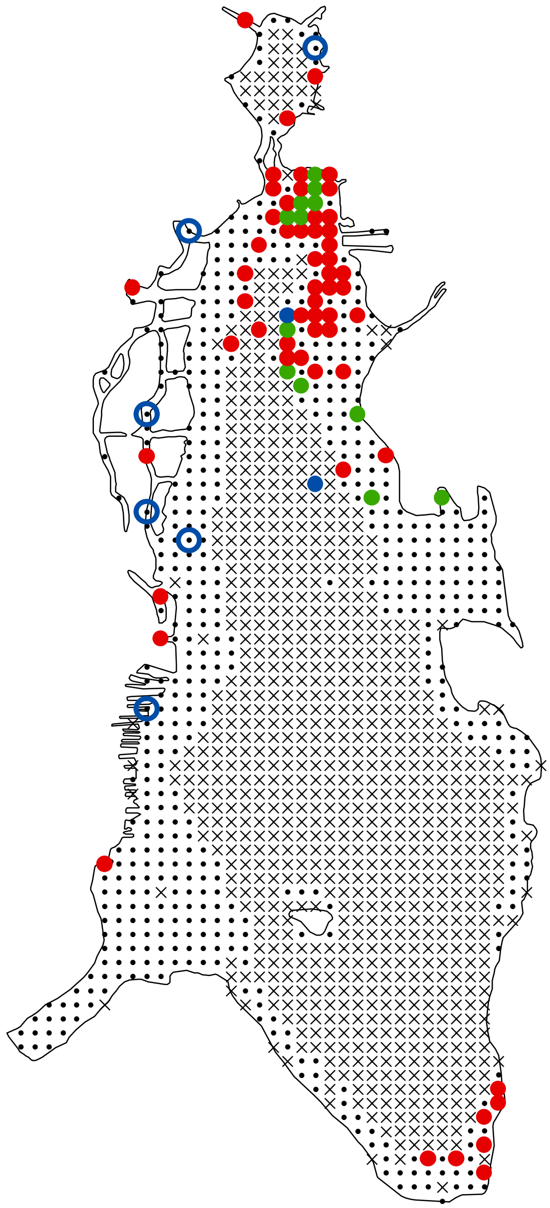
NO AQUATIC PLANTS FOUND

NOT SAMPLED

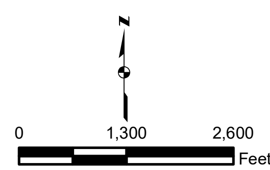



*Source: WDNR and SEWRPC*

## Figure A.3
## Water Stargrass Rake Fullness in Nagawicka Lake: July 2024



NOTE: Survey was conducted on Nagawicka Lake from July 8th-11th, 2024.




**RAKE FULLNESS RATING**

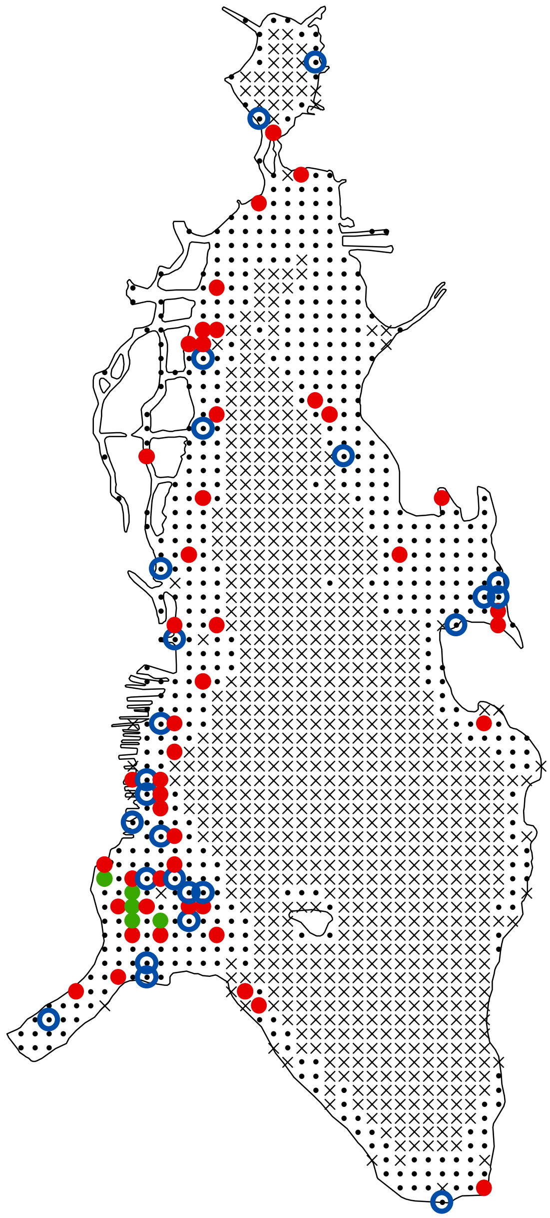

VISIBLE NEARBY

NO AQUATIC PLANTS FOUND

NOT SAMPLED

*Source: WDNR and SEWRPC*

## Figure A.4
## Sago Pondweed Rake Fullness in Nagawicka Lake: July 2024



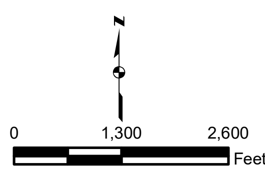
NOTE: Survey was conducted on Nagawicka Lake from July 8th-11th, 2024.

**RAKE FULLNESS RATING**

1 2 3

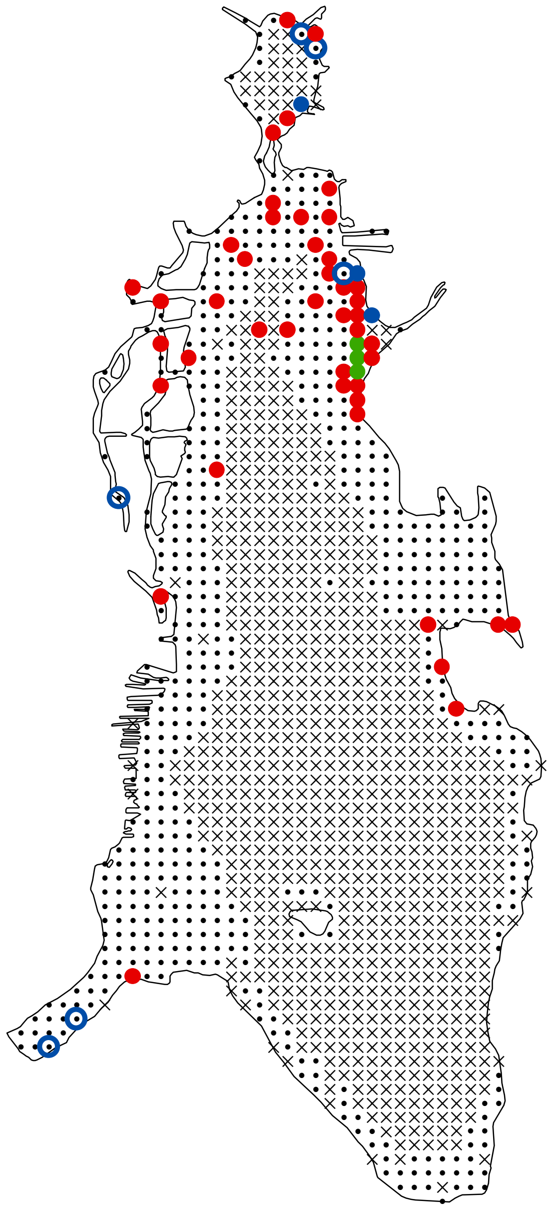
VISIBLE NEARBY

• NO AQUATIC PLANTS FOUND × NOT SAMPLED



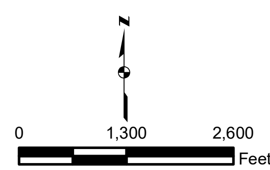

*Source: WDNR and SEWRPC*

## Figure A.5
## Elodea Rake Fullness in Nagawicka Lake: July 2024



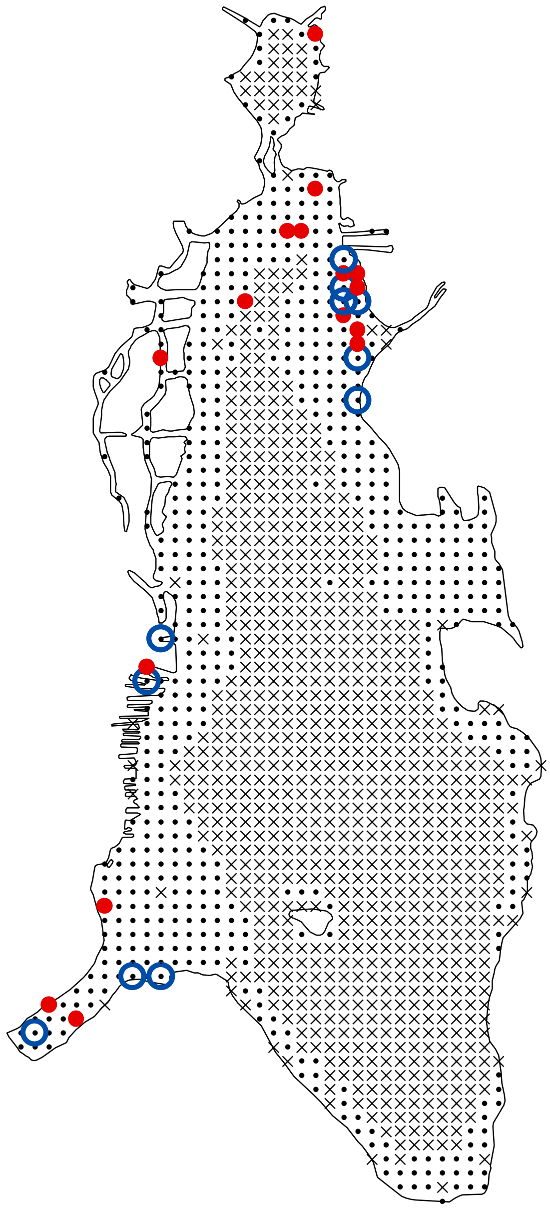
NOTE: Survey was conducted on Nagawicka Lake from July 8th-11th, 2024.

**RAKE FULLNESS RATING**

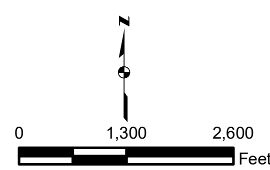

*Source: WDNR and SEWRPC*

## Figure A.6
## Eurasian Watermilfoil Rake Fullness in Nagawicka Lake: July 2024



NOTE: Survey was conducted on Nagawicka Lake from July 8th-11th, 2024.

**RAKE FULLNESS RATING**

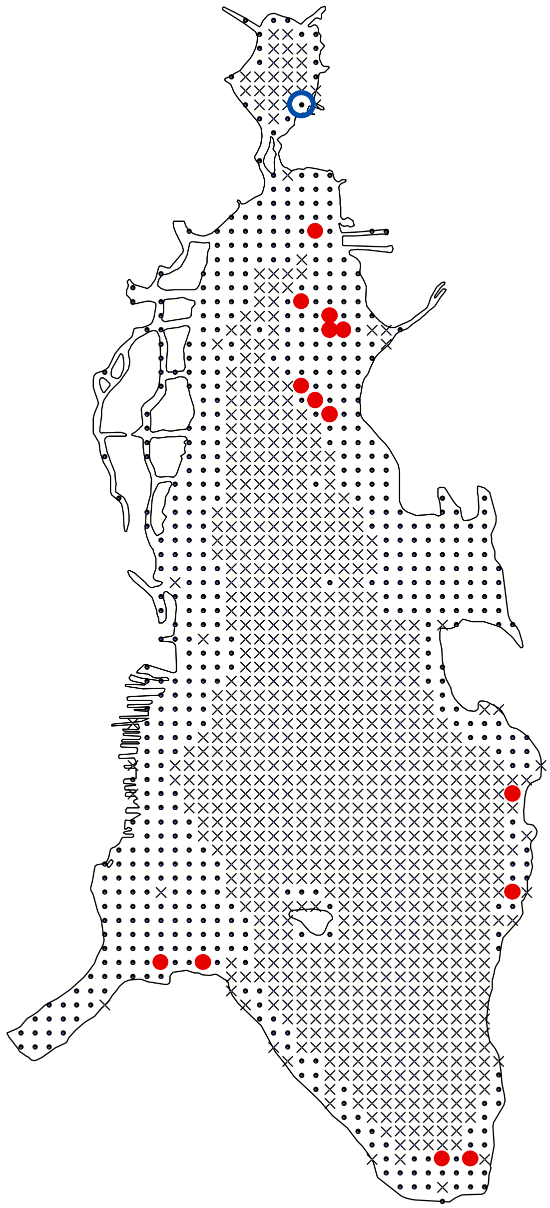




VISIBLE NEARBY

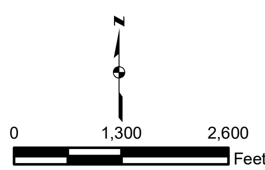
• NO AQUATIC PLANTS FOUND × NOT SAMPLED

*Source: WDNR and SEWRPC*

## Figure A.7
## Curly-Leaf Pondweed Rake Fullness in Nagawicka Lake: July 2024



NOTE: Survey was conducted on Nagawicka Lake from July 8th-11th, 2024.



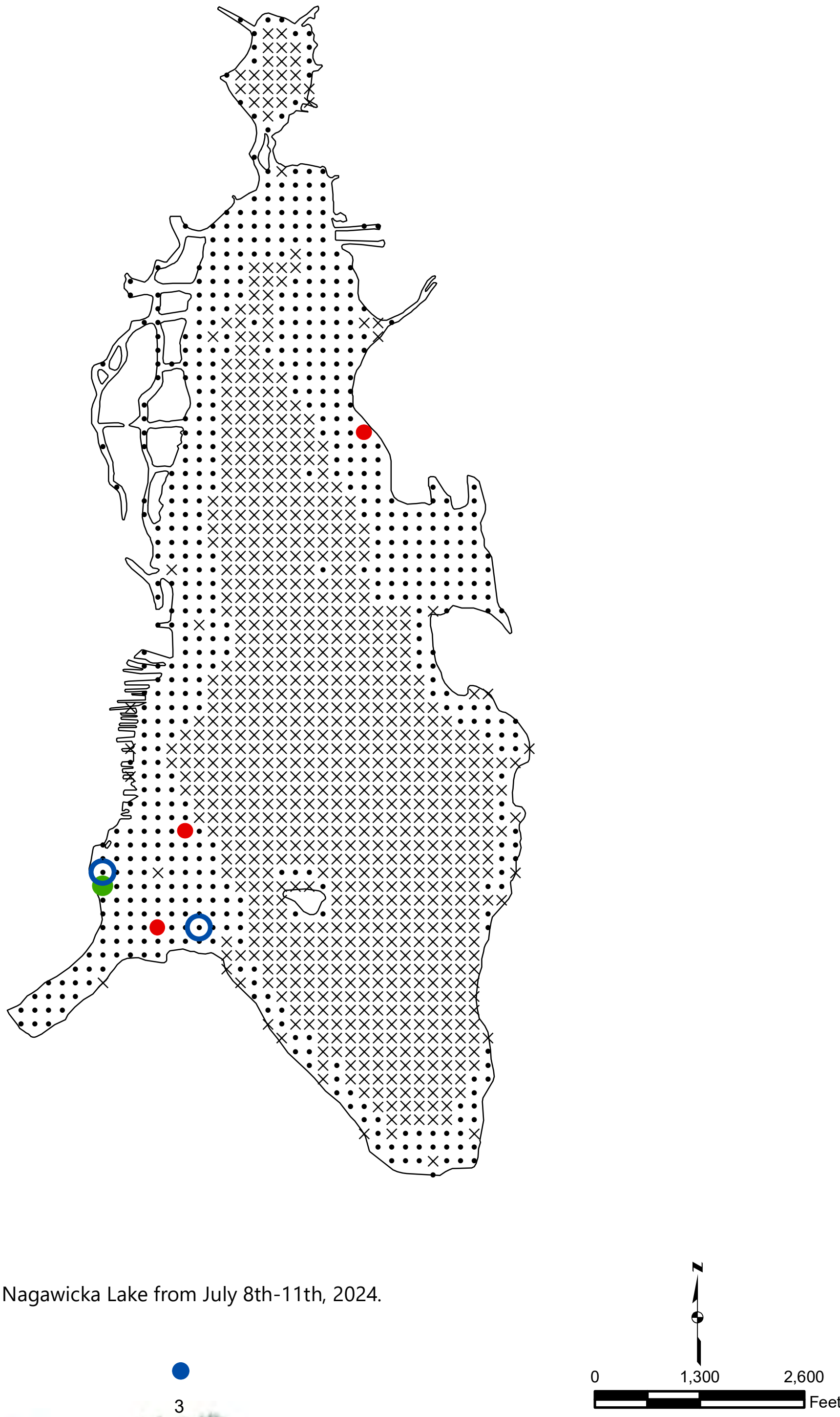

**RAKE FULLNESS RATING**


VISIBLE NEARBY

• NO AQUATIC PLANTS FOUND × NOT SAMPLED

*Source: WDNR and SEWRPC*

## Figure A.8
## Spiny Naiad Rake Fullness in Nagawicka Lake: July 2024




NOTE: Survey was conducted on Nagawicka Lake from July 8th-11th, 2024.

**RAKE FULLNESS RATING**


*Source: WDNR and SEWRPC*