MEMORANDUM REPORT
NO. 190 (2ND EDITION)

AQUATIC PLANT MANAGEMENT PLAN UPDATE FOR DELAVAN LAKE

WALWORTH COUNTY, WISCONSIN

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July 2022

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF MAPS

LIST OF TABLES

INTRODUCTION 1

Credit: SEWRPC Staff

The Southeastern Wisconsin Planning Commission (Commission) completed this aquatic plant inventory and management study on behalf of the Delavan Lake Sanitary District (DLSD). DLSD financed the project cost. This memorandum is the Commission's third study focusing on Walworth County's Delavan Lake.[1]

1.1 PROJECT SETTING, BACKGROUND, SCOPE, AND INTENT

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

The Lake is intensively used for a diverse array of water-based recreation. Although a large area of the Lake is too deep to support growth of rooted aquatic plants, nearshore areas, bays, and shallow areas support aquatic vegetation. Shallow water areas are most prevalent in the northern and southwestern parts of the Lake. There are five areas around the Lake designated by the Wisconsin Department of Natural Resources (WDNR) as sensitive areas, a situation limiting aquatic plant management activity in these areas. To help support a wide variety of recreational uses, DLSD manages aquatic plant populations under a permit issued by the WDNR. The ongoing management program relies primarily upon mechanical aquatic plant harvesting. According to available data, the aquatic plant community is responding well to current management practices, and lake recreational use has not been unduly restricted in most areas.

DLSD's aquatic plant management (APM) permit was granted for a five-year period beginning in 2017.[2] A new permit was needed, which required a comprehensive on-the-water aquatic plant inventory. To support

[1] *The two earlier Commission reports include: SEWRPC Community Assistance Planning Report No. 253,* A Lake Management Plan for Delavan Lake, Walworth County, Wisconsin*, May 2002; and SEWRPC Memorandum Report No. 190,* An Aquatic Plant Management Plan for Delavan Lake, Walworth County, Wisconsin, *May 2011.*

[2] *Delavan Lake Sanitary District,* An Aquatic Plant Management Plan Update for Delavan Lake, Walworth County, Wisconsin*, 2017.*

this endeavor, the Commission completed an aquatic plant inventory during 2020. The resultant data were used to evaluate the Lake's plant community conditions and apparent reaction to recent management practices. This information was then used to update the 2017 APM plan. The draft plan update was reviewed in 2021 by DLSD and regulators.

This updated APM plan summarizes information and recommendations needed to manage nuisance plants including Eurasian watermilfoil, curly-leaf pondweed, duckweeds, and coontail throughout the growing season as well as wild celery in late summer. 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. It also provides specific recommendations related to each alternative. These measures focus on those that DLSD can implement and collaborate with Lake residents/users and the WDNR.

The current study is not intended to be a comprehensive evaluation of the myriad factors influencing the Lake's overall health and recreational use potential and therefore does not address watershed issues, land use, in-depth water quality or quantity interpretations, history, recreational use, fish and wildlife, and other such topics typical of comprehensive lake plans.

In summary, this document helps interested parties understand the particular plant management measures to be used in and around the Lake. These data and suggestions can be valuable resources when developing requisite APM permit applications and implementing future aquatic plant management efforts.

INVENTORY FINDINGS AND RELEVANCE TO RESOURCE MANAGEMENT 2

Credit: SEWRPC Staff

Natural resource planning relies upon data to quantify conditions, identify management challenges and limitations, and predict the influence of potential courses of action. These factors are collectively considered to evaluate and recommend practices that promote sustainable use, help safeguard human and environmental health, balance diverse lake user interests, address sometimes conflicting lake user desires, and comply with regulatory objectives and requirements. The following sections briefly describe data collection efforts, summarize and highlight resultant data, interpret data trends and relationships, and make conclusions useful to guide resource planning.

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 Delavan Lake APM plan considered input from many entities including the Delavan Lake Sanitary District (DLSD) and the Wisconsin Department of Natural Resources (WDNR). Objectives of the Delavan Lake APM program include the following:

- Effectively control the quantity and density of nuisance aquatic plant growth in well-targeted portions of Delavan Lake. This objective helps:
    - Enhance water-based recreational opportunities.
    - Improve community-perceived aesthetic values.
    - 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 District preserve and enhance the Lake's water quality, its biotic communities, its habitat value, and its 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 Delavan Lake.

- Promote a high-quality water-based experience for residents and visitors to Delavan Lake consistent with the policies and practices of the WDNR, as described in the regional water quality management plan, as amended.[3]

To meet these objectives, DLSD executed an agreement with the Southeastern Wisconsin Regional Planning Commission (Commission) to investigate the characteristics of Delavan Lake and to develop an aquatic plant management update. 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 these inventories.

2.2 AQUATIC PLANT COMMUNITY COMPOSITION, CHANGE, AND QUALITY

The Lake's aquatic plant community has been evaluated several times since 1948. Recent surveys have primarily been conducted by Aron & Associates, WDNR, DLSD, and Commission staff. Species lists and abundance data derived from the 2015 and 2020 surveys for the Lake are compared in Table 2.1. The 2015 and 2020 surveys both used the same point-intercept grid and methodology.[4,5,6] Therefore, the same points were sampled using the same techniques on roughly the same date approximately five years apart. Such consistency enables more detailed evaluation of aquatic plant abundance and distribution change than has been possible in the past.

Each aquatic plant species has preferred habitat conditions in which that species generally 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 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 very little diversity, while other areas of the same lake may exhibit high 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 maximum depth of colonization, species richness, biodiversity, evaluation of sensitive species, and relative species abundance. Metrics derived from the 2015 and 2020 point-intercept surveys are described below.

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[3] *SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, Volume One, Inventory Findings*, September 1978,* Volume Two, Alternative Plans*, February 1979,* 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*.

[4] *It is noteworthy that sampling methodology changed from transect-based methods in the earlier surveys (1967 through 2008) to a point-intercept method beginning in 2014*.

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

[6] *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*.

Table 2.1
Aquatic Plant Abundance, Delavan Lake: July 2015 Versus August 2020

Aquatic Plant Species	Native or Invasive	Number of Points Found[a] (2015/2020)	Frequency of Occurrence Within Vegetated Areas[b] (2015/2020)	Average Rake Fullness[c] (2015/2020)	Relative Frequency of Occurrence[d] (2015/2020)	Visual Sightings[e] (2015/2020)
Myriophyllum spicatum (eurasian watermilfoil)	Invasive	407/144	74.1/31.9	1.4/1.2	24.1/14.9	18/12
Potamogeton crispus (curly-leaf pondweed)	Invasive	31/13	5.6/2.9	1.0/1.2	1.8/1.3	9/2
Ceratophyllum demersum (coontail)	Native	339/335	61.7/74.1	1.3/1.7	20.1/34.6	8/5
Chara spp. (muskgrasses)*	Native	65/4	11.8/0.9	1.4/1.0	3.9/0.4	1/0
Elodea canadensis (common waterweed)	Native	97/47	17.7/10.4	1.2/1.1	5.8/4.9	5/0
Heteranthera dubia (water stargrass)	Native	73/80	13.3/17.7	1.0/1.3	4.3/8.3	13/13
Lemna minor (small duckweed)	Native	43/29	7.8/6.4	1.0/1.0	2.6/3.0	34/3
Lemna trisulca (forked duckweed)	Native	251/67	45.7/14.8	1.0/1.0	14.9/6.9	21/3
Myriophyllum sibiricum (northern watermilfoil)	Native	5/0	0.9/0.0	1.0/0.0	0.3/0.0	0/0
Nymphaea odorata (white water lily)	Native	6/10	1.1/2.2	1.5/1.2	0.4/1.0	39/10
Potamogeton friesii (fries' pondweed)*	Native	8/7	1.5/1.6	1.0/1.1	0.5/1.7	1/0
Potamogeton illinoensis (Illinois pondweed)	Native	1/0	0.2/0.0	1.0/0.0	0.1/0.0	2/0
Potamogeton nodosus (long-leaf pondweed)*	Native	7/4	1.3/0.9	1.0/1.8	0.4/0.4	9/7
Potamogeton pusillus (small pondweed)*	Native	25/0	4.6/0.0	1.0/0.0	1.5/0.0	3/0
Potamogeton zosteriformis (flat-stem pondweed)	Native	2/0	0.4/0.0	1.0/0.0	0.1/0.0	0/0
Stuckenia pectinata (sago pondweed)[f]	Native	134/51	24.4/11.3	1.1/1.1	7.9/5.3	34/28
Vallisneria americana (eelgrass/water celery)[f]	Native	88/143	16.0/31.6	1.2/1.5	5.2/14.8	24/14
Wolffia columbiana (common watermeal)	Native	41/33	7.5/7.3	1.0/1.0	2.4/3.4	108/29

Notes:

- During the 2015 survey, sampling occurred at 866 sampling points between July 22 and 29, 2015. Of the sampling points visited, 548 were vegetated. During the 2020 survey, sampling occurred at 615 sampling points between August 17 and 21, 2020. Of the sampling points visited, 452 had vegetation.
- Red text indicates non-native and/or invasive species.
- An asterisk (*) next to a species name indicates that the species is considered "sensitive," with a coefficient of conservatism C value of seven or greater.
- See Appendix A for distribution maps and identifying features.

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

[b] Frequency of Occurrence Within Vegetated Areas, *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 points 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 points 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. (It is likely that visual sightings were not taken in 2011*).

[f] *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

Maximum Depth of Colonization

The maximum depth to which aquatic plants grow in a lake, known as the maximum depth of colonization (MDC), is a useful indicator of water quality, as turbid and/or eutrophic (nutrient-rich) lakes generally have shallower MDC than lakes with clear water.[7] The MDC of Delavan Lake was generally 20 feet below the water surface during 2015 and 2020, indicating generally high water clarity. In the Lake, steep lake contours contribute to a reduced area that is shallow enough for plants to colonize, limiting aquatic plant abundance within the Lake. 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 *Chara* spp. and *Nitella* spp., 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 feet and 35 feet, respectively, in Silver Lake, Washington County.

Species Richness

The number of different 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 generally have greater species richness. Aquatic plants provide a wide variety of benefits to lakes, examples of which are briefly described in Table 2.2.

Surveys of aquatic plants in Delavan Lake have been conducted by various public and private organizations since 1948. From the 1950s to the time of the Lake rehabilitation project in 1989-1990, the number of aquatic plant species in the Lake had been in a state of decline. From as many as 25 species observed during the 1950s, the number of species had decreased to only seven species by the time of the 1960s, with this number declining to only four species by 1968. By the mid-1970s, white water lily was considered the dominant plant species in the Lake, and, by 1972, all major "weed" beds in the Lake were reported to have disappeared, with only single plants and scattered patches of plants being reported in the Lake. During the 1980s, two additional aquatic plant surveys were conducted, prior to the major lake rehabilitation project. During these surveys, only three species of aquatic macrophytes were identified with the dominant plant being curly-leaf pondweed (*Potamogeton crispus*), an invasive nonnative plant, along with white water lily and another, unidentified pondweed.[8]

As a result of increased water clarity and a decrease in rough fish populations brought about by the aforementioned lake rehabilitation project during 1989-1990, significant changes occurred in the aquatic plant communities in the Lake. In the surveys conducted between 1990 and 1994, as well as in those conducted between 1996 and 1999, a total of 29 species of aquatic macrophytes, including the two emergent species—cattail (*Typha latifolia*) and bulrush (*Schoenoplectus* spp.)—were reported to occur in Delavan Lake.[9] In surveys between 2002 and 2009, an average of 11 native aquatic plant species were found.[10]

The Lake has maintained stable species richness throughout the surveys that followed with only slight increases or decreases from year to year (See Table 2.3). It is not uncommon for aquatic plant community diversity to fluctuate in response to a variety of drivers such as weather/climate, predation, and lake-external stimuli such as nutrient supply. This is especially true in the case of a lake's individual pondweed species, which tend to vary in abundance throughout the growing season in response to temperature, insolation, and other ecological factors. The 2020 aquatic plant survey identified 12 native aquatic plant species in Delavan Lake.

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

[8] *E.R. Schumacher and L. Burns,* General Fishery Survey and Management Recommendations, Delavan Lake, 1975, *Wisconsin Department of Natural Resources Intradepartmental* Memo, 1978.

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

[10] *Aron. & Associates,* Delavan Lake Aquatic Plant Survey*, 2013*.

Table 2.2
Examples of Positive Ecological Qualities Associated with Aquatic Plant Species Present in Delavan Lake

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides good shelter for young fish; supports insects valuable as food for fish and ducklings; native
Chara spp. (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
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
Stuckenia pectinata (sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young 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

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 percent 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), a metric that ranges from 0 (no diversity) to 1 (infinite diversity). 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. Promoting biodiversity not only helps sustain an ecosystem but preserves the spectrum of options useful for future management decisions.

Data collected during 2020 reveal that Delavan Lake's SDI was 0.82, a very slight decrease from 0.86 measured during 2015. Although the number of native species found in Delavan Lake decreased from 17 to 12, the additional species found in the previous survey were in low abundance and thus did not greatly decrease the SDI. 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.

Even though the Lake exhibits good species richness and biodiversity, no one location in the Lake contained all identified aquatic plant species. During 2020, between one and seven aquatic plant species were found at any one sampling point throughout the Lake (Figure 2.1). Delavan Lake's greatest species richness occurred in the northeastern and northwestern portions of the Lake.

Sensitive Species

Aquatic plant metrics, such as species richness and the floristic quality index (FQI), can be useful for evaluating lake health. In hard water lakes, such as those common in Southeastern Wisconsin, species richness generally increases with water clarity and decreases with nutrient enrichment.[11] The FQI is an assessment metric used to evaluate how closely a lake's aquatic plant community matches that of undisturbed, pre-settlement

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

Table 2.3
Submerged Aquatic Plant Species Observed in Delavan Lake: 2010-2020

Submerged Aquatic Plant Species	2010	2011	2012	2013	2015	2020
Invasive Aquatic Plants						
Myriophyllum spicatum (eurasian watermilfoil)	X	X	X	X	X	X
Potamogeton crispus (curly-leaf pondweed)	X	X	X	X	X	X
Total Invasive Species Observed	2	2	2	2	2	2
Native Aquatic Plants						
Ceratophyllum demersum (coontail)	X	X	X	X	X	X
Chara spp. (muskgrasses)	X	X	X	X	X	X
Elodea canadensis (common waterweed)	X	X	X	X	X	X
Heteranthera dubia (water stargrass)	X	X	X	X	X	X
Lemna minor (small duckweed)	X	X	X	X	X	X
Lemna trisulca (forked duckweed)	X	X	X	X	X	X
Myriophyllum sibiricum (northern watermilfoil)	--	--	--	--	X	--
Nuphar variegata (spatterdock)	--	X	--	X	--	--
Nymphaea odorata (white water lily)	--	X	X	X	X	X
Potamogeton foliosis (leafy pondweed)	--	--	--	X	--	--
Potamogeton friesii (fries' pondweed)	--	--	X	--	X	X
Potamogeton illinoensis (Illinois pondweed)	--	X	--	--	X	--
Potamogeton natans (floating-leaf pondweed)	X	--	--	X	X	--
Potamogeton nodosus (long-leaf pondweed)	--	--	X	--	X	X
Potamogeton pusillus (small pondweed)	--	--	--	--	X	--
Potamogeton zosteriformis (flat-stem pondweed)	--	--	X	X	X	--
Ranunculus aquatilus (white water crowfoot)	--	--	X	--	--	--
Stuckenia pectinata (sago pondweed)	X	X	X	X	X	X
Vallisneria americana (eelgrass/water celery)	X	X	X	X	X	X
Wollfia spp. (watermeal)	--	--	X	--	X	X
Zannichellia palustris (horned pondweed)	--	--	X	--	--	--
Total Native Species Observed	9	11	15	13	17	12
Total Species Richness	11	13	17	15	19	14

Source: Wisconsin Department of Natural Resources, Aron & Associates, Delavan Lake Sanitary District, and SEWRPC

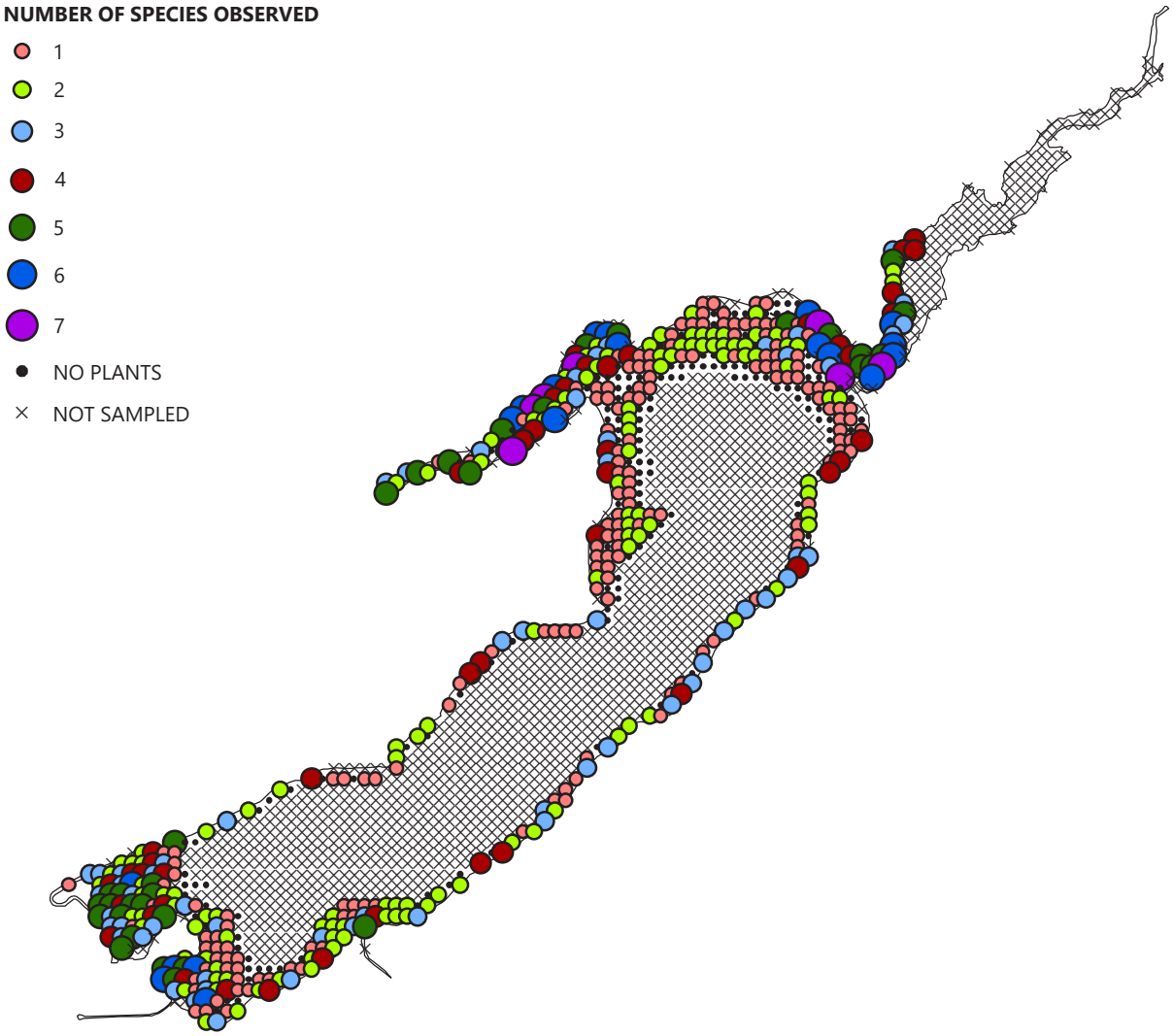
conditions.[12] To formulate this metric, Wisconsin aquatic plant species were assigned conservatism (C) values on a scale from zero to ten that reflect the likelihood that each species occurs in undisturbed habitat. These values were assigned based on the species substrate preference, tolerance of water turbidity, water drawdown tolerance, rooting strength, and primary reproductive means. Native "sensitive" species that are intolerant of ecological disturbance receive high C values, while natives that are disturbance tolerant receive low C values. Invasive species are assigned a C value of 0. A lake's FQI is calculated as the average C value of species identified in the lake, divided by the square root of the lake's species richness. The FQI decreased in Delavan Lake from 22.3 in 2015 to 17.8 in 2020. As mentioned previously, plant communities naturally fluctuate based on many different factors and slight changes in FQI may be reflective of these fluctuations rather than a persistent trend in the aquatic plant community. Both surveys had FQI values that are close to the average for the Southeastern Wisconsin Till Plains ecoregion of 20.0, indicating that this Lake has a stable and healthy aquatic plant community.

Relative Species Abundance

In the last decade, muskgrass (*Chara* spp.), a type of macroalgae, has become a more abundant aquatic species in the Lake. This is a critical species to protect, as muskgrass has several unique environmental preferences as well as beneficial functions in lakes. Muskgrass is nearly always associated with hard water lakes, particularly those with significant groundwater seepage and springs. This species has been found to promote marl formation and induce dissolved phosphorus to be precipitated to the lake bottom, reducing

[12] *S. Nichols, "Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications,"* Lake and Reservoir Management*, 15(2), 1999.*

Figure 2.1
Aquatic Plant Species Richness, Delavan Lake: August 2020



Note: Samples were collected in Delavan Lake between August 17, and August 21, 2020.

Source: Wisconsin Department of Natural Resources and SEWRPC

phosphorus concentrations in the water column and thus improving water clarity.[13] Additionally, muskgrass is a favorite waterfowl food and helps stabilize lake-bottom sediment, as it has been observed to grow deeper than most vascular plants. Its prevalence in a lake's aquatic plant community may tangibly contribute to lake water quality, promoting the growth of other desirable native plant species.

Native aquatic plants that have been found over the years in varying abundance include eelgrass or water celery (*Vallisneria americana*) and Sago pondweed (*Stuckenia pectinata*). Exotic Eurasian watermilfoil (EWM) (*Myriophyllum spicatum*) has been found throughout the Lake since the 1990s. However, overall EWM abundance has decreased significantly.

Changing aquatic plant communities, such as those described in the preceding paragraphs, are often the result of change in and around the lake. Causes of change include aquatic plant management practices, land use (which in turn commonly affects nutrient and water supply and availability), lake use, climate, and

[13] *M. Scheffer, and E.H. van Ness, "Shallow Lakes Theory Revisited: Various Alternative Regimes Driven by Climate, Nutrient, Depth, and Lake Size,"* Hydrobiologia, *584, 2007.*

natural biological processes such as natural population cycles of specific plants. In regard to plant-specific population cycles, it is not uncommon for various pondweed species to succeed each other during the growing season, with some species being more prevalent in cooler water, while others are more prevalent in warmer water. In contrast to such seasonal succession, aquatic plants such as EWM are known to have year-to-year abundance and relative scarcity cycles, possibly as a consequence of climatic factors and/or predation cycles related to the relative abundance of milfoil weevils (*Eurhychiopsis lecontei*).

Based on the 2020 point-intercept survey, the four most abundant submerged aquatic plant species in Delavan Lake were, in decreasing order of abundance: 1) coontail, 2) EWM, 3) water celery, and 4) water stargrass (*Heteranthera dubia*).

Apparent Changes in Observed Aquatic Plant Communities: 2015 Versus 2020

The distribution of each aquatic plant species identified as part of the 2020 survey is mapped in Appendix A. The 2020 aquatic plant inventory identified 14 species of aquatic plants in Delavan Lake. In contrast, the 2015 aquatic plant inventory identified 19 aquatic plant species in Delavan Lake. The Lake exhibited a decrease from 2015 but, overall, the number of submerged plant species in the Lake has been relatively stable over time (Table 2.3).

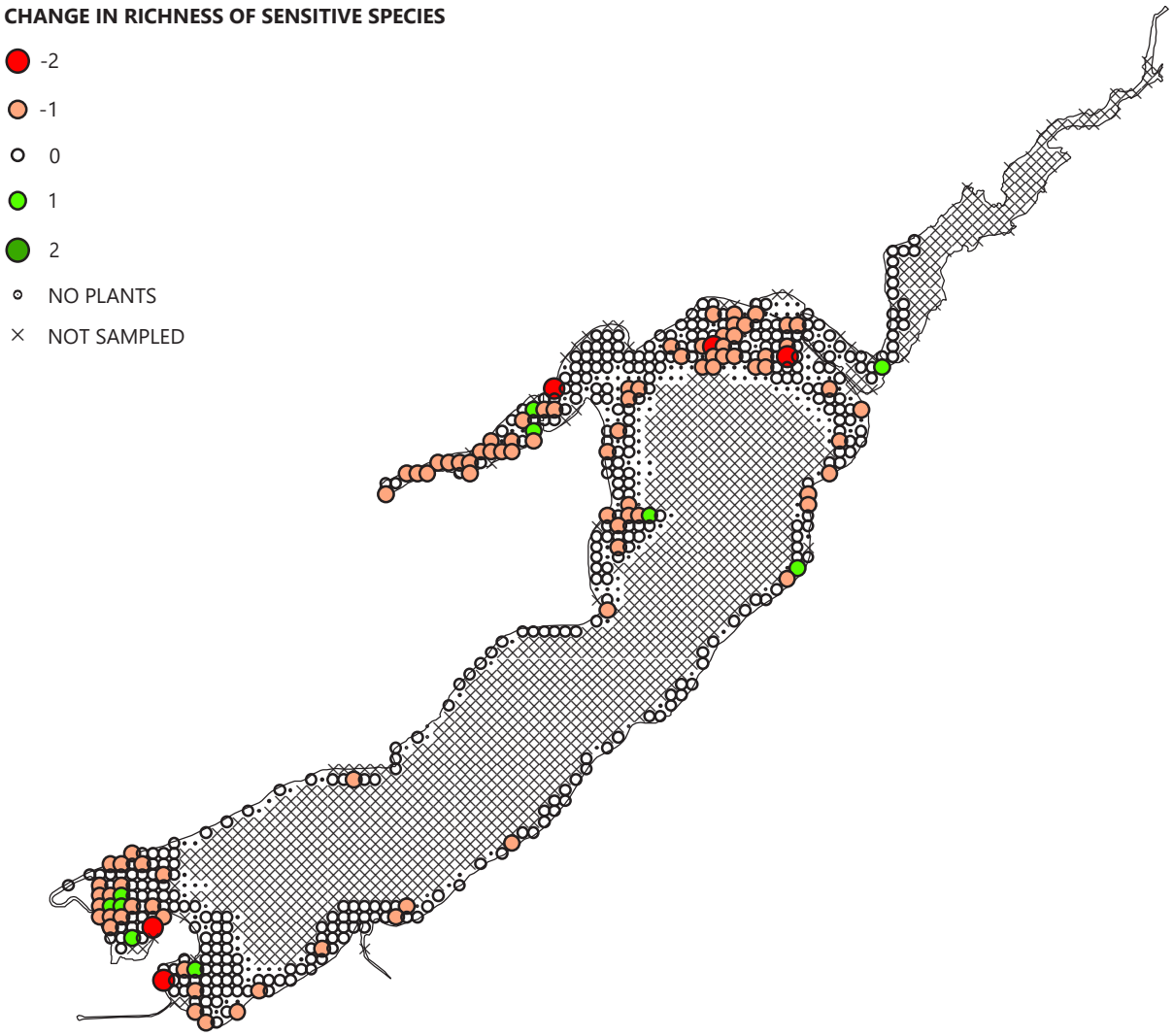
As was described earlier, sensitive aquatic plant species are likely the most vulnerable to human disturbance. Therefore, changes in sensitive species abundance can indicate the general magnitude of human disturbance derived stress on a waterbody's ecosystem. The number of sensitive species (i.e., species with C value of seven or greater) at each sample point during 2015 and 2020 were contrasted (Figure 2.2). Overall, sensitive species richness only slightly decreased reflecting a stable and healthy plant community and the natural periodicity of plant communities.

In addition to the number of different aquatic plant species detected in the Lake, several other comparisons can be drawn between the 2015 and 2020 aquatic plant survey results, as examined below.

General Trends

- Overall, most plant species, including EWM, were found at fewer points in 2020 than in 2015.
- Species such as Fries' pondweed (*Potamogeton friesii*) and long-leaf pondweed (*Potamogeton nodosus*) were found less frequently but are not historically abundant throughout the Lake.
- One species, water celery, exhibited the greatest increase in abundance, from being identified at 88 littoral points in 2015 to 143 littoral points in 2020: an increase of 60 percent.
- The two exotic species (EWM and CLP) were found at significantly fewer points in 2020 than 2015.
- Coontail remains the most widespread plant in the Lake and its frequency of occurrence relative to all other species in the Lake was similar in both surveys.
- Invasive EWM was present but not as abundant in 2020. EWM was the second most widespread plant in 2015 and third most widespread plant in 2020. Nevertheless, the lake use, habitat value threats, and attendant management challenges posed by EWM are serious. EWM must continue to be monitored and managed vigilantly and aggressively.
- Based on average rake fullness, aquatic plant growth density remained similar between 2015 and 2020.
- Four submerged species observed in 2015 (northern watermilfoil (*Myriophyllum sibiricum*), Illinois pondweed (*Potamogeton illinoensis*), small pondweed (*Potamogeton pusillus*), and flat-stem pondweed (*Potamogeton zosteriformis*)) were not observed in 2020. However, these species were not observed in high abundance in 2015 so it may reflect natural periodicity.

Figure 2.2
Change in Sensitive Species Richness, Delavan Lake: 2015 Versus 2020



Note: Samples were collected in Delavan Lake between August 17, and August 21, 2020.

Source: Wisconsin Department of Natural Resources and SEWRPC

- Sago pondweed (*Stuckenia pectinata*), 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*, was found at 60 percent fewer point in 2020 than in 2015.

- Curly-leaf pondweed (CLP) remained sparse between 2015 and 2020. Since CLP senesces early in the season, the mid- to late-summer sampling timeframe may not accurately represent this plant's true abundance in the Lake.

Eurasian Watermilfoil

EWM is an ongoing and serious concern in many Wisconsin lakes, especially nutrient-rich lakes such as those common in Southeastern Wisconsin. EWM has been one of DLSD's primary targets for control through its ongoing aquatic plant management program. Additionally, riparian landowners also direct substantial effort to EWM control.

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-bottom sediment, warmer water

with moderate clarity and high alkalinity, and tolerates a wide range of pH and salinity.[14,15] 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.[16] For reasons such as these, EWM can grow to dominate an aquatic plant community in as little as two years.[17,18] 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 10 to 15 years.[19]

EWM is a significant recreational use problem in Southeastern Wisconsin lakes. For example, boating through dense EWM beds can be difficult and unpleasant. Because EWM can reproduce from stem fragments, recreational use conflicts can help spread EWM. Human produced EWM fragments (e.g., fragments created by power boating through EWM), as well as fragments generated from natural processes (e.g., wind-induced turbulence, animal feeding/disturbance) readily colonize new sites, especially disturbed sites, contributing to EWM spread. EWM fragments can remain buoyant for two to three days in summer and two to six days in fall, with larger fragments remaining buoyant longer than smaller ones.[20] 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 very important to remove all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies.

EWM is widespread in Delavan Lake, occurring chiefly in nearshore and other shallow areas where water is less than 10 feet deep. EWM was observed at 407 points of 623 points shallower than the MDC (i.e., about 65 percent of visited points) in Delavan Lake during 2015 and 144 points of the 599 points visited (i.e., about 24 percent of points shallower than the MDC) during 2020 (see Table 2.1). Therefore, the area occupied by EWM relative to other plants was reduced significantly between 2015 and 2020. In addition, EWM average rake fullness remained low between 2015 and 2020 (Figure 2.3).

Other Exotic Submergent Aquatic Plants

CLP continues to be present in Delavan 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 that it is presently a relatively minor species in terms of dominance, and, as such, is less likely to interfere with recreational boating activities, the plant can grow dense stands 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.

2.3 PAST AND PRESENT AQUATIC PLANT MANAGEMENT PRACTICES

Aquatic plants have been controlled on Delavan Lake since at least the 1950s – the earliest date that control program records were kept by State agencies. However, aquatic plant control on the Lake probably predates the 1950s by several decades. Early aquatic plant control relied on chemical treatment with sodium arsenite. Sodium arsenite applications were discontinued in 1969 and were supplanted by organic-based herbicides. To control floating algae, copper sulfate and Cutrine-Plus were applied to the Lake.

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[14] *U. S. Forest Service, Pacific Islands Ecosystems at Risk (PIER), 2019. May be downloaded at the following website: hear.org/pier/species/myriophyllum_spicatum.htm*

[15] *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.*

[16] Ibid.

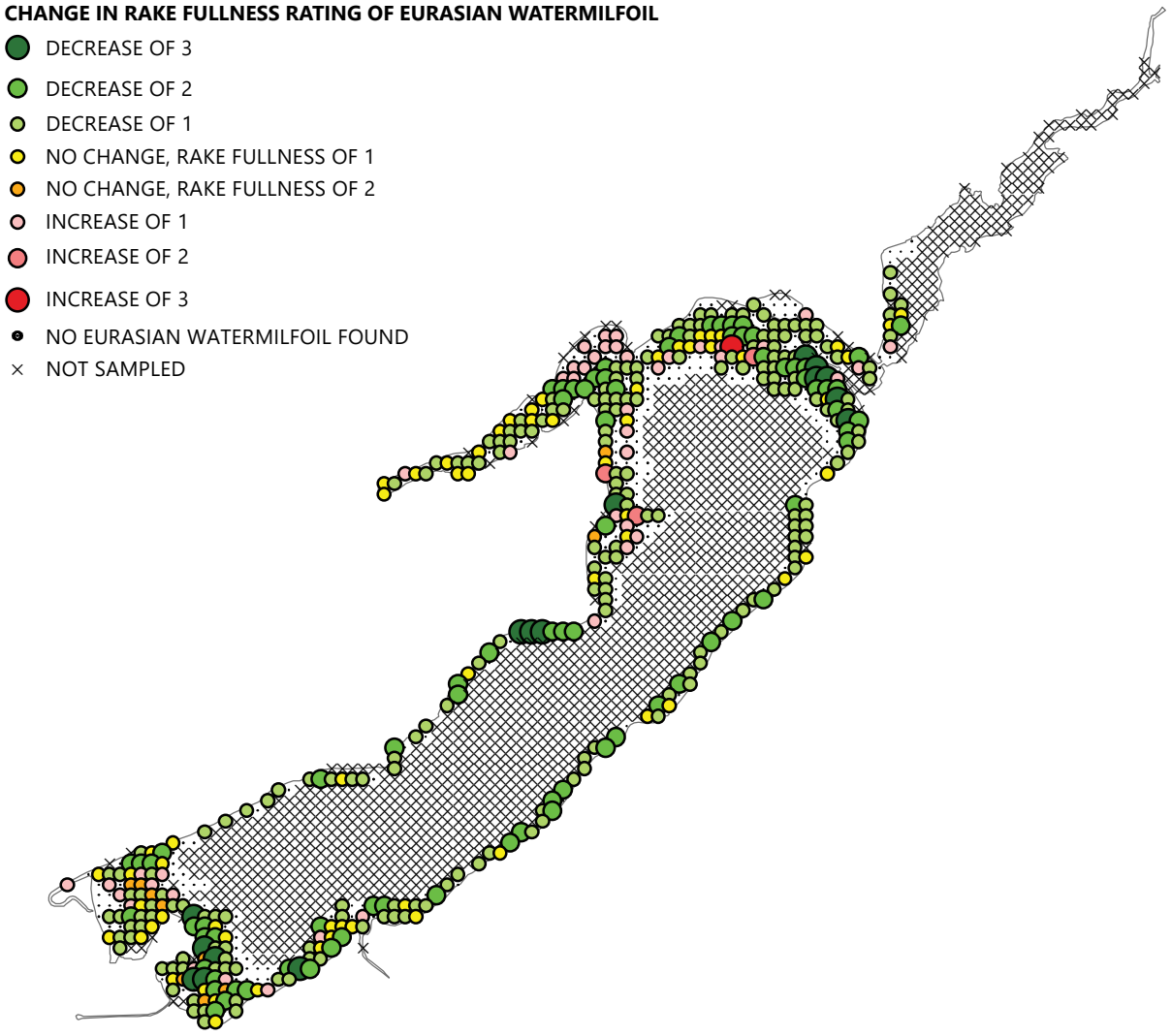
[17] *S.R. Carpenter,* "*The Decline of* Myriophyllum spicatum *in a Eutrophic Wisconsin (USA) Lake,*" Canadian Journal of Botany, *58(5), 1980.*

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

[19] *S.R. Carpenter,* op. cit.

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

Figure 2.3
Change in Eurasian Watermilfoil, Delavan Lake: 2015 Versus 2020



Note: Samples were collected in Delavan Lake between August 17, and August 21, 2020.

Source: Wisconsin Department of Natural Resources and SEWRPC

More recently, mechanical aquatic macrophyte harvesting has been the primary aquatic plant control method used on the Lake and chemical treatments have been limited to mostly private property applications.[21] The volume of aquatic plants harvested each year varies substantially (Table 2.4). 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 the 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 900 pounds per cubic yard.

[21] *See earlier reports for historic chemical treatment records: SEWRPC Community Assistance Planning Report No. 253,* A Lake Management Plan for Delavan Lake, Walworth County, Wisconsin*, May 2002; SEWRPC Memorandum Report No. 190,* An Aquatic Plant Management Plan for Delavan Lake, Walworth County, Wisconsin, 2nd Edition*, May 2011; and Delavan Lake Sanitary District,* An Aquatic Plant Management Plan Update for Delavan Lake, Walworth County, Wisconsin*, 2017.*

- 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 wet weight is 6.7 percent of dry 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 other studies.[22, 23]

Using these methods, the Commission estimates that aquatic plant harvesting has removed nearly 20,500 pounds of phosphorus from the Lake during the 24 years for which plant harvest records are available (see Figure 2.4). Over the period of record, a mean of about 818 pounds of phosphorus were removed from the Lake each year. The WDNR's Presto-Lite tool estimates that the average total annual phosphorus load to the Lake is 7,748 pounds. Therefore, on average aquatic plant harvesting is removing about 11 percent of the phosphorus from the Lake than is contributed annually by runoff and tributary streams. However, during 2021 about 1,800 pounds of phosphorus were removed, which accounted for 23 percent of the annual load.

Table 2.4
Volume of Aquatic Plants Harvested from Delavan Lake: 1997-2021

Year	Plant Material Removed (cubic yards)	Equivalent Phosphorus Removal (pounds)
1997	3,835	931
1998	1,430	347
1999	1,765	428
2000	4,155	1,008
2001	2,869	696
2002	5,026	1,220
2003	5,949	1,444
2004	2,288	555
2005	4,177	1,014
2006	2,749	667
2007	1,332	323
2008	1,385	336
2009	1,746	424
2010	2,392	581
2011	1,864	452
2012	4,230	1,027
2013	2,717	659
2014	2,875	698
2015	4,891	1,187
2016	3,278	796
2017	4,634	1,125
2018	4,319	1,048
2019	3,845	933
2020	3,093	751
2021	7,406	1,797

Note: The mean annual total phosphorus removal is the average of three phosphorus removal calculations from studies on Pewaukee Lake by Wisconsin Lutheran College, a study on Whitewater and Rice Lakes, and a study in Minnesota.

Source: Delavan Lake Sanitary District

2.4 IDENTIFIED SENSITIVE AREAS

The WDNR has identified five sensitive areas in Delavan Lake (Map 2.1).[24] Sensitive Areas 1 and 2 occupy the northeastern inlet of Delavan Lake. Sensitive Area 3 is located in the northwestern corner, and Areas 4 and 5 are located in the southwestern corner of the Lake in Viewcrest and Highlands Bays.

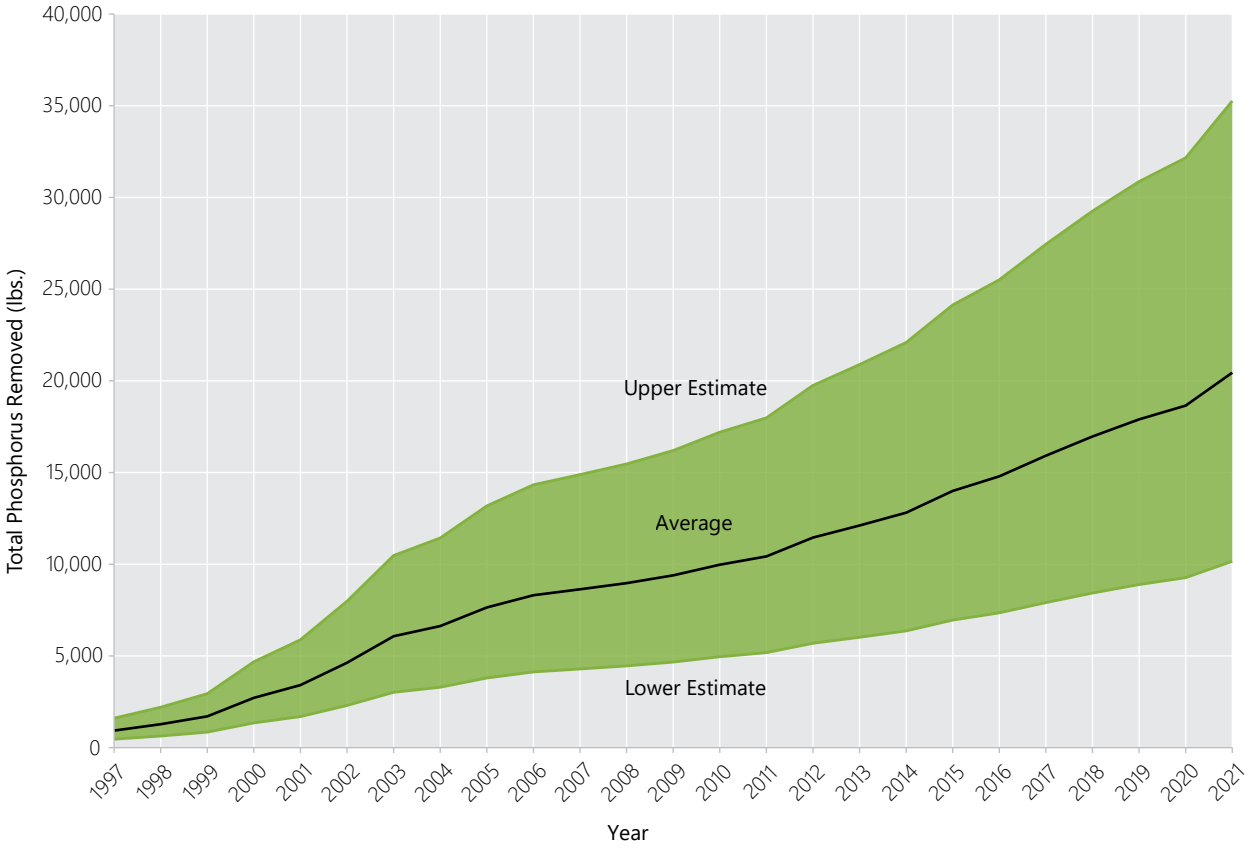
WDNR sensitive area reports include management recommendations and other information that both benefit and constrain aquatic plant management and riparian landowners. A copy of the sensitive area report for Delavan Lake is included in Appendix B. In general, the WDNR's management recommendations are designed to help maintain the valuable functions sensitive areas provide lakes. All sensitive areas trap sediment and nutrients and thereby help protect Delavan Lake's water quality. They also provide spawning, nursery, and foraging opportunities to native fish and are excellent habitat for waterfowl, furbearers, and

[22] *K.M. Carvalho and D.F. Martin, "Removal of Aqueous Selenium by Four Aquatic Plants,"* Journal of Aquatic Plant Management*, 39: 33-36, 2001.*

[23] *G. Thiébaut, "Phosphorus and Aquatic Plants." In: P.J. White and J.P. Hammond (eds), The Ecophysiology of Plant-Phosphorus Interactions,* Plant Ecophysiology, *7, 2008.*

[24] *The WDNR is granted authority to define sensitive areas under Section NR 107.05(3)(i) of the* Wisconsin Administrative Code.

Figure 2.4
Delavan Lake Cumulative Phosphorous Removal by Harvesting: 1997-2021



Note: The mean annual total phosphorus removal is the average of three phosphorous removal calculations from studies on Pewaukee Lake by Wisconsin Lutheran College, a study on Whitewater and Rice Lakes, and a study in Minnesota.

Source: Delavan Lake Sanitary District and SEWRPC

herptiles. However, protecting these areas requires limitations and restrictions be placed upon aquatic plant management. A few examples of these limitations and restrictions include the following:

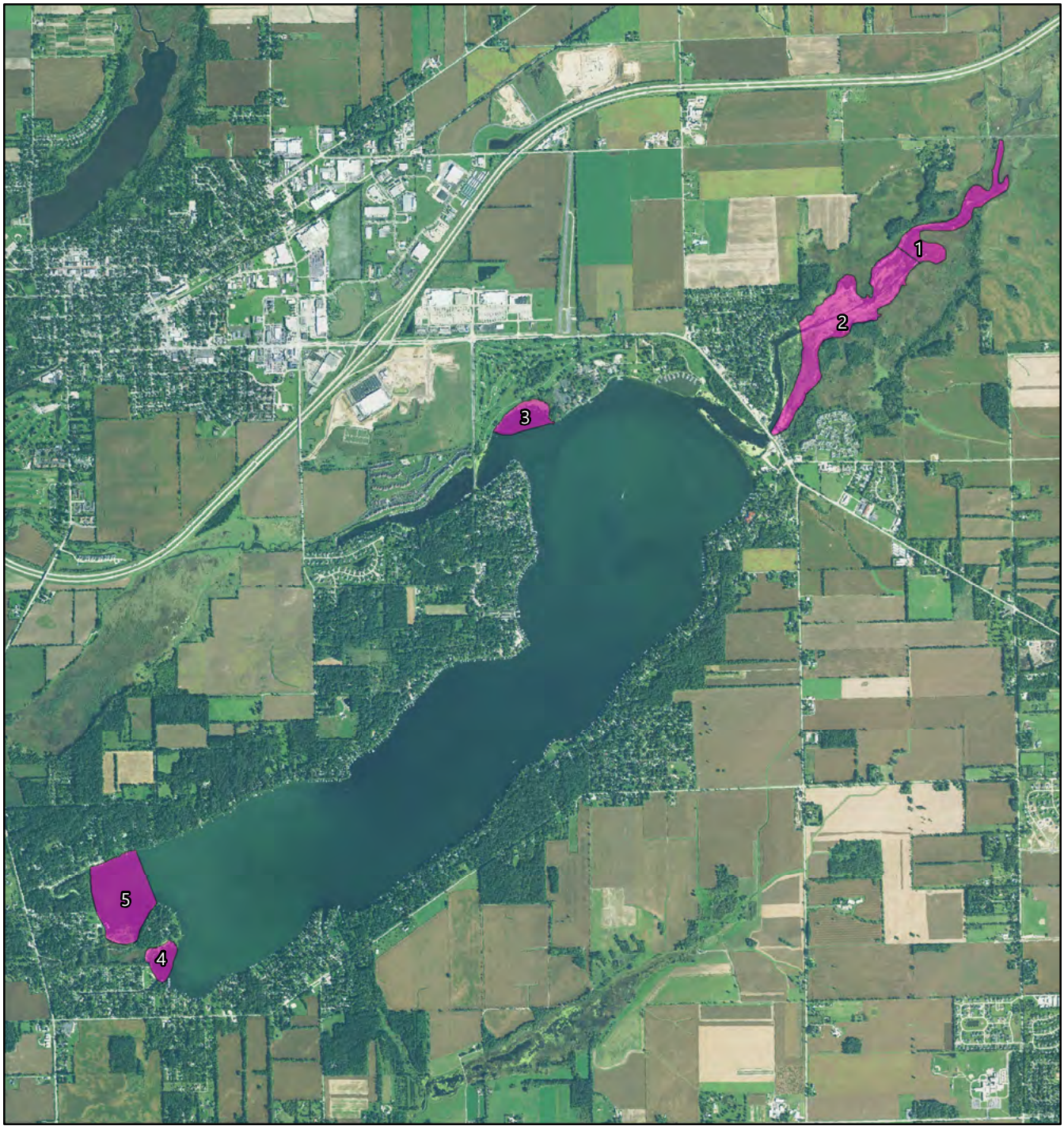
- No mechanical harvesting in Sensitive Areas 1 and 3
- Chemical treatment is only permitted in the designated Sensitive Areas to target infestations of exotic species such as purple loosestrife, EWM, or CLP
- Fallen trees along the shorelines in these Sensitive Areas should not be removed unless navigation is impaired, in which case the tree should be cut into smaller pieces and placed outside of boating lanes

2.5 CYANOBACTERIA, FLOATING ALGAE, DUCKWEEDS, AND WATERMEAL

Cyanobacteria and Algae

Algae is an important and healthy part of lake ecosystems. Algae is a foundational component of lake food chains and produces oxygen in the same way as rooted plants. Many forms of free-floating algae exist including single-cell, colonial, and filamentous algae (see Figure 2.5). Most algae strains are beneficial to lakes when present in moderate levels. However, the presence of toxic blue-green algal strains (also called cyanobacteria) and excessive growth patterns should be considered issues of concern (see Figure 2.6). As with aquatic plants, algae grows faster in the presence of abundant phosphorus (particularly in stagnant areas). Consequently, when toxic or high volumes of algae begin to grow in a lake, it often signifies phosphorus enrichment or pollution.

Map 2.1
WDNR-Designated Delavan Lake Sensitive Areas: 2020



1 SENSITIVE AREAS

N

0 2,000 4,000 Feet

Source: Wisconsin Department of Natural Resources and SEWRPC
Date of Photography: April 2015

Algae populations are quantified by abundance and composition. Suspended algal abundance is estimated by measuring lake-water chlorophyll-*a* concentration. High concentrations are often associated with green-colored water. Samples also can be examined to determine if the algae is toxic or nontoxic. Although green-colored water was not seen on Delavan Lake during the 2020 aquatic plant survey, filamentous algae was found to be dense in the northern portion of the Lake (See Appendix A) and has been documented at high levels in previous studies.[25]

Duckweeds (Lemna spp. and Sprirodela polyrhiza)

Small duckweeds (*Lemna minor*, *Lemna turionifera*, *Lemna perpusilla*, and *Lemna trisulca*), are small free-floating plants found in quiet waters (See Appendix A). Since they are free-floating, they are not dependent on water depth, sediment type, or water clarity. These can often be found in dense clusters near shorelines and in smaller bays of lakes where wind action is low or in small ponds. Duckweeds are often mistaken for algal blooms. However, they can become dense and present recreational restrictions as they make it difficult to discern water depth and potential recreational obstacles such as fallen trees or dense aquatic plant growth.

Greater duckweed (*Spirodela polyrhiza*) is very common in Wisconsin and is often found mixed with other duckweeds (*Lemna* spp.) and watermeals (*Wolffia* spp.). It tends to be larger than *Lemna* spp. and can be distinguished by a larger number of roots and a distinct purple color on the underside of its leaves.

Watermeals (Wolffia spp.)

Watermeals are the smallest flowering plants known. Three species are found in Wisconsin: *Wolffia borealis*, *Wolffia brasiliensis*, and *Wolffia columbiana*. These aquatic plants resemble tiny green beads floating on the water and are difficult to differentiate without a hand lens or light microscope. *Wolffia* species are free-floating, without roots, and are often found along shorelines and in bays mixed in with duckweed species (See Appendix A).

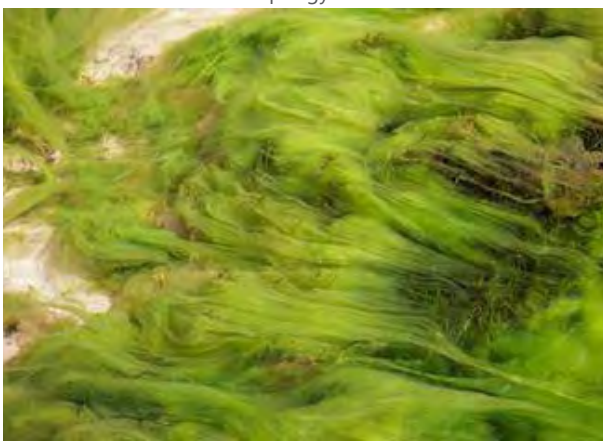
DLSD Control of these Species

At the time of this report publication DLSD was in the progress of addressing the density of these species around the Lake. A pilot program using suction harvesting was tested at the Community Park Public Boat Launch and the Public Beach in 2021. This program will be evaluated for potential use in future projects that could include areas such as the inlet and outlet to Delavan Lake, View Crest Channel, and the High Lands Channel beach area (Map 2.2). For further information on these efforts see Appendix C.

Figure 2.5
Common Types of Non-Toxic Algae

Hydrodictyon

Spirogyra



Chlamydomonas

Source: (1) Lewis Lab (2) University of New Mexico
(3) Taranaki Regional Council & Landcare Research

[25] *Delavan Lake Sanitary District,* An Aquatic Plant Management Plan Update for Delavan Lake, Walworth County, Wisconsin*, 2017*; *Aron & Associates*, Delavan Lake Aquatic Plant Survey, *2008*.

2.6 PURPLE LOOSESTRIFE

Purple loosestrife (*Lythrum salicaria*) is a wetland plant that originated in Europe. The plant was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the state, and has been recorded in 70 of Wisconsin's 72 counties. It can often be mistaken for native species such as blue vervain (*Verbena hastata*) and swamp loosestrife (*Decodon vertiillatus)* (Appendix A).

Purple loosestrife is a three to nine foot semi-woody plant that has a square stem with smooth, opposite leaves. It has showy purple to pink flowers with five to six petals that are formed into numerous long spikes that bloom from July to September. It also has a large woody taproot with fibrous rhizomes that form a dense underground mat. Its optimal habitat includes marshes, stream and lake edges, and wet prairies.

This plant species can germinate in a variety of soil types, although optimum sites for growth include moist soil with neutral to slightly acidic pH. It spreads mainly by seeds, but also by its large underground taproot. Mature plants can release more than two million seeds in a single year. Plants may be quite large and several years old before they begin flowering. It is difficult to look for non-flowering plants, so the best time to spot purple loosestrife is mid-summer when they are flowering.

Figure 2.6
Appearance of Toxic Algae Blooms

Microcystis

Cylindrospermopsis

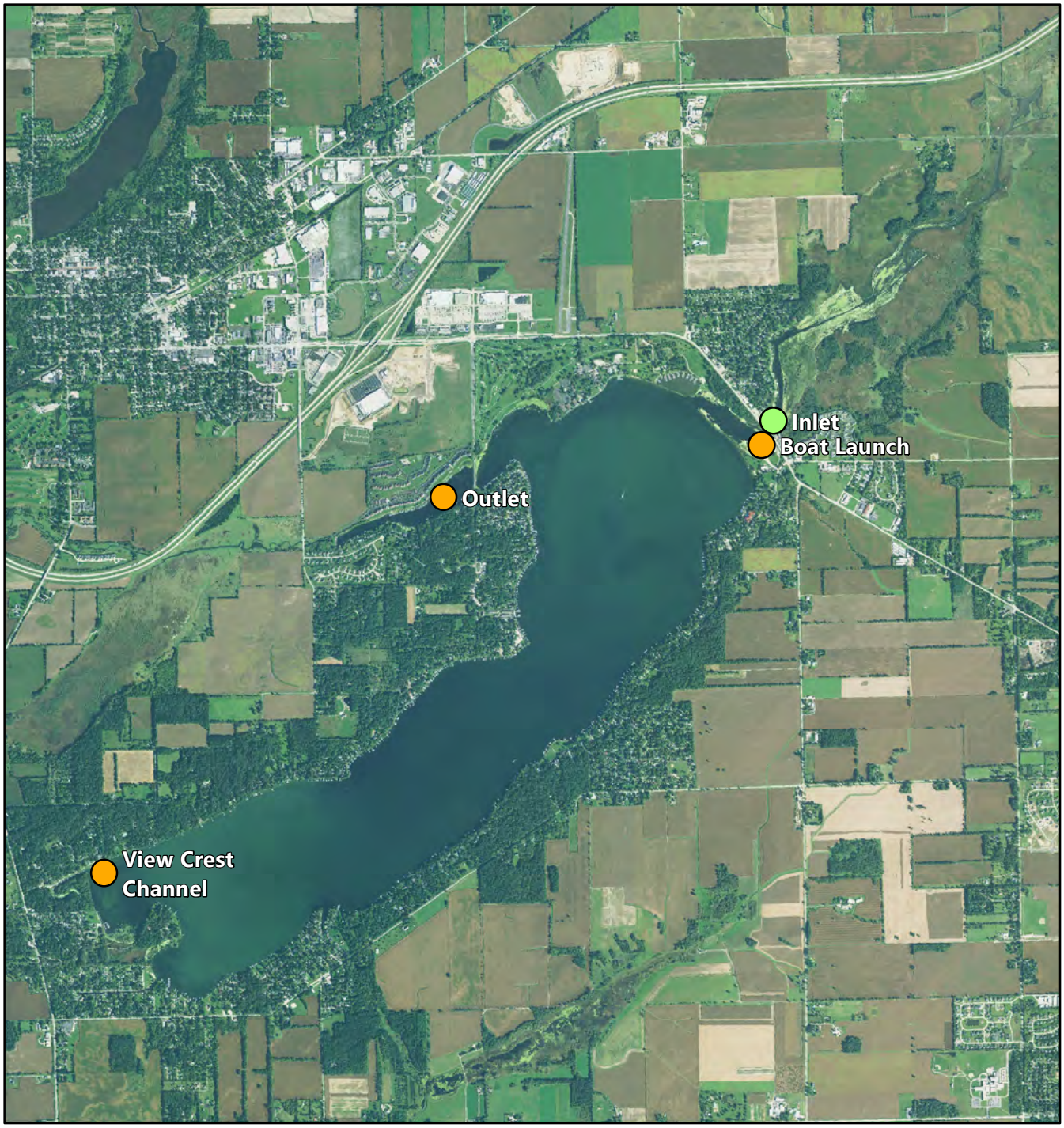
Source: (1) National Oceanic and Atmospheric Administration
(2) St. John's River Water Management District

Often, purple loosestrife grows faster and taller than most native wetland plants. Once established on a lakeshore or adjacent wetland, it displaces native plants and reduces wildlife habitat. As native vegetation is displaced, rare plants are often the first to disappear. Thick stands of purple loosestrife can choke out recreational waterways, and eventually overrun large acres of wetlands. This can result in a loss of open water habitat.

Prevention is the best way to control the spread of purple loosestrife. Small young plants can be hand pulled, while older and taller plants can be dug up with a shovel. It is important to try to dig up as much of the root as possible because it may re-sprout. Plants should be controlled prior to seed dispersal (usually before the first week in August), and flowers should be cut and tightly bagged. Glyphosate (Round Up/ Rodeo) is the most commonly used chemical for killing loosestrife. It should be applied in late July or August and should only be sprayed on 25 percent of each plant's foliage to be effective. It is best used on freshly cut stems. Any herbicide applied on or near surface water requires a permit from the regional WDNR Aquatic Plant Coordinator.

Biological control is considered the most effective and cheapest option for controlling larger-scale infestations of purple loosestrife. Purple loosestrife beetles and their larvae (*Galerucella calmariensis* and *G. pusilla*) feed almost exclusively on loosestrife buds, stems, and leaves, reducing plant height and seed output, thereby allowing native plants to successfully grow within a few years. Beetle populations remain relatively localized, and it may take three to five years for the beetle population to build up to levels that will affect the purple loosestrife plant population. Periodic beetle re-stocking may be required to maintain high genetic diversity and account for winter die-offs. Use of chemical treatments should not be combined with this method because purple loosestrife beetles are very susceptible to chemical pesticides.

Map 2.2
Current and Potential Duckweed, Watermeal, and Algae Skimming Locations on Delavan Lake: 2022



CURRENT HARVESTING LOCATION

POSSIBLE HARVESTING LOCATION

N

0 2,000 4,000 Feet

Source: Wisconsin Department of Natural Resources and SEWRPC
Date of Photography: April 2015

The rearing of new beetle populations has been the focus of many citizen and classroom based projects throughout Wisconsin. Written protocol for successful and economical beetle rearing has been established (Appendix D) and can be facilitated through the county Aquatic Invasive Species Coordinator.

2.7 ADDITIONAL AQUATIC INVASIVE SPECIES

Sacred Lotus (*Nelumbium speciosum*, *Nelumbo nucifera*, and *Nelumbium nelumbo*)

Sacred lotus has been classified as a prohibited species in Wisconsin under *Wisconsin Administrative Code* NR 40 and was found in the Delavan Lake inlet in the fall of 2010. A rapid response grant was implemented for removal and DLSD continues to actively monitor for this species on a monthly basis at Geneva Landings and remove it as needed (Map 2.3).

Dense mats of this species, which resemble native water lilies, can inhibit other native aquatic vegetation and decrease biodiversity. Large growths of this aquatic plant can also negatively impact wildlife habitat and human recreational activities.

Individual flowers can emerge up to 6 inches above the water surface. Each flower is 4 to 10 inches across, with approximately 15 pink petals and a golden yellow center receptacle shaped like an inverted cone (Figure 2.7). This plant flowers during the summer months but its flowers are short-lived opening in the morning and losing petals by afternoon. Each flower is replaced by a seedpod spanning 3 to 5 inches across and 3/4 to 1 inch deep. At the end of the growing season, seedpods bend down to release seeds into the water.

Yellow Floating Heart (*Nymphoides peltata*)

Yellow floating heart is also a prohibited species under *Wisconsin Administrative Code* NR 40. It grows in dense patches, excluding native species and even creating stagnant areas with low oxygen levels underneath the floating mats. This plant's dense growth can make recreational activities such as fishing, swimming, and canoeing difficult, if not impossible.

This species was found in stormwater ponds near the Delavan Lake outlet in 2008. A rapid response grant was obtained, and the species was removed. DLSD continues to monitor for yellow floating heart however it has not been found in the Lake (Map 2.3).

This plant resembles native yellow water lilies, or spatterdock (*Nuphar variegata*). However, yellow floating heart leaves are heart-shaped and are much smaller, approximately 1 to 4 inches wide across. Unlike the cup-shaped flowers of spatterdock, yellow floating heart flowers are bright yellow and have five petals with a distinctive fringe along the edges (see Figure 2.8).

Pennywort (*Hydrocotyle ranunculoides*)

Another species prohibited under *Wisconsin Administrative Code* NR 40 is pennywort (Figure 2.9). This plant was initially found and treated in the Delavan Lake inlet in fall 2010. It has since been found at several locations throughout the Lake. DLSD actively monitors for pennywort throughout the growing season and removes it when found (Map 2.4).

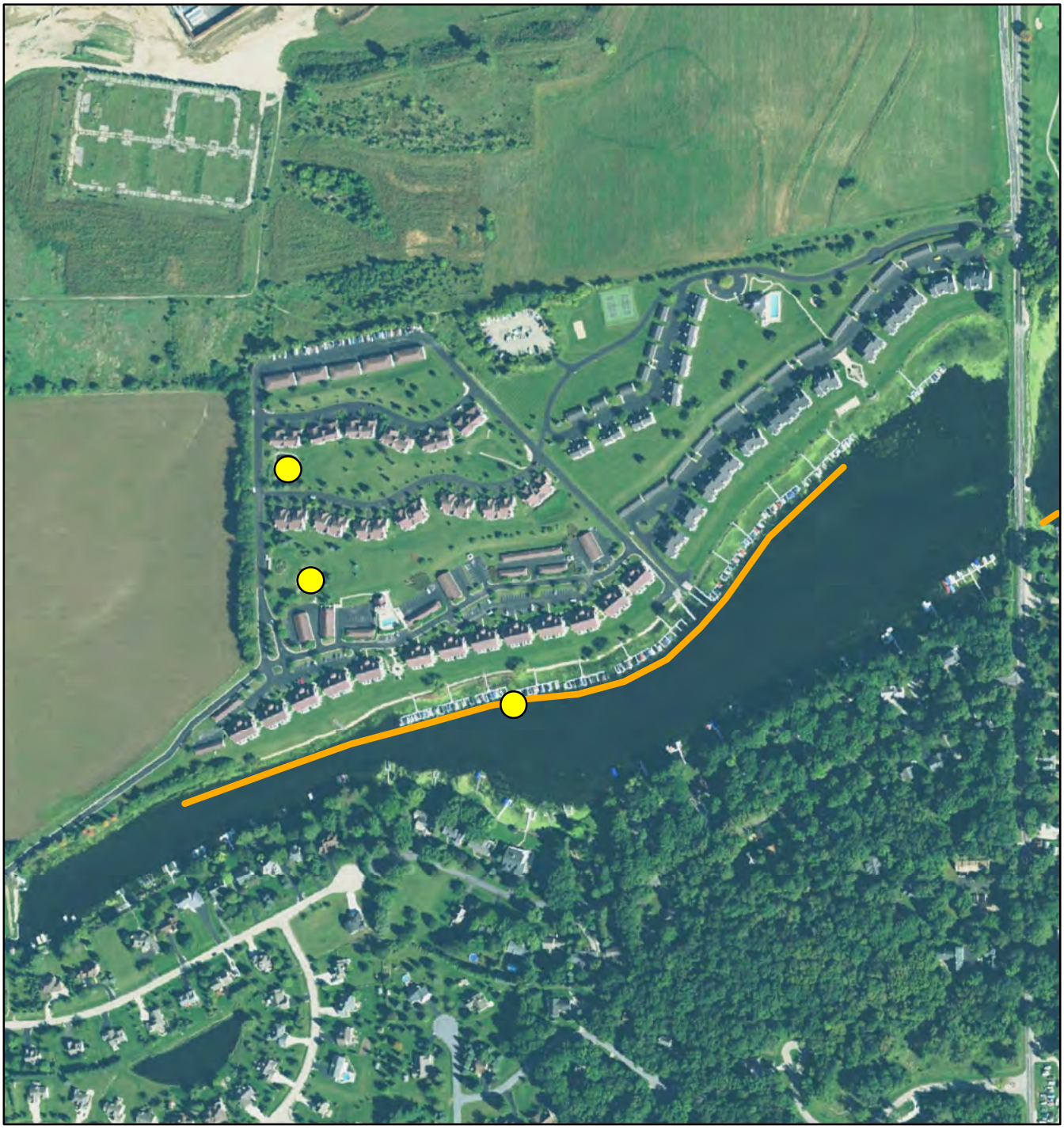
This plant can grow extremely fast and create dense floating beds of leaves. These dense patches can exclude native submerged species by blocking sunlight and can even create stagnant areas with low oxygen levels underneath the floating mats. This plant's dense growth can make recreational activities difficult.

Starry Stonewort (*Nitellopsis obstusa*)

Finally, DLSD is monitoring for starry stonewort, a novel aquatic invasive macroalga species in Wisconsin. First observed within Wisconsin in Little Muskego Lake during September 2014, SSW has since been found in 17 lakes and rivers in Southeastern Wisconsin including Geneva Lake.[26] Geneva Lake is the only lake in Walworth County with verified observations of SSW. This species can form dense beds, with reported maximum heights of 4 to 7 feet, outcompete both native and other invasive plant species, and cover

[26] *dnr.wi.gov/lakes/invasives/AISLists.aspx?species=STARRY_STONEW*

Map 2.3
Current Sacred Lotus and Yellow Floating Heart Monitoring Locations on Delavan Lake: 2022



YELLOW FLOATING HEART MONITORING LOCATION

SACRED LOTUS MONITORING AREA

N

0 280 560 Feet

Source: Wisconsin Department of Natural Resources and SEWRPC
Date of Photography: April 2015

fish spawning areas.[27,28,29] This species is capable of both sexual and asexual reproduction, which can occur through plant fragments as well as the star-shaped bulbils for which the species is named (see Figure 2.10).[30] Only male species have been observed in North America thus far, indicating that all spread has been through asexual reproduction. Bulbils may stay viable in lake sediment for several years, making it extremely difficult to eradicate SSW from a waterbody. At the time of this report, starry stonewort had not been reported in Delavan Lake.

Figure 2.7
Sacred Lotus (*Nelumbo nucifera*)

Source: Delavan Lake Sanitary District

2.8 POTENTIAL AQUATIC PLANT CONTROL METHODOLOGIES

Aquatic plant management techniques can be classified into six categories.

1. *Physical measures* include lake bottom coverings.

2. *Biological measures* include the use of organisms such as herbivorous insects.

3. *Manual measures* involve physically removing plants by hand or using hand-held tools such as rakes.

4. *Mechanical measures* rely on artificial power sources and remove aquatic plants with a machine known as a harvester or by suction harvesting. On Delavan Lake this will include the following:

    a. Surface water suctioning for algae, duckweed (*Lemna* spp. and *Spirodela* spp.), and watermeal (*Wolffia* spp.) removal (See Appendix C for more information).

    b. Mechanical harvesting with fine mesh for duckweed and watermeal removal.

    c. Continued investigation of new technology of harvesting equipment and management techniques.

    d. A continued relationship with manufacturers to increase productivity and efficiency of harvesting.

5. *Chemical measures* use aquatic herbicides to kill nuisance and nonnative plants *in-situ*.

6. *Water level manipulation measures* use lake drawdowns to kill aquatic plants through freezing and desiccation.

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

[27] Ibid.

[28] *dnr.wisconsin.gov/sites/default/files/topic/Invasives/Nitellopsis%20obtusa.pdf*

[29] *G.D. Pullman and G. Crawford, "A Decade of Starry Stonewort in Michigan,"* Lakeline *36-42, 2010.*

[30] *dnr.wisconsin.gov/topic/Invasives/fact/StarryStonewort.html*

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." More details about aquatic plant management each 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 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]

Figure 2.8
Yellow Floating Heart (*Nymphoides peltata*)

Source: Lyn Gettys - UF/IFAS

Figure 2.9
Pennywort (*Hydrocotyle ranunculoides*)

Source: Wisconsin Department of Natural Resources

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 have been used to control EWM. Milfoil weevils do best in waterbodies with balanced panfish populations,[35]

[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.*

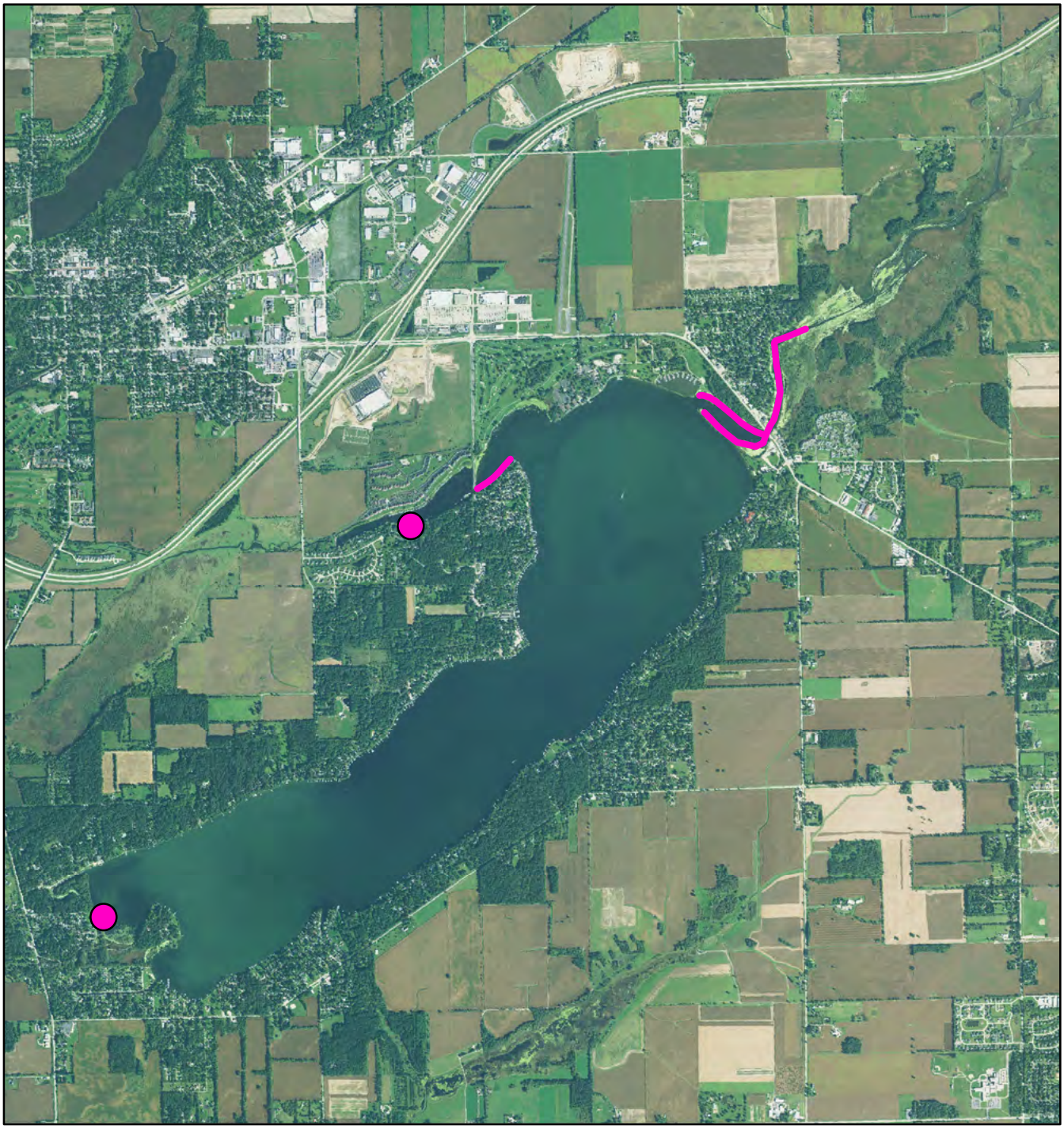
[32] *Aquatic plant harvesters must report harvesting activities as one of the permit requirements.*

[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, 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, (eds),* 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.*

Map 2.4
Current Pennywort Monitoring and Treatment Locations on Delavan Lake: 2022



PENNYWORT MONITORING SITE

PENNYWORT MONITORING AREA

N

0 2,000 4,000 Feet

Source: Wisconsin Department of Natural Resources and SEWRPC
Date of Photography: April 2015

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.

Figure 2.10
Starry Stonewort (*Nitellopsis obtusa*)

Note: Note the small, star-shaped white bulbils

Source: Paul Skawinski

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 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. Since hand raking and hand pulling are readily allowed by WDNR, and since both are practical methods to control riparian landowner scale problems, these methods are described in more detail in the following paragraphs.

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

- Tools are relatively 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)

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, CLP) during the high growth season when native and nonnative species often commingle. 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.[36]

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

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

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.

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 very early in the season (e.g., EWM, CLP) 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 CLP. 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,[37] 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 ultimately reduce regrowth of nuisance plants while maintaining, or even enhancing, native plant communities.

Cut plant fragments can escape the harvester's collection system and form mats or accumulate on shorelines. This negative side effect is fairly common. 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 and DASH

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.

An alternative aquatic plant suction harvesting method has emerged called Diver Assisted Suction Harvesting (DASH). 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 essentially a mechanically assisted method for

[37] *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.*

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. 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 techniques and hand raking which in turn reduces native plant loss; and 3) lower potential for disturbing fish habitat.

Given how costly DASH can be and how widespread EWM is found in the Lake, DASH is not considered a viable control option for managing EWM. Nevertheless, DASH can provide focused relief of nuisance native and non-native plants around piers and other critical areas. If individual property owners chose to employ DASH, a NR 109 permit is required.

Chemical Measures

Aquatic chemical herbicide use is stringently regulated. A WDNR permit and direct WDNR staff oversight is required during application. Chemical herbicide treatment is used for short time periods to temporarily control excessive nuisance aquatic plant growth. Chemicals are applied to growing plants in either liquid or granular form. Advantages of chemical herbicides aquatic plant growth control include relatively low cost as well as the ease, speed, and convenience of application. However, many drawbacks are also associated with chemical herbicide aquatic plant control including the following examples.

- **Unknown and/or conflicting evidence about the effects of long-term chemical exposure on fish, fish food sources, and humans.** The U.S. Environmental Protection Agency, the agency responsible for approving aquatic plant treatment chemicals, studies aquatic plant herbicides to evaluate short-term exposure (acute) effects on human and wildlife health. Some studies also examine long-term (chronic) effects of chemical exposure on animals (e.g., the effects of being exposed to these herbicides for many years). However, it is often impossible to conclusively state that no long-term effects exist due to the animal testing protocol, time constraints, and other factors. Furthermore, long-term studies cannot address all potentially affected species.[38] For example, conflicting studies/opinions exist regarding the role of the chemical 2,4-D as a human carcinogen.[39] Some lake property owners judge the risk of using chemicals as being excessive despite legality of use. Consequently, the concerns of lakefront owners should be considered whenever chemical treatments are proposed. Moreover, if chemicals are used, they should be applied as early in the season as practical. This helps assure that the applied chemical decomposes before swimming, water skiing, and other active body-contact lake uses begin.[40] Early season application also is generally the best time to treat EWM and CLP for a variety of technical reasons explained in more detail as part of the "loss of native aquatic plants and related reduction or loss of desirable aquatic organisms" bullet below.

- **Reduced water clarity and increased risk of algal blooms.** Water-borne nutrients promote growth of both aquatic plants and algae. If rooted aquatic plant populations are depressed, demand for dissolved nutrients will be lessened. In such cases, algae tends to become more abundant, a situation reducing water clarity. For this reason, lake managers must avoid excessive chemical use and needlessly eradicating native plants. Lake managers must strive to maintain balance between rooted aquatic plants and algae - when the population of one declines, the other may increase in abundance to nuisance levels. In addition to upsetting the nutrient balance between rooted aquatic plants and algae, dead chemically treated aquatic plants decompose and contribute nutrients to lake water, a condition that may exacerbate water clarity concerns and algal blooms.

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[38] *U.S. Environmental Protection Agency, EPA-738-F-05-002, 2,4-D RED Facts, June 2005.*

[39] *M.A. Ibrahim, G.G. Bond, T.A. Burke, et al., "Weight of the Evidence on the Human Carcinogenicity of 2,4-D,"* Environmental Health Perspectives*, 96, 213-222, 1991.*

[40] *Though the manufacturers indicate that swimming in 2,4-D-treated lakes is allowable after 24 hours, it is possible that some swimmers may want more of a wait time to lessen chemical exposure. Consequently, allowing extra wait time is recommended to help lake residents and lake users can feel comfortable that they are not being unduly exposed to aquatic plant control chemicals.*

- **Reduced dissolved oxygen/oxygen depletion.** When chemicals are used to control large mats of aquatic plants, the dead plant material generally settles to the bottom of a lake and decomposes. Plant decomposition uses oxygen dissolved in lake water, the same oxygen that supports fish and many other vital beneficial lake functions. In severe cases, decomposition processes can deplete oxygen concentrations to a point where desirable biological conditions are no longer supported.[41] Ice covered lakes and the deep portions of stratified lakes are particularly vulnerable to oxygen depletion. Excessive oxygen loss can inhibit a lake's ability to support certain fish and can trigger processes that release phosphorus from bottom sediment, further enriching lake nutrient levels. These concerns emphasize the need to limit chemical control and apply chemicals in early spring, when EWM and CLP have not yet formed dense mats.

- **Increased organic sediment deposition.** Dead aquatic plants settle to a lake's bottom, and, because of limited oxygen and/or rapid accumulation, may not fully decompose. Flocculent organic rich sediment often results, reducing water depth. Care should be taken to avoid creating conditions leading to rapid thick accumulations of dead aquatic plants so as to promote more complete decomposition of dead plant material.

- **Loss of native aquatic plants and related reduction or loss of desirable aquatic organisms.** EWM and other invasive plants often grow in complexly intermingled beds. Additionally, EWM is physically similar to, and hybridizes with, native milfoil species. Native plants, such as pondweeds, provide food and spawning habitat for fish and other wildlife. A robust and diverse native plant community forms the foundation of a healthy lake and the conditions needed to provide and host desirable gamefish. Fish, and the organisms fish eat, require aquatic plants for food, shelter, and oxygen. If native plants are lost due to herbicide application, fish and wildlife populations often suffer. For this reason, if chemical herbicides are applied to the Lake, these chemicals must target EWM or CLP and therefore should be applied in early spring when native plants have not yet emerged. Early spring application has the additional advantage of being more effective due to colder water temperatures, a condition enhancing herbicidal effects and reducing the dosing needed for effective treatment. Early spring treatment also reduces human exposure concerns (e.g., swimming is not particularly popular in very early spring).

- **Need for repeated treatments.** Chemical herbicides are not a one-time silver-bullet solution – instead, treatments generally need to be regularly repeated to maintain effectiveness. Treated plants are not actively removed from the lake, a situation increasing the potential for viable seeds/fragments to remain after treatment, allowing target species resurgence in subsequent years. Additionally, leaving large expanses of lake bed devoid of plants (both native and invasive) creates a disturbed area without an established plant community. EWM thrives in disturbed areas. In summary, applying chemical herbicides to large areas can provide opportunities for exotic species reinfestation and new colonization that necessitates repeated and potentially expanded herbicide applications.

- **Hybrid watermilfoil's resistance to chemical treatment**. The presence of hybrid watermilfoil complicates chemical treatment programs. Research suggests that certain hybrid strains may be more tolerant to commonly utilized aquatic herbicides such as 2,4-D and Endothall.[42,43] Consequently, further research regarding hybrid watermilfoil treatment efficacy is required to apply appropriate herbicide doses. This increases the time needed to acquire permits and increases application program costs. Hybrid watermilfoil was verified to exist in Delavan Lake in 2014.

- **Effectiveness of small-scale chemical treatments**. Small-scale EWM treatments using 2,4-D have yielded highly variable results. A study completed in 2015 concluded that less than half of 98

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[41] *The WDNR's water quality standard to support healthy fish communities is 5 mg/L for warmwater fish communities and 7 mg/L for coldwater fish communities.*

[42] *L.M. Glomski and M.D. Netherland, "Response of Eurasian and Hybrid Watermilfoil to Low Use Rates and Extended Exposures of 2,4-D and Triclpyr",* Journal of Aquatic Plant Management, *48, 12-14, 2010.*

[43] *E.A. LaRue, M/P/ Zuellig, M.D. Netherland, et al., 'Hybrid Watermilfoil Lineages are More Invasive and Less Sensitive to a Commonly Used Herbicide than Their Exotic Parent (Eurasian Watermilfoil),"* Evolutionary Applications*, 6, 462-471, 2013.*

treatment areas were effective, or had more than a 50 percent EWM reduction.[44] For a treatment to be effective, a target herbicide concentration must be maintained for a prescribed exposure time. However, wind, wave, and other oftentimes difficult to predict mixing actions often dissipate herbicide doses. Therefore, when deciding to implement small-scale chemical treatments, the variability in results and treatment cost of treatment should be examined and contrasted.

Considering the expanse of EWM and the size of Delavan Lake, a whole-lake treatment, or large spot treatment would be too costly.[45] However, small spot treatments enclosed with a barrier (e.g., turbidity barrier) could be a viable alternative for treating shoreline areas and navigation lanes if determined feasible by DLSD. Whatever the case, monitoring should continue to ensure that EWM does not become more problematic. If further monitoring suggests a dramatic change in these invasive species populations, management recommendations should be reviewed.

Water Level Manipulation

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.[46] In Wisconsin, water level manipulation is generally 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 long 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 generally 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 (*Nymphaea* spp. and *Nuphar* spp.) and milfoils (*Myriophyllum* spp.) can be greatly reduced by winter drawdowns while other species, such as duckweeds (*Lemna* spp.), may increase in abundance.[47] Two studies from Price County, Wisconsin show reduced abundance of invasive EWM and CLP and increased abundance of native plant species following winter drawdowns.[48,49] 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.[50]

Water level manipulation can also have unintended impacts on water chemistry and lake fauna.[51,52] 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

[44] *M. Nault, S. Knight, S. Van Egeren, et al., "Control of Invasive Aquatic Plants on a Small Scale,"* LakeLine*, 35: 35-39, 2015.*

[45] *WDNR has been studying the efficacy of spot treatments versus whole lake treatments for the control of EWM and it has been found that spot treatments are not an effective measure for reducing EWM populations, while whole lake treatments have proven effective depending on conditions.*

[46] *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.*

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

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

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

[50] *Blanke et al., op. cit.*

[51] Ibid.

[52] *Cooke, op. cit.*

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.

MANAGEMENT RECOMMENDATIONS AND PLAN IMPLEMENTATION 3

Credit: SEWRPC Staff

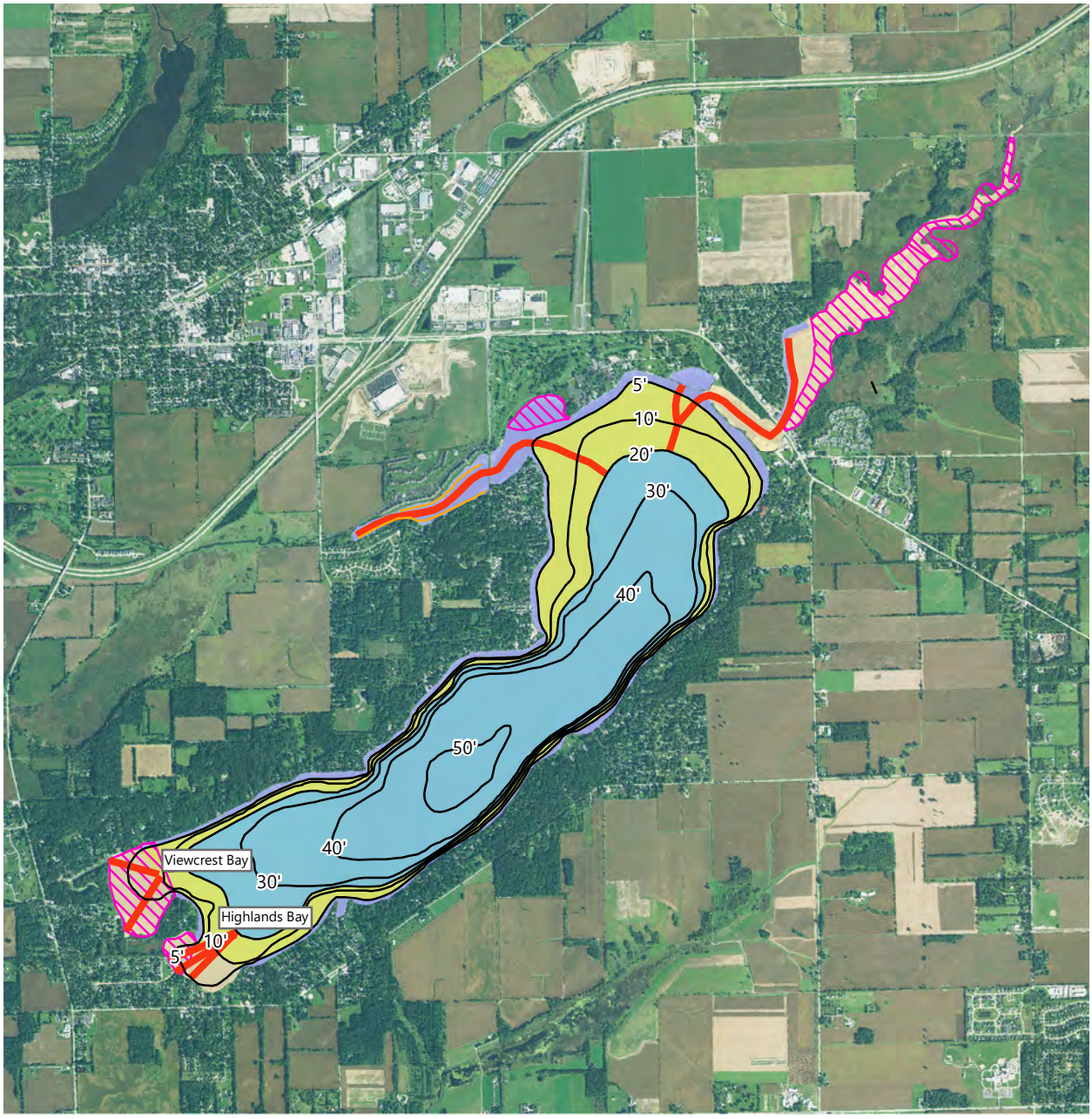
Delavan Lake generally contains a robust and fairly diverse aquatic plant community. Although EWM is present throughout the Lake and is more abundant in the southwestern bays, its density has reduced significantly. Furthermore, the Lake contains several WDNR-designated Sensitive Areas with a particularly rich array of sensitive and rare native aquatic plant species. On account of this and other factors, aquatic plant management continues to be an important approach to maintaining the excellent natural resource service the Lake provides.

Holistic management alternatives and recommended refinements to the existing aquatic plant management plan are presented in this chapter. Given the scope of this study, little emphasis is given to measures whose scope and location are more suitably taken up by other governmental agencies. For example, agencies with jurisdiction over areas tributary to the Lake (e.g., Town or County government) may be better suited to address measures to reduce nutrient inputs to the Lake. Reduced nutrient input can passively reduce aquatic plant abundance and thereby tangibly influence aquatic plant management. Nevertheless, to most effectively manage aquatic plants, DLSD should actively seek out and collaborate with such agencies.

3.1 RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN

The most effective plans to manage nuisance and invasive aquatic plant growth generally rely on a *combination* of methods and techniques. A single-minded "silver bullet" strategy rarely produces the most efficient, most reliable, or best overall result. Therefore, to enhance lake access, recreational use, and lake health, this plan recommends a combination of several aquatic plant management techniques. For the reader's convenience, the various elements of the recommended aquatic plant management plan are schematically presented (Figures 3.1, 3.2, and 3.3) and are briefly summarized in the following paragraphs. The WDNR will use data and conclusions generated as part of the Commission's study to help evaluate the Lake's aquatic plant community and draft the 2022 – 2026 Aquatic Plant Control permit which outlines WDNR-approved aquatic plant control practices. Additional details useful to implement the plant management plan follow this summary.

Figure 3.1
Recommended Aquatic Plant Management Plan for Delavan Lake: 2022



HABITAT: ECOLOGICALLY VALUABLE AREAS: NO AQUATIC PLANT MANAGEMENT RECOMMENDED DURING FISH SPAWNING SEASON

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

BOATING/RECREATION: SURFACE CUT EURASIAN WATERMILFOIL, HARVESTING MODERATE PRIORITY

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

SENSITIVE AREAS

—20'— WATER DEPTH CONTOUR IN FEET

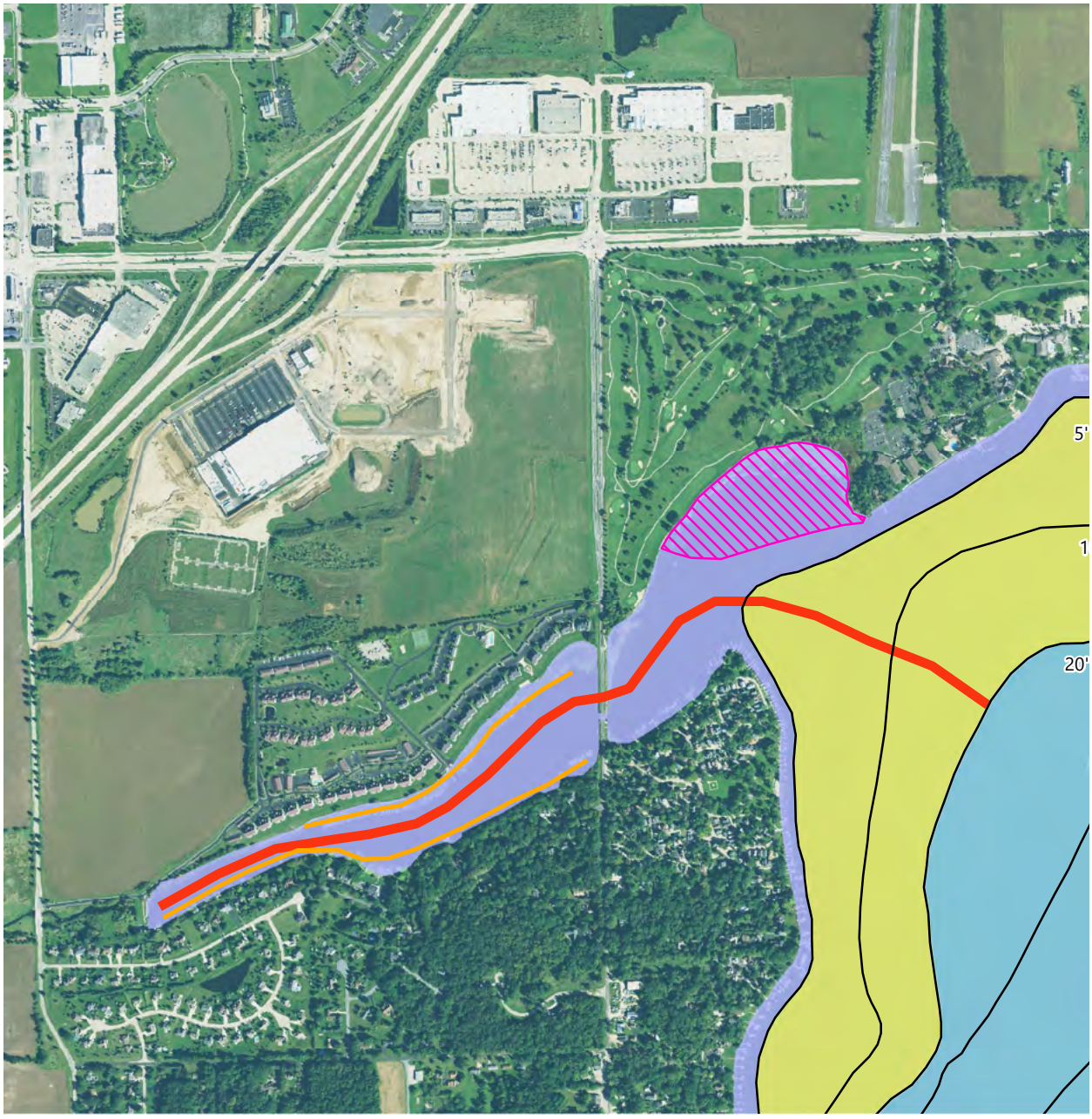
HARVESTING LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

HARVESTING LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 30 FEET WIDE AFTER JUNE 15TH

N

Note: Not to Scale
Source: Wisconsin Department of Natural Resources and SEWRPC
Date of Photography: April 2015

Figure 3.2
Recommended Aquatic Plant Management Plan for Northwest Bay of Delavan Lake: 2022



HABITAT: ECOLOGICALLY VALUABLE AREAS: NO AQUATIC PLANT MANAGEMENT RECOMMENDED DURING FISH SPAWNING SEASON

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

BOATING/RECREATION: SURFACE CUT EURASIAN WATERMILFOIL, HARVESTING MODERATE PRIORITY

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

SENSITIVE AREAS

—20'— WATER DEPTH CONTOUR IN FEET

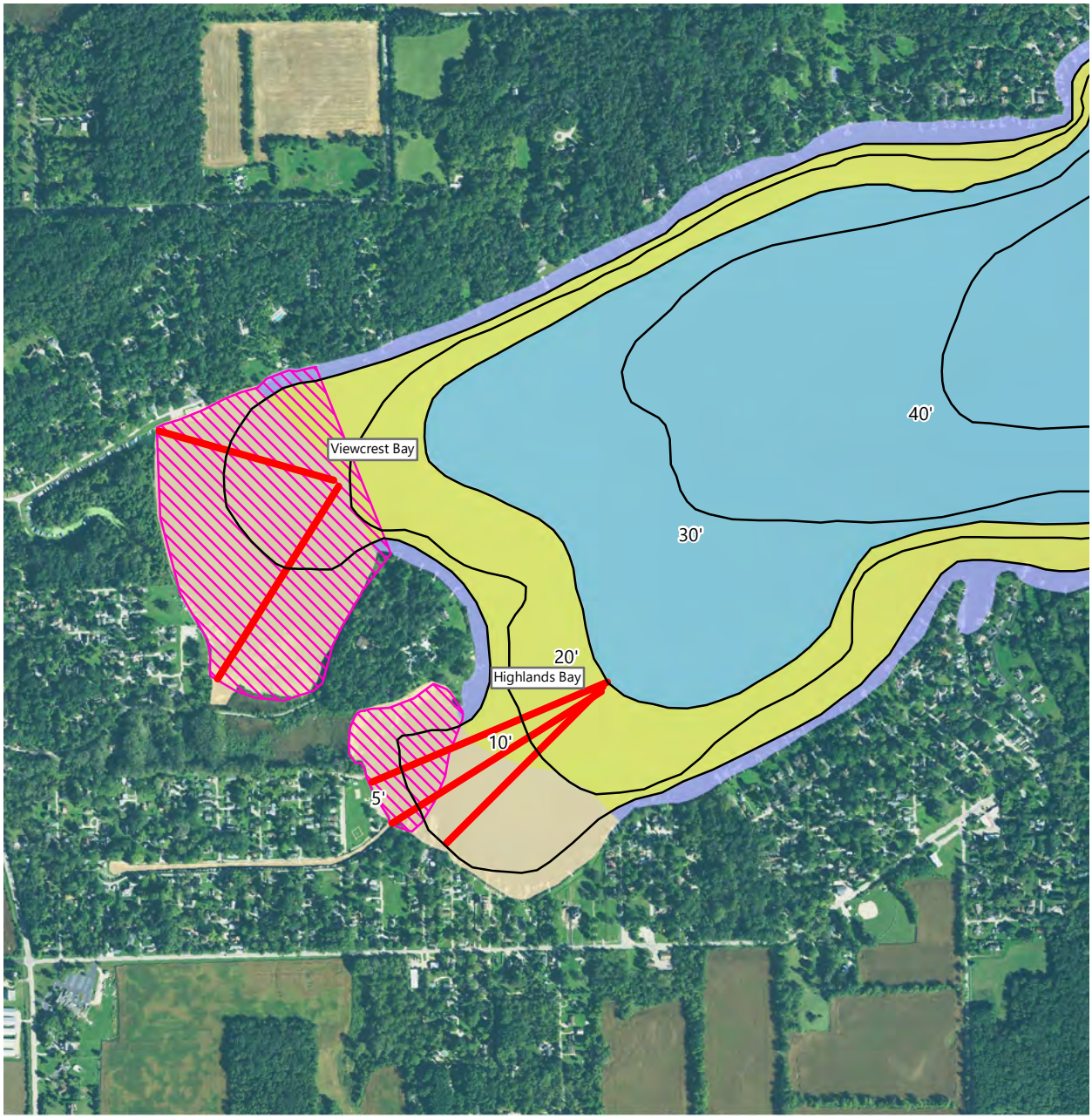
HARVESTING LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

HARVESTING LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 30 FEET WIDE AFTER JUNE 15TH

N

Note: Not to Scale
Source: Wisconsin Department of Natural Resources and SEWRPC
Date of Photography: April 2015

Figure 3.3
Recommended Aquatic Plant Management Plan for Southwest Bays of Delavan Lake: 2022



HABITAT: ECOLOGICALLY VALUABLE AREAS:
NO AQUATIC PLANT MANAGEMENT
RECOMMENDED DURING FISH SPAWNING SEASON

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

BOATING/RECREATION: SURFACE CUT EURASIAN WATERMILFOIL, HARVESTING MODERATE PRIORITY

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

SENSITIVE AREAS

—20'— WATER DEPTH CONTOUR IN FEET

HARVESTING LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

N

Note: Not to Scale
Source: Wisconsin Department of Natural Resources and SEWRPC
Date of Photography: April 2015

1. **Mechanically harvest invasive and nuisance aquatic plants.** Mechanical harvesting should remain the primary means to manage invasive and nuisance aquatic plants on Delavan Lake. Harvesting must avoid, or must be substantially restricted, in certain areas of the Lake. This includes areas of particular ecological value, areas that provide unique habitat, areas that are difficult to harvest due to lake morphology (e.g., excessively shallow water depth), and where boat access is not desired or necessary (e.g., marshland areas). Several DNR-designated sensitive areas are present in Delavan Lake, a situation restricting mechanical harvesting to lanes that protect sensitive areas yet allow riparian residents and boat launch users to access and navigate the Lake, engage in a variety of water-related recreational pursuits, and access open water areas. Care should be taken to avoid native aquatic plants especially pondweeds (*Potamogeton* spp.) and water lilies (*Nuphar variegata* and *Nymphaea odorata*). Harvesting should focus on areas of profuse invasive and nuisance (coontail and late season water celery) plant growth.

2. **Manually remove nearshore invasive and nuisance plant growth.** Manual removal involves controlling aquatic plants by hand or using hand-held non-powered tools. Riparian landowners should consider manual removal of undesirable plants an integral and vital part of the Lake's overall plant management plan. Manual removal is often the plan element that yields the transitional interface between landowner uses, desires, and concerns, and public management of the overall waterbody. Manual removal does not require a permit if riparian landowners remove only invasive plants without injuring native plants or remove nuisance native aquatic plants along 30 or less feet of shoreline (inclusive of dock, pier, and other lake access areas) and generally not more than 100 feet into the lake.

3. **Chemically treat nonnative plants around private piers**. Large-scale chemical treatment is not part of DLSD's aquatic plant management plan for a variety of reasons. Nevertheless, DLSD may want to consider a rapid response chemical treatment for Chapter NR 40 prohibited species (e.g., hydrilla, *Hydrilla verticillata)*, where appropriate, if such a species were to appear in the Lake in the future. Individual property owners with frontage not abutting designated sensitive areas may pursue a Chapter NR 107 permit to treat their shorelines. This method of aquatic plant control has a number of drawbacks (e.g., water quality, comparatively nonselective, chemical side effects, and more) and should only be considered under special circumstances. When employed, a physical barrier (e.g., turbidity barrier) should be used to reduce chemical dispersal.

4. **Use DASH in high-use, congested, nearshore areas.** Riparian landowners could supplement or supplant manual harvesting by using DASH. If an individual landowner chooses to implement DASH, the activity is typically confined to the same area undergoing manual aquatic plant control – it is not a method to increase the amount of lakefront undergoing active management. DASH requires a Chapter NR 109 permit.

5. **Continue participation in the Clean Boats Clean Waters program.** (a State program targeting invasive species prevention) to proactively encourage Lake users to clean boats and equipment before launching and using them in Delavan Lake.[53] This will help lower the probability of invasive species entering the Lake.

6. **Continue monitoring the Lake for invasive species.** The Lake should be monitored regularly for known invasive species such as EWM, CLP, sacred lotus, pennywort, and yellow floating heart and potential species such as starry stonewort.

    a. Public outreach, education, and resources for Lake residents on aquatic invasive species and best management practices is recommended.[54]

    b. DLSD staff will continue to collect aquatic invasive species specimens according to DNR protocols.

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

[54] *SEWRPC Community Assistance Planning Report No. 333,* Waukesha County Aquatic Invasive Species Strategic Plan, *February 2018.*

c. New aquatic invasive species found during monitoring should be reported to appropriate WDNR staff and followed up by collaboration with DLSD in order to determine best practices for treatment and/or removal.

7. **Algicides may be considered** in order to provide control of filamentous algae when there is a severe navigational obstruction within the Lake.

Mechanical Harvesting

DLSD operates four (Aquarius Systems brand) aquatic plant harvesters on the lake: (3) HM-420, (1) HM-220 and (1) Trans T-12 transport Barge. The HM- 420 harvesters are well suited to the open waters of the main lake and the outlet area. The HM-220 is best suited to the Delavan Lake Inlet area which is much shallower. In all areas of the lake including shallow waters, slow speed operation and extreme diligence must be taken to avoid contacting the lake bottom with the cutter head. In all areas, at least one foot of living plant material must remain attached to the lake bottom after cutting.

The approximate orientation and extent of proposed harvesting within Delavan Lake are similar to those published in the 2017 aquatic plant management plan. The general locations of harvesting are schematically illustrated in Figures 3.1, 3.2, and 3.3. The precise locations of the harvest lanes must be chosen carefully and must be maintained in a fixed position throughout the year to avoid unintentional disturbance to adjacent sensitive areas. Lane position should consider water depth, plant species present, lane use, and boating habits/practices on the Lake. For example, whenever possible, lanes should favor deeper water areas, should support the Lake's recreational uses, and should attempt to focus plant harvest on invasive species. Additional information regarding cutting patterns and depth is provided below.

1. **Except for navigational access lanes, harvesters must not be operated nearshore in water less than 36 inches deep**. Mechanical harvesting may possibly be expanded in shallow, obstacle-prone nearshore areas throughout the Lake if a small-scale harvester is available. Even though DLSD's harvesters may be able to navigate in waters as shallow as 12 inches when empty, at least 12 inches of plant growth should remain standing after harvesting. Therefore, aside from regulatory restrictions, mechanically harvesting aquatic plants in extremely shallow water (e.g., areas with less than 18 inches of water depth) is not practical.

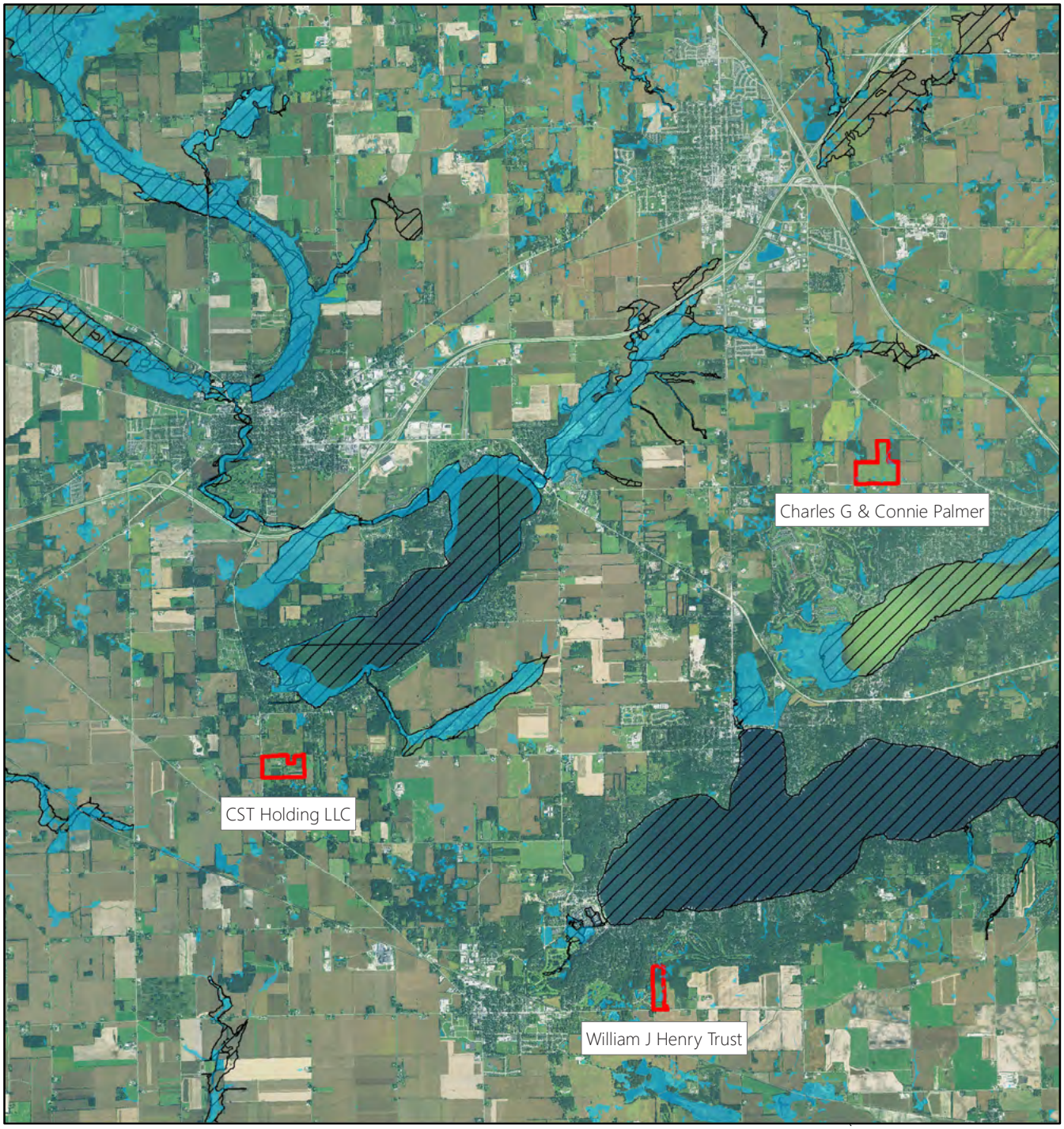
2. **Maintain at least 12 inches of living plant material after harvesting**. DLSD's current aquatic plant harvesters can cut aquatic plants up to five feet below the water surface. Harvesting equipment operators must not intentionally denude the lakebed. Instead, the goal of harvesting is to maintain and promote healthy native aquatic plant growth. Harvesting invasive aquatic plants can promote native plant regrowth since many invasive aquatic plants grow very early in the season depriving later emerging native plants of light and growing room.

3. **Collect and properly dispose harvested plants and collected plant fragments**. To this end, surface skimming is allowed in all locations except for WDNR Sensitive Areas. Outside of mapped areas, the harvester may surface skim free-floating vegetation that has been previously cut or uprooted, but not collected, to a depth of one foot. Use of the cutter head is not permitted for this action. In addition, plant cuttings and fragments must be immediately collected upon cutting to the extent practicable. Plant fragments accumulating along shorelines should be collected by riparian landowners. Fragments collected by the landowners can be used as garden mulch or compost.

   All harvested and collected plant material will be deposited at the DNR approved disposal sites: Charles G. Palmer and Connie Palmer property (parcel number J G 2000001); CST Holding, LLC property (parcel number E W 600007); and the William J. Henry Trust property (parcel number E W 2400004) (Maps 3.1 and 3.2). Disposing any aquatic plant material within identified floodplain and wetland areas is prohibited.

   Plant material will be collected and disposed daily to reduce undesirable odors and pests, to avoid leaching nutrients back into waterbodies, and to minimize visual impairment of lakeshore areas. Operators will stringently police the off-loading to assure efficient and neat operation.

Map 3.1
Delavan Lake Harvested Plant Disposal Sites



DISPOSAL LOCATION

IDENTIFIED WETLANDS

100-YEAR FLOODPLAIN

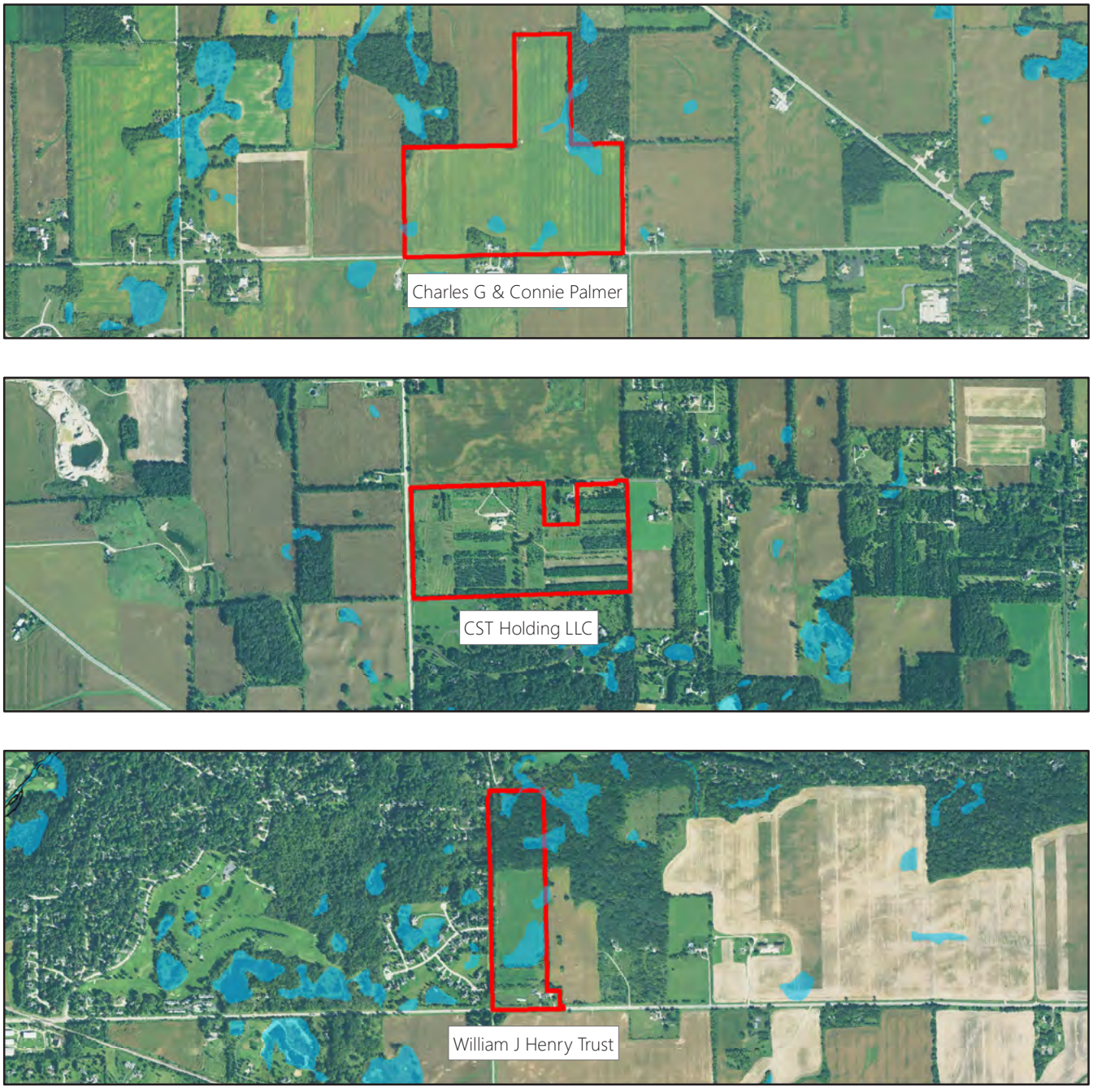
N

0 5,000 10,000 Feet

Date of Photography: May 2018

Source: Delavan Lake Management District, Wisconsin Department of Natural Resources, and SEWRPC

Map 3.2
Delavan Lake Harvested Plant Disposal Sites Continued



Date of Photography: May 2018

Source: Delavan Lake Management District, Wisconsin Department of Natural Resources, and SEWRPC

4. **Adapt harvester cutting patterns and depths to support lake use and promote ecological health**. Aquatic plant harvesting techniques should vary in accordance with the type and intensity of human recreational use, lake characteristics, the distribution and composition of aquatic plants, and other biological considerations. For example, in sensitive areas, relatively wide transit lanes connect boat launches, highly populated shorelines, and open-water areas. The approaches to employ in differing management areas are described below.

    a. Navigation Lanes are given high priority: Channels about 50-feet wide should be prioritized to maintain navigation access lanes to and from boat landings and common navigation lanes to provide travel thoroughfares for recreational watercraft. These channels generally parallel the shoreline. Plant cutting depths vary from 18 to 60 inches, as water depth allows. At least one foot of plant material must remain on the Lake bottoms to minimize resuspension of lake-bottom sediment and maintain desirable plant communities.

    b. Boating/Recreation Areas are given medium priority: These areas should be top cut to a maximum depth of three feet to control surface matting of EWM growth and promote native species growth. Again, at least one foot of plant material must remain on the Lake bottom to minimize resuspension of lake-bottom sediment and maintain desirable plant communities.

    c. Littoral Zone Areas are given low priority: These areas are for alleviating nuisance, surface-matting growth for riparian owners. Harvesting from pier heads to shore will not be mechanically harvested; only manual methods will be used.

    d. Ecologically Valuable Areas (Sensitive Areas) are given low priority: Channels should be cut to a width of 50 feet to allow for boat navigability. Harvesting in Viewcrest and Highland Bays should be limited to the top three feet of Eurasian watermilfoil to promote native species growth.

    e. Highlands Channel is given medium priority: Use the clipper when there is a navigational impediment. The clipper should be started farthest from the entrance to the inlet of the Lake. Use should be limited to once every two weeks.

    f. Duckweed removal is given low priority: Utilize skimming of duckweeds and watermeal when necessary to improve navigation.

    g. Removal of floating filamentous algae is given low priority: Mechanical harvesting may be used to collect nuisance floating filamentous algae within the Lake.

5. **Limit aquatic plant management and human disturbance before June 15th**. Restrict harvesting to navigation channels only in those areas necessary to facilitate boating to piers and channels, leaving 12 inches of plant growth on the lake bottom in order to protect spring fish spawning. Water and weather temperatures should be checked regularly before June 15th and fish spawning activities should be monitored in order to maintain a healthy fishery.

6. **Immediately return incidentally captured living animals to the water**. As harvested plants are brought on board the harvester, plant material must be actively examined for live animals. Animals such as turtles, fish, and amphibians commonly become entangled within harvested plants, particularly when cutting large plant mats. A second deckhand equipped with a net should accompany and help the harvester operator rescue animals incidentally collected during aquatic plant harvesting. If a second deckhand is not available, the harvester operator shall halt harvesting and remove animals incidentally collected during plant harvesting. Such stop-and-start work can dramatically decrease harvesting efficiency. Therefore, the WDNR recommends two staff be present on operating harvesters.

7. **Insurance, maintenance, repair, and storage**. Appropriate insurance covering the harvester and ancillary equipment will be incorporated into DLSD's policy. DLSD will provide liability insurance for harvester operators and other staff. Insurance certificates will be procured and held by DLSD. Routine day-to-day equipment maintenance will be performed by the harvester operator or other individuals identified by DLSD in accordance with the manufacturer's recommendations and suggestions. To this

end, harvester operators shall be familiar with equipment manuals and appropriate maintenance/ manufacturer contacts. Operators will immediately notify DLSD staff of any equipment malfunctions, operating characteristics, or sounds suggesting malfunction and/or the need for repair. Equipment repair beyond routine maintenance will be arranged by DLSD. Maintenance and repair costs will be borne by DLSD. DLSD will be responsible for properly transporting and storing harvesting equipment during the off season.

8. **Management, record keeping, monitoring, and evaluation**. DLSD staff manage harvesting operations, and, although they may delegate tasks, are ultimately responsible for overall plan execution and logistics. Nevertheless, daily harvesting activities will be documented in writing by the harvester operator in a permanent harvester operations log. Harvesting patterns, harvested plant volumes, weed pickup, plant types, and other information will be recorded. Daily maintenance and service logs recording engine hours, fuel consumed, lubricants added, oil used, and general comments will be recorded. Furthermore, this log should include a section to note equipment performance problems, malfunctions, or anticipated service. Monitoring information will be summarized in an annual summary report prepared by DLSD, submitted to the WDNR, and available to the general public. The report will also present information regarding harvesting operation and maintenance, equipment acquisitions and/or needs, expenditures, and budgets.

9. **Logistics, supervision, and training**. Harvesting equipment is owned and operated by DLSD. DLSD staff or delegated board members are responsible for overall harvesting program oversight and supervision. Although DLSD staff are ultimately responsible for equipment operation, they may delegate tasks to competent individuals when technically and logistically feasible. DLSD must assure such individuals are appropriately trained to successfully and efficiently carry out their respective job functions. For example, DLSD members/staff likely have extensive experience operating and maintaining harvesting equipment and have detailed knowledge of lake morphology, plant growth, and overall lake biology. These individuals should actively share this knowledge through an on-the-job training initiative. The equipment manufacturer may also be able to provide advice, assistance, and insight regarding equipment operation. Boating safety courses are available through many media and are integral to individuals involved with on-the-water work.

   All harvester operators must successfully complete appropriate training, must be thoroughly familiar with equipment function, must be able to rapidly respond to equipment malfunction, must be familiar with the Lake's morphology and biology, and must recognize landmarks to help assure adherence to harvesting permit specifications and limitations. Additionally, harvester operators must be able to recognize the various native and invasive aquatic plants present in the Lake. Such training may be provided through printed and on-line study aids, plant identification keys, and the regional WDNR aquatic species coordinator. At a minimum, training should:

   - Explain "deep-cut" versus "shallow-cut" techniques and when to employ each in accordance with this plan

   - Discuss equipment function, capabilities, limitations, hazards, general maintenance, and the similarities and differences between the various pieces of equipment they may be expected to operate

   - Review the aquatic plant management plan and associated permits with special emphasis focused on the need to restrict cutting in shallow and nearshore areas

   - Help operators identify WDNR-designated Sensitive Areas and be well versed regarding the aquatic plant management restrictions therein

   - Assure operators can confidently identify aquatic plants and understand the positive values such plants provide to the Lake's ecosystem which in turn encourages preservation of native plant communities

- Reaffirm that all harvester operators are legally obligated to accurately track and record their work to include in permit-requisite annual reports

The training program must integrate other general and job-specific items such as boating navigational conventions, safety, courtesy and etiquette, and State and local boating regulations. Other topics that should be covered include first aid training, safety training, and other elements that help promote safe, reliable service.

Nearshore Manual Aquatic Plant Removal

In nearshore areas where other management efforts are not feasible, raking may be a viable and practical method to manage overly abundant and/or undesirable plant growth. Should Delavan Lake residents decide to utilize raking to manually remove aquatic plants, DLSD or other interested party could acquire a number of specially designed rakes for riparian owners to use on a trial basis and/or rent or loan. If those rakes satisfy users' needs and objectives, additional property owners would be encouraged to purchase their own rakes.

Hand-pulling EWM and CLP is considered a viable option in Delavan Lake and should be employed wherever practical. Volunteers or homeowners could employ this method, as long as they are properly trained to identify EWM, CLP, or any other invasive plant species of interest. WDNR provides a wealth of guidance materials (including an instructional video describing manual plant removal) to help educate volunteers and homeowners.[55]

Pursuant to Chapter NR 109 *Aquatic Plants: Introduction, Manual Removal and Mechanical Control Regulations* of the *Wisconsin Administrative Code*, riparian landowners may rake or hand pull aquatic plants without a WDNR permit under the following conditions:

- EWM, CLP, and purple loosestrife may be removed by hand if the native plant community is not harmed in the process.
- Raked, hand-cut, and hand-pulled plant material must be removed from the lake.
- No more than 30 lineal feet of shoreline may be cleared, however, this total must include shoreline lengths occupied by docks, piers, boatlifts, rafts, and areas undergoing other plant control treatment. In general, regulators allow vegetation to be removed up to 100 feet out from the shoreline.
- Plant material that drifts onto the shoreline must be removed.
- The subject shoreline cannot be a designated sensitive area.

Any other manual removal technique requires a State permit, unless specifically used to control designated nonnative invasive species such as EWM. Mechanical equipment (e.g., dragging equipment such as a rake behind a motorized boat or the use of weed rollers) is not authorized for use in Wisconsin at this time. Nevertheless, riparian landowners may use mechanical devices to cut or mow exposed lakebed. Furthermore, purple loosestrife may also be removed with mechanical devices if native plants are not harmed and if the control process does not encourage spread or regrowth of purple loosestrife or other nonnative vegetation.

Permits are also required if riparian property owners abut a sensitive area or if another group actively engages in such work.[56] Several areas in Delavan Lake are designated sensitive areas and a permit is therefore required to manually remove aquatic plants in many shoreline areas around the Lake.

[55] *Visit dnr.wi.gov/lakes/plants for more information on identification and control of invasive aquatic plants.*

[56] *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.*

Prior to the hand-pulling season, shoreline residents should be reminded of the utility of manual aquatic plant control through an educational campaign. This campaign should also foster shoreline resident awareness of native plant values and benefits, promote understanding of the interrelationship between aquatic plants and algae (i.e., if aquatic plants are removed, more algae may grow), assist landowners in identifying the types of aquatic plants along their shorelines, and familiarize riparian landowners with the specific tactics they may legally employ to "tidy up" their shorelines.[57]

Suction Harvesting and DASH

Suction harvesting may be a practical method to control aquatic plants, but it is not likely to be a cost-effective, environmentally friendly, or practical method to manage aquatic plants alone. For this reason, suction harvesting is not practical for widespread application at the Lake. However, it may provide a practical alternative in excessively shallow nearshore areas where increased water depth could meaningfully improve navigability.

Given how time consuming and costly DASH can be to employ, and given the limited presence of invasive and nuisance plant growth across the Lake, DASH will likely not be a primary component of DLSD's general nuisance and invasive plant management strategy. Nevertheless, some lake districts have employed DASH to aggressively combat small-scale pioneer infestations of invasive species. DLSD may wish to consider using DASH should such a situation arise in the future.

DASH may be of interest to private parties in specific situations. For example, DASH could be employed by individuals to control nuisance native and nonnative plants around piers and other congested areas. If an individual landowner or groups of landowners choose to utilize DASH, the activity is typically confined to the same area as riparian landowner manual aquatic plant control (30 feet of shoreline per property generally extending no more than 100 feet in areas including piers and other navigation aids). DASH requires a permit under *Wisconsin Administrative Code* Chapter NR 109 *Aquatic Plants: Introduction, Manual Removal and Mechanical Control Regulations*.

Chemical Treatment

Considering the low expanse of EWM in Delavan Lake, small spot treatments enclosed with a barrier (e.g., turbidity barrier) could be a viable alternative for treating shoreline areas and navigation lanes if determined feasible by DLSD. Whatever the case, monitoring should continue to ensure that EWM does not become more problematic. If further monitoring suggests a dramatic change in invasive species populations, management recommendations should be reviewed.

3.2 SUMMARY AND CONCLUSIONS

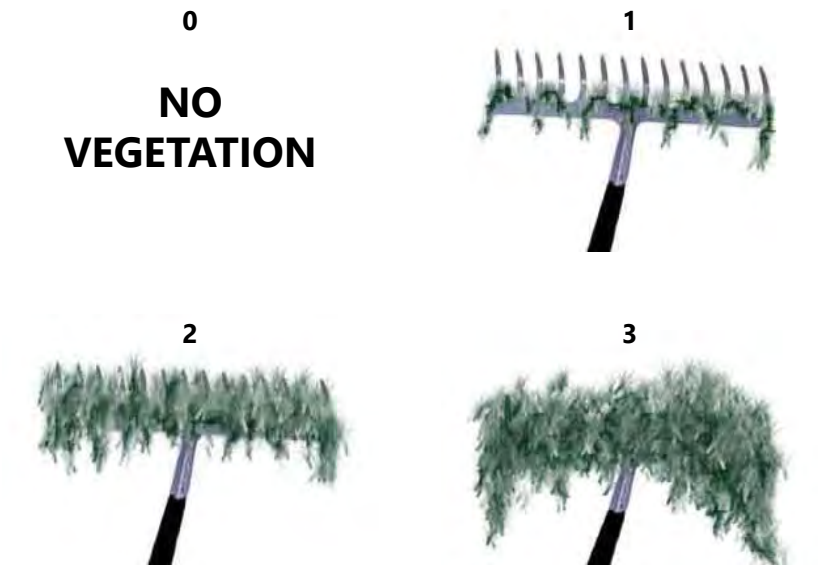
As requested by DLSD, the Commission worked with DLSD to develop a scope of work and secure funding to provide information useful to short- and long-term lake management. The primary motivation for this effort was to gather information needed to renew DLSD's aquatic plant management permit. This report, 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. Figures 3.1, 3.2, and 3.3 summarize and generally locate where aquatic plant management recommendations should be implemented.

Successfully implementing this plan will require vigilance, cooperation, and enthusiasm, not only from local management groups, but also from State and regional agencies, Walworth County, municipalities, and residents/users of the Lake. The recommended measures help foster conditions sustaining and enhancing the natural beauty and ambiance of the Delavan Lake ecosystem while promoting a wide array of water-based recreational activities suitable for the Lake's intrinsic characteristics.

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

APPENDIX A
LAKE AQUATIC PLANT SPECIES DETAILS

Figure A.1
Rake Fullness Ratings



Source: Wisconsin Department of Natural Resources and SEWRPC

SOURCES OF INFORMATION:

Borman, S., Korth, R., & Temte, J. (2014). Through the Looking Glass: A Field Guide to Aquatic Plants, Second Edition. Stevens Point, WI, USA: Wisconsin Lakes Partnership.

Robert W. Freckman Herbarium: wisplants.uwsp.edu

Skawinski, P. M. (2014). Aquatic Plants of the Upper Midwest: A Photographic Field Guide to Our Underwater Forests, Second Edition. Wausau, Wisconsin, USA: Self-Published.

University of Michigan Herbarium: michiganflora.net/home.aspx

UW-System WisFlora. 2016. wisflora.herbarium.wisc.edu/index.php

Native

COMMON, NORTHERN, AND BRAZILIAN WATERMEAL

***Wolffia* spp.**

Credit: Wikimedia Commons User Stefan.lefnaer

Identifying Features

- Free-floating, green plant without roots, stems, or leaves, spherical or oblong
- Individual plants hardly larger than a pinhead
- Common Watermeal (*W. columbiana*) pale green, asymmetrical globes
- Northern Watermeal (*W. borealis*) flattened, ellipsoid, and dotted, with a pointed apex
- Brazilian Watermeal (*W. brasiliensis*) dotted, ellipsoid, with a rounded apex

Ecology

- Found throughout Wisconsin, except northern lakes and forest ecoregion
- Often found with duckweed species
- Not dependent on depth, sediment type, or water clarity
- Requires adequate nutrients in the water to sustain growth

Native

COMMON WATERWEED

Elodea canadensis

Credit: Flickr User Corey Raimond

Identifying Features

- Slender stems, occasionally rooting
- Leaves lance-shaped, in whorls of three (rarely two or four), 6.0 to 17 mm long and averaging 2.0 mm wide
- When present, tiny male and female flowers on separate plants (females more common), raised to the surface on thread-like stalks

Ecology

- Found in lakes and streams over soft substrates tolerating pollution, eutrophication and disturbed conditions
- Often overwinters under the ice
- Produces seeds only rarely, spreading primarily via stem fragments
- Provides food for muskrat and waterfowl
- Habitat for fish or invertebrates, although dense stands can obstruct fish movement

Credit: Wikimedia Commons User Christian Fischer

Native

COONTAIL

Ceratophyllum demersum


Credit: Flickr User Bill Keim

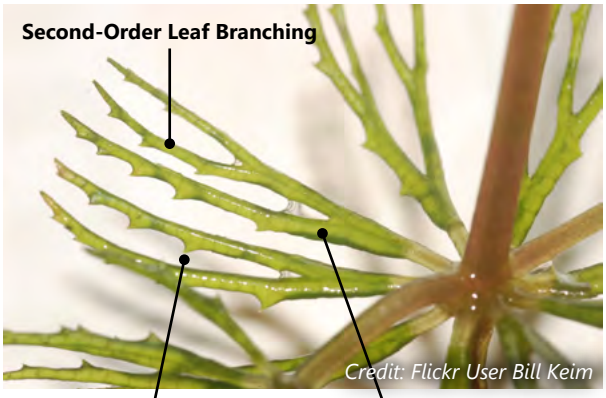
Identifying Features

- Often bushy near tips of branches, giving the raccoon tail-like appearance ("coontail")
- Whorled leaves with one to two orders of
- branching and small teeth on their margins
- Flowers (rare) small and produced in leaf axils

Coontail is similar to spiny hornwort (C. echinatum) and muskgrass (Chara spp.), but spiny hornwort has some leaves with three to four orders of branching, and coontail does not produce the distinct garlic-like odor of muskgrass when crushed

Ecology

- Common in lakes and streams, both shallow and deep
- Tolerates poor water quality (high nutrients, chemical pollutants) and disturbed conditions
- Stores energy as oils, which can produce slicks on the water surface when plants decay
- Anchors to the substrate with pale, modified leaves rather than roots
- Eaten by waterfowl, turtles, carp, and muskrat



Nonnative/ Exotic

CURLY-LEAF PONDWEED

Potamogeton crispus

Credit: Paul Skawinski

Identifying Features

- Stems slightly flattened and both stem and leaf veins often somewhat pink
- Leaf margins very wavy and finely serrated
- Stipules (3.0 to 8.0 mm long) partially attached to leaf bases, disintegrating early in the season
- Produces pine cone-like overwintering buds (turions)

Curly-leaf pondweed may resemble clasping-leaf pondweed (*P. richardsonii*), but the leaf margins of the latter are not serrated

Ecology

- Found in lakes and streams, both shallow and deep
- Tolerant of low light and turbidity
- Disperses mainly by turions
- Adapted to cold water, growing under the ice while other plants are dormant, but dying back during mid-summer in warm waters
- Produces winter habitat, but mid-summer die-offs can degrade water quality and cause algal blooms
- Maintaining or improving water quality can help control this species, because it has a competitive advantage over native species when water clarity is poor

Credit: Paul Skawinski

Nonnative/ Exotic

EURASIAN WATERMILFOIL

Myriophyllum spicatum

Credit: Paul Skawinski

Identifying Features

- Stems spaghetti-like, often pinkish, growing long with many branches near the water surface
- Leaves with 12 to 21 pairs of leaflets
- Produces no winter buds (turions)

Eurasian watermilfoil is similar to northern watermilfoil (*M. sibiricum*). However, northern watermilfoil has five to 12 pairs of leaflets per leaf and stouter white or pale brown stems

Credit: Paul Skawinski

Ecology

- Hybridizes with northern (native) watermilfoil, resulting in plants with intermediate characteristics
- Invasive, growing quickly, forming canopies, and getting a head-start in spring due to an ability to grow in cool water
- Grows from root stalks and stem fragments in both lakes and streams, shallow and deep; tolerates disturbed conditions
- Provides some forage to waterfowl, but supports fewer aquatic invertebrates than mixed stands of aquatic vegetation

Native

FILAMENTOUS ALGAE

Spirogyra spp.

Credit: Flickr User Ann-Sophie Qvarnström

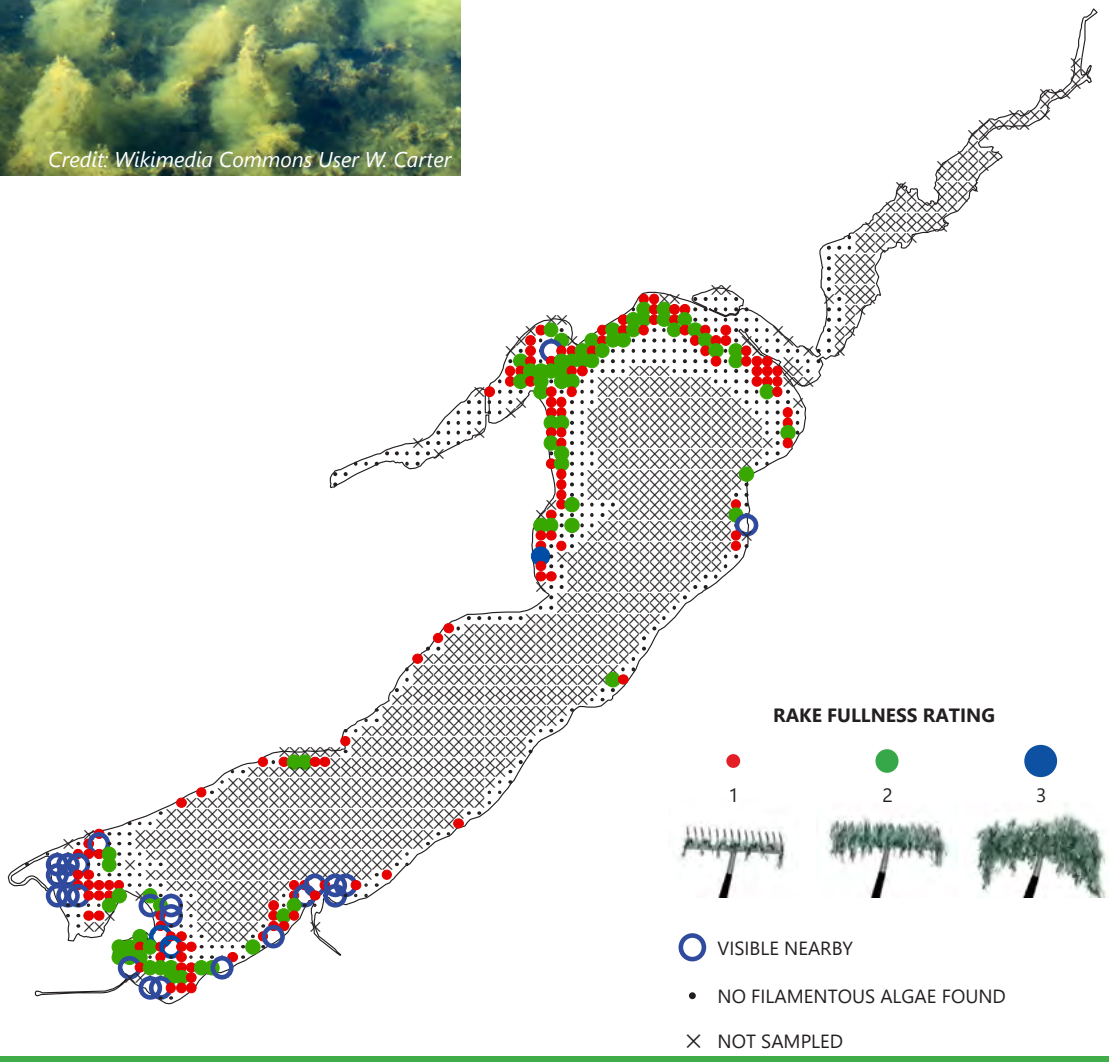
Identifying Features

- Consists of fine, green filaments that can form floating balls, be stiff like steel wool, or feel slimy
- No leaves, roots, stems, or flowers
- Often forms dense mats
- Non Toxic producing

Ecology

- Forms green, cottony masses that are free-floating or attached to rocks, debris, or other plants
- Commonly floats when bubbles, generated by the algae or created by its decay, get trapped in the mats and make it buoyant
- Provides food and shelter for aquatic invertebrates and young fish

Credit: Wikimedia Commons User W. Carter



Native

FRIES' PONDWEED

Potamogeton friesii

Credit: Flickr User Lliam Rooney

Identifying Features

- Slender stems slightly compressed
- Submerged leaves linear with no petiole, one row of lacunar cells on each side of midvein, and 5-7 veins
- Tip of leaf rounded with short bristle
- Winter bud fan shaped and in two planes, with inner leaves at 90 degrees from outer leaves

Fries' pondweed is similar to other narrow-leaved pondweeds such as small pondweed (*P. pusillis*) and stiff pondweed (*P. strictifolius*) but other narrow pondweeds do not create a fan shaped winter bud

Ecology

- Common in calcareous lakes and slow-moving streams
- Overwinters largely as winter buds (turions)
- Provides food for waterfowl,
- Provides habitat for fish and aquatic invertebrates

Credit: Flickr User Brenton Butterfield

Native

LARGE DUCKWEED

Spirodela polyrrhiza


Credit: Flickr User gailhampshire

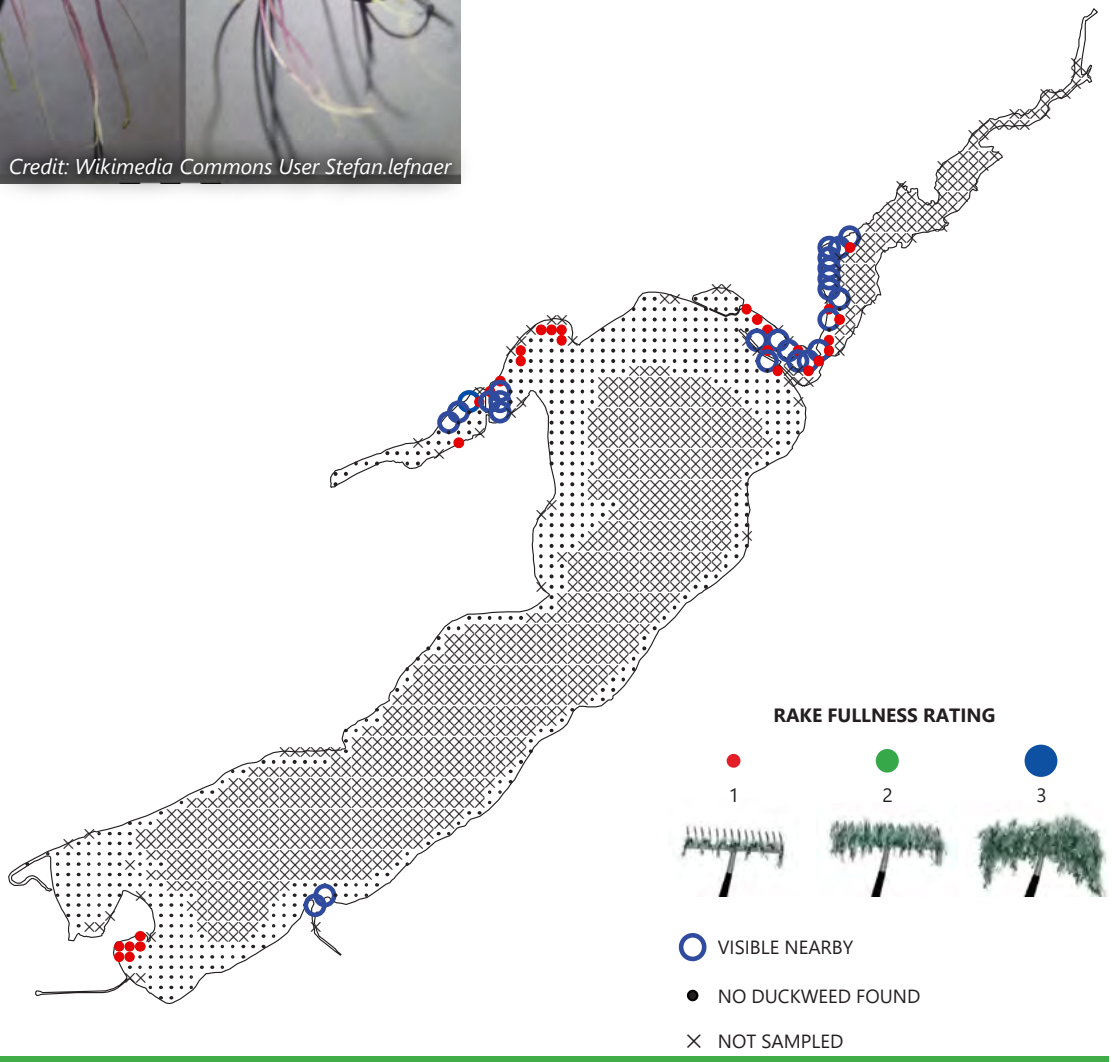
Identifying Features

- Free-floating, nearly cicular fronds with 5 – 15 veins
- Often has several fronds in a cluster, with multiple roots
- Typically green above and a reddish-purple beneath

Ecology

- Found throughout Wisconsin
- Often found with duckweed species
- Not dependent on depth, sediment type, or water clarity
- Requires adequate nutrients in the water to sustain growth


Credit: Wikimedia Commons User Stefan.lefnaer



Native

LONG-LEAF PONDWEED

Potamogeton nodosus


Credit: Wikimedia Commons User Stefan.lefnaer

Identifying Features

- Floating leaves 5.0 to 13 cm long, tapering to leaf stalks that are longer than the attached leaf blades
- Submersed leaves up to 30 cm long and 1.0 to 2.5 mm wide, with seven to 15 veins, and long leaf stalks
- Stipules 4.0 to 10 cm long, free from the leaves, disintegrating by mid-summer

Long-leaf pondweed may be distinguished from other pondweeds that have similar floating leaves (e.g., *P. illinoensis* and *P. natans*) by the long leaf stalks of its submersed leaves. The floating leaves of *P. natans* also differ by having a heart-shaped base and by being held to the leaf stalks at roughly 90-degree angles. In *P. illinoensis* the stalks of floating leaves, if produced, are shorter than the leaf blades

Ecology

- Streams and lakes, shallow and deep, but more often in flowing water
- Emerges in spring from buds formed along rhizomes
- Provides food for waterfowl, muskrat, beaver, and deer
- Harbors large numbers of aquatic invertebrates, which provide food for fish


Credit: Wikimedia Commons User Stefan.lefnaer

Native

MUSKGRASSES

Chara spp.


Credit: Flickr User Jeremy Halls

Identifying Features

- Leaf-like, ridged side branches develop in whorls of six or more
- Often encrusted with calcium carbonate, which appears white upon drying (see photo below)
- Yellow reproductive structures develop along the whorled branches in summer
- Emits a garlic-like odor when crushed

Stoneworts (*Nitella* spp.) are similar large algae, but their branches are smooth rather than ridged and more delicate

Ecology

- Found in shallow or deep water over marl or silt, often growing in large colonies in hard water
- Overwinters as rhizoids (cells modified to act as roots) or fragments
- Stabilizes bottom sediments, often among the first species to colonize open areas
- Food for waterfowl and excellent habitat for small fish


Credit: Wikimedia Commons User Lamiot

Native

SAGO PONDWEED

Stuckenia pectinata


Credit: Flickr User Christian Fischer

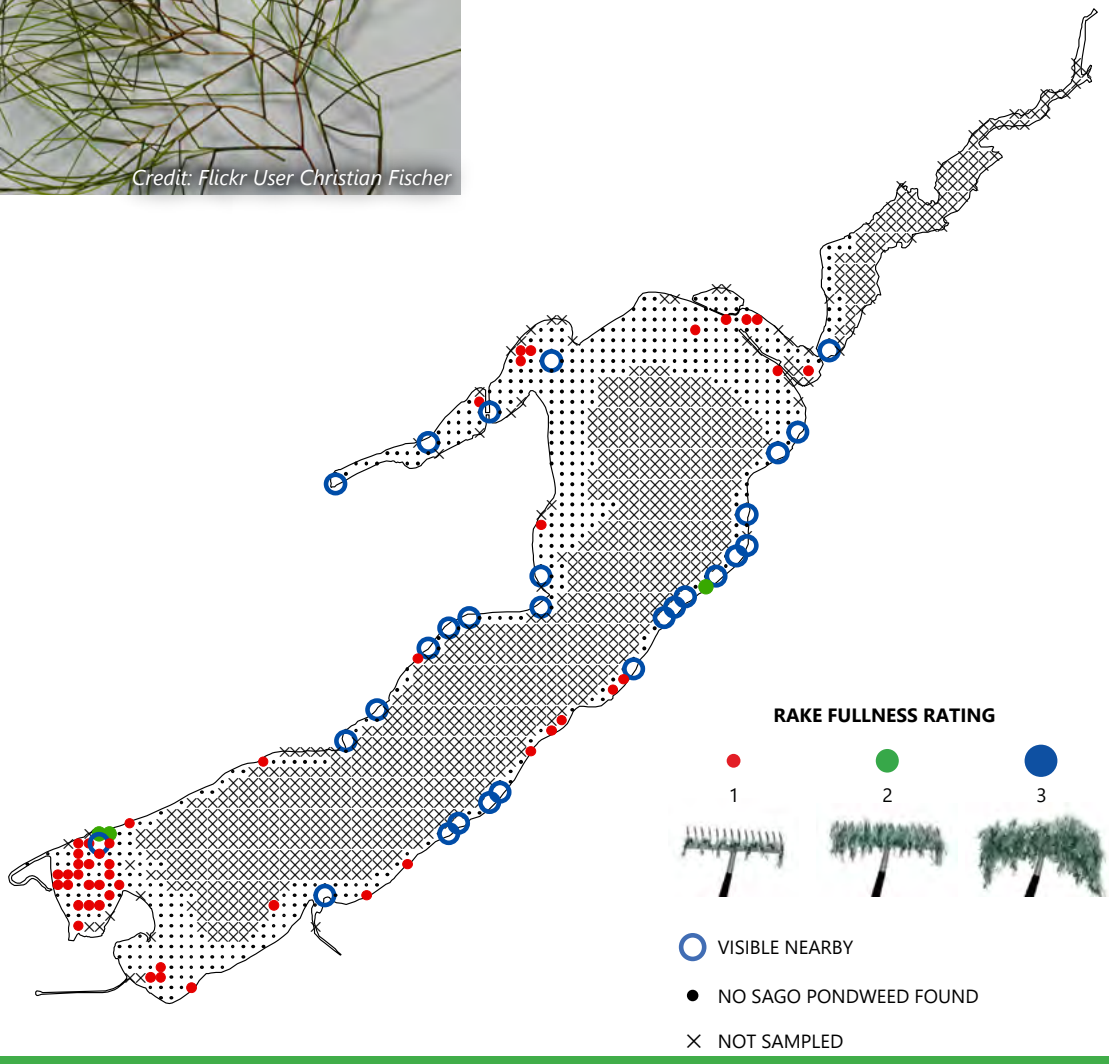
Identifying Features

- Stems often *slightly zig-zagged* and forked multiple times, yielding a fan-like form
- Leaves one to four inches long, very thin, and ending in a sharp point
- Whorls of fruits spaced along the stem may appear as beads on a string

Ecology

- Lakes and streams
- Overwinters as rhizomes and starchy tubers
- Tolerates murky water and disturbed conditions
- Provides abundant fruits and tubers, which are an *important food for waterfowl*
- Provides habitat for juvenile fish

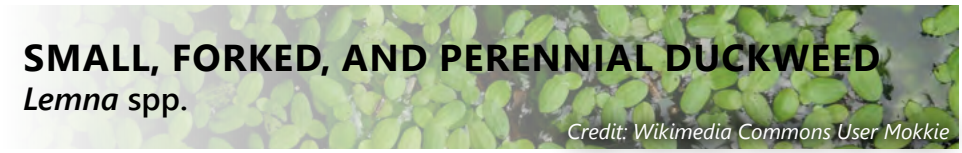

Credit: Flickr User Christian Fischer



Native

SMALL, FORKED, AND PERENNIAL DUCKWEED

Lemna spp.


Credit: Wikimedia Commons User Mokkie

Identifying Features

- Free-floating, green, round fronds
- May have several fronds in a cluster, but each frond has only one root
- Small Duckweed (*L. minor*) is smooth and flat on the top
- Forked Duckweed (*L. trisulca*) has pointed fronds, giving it an "oar and rowboat" appearance
- Perennial Duckweed (*L. turionifera*) has a row of small bumps down the middle

Ecology

- Free-floating duckweed is not dependent on depth, sediment type, or water clarity
- Associated with eutrophic waters

Credit: Flickr User Andreas Rockstein

Credit: Wikimedia Commons User Petr Filippov

Credit: Wikimedia Commons User Stefan.lefnaer

Nonnative/ Exotic

PURPLE LOOSESTRIFE

Lythrum salicaria

Credit: Wikimedia Commons User Liz West

Identifying Features

- Terrestrial or semi-aquatic, emergent forb
- Stems often angled with four, five, or more sides, and growing one to two meters tall
- Flowers deep pink or purple, six-parted, 12 to 25 mm wide, and in groups
- Leaves lance-like, four to 11 cm long and either opposite or in whorls of three

Purple loosestrife, if small, is similar to winged loosestrife (Lythrum alatum), but winged loosestrife differs in having leaves generally smaller (<5.0 cm long), leaves mostly alternate (only lower leaves opposite), and flowers mostly held singly in the leaf axils rather than in pairs or groups

Ecology/Control

- Found in shallows, along shores, and in wet to moist meadows and prairies
- Invasive and continues to escape from ornamental plantings
- Galerucella beetles have been successfully used to control purple loosestrife. Plants may also be dug or pulled when small, but they subsequently should be placed in a landfill or burned. Several herbicides are effective, but application near water may require permits and aquatic-use formulas

Native

WATER CELERY OR EELGRASS

Vallisneria americana

Credit: Wikimedia Commons User Fredlyfish4

Identifying Features

- Leaves ribbon-like, up to two meters long, with a prominent stripe down the middle, and emerging in clusters along creeping rhizomes
- Male and female flowers on separate plants, female flowers raised to the surface on spiral-coiled stalks

The foliage of eelgrass could be confused with the submersed leaves of bur-reeds (*Sparganium* spp.) or arrowheads (*Sagittaria* spp.), but the leaves of eelgrass are distinguished by their prominent middle stripe. The leaves of ribbon-leaf pondweed (*Potamogeton epihydrus*) are also similar to those of eelgrass, but the leaves of the former are alternately arranged along a stem rather than arising from the plant base

Ecology

- Firm substrates, shallow or deep, in lakes and streams
- Spreads by seed, by creeping rhizomes, and by offsets that break off and float to new locations in the fall
- All portions of the plant consumed by waterfowl; an especially important food source for Canvasback ducks
- Provides habitat for invertebrates and fish

Credit: Wikimedia Commons User Fredlyfish4

Native

WATER STARGRASS

Heteranthera dubia

Credit: Wikimedia Commons User Fritzflohrreynolds

Identifying Features

- Stems slender, slightly flattened, and branching
- Leaves narrow, alternate, with no stalk, and lacking a prominent midvein
- When produced, flowers conspicuous, yellow, and star-shaped (usually in shallow water) or inconspicuous and hidden in the bases of submersed leaves (in deeper water)

Yellow stargrass may be confused with pondweeds that have narrow leaves, but it is easily distinguished by its lack of a prominent midvein and, when present, yellow blossoms

Ecology

- Found in lakes and streams, shallow and deep
- Tolerates somewhat turbid waters
- Overwinters as perennial rhizomes
- Limited reproduction by seed
- Provides food for waterfowl and habitat for fish

Credit: Flickr User Jill Lee

Native

WHITE WATER LILY

Nymphaea odorata

Credit: Flickr User Ryan Hodnett

Identifying Features

- Leaf stalks round in cross-section with four large air passages
- Floating leaves round (four to 12 inches wide under favorable conditions), *with a notch* from the outside to the center, and reddish-purple underneath
- Flowers white with a yellow center, three to nine inches wide

Pond lilies (*Nuphar* spp.) are superficially similar, but have yellow flowers and leaves somewhat heart-shaped. American lotus (*Nelumbo lutea*) is also similar, but its leaves are unnotched

Ecology

- Found in shallow waters over soft sediments
- Leaves and flowers emerge from rhizomes
- Flowers opening during the day, closing at night
- Seeds consumed by waterfowl, rhizomes consumed by mammals

Credit: Wikimedia Commons User Kurt Stüber

DELAVAN LAKE INTEGRATED SENSITIVE AREAS REPORT

APPENDIX B

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

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

General Lake Information

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

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

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

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

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

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

Exotic Species

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

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

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

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

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

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

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

and most importantly, prevention through public education plays an important role in the management of this species.

Shoreland Management

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

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

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

Introduction

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

wildlife). The wildlife biologist and wildlife technician canoed the inlet from 5:20 AM to 7:00 AM that morning.

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

Overview of Sensitive Area Designations

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

Whole Lake Recommendations:

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

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

Final – January 22nd, 2007

Resource Value of Sensitive Area Site 1 – Delavan Lake

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

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

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

Table 1. Plants observed in Sensitive Area 1.

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

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

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

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

Management Recommendations for Sensitive Area #1

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

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

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

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

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

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

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

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

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

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

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

*Boardwalks only. See Recommendation # 7.

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

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

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

Resource Value of Sensitive Area Site 2 – Delavan Lake

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

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

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

Final – January 22nd, 2007

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

Table 2. Plants observed in Sensitive Area 2.

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

Management Recommendations for Sensitive Area # 2

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Resource Value of Sensitive Area Site 3 – Delavan Lake

Sensitive Area 3 in Lake Lawn Bay of Delavan Lake serves as a fish and wildlife refuge and has a diverse wildlife population. The area acts as a nutrient buffer to reduce algae blooms, a biological buffer reducing the likelihood of exotic invasions, a physical buffer against shoreline erosion, a micro-habitat that increases biodiversity, and allows

for sediment stabilization. See Appendix 1 for a complete list of aquatic plants found in sensitive areas of Delavan Lake, and Appendix 2 for fish information.

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

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

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

Table 3. Plants observed in Sensitive Area 3.

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

Final – January 22nd, 2007

Management Recommendations for Sensitive Area # 3

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

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

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

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

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

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

7. No mechanical harvesting should be conducted.

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

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

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

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

Final – January 22nd, 2007

Resource Value of Sensitive Area Site 4 – Delavan Lake

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

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

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

Table 4. Plants observed in Sensitive Area 4.

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

Final – January 22nd, 2007

Management Recommendations for Sensitive Area # 4

1. Harvest cruising lanes for fish.

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

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

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

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

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

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

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

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

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

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

amphibians, and reptiles. This site could be used to educate citizens about wetlands and sensitive areas.

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

Resource Value of Sensitive Area Site 5 – Delavan Lake

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

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

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

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

Table 5. Plants observed in Sensitive Area 5.

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

Management Recommendations for Sensitive Area # 5

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

2. Protect and restore emergent aquatic plants.

3. Harvest cruising lanes for fish.

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

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

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

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

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

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

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

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

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

Conclusion

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

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

Final – January 22nd, 2007

Table 5. Plants observed in Sensitive Area 5.

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

Management Recommendations for Sensitive Area # 5

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

2. Protect and restore emergent aquatic plants.

3. Harvest cruising lanes for fish.

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

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

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

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

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

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

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

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

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

Conclusion

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

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

Final – January 22nd, 2007

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APPENDIX 1 - Aquatic plants within sensitive areas of Delavan Lake

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

Final – January 22nd, 2007

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

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

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

Algae					
Chara (muskgrass)			X		
filamentous	X	X			X

Final – January 22nd, 2007

APPENDIX 2 – Fish Species in Delavan Lake
Doug Welch, Fisheries Biologist

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

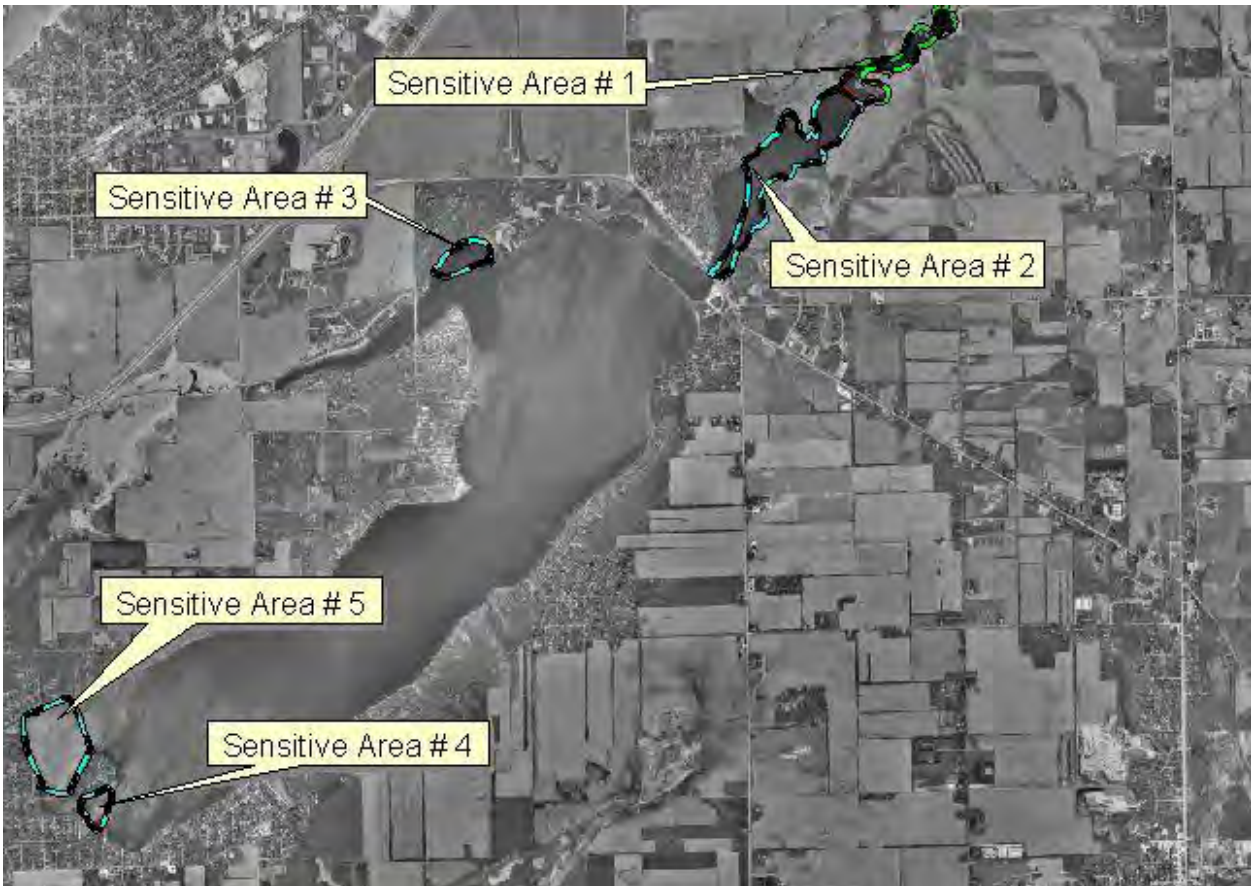
The shoreline of Delavan Lake is highly developed, and the sensitive areas give the fish population a natural area to sustain themselves. Walleye, northern pike, musky, smallmouth bass, largemouth bass, perch, suckers, and minnows use the sensitive areas on Delavan Lake as nurseries, feeding areas and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

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

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

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

Delavan Lake Sensitive Areas Map



State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary
Gloria L. McCutcheon, Regional Director

Waukesha Service Center
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Waukesha, Wisconsin 53188
Telephone 262-574-2100
FAX 262-574-2117

January 22nd, 2007

Completed Sensitive Area Designation for Delavan Lake

Dear Delavan Lake Community Members,

The Department of Natural Resources (Department) recently completed the report regarding sensitive areas on Delavan Lake. The Department notified residents (via a direct mailing) of the proposed sensitive areas in April 2006. A public presentation on the proposed sensitive areas occurred on May 20, 2006. The comment period extended to July 31st, 2006. This letter serves to notify you that the process of designating sensitive areas on Delavan Lake has been completed.

A number of letters, e-mails and verbal comments were provided to the Department by landowners. The Department responded to all the comments either by letter or e-mail. A copy of the final report and maps can be found at http://dnr.wi.gov/org/water/fhp/lakes/sensitiveareas.asp.

Sensitive areas are defined in Natural Resource Code NR 107.05 (3)(i)(1) as "areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or lifestage requirements, or offering water quality or erosion control benefits to body of water."

The Department appreciates the time that many of you took to submit your comments regarding the sensitive areas on Delavan Lake. If you have any additional questions, please contact me at 262.574.2130.

Sincerely,

Heidi J. Bunk
DNR Lakes Biologist

Cc: Delavan Lake Sanitary District
Delavan Lake Improvement Association
Walworth County
Town of Delavan
City of Delavan
Pam Schense, Water Management Specialist
Warden Jon Hagan

SURFACE WATER SUCTIONING PILOT PROGRAM ON DELAVAN LAKE

APPENDIX C

This pilot project is to suction floating filamentous algae, duckweed and watermeal from the surface of Delavan Lake at the Community Park Public Boat Launch and Public Beach in 2021.

Blue-green algae is also present in Delavan Lake, although it is unknown which type(s) of Blue-green algae is in the lake. Some, but not all, Blue-green algae produces toxins when it dies. A large die-off could occur from the surface suctioning process which would produce a large amount of toxin. Blue-green algae is not a target species for this project, but it will be mixed into some of the material that is suctioned off the surface of the lake. These toxins would likely become airborne in mist during the surface suctioning process.

Toxins that can be produced by Blue-green algae include neurotoxins, hepatotoxins, cytotoxins, or endotoxins, any of which can have extremely adverse effects on animals and humans.

Because some Blue-green algae would be present, it is necessary to protect workers that will be in the lake and close to the suctioned material during the suctioning process. Personal Protection Equipment (PPE) must include respirators with appropriate filters so that no person inhales the airborne particulates from the Blue-green algae. The selected PPE must be approved by OSHA, State, and County health officials.

On May 25, 2021 we were advised by Gina Laliberte, Statewide Blue-green algae Coordinator for DNR, that to the best of her knowledge there is no data available regarding the efficacy of respirators to filter out blue-green algae droplets.

In addition, Gina stated that some of the toxins that can be produced persist in the soil and are taken up into the plant tissue of crops which would have a detrimental effect on consumers of the crops. This could also expose bugs and birds to the toxins. For that reason, our plan to dispose of the suctioned material on farm fields will not be possible. Gina did suggest a manure digester, but we are not sure if that has been tested.

Due to these safety issues, Heidi Bunk, DNR Lakes Biologist, has recommended that the Delavan Lake Sanitary District delay the implementation of the Pilot Surface Water Suctioning Project until we have the data needed to ensure the safety of our workers. Heidi recommended that we work with health officials on this issue such as the Walworth County Health Department or the State of Wisconsin Department of Health and Human Services.

The good news is that the only expenses incurred to date is strictly staff time for writing the plan, permit, and grant. We should be able to cancel/put on hold the purchase of any equipment.

Jane (Aquarius) has worldwide connections that she is contacting to see if any of them have done research on Blue-green algae and can provide data they have collected.

Aquatic plant harvesting is a different process. While there could be Blue-green algae present on some of the aquatic plants that are harvested, the algae is not as concentrated as it would be during surface suctioning. Plus, the plants are conveyed onto the harvester where they lose a great deal of the lake water. In addition, workers sit high 5' above the conveyors placing them a good distance from plants and any Blue-green algae. For surface water suctioning workers would be in the water using the suctioning hose and once suctioned the material will be conveyed in a hose to storage tanks so no water would be lost.

Heidi is willing to help design a study for the Delavan Lake Sanitary District to implement, if the District wishes. This study would look at numerous parts of the lake on a weekly basis to determine the type of blue-green algae present, density of the algae and the concentration of toxins present at the time samples are taken. This study would help give the District a better overall picture of blue-green algae species present in the lake, the range of blue-green algae density and the range of toxin concentrations released. This would be an expensive study and is not required.

INTRODUCTION

Delavan Lake is a 2,072 acre drainage lake, located in the Town and City of Delavan in Walworth County, Wisconsin. It lies within the Turtle Creek Watershed, which is a sub-watershed of the lower Rock River Watershed (Map C.1). Drainage lakes are characterized as having both a defined inlet and outlet. Jackson Creek, lying on the Northeastern end, is the lake inlet and Swan Creek, located at a Northwest area of the lake, is the outlet. The lake offers recreational and leisure opportunities for residents and visitors and is an important natural resource that provides tremendous economic benefits for Delavan and Walworth County.[3]

The Delavan Lake Sanitary District (DLSD), Delavan Lake Improvement Association (DLIA) and the Town of Delavan Lake Commission all work to preserve and protect the lake. However, the DLSD has been the agency responsible for the management of aquatic plants in Delavan Lake since January of 1997. There have been numerous studies and plans conducted over the years concerning Delavan Lake, including several aquatic plant management plans and updates of those plans. This plan will be a supplement to An Aquatic Plant Management Plan Update of Delavan Lake, Walworth County, WI, 2017. This plan supplement will amend the 2017 Aquatic Plant Management Plan Update to incorporate a plan for a one year pilot program to removal excess filamentous algae, blue-green algae, duckweed and watermeal via surface suctioning. This one year pilot program will help DLSD to determine if the methodology is successful.

The goal of the surface suctioning is not to eradicate algae, duckweed or watermeal as these are all important components of a healthy lake ecosystem. The goal of the surface suctioning pilot program is to remove an overabundance of these plants in order to improve water quality and provide protection from nuisance algae blooms for lake users as well as lake inhabitants and enhance the overall experience for lake users. In addition, the removal of excess filamentous algae, duckweed and watermeal may reduce phosphorous levels. Blue-green algae is not actually a target species, but evidence supports that it will often be present with filamentous algae and will also be suctioned off. For this reason, safeguards will be in place to protect the public and workers from irritants associated with blue-green algae.

Filamentous Algae is an essential part of the lake ecosystems, but Delavan Lake often experiences excessive amounts of filamentous algae that negatively impact user enjoyment of the lake. Excessive algae can impede aquatic plant growth when it blocks sunlight from underwater habitats causing fish kills by clogging fish gills or reducing the ability of fish to hunt. Decomposing algae consumes dissolved oxygen causing "dead zones" and fish die off.

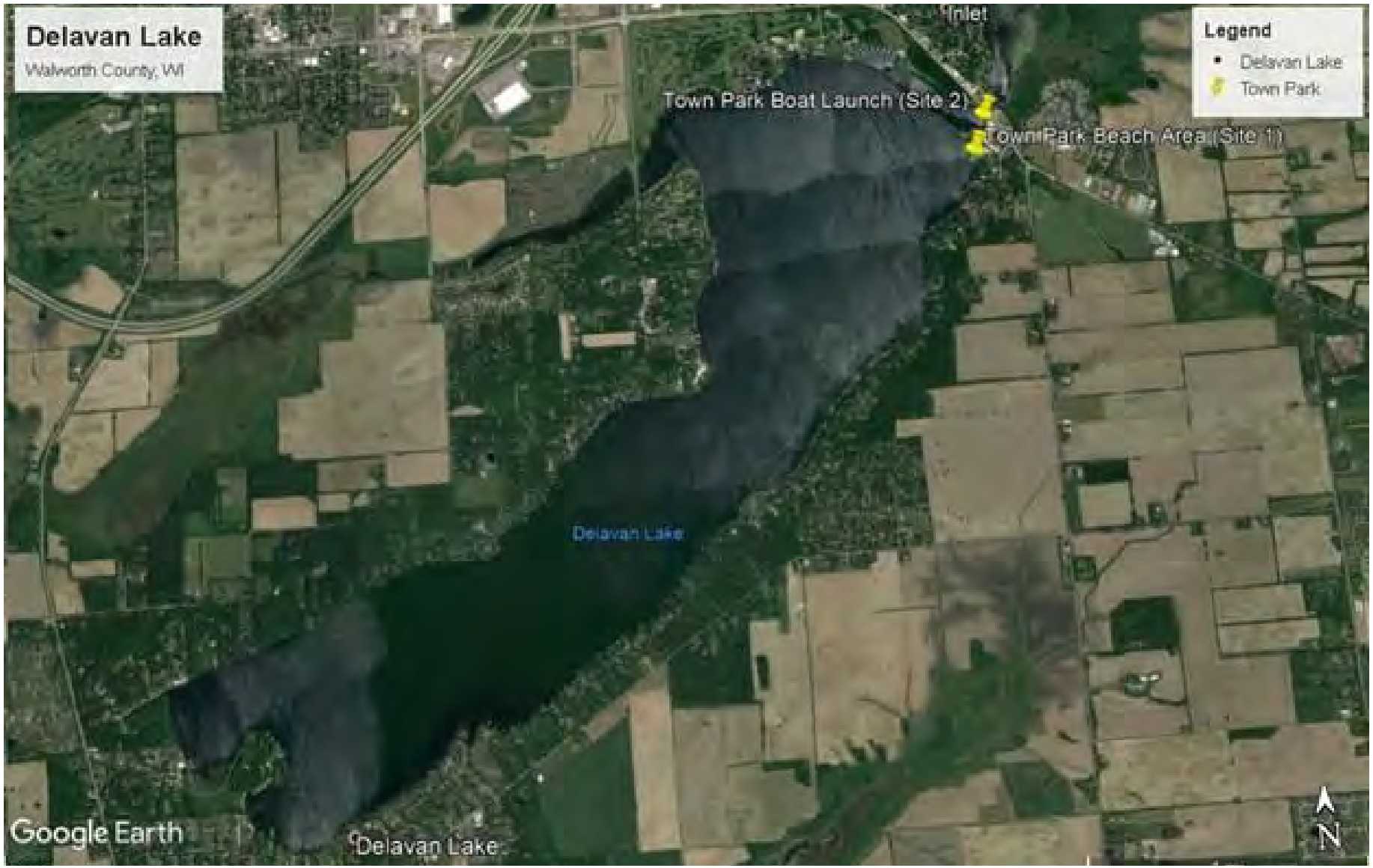
Filamentous Algae Bloom at View Crest Subdivision on the NW end of Delevan Lake

In addition, blue-green algae has been reported on Delavan Lake on several occasions. Some, but not all, Blue-green algae produce toxins which can cause illness in humans and animals. blue-green algae is not readily identified without laboratory identification, therefore removal of algae from sites with high human activity is desirable.

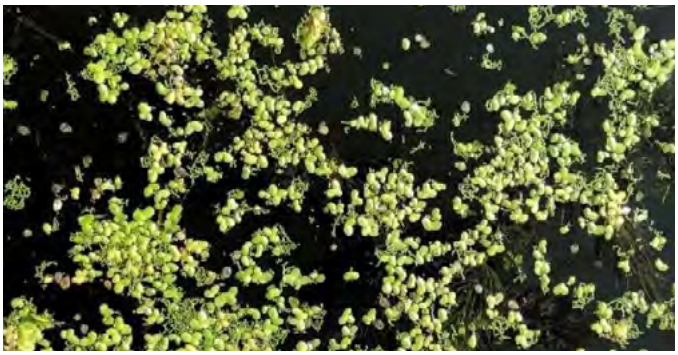
Potential Blue-Green Algae Bloom on Delavan Lake

[3] *Eiswerth, M., Dashian, R., Skidmore, M., University of Wisconsin Whitewater, 2005, What is the Value of a Clean and Healthy Lake to a Local Community*

Map C.1
Delavan Lake Walworth County, WI



Delavan Lake has documented Small Duckweed, *Lemna minor*, Forked Duckweed, *Lemna trisulca* and Watermeal, *Wolffia columbiana*. All three are native free floating leaf plants that are important waterfowl food. However, after large rain events produce runoff from upsteam basins which contain large amounts of nutrients, the result is generally an excessive increase in duckweeds and watermeal that can cover an area completely blocking sunlight from native plants beneath the water's surface.



This can have a negative effect on respiration rates (photosynthesis) of the aquatic plants below the water surface, which can reduce dissolved oxygen levels. Historically, DLSD has been permitted by the Wisconsin Department of Natural Resources (DNR) to chemically treat nuisance populations of duckweeds and watermeal, however these treatments are no longer allowed. The pilot program to remove excess duckweeds and watermeal by suctioning is attempt to treat this issue that can no longer be addressed with chemical means.

Duckweeds and Watermeal

Delavan Lake Sanitary District is proposing a one year pilot program to remove excess filamentous algae, blue-green algae, duckweed and watermeal in order to supplement Delavan Lakes existing aquatic plant management plan. The one year pilot program will help DLSD investigate the effectiveness of the methodology and make changes as needed. Since there is very little literature on this type of program, DLSD plans to conduct surface water suctioning at only two sites on the lake during the 2021 open water season. These sites are the public beach (Site 1) and the public boat launch (Site 2) (Map C.2). Both of these sites have high human activity. Records show in 2020 the public boat launch saw 14,258 boats launched, generally with two or more occupants per boat. The public beach not only hosts the annual 4th of July celebration but is also visited by several hundred beach goers per year. These locations have also historically been sites with excess filamentous algae, duckweed and watermeal.

The surface suctioning pilot project will be conducted twice per month, if lake conditions warrant, starting the week of June 21 and will continue through the week of August 16, 2021. Evaluation of this pilot program will be based on finding a substantial visual difference after four crew members conduct surface suctioning for four hours a day, twice per month. Before and after photographs will be taken of both sites for each occurrence. A log will be kept concerning any changes that need to be made to the program and Heidi Bunk will be apprised of these changes before they are undertaken.

If this pilot program is deemed successful DLSD will expand the program to include at a minimum of four sites, including Inlet area, View Crest channel, Outlet area and the beach area by High Lands Channel.

Map C.2
Surface Suction Locations

Methodology

Surface suctioning of filamentous algae, blue-green algae, duckweed and watermeal in 2021 will occur at the Town of Delavan Community Park Public Beach and Public Boat Launch area because these sites are well known for having nuisance populations of these during the summer and fall. Timing of treatment will be dependent on lake and weather conditions. This program will begin the week of June 21, 2021 and be conducted two times per month until the week of August 16, 2021

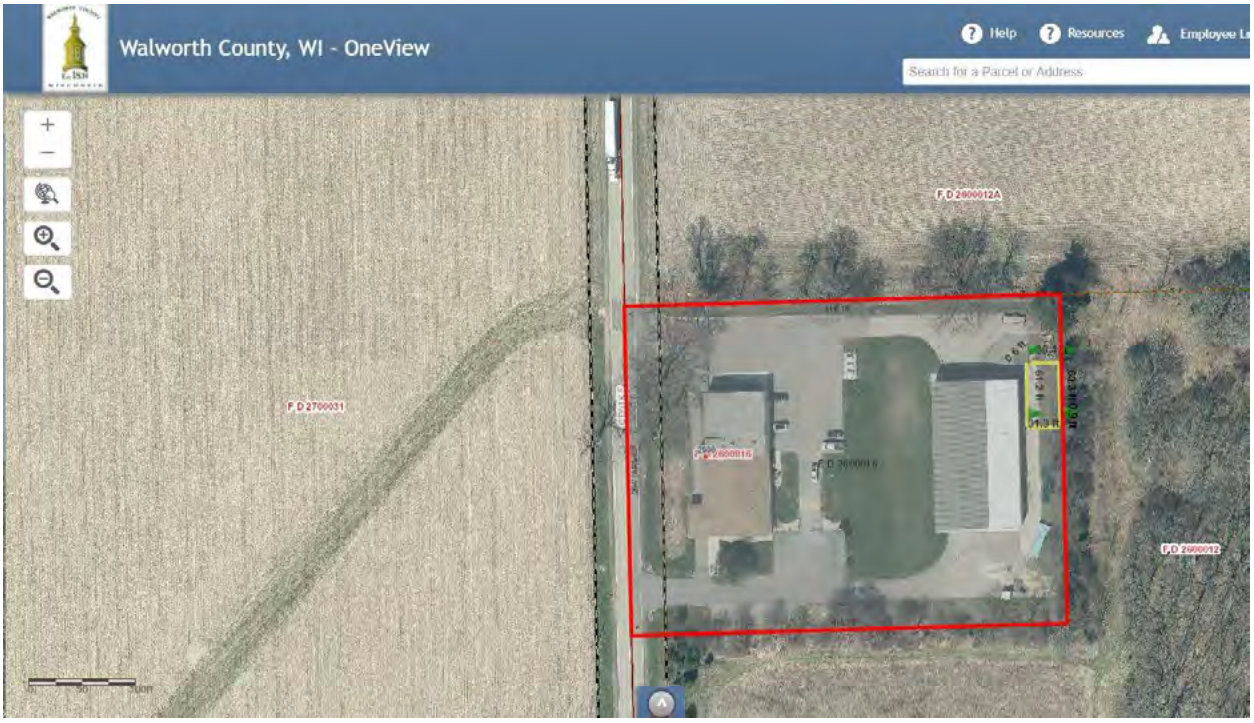
Surface suctioning crews will consist of 3-4 people that have been trained in the correct usage of the equipment, target species, safety measures and proper disposal. All crew members will be outfitted with chest waders, long rubber gloves (to shoulder), appropriate respirators and safety glasses. Due to the necessary safety equipment and the high summer temperatures and humidity, work will be conducted between 6am and 10am.

Equipment will include, one 30 foot x 10 foot barge that has been outfitted to act as a work platform and power source for a Salaroll pump in combination with a grinder pump, that will be used to suction filamentous algae, blue-green algae, duckweed and watermeal off the water surface. Suction capacity of the pump is 53 gallons per minute with a lift of 33 feet. Pump discharge capacity is 44 gallons per minute with a discharge length of 600 feet and discharge lift of 328 feet.[4] Suctioned material will be fed into one of two 1000 gallon CRMI white plastic vertical storage tanks that will be located on a 24 foot weight appropriate trailer that is parked as close as possible to the work site at Community Park. Once full, the 1000 gallon tanks will be transported on the trailer to DLSD's main facility where the content will be transferred to geotextile bags and placed on the ground at the edge of DLSD property (See Map C.3) for dewatering. Walworth County Zoning Maps shows no wetlands near dewatering site (See Map C.4). The Geotextile dewatering bags will be left to dry on site. Once completely dried, geotextile bags will be cut open, added to harvested aquatic plant load and disposed of at one of the DNR approved disposal sites (Map C.5) for harvested aquatic plants.

Proposed Transport for Suctioned Material

[4] *SalaRollpump Performance Literature*

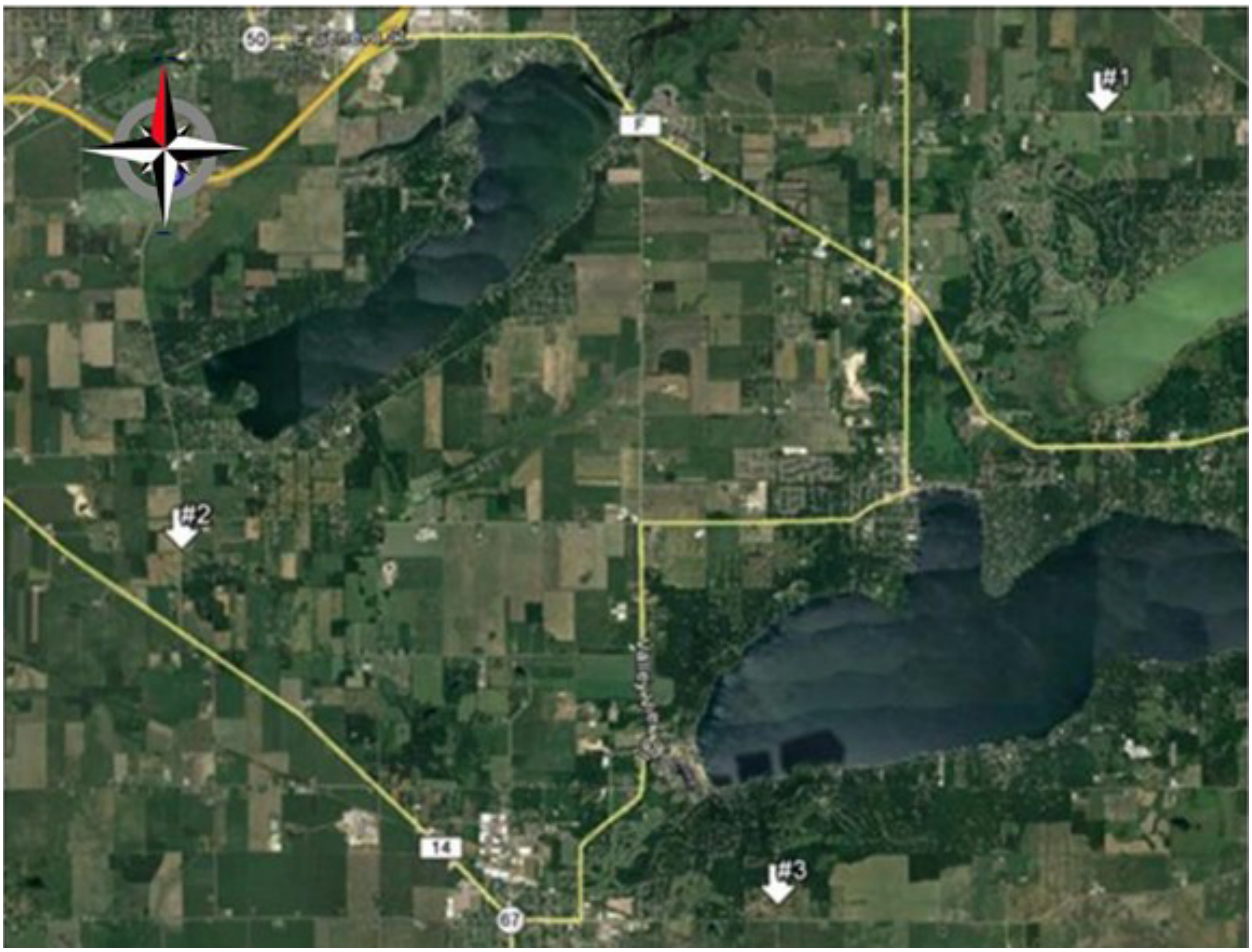
Map C.3
Location of Geotextile Dewatering Bags



Note: Proposed Dewatering Location (yellow)
(2) Geostrux Container Tubes, 22.5' x 20.0'
(2) 20 Mil Woven Coated PE Base Layer, 30.0' x 30.0'

Map C.4
Zoning Surrounding DLSD Property Showing No Wetlands Near Dewatering Site

Map C.5
Mechanical Harvesting Disposal Sites 2017-2021



Disposal Site	Parcel Number	Legal Description	Owner
1	J G 2000001	W1/2 NE1/4 NE1/4 and S1/2 of NE1/4, EXC. 66' ALG E LN SD PAR. And NW1/2 SE1/4, SEC 20 T2N R17E 138A	Charles G. Palmer and Connie Palmer
2	E W 600007	N1/2 SE1/4 SEC 6 T1N R16E. EXC HWY Land. EXC CSM 1968 74.89 A. M/L	CST Holding LLC
3	E W 2400004	W1/2 W1/2 NW1/4 and 6A IN SW COR E1/2 W1/2 NW1/4 being 2.881/4 CHS E and W by 3.31 CHS N and S Sec 24 T1N R16E 40.6A	William J Henry Trust

APPENDIX D
PURPLE LOOSESTRIFE BIOLOGICAL CONTROL

Purple Loosestrife Biological Control

Helping Native Plants Battle Invasive Species

Golden Sands
Resource Conservation
& Development Council, Inc.

February to March

Plan

Meet with local partners to gauge interest

Locate and solidify needed permission for root digging, beetle collection, and release area work sites

Submit DNR permit authorization application

Contact potential volunteers, explain process, and confirm intention to help dig and/or raise beetles

April

Spring Dig

Collect purple loosestrife roots and shoots in April

Place potted plants in a pool filled with water

Keep water two inches below the top of the soil so to not drown larvae

Cover with nets to keep predators out

Mid-May

Add Beetles

Collect beetles from the wild in mid-May

Collect 8-10 beetles for every potted plant

Place beetles on plant inside the net

By mid-summer, the beetles will have reproduced into as many as 1,000 beetles per plant!

May to June

Watch and Maintain

Keep pools filled with water

Make sure beetles do not eat their entire food source

Once the food source is almost gone, the plant can be moved to an existing stand, and nets can be removed

Late June to Early July

Release

Release beetles into a stand of purple loosestrife when their food source is low, usually late June to early July

The beetles can then go to work on controlling the existing stand!

After releasing, fill out and return the DNR insect release form to the state

Throughout the summer

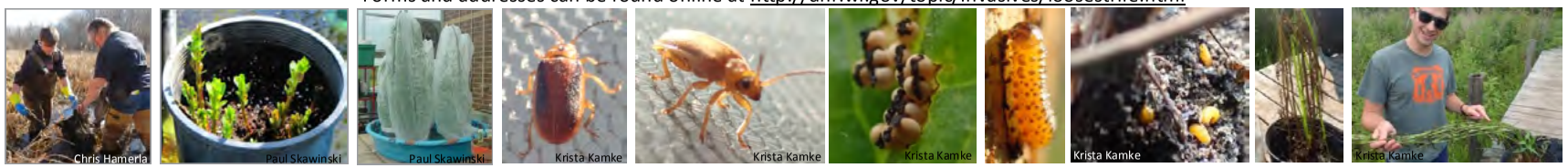
Biological Control

By eating the plant, the beetles stress the plant so it does not flower

This helps native plants take back the wetland, as every year, each purple loosestrife plant produces over 1 million seeds from pollinated flowers

Remember to collect the plant pots for rearing next year!

Forms and addresses can be found online at http://dnr.wi.gov/topic/Invasives/loosestrife.html



To learn more, find and contact your local Aquatic Invasive Species Coordinator at http://dnr.wi.gov/lakes/invasives/topics.aspx