LAKE NAMAKAGON CHAIN AQUATIC PLANT MANAGEMENT PLAN

BAYFIELD COUNTY, WI

AUGUST 2023

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INTRODUCTION

This Aquatic Plant Management Plan for Lake Namakagon, Garden Lake, and Jackson Lake in Bayfield County, Wisconsin presents a strategy for managing aquatic plants by protecting native plant populations, controlling the growth of hybrid Eurasian northern water-milfoil (HWM), and preventing establishment of additional invasive species. The plan includes data about the plant community, watershed, and water quality of the lakes. Based on this information and public input, goals and strategies for the management of aquatic plants in the lakes are presented. This plan will guide the Namakagon Lake Association (NLA) and the Wisconsin Department of Natural Resources in aquatic plant management for the lakes over the next 5 years (from 2024 through 2028).

PUBLIC INPUT FOR DEVELOPMENT

The Lake Namakagon Aquatic Plant Management (APM) Committee provided input for the development of this aquatic plant management at meetings held April 27, 2023, May 11, 2023, and June 15, 2023. The plan was released for public review July 15, 2023. The public comment period ran through August 15, 2023. One comment related to the lake map resulted in updates to Figure 4.

LAKE MANAGEMENT CONCERNS

The APM Committee expressed a variety of concerns that are reflected in goals, objectives, and actions for aquatic plant management in this plan. Aquatic plant management concerns and opportunities included the following: need for AIS prevention, avoiding unintended impacts from control measures, identifying best management practices for monitoring and control of hybrid Eurasian northern water-milfoil, shoreline and in-lake homeowner best practices, effective communication and coordination, recruiting and supporting volunteers, and identifying and maintaining partnerships.

STAKEHOLDER SURVEYS

Stakeholder use and perception of the Namakagon Chain have been assessed through a variety of surveys (Shiffered and Judd, 1998 and Foth, 2008). These studies suggest that the most common activities on the Namakagon Chain include motorized boating, entertaining, relaxation, fishing, wildlife observation, and swimming. Of these activities, motorized boating was most highly valued, followed by relaxation, scenic enjoyment, and fishing. In general, survey respondents indicate that the Namakagon Chain is a peaceful site to live and recreate and is generally in good health as both a fishery and ecological resource. A detailed shoreland health survey was conducted in a lake management planning effort. (Northland, 2016)

LAKE INFORMATION

Lake Namakagon (WBIC 2732600) is a 2,897 acre drainage lake located in Bayfield County, Wisconsin mostly within the Town of Namakagon. It has a maximum depth of 51 feet and a mean depth of 16 feet. The Namakagon Chain also includes Garden Lake (WBIC 2735500) – a 558 acre drainage lake with a maximum depth of 23 feet and Jackson Lake (WBIC 2734200) – a 149 acre drainage lake with a maximum depth of 13 feet. Lake information is summarized in Table 1. The lakes with are shown with WNDR sensitive areas and access sites indicated in Figure 4.

Table 1. Namakagon Chain Lake Characteristics

Lake	WBIC	Size (acres)	Maximum Depth	Trophic State	Lake Classification
Namakagon	2732600	2,897	51	Eutrophic	Deep, drainage
Garden	2735500	558	23	Eutrophic	Shallow, drainage
Jackson	2734200	149	13	Eutrophic	Shallow, drainage

WATER QUALITY

Water quality is frequently reported by the trophic state or nutrient level of the lake. Nutrient rich lakes are classified as eutrophic. These lakes tend to have abundant aquatic plant growth and low water clarity due to algae blooms. Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms. Oligotrophic lakes are nutrient poor with little growth of plants and algae.

Secchi depth readings are one way to assess the trophic state of a lake. The Secchi depth reported is the depth at which the black and white Secchi disk is no longer visible when it is lowered into the water. Greater Secchi depths occur with greater water clarity. It is important to note that factors other than nutrient status (such as tannins in the water) may reduce water clarity and influence Secchi depth results.

Citizen volunteers monitored lake water quality for many years on the Namakagon Chain. Figures 1-3 illustrate mean July and August Secchi depths for project lakes (WDNR, http://dnr.wi.gov/lakes/CLMN/). There is no particular trend in water clarity over the years. In general, clearest water is found in Lake Namakagon.

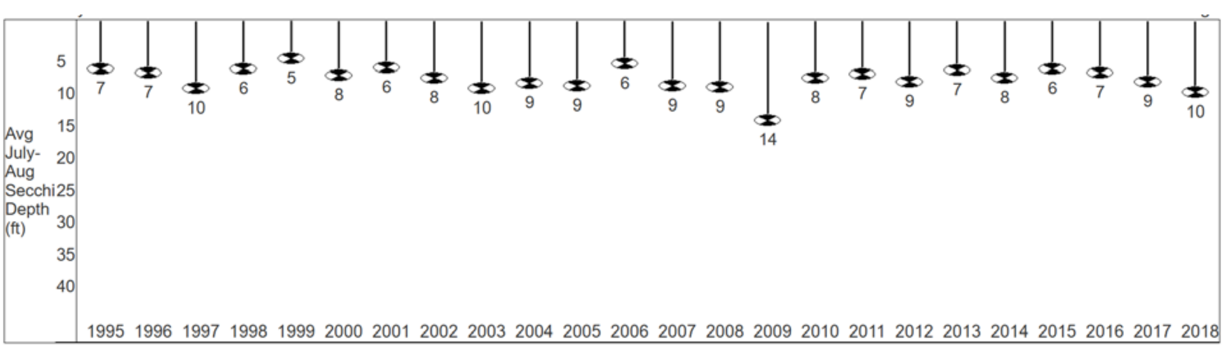

Figure 1. Lake Namakagon July – August Secchi Depth (1995-2018)

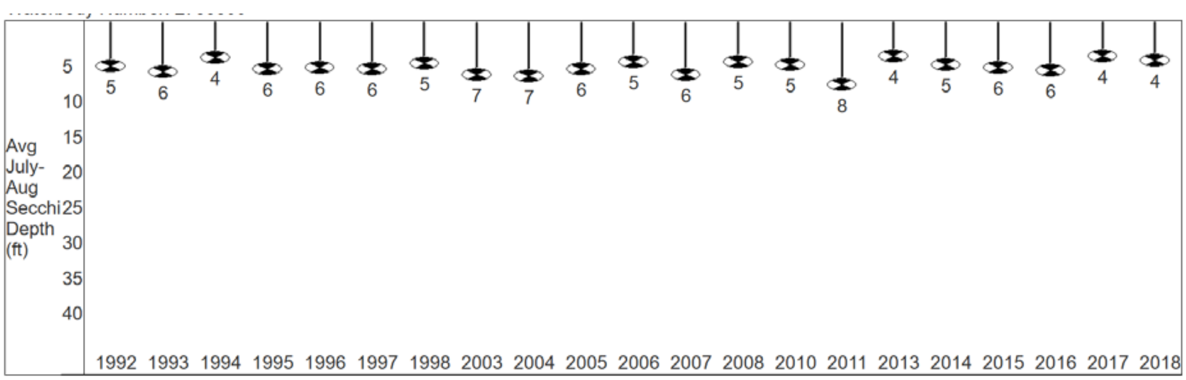

Figure 2. Garden Lake July – August Secchi Depth (1992-2018)

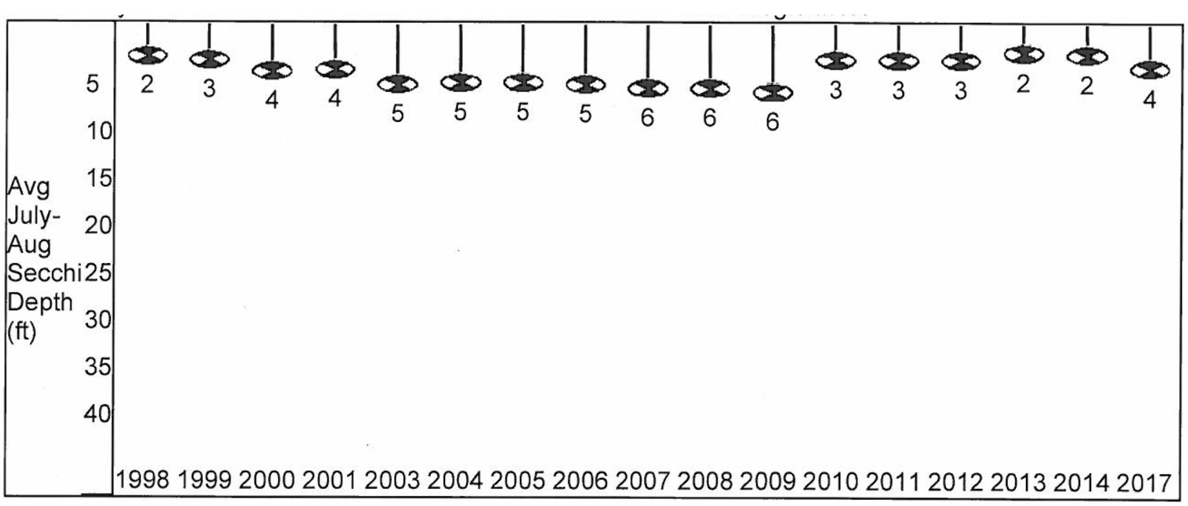

Figure 3. Jackson Lake July-August Secchi Depth (1998-2017)

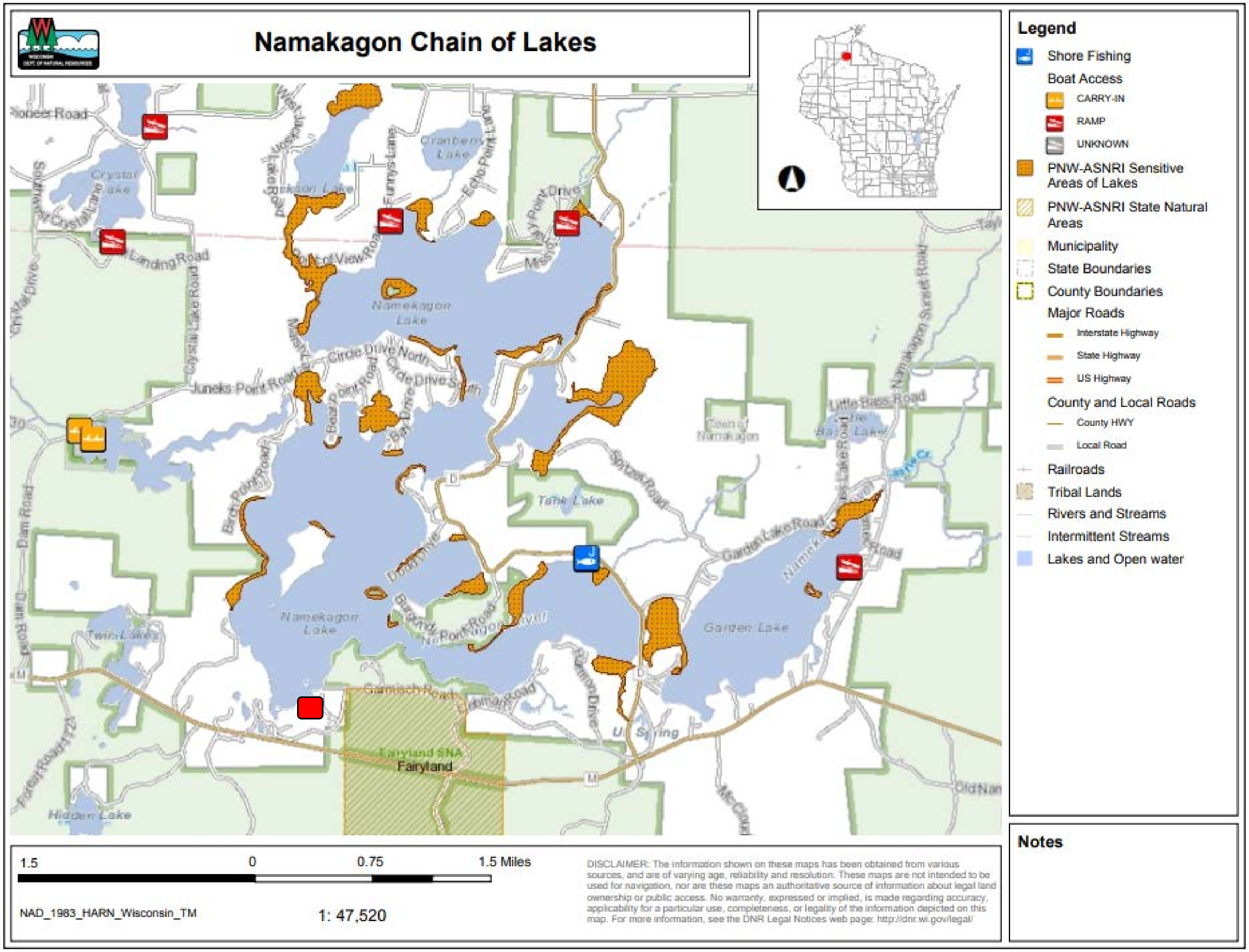

Figure 4. Map of Namakagon Chain of Lakes

Secchi depth readings, phosphorus concentrations, and chlorophyll measurements can each be used to calculate a Trophic State Index (TSI) for lakes. TSI values range from 0 – 110. TSI values from 40 to 50 characterize mesotrophic lakes. Lakes with TSI values greater than 50 are considered eutrophic, and lakes with TSI values below 40 are considered oligotrophic.

TSI values for project lakes based on Wisconsin Department of Natural Resources (WDNR) records for July and August are shown in Figures 5-7 below. The WDNR characterizes each of the lakes as eutrophic based on this information. However, the 2016 Northland College study characterized Lake Namakagon as mesotrophic considering historical water quality data based on mean summer total phosphorus and Secchi data (although the time period was not specifically indicated). Based on the monitoring results available to the WDNR, Namakagon and Jackson Lake water quality for recreation is considered GOOD and for fish and aquatic life is considered EXCELLENT.[1][2] Jackson Lake is listed as an impaired water for total phosphorus and is considered impaired and in POOR condition for recreation and for fish and aquatic life.[3] However, because it is a stained drainage lake with minimal shoreline development in a forested watershed, it may be a natural impairment that is not controllable.

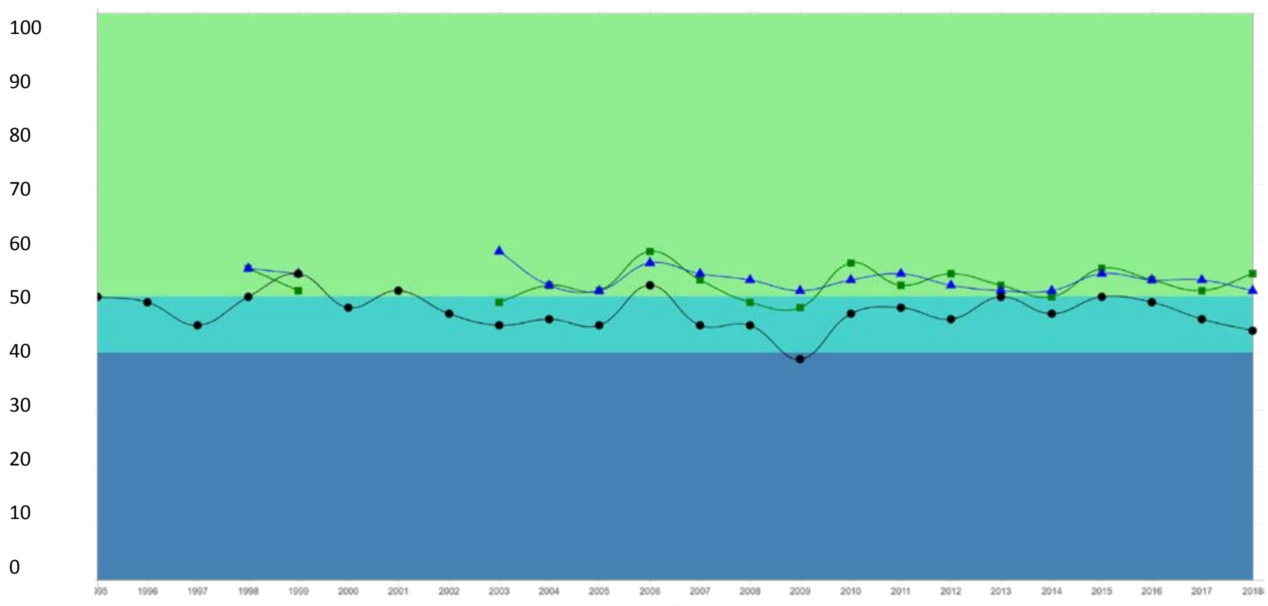

Figure 5. Trophic State Index for Lake Namakagon (1995 – 2018)

[1] https://dnr.wi.gov/water/waterDetail.aspx?key=17437 (accessed from web site 03/20/2023)
[2] https://dnr.wi.gov/water/waterDetail.aspx?key=21004 (accessed from web site 03/20/2023)
[3] https://dnr.wi.gov/water/waterDetail.aspx?key=17444 (accessed from web site 03/20/2023)

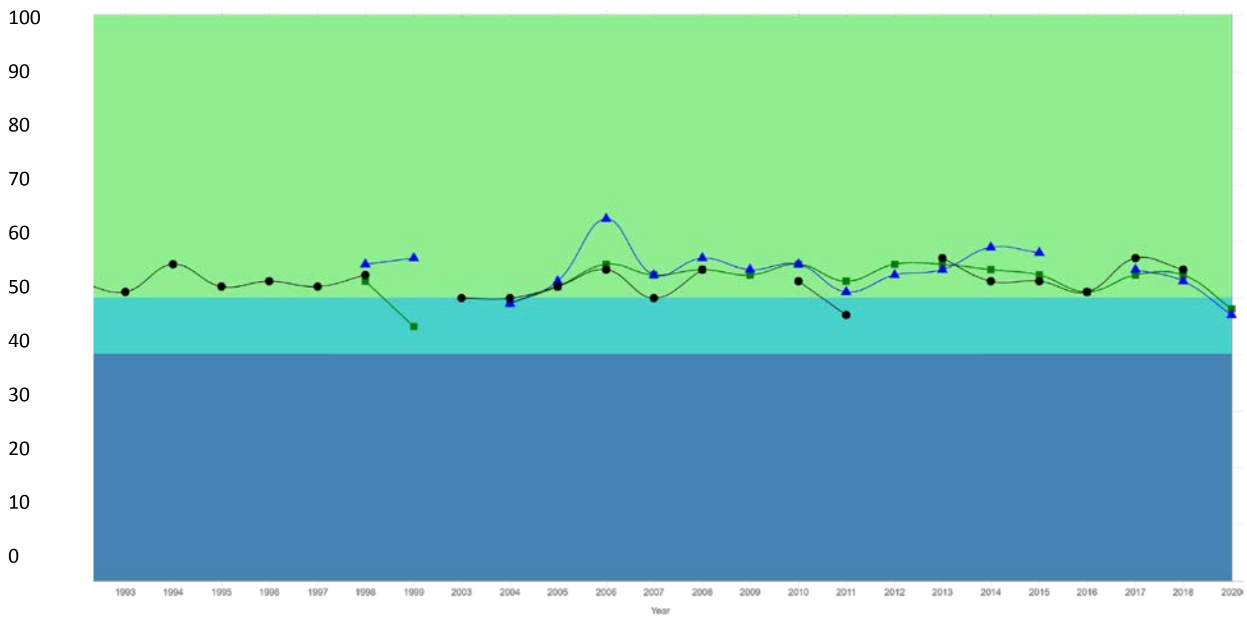

Figure 6. Trophic State Index for Garden Lake (1992-2018)

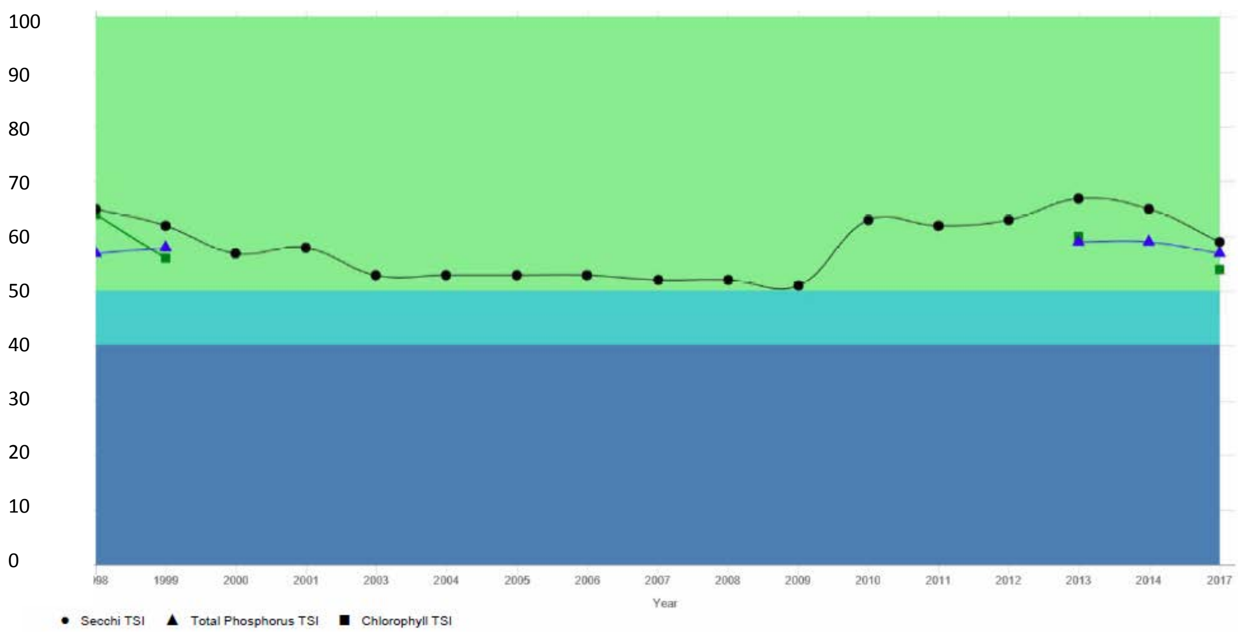

Figure 7. Trophic State Index for Jackson Lake (1998-2017)

LAKE CLASSIFICATION

The Wisconsin Department of Natural Resources sets water quality standards for lakes based on total phosphorus (TP) in NR 102.06(4). The TP standard for stratified drainage lakes is 30 µg/L. A lake with surface water inflow/outflow from a river or stream is classified as a drainage lake. Stratified lakes exhibit thermal layering throughout the summer or they undergo intermittent stratification. The summer index period for total phosphorus is June 1 – September 15 (Wisconsin Department of Natural Resources, 2023). The WDNR confirms Lake Namakagon meets standards for a stratified drainage lake in its 2024 proposed healthy waters list.

The TP standard for non-stratified (shallow) drainage lakes is 40 µg/L. A non-stratified, shallow lake, results in a value of less than 3.8 according to the following equation:

$$\frac{\text{Maximum Depth (feet)}*0.3048 - 0.1}{\text{Log 10 (Lake Area (acres)}*0.40469)}$$

(WDNR, 2014)

According to this equation, Jackson Lake is a shallow lake with a result of 2.6. Northland College investigators also identified Jackson Lake as mixed in their water quality study (Northland, 2016). If TP results from Jackson Lake for only the summer index period are considered, Jackson Lake does not meet the total phosphorus standard for a shallow drainage lake (Average of 9 readings from July 15 – September 15, 2013-2017 Citizen Lake Monitoring data = 48.5µg/L).

Garden Lake is also a shallow lake, according to this equation, with a result of 3.0. If TP results from Garden Lake for only the summer index period are considered, Garden Lake meets the total phosphorus standard of 40 µg/L (Average of 8 readings from June 1 – September 15, 2015-2020 Citizen Lake Monitoring data = 26.4 µg/L).

NORTHLAND COLLEGE WATER QUALITY MONITORING

The Burke Center at Northland College is working with the Namakagon Lake Association to establish a long-term water quality monitoring program for the Namakagon Chain. They will operate and maintain water quality sensors attached to buoys in each of these three lakes and sample the lakes approximately every ~2-3 weeks from May to October beginning in 2023.

Water quality buoys with sensors attached will measure surface water temperature, conductivity, dissolved oxygen concentrations, chlorophyll-a (a proxy for algae concentrations), and dissolved organic matter (measure of natural brown staining of water). The buoy data will be available to the public on an hour-by-hour basis via HydroVu, a website associated with the sensors. A second set of sensors will record temperature at 1 m intervals to measure lake stratification.

Staff and students from the Burke Center will sample at the buoy locations and analyze samples for concentrations of total phosphorus, nitrate, ammonium, and chlorophyll-a, among other parameters. Burke Center staff and students will provide data summaries to the Town of Namakagon, Namakagon Lake Association, and other interested parties upon request.

WATERSHED

The watershed of the Namakagon Chain is about 62 square miles, not including the lakes themselves. A lake's water quality is influenced by land cover in its watershed. Watershed land cover shown in Figure 8 and summarized in Figure 9 was based on a combination of 2011 data from the National Land Cover Dataset (NLCD) and parcel specific shoreland habitat assessments (Northland, 2016). Historical, current, and anticipated future land use and land cover information were used to calculate annual phosphorus loads to the Namakagon Chain. Total acreages of land covers were multiplied by expected annual pounds/acre/year phosphorus runoff values. Current land cover is largely undeveloped, and shoreland and road development has resulted in a relatively small estimated increase in phosphorus loading from estimates of loading from the mid-nineteenth century. However, phosphorus loading is predicted to increase and water quality to decline if the watershed's private forests are converted into residential uses (Northland, 2016).

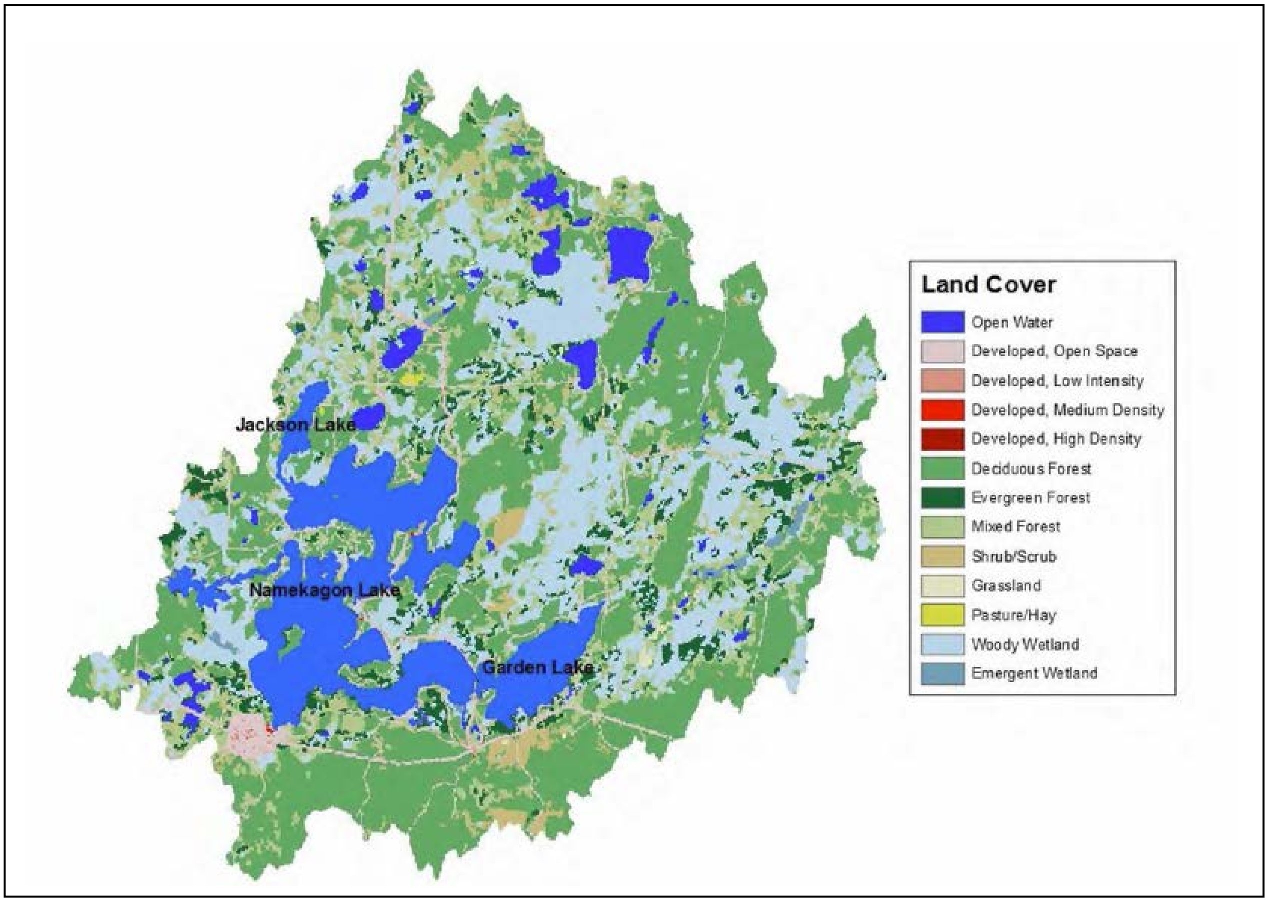

Figure 8. Lake Namakagon Watershed Land Cover (Northland, 2016)

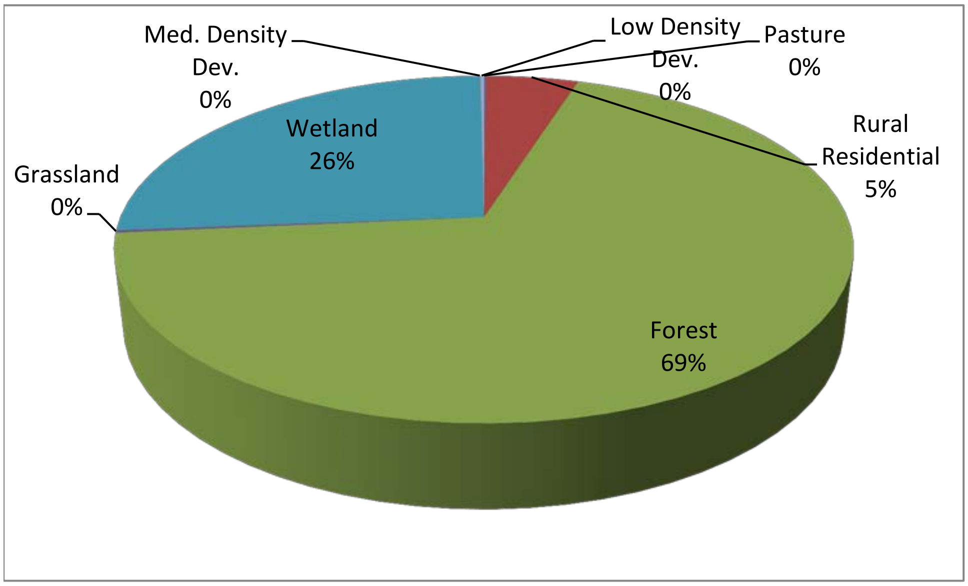

Figure 9. Watershed Land Cover Composition (Northland, 2016)

AQUATIC USE AND HABITAT

PRIMARY HUMAN USE AREAS

The Namakagon Chain has three public and seven private launches, two public swimming beaches, and a number of walk/carry-in access points as shown in Figure 4. The Namakagon Lake Association reports the following on its web site:

With over 3,000 acres of water, there is plenty of room to explore by boat, kayak, or canoe. Sailing and water skiing are also popular, and there are boat rentals and several public boat launches. Quiet boats can explore Lake Namakagon's many bays and islands, including Paines Island where local pairs of eagles nest in the spring.

A Class A muskie lake, Lake Namakagon is one of only three lakes in Wisconsin managed as a trophy muskie lake. There are also healthy populations of walleye, northern pike, bluegill, crappie, and largemouth and smallmouth bass. In the winter there is ice fishing.

WATER BODIES WITH EWM AND HYBRID EWM PRESENT

Lake Namakagon is one of only a few lakes in adjacent counties where hybrid Eurasian-northern water-milfoil has been confirmed, although there are several with Eurasian water-milfoil as shown in Figure 10 and listed in Table 2.

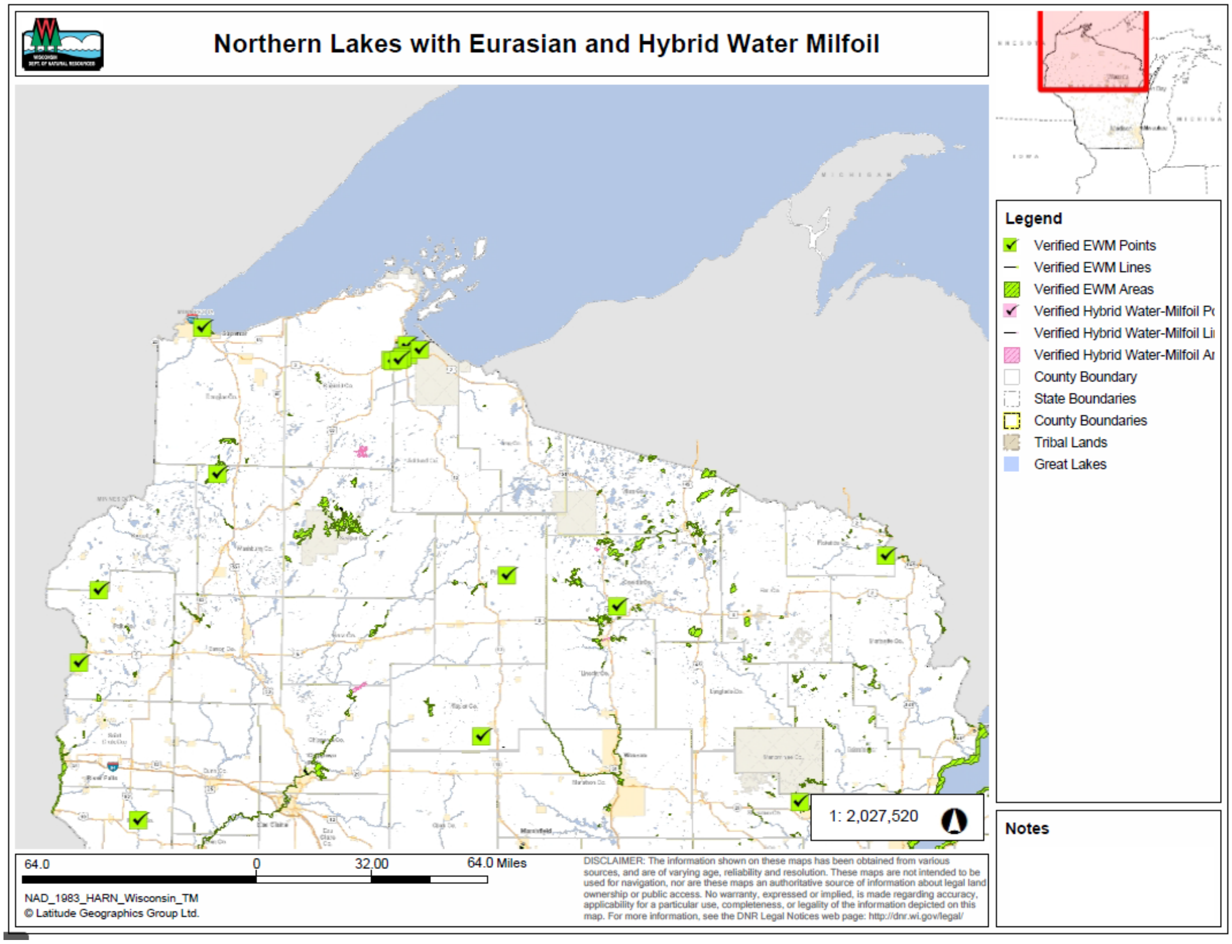

Figure 10. Northern Wisconsin Lakes with Eurasian and Hybrid Water-milfoil (WDNR 2023)

Table 2. Eurasian Water-milfoil (EWM) and Hybrid Eurasian-Northern Water-milfoil Locations

Bayfield County	Buskey Bay	EWM	Verified and Vouchered	2007
	Eagle Lake (Pike Chain)	EWM	Verified and Vouchered	2005
	Fish Creek Sloughs	EWM	Verified and Vouchered	2012
	Flynn Lake	EWM	Verified and Vouchered	2014
	George Lake	EWM	No Longer Observed	2011
	Hart Lake	EWM	Verified and Vouchered	2004
	Lake Millicent	EWM	Verified and Vouchered	2008
	Lake Superior -- Long Bridge Access	EWM	Verified	2019
	McCarry Lake	EWM	Verified and Vouchered	2017
	Lake Namakagon	Hybrid	Verified	2016
	Prentice Park Slough - Short Bridge	EWM	Verified	2019
	Sand Bar Lake	EWM	Verified and Vouchered	2004
	Tomahawk Lake	EWM	Verified and Vouchered	2004
	Twin Bear Lake	EWM	Verified and Vouchered	2004
	Washburn Harbor	EWM	Verified	1992
Sawyer County	Barber Lake	EWM	Verified	2021
	Big Sissabagama Lake	EWM	Verified and Vouchered	2022
	Callahan Lake	EWM	Verified and Vouchered	2005
	Chippewa Lake (N of CTH B)	EWM	Verified	2006
	Clear Lake	EWM	Verified and Vouchered	1999
	Connors Lake	EWM	Verified and Vouchered	2002
	Hayward	Hybrid	Verified	2012
	Hayward Lake	EWM	Verified	2011
	Lake Chippewa (Chippewa Flowage)	EWM	Verified and Vouchered	1991
	Little Lac Courte Oreilles	EWM	Verified and Vouchered	2015
	Little Round Lake	EWM	Verified and Vouchered	1999
	Lost Land Lake	EWM	Verified and Vouchered	2013
	Lost Land Lake	Hybrid	Verified	2014
	Mud Lake	EWM	Verified and Vouchered	2005
	Mud Lake	EWM	Verified and Vouchered	2005
	North Fork Chief River (From Lake Chippewa to Callahan Lake)	EWM	Verified and Vouchered	2006
	Osprey Lake	EWM	Verified and Vouchered	2005
	Radisson Flowage	EWM	Verified and Vouchered	2003
	Round Lake	Hybrid	Verified and Vouchered	2022
	Round Lake (Big Round)	EWM	Verified and Vouchered	1993
	Tiger Cat Flowage	EWM	No Longer Observed	2013
	Whitefish Lake	EWM	Verified and Vouchered	2008
Ashland County	Chequamegon Bay (at Ashland marina)	EWM	Verified	1997
	Kakagon Slough	EWM	Verified	2011
Douglas County	Allouez Bay	EWM	Verified	2018
	Cranberry Lake	EWM	Verified and Vouchered	2006
	Hog Island Inlet	EWM	Verified	2016
	Minong Flowage	EWM	Verified and Vouchered	2002
	Red Lake	EWM	Verified and Vouchered	2016
	St. Croix (Gordon) Flowage	EWM	Verified and Vouchered	2007
	Superior Bay, Lake Superior	EWM	Verified	2006

FUNCTIONS AND VALUES OF NATIVE AQUATIC PLANTS

Naturally occurring native plants are extremely beneficial to the lake. They provide a diversity of habitats, help maintain water quality, sustain fish populations, and support common lakeshore wildlife such as loons and frogs. (Borman, 1997)

WATER QUALITY

Aquatic plants can improve water quality by absorbing phosphorus, nitrogen, and other nutrients from the water that could otherwise fuel nuisance algal growth. Some plants can even filter and break down pollutants. Plant roots and underground stems help to prevent re-suspension of sediments from the lake bottom. Stands of emergent plants (whose stems protrude above the water surface) and floating plants help to blunt wave action and prevent erosion of the shoreline.

Emergent plants are found on sand and gravel bars and around Lake Namakagon's numerous islands. The emergent community is dominated by creeping spikerush (*Eleocharis palustris*), hardstem bulrush (*Schoenoplectus acutus*), and common bur-reed (*Sparganium eurycarpum*). Emergents are also found in shallow, sandy muck areas. Floating-leaf species dominate just beyond the emergents in up to 4 feet of water in sheltered areas, like Sugar Bay, with nutrient-rich organic muck bottoms (Berg, 2016).

FISHING

Habitat created by aquatic plants provides food and shelter for both young and adult fish. Invertebrates living on or beneath plants are a primary food source for many species of fish. Other fish, such as bluegills, graze directly on the plants themselves. Plant beds in shallow water provide important spawning habitat for many fish species.

WATERFOWL

Plants offer food, shelter, and nesting material for waterfowl. Birds eat both the invertebrates that live on plants and the plants themselves.

PROTECTION AGAINST INVASIVE SPECIES

Non-native invasive aquatic species threaten native plants in Northern Wisconsin. The most common are Eurasian water-milfoil (EWM) and curly leaf pondweed (CLP). These species are described as opportunistic invaders. This means that they take over openings in the lake bottom where native plants have been removed. Without competition from other plants, these invasive species may successfully become established and spread in the lake. This concept of opportunistic invasion can also be observed on land, in areas where bare soil is quickly taken over by weeds.

Removal of native vegetation not only diminishes the natural qualities of a lake, but it increases the risk of non-native species invasion and establishment. The presence of invasive species can change many of the natural features of a lake and often leads to expensive annual control plans. Allowing native plants to grow may not guarantee protection against invasive plants, but it can discourage their establishment. Native plants may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm (WDNR, 2007).

HABITAT AREAS

The Department of Natural Resources designates critical habitat areas that include both sensitive areas and public rights features. The critical habitat area designation provides a holistic approach to ecosystem assessment and protection of those areas within a lake that are most important for preserving the character and qualities of the lake. These sites are those sensitive and fragile areas that support wildlife and fish habitat, provide the mechanisms that protect the water quality in the lake, harbor quality plant communities, and preserve the places of serenity and aesthetic beauty for the enjoyment of lake residents and visitors.

Critical habitat areas include sensitive areas that offer critical or unique fish and wildlife habitat, including seasonal or life stage requirements, or offer water quality or erosion control benefits to the area (Administrative code 107.05(3)(1)(1)). The Wisconsin Department of Natural Resources is given the authority for the identification and protection of sensitive areas of the lake in this code. Public rights features are areas that fulfill the right of the public for navigation, quality and quantity of water, fishing, swimming, or natural scenic beauty. Protecting these critical habitat areas requires the protection of shoreline and in-lake habitat.

SENSITIVE AREAS

Wisconsin Department of Natural Resources staff conducted the Lake Namakagon sensitive area designation survey in July and August of 2000 (WDNR, 2000). Survey participants identified a total of 33 sensitive area sites in Lake Namakagon. Sensitive area sites are shown in Figure 4. These sites include approximately 17.5 miles, or about 40%, of the Lake Namakagon shoreline. The sites were selected primarily because of two major habitat features: 1) aquatic vegetation or 2) gravel/rubble substrate.

RECOMMENDATIONS: SENSITIVE AREA SITES BASED ON AQUATIC VEGETATION HABITAT

The 22 aquatic vegetation-based sites contain aquatic plant communities that provide critical habitat for fish and wildlife, as well as for shoreline erosion prevention and bank stabilization.

Management Recommendations:

1. Limit the removal of aquatic vegetation to the construction of navigation channels only. If navigation channels are necessary, minimize the length and width of the channel. Note that at some sensitive area sites, removal of any aquatic vegetation is not recommended.

2. Control the spread of exotic species such as purple loosestrife. Contact a WDNR aquatic plant specialist for assistance in controlling exotic species.

3. Prohibit littoral zone alterations covered by Chapter 30 Wisconsin Statutes, unless there is clear evidence that such alterations would benefit the lake's ecosystem. Examples of such alterations regulated in Chapter 30 Wisconsin Statutes include: placement of rip-rap on lake beds or banks with the intent to improve stability; dredging of lake bottom material with the intent to improve recreational habitat or navigable access; and placement of fish cribs or similar devices with the intent to improve fishing habitat.

4. Do not remove large woody cover such as logs, downed trees, and stumps within the littoral zone in order to provide cover habitat for fish, wildlife, and other organisms.

5. Preserve/restore the terrestrial vegetation for shoreline cover. Keep lake view corridors to 30 feet or less. Natural vegetative cover acts as a buffer against shoreline erosion and silt runoff. Rock rip-rap is often not required for shoreline stabilization if a healthy plant community already exists.

6. Use best management practices within the lake's watershed (such as those covered in *Wisconsin's Forestry Best Management Practices for Water Quality*, WDNR publication # FR093) to reduce the potential of silt, debris, or nutrients from entering the lake system.

7. Encourage local contractors and town and county road crews to learn and implement best management practices in road design, maintenance, and construction to protect water quality.

RECOMMENDATIONS: SENSITIVE AREA SITES BASED ON GRAVEL/RUBBLE SUBSTRATE HABITAT

The eleven fishery-based sensitive area designation sites contain gravel and rubble lake bottom substrate that provides important seasonal habitat for successful walleye and/or smallmouth bass spawning. Walleyes require areas of clean gravel/rubble substrate void of sediment for natural reproduction to occur in a lake. The ideal spawning habitat for smallmouth bass is an area of gravel/rubble substrate containing a shallow layer of fine sediments. The bass clears away a small portion of the fine sediment layer to expose gravel, therein constructing a "nest" in which to spawn. If these types of habitat are degraded, the natural walleye and smallmouth bass populations may decline or be lost altogether.

Management Recommendations:

1. Prohibit alterations of gravel/rubble substrate at these sites, unless alterations would improve fish spawning success. Chapter 30 Wisconsin Statutes requires permits for such alterations.

2. Utilize proper erosion control measures to preserve gravel/rubble habitat if near-shore construction should occur in these areas. Uncontrolled or poorly conducted construction activities would threaten important fish spawning habitat.

3. Preserve/restore natural vegetative buffers along the shoreline to provide the best long-term and natural protection against shoreline erosion and silt runoff.

4. Aquatic plant management may be appropriate in certain circumstances (e.g., exotic species control). In general, however, aquatic vegetation removal is not advisable because aquatic plants provide protective cover, shade, food sources, and reproductive areas for fish, macroinvertebrates, and/or wildlife.

FISHERY

A comprehensive fish survey was most recently completed on Lake Namakagon and Garden Lake in 2021. Results from that survey indicate a diverse fish community with walleye (*Sander vitreus)*, muskellunge (*Esox masquinongy)*, northern pike (*E. Lucius)*, largemouth bass (*Micropterus salmoides)*, smallmouth bass (*M. dolomieui)*, bluegill (*Lepomis macrochirus)*, pumpkinseed (*L. gibbosus)*, rock bass (*Ambloplites rupestris)*, black crappie (*Pomoxis nigromaculatus)*, yellow perch (*Perca flavescens)*, white sucker (*Catostomus commersoni)*, yellow bullhead (*Ictalurus natalis)*, black bullhead (*I. melas)*, trout perch (*Percopsis omniscomaycus)*, tadpole madtom (*Noturus gyrinus)*, common shiner (*Notropis cornutlus)*, golden shiner (*Notemigonus crysoleucas)*, spottail shiner (*N. hudsonius)*, shorthead redhorse (*Moxostoma macrolepidotum*), mudpuppy (*Necturus maculosus*), creek chub (*Semotilus atromaculatus*), bluntnose minnow (*Pimephales notatus*), and burbot (*Lota lota*) present. Results from an angler creel survey conducted from May of 2021 to March of 2022 indicate that muskellunge, black crappie, and walleye are the species most sought after by anglers. Muskellunge density was estimated at 0.25 fish/acre in 2021 which is slightly higher than the 2002 estimate of 0.20 fish/acre. This density is considered low compared to muskellunge densities in other northern Wisconsin lakes. Walleye density was estimated at 4.31 fish/acre from the 2021 survey, which is higher than the 2017 estimate of 2.34 fish/acre. Average density in northern Wisconsin walleye lakes is around 3 fish/acre.[4]

WALLEYE POPULATION

Walleye population estimates were completed by WDNR in 1989, 1993, 2002, and 2021 using fyke netting for marking walleye and electrofishing for recapture. The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) completed walleye population estimates in 2000, 2011, and 2017 using electrofishing for both mark and recapture. Walleye density declined from 1989 to 2017 and increased since 2017 (Figure 11). In general, walleye populations have declined in northern Wisconsin over the last few decades due to a multitude of complex interacting factors, both abiotic and biotic. However, the 2021 increase in walleye abundance is a promising sign that this population has recovered in recent years to the abundance levels observed in the early 2000s and in 2011. Annual fall electrofishing surveys targeting age-1 walleye have indexed strong year classes since 2016 indicating that natural reproduction has been successful in recent years and that the population should be sustained into the coming years (Figure 12).

[4] Fishery information provided by Nathan Thomas, WDNR Fisheries Biologist, March 21, 2023.

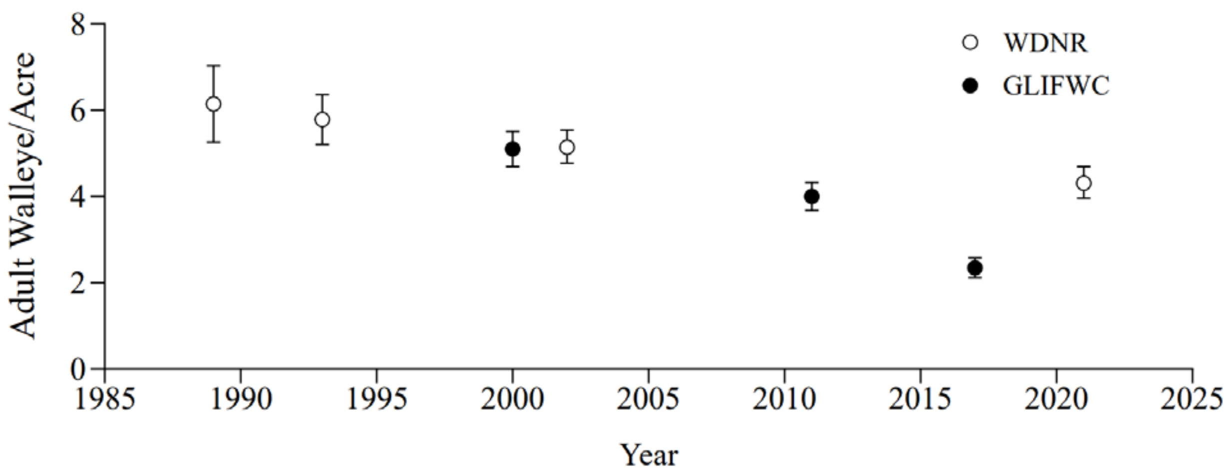

Figure 11. Estimated Adult Walleye/Acre in Lake Namakagon
From mark recapture surveys conducted by Wisconsin Department of Natural Resources (WDNR; white circles) and Great Lakes Indian Fish and Wildlife Commission (GLIFWC; black circles) with error bars representing the 95% confidence interval of the estimate.

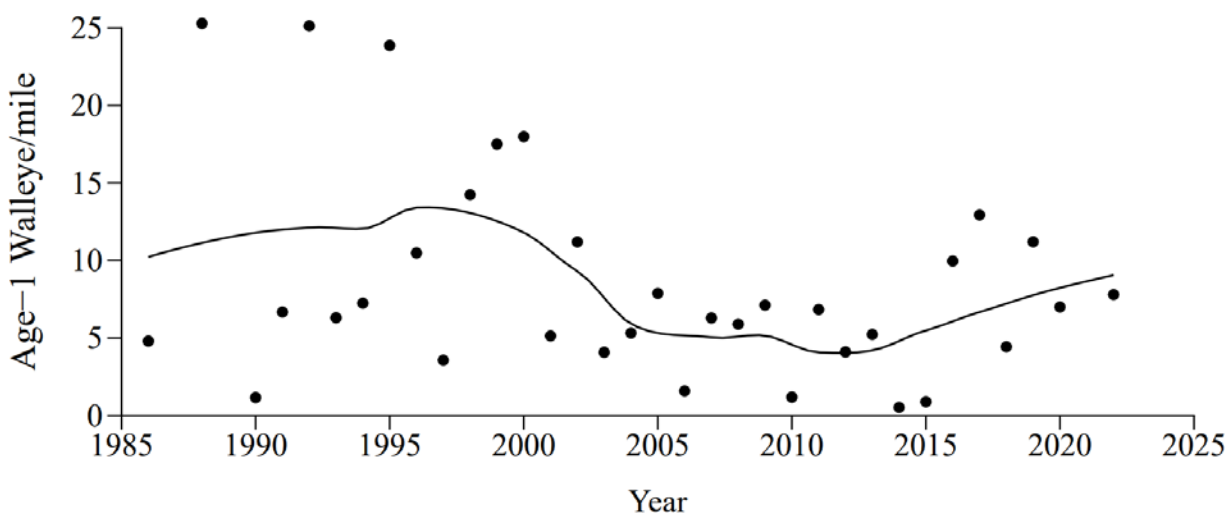

Figure 12. Number of age-1 Walleye Captured/Mile of Shoreline Sampled.
From fall electrofishing surveys conducted on Lake Namakagon. Black line represents a running average trend line through time.

FISHERIES MANAGEMENT

Fisheries management has primarily focused on walleye and muskellunge. The lake chain is classified as a trophy muskellunge fishery meaning there are large fish, but the numbers of fish are relatively low. There is limited natural reproduction of muskellunge, so the population has been sustained through stocking since 1997 (Table 3). The walleye population is sustained through natural reproduction with some limited stocking (Table 3). Fishing regulations have been the primary method of managing the walleye population. Current management objectives for walleye and muskellunge are to maintain a walleye population that is sustained through natural reproduction and maintain a trophy muskellunge fishery. Working with residents, the NLA and conservation groups, DNR fisheries management staff will develop a comprehensive long-term fisheries management plan using data collected in the 2021 fishery survey and 2021-2022 angler creel survey. This fisheries management plan will include quantitative objectives for fishery metrics and specific fish habitat conservation goals.

FISHERIES CONCERNS RELATED TO PLANT MANAGEMENT

When treating plants with herbicides, fish may be negatively impacted as fish and their eggs may be susceptible to the herbicides. A study found long-term 2,4-D treatments of EWM in a northern Wisconsin lake likely caused recruitment failure in largemouth bass, northern pike, bluegill, yellow perch, smallmouth bass, and black crappie. Thus, 2,4-D alternatives should be considered, and aquatic plant management plans should limit the spatial scope and frequency of treatments within a lake (Schleppenbach et. al., 2022). Musky could have newly distributed eggs during an early season EWM treatment, so caution regarding repeated use may be warranted.

A study of the effects of the herbicides diquat, fluridone, and endothall on the early life stages of walleye, largemouth bass, and smallmouth bass indicated that diquat is more toxic to the fish tested than fluridone which is more toxic than endothall (Paul E. A., et. al., 1994). Very early life stages of walleye were found to be the most sensitive, and walleye were more sensitive than bass to all herbicides tested. The study reported a 96-hour LC-50[1] ranging from 0.74-4.9 mg/L for diquat, depending upon the species and lifestage. Application rates of 2 gallons per acre in 4 feet of water (as applied at Lakewoods in April 2017) predict a concentration of 0.37 mg/L. However, herbicides rapidly dissipate and diquat also binds to sediments with predicted concentrations reported to decrease to 0.1 mg/L in 24 hours and .001 mg/L in 48 hours (Syngenta).

[1] An **LC50** value is the concentration of a material in air that will kill 50% of the test subjects when administered as a single exposure.

Table 3. WDNR Fish Stocking Lake Namakagon[5]

Year	Species	Age Class	Number Stocked	Avg. Length (in.)
2021	MUSKELLUNGE	LARGE FINGERLING	787	14.1
2021	WALLEYE (Non-DNR)	LARGE FINGERLING	21133	5.8
2020	WALLEYE (Non-DNR)	LARGE FINGERLING	7860	6.5
2019	MUSKELLUNGE	LARGE FINGERLING	750	12.6
2018	MUSKELLUNGE	LARGE FINGERLING	554	12.2
2018	WALLEYE	LARGE FINGERLING	3097	6.4
2017	MUSKELLUNGE	LARGE FINGERLING	825	11.3
2015	MUSKELLUNGE	LARGE FINGERLING	2,500	12.4
2013	MUSKELLUNGE	LARGE FINGERLING	2,500	11.57
2011	MUSKELLUNGE	LARGE FINGERLING	2,500	10
2009	MUSKELLUNGE	LARGE FINGERLING	2,500	10.5
2007	MUSKELLUNGE	LARGE FINGERLING	2,491	12.1
2005	MUSKELLUNGE	LARGE FINGERLING	2,500	12
2003	MUSKELLUNGE	LARGE FINGERLING	2,500	12
2001	MUSKELLUNGE	LARGE FINGERLING	3,227	10.2
1999	MUSKELLUNGE	LARGE FINGERLING	2,500	11.25
1997	MUSKELLUNGE	LARGE FINGERLING	2,500	10.8
1993	MUSKELLUNGE	FINGERLING	3,300	11.93
1992	MUSKELLUNGE	FINGERLING	2,500	10
1991	MUSKELLUNGE	FINGERLING	2,500	11
1990	MUSKELLUNGE	FINGERLING	1,250	11
1989	MUSKELLUNGE	FINGERLING	2,500	10
1988	MUSKELLUNGE	FINGERLING	5,000	10.33
1987	MUSKELLUNGE	FINGERLING	3,246	9
1986	MUSKELLUNGE	FINGERLING	2,500	9
1985	MUSKELLUNGE	FINGERLING	4,000	11.5
1984	MUSKELLUNGE	FINGERLING	1,000	11
1983	MUSKELLUNGE	FINGERLING	1,000	10
1992	WALLEYE	FINGERLING	11,250	5.1
1977	WALLEYE	FRY	384,000	

[5] https://dnr.wi.gov/fisheriesmanagement/Public/Summary/Index (accessed 03/20/2023)

AQUATIC PLANT SURVEY RESULTS

LAKE NAMAKAGON 2022

An aquatic plant inventory was completed for Lake Namakagon in August 2022 according to the WDNR-specified point intercept method (Appendix A). A full description of the survey and results are found in the report: *Warm-water Point-intercept Macrophyte Survey Namekagon Lake - WBIC: 2732600 Bayfield County, Wisconsin.* Results and figures in this section are taken directly from this report (Berg, 2022).

The survey collected data on the richness, diversity, abundance, and distribution of native aquatic plant populations. These data provide a baseline for long-term monitoring of the lake's aquatic plant community as well as a way to measure any impacts on the lake's plants when active management occurs. Other goals included documenting the current density of hybrid water-milfoil (HWM) within its known distribution, removing as many of these plants as possible, searching for additional HWM populations, and reporting any other exotic (also referred to as invasive in this document and other sources) species found. A general boat survey was conducted prior to the point intercept survey to gain familiarity with the lakes and the species present on them.

The WDNR developed the 1,291 point survey sampling grid for Lake Namakagon using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth, and total acreage. Lake Namakagon has extremely varied underwater topography with numerous flats, saddles, and sunken islands. With the exception of Sugar and Mumm's Bay, the north bays of the Upper Lake, and the finger bay near the Namakagon River outlet, most shorelines dropped off rapidly into over 15 feet of water (Figure 13).

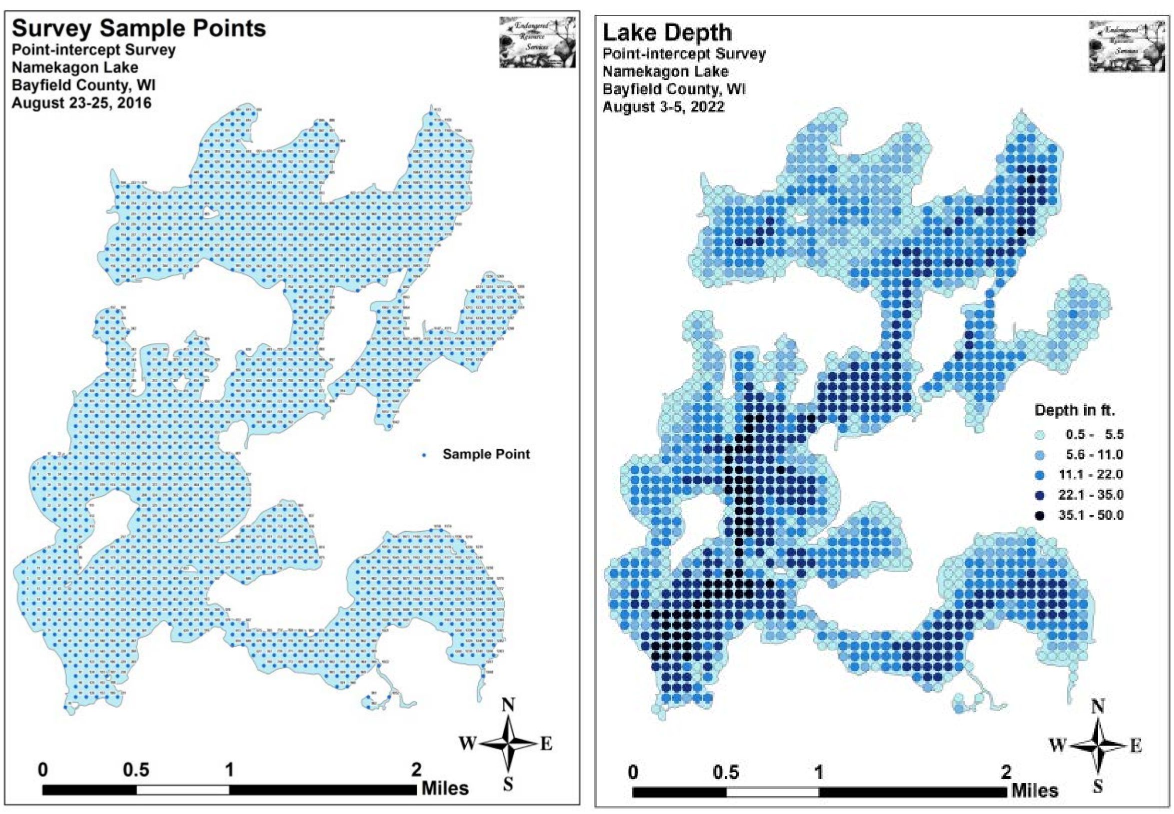

Figure 13. Survey Sample Points and Lake Depth

Nutrient poor sand and sandy muck dominated the majority of the littoral (depths at which plants can grow) lake bottom. Most rock areas occurred around islands, on sunken islands, or along the immediate shoreline. Nutrient rich organic muck dominated Sugar Bay, the northwest bays of the Upper Lake near the Jackson Lake Channel, the bay in the lower lake near the Garden Lake Channel, and near the river outlet (Figure 14). Where rake samples were possible (15 feet deep or less), the bottom substrate of the littoral zone consisted of 52.7% pure sand, 35.2% sandy and organic muck, and 12.1% gravel and rock. The littoral zone extended to 12.5 feet. Plant coverage was spotty with 426 out of 593 points (71.8%) having at least some macrophytes present (Figure 14).

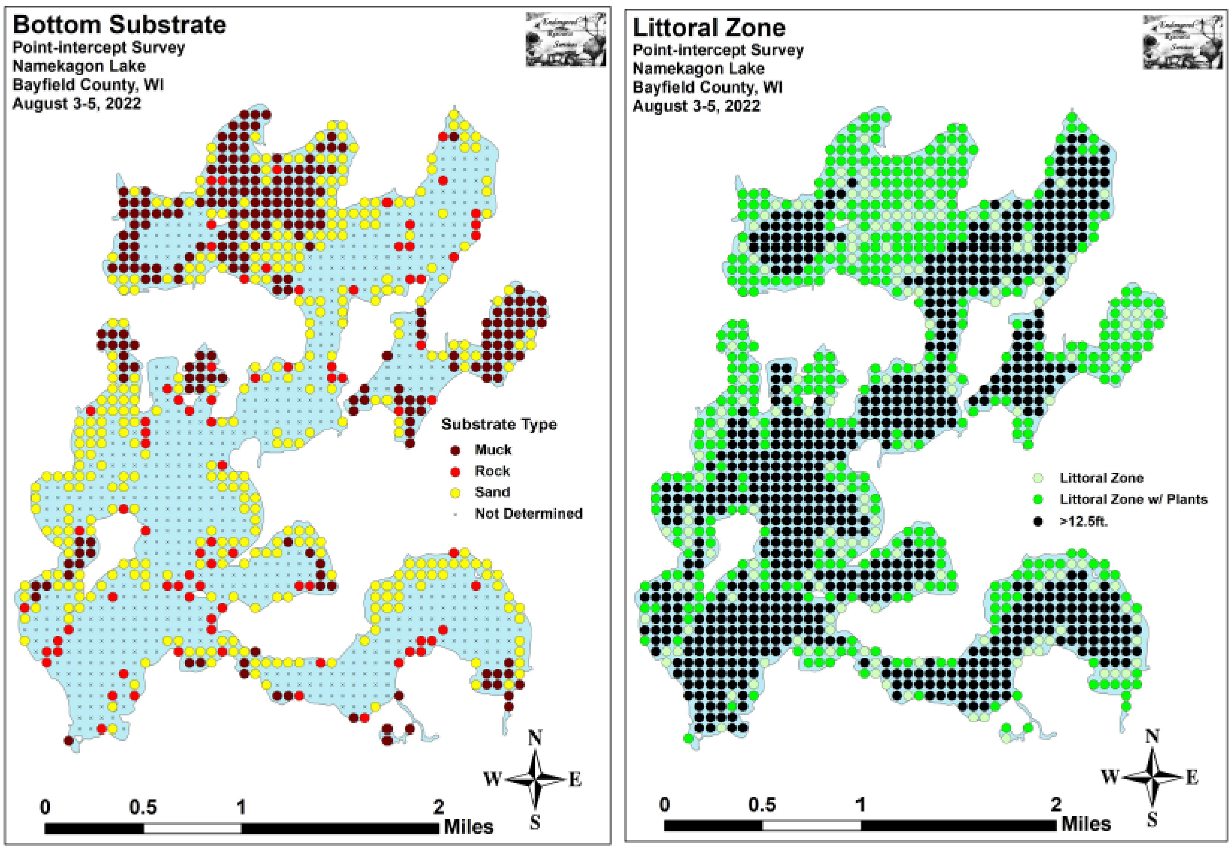

Figure 14. Bottom Substrate and Littoral Zone (Berg, 2016)

LAKE NAMAKAGON AQUATIC PLANT SURVEYS

Summary statistics from point intercept surveys in 2016 and 2022 are included in Table 4.

Table 4. Lake Namakagon Aquatic Macrophyte Point Intercept Survey Summary Statistics

Summary Statistics	2016	2022
Total number of points sampled	1,291	1,291
Total number of sites with vegetation	387	426
Total number of sites shallower than the maximum depth of plants	515	593
Frequency of occurrence at sites shallower than maximum depth of plants	75.1	71.8
Simpson Diversity Index	0.90	0.92
Maximum depth of plants (ft)	11.0	12.5
Mean depth of plants (ft)	5.4	5.5
Median depth of plants (ft)	5.5	5.0
Average number of all species per site (shallower than max depth)	2.01	1.87
Average number of all species per site (vegetative sites only)	2.68	2.60
Average number of native species per site (shallower than max depth)	2.01	1.87
Average number of native species per site (sites with native species only)	2.68	2.60
Species richness	48	54
Species richness (including visuals)	51	57
Species richness (including visuals and boat survey)	60	65
Mean total rake fullness (vegetative sites only)	1.73	1.84

Plant diversity was exceptionally high in 2022 with a Simpson Index value of 0.92 – up from 0.90 in 2016. Total richness was also very high with 54 species found in the rake (up from 48 species in 2016). This total increased to 65 species when including visuals and plants seen during the boat survey (up from 60 in 2016).

Despite the increase in overall richness, mean native species richness at sites with native vegetation saw a non-significant decline (p=0.21) from 2.68 species/site in 2016 compared to 2.60 species/site in 2022. Visual analysis of the maps showed many areas of the lower lake, as well as many nearshore areas, saw a general increase in richness. These gains appear to have been offset by additional low richness colonization of deepwater areas.

Total rake fullness underwent a significant increase (p=0.01) from a low/moderate mean rake fullness of 1.73 in 2016 to a moderate 1.84 in 2022. Visual analysis of the maps suggested most increases in biomass occurred in the bays of the Upper and Lower Lake, while most declines occurred in the Middle Lake areas – especially along the western shoreline and extending to the outlet bay.

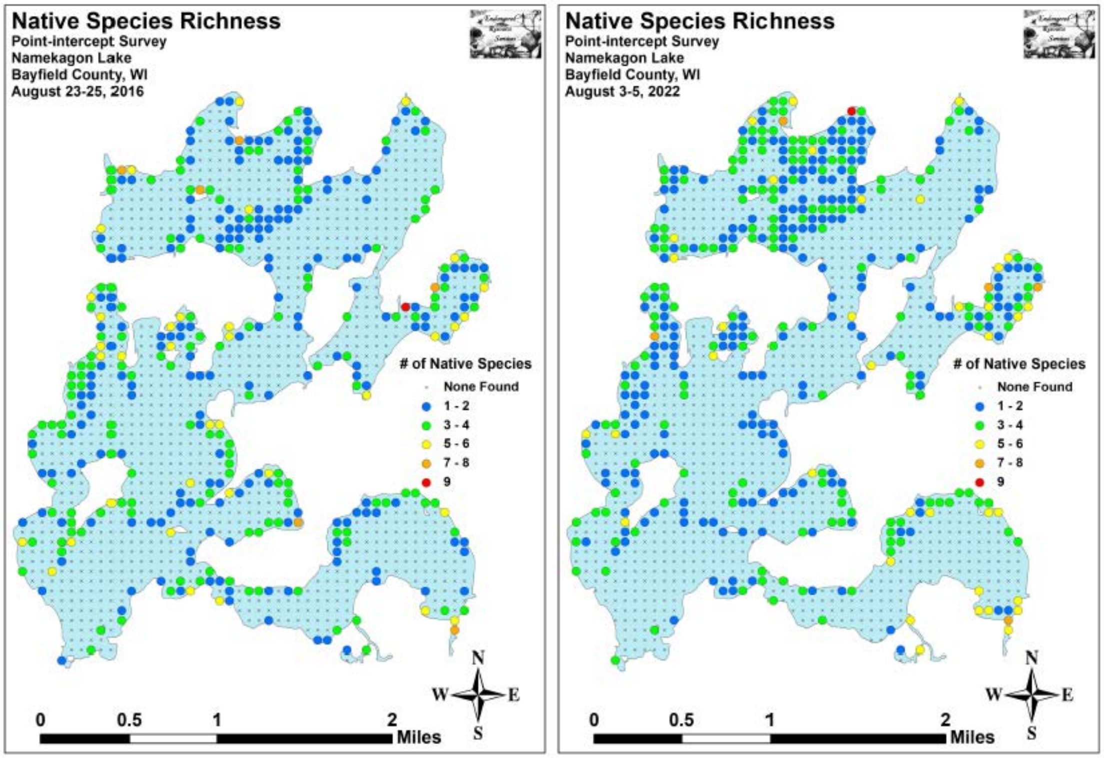

Figure 15. Native Species Richness 2016 and 2022 (Berg, 2022)

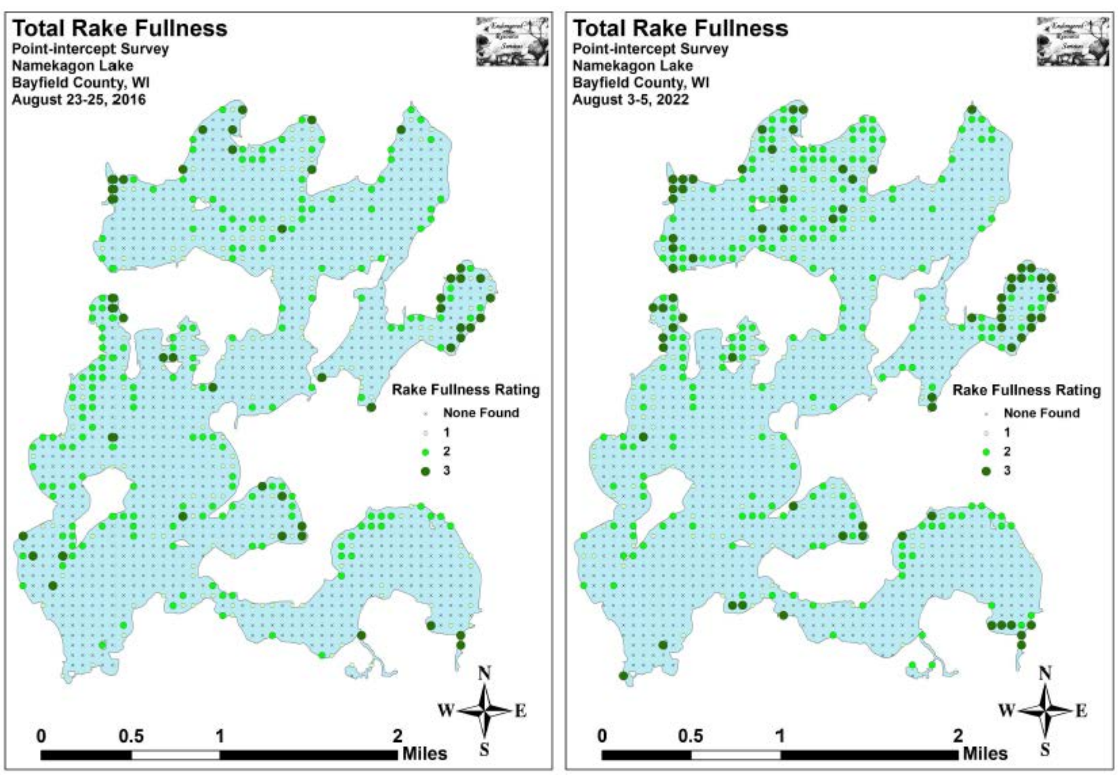

Figure 16. Total Rake Fullness 2016 and 2022 (Berg, 2022)

LAKE NAMAKAGON AQUATIC PLANT DIVERSITY

The Lake Namakagon ecosystem is home to a rich and diverse plant community that is primarily a function of the local water depth and substrate. This community can be subdivided into four distinct zones (emergent, floating-leaf, shallow submergent, and deep submergent) with each zone having its own characteristic functions in the lake ecosystem. Depending on the local bottom type (sand, rock, firm nutrient poor sandy muck, or soft nutrient rich organic muck (boggy)), these zones often had somewhat different species present. Descriptions of the various plant community zones with example aquatic plant photographs are found in the full plant survey report.

A total of 50 native index plants were identified in the rake during the 2022 point intercept survey. They produced a mean Coefficient of Conservatism of 6.6 and a Floristic Quality Index of 46.5. Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Namekagon Lake slightly below average for this part of the state. The FQI value was, however, almost double the median FQI of 24.3 for the Northern Lakes and Forest Region (Nichols 1999). Plants included three-way sedge, a state Species of Special Concern.[6]

[6] Special concern species are those species about which some problem of abundance or distribution is suspected but not yet proved. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.

Table 5. Lake Namakagon Frequencies and Mean Rake Sample of Aquatic Macrophytes (2022)

Species	Common Name	Total Sites	Rel. Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Vallisneria americana	Wild celery	214	19.31	50.23	36.09	1.25	8
Najas flexilis	Slender naiad	123	11.10	28.87	20.74	1.30	0
Elodea canadensis	Common waterweed	111	10.02	26.06	18.72	1.46	0
Potamogeton pusillus	Small pondweed	90	8.12	21.13	15.18	1.40	2
Potamogeton gramineus	Variable pondweed	60	5.42	14.08	10.12	1.53	16
Potamogeton zosteriformis	Flat-stem pondweed	54	4.87	12.68	9.11	1.31	22
Potamogeton richardsonii	Clasping-leaf pondweed	45	4.06	10.56	7.59	1.18	9
Potamogeton amplifolius	Large-leaf pondweed	43	3.88	10.09	7.25	1.28	13
Potamogeton robbinsii	Fern pondweed	43	3.88	10.09	7.25	1.72	0
	Filamentous algae	38	*	8.92	6.41	1.24	0
Nymphaea odorata	White water lily	34	3.07	7.98	5.73	1.65	6
Chara sp.	Muskgrass	30	2.71	7.04	5.06	1.20	0
Ceratophyllum demersum	Coontail	27	2.44	6.34	4.55	1.30	1
Potamogeton spirillus	Spiral-fruited pondweed	23	2.08	5.40	3.88	1.39	2
Myriophyllum sibiricum	Northern water-milfoil	18	1.62	4.23	3.04	1.50	4
Brasenia schreberi	Watershield	16	1.44	3.76	2.70	1.69	1
Pontederia cordata	Pickerelweed	15	1.35	3.52	2.53	2.20	7
Sparganium fluctuans	Floating-leaf bur-reed	15	1.35	3.52	2.53	1.87	7
Bidens beckii	Water marigold	14	1.26	3.29	2.36	1.07	3
Nitella sp.	Nitella	14	1.26	3.29	2.36	1.36	0
Nuphar variegata	Spatterdock	12	1.08	2.82	2.02	1.58	6
Potamogeton praelongus	White-stem pondweed	12	1.08	2.82	2.02	1.33	12
Eleocharis palustris	Creeping spikerush	8	0.72	1.88	1.35	1.50	0
Sparganium emersum	Short-stemmed bur-reed	8	0.72	1.88	1.35	1.25	3
Potamogeton friesii	Fries' pondweed	7	0.63	1.64	1.18	1.14	0
Utricularia vulgaris	Common bladderwort	7	0.63	1.64	1.18	1.57	1
Heteranthera dubia	Water star-grass	6	0.54	1.41	1.01	1.00	0
Eleocharis acicularis	Needle spikerush	5	0.45	1.17	0.84	1.20	0
Equisetum fluviatile	Water horsetail	5	0.45	1.17	0.84	1.40	1
Schoenoplectus acutus	Hardstem bulrush	5	0.45	1.17	0.84	2.40	3
Potamogeton epihydrus	Ribbon-leaf pondweed	4	0.36	0.94	0.67	1.75	2
Sagittaria latifolia	Common arrowhead	4	0.36	0.94	0.67	1.50	2
Carex lasiocarpa	Narrow-leaved woolly sedge	3	0.27	0.70	0.51	2.33	2
Dulichium arundinaceum	Three-way sedge	3	0.27	0.70	0.51	2.00	1
Sparganium eurycarpum	Common bur-reed	3	0.27	0.70	0.51	1.00	4
Ceratophyllum echinatum	Spiny hornwort	2	0.18	0.47	0.34	1.00	0

* Excluded from the Relative Frequency Calculation

Table 5. Lake Namakagon Frequencies and Mean Rake Sample of Aquatic Macrophytes (2022) continued

Species	Common Name	Total Sites	Rel. Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Eleocharis erythropoda	Bald spikerush	2	0.18	0.47	0.34	2.00	0
Myriophyllum spicatum* X *sibiricum	**Hybrid water-milfoil**	2	0.18	0.47	0.34	1.50	0
Potamogeton natans	Floating-leaf pondweed	2	0.18	0.47	0.34	1.50	0
Potamogeton vaseyi	Vasey's pondweed	2	0.18	0.47	0.34	1.00	0
Potamogeton X *scoliophyllus*	Large-leaf X Illinois pondweed Hybrid (likely)	2	0.18	0.47	0.34	2.00	0
Sagittaria cristata	Crested arrowhead	2	0.18	0.47	0.34	1.00	3
Callitriche hermaphroditica	Autumnal water-starwort	1	0.09	0.23	0.17	1.00	0
Carex comosa	Bottle brush sedge	1	0.09	0.23	0.17	1.00	1
Carex utriculata	Common yellow lake sedge	1	0.09	0.23	0.17	1.00	0
Glyceria borealis	Northern manna grass	1	0.09	0.23	0.17	2.00	0
Isoetes echinospora	Spiny spored-quillwort	1	0.09	0.23	0.17	1.00	1
Lemna trisulca	Forked duckweed	1	0.09	0.23	0.17	1.00	0
Potamogeton foliosus	Leafy pondweed	1	0.09	0.23	0.17	1.00	0
Ranunculus aquatilis	White water crowfoot	1	0.09	0.23	0.17	1.00	0
Sagittaria graminea	Grass-leaved arrowhead	1	0.09	0.23	0.17	1.00	2
Schoenoplectus tabernaemontani	Softstem bulrush	1	0.09	0.23	0.17	2.00	0
Sparganium natans	Small bur-reed	1	0.09	0.23	0.17	1.00	0
Stuckenia pectinata	Sago pondweed	1	0.09	0.23	0.17	1.00	0
Typha latifolia	Broad-leaved cattail	1	0.09	0.23	0.17	1.00	4
	Aquatic moss	1	*	0.23	0.17	1.00	0
	Freshwater sponge	1	*	0.23	0.17	1.00	0

Table 6. Lake Namakagon Observed Aquatic Macrophytes (2022)

Species	Common Name
Calamagrostis canadensis	Bluejoint
Callitriche palustris	Common water-starwort
Decodon verticillatus	Swamp loosestrife
Acorus americanus	Sweet-flag
Bolboschoenus fluviatilis	River bulrush
Iris pseudacorus	**Yellow iris**
Myosotis scorpioides	**Common forget-me-not**
Phragmites australis americanus	Common reed
Potamogeton alpinus	Alpine pondweed
Typha* X *glauca	**Hybrid cattail**
Utricularia intermedia	Flat-leaf bladderwort

SIGNIFICANT CHANGES IN AQUATIC PLANTS (2016 – 2022)

Lakewide, 14 species showed significant changes in distribution from 2016 to 2022. Wild celery, Clasping-leaf pondweed, Northern water-milfoil, Water marigold, and freshwater sponges suffered highly significant declines ($p<0.001$). Spiny-spored quillwort saw a moderately significant decline ($p=0.006$); and Variable pondweed ($p=0.02$) and Grassleaved arrowhead ($p=0.04$) experienced significant declines. Conversely, Common waterweed, Small pondweed, and Slender naiad enjoyed highly significant increases ($p<0.001$); and Flat-stem pondweed ($p=0.002$), filamentous algae ($p=0.002$), and Spiralfruited pondweed ($p<0.01$) underwent moderately significant increases.

Northern water-milfoil suffered a highly significant decline ($p=0.004$) in distribution (60 sites in 2016/18 sites in 2022) and fell in community rank from the fourth to the fourteenth most common species. Although this species is known to go through natural but dramatic boom/bust population cycles, visual analysis of the maps showed the only place it was still regularly found was in areas of the lower lake where herbicide treatments have not occurred (Figure 17).

Similar to Northern water-milfoil, Water marigold disappeared from most parts of the lake that were treated in 2022. In addition to this highly significant decline ($p<0.001$) in distribution, it fell from the sixth-ranked to the eighteenth-ranked species in the macrophyte community.

Declines in these species were noted in other cases where ProcellaCOR was used to control Eurasian water-milfoil and Hybrid water-milfoil across Wisconsin. Preliminary results from pre and post-treatment monitoring conducted on a subset of Wisconsin lakes observed negative impacts to dicot species such as Northern water-milfoil (*Myriophyllum sibiricum*), White water crowfoot (*Ranunculus aquatilis*), Water marigold (*Bidens beckii*), and Coontail (*Ceratophyllum demersum)* following treatment (WDNR, 2022) (Onterra, LLC, 2022). Native dicots such as the water-milfoils (esp. Northern water-milfoil), Water marigold, and Bladderworts are also known to be susceptible to 2,4-D (Nault, M. et. al., 2012).

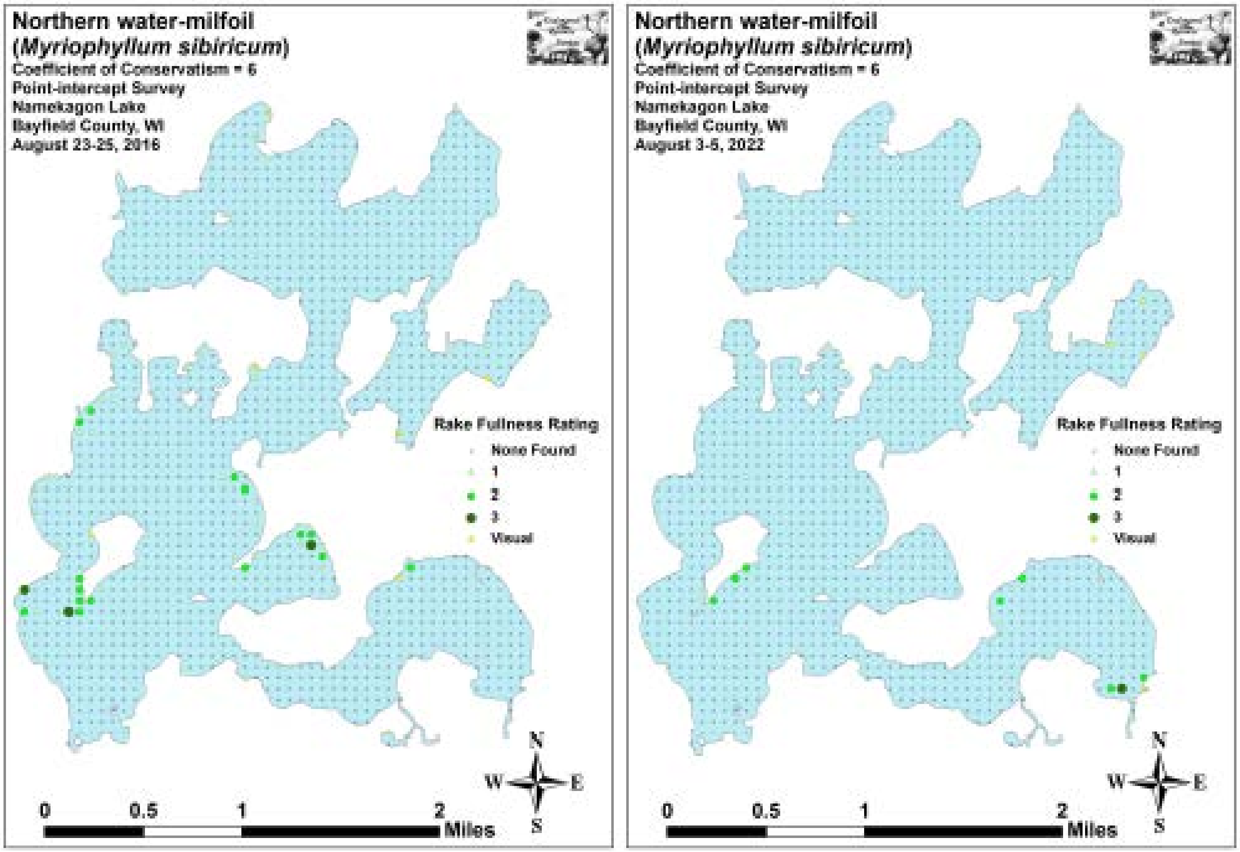

Figure 17. Northern Water-milfoil Distribution 2016 and 2022

JACKSON LAKE 2018 AQUATIC PLANT SURVEY

Endangered Resource Services completed an aquatic plant survey using the point intercept method for Jackson Lakes in mid-August 2018. A full description of the survey and results are found in the report: *Point-intercept Macrophyte Survey and* Hybrid Eurasian water-milfoil (*Myriophyllum spicatum* X *sibiricum*) *Shoreline Survey* Jackson Lake – WBIC: 2734200 *Bayfield County, Wisconsin.* Results in this section are taken directly from this report (Berg, 2018).

Macrophytes (aquatic plants) were growing at 107 out of 368 points which approximated to 29.1% of the entire lake bottom and 70.4% of the 6.0 ft. deep littoral zone. Overall diversity was exceptionally high with a Simpson Index value of 0.95. Total richness was moderate with 45 species found growing in and immediately adjacent to the water. Localized richness was moderately high with a mean of 3.18 native species/site with vegetation. Plant density was moderately high with a mean rake fullness of 2.29 at sites with vegetation.

White water lily (*Nymphaea odorata*), Pickerelweed (*Pontederia cordata*), Watershield (*Brasenia schreberi*), and Coontail (*Ceratophyllum demersum*) were the most common vascular species (38.32%, 34.58%, 18.69%, and 16.82% of survey points with vegetation respectively). Collectively, they accounted for 34.12% of the total relative frequency. The 39 native index species found in the rake produced a mean Coefficient of Conservatism (C) of 6.3 and a Floristic Quality Index of 39.4. For this part of the state, this was below the mean C of 6.7, but much above the median FQI of 24.3. Northern wild rice (*Zizania palustris*) was seen at a single survey point. The total Wild rice population in the lake was estimated to be <200 plants. Despite searching over 18.2km of transects, HWM was not found anywhere in the lake in 2018. A small (0.05-acre) dense bed of HWM was found in Jackson Lake in an August 2022 HWM bed mapping survey.

Table 7. Jackson Lake Aquatic Macrophyte P/I Survey Summary Statistics (2018)

Total number of points sampled	368
Total number of sites with vegetation	107
Total number of sites shallower than the maximum depth of plants	152
Freq. of occur. at sites shallower than max. depth of plants (in percent)	70.4
Simpson Diversity Index	0.95
Maximum depth of plants (ft)	6.0
Average number of all species per site (shallower than max depth)	2.24
Average number of all species per site (vegetative sites only)	3.18
Species richness	42
Species richness (including visuals)	43
Species richness (including visuals and boat survey)	45

GARDEN LAKE 2018 AQUATIC PLANT SURVEY

Endangered Resource Services completed an aquatic plant survey using the point intercept method for Garden Lakes in mid-August 2018. A full description of the survey and results are found in the report: *Point-intercept Macrophyte Survey and* Hybrid Eurasian water-milfoil (*Myriophyllum spicatum* X *sibiricum*) *Shoreline Survey* Garden Lake – WBIC 2735500 *Bayfield County, Wisconsin* (Berg, 2018) . Results in this section are taken directly from this report.

Macrophytes were growing at 134 out of 734 points which approximated to 18.3% of the entire lake bottom and 73.6% of the 7.0 ft. littoral zone. Overall diversity was high with a Simpson Index value of 0.90. Total richness was moderate with 50 species found growing in and immediately adjacent to the water. Localized richness was also moderate with a mean of 2.69 native species/site with vegetation. Plant density was moderate with a mean rake fullness of 1.97 at sites with vegetation.

Wild celery (*Vallisneria americana*), Slender naiad (*Najas flexilis*), Variable pondweed (*Potamogeton gramineus*), and Muskgrass (*Chara* sp.) were the most common species (67.16%, 31.34%, 16.42%, and 14.93% of survey points with vegetation respectively). Collectively, they accounted for 48.20% of the total relative frequency. The 36 native index species found in the rake produced a mean Coefficient of Conservatism of 6.6 and a Floristic Quality Index of 39.7. For this part of the state, this was slightly below the mean C of 6.7, but much above the median FQI of 24.3. Despite searching over 49.8km of transects, HWM was not found anywhere in the lake in 2018, nor has it been found in subsequent searches.

Table 8. Garden Lake Aquatic Macrophyte P/I Survey Summary Statistics (2018)

Total number of points sampled	734
Total number of sites with vegetation	134
Total number of sites shallower than the maximum depth of plants	182
Freq. of occur. at sites shallower than max. depth of plants (in percent)	73.6
Simpson Diversity Index	0.90
Maximum depth of plants (ft)	7.0
Average number of all species per site (shallower than max depth)	1.98
Average number of all species per site (vegetative sites only)	2.69
Species richness	37
Species richness (including visuals)	42
Species richness (including visuals and boat survey)	50

INVASIVE SPECIES: HYBRID EURASIAN NORTHERN WATER-MILFOIL

COMPARISON OF HYBRID WATER-MILFOIL IN 2016 AND 2022 (POINT INTERCEPT)

No Hybrid water-milfoil plants were found at rake sample points in the Lake Namakagon 2016 point intercept survey.

In a 2016 search looking specifically for HWM, plant surveyors found and rake removed approximately 89 individual hybrid water-milfoil plants from the Lakewoods Resort Marina during the August survey (Figure 18). Almost all of these were growing over organic muck in 2-5 feet of water, although a couple plants at the north end of the area were growing in 7-8 feet at the edge of the local littoral zone. Most of the plants were submerged, 1-2 foot long, new sprouts mixed in with the bay's moderately dense native vegetation - making them difficult to see. The only HWM found outside of the marina were three large canopied plants with multiple stems that were removed in the area southwest of Paine's Island. They were growing in 5-7 feet of water over sandy muck imbedded within a dense northern water-milfoil bed. This made it difficult to get the roots.

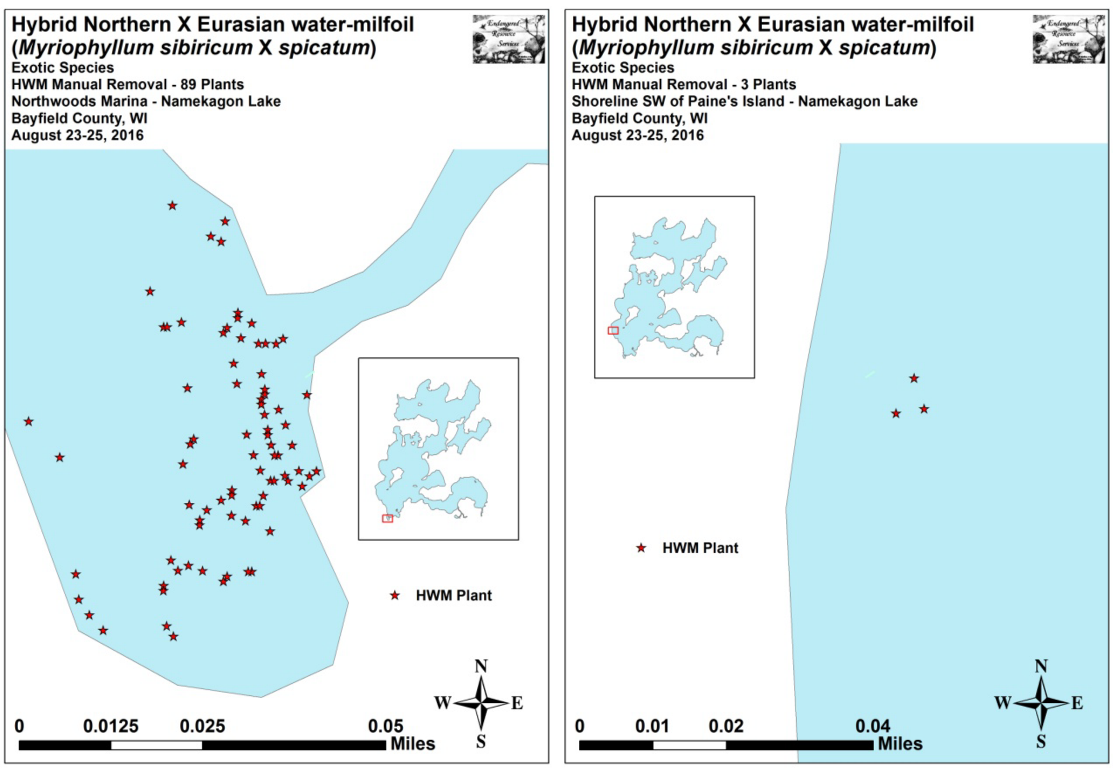

Figure 18. Hybrid Water-milfoil Distribution and Manual Removal Areas Lakewoods Resort Marina and the Bay Southwest of Paine's Island (Berg, 2016)

Following an extensive herbicide treatment in 2022, HWM was found in the rake during the point intercept survey at just two points (0.15% of the entire lake bottom and 0.34% of the littoral zone) – one in the Lakewoods Marina and the other in Sugar Bay. One point had a rake fullness of 2, and the other was a 1 for a mean rake fullness of 1.50. The single point with a rake fullness of 2 or 3 extrapolated to 0.08% of the entire lake and 0.17% of the littoral zone having a significant infestation. Compared to the 2016 survey, none of these increases were significant.

A late-summer/fall 2022 HWM bed mapping survey located four areas where HWM remained following the June 2022 herbicide treatment (Berg, 2022). There were very small dense areas of HWM growth in Lakewoods Bay (0.04 acres) (Figure 19), Governor's Island Bay (0.07 acres) (Figure 20), and in Jackson Lake (0.05 acres) (Figure 21). None of these areas reached herbicide treatment thresholds established in the 2018 aquatic plant management plan. New beds totaling 5.09 acres were found established in Bluegill/Sugar Bay (Figure 22). The Namakagon Lake Association Board decided not to treat this area which receives little boat traffic and has a high diversity of native species.

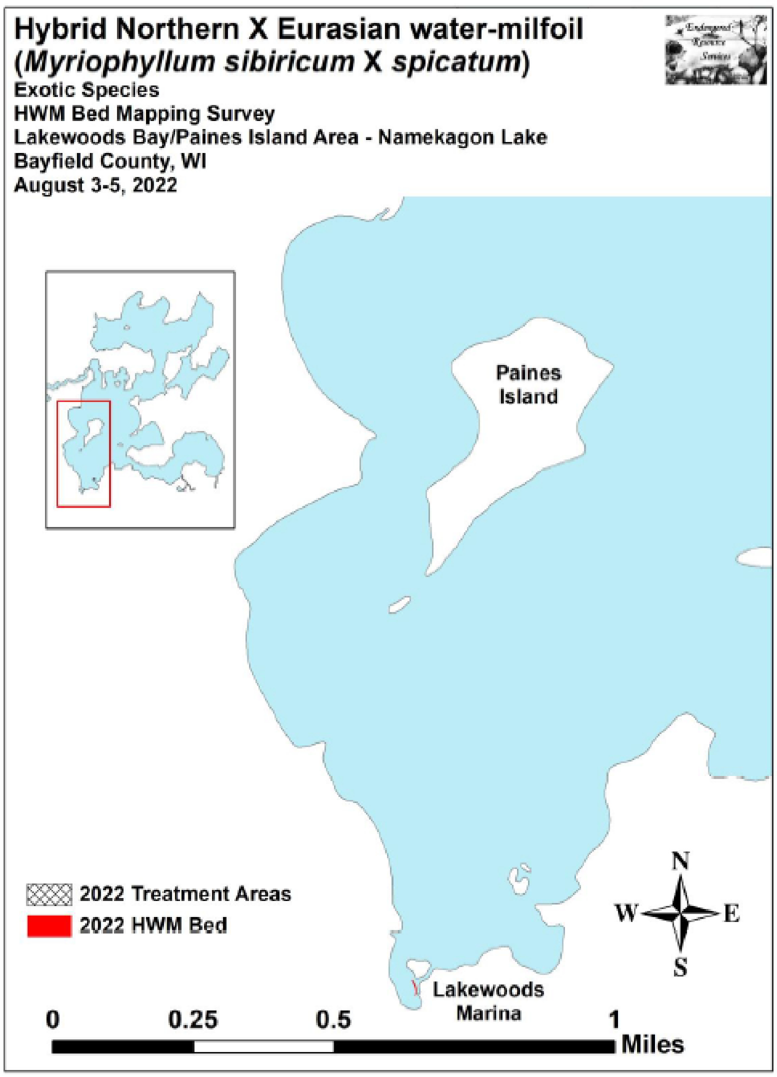

Figure 19. Lakewoods Marina 2022 HWM Bed (0.04 acres)

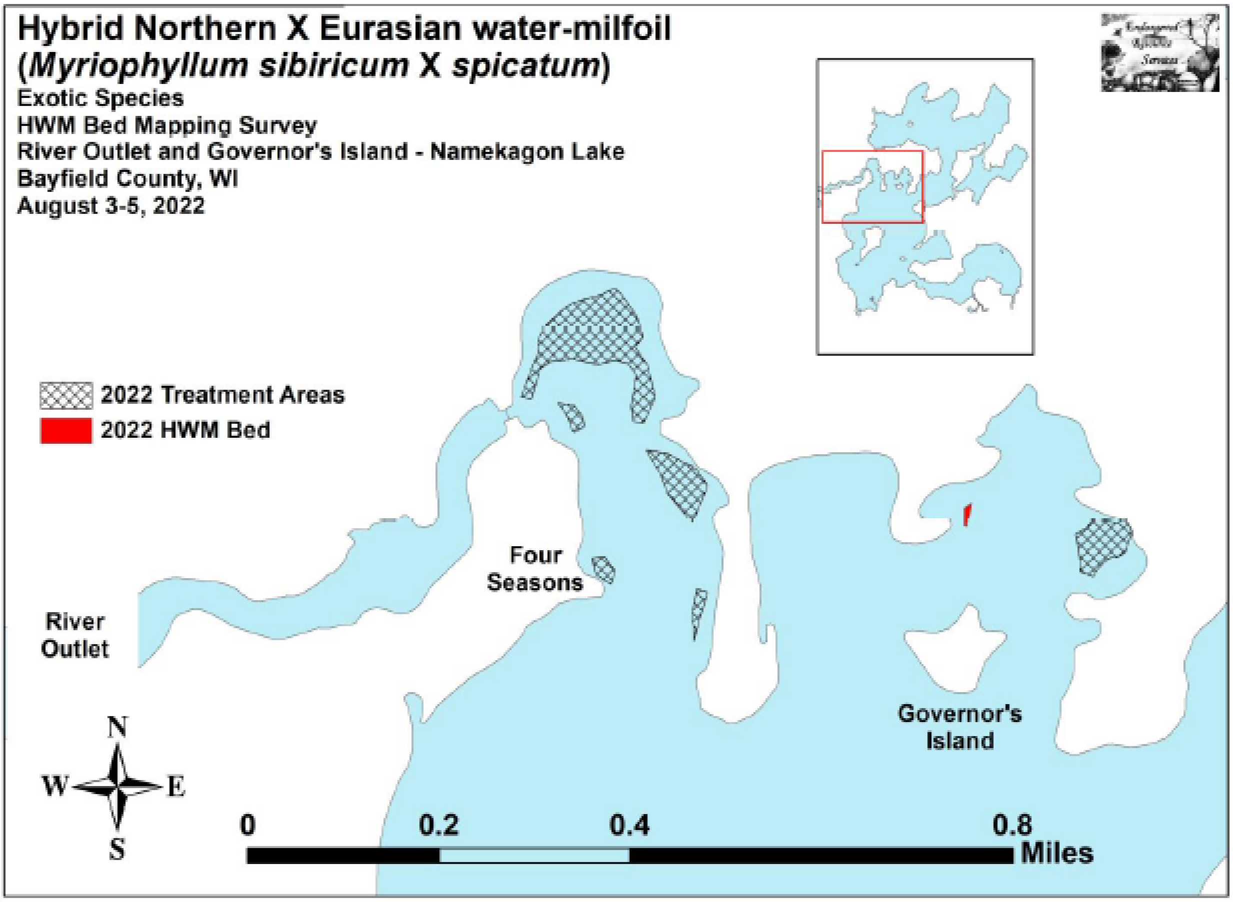

Figure 20. Governor's Island Bay 2022 HWM Bed (0.07 acres)

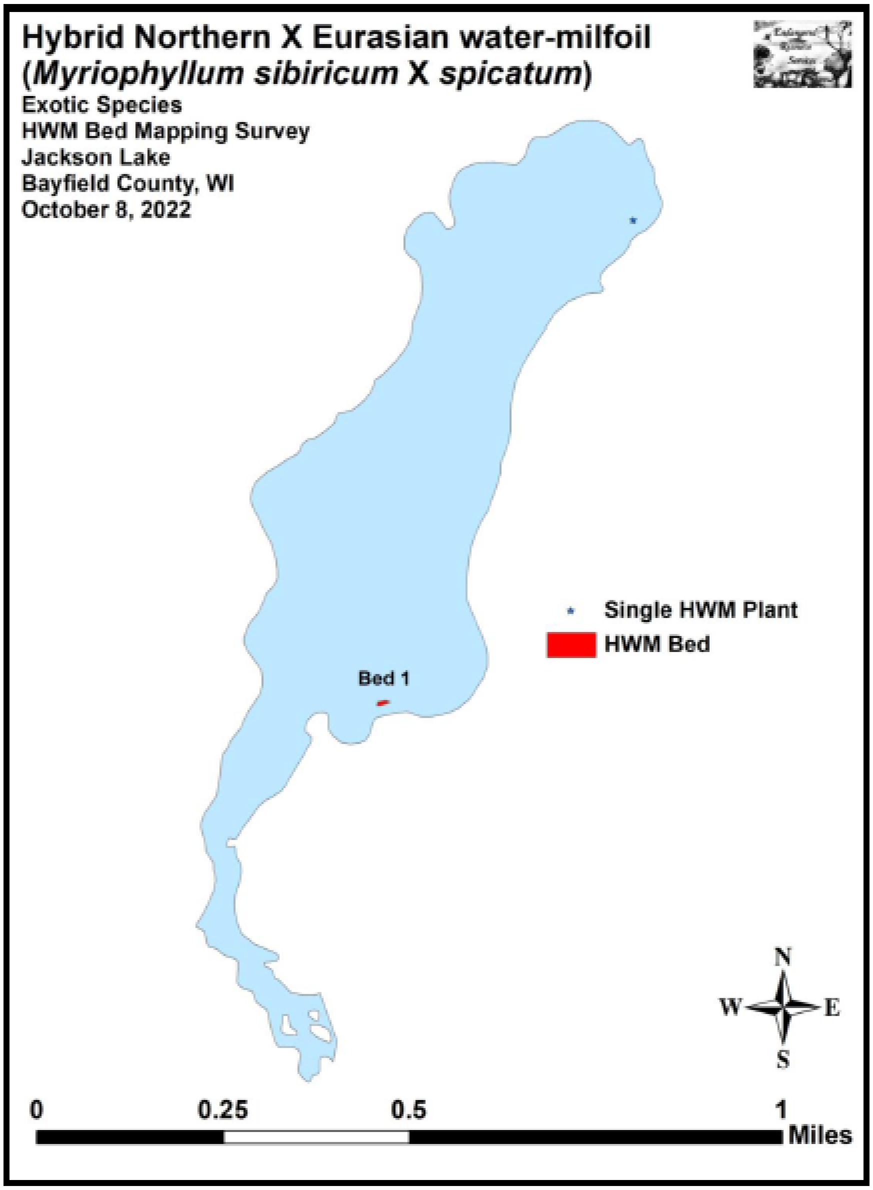

Figure 21. Jackson Lake 2022 HWM Bed (0.05 acres)

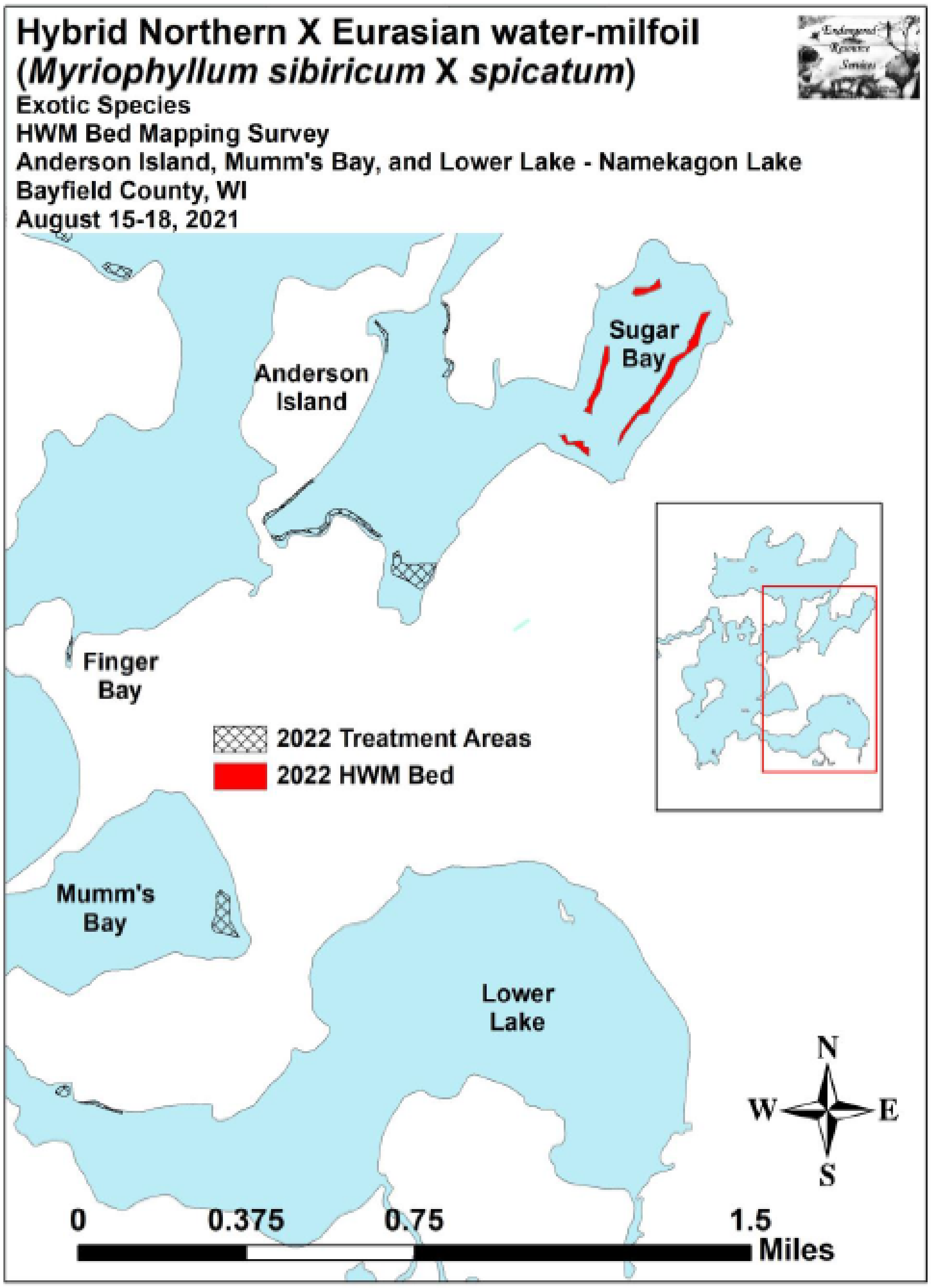

Figure 22. Bluegill Bay/Sugar Bay 2022 HWM Beds (5.09 acres)

OTHER NON-NATIVE INVASIVE SPECIES

PURPLE LOOSESTRIFE

A single purple loosestrife (*Lythrum salicaria*) plant in a wetland immediately adjacent to the lake near the river outlet was located and removed during the 2016 plant survey (Figure 23). Purple loosestrife was not seen during the 2022 plant survey.

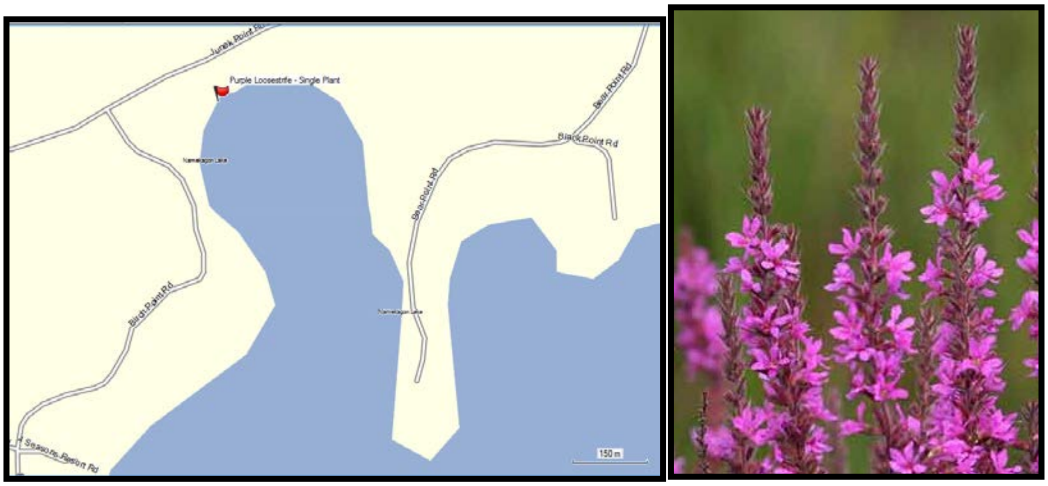

Figure 23. Purple Loosestrife Distribution (Berg, 2016)

FORGET-ME-NOT

Common forget-me-not (*Myosotis scorpioides*) was found at the Lakewoods Resort Marina along the cold-water seeps that are bubbling up due east of the landing in both 2016 and 2018 (Figure 24). A common exotic in this habitat throughout northern Wisconsin, it is likely that an exhaustive search for this species would find it in many other places along the lakeshore.

Figure 24. Common Forget-me-not Distribution (Berg, 2016)

NARROW LEAF CATTAIL

Native to southern but not northern Wisconsin, narrow-leaved cattail (*Typha angustifolia*) and its hybrids with broad-leaved cattail are becoming increasingly common in northern Wisconsin where they also tend to be invasive. A single stand of approximately 50 individual hybrid cattails was located in shallow water along the north entrance to Mumm's Bay in 2016 (Figure 25), and the plant is becoming increasingly common in this area as of 2022.

Figure 25. Hybrid Cattail Distribution (Berg, 2016)

YELLOW IRIS

Yellow iris is now well established in the lower lake northeast of Garmisch Resort. Dense clusters dominated the shoreline at several residences, and satellite plants are appearing both along the adjacent properties and elsewhere in the lake (Figure 26).

Figure 26. Yellow Iris Distribution and Shoreline Cluster of Plants

AQUATIC PLANT MANAGEMENT

This section reviews Namakagon Lake Association aquatic plant management activities. Potential management methods are included in a reference companion document to this plan.

HYBRID WATER-MILFOIL MANAGEMENT IN LAKE NAMAKAGON

The Namakagon Lake Association applies an integrated pest management strategy for hybrid water-milfoil management with a combination of methods used depending upon growth characteristics. The Lake Namakagon Hybrid water-milfoil Containment Decision Matrix, which guides HWM management, was developed for the 2018 aquatic plant management plan and updated in 2022. The 2022 updated matrix is presented as Table 9. An overview of HWM growth and treatment is presented in Table 10.

Table 9. Lake Namakagon Hybrid Water-milfoil Containment Decision Matrix (2022)

HWM Growth Condition	Control Methods[8]	Monitoring	Considerations	Lead /Partners
Scattered growth no defined edge <4 feet deep	**Hand pulling** Plant ID – guidance to lead volunteers, lab verification of HWM (sample each area where suspected, locate lab)	Volunteer Monitoring (ongoing/monthly) Professional Meandering Survey (annually)	Pilot no-pull location(s) to assess HWM and native plant growth. Establish transects or GPS points to monitor HWM and native plants. *Choose area where herbicide treatment success is likely if needed as back-up (enclosed bay).*	Volunteers Paid summer help (?)
Scattered growth >4 feet deep OR <10% FOO and >½ acre beds OR bed (10-20% or > FOO) in flowing water	DASH was in this category, but will not be considered as a control method.			
Dense growth in beds: >0.25 acre	**Contact herbicide treatment:** ProcellaCOR	Pre and post quantitative monitoring (professional)	Minimum bed size for effective herbicide treatment will vary with site conditions and herbicide chosen.	
Combined dense growth in beds and scattered growth in bay – minimum treatment area = 5 acres	**Systemic herbicide treatment:** 2,4-D	Pre and post quantitative monitoring (professional)	Expanding treatment area to reach minimum size not appropriate where edges drop off into deep water.	
Lakewide scattered growth of HWM	**Weevil establishment** depending upon results of trial	Weevil stem counts, HWM meandering or PI survey (annually)	Sunfish populations may limit weevil survival.	Uncertain results
Lakewide dense growth of HWM (tentative thresholds: 5% of lake surface area =145 acres. *It might also be possible to consider lake basins separately.*)	**Whole lake herbicide treatment** (fluridone) For follow-up clean up see above procedures	Pre and post quantitative monitoring (professional)	Fluridone: treatment can be very effective for 1-4 years for EWM. However, native plants are impacted for a similar time period. [9] Triclopyr: A water body should not be treated with triclopyr if there is an outlet, or in moving waters such as rivers or streams.[10]	

[8] Control methods considered but eliminated as an option for the Lake Namakagon system include benthic barriers and harvesting.
[9] http://dnr.wi.gov/lakes/plants/research/Project.aspx?project=111623277
[10] http://dnr.wi.gov/lakes/plants/factsheets/TriclopyrFactsheet.pdf

Definitions

HWM Bed: 10-20% or > FOO, defined edge (while proposed in the plan, actual bed mapping used the following definition: *a "bed" was determined to be any area where we visually estimated that HWM made up >50% of the area's plants, was generally continuous with clearly defined borders, and was canopied or close enough to being canopied that it would likely interfere with boat traffic).*

Scattered growth : <10% FOO, no defined edge

Objective measures: FOO (frequency of occurrence = HWM plants/total plants sampled), Rake Density

2016 HWM DISCOVERY AND RESPONSE

In June 2016, hybrid Eurasian X northern water-milfoil (*Myriophyllum spicatum* X *sibiricum*) (HWM) was discovered at the Lakewoods Resort Marina Landing. Following DNA confirmation in July, hand removal efforts were completed several times throughout the summer and early fall by WDNR, Bayfield County Land and Water Conservation Department (BCLWCD), volunteers from the Namakagon Lake Association, and employees from Lakewoods Resort. At one of the hand pulling events where professionals and volunteers worked together, there was coverage by the Ashland Daily Press. WDNR, BCLWCD, and others completed a shoreline survey of the lake on August 15, 2016 as part of a Wisconsin Lakes Partnership meeting (Figure 27). They found a few scattered plants in the bay southwest of Paines Island and two additional plants in the bay near the river outlet (although one was later identified as northern rather than hybrid water-milfoil) (WDNR, 2016). A total of about 10-12 garbage bags of HWM were removed from Lake Namakagon in 2016.

Matthew Berg of Endangered Resource Services completed a full point intercept survey of Lake Namakagon in August 2016. At the time of the survey, Matt and a student removed 89 HWM plants from the Lakewoods Resort Marina (Berg, 2016). This was approximately 5-20 lbs. of wet plant material (WDNR, 2016).

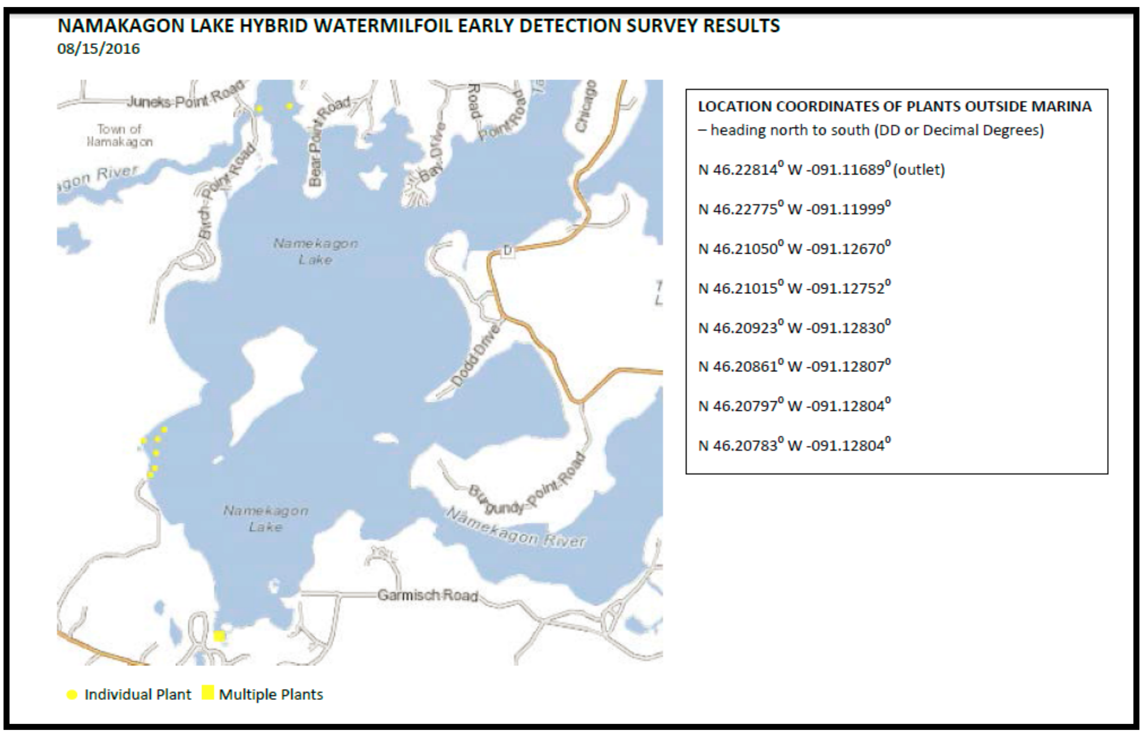

Figure 27. Lake Namakagon Hybrid Water-milfoil Early Detection Survey Results (2016)

2017 HERBICIDE TREATMENT

The Namakagon Lake Association completed an herbicide treatment to control HWM in the Lakewoods Marina area on April 17, 2017 when the water temperature was 46 degrees F. The treatment covered 2.3 acres and used 4.6 gallons of diquat (Reward) herbicide. Wind speed was low at 7 miles per hour from the NNW during treatment (blowing into the bay) (Dressel, 2017). Rhodamine dye was used as a tracer for the herbicide. Dye monitoring verified there was little or no drift outside of the bay where herbicide treatment occurred (Toshner P. , 2018).

The treatment area encompassed the entire bay where the Lakewoods marina is located. The marina includes a boat launch and mooring for rentals and private boats. The deepest point of the bay is approximately 10 feet. The water is heavily stained, and there is groundwater seepage into the bay. The substrate is highly silty (and turns to sand a few feet from shore) (WDNR, 2016). The ice goes out in this bay before the rest of the lake, and the treatment occurred about 2 weeks after ice-out in 2017 (Toshner P. , 2018).

Species richness lists were created for the bay pre-treatment (fall 2016) and post-treatment (summer 2017). Results indicated that the native plant community did not experience negative impacts with similar species richness and thriving plants. A successful treatment was evidenced by low HWM plant growth during the remainder of the summer 2017 as described below.

FOLLOW UP HAND PULLING

NLA volunteers and Department of Natural Resources staff returned to the herbicide treatment area more than 10 times during the summer of 2017. During these visits, volunteers and staff pulled an estimated less than 100 HWM plants – perhaps a total of one garbage bag (Toshner P. , WDNR Lakes Biologist, 2017). Hybrid water-milfoil plants were first observed growing in the bay again in June, especially in mucky areas. By late summer 2017, there were just a few clumps of healthy plants (Figure 28).

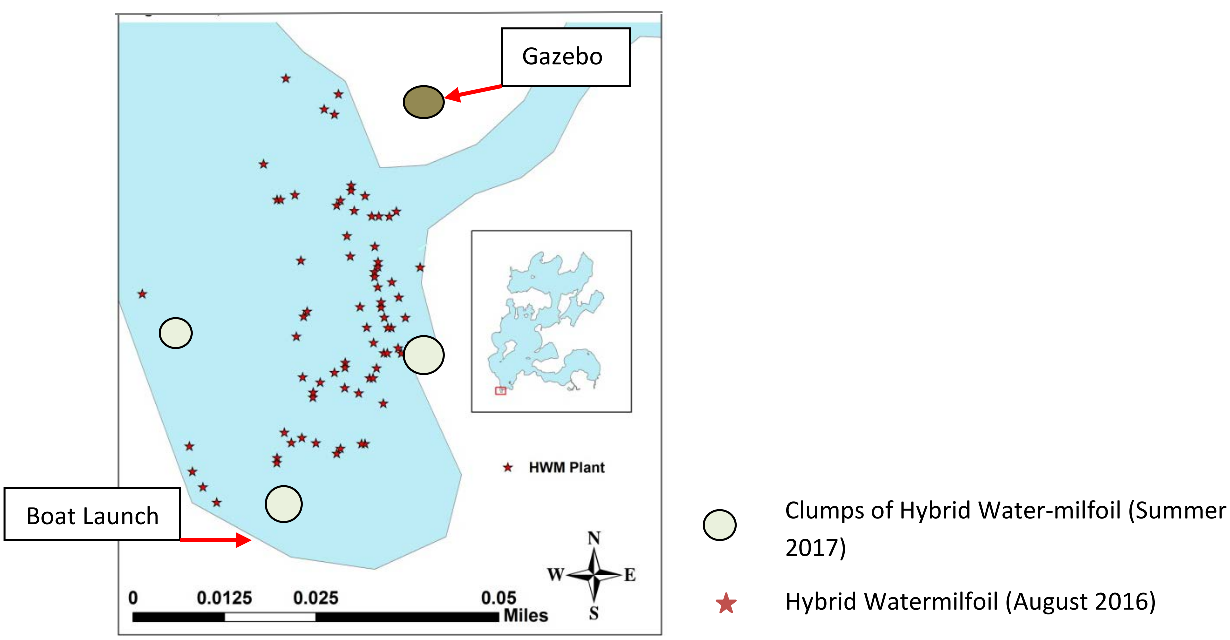

Figure 28. Lakewoods Bay Hybrid Water-milfoil Clumps (2017)

FOLLOW UP MONITORING

In October 2017, staff from Bayfield County and NLA Volunteers completed an AIS survey of Lake Namakagon focusing on locations where EWM or HWM was previously found. They found widespread suspected HWM plants near the Namakagon River outlet on the lakeside of the bridge and a few near Paines Island. Unfortunately, the lab lost plants sent in for DNA verification. About 2 hours were spent hand pulling the plants found during this survey. GPS points were not recorded (Teal, 2017). Lake volunteers generated a comprehensive map where suspected HWM has been found on Lake Namakagon in 2016 and 2017, at a meeting at the Namakagon Town Hall December 18, 2017 (Figure 29). However, the plants were not verified by DNA testing in all locations.

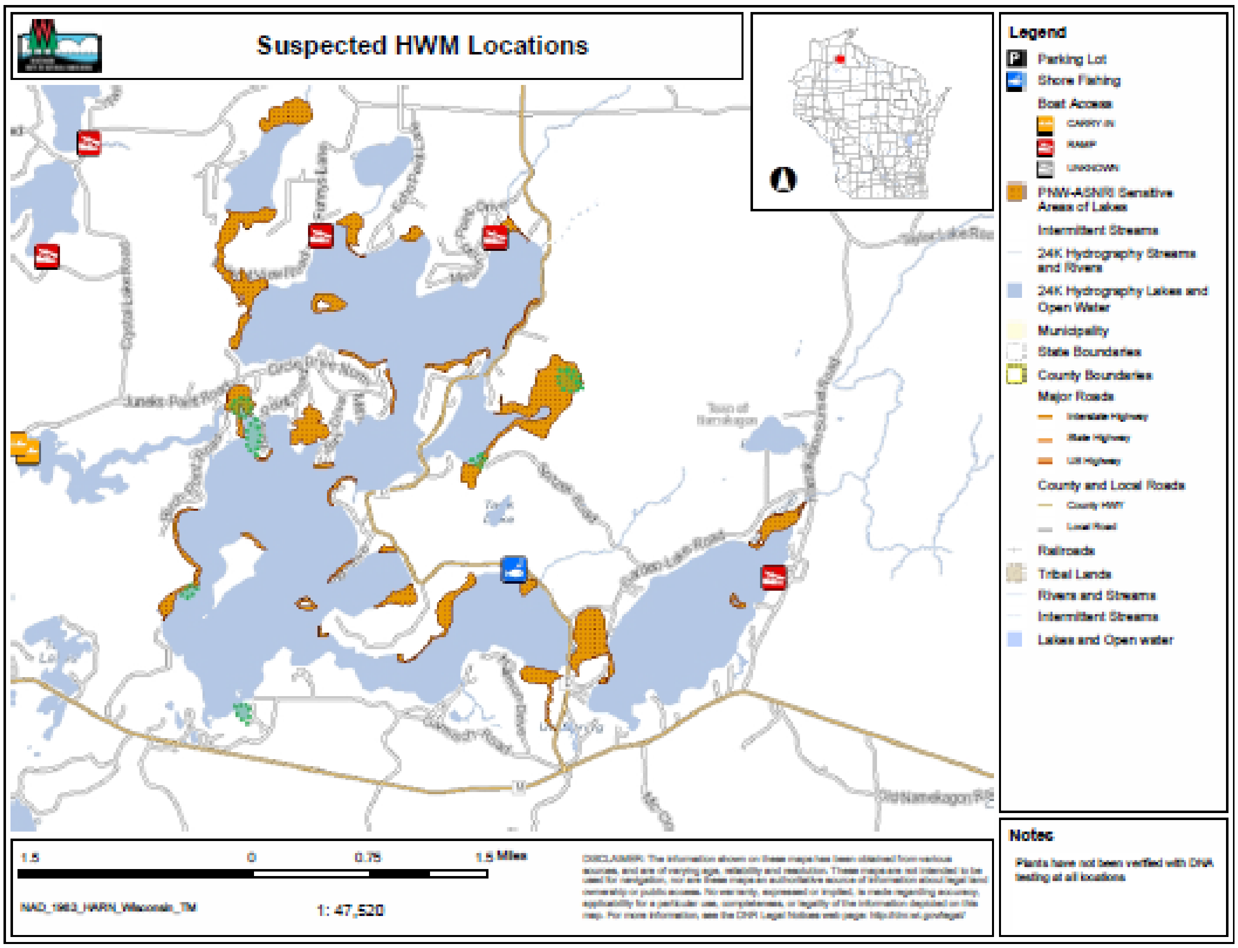

Figure 29. Hybrid Watermilfoil Suspected Locations (2016 and 2017)
Suspected locations indicated with green shading

2018 HAND REMOVAL AND BED MAPPING

Hand removal efforts continued at the Lakewoods Marina in 2018. Scattered HWM plants were also rake removed during a lakewide survey to locate areas of dense HWM growth (Berg, 2018).

Figure 30. HWM Beds (Red) and High Density Areas (Yellow) Fall 2018

2019 HERBICIDE TREATMENT AND BED MAPPING

A June 11, 2019 herbicide treatment using diquat (Tribune at 2 gal./acre) targeted 6.9 acres of HWM in 4 dense beds. Treatment bed sizes ranged from 1.51 to 6.58 acres (Dressel D. , 2019). Plant surveyor, Matt Berg, also led 7 HWM hand-pulling workshops in 2019.

Bed mapping in the fall of 2019 identified 12.3 acres of HWM growth in 18 dense beds (Figure 31). Of these, 17 areas were true beds (red polygons) with continuous plants (11.57 acres) while one was better described as a "high density area" (yellow polygon) with only scattered plants (0.73 acre).

2020 HERBICIDE TREATMENT AND BED MAPPING

A May 27, 2020 herbicide treatment using diquat (Tribune at 2 gal./acre) targeted 9.92 acres of HWM in 6 dense beds. Treatment bed sizes ranged from 0.8 to 3.18 acres. A single bed of 0.07 was treated with ProcellaCOR (6 pdus/acre ft.) (Dressel D. , 2020).

Bed mapping September 4, 2020 identified 9.87 acres of HWM growth in 26 dense beds in Lake Namakagon (Figure 32). HWM continued to expand into many parts of the lake where there was no evidence of HWM during previous surveys. As in 2019, the majority of HWM plants were near highly developed and/or disturbed shorelines; especially near resort docks and boat landings. These areas have high volume watercraft traffic which tends to disturb the bottom making it easy for HWM to establish. Once canopied, these plants also frequently suffer prop-clipping which accelerates their natural spread from fragmentation. Shoreline surveys were also conducted in Jackson and Garden Lakes where no HWM was found (Berg, 2020).

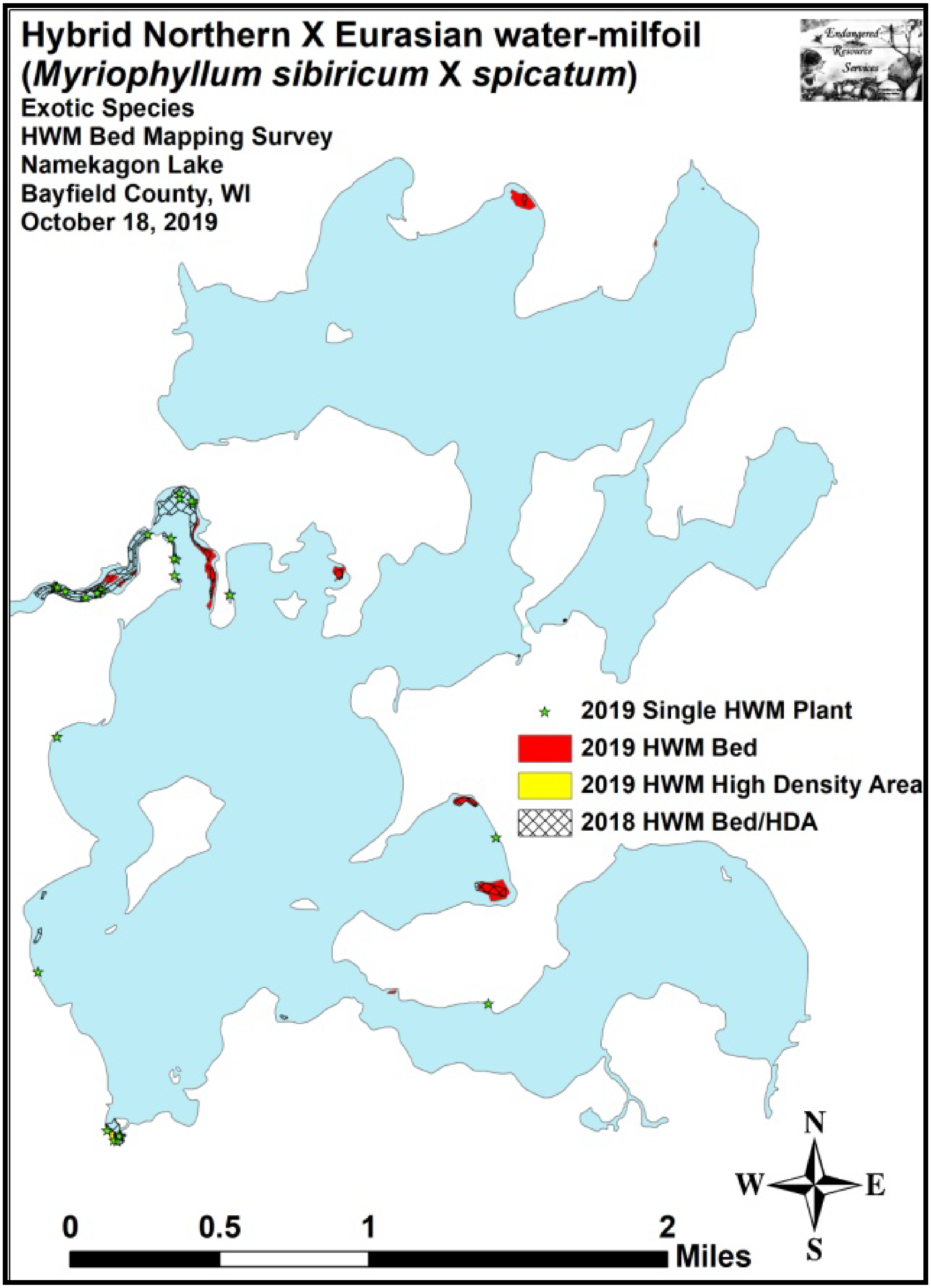

Figure 31. HWM Bed Mapping 2019

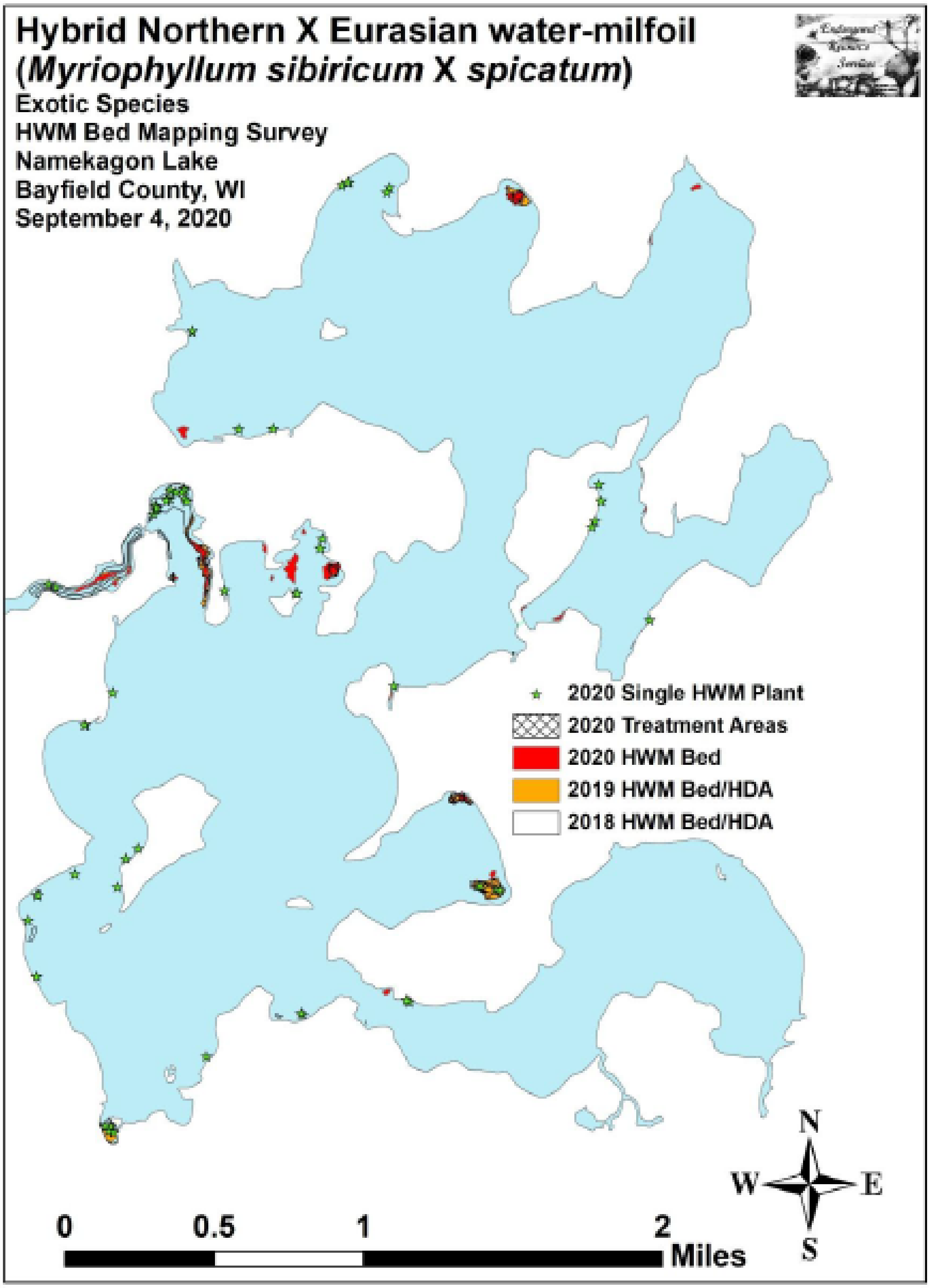

Figure 32. HWM Bed Mapping 2020

2021 HERBICIDE TREATMENT AND BED MAPPING

A June 15, 2020 herbicide treatment trial used 3 different herbicides to control HWM in Lake Namakagon. Diquat (Tribune at 2 gal./acre) targeted 2 beds of HWM (0.11 acres and 1.49 acres). A single bed of 11.42 acres was treated with 2,4-D amine (4 ppm). ProcellaCOR (5-6 pdus/acre ft.) was used on 4 beds ranging from 0.23 to 1.44 acres (Dressel D. , 2021).

PRE AND POSTTREATMENT SURVEY RESULTS

Endangered Resource Services completed pre and post-treatment point intercept surveys in the treatment areas for the first time in Lake Namakagon in 2021. During the May 22, 2021 pre-treatment survey, HWM was present in the rake at 57 points (22.80% coverage) with 28 additional visual sightings. In the July 31, 2021 post-treatment survey, HWM was present in the rake at 37 points (14.80% coverage) with eight additional visual sightings. The herbicide treatments produced a highly significant decline ($p<0.001$) in HWM total density and visual sightings; a moderately significant decline ($p=0.001$) in rake fullness 3; and significant declines in rake fullness 2 ($p=0.03$) and total distribution ($p=0.02$).

Despite these declines, no beds showed complete control. Control of diquat-treated areas near the outlet was especially poor as HWM appeared to have barely been burned, and significant small beds were already re-canopying. The 2,4-D treatment area in the bays northeast of Governor's Island showed nearly complete control on the west side and strong control on the east side. The only surviving HWM here were severely burned to the root crowns and appeared to all have been large, multi-stemmed plants. ProcellaCOR areas showed marginal control on the outer edges of the beds.

Northern water-milfoil (*Myriophyllum sibiricum*) had highly significant declines ($p<0.001$) in both distribution (36 sites) and density from pre to post treatment surveys. Similarly, Common waterweed (*Elodea canadensis*) saw a significant decline ($p=0.03$) in distribution and a nearly-significant decline ($p=0.07$) in density. A moderately significant decline ($p=0.001$) in Water star-grass was also documented.

Coontail (*Ceratophyllum demersum*) and Wild celery (*Vallisneria americana*) exhibited significant increases in distribution and density from pre to post-treatment measurements.

BED MAPPING RESULTS

Garden and Jackson Lakes remained free of HWM in 2021. In Lake Namekagon, although most chemically-treated areas showed reduced amounts of HWM, many other areas showed significant expansion. In total, 33 beds covering 23.14 acres were mapped. Outside of the areas with dense growth, 169 additional plants were mapped. For the first time ever, floating HWM fragments were common throughout many parts of lake, especially in Upper Lake where they were abundant.

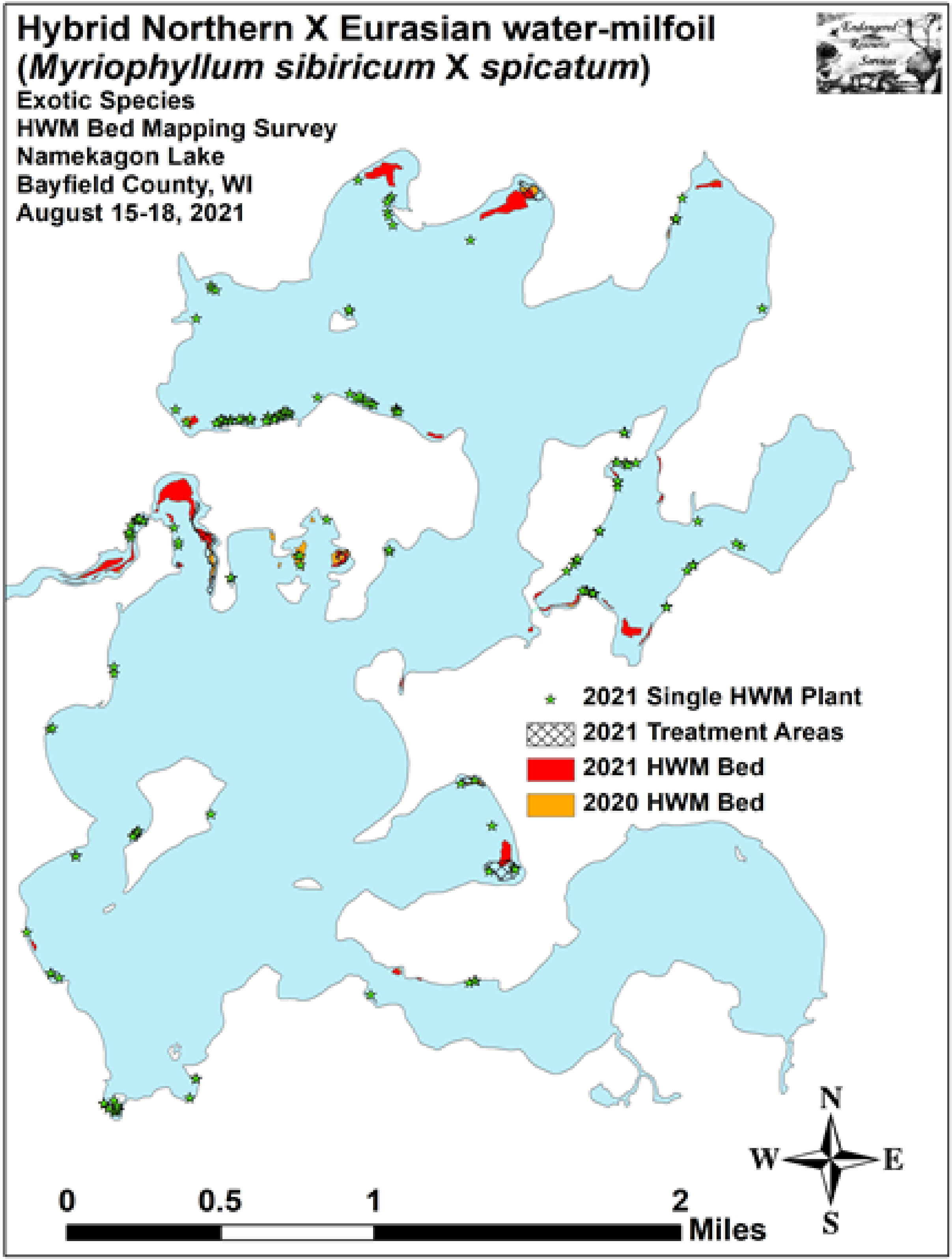

Figure 33. HWM Bed Mapping 2021

2022 HERBICIDE TREATMENT AND BED MAPPING

Herbicide treatment trials continued in 2022. This time the use of Diquat was eliminated because of previous limited effectiveness. A single bed of 8.67 acres was treated with 2,4-D amine (4 ppm). ProcellaCOR (4-8 pdus/acre ft.) was used on 23 beds ranging from 0.21 to 7.2 acres (Dressel D. , 2022). In some cases small beds were combined and/or buffered (enlarged beyond HWM growth) in an attempt to increase treatment effectiveness. The total ProcellaCOR treatment area covered 34.47 acres with a volume of 212.35 acre feet.

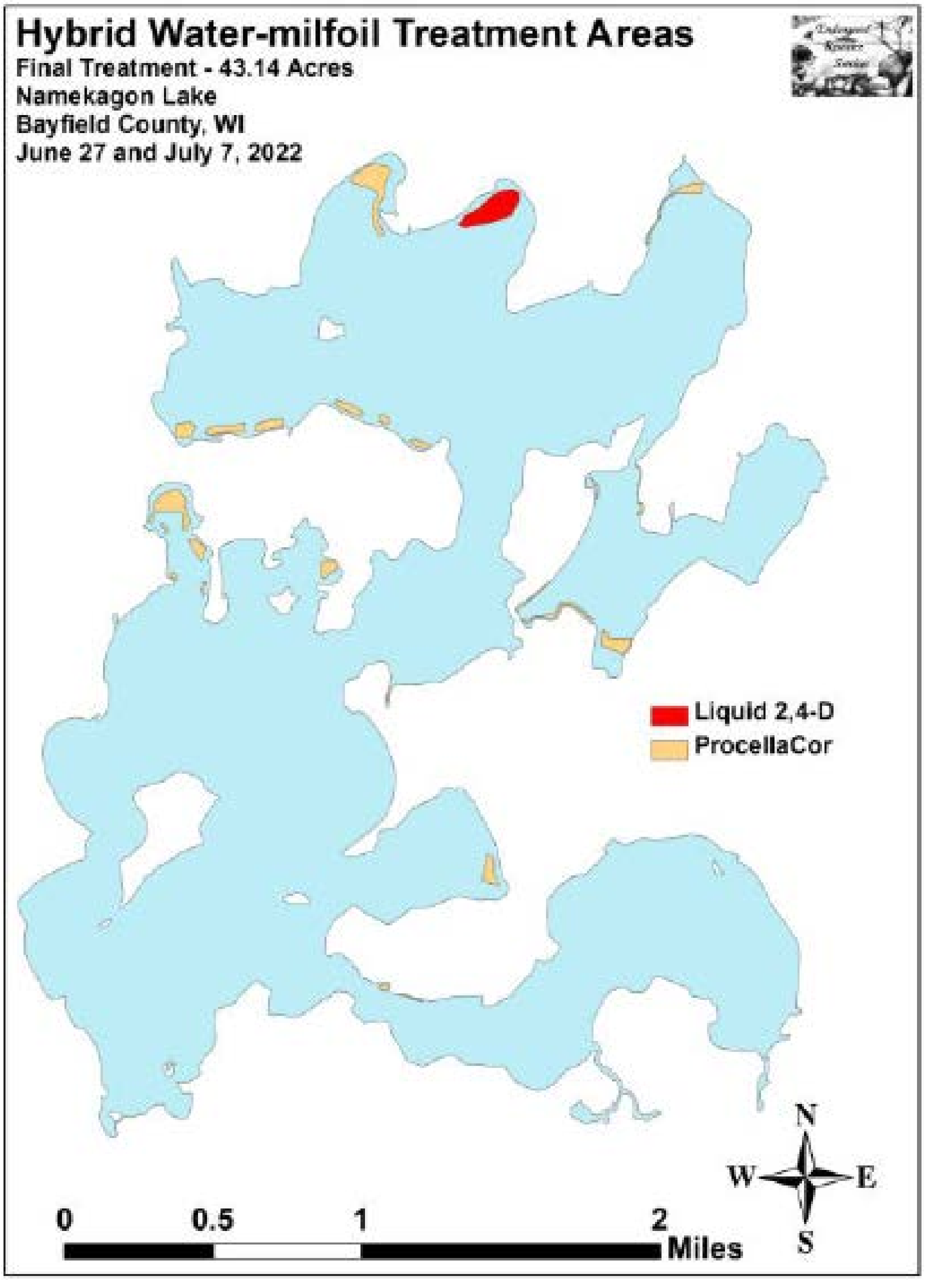

Figure 34. HWM 2022 Treatment Areas

PRE AND POST-TREATMENT SURVEY RESULTS

Endangered Resource Services completed pre and post-treatment point intercept surveys in the treatment areas. During the pre-treatment survey on June 16, 2022, HWM was present at 40 points with 25 additional visual sightings. Post-treatment, on August 3, 2022, HWM was found at two points and both occurred in the ProcellaCOR areas. Each was a badly burned individual stem (rake fullness of 1), and only the individual in Governor's Island Bay showed signs of regrowth. **Other than these individuals, we saw no other evidence of HWM at or between points in any of the 24 treatment areas**. We also saw no evidence of floating fragments in any of the treatment areas.

The overall treatment produced a highly significant decline (*p*<0.001) in HWM total density, total distribution, rake fullness 2, rake fullness 1, and visual sightings; and a nearly significant decline in rake fullness 3. Breaking the data out by treatment type offered little additional information.

Similar to HWM, the native Northern water-milfoil was essentially eliminated from the treatment areas. During the pre-treatment survey, it was present at 25 sites with a mean rake of 1.20. None was visible within treatment beds during the post-treatment survey. Statistically, both the declines in distribution and density were highly significant (*p*<0.001). Water marigold (*Bidens beckii*) was the only other species that showed a significant decline post-treatment. Present at 19 points with a mean rake of 1.16 during the pre-treatment survey, there was a significant decline (*p*=0.02) in distribution to eight sites post-treatment. However, its density underwent a non-significant increase (*p*=0.31) to a mean rake of 1.25. Declines in Northern water-milfoil (Figure 17) and Water marigold were also noted in a comparison between the 2016 and 2022 whole lake point intercept survey.

Other native species either showed no significant changes or demonstrated significant increases (7 native species) in distribution and density from pre to post-treatment.

BED MAPPING RESULTS

In Lake Namakagon, there was no evidence of HWM beds in any of the treatment areas or the areas immediately outside the treatment areas. In fact, even HWM plants well away from the treatment areas in Upper and Middle Lake appeared to have been residually killed. In total, 6 beds covering 5.19 acres were mapped (Figures 19 – 22). Outside of these areas, no additional HWM plants or any evidence of floating HWM fragments were found in Lake Namakagon. A single 0.05-acre HWM bed was found in Jackson Lake.

No herbicide treatment is planned for 2023. Three of the identified beds do not approach the size threshold for chemical treatment. HWM growth in Bluegill/Sugar Bay, which totals 5.08 acres, is in an area with extensive native plants and low levels of boat traffic. Herbicide treatment will be avoided here because of the low likelihood for spread and potential impacts on native plants.

Table 10. Lake Namakagon Hybrid Watermilfoil Growth and Control Efforts

	Acres in beds (treated)	Date of Treatment (temp F)	Acres in bed (mapped late summer/fall)	Herbicides used for Control	Hand Pulling	Native Species Declines	Comments
2016	none	NA		none	Yes	Not evaluated	Primary location: Lakewoods Resort Bay
2017	2.3 acres	April 17 (46° F)		Diquat	Yes (Lakewoods, Outlet and Paines Island)	Qualitative evaluation only	Formal pre and post point intercept not completed, but plant lists and observations showed no impact to native plants.
2018	NA	NA	6.89 acres (beds) 13.48 acres (HADs)	none	Yes (Lakewoods and scattered locations)	Not evaluated	Widespread HWM growth found during fall survey. While covering a low percentage of the lake, HWM has spread considerably.
2019	6.9 acres	June 11 (68° F)	18 beds covering 12.3 acres	Diquat	7 hand-pulling workshops	Not evaluated	Treatment bed sizes ranged from 1.51 to 6.58 acres.
2020	9.9 acres	May 27 (61° F)	26 beds covering 9.87 acres	Diquat ProcellaCOR	No	Not evaluated	Treatment bed sizes ranged from .07 to 3.18 acres.
2021	**15.3 acres**	**June 15 (72° F)**	33 beds covering 23.14 acres	**Diquat ProcellaCOR 2,4-D**	No	Northern watermilfoil Water marigold	Treatment bed sizes ranged from 0.21 to 11.42 acres. Pre and post-treatment survey completed. Significant reduction in HWM measured pre to post-treatment.
2022	**43.14 acres**	**July 7 (69° F)**	5.19 acres	**ProcellaCOR 2,4-D**	No	Northern watermilfoil Water marigold	Mapped beds include new infestation in Bluegill Bay (5.08 acres) and new discovery in Jackson Lake (0.05 acres).
2023	NA	NA	TBD	none	Planned for Jackson Lake	No evaluation planned	NO TREATMENT PLANNED

*Control efforts highlighted in bold had measured statistically significant reductions

NA: Not Applicable HAD: High Density Area

HWM Bed: any area where HWM made up >50% of the area's plants (visual estimate), was generally continuous with clearly defined borders, and was canopied or close enough to being canopied that it would likely interfere with boat traffic.

VOLUNTEER MONITORING GUIDANCE

Volunteer monitors survey lake areas and treated web beds. Plant surveyor, Matt Berg, offered the following suggestions for volunteer monitors in the aquatic plant survey report:

> Because the native northern watermilfoil is widely distributed throughout the lake and closely resembles HWM, finding and identifying HWM will likely be challenging for volunteers. To assist in identification, surveyors should remember that northern watermilfoil has leaflets numbering <24 whereas EWM normally has >26 while HWM tends to have leaflet numbers that range from 20-30 – intermittent between both parent species (Figure 35). EWM and HWM also tend to have a bright red growth tip on the top of the plant whereas NWM has a bright lime green growth tip. In the fall, NWM also forms winter buds on the tips of shoots whereas EWM/HWM have none (Figure 36). Hybrid and Eurasian watermilfoil tend to grow in similar habitats as northern watermilfoil, so knowledge of locations of northern watermilfoil growth can be helpful.

Eurasian Watermilfoil **Hybrid Watermilfoil** **Northern Watermilfoil**

Figure 35. Eurasian, Hybrid, and Northern Watermilfoil Identification (Berg, 2016)

Figure 36. Limp Nature of EWM/HWM Leaflets along Stem – Stiff Nature of NWM Leaflets along Stem and Overwintering Turions October 2016 (Berg, 2016)

AIS RAPID RESPONSE GRANTS

The Namakagon Lake Association received two, $20,000 Wisconsin DNR Aquatic Invasive Species (AIS) Rapid Response Grants (AIRR21817 in 2016 and AIRR25320 in 2018). The DNR awarded a $149,962 AIS control grant to the NLA in 2022. About half of the grant was used for the 2022 HWM treatment and monitoring.

PREVENTING INVASIVE SPECIES

AQUATIC INVASIVE SPECIES EDUCATION

The Namakagon Lake Association (NLA) communicates with lake residents and visitors with the following methods:

- Annual meeting presentations
- Newsletter – distributed by mail (about 220 addresses)
- Email list – (about 220 addresses)
- NLA website
- Signs at boat landings
- NLA board meetings and annual meetings
- Conferences and workshops
- Written information: APM Plan Summary, Mailings, NLA brochure
- Private road association meetings

CLEAN BOATS CLEAN WATERS PROGRAM

Clean Boats Clean Waters (CBCW) educators provide boaters with information on the threat posed by Eurasian water milfoil and other invasive species. They offer tips on how to keep boats, trailers, and equipment free of aquatic hitchhikers. They also collect information on boater behavior, concerns, and knowledge of existing local and state laws related to anti-AIS measures.

The Namakagon Lake Association received funding to support landing monitors at three public landings (County D, Funnys Bay, and Lakewood Resort) in 2023. The total hours these landings were staffed in recent years are reported in Figure 37 to Figure 39. The NLA hires adults to staff the landings. The CBCW coordinator is a volunteer. The Bayfield County Sheriff's Department provides enforcement as needed.

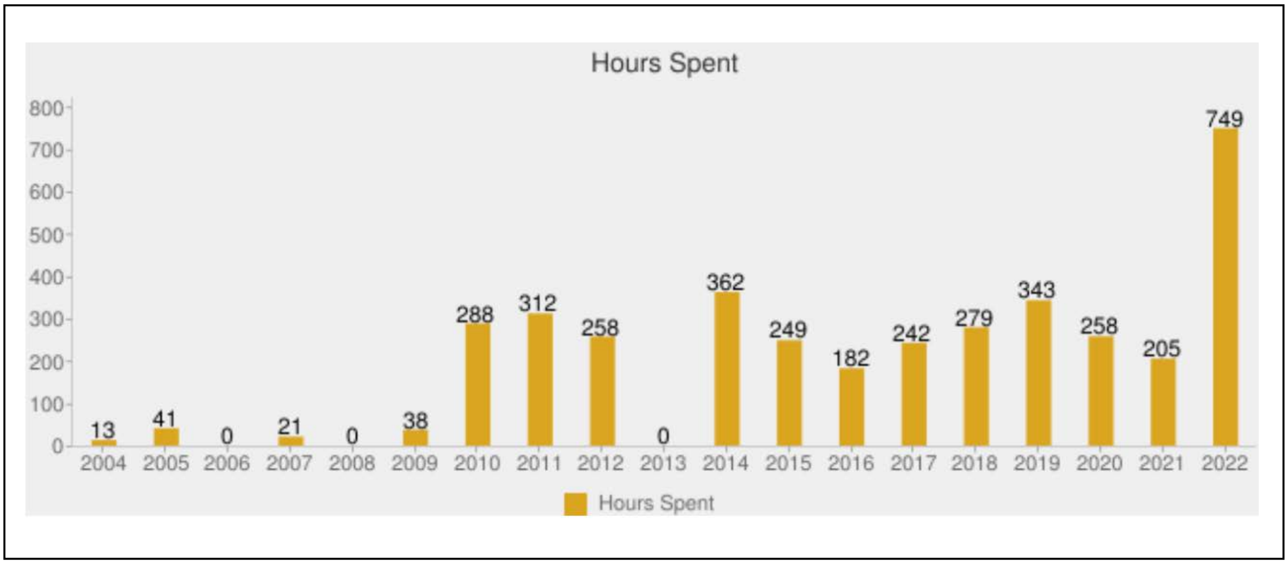

Figure 37. Clean Boats, Clean Waters Staffing County D Landing

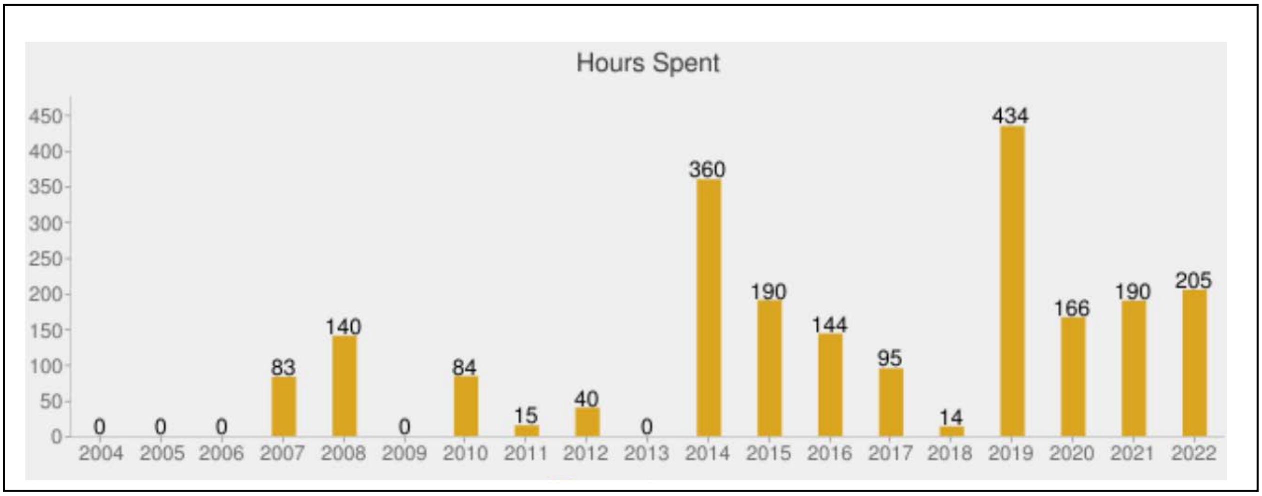

Figure 38. Clean Boats, Clean Waters Staffing Funnys Bay

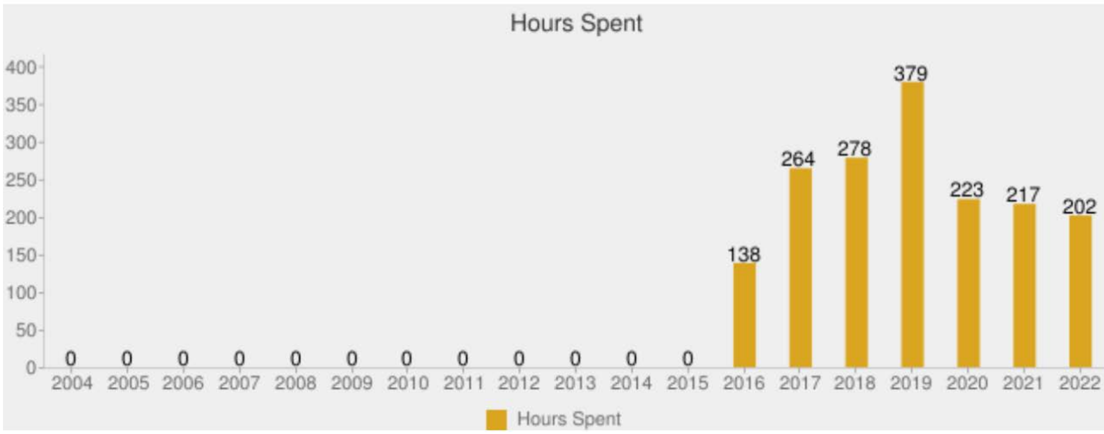

Figure 39. Clean Boats, Clean Waters Staffing Lakewoods Resort

LANDING SURVEILLANCE CAMERAS

Landing Monitoring Cameras were installed at two landings (County D and Funnys Bay) with WNDR grant AEPP-211-10 in 2010. Cameras are also in place at Lakewoods Resort and Garden Lake. Volunteers review the video from the cameras except for from Garden Lake. The Bayfield County Sheriff's Department has issued citations resulting from video evidence.

MONITORING

NLA volunteer monitoring occurs adjacent to public access sites and in strategic bays.

DECONTAMINATION STATIONS

Boat washing stations use hot water and/or high pressure to remove potential aquatic invasive species from boats, trailers, and equipment. The hot water kills the AIS, and the high pressure removes them. At 140°F, a hot water rinse for 10 seconds in each spot will kill all adult mussels and most other AIS. At 120°F, a contact time of two minutes is needed to destroy zebra mussels (MNDNR 2017). The Lake Owen North Outlet Landing in Bayfield County has a staffed, hot water, high pressure washer. Use of boat washing stations is voluntary in Wisconsin unless there are local ordinances to require decontamination. Bayfield County passed an ordinance in July 2020 which requires decontamination if offered at a public or private water access.

Several lake organizations in Burnett and Washburn County, Wisconsin have installed decontamination stations which use a mild bleach solution to decontaminate boats. The US Forest Service Two Lakes Campground boat landing on Lake Owen also uses this system. The solution of 2.5 tablespoons of household bleach/gallon of water is sprayed on boats and trailers. A contact time of ten minutes is required when using this solution. The bleach solution must be replaced regularly – daily replacement is preferred. Signage is installed to provide instructions for and to encourage use (NW WI ZM Team 2018). Tools for plant and debris removal generally accompany signs.

Self-service commercial systems for boat decontamination are also available. CD3 systems include a large sign board structure, vacuum, blower, and hand tools. CD3 Systems are equipped with technology that logs tool use and provides automatic reports and maintenance alerts. These systems are installed at Bone Lake and Half Moon Lake in Polk County.

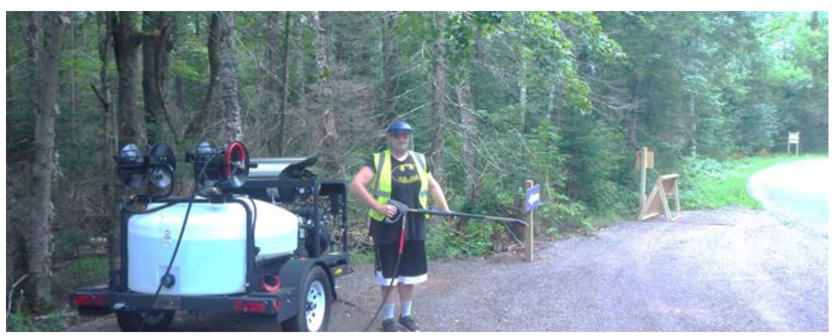

Figure 40. Lake Owen Decontamination Stations

Table 11. Aquatic Invasive Species Prevention Options (2022 costs)

Method	Installation Cost	Lifetime	Annual Cost	Labor	Advantages	Disadvantages	WDNR Grants
Clean Boats, Clean Waters	$0	NA	$200 (t-shirts, hats, data sheets) + labor	$10 - $17/hour	Person-to person education	Difficult to find staff Payroll management required (cost and responsible party) Insurance needed (liability, workers comp.) May need 2 staff with students	Funding available up to $4,000/landing 75% funding 200-hour minimum
ILIDS Camera*	$11,000	6 years	$2,500 (not grant eligible)	Volunteers to view video (optional)	Doesn't require staff Audio and video reminders Threat of enforcement Provide visit counts	Moderate/high cost	Funding available up to $24,000 (depreciated), 75% funding
Security Camera	$2,000				Low cost May be installed for other purposes	Security Camera	Funding eligibility uncertain
Decontamination Station: Sign, mild bleach sprayer, and tools	$200 - $500	NA	$50	Volunteer or staff to change bleach solution)	Low cost Doesn't require staff – although effectiveness would likely increase with staffing	Need 10 minute contact time May not be used Need to change bleach solution every day or so Siting station may be complicated	75% funding available

Method	Installation Cost	Lifetime	Annual Cost	Labor	Advantages	Disadvantages	WDNR Grants
Decontamination Station: Hot water, high pressure wash*	$15,000 - $20,000	10 years	$500 (fuel, maintenance, winter storage) + labor	$ varies	10 second hot water, 2 minute warm water contact kills ZM and other AIS	High cost Difficult to find staff Training and procedures require oversight Need to drain away from lake or contain water	Funding available up to $24,000 (depreciated), 75% funding
Decontamination Station: CD3 system* (signs, hand tools, blower, vacuum)	$25,000 - $30,000	8 years	$1,200 - $1,500 (not grant eligible)	$0	Doesn't require staff	High cost May not dry enough to remove zebra mussels	Funding available up to $24,000 (depreciated), 75% funding

*DEPRECIATION REEQUIREMENTS APPLY - While there is no longer a $4k limit for ILIDS, all equipment that has a useful life of greater than one year and cost of $5,000 or more per unit must be depreciated and prorated for the duration of the grant period (up to 4 years for prevention grants).

Example: Grantee builds a decontamination unit for AIS prevention at a cost of $8,800. The life of the decontamination unit is 10 years. Therefore, the amount that can be claimed each year in reimbursement requests for the decontamination unit is $880 ($8,800 divided by 10 years = $880 each year). If the life of the grant is 3 years, under this scenario, the grantee would be eligible to claim a total of $2,640 ($880/year x 3 years = $2,640) towards the purchase of the decontamination unit. Depreciation applies in the following cases:

- If the grantee receives a donated piece of equipment that has a value of $5,000 or more.
- If one unit of equipment is purchased at a cost of $5,000 or more.
- If the total cost of components of a customized piece of equipment is $5,000 or more.

PLAN GOALS, OBJECTIVES, AND ACTIONS

Plan goals, objectives, and strategies or actions are detailed below. The implementation plan or action plan details how action steps will be carried out over the next 2 year period. This action plan will be updated annually in June.

Goals are broad statements of desired results.

Objectives are the measurable accomplishments toward achieving a goal. Methods to evaluate progress toward plan objectives are listed below the objectives and are included in the implementation plan as "Evaluation Actions."

Actions are the steps taken to accomplish objectives and ultimately goals.

Namakagon Lake Association Mission Statement

THE NAMAKAGON LAKE ASSOCIATION, INC. WAS FORMED IN 1995 FOR THE PURPOSE OF PRESERVING AND PROTECTING LAKE NAMAKAGON AND ITS ENVIRONS. THE NAMAKAGON LAKE ASSOCIATION, INC. (NLA) IS A NOT FOR PROFIT ORGANIZATION THAT RELIES ON THE CONTRIBUTIONS AND MEMBERSHIP FEES OF LAND OWNERS AND OTHER CONCERNED CITIZENS FOR ITS FUNDING. IT IS OUR GOAL TO PRESERVE AND PROTECT LAKE NAMAKAGON AS AN ENVIRONMENTALLY HEALTHY WATERSHED, BY SPONSORING EDUCATIONAL PROGRAMS, ADOPTING A PROACTIVE ROLE IN THE FORMULATION OF WATER AND SHORE LAND REGULATIONS, AND RESPONSIBLE USE OF THIS UNIQUE AND IRREPLACEABLE RESOURCE FOR ALL CITIZENS.

GOAL 1. *PROTECT* THE NATURAL FUNCTIONS THAT DIVERSE NATIVE PLANTS PROVIDE BOTH IN THE WATER AND ON THE SHORE.

GOAL 2. *PREVENT* THE INTRODUCTION OF AQUATIC INVASIVE PLANTS AND ANIMALS.

GOAL 3. *EDUCATE* LAKE RESIDENTS AND VISITORS ABOUT THE IMPORTANCE OF NATIVE AQUATIC AND SHORELAND PLANTS, THE THREATS FROM INVASIVE SPECIES, AND THE PLAN MANAGEMENT STRATEGIES.

GOAL 4. *ID, CONTROL, AND CONTAIN* AQUATIC AND SHORELAND INVASIVE SPECIES.

GOAL 5. *COORDINATE AND COMMUNICATE* WITH OUR PARTNERS.

GOAL 1. *PROTECT* THE NATURAL FUNCTIONS THAT DIVERSE NATIVE PLANTS PROVIDE BOTH IN THE WATER AND ON THE SHORE.

OBJECTIVE A. CONTROL MEASURES RESULT IN MINIMAL DAMAGE TO NATIVE AQUATIC SPECIES.

There will be no statistically significant decline in native plant frequency of occurrence[10] (with the exception of those most susceptible to damage from the herbicide used) within treatment areas, and throughout Lake Namakagon, Jackson, and Garden Lakes.

EVALUATION ACTIONS

1. Conduct whole lake aquatic plant point intercept aquatic plant surveys every 3-5 years (2025-2027).

    a. Assess lake-wide changes in aquatic plant species, with particular emphasis on those sensitive to herbicides used in control measures.
    b. Assess spread of HWM and resulting impacts to native aquatic plants if control measures are not implemented (such as in Bluegill Bay).

2. Conduct point intercept surveys within treatment areas in late-August the year prior to treatment (pre-treatment monitoring) and the year of treatment (post-treatment monitoring) (see goal 4).

3. If a statistically significant decline in native plants occurs following HWM treatment, conduct follow-up monitoring for 2 – 4 years to measure recovery of native plants by:

    a. Extending point intercept, post-treatment monitoring beyond the treatment year in selected treatment areas (Mogasheen area is proposed for initial follow-up monitoring in 2023).
    b. Recording qualitative observations of native plant recovery during the HWM bed mapping survey in mid- August for remaining treatment areas.

ACTION

4. Consider and work to minimize native plant and animal impacts when developing and adapting HWM control strategies.

[10] Frequency of occurrence is the percentage of points out of all points sampled where a particular plant species is found.

OBJECTIVE B. NATIVE PLANTS GROW ALONG OUR SHORELINES.

EVALUATION ACTIONS

1. Record numbers (square feet, shoreline length) of native plantings installed along the shoreline of each lake whether through Healthy Lakes grant funding or at property owner's expense.
2. Consider Lake Shoreland and Shallows Habitat Monitoring to record a baseline of shoreland habitat conditions and identify potential restoration sites.

ACTIONS

3. Encourage property owners to preserve and restore shorelines to native vegetation with outreach and technical support.
4. Seek property owner participation, then obtain and administer Healthy Lakes grant funding to support shoreland projects.

GOAL 2. *PREVENT* THE INTRODUCTION OF AQUATIC INVASIVE PLANTS AND ANIMALS.

OBJECTIVE

A. Protective measures are established, and people take preventative action at likely invasive species points of entry.

ACTIONS

1. Continue the Clean Boats, Clean Waters program at three public landings (County D, Funnys Bay, and Lakewoods Resort).

2. Operate landing monitoring cameras at four landings (County D, Funnys Bay, Lakewoods Resort, and Garden Lake). Volunteers review the video from the cameras.

3. Install decontamination stations using signs, tools, and a mild bleach solution at landings and other locations. Consider other decontamination methods when funding, staffing and logistics allow.

GOAL 3. *EDUCATE* LAKE RESIDENTS AND VISITORS ABOUT THE IMPORTANCE OF NATIVE AQUATIC AND SHORELAND PLANTS, THE THREATS FROM INVASIVE SPECIES, AND THE PLAN MANAGEMENT STRATEGIES.

OBJECTIVE A. RESIDENTS AND LAKE USERS UNDERSTAND THE ROLE AND IMPORTANCE OF NATIVE PLANTS, THE THREATS FROM INVASIVE SPECIES, AND THE RATIONALE FOR INVASIVE SPECIES MANAGEMENT.

Behaviors to encourage/messages

Maintain native aquatic plants for the benefits they provide: protection against invasive species, breaking the force of waves along the shoreline, lake health, fish and waterfowl habitat, etc.

Describe threats from invasive species and the rationale for the control strategy.

Encourage residents to talk to their kids and grandkids about lake stewardship.

Target Audiences

Lake residents
Resort owners and other businesses
Visitors who are out on the lake

OBJECTIVE B. RESIDENTS AND LAKE USERS PREVENT INTRODUCTION OF INVASIVE SPECIES.

Target Audiences

Lake residents
Dock service providers
Resort owners and other businesses
Fishing tournament organizers
Landing users
Visitors who are out on the lake

Behaviors to Encourage/Messages

INSPECT, REMOVE, DRAIN, NEVER MOVE

Draining and drying all internal compartments, especially wake boat ballast tanks, is critically important to reduce transport of zebra mussels and other invasive species. This also includes live wells, engines, etc. Provide information about drying time required as a card/handout to boaters.

Learn invasive plant identification with resources from the NLA, county, and WDNR. (Provide contacts on NLA website.)

Check docks, lifts, rafts, and other equipment for zebra mussels when removed from water in the fall.

Talk to your neighbors about invasive species prevention. Quarantine docks, lifts, and other equipment for at least one month when moved from another lake or river.

ACTIONS/SPECIFIC METHODS TO ENCOURAGE

Signs at the landings and lake access points. Add a QR code to the bleach station decontamination sign with a link to more information.

OBJECTIVE C. LAKE RESIDENTS PRESERVE AND RESTORE SHORELAND BUFFERS OF NATIVE VEGETATION.

Target Audience

Lake residents

Behaviors to Encourage/Messages

Maintain native shoreland plants for the benefits they provide: habitat for shoreland species, protection against erosion, and natural beauty.

Install native plantings. Grant support is available, and a deed restriction is not required.

When you plant or have landscaping projects completed, know what you are planting and the source of the soil you use; be sure not to introduce invasive plants.

Provide examples/identification of common invasive shoreland plants.

Provide suggestions of species and sources of native plants for your shoreland area. Recommended plantings are included at https://healthylakeswi.com/best-practices/#350. A native plant guide is also found on the Healthy Lakes web site.

ACTIONS/SPECIFIC METHODS TO ENCOURAGE

1. Demonstration sites and garden tours
2. Wisconsin Shoreland Evaluation Tool https://survey.healthylakeswi.com/

OBJECTIVE D. VOLUNTEERS SUPPORT AQUATIC PLANT MANAGEMENT PLAN IMPLEMENTATION.

Target Audiences

Lake residents
Resort owners and other businesses
Partner organizations

Behaviors to Encourage/Messages

Volunteer to help celebrate and protect Lake Namakagon.

The lakes are central to the community. We need more people to help support important lake protection work.

ACTIONS/ SPECIFIC METHODS TO ENCOURAGE

1. Volunteer monitoring training

2. Community events – celebrate the lakes, discuss the threats to our valued resource and what each person or organization can do about them, provide hands-on volunteer plant ID training. Coordinate with businesses including Lakewoods.

3. Encourage volunteers with events and appreciation measures
   - Provide food and drink, encourage socializing
   - Recognize volunteers at least annually

4. Appoint and support a volunteer coordinator
   - Provide a list of volunteer activities and the approximate time commitment required for each.
   - Develop a sign-up sheet, perhaps make available for sign up on-line.
   - Initial list of volunteer activities: board members, monitoring/ID, viewing landing camera footage, attending educational events.
   - Recruit volunteers from other partner organizations.

ACTIONS/COMMUNICATION METHODS FOR ALL OBJECTIVES

1. Newsletter – distributed by mail (about 220 addresses including resorts and realtors)
2. Email list – (about 220 addresses)
3. NLA website
4. Facebook (use photos)
5. Annual meeting presentations
6. NLA board meetings
7. Conferences and workshops
8. Written information: APM Plan Summary, Mailings, NLA brochure
9. Private road association and other organization meetings

GOAL 4. *ID, CONTROL AND CONTAIN* AQUATIC AND SHORELAND INVASIVE SPECIES.

OBJECTIVE A. RAPIDLY IDENTIFY AND RESPOND TO NEW AQUATIC AND SHORELAND INVASIVE SPECIES.

ACTIONS

1. Complete annual professional meandering surveys of the Namakagon Chain.
    a. Bayfield County and DNR staff are coordinating this survey in 2023.
    b. Endangered Resources Services HWM surveys provide ability to identify potential invasive species each year in mid-August.
2. Encourage homeowners to install cinder blocks or plate samplers along their docks to monitor for potential zebra mussel infestation and report to NLA.

Figure 41. Zebra Mussel Monitoring Equipment: Cinder Blocks and Sampling Plates

3. Update and follow the Rapid Response Plan for invasive species (see Appendix B).

OBJECTIVE B. CONTAIN HYBRID WATERMILFOIL (HWM)

- Seek >90% reduction in frequency of occurrence with each control measure.
- Use multiple control measures in sequence if reduction objective is not met.
- Limit expansion of HWM following successful containment.

EVALUATION ACTIONS

1. Volunteers will identify where HWM is growing and report to professional monitor.
    a. Provide volunteers with information and training to identify and distinguish between HWM and other species such as Northern water milfoil.
    b. Trained lead volunteers will interact directly with agency and consultant experts to gain additional experience with plant identification. Their contact information (email/phone) will be provided to other lake residents to verify identification.
    c. Develop reporting and tracking systems for volunteer monitoring – RECORD GPS POINTS AND MAP IF POSSIBLE – consider Avenza or Google Earth Pro (free) for monitoring.
    d. Coordinate volunteer monitoring efforts (location and reporting).
        - Lead volunteers are assigned by lake area. Four board members currently serve as lead volunteers – more are needed.
        - Volunteers will also observe and record native plant recovery within HWM treatment beds where there were visible native plant impacts.

2. Professional Monitor will complete annual HWM bed mapping survey in mid-August.

3. Professional Monitor will complete HWM pre-monitoring for selected treatment beds in late August the year before treatment.

4. Professional Monitor will complete HWM post-monitoring in treated HWM beds the year of treatment in late-August.

ACTIONS

5. Select HWM control measures based upon likelihood of spread of HWM and impacts to native plant community.
    a. Control measures will be more aggressive in **low-tolerance areas** to limit spread to remaining areas of the Namakagon Chain. Low tolerance areas include areas of concentrated boat traffic such as public and private boat landings, resorts, and the channel between Garmish and the main lake (see Figure 42).
    b. Control measures will be less aggressive (herbicide treatments will be avoided or delayed) in **high-tolerance areas** where there is little boat traffic and a diverse native

plant community – especially where sensitive species are present. Initial proposed high-tolerance areas include Bluegill Bay, Mumms Bay, and Governor's Island.

c. Control measures will be selected immediately following and based on mid-August bed mapping survey using guidance in the HWM Containment Decision Matrix. The matrix may be modified using adaptive management. Adaptive management is a systematic approach for improving resource management by learning from management outcomes. Adaptive management uses results of monitoring, evaluation of project activities, and updated information to modify and guide future project implementation.

6. Conduct control measures for HWM – see HWM Containment Decision Matrix
   a. Carry out treatment strategy for herbicide treatments
      - Inform professional monitor, obtain pre and post-treatment monitoring cost estimate.
      - Solicit bids from licensed herbicide applicators.
      - Obtain required WDNR permits for aquatic plant management.
      - Contract with herbicide applicator will indicate that treatment will occur under conditions that increase product efficacy.
      - Document efficacy of various control measures with pre and post-monitoring.

   b. Carry out treatment strategy for hand-pulling
      - Identify low-tolerance areas and areas of new infestation where hand-pulling is practical (low-density, scattered growth in shallow areas).
      - Inform and coordinate volunteers
      - Seek partner support for hand-pulling efforts.

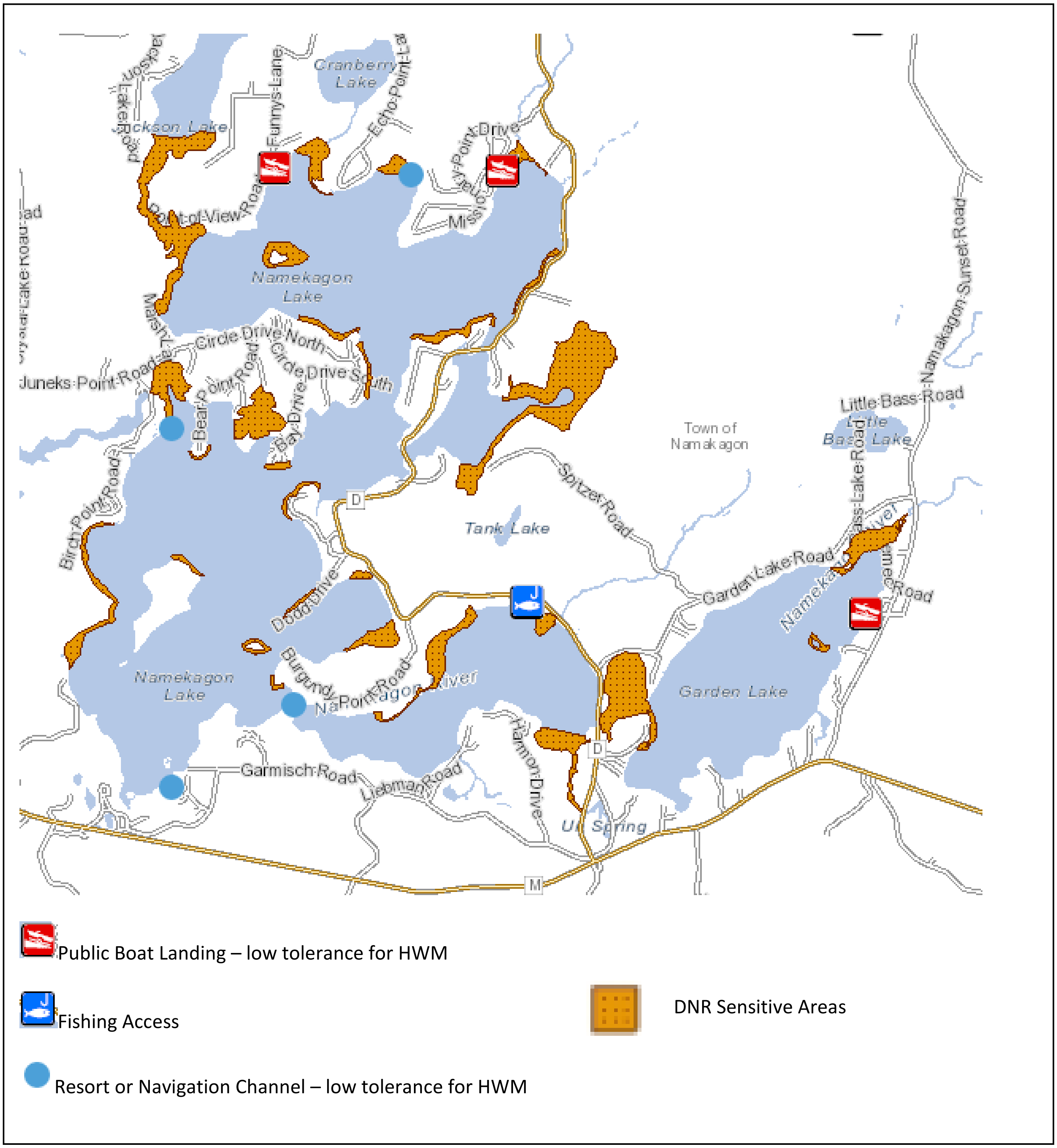

Figure 42. Low-Tolerance Areas: Priorities for HWM Containment

OBJECTIVE C. MINIMIZE UNINTENDED CONSEQUENCES OF MANAGEMENT/CONTROL EFFORTS.

ACTIONS/PROGRAM GUIDANCE

- Avoid fragments which may spread plants when hand-pulling.
- Consider timing and location of chemical treatments to avoid negative impacts to spawning and fish nursery habitat.
- Equipment used for monitoring is decontaminated if used on any other water body.
- Avoid herbicide treatments using the same chemical for more than 2 consecutive years to prevent development of herbicide resistance. [11]

- [11] WDNR factsheets for ProcellaCOR (WSSA Group 4 herbicide) and 2,4-D (WSSA Group 4 herbicide) state: *It is important to note that repeated use of herbicides in the same WSSA group (i.e., with the same mechanism of action) can lead to herbicide-resistant plants, even in aquatic environments. In order to reduce the risk of developing resistant genotypes, avoid using the same type of herbicides year after year, and utilize effective integrated pest management strategies as part of any long-term control program.*

Table 12. Lake Namakagon Hybrid Watermilfoil Containment Decision Matrix

HWM Growth Condition	Control Methods[12]	Monitoring	Considerations	Lead /Partners
Scattered growth, no defined edge, <4 feet deep. Hand pull in low-tolerance and areas of new infestation.	**Hand pulling** Plant ID – provide guidance to volunteers	Volunteer Monitoring (ongoing/monthly) Professional Bed Mapping Survey (annually in mid-August)	Seek assistance from partners	Volunteers USFS Bayfield County WDNR
Dense growth in beds: ≥0.5 acre Control measures will be more aggressive in low tolerance areas. Treatment may be delayed or avoided in high-tolerance areas.	**Contact herbicide treatment:** ProcellaCOR Treatment timing: actively growing HWM (likely mid-June to early-July), sunny day, low wind	Pre and post quantitative monitoring – annually in late August (professional)	Minimum bed size for effective herbicide treatment will vary with site conditions and herbicide chosen. Beds identified for treatment following annual mid-August bed mapping survey. Pre- treatment monitoring of selected treatment beds will occur in late-August the year before treatment. The ProcellaCOR label does not allow treating in the same area more than 2 consecutive years. (A different herbicide may be considered.)	
Combined dense growth in beds and scattered growth: ≥5 acres	**Systemic herbicide treatment:** 2,4-D	Pre and post quantitative monitoring (professional)	Expanding treatment area to reach minimum size not appropriate where edges drop off into deep water. Avoid treating the same area with the same chemical more than 2 consecutive years.	

Definitions

HWM Bed: any area where it is visually estimated that HWM makes up >50% of the area's plants, is generally continuous with clearly defined borders, and is canopied or close enough to being canopied that it would likely interfere with boat traffic.

Scattered growth : No defined edge; individual plants or small clumps of plants.

Objective measures: FOO (frequency of occurrence = HWM plants/total plants sampled), Rake Fullness

[12] Control methods considered but eliminated as options for the Lake Namakagon system include benthic barriers, harvesting, diver assisted suction harvesting (DASH), and weevils. Harvesting is a concern because of potential spread of plant fragments. DASH has limited effectiveness, especially in water with limited visibility.

OBJECTIVE D. CONTROL SHORELAND INVASIVE SPECIES

- Purple loosestrife
- Yellow iris
- Garlic mustard

ACTION

1. Implement control measures for shoreland invasive species.
    a. Seek partnerships for inventory and control measures.
    b. Inventory – yellow iris (mid-June), purple loosestrife (mid-July).
    c. Inform residents of concerns regarding these invasive species and suggest appropriate control measures.
    d. Permits are needed for herbicide control near water. If coordinated effort for chemical control is undertaken, obtain permission from landowner (including USFS) prior to obtaining permits.
    e. Solicit bids and hire licensed applicator to control with herbicide.

GOAL 5. *COORDINATE AND COMMUNICATE* WITH OUR PARTNERS.

OBJECTIVES

A. Keep up with evolving technology and best practices.

B. Enhance response time – e.g., permit review, grant cycles.

C. Maintain communication channels with partners.

D. Identify and encourage new stakeholder involvement.

E. Avoid duplication of efforts by project partners.

ACTIONS

1. Continue Advisory Committee to support implementation of the aquatic plant management plan

   Initial Advisory Committee List (*Encourage organizations to sign onto/adopt the plan).*

   - Namakagon Lake Association
   - Bayfield County
   - Great Lakes Indian Fish and Wildlife Commission
   - US Forest Service
   - Wisconsin Department of Natural Resources
   - Town of Namakagon

2. Maintain list of potential partners and encourage participation through letters, presentations, one-on-one outreach, etc.

   Stakeholders/Partners

   - Other lake organizations
   - Sportsman's groups
   - Tournament sponsors
   - Chamber of Commerce
   - Towns of Namakagon and Grandview
   - Business such as Lakewoods and other resorts, taverns, restaurants, lake service providers
   - Namakagon Community Club
   - Cable Chamber of Commerce
   - Cable Natural History Museum
   - Lions Club (current environmental focus)
   - Youth clubs such as Boy Scouts

WDNR SURFACE WATER GRANTS

Wisconsin Department of Natural Resources Aquatic Invasive Species Grants are available to assist in funding some of the action items in the implementation plan. Grants provide up to 75 percent funding. Draft grant applications are due September 15 and final applications are due November 15 of each year.

The Namakagon Lake Association currently has a 75 percent WDNR AIS Control Grant. The WDNR awarded a $149,962 AIS control grant to the NLA in 2022. The grant time period is March 15, 2022 through December 31, 2024. About half of the grant was used for the 2022 HWM treatment and monitoring. The grant project scope includes professional monitoring and plant surveys, chemical treatment, permitting, and coordination. Volunteer monitoring and hand pulling provide a portion of the grant match.

APPENDIX A. AQUATIC PLANT SURVEY METHODS

Prior to beginning the point-intercept surveys, a general boat survey of the lake was conducted to gain familiarity with the species present. All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2006, Skawinski 2014), and a field datasheet was developed.

Survey sampling grids were developed by the WDNR using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth, and total acreage. Using this grid, plant surveyors located each point using a handheld mapping GPS unit (Garmin 76CSx), recorded a depth reading with a metered pole rake or hand held sonar (Vexilar LPS-1), and used a rake to sample an approximately 2.5 foot section of the bottom. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 43). Visual sightings of all plants were also recorded within 6 feet of the sample point not found in the rake. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

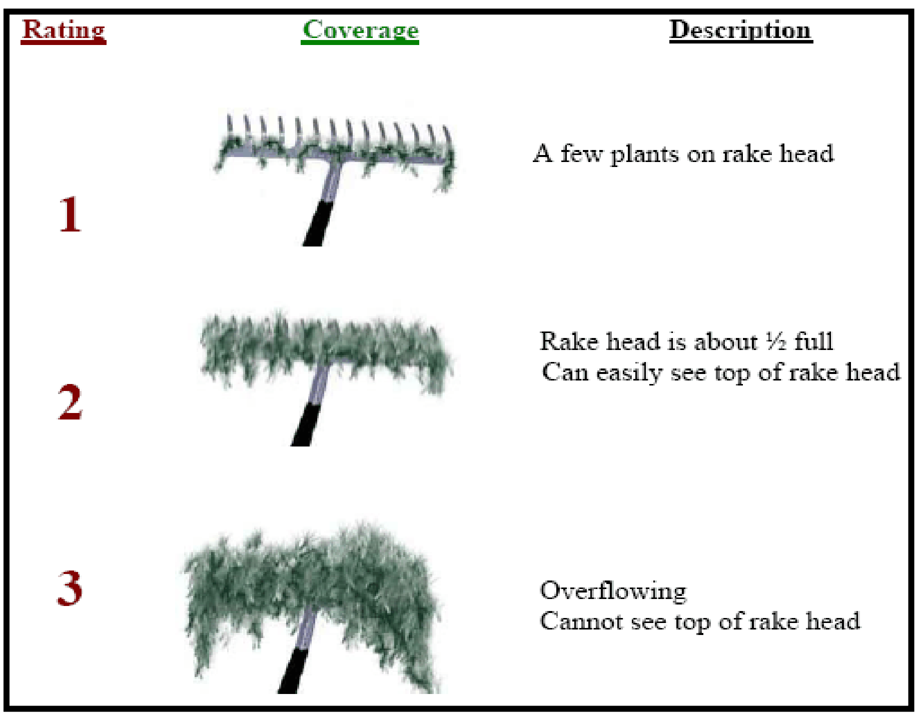

Figure 43. Rake Fullness Ratings (UWEX 2010)

DATA ANALYSIS

Following the survey, data was entered into the standard APM spreadsheet (UWEX 2010), and the following were calculated:

Total number of sites visited: This included the total number of points on the lake that were accessible to be surveyed by boat.

Total number of sites with vegetation: These included all sites where vegetation was found in a rake sample. For example, if 20% of all sample sites have vegetation, it suggests that 20% of the lake has plant coverage.

Total number of sites shallower than the maximum depth of plants: Number of sites that were in the littoral zone. Because not all sites that are within the littoral zone actually have vegetation, this value estimates how prevalent vegetation is throughout the littoral zone. For example, if 60% of the sites shallower than the maximum depth of plants have vegetation, then 60% of the littoral zone has plants.

Frequency of occurrence: The frequency of all plants (or individual species) is generally reported as a percentage of occurrences within the littoral zone. It can also be reported as a percentage of occurrences at sample points with vegetation.

Frequency of occurrence example:
Plant A is sampled at 70 out of 700 total littoral points = 70/700 = .10 = 10%
This means that Plant A's frequency of occurrence = 10% when considering the entire littoral zone.

Plant A is sampled at 70 out of 350 total points with vegetation = 70/350 = .20 = 20%
This means that Plant A's frequency of occurrence = 20% when only considering the sites in the littoral zone that have vegetation.

From these frequencies, we can estimate how common each species was at depths where plants could grow, and at points where plants actually were growing.

Note: the second value will be greater as not all the points (in this example, only ½) had plants growing at them.

Simpson's Diversity Index: A diversity index allows the entire plant community at one location to be compared to the entire plant community at another location. The plant community at a single location can also be compared over time thus allowing a measure of community degradation or restoration at that site. With Simpson's Diversity Index, the index value represents the probability that two individual plants (randomly selected) will be different species. The index values range from 0 – 1, where 0 indicates that all the plants sampled are the same species, to 1, where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be more resistant to invasion by exotic species.

Maximum depth of plants: The deepest point where vegetation was sampled. In clear lakes, plants may be found at depths of over 20 feet, while in stained or turbid locations, they may only be found in a few feet of water. While some species can tolerate very low light conditions, others are only found near the surface. In general, the diversity of the plant community decreases with increased depth.

Mean and median depth of plants: The mean depth of plants indicates the average depth in the water column where plants were sampled. Because a few samples in deep water can skew this data, median depth is also calculated. This tells us that half of the plants sampled were in water shallower than this value, and half were in water deeper than this value.

Number of sites sampled using rope/pole rake: This indicates which rake type was used to take a sample. We use a 20 foot pole rake and a 35 foot rope rake for sampling.

Average number of species per site: This value is reported using four different considerations. 1) **shallower than maximum depth of plants** indicates the average number of plant species at all sites in the littoral zone.
2) **vegetative sites only** indicate the average number of plants at all sites where plants were found. 3) **native species shallower than maximum depth of plants** and 4) **native species at vegetative sites only** excludes exotic species from consideration.

Species richness: This value indicates the number of different plant species found in and directly adjacent to (on the waterline) the lake. Species richness alone only counts those plants found in the rake survey. The other two values include those seen at a sample point during the survey but not found in the rake, and those that were only seen during the initial boat survey or inter-point. Note: Per WDNR protocol, filamentous algae, freshwater sponges, aquatic moss and the aquatic liverworts (*Riccia fluitans* and *Ricciocarpus natans)* are excluded from these totals.

Average rake fullness: This value is the average rake fullness of all species in the rake at all sites. It only takes into account those sites with vegetation.

Relative frequency: This value shows a species' frequency relative to all other species. It is expressed as a percentage, and the total of all species' relative frequency will add up to 100%. Organizing species from highest to lowest relative frequency value gives us an idea of which species are most important within the macrophyte community.

Relative frequency example:

Suppose that we sample 100 points and found 5 species of plants with the following results:

Plant A was located at 70 sites. Its frequency of occurrence is thus 70/100 = 70%

Plant B was located at 50 sites. Its frequency of occurrence is thus 50/100 = 50%

Plant C was located at 20 sites. Its frequency of occurrence is thus 20/100 = 20%

Plant D was located at 10 sites. Its frequency of occurrence is thus 10/100 = 10%

To calculate an individual species' relative frequency, we divide the number of sites a plant is sampled at by the total number of times all plants were sampled. In our example that would be 150 samples (70+50+20+10).

Plant A = 70/150 = .4667 or 46.67%

Plant B = 50/150 = .3333 or 33.33%

Plant C = 20/150 = .1333 or 13.33%

Plant D = 10/150 = .0667 or 6.67%

This value tells us that 46.67% of all plants sampled were Plant A.

Floristic Quality Index (FQI): This index measures the impact of human development on a lake's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each native index species found in the lake during the point intercept survey**, and multiplying it by the square root of the total number of plant species (N) in the lake ($FQI=(\Sigma(c1+c2+c3+\ldots cn)/N)*\sqrt{N}$). Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area, and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Lake Namakagon is in the Northern Lakes and Forests Ecoregion.

** Species that were only recorded as visuals or during the boat survey, and species found in the rake that are not included in the index are excluded from FQI analysis.

APPENDIX B. EARLY DETECTION AND RAPID RESPONSE TO AIS

Definition: Aquatic Invasive Species (AIS) are non-native plant and animal species that can out-compete and overtake native species damaging native lake habitat and sometimes creating nuisance conditions. Hybrid watermilfoil is currently present in Lake Namakagon and Jackson Lake. Shoreland invasive species present in Lake Namakagon include purple loosestrife, forget-me-not, narrow-leaf cattail, and yellow iris. Additional AIS threaten the lakes and will be monitored throughout the lake by volunteers and consultants.

1. Maintain a non-lapsable contingency fund for rapid response to HWM or other invasive species (NLA Board).

2. Conduct volunteer and professional monitoring (APM Monitor) at the public landings and other likely areas of AIS introduction. If a suspected plant is found, contact the AIS Identification Volunteer(s).

3. Direct lake residents and visitors to contact the AIS Identification Volunteer(s) if they see a plant or animal in the lake they suspect might be an AIS. Signs at the public boat landings, web pages, handouts at annual meetings, and newsletter articles will provide photos and descriptions of AIS that have a high likelihood of threatening project lakes, contact information, and instructions.

4. The AIS Identification Volunteer(s) will tentatively confirm identification of plant or animal AIS with Bayfield County or lake management consultant then,
   a. Document the sample with a digital photo if possible.
   b. Record GPS location coordinates of collection location if possible. Note that cell phone applications are available to identify GPS points.
   c. Alternatives are marking with a float and/or on a map.
   d. Fill out an AIS Incident Report from the Wisconsin DNR. This form can be found at: https://dnr.wisconsin.gov/topic/Invasives/report.html. Contact Wisconsin DNR and deliver plant samples to Polk County LWRD or Wisconsin DNR, 810 West Maple St., Spooner, WI 54801.
      - If the sample is a plant, collect 3-5 intact specimens and attempt to keep all parts of the plant present (roots, leaves, fruits, and flowers if present). Place in plastic, sealed bag(s) and refrigerate or put on ice.
      - If the sample is an animal, collect up to five specimens. Place in a jar with water, put on ice and transport to refrigerator. Transfer specimen to a jar filled with rubbing alcohol (except for Jellyfish – leave in water).

5. If identification is positive:
    a. Inform the person who reported the AIS and the board, who will then inform Bayfield County and lake management consultant.
    b. Mark the location of AIS with a more permanent marker and GPS points. (AIS Identification Volunteer(s)).
    c. Post a notice at the public landing (WDNR has these signs available) and include a notice in the next newsletter. Notices will inform residents and visitors of the approximate location of AIS and provide appropriate means to avoid its spread (NLA Board).

6. Determine the extent of the AIS introduction (NLA in cooperation with Bayfield County and WDNR). Divers may be used. If small amounts of AIS are found during this assessment, divers may be directed to identify locations with GPS points and hand pull plants/remove animals found. All plant fragments will be removed from the lake when hand pulling.

7. Select a control plan in cooperation with the WDNR (NLA Board). The goal of the rapid response control plan will be eradication of the AIS.

   Control methods may include hand pulling, use of divers to manually or mechanically remove the AIS from the lake bottom, application of herbicides, and/or other effective and approved control methods.

8. Implement the selected control plan including applying for the necessary permits. Regardless of the control plan selected, it will be implemented by persons who are qualified and experienced in the technique(s) selected.

9. The NLA will work with the WDNR to apply for an Early Detection and Rapid Response AIS Control Grant.

10. Frequently inspect the area of the AIS to determine the effectiveness of the treatment and whether additional treatment is necessary (APM monitor, WNDR and/or other agency representatives).

11. Review the procedures and responsibilities of this rapid response plan on an annual basis. Changes may be made with approval of the NLA Board.

EXHIBIT A[13]

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APM MONITOR

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[13] This list is current as of 2023. Refer to the Namakagon Lake Association web site http://nlaonline.org/ for updated information.

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