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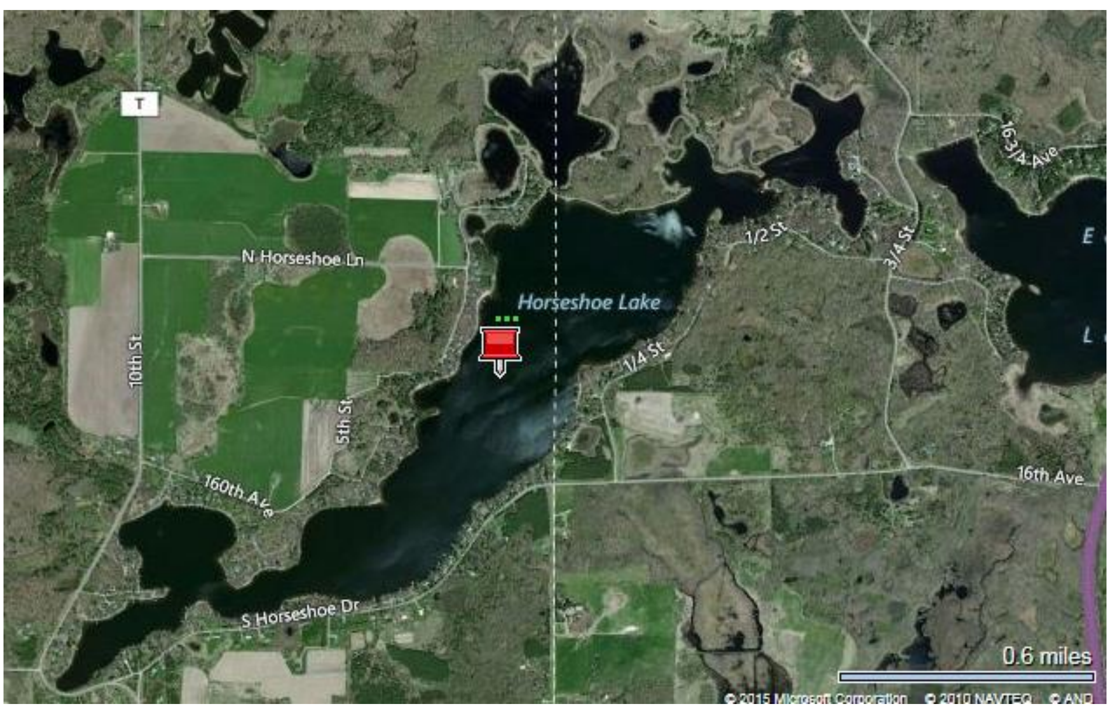
HORSESHOE LAKE, BARRON AND POLK COUNTIES

2023-27 AQUATIC PLANT MANAGEMENT PLAN
WDNR WBIC: 2630100

Prepared by: Dave Blumer & Megan Mader

October, 2022



HORSESHOE LAKE PUBLIC
INLAND LAKE PROTECTION AND
REHABILITATION DISTRICT
TURTLE LAKE, WI 54889

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AQUATIC PLANT MANAGEMENT PLAN-HORSESHOE LAKE

PREPARED FOR THE HORSESHOE LAKE PUBLIC INLAND LAKE PROTECTION AND REHABILITATION DISTRICT

1.0 Introduction

Horseshoe Lake is located in northern Wisconsin on the Polk/Barron County line just north of Turtle Lake, Wisconsin. This lake is frequented often for swimming, fishing, and recreational boaters. Routine monitoring by Barron County Soil and Water Conservation Department staff in the fall of 2006 discovered suspicious vegetation that resembled Eurasian watermilfoil (EWM) a non-native, invasive species. Wisconsin Department of Natural Resources (WDNR) vouchering later identified the suspicious plant as hybrid watermilfoil (HWM) a cross between the native northern watermilfoil (*Myriophyllum sibiricum*) and the non-native invasive Eurasian watermilfoil (*Myriophyllum spicatum*). In 2018, "regular" EWM was found in the lake. It is suspected, but unverifiable, that finding EWM was a new introduction, not part of the original identification in 2006. Both EWM and HWM have been shown to have the capability to spread from lake to lake, and to spread through a lake once introduced.

From 2007 to 2015, the Horseshoe Lake Improvement Association used physical removal by property owners, diver removal, and application of aquatic herbicides to manage HWM in the lake. In 2010, the first Aquatic Plant Management Plan (APM Plan) for Horseshoe Lake was prepared by SEH Inc. for the purpose of guiding HWM and other aquatic invasive species (AIS) management. The 2010 plan was updated in 2015.

This document serves as an update to the 2015-19 APM Plan, reviewing what was done between 2015 and 2021 and guiding management actions from 2023 to 2027.

2.0 Horseshoe Lake Public Inland Lake Protection and Rehabilitation District

The Horseshoe Lake Public Inland Lake Protection and Rehabilitation District (District) was formed in 2016 in place of the Horseshoe Lake Improvement Association. The purpose of the District is to bring lakeshore owners together to discuss matters that affect the quality of life on the lake, agree on appropriate actions and establish a yearly budget. The District operates under the guidelines and requirements of Section 33 of the Wisconsin Statues. All Horseshoe lakeshore property owners of record are voting members of the District and are encouraged to participate in District member meetings.

The District posts information about what it does on its webpage at www.hlake.org.

3.0 Public Participation and Stakeholder Input

Over the course of the last 18 months while this plan has been under development, several meetings of the District have been held to discuss its content; how to best to manage EWM and HWM in the lake; how to manage other AIS in and around the lake like curly-leaf pondweed (*Potamogeton crispus*, CLP)and purple loosestrife (*Lythrum salicaria*, PL); and how to address water quality, lake habitat and runoff diversion (particularly after the 2019 tornado that devastated many of the large mature oaks and pines around the lake).

With the completion of the first draft of this APM Plan, a copy was sent to the District Board who in turn posted it on their District Webpage for constituent review. It was also posted on the consultant's client webpage as another location to access the plan for review. The APM Plan was posted in late June and was left open for comment through July 23, 2022. Comments received were incorporated into the final APM Plan which was approved by the District at their annual meeting on August 20, 2022.

A presentation was given to the District constituency at the 2022 Annual Meeting held on August 20. Nearly 50 people were in attendance. The goals of the new APM Plan were discussed with the constituency by the Consultant. In addition to this, a short questionnaire was gone through with those in attendance. The Questionnaire was intended to gain clarity on several parts of the new APM Plan including the need to include shoreland habitat improvement in the plan, how much vegetation interferes with lake use, and familiarity with non-native milfoils, purple loosestrife, and curly-leaf pondweed.

WDNR comments about the APM Plan made in an email dated August 12, 2022 were addressed along with the comments made and data gained at the 2022 Annual Meeting. The final APM Plan was submitted to the WDNR for approval in early September 2022.

4.0 Overall Management Goal

The main management goal of this APM Plan focuses on protecting and enhancing the native aquatic plant diversity, distribution, and density that exists in Horseshoe Lake. Maintaining a healthy and diverse native aquatic plant community is the most important factor in ensuring that Horseshoe Lake does not experience deteriorating conditions over the next five years. The most important objective for this goal is to prevent EWM/HWM and other AIS from negatively impacting native aquatic plants in the system. An integrated approach to pest management is recommended including physical and diver removal of AIS, application of aquatic herbicides, biological control, and reduction of nutrients to the lake. This management plan presents a strategy that strives to keep EWM, HWM, and other AIS in check while protecting native aquatic plants and is considered maintenance in nature.

4.1 Implementation Goals

The following four goals form the basis of the APM Plan. Each goal is accompanied by several objectives and many action items. For more information, go to the Goals, Objectives, and Management Actions in Section 12 of this document or Appendix A.

Goal 1 – Protect and enhance the native aquatic plant community.

Goal 2 – Manage existing aquatic invasive species (AIS) in the lake and along its shoreline in a way that minimizes its impact on the native aquatic plant community, lake use, and accessibility.

Goal 3 – Reduce the threat that new AIS will be introduced and go undetected in Horseshoe Lake, that existing AIS will be carried to other lakes, and improve the level of knowledge property owners and lake users have related to AIS.

Goal 4 - Improve the level of knowledge property owners and lake users have related to how their actions impact the aquatic plant community, lake community, and water quality.

5.0 Lake Characteristics

Horseshoe Lake is a 398-acre, mesotrophic, stratified, deep seepage lake located on the Polk/Barron County Line in T34N, R14&15W, Sections 7, 12, 13, just north of Turtle Lake, Wisconsin. The lake is bordered by Echo Lake to the east, undeveloped wetland complexes and Mudd Lake to the north, forest and agricultural land to the west, and Horseshoe Lake Road to the south. The lake is approximately 57-feet deep at its deepest point and averages 20-feet deep. The lakeshore is 8.6 miles long and is almost fully developed except on the northern shoreline where there is a large wetland complex that is public land (Figure 1). It is in this area that all of the sensitive areas designated by the state exist. Mature pine and mixed hardwood surround most of the lake, but was severely impacted by a large storm event in July 2019 that took down 100's of large, mature trees around the lake.

The lake is considered an Area of Special Natural Resource Interest (ASNRI) and the northern portion is designated as a Public Rights Feature (PRF). Horseshoe Lake can be accessed through a Polk County public boat landing on the southwest end of the lake. It has immediate parking for up to 8-10 boats and additional parking on the sides of the road to the landing.

Primarily considered a seepage lake, water levels fluctuate greatly. Water levels were down to what is likely considered more normal in 2021, but for several years prior to 2021, the water level was high to extremely high. At some point in the past, a manmade channel was dug between the northeast corner of Buckwald Bay and Echo Lake to allow flow through from Horseshoe Lake into Echo Lake during high water periods. Water levels in Echo Lake, also normally considered a seepage lake, also fluctuate greatly. The only outlet on Echo Lake is an intermittent stream often blocked by beaver dams preventing significant relief during high water periods on both lakes.

Figure 1: Public land (green) and designated sensitive areas (blue) on Horseshoe Lake

5.1 Watershed Characteristics

Horseshoe Lake is part of the Beaver Brook Watershed located in southeastern Polk County extending into a portion of Barron County. The watershed is relatively small at 44,483 acres and consists of 75 miles of streams and rivers, 1,801 acres of lakes and 5,965 acres of wetlands. The watershed is dominated by forest (31%), agriculture (26%) and grassland (22%) and is ranked high for nonpoint source issues affecting streams and medium for nonpoint source issues affecting lakes and groundwater. Figure 2 shows the immediate watershed of Horseshoe Lake which covers approximately 1572 acres. Figure 3 shows the percent of different land use within it.

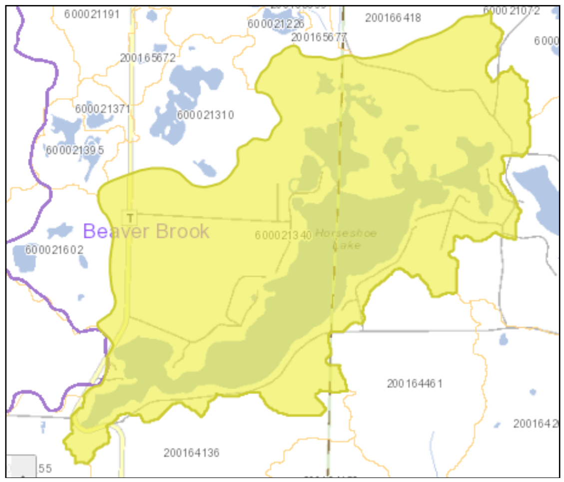

Figure 2: Horseshoe Lake watershed

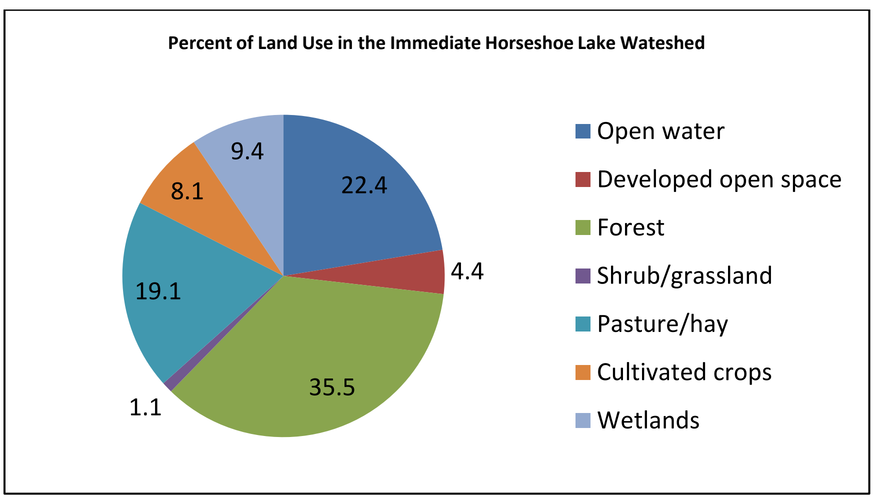

Figure 3: Land use in the Horseshoe Lake watershed

5.2 Fisheries and Wildlife

Horseshoe Lake is a warm water fishery with largemouth bass and northern pike being the most common game fish. Currently, a low number a walleye are present. The lake is not actively managed for walleye and no signs of walleye natural reproduction are present. Walleye stocking has only occurred twice with nearly 19,000 fingerlings stocked in 1994 and just over 10,000 fingerlings stocked in 2008. A 26 inch minimum length limit with a daily bag of two fish was enacted for northern pike with support from the lake organization. The size limit was enacted in an effort to increase the average size of northern pike. Panfish including bluegill, rock bass, crappie, and yellow perch are common and reproduce naturally. Other non-game fish including white sucker and various minnow species are also present.

According to WDNR Wildlife Biologists, some common furbearers in this area include muskrat, beaver, mink, otter, red fox, and raccoon. Waterfowl species include but are not limited to Canada goose, mallard, wood duck, and hooded merganser.

The Natural Heritage Inventory (NHI) database contains recent and historic element (rare species and plant community) observations. Each species has a state status ranking with either SC as Special Concern, P as Protected, or END as Endangered. According to the list for Polk and Barron Counties in the Horseshoe Lake area, there are two bird species: bald eagle (SC/P) and trumpeter swan (END); three plant species: Robbin's spike rush (SC), Spotted pondweed (END), and Torrey's bulrush (SC); and five ecological communities (lake- shallow hard seepage, northern dry mesic forest, northern mesic forest, northern sedge meadow, and northern wet forest). The 2020 point-intercept aquatic plant survey found Long-beaked bald rush (*Rhynchospora scirpoides*), a Threatened species in WI.

5.3 Wetlands

A wetland is an area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions. Wetlands have many functions which benefit the ecosystem surrounding Horseshoe Lake. Wetlands with a higher floral diversity of native species support a greater variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl.

Wetlands also provide flood protection within the landscape. Due to the dense vegetation and location within the landscape, wetlands are important for retaining stormwater from rain and melting snow moving towards surface waters and retaining floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide water quality protection because wetland plants and soils have the capacity to store and filter pollutants ranging from pesticides to animal wastes.

Wetlands also provide shoreline protection to Horseshoe Lake by acting as buffers between land and water. They protect against erosion by absorbing the force of waves and currents, and by anchoring sediments. This shoreline protection is important in waterways where boat traffic, water current, and wave action cause substantial damage to the shore. Wetlands also provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months. Aesthetics, recreation, education and science are also all services wetlands provide. Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes.

Horseshoe Lake has wetlands all around the lake, most associated with shoreland on the northern portions of the lake and in the Mudd Lake area.

5.4 Coarse Woody Habitat (Wolter, 2012)

Coarse woody habitat (CWH) in lakes is classified as trees, limbs, branches, roots, and wood fragments at least 4 inches in diameter that enter a lake by natural (beaver activity, toppling from ice, wind, or wave scouring) or human means (logging, intentional habitat improvement, flooding following dam construction). CWH in the littoral or near-shore zone serves many functions within a lake ecosystem including erosion control, as a carbon source, and as a surface for algal growth which is an important food base for aquatic macro invertebrates. Presence of CWH has also been shown to prevent suspension of sediments, thereby improving water clarity. CWH serves as important refuge, foraging, and spawning habitat for fish, aquatic invertebrates, turtles, birds, and other animals. The amount of littoral CWH occurring naturally in lakes is related to characteristics of riparian forests and likelihood of toppling. However, humans have also had a large impact on amounts of littoral CWH present in lakes through time. During the 1800's the amount of CWH in northern lakes was increased beyond natural levels as a result of logging practices. But time changes in the logging industry and forest composition along with increasing shoreline development have led to reductions in CWH present in many northern Wisconsin lakes.

CWH is often removed by shoreline residents to improve aesthetics or select recreational opportunities (swimming and boating). Jennings et al. (2003) found a negative relationship between lakeshore development and the amount of CWH in northern Wisconsin lakes. Similarly, Christensen et al. (1996) found a negative correlation between density of cabins and CWH present in Wisconsin and Michigan lakes. While it is difficult to make precise determinations of natural densities of CWH in lakes it is believed that the value is likely on the scale of hundreds of logs per mile. The positive impact of CWH on fish communities have been well documented by researchers, making the loss of these habitats a critical concern.

In the previous plan, a recommendation was made to increase the amount of coarse woody habitat in Horseshoe Lake. A large storm event in July 2019 added significant coarse woody habitat to the lake increasing the number of locations where it was present from 23 points in 2016 to 100 in 2020 (Figure 4). The addition of coarse woody habitat through the installation of Fishsticks is no longer a recommendation, but if property owners were interested, additional coarse woody habitat would only benefit the lake, not hurt it.

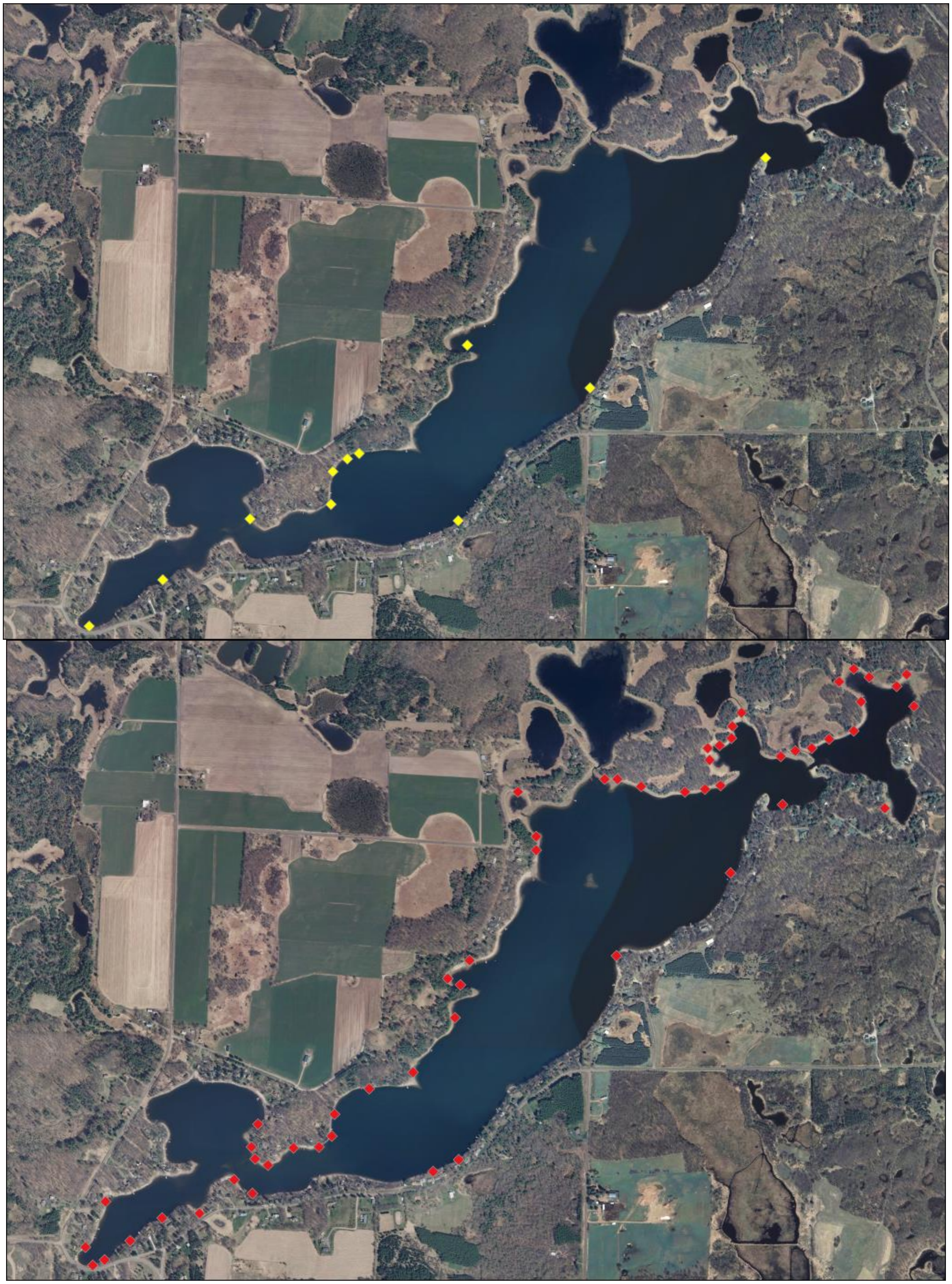

Figure 4: Coarse woody habitat locations - 2016 (top), 2020 (bottom)

5.5 Shorelands

How the shoreline of a lake is managed can have big impacts on the water quality and health of that lake. Natural shorelines prevent polluted runoff from entering lakes, help control flooding and erosion, provide fish and wildlife habitat, may make it harder for aquatic invasive species to establish themselves, muffle noise from watercraft, and preserve privacy and natural scenic beauty. Many of the values lake front property owners appreciate and enjoy about their properties - natural scenic beauty, tranquility, privacy, relaxation - are enhanced and preserved with good shoreland management. And healthy lakes with good water quality translate into healthy lake front property values.

Shorelands may look peaceful, but they are actually the hotbed of activity on a lake. 90% of all living things found in lakes - from fish, to frogs, turtles, insects, birds, and other wildlife - are found along the shallow margins and shores. Many species rely on shorelands for all or part of their life cycles as a source for food, a place to sleep, cover from predators, and to raise their young. Shorelands and shallows are the spawning grounds for fish, nesting sites for birds, and where turtles lay their eggs. There can be as much as 500% more species diversity at the water's edge compared to adjoining uplands.

Lakes are buffered by shorelands that extend into and away from the lake. These shoreland buffers include shallow waters with submerged plants, the water's edge where fallen trees and emergent plants like rushes might be found, and upward onto the land where different layers of plants (low ground cover, shrubs, trees) may lead to the lake. A lake's littoral zone is a term used to describe the shallow water area where aquatic plants can grow because sunlight can penetrate to the lake bottom. Shallow lakes might be composed entirely of a littoral zone. In deeper lakes, plants are limited where they can grow by how deeply light can penetrate the water.

Shorelands are critical to a lake’s health. Activities such replacing natural vegetation with lawns, clearing brush and trees, importing sand to make artificial beaches, and installing structures such as piers, can cause water quality decline and change what species can survive in the lake.

5.5.1 Protecting Water Quality

Shoreland buffers slow down rain and snow melt (runoff). Runoff can add nutrients, sediments, and other pollutants into lakes, causing water quality declines. Slowing down runoff will help water soak (infiltrate) into the ground. Water that soaks into the ground is less likely to damage lake quality and recharges groundwater that supplies water to many of Wisconsin's lakes. Slowing down runoff water also reduces flooding, and stabilizes stream flows and lake levels.

Shoreland wetlands act like natural sponges trapping nutrients where nutrient-rich wetland sediments and soils support insects, frogs, and other small animals eaten by fish and wildlife.

Shoreland forests act as filters, retainers, and suppliers of nutrients and organic material to lakes. The tree canopy, young trees, shrubs, and forest understory all intercept precipitation, slowing runoff, and contributing to water infiltration by keeping the soil's organic surface layer well-aerated and moist. Forests also slow down water flowing overland, often capturing its sediment load before it can enter a lake or stream. In watersheds with a significant proportion of forest cover, the erosive force of spring snow melts is reduced as snow in forests melts later than snow on open land, and melt water flowing into streams is more evenly distributed. Shoreland trees grow, mature, and eventually fall into lakes where they protect shorelines from erosion, and are an important source of nutrients, minerals and wildlife habitat.

5.5.2 Natural Shorelands Role in Preventing Aquatic Invasive Species

In addition to removing essential habitat for fish and wildlife, clearing native plants from shorelines and shallow waters can open up opportunities for invasive species to take over. Like tilling a home garden to prepare it for seeding, clearing shoreland plants exposes bare earth and removes the existing competition (the cleared shoreland plants) from the area. Nature fills a vacuum. While the same native shoreland plants may recover and reclaim their old space, many invasive species possess "weedy" traits that enable them to quickly take advantage of new territory and may fill the voided space before natives can return.

5.5.3 Threats to Shorelands

When a landowner develops a waterfront lot, many changes may take place including the addition of driveways, houses, decks, garages, sheds, piers, rafts and other structures, wells, septic systems, lawns, sandy beaches and more. Many of these changes result in the compaction of soil and the removal of trees and native plants, as well as the addition of impervious (hard) surfaces, all of which alter the path that precipitation takes to the water.

Building too close to the water, removing shoreland plants, and covering too much of a lake shore lot with hard surfaces (such as roofs and driveways) can harm important habitat for fish and wildlife, send more nutrient and sediment runoff into the lake, and cause water quality decline.

Changing one waterfront lot in this fashion may not result in a measurable change in the quality of the lake or stream. But cumulative effects when several or many lots are developed in a similar way can be enormous. A lake's response to stress depends on what condition the system is in to begin with, but bit by bit, the cumulative effects of tens of thousands of waterfront property owners "cleaning up" their shorelines, are destroying the shorelands that protect their lakes. Increasing shoreline development and development throughout the lake's watershed can have undesired cumulative effects.

Since the July 2019 storm, many property owners have been removing downed trees and repairing damage caused by the storm. The process of doing this created a lot of new disturbed area in the shoreland area. The District has repeatedly recommended, and even supplied resources to property owners to implement practices to minimize runoff and sediment loss into the lake during these repair projects.

5.5.4 Shoreland Preservation and Restoration

If a native buffer of shoreland plants exists on a given property, it can be preserved and care taken to minimize impacts when future lake property projects are contemplated. If a shoreline has been altered, it can be restored. Shoreline restoration involves recreating buffer zones of natural plants and trees. Not only do quality wild shorelines create higher property values, but they bring many other values too. Some of these are aesthetic in nature, while others are essential to a healthy ecosystem. Healthy shorelines mean healthy fish populations, varied plant life, and the existence of the insects, invertebrates and amphibians which feed fish, birds and other creatures. Figure 5 shows the difference between a natural and unnatural shoreline adjacent to a lake home.[1]

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[1] More information about healthy shorelines and how they can be restored can be found at the following websites (last accessed 8-26-2021):

(footnote continued)

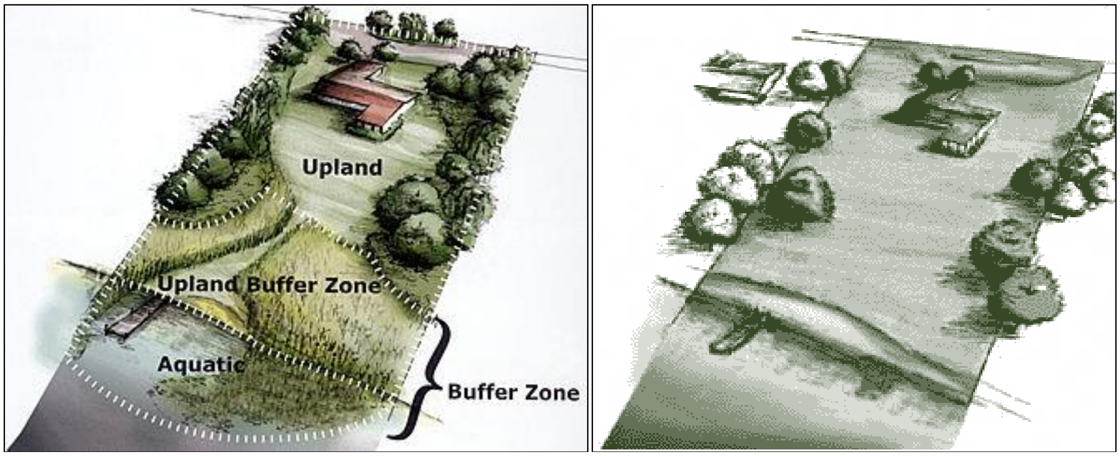

Figure 5: Healthy, AIS resistant shoreland (left) vs. shoreland in poor condition

Much of the shoreland on Horseshoe Lake has been developed with homes and cabins. With development comes shoreland that is no longer in a natural state, instead replaced with turf grass, exposed earth, and rip rap to the edge of the lake bed. For several years in the not-so-distant past, low water exposed a great deal of the lake bed. In the more recent past few years, high water has impacted shorelands. Most property owners are aware that they can only do a minimal amount of clearing on that exposed lake bed, similar to what could be done if it were still under water. During periods of high water, more concern is placed on what can be done to protect the shore and upland areas from erosion caused by waves. For many, the answer lies in placing rock riprap along their shore. While this practice is logical and viable and is generally supported by those who work to protect lakes, there are ways to do it that are more environmentally and lake sensitive.

Shoreland protection practices can be placed in two categories: soft armoring and hard armoring (Figure 6). Soft armoring techniques (sometimes called bio-engineering) involve creating a naturally occurring slope with a combination of natural elements which includes rock and vegetation. According to Alberta Environmental and Sustainable Resource Development (AESRC) (2021) soft techniques will absorb the energy of the waves along the shoreline reducing the potential of erosion, strengthen the shoreline long term, prevent ongoing maintenance, maintain and enhance natural habitat, filter nutrients and pollution from upland runoff and help improve water quality.

Hard armoring (retaining walls, rock, rip/rap, concrete, gabions) have been traditionally used as erosion protection along shorelines. These methods, however, are difficult to implement and maintain successfully over a long period of time. In addition these techniques are often more expensive then soft armoring techniques and require the use of

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https://www.cleanlakesalliance.org/shoreline-health/

https://dnr.wi.gov/topic/ShorelandZoning/documents/WT-748.pdf heavy equipment which causes damage to sensitive areas. Hard techniques (especially vertical retaining or gabion walls) enhance erosion of the shoreline at the base and sides of the wall, disrupt the normal flow and filtration of water from upland, provide almost no natural habitat for wildlife and are most expensive and troublesome to fix[2].

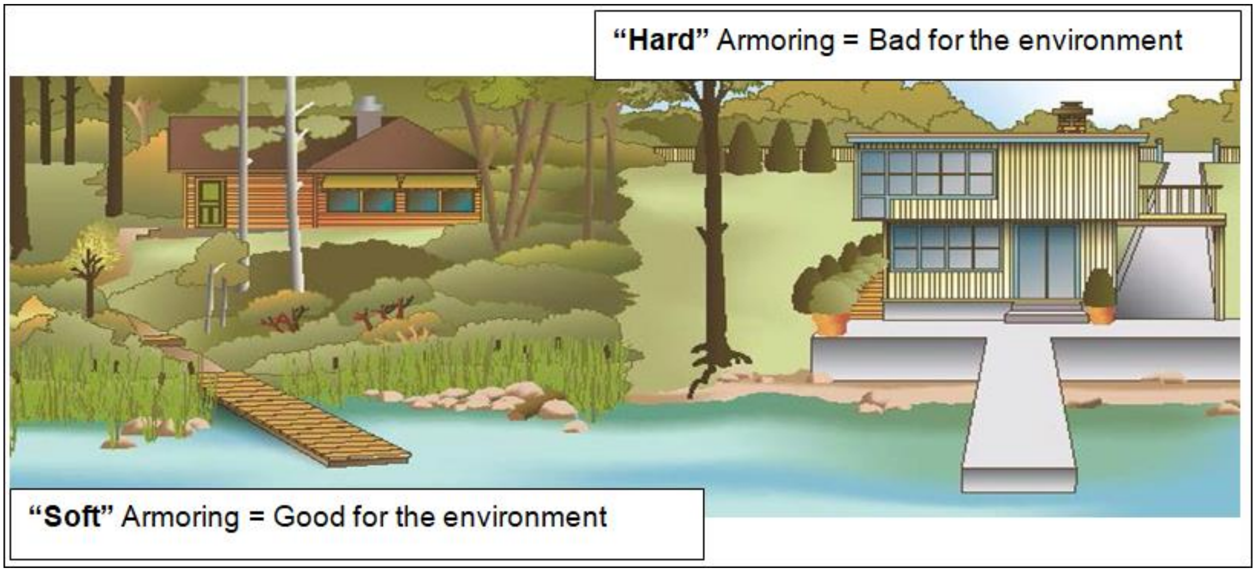

Figure 6: Soft and hard armoring of the shoreland AESRC (2021)

5.6 Water Quality

Water clarity and water chemistry are important indicators of water quality. Secchi disk readings of water clarity and chemistry parameters including total phosphorus, chlorophyll a, and temperature and oxygen profiles have been collected by Wisconsin Citizen Lake Monitoring Network (CLMN), formerly the Self-help Lake Monitoring Program, volunteers since 1995. The WDNR website indicates CLMN volunteers have collected water quality data from 1995-2021, including data for Secchi readings of water clarity, chlorophyll, and total phosphorus. Lake level, appearance, color and perception of the lake were also recorded. Lake levels through about 2005 appear to be mostly normal. However, from the period of 2007-2013 lake level is recorded as low or extremely low. Between 2014 and 2015 the water level was listed as normal. Between 2016 and 2020 the water level was listed as high, and comments made by volunteers and resource professionals indicated water levels as extremely high. In 2021, water levels went back down to more normal conditions, and have continued to go down through 2022.

From 2016 to 2020, the appearance of the water in the lake was predominately clear with a few murky readings. The color of the water was mostly blue. Perception is based on a volunteer's familiarity with lake conditions at any given time of year. From 2016-2020 it was listed as being "beautiful, could not be nicer" up to early July and then "minor aesthetic problems" or "enjoyment somewhat impaired" between July and September.

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[2] More information about soft and hard armoring shoreland protection strategies go to: https://www.parklandcounty.com/en/live-and-play/resources/Documents/PRC/iceheave/Shoreline-Stabilization-Sample-Plans.pdf (last accessed 8-26-2021).

5.6.1 Water Clarity

Water clarity is a measurement of how deep sunlight can penetrate into the waters of a lake. It can be measured in a number of ways, the most common being an 8" disk divided into four sections, two black and two white, lowered into the lake water from the surface by a rope marked in measurable increments (Figure 7). The water clarity reading is the point at which the Secchi disk when lowered into the water can no longer be seen from the surface of the lake. Water color (like dark water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (like sediment or algae), and weather conditions (cloudy, windy, or sunlight) can impact how far a Secchi disk can be seen down in the water. Some lakes have Secchi disk readings of water clarity of just a few inches, while other lakes have conditions that allow the Secchi disk to be seen for dozens of feet before it disappears from view.

Figure 7: Black and white Secchi disk

Figure 8 shows the average summer (July-August) Secchi disk readings from all data recorded as reported from the CLMN Water Quality Monitoring website at https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=493139.

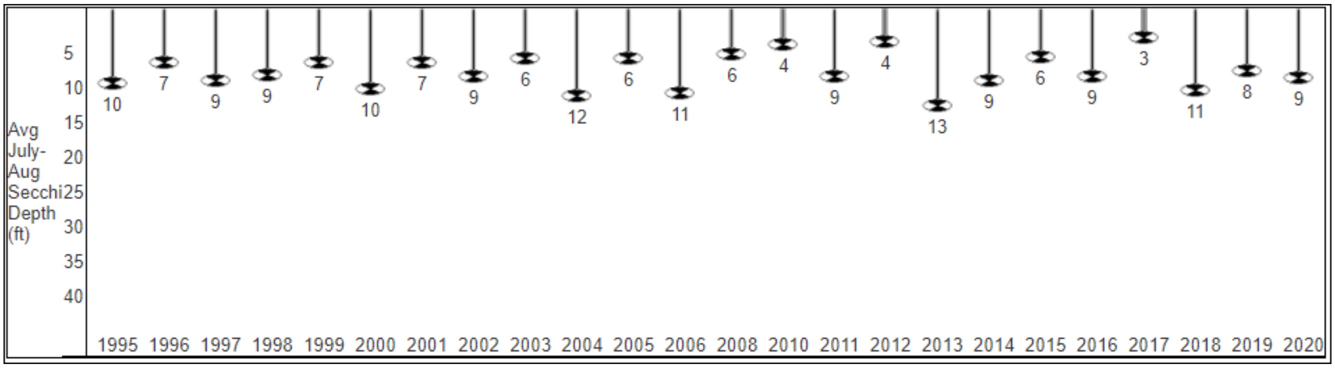

Figure 8: Average summer (July and August) Secchi disk readings at the Deep Hole in Horseshoe Lake

Figure 9 shows the mean monthly Secchi disk readings for all data recorded by CLMN volunteers in the WDNR SWIMS database. Water clarity starts out high in the spring and early summer and then starts to drop in July with the worst readings in August and September. October water clarity again gets better due to the colder temperatures and die off of algae in the lake.

Figure 10 shows the mean annual Secchi disk reading of water clarity for all data recorded in the WDNR SWIMS database. The trend line added to the data indicates that the water clarity has declined slightly since 1994, although it has a very large range from a low around 6ft (2017) to a high of around 16ft (2013) over that time period.

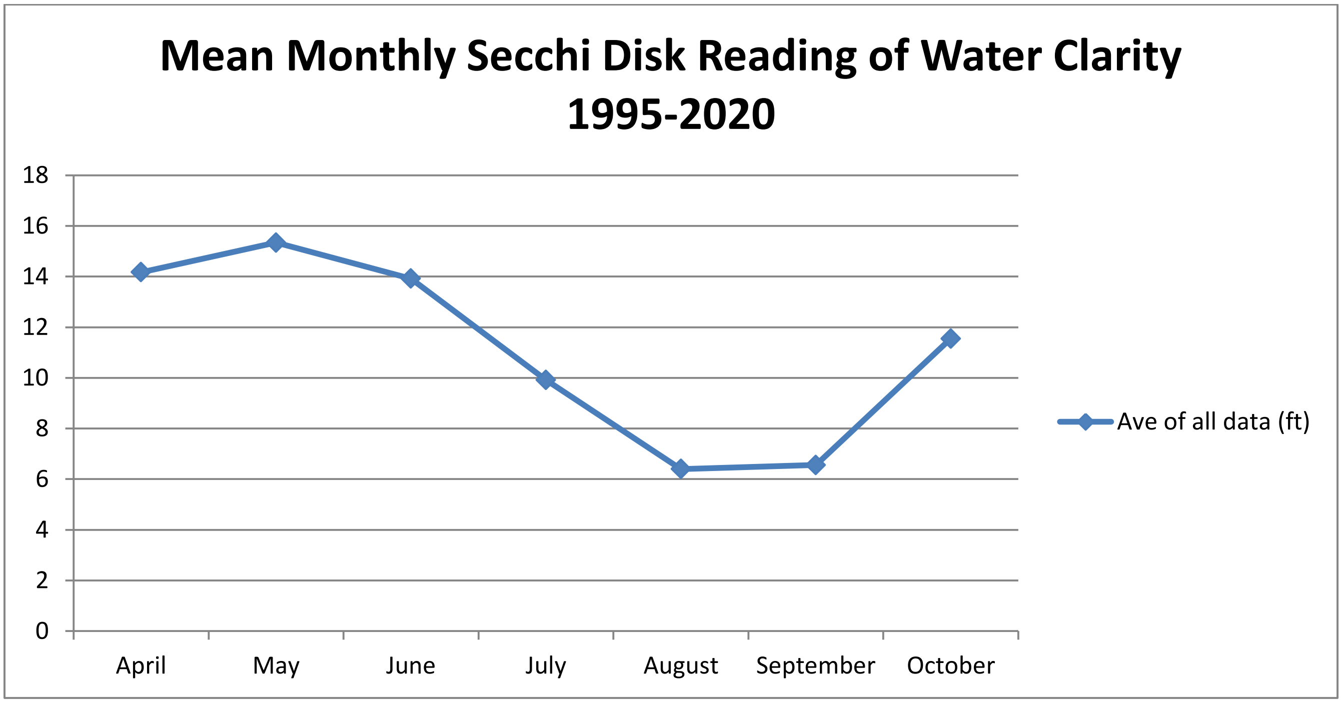

Figure 9: Mean monthly Secchi Disk readings of water clarity (CLMN)

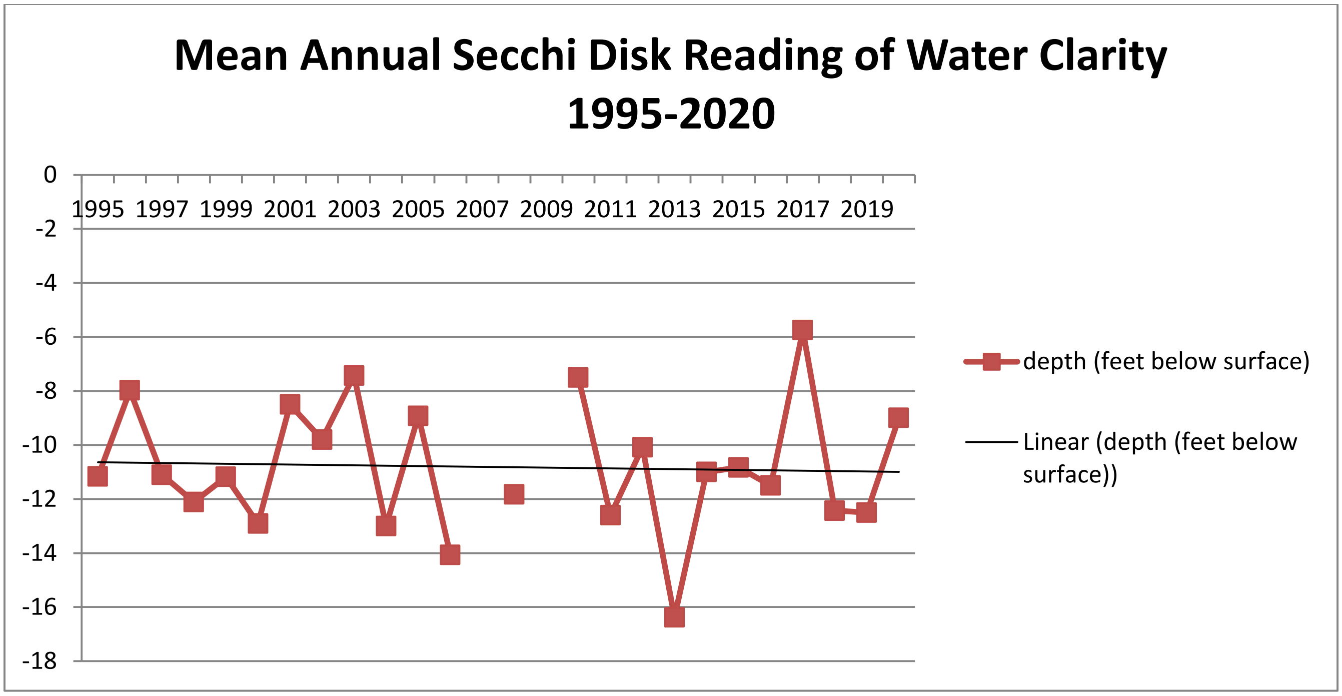

Figure 10: Mean annual Secchi Disk readings of water clarity (CLMN)

5.6.2 Phosphorus and Chlorophyll-a

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. There are many sources of excess phosphorus to lake water including but not limited to farm runoff, roadway runoff, failing septic systems, and decay of grass clippings, leaves, and other lawn debris that end up in the lake. The phosphorus standard set by the WDNR for deep, seepage, stratified lakes like Horseshoe is 20µg/l (NR 102.06-4.4). Based on mean monthly concentrations of water samples collected by District CLMN volunteers and analyzed at the WI State Lab of Hygiene, since 2008 only the months June and July remain under that threshold (Figure 11). Annually, since 2008, mean TP concentrations have been higher than this in 5 of the 12 years with data, with 4 of them coming since 2016 suggesting an increasing trend in total phosphorus (Figure 12).

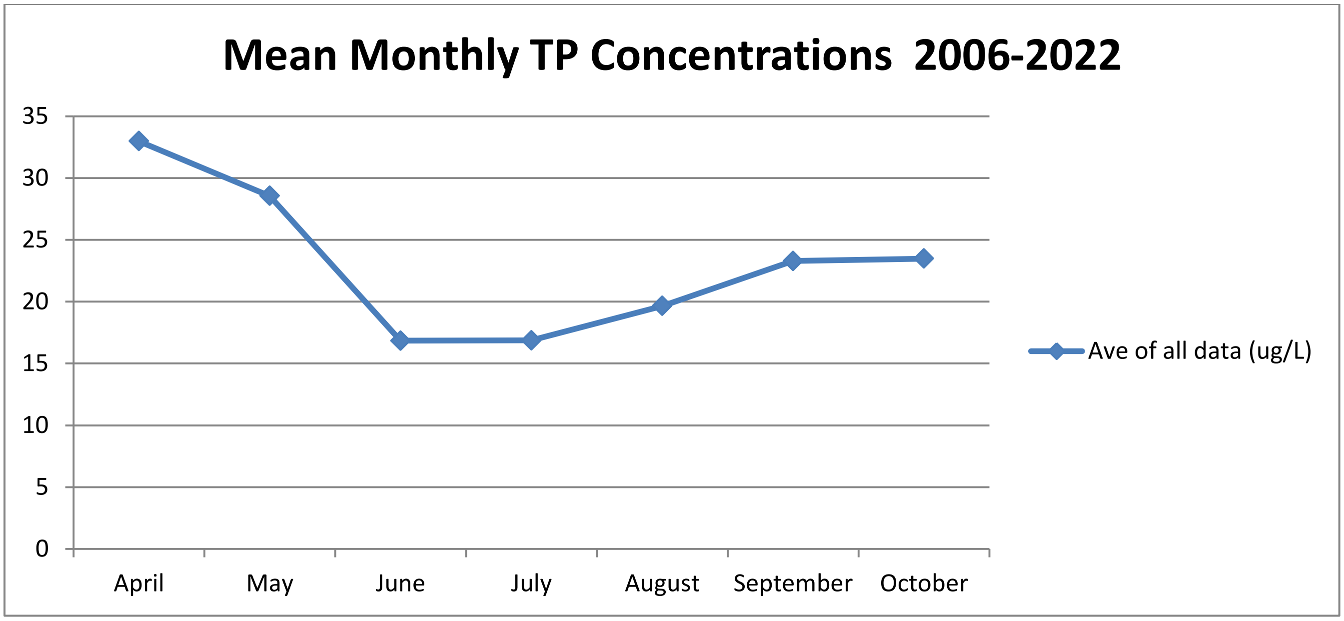

Figure 11: Mean monthly TP concentrations from 2006 to 2022 (CLMN)

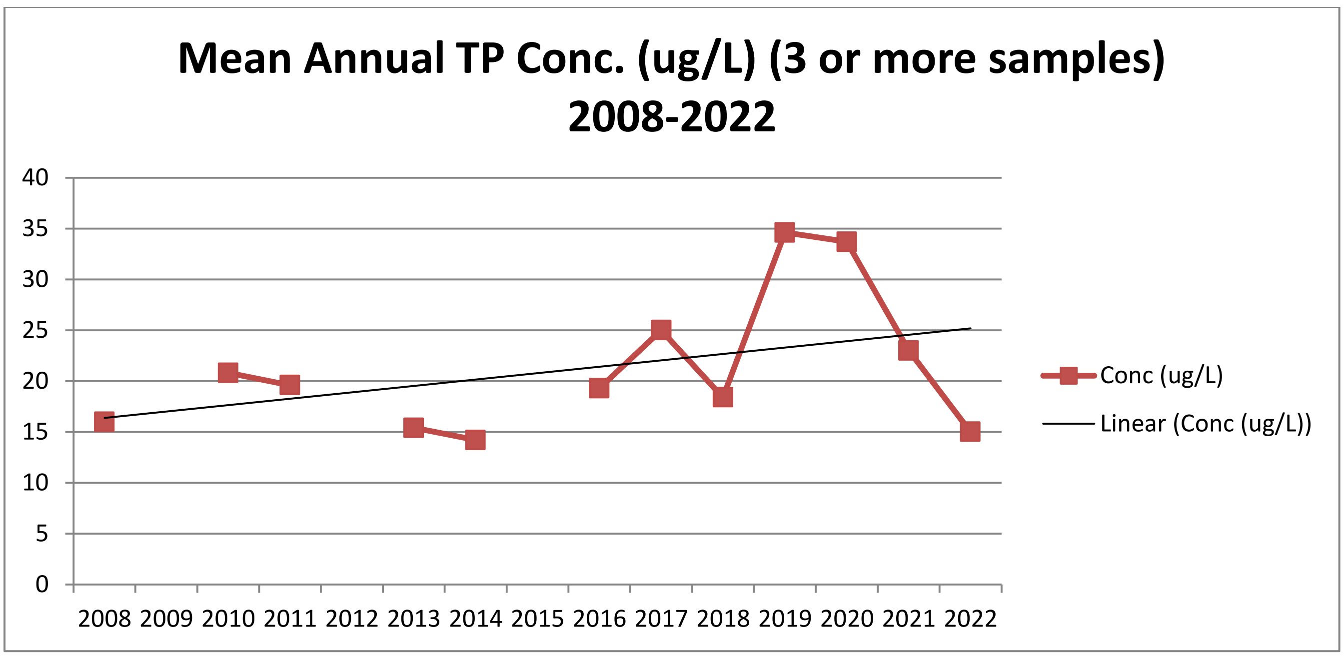

Figure 12: Mean annual TP concentrations from 2008 to 2022 (in years with 3 or more TP samples) (CLMN)

Chlorophyll-a is the green pigment found in plants and algae. The chlorophyll-a concentration is used as a measure of the algal population in a lake. Values greater than 10µg/l are considered indicative of eutrophic conditions and concentrations of 20µg/l or higher are associated with algal blooms, and is generally considered the starting point for lake use impairment (WI-DNR, 2021). WisCALM standards for chlorophyll-a is having fewer than 5% of the total lake use days on the lake with chlorophyll-a concentrations <20µg/l. When looking at the available data, chlorophyll-a has never been above this threshold in the months of May, June, or July. In August there are three years (2008, 2021, and 2021 where this threshold was exceeded. In September there were two years – 2010 and 2021. When looking at whole monthly averages though, this threshold has not been exceeded, though it is close in the months of August and September (Figure 13) Mean Annual chlorophyll-a has never even been close to this threshold (Figure 14).

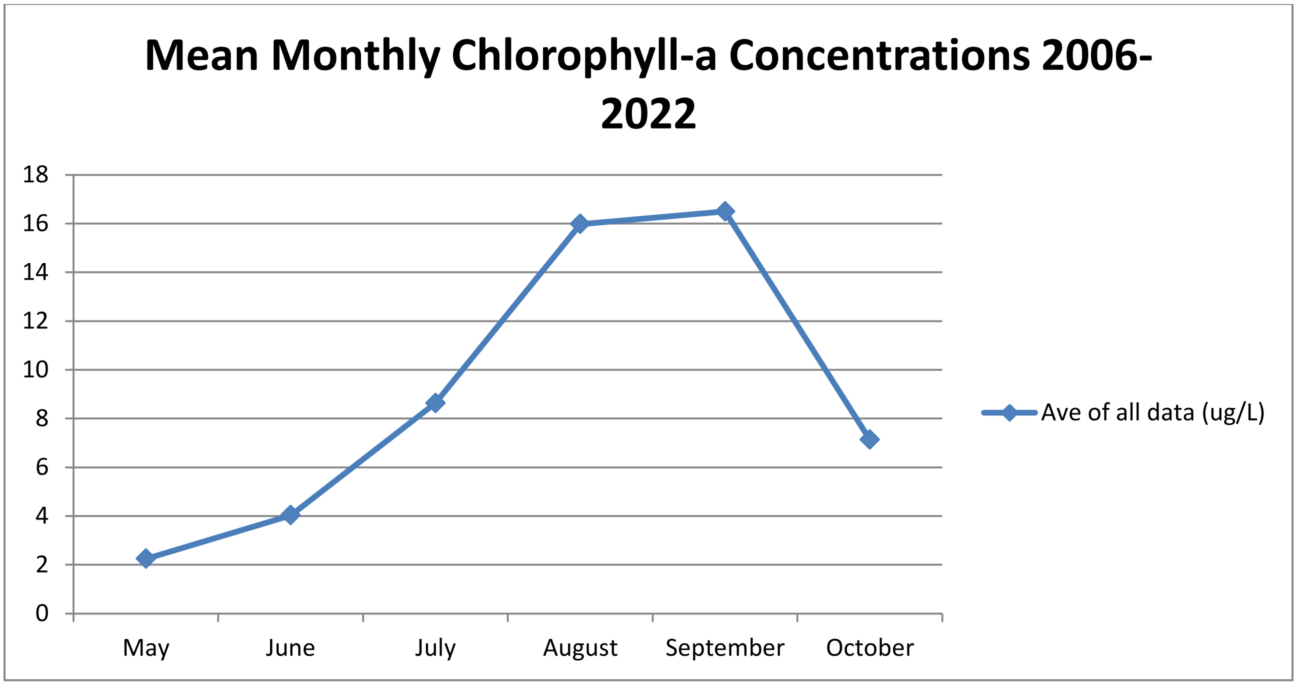

Figure 13: Mean monthly Chlorophyll-a concentrations from 2006 to 2022 (CLMN)

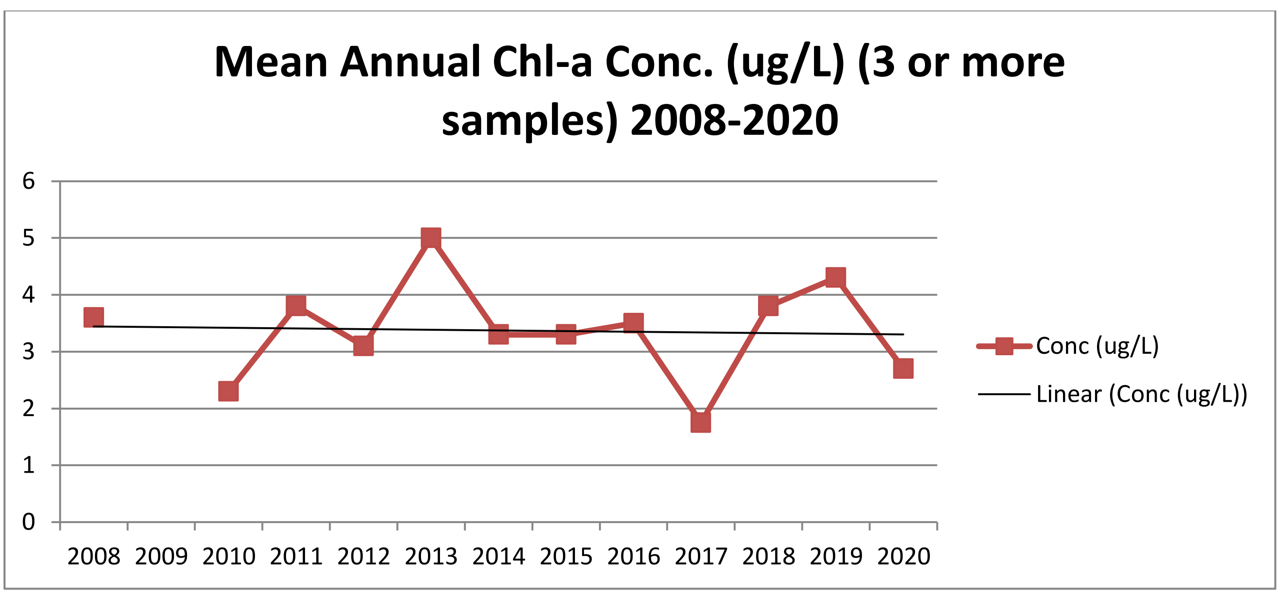

Figure 14: Mean annual Chlorophyll-a concentrations from 2008 to 2022 (CLMN)

Based on long-term trend data for Secchi depth, TP, and Chla retrieved from the WI-DNR SWIMS database, Horseshoe Lake is classified as a eutrophic, or nutrient-rich, system with TSI values ranging in the low 50's. Figure 15 reflects the summer (July & August) mean TSI values for Secchi, TP, and Chla through 2021 in Horseshoe Lake (WI-DNR, Citizen Lake Monitoring Network).

Of note in Horseshoe Lake is that TSI values for TP and Chla are generally the same, but much higher than the TSI values for Secchi depth. This is one of several familiar patterns that often emerge when comparing these three values (Carlson & Havens, 2005). This pattern suggests that large chlorophyll-containing particulates, such as Aphanizomenon (a type of algae) flakes, dominate the surface water. As such, there does not exist a good potential to control algal blooms with food web manipulation, unless that manipulation directly affects nutrient inputs to the water column (Carlson & Havens, 2005).

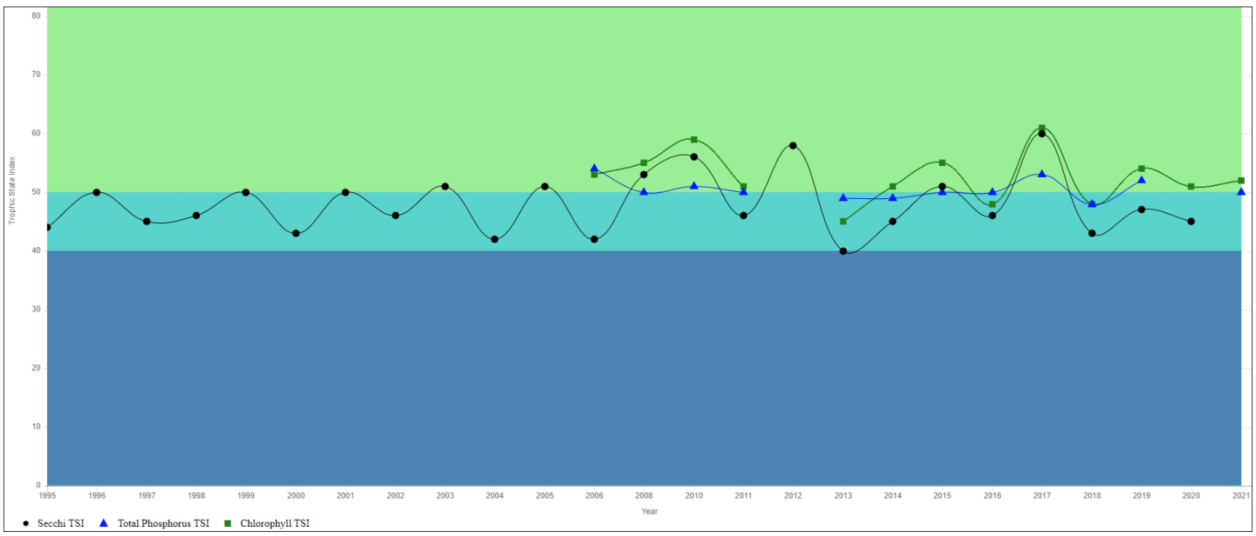

Figure 15: Summer (July and August) TSI values for total phosphorus and chlorophyll-a at the Deep Hole on Horseshoe Lake

5.6.3 Temperature and Dissolved Oxygen

Temperature and dissolved oxygen are important factors that influence aquatic organisms and nutrient availability in lakes. As temperature increases during the summer in deeper lakes, the colder water sinks to the bottom and the lake develops three distinct layers as shown in Figure 16. This process, called stratification, prevents mixing between the layers due to density differences which limits the transport of nutrients and dissolved oxygen between the upper and lower layers. In most lakes in Wisconsin that undergo stratification, the whole lake mixes in the spring and fall when the water temperature is between 53 and 66°F, a process called overturn. Overturn begins when the surface water temperatures become colder and therefore denser causing that water to sink or fall through the water column. Below about 39°F, colder water becomes less dense and begins to rise through the water column. Water at the freezing point is the least dense which is why ice floats and warmer water is near the bottom (called inverse stratification) throughout the winter.

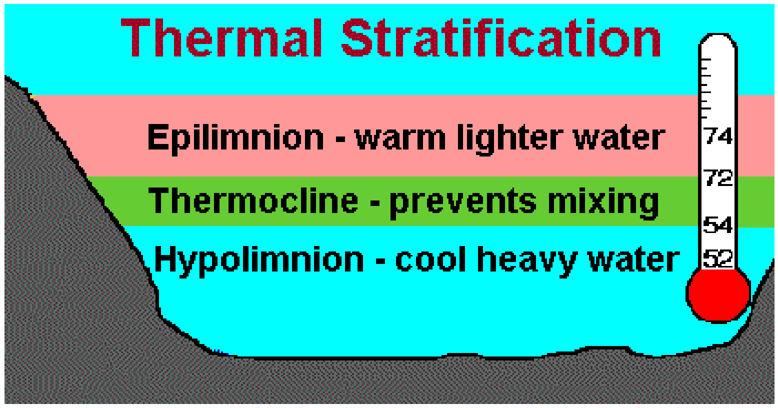

Figure 16: Summer thermal stratification

During the summer months, the upper warm layer, called the epilimnion, remains well oxygenated due to wind and wave action and photosynthesis. The middle layer, called the metalimnion or thermocline, is where changes in temperature and dissolved oxygen are greatest. This middle layer acts as a barrier that prevents warmer, oxygen rich waters in the upper layer from mixing with colder, deeper waters It is common for dissolved oxygen levels to be depleted in the lower layer, called the hypolimnion, as there is no source of new oxygen and the decomposition of organic matter consumes oxygen.

A dissolved oxygen level of 2mg/l or less, called hypoxia, is an important criterion of sediment phosphorus release. When near-bottom dissolved oxygen is at 2mg/l or less, the sediment-water interface is likely anoxic (no oxygen) and therefore releasing phosphorus. If the phosphorus released from sediments reaches the upper part of the lake through spring or fall overturn or when natural or human induced wave action mixes the lake, it can provide a significant internal source of phosphorus to fuel algae blooms.

Horseshoe Lake is dimictic, meaning that the lake experiences spring and fall overturn with thermal stratification occurring in the summer. Oxygen levels lower than 2mg/l generally only occur at the Deep Hole below 35-40 feet in June and early July, and then below 15-20 feet from mid-July to mid-September.

6.0 Aquatic Plant Management 2007-2021

Routine monitoring by Barron County Soil and Water Conservation Department staff in the fall of 2006, discovered suspicious vegetation that resembled Eurasian watermilfoil in the lake. Wisconsin Department of Natural Resource vouchering later identified the plant as hybrid watermilfoil a cross between the native northern watermilfoil and the non-native invasive Eurasian watermilfoil. Like its non-native parent, HWM has been shown to have the capability to spread from lake to lake, and to spread through a lake once introduced. Curly-leaf pondweed and purple loosestrife, two other non-native invasive plant species had also been documented in the lake. Because of the risk to the lake posed by this new introduction of a non-native aquatic invasive species management planning and implementation began. Table 1 provides a quick breakdown of all the invasive species management pertaining to HWM, CLP, and PL from 2007 to 2015. Table 2 provides the same breakdown from 2016 to 2021. Sections 6.1 to 6.7 provide more detail about management from 2015 to 2021. While property owners and resource professionals have managed PL in the last two years, no management of CLP or EWM/HWM using aquatic herbicides has been complete since 2019. Diver removal was used exclusively for EWM/HWM in 2020, and also incorporated to some level in 2021 and 2022. However, chemical application permits to treat EWM/HWM submitted to the WDNR in both 2021 and 2022, were denied.

Table 1: 2007-2015 Completed and proposed AIS management

Management History - Horseshoe Lake 2007-2015									
Task	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
APM Plan				X					X
AIS Control Grant					X				
AIS Education Grant									
AIS Early Detection Grant	X		X						
Spring HWM Treatment (acres)				14.36	2.45	6.83	3.5	6.86	P 5.99
Summer HWM Treatment (acres)		2.48			3.05				
HWM Physical/Diver Removal	X	X	X	X			X		P
Pre Treatment Plant Survey					X	X	X	X	P
Post Treatment Plant Survey					X	X	X	X	
Summer HWM Survey	X	X					X		P
Fall HWM Bed Mapping		X	X	X	X	X	X	X	
CLP Survey	X	X					X		
CLP Physical Removal		X	X	X	X	X			
PL physical removal				X	X	X	X	X	
PL beetle rearing/collection and release			X	X	X	X	X		
Whole-lake PI Plant Survey		X					X		
Residual Testing									
Weevil Monitoring								X	
Lake Use Survey			X						
Wild Rice Mapping		X					X		
X - Completed P - Proposed									

Table 2: 2016-2021 Completed and proposed AIS management

Management History - Horseshoe Lake 2016-2021						
Task	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
APM Plan						X
AIS Control Grant				X(denied)		
AIS Education Grant					X	
Lake Planning Grant	X					
Spring HWM Treatment (acres)	1.03	4.14	1.84	7.11	0	0
HWM Physical/Diver Removal					X	X
Pre Treatment Plant Survey				X		
Post Treatment Plant Survey				X		
Summer HWM Survey						
Fall HWM Bed Mapping	X	X	X	X	X	P
CLP Survey						
CLP Physical Removal	X	X	X	X	X	X
PL physical removal	X	X	X	X	X	X
PL beetle rearing/collection and release						
Whole-lake PI Plant Survey					X	
Residual Testing						
Weevil Monitoring						
Lake Use Survey						
Wild Rice Mapping						
X - Completed P - Proposed						

6.1 2015

Application of Navigate® herbicide to 18 different areas totaling 5.99 acres was completed by Northern Aquatic Services (NAS) on May 26th. Depending on the size and depth of the treated area, the herbicide was put in at 3.0 to 4.0 ppm.

A fall HWM bed-mapping survey was completed on September 20, 2015 by ERS. At the time of the fall survey, water clarity was approximately 5-ft making it difficult to find plants that might have been present in deep water. This poor clarity appeared to be limiting plant growth in general and HWM growth in particular. No areas of HWM were found that could be defined as a bed. Similar to 2014, HWM was nearly undetectable in the majority of the lake during the fall survey. Only two small areas of HWM that totaled 0.26 acres and included at most 100 plants were located. Only 22 plants were identified outside of the two previously mentioned areas and all of these plants were rake removed by the plant survey specialist (Figure 17).

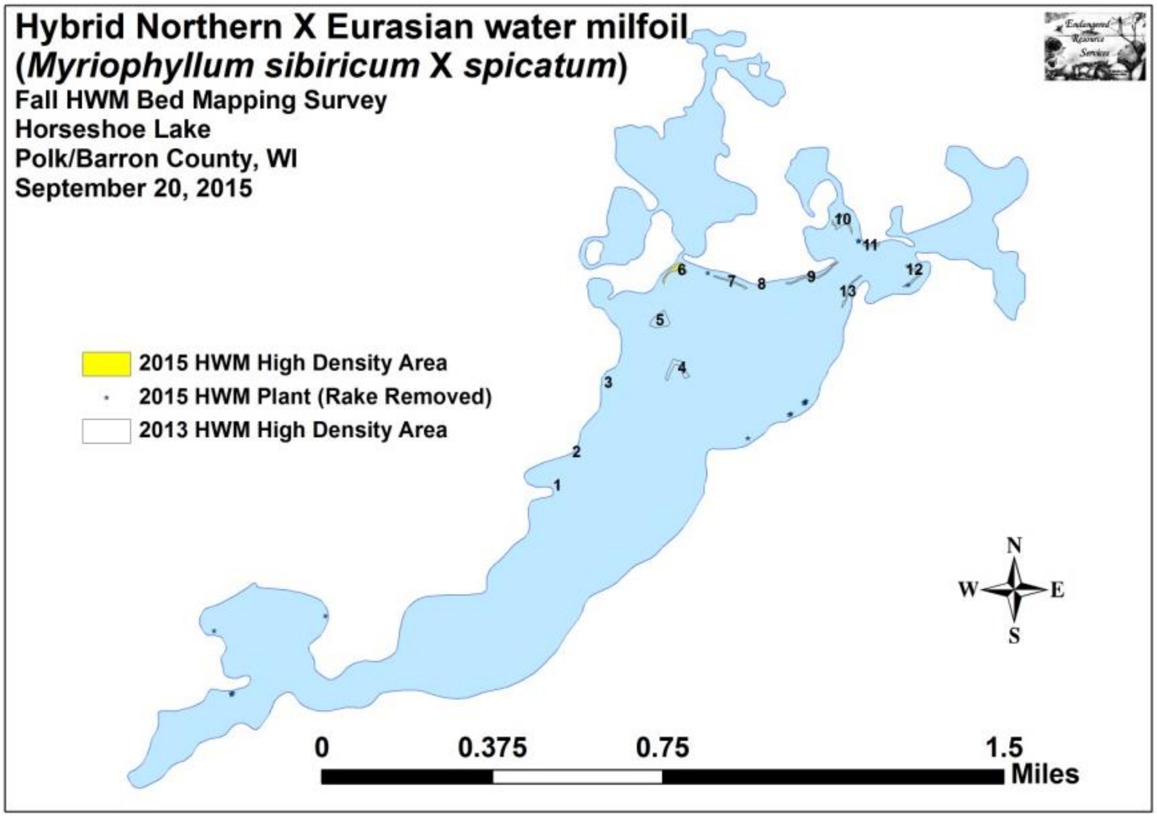

Figure 17 - September 2015 fall HWM survey results

6.2 2016

Application of Navigate® herbicide to one area totaling 1.03 acres was completed by NAS on May 24th. The herbicide was applied at 3.5 ppm.

On October 9th, 2016 the entire visible littoral zone on Horseshoe Lake was surveyed. Water clarity was approximately 6-7ft making it potentially difficult to find young plants that may have been present in deeper water. Few areas were found where HWM was canopied, continuous, and dominated the plant community. Most mapped areas were better defined as "High Density Areas" where HWM was canopied and regular, but not a solid mat or completely excluding native plant species. Under these criteria 13 areas were mapped that totaled 1.93 acres. Outside of these areas, an additional 22 HWM plants were located all of which were rake removed by the surveyor (Figure 18).

Also in 2016, ERS removed what appeared to be regular EWM from the lake. Prior to this date, all of the non-native milfoil found was thought to be hybrid.

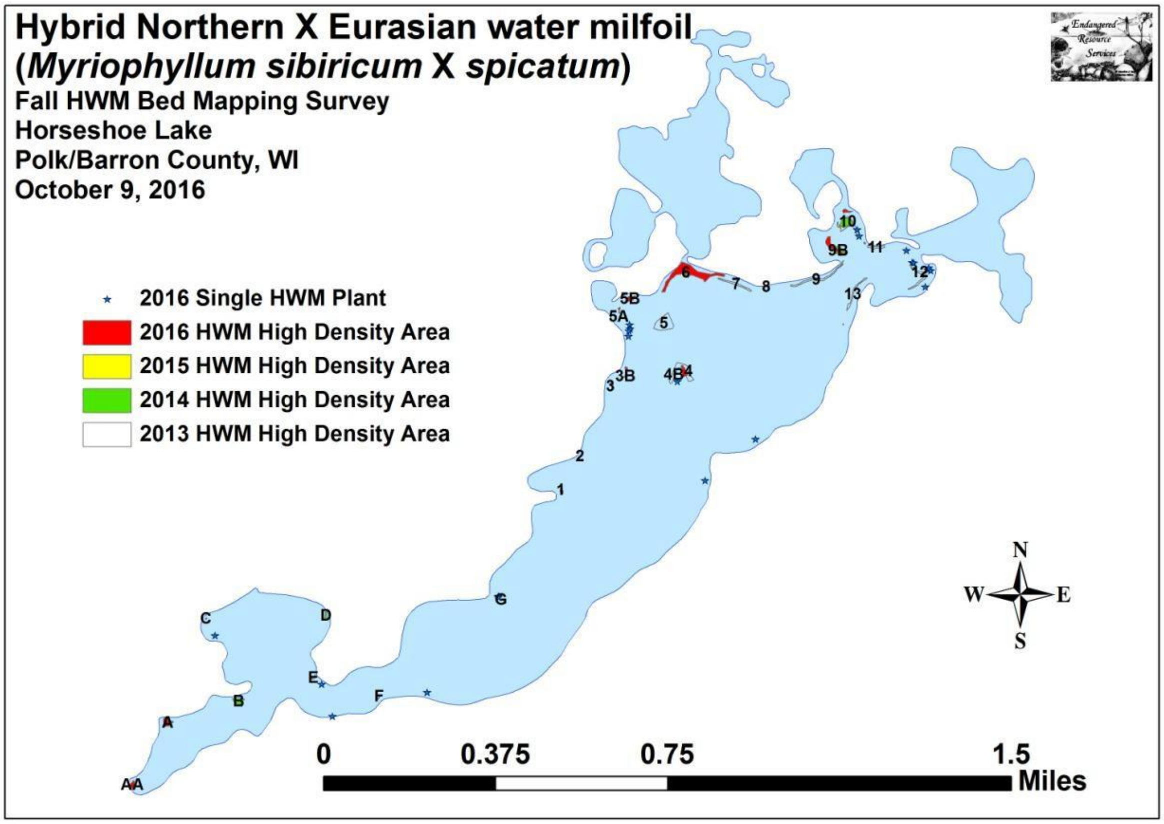

Figure 18: October 2016 fall HWM survey results

6.3 2017

Application of Navigate® herbicide to 10 different areas totaling 4.14 acres was completed by NAS on May 24th. Depending on the size and depth of the treated area, the herbicide was put in at 3.5 to 4.0 ppm.

A fall HWM bed-mapping survey was completed on October 15th, 2017 by ERS. At the time of the fall survey, water clarity was approximately 5-ft making it difficult to find young plants that might have been present in deep water. This poor clarity appeared to be limiting plant growth in general and HWM growth in particular as there were very few HWM plants anywhere where the water was greater than 8-ft deep. Few areas of HWM were found that met the definition of a true bed. ERS mapped 13 HDA totaling only 1.60 acres. There were 38 additional HWM plants found outside of the 13 areas which were removed by the survey specialist (Figure 19).

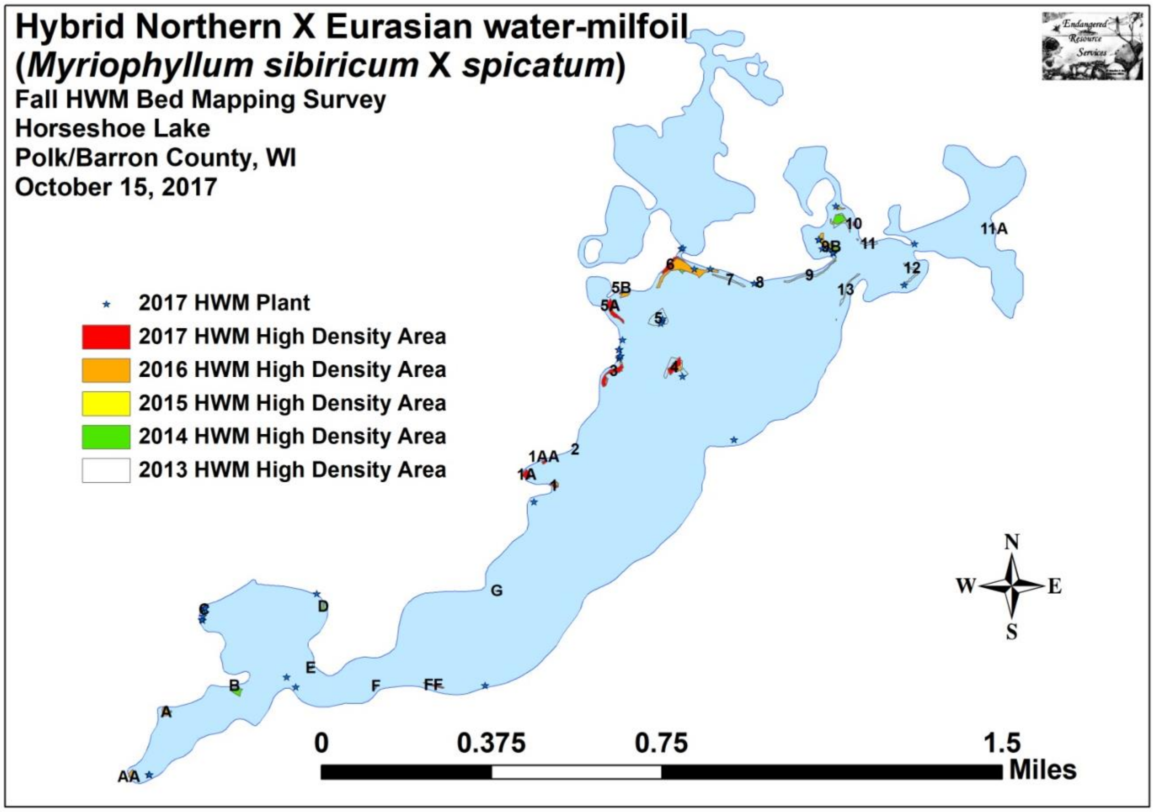

Figure 19 – October 2017 fall HWM survey results

6.4 2018

Application of Sculpin® herbicide to 9 different areas totaling 1.84 acres was completed by NAS on June 12th. Herbicide was applied at 4.0 ppm.

A fall HWM bed-mapping survey was completed on October 22, 2018 by LEAPS. LEAPS mapped 11 areas totaling only 7.88 acres, the most in several years (Figure 20). Beds B and C (ERS bed identifiers) in Figure 19 were determined to be "regular" EWM, not HWM.

From this point on E-HWM will be used to refer to the non-native milfoil managed in Horseshoe Lake.

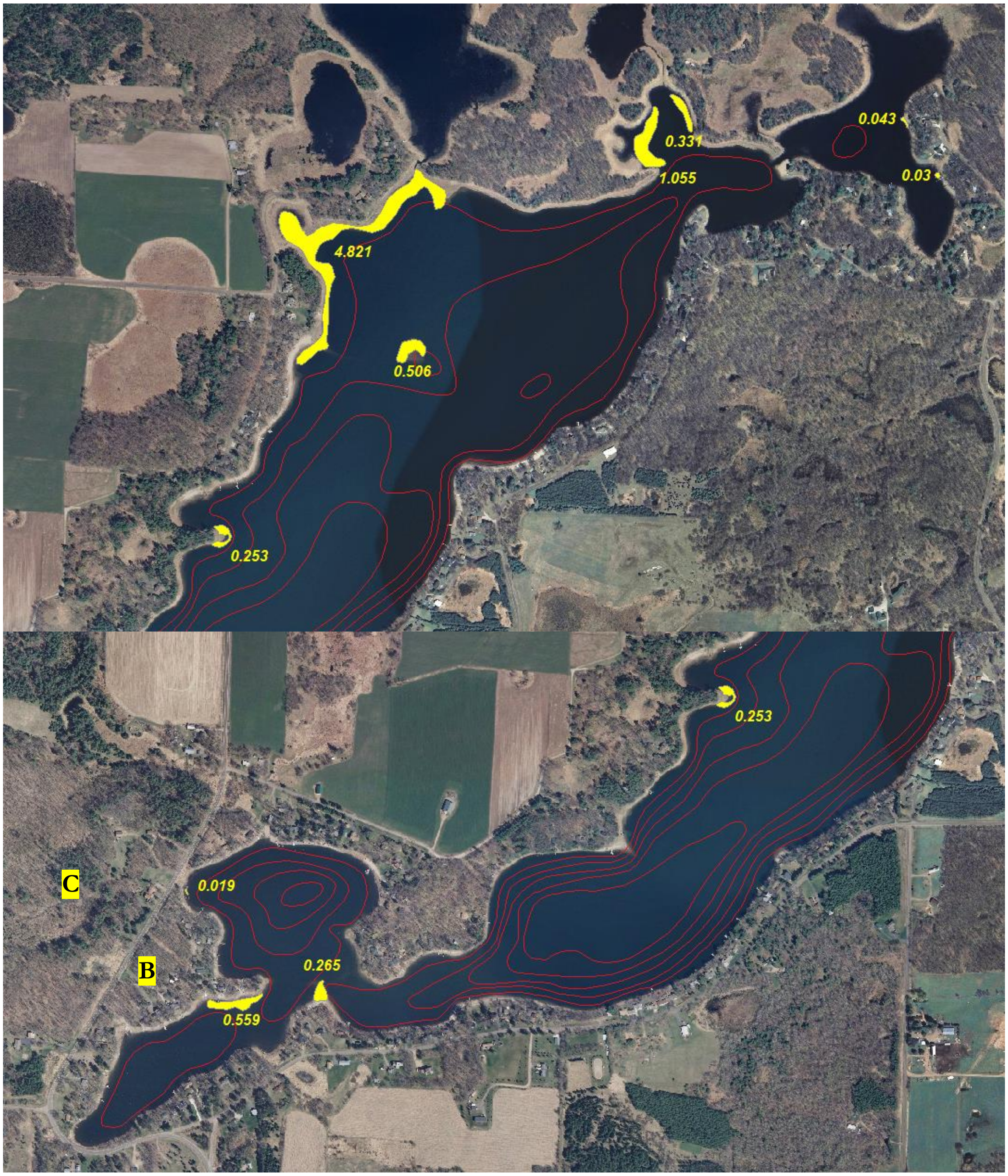

Figure 20: October 2018 fall E-HWM survey results

6.5 2019

In the fall 2018 survey work, a greater than normal amount of E-HWM was identified leading to the newly formed District applying for AIS control grant funding to implement a chemical control of E-HWM. Unfortunately, they were told that the treatment plan was not eligible for AIS control grant funding because the treatment areas were too small and that the WDNR grant program no longer supported the use of granular herbicides in most cases. As a result, a modified E-HWM treatment plan was proposed that combined the use of liquid and granular 2,4-D based herbicides.

Using a combined approach of both liquid and granular herbicide in the same treatment area was based on a study completed by Vassios et al. (2014). The study looked at the how different parts of the EWM plant absorped and translocated the herbicide applied – liquid or granular. The study concluded that while there were no significant differences in overall herbicide absorption by EWM following liquid and granular treatments; differences were observed between plant parts. Apical meristems accumulated the most radioactivity, whereas roots accumulated very little radioactivity following liquid treatment. Granular applications resulted in 7.5 times more radioactivity in the EWM roots then the liquid application; therefore, long-term control of well-established EWM plants could improve with granular applications, especially in areas where rapid herbicide dilution could be an issue (Vassios, Nissen, Koschnick, & Heilman, 2014).

With the 2019 chemical treatment on Horseshoe Lake this data was expanded to assume that using both liquid and granular hetbicides on the same location could increase the effectiveness of control as herbicide would be drawn into all parts of the plant at the same time. Pre and post-treatment aquatic plant survey data was collected from the two areas included in the 2019 chemical treatment plan that used both liquid and granular herbicide is combination. On this limited scale, there appeared to be no difference between results, so this approach is no longer included as a management recommendation.

6.6 2020

In 2019 the WDNR denied the AIS control grant application to provide funding for the 2019 treatment. In 2020, the WDNR took an additional step and denied a chemical treatment permit request. As a result, only physical removal using a rake and hand-pulling were used to control E-HWM. An AIS education grant was submitted for 2020 and 2021 to provide planning support for management and to update the exiting APM Plan that was completed in 2015.

6.7 2021

Both physical removal and scuba diver removal of E-HWM was completed in 2021. Divers were under water on three different dates. The first was in June by a single scuba diver. The second and third times were completed using a Hookah Brownie snuba diving system owned by a member of the District. Snuba combines snorkeling with a floating air compressor piping air into a regulator worn by the diver. No scuba tanks are required and 40-ft air lines allow a substantial amount of diver mobility. Diving weights, masks, and flippers are worn. Divers pull milfoil by hand and place it in mesh bags while still under the water. Kayaks or other small craft may be on the surface to help collect any escaped fragments.

During the 2021 diver removal, there is no doubt that regular EWM is also present in the lake. There is a clearly visible different between the HWM which is still all over in the lake, and EWM which is only in a couple of isolated areas, for now.

6.8 2022

A chemical application permit was submitted in 2022 to apply aquatic herbicides (ProcellaCOR) on two E-HWM beds covering 2.33 acres. But this chemical treatment proposal was also denied with the State stating "*The permit application is not in line with the approved management plan. The criteria listed within the APM plan for Horseshoe Lake states: Unless there are extenuating circumstances, application of herbicide will only be implemented in a given year if the total area supporting bed or high-density area growth reaches or exceeds 2.5% (5-7 acres) of the littoral zone.*"

E-HWM management between 2023 and 2027 will follow guidelines in this new APM Plan.

7.0 2008, 2013, 2020 Whole Lake Point Intercept Aquatic Plant Surveys

Whole-lake, point-intercept (PI), aquatic plant surveys have been completed in 2008, 2013, and 2020. Through these surveys it is possible to compare changes in the lake's aquatic vegetation over time. The latest whole-lake, point-intercept survey was completed on August 16-17, 2020. In previous PI surveys, CLP was also identified through a mid to late-June PI survey. This portion of the PI survey was not repeated in 2020, due to the limited amount of CLP found during previous surveys. Plant data in this section is taken from the 2020 Horseshoe Lake Point-intercept, Aquatic Plant Survey Report completed by Endangered Resources Services (Berg, 2020)

In August 2020, 539 points were surveyed on the lake. Aquatic plants were growing at 246 sites or approximately 45.6% of the entire lake bottom and in 76.9% of the 18.5-ft littoral zone (Figure 21). Both the depth of the littoral zone and the number of sites with vegetation were down from 2013 and 2008 when the littoral zone extended to 21.5ft (2013) and 24.5ft (2008) and the number of points with plants was 329 (2013) and 209 (2008). Speculation on the part of the plant surveyor suggests this likely due, at least in part, to the more "normal" water level in 2020. The mean depth of plant growth in 2020 was also less than in 2013 at 6.79-ft vs. almost 8.0-ft in 2013. Again this may be due in part to the change in water level.

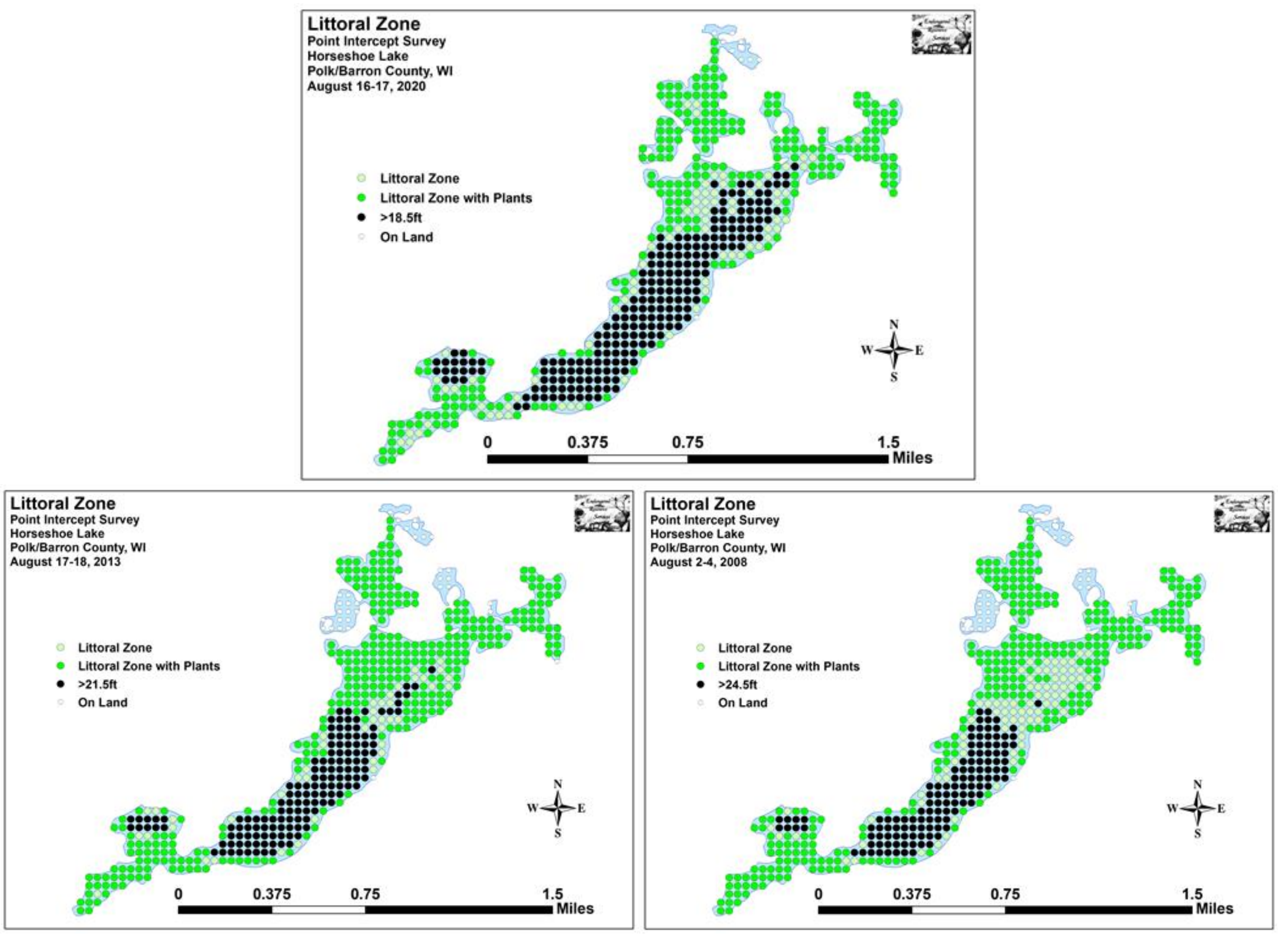

Figure 21: 2020 (top), 2013 (left), and 2008 (right) littoral zone

Table 3 reflects the aquatic plant survey statistics for 2008, 2013, and 2020. Plant diversity was exceptionally high in 2020 with a Simpson Diversity Index value of 0.93 – down from 0.94 in 2013, but identical to 2008. A diversity index allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to 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.

Richness was also very high for such a small lake with 54 species found in the rake (similar to 52 in 2013/47 in 2008). This total increased to 68 when including visuals and plants seen during the boat survey (up sharply from 59 in 2013/54 in 2008). Although total richness increased, mean native species richness at sites with native vegetation experienced a moderately significant decline from 3.28/site in 2008 to 2.80/site in 2013, and a further significant decline to 2.51/site in 2020.

Total rake fullness experienced a highly significant decline from an estimated high mean density of 2.60 in 2008 to a moderate 2.21 in 2013 (Figure 22). In 2020, this trend reversed as a highly significant increase to a moderately high mean rake fullness of 2.44 was found (Figure 22).

Table 3: Aquatic Macrophyte P/I Survey Summary Statistics Horseshoe Lake - Polk/Barron Counties, Wisconsin August 2-4, 2008, August 17-18, 2013, and August 16-17, 2020

Summary Statistics:	2008	2013	2020
Total number of points sampled	515	515	539
Total number of sites with vegetation	309	329	246
Total number of sites shallower than the max. depth of plants	389	372	320
Freq. of occurrence at sites shallower than max. depth of plants	79.4	88.4	76.9
Simpson Diversity Index	0.93	0.94	0.93
Maximum depth of plants (ft)	24.5	21.5	18.5
Mean depth of plants (ft)	7.9	8.0	7.0
Median depth of plants (ft)	6.5	7.0	6.5
Ave. number of all species per site (shallower than max depth)	2.63	2.49	1.93
Ave. number of all species per site (veg. sites only)	3.31	2.82	2.51
Ave. number of native species per site (shallower than max depth)	2.61	2.47	1.93
Ave. number of native species per site (sites with native veg. only)	3.28	2.80	2.51
Species richness	47	52	54
Species richness (including visuals)	51	54	60
Species richness (including visuals and boat survey)	54	59	68
Mean rake fullness (veg. sites only)	Est. 2.60	2.21	2.44

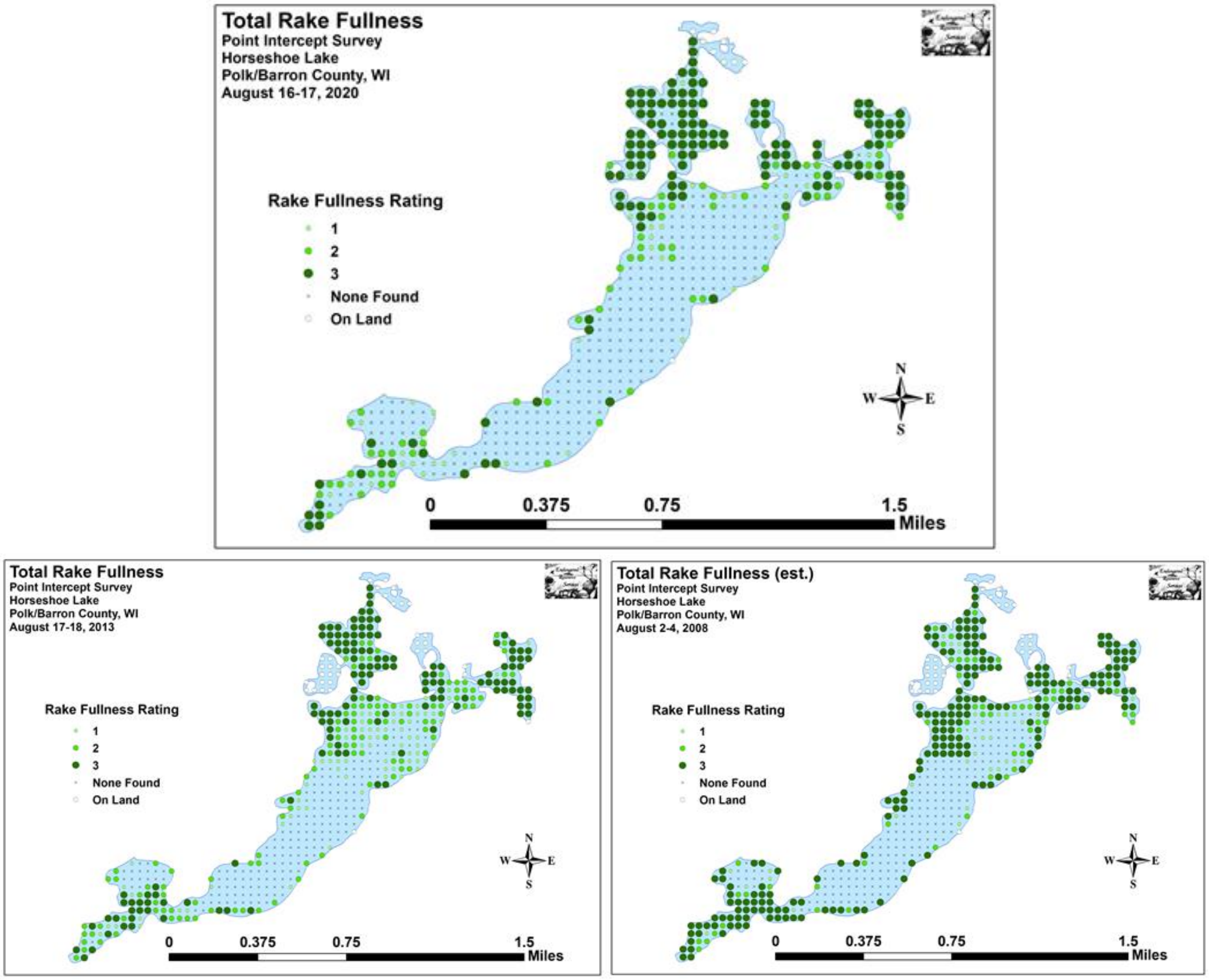

Figure 22: 2020 (top), 2013 (left), and 2008 (right) rake fullness rating

7.1 Comparison of Native Aquatic Plant Species in 2008, 2012, and 2020

The August 2008 survey found Common waterweed, Fern pondweed, Nitella, and Creeping bladderwort were the most common macrophyte species (Aquatic moss was the fourth most common species, but it was excluded from analysis as it is not included in the relative frequency calculation). They were present at 52.75%, 48.22%, 27.51%, and 18.77% of survey points with vegetation respectively and accounted for 44.48% of the total relative frequency. Small pondweed (5.57%), Coontail (4.40%), White water lily (4.40%), and Flat-stem pondweed (4.20%) also had relative frequencies over 4.0%.

In August 2013, Fern pondweed, Nitella, Common waterweed, and Small pondweed were identified as the most common species. Present at 39.21%, 28.88%, 24.01%, and 22.80% of sites with vegetation, they accounted for 40.78% of the total relative frequency. White water lily (5.83%) and Northern naiad (4.64%) also had relative frequencies over 4.0%.

The August 2020 survey identified Fern pondweed (41.06%), Watershield (23.17%), White water lily (22.76%), and Wild celery (16.67%) as the most common species with a combined relative frequency of 41.26%. Creeping bladderwort (5.99%), Common bladderwort (5.02%), Coontail (4.85%), and Northern naiad (4.53%) also had relative frequencies over 4.00%.

From 2013 to 2020, 20 species underwent significant changes in distribution. Common waterweed, Nitella, Aquatic moss, Small pondweed, Vasey's pondweed, and Clasping-leaf pondweed suffered highly significant declines; and Sessile-fruited arrowhead, Reed canary grass, Whorled-water-milfoil, and Small bladderwort saw significant declines. Despite these losses, Watershield, Wild celery, and Small duckweed enjoyed highly significant increases; Creeping bladderwort, and Spotted pondweed underwent moderately significant increases; and Coontail, Flat-stem pondweed, Common bladderwort, Bald spikerush, and Narrow-leaved woolly sedge had significant increases.

Many of the changes seen from 2013 to 2020 appear to have occurred on the outer edge of the littoral zone. The poor clarity that was seen during the 2020 survey may be the best explanation of why deep water species like Nitella and Aquatic moss had largely disappeared, and why other species like Small pondweed and Vasey's pondweed had already set turions and senesced. Conversely, several species that saw significant gains like Watershield, the bladderworts, Bald spikerush, and sedges were dominant species in shallow, previously inaccessible areas.

7.2 Comparison of Floristic Quality Indexes in 2008, 2013, and 2020

The Floristic Quality Index (FQI) 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. 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, North 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. Horseshoe Lake is in the North Central Hardwood Forests Ecoregion.

The 2020 point-intercept survey had 49 native index plants in the rake. They produced a mean Coefficient of Conservatism of 6.6 and a Floristic Quality Index of 45.9. Nichols (1999) reported an average mean C for the North Central Hardwood Forests Region of 5.6 putting Horseshoe Lake well above average for this part of the state. The FQI was also more than double the median FQI of 20.9 for the North Central Hardwood Forests (Nichols 1999). High value index plants of note included Spiny hornwort (C = 10), Three-way sedge (C = 9), Waterwort (C = 9), the State Endangered Species Spotted pondweed (C = 10), Grass-leaved arrowhead (C = 9), Water bulrush (C = 9), Creeping bladderwort (C = 9), Flat-leaf bladderwort (C = 9), and Small bladderwort (C = 10). Six other high-value species were documented during the survey – the State Species of Special Concern[3] ** Vasey's pondweed (C = 10) was only recorded as a visual while the five other species were not included in the index. They included Torrey's three-square bulrush and Robbins' spikerush (C = 10) – two other state special concern species, Long-beaked bald rush (C = 10) – a State Threatened Species, and Narrow-leaved woolly sedge (C = 9) and Pursh's bulrush (C = 9).

The 2013 point-intercept survey found a total of 47 native index plants in the rake. They produced a mean Coefficient of Conservatism of 6.7 and a Floristic Quality Index of 46.2. The 2008 survey found a total of 43 native index species. They produced a mean Coefficient of Conservatism of 6.7 and a Floristic Quality Index of 44.2.

All of these numbers indicate that the health of the aquatic plant community lake wide remains high. However, much of the health is driven by those areas that are completely natural including Mudd Lake and the other areas off the main body of the lake.

7.3 Wild Rice

Wild rice is an aquatic grass which grows in shallow water in lakes and slow flowing streams. This grass produces a seed which is a nutritious source of food for wildlife and people. The seed matures in August and September with the ripe seed dropping into the sediment, unless harvested by wildlife or people. It is a highly protected and valued natural resource in Wisconsin. Only Wisconsin residents may harvest wild rice in the state. According to the WDNR Surface Water Data Viewer, Horseshoe Lake is not wild rice water. Wild rice was not documented in the 2008, 2013, or 2020 whole-lake PI aquatic plant surveys.

7.4 Curly-leaf Pondweed Point-intercept and Bed Mapping Surveys

Early season CLP bedmapping was last completed in 2013. CLP was present in the rake at only two sample points or approximately 0.4% of the entire lake. Each had a rake fullness rating of 1 suggesting CLP did not pose a significant infestation issue anywhere in the lake. CLP was also recorded as a visual at a single additional point (Figure 19). These values were similar to 2008 when CLP was found at three points and recorded it as a visual at another; and 2008 when no CLP was seen at any points. No true CLP beds were located on the lake in 2013. In total 21 individual plants were found and all were rake removed by the survey crew. These plants were restricted to two areas: around the rock island and the flat northeast of the rock island (Figure 23). In total, these two small areas covered just 1.02 acres or 0.26% of the lake's 398 acres.

CLP was not seen during the single late-summer survey in 2020. A historically rare species in the lake, most CLP plants undergo their annual senescence by early July. Because of this, it isn't surprising that it was not found in August of 2020. There is at least one family that is familiar with CLP and spends time each year looking for and removing it from the lake.

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[3] "Special Concern" species like Robbins' spikerush, Vasey's pondweed and Torrey's three-square bulrush 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.

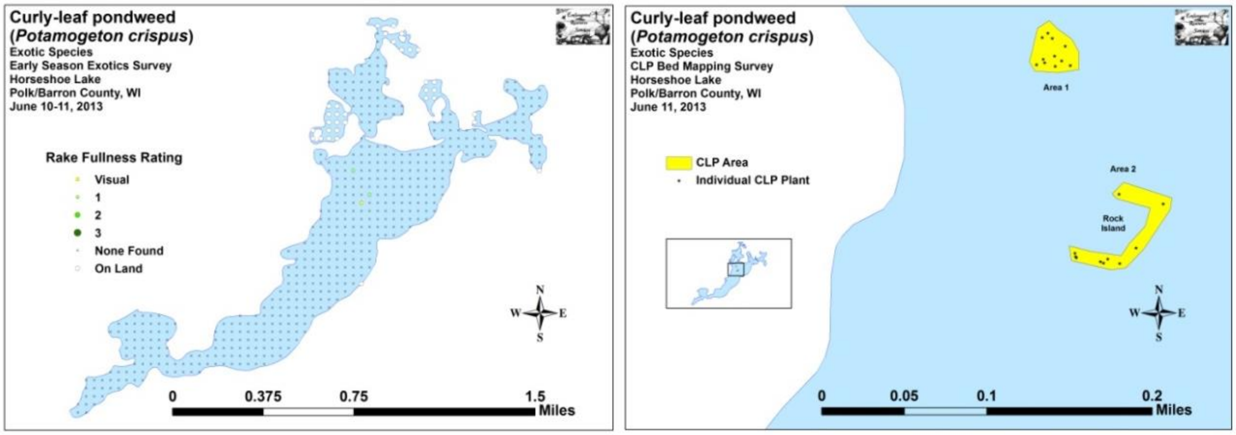

Figure 23: 2013 CLP survey results

7.5 Hybrid Watermilfoil Early and Summer Point-intercept Surveys

The August 2008 survey found HWM in the rake at five points (mean rake 1.60) with 12 additional visual sightings. Both the August 2013 and 2020 surveys noted HWM was difficult to find as it was recorded as a visual at a single point during each of these follow-up surveys (Figure 24). Statistically, from 2008 to 2013, this demonstrated a moderately significant decline in total HWM; a significant reduction in total distribution; and a moderately significant decline in visual sightings. These results suggest the lake's current management strategy of targeted small-scale herbicide treatments coupled with manual removal is holding HWM in check.

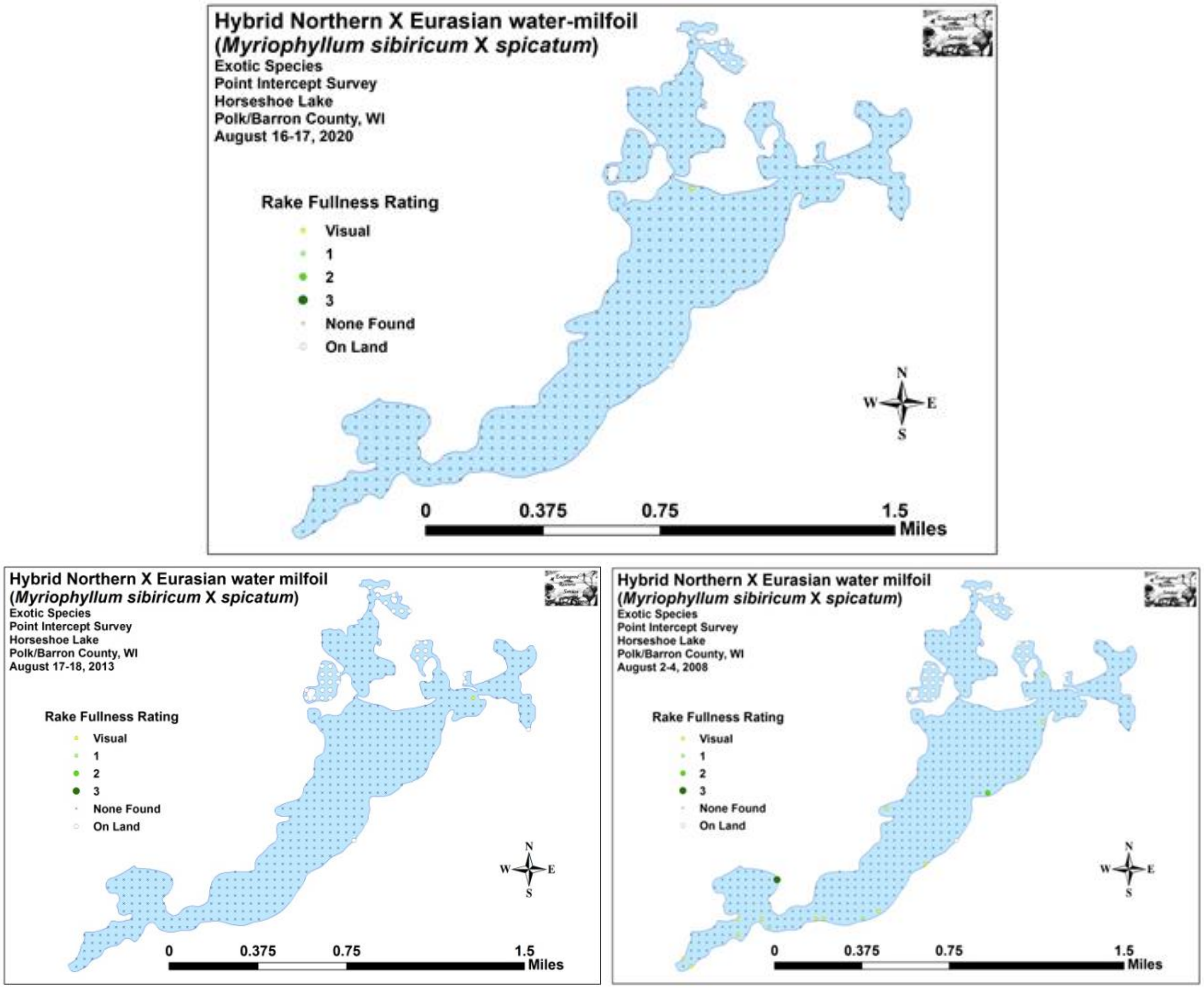

Figure 24: 2020 (top), 2013 (left), and 2008 (right) summer point-intercept survey results for HWM

8.0 Aquatic Invasive Species

Past invasive species monitoring efforts have identified several different plant and animal non-native, invasive species in Horseshoe Lake. Most of these species are considered aquatic, although some are also considered shoreland or wetland type invasive species.

8.1 Non-native, Aquatic Invasive Plant Species

Eurasian watermilfoil and curly-leaf pondweed are the most problematic non-native, aquatic invasive species in the lake. Both are submerged vegetation species (rooted to the bottom of the lake and growing under the surface of the water) that have the potential to outcompete more desirable native aquatic plants. Purple loosestrife, Japanese knotweed, and reed canary grass are shoreland or wetland plants not generally problematic within the lake, but can be very problematic on the shores and in the wetlands adjacent to the lake. More information is given for each non-native species in the following sections.

8.1.1 Eurasian Watermilfoil

EWM (Figure 25) is a submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits,

EWM is difficult to distinguish from Northern water milfoil. EWM has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

EWM grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

Unlike many other plants, EWM does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, trailers, bilges, live wells, and bait buckets; and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, EWM is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of EWM provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of EWM also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by EWM may lead to deteriorating water quality and algae blooms in infested lakes. Since 2016, it has been thought that the original EWM is present in Horseshoe Lake. Evidence in 2019, 2020, and 2021 support this belief.

Figure 25: EWM complete root and stem and floating fragment with adventitious roots

8.1.2 Hybrid Watermilfoil

Like pure Eurasian Water Milfoil, EWM-NWM hybrids grow very quickly and can choke waterways, hampering boat access, fish passage, and water supply intakes. The plants fragment easily, and fragments attached to watercraft can take root in un-infested lakes. Pure Northern Water Milfoil is a species that is native to Wisconsin and it is not considered invasive. At least one study (LaRue, 2012) provides compelling evidence that hybrid lineages between introduced EWM and native NWM are more invasive than pure parental EWM, especially in novel habitats resulting from the application of the herbicide 2,4-D, which is routinely used to control nuisance populations of watermilfoil. Specifically, it was shown that hybrid watermilfoil genotypes exhibited faster vegetative growth and reduced sensitivity to 2,4-D in two laboratory experiments, and that they occurred more frequently than parental watermilfoil species in lakes with a history of 2,4-D treatment. Furthermore, comparisons of multiple, genetically distinct hybrid and EWM demonstrates that increased vegetative growth and reduced 2,4-D sensitivity are generally associated with hybridity in invasive watermilfoils. Hybrid water milfoil is the species most present in Horseshoe Lake (Figure 26).

Figure 26: Hybrid EWM in Horseshoe Lake, early in the 2000's (left), 2022 (right)

8.1.3 Curly-leaf Pondweed

Curly-leaf pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. By early July, the plant completes its life cycle, dies, and drops to the lake bottom (Figure 27). CLP is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures.

CLP spreads through burr-like winter buds (turions), which are moved among waterways (Figure 28). These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf pondweed one of the first nuisance aquatic plants to emerge in the spring. It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and outcompete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. CLP forms surface mats that interfere with aquatic recreation (Figure 24).

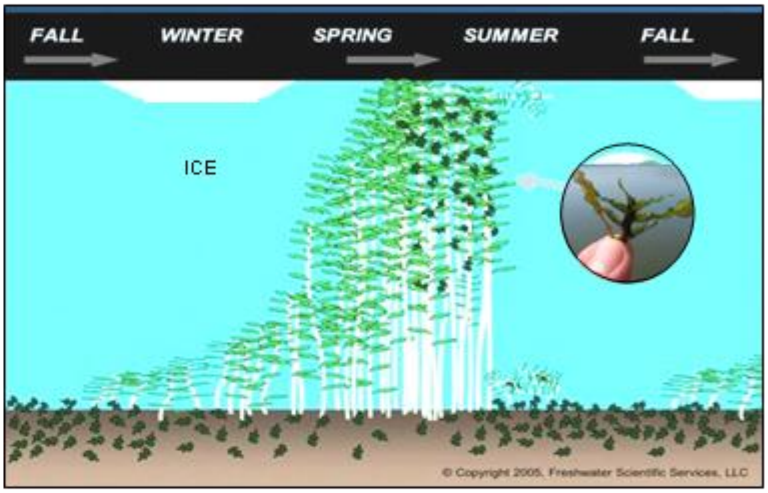

Figure 27: Diagram showing annual CLP life-cycle in northern lakes

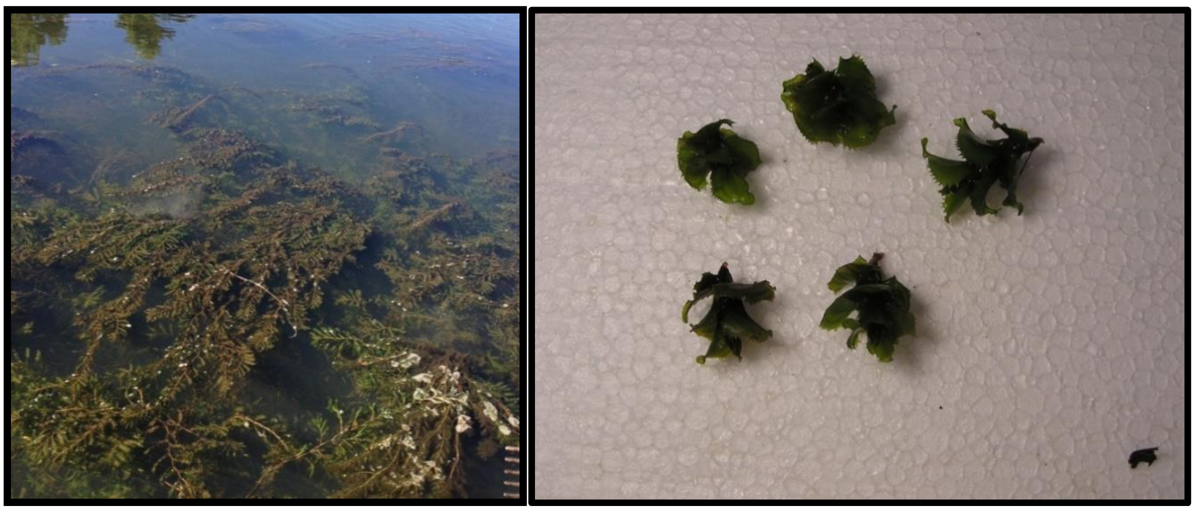

Figure 28: CLP plants and turions

8.1.4 Purple Loosestrife

Purple loosestrife (Figure 29) is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers that vary from purple to magenta possess 5-6 petals aggregated into numerous long spikes, and bloom from August to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens.

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local perturbation is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Plants may be quite large and several years old before they begin flowering. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. Invasion usually begins with a few pioneering plants that build up a large seed bank in the soil for several years. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland or shoreland area. The plant's ability to adjust to a wide range of environmental conditions gives it a competitive advantage; coupled with its reproductive strategy, purple loosestrife tends to create monotypic stands that reduce biotic diversity.

Purple loosestrife has been identified and removed from several locations in Horseshoe Lake, but still persists.

Figure 29: Purple loosestrife from Horseshoe Lake

8.1.5 Narrow-leaf Cattail, Reed Canary Grass, Giant Reed Grass, and Japanese Knotweed

The following species could be introduced to the lake and should be monitored for (Figure 30).

8.1.5.1 Narrow-leaf Cattail (*Typha angustifolia*)

Narrow-leaf cattails have leaves that are erect, linear, and flat. The leaf blades are 0.15-0.5” wide, and up to three feet long. About 15 leaves emerge per shoot that are dark green in color and rounded on the back of the blade. The top of the leaf sheath has thin, ear-shaped lobes at the junction with the blade that usually disintegrates in the summer.

Numerous tiny flowers are densely packed into a cylindrical spike at end of the stem that is divided into the upper section of yellow, male flowers and the lower brown, sausage-shaped section of female flowers. The gap between male and female sections is about 0.5-4" in narrow-leaved cattail. They flower in late spring. These plants also reproduce vegetatively by means of starchy underground rhizomes that form large colonies.

For more information about narrow-leaf cattail including how to control it, go to: https://dnr.wisconsin.gov/topic/Invasives/fact/NarrowLeavedCattail.html.

8.1.5.2 Reed Canary Grass (*Phalaris arundinacea*)

Reed canary grass is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades. Blades are flat and have a rough texture on both surfaces. Single flowers occur in dense clusters from May to mid-June. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas such as bergs and spoil piles.

For more information about reed canary grass including how to control it, go to: https://dnr.wisconsin.gov/topic/Invasives/fact/ReedCanaryGrass.html.

8.1.5.3 Common Reed Grass (*Phragmites australis*)

Often just called phragmites, common reed grass is a perennial wetland grass that grows three to 20 feet tall with dull, very slightly ridged, stiff and hollow stems. It creates dense clones where canes remain visible in winter. Leaf sheaths tightly clasp the stem, are difficult to remove, and stay on throughout the winter. Its flowers are bushy, light brown to purple plumes that are composed of spikelets that bloom July-September. The plumes are 7.5-15 inches long and resemble feather dusters. It roots are stout, oval rhizomes that can reach up to six feet deep into the ground and 10 feet horizontally.

For more information about common reed grass including how to control it, go to: https://dnr.wisconsin.gov/topic/Invasives/fact/Phragmites.html.

8.1.5.4 Japanese Knotweed *(Fallopia japonica or Polygonum cuspidatum)*

Japanese knotweed is an herbaceous perennial that forms large colonies of erect, arching stems (resembling bamboo). Stems are round, smooth and hollow with reddish-brown blotches. Plants reach up to 10' and the dead stalks remain standing through the winter.

New infestations of Japanese knotweed often occur when soil contaminated with rhizomes is transported or when rhizomes are washed downstream during flooding. It poses a significant threat to riparian areas where it prevents streamside tree regeneration and increases soil erosion. Root fragments as small as a couple of inches can resprout, producing new infestations. The plant can disrupt nutrient cycling in forested riparian areas, and contain allelopathic compounds (chemicals toxic to surrounding vegetation).

For more information about reed canary grass including how to control it, go to: https://dnr.wisconsin.gov/topic/Invasives/fact/JapaneseKnotweed.html.

Figure 30: Narrow-leaf cattail (upper left), Reed canary grass (upper right), Phragmites (lower left), and Japanese knotweed (lower right)

8.2 Non-native Aquatic Invasive Animal Species

Several non-vegetative, aquatic, invasive species are in nearby lakes, but have not been identified in Horseshoe Lake. It is important for lake property owners and users to be knowledgeable of these species in order to identify them if and when they show up in Horseshoe Lake.

8.2.1 Chinese Mystery Snails

Chinese mystery snails have not been identified in Horseshoe Lake, but are common in nearby lakes.

The Chinese mystery snails and the banded mystery snails (Figure 31) are non-native snails that have been found in a number of Wisconsin lakes. There is not a lot yet known about these species, however, it appears that they have a negative effect on native snail populations. The female mystery snail gives birth to live crawling young. This may be an important factor in their spread as it only takes one impregnated snail to start a new population. Mystery snails thrive in silt and mud areas although they can be found in lesser numbers in areas with sand or rock substrates. They are found in lakes, ponds, irrigation ditches, and slower portions of streams and rivers. They are tolerant of pollution and often thrive in stagnant water areas. Mystery snails can be found in water depths of 0.5 to 5 meters (1.5 to 15 feet). They tend to reach their maximum population densities around 1-2 meters (3-6 feet) of water depth. Mystery snails do not eat plants. Instead, they feed on detritus and in lesser amounts algae and phytoplankton. Thus removal of plants in your shoreline area will not reduce the abundance of mystery snails.

Lakes with high densities of mystery snails often see large die-offs of the snails. These die-offs are related to the lake's warming coupled with low oxygen (related to algal blooms). Mystery snails cannot tolerate low oxygen levels. High temperatures by themselves seem insufficient to kill the snails as the snails could move into deeper water.

Many lake residents are worried about mystery snails being carriers of the swimmer's itch parasite. In theory they are potential carriers, however, because they are an introduced species and did not evolve as part of the lake ecosystem, they are less likely to harbor the swimmer's itch parasites.

Figure 31: Chinese Mystery Snails

8.2.2 Rusty Crayfish

Rusty crayfish have not been identified in Horseshoe Lake.

Rusty crayfish (Figure 32) live in lakes, ponds and streams, preferring areas with rocks, logs and other debris in water bodies with clay, silt, sand or rocky bottoms. They typically inhabit permanent pools and fast moving streams of fresh, nutrient-rich water. Adults reach a maximum length of 4 inches. Males are larger than females upon maturity and both sexes have larger, heartier, claws than most native crayfish. Dark "rusty" spots are usually apparent on either side of the carapace, but are not always present in all populations. Claws are generally smooth, with grayish-green to reddish-brown coloration. Adults are opportunistic feeders, feeding upon aquatic plants, benthic invertebrates, detritus, juvenile fish and fish eggs.

Rusty crayfish reduce the amount and types of aquatic plants, invertebrate populations, and some fish populations--especially bluegill, smallmouth and largemouth bass, lake trout and walleye. They deprive native fish of their prey and cover and out-compete native crayfish. Rusty crayfish will also attack the feet of swimmers. On the positive side, rusty crayfish can be a food source for larger game fish and are commercially harvested for human consumption.

It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except the Mississippi River). It is also illegal to release crayfish into a water of the state without a permit.

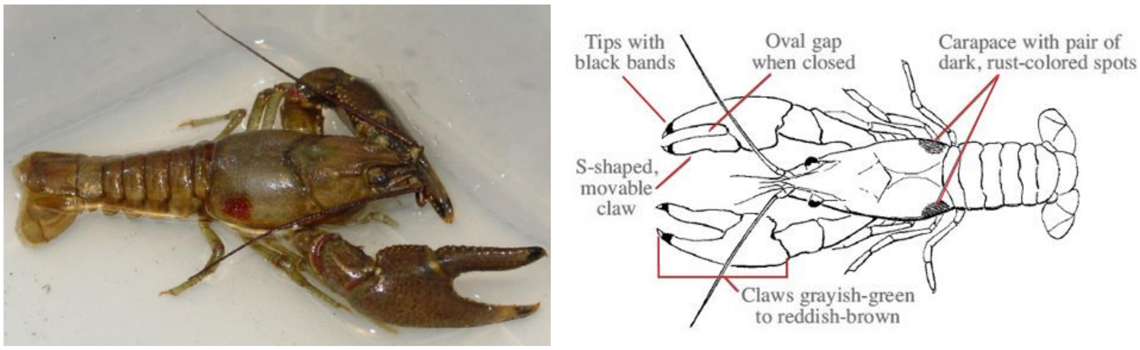

Figure 32: Rusty Crayfish and identifying characteristics

8.2.3 Zebra Mussels

Zebra mussels have not been identified in Horseshoe Lake. The closest population is in Deer Lake just east of St. Croix Falls along Hwy 8. There are also zebra mussels in Big and Middle Mckenzie lakes on the Burnett/Washburn County line just a few miles west of Spooner, WI.

Zebra mussels (Figure 33) are an invasive species that have inhabited Wisconsin waters and are displacing native species, disrupting ecosystems, and affecting citizens' livelihoods and quality of life. They hamper boating, swimming, fishing, hunting, hiking, and other recreation, and take an economic toll on commercial, agricultural, forestry, and aquacultural resources. The zebra mussel is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986, and have been spreading throughout them since that time. They were most likely brought to North America as larvae in the ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes.

Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.

Once zebra mussels are established in a water body, very little can be done to control them. It is therefore crucial to take all possible measures to prevent their introduction in the first place. Recently, the WDNR has supported the installation of Decontamination Stations at public boat landings. The main purpose for these stations is to prevent the spread of zebra mussels by encouraging boaters to spray their watercraft down with a light bleach and water combination. Draining all water from the boat and livewells is also important.

Since 2020, the District has installed two zebra mussel plant samplers in the lake each year, one at the public boat landing and one at narrows of the lake.

Figure 33: Zebra Mussels (not from Horseshoe Lake)

8.3 AIS Prevention Strategy

Horseshoe Lake already has several established AIS. However there are many more that could be introduced to the lake. The District has and will continue to implement a watercraft inspection and AIS Signage program at the public access point on the lake. Information will be shared with lake residents and users in an effort to expand the watercraft inspection message. In addition to the watercraft inspection program, an in-lake and shoreland AIS monitoring program will be implemented. Both of these programs will follow UW-Extension Lakes and WDNR protocol through the Clean Boats, Clean Waters program and the Citizen Lake Monitoring Network Aquatic Invasive Species Monitoring program.

Additionally, having an educated and informed lake constituency is the best way to keep non-native aquatic invasive species at bay in Horseshoe Lake. To foster this, the District will host and/or sponsor lake community events including AIS identification and management workshops; distribute education and information materials to lake property owners and lake users through the newsletter, webpage, and general mailings.

9.0 Integrated Pest Management

Integrated Pest Management (IPM) is an ecosystem-based aquatic plant management strategy that focuses on long-term prevention and/or control of a species of concern. IPM considers all the available control practices such as: prevention, biological control, biomanipulation, nutrient management, habitat manipulation, substantial modification of cultural practices, pesticide application, water level manipulation, mechanical removal and population monitoring (Figure 34). In addition to monitoring and considering information about the target species' life cycle and environmental factors, groups can decide whether the species' impacts can be tolerated or whether those impacts warrant control. Then, an IPM-based plan informed by current, comprehensive information on pest life cycles and the interactions among pests and the environment can be formed.

After monitoring and considering information about the target species' life cycle and environmental factors, groups can decide whether the species' impacts can be tolerated or whether those impacts warrant control. If control is needed, data collected on the species and the waterbody will help groups select the most effective management methods and the best time to use them.

The most effective, long-term approach to managing a species of concern is to use a combination of methods. Approaches for managing pests are often grouped in the following categories:

- **Assessment** – is the use of learning tools and protocols to determine a waterbodies' biological, chemical, physical and social properties and potential impacts. Examples include: point-intercept (PI) surveys, water chemistry tests and boater usage surveys. This is the most important management strategy on every single waterbody.

- **Biological Control** – is the use of natural predators, parasites, pathogens and competitors to control target species and their impacts. An example would be beetles for purple loosestrife control.

- **Cultural controls** – are practices that reduce target species establishment, reproduction, dispersal, and survival. For example, a Clean Boats, Clean Waters program at boat launches can reduce the likelihood of the spread of species of concern.

- **Mechanical and physical controls** – can kill a target species directly, block them out, or make the environment unsuitable for it. Mechanical harvesting, hand pulling, and diver assisted suction harvesting are all examples.

- **Chemical control** – is the use of pesticides. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Groups should use the most selective pesticide that will do the job and be the safest for other organisms and for air, soil, and water quality.

(Additional information on each method is outlined in the following section).

IPM is a process that combines informed methods and practices to provide long-term, economic pest control. A quality IPM program should adapt when new information pertaining to the target species is provided or monitoring shows changes in control effectiveness, habitat composition and/or water quality.

While each situation is different, eight major components should be established in an IPM program:

1. Identify and understand the species of concern

2. Prevent the spread and introduction of the species of concern
3. Continually monitor and assess the species' impacts on the waterbody
4. Prevent species of concern impacts
5. Set guidelines for when management action is needed
6. Use a combination of biological, cultural, physical/mechanical and chemical management tools
7. Assess the effects of target species' management
8. Change the management strategy when the outcomes of a control strategy create long-term impacts that outweigh the value of target species control.

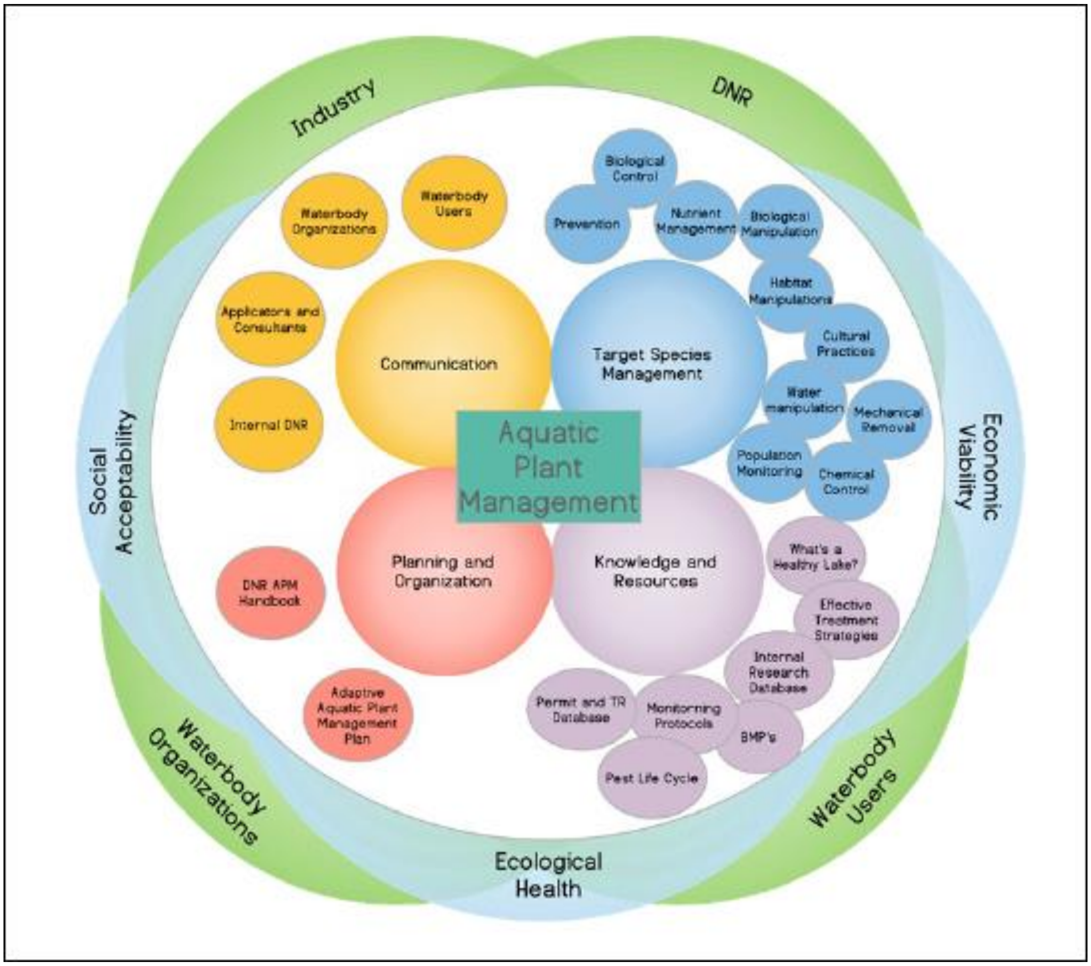

Figure 34: Wisconsin Department of Natural Resources: Wisconsin Waterbodies – Integrated Pest Management March 2020

10.0 Management Alternatives

Nuisance aquatic plants can be managed a variety of ways in Wisconsin. The best management strategy will be different for each lake and depends on which nuisance species needs to be controlled, how widespread the problem is, and the other plants and wildlife in the lake. In many cases, an integrated approach to aquatic plant management that utilizes a number of control methods is necessary. The eradication of non-native aquatic invasive plant species such as EWM (or HWM) or CLP is generally not feasible, but preventing them from becoming a more significant problem is an attainable goal. It is important to remember however, that regardless of the plant species targeted for control, sometimes no manipulation of the aquatic plant community is the best management option. Plant management activities can be disruptive to a lake ecosystem and should not be done unless it can be shown they will be beneficial and occur with minimal negative ecological impacts.

Protecting native plants and limiting negative impacts caused by E-HWM is a primary focus of plant management in Horseshoe Lake. Generally, control methods for nuisance aquatic plants can be grouped into five categories:

- Physical control: hand-pulling, snorkel/scuba, cutting, or raking
- Mechanical: Diver Aided Suction Harvest (DASH), large and small-scale mechanical harvesting
- Aquatic plant habitat manipulation: dredging, drawdowns, bottom barriers, and shading
- Biological control: the use of species that compete successfully with the nuisance species for resources
- Chemical control: use of herbicides

Each of the above control categories are regulated by the WDNR and most activities require a permit from the WDNR to implement. Mechanical harvesting of aquatic plants and under certain circumstances, physical removal of aquatic plants, is regulated under Wisconsin Administrative Rule NR 109[4]. The use of chemicals and biological controls are regulated under Administrative Rule NR 107[5]. These two WI rules are currently undergoing modifications and will be combined under one rule starting in 2023. Certain habitat altering techniques like the installation of bottom covers and dredging require a Chapter 30 waterway protection permit[6].

Informed decision-making on aquatic plant management implementation requires an understanding of plant management alternatives and how appropriate and acceptable each alternative is for a given lake. The following sections list scientifically recognized and approved alternatives for controlling aquatic vegetation.

10.1 No Management

When evaluating the various management techniques, the assumption is erroneously made that doing nothing is environmentally neutral. In dealing with nonnative species like EWM (or E-HWM), the environmental consequences

[4] For more information about NR 109 go to: https://docs.legis.wisconsin.gov/code/admin_code/nr/100/109.pdf

[5] For more information about NR 107 go to: https://docs.legis.wisconsin.gov/code/admin_code/nr/100/107.pdf

[6] For more information about Chapter 30 go to: https://docs.legis.wisconsin.gov/statutes/statutes/30.pdf

of doing nothing may be high, possibly even higher than any of the effects of management techniques. Unmanaged, these species can have severe negative effects on water quality, native plant distribution, abundance and diversity, and the abundance and diversity of aquatic insects and fish (Madsen, 1997). Nonindigenous aquatic plants are the problem, and the management techniques are the collective solution. Nonnative plants are a biological pollutant that increases geometrically, a pollutant with a very long residence time and the potential to "biomagnify" in lakes, rivers, and wetlands (Madsen J. , 2000).

Foregoing any management of E-HWM in Horseshoe is not a recommended option. To keep E-HWM from causing greater harm, some form of management will need to be implemented.

10.2 Hand-pulling/Manual Removal

Manual or physical removal of aquatic plants by means of a hand-held rake or cutting implement; or by pulling the plants from the lake bottom by hand is allowed by the WDNR without a permit per NR 109.06 Waivers under the following conditions:

- Removal of native plants is limited to a single area with a maximum width of no more than 30 feet measured along the shoreline provided that any piers, boatlifts, swim rafts and other recreational and water use devices are located within that 30-foot wide zone and may not be in a new area or additional to an area where plants are controlled by another method (Figure 35)
- Removal of nonnative or invasive aquatic plants as designated under s. NR 109.07 is performed in a manner that does not harm the native aquatic plant community
- Removal of dislodged aquatic plants that drift on-shore and accumulate along the waterfront is completed.
- The area of removal is not located in a sensitive area as defined by the department under s. NR 107.05 (3) (i) 1, or in an area known to contain threatened or endangered resources or floating bogs
- Removal does not interfere with the rights of other riparian owners
- If wild rice is involved, the procedures of s. NR 19.09 (1) are followed.

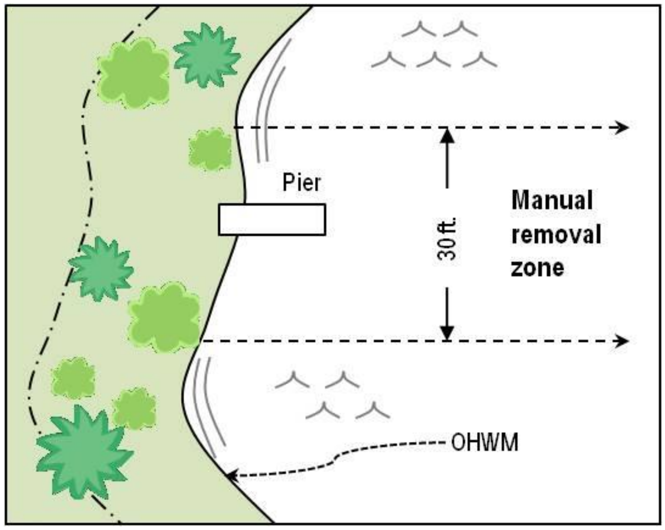

Figure 35: Aquatic vegetation manual removal zone

Although up to 30 feet of aquatic vegetation can be removed, removal should only be done to the extent necessary. There is no limit as to how far out into the lake the 30-ft zone can extend, however clearing large swaths of aquatic plants not only disrupts lake habits, it also creates open areas for non-native species to establish. Physical removal of aquatic plants requires a permit if the removal area is located in a "sensitive" or critical habitat area previously designated by the WDNR. Manual or physical removal can be effective at controlling individual plants or small areas of plant growth. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. In shallow, hard bottom areas of a lake, or where impacts to fish spawning habitat need to be minimized, this is the best form of control. If water clarity in a body of water is such that aquatic plants can be seen in deeper water, pulling aquatic invasive species while snorkeling or scuba diving is also allowable without a permit according to the conditions in NR 106.06(2) and can be effective at slowing the spread of a new aquatic invasive species infestation within a lake when done properly.

In Horseshoe Lake, E-HWM and CLP growing in many areas of the lake may be best managed by hand-pulling/manual removal. The District will continue to work with residents on the lake to teach them how to identify non-native aquatic plant species and how to properly remove them from around their docks and in their swimming areas. Scuba diver removal by the local lake diving team and its SNUBA equipment will continue.

10.3 Diver Assisted Suction Harvesting

Diver assisted suction harvesting or DASH, as it is often called, is a fairly recent aquatic plant removal technique. It is called "harvesting" rather than "dredging" because, although a specialized small-scale dredge is used, bottom sediment is not removed from the system. The operation involves hand-pulling of weeds from the lake bed and inserting them into an underwater vacuum system that sucks up plants and their root systems taking them to the surface. It requires water pumps on the surface (generally on a pontoon system) to move a large volume of water to maintain adequate suction of materials that the divers are processing. Only clean water goes through the pump. The material placed by the divers into the suction hose along with the water is deposited into mesh bags on the surface with the water leaving through the holes in the bag. The bags have a large enough 'mesh' size so that silts, clay, leaves and other plant material being collected do not immediately clog them and block water movement. If a fish or other living marine life is sucked into the suction hose it comes out the discharge unharmed and is returned to the body of water. It can have some negative impacts to other nearby non-target plants if not done carefully, particularly those plants that are perennials and expand their populations by sub-sediment runners (Eichler, Bombard, Sutherland, & and Boylen, 1993).

DASH could be an effective way to manage small areas of E-HWM and CLP in Horseshoe Lake, provided the conditions for harvest are conducive to it. However, since physical removal by property owners and divers has been and continues to be used effectively on the lake, it is not recommended. Contracted large-scale removal of AIS through DASH would likely be very expensive for the amount of AIS removed. If the DASH equipment was owned and operated by the District, the monetary cost for removal would likely be less over time, but the man-power required to complete it would be more.

10.4 Mechanical Removal

Mechanical management involves the use of devices not solely powered by human means to aid removal. This includes gas and electric motors, ATV's, boats, tractors, etc. Using these instruments to pull, cut, grind, or rotovate aquatic plants is illegal in Wisconsin without a permit. DASH is also considered mechanical removal. To implement mechanical removal of aquatic plants a Mechanical/Manual Aquatic Plant Control Application is required annually. The application is reviewed by the WDNR and other entities and a permit awarded if required criteria are met. Using repeated mechanical disturbance such as bottom rollers or sweepers can be effective at control in small areas, but in Wisconsin these devices are illegal and generally not permitted.

10.4.1 Large and Small-scale Mechanical Harvesting

Large-scale mechanical harvesting is more traditionally used for control of CLP, but can be an effective way to reduce EWM biomass in a water body. It is typically used to open up channels through existing beds of EWM to improve access for both human related activities like boating, and natural activities like fish distribution and mobility on lakes in maintenance mode where EWM is well-established and restoration efforts have been discontinued.

There are a wide range of small-scale mechanical harvesting techniques, most of which involve the use of boat mounted rakes, scythes, and electric cutters. As with all mechanical harvesting, removing the cut plants is required. Commercial rakes and cutters range in prices from $200 for rakes to around $3000 for electric cutters with a wide range of sizes and capacities. Using a weed rake or cutter that is run by human power is allowed without a permit, but the use of any device that includes a motor, gas or electric, would require a permit. Dragging a bed spring or bar behind a boat, tractor or any other motorized vehicle to remove vegetation is also illegal without a permit. Although not truly considered mechanical management, incidental plant disruption by normal boat traffic is a legal method of management. Active use of an area is often one of the best ways for riparian owners to gain navigation relief near their docks. Most aquatic plants won't grow well in an area actively used for boating and swimming. It should be noted that purposefully navigating a boat to clear large areas is not only potentially illegal it can also re-suspend sediments, encourage aquatic invasive species growth, and cause ecological disruptions.

Large-scale mechanical harvesting is not recommended in Horseshoe Lake; however, small-scale harvesting by human power is and will continue to be used to manage AIS in Horseshoe Lake.

10.5 Aquatic Plant Habitat Alterations

10.5.1 Bottom Barriers and Shading

Physical barriers, fabric or other, placed on the bottom of the lake to reduce E-HWM growth would eliminate all plants, inhibit fish spawning, affect benthic invertebrates, and could cause anaerobic conditions which may release excess nutrients from the sediment. Gas build-up beneath these barriers can cause them to dislodge from the bottom and sediment can build up on them allowing E-HWM to re-establish. Bottom barriers are typically used for very small areas and provide only limited relief. Currently the WDNR does not permit this type of control.

Creating conditions in a lake that may serve to shade out EWM growth has also been tried with mixed success. The general intention is to reduce light penetration in the water which in turns limits the depth at which plants can grow. Typically dyes have been added to a small water body to darken the water.

Bottom barriers and attempts to further reduce light penetration in Horseshoe Lake are not recommended.

10.5.2 Dredging

Dredging is the removal of bottom sediment from a lake. Its success is based on altering the target plant's environment. It is not usually performed solely for aquatic plant management but rather to restore lakes that have been filled in with sediment, have excess nutrients, inadequate pelagic and hypolimnetic zones, need deepening, or require removal of toxic substances (Peterson, 1982).

Dredging is not a recommended management action for Horseshoe Lake, except in those areas where creating a navigable waterway is necessary including between Buckwald Bay and the main basin of the lake and possibly between Mudd Lake and the main basin of the lake. However if dredging were completed in these areas it would not be for aquatic plant control.

10.5.3 Drawdown

Drawdown, like dredging, alters the plant environment by removing all water in a water body to a certain depth, exposing bottom sediments to seasonal changes including temperature and precipitation.

It is not possible to draw down Horseshoe Lake as there is no viable outlet except under extreme high water conditions where water may flow from Horseshoe Lake to Echo Lake or vice versa. As a seepage lake, the water level in Horseshoe Lake fluctuates greatly with the environmental conditions present at any given time. Under drought conditions the lake level will be very low. Under more normal conditions the lake level may be normal or even high.

10.6 Biological Control

Biological control involves using one plant, animal, or pathogen as a means to control a target species in the same environment. The goal of biological control is to weaken, reduce the spread, or eliminate the unwanted population so that native or more desirable populations can make a comeback. Care must be taken however, to insure that the control species does not become as big a problem as the one that is being controlled. A special permit is required in Wisconsin before any biological control measure can be introduced into a new area.

10.6.1 EWM Weevils

While many biological controls have been studied, only one has proven to be effective at controlling EWM under the right circumstances. *Euhrychiopsis lecontei* is an aquatic weevil native to Wisconsin that feeds on aquatic milfoils (Figure 36). Their host plant is typically northern watermilfoil; however they seem to prefer EWM when it is available. Milfoil weevils are typically present in low numbers wherever northern or Eurasian water milfoil is found. They often produce several generations in a given year and over winter in undisturbed shorelines around the lake. All aspects of the weevil's life cycle can affect the plant. Adults feed on the plant and lay their eggs. The eggs hatch and the larva feed on the plant. As the larva mature they eventually burrow into the stem of the plant. When they emerge as adults later, the hole left in the stem reduces buoyancy often causing the stem to collapse. The resulting interruption in the flow of carbohydrates to the root crowns reduces the plant's ability to store carbohydrates for over wintering reducing the health and vigor (Newman et al. (1996).

Figure 36: EWM weevil

The weevil is not a silver bullet. They do not work in all situations. The extent to which weevils exist naturally in a lake, adequate shore land over wintering habitat, the population of bluegills and sunfish in a system, and water quality characteristics are all factors that have been shown to affect the success rate of the weevil. In a weevil survey completed on Horseshoe Lake in 2014, no weevils in any form were identified suggesting that there is not a viable population in the lake. Further monitoring and possible weevil rearing is not recommended, but would not hurt if there were interested people to do so on the lake.

10.6.2 Purple Loosestrife Bio-Control with Galerucella Beetles

Galerucella beetles are currently approved for the control of purple loosestrife in Wisconsin (Figure 37). The entire lifecycle of Galerucella beetles is dependent on purple loosestrife. In the spring, adults emerge from the leaf litter below old loosestrife plants. The adults then begin to feed on the plant for several days until they begin to reproduce. Females lay their eggs on loosestrife leaves and stems. When the larvae emerge from these eggs they begin feeding on the leaves and developing shoots. When water levels are high these larvae will burrow into the loosestrife stems to pupate into adult beetles. These new adults emerge and begin feeding on the loosestrife again (Sebolt, 1998). Galerucella beetles do not forage on any plants other than purple loosestrife. Because of this the populations, once established, are self-regulating. When the purple loosestrife population drops off, the beetle population also declines. When the loosestrife returns, the beetle numbers will usually increase. These beetles do not eradicate purple loosestrife entirely, but do help to reduce its dominance which will allow other native plants to recover.

Figure 37: Galerucella beetle

Using Galerucella beetles for control of purple loosestrife is recommended for Horseshoe Lake. Some beetles have been released on the lake in the past. Beetles could be reared by volunteer and then distributed on the lake, or potentially collected from nearby locations in Turtle Lake and then released on Horseshoe Lake. In both cases, WDNR permitting would be needed.

10.6.3 Other Biological Controls

There are other forms of biological control being used or researched. It was thought at one time that the introduction of plant eating carp could be successful. It has since been shown that these carp have a preference list for certain aquatic plants. EWM is very low on this preference list (Pine & Anderson, 1991). Use of "grass carp" as they are referred to in Wisconsin is illegal as there are many other environmental concerns including what happens once the target species is destroyed, removal of the carp from the system, impacts to other fish and aquatic plants, and preventing escapees into other lakes and rivers. Several pathogens or fungi are currently being researched that when introduced by themselves or in combination with herbicide application can effectively control EWM and lower the concentration of chemical used or the time of exposure necessary to kill the plant (Sorsa, Nordheim, & Andrews, 1988). None of these have currently been approved for use in Wisconsin and are not recommended for use on Horseshoe Lake.

10.6.4 Native Plant Restoration

A healthy population of native plants might slow invasion or reinvasion of non-native aquatic plants. It should be the goal of every management plan to protect existing native plants and restore native plants after the invasive species has been controlled. In many cases, a propagule bank probably exists that will help restore native plant communities after the invasive species is controlled (Gettsinger, Turner, Madson, & Netherland, 1997). This is certainly the case in Horseshoe Lake. If E-HWM can be controlled, enough native plants currently still exist to repopulate treatment areas. The goal of this plan is to enhance, protect, and restore native plant populations while controlling E-HWM and other non-native invasive species.

10.7 Chemical Control

Aquatic herbicides are granules or liquid chemicals specifically formulated for use in water to kill plants or cease plant growth. Herbicides approved for aquatic use by the U.S. Environmental Protection Agency (EPA) are considered compatible with the aquatic environment when used according to label directions. Some individual states, including Wisconsin, also impose additional constraints on herbicide use.

The WDNR evaluates the benefits of using a particular chemical at a specific site vs. the risk to non-target organisms, including threatened or endangered species, and may stop or limit treatments to protect them. The WDNR frequently places conditions on a permit to require that a minimal amount of herbicide is needed and to reduce potential non-target effects, in accordance with best management practices for the species being controlled. For example, certain herbicide treatments are required by permit conditions to be in spring because they are more effective, require less herbicide and reduce harm to native plant species. Spring treatments also means that, in most cases, the herbicide will be degraded by the time peak recreation on the water starts.

The WDNR encourages minimal herbicide use by requiring a strategic Aquatic Plant Management Plan for management projects over 10 acres or 10% of the water body or any projects receiving state grants. WDNR also requires consideration of alternative management strategies and integrated management strategies on permit applications and in developing an APM Plan, when funding invasive species prevention efforts, and by encouraging the use of best management practices when issuing a permit. The WDNR also supervises treatments, requires that adjacent landowners are notified of a treatment and are given an opportunity to request a public meeting if they want, requires that the water body is posted to notify the public of treatment and usage restrictions, and requires reporting after treatment occurs.

The advantages of using chemical herbicides for control of aquatic plant growth are the speed, ease and convenience of application, the relatively low cost, and the ability to somewhat selectively control particular plant types with certain herbicides. Disadvantages of using chemical herbicides include possible toxicity to aquatic animals or humans, oxygen depletion after plants die and decompose which can cause fishkills, a risk of increased algal blooms as nutrients are released into the water by the decaying plants, adverse effects on desirable aquatic plants, loss of fish habitat and food sources, water use restrictions, and a need to repeat treatments due to existing seed/turion banks and plant fragments. Chemical herbicide use can also create conditions favorable for non-native aquatic invasive species to outcompete native plants (for example, areas of stressed native plants or devoid of plants).

When properly applied, the possible negative impacts of chemical herbicide use can be minimized. Early spring to early summer applications are preferred because exotic species are actively growing and many native plants are dormant, thus limiting the loss of desirable plant species; plant biomass is relatively low minimizing the impacts of de-oxygenation and contribution of organic matter to the sediments; fish spawning has ceased; and recreational use is generally low limiting human contact. The concentration and amount of herbicides can be reduced because colder water temperatures enhance the herbicidal effects. Selectivity of herbicides can be increased with careful selection of application rates and seasonal timing (Sprecher, Getsinger, & Stewart, 1998). Lake hydro-dynamics must also be considered; steep drop-offs, inflowing waters, lake currents and wind can dilute chemical herbicides or increase herbicide drift and off-target injury. This is an especially important consideration when using herbicides near environmentally sensitive areas or where there may be conflicts with other water uses in the treatment vicinity.

10.7.1 How Chemical Control Works

There are two main classes of aquatic herbicides that attack plants in different ways. Systemic herbicides are absorbed through the stem, leaves, and/or roots and then move through the entire plant. Most systemic herbicides require 16-24 hours of contact time with the target plant species to result in death. If the contact time is not long enough, systemic herbicides may only retard or "burn" the target plants rather than killing them. Target plants impacted by the herbicide usually drop out of the water column in two to three weeks. ProcellaCOR®, a newer systemic herbicide only requires around four hours of contact time to kill the target plant.

Contact herbicides kill the plant at the point of contact. The herbicide is not drawn into the whole of the plant, but it can be very effective at knocking the target plant species out of the water column very quickly, minimizing its ability to sustain itself through photosynthesis and drawing of nutrients from the sediment. Certain parts of the plant, like its roots, may not be impacted by the herbicide. Contact herbicides are mostly used when a more immediate removal of a plant is desired, even if the longer term results may not be as good as when using a systemic herbicide.

10.7.2 Micro and Small-scale Herbicide Application

The determining factor in designating chemical treatments as micro or small-scale is the size of the area being treated. Small-scale herbicide application involves treating areas less than 10 acres in size. The dividing line between small-scale and micro treatments is not clearly defined, but is generally considered to be less than an acre. Small-scale chemical application is usually completed in the early season (April through May). Recent research related to micro and small-scale herbicide application generally shows that these types of treatment are less effective than larger scale treatments due to rapid dilution and dispersion of the herbicide applied. Some suggested ways to increase the effectiveness is to increase the concentration of herbicide used, use a contact herbicide that does not require as long a contact time to effective, or in some manner contain the herbicide in the treated area by artificial means such as installing a limno-barrier or curtain.

10.7.2.1 Small-scale Limno-Barrier Application

Small-scale herbicide applications can be made more effective by installing a limno-barrier or curtain around a treatment area to help hold the applied herbicide in place, longer. By doing so, the herbicide/target species contact time is increased. The curtain is generally a continuous sheet of plastic that extends from the surface to the bottom of the lake (Figure 38). The surface edge of the curtain is generally supported by floatation devices. The bottom of the curtain is held in place by some form of weighting. The curtain or barrier, sometimes thousands of feet of it is installed around the proposed treatment area with the purpose of holding the herbicide in place longer by preventing dilution and drift away from the treated area (Figure 39).

Figure 38: Limno-curtain material on a roll before installation (photo from Marinette Co. LWCD)

Figure 39: Limno-curtain installed on Thunder Lake (photo from Marinette Co. LWCD)

In the Thunder Lake, Marinette County limno-curtain trial completed in 2020, a curtain was installed around two small areas (0.9 and 2.9 acres) of dense growth EWM prior to chemical treatment. Liquid 2,4-D was applied at 4.0ppm inside the barrier. The barriers stayed in place until 48 hours after treatment. Herbicide concentration testing (see following section) was completed within the treated areas to determine how long the herbicide stayed in place and at what concentration. Figure 40 reflects what happened to the herbicide that was applied within the barrier in Thunder Lake. Herbicide concentrations stayed relatively high for a longer period of time (48 hrs). Once the curtain was removed, the herbicide dissipated rapidly. Similar studies have been completed on other lakes with similar results.

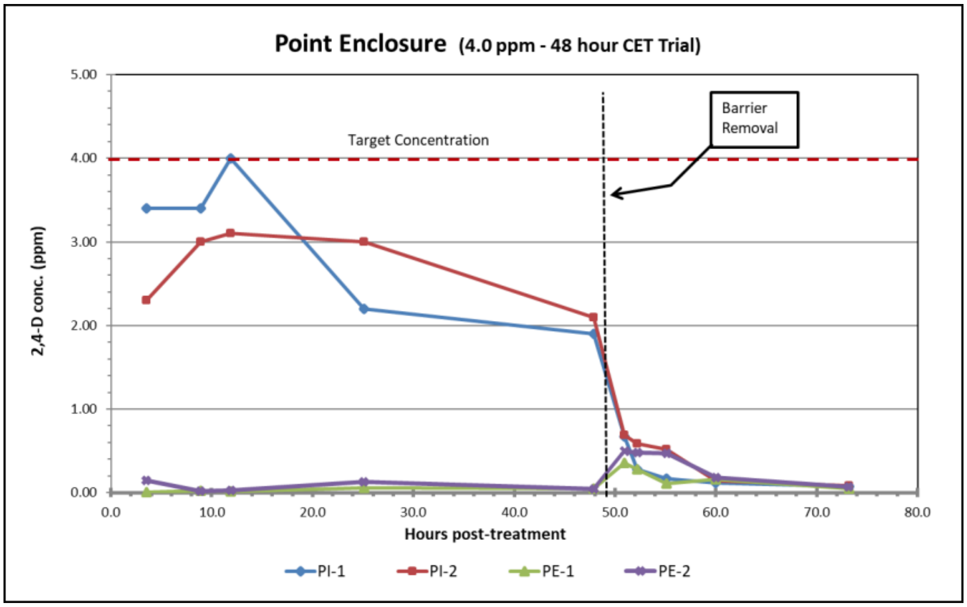

Figure 40: Herbicide concentration results from 2020 Thunder Lake limno-curtain trial (Marinette Co LWCD)

10.7.1 Large-scale Herbicide Application

Large-scale herbicide application involves treating areas more than 10 acres in size. Like small-scale applications, this is usually completed in the early-season (April through May) for control of non-native invasive species like E-HWM and CLP while minimizing impacts on native species. It is generally accepted that lower concentration of herbicide can be used in large-scale applications as the likelihood of the herbicide staying in contact with the target plant for a longer time is greater. If the volume of water treated is more than 10% of the volume of the lake, or the treatment area is ≥160 acres, or 50% of the lakes littoral zone, effects can be expected at a whole-lake scale. Large-scale herbicide application can be extended in some lakes to include whole bay or even whole lake treatments. The bigger the treatment area, the more contained the treatment area, and the depth of the water in the treatment area, are factors that impact how whole bay or whole lake treatments are implemented.

An approved Aquatic Plant Management Plan is required by the WDNR when completing any management action that includes the use of aquatic herbicides. When implementing large-scale herbicide applications, pre and post treatment plant surveys and herbicide concentration testing may be required (see Sections 10.7.3 and 10.7.4). Even if not required, both are recommended to gain a better understanding of the impact and fate of the herbicide used.

Large-scale herbicide applications are not expected to be needed in Horseshoe Lake in the next five years.

10.7.2 Recommended Aquatic Herbicides for E-HWM

There are several aquatic herbicide options currently available in the State of Wisconsin (as approved by the Environmental Protection Agency) to be used for control of E-HWM.

10.7.2.1 ProcellaCOR®

ProcellaCOR® is a relatively new systemic, selective herbicide that can be used to target E-HWM with limited impact to most native species. It is also very fast acting, making it an effective control measure on smaller beds like those located in Horseshoe Lake, especially ones in high boat traffic areas and/or deeper water. In addition, applications rates are measured in ounces, not gallons, as is common with almost all other liquid herbicides. While it is more expensive to use than 2,4-D equivalents, it has been shown to provide two or more years of control without re-application. ProcellaCOR® is recommended for future E-HWM management implementation with a preferred treatment bed size of at least an acre.

10.7.2.2 Triclopyr

Triclopyr is a selective, systemic herbicide used to control certain aquatic plants (like E-HWM) by mimicking plant hormones. Liquid triclopyr (Renovate®) or granular triclopyr combined with granular 2,4D (Renovate Max G®) may be an option for larger treatment areas, however neither triclopyr nor 2,4D based herbicides are recommended for small-scale (<5ac) E-HWM treatments as required contact times are often in the 16-24 hour range and difficult to attain due to dilution. It can be more effective if a limno-barrier is used. Triclopyr products are generally more expensive than 2,4D products.

10.7.2.3 2,4-D (liquid)

2,4D is a commonly used systemic herbicide that targets plants like E-HWM. Shredder Amine 4®, also referred to as 2,4D Amine 4®, is a liquid formulation of 2,4D. It has been successfully used on Horseshoe Lake to control E-HWM, and is a viable option again in the future if E-HWM beds that are included in a management plan reach at least five acres in size. Like triclopyr, 2,4D requires a contact time of 16-24 hours to be effective. And like triclopyr, it can be more effective is a limno-curtain is used.

ProcellaCOR, triclopyr, and 2,4D target dicot species or plants like E-HWM, northern and other native milfoils, several related species, and lily pads. Monocot species like curly-leaf pondweed (CLP), flat-stem pondweed, and other native pondweed are generally not affected by these herbicides.

10.7.2.4 Endothall (liquid)

Endothall is a non-selective contact herbicide. As such, it is not species specific and will negatively impact any aquatic plant it comes in contact with. This herbicide is most often used to control another non-native, aquatic invasive plant species –CLP very early in the season when other native aquatic plants have not begun to actively grow. Because it is a contact herbicide, at high enough concentrations it can also be used to manage E-HWM, but not generally by itself. It may be combined with an herbicide like 2,4D or ProcellaCOR to treat CLP and E-HWM simultaneously. The manufacturer of Aquathol K®, the most common trade name for an endothall based herbicide recommends that treatment areas using endothall-based herbicides be at least five acres in size for the product to be effective.

10.7.2.5 Diquat (liquid)

Diquat is another non-selective herbicide that is commonly used to control emergent and submersed aquatic vegetation. As a contact herbicide, it is not species specific and will negatively impact any aquatic plant it comes in contact with. It is fast-acting and has no restrictions for swimming, fish, or wildlife, but there may be irrigation and drinking water restrictions for up to 5 days.

It may be beneficial to alternate the use of different herbicides in an effort to reduce the ability of target plants to build up a resistance to an herbicide that is applied too often. Using a non-selective contact herbicide in Horseshoe Lake is generally not recommended, unless it is being used as a follow-up to a previous treatment using a different herbicide to manage what was missed.

10.7.3 Pre and Post Treatment Aquatic Plant Surveying

When introducing new chemical treatments to lakes where the treatment size is greater than ten acres or greater than 10% of the lake littoral area and more than 150-ft from shore, the WDNR requires pre and post chemical application, point-intercept (PI) aquatic plant surveying. The protocol for a pre and post treatment survey is applicable for chemical treatment of CLP and E-HWM.

The number of pre and post treatment sampling points required is based on the size of the treatment area. Survey points are concentrated within the treated areas, with a few points outside of the treated areas or in other areas that may be of concern. Ten to twenty acres generally requires at least 100 sample points. Thirty to forty acres requires at least 120 to 160 sampling points. Areas larger than 40 acres may require as many as 200 to 400 sampling points. Regardless of the number of points, each designated point is sampled by rake recording depth, substrate type, and the identity and density of each plant pulled out, native or invasive.

In the year prior to an actual treatment, the area to be treated must have a mid-season/summer/warm water point intercept survey completed that identifies the target plant and other plant species that are present. A pre-treatment readiness aquatic plant survey is done in the year the herbicide is to be applied, prior to application to confirm the presence and level of growth of the target species. A post-treatment survey should be scheduled when native plants are well established, generally mid-July through mid-August and can be done in the year following application. If treating CLP a post treatment survey needs to be completed before seasonal growth ends (i.e. mid-June). For the post-treatment survey, repeat the PI for all species in the treatment polygons, as was done the previous summer. For whole-lake scale treatments, a full lake-wide PI survey should be conducted.

10.7.4 Chemical Concentration Testing

Chemical concentration testing is often done in conjunction with treatment to track the fate of the chemical herbicide used. Testing is completed to determine if target concentrations are met, to see if the chemical moved outside its expected zone, and to determine if the chemical breaks down in the system as expected. Monitoring sites are located both within and outside of the treatment area, particularly in areas that may be sensitive to the herbicide used, where chemical drift may have adverse impacts, where movement of water or some other characteristic may impact the effect of the chemical, and where there may be impacts to drinking and irrigation water. Water samples are collected prior to treatment and for a period of hours and/or days following chemical application.

Chemical concentration testing is only recommended in Horseshoe Lake if ProcellaCOR is used, if management efforts exceed 10% of the littoral zone, or if the WDNR requests it.

10.8 Herbicide Use in Horseshoe Lake

The use of aquatic herbicides in tandem with physical removal by property owners and divers has and will continue to keep E-HWM at very low levels and under control in Horseshoe Lake without having a significant negative impact on native aquatic vegetation. Ideally, the use of herbicides would be limited in nature and used only when the level of E-HWM in a given area exceeds what is manageable by other means. Through careful management planning that includes abundant aquatic plant surveys and calculated herbicide application rates the current use of aquatic herbicides can be continued without negatively impacting native aquatic vegetation, while at the same time minimizing the negative impacts of E-HWM to the lake.

2,4-D or triclopyr-based herbicides, and ProcellaCOR can be used effectively to control E-HWM in Horseshoe Lake. For all treatment areas, ProcellaCOR is likely the best alternative. In larger-scale (>10 acres) applications the cost of

ProcellaCOR might be somewhat restrictive so it might be feasible to consider other herbicides. Using different herbicides at different times may actually improve efficiency as there is some research that suggests HWM is less susceptible to 2,4-D based herbicides at the concentrations traditionally used for submerged aquatic plant control (Poovey, 2007) (Glomski, 2010).

11.0 Management Discussion

Horseshoe Lake supports a valuable aquatic plant community with a number of uncommon species and a quality fishery valued by the lake community and the general public. The lake currently has only two known fully aquatic invasive species – limited curly-leaf pondweed and Eurasian/Hybrid watermilfoil. The main goal of the Aquatic Plant Management Plan is to control E-HWM in a sound, ecological manner. CLP management only consists of physical or diver removal.

11.1 E-HWM Management

The biggest failure of the previous APM Plan for Horseshoe Lake was the criteria put in place for management of E-HWM using aquatic herbicides. In the previous plan, aquatic herbicides could only be incorporated as a management tool when the amount of E-HWM in the lake reached or exceeded 6.0 acres. This value was too high and allowed the spread of E-HWM into new areas and the expansion of it in already known areas. It is difficult to determine if the amount of E-HWM in the lake is negatively impacting native aquatic vegetation because management actions completed under the last APM Plan managed to keep E-HWM below 2.0 acres in every year except 2018. Larger areas of E-HWM like what are present now could negatively impact the growth of native aquatic vegetation, but this has not been confirmed.

No management using aquatic herbicides has been completed in the last 3 years. As a result, E-HWM as identified in the fall survey has jumped from 0.09 acres in 2020 to 6.85 acres in 2022. Since HWM was first found in Horseshoe Lake in 2007, the amount of E-HWM in Horseshoe Lake as identified by fall bed-mapping surveys has fluctuated between <1 (2015 and 2020) and about 8 acres (2018) (Table 4). These values represent < 1% to about 2.5% of the littoral zone.

Table 4: E-HWM distribution and bed size based on fall bed-mapping surveys

2013 to 2022 Fall HWM Beds/High Density Areas							
Year	# of Beds	Total Acreage	Smallest Bed	Largest Bed	Beds ≥0.5 ac	Beds ≥0.75 ac	Beds ≥1.0 ac
2013	13	2.54	0.01	0.65	1	0	0
2014	14	1.13	<0.01	0.29	0	0	0
2015	2	0.26	0.02	0.24	0	0	0
2016	10	1.93	<0.01	1.12	1	1	1
2017	13	1.6	<0.01	0.35	0	0	0
2018	11	7.88	0.02	4.82	4	2	2
2019	8	1.04	0.06	0.17	0	0	0
2020	3	0.09	<0.01	0.07	0	0	0
2021	5	1.05	0.02	0.8	1	1	1
2022	5	6.85	0.26	3.73	4	3	3

Based on these numbers it is a reasonable goal to keep the level of E-HWM in Horseshoe Lake as identified in a fall bed-mapping survey or the equivalent, below 2.0 acres in any given year. Any amount of E-HWM can and should be managed, albeit in different ways. A combination of manual/physical removal and chemical control methods are recommended for Horseshoe Lake.

11.1.1 Physical Removal and/or DASH

Physical methods, including hand-pulling, rake removal, snorkel, divers, and/or diver-assisted suction harvest (DASH) can be implemented at any time for any amount of E-HWM. Hand-pulling rake removal, snorkel, and diver removal of E-HWM does not require a permit to implement. Implementation of DASH requires a mechanical harvesting permit from the WDNR. Implementing hand-pulling, rake removal, snorkel, diver, and/or DASH removal of E-HWM will depend only on the resources, financial and human, available to the District in any given year. These management alternatives can be used in any combination to remove E-HWM from the lake regardless of the size of the bed.

11.1.2 Application of Aquatic Herbicides

If any individual bed with a reasonable buffer or adjacent beds that can be reasonably combined reach or exceed 1.0 acres, herbicide application can be considered. For beds between 1.0 and 5.0 acres, ProcellaCOR should be used. For beds that reach 5 acres or larger, 2,4D, triclopyr-based, or ProcellaCOR herbicides can be considered dependent on the financial resources available. Smaller areas may be treated with 2,4D or triclopyr-based herbicides if a limno-barrier is installed around the treatment area prior to actual treatment.

In general, E-HWM management involving the use of aquatic herbicides in Horseshoe Lake will be based on the following criteria.

1) Late summer or fall E-HWM bedmapping will be completed every year.
2) Any amount of E-HWM in the lake can be managed at any time if herbicide application is not used. Non-chemical management actions include hand pulling, rake removal, and snorkel/scuba diver removal, and/or DASH removal.
3) Herbicide application using ProcellaCOR may be implemented if prior year bed mapping identifies an individual bed or combination of beds of E-HWM that are at least 1.0 acres in size. In order to use 2,4D or triclopyr-based herbicides, the minimum size required is 5.0 acres, unless a limno-barrier is installed.
    a. If and when the WDNR approves the use of ProcellaCOR on smaller areas, this management action may be considered.
4) Herbicides applied to E-HWM beds that reach or exceed 10.0 acres in total in a given year will be considered large-scale herbicide applications. With a large-scale chemical treatment, the following activities will be added in support of that treatment.
    a. Pre and post-treatment, point-intercept surveys will be completed in the year prior, and at least the year after the planned herbicide application. A third survey could be completed in the year of application.
    b. Herbicide concentration testing will be completed unless deemed unnecessary by the WDNR.
5) The same area will not be chemically treated with the same herbicide, two years in a row.

Concerns exist when herbicide treatments using the same herbicide are done over multiple and subsequent years. Target plant species may build up a tolerance to a given herbicide, making it less effective. Susceptible plant species may be damaged and/or disappear from the lake (ex. water lilies), issues with fish and other wildlife might occur, and concern over recreational use in chemically treated water may be voiced. By using several different aquatic herbicides interspersed with physical removal efforts between treatments, many of these concerns are minimized.

Recent research completed by the WDNR suggests that large-scale or whole-lake application of aquatic herbicides can be more detrimental to the native aquatic plant community than the AIS meant to be controlled by the treatment (Mikulyuk, et al., 2020). Given the treatment history of Horseshoe Lake and the results of management, small-scale spot treatments do not appear to be causing great ecological harm to the aquatic plant community, and will continue to be the preferred method of management when the amount of E-HWM in an individual bed or combination of beds reaches or exceeds 1.0 acres.

11.2 Other AIS Monitoring and Management

CLP will be monitored by the District and physical removal completed by local divers or by District volunteers. If DASH is incorporated for the removal of E-HWM, it can also be used for CLP if the timing of both corresponds. It is not expected that any management using aquatic herbicides will be necessary to control CLP during the five years covered by this APM Plan.

District volunteers will continue to monitor the shoreline for purple loosestrife removing what is found if possible. Over the course of the next five years, the District may choose to get involved in rearing beetles for biological control of purple loosestrife, or possibly collect and transfer beetles from local sources for transfer to Horseshoe Lake when possible. Releasing beetles for control of purple loosestrife is not counter-productive to the removal of flower heads to prevent seeding. Beetles need the leafy material to survive, not the flower itself.

Horseshoe Lake volunteers will participate in the Citizen Lake Monitoring Network Aquatic Invasive Species Monitoring Program annually looking for zebra mussels, spiny waterflea, rusty crayfish, hydrilla, and other AIS not already in the lake.

11.3 Shoreland Improvement Projects

In 2016, under one of the recommendations from the 2015-2019 APM Plan, a shoreland habitat assessment was completed on Horseshoe Lake following WDNR guidelines. The purpose of the survey was to identify and then to provide management recommendations to individual property owners based on an evaluation of their property for the potential to implement shoreland habitat improvement and runoff reduction projects. Priority rankings for each property, based on several different parameters, were developed by LEAPS in order to identify projects that could realistically be completely on each parcel that would benefit the lake. The parameters used to determine the priority were considered to be those that would contribute most significantly to the rainwater runoff. This includes percentage of canopy cover, as well as the percentage of undisturbed vegetation and a summed percentage of ground covered by manicured lawn and impervious surfaces. Additional consideration was given to the number of buildings present in the riparian zone, the presence or absence of trails to the lake, lawns that sloped directly to the lake, bare soil deposits that can run into the lake, and any other runoff concerns such as the large patches of artificial beach. For each factor being considered, there are value ranges assigned to determine the color, the value ranges can be seen below in Table 5. Values that fall within the red range are worth 2 points, values in the yellow range are worth 1 point, and values in the white range are not given any points. The points are then summed and the properties prioritized based on the point range for the entire lake.

Table 5: Value ranges for color assignments of each parameter of concern

Parameter	Red Range (2 points)	Yellow Range (1 Point)	White Range (No points)
Percent canopy cover	0-15%	16-30%	>30%
Percent shrub and herbaceous (undisturbed)	0-15%	16-30%	>30%
Percent lawn and impervious surface	>65%	31-65%	0-30%
Number of buildings	>1	1	0
Trail to lake	>1	1	0
Presence/ Absence of lawn sloping to lake	N/A	1 (Present)	0 (Absent)
Presence/ absence of bare soil deposits	1 (Present)	N/A	0 (Absent)
Presence/ absence of other runoff concerns	1 (Present)	N/A	0 (Absent)

To establish project potential rankings for the lake, it was important to consider the entire lake. The maximum possible score (project potential) for each individual property was 16 points, but the highest scoring parcel only scored 11 points. From here, four levels of project implementation were established: Green, Light Green, Yellow, and White. These colors correspond to the potential for projects that could benefit the health of the lake. Green properties have the greatest potential for projects; white properties have little or no potential for projects. The best thing for white parcels is to maintain them as they are. Table 6 summarizes the survey results for the entire lake. Potential projects are based on the WDNR Healthy Lakes and Rivers Initiative and can be funded in part by WDNR Healthy Lakes and Rivers grants.

Table 6: Project potential for individual parcels

Color	Overall Score	Priority	Number of Parcels
Green – highest potential for projects	8-11 Points	High	17
Light Green – moderate potential for projects	7 Points	Moderate	36
Yellow – lower potential for projects	4-6 Points	Low	85
White – little need for potential project	0-3 Points	No Concern	130

11.3.1 Lake Management Best Practices (Healthy Lakes and Rivers Initiative)

The Healthy Lakes Initiative is a program that has been set up by the WDNR to provide support through information and grant funding to small scale projects that will help improve both shoreline habitat and lake health. The grants available for these projects are intended for fairly small, inexpensive projects, so there is $1000 limit in grant funding per project. This program is focused on helping individual property owners improve their shoreline. There are five projects that are eligible for Healthy Lakes Grants. The projects that qualify for these grants are installing fish sticks, rain gardens, native plantings, diversions, and rock infiltrations.

11.3.1.1 Fish Sticks Installation

Fish Sticks involve taking trees from the inland area of the lake, and installing them in the lake to mimic shore trees that will eventually fall into the lake (Figure 41). The trees used must be taken from a minimum of 35 feet inland and are then secured to the shore with cables for approximately 3 years. This provides habitat for fish, birds, and many other animals. In addition to providing habitat, fish sticks help protect the shoreline from bank erosion. Fish sticks project costs range anywhere from $100 to $1000, averaging about $500. These are very low maintenance because it is only necessary to occasionally check the cables to ensure they are secure. This practice would work well for almost any of the developed parcels on Horseshoe Lake.

Figure 41: Fishsticks installation (left) and after ice out (right)

11.3.1.2 Rain Gardens

Rain gardens are shallow depressions that contain loose soil and native plants (Figure 42). These are intended to capture the runoff, allowing the water to be filtered, naturally through the ground instead of flowing directly into the lake. Rain gardens are designed to allow the rainwater to soak into the ground with 1-2 days, to prevent any of the issues created by standing water. The project cost for rain garden range anywhere from $500 to $9,500, but this is very dependent on the size of the rain garden. The maintenance is fairly low, only requiring watering for about two weeks, until the plants have established, and weeding is occasionally needed during the first year. This project is best suited to parcels on a smaller incline to catch rainwater runoff that would otherwise run into the lake.

Figure 42: Rain garden installation (left) and upon completion (right)

11.3.1.3 Native Plantings

Native plantings (Figure 43) are intended to establish a buffer zone between the developed portion of a parcel and the lake. The buffer helps filter and slow rainwater runoff so much of it filters into the ground. This buffer zone is created by changing a strip of turf grass, at least ten feet wide, along the shoreline to a natural area composed of native shoreline plants. Similar to rain gardens, these are fairly low maintenance requiring water only until the plants have become established. The only ongoing maintenance is the removal of any invasive species that find their way into the planting. On average, native plantings cost around $1000. This project will work for almost any developed parcel that does not have a sand beach as the primary frontage.

Figure 43: Completed native planting (photo from HealthyLakesWI.com)

11.3.1.4 Diversions

Diversions (Figure 44) are placed across a sloping path or driveway to divert runoff water to an area where it can be absorbed into the ground instead of flowing directly into the lake. In addition to helping improve lake health, these can also reduce the effects of erosion on the paths that the diversions are installed on. Diversions are created by entrenching a log or creating a small earthen berm approximately 30 degrees from the angle of the slope. The cost of these range anywhere from $25 to $3,750, but the average diversion costs $200. These are very low maintenance, and only require some debris removal that could get stuck in the diversion and occasionally ensuring everything is still secure and in place. This practice does not work well for the purposes of this particular survey, but it is mentioned here as a nod to projects that could be completed further inland than this survey was meant to assess.

Figure 44: Completed diversion (photo from HealthyLakesWI.com)

11.3.1.5 Rock Infiltration Trenches

Rock infiltrations (Figure 45) are meant for relatively low traffic areas as a way to catch rainwater runoff and divert it into the ground. These consist of a pit which is no more than five feet deep. This pit is lined with filter fabric and filled with small rock. More filter fabric is placed on top and larger rock is then placed over that to hold everything in place. These range in price from $500 to $9,500, on average costing $3800. This requires some maintenance to function properly. It is necessary to remove any debris such as leaves or pine needles that may collect. It is also necessary to occasionally clean out the rock as it collects sediment. This works well around building that can be seen in the riparian zone. The rock infiltrations allow for rainwater coming off of the roof to be collected and filtered without damaging the building it surrounds.

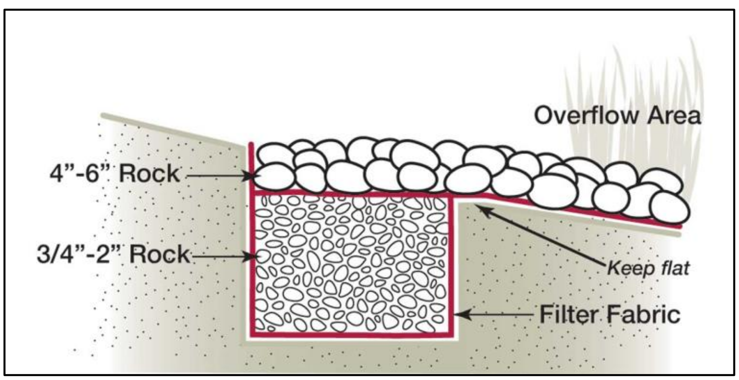

Figure 45: Rock Infiltration Set-up

11.3.1.6 Example Parcels (Not From Horseshoe Lake)

These parcels are simply meant to give an idea of properties that would have low or no significant potential to implement shoreland habitat improvement or runoff reduction projects. The properties shown in Figure 46 have been assessed with the same protocol as the properties surrounding Horseshoe Lake, and have been deemed as having little or no potential for additional projects. Each property is a little different, but in each parcel, the majority of the land within the riparian zone is comprised of undisturbed, native vegetation. The parcels that are level have some manicured lawn within that zone, but this is treated more like a well-maintained trail. For parcels with a steep slope, having a trail or stairway down to the lake while leaving the rest of the area as native vegetation works best. Not only is this the most lake-friendly approach, but the maintenance and general upkeep of this area becomes much safer, easier, and cost effective.

Figure 46: Developed Parcels with low or little potential (or need) for restoration projects

11.3.2 Shoreland Habitat Improvement and Runoff Reduction Projects on Horseshoe Lake

Perhaps the easiest shoreland best management practice to improve shoreland habitat and reduce runoff into the lake is the installation of buffers along the lakeshore. Presently, 67 out of 283 parcels that were evaluated during the 2016 assessment had mowed lawn down to the edge of the lake. Over the course of the next five years, it is a goal of this plan to decrease the number of parcels without a shoreland buffer or native planting by 20%. To accomplish this, mowed grass down to the edge of the lake would need to be replaced with native plantings on 13-15 parcels.

A survey completed on a subset of District constituents at the 2022 annual meeting confirmed an interest on their part to work toward a shoreline that would be better for the lake. Of the people surveyed, about 50% of respondents felt shoreland improvement projects should be a goal of this plan. More than 50% of the respondents felt that their property could be improved for the benefit of the lake.

12.0 Aquatic Plant Management Goals, Objectives, and Actions

The following Goals, Objectives, and associated Actions will guide aquatic plant management in Horseshoe Lake between 2023 and 2027.

12.1 Goal 1 – Protect and enhance the native aquatic plant community.

This goal was also in the last APM Plan with the objective of maintaining or improving measures of the health of the aquatic plant community. From the Table below, only Frequency of Occurrence, Average native species per site, and Mean C were below the goal set in the 2015-19 APM Plan and this was likely due to the more normal water levels experienced in 2020. Once again the goal for the next five years is to see no decline in measures of a healthy, diverse, and sustainable aquatic plant community that can be tied directly to the use of aquatic herbicides, as measured by a repeat whole-lake, point-intercept survey.

12.1.1 Objective 1

Over the course of the next five years (2023-27) the following measures of a healthy native aquatic plant community (Table 7) will be maintained or exceeded:

Table 7: Past and target aquatic plant community health values

Parameter	2008	2013	2019 (Goal)	2020 Results	2026 (Goal)
Rake Species Identified	47	52	≥49	54	**≥51**
Visual Survey Species	51	54	≥53	60	**≥55**
Frequency of Occurrence	79.43	88.44	≥83.94	82.83	**≥83.57**
Simpsons Diversity Index	0.93	0.94	≥0.93	0.93	**≥0.93**
Ave. Native Spec/site (shallower than max depth)	2.61	2.47	≥2.54	1.87	**≥2.31**
Mean C	6.7	6.7	≥6.7	6.6	**≥6.7**
FQI	44.2	46.2	≥45.2	45.9	**≥45.4**

Action Item: Implement aquatic plant management actions that will do the most for protecting and enhancing the native plant population while controlling the target species.

Action Item: Determine appropriate management actions annually based on management and survey results from the previous year.

12.1.2 Objective 2

Prepare summary reports for annual aquatic plant surveys and management actions that can be used to help guide successive year management.

Action Item: Complete aquatic plant survey results reports annually.

Action Item: Complete End-of Year Summary Reports annually.

12.1.3 Objective 3

Measure the five year impact of AIS management actions on the native aquatic plant community in Horseshoe Lake.

Action Item: Repeat a whole lake, point-intercept, aquatic plant survey in 2025.

Action Item: Compare 2025 plant survey results to 2022 to 2026 goals, objectives, and actions to determine success or failure of management actions over a five year period.

Action Item: Review and revise the existing APM Plan for implementation in 2026.

12.2 Goal 2 – Manage existing AIS in the lake and along its shoreline in a way that minimizes its impact on the native aquatic plant community, lake use, and accessibility.

An integrated approach to management including physical removal, diver removal, and the use of herbicides will be implemented between 2023 and 2027 to keep the amount of E-HWM growth below 2.0 acres of the littoral zone in any given year. Any amount of E-HWM can be managed at any time provided chemical application is not used. If aquatic herbicides are used, treated areas must be at least 1.0 acres in size. The same treatment area will not be chemically treated in two or more consecutive years with the same herbicide. All herbicide applications will take place in the early season generally expected to be before June 15 annually.

There are two additional non-native aquatic plant species present in Horseshoe Lake. Curly-leaf pondweed is limited. Only monitoring and physical removal will be completed by District volunteers. Purple loosestrife has been identified in several locations along the shoreline of Horseshoe Lake. Monitoring for purple loosestrife will be completed by District volunteers every year and physical removal implemented.

12.2.1 Objective 1

Determine how much E-HWM is present in the lake each year.

Action Item: E-HWM bedmapping will be completed annually in the late summer by a hired contractor or trained District volunteer to identify potential areas for management consideration.

12.2.2 Objective 2

Implement E-HWM management actions to keep E-HWM below 2.0 acres each year.

Action Item: If the amount of E-HWM in any given bed is <1.0 acre, implement an integrated approach to management that includes physical removal by property owners, rake removal, snorkel, scuba diver, and potentially DASH (if resources are available).

Action Item: If the amount of E-HWM in any given bed or combined beds is ≥1.0acres, implement an integrated approach to management that includes physical removal by property owners, rake removal, snorkel, scuba diver, and potentially DASH (if resources are available), and/or the application of aquatic herbicides (if the resources are available). See p. 76 of this plan for specific bed sizes as they pertain to specific herbicides.

12.2.3 Objective 3

Measure the effectiveness and impacts of herbicide treatments on target and non-target plants within the treated areas on an annual basis.

Action Item: If aquatic plant herbicides are used for management, consider implementing a pre-treatment sub-PI survey within a proposed treatment area in the year prior to treatment, and a post-treatment sub-PI survey either in the year of treatment or the year following treatment. This action must be done if the expected treatment area(s) reaches or exceeds 10 acres of the lake.

Action Item: Complete a pre-chemical treatment readiness survey in the year of proposed management to assess the readiness of the proposed treatment area and make modification to the proposed treatment area if necessary.

Action Item: If aquatic plant herbicides are used for management, consider implementing an herbicide concentration testing program in the year of management. This action must be done if the expected treatment area(s) reaches or exceeds 10 acres of the lake.

12.2.4 Objective 4

Monitor and remove CLP in Horseshoe Lake annually

Action Item: Complete on-the-water monitoring of CLP via the CLMN AIS Monitoring Program.

Action Item: Physically remove CLP by rake, snorkel, diver, or potentially DASH when found.

12.2.5 Objective 5

Track the distribution and density of purple loosestrife along the shores of Horseshoe Lake and implement management actions annually.

Action Item: Complete a visual inspection of the entire shoreland in late July or early August and record the location of any purple loosestrife found on a map. Remove any purple loosestrife or at a minimum remove its flowering heads if possible.

12.3 Goal 3 – Reduce the threat that a new aquatic invasive species will be introduced and go undetected in Horseshoe Lake, that existing AIS will be carried to other lakes, and improve the level of knowledge property owners and lake users have related to aquatic invasive species.

Horseshoe Lake is already a source lake for E-HWM being carried out attached to boats and/or trailers and taken to other lakes. The District will continue to implement a watercraft inspection program according to WDNR/UW-Extension Lakes protocol. This program will either be paid for by the District or through a small-scale CBCW grant. Watercraft inspection data will be entered into the WDNR SWIMS database annually.

Appropriate AIS signage will be maintained at the public access on Horseshoe Lake to improve the AIS awareness of many lake users.

AIS monitoring to track the AIS already present in Horseshoe Lake and to monitor for possible new AIS will be completed following WDNR/UW-Extension Lakes protocol through the Citizen Lake Monitoring Network (CLMN) AIS Monitoring Program. Zebra mussels, spiny waterflea, hydrilla, banded mystery snails, and other species will be watched for and survey data entered into the WDNR SWIMS database annually.

The District will continue efforts to educate and inform property owners and lake users about AIS already in Horseshoe Lake and AIS not already in Horseshoe Lake. Efforts will include annual education events; distribution of AIS publications, placement of E-HWM maps at the public access, and discussion forums of various types related to management actions and alternatives.

12.3.1 Objective 1

Implement a Clean Boats Clean Waters (CBCW) water craft inspection program annually.

Action Item: Attempt to get 200 hours of paid watercraft inspection at the public access.

Action Item: Apply for small-scale CBCW grants annually to support watercraft inspection efforts.

12.3.2 Objective 2

Maintain current and complete AIS Signage at the public access on Horseshoe Lake annually.

Action Item: Inspect the public access for appropriate AIS signage annually.

Action Item: Repair, replace, and/or install current WDNR AIS signs at the public access.

12.3.3 Objective 3

Reduce the likelihood that new AIS goes undetected in Horseshoe Lake and track existing AIS for additional spread.

Action Item: Participate in CLMN AIS Monitoring at least monthly between May and October each year.

12.3.4 Objective 4

Plan, coordinate, and implement an annual AIS education event(s) alone or in cooperation with other Stakeholders.

Action Item: Seek out other stakeholders including but not limited to the Echo Lake Association, Polk County Association of Lakes and Rivers, Town, and County entities to explore cooperative education and information events.

12.3.5 Objective 5

Distribute information and education materials to property owners and lake users.

Action Item: Research AIS and lake stewardship materials with little or no cost to attain and make available at events including but not limited to Annual Meetings, Lake Fairs, Summer Picnic, etc.

12.3.6 Objective 6

Solicit public input and review of annual AIS management planning efforts.

Action Item: Complete preliminary AIS management planning by January 31 each year and post on the District webpage for public comment.

Action Item: Provide a summary of coming year AIS management plans in a spring newsletter to be published and distributed prior to April 30 each year.

Action Item: Present current year AIS management actions at the Annual Meeting held in August each year.

12.4 Goal 4 - Improve the level of knowledge property owners and lake users have related to how their actions impact the aquatic plant community, lake community, and water quality.

An important part of controlling undesirable aquatic plant growth and the production of algae is reducing the amount of nutrients (mainly phosphorus) that enters the lake. The District will attempt to get 13-15 properties to install new native plantings along the shoreline by 2026 by promoting and encouraging the implementation of simple and generally inexpensive best management practices included in the WDNR Healthy Lakes and Rivers Program. The total number of native plantings completed will be monitored by the District and reported at the end of this five year plan.

The District will continue to collect water quality data through the CLMN Expanded Water Quality Monitoring program.

12.4.1 Objective 1

Increase the amount of shoreland with a natural buffer in place by 20% (13 to 15 parcels) through native plantings and other best management practices.

Action Item: Distribute shoreland improvement education and information materials to lake property owners through the newsletter, webpage, and general mailings.

Action Item: Host and/or sponsor annual lake community events that encourage land owner participation in best management practices.

Action Item: Support property owners who wish to complete shoreland restoration or habitat improvement projects through District sponsorship of at least one Healthy Lakes grant application by 2026.

Action Item: Recognize property owners who participate in and/or complete shoreland restoration and habitat improvement projects in the newsletter, on the webpage, in local news publications, and/or at the site of the project.

12.4.2 Objective 2

Continue to collect long-term trend water quality data in Horseshoe Lake.

Action Item: Collect CLMN water quality data (water clarity, total phosphorus, chlorophyll a, and dissolved oxygen and temperature) in the Deep Hole.

12.4.3 Objective 3

Determine why Horseshoe Lake experiences significant algae blooms in the late summer and fall and take steps to mediate the situation.

Action Item: Work with the WDNR, USGS, UW-System, and other water quality experts to develop a plan to collect data that will help explain why the lake experiences significant algae blooms in the late summer and fall.

Action Item: Implement that plan with the help of WDNR surface water grant funding and Resource Professionals.

Action Item: Work toward the development of a water quality focused comprehensive lake management plan based on data collected in the previous action item.

13.0 Outside Resources to help with Future Planning

Many of the actions recommended in this plan cannot be completed solely by the District. They will continue to need the help of an outside consultant or other outside resource. Multiple outside resources and expertise exist to help guide implementation. The following is a list of outside resources that the District will need to partner with to implement the actions in this plan.

13.1.1 Barron and Polk County Departments

13.1.1.1 Land Conservation

In most cases, the Land Conservation Department for a given county has a mission is to administer land and water conservation projects to meet local priorities, conditions, and the needs of county land users. County management plans and often state-funded, cost-share programs are administered for the purpose of implementing conservation practices. These Land Conservation Departments are responsible for administering programs such as: Aquatic Invasive Species Program; Environmental Reserve Fund; short-term, grant-funded programs; providing technical assistance for all types of conservation practices; implementing information and education programs; updating various soil and water resource inventories; and nurturing partnerships with other county, state, and federal agencies.

https://www.barroncountywi.gov/index.asp?SEC=89D075CD-5873-4056-8599-65155CFB943F

https://polkcountywi.govoffice3.com/landwater?&pri=0

13.1.1.2 Forestry, Parks, and Recreation

The primary responsibilities of the Douglas County Forestry Department are to: 1) Provide stewardship to forest resources; 2) Develop and maintain recreational opportunities; and 3) Serve as an informational resource to the public. Management must balance local needs by integrating sound forestry and practices related to wildlife, fisheries, endangered resources, water quality, soil, and recreation. Forest resources are managed for environmental needs such as the protection of watersheds and rare plant and animal communities as well as the maintenance of plant and animal diversity. These same resources, however, also must provide for societal needs including recreational opportunities and production of raw materials for wood-using industries.

https://www.barroncountywi.gov/index.asp?SEC=78C8C3FE-65F1-4B98-817B-49C42D732589
https://polkcountywi.govoffice3.com/fpt?&pri=0

13.1.1.3 Cooperative Extension

County-based Extension educators are University of Wisconsin (UW) faculty and staff who are experts in agriculture and agribusiness, community and economic development, natural resources, family living, and youth development. Extension county-based faculty and staff live and work with the people they serve in communities across the State. Extension specialists work on UW System campuses where they access current research and knowledge. Collaboration between county and campus faculty is the hallmark of Cooperative Extension in Wisconsin.

https://www.barroncountywi.gov/index.asp?SEC=50C303EF-0521-438F-B290-5C0373F46D27

https://polk.extension.wisc.edu/

13.1.2 University and Collegiate

13.1.2.1 Lake Superior Research Institute – UW-Superior

The Lake Superior Research Institute (LSRI) at UW-Superior was created in 1967 and formally recognized by the UW Board of Regents in 1969. LSRI's mission is to conduct environmental research and provide services that directly benefit the people, industries, and natural resources of the Upper Midwest, the Great Lakes Region, and beyond; provide non-traditional learning and applied research opportunities for undergraduate students; and foster environmental education and outreach in the Twin Ports and surrounding communities.

Areas of expertise include: analytical chemistry; aquatic invasive species monitoring and outreach; benthic and zooplankton taxonomy; habitat restoration; microbiology; sediment and aquatic toxicology; quality assurance and data management; watershed management and planning; and wetland assessment and monitoring. Current research includes: aquatic and sediment toxicity testing, aquatic invasive species ecology, ballast water management system testing, beach monitoring and microbial source testing, biological monitoring and inventory of aquatic and terrestrial communities, endangered species management planning, habitat restoration, and mercury analysis in biota.

https://www.uwsuper.edu/lsri/index.cfm

13.1.2.2 Mary Griggs Burke Center for Freshwater Innovation

The Mary Griggs Burke Center for Freshwater Innovation (Burke Center) at Northland College in Ashland, WI focuses on scientific research, communication, and thought leadership on water issues in the Great Lakes region and beyond. The Burke Center specializes in "translating" science to the general public, government agencies, NGOs, agriculture, and the private sector, helping to edify water policy in a wide variety of geographies and subject areas. Two such areas are Integrated Ecosystem Management and Environmental Monitoring and Assessment.

Effective management of freshwater ecosystems is dependent on an understanding of how human activities and value sets intersect with the environmental processes that sustain water resource integrity. Their work focuses on integrating approaches from the natural and social sciences to conduct and develop integrated assessments and management plans for freshwater ecosystems.

Public decision-making surrounding water resources is dependent on a range of data that describe the condition of freshwater ecosystems and the current—and potential future—stressors that may impact their integrity. Their work focuses on the use of environmental monitoring and analytical technologies to develop long-term data sets to support public decision-making for freshwater resources. The Burke Center is involved in multiple projects that collect and analyze a variety of data including bacteria, e-coli, zooplankton, aquatic plants, wild rice, water quality, etc.

https://www.northland.edu/centers/mgbc/

13.1.2.3 Center for Land Use Education

The Center for Land Use Education (CLUE) is a joint venture of the College of Natural Resources at the UW-Stevens Point and the UW-Madison Division of Extension. It is a focal point for land-use planning and management education. Through applied research, teaching and outreach, CLUE specialists and faculty support students, local government officials, communities and K-12 audiences on a variety of land and water topics including planning and zoning, land divisions, fragmentation, sustainability, bio- and renewable energy, food systems, shorelands and wetlands. By providing up-to-date and comprehensive training on planning and zoning tailored to address specific local needs, CLUE specialists are able to assist towns, villages, cities and counties in making sound land use decisions.

https://erc.cals.wisc.edu/programs/center-for-land-use-education/

13.1.2.4 Center for Watershed Science and Education

The Center for Watershed Science and Education (CWSE) at UW-Stevens Point supports watershed understanding and stewardship across and beyond the state of Wisconsin. The center includes specialists with expertise in groundwater, lakes, streams, water chemistry and analysis, and data science. The center helps individuals, organizations and private and public water resources professionals understand water quality and quantity in private wells, groundwater, lakes and rivers. Through their programming, center staff provides guidance on sampling and data collection, education on water quantity and quality, and interpretation and evaluation of monitoring results. The center also performs applied research and creates data visualization tools to improve watershed understanding.

Current research explores the movement of nitrate-nitrogen in soil and groundwater, the quantity and chemistry of groundwater, changes in lake water quality and the occurrence of pharmaceuticals and new pesticides in the water.

https://erc.cals.wisc.edu/programs/center-for-watershed-science-and-education/

13.1.2.5 Center for Limnological Research and Rehabilitation

The Center for Limnological Research and Rehabilitation (CLRR) at UW-STOUT focuses on eutrophication issues and management solutions for freshwater systems. They provide limnological research services to the surrounding community, including: diagnosing eutrophication-related problems in lakes and reservoirs; conducting comprehensive hydrologic and limnological monitoring programs; identifying and quantifying important phosphorus sources that drive cyanobacterial blooms; and developing and implementing management plans to sustainably rehabilitate degraded aquatic systems.

Their laboratory facilities provide an array of analytical capabilities for the examination of nutrients (primarily phosphorus species) and algae in water and sediment. They have a variety of field monitoring equipment for quantifying tributary flow and phosphorus loads discharging into lakes, boats and sampling equipment for monitoring lake chemistry and biology, and coring capabilities for the examination of aquatic sediment. In particular, they have unique expertise for determining important mobile phosphorus fractions in aquatic sediments and nutrient exchanges between sediments and the overlying water.

https://www.uwstout.edu/directory/center-limnological-research-and-rehabilitation

13.1.2.6 Natural Resources Education Program

13.1.2.6.1 NRE Water Programming - Leading and facilitating water quality projects across the state

Natural Resource Educators (NRE) are providing leadership on nutrient reduction and water quality projects across the state. Key efforts include outreach to increase local capacity to reduce nonpoint source pollution in the Lower Fox, Wisconsin, St. Croix, Red Cedar and Rock River watersheds and the Lower Fox River Demo Farm Network initiative. Projects are carried out in collaboration with federal, state and local partners as well as producer-led watershed initiatives. The Demo Farm initiative works with farmers and their advisers to conduct on-farm demonstrations that measure and share the effectiveness of conservation practices to reduce erosion and sediment runoff, control phosphorus runoff and address other nonpoint sources of pollution.

13.1.2.6.2 *NRE Forestry Programming - Engaging private woodland owners to encourage sustainable forest management.*

ERC-based Natural Resources Educators and key partners are leading classes (Learn About Your Land and Your Land, Your Legacy) and other efforts to engage landowners in the sustainable management of Wisconsin's privately-owned forests. NREs create content for landowners on a variety of topics in publication, video, and website formats.

https://erc.cals.wisc.edu/programs/regional-natural-resources-education-program/

13.1.2.7 Aquatic Invasive Species Outreach

Wisconsin's aquatic invasive species (AIS) program focuses on preventing the introduction of new invasive species to Wisconsin, containing the spread of invasives that are already in the state, and managing established populations when possible. In close cooperation with the Wisconsin Department of Natural Resources and Extension Lakes program, UW– Madison Division of Extension education efforts focus on working with resource professionals and citizens statewide to teach boaters, anglers and other water users the steps they should take to prevent transporting aquatic invasives to new waters. Efforts also address other potential mechanisms of introduction, including aquarium pet release and water gardening.

https://erc.cals.wisc.edu/programs/aquatic-invasive-species-outreach/

13.1.2.8 UW-Extension Lakes Program

Based at UW-Stevens Point, the Extension Lakes Program seeks to preserve Wisconsin's legacy of lakes through education, communication and collaboration. The program works with over 800 local lake associations and lake districts in Wisconsin, assisting them through education and capacity building. Lakes also partners with the Wisconsin DNR to coordinate a number of programs and projects to assist those concerned with the future of our lakes, including the Citizen Lake Monitoring Network, the Clean Boats, Clean Waters program and the Lake Leaders Institute. The *Lake Tides* newsletter reaches thousands of readers throughout the region.

https://erc.cals.wisc.edu/programs/extension-lakes-program/

14.0 Implementation and Evaluation

This plan is intended to be a tool for use by the District to move forward with aquatic plant management actions that will maintain the health and diversity or Horseshoe Lake and its aquatic plant community. This plan is not intended to be a static document, but rather a living document that will be evaluated on an annual basis and updated as necessary to ensure goals and community expectations are being met. This plan is also not intended to be put up on a shelf and ignored. Implementation of the actions in this plan through funding obtained from the WDNR and/or District funds is highly recommended. An Implementation and Funding Matrix is provided in Appendix B.

15.0 Wisconsin Department of Natural Resources Grant Programs

The WDNR Surface Water Grant Program can provide cost-sharing for aquatic plant management actions assuming they are being implemented under the guidelines of a WDNR approved Aquatic Plant Management Plan. Under the Aquatic Invasive Species (AIS) Population Control grant category, up to 75% of management and planning costs can be reimbursed. This grant program requires sponsor match and formal application for the funding. Funding awards are not a sure thing, as WDNR grants are a competitive program with way more funding requests each year than there is money to give.

For more information about WDNR Surface Water Grants go to: https://dnr.wisconsin.gov/aid/SurfaceWater.html.

16.0 Works Cited

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