WOLF LAKE MANAGEMENT PLAN

October 2022

WOLF LAKE ADVISORY GROUP

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PROCEDURE FOR MODIFYING LAKE MANAGEMENT PLAN

The Wolf Lake Property Owners Association (WLA) will maintain an agenda item of "modifying lake management plan" on its meeting notices.
Suggested changes or additions will be made at least once every five years and approved by the Lake Management Plan Committee. Per procedure, the updates to the plan will be sent out for public review before final approval.

BASELINE INFORMATION

Wolf Lake is a 49-acre natural seepage lake located in the Town of Jackson, Adams County, in the Central Sands Area of Wisconsin. A "seepage lake" is a natural lake with no stream inlet or outlet and fed by precipitation, runoff and groundwater. It is one of many lakes in the Town of Jackson, most of which are seepage lakes similar to Wolf Lake.

Wolf Lake is part of the Neenah Creek Watershed, a large watershed of 182 square miles from which water flows into the Fox River and eventually into Lake Michigan. The Central Sand Hills, which contain Wolf Lake, are an ecological landscape (a recessional moraine) on the eastern edge of what was Glacial Lake Wisconsin. The area is characterized by glacial moraines and glacial outwash, as well as the kettle holes that formed natural lakes—such as Wolf Lake. Elevations average between 900 to 1000 feet above sea level. Wolf Lake is a no-motor lake for boat traffic.

There are four Native American burial mound groups in the watershed. Both federal and state laws prohibit further disturbance of these sites without permission of the federal government and input from the local tribes.

Land Use in Surface and Ground Watersheds

Land Use is very important in looking at ways to maintain or improve water quality. Studies have shown that types of land use affect sedimentation rate, erosion rate and runoff rate (with included pollutants). Increased sedimentation can not only fill in shallow areas of water, but also causes excessive turbidity that harms aquatic life by destroying habitat and smothering oxygen. Increased runoff carries with it pollutants besides sediments, including pathogens, nutrients that affect algal & aquatic plant growth (nitrogen & phosphorus), pesticide residue, fertilizer chemicals, organic matter, metals, petroleum products and road salt. Increased runoff can also reduce ground water recharge and increase shore erosion. Addition of such substances not only degrades water quality and habitat, but also limits aesthetic and recreational enjoyment.

Studies also suggest that an increase in impervious surface around a waterbody of 20% may negatively impact water quality. Impervious surfaces include areas such as pavements, roofs, decks, sidewalks, compacted soil, cement patios, etc. Similarly, traditional closely-mowed lawns, as opposed to unmown lawns or native vegetation, tend to have high runoff rates and low infiltration rates. Soil types may also influence runoff amounts. Runoff from general

residential (i.e., not necessarily highly-developed) was twice as much as runoff from forested land. Runoff in highly-developed areas may be up to fourteen times more than forested lands and twice as much as from agricultural lands. With a partly-developed residential shore and steep hills, residential runoff at Wolf Lake could be one of the main negative impacts on its overall water quality in the future if steps are not taken to address this problem.

Original upland vegetation of the area around Wolf Lake included oak-forest, oak savanna, pine barrens and tallgrass prairie. Wetland areas were also common, including wet-mesic prairies, wet prairie, coastal plain marshes and fen. Hills and kettles created by glacial deposits make up the southeast area of Adams County, where Wolf Lake is located.

The Adams County Land & Water Conservation Department conducted a land use evaluation for both the ground and surface watersheds of Wolf Lake. Both the surface and ground watersheds of Wolf Lake are fairly small. Overall, the two most common current land uses in the Wolf Lake watersheds are woodlands and residences. In the surface watershed, non-irrigated agriculture is substantial.

Figure 1: Watersheds Land Use 2022
https://adams-county-wi.maps.arcgis.com/

Land use varied between the surface and ground watersheds of Wolf Lake. The ground watershed, which is quite small, was mainly residential (45.0%) and woodlands (34.7%). The remaining land uses were water (18.1%) and open land (1.2%). However, while the ground watershed was dominated by woodlands (56.5%), non-irrigated agriculture was also significant (13.1%), as were residential areas (19.2%). There were more open lands in the ground watershed (3.8%), but water was a smaller factor (7.4%).

A number of wetlands are located in the Wolf Lake surface and ground watersheds. In the past, wetlands were seen as "wasted land" that only encouraged disease-transmitting insects. Many wetlands were drained and filled in for cropping, pasturing, or even residential development. In the last few decades, however, the importance of wetlands has become evident, even as wetlands continue to decline in acreage. More than 1/3 of the lake has wetlands at or near the shore that serve as filters and trappers that help keep the lake as clean as it is. It is essential to preserve these wetlands for the health of Wolf Lake.

Prior modeling indicated that phosphorus input from the watershed into the lake is mostly agriculture and residential, with each about 35%. Thus, concentrating on these two land uses are likely to reap the most results in maintaining the high water quality at Wolf Lake.

Shores

Wolf Lake has a total shoreline of 1.4 miles (7392 feet). About 1/3 of the northern shore is owned by the Wisconsin Department of Natural Resources and has been left unaltered. Included in that area are a bog and a sedge meadow. Areas immediately at the shore are steeply sloped.

The balance of the shore consists of privately-owned lots and a boat ramp area owned by the Town of Jackson. Two different developers developed that part of Wolf Lake's shoreline. Both included covenants that required buildings to be erected using native materials, mostly wood. Most of the areas near the shore are steeply sloped, except at the far northeast end, where the land is flatter. Buildings are generally located 70 or more feet back from the shore.

A 2004 inventory included classifying areas of the Wolf Lake shorelines as having "adequate" or "inadequate" buffers. An "adequate" buffer was defined as one having the first 35 feet landward covered by native vegetation. An "inadequate" buffer was anything that didn't meet the definition of "adequate buffer", including native vegetation strips less than 35 feet landward. Using these definitions, 32.6% (about 2510 feet) of Wolf Lake's shoreline had an "adequate buffer", leaving 67.4% (4882 feet) as "inadequate." Most of the "inadequate" buffer areas were found with traditional mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line. Many of these could easily be met by not mowing as close to the shore.

Adams County Shoreland Ordinance requires all waterfront property to have a 35 foot landward buffer as of July 1, 2015. Property owners on Wolf Lake who didn't meet the requirements at that time were contacted by the Adams County Land & Water Conservation Department for technical and financial assistance in buffer restoration. New property owners that have insufficient buffers should contact ACLWC for more information and assistance on restoring the shoreline buffer.

Morphology, Sediment and Soils

Wolf Lake has an oval basin with a moderately-sloped littoral zone over most of the lake and a gradually sloped littoral zone in the southeast corner. Gradual slopes provide a more stable rooting base and broader area of shallow water that would favor plant growth.

The dominant sediment in Wolf Lake was marl, especially at depths greater than 10 feet. A hard, high-density sediment, sand, was common in the shallow zone; mixed with silt, it was dominant in the shallow zone. Silt/marl mixtures were common at depths of 1.5-10 feet.

Except for some pockets of muck and silt loam, the soils in the surface and ground watersheds for Wolf Lake are loamy sand and sand, with slopes from very flat up to 25%. Sandy soils occupy 15.4% of the ground watershed and 35.3% of the surface watershed. 32.83% of the ground watershed is covered with loamy sand, which also covers 44.6% of the surface watershed.

Critical Habitat

Two areas on Wolf Lake have been designated as "critical habitat" area by the WDNR. Wisconsin Rule 107.05(3)(i)(I) defines these as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, sensitive areas often can provide the peace, serenity and beauty that draw many people to lakes in the first place.

CHD1 extends along approximately 425 feet of the southeastern shoreline of Wolf Lake, up to the ordinary high water mark. Sediment includes marl, sand, silt and mixtures thereof. 65% of the shore is wooded; 5% is native herbaceous cover; the remaining shore is hard structure and rock riprap. Large woody cover is common for habitat. With little human disturbance along this shoreline, the area has natural scenic beauty.

CHD2 extends along approximately 1900 feet of the northern shoreline. This area extends landward from the shore to cover the deep marsh and wetlands located near the shore. Sediment includes marl, peat, silt and mixtures thereof. 46.43% of the shore is wooded; 14.28% has shrubs; 20% is native herbaceous cover. The remaining shoreline is rock,

cultivated lawn and hard structure. Sedge meadow and deep marsh wetlands are found along this shoreline. Large woody cover is abundant for habitat. With no human disturbance along this shoreline, the area has natural scenic beauty.

Contact Wolf Lake Property Owners Association or DNR website for more information on understanding and maintaining the Critical Habitat areas.

Figure 2: Critical Habitat Map

Fishery/Wildlife/Endangered Species

In 2012, a rare endangered *Charophtye*, *Lychnothmanus barbatus*, was discovered in Wolf Lake while looking for an unusual *Nitella.* This was the first time this *Charophyte* had ever been found in the Western Hemisphere of the world A sediment core at Wolf Lake indicated that it had been in Wolf Lake since before people settled in Adams County. Since the discovery in Wolf Lake, it the same species has been found in several other lakes in Adams County. Studies about this plant-like algae are currently underway.

A 1948 fishery inventory of Wolf Lake described it as "a small bass lake, fertile, hard water, moderate plankton, with heavy fishing pressure." Bluegills were the most abundant fish found then. At that time, it was also recommended that trout no longer be stocked in Wolf Lake.

Stocking of fish by the WDNR in Wolf Lake started in 1937 with smallmouth bass, perch and bluegill. Annual stocking of bluegills, crappie, largemouth bass and/or perch continued through 1942. Stocking resumed in 1946 with sunfish and largemouth bass and continued through 1949. A few brown trout were stocked in 1991. Largemouth bass and bluegill are generally found in great numbers, but bullheads, perch, rock bass and pumpkinseed are scarce. Fish cribs were installed in the lake in 1997 to encourage reproduction. Perch were stocked through a Conservation Aids grant from Adams County Land & Water Conservation Department in 2005-2006.

Public Use and Value

In 2011, the WLA conducted a mailed citizen survey about lake issues to landowners in both the surface and ground watersheds. 45% of the respondents were full-time residents. 67% had full-time residence in Wisconsin. Most of the respondents lived on the lake. 65% had owned the property more than 16 years. The main three reasons respondents had chosen to purchase land in the Wolf Lake vicinity were water quality (70%), scenic quality (48%) and proximity to their main residence (48%).

The most common activities around the lake engaged in by the respondents were boating (61%), fishing (65%), wildlife viewing (65%), and scenic enjoyment (70%). Since Wolf Lake is a no-motor lake, the most common type of boat used on the lake was a foot paddle boat (74%). However, kayaks and rowboats were also frequently used (61% each). 72% of the respondents used their boating equipment only on Wolf Lake.

100% of the respondents rated the water quality of Wolf Lake "good" or "very good". Most of them (68%) felt the water quality had remained steady over the years. The major issue of concern was the level of aquatic plant growth (87%), followed by the issue of algae/scum on the water (39%). 52% of the respondents believed the amount of aquatic plant growth had increased.

Fishing, one of the main uses of the lake, was rated as "good" or "very good" by 44% of the respondents. 56% of those answering felt its quality had remained the same, but 44% felt fishing quality had declined.

80% of the septic systems were over 10 years old, with the most common size being 500 to 1000 gallons (80%). 91% of the respondents had only 1 or 2 people using the property. The most common size of waterfront was 50 to 100 feet (88%).

A public meeting was held to gain further information. Aquatic plant control and monitoring were identified at that meeting as the priority issues. Other issues of concern included fishing management, navigational difficulties in some of the bays, maintenance of the lake as a no-motor lake, and development of a newcomer packet.

Lake Chemistry

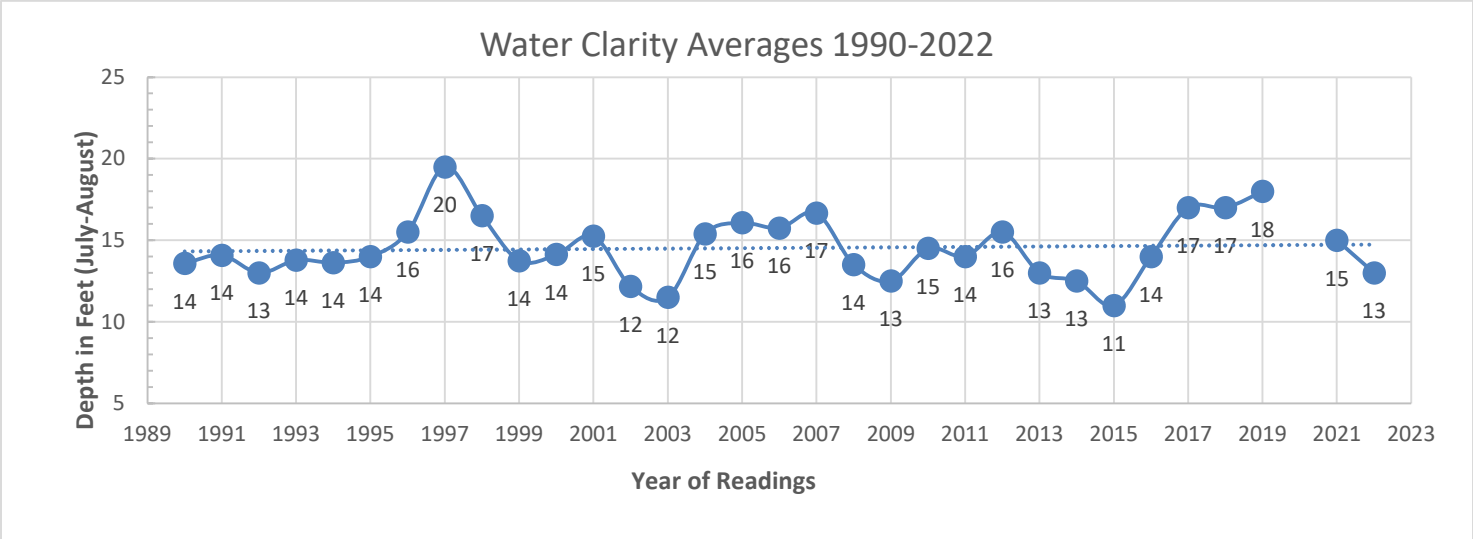
One indicator of water quality is a lake's trophic status, an index for measuring a lake's nutrient status. Oligotrophic lakes have clear, often cold, water with low overall productivity and very desirable fisheries of large game fish. Eutrophic lakes have poor water clarity, with high production of plants and frequent algal blooms likely. Eutrophic lakes also may have fish kill histories due to oxygen depletion and often have rough fish, such as carp, that contribute to the "muddiness" of the lake water. Mesotrophic lakes are those in between oligotrophic and eutrophic lakes, with more production and accumulated organic matter than oligotrophic lakes, but only occasional algal blooms, and a good mixed fishery.

There are three lake chemistry readings that Wisconsin has traditionally used to determine a lake's trophic status. These are Secchi disk readings, which test water clarity; total phosphorus level, which indicates the amount of phosphorus available for aquatic plant and algae production; and chlorophyll-a, which correlates to algal blooms. Wolf Lake has had volunteers taking such information for many years. In addition, measurements were taken several times by Adams County Land & Water Conservation Department from 2004 to 2006. Citizen volunteers have continued to participate in the Citizen Lake Monitoring Program to test the lake waters at least three times per growing season through 2022.
Data presented is taken from the "growing season" which is July and August data only. All data can be found on the Wisconsin DNR website, Citizen Lake Monitoring Reports
https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=013143

Secchi Disk Readings:

Due to a couple of very diligent volunteers, Wolf Lake has a long, fairly regular, history on water chemistry. Timely monitoring has been occurring since 1990. The overall average growing season water clarity level in Wolf Lake from 1990 through 2022 was 14.5 feet, in the "very good" category.

Figure 3: Water Clarity Averages

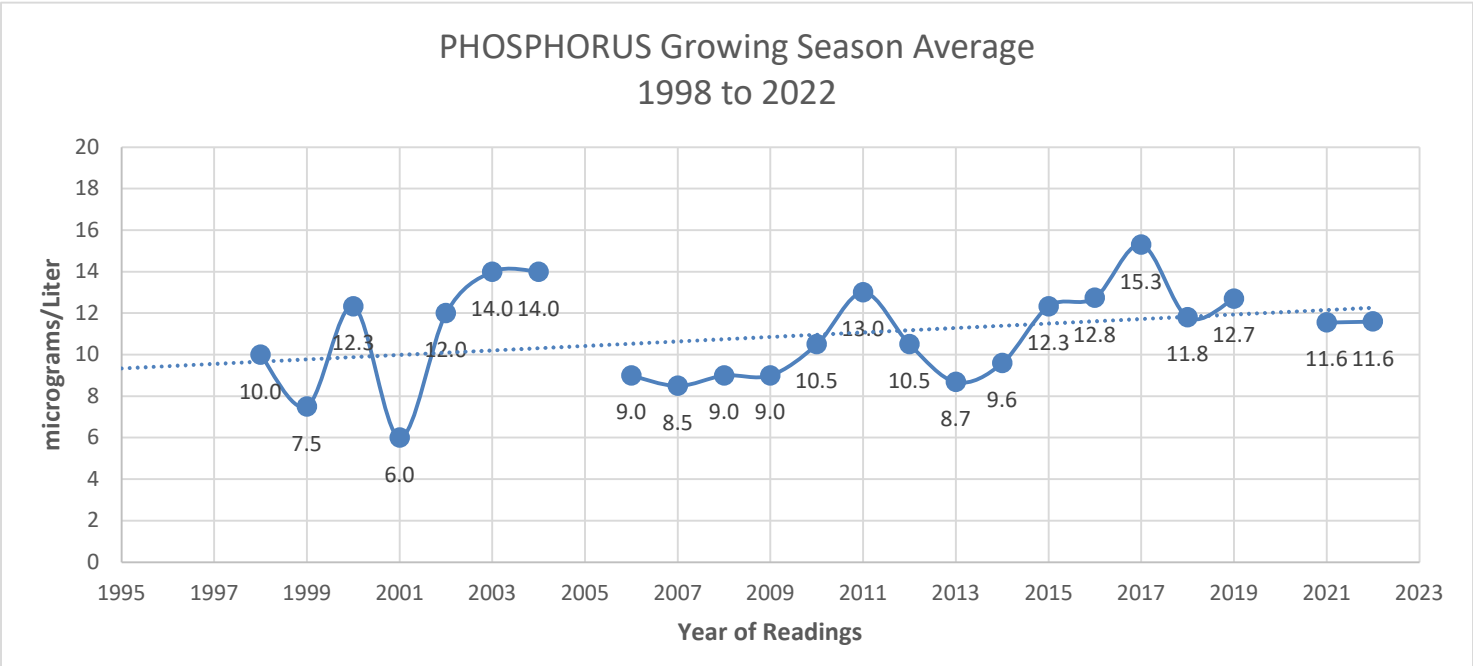


Total Phosphorus Readings:

The readings for growing season total phosphorus in Wolf Lake tend to be low. The overall average from 1998 through 2022 was 10.9* micrograms/liter, in the "good" category.

* August 2022 data not collected

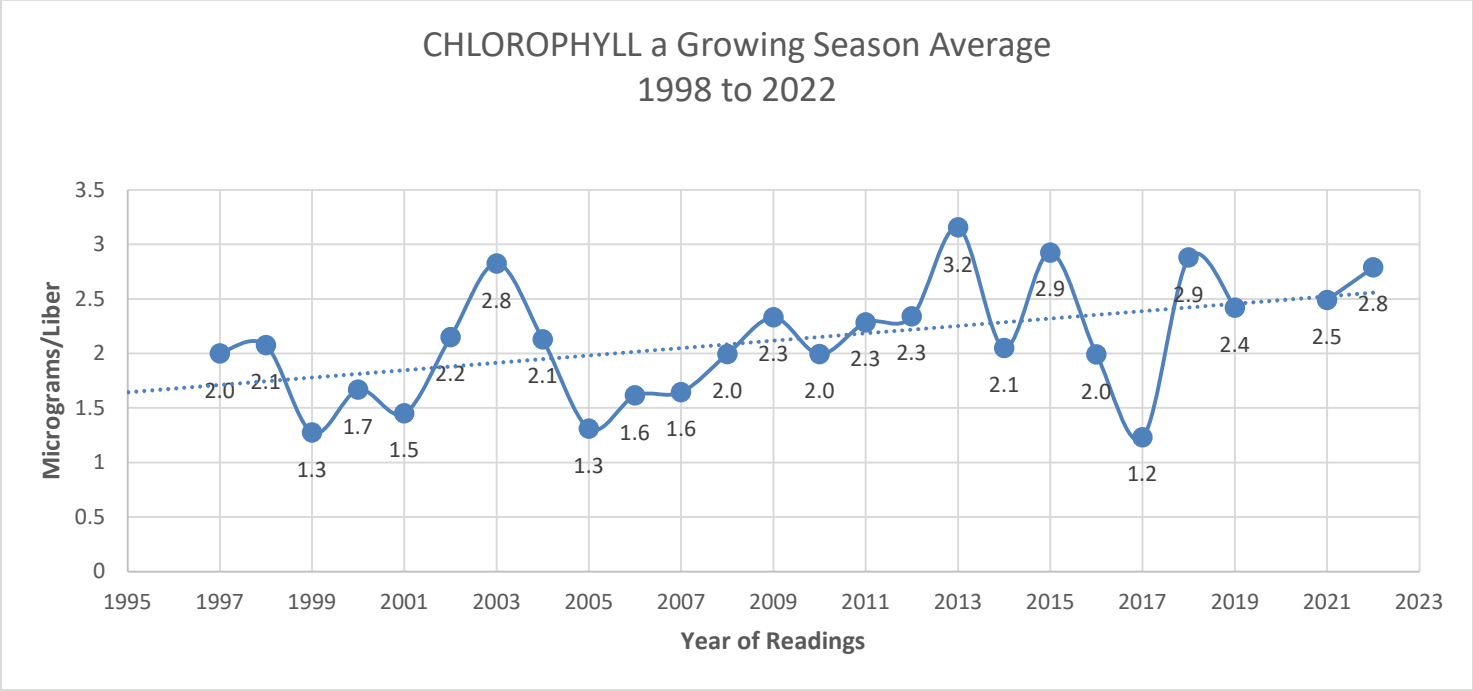
Figure 4: Total Phosphorus Averages



Chlorophyll a

Chlorophyll a is the third factor often used in evaluating water quality, since studies have shown it is correlated with algal bloom frequency. The growing season average for Wolf Lake from 1990 through 2022 was 2.1 micrograms/liter, which falls in the "very good" category.

Figure 5: Chlorophyll-a Averages



Trophic State Index

The three "trophic" parameters suggest that Wolf Lake is an oligotrophic/ mesotrophic, maintaining very good water clarity, good total phosphorus levels and very good Chlorophyll a readings. For 2022 the overall Trophic State Index (based on chlorophyll) for Wolf Lake - Deep Hole was 43. The TSI suggests that Wolf Lake - Deep Hole was mesotrophic. Mesotrophic lakes are characterized by moderately clear water but have an increasing chance of low dissolved oxygen in deep water during the summer.

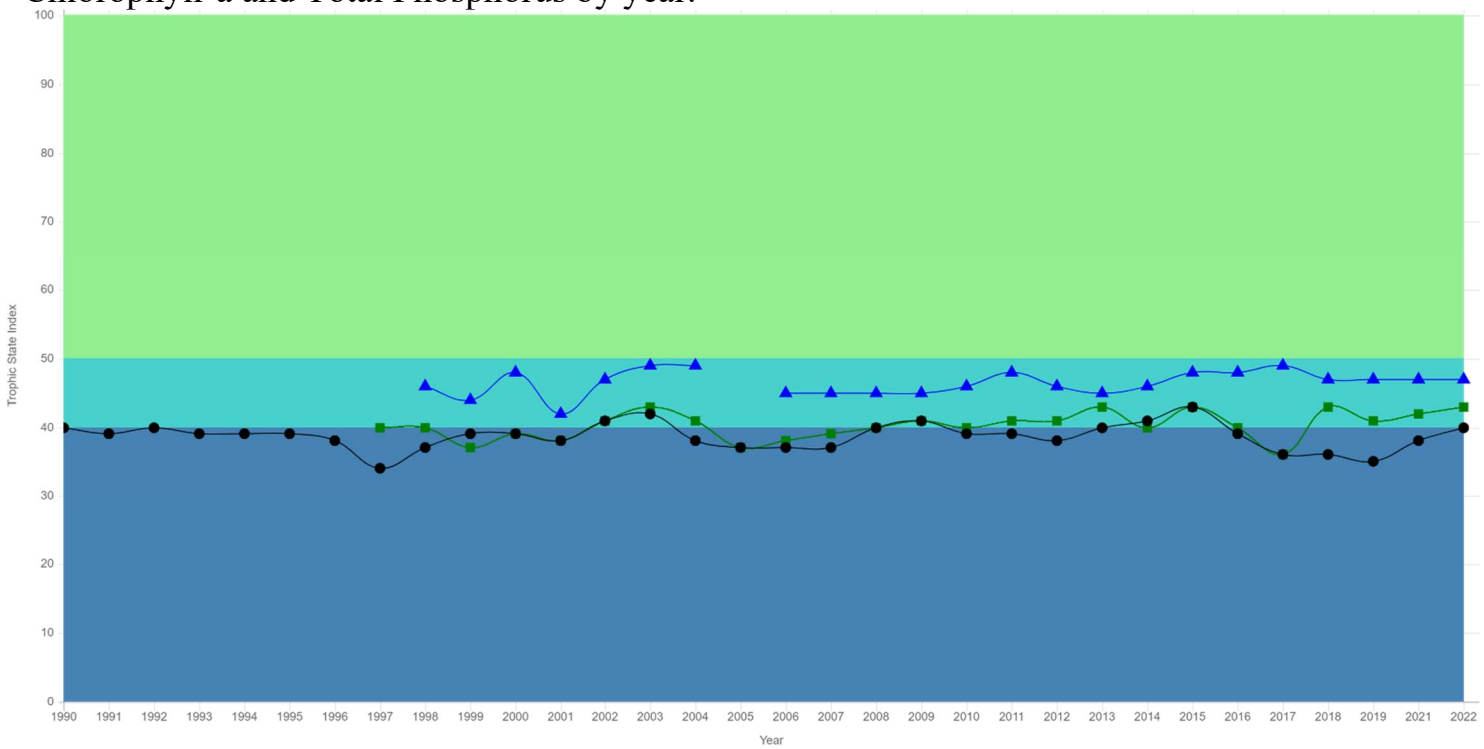
Trophic State	TSI	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/l)	(ug/l)	(m)
Oligotrophic	<30 to 40	0 to 12	0 to 2.6	> 8 to 4
Mesotrophic	40 to 50	12 to 24	2.6 to 7.3	4 to 2
Eutrophic	50 to 70	24 to 96	7.3 to 56	2 to 0.5
Wolf Lake		**10.9**	**2.1**	**14.5 ft/4.4m**

SI	TSI Description
TSI < 30	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
TSI 30-40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
TSI 40-50	Water moderately clear but increasing chance of low dissolved oxygen in deep water during the summer.
TSI 50-60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
TSI 60-70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
TSI 70-80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
TSI > 80	Algal scums, summer fish kills, few plants, rough fish dominant. Very poor water quality.

Trophic state index (TSI) is a score from 0 to 110, with lakes that are less fertile having a low TSI. We base the overall TSI on the Chlorophyll TSI when we have Chlorophyll data. If there is no chemistry data, the TSI Secchi is used. This is done rather than averaging, because the TSI is used to predict biomass. This makes chlorophyll the best indicator.

Figure 6: Trophic State Index

Displays average summer (July-August) Trophic State Index (TSI) values for Secchi, Chlorophyll-a and Total Phosphorus by year.



Past Summer (July-August) Trophic State Index (TSI) averages.

■=TSI(Chl) ▲= TSI(TP) ●= TSI(Sec)

Aquatic Plants

Several aquatic plant surveys have been done on Wolf Lake, with the most recent one completed in 2022. In 2005, the dominant species were *Elodea Canadensis* (common waterweed), followed by *Chara* (muskgrass) and *Najas guadelupensis* (Southern naiad). Another plant survey was conducted in 2006, using a different collection method. At that time, *Najas flexilis* (bushy pondweed) dominated, but it was closely followed by *Elodea canadensis*, *Ceratophyllum demersum* (coontail), and *Chara.* In the 2010 surveys, *Chara* dominated, followed by *Myriophyllum sibiricum* (Northern watermilfoil), *Chara*, and *Najas flexilis.* In 2015, *Chara* again dominated the aquatic community. Far beyond, but most common after Muskgrass, were *Nymphaea odorata* (White Water Lily) and *Potamogeton natans* (Floating-Leaf Pondweed).

Submergent plants dominate the Wolf Lake aquatic plant community, making up 73% of the aquatic plant population in 2015. However, the lake also has a significant emergent plant population, especially in areas of the lake where no buildings have been installed.

Forty-three species were found in 2015. This was somewhat lower than the numbers found in 2010, the last surveys done, but the lake level was lower in 2015, leading to several emergent plants not being counted in 2015 because they were no longer in the water. Reed Canarygrass (*Phalaris arundinacea*) and Eurasian Watermilfoil (*Myriophyllum spicatum*). Of these two, Eurasian Watermilfoil is the more widely-spread. The WLA has treated it chemically for the last 20 years to reduce the population. However, the plant remains present in the lake and has recently hybridized with the native Northern Milfoil.

In the 2022 survey, 17 species were collected/sighted. Reed Canarygrass, Eurasian Watermilfoil and Northern Milfoil were not sighted in this survey.

Wolf Lake was the first lake in the Western Hemisphere where the most endangered Charophyte in the world was discovered in 2010 by accident. While looking for an unusual Nitella species, Lychnothamnus barbatus (Bearded Stonewort) was found instead. It is not yet known whether this species is native to Central Wisconsin. Since it was found in Wolf Lake in 2010, it has been found in seven other lakes in Adams County, as well as five lakes in Waushara County and one in Sauk County. This discovery was recently discussed in an article in the American Journal of Botany, 104:1108-1116 (July 2017) called "First Discovery of the Charophycean Green Algae *Lychnothamnus barbus* (Charophyceae) Extant in the New World (K. Karol et al).

Figure 8: Aquatic Plants Found in Wolf Lake

Scientific Name	Common Name	2006 (t)	2010 (t)	2006 (pi)	2010 (pi)	2015 (pi)	2022 (pi)
Ascelpias incarnata	Swamp Milkweed				X		
Aster umbellatus	Hairy Flat-Topped Aster				X		
Bidens comosus	Swamp Tickseed		X		X		
Bidens frondosus	Common Beggars-Tick		X				
Carex spp	Sedge		X		X	X	
Carex comosa	Bristly Sedge		X		X		
Ceratophyllum demerusum	Coontail	X	X	X	X	X	X
Chara spp.	Muskgrass (Stonewort)	X	X	X	X	X	X
Chara aspera	Rough Stonewort					X	
Chara globulatis	Globular Stonewort					X	X
Cicuta bulbifera	Bulb-Bearing Water Hemlock				X	X	
Cladium marisicoides	Twig Rush					X	
Comarum palustre	Marsh Cinquefoil					X	
Cornus racemosa	Gray Dogwood		X				
Dulchium arundinaceaum	3-Way Sedge		X			X	
Eleocharis acicularis	Needle Spikerush	X	X			X	
Eleocharis palustris	Common Spikerush	X	X	X	X	X	
Elodea canadensis	Common Waterweed	X	X	X	X	X	
Elodea spp	Waterweed						X
Epilobium coloratum	Cinnamon Willow Herb		X		X		
Eupatorium perfoliatum	Boneset		X		X	X	
Euthamia graminifolia	Grass-Leaved Goldenrod		X		X		
Impatiens capensis	Jewelweed		X		X		
Iris versicolor	Blue-Flag Iris	X	X	X	X	X	
Juncus spp	Rush		X		X	X	
Lemna minor	Lesser Duckweed	X	X	X	X		
Lycopus uniflorus	Northern Bugleweed		X		X		
Lychnothamnus barbatus	Bearded Stonewort (Charophycean green alga)					X	X
Myriophyllum heterophyllum	Various-Leaved Milfoil		X		X		
Myriophyllum sibiricum	Northern Milfoil	X	X	X	X	X	
Myriophyllum spicatum	Eurasian Watermilfoil	X	X	X	X	X	X
Najas flexilis	Bushy Pondweed	X	X	X	X	X	X
Najas guadalupensis	Southern Naiad		X		X	X	
Nitella spp	Stonewort	X		X	X	X	X
Nymphaea odorata	White Water Lily	X	X	X	X	X	X
Phalaris arundinacea	Reed Canary grass	X	X	X	X	X	
Polygonum amphibium	Water Smartweed		X		X	X	
Polygonum lapathifolium	Hearts Ease		X		X		
Potamogeton amplifolius	Large-Leaf Pondweed	X	X	X	X	X	X
Potamogeton crispus	Curly-Leaf Pondweed	X		X			
Potamogeton foliosus	Leafy Pondweed		X		X		
Potamogeton diversifolious	Water-Thread Pondweed	X					
Potamogeton friesii	Fries' Pondweed		X		X	X	

Scientific Name	Common Name	2006 (t)	2010 (t)	2006 (pi)	2010 (pi)	2015 (pi)	2022 (pi)
Potamogeton gramineus	Variable Pondweed	X	X	X	X	X	X
Potamogeton illinoensis	Illinois Pondweed	X	X	X	X	X	X
Potamogeton natans	Floating-Leaf Pondweed	X	X	X	X	X	X
Potamogeton praelongus	White-Stemmed Pondweed	X	X	X	X	X	
Potamogeton pusillus	Small Pondweed	X		X	X	X	X
Potamogeton pusillus spp pusillus	Small Pondweed					X	
Potamogeton richardsonii	Clasping-Leaf Pondweed		X		X	X	
Potamogeton robbinsii	Fern-Leaf Pondweed					X	
Potamogeton zosteriformis	Flat-Stemmed Pondweed	X	X	X	X	X	X
Ranunculus longirostris	Beaked Crowfoot	X					
Sagittaria spp.	Arrowhead	X		X	X	X	X
Sagitttaria latifolia	Common Arrowhead		X				
Salix spp	Willow		X		X	X	
Schoenoeplectus spp	Bulrush	X		X			
Schoenoplectus acutus	Hard-Stemmed Bulrush					X	
Schoenoplectus pungens	Chairmaker's Rush		X				
Schoenoplectus tabernaemontani	Soft-Stemmed Bulrush		X		X	X	
Scirpus atrovirens	Black Bulrush				X		
Scirpus pendulus	Rufous Bulrush				X		
Solanum dulcamara	Bitter Nightshade		X		X	X	
Spirodela polyrhiza	Greater Duckweed		X				
Stuckenia pectinata	Sago Pondweed		X	X	X		X
Traidenum fraseri	Bog St. John's Wort				X		
Typha angustifolia	Cattail	X	X	X	X	X	
Utricularia gibba	Creeping Bladderwort		X				
Utricularia minor	Lesser Bladderwort		X				
Utricularia vulgaris	Greater Bladderwort		X		X	X	
Vallisneria americana	Water Celery		X		X		
Verbena hastata	Blue Vervain				X		
Wolffia columbiana	Watermeal				X	X	
Zosterella dubia	Water Stargrass		X		X		
Freshwater Moss		X					
Freshwater Sponge			X				
Filamentous algae							X

t - Transect survey
pi - Point Intercept survey

Summary of Statistics for 2022 Survey	
Total number of sites visited (total number of sites where the boat stopped, even if much too deep to have plants)	184
Total number of sites with vegetation (total number of sites where at least one plant was found)	108
Maximum depth of plants (the depth of the deepest site sampled at which vegetation was present)	26.00 ft

Total number of sites shallower than maximum depth of plants (number of sites where the depth was less than or equal to the maximum depth where plans were found)	135
Frequency of occurrence at sites shallower than maximum depth of plants (number of times a species was seen divided by the total number of sites shallower than the maximum depth of plants)	80
Simpson Diversity Index (a nonparametric estimator of community heterogeneity. It is based on Relative Frequency and thus is not sensitive to whether all samples sites (including non-vegetated sites) are included - the closer the Simpson Diversity Index is to 1, the more diverse the community)	0.86
Average number of all species per site (shallower than max depth)	1.41
Average number of all species per site (vegetated sites only)	1.77
Average number of native species per site (shallower than max depth)	1.39
Average number of native species per site (vegetated sites only)	1.73
Species richness (the number of species collected)	15
Species Richness Including Visuals (total number of species collected including visual sightings)	17
Floristic Quality Index (FQI) - a tool used to assess an area's ecological integrity based on its plant composition	19.341

Notes on 2022 survey: the list of species that was observed does not include a lot of the species that have been listed previously. This was not an oversight, but instead a different method of sampling. The previous P.I. survey data from 2006-2015 includes species that were visually observed along the shoreline. The 2022 survey strictly focused on identifying aquatic vegetation that is "in" the lake. It is also important to keep in mind that there are gaps in the lake between the locations on our survey maps, so realistically, there could definitely be missing plants. One thing to note, is that the PI surveys conducted by the person in the position at that previous times were not necessarily following DNR protocols for P.I. surveys. This does not invalidate the data gathered, but basically puts an asterisk next to any of those surveys.

Aquatic Invasives

Wolf Lake has three verified aquatic invasive plants: Eurasian Watermilfoil (*Myriophyllum spicatum*); Hybrid Eurasian Watermilfoil; Reed Canarygrass (*Phalaris arundinacea*). Reed Canarygrass has remained a small part of the aquatic plant community. Eurasian Watermilfoil has also remained fairly stable but has also been the subject of almost annual chemical treatments. It is also known that the invasive has hybridized with the native milfoil in some places in the lake.

Two invasive animals have also been found in Wolf Lake: Chinese Mystery Snails and Banded Mystery Snails. So far, they have not reached a level that they appear to be interfering with native populations.

Aquatic plant management

Aquatic plant management is important not only to keep the invasive plant population down but also to control nuisance aquatic plants, those that may interfere with owners' access to the lake.

The DNR has recognized the benefits of combining multiple control methods to achieve management goals. Some aquatic plant management methods are listed in the following table, with recommendations on which to use on Wolf Lake.

Figure 7: Alternatives to Aquatic Plant Management

BIO CONTROLS	
Grass Carp	• not permitted in Wisconsin
Native Plant Community Restoration (Nutrient controls in watershed and on property)	• Wolf Lake already has a lot of native shore vegetation, but some of the waterfront owners could increase the landward area of their buffers Will be part of the management plan to maintain buffers and control runoff
CHEMICAL CONTROLS	
Copper chemical	generally not permitted--remains in sediment doesn't biodegrade
2-4, D & other chemicals	• have used over the past 20 years, but EWM still recurring at similar rate • many chemicals are too broad-scale and create risk of harming good diverse native aquatic plant community expensive • results not long-lasting, have to reapply • discouraged by DNR Will be part of management plan, but only as a last effort if EWM becomes uncontrollable with other mechanical methods of removal. Permit will be required
installation of alum	• binds up phosphorus, but not practical for rooted plants, which are bulk of Wolf plant community • expensive • variable and questionable long-term results
MECHANICAL CONTROLS	
Hand pulling invasive species	• requires disposal of removed plants or run risk of dead plants increasing nutrient load Will be part of management plan for errant EWM found.
cutting & removal	• creates risk of fragmentation for spread of EWM • may be appropriate to clear navigational channels in areas of Wolf Lake where there is heavy water/pond lily growth that blocks access Will be part of management plan for nuisance aquatic plants (water lilies). Permit will be required
mechanical harvesting	• Wolf Lake is a no-motor lake • non-selective and short-term • may resuspend sediments & release nutrients from sediments • creates risk of fragmentation for spread of EWM Will be part of the management plan for control of nuisance aquatic plants (water lilies) with emphasis on removal all cut material. Permit will be required
suction harvesting (D.A.S.H.)	• slow and cost-intensive • creates risk of fragmentation for spread of EWM • may resuspend sediments & release nutrients from sediments Will be part of the management plan to use DASH to control EWM with proper training on plant removal. Permit will be required
dredging/sediment removal	• very expensive • since Wolf Lake still has large usable areas, • not cost-effective for this lake • requires disposal of removed material
drawdown	• not possible as Wolf Lake is a natural lake
benthic barrier	• expensive for a small lake association like Wolf Lake • only likely to be effective in small areas not possible for floating-leaf plants that are major navigational barriers • dead plants may add to nutrient loading • affects all plants, not just invasive ones, so would harm significant native population

The Eurasian Watermilfoil has been chemically treated starting in 2001, efforts to control the growth have been somewhat successful, however chemical treatment has now been discouraged, with focus on manual methods of controlling the invasive population.

The following table outlines the invasive aquatic plant treatment from 2001-2022.

Figure 9: EWM Treatment history

Year	Area (in acres)	Treatment	Comments
2001 *	Spring 0.2 Fall 0.9	Navigate (2, 4-D) (30pounds)	Documented in *The Aquatic Plant Community of Wolf Lake, Adams County, Wisconsin 2005*
6/5/2002	8.39*	Navigate (2, 4-D) (839 pounds)	Documented in *Wolf Lake Aquatic Plant Management Plan Sept 11, 2002*
5/13/2003	9.5 *	Navigate (2, 4-D) (950 pounds)	Documented in *Wolf Lake Aquatic Plant Management Plan Oct, 25, 2004*
7/20/2004	2*	Navigate (2, 4-D) (200pounds)	Documented in *Wolf Lake Aquatic Plant Management Plan Oct, 25, 2004* Aquatic Biologists Inc (ABI).
2005	Spring 5.0 Fall 0.7	Navigate (2, 4-D) (500pounds)	Documented in *The Aquatic Plant Community of Wolf Lake, Adams County, Wisconsin 2005*
2006	2*	*unknown*	Applied for permit. Treatment possible, no documentation.
2007	*Spring and Fall * unknown*	*unknown*	May and September treatment and areas unknown. Documented in spring letter to association April 11, 2007.
2008	*unknown*	*unknown*	Treatment possible, no documentation found.
2009	*unknown*	*unknown*	Treatment possible, no documentation found.
2010	2.3	Navigate (345 pounds)	
6/2/2011	9.0	Navigate (granular 2, 4-D) (1350 pounds)	
5/9/2012	1.2	Navigate (414 pounds)	
6/7/2013	6.0	DMA 4 IVM (liquid 2, 4-D) (133 gallons)	Post treatment lily pad impact, quantity applied was miscalculated. Resulted in plan update
2014	***No treatment***		permit denied due to impact of treatment on lily pad population in previous year
5/27/2015	5.6	DMA 4 IVM (40 gallons)	
2016	***No treatment***		
7/242017 7/25/2017	~12,000 pounds EWM	D.A.S.H.	EWM plants noted very large.
5/22/2018	4.9	Aquastrike (16 gallons)	
2019	***No treatment***		Water level high, EWM density low
6/16/2020	11	Weeder 64 (110 gallons)	Cason
5/19/2021	1.41	Tribune (4.25 gallons)	Cason
06/02/2022	3.23 acres	Procellacor (66 PDU) (Florpyrauxifen-benzyl)	Cason. August 2022 visual inspection for EWM resulted in two small plants located and removed.

* information located in annual meeting minutes

Fishery and Endangered Populations

A 1948 fishery inventory of Wolf Lake described it as "a small bass lake, fertile, hard water, moderate plankton, with heavy fishing pressure." Bluegills were the most abundant fish found then. At that time, it was also recommended that trout no longer be stocked in Wolf Lake.

Stocking of fish by the WDNR in Wolf Lake started in 1937 with smallmouth bass, perch and bluegill. Annual stocking of bluegills, crappie, largemouth bass and/or perch continued through 1942. Stocking resumed in 1946 with sunfish and largemouth bass and continued through 1949. A few brown trout were stocked in 1991.

A 1963 fish inventory found both largemouth bass and bluegills abundant, with pumpkinseed also common. Rock bass, black crappie and green sunfish were present, but not in great numbers. Yellow perch were scarce. By 1973, yellow perch, black crappie and green sunfish were found in greater numbers, but pumpkinseed and rock bass had become scarce, as were brown bullheads and northern pike. Largemouth bass and bluegills continued to be found in large numbers. Inventories repeated in 1982 and 1996 noted this trend continued: largemouth bass and bluegill found in great numbers, but bullheads, perch, rockbass and pumpkinseed still scarce.

The Wisconsin Rapids fisheries crew with the Department of Natural Resources surveyed Wolf Lake, Adams County, with electrofishing on the night May 21st, 2014, with a primary objective to count and measure largemouth bass and panfish. The water was clear with a temperature of 65°F and weather conditions were good. The entire shoreline (1.31 miles) was surveyed with a maxiboom shocker using pulsed direct current and two dip netters. All fish were netted. Due to the low conductivity of the water, all species were collected for the entire shoreline length to help ensure sample size was sufficient.

This is a summary of the numbers and sizes of fish caught during the survey. One 17.3-inch northern pike was caught. One 7.2-inch yellow perch was caught. Four rock bass were caught.

Largemouth Bass

We netted 33 largemouth bass during our survey, giving a catch rate of 25.1 fish per mile. Fish ranged in length from 8.0 inches to 16.7 inches with an average of 11.6 inches. 52 percent of the fish were of at least quality size (12 inches), and 9 percent were at least of preferred size (15 inches).

Bluegill

We netted 132 bluegills during the survey, giving a catch rate of 100.8 fish per mile. Bluegills were the most numerous of the fish species collected during our survey. The bluegill ranged in size from 2.0 to 8.0 inches with an average length of 6.3 inches. 66 percent of the fish were at least of quality size (6 inches) and 12 percent of the fish were at least of preferred sized (8 inches).

Black crappie

We netted 16 black crappies during the survey, giving a catch rate of 12.2 fish per mile. The black crappies caught ranged in size from 8.9 to 11.5 inches with an average length of 9.9 inches. All of the fish caught were at least of quality size (8 inches).

Pumpkinseed

We netted 13 pumpkinseeds during the survey, giving a catch rate of 9.9 fish per mile. Pumpkinseed ranged in length from 5.1 to 7.8 inches with an average length of 6.7 inches.

Six fish cribs were installed in the lake in 1997 to encourage reproduction.

Muskrat and mink are also known to use this habitat for cover, reproduction and feeding. Seen during the field survey were various types of waterfowl, songbirds, and turkey. Frogs and salamanders are known to use this area for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. A pair of eagles has nested here for the past several years. Sandhill cranes nest in the Wolf Lake area in most years. Upland wildlife feed and nest here as well.

Red Banded Killifish was the only endangered or threatened species reported around or in Wolf Lake. It was reported as scarce in a 1996 fish survey.

Figure 10: *Fundulus diaphanous* (Banded Killifish)

GOALS AND ACTION INTRODUCTION

The Following pages outline the goals defined by the members of Wolf Lake Property Owners Association (WLPOA) and describe the actions planned to achieve these goals. The actions will be reviewed by the WLPOA board and members annually.

Wolf Lake Management Plan – Goals and Action Plans

Education				
Goal: Educate community and public about lake management concerns to increase use of practices that will maintain/improve water quality and reduce introduction of new invasives, as well as take personal responsibility for keeping lake healthy.				
	Action Items	***Who***	***When***	***Resource***
1	Establish community events, exclusive of the Annual Meeting to encourage and educate the Wolf Lake Assn's membership in regard to Lake conservation practices, as well as to recruit volunteers for various lake projects.	WLPOA Adams LWCD	Ongoing	Time LWCD Staff
2	Promote and maintain our website, wolflakepoa.org, for the posting of lake association and educational information.	WLPOA	Ongoing	Time
3	Create a Facebook community page for interaction of members with WLPOA. Any issues needing resolution will be mirrored on the website. "WLPOA only" information will only be available on the website.	WLPOA	Ongoing	Time
4	Encourage waterfront owners to skim off floating plant fragments and algae to remove some nutrients from the lake. Use the website and Facebook community to promote this effort.	WLPOA	Ongoing	Time
5	All waterfront owners who have a buffer less than 35 feet landward from the lakeshore should be encouraged to comply with the Wisconsin state requirements.	WLPOA Adams Pl and Zoning	Ongoing	Time County Staff
6	Place informational kiosks at the launch area about actions citizens can take to improve/maintain water quality & other lake issues and maintain exotic invasive species signage at public boat access. LWCD will provide flyers. WLPOA will need to make and maintain weatherproof document holders and mount at boat launch area.	WLPOA Adams LWCD	Ongoing	Time
7	Develop and distribute an informational packet regarding lake issues, water quality & best management practices to watershed WLPOA members, including yard care.	WLPOA Adams LWCD	Ongoing	Time County staff
8	Request that Lakefront property owners not use fertilizers or chemicals within 200 ft of the water. State law only allows application of phosphorus fertilizer after soil testing shows the need. Ask that lake owners use no fertilizer at all unless soil tests show that such is needed.	WLPOA Adams LWCD WDNR	Ongoing	Time
9	Inform waterfront property owners of the right to clear only a 30-foot-wide corridor (for 100 ft of shoreline owned) in the shoreline riparian areas of their property.	WLPOA Adams LWCD WDNR	Ongoing	Time
10	Continue to participate in the Adams County Lake Alliance to obtain up to date information on lake issues.	WLPOA ACLA	Ongoing	Time

Aquatic Species Management

Goal: Maintain healthy aquatic plant populations to improve the aquatic ecosystem, including controlling current invasive species, such as EWM, and preventing introduction of other invasive aquatic species using an integrated approach.

	Action Items	Who	When	Resource
1	Continue volunteer monitoring of aquatic plant growth at least monthly during growing season to identify any areas of especially dense growth that will interfere with recreational activities or habitat - with an emphasis on monitoring aquatic invasives.	WLPOA Adams LWCD	Ongoing	Time County staff
2	Continue to participate in Citizen Invasive Species Monitoring (plants and animals) and enter information into SWIMS database.	WLPOA Adams LWCD	Ongoing	WLA County Staff
3	Develop, purchase, and maintain a DASH Boat and staffing crew to maintain levels of invasive aquatic plant species at a level which does not require the use of aquatic herbicides for control of invasive species.	WLPOA WDNR Adams LWCD	Ongoing	Time WLPOA funds
4	Develop a training and quality control program for DASH participants that will promote diver and operator safety and ensure the ability to identify and target only species desired for removal by DASH.	WLPOA WDNR Adams LWCD	Ongoing Spring 2023	Time County Staff
5	Use herbicide treatments for control of EMW only as a measure of last resort, with the goal of keeping accumulated area of EMW under 3 acres. Prepare annual map of EWM distribution and provide to WDNR Aquatic Plant Staff.	WLPOA Adams LWCD WDNR	Ongoing	Time County Staff
6	Annually develop treatment map, using Adams County LWCD/WDNR recommendations for pre/post treatment evaluations. Establish pre-treatment criteria for deciding whether chemical treatment that year is appropriate or required.	WLPOA Adams LWCD	Annually	Time County Staff
7	Continue to Consult with Adams County LWCD & WDNR about alternative treatment methods for invasive aquatic species, such as the ongoing use of DASH or other emergent technologies.	WLPOA Adams LWCD WDNR	Ongoing	County Staff WDNR
8	Work with WDNR to develop harvesting map, esp. channels in water lilies. Provide an annual map to WDNR for any mechanical removal for navigational purposes.	WLPOA Adams LWCD WDNR	Ongoing	County Staff WDNR
9	Hold EMW harvesting events at least twice per summer to remove invasive plants using both DASH and shore hand pulling/harvesting.	WLPOA Adams LWCD	Ongoing	WLA County Staff
10	Continue to conduct aquatic plant surveys every 4 to 5 years to help keep track of plant management and control success. Survey conducted Aug 1, 2022.	WLPOA Adams LWCD WDNR	Ongoing	Time County Staff WDNR
11	Continue to participate in Citizen Invasive Species Monitoring (plants and animals) and enter information into SWIMS database.	WLPOA Adams LWCD	Ongoing	WLA County Staff
12	Maintain an on-going dialogue with Adams LWCD and ACLA pertaining to the introduction of new invasives or re-introduction of old invasive species that may present themselves as a re-emergent threat.	WLPOA Adams LWCD ACLA	Ongoing	Time

Water Quality

Goals: Maintain & improve present water quality & prevent algae blooms. Restore natural shore conditions in riparian areas & incorporate stormwater runoff protection to reduce erosion in and around Wolf Lake, as well as construction and roadway runoff.

	Action Items	Who	When	Resource
1	Keep in-lake phosphorus goal of 20 micrograms/liter as the long-term mean. Should the mean rise above that mark, consultation will occur immediately to determine steps to take to regain that mean. 1992-2022 mean is 10.9 micrograms/liter.	WLPOA Adams LWCD	Ongoing	Time
2	Continue using volunteers for monitoring of lake water quality with participation in the WDNR Citizen Monitoring Program, with monitoring results being posted to the Wisconsin state website.	WLPOA Adams LWCD	Ongoing	Time
3	Monitor reports from the Wisconsin Initiative on Climate Change to determine if water quality standards need to be adjusted to account for significant changes in temperature and precipitation.	WLPOA	Ongoing	Time
4	Monitor lake waterfront property to identify stormwater runoff problems.	Adams LWCD WLPOA	Ongoing	Time
5	Conduct shore habitat assessment using WDNR protocol, using information to take further steps to gain funding. Coordinate with Adams LWCD for grant application.	Adams LWCD WLPOA	Ongoing	County staff Time
6	Re-assess boat landing for stormwater runoff issues. Coordinate with Jackson Township regarding any issues noted.	WLPOA Adams PI & Zoning WDNR	Ongoing	Time Jackson staff
7	Monitor Lake Levels using well installed in 2013.	WLPOA	Ongoing	Time

Fishery and Wildlife Management

Goal: Improve Fishery Habitat and fish populations on Wolf Lake.

	Action Items	Who	When	Resource
1	Consult with WDNR Fishery Biologists regarding information relating to the maintenance of healthy sport fishing on Wolf Lake. With WDNR assistance, develop steps that could be taken to better manage our fish populations.	WLPOA WDNR	Ongoing	Time WDNR
2	Encourage catch & release to help maintain predator-prey ratio in fish. Contact WDNR regarding what can be done to educate anglers and promote this activity.	WLPOA WDNR	Ongoing	Time WDNR
3	After above steps are completed, discuss with WDNR and Town of Jackson regarding appropriate steps for fish/fishing management.	WLPOA WDNR	Ongoing	Time WDNR

Recreational Management

Goal: Maintain recreational opportunities for lake users, while maintaining peace, solitude, and preservation of public safety for lake users.

1	Maintain no-motor designation of the lake.	WLPOA Jackson Township	Ongoing	Time
2	Petition Jackson Township to restrict the gross weight of vehicles allowed on the ice surface of Wolf Lake to no more than 1000 pounds. (No trucks)	WLPOA Jackson Township	Ongoing	Time

Critical Habitat and Wildlife Diversity

Goal: Protect Critical Habitat of Wolf Lake and Encourage wildlife diversity on and around the lake for the purpose of maintaining and enhancing the natural setting, peace, and serenity of Wolf Lake.

1	Provide education on the location and importance of the critical habitat areas of Wolf Lake.	WLPOA Adams LWCD	Ongoing	Time County staff
2	Continue survey of Lake users & owners to determine if they would like to encourage types of wildlife, including songbirds & waterbirds.	WLPOA Adams LWCD	Ongoing	Time County staff
3	Form relationships and a cooperative plan with agricultural producers in the watershed that encourages the reduction of aquatic phosphorus levels by emphasizing the use of Best Management Practices.	WLPOA Adams LWCD Local Ag Assn's	Ongoing	Time

Revision History from 2017 to 2022

- Updated Advisory Group
- Updated WLM Plan approval to match WLPOA by laws which require Board approval for updates.
- Updated Watershed Land use map from https://adams-county-wi.maps.arcgis.com/
- Added ACLWC for information on restoring shoreline buffer.
- Critical Habitat information available from WLPOA or DNR website
- Updated Lake Chemistry section to include means up to year 2022 (July only) and added Trophic State Index (add data acquired from Wisconsin DNR Citizen Lake Monitoring for Wolf Lake)
- Add 2022 DNR Aquatic Plant Survey information (plant species observed as well as summary provided by DNR)
- Updated Alternatives to Aquatic Plant Management to include control of invasives as well as nuisance aquatic plants.
- Added EWM treatment history
- Added 2014 Fish Survey results that were obtained by DNR
- Updated Goals and Actions to include use of DASH and updated other items to match plan.