Archibald Lake

Oconto County, Wisconsin

Aquatic Plant Management Plan

November 2023

Sponsored by:

Archibald Lake Association

WDNR Surface Water Grant Program

AEPP-689-23

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Onterra, LLC
Lake Management Planning

Archibald Lake

Oconto County, Wisconsin

Aquatic Plant Management Plan

November 2023

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Acknowledgements

This management planning effort was truly a team-based project and could not have been completed without the input of the following individuals:

Archibald Lake Planning Committee

Bill Ciske – Planning Committee Chair	Joseph Harrison	Mike Gonnering
Karla Doyle – ALA President	Larry Schmechel	Richard Dvorak
Ken Schwebke	Gary Miller	
Katherine Wiggins	Matt Marty	

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1.0 INTRODUCTION

Photograph 1.0-1. Archibald Lake, Oconto County.

Archibald Lake, Oconto County, is a 392-acre two-basin seepage lake with a maximum depth of 58 feet and a mean depth of 17 feet (Map 1, Photograph 1.0-1). This oligotrophic lake has a relatively small watershed when compared to the size of the lake. The lake is listed as an Area of Special Natural Resource Interest (ASNRI) outstanding/exceptional resource water under NR 102. The Chequamegon-Nicolet National Forest (CNNF) borders much of the lake's east basin, in the form of the Cathedral Pines State Natural Area. This stand of pines covers 1,874 acres and is "some of the finest old growth pine-hemlock stands on the CNNF" (WDNR website, Cathedral Pines No. 496). A connected wetland within the CNNF has a Sensitive Area Designation by the WDNR (Map1). More information on this protected site can be found here:

https://apps.dnr.wi.gov/swims/Documents/DownloadDocument?id=25382650

The Archibald Lake Association (ALA), formed in 1958, have been among the most ambitious and diligent lake associations in the state of Wisconsin, initiating several grant-funded projects for lake management planning and aquatic invasive species (AIS) control. Volunteers participate in an Adopt-A-Shoreline invasive species monitoring program, Clean Boats Clean Waters (CBCW), and the Citizens Lake Monitoring Network (CLMN).

Following the discovery of Eurasian watermilfoil (*Myriophyllum spicatum*; EWM) in 2009, the ALA has been very pro-active in managing the EWM within Archibald Lake to keep a lowered overall EWM population in the lake. In 2016, the ALA received their first AIS-EPP grant and contracted with Onterra, LLC to update their *Comprehensive Lake Management Plan (CLMP)* and to continue professional EWM monitoring activities on Archibald Lake. The *CLMP* was completed and approved in May 2018.

The *CLMP* indicated that Archibald Lake's trophic parameters (chlorophyll-a, phosphorus, water clarity) are in the *excellent* category for deep seepage lakes. The favorable water quality conditions observed in Archibald Lake are a result of having a largely forested watershed, and the natural and un-manicured condition of most near-shore properties.

The aquatic plant community within the lake and along the shorelines of Archibald Lake was found to be of good quality. Archibald Lake contains a high number of native plant species, although over half of Archibald Lake's aquatic plant community was comprised of just three species in 2016: muskgrasses, slender naiad, and wild celery. Hardwater lakes rich in calcium like Archibald Lake are often dominated by muskgrasses. This dense carpet of muskgrasses makes it difficult for some aquatic plant species to become established, including Eurasian watermilfoil.

In 2022 the ALA was successful in their WDNR grant application to fund the update of their *Aquatic Plant Management Plan*. This report serves to incorporate the results of the 2022 EWM control and monitoring program, include an updated vegetation report based upon the 2022 whole-lake point-intercept survey, and conduct a riparian stakeholder survey to solicit perception and support for various management techniques. Having an updated *Aquatic Plant Management Plan* will allow the ALA to ensure eligibility for future AIS Grants.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa. The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All of this information is communicated through multiple meetings that involve the lake group as a whole or a focus group called a Planning Committee and the completion of a stakeholder survey.

The highlights of this component are described below. Materials used during the planning process can be found in Appendix A.

2.1 Strategic Planning Committee Meeting

The ALA planning committee meeting attendees were supplied with the draft report sections prior to the meeting and much of the meeting time was utilized to detail the results, discuss the conclusions and initial recommendations, and answer committee questions.

On July 5, 2023, Eddie Heath met with the eight-member planning committee for approximately three and a half hours at the Lakewood Library. The first portion of this meeting largely consisted of a presentation of the available data from the system and the latest science and perspective on aquatic plant management activities. The second portion concentrated on the development of management goals and actions that make up the framework of the implementation plan by the AIS planning committee.

2.2 Management Plan Review and Adoption Process

On July 28, 2023, the Official First Draft of the ALA's Aquatic Plant Management Plan for Archibald Lake was supplied to WDNR (AIS, lakes, and fisheries programs), Great Lakes Indian Fish and Wildlife Commission (GLIFWC), and Oconto County by Onterra via email. At that time, the Official First Draft was made available for public review on an Onterra-hosted website and advertised as an official comment period through a combination of ALA outreach events which included an email blast sent to the entire ALA membership on August 3, 2023 and an announcement by ALA Planning Committee Chair Bill Ciske at the annual picnic on August 12, 2023. During an October 7, 2023 Wrap-Up Meeting, Eddie Heath of Onterra presented the draft Implementation Plan developed by the ALA Planning Committee, supporting information the ALA Planning Committee used to arrive at this plan, and answered questions from the audience. This meeting further alerted meeting attendees of the draft Plan's existence on the web and the fact that written comments were welcomed at this time.

The public comment period remained active until Brenda Nordin approved the management plan on November 28, 2023. No additional agency comments were received. A series of comments on the Implementation Plan were received from a former ALA board member and incorporated.

2.3 Riparian Stakeholder Survey

As a part of this project, a stakeholder survey was distributed to all Archibald Lake Association members and riparian property owners around Archibald Lake. The survey was designed by Onterra staff and the Archibald Lake Association planning committee and reviewed by a WDNR social scientist. During late-May, June, and early July of 2023, the eight-page, 32-question survey was posted online through Survey Monkey for stakeholders to answer electronically. Stakeholders were invited to participate in the survey via a mailed postcard containing information on how to participate. If requested, a hard copy was sent with a self-addressed stamped envelope for returning the survey anonymously. The returned hardcopy surveys were entered into the online version by the third-party business, who handled the distribution logistics, for analysis.

Of the 127 surveys distributed, 76 (60%) of the surveys were completed. In instances where stakeholder survey response rates are 60% or above, the results can generally be interpreted as being a statistical representation of the population offered to participate. The data were analyzed and summarized by Onterra for use at the planning meeting and within the management plan. The full survey results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a general summary is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people who use and care for Archibald Lake. Approximately 72% of respondents have owned their lake property for over 25 years (Figure 2.3-1).

Question 7: How many years have you owned or rented your property on or near Archibald Lake?

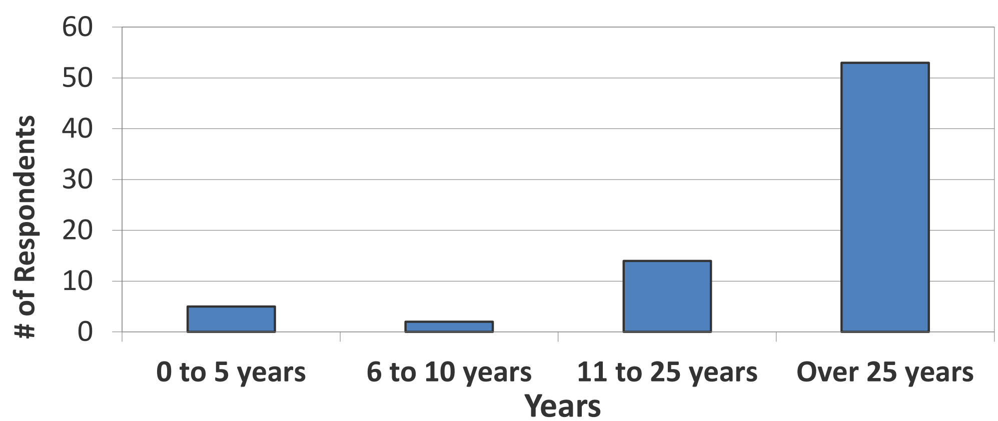

Figure 2.3-1. Select survey responses from the ALA Stakeholder Survey. Additional questions and response charts are found in Appendix B.

Approximately 22% of stakeholder respondents live on the system year-round, while 49% use their property as a vacation home, 22% as a seasonal residence, and the remaining 7% have other uses (Figure 2.3-2).

Question 8: How is your property on or near Archibald Lake used?

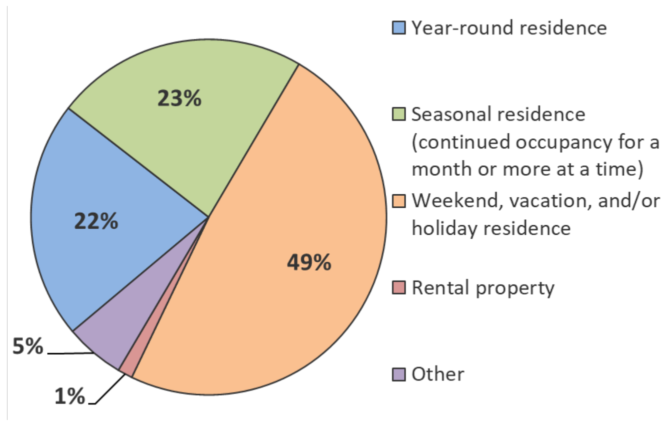

Figure 2.3-2. Select survey responses from the ALA Stakeholder Survey. Additional questions and response charts are found in Appendix B.

Relaxing/entertaining was the highest ranked activities when riparians were asked why they own property on Archibald Lake (Figure 2.3-3). Riparian respondents also ranked fishing, boating, and nature viewing as top reasons they choose to be on the system.

Question 10: Please rank up to three activities that are important reasons for owning your property on or near Archibald Lake, with 1 being the most important.

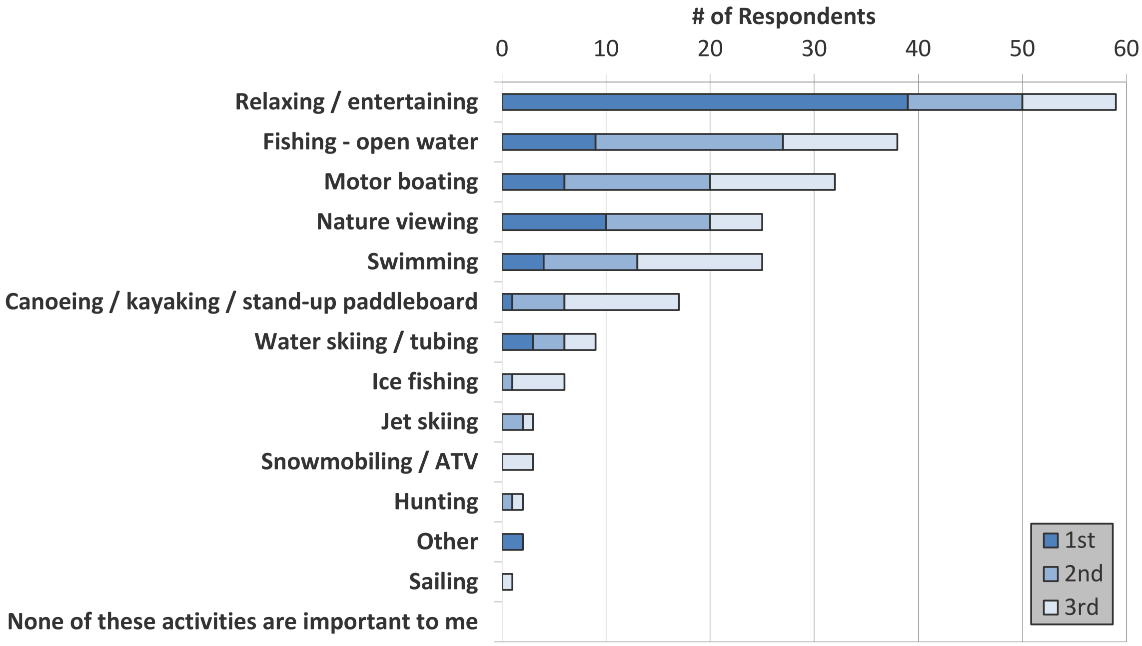

Figure 2.3-3. Select survey responses from the ALA Stakeholder Survey. Additional questions and response charts are found in Appendix B.

Even though silent sports such as canoeing/kayaking/paddle boarding were ranked by respondents as the 6th highest activity on the lakes (Figure 2.3-3), 77% of respondents indicated they use that type of watercraft on the lakes (Figure 2.3-4). Approximately 78% of survey respondents indicated they use a pontoon boat and 49% indicated that they use a motor boat with greater than 25 hp motor.

Question 10: What types of watercraft do you currently use on Archibald Lake?

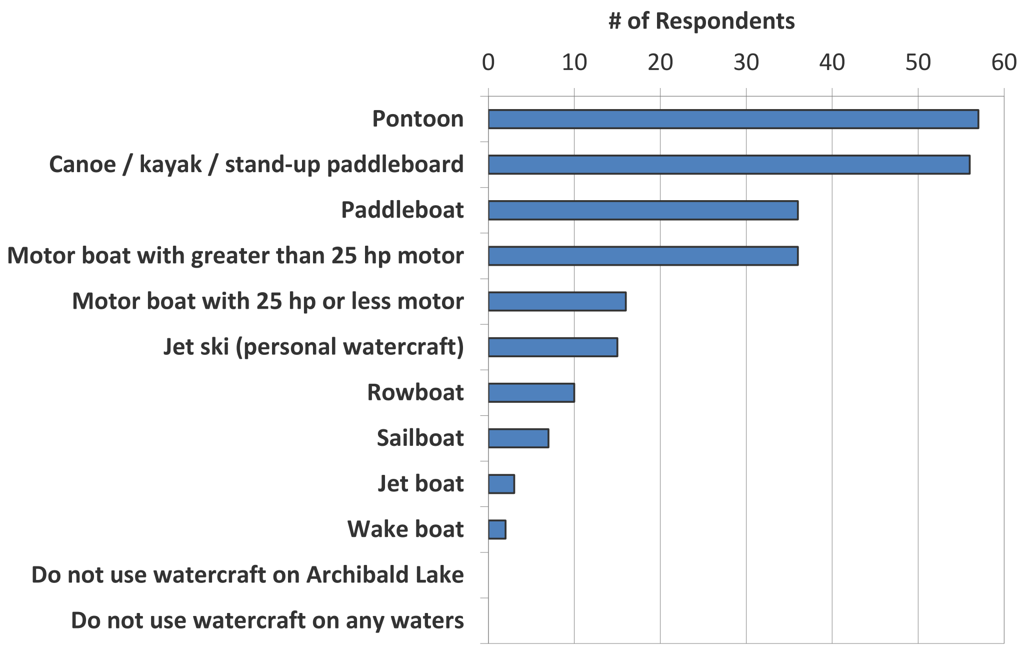

Figure 2.3-4. Select survey responses from the ALA Stakeholder Survey. Additional questions and response charts are found in Appendix B.

3.0 AQUATIC PLANTS

3.1 Primer on Aquatic Plant Data Analysis & Interpretation

Native aquatic plants are an important element in every healthy aquatic ecosystem, providing food and habitat to wildlife, improving water quality, and stabilizing bottom sediments. Because most aquatic plants are rooted in place and are unable to relocate in wake of environmental alterations, they are often the first community to indicate that changes may be occurring within the system. Aquatic plant communities can respond in a variety of ways; there may be increases or declines in the occurrences of some species, or a complete loss. Or, certain growth forms, such as emergent and floating-leaf communities may disappear from certain areas of the waterbody. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide relevant information for making management decisions.

The point-intercept method as described Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010 (Hauxwell et al. 2010) have been conducted on Archibald Lake in 2010, 2013, 2016, and 2022. A total of 687 points were on the point intercept survey with a spacing of 43 meters apart. At each point-intercept location within the *littoral zone*, information regarding the depth, substrate type (soft sediment, sand, or rock), and the plant species sampled along with their relative abundance on the sampling rake was recorded.

A pole-mounted rake was used to collect the plant samples, depth, and sediment information at point locations of 15 feet or less. A rake head tied to a rope (rope rake) was used at sites greater than 15 feet. Depth information was collected using graduated marks on the pole of the rake (at depths < 15 ft) or using an onboard sonar unit (at depths > 15 feet). Also, when a rope rake was used, information regarding substrate type was not collected due to the inability of the sampler to accurately "feel" the bottom with this sampling device. At each point that is sampled the surveyor records a total rake fullness (TRF) value ranging from 0-3 as a somewhat subjective indication of plant biomass. The point-intercept survey produces a great deal of information about a lake's aquatic vegetation and overall health. These data are analyzed and presented in numerous ways; each is discussed in more detail the following section.

Species List

The species list is simply a list of all of the aquatic plant species, both native and non-native, that were located during the surveys completed in Archibald Lake during monitoring timeframe. The list also contains each species' scientific name, common name, status in Wisconsin, and coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in growth forms that are present, can be an early indicator of changes in the ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain aquatic plant species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of the whole-lake point-intercept surveys that have been completed; plant samples were collected from plots laid out on a grid that covered the lake. Using the data

Littoral Zone is the area of a lake where sunlight is able to penetrate down to the sediment and support aquatic plant growth.

collected from these plots, an estimate of occurrence of each plant species can be determined. The occurrence of aquatic plant species is displayed as the *littoral frequency of occurrence*. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are within the maximum depth of plant growth (littoral zone), and is displayed as a percentage.

Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

Floristic Quality Assessment

The floristic quality of a lake's aquatic plant community is calculated using its native *species richness* and their *average conservatism*. Species richness is the number of native aquatic plant species that were physically encountered on the rake during the point-intercept survey. Average conservatism is calculated by taking the sum of the coefficients of conservatism (C-values) of the native species located and dividing it by species richness. Every plant in Wisconsin has been assigned a coefficient of conservatism, ranging from 1-10, which describes the likelihood of that species being found in an undisturbed environment. Species which are more specialized and require undisturbed habitat are given higher coefficients, while species which are more tolerant of environmental disturbance have lower coefficients.

For example, algal-leaf pondweed (*Potamogeton confervoides*) is only found in nutrient-poor, acid lakes in northern Wisconsin and is prone to decline if degradation of these lakes occurs. Because of algal-leaf pondweed's special requirements and sensitivity to disturbance, it has a C-value of 10. In contrast, sago pondweed (*Stuckenia pectinata*) with a C-value of 3, is tolerant of disturbance and is often found in greater abundance in degraded lakes that have higher nutrient concentrations and low water clarity. Higher average conservatism values generally indicate a healthier lake as it is able to support a greater number of environmentally-sensitive aquatic plant species. Low average conservatism values indicate a degraded environment, one that is only able to support disturbance-tolerant species.

On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept surveys (equation shown below). This assessment allows the aquatic plant community of Archibald Lake to be compared to other lakes within the region and state.

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

Archibald Lake falls within the Northern Lakes and Forests (NLF) *ecoregion* (Figure 3.1-1), and the floristic quality of its aquatic plant community will be compared to other lakes within this ecoregion as well as the entire State of Wisconsin. Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems within the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Ecoregional and state-wide medians were calculated from whole-lake point-intercept surveys conducted on 392 lakes throughout Wisconsin by Onterra and WDNR ecologists.

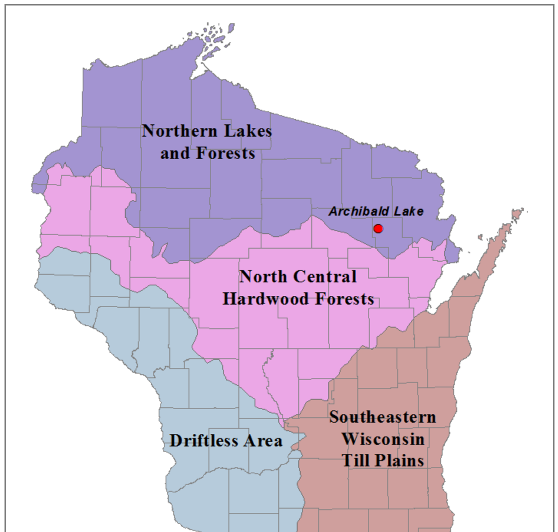

Figure 3.1-1. Location of Archibald Lake within the ecoregions of Wisconsin. After Nichols 1999.

Species Diversity

Species diversity is often confused with species richness. As defined previously, species richness is simply the number of species found within a given community. While species diversity utilizes species richness, it also takes into account evenness or the variation in abundance of the individual species within the community. For example, a lake with 10 aquatic plant species that had relatively similar abundances within the community would be more diverse than another lake with 10 aquatic plant species where 50% of the community was comprised of just one or two species.

An aquatic system with high species diversity is more stable than a system with a low diversity. This is analogous to a diverse financial portfolio in that a diverse aquatic plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. Some managers believe a lake with a diverse plant community is also better suited to compete against exotic infestations than a lake with a lower diversity. However, in a recent study of 1,100 Minnesota lakes, researchers concluded that more diverse communities were not more resistant or resilient to invaders (Muthukrishnan et al. 2018).

The diversity of a lake's aquatic plant community is determined using the Simpson's Diversity Index (1-D):

$$D = \sum (n/N)^2$$

where: n = the total number of instances of a particular species
N = the total number of instances of all species
D is a value between 0 and 1

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. The Simpson's Diversity Index value from Archibald Lake is compared to data collected by Onterra and the WDNR Science Services on 212 lakes within the Northern Lakes and Forests (lakes only, does not include flowages) Ecoregion and on 392 lakes throughout Wisconsin.

3.2 Archibald Lake Aquatic Plant Survey Results

Whole-lake point-intercept surveys have been completed on Archibald Lake in 2010, 2013, 2016, and 2022. This report will highlight the 2022 point-intercept survey results and will integrate comparisons to the previous surveys throughout the section. A full matrix of aquatic plant frequencies can be found in Appendix C.

The data that continues to be collected from Wisconsin lakes is revealing that aquatic plant communities are highly dynamic, and populations of individual species have the capacity to fluctuate, sometimes greatly, in their occurrence from year to year and over longer periods of time. These fluctuations can be driven by a combination of natural factors including variations in temperature, ice and snow cover (winter light availability), nutrient availability, water levels and flow, water clarity, length of the growing season, herbivory, disease, and competition (Lacoul and Freedman 2006). Adding to the complexity of factors which affect aquatic plant community dynamics, human-related disturbances such as the application of herbicides for non-native plant management, mechanical harvesting, watercraft use, and pollution runoff also affect aquatic plant community composition (Asplund and Cook 1997); (Lacoul and Freedman 2006).

A total of 36 aquatic plant species were recorded in Archibald Lake during the 2022 point-intercept survey. Of these 36 species, muskgrasses (*Chara* spp.), wild celery (*Vallisneria americana*), slender naiad (*Najas flexilis*), and southern naiad (*N. guadalupensis*), were the most frequently encountered (Photo 3.2-1 and 3.2-4). Three non-native species have been documented on Archibald Lake in the past including Eurasian watermilfoil, flowering rush, and giant reed. Because of their ecological, economical, and sociological significance, the non-native plants and their management in Archibald Lake they are discussed in the subsequent *Non-Native Aquatic Plants in Archibald Lake* subsection (3.3).

In addition to the point intercept surveys, one community mapping survey was completed as a part of the comprehensive management project in 2016. Table 3.2-1 displays the 59 species that have been documented during all surveys completed on Archibald Lake. Table 3.2-1 is organized by growth form which separates out species based on whether they are emergent species, floating-leaf species, submergent species, or free-floating species. Species with an "X" on the table indicates the species was physically encountered on the rake during the point-intercept survey. Examples of other species that were observed, but were not sampled on the survey rake are referred to as incidentals and are listed with an "I" on table 3.2-1. Often these species are found growing on the shoreline or in shallow areas of the lake.

Data regarding substrate hardness collected during the 2016 acoustic survey revealed that Archibald Lake's average substrate hardness ranges from hard to moderately hard with deeper areas containing softer, more flocculent sediments (Figure 3.2-1). On average, the hardest substrates (sand/rock/gravel) are found within 1 to 8 feet of water. The greatest transition between hard and softer substrates is found between 9 and 16 feet of water, with hardness declining rapidly with depth. In 16 feet of water and deeper, substrate hardness remains relatively constant. Figure 3.2-1 illustrates the spatial distribution of substrate hardness in Archibald Lake. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in soft substrates, others only in sandy areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because of the different habitat types that are available.

Table 3.2-1. Aquatic plant species located on Archibald Lake.

Growth Form	Scientific Name	Common Name	Status in Wisconsin	Coefficient of Conservatism	2010	2013	2016	2022
Emergent	*Butomus umbellatus*	Flowering-rush	Non-Native - Invasive	N/A	I	X	I	
Emergent	*Carex comosa*	Bristly sedge	Native	5			I	
Emergent	*Carex vesicaria*	Blister sedge	Native	7			I	
Emergent	*Dulichium arundinaceum*	Three-way sedge	Native	9			I	
Emergent	*Eleocharis palustris*	Creeping spikerush	Native	6			I	
Emergent	*Iris versicolor*	Northern blue flag	Native	5			I	
Emergent	*Phragmites australis subsp. australis*	Giant reed	Non-Native - Invasive	N/A			I	
Emergent	*Sagittaria latifolia*	Common arrowhead	Native	3	I		I	
Emergent	*Schoenoplectus acutus*	Hardstem bulrush	Native	5		X	X	
Emergent	*Schoenoplectus pungens*	Three-square rush	Native	5	I			
Emergent	*Schoenoplectus tabernaemontani*	Softstem bulrush	Native	4	I		I	X
Emergent	*Typha latifolia*	Broad-leaved cattail	Native	1	I		I	
FL	*Brasenia schreberi*	Watershield	Native	7	X	X	X	X
FL	*Nuphar variegata*	Spatterdock	Native	6	I	X	X	X
FL	*Nymphaea odorata*	White water lily	Native	6	X	X	X	X
FL	*Persicaria amphibia*	Water smartweed	Native	5	I	I	X	X
FL	*Sparganium fluctuans*	Floating-leaf bur-reed	Native	10		X		
FL/E	*Sparganium emersum var. acaule*	Short-stemmed bur-reed	Native	8			I	
FL/E	*Sparganium sp.*	Bur-reed sp.	Native	N/A		X		
Submergent	*Ceratophyllum demersum*	Coontail	Native	3	X	X	X	X
Submergent	*Chara spp.*	Muskgrasses	Native	7	X	X	X	X
Submergent	*Elatine minima*	Waterwort	Native	9				X
Submergent	*Elodea canadensis*	Common waterweed	Native	3	X	X	X	X
Submergent	*Heteranthera dubia*	Water stargrass	Native	6	X	X	X	X
Submergent	*Isoetes spp.*	Quillwort spp.	Native	8				X
Submergent	*Myriophyllum heterophyllum*	Various-leaved watermilfoil	Native	7		X		
Submergent	*Myriophyllum sibiricum*	Northern watermilfoil	Native	7	X	X	X	X
Submergent	*Myriophyllum spicatum*	Eurasian watermilfoil	Non-Native - Invasive	N/A	I	X	I	X
Submergent	*Najas flexilis*	Slender naiad	Native	6	X	X	X	X
Submergent	*Najas guadalupensis*	Southern naiad	Native	7	X	X	X	X
Submergent	*Najas guadalupensis & N. flexilis*	Southern & Slender naiad	Native	N/A	X	X	X	X
Submergent	*Nitella spp.*	Stoneworts	Native	7		X	X	X
Submergent	*Potamogeton amplifolius*	Large-leaf pondweed	Native	7	X	X	X	X
Submergent	*Potamogeton berchtoldii*	Slender pondweed	Native	7				X
Submergent	*Potamogeton berchtoldii & P. pusillus*	Slender and small pondweed	Native	7	X	X	X	X
Submergent	*Potamogeton epihydrus*	Ribbon-leaf pondweed	Native	8			I	
Submergent	*Potamogeton foliosus*	Leafy pondweed	Native	6		X		
Submergent	*Potamogeton friesii*	Fries' pondweed	Native	8			X	X
Submergent	*Potamogeton gramineus*	Variable-leaf pondweed	Native	7	X	X	X	X
Submergent	*Potamogeton gramineus & P. illinoensis*	Variable-leaf & Illinois pondweed	Native	N/A	X	X	X	X
Submergent	*Potamogeton illinoensis*	Illinois pondweed	Native	6	X	X	X	
Submergent	*Potamogeton natans*	Floating-leaf pondweed	Native	5	X	X	X	X
Submergent	*Potamogeton nodosus*	Long-leaf pondweed	Native	5	X			
Submergent	*Potamogeton praelongus*	White-stem pondweed	Native	8	X	X	X	X
Submergent	*Potamogeton pusillus*	Small pondweed	Native	7	X	X	X	X
Submergent	*Potamogeton richardsonii*	Clasping-leaf pondweed	Native	5	X	X	X	X
Submergent	*Potamogeton robbinsii*	Fern-leaf pondweed	Native	8		X	X	X
Submergent	*Potamogeton strictifolius*	Stiff pondweed	Native	8			X	X
Submergent	*Potamogeton zosteriformis*	Flat-stem pondweed	Native	6	X	X	X	X
Submergent	*Ranunculus aquatilis*	White water crowfoot	Native	8			X	X
Submergent	*Sagittaria sp. (rosette)*	Arrowhead sp. (rosette)	Native	N/A			X	X
Submergent	*Stuckenia pectinata*	Sago pondweed	Native	3	I			X
Submergent	*Utricularia gibba*	Creeping bladderwort	Native	9				X
Submergent	*Utricularia intermedia*	Flat-leaf bladderwort	Native	9			X	X
Submergent	*Utricularia vulgaris*	Common bladderwort	Native	7			X	X
Submergent	*Vallisneria americana*	Wild celery	Native	6	X	X	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	Native	5	I	X	X	X
S/E	*Schoenoplectus subterminalis*	Water bulrush	Native	9			X	X
FF	*Lemna minor*	Lesser duckweed	Native	5			X	

X = Located on rake during point-intercept survey; I = Incidentally located; not located on rake during point-intercept survey
FL = Floating-leaf; F/L = Floating-leaf & Emergent; S/E = Submergent and/or Emergent; FF = Free-floating

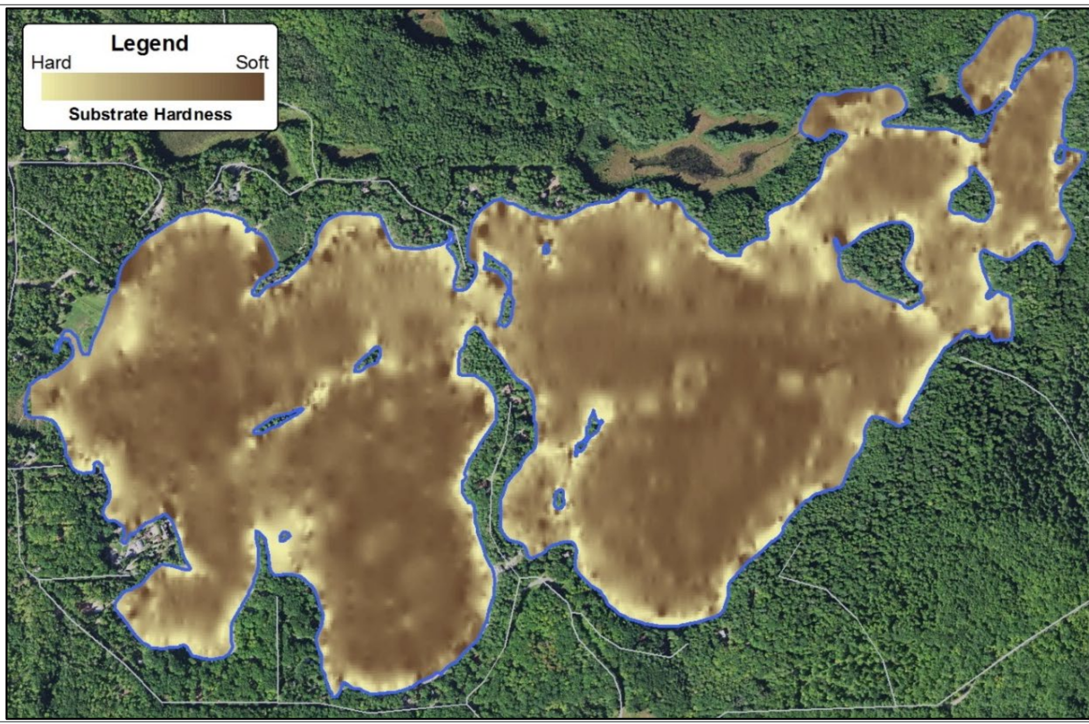

Figure 3.2-1. Archibald Lake spatial distribution of substrate hardness. Created using data from August 2016 acoustic survey.

The recorded maximum depth of aquatic plant growth was 21 feet in the 2022 survey (Figure 3.2-2). This represents a slight increase in the recorded maximum depth of plant growth from the 2010 maximum depth of 18 feet. Aquatic plant occurrence is low in these deeper depths, but changes in Archibald Lake's water clarity are believed to be the driving factor influencing the maximum depth of plant growth. Studies have shown that zebra mussels usually do not have detectable effects on the lake's ecosystem until their population rapidly expands about five to 10 years after their introduction (Karatayev et al. 1997). Zebra mussels were discovered in Archibald Lake in 2020, so it is too early to expect noticeable changes to water quality parameters.

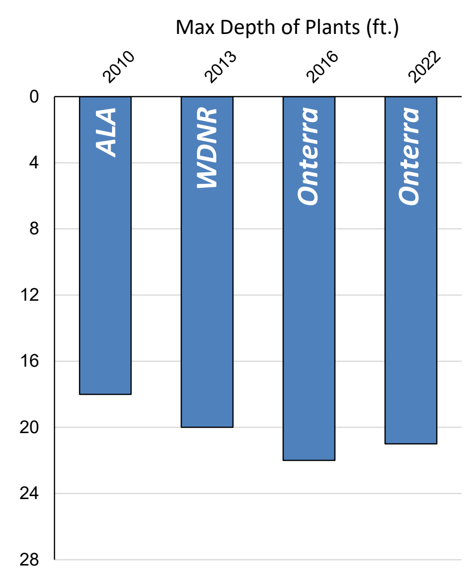

Figure 3.2-2. Maximum depth of plants from point-intercept surveys.

Whole-lake point-intercept surveys are used to quantify the abundance of individual plant species within the lake. Of the 535 point-intercept sampling locations that fell at or shallower than the maximum depth of plant growth (the littoral zone) in 2022, approximately 74% contained aquatic vegetation (Map 2). Aquatic plant rake fullness data collected in 2022 indicates that 46% of the 535 sampling locations contained vegetation with a total rake fullness rating (TRF) of 1, 17% had a TRF rating of 2, and 11% had a TRF rating of 3 (Figure 3.2-3). The TRF data indicates that where aquatic plants are present in Archibald Lake, they are at a moderate to high abundance. A review of the TRF values over time shows a decline of overall aquatic plant abundance but proportions of TRF values are relatively the same.

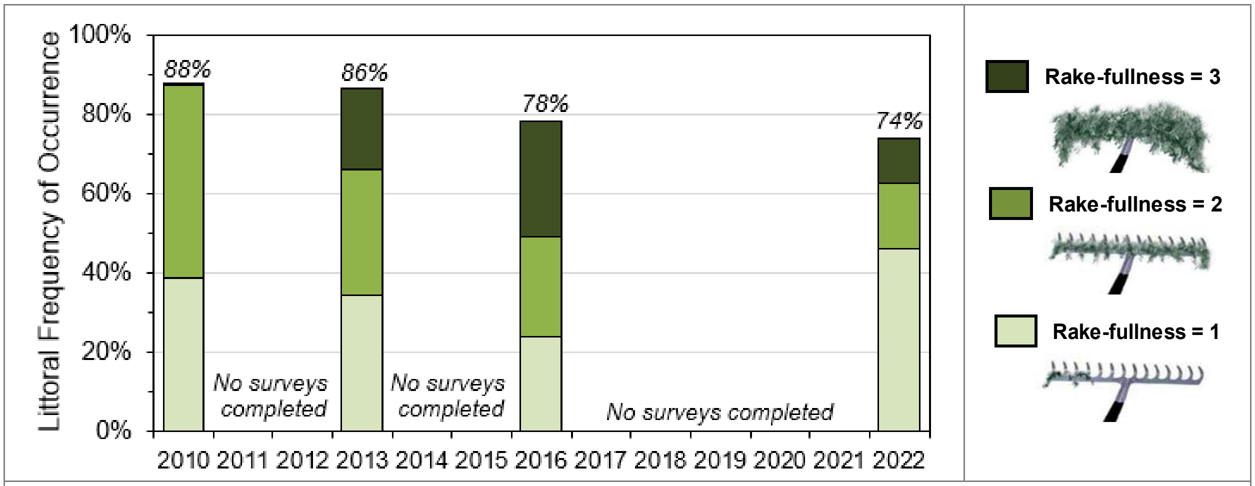

Figure 3.2-3. Aquatic vegetation total rake fullness (TRF) ratings within littoral areas.

Whole-lake point-intercept surveys are used to quantify the abundance of individual species within the lake. Figure 3.2-7 shows the littoral frequency of occurrence (LFOO) of aquatic plants from the 2022 point-intercept survey. These data indicate that muskgrasses, slender and southern naiad, and wild celery are the most frequent native aquatic plant species found in Archibald Lake during 2022 (Photograph 3.2-1).

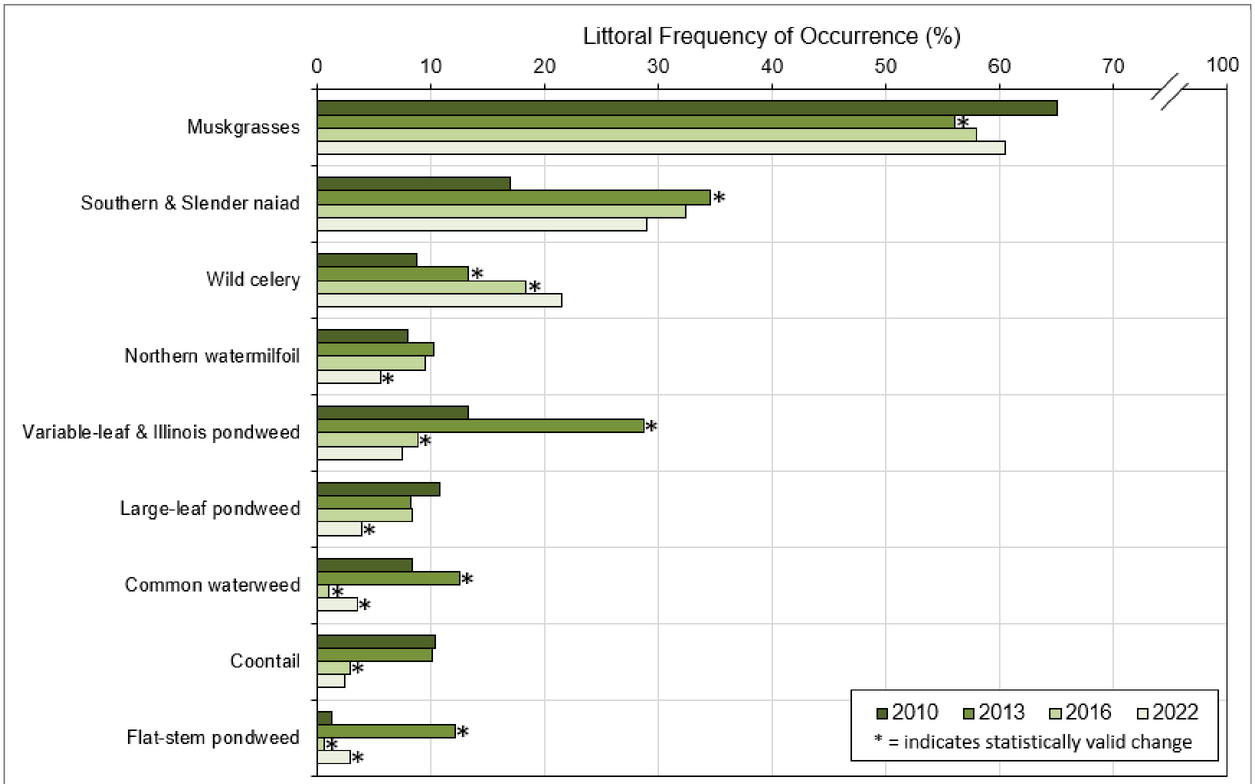

Figure 3.2-4. Littoral frequency of occurrence of aquatic plant species in Archibald Lake. Species with >10% LFOO are displayed.

In the field, it is often difficult to distinguish between certain species of aquatic plants that are very similar morphologically, especially when flowering/fruiting material is not present. Because of this, the littoral occurrences of the following morphologically-similar species were combined for this analysis: slender naiad (*Najas flexilis*) and southern naiads (*N. guadalupensis*), variable-leaf (*Potamogeton gramineus*) and Illinois pondweeds (*P. illinoensis*), as well as small pondweed (*P. pusillus*) and slender pondweed (*P. berchtoldii*).

Photograph 3.2-1. The aquatic macroalgae muskgrasses (*Chara* spp.). Photo credit Onterra.

Muskgrasses are a genus of macroalgae of which there are seven species in Wisconsin (Photograph 3.2-4). In 2022, muskgrasses had a littoral frequency of occurrence of approximately 60.6% (Figure 3.2-5). Dominance of the aquatic plant community by muskgrasses is common in hardwater lakes like Archibald Lake, and these macroalgae have been found to be more competitive against vascular plants (e.g. pondweeds, milfoils, etc.) in lakes with higher concentrations of calcium carbonate in the sediment (Kufel and Kufel 2002); (Wetzel 2001). Muskgrasses require lakes with good water clarity, and their large beds stabilize bottom sediments. Studies have also shown that muskgrasses sequester phosphorus in the calcium carbonate incrustations which form on these plants, aiding in improving water quality by making the phosphorus unavailable to phytoplankton (Coops 2002). In Archibald Lake, muskgrasses were abundant across littoral depths of 1 to 21 feet in 2022.

Starry stonewort (*Nitellopsis obtusa*; SSW; Photograph 3.2-2) is a non-native, invasive macroalgae that was first observed in the United States in 1978 within the St. Lawrence River. Interestingly, this species receives special protections in its native range due to low population numbers. SSW was discovered in a southeastern Wisconsin lake in 2014, and has now been verified from approximately two dozen inland lakes within five counties. Starry stonewort was also found in Sturgeon Bay in 2016 and subsequent investigations indicate this species is present in coastal areas of Lake Michigan and Green Bay. SSW is not known to be found in Archibald Lake, but the system likely contains ideal condition suitable for establishment if the invasive macroalgae was introduced.

Like other invasive species, starry stonewort has been shown to dominate aquatic plant communities, in some cases growing to nuisance levels and hindering recreation. However this species does not act invasively in all situations. To date, there have not been any effective chemical management strategies for SSW. Copper-based algaecides can temporarily suppress SSW populations (months), but have been shown to be ineffective at long-term control.

Photograph 3.2-2. Starry stonewort, not documented from Archibald Lake. Non-native, invasive macroalgae. Photo credit Onterra from Geneva Lake, WI.

Photograph 3.2-3. Slender naiad (Najas flexilis; left) and southern naiad (N. guadalupensis; right). Photo credit Onterra.

Slender and southern naiad, were the second-most frequently encountered aquatic plant in 2022 with a littoral frequency of occurrence of 29% (Figure 3.2-4), is a submersed, annual plant that produces numerous seeds. Slender naiad is considered to be one of the most important sources of food for a number of migratory waterfowl species (Borman 2007). In addition, slender naiad's small, condensed network of leaves provide excellent habitat for aquatic invertebrates. Southern naiad is similar to slender naiad, and they are often difficult to separate (Photograph 3.2-3). While southern naiad is native to North America, observations have been indicating that populations of this plant have been expanding and behaving invasively, particularly in northern Wisconsin lakes. It is not known if this behavior represents recent introductions of these plants to waterbodies where it was not found naturally, or if certain environmental conditions are favoring the expansion of southern naiad. In Archibald Lake, slender and southern naiad were most prevalent between 1 and 17 feet of water. As is discussed further in this section, southern naiad was recorded during the previous point-intercept surveys completed on Archibald Lake, and the data indicates southern naiad occurrence has not increased over this time period.

Wild celery, also known as tape or eel grass, was the third-most frequently encountered aquatic plant species with a littoral frequency of occurrence of 21.5% during the 2022 point-intercept survey (Figure 3.2-4). Wild celery is relatively tolerant of low-light conditions and is able to grow in deeper water. Its long leaves provide excellent structural habitat for numerous aquatic organisms while its extensive root systems stabilize bottom sediments. Additionally, the leaves, fruit, tubers, and winter buds of wild celery are food sources for numerous species of waterfowl and other wildlife. In Archibald Lake, wild celery was most abundant between 3 and 16 feet of water.

Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For example, while muskgrasses were found at 60.6% of the littoral sampling locations in Archibald Lake in 2022, its relative frequency of occurrence is 30.0% (Figure 3.2-5). Explained another way, if 100 plants were randomly sampled from Archibald Lake, 30 of them would be muskgrasses. Figure 3.2-12 displays the relative frequency of occurrence of aquatic plant species from each of the point-intercept surveys in Archibald Lake.

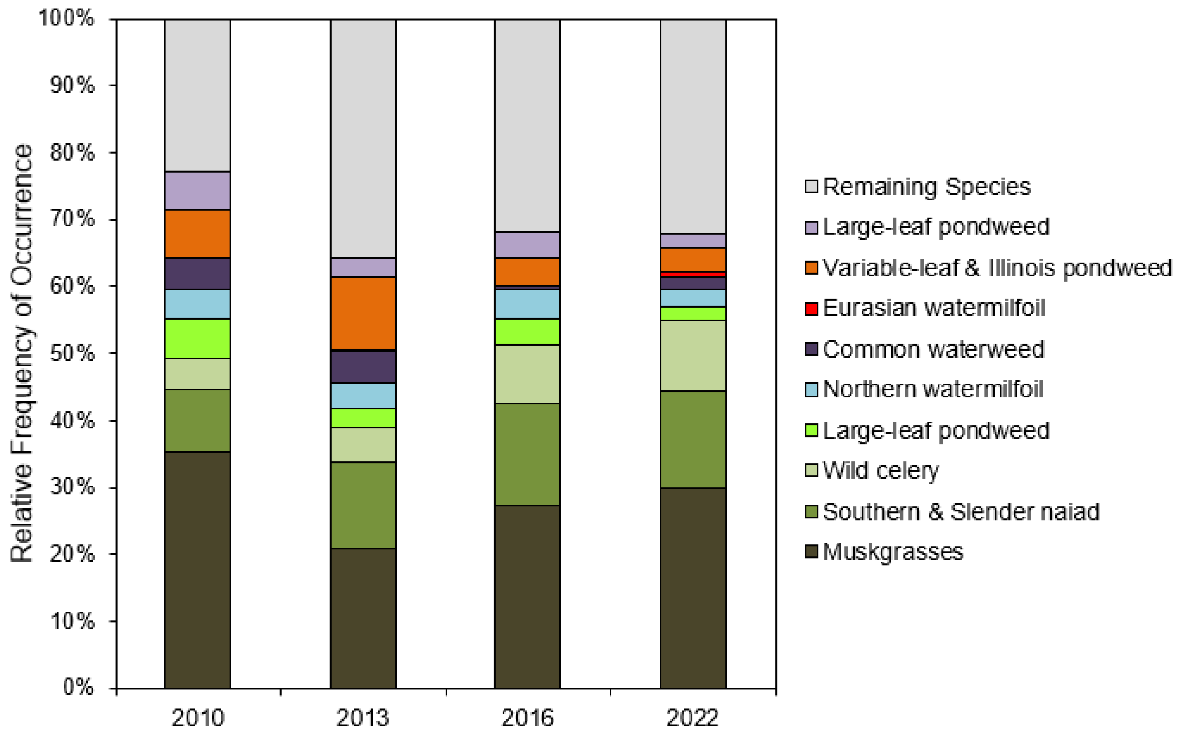

Figure 3.2-5. Relative frequency of occurrence of aquatic plants in Archibald Lake.

Aquatic plant communities are dynamic and the abundance of certain species from year to year can fluctuate depending on climatic conditions, water levels, changes in clarity, herbivory, competition, and disease among other factors. Certain native aquatic plants can also decline following the implementation of herbicide applications to control non-native aquatic plants; however, the treatments completed to control flowering rush and Eurasian watermilfoil in Archibald Lake have been relatively small and are not believed to have been able to impact native plant populations on a lake-wide level. Rather, these observed reductions and increases in occurrence of certain species are believed to be due to varying interannual environmental conditions. Ongoing collection of aquatic plant data from Wisconsin's lakes shows that aquatic plant populations have the capacity to fluctuate widely on an interannual basis under natural conditions. It is not known what has driven the changes observed in Archibald Lake, but it is likely the result of a combination of primarily natural factors. Having a species-rich plant community like that found in Archibald Lake is important as when conditions are unfavorable for some species, other species can fill in to fulfill their ecological role.

As discussed in the primer section, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. Archibald Lake's native aquatic plant species richness in 2022 exceeded the 75th percentile value for lakes within the Northern Lakes and Forests Lakes (NLFL) ecoregion and for lakes throughout Wisconsin (Figure 3.2-6).

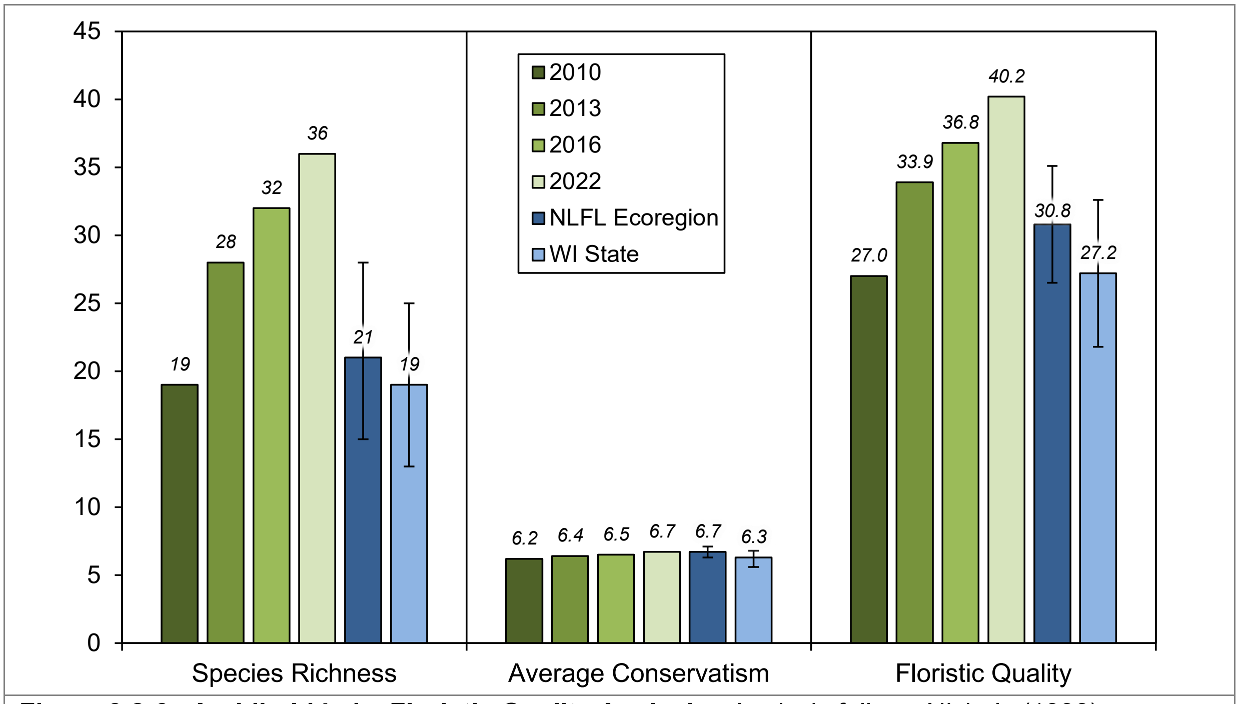

Figure 3.2-6. Archibald Lake Floristic Quality Analysis. Analysis follows Nichols (1999).

The species richness recorded in 2022 (36) was also higher than that recorded during all previous point-intercept surveys. As mentioned in the *2018 Comprehensive Management Plan* report, the large differences in species richness between these surveys are likely due to differences in the surveyors' aquatic plant identification abilities. The changes in the aquatic plant species list between these surveys can be viewed in Table 3.2-1.

The average conservatism of the 36 native aquatic plants recorded on the rake in 2022 was 6.7, falling at the median value (6.7) for lakes within the NLFL ecoregion and above the median value (6.3) for lakes throughout Wisconsin (Figure 3.2-6). This indicates that Archibald Lake has an average number of native aquatic plant species with high conservatism values when compared to the majority of lakes within the NLFL ecoregion.

Using Archibald Lake's 2022 native aquatic plant species richness and average conservatism to calculate the Floristic Quality Index value yields a high value of 40.2, exceeding the 75th percentile values for lakes within the NLFL ecoregion and the state. This indicates that Archibald Lake's aquatic plant community is of higher quality in terms of species richness and community composition than the majority of lakes within the ecoregion and the state.

Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Archibald Lake contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Archibald Lake's diversity values rank. Using data collected by Onterra, quartiles were calculated for lakes within the NLFL Ecoregion (Figure 3.2-7). Using the data collected from the whole-lake point-intercept surveys, Archibald Lake's aquatic plant species diversity has varied slightly over time. In 2022, Simpson's diversity was at 0.82.

Figure 3.2-8 investigates the average number of native plant species at each littoral point-intercept sampling location. The 2022 survey indicated 2.2 native species per littoral sampling site which is a healthy value. Map 3 displays these data over Archibald Lake.

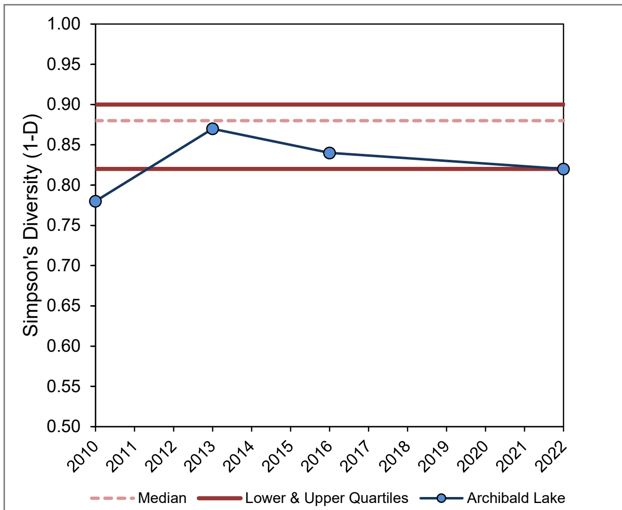

Figure 3.2-7. Archibald Lake Simpson's Diversity Index.

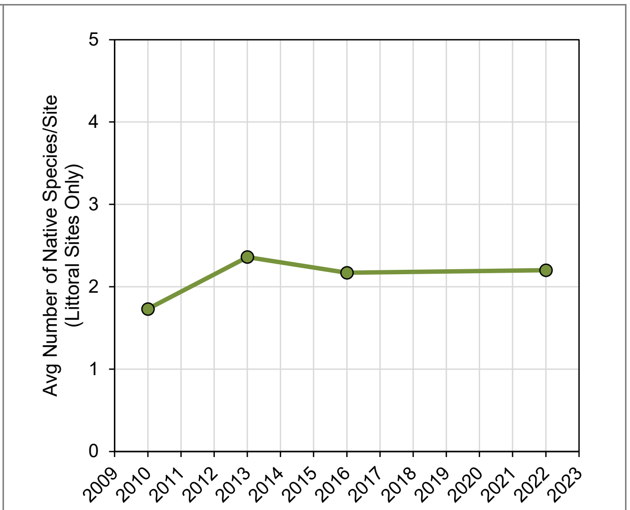

Figure 3.2-8. Average number of native aquatic plant species per littoral sampling site.

3.3 Non-native Aquatic Plants in Archibald Lake

All the aquatic plant data discussed so far was collected as part of point-intercept surveys. The subsequent materials will also incorporate data from AIS mapping surveys. Additional explanation about how these two surveys differ is discussed below.

The point-intercept survey provides a standardized way to gain quantitative information about a lake's aquatic plant population through visiting predetermined locations and using a rake sampler to identify all the plants at each location (Photograph 3.3-1). The point-intercept survey can be applied at various scales. Most commonly, the point-intercept survey is applied at the whole-lake scale to provide a lake-wide assessment of the overall plant community. More focused point-intercept surveys, called sub-sample point-intercept surveys, may be conducted over specific areas to monitor an active management strategy such as herbicide treatments or mechanical harvesting. These types of sub-sample point-intercept surveys have not been conducted as part of ongoing herbicide treatment monitoring on Archibald Lake in the past.

Photograph 3.3-1. Conducting a point-intercept survey. Photo credit Onterra.

While the point-intercept survey is a valuable tool to understand the overall plant population of a lake, it does not offer a full account (census) of where a particular species exists in the lake. During the EWM mapping survey, the entire littoral area of the lake is surveyed through visual observations from the boat (Photograph 3.3-2). Field crews supplemented the visual survey by deploying a submersible camera along with periodically doing rake tows. The EWM population is mapped using sub-meter GPS technology by using either 1) point-based or 2) area-based methodologies. Large colonies >40 feet in diameter are mapped using polygons (areas) and are qualitatively attributed a density rating based upon a five-tiered scale from *highly scattered* to *surface matting*. Point-based techniques were applied to AIS locations that were considered as *small plant colonies* (<40 feet in diameter), *clumps of plants*, or *single or few plants*.

Photograph 3.3-2. Conducting an EWM mapping survey. Photo credit Onterra.

Overall, each survey has its strengths and weaknesses, which is why both are utilized in different ways as part of this project.

Eurasian watermilfoil (Myriophyllum spicatum)

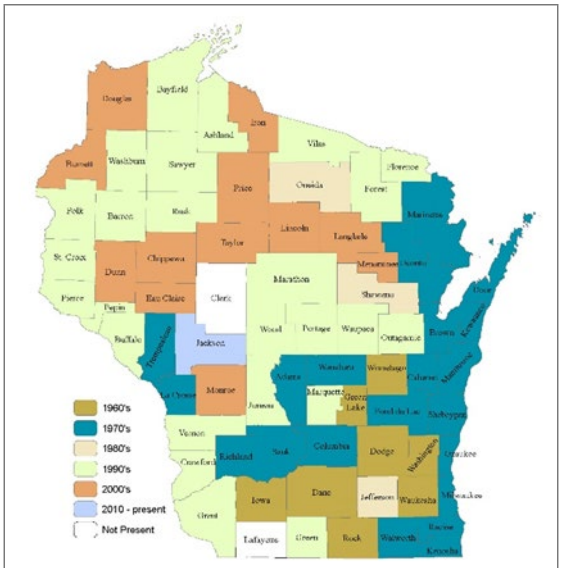

Figure 3.3-1. Spread of Eurasian watermilfoil within WI counties. WDNR Data 2022 mapped by Onterra.

Eurasian watermilfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.3-1). Eurasian watermilfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian watermilfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian watermilfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating. However, in some lakes, EWM appears to integrate itself within the community without becoming a nuisance or having a measurable impact to the ecological function of the lake.

The non-native plant that is of primary concern in Archibald Lake is EWM. EWM was first discovered in Archibald Lake in 2009. Since its discovery, numerous control efforts have targeted EWM, including volunteer-based hand-removal efforts and spot herbicide treatments. Onterra was contracted by Archibald Lake Association to develop an EWM control strategy for 2023.

WDNR Long-Term EWM Trends Monitoring Research Project

Starting in 2005, WDNR Science Services began conducting annual point-intercept aquatic plant surveys on a set of lakes to understand how EWM populations vary over time. This was in response to commonly held beliefs of the time that once EWM becomes established in a lake, its population would continue to increase over time.

Like other aquatic plants, EWM populations are dynamic and annual changes in EWM frequency of occurrence have been documented in many lakes, including those that are not being actively managed for EWM control (no herbicide treatment or hand-harvesting program). The data are clearest for unmanaged lakes in the Northern Lakes and Forests Ecoregion (NLF) and the North Central Hardwood Forests Ecoregion (NCHF) (Figure 3.3-2).

The results of the study clearly indicate that EWM populations in unmanaged lakes can fluctuate greatly between years (Figure 3.3-2). Following initial infestation, EWM expansion was rapid on some lakes, but overall was variable and unpredictable (Nault 2016). On some lakes, the EWM populations reached a relatively stable equilibrium whereas other lakes had more moderate year-to-year variation. Regional climatic factors also seem to be a driver in EWM populations, as many EWM populations declined in 2015 even though the lakes were at vastly different points in time following initial detection within the lake. 2019 also experienced record rainfall which may have had an impact on the EWM population indirectly through a decrease in water clarity.

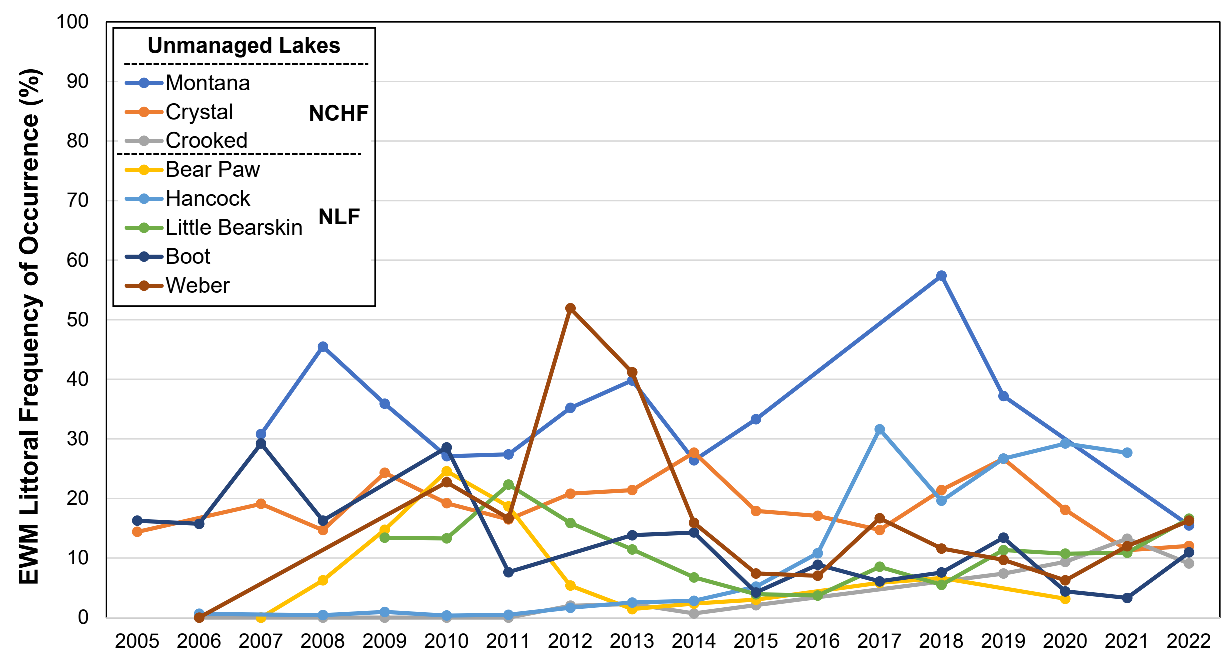

Figure 3.3-2. LFOO of EWM in northern ecoregions without management. Data provided by and used with permission from WDNR. LFOO = littoral frequency of occurrence.

EWM population of Archibald Lake

Using data from the point-intercept surveys that have been completed over the years, the littoral frequency of occurrence of EWM can be compared for Archibald Lake (Figure 3.3-3). The frequency of occurrence of EWM has remained very low within the lake over the monitoring timeframe. A statistically valid increase in occurrence was observed from the 2016 and 2022 surveys. EWM was sampled at its highest occurrence in Archibald Lake (1.3%) in 2022 since monitoring began in 2010.

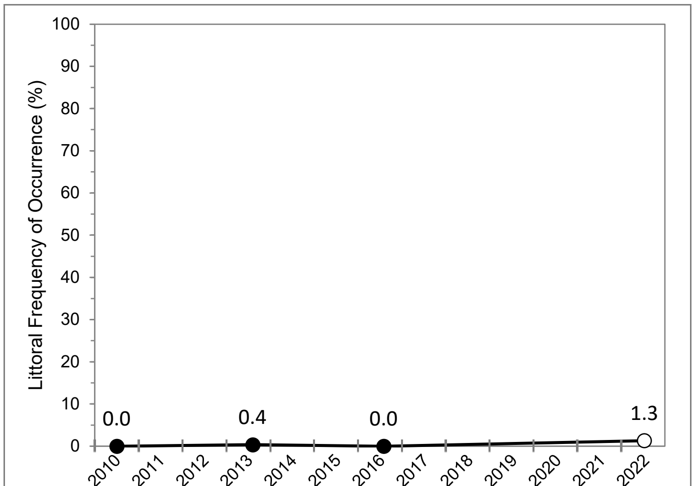

Figure 3.3-3. EWM littoral frequency of occurrence within Archibald Lake. Data from available point-intercept surveys.

The EWM population in Archibald Lake was mapped during a September 1, 2022 survey by Onterra ecologists. A total of 1.4 acres of colonized EWM was mapped throughout the system of which 0.7 acres was of a dominant density, and another 0.7 acres was described as a lower scattered density (Figure 3.3-4). It is important to note that Figure 3.3-4 displays only those EWM occurrences that were mapped with area-based (polygons) mapping methodologies. Many additional EWM occurrences were mapped with point-based methodologies throughout the system and are described as either single or few plants, clumps of plants, or small plant colonies. Any EWM mapped with point-based methods do not contribute to the acreages displayed on Figure 3.3-4.

Most of the EWM population is typically found to be growing between approximately 3-14 feet of water in Archibald Lake. The results of the 2022 mapping survey are displayed on Maps 4-10. Multiple *Dominant* or *Highly Dominant* colonies of EWM were mapped in off shore locations of Archibald Lake, while point-based methodologies were used to map throughout other areas of the lake. Overall, this is a modest EWM population and the ALA has been effectively managing the non-native species each year.

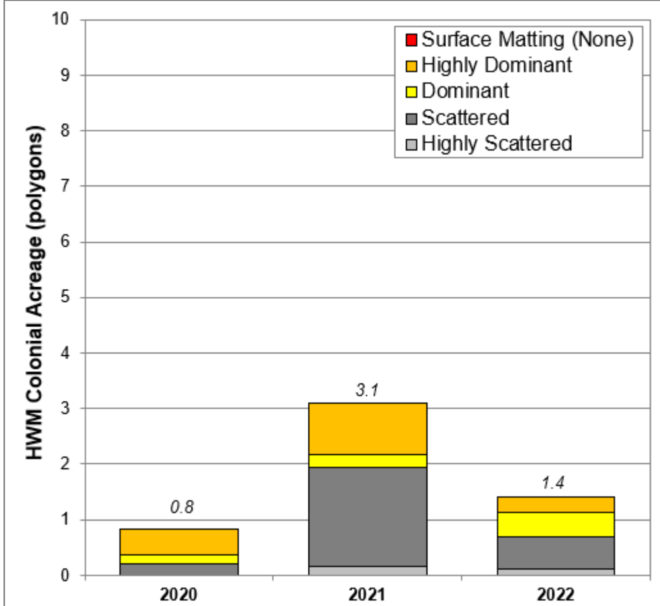

Figure 3.3-4. Archibald Lake acreage of colonized EWM (polygons) from 2020-2022. Created using data from Onterra late-summer EWM mapping surveys.

Archibald Lake Historic EWM Management

The term *Best Management Practice (BMP)* is often used in environmental management fields to represent the management option that is currently supported by that latest science and policy. When used in an action plan, the term can be thought of as a placeholder with anticipation of having an evolving definition over time. During early management of the lake, the BMP for managing EWM was through 2,4-D spot treatments (Table 3.3-1). Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. Spot treatments typically rely on a short exposure time to cause mortality as the herbicide dissipates out of the spots rapidly. Due to the size and shape of Archibald Lake (having two basins), essentially all previous herbicide applications have been spot treatments.

Table 3.3-1. Herbicide use history targeting EWM in Archibald Lake. Complication of data assisted by WDNR

Treatment Date	Acreage	Product Used	Type	Active Ingredient	Amount of Produc
9/29/2009	2.0	Navigate	granular	2,4-D (ester)	300 lbs
6/3/2010	2.0	Navigate	granular	2,4-D (ester)	575 lbs
7/11/2011	0.5	Renovate Max G	granular	Triclopyr/2,4-D (amine)	141 lbs
	0.5	Aquathol Super K	granular	Endothall (dipotassium salt)	33 lbs
6/5/2013	11.4	Navigate	granular	2,4-D (ester)	2,801 lbs
6/16/2014	8.0	Tribune	liquid	Diquat dibromide	16 gallons
7/2/2020	2.0	Alligare 2,4-D Amine	liquid	2,4-D (amine)	30 gallons
6/2/2021	1.5	Agristar 2,4-D Amine 4	liquid	2,4-D (amine)	34 gallons
6/7/2022	3.5	ProcellaCOR EC	liquid	florpyrauxifen-benzyl	74 PDU
	2.4	Agristar 2,4-D Amine 4	liquid	2,4-D (amine)	45 gal
6/16/2023	5.0	ProcellaCOR EC	liquid	florpyrauxifen-benzyl	163 PDU
6/5/2023	1.1	Agristar 2,4-D Amine 4	liquid	2,4-D (amine)	17.2 gal

The Archibald Lake Comprehensive Management Plan was finalized in May 2018. Within the management planning process, specific goals and actions related to managing EWM were developed. One management action within the Plan is to *Conduct EWM Population Control Using Hand Harvesting and/or Herbicide Spot Treatment*. If the following trigger is met, the ALA would consider conducting herbicide spot treatments: "colonized (polygons) areas where a sufficiently large treatment area can be constructed to hold concentration and exposure times." It is believed that these populations of EWM are too large to be controlled using hand-harvesting techniques. It is also likely that these areas may be too small for herbicides like 2,4-D to be effective, so they would likely need to be targeted with herbicides that require short exposure times.

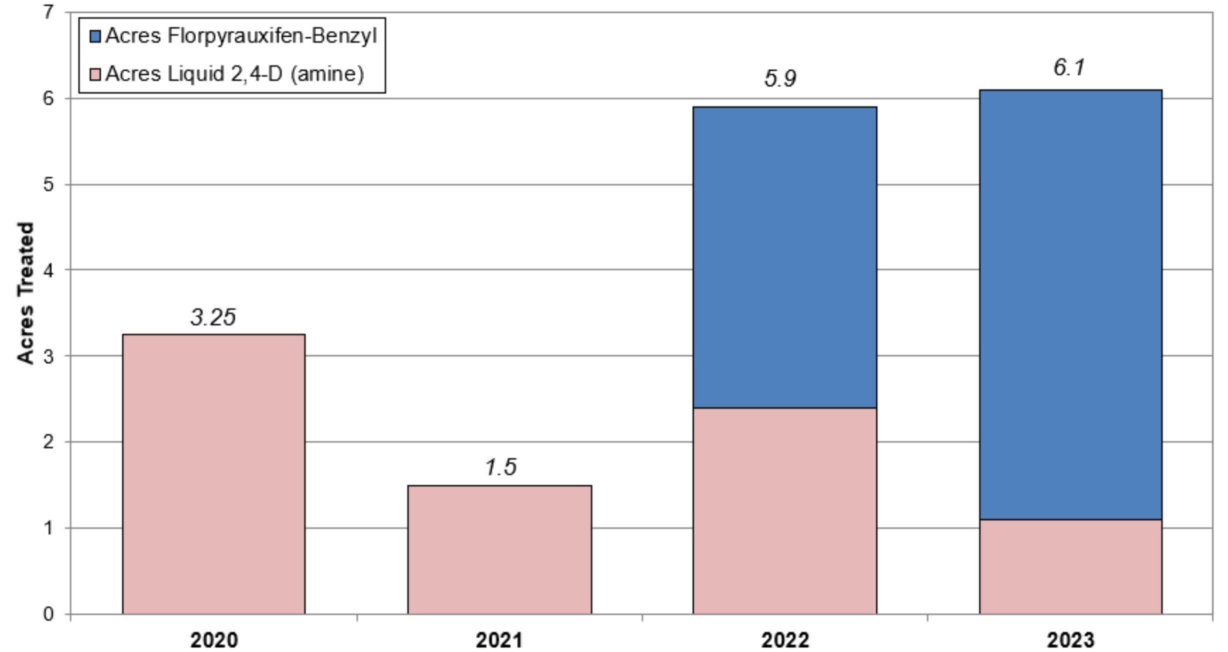

Figure 3.3-5. 2020-2023 aquatic plant herbicide management activities on Archibald Lake.

The Management Plan also contained a management action to *Investigate and Study Alternative Management Methodologies.* The ALA partnered with regional WDNR staff to investigate the potential for herbicide treatments with barrier curtains to target smaller areas of EWM than outlined within their Plan with 2,4-D in 2020-2021 (Figure 3.3-5).

The goal was to "contain" the herbicide in place with the use of barrier curtains, allowable to be in place for up to 72 hours after the treatment is conducted (other restrictions and safety measures apply). Typically, areas already somewhat contained by a bay or shoreline were chosen to minimize the amount of curtain material needed (Photograph 3.3-3).

Photograph 3.3-3. Herbicide enclosure on Archibald Lake. Photo credit Archibald Lake Association.

The majority of research trials that have taken place in Wisconsin utilized an economical-priced herbicide like 2,4-D to determine if the herbicide can be held in place long enough to be effective. Recently, some lake groups are considering barrier curtains to contain the herbicide to limit non-target collateral impacts to native plants. Barrier curtain construction and placement is the responsibility of the lake group, requiring advance planning efforts and a formidable volunteer base.

The ALA constructed a barrier curtain and conduct its first trial 2,4-D treatment with a barrier in 2020. This trial program expanded to three additional trial barrier 2,4-D treatments in 2021 and one barrier 2,4-D treatment in 2022. In annual EWM Control & Monitoring Reports, the ALA has been monitoring the effectiveness of these treatments and continuing to strive for greater longevity of results.

While understood in terrestrial herbicide applications for years, tolerance evolution is an emerging topic amongst aquatic herbicide applicators, lake management planners, regulators, and researchers. Herbicide resistance is when a population of a given species develops reduced susceptibility to an herbicide over time, such that an herbicide use pattern that once was effective no longer produces the same level of effect. This occurs in a population when some of the targeted plants have an innate tolerance to the herbicide and some do not. Following an herbicide treatment, the more tolerant strains will rebound whereas the more sensitive strains will be controlled. Thus, the plants that re-populate the lake will be those that are more tolerant to that herbicide resulting in a more tolerant population over time. Onterra maintains concern for future use of 2,4-D in Wisconsin Lakes, as the extensive use of this product may have created herbicide resistance and therefore herbicide rotation away from this herbicide is recommended.

The active ingredient florpyrauxifen-benzyl is sold exclusively by SePRO under the tradename ProcellaCOR™. ProcellaCOR™ has been the state's most popular spot-treatment strategy for EWM management in recent years. This herbicide has largely been used in spot treatment scenarios, but has recently been adopted as a whole-lake treatment option on a number of

Wisconsin lakes. Onterra has monitored over 50 ProcellaCOR™ treatments in Wisconsin since 2019 with data analysis related to herbicide concentration monitoring and native aquatic plant impacts being investigated in the majority of treatments. Analysis of these data have allowed lake managers to better understand the ways in which the herbicide dissipates or mixes within a lake in the hours and days after application. Additionally, aquatic plant monitoring data provides insights as to which native species are typically impacted with ProcellaCOR™ treatments. The WDNR's fact sheet on this chemistry can be found here:

https://apps.dnr.wi.gov/swims/Documents/DownloadDocument?id=332109305

The ALA has adopted this herbicide into its program in 2022, conducting a trial treatment in a protected bay. The year of treatment results were promising, with more information being collected in 2023 to understand the longevity of the results. Another trial ProcellaCOR™ treatment was conducted in spring 2023 on a more exposed location.

Lake managers continue to learn how to successfully implement this form of treatment after being registered for use in Wisconsin only a few years ago. ProcellaCOR™ is in a new class of synthetic auxin mimic herbicides (arylpicolinates) with short concentration and exposure time (CET) requirements compared to other systemic herbicides. Uptake rates of ProcellaCOR™ into EWM were two times greater than reported for triclopyr (Haug 2018) (Vassios et al. 2017). The active ingredient of ProcellaCOR™, florpyrauxifen-benzyl, is primarily degraded by photolysis (light exposure), with some microbial degradation. The active ingredient is relatively short-lived in the environment, with half-lives of 4-6 days in aerobic environments and 2 days in anerobic environments (WSDE 2017). Preliminary research suggests that florpyrauxifen-benzyl may have a different or quicker breakdown pattern in waters with high pH and high biomass of aquatic plants. Based upon limited historical data, Archibald Lake's mid-summer pH is around 8.3.

The primary breakdown product of florpyrauxifen-benzyl is florpyrauxifen acid. Florpyrauxifen acid has been shown to persist in the lake longer than the active ingredient. This chemical metabolite is reported to have activity as an herbicide on aquatic plants, albeit to a lower degree than the active ingredient. It is unclear at this time the exact role that the acid metabolite may play in contributing to EWM reductions, particularly in areas not located directly within the herbicide application area.

Onterra's experience monitoring ProcellaCOR™ treatments indicates that EWM control has been high with almost no EWM being located during the summer post treatment surveys. Some treated sites have shown EWM population recovery two-years after treatment, while most other sites have demonstrated three years and counting of continued EWM reductions to-date.

Native aquatic plant monitoring data indicates that northern watermilfoil is highly susceptible to ProcellaCOR™ with frequency of occurrences typically reduced to 0% in the year of treatment with little to no sign of recovery during the year after treatment. Other species that have shown a degree of susceptibility to this chemical include water marigold (*Bidens beckii*), coontail, and potentially water stargrass. In many of the treatments that Onterra has monitored, coontail occurrence has been reduced by approximately 50% during the year of treatment, but is not typically reduced to 0%.

Pondweed species appear to be largely unaffected by this herbicide, with some lakes having large increases in species, such as clasping-leaf pondweed, during the years following treatment.

Onterra's experience is that adjacent populations of floating-leaf species (i.e. water lilies) may initially shows signs of herbicidal stress such as leaf twisting (epinasty), but typically rebound a few weeks after treatment including in intentional whole-lake treatment scenarios.

Archibald Lake Future EWM Management Discussions

During the Planning Committee meetings held as part of this project, three broad Eurasian watermilfoil management goals were discussed including a generic potential action plan to help reach each of the goals (Figure 3.3-6). During these discussions, conversation regarding risk assessment of the various management actions was also discussed. Onterra provided extracted relevant chapters from the WDNR's *APM Strategic Analysis Document* to serve as an objective baseline for the for the ALA to weigh the benefits of the management strategy with the collateral impacts each management action may have on the Archibald Lake ecosystem. These chapters are included as Appendix D. The ALA Planning Committee also reviewed these management perspectives in the context of perceived riparian stakeholder support, which is discussed in the subsequent sub-section.

1. **No Coordinated Active Management**
   (Let Nature Take its Course)
   - Focus on education of manual removal methods for property owners
   - Lake organization does not oppose contracted manual removal efforts, but does not organize or pay for them
2. **Reduce EWM Population on a lake-wide level**
   (Lake-Wide Population Management)
   - Would rely on herbicide treatment strategies (risk assessment)
   - Will not eradicate EWM
   - Set triggers (thresholds) of implementation and tolerance
   - May be inconsistent with regulatory framework
   - May be unrealistic on some systems
3. **Minimize navigation and recreation impediment**
   (Nuisance Control)
   - Manual removal alone is not able to accomplish this goal on most systems, with herbicides or a mechanical harvester being required

Figure 3.3-6. Potential EWM Management Perspectives

<u>Let Nature Take its Course:</u> In some instances, the EWM population of a lake may plateau or reduce without conducting active management, as shown in the WDNR Long-Term EWM Trends Monitoring Research Project on Figure 3.3-2. Some lake groups decide to periodically monitor the EWM population, typically through a semi-annual EWM mapping survey or point-intercept survey, but do not coordinate active management (e.g., hand-harvesting or herbicide treatments). This requires that the riparians tolerate the conditions caused by the EWM, acknowledging that some years may be problematic to recreation, navigation, and aesthetics. Individual riparians may choose to hand-remove the EWM within their recreational footprint, but most often the lake group chooses not to assist financially or with securing permits (only necessary if Diver Assisted Suction Harvest [DASH] is used). In some instances, the lake group may select this management goal, but also set an EWM population threshold or management *trigger* where they would revisit their management strategy if the population reached that level. Said another way, the lake group would let nature take its course up until populations reached a certain lake-wide level or site-specific density threshold. At that time, the lake group would investigate whether active management measures may be justified.

Lake-Wide Population Management: Some believe that there is an intrinsic responsibility to correct for changes in the environment that are caused by humans. For lakes with EWM populations, that may be to manage the EWM population at a reduced level with the perceived goal to allow the system to function as it had prior to EWM establishment. It must also be acknowledged that some lake managers and natural resource regulators question whether that is an achievable goal as management actions have unintended collateral impacts.

In early EWM populations, the entire population may be targeted through hand-harvesting or spot treatments. On more advanced or established populations, this may be accomplished through large-scale control efforts such as water-level drawdowns or whole-lake herbicide treatment strategies. In areas of the state that contain established and prevalent EWM populations, lake-wide population management is often considered too aggressive by local WDNR regulators. In these instances, the nuisance conditions are targeted for management and other areas are tolerated or avoided.

Nuisance Control: Some lake groups acknowledge that the most pressing issue with the EWM population on their lake is the reduced recreation, navigation, and aesthetics compared to before EWM became established in their lake. Particularly on lakes with large EWM populations that may be impractical or unpopular to target on a lake-wide basis, the lake group would coordinate (secure permits and financially support the effort) a strategy to improve these cultural ecosystem services.

There has been a change in preferred strategy amongst many lake managers and regulators when it comes to established EWM population in recent years. Instead of chasing the entire EWM population with management, focusing on the areas that are causing the largest impacts can be more economical and cause less ecological stress. The majority of EWM management in Wisconsin would be considered nuisance management, where dense areas that are causing navigation or recreation issues are prioritized for management and dense areas not meeting these criteria being left unmanaged. Mechanical harvesting and herbicide spot treatments are most typically employed to reach nuisance management goals, although hand-harvesting/DASH is sometimes employed to target small footprints.

Stakeholder Survey Responses to Eurasian Watermilfoil Management

As discussed in Section 2.3, the stakeholder survey asks many questions pertaining to perception of the lake and how it may have changed over the years. The return rate of the 2023 survey was 60%. Since the response rate was at or above 60%, the survey results can be understood in the context of the entire population offered to participate in the survey.

In an effort to understand how EWM impacts stakeholders, the 2023 stakeholder survey asked if the Eurasian watermilfoil population ever had a negative impact on your enjoyment of Archibald Lake. Prior to this question, stakeholders were asked if they were confidently able to identify EWM within the lake. Stakeholders who answered fairly confident or very confident were guided to answer the question if EWM ever impacted their enjoyment of the lake. The category with the highest number of respondents indicating *Yes* were aesthetics, swimming, and motor boating

(Figure 3.3-7). Relaxing/entertaining and motor boating were ranked as the first and third-highest reasons for owning or renting property on the lake (Section 2.3, Figure 2.3-3).

Queston 26: If you answered "fairly confident" or "very confident" in the previous question, has the Eurasian watermilfoil population ever had a negative impact on your enjoyment of Archibald Lake?

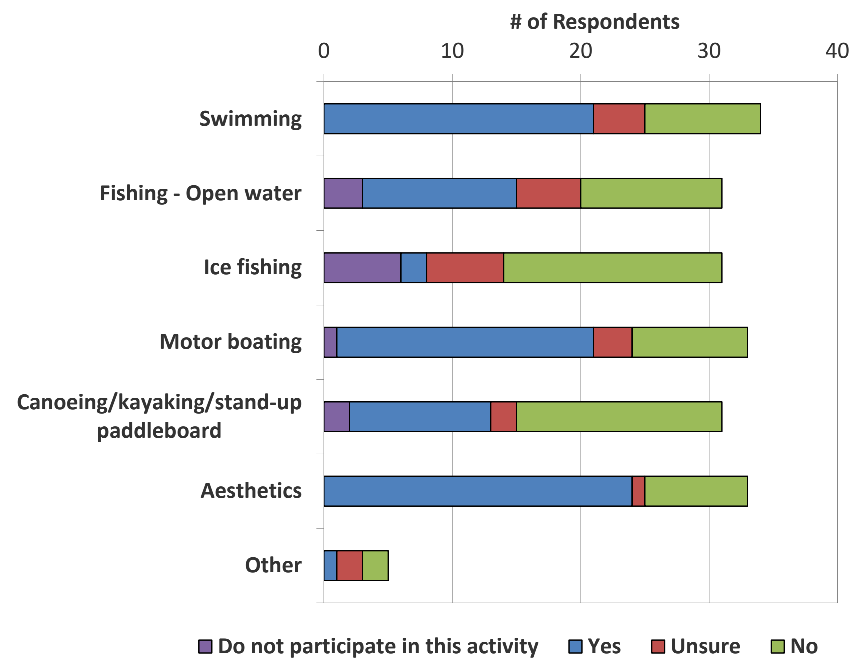

Figure 3.3-7. Select survey responses from the ALA Stakeholder Survey. Additional questions and response charts are found in Appendix B.

In 2023, riparian and ALA members were asked about a number of management techniques for managing non-native aquatic plants. Figure 3.3-8 highlights the level of support stakeholders have for each management technique offered.

Question 29: The Archibald Lake Association is currently assessing future EWM management techniques. What is your level of support or opposition for the future use of the following EWM management techniques in Archibald Lake?

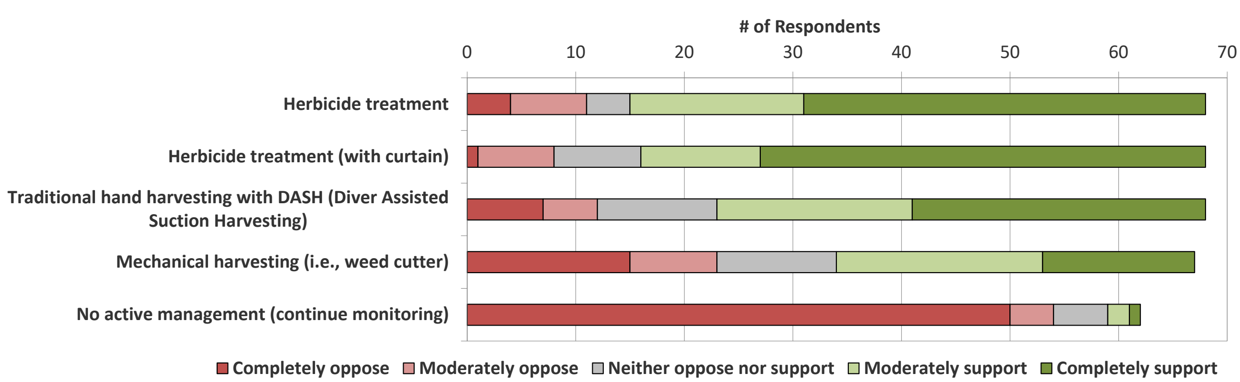

Figure 3.3-8. Select survey responses from the ALA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Within the 2023 survey, stakeholders were also asked if they were not supportive or somewhat unsupportive for any of the management techniques offered, what was the reason for their concern (Figure 3.3-9). The 2023 respondents indicated most concern for herbicide treatments which included potential impacts to native plant and non-plant species, potential impacts to human health, and future impacts are unknown. The top concern regarding mechanical harvesting and hand harvesting was potential cost of technique is too high.

Queston 30: What concerns, if any, do you have for the future use of aquatic herbicides, hand harvesting/DASH, and/or mechanical harvesting to target Eurasian watermilfoil in Archibald Lake?

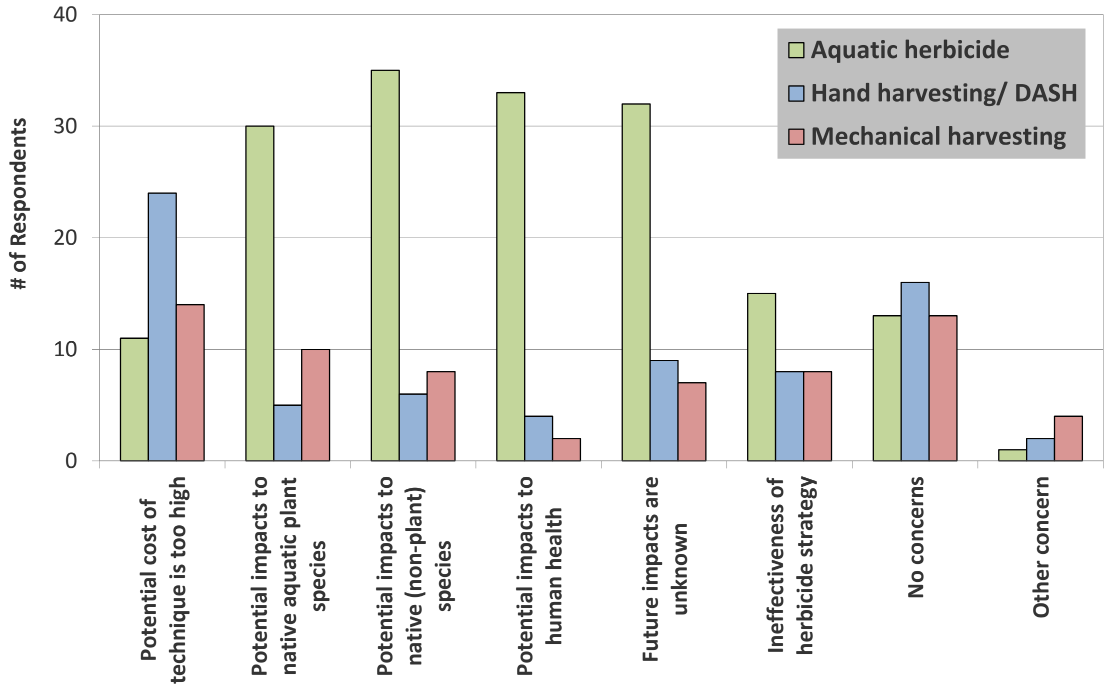

Figure 3.3-9. Select survey responses from the ALA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Giant Reed (Phragmites australis subsp. australis)

During a 2014 survey, Onterra ecologists documented the presence of another non-native species found in Wisconsin; giant reed (Photograph 3.3-4). Giant reed (*Phragmites australis* subsp. *australis*) is a tall, perennial grass that was introduced to the United States from Europe. A native strain (*P. australis* subsp. *americanus*) of this species also exists in Wisconsin and the plant material collected from Archibald Lake in 2014 was sent to the UWSP herbarium where it was later confirmed to be of the non-native variety. This species can form towering, dense colonies that

Photograph 3.3-4. Giant Reed (Phragmites australis) observed during a 2014 survey. Photo credit Onterra

overtake native vegetation and replace it with a monoculture that provides inadequate sources of food and habitat for wildlife.

Because this species has the capacity to displace the valuable wetland plants along the exposed shorelines, it was recommended that these plants be removed by cutting and bagging the seed heads and applying herbicide to the cut ends. Giant reed control has been most effective utilizing a foliar application of an enzyme-specific herbicide (imazapyr or glyphosate) applied to the plants during the late summer as the plants are actively transporting sugars and nutrients from their leaves to their rhizomes in preparation for over wintering. This will ensure translocation of the herbicide to the rhizomes where the entire plant can be controlled. A permit issued by the WDNR is required to place herbicide on plants that are located within the water.

Six areas of phragmites were found around the shoreline of Archibald Lake in 2016 (Map 11). These colonies have been monitored over the last few years. Previously, phragmites was only found in one area on the eastern shore in the west basin (and was controlled with herbicide applications) and it seems to have become more widespread. If continual monitoring indicates expansion, an effort should be made to remove these plants. Because this species has the capacity to displace the valuable wetland plants along the exposed shorelines, it is recommended that these plants be removed by cutting and bagging the seed heads and applying herbicide to the cut ends. This management strategy is most effective when completed in late summer or early fall when the plant is actively storing sugars and carbohydrates in its root system in preparation for over-wintering. A permit issued by the WDNR will likely be needed to place herbicide on plants that are located within the water.

Flowering Rush (Butomus umbellatus)

Flowering rush (*Butomus umbellatus*) is an invasive aquatic plant that is native to Europe (Photograph 3.3-5). This perennial plant flowers in late summer to early fall. It ranges in size from 1-5 feet, generally growing it shallow water, though it can be found growing submersed in up to 10 feet. Like other non-native invasive plants, flowering rush displaces native aquatic and wetland plants and can alter ecosystem functions.

Photograph 3.3-5. Flowering rush in Archibald Lake. Photo credit Onterra.

Flowering rush was first discovered in Archibald in 1989. In 2010, the ALA received a grant to research and control the flowering rush populations in Archibald Lake. In 2011, two trial areas were treated with granular endothall (Aquathol® SuperK) and a granular combination triclopyr and 2,4-D product (Renovate Max G®). A statistically valid decrease was seen with the combination auxin treatment (2,4-D and triclopyr); and while there was a decrease in the granular endothall site, it was not statistically significant. In 2013, the granular combination auxin herbicide as well as liquid diquat (Reward ®) were tested to treat the flowering rush and in 2014 and 2015. The principal investigators of the study determined that diquat was the best for controlling and the regrowth of flowering rush tubers. Diquat was shown to be effective in treating emergent as well as submergent flowering rush populations. (Fleming and Feming 2016) found there to be an 86% reduction in flowering rush populations from 2011 to spring 2015 and a 98% reduction from 2011 to fall of 2015. More information on the flowering rush research project can be found in the url below, a presentation given by Brenda Nordin (WDNR) and Steve Fleming (ALA) a the 2017 Wisconsin Lakes Partnership Conference:

https://www3.uwsp.edu/cnr-ap/UWEXLakes/Documents/programs/convention/2017/FridayConcurrent/7/SteveFlemingBrendaNordin_ArchibaldLakeFloweringRushControl.pdf

Map 11 displays the locations that flowering rush was found in 2016. A total of 0.05 acres were mapped as well as *single or few plants, clumps of plants* and one *small plant colony*. Flowering rush was found mainly within the western basin but a *clump of plants* and *single or few* plants were found on the western shore of the eastern basin. A submergent colony of flowering rush was noted by the ALA in the far eastern part of the lake that went undetected during Onterra's 2016 community mapping surveys. No active management has occurred on flowering rush since 2016.

4.0 SUMMARY & CONCLUSIONS

The design of this project was intended to fulfill three primary objectives;

1) Collect detailed information regarding invasive plant species within Archibald Lake, with the primary emphasis being on Eurasian watermilfoil.
2) Collect sociological information from Archibald Lake riparians regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.
3) Create an updated aquatic-plant management plan for the ALA considering the evolution of BMPs and changes on regulatory support for various techniques since the previous management planning effort.

The three objectives were fulfilled during the project and have led to a good understanding of Archibald Lake's aquatic plant community, the lake in general, and the folks that care about the lake.

The native aquatic plant community of Archibald Lake continues to be stable over time. The influence of water levels, especially just prior to the 2016 aquatic plant survey, seems to be the largest driver of changes in aquatic plant populations. While herbicide treatments have the capacity to negatively impact some aquatic species, the spot treatment conducted on Archibald Lake have been relatively small and had minimal impact on the system-wide aquatic plant community.

Archibald Lake is dominated by a low-growing species called muskgrasses. While resembling true aquatic plants, they are actually a large species of algae. Dominance of the aquatic plant community by muskgrasses is common in hardwater lakes like Archibald Lake. Muskgrasses require lakes with good water clarity, and their large beds stabilize bottom sediments. As the influence of zebra mussels continue to manifest, it is likely that muskgrasses will continue to dominate the aquatic plant community of Archibald Lake. The same conditions that favor muskgrasses are likely to favor a new aquatic invasive species of Wisconsin waters – starry stonewort (*Nitellopsis obtusa*). Found in nearby Green Bay and a system in Shawano County (Cloverleaf Lakes), this non-native macroalgae has no known control mechanisms once established in a lake. It would be prudent for the ALA to take steps to prevent this species from being exposed to Archibald Lake.

After being first detected in 2009, Eurasian watermilfoil (EWM) continues to be present in Archibald Lake, but at low population levels. A review of eight lakes in the northern half of Wisconsin that have not conducted any management (no herbicide treatments) show a lot of variation in most EWM populations over time, increasing and decreasing likely in response to climactic and corresponding water quality factors. As discussed as part of this project, EWM "acts" differently in every lake. In some lakes, EWM tends to integrate itself into the aquatic plant community and not cause impacts to recreation, navigation, or ecological function. In other lakes, there is no amount or level of aggressive management activities than can slow an eventual high and impactful EWM population in a lake. After being present in Archibald Lake for 15 years, the fact that EWM has not reached high population levels cannot be completely attributed to successful management. But as aspects of Archibald Lake change over time, such as water clarity, water levels, and other factors, it cannot be ruled out that EWM may proliferate quicker in the future.

The *2018 Comprehensive Management Plan* contained a management action to *Investigate and Study Alternative Management Methodologies.* The ALA partnered with regional WDNR staff to investigate the potential for herbicide treatments with barrier curtains to target smaller areas of EWM than outlined within their Plan with 2,4-D in 2020-2021. The goal was to “contain” the herbicide in place with the use of barrier curtains. After a few years of trials, the ALA has been able to install some of the best constructed and effective curtains Onterra has monitored. The ALA continues to use liquid 2,4-D amine within the curtain treatments, as it is economically priced and proven effective. However, the ALA will need to continually review the effectiveness of 2,4-D in Archibald Lake, as the repeated use of this herbicide may eventually result in herbicide resistance.

In 2021 and 2022, the ALA also initiated a series of trail herbicide spot treatments using ProcellaCOR™. This new herbicide is reported to be effective and shorter exposure times compared to 2,4-D. In 2021, the ALA adopted this strategy in a confined bay where herbicide exposure times were contained by the geography of the bay. This treatment was highly effective. In 2022, the ALA targeted a five-acres site on an exposed shoreline with ProcellaCOR. This type of scenario is the most challenging to be effective, so post treatment monitoring will be critical in understanding the future role of this tool in Archibald Lake.

5.0 AQUATIC PLANT IMPLEMENTATION PLAN SECTION

The Archibald Lake Association's *Comprehensive Lake Management Plan (CLMP)* for Archibald Lake was finalized and approved by the WDNR in May 2018. The Implementation Plan Strategy Section of the *2018 CLMP* (pg 87) includes the following strategic management goals along with specific management actions developed to help reach the objectives.

1. Control Existing and Prevent Further Aquatic Invasive Species Infestations within Archibald Lake
   - Continue Clean Boats Clean Waters watercraft inspections
   - Coordinate volunteer monitoring of AIS
   - Initiate Rapid Response Plan Following Detection of New AIS
   - Coordinate annual professional monitoring of EWM monitoring
   - Conduct EWM Population Control Using Hand-Harvesting and/or Herbicide Spot Treatments
   - Control Flowering Rush Populations
   - Control Phragmites Populations
   - Investigate and Study Alternative Management Methodologies
   - Coordinate Periodic Quantitative Vegetation Monitoring
2. Maintain Current Water Quality Conditions
   - Monitor water quality through WDNR Citizens Lake Monitoring Network
3. Increase ALA's Capacity to Communicate with Lake Stakeholders and Facilitate Partnerships with Other Management Entities
   - Use education to promote lake protection and enjoyment through stakeholder education
   - Continue ALA's involvement with other entities that have responsibilities in managing (management units) Archibald Lake.
   - Conduct Periodic Riparian Stakeholder Surveys
   - Educate Stakeholders on Boating Regulation and Boating Safety
   - Educate Stakeholders on Swimmers Itch
4. Improve Lake and Fishery Resource of Archibald Lake
   - Educate Stakeholders on the Importance of Shoreland Condition and Shoreland Restoration
   - Protect natural shoreland zones around Archibald Lake
   - Coordinate with WDNR and private landowners to expand coarse woody habitat in Archibald Lake
   - Coordinate with WDNR to Increase Walleye Population
   - Continue the Loon Watch Program

Figure 6.0-1. Archibald Lake Association management goals from 2018 CLMP. From *Archibald Lake Comprehensive Lake Management Plan* (May 2018)

The objective of this project was to revisit the aquatic plant-related goals and actions of the *Archibald Lake Comprehensive Management Plan* and adjust them appropriately based upon evolved current best management practices (BMPs), the lessons learned during the years since the last plan was developed, and the information gathered during the studies completed in 2022 As a result, this project largely updates the Implementation Plan Management Goal #1 of the ALA's

Comprehensive Management Plan (Figure 5.0-1). The ALA will continue to follow the remaining goals outlined in the 2018 *Comprehensive Management Plan.*

Within the following management actions, the ALA Board of Directors is listed as the facilitator for all management actions. The Board of Directors will be responsible for deciding whether the formation of sub-committees and/or directors is needed to carry out the various management actions.

The updated Implementation Plan presented below was created through the collaborative efforts of ALA Board of Directors, planning committee members, and ecologist/planners from Onterra. The Implementation Plan represents the path the ALA will follow in order to meet their lake management goals. The Implementation Plan is a living document that will be under constant review and adjustment depending on the condition of the lake, availability of funds, level of volunteer involvement, and needs of the stakeholders. The ALA has designed an ambitious, but achievable Implementation Plan as part of this effort.

Management Goal 1: Ensure the ALA has a Functioning and Up-to-Date Management Plan

Management Action:	Periodically update lake management plan
Timeframe:	Periodic
Facilitator:	Board of Directors
Description:	The term *Best Management Practice (BMP)* is often used in environmental management fields to represent the management option that is currently supported by that latest science and policy. When used in an action plan, the term can be thought of as a placeholder with anticipation of having an evolving definition over time. ***Comprehensive Management Plan*** The WDNR recommends *Comprehensive Lake Management Plans (CLMP)* generally get updated every 10 years. Implementation projects require a completion data of “no more than 10 years prior to the year in which an implementation grant application is submitted.” This allows a review of the available data from the lake, as well as to consider changing BMPs for water quality, watershed, and shoreland management. Although the ALA is not pursuing grant for implementing water quality or watershed management activities, they will roughly adhere to the 10-year recommended interval of investigations into these parameters to ensure the health of Archibald Lake. Likely at the time of the next Aquatic Plant Management (APM) Plan update, as discussed below, the ALA will consider taking a more comprehensive approach of investigating water quality and other lake parameters.

	Aquatic Plant Management Plan BMPs for aquatic plant management change rapidly, as new information about effectiveness, non-target impacts, and risk assessment emerges. To be eligible to apply for grants that provide cost share for AIS control and monitoring, "a current plan has a completion date of no more than 5 years prior to submittal of the recommendation for approval. The department may determine that a longer lifespan is appropriate for a given management plan if the applicant can demonstrate it has been actively implemented and updated during its lifespan. However, a [whole-lake] point-intercept survey of the aquatic plant community conducted within 5 years of the year an applicant applies for a grant is required." It is important to work with the regional WDNR Lakes Biologist to understand what is required at this time, as it is more subjective in comparison to the requirements of a *CLMP* as it relates to the specific management actions being considered. The ALA is focused on making sure their management plan is in good standing for grant eligibility and access to APM-related permits. As discussed above, the ALA is likely to consider commencing a comprehensive planning effort in roughly 2028, which would have an *Aquatic Plant Management Plan* component built into the overall comprehensive plan. Investigating changes in water quality following almost a decade since zebra mussels established will be an important component of this effort. ***Annual Control & Monitoring Plan*** It is important to note that the management plan provides a framework to guide the management action, but does not include the specific control plan for a given year. If the action being considered does not fall within the framework of the overall management plan, it is likely that an updated plan is needed regardless of its relative age. If the ALA intends to conduct active management towards aquatic plants, a proceeding written control and monitoring plan, consistent with the *Management Plan*, would be produced typically January-March prior to its implementation. The control plan is useful for WDNR and other regulators when considering approval of the action, as well as to convey the control plan to ALA members for their understanding.

Management Action:	Conduct periodic riparian stakeholder surveys
Timeframe:	Periodic: every 5 years, corresponding with management plan updates
Facilitator:	Board of Directors
Description:	Formal riparian stakeholder user surveys have been performed by the association in 2016 and 2023. Approximately once every 5-6 years, potentially at the time of a Plan update or prior to a large management effort, an updated stakeholder survey would be distributed to the ALA members and Archibald Lake riparians. Periodically conducting an anonymous stakeholder survey would gather comments and opinions from lake stakeholders to gain important information regarding their understanding of the lake and thoughts on how it should be managed. This information would be critical to the development of a realistic plan by supplying an indication of the needs of the stakeholders and their perspective on management. The stakeholder survey could partially replicate the design and administration methodology conducted during 2023, with modified or additional questions as appropriate. The survey would again need to receive approval from a WDNR Research Social Scientist, particularly if WDNR grant funds are used to offset the cost of the effort.

Management Action:	Convey updated aquatic plant management information and messaging to ALA members and Archibald Lake riparians
Timeframe:	Ongoing
Facilitator:	Board of Directors
Description:	Emerging science and new information is continually coming out of the aquatic plant management field, impacting management philosophies and what is considered the Best Management Practices (BMP). The ALA understands the importance of keeping Archibald Lake riparians informed of this rapidly changing landscape. To accomplish this educational objective, the ALA plans to highlight key topics from the plan and share educational materials on the subjects over time. The ALA believes that creating smaller modules of information and spreading out the delivery over time will be an effective educational initiative. In addition to these primary changes in EWM management, the ALA has identified the following list to serve as a basis for their education and outreach in regards to aquatic plant management: • EWM herbicide resistance • Unrealistic expectations (e.g. eradication, silver-bullet strategies) • Role of native aquatic plants, particularly floating-leaf (e.g. water lilies) and emergent (e.g. bulrushes, cattails) communities • Human tolerance to EWM conditions • Shoreland emergent AIS populations and management (e.g. flowering rush and phragmites)

Management Goal 2: Monitor Aquatic Vegetation on Archibald Lake

Management Action:	Coordinate volunteer monitoring of AIS
Timeframe:	Continuation of current effort
Facilitator:	Board of Directors
Description:	ALA members have received past training on AIS identification from WDNR and UW-Extension staff. The ALA also has a dedicated GPS to transfer information to and from professional surveyors. These surveys would be conducted to augment professional surveys, not replace them. Volunteers would look for known AIS that exist in Archibald (EWM, phragmites, flowering rush) as well as those species that are currently found in the lake. The Adopt-a-Shoreline Coordinator would coordinate the volunteers at the beginning of the growing season to ensure complete coverage of the Archibald Lake littoral zone and shoreline. The Coordinator would also be responsible for collecting all reporting forms (available on the ALA website) and compiling the information into a useable format. Although most shorelines have been patrolled on an annual basis over the last several years, more volunteers are needed to assure future coverage. The association will take the following action steps: • Volunteers from ALA update their skills by attending a training session conducted by the FLOW (Forest, Langlade, Marinette, & Oconto County) AIS Coordinator – (flowais@lumberjackrcd.org) • Trained volunteers recruit and train additional association members • Complete lake surveys following protocols • Report results to consultant and ALA, entering hours spent into SWIMS

Management Action:	Periodically monitor the Eurasian watermilfoil population
Timeframe:	Periodic: annually; Timing: during latter part of growing season
Facilitator:	Board of Directors
Description:	As the name implies, the Late-Season EWM Mapping Survey is a professionally contracted survey completed towards the end of the growing season when the plant is at its anticipated peak growth stage, allowing for a true assessment of the amount of this exotic within the lake. For Archibald Lake, this survey would likely take place in late-August to the end of September, dependent on the growing conditions of the particular year. This survey would include a complete meander survey of the system's littoral zone by professional ecologists and mapping using GPS technology (sub-meter accuracy is preferred). Late-season EWM mapping surveys have periodically occurred on Archibald Lake from multiple contractors. The ALA will likely continue conducting annual Late-Season EWM Mapping Surveys to drive annual EWM management strategies.

Management Action:	Coordinate periodic whole-lake point-intercept aquatic plant surveys
Timeframe:	Periodic: at least once every 5 years, Timing: during July-August
Facilitator:	Board of Directors
Description:	The whole-lake point-intercept aquatic plant monitoring methodology as described Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010 (Hauxwell et al. 2010) has been utilized on Archibald Lake in 2010, 2013, 2016, and 2022. In some years, focused sub-sample point-intercept surveys have been conducted. However, this management action is specifically referencing the whole-lake point-intercept survey methodology. This survey provides quantitative population estimates for all aquatic plant species within the lake and is designed to allow comparisons with past surveys in Archibald Lake as well as to other waterbodies throughout the state. At each point-intercept location within the *littoral zone,* information regarding the depth, substrate type (soft sediment, sand, or rock), and the plant species sampled along with their relative abundance (rake fullness) on the sampling rake is recorded. The ALA will ensure the whole-lake point-intercept surveys is conducted at least once every five years to maintain eligibility for WDNR AIS Control Grants, or potentially more frequently if prompted by a specific rationale. Such rationale would include large-scale herbicide management towards EWM, where pre- and post-treatment whole-lake vegetation comparisons are desired.

Management Goal 3: Prevent Establishment of New Aquatic Invasive Species in Archibald Lake

Management Action:	Monitor Archibald Lake entry points for aquatic invasive species
Timeframe:	Continuation of current effort
Facilitator:	Board of Directors
Description:	The intent of this program is not only be to prevent additional invasive species from entering Archibald Lake through its public access locations, but also to prevent the infestation of other waterways with invasive species that originated in Archibald Lake. The ALA will continue to promote and coordinate a volunteer-based watercraft inspection program (Clean Boat Clean Waters program) at the Archibald Lake public landing. It would be most helpful to have watercraft monitors at the landing

	during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on lakes and educating people about how they are the primary vector of its spread. Some WDNR grant programs, such as the AIS Control Grants, garner additional ranking points to applicants that conduct a minimum of 200 annual hours of Clean Boats Clean Waters (CBCW). While the ALA has been able to meet past watercraft inspections commitments, this program has resulted in volunteer fatigue over the past few years. The ALA will continue to investigate ways to increase volunteerism as it relates to watercraft inspections. The ALA may also investigate a paid watercraft inspection model, with cost share through the WDNR's streamline Clean Boats Clean Waters (CBCW) program: *https://dnr.wisconsin.gov/sites/default/files/topic/Aid/grants/surfacewater/CF0002.pdf#page=22* The ALA is also considering a watercraft inspection model slightly different from CBCW, where volunteers would periodically stop at the landing and check parked trailers for hitchhikers such as aquatic plants. ALA-branded placards would be placed on the vehicles to either remind them to remove all aquatic plants from their boat trailer, or that their trailer passed inspection.

Management Action:	Investigate supplemental aquatic invasive species prevention and containment methods.
Timeframe:	Ongoing
Facilitator:	Board of Directors
Description:	Archibald Lake is an extremely popular regional destination, especially from anglers, making the lake vulnerable to new infestations of exotic species. In addition to its watercraft inspection program, the ALA would like to investigate supplemental prevention steps it can take to project Archibald Lake from new aquatic invasive species. Volunteerism for this task has waned in recent years. The ALA finds the opportunity of including supplemental prevention efforts appealing, particularly as it would relieve pressure on their exhausted volunteer base while continuing to provide protective actions for the lake. The ALA should work with the FLOW (Forest, Langlade, Marinette, & Oconto County) AIS Coordinator, to ensure they have updated signage at their landing promoting CBCW messaging to provide this form of education even when volunteer monitors are absent. While not being considered at the current time, the ALA will periodically investigate alternative prevention efforts such as decontamination stations (e.g., pressure washer), water-less cleaning stations (e.g. CD3 systems), and remote video surveillance (e.g., I-Lids™) for applicability at the landing location.

Management Goal 4: Actively manage EWM to suppress proliferation within Archibald Lake

Management Action:	Conduct Integrated Pest Management Program towards EWM
Timeframe:	Ongoing
Facilitator:	Board of Directors
Description:	The objective of this action will be to maintain an overall lowered EWM population in Archibald Lake compared to if no action would be taken. The ALA understands the importance of their native aquatic plant community, and would strive to understand any collateral native plant impacts surrounding any management actions it takes. In order to reach this objective, the ALA has developed a multi-pronged approach as part of this Integrated Pest Management (IPM) Program. Each management technique described below is discussed in regards to site selection and corresponding monitoring strategy. The following bullets are a general guide to the IPM Program, with more specific information contained below. **General IPM Program** • ***Herbicide Treatment*** It would be the ALA's preference to gain multi-year EWM population reductions through the use of herbicide treatments. • ***Manual Removal*** The ALA feels that manual removal efforts are only justified when EWM populations are relatively low, such as following-up after an herbicide treatment to target rebounding plants. **IPM Program Details** 1. ***Herbicide Treatment*** The ALA believes that dense areas of EWM that are impacting navigation, recreation, and aesthetics of the system can have these qualities restored for multiple years by conducting ProcellaCOR™ treatments using BMPs for implementation. Specifically, the ALA would consider targeting EWM colonies of *dominant, highly dominant*, or *surface matting* within the lake with direct application. Selection preference would be given to areas of high use and/or high riparian frontage as budgeting allows. Herbicide spot treatments using ProcellaCOR™ would be considered if the colonies have a size/shape/location that are likely to hold sufficient concentrations and exposure times (CETs) for an effective treatment. In general, this would be areas confined to bays (not exposed), broad in shape (not narrow bands), and of sufficient size to hold core CETs (likely at least 5 acres or larger). Smaller areas may be considered for treatment with a barrier curtain. Barrier curtain treatments are the most practical when the EWM population is up against a shoreline, preferably in a semi-enclosed bay. At this time, the ALA

would continue to use liquid 2,4-D amine within barrier curtain treatments, but is open to other herbicides if new information about applicability emerges. The ALA encourages more scientific discovery on ProcellaCOR™ and barrier curtains, as Onterra relayed concerns about the potential for herbicide binding to the barrier itself and not being available for impact.

If the ALA decides to pursue future herbicide management towards EWM, the following set of bullet points would occur:

- Early consultation with WDNR would occur. The ALA strives to work with the WDNR early in their planning stages to be alerted of any concerns that may be resolved or mitigated.
- The preceding annual *EWM Control & Monitoring Report*, produced in Jan-March would outline the precise control and monitoring strategy.
- EWM efficacy would occur by comparing annual late-summer EWM mapping surveys. Specifically, these would be conducted during the *year prior to treatment*, *year of treatment*, and *year after treatment*.
- If grant funds are being used, large areas are being targeted, and/or new-to-the-region herbicide strategies are being considered, the WDNR may request a quantitative evaluation monitoring plan be constructed that is consistent with the *Draft Aquatic Plant Treatment Evaluation Protocol (October 1, 2016):*
  https://apps.dnr.wi.gov/swims/Documents/DownloadDocument?id=158140137

  This generally consists of collecting quantitative point-intercept data the *late-summer prior to treatment* (pre) and the summers following the treatment (*year of treatment and year after treatment*) within the application area or within an area of potential impact (AOPI).
- Herbicide concentration monitoring may also occur surrounding the treatment if grant funds are being used or the ALA believes important information would be gained from the effort.
- An herbicide applicator firm would be selected in late-winter and a permit application would be applied to the WDNR as early in the calendar year as possible, allowing interested parties sufficient time to review the control plan outlined within the annual report as well as review the permit application.
- Unless specified otherwise by the manufacturer of the herbicide, an early-season use-pattern would likely occur. This would consist of the herbicide treatment occurring towards the beginning of the growing season (typically in early- to mid-June), active growth tissue is confirmed on the target plants, and is after sensitive fish species of concern, like walleye, have outgrown their most-sensitive life stage to herbicide exposure (first 14 days after hatching). A focused pretreatment survey would take place approximately a week or so prior to treatment. This site visit would evaluate the growth stage of the EWM (and native plants) as well as to confirm the proposed treatment area extents and water depths. This information would be used to finalize the permit, potentially with adjustments and dictate

	approximate ideal treatment timing. Additional aspects of the treatment may also be investigated, depending on the use pattern being considered, such as the role of stratification. 2. ***Manual Removal*** The ALA has implemented manual removal efforts in the past with varying levels of success. Learning from previous efforts, the ALA will consider targeting scale-appropriate EWM populations in the future with this management tool. In other words, these manual removal efforts can be effective when targeting a hand-full of EWM plants or clumps of EWM, but not defined colonies of EWM.

6.0 LITERATURE CITED

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