# Presque Isle Wilderness Waters Program

## Aquatic Plant Management Plan – Oxbow Lake

**Prepared for:**

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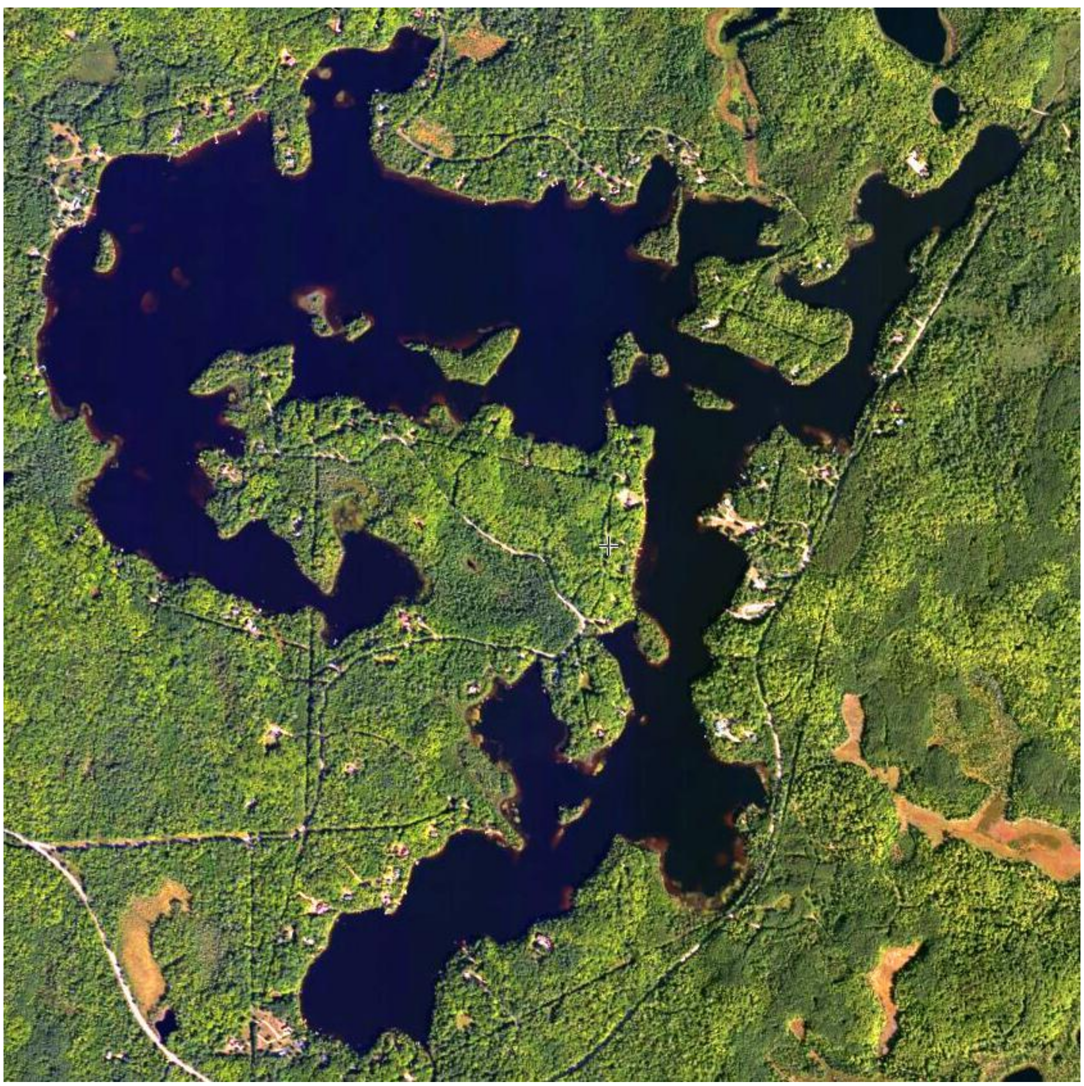

**2020**

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**This plan is a product of a WDNR Aquatic Invasive Species Control Grant (Subchapter II – Education, Prevention, and Planning Projects) awarded to:**


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WHITE WATER ASSOCIATES, INC.

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# CHAPTER 1 Introduction

The ***Presque Isle Wilderness Waters Program*** results from the efforts of the Presque Isle Town Lakes Committee, an organization that has been active since 2005. The Lakes Committee views stewardship as an ongoing endeavor that is integrated, coordinated, and administered by the Lakes Committee. The Lakes Committee takes a broad perspective that allows an appropriate range of geographic scales from which to approach lake stewardship. A discrete "lake specific" focus goes hand-in hand with waterscape-wide awareness.

This aquatic plant management plan (APMP) addresses Oxbow Lake in Vilas County, Wisconsin. Despite this specificity, it maintains the waterscape perspective crucial to effective lake stewardship. This is especially important when it comes to preventing introduction and establishment of aquatic invasive species (AIS). The closely related ***Wilderness Waters Adaptive Management Plan*** (Stine et al., 2019) offers additional overarching waterscape level inspection that allows greater opportunity and efficiency in water resource management and education.

A 2018 systematic survey of aquatic plants using the Wisconsin Department of Natural Resources (WDNR) "point-intercept" method was an important underpinning of this aquatic plant management plan. An analysis of the plant data along with water quality and other lake information allowed the preparation of the plan.

Aquatic plants rarely get the respect they merit, although this is slowly changing. We still call an aquatic plant bed a "weed bed." Many aquatic plants have "weed" in their names (e.g., duckweed, pondweed, or musky weed). Likely this term was borrowed from "seaweed" and not intended as derogatory, but in today's use, "weed" connotes an unwanted, aggressively growing plant. Such is not the case for the vast majority of aquatic plants. In fact, aquatic plants are a vital part of a lake ecosystem, recycling nutrients, providing vertical and horizontal structure, and creating habitat for animal life. Invertebrates, including crustaceans and insects, live on or within this "aquatic forest." Fish find food and shelter within aquatic plant beds. Waterfowl eat parts of plants directly as well as feed on invertebrates associated with the plants. Muskrats eat aquatic plants and particularly love cattails and bulrushes. Otter and mink hunt invertebrates and small vertebrates within the shelter of submergent and emergent beds. In shallow water, great blue herons find fishes among the plants.

In lakes that receive an excess of nutrients (particularly from fertilizers or leaking septic tanks), plant growth can become too lush or dominated by only a few species. As these abundant plants die, their decomposition can depress dissolved oxygen levels and diminish suitability for fish. Algae can respond rapidly to nutrient influxes and create nuisance conditions. These phenomena can cause humans to view all aquatic plants in a negative light.

On another negative front, non-native plant species, transported on boats and trailers or dumped from home aquariums, private ponds and water gardens may proliferate in a water body negatively influence the community of native species. Eurasian water-milfoil (*Myriophyllum spicatum*) is one of the invasive plant species capable of this kind of population boom. Fortunately, this kind of rampant growth of aquatic invasive plants does not always occur. On occasion, even a native plant species can exhibit rampant growth and results in a population that is viewed by some as a recreational nuisance. The Southern Naiad (*Najas guadalupensis*) has exhibited this kind of behavior in some northern Wisconsin lakes.

For most lakes, native aquatic plants are an overwhelmingly positive attribute, greatly enhancing the aesthetics of the lake and providing good opportunities for fishing, boating, swimming, snorkeling, sight-seeing, and hunting. In some lakes even the presence of an aquatic invasive plant species is not a significantly negative phenomenon.

When it comes to aquatic plant management, it is useful to heed the mantra of the medical profession: "First, do no harm." It is both a social and scientific convention that aquatic plant management is more effective and beneficial when a lake is considered as an entire and integrated ecosystem. Actions taken to curtail specific plant population (for example, herbicide use to treat Eurasian water-milfoil) will invariably impact other desirable native species. Rare plants, important habitats, or culturally significant plants (such as wild rice) should always be given careful consideration and protection.

Anyone involved in aquatic plant management should be aware that a permit may be required to remove, add, or control aquatic plants. In addition, anyone using Wisconsin's lakes must comply with the "Boat Launch Law" that addresses transport of aquatic plants on boat trailers and other equipment. A good review of the laws, permits, and regulations that affect management and behavior surrounding aquatic plants can be found in the WDNR guidelines called ***Aquatic Plant Management in Wisconsin***.[1]

In preparing this plan, we followed guidelines in ***Aquatic Plant Management in Wisconsin***. The resulting plan is an adaptive plan (Walters, 1986). Simply put, it will be

[1] *http://www4.uwsp.edu/cnr/uwexlakes/ecology/APM/APMguideFull2010.pdf*

modified as new information becomes available. The WDNR Guidance document outlines three objectives that may influence preparation of an aquatic plant management plan. Currently, the principle motivation for this plan lies in the first two objectives:

- ***Protection*** - preventing the introduction of nuisance or invasive species into waters where these plants are not currently present;
- ***Maintenance*** - continuing the patterns of recreational use that have developed historically on and around a lake; and
- ***Rehabilitation*** - controlling an imbalance in the aquatic plant community leading to the dominance of a few plant species, frequently associated with the introduction of invasive non-native species.

During projects with the WDNR Planning Grant Program and through past efforts, Town Lakes Committee has followed the seven-step plan outlined in the Guidance Document for developing an aquatic plant management plan:

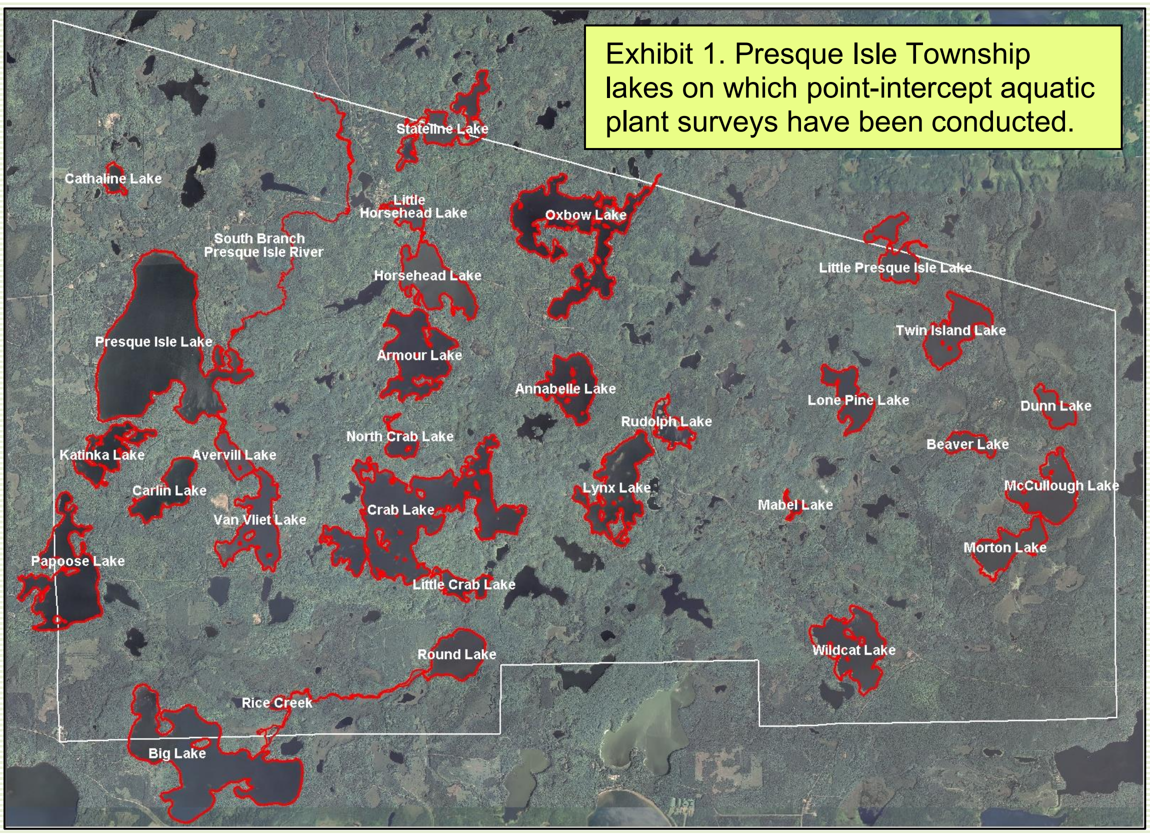
1. Goal setting – Getting the effort organized, identifying problems to be addressed, and agreeing on the goals;
2. Inventory – Collecting baseline information to define the past and existing conditions;
3. Analysis – Synthesizing the information, quantifying and comparing the current conditions to desired conditions, researching opportunities and constraints, and setting directions to achieving the goals;
4. Alternatives – Listing possible management alternatives and evaluating their strengths, weaknesses and general feasibility;
5. Recommendations – Prioritizing and selecting preferred management options, setting objectives, drafting the plan;
6. Implementation – Formally adopting the plan, lining up funding, and scheduling activities for taking action to achieve the goals;
7. Monitor & Modify – Developing a mechanism for tracking activities and adjusting the plan as it evolves.

Including this introductory chapter, this APMP is organized in six Chapters. The study area is described in Chapter 2. Chapter 3 states the purpose and goals for the plan. Chapter 4 presents an inventory and analysis of information that pertain to the plan including the results of the aquatic plant survey. Chapter 5 provides recommendations that support the overall goals and establish the stewardship component of plan. Finally, Chapter 6 presents actions and objectives for implementing the plan. Five appendices complete this document.

# CHAPTER 2

# Study Area

Presque Isle Township is one of the northern-most townships in Vilas County, Wisconsin. Presque Isle Township's northern border is shared with the State of Michigan. In fact some of the Presque Township lakes lie on the state border. The location of the subject of this APM Plan (Oxbow Lake) is shown in Exhibit 1 along with other lakes in Presque Isle Township that have had point-intercept aquatic plant surveys conducted. Exhibit 2 is an aerial view of Oxbow Lake.



"Almost an island" is the literal translation of the French phrase "Presque Isle." Early French missionaries, perhaps disoriented by the preponderance of water in this north central Wisconsin landscape applied the name, "Presque Isle" to describe an area where the water seemed to dominate the land. The French visitors and Native Americans certainly recognized this landscape as special. Modern ecologists and recreationist share this view. The region that includes the Township of Presque Isle, Wisconsin is an ecological landscape marvelously rich in surface waters. Aerial photography reveals a concentration of lakes and streams that is unique in North America. Presque Isle Township has eighty-four lakes. The Presque Isle area could as easily be termed a "waterscape" as a "landscape."

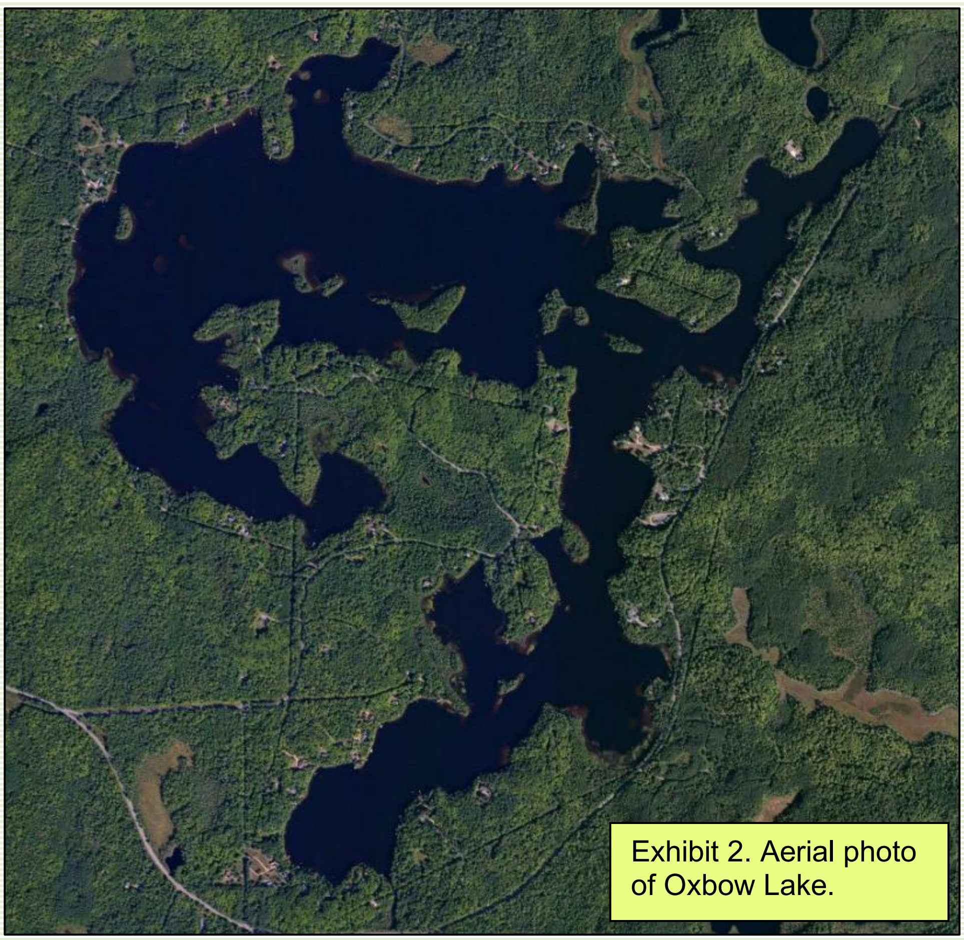


Exhibit 2. Aerial photo of Oxbow Lake.

Descriptive parameters for Oxbow Lake are in Exhibit 3. It is a drainage lake of 523 acres and maximum depth of 44 feet. Oxbow Lake has a Shoreline Development Index (SDI) of 4.2. The SDI is a quantitative expression derived from the shape of the lake defined as the ratio of the shoreline length to the length of the circumference of a circle of the same area as the lake. A perfectly round lake has an index of 1. Increasing irregularity of a lake's shoreline in the form of bays and projections of the shore results in SDIs greater than 1. For example, fjord lakes with extremely irregular shorelines sometimes have SDI's exceeding 5. A higher shoreline development index indicates that a lake has relatively more productive littoral zone habitat. Oxbow Lake's shoreline in one of the highest SDI we have observed on inland lakes.

| Exhibit 3. Water Body Parameters | |
|---|---|
| Water Body Name | Oxbow |
| County | Vilas |
| Township/Range/Section | T43N-R06E-S1; T43N-R07E-S6; T44N-R06E-S36; T44N-R07E-S31 |
| Water Body Identification Code | 2954800 |
| Lake Type | Drainage |
| Surface Area (acres) | 523 |
| Maximum Depth (feet) | 44 |
| Maximum Length (miles) | 1.5 |
| Maximum Width (miles) | 1.25 |
| Shoreline Length (miles) | 13.5 |
| Shoreline Development Index | 4.2 |
| Total Number of Piers (2020 aerial) | 98 |
| Number of Piers / Mile of Shoreline | 7.3 |
| Total Number of Homes (2020 aerial) | 151 |
| Number of Homes / Mile of Shoreline | 11.2 |

Oxbow Lake has one public access site. We observe a total of 98 piers on the shoreline of Oxbow Lake from recent aerial photography or about 7.3 piers per mile of shoreline. The riparian area is of high quality and undisturbed in many areas. It consists of both upland and wetland areas (Exhibit 4).

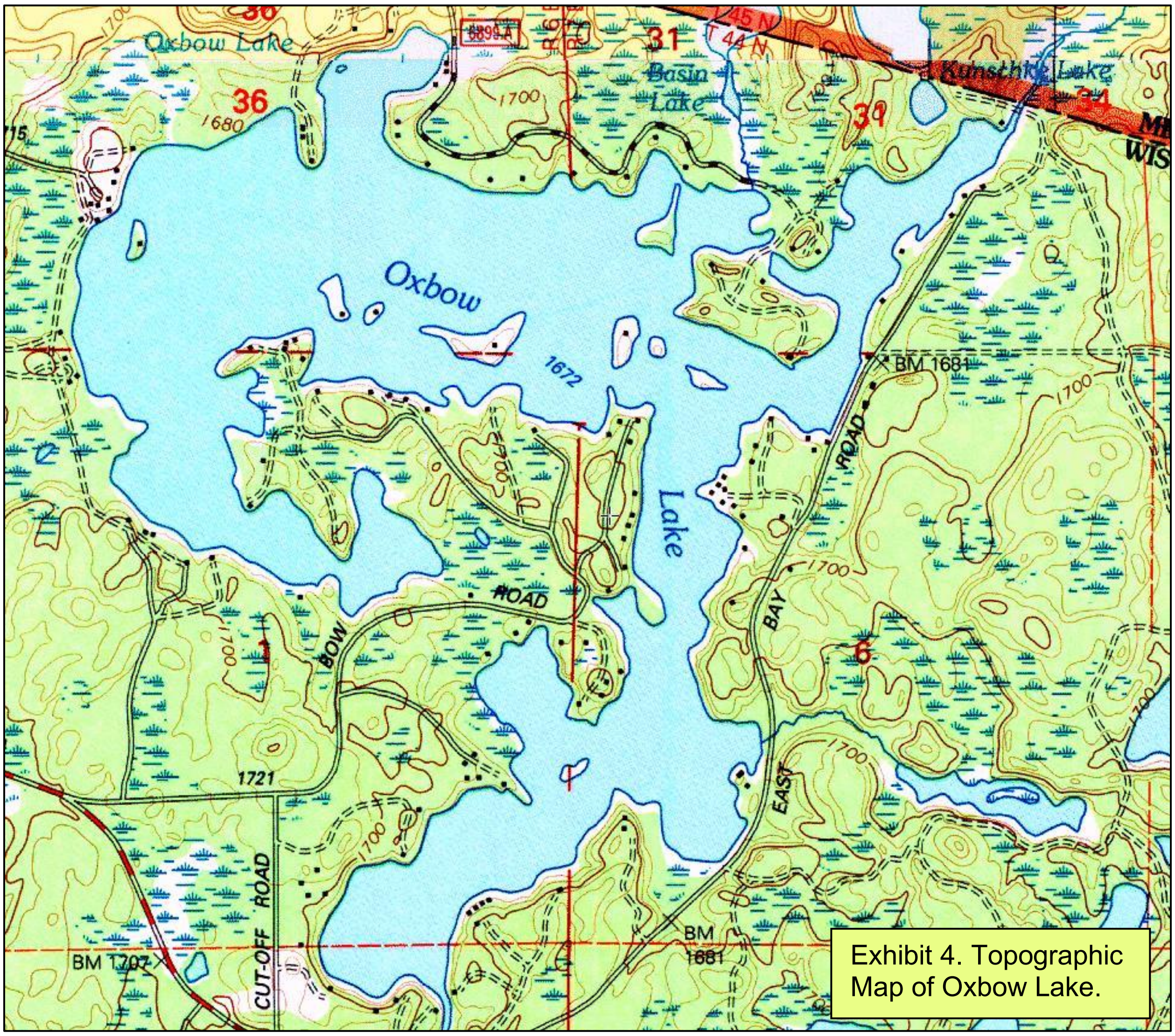



Exhibit 4. Topographic Map of Oxbow Lake.

# CHAPTER 3

# Purpose and Goal Statements

This plan approaches aquatic plant management with a healthy dose of humility. We do not always understand the causes of environmental phenomena or the effects of our actions to manage the environment. With that thought in mind, we have crafted a statement of purpose and goals for this plan:

> ***Comprehensive aquatic plant surveys in 2007, 2014, and 2018 establish that Oxbow Lake has a healthy and diverse aquatic plant community. This plant community is essential to, and part of, a high quality aquatic ecosystem that benefits the human community. The purpose of this aquatic plant management plan is to maintain a balanced, high quality, and diverse native aquatic plant community in Oxbow Lake.***

Supporting this purpose, the goals of this aquatic plant management plan are:

***(1) Monitor and protect the native aquatic plant community;***
***(2) Monitor for AIS and prevent establishment of new non-native biota;***
***(3) Consider and evaluate the efficacy of active aquatic plant management; and***
***(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that can alter the plant community, minimizing physical removal of native riparian and littoral zone plants, and living with a lake whose natural healthy state includes aquatic plants.***

The purpose and goals are the foundation for the aquatic plant management plan presented in this document. They inform the objectives and actions outlined in Chapter 5 and are the principal motivation of Oxbow Lake stewards.

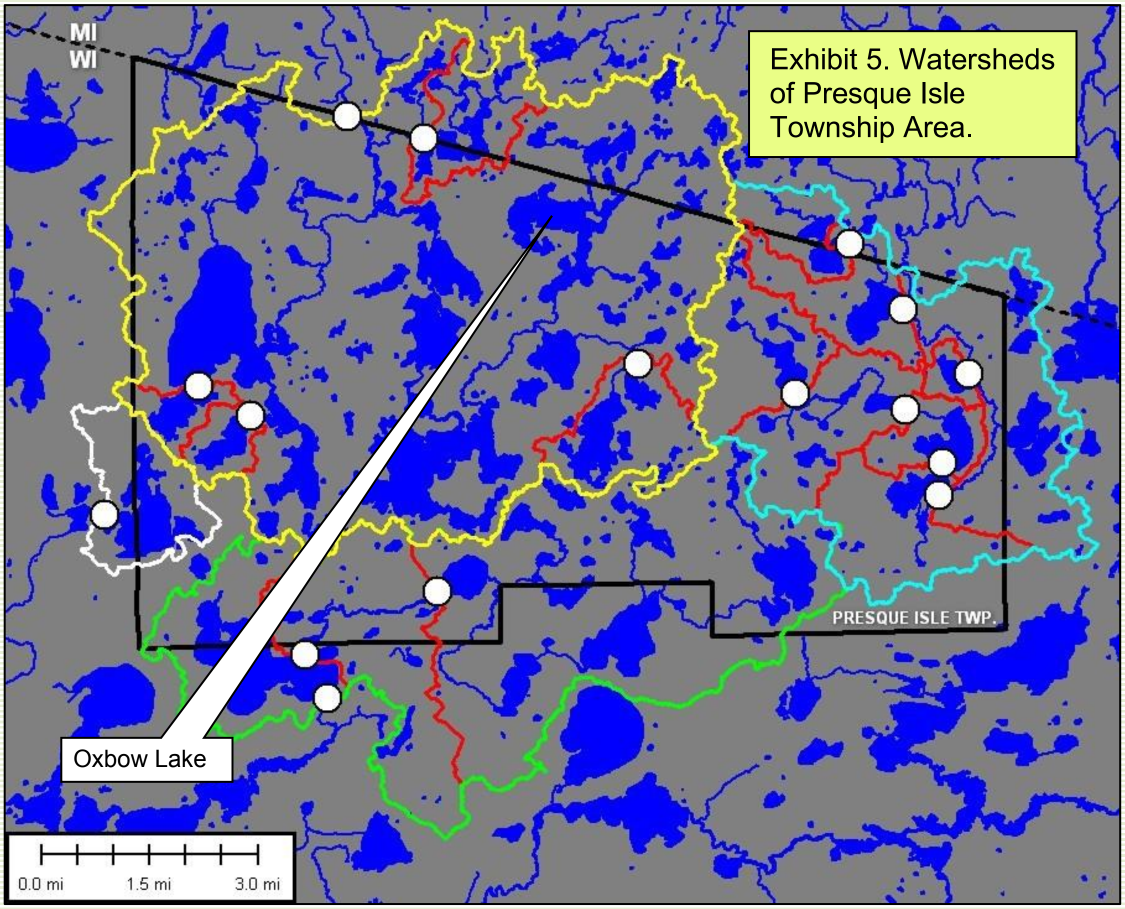
# CHAPTER 4

# Information and Analysis

Our efforts in the Wilderness Waters Program have compiled information about historical and current conditions of the Oxbow Lake ecosystem and its surrounding watershed. Of particular importance to this aquatic plant management plan is the aquatic plant survey that was conducted using the ***WDNR Protocol for Aquatic Plant Survey, Collecting, Mapping, Preserving, and Data Entry*** (Hauxwell et al., 2010). The results of this comprehensive "point-intercept" survey along with relevant components of other information are presented in this chapter under nine respective subheadings: watershed, aquatic plant management history, aquatic plant community description, fish community, water quality and trophic status, water use, riparian area, wildlife, and stakeholders.

## Part 1. Watershed

The Presque Isle Township waterscape sits on a large-scale watershed divide. Some of the water drains north through the Presque Isle River system and eventually enters Lake Superior. Some of the water drains into the Wisconsin River system to the Mississippi River and to the Gulf of Mexico. In fact there are two federal hydrologic sub-basins (designated by 8-digit HUC codes) that include Presque Isle Township. The Black-Presque Isle Rivers sub-basin (HUC#04020101) drains north to Lake Superior and the Flambeau River sub-basin (HUC#0705002) drains southwesterly to the Mississippi River. The Black-Presque Isle Rivers sub-basin contains two federal hydrologic sub-watersheds within Presque Isle Township: the South Branch Presque Isle River sub-watershed (HUC#040201010303) and the Pomeroy Creek-East Branch Presque Isle River sub-watershed (HUC#040201010301). The Flambeau River sub-basin contains one sub-watershed within Presque Isle Township: the Rice Creek sub-watershed (HUC#07050020103). Exhibit 5 illustrates these watersheds and the watersheds of the water bodies subject to the Wilderness Waters Program studies. Oxbow Lake is contained within the South Branch Presque Isle River sub-watershed (Exhibit 5).




Description: Portions of 3 federal hydrologic sub-watersheds are illustrated: (1) S.Br. Presque Isle River (bounded by yellow), (2) Pomeroy Cr-E.Br. Presque Isle River (bounded by blue and yellow), and (3) Rice Cr. (bounded by green, yellow, and blue). Also shown are the smaller watersheds of individual water bodies subject to the Wilderness Waters studies (bounded by red and, in the case of Papoose Lake, bounded by white). White dots show outlet points for the smaller watersheds.

The elevation in Presque Isle Township ranges from around 1,550 feet above sea level to 1,750 feet above sea level. A digital elevation model is provided as Exhibit 6 and shows the relative elevations for the area with orange areas of the landscape being the highest elevations and greens and blues being the lowest elevations.

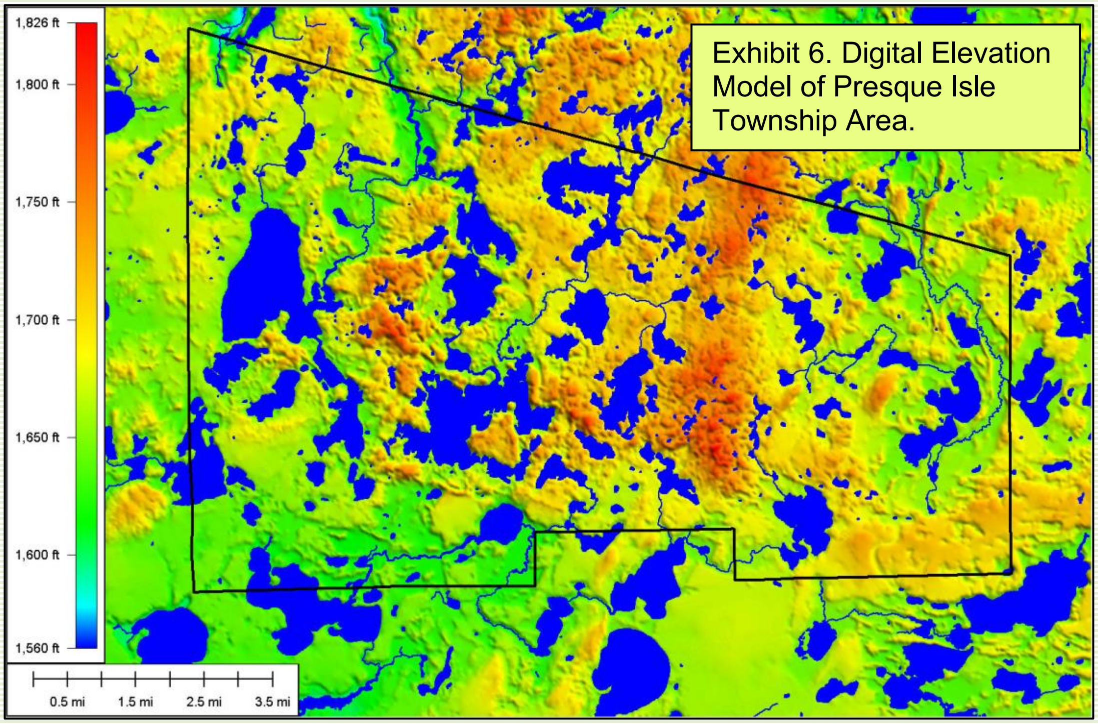



Exhibit 6. Digital Elevation Model of Presque Isle Township Area.

The watershed (drainage basin) is all of the land and water areas that drain toward a particular river or lake. A water body is greatly influenced by its watershed. Watershed size, topography, geology, land use, soil fertility and erodibility, and vegetation are all factors that influence water quality. The Oxbow Lake watershed is about 5,925 acres. The cover types in the watershed are presented in Exhibit 7. Forest and surface water comprise the largest components. Soil group B is most prevalent, followed by group D, while groups A and C make up around 20%. Soil group A has the highest infiltration capacity, and the lowest runoff potential. Conversely, soil group D has the lowest infiltration capacity, and the highest runoff potential. The watershed to lake area ratio is 11:1. Water quality often decreases with an increasing ratio of watershed area to lake area. As the watershed to lake area increases there are more sources of runoff. In larger watersheds, runoff water can leach more minerals and nutrients and carry them to the lake. Runoff to a lake (such as after a rainstorm or snowmelt) differs greatly among land uses. Forest cover is the most protective as it exports much less soil (through erosion) and nutrients (such as phosphorus and nitrogen) to the lake than agricultural or urban land use.

| Exhibit 7. Cover Types and Soil Groups of the Oxbow Lake Watershed. | | | |
|---|---|---|---|
| Cover Type | | Acres | Percent |
| Agriculture | | 0 | 0 |
| Commercial | | 0 | 0 |
| Forest | | 3445.9 | 58.2 |
| Grass/Pasture | | 4.2 | 0.1 |
| High-density Residential | | 0 | 0 |
| Low-density Residential | | 336.6 | 5.7 |
| Water | | 2136.7 | 36.1 |
| Total | | 5923.4 | 100.0 |

| Soil Group | Acres | Percent | **Hydrologic Soil Groups** - Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups* based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. Where A has the smallest runoff potential and D the greatest. |
|---|---|---|---|
| A | 893.5 | 15.1 | **Group A** is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission. |
| B | 2680.8 | 45.3 | **Group B** is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. |
| C | 318.8 | 5.4 | **Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure. |
| D | 2030.2 | 34.3 | **Group D** soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This soil has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material. |

*(*USDA, Natural Resources Conservation Service, 1986*)

## Part 2. Aquatic Plant Management History

As far as we can determine, no systematic or large-scale plant management activity has ever taken place in Oxbow Lake. Over the years, no nuisance issues have warranted control action. It is our understanding that the plant survey conducted in 2007 was the first effort of its kind on this water body. A second aquatic plant survey was conducted in 2014 and a third in 2018. All three surveys used the same methodology allowing more robust comparisons. Findings from the 2018 survey are presented and discussed in the next section (Part 3) and compared to findings from 2007 and 2014.

## Part 3. Aquatic Plant Community Description

Why do lakes need aquatic plants? In many ways, they are underwater forests. Aquatic plants provide vertical and horizontal structure in the lake just like the many forms and variety of trees do in a forest. Imagine how diminished a forest's biodiversity becomes in the advent of a clear-cut. Similarly, a lake's biodiversity in large part depends on a diversity of plants.

Aquatic plants are beneficial in many ways. Areas with plants produce more food for fish (insect larvae, snails, and other invertebrates). Aquatic vegetation offers fish shelter and spawning habitat. Many submerged plants provide food for waterfowl and habitat for insects on which some waterfowl feed. Aquatic plants further benefit lakes by producing oxygen and absorbing nutrients (phosphorus and nitrogen) from runoff. Aquatic plants also protect shorelines and lake bottoms by dampening wave action and stabilizing sediments.

The distribution of plants within a lake is generally limited by light availability, which is, in turn, controlled by water clarity. Aquatic biologists often estimate the depth to which rooted aquatic plants can exist as about two times the average Secchi clarity depth. For example, if the average Secchi depth is eight feet then it is fairly accurate to estimate that rooted plants might exist in water as deep as sixteen feet. At depths greater than that (in our hypothetical example), light is insufficient for rooted plants to grow. In addition to available light, the type of substrate influences the distribution of rooted aquatic plants. Plants are more likely to be found in muddy or soft sediments containing organic matter, and less likely to occur where the substrate is sand, gravel, or rock. Finally, water chemistry influences which plants are found in a body of water. Some species prefer alkaline lakes and some prefer more acidic lakes. The presence of nutrients like phosphorous and nitrogen also influence plant community composition.

As mentioned earlier, non-native invasive plant species can reach high densities and wide distribution within a lake. This diminishes the native plant community and the related habitat. At times, even a native plant species can reach nuisance levels with respect to certain kinds of human recreation. These cases may warrant some kind of plant management. It should be noted, however, herbicides, or other means are expensive (in time and/or money) and by no means permanent. Long-term outcomes of these manipulations are difficult to predict. In addition, permits are required in many cases of aquatic plant management.

Aquatic plant surveys were conducted on Oxbow Lake in 2007, 2014 and 2018. In each year, the survey used the WDNR point-intercept protocol. This formal survey assessed the plant species composition of each point on a grid of 843 points distributed evenly over the lake. Using latitude-longitude coordinates and a handheld GPS unit, we navigated to the points and used a rake to sample plants. Plants were identified, recorded, and all data were entered into a dedicated spreadsheet for storage and data analysis. These systematic surveys provided baseline data about the lake and allow analysis of change in the plant community over the time period of the surveys.

An examination of changes in the aquatic plant community over nearly a decade is robust because the plant surveys were conducted using the same protocol. Future aquatic plant monitoring will allow additional analysis. Changes in a lake environment might manifest as loss of species, change in species abundance or distribution, difference in the relative composition of various plant life forms (emergent, floating leaf, or submergent plants), and/or appearance of an AIS or change in its population size. Monitoring can track changes and provide valuable insight on which to base management decisions. In the remainder of this section, we provide a report of the aquatic plant findings for Oxbow Lake and compare the plant communities of 2007, 2014, and 2018. Tables 1, 2, and 3 provide analyzed data from these surveys. These tables along with supporting figures for the aquatic plant survey are provided in Appendix B.

Species richness refers to the total number of species documented in a community. When considering plant species recorded at sampling points only, species richness was lowest in 2007 (23 species collected on the rake), intermediate in 2014 (29 species collected on the rake), and highest in 2018 (39 species collected on the rake) (see Tables 1 and 3). During the 2014 and 2018 surveys, additional plant species observed but not collected at the sampling points were also documented increasing the overall richness somewhat. The species richness observed in all three years could be considered a diverse community but the richness documented in 2018 was especially high.

In 2018, the number of species encountered at any given sample point ranged from 0 to 7. The actual number of species encountered at each of the vegetated sites is graphically displayed on Figure 1. The number of sample points where aquatic vegetation was present was quite similar for 2018 (120 sites) and 2014 (111 sites). Information for 2007 was not available. The average number of native species encountered at the vegetated sites was quite similar between years (see Table 3) with the highest average (2.34) found in 2018. Plant density is estimated by a "rake fullness" metric (3 being the highest possible density). These densities (considering all species in 2018) are displayed for each sampling site on Figure 2.

The maximum depth of rooted plant has decreased over the three survey years (Tables 1 and 3 and Figure 3). This is associated with water clarity and that parameter has also decreased over the years of the three surveys (annual mean Secchi readings of 11.1 feet in 2007, 7.8 feet in 2014, and 6.5 feet in 2018; Table 3 and Appendix C). Both are related to increased water level. Frequency of occurrence at sites shallower than maximum depth of plants was 45.5% in 2007, 32.9% in 2014, and 44.0% in 2018 (Table 3). The 2018 vegetated sites are displayed as a black dot within a circle on Figure 4. The fact that this frequency of occurrence is less than 100% indicates that although availability of appropriate depth limits the distribution of plants, it is not the only habitat factor involved. Substrate is another feature that influences plant distribution (e.g., soft substrate often harbors more plants than hard substrate). Figures 5 presents the substrates encountered during the aquatic plant survey (mud, sand, or rock).

Table 2 provides a list of the species encountered, including common and scientific name along with summarizing statistics for the 2018 survey.[2] Several metrics are provided, including total number of sites in which each species was found and frequency of occurrence at sites ≤ the maximum depth of rooted vegetation. This frequency metric is standardized as a "relative frequency" (also shown in Table 2) by dividing the frequency of occurrence for a given species by the sum of frequency of occurrence for all plants and multiplying by 100 to form a percentage. The resulting relative frequencies for all species total 100%. The relative frequencies for the plant species collected with a rake at sample points in 2007, 2011, and 2018 are graphically displayed on Figure 6. There have been some rather substantial shifts in frequency of occurrence over the years of plant surveys on Oxbow Lake. Common waterweed (*Elodea canadensis*) had the highest relative frequency (24%) of any species in 2007 (Figure 6). In 2014 and 2018, this species was present at relative frequencies of less than 0.5% and was found at only 1 site in 2018. Thread-like naiad (*Najas gracillima*) had the highest relative frequency of any species in 2018, but was not documented in either the 2007 or 2014 surveys. Berchtold's pondweed (*Potamogeton berchtoldii)* had fairly high relative frequencies in 2014 and 2018, but was not documented in 2007. Southern naiad (*Najas guadalupensis*) had high relative frequency in 2007, but was absent from the 2014 and 2018 survey data. In recent years, this species has shown a tendency to attain very high population levels in some northern Wisconsin lakes and it

[2] *If you more are interested in learning about the biology of any of the individual plant species found in the lake, visit the University of Wisconsin Steven Point Freckmann Herbarium website at: http://wisplants.uwsp.edu/ or obtain a copy of "Through the Looking Glass (A Field Guide to the Aquatic Plants in Wisconsin)."*

is interesting that it has not displayed this population expansion in Oxbow Lake. Four plants (*Chara sp., Brasenia schreberi, Potamogeton amplifolius*, and *P. gramineus*) have displayed fairly consistent and moderate relative frequencies across all three survey years (Figure 6). *Najas flexilis* had a moderately high relative frequency in 2018, but was absent from the 2007 and 2014 data sets.

Figure 7 displays sampling sites with emergent and floating aquatic plants. As examples of individual species distributions, we show the occurrences of a few of the most frequently and least frequently encountered plants in Figures 8-14.

"Species richness" is the term given to the total number of species in a given area. For example, the total number of plant species in a lake would be its plant species richness. Generally speaking, a high species richness means high biodiversity and this is considered a healthy and desirable condition in an ecosystem. But species richness doesn't tell the whole story. As an example, consider the plant communities of two hypothetical ponds each with 1,000 individual plants representing ten plant species (in other words, richness is 10). In the first pond each of the ten species populations is comprised of 100 individuals. In the second pond, Species #1 has a population of 991 individuals and each of the other nine species is represented by one individual plant. Intuitively, we would say that first pond is more diverse because there is more "even" distribution of individual species. The "Simpson Diversity Index" takes into account both richness and evenness in estimating diversity. It is based on a plant's relative frequency in a lake. The closer the Simpson Diversity Index is to 1, the more diverse the plant community. The Simpson Diversity Index for Oxbow Lake aquatic plants was 0.93 in 2018 (Table 1) which indicates a very diverse aquatic plant community. The 2014 value (0.93) and 2007 value (0.88) reflect similarly diverse aquatic plant communities and excellent stability in this parameter over time (Table 3).

Another measure of floristic diversity and quality is the *Floristic Quality Index* (FQI). Floristic quality is an assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions (Nichols, 1999). Among other applications, it forms a standardized metric that can be used to compare the quality of different lakes (or different locations within a single lake) and monitor long-term changes in a lake's plant community (an indicator of lake health). The FQI for a lake is determined by using the average *coefficient of conservatism* times the square root of the number of native plant species present in the lake. Knowledgeable botanists have assigned to each native aquatic plant a *coefficient of conservatism* representing the probability that a plant is likely to occur in pristine environments (relatively unaltered from presettlement conditions). The coefficients range from 0 to 10, with 10 being assigned to those species most sensitive to disturbance. As more environmental disturbance occurs, the less conservative species become more prevalent.

Nichols (1999) analyzed aquatic plant community data from 554 Wisconsin Lakes to ascertain geographic (ecoregional) characteristics of the FQI metric. This is useful for considering how the Oxbow Lake FQI values compare to other lakes and regions. Table 3 provides the Oxbow Lake FQI values for 2007 (33.5), 2014 (37.0), and 2018 (45.4). The statewide medians for number of species and FQI are 13 and 22.2, respectively. Oxbow Lake values are significantly higher than these statewide values. Nichols (1999) determined that there are four ecoregional-lake types groups in Wisconsin: (1) Northern Lakes and Forests Lakes, (2) Northern Lakes and Forests Flowages, (3) North Central Hardwoods and Southeastern Till Plain Lakes and Flowages, and (4) Driftless Area and Mississippi River Backwater Lakes. Oxbow Lake is located in the Northern Lakes and Forests Lakes group. Nichols (1999) found species numbers for the Northern Lakes and Forests Lakes group had a median value of 13. Oxbow Lake data is much higher than that find. Finally, the Oxbow Lake FQI values are significantly higher than the median value for the Northern Lakes and Forests Lakes group (24.3). These findings support the contention that the Oxbow Lake plant community is healthy and diverse. The increasing trend of FQI values in Oxbow Lake could reflect improving conditions in the lake with respect to requirements of more sensitive plant species. One possible explanation of this increase could be due to thread-like naiad (*Najas gracillima*) which has a high *coefficient of conservatism* value, meaning it has a high sensitivity to disturbance. As previously stated, this species was present with a high relative percent frequency in 2018. This trend is worthy of monitoring with future aquatic plant surveys on Oxbow Lake. We examined the individual *coefficients of conservatism (C)* for the top five plant species (in terms of relative percent frequency) for the three survey years. The averages for these top five species did not vary much between the survey years (mean C=7.2 in 2007, 7.0 in 2014, and 7.2 in 2018).

We observed no aquatic plants in Oxbow Lake that would be considered a nuisance-level population density/distribution. Reed canary grass (*Phalaris arundinacea*) was observed on the boat survey in 2018. This plant is *Restricted* in Wisconsin. Thread-like Naiad (*Najas gracillima*) and Small purple bladderwort (*Utricularia resupinata*) were observed in 2018 in Oxbow Lake. They are both considered a *Special Concern* species in Wisconsin.

Oxbow Lake is home to one of the most diverse (as measured by species richness and Simpson's Diversity Index) and high quality (as measured my Floristic Quality Index) plant communities of the many lakes studied in Presque Isle Township. This is no small statement given that most of the lakes in Township are diverse and high quality. Changes in the plant community have occurred over the years and these may be natural fluctuations of the individual populations and tied to many environmental phenomena (like changes in water clarity, temperature, or level). The changes may simply indicate a dynamic plant community. Not only is the Oxbow Lake plant community diverse and high quality, but there seems to be a mild upward trend in both measures. This is remarkably good news for lake stewards of Oxbow Lake and the region.

It is important to note that during the period covered by these aquatic plant surveys, Presque Isle Township implemented special boating regulations for Oxbow Lake. These were intended to minimize shoreline damage and disturbance of native aquatic plants from excessive energy from boat wakes made close to shore (in the littoral zone). It may not be possible to prove a causal relationship between the boating regulations and the high quality plant community given the data we have, but we can emphatically state that the regulations have certainly done no harm to the plant community (in fact, the trend is in the opposite direction). Very little data exists for assessing the benefit of boating regulations on native plant communities. The Oxbow Lake data set and circumstances offer a unique opportunity to follow the outcomes of far-sighted regulations put in place as a protective action of a high quality natural ecosystem.

## Part 4. Fish Community

It was beyond the scope of the current Wilderness Waters project to characterize the fish community and fish habitat of this water body. The WDNR Lake Pages website (http://dnr.wi.gov/lakes/lakepages/) indicates that the bottom is comprised of 60% sand, 20% gravel, 15% rock, and 5% muck and that fish species present include musky, panfish, largemouth bass, smallmouth bass, northern pike and walleye. In 1974, 1976, 1978, 1981, and 1983 walleye were stocked and in 1980 and 1984 muskellunge were stocked in Oxbow Lake.

## Part 5. Water Quality and Trophic Status

Oxbow Lake is a 523 acre drainage lake with a maximum depth of 44 feet. Existing water quality information includes data retrieved from the Wisconsin DNR SWIMS database between 1984 and 2019. Secchi disk measurements were collected by Citizen Lake Monitoring Network (CLMN) volunteers in 1996 and from 2006 to 2019. The water quality information is briefly summarized in this section, but more fully interpreted in Appendix C.

Temperature showed stratification in Oxbow Lake in the ice-free season. Average water clarity is considered "fair." The trophic state is mesotrophic. Water quality would be classified as "very good" with respect to phosphorus concentrations. Chlorophyll *a*, nitrogen, hardness, conductivity, calcium, magnesium, sodium, and potassium are considered low. The pH of Oxbow Lake is neutral.

## Part 6. Water Use

Oxbow Lake has one public access site, and is used by riparian owners and their guests for a variety of recreational activities. There is a small area of State of Wisconsin Land at the public boat access.

## Part 7. Riparian Area

Part 1 (Watershed) describes the larger riparian area context of Oxbow Lake. The near shore riparian area can be appreciated by viewing Exhibits 2 and 4. Our review of recent aerial photography reveals 151 houses on the lake. The lake is lightly developed and has an intact forested riparian zone that extends for hundreds of feet back from the lake. The forest is a mixture of coniferous and deciduous trees and shrubs. This intact riparian area provides numerous important functions and values to the lake. It effectively filters runoff to the lake. It provides excellent habitat for birds and mammals. Trees that fall into the lake from the riparian zone contribute important habitat elements to the lake. Educating riparian owners as to the value of riparian areas is important to the maintenance of these critical areas.

The WDNR, in 2016, formulated a protocol called *Lake Shoreland and Shallows Habitat Monitoring* (WDNR, 2016). It provides a standard methodology for surveying, assessing, and mapping habitat in lakeshore areas, including the Riparian buffer, Bank, and Littoral Zones (WDNR, 2016). In 2018, a shoreland and shallows water assessment was conducted on Oxbow Lake. This information will be useful to local and regional resource managers, community stakeholders, and others interested in protecting and enhancing Wisconsin's lakes and rivers (WDNR, 2016). Part of the shallow water habitat survey includes documenting woody habitat. A detailed report can be found in Appendix D.

## Part 8. Wildlife

A study of wildlife was beyond the scope of the current study, but would be valuable to study and interpret in future iterations of the plan. This would be especially true of wetland and water oriented wildlife such as frogs, waterfowl, fish-eating birds, aquatic and semi-aquatic mammals, and invertebrate animals. In the future, it would be desirable to monitor indicator species of wildlife such as common loons, bald eagles, and osprey. Also of special importance would be monitoring the populations of aquatic invasive animal species that already exist in the lake (banded mystery snail) and monitoring for the presence of currently not present aquatic invasive wildlife species (for example, rusty crayfish, spiny water flea, or zebra mussel) and fish species (for example, rainbow smelt or common carp).

Oxbow Lake is currently designated as a *priority navigable water* (PNW) (WI Admin. Code, 2014). Priority Navigable Waters meet any of these standards: navigable waterways, or portions thereof, that are considered ORW/ERW or trout streams; lakes less than 50 acres in size; tributaries and rivers connecting to inland lakes containing naturally-reproducing lake sturgeon populations; waters with self-sustaining walleye populations in ceded territories; waters with self-sustaining musky populations; or perennial tributaries to trout streams (WI Admin. Code, 2014). Oxbow Lake is considered a PNW because it has self-sustaining musky and walleye populations.

## Part 9. Stakeholders

During the ongoing lake planning process, the Oxbow Lake Association and the Town Lakes Committee have represented Oxbow Lake stakeholders. Additional stakeholders and interested citizens are invited to participate as the plan is refined and updated in order to broaden input, build consensus, and encourage participation in stewardship. No contentious direct plant management actions (for example, harvesting or use of herbicides) are a component of the current plan. The Town Lakes Committee has conducted a township wide lake users' survey that is presented in the overarching ***Wilderness Waters Adaptive Management Plan*** (Stine et al., 2019).

**CHAPTER 5**

# Recommendations, Actions, and Objectives

In this chapter we provide recommendations for specific objectives and associated actions to support the APM Plan's goals stated in Chapter 3 and re-stated here for convenient reference:

***(1) Monitor and protect the native aquatic plant community;***

***(2) Monitor for AIS and prevent establishment of new non-native biota;***

***(3) Consider and evaluate the efficacy of active aquatic plant management; and***

***(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that can alter the plant community, minimizing physical removal of native riparian and littoral zone plants, and living with a lake whose natural healthy state includes aquatic plants.***

Since Oxbow Lake is a healthy ecosystem, we could simply recommend an alternative of "no action." In other words, Oxbow Lake continues without any effort or intervention on part of lake stewards. Nevertheless, we consider the "no action" alternative imprudent. Many forces threaten the quality of the lake and Wilderness Waters Program and Town Lakes Committee feels a great responsibility to minimize the threats. We therefore outline in this section a set of actions and related management objectives that will actively engage lake stewards in the process of management.

The actions are presented in tabular form. Each "action" consists of a set of four statements: (1) a declarative "action" statement that specifies the action (2) a statement of the "objective" that the action serves, (3) a "monitoring" statement that specifies the party responsible for carrying out the action and maintaining data, and (4) a "status" statement that suggests a timeline/calendar and indicates status (not yet started, ongoing, or completed). At this time, we recommend no direct manipulation of plant populations in Oxbow Lake.

## Recommended Actions for the Oxbow Lake APM Plan

***Action #1:*** Formally adopt the Aquatic Plant Management Plan.

***Objective:*** To provide foundation for long-term native plant community conservation and stewardship and to be prepared for response to AIS introductions.

***Monitoring:*** The Lake Association and Town Lakes Committee oversee activity and maintains the plan.

***Status:*** Planned for 2020.

***Action #2:*** Monitor water quality.

***Objective***: Continue with collection and analysis of water quality parameters to detect trends in parameters such as nutrients, chlorophyll *a*, and water clarity.

***Monitoring:*** The Lake Association or Town Lakes Committee oversees activity and maintains data.

***Status:*** Ongoing.

***Action #3:*** Monitor the lake for aquatic invasive plant species.

***Objective***: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS.

***Monitoring:*** The Lake Association or Town Lakes Committee oversees activity and maintains data.

***Status:*** Ongoing.

***Action #4:*** Monitor the lake for aquatic invasive animal species.

***Objective***: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS.

***Monitoring:*** The Lake Association or Town Lakes Committee oversees activity and maintains data.

***Status:*** Ongoing.

| Recommended Actions for the Oxbow Lake APM Plan |
|---|
| ***Action #5:*** Form an Aquatic Invasive Species Rapid Response Team and interface with the Town Lakes Committee AIS Rapid Response Coordinator.<br>***Objective:*** To be prepared for AIS discovery and efficient response.<br>***Monitoring:*** The Lake Association and/or Town Lakes Committee coordinate activity.<br>***Status:*** Planned for 2020. |
| ***Action #6:*** Conduct quantitative plant survey every five years using WDNR Point-Intercept Methodology.<br>***Objective:*** To watch for changes in native species diversity, floristic quality, plant abundance, and plant distribution and to check for the occurrence of non-native, invasive plant species.<br>***Monitoring:*** Town Lakes Committee (Wilderness Waters Program) oversees and maintains data; copies to WDNR.<br>***Status:*** Anticipated in 2023. |
| ***Action #7:*** Update the APM plan approximately every five years or as needed to reflect new plant information from plant surveys and monitoring.<br>***Objective:*** To have current information and management science included in the plan.<br>***Monitoring:*** Lake Association and/or Town Lakes Committee (Wilderness Waters Program) oversees and maintains data; copies to WDNR.<br>***Status:*** Ongoing. |
| ***Action #8:*** Develop a Citizen Lake Monitoring Network to monitor for invasive species and develop strategies including education and monitoring activities (see http://www.uwsp.edu/cnr/uwexlakes/clmn for additional ideas).<br>***Objective:*** To create a trained volunteer corps to monitor aquatic invasive species and to educate recreational users regarding AIS.<br>***Monitoring:*** The Lake Association oversees activity and reports instances of possible introductions of AIS.<br>***Status:*** Anticipated to begin in 2020. |

## Recommended Actions for the Oxbow Lake APM Plan

***Action #9:*** Become familiar with and recognize the water quality and habitat values of ordinances and requirements on boating, septic, and property development.

***Objective:*** To protect native aquatic plants, water quality, and riparian habitat.

***Monitoring:*** Lake residents and other stakeholders.

***Status:*** Ongoing.

***Action #10:*** Promote adherence to, and enforcement of, the Town of Presque Isle's 200 foot no-wake ordinances (from shoreline and islands).

***Objective:*** To minimize recreational impacts on the aquatic plant community and shoreline habitats, and promote safe boating.

***Monitoring:*** Town Lakes Committee oversees activity and assesses effectiveness.

***Status:*** Ongoing.

***Action #11:*** Create an education plan for the property owners and other stakeholders that will address issues concerning aquatic and riparian plant communities.

***Objective:*** To educate stakeholders about issues and topics that affect the lake's aquatic and riparian plant communities, including topics such as: (1) the importance of the aquatic plant community; (2) no or minimal mechanical removal of plants along the shoreline is desirable and that any plant removal should conform to Wisconsin regulations; (3) the value of a natural shoreline in protecting the aquatic plant community and lake health; (4) nutrient sources to the lake and the role excess nutrients play in degradation of the aquatic plant community; (5) the importance of reducing or eliminating use of fertilizers on lake front property; (6) the importance of minimizing transfer of AIS to the lake by having dedicated watercraft and cleaning boats that visit the lake.

***Monitoring:*** Town Lakes Committee oversee(s) activity and assesses effectiveness.

***Status:*** Anticipated to begin in 2020.

### Recommended Actions for the Oxbow Lake APM Plan

***Action #12:*** Identify and highlight high quality areas of littoral zone and riparian areas through review of aquatic plant and shoreland assessment data through various reports and online tools.

***Objective:*** To (1) educate lake users on the value of these areas and the importance of good stewardship to their maintenance, (2) recognize landowners who implement good practices (e.g., large percentage of buffer area intact; three vegetative layers intact – herbaceous, shrubs, trees; areas of high native aquatic plant diversity and abundance), and (3) encourage landowners to implement good practices.

***Monitoring:*** Town Lakes Committee and/or lake association promotes and oversees activity.

***Status:*** Ongoing.

***Action #13:*** Lake leaders should encourage and assist landowners to take on lake shore/shallow water improvement projects to rehabilitate areas identified through formal shoreland/shallow water assessments and/or lake user observations (sites might include areas of active erosion, channelized flow, point source pollution, imperious surfaces, and lawns) *Vilas County Land and Water Conservation* looks for partners in this endeavor and can provide planning and sponsorship of projects.

***Objective:*** To rehabilitate specific areas of shoreland to improve natural functions and values.

***Monitoring:*** Lake groups and lake leaders monitor and report progress to Town Lakes Committee.

***Status:*** Ongoing.

***Action #14:*** As part of an education program, encourage commitment from property owners to adopt practices that maintain/improve health of shoreland areas. In many cases, these are "practices" that mean less or no work (e.g., now mowing, no weed wacking, no leaf blowing, no removing large woody material).

***Objective:*** To engage landowners in simple practices that improve/maintain health of the lake and shoreland.

***Monitoring:*** Each landowner can monitor changes in the shoreland over time by simple means (e.g., annual mid-summer photographs or a catalog of plants and animals seen over time).

***Status:*** Anticipated to begin in 2020.

# CHAPTER 6

# Contingency Plan for AIS

Unfortunately, sources of aquatic invasive plants and other AIS are numerous in Wisconsin. Some infested lakes are quite close to Presque Isle Township. There is an increasing likelihood of accidental introduction of AIS to Presque Isle Township Lakes through conveyance of life stages by boats, trailers, and other vectors. It is important for the Town Lakes Committee and other lake stewards to be prepared for the contingency of aquatic invasive plant species colonization in a Presque Isle Township water body. As part of this grant an Aquatic Invasive Survey was conducted using the *Aquatic Invasive Species Early Detection Monitoring Standard Operating Procedure* (2014) and also an educational seminar was conducted. Further discussion is found in Appendix E.

For riparian owners and users of a lake ecosystem, the discovery of AIS is a tragedy that elicits an immediate desire to "fix the problem." Although strong emotions may be evoked by such a discovery, a deliberate and systematic approach is required to appropriately and effectively address the situation. An aquatic plant management plan (one including a contingency plan for AIS) is the best tool by which the process can be navigated. In fact the APM plan is a requirement in Wisconsin for some kinds of aquatic plant management actions. One of the actions outlined in the previous chapter was to establish an Aquatic Invasive Species Rapid Response Team. This team and its coordinator are integral to the management process. It is important for this team to be multi-dimensional (or at least have quick access to the expertise that may be required). AIS invade not just a single lake, but an entire region since the new infestation is an outpost from which the AIS can more easily colonize other nearby water bodies. For this reason it is strategic for the Rapid Response Team to include representation from regional stakeholders.

Exhibit 9 provides a flowchart outlining an appropriate rapid response to the suspected discovery of an aquatic invasive plant species. The response will be most efficient if an AIS Rapid Response Team has already been established and is familiar with the contingency plan. In the remainder of this chapter we further describe the approach.

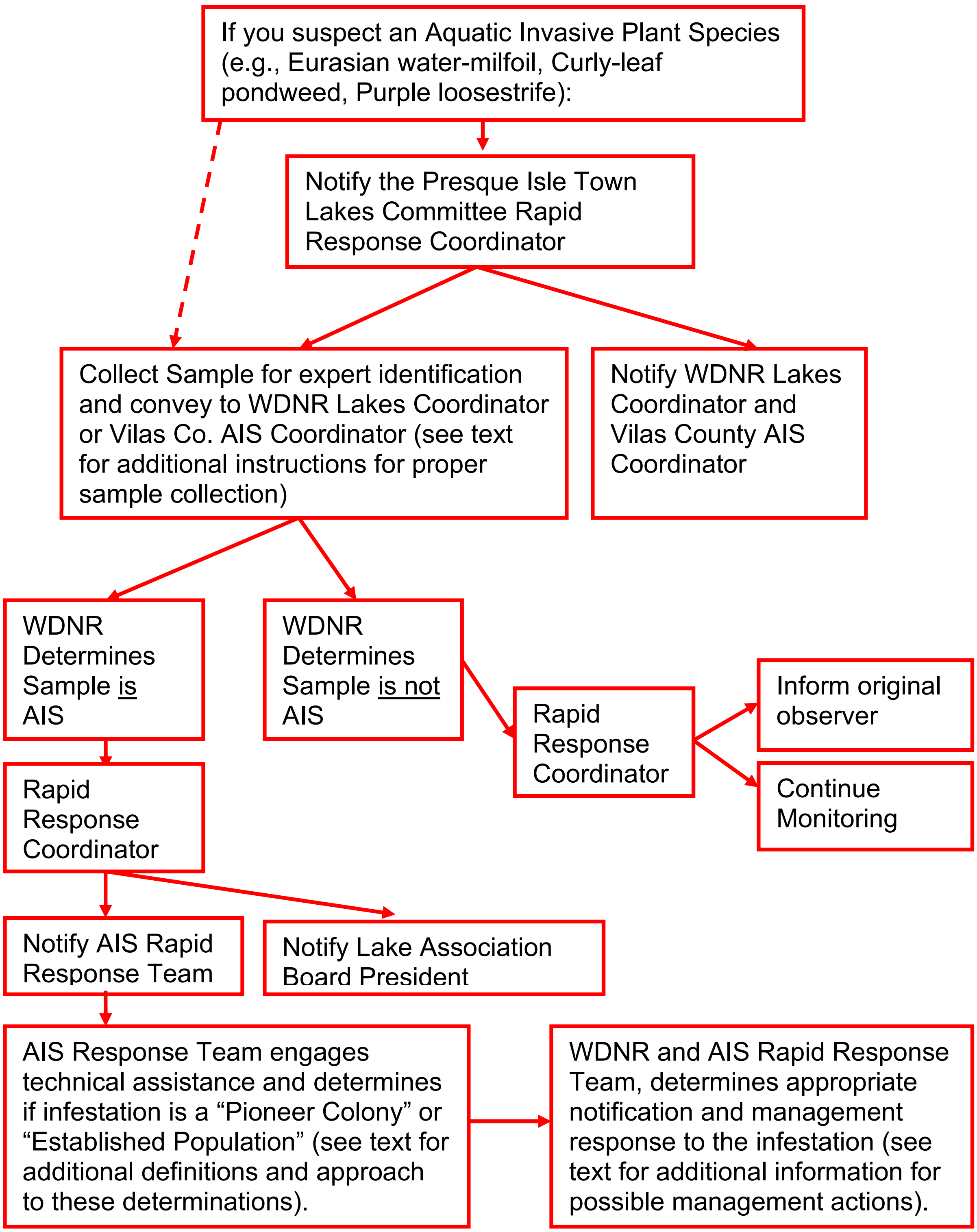
When a suspect aquatic invasive plant species is found, either the original observer or a member of the Rapid Response Team (likely the coordinator) should collect an entire plant specimen including roots, stems, and flowers (if present). The sample should be placed in a sealable bag with a small amount of water to keep it moist. Place a label in the bag written in pencil with date, time, collector's name, lake name, location, town, and county. Attach a lake map to the bag that has the location of the suspect AIS marked and GPS coordinates recorded (if GPS is available). The sample should be placed on ice in a cooler or in a refrigerator. Deliver the sample to the WDNR Water Resource Management Specialist (Kevin Gauthier in Woodruff) or the Vilas County AIS Coordinator (Alan Wirt) as soon as possible (at least within three days). The WDNR or their botanical expert(s) will determine the species and confirm whether or not it is an aquatic invasive plant species.

If the suspect specimen is determined to be an invasive plant species, the next step is to determine the extent and density of the population since the management response will vary accordingly. The Rapid Response Team should conduct (or have its consultant conduct) a survey to define the colony's perimeter and estimate density. If less than five acres (or <5% of the lake surface area), it is designated a "Pioneer Colony." If greater than five acres (or >5% of the lake surface area) then it is designated an "Established Population." Once the infestation is characterized, "at risk" areas should also be determined and marked on a map. For example, nearby boat landing sites and areas of high boat traffic should be indicated.

When "pioneer" or "established" status has been determined, it is time to consult with the WDNR Lakes Coordinator to determine appropriate notifications and management responses to the infestation. Determining whether hand-pulling or chemical treatment will be used is an important and early decision. Necessary notifications of landowners, governmental officials, and recreationists (at boat landings) will be determined. Whether the population's perimeter needs to be marked with buoys will be decided by the WDNR. Funding sources will be identified and consultants and contractors will be contacted where necessary. The WDNR will determine if a further baseline plant survey is required (depending on type of treatment). A post treatment monitoring plan will be discussed and established to determine the efficacy of the selected treatment.

Once the Rapid Response Team is organized, one of its first tasks is to develop a list of contacts and associated contact information (phone numbers and email addresses). At a minimum, this contact list should include: the Rapid Response Coordinator, members of the Rapid Response Team, County AIS Coordinator, WDNR Lakes Management Coordinator, Lake Association Presidents (or other points of contact), local WDNR warden, local government official(s), other experts, chemical treatment contractors, and consultant(s).

**Exhibit 9. Aquatic Invasive Plant Species Rapid Response**



# Appendix A

# Literature Cited

## LITERATURE CITED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# Appendix B

# Aquatic Plant Survey Tables and Figures

## Table of Contents

**Table 1. Summary statistics for the 2018 point-intercept aquatic plant surveys for Oxbow Lake.**

| Summary Statistic | Value | Notes |
|---|---|---|
| Total number of sites on grid | 843 | Total number of sites on the original grid (not necessarily visited) |
| Total number of sites visited | 642 | Total number of sites where the boat stopped, even if much too deep to have plants. |
| Total number of sites with vegetation | 120 | Total number of sites where at least one plant was found |
| Total number of sites shallower than maximum depth of plants | 273 | Number of sites where depth was less than or equal to the maximum depth where plants were found. This value is used for Frequency of occurrence at sites shallower than maximum depth of plants. |
| Frequency of occurrence at sites shallower than maximum depth of plants | 43.96 | Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants. |
| Simpson Diversity Index | 0.93 | A nonparametric estimator of community heterogeneity. It is based on Relative Frequency and thus is not sensitive to whether all sampled sites (including non-vegetated sites) are included. The closer the Simpson Diversity Index is to 1, the more diverse the community. |
| Maximum depth of plants (ft.) | 10.00 | The depth of the deepest site sampled at which vegetation was present. |
| Number of sites sampled with rake on rope | 16 | |
| Number of sites sampled with rake on pole | 341 | |
| Average number of all species per site (shallower than max depth) | 1.03 | |
| Average number of all species per site (vegetated sites only) | 2.34 | |
| Average number of native species per site (shallower than max depth) | 1.03 | Total number of species collected. Does not include visual sightings. |
| Average number of native species per site (vegetated sites only) | 2.34 | Total number of species collected including visual sightings. |
| Species Richness | 39 | |
| Species Richness (including visuals) | 40 | |
| Floristic Quality Index (FQI) | 45.4 | |

**Table 2. Plant species recorded and distribution statistics for the 2018 Oxbow Lake aquatic plant survey.**

| Common name | Scientific name | Frequency of occurrence at sites less than or equal to maximum depth of plants | Frequency of occurrence within vegetated areas (%) | Relative Frequency (%) | Number of sites where species found | Number of sites where species found (including visuals) | Average Rake Fullness |
|---|---|---|---|---|---|---|---|
| Thread-like Naiad | *Najas gracillima* | 16.48 | 37.50 | 16.01 | 45 | 45 | 1.00 |
| Berchtold’s pondweed | *Potamogeton berchtoldii* | 13.19 | 30.00 | 12.81 | 36 | 36 | 1.00 |
| Muckgrass | *Chara sp.* | 8.79 | 20.00 | 8.54 | 24 | 25 | 1.17 |
| Large-leaf pondweed | *Potamogeton amplifolius* | 7.69 | 17.50 | 7.47 | 21 | 56 | 1.00 |
| Watershield | *Brasenis schreberi* | 7.69 | 17.50 | 7.47 | 21 | 46 | 1.00 |
| Narrow-leaved bur-reed | Sparganium angustifolium | 6.59 | 15.00 | 6.41 | 18 | 25 | 1.00 |
| Nitella | *Nitella sp.* | 4.76 | 10.83 | 4.63 | 13 | 13 | 1.08 |
| Variable pondweed | *Potamogeton gramineus* | 4.40 | 10.00 | 4.27 | 12 | 22 | 1.00 |
| Water marigold | *Bidens beckii* | 3.30 | 7.50 | 3.20 | 9 | 9 | 1.00 |
| Needle spikerush | *Eleocharis acicularis* | 2.93 | 6.67 | 2.85 | 8 | 9 | 1.00 |
| Wild celery | *Vallisneria Americana* | 2.93 | 6.67 | 2.85 | 8 | 8 | 1.00 |
| Spatterdock | *Nuphar variegata* | 2.56 | 5.83 | 2.49 | 7 | 24 | 1.00 |
| Common bladderwort | *Utricularia vulgaris* | 2.56 | 5.83 | 2.49 | 7 | 15 | 1.00 |
| Creeping spikerush | *Eleocharis palustris* | 2.20 | 5.00 | 2.14 | 6 | 31 | 1.00 |
| Fern pondweed | *Potamogeton robbinsii* | 1.83 | 4.17 | 1.78 | 5 | 6 | 1.00 |
| Quillwort | *Isoetes sp.* | 1.83 | 4.17 | 1.78 | 5 | 5 | 1.00 |
| Pickerelweed | *Pontederia cordata* | 1.47 | 3.33 | 1.42 | 4 | 11 | 1.00 |
| White water lily | *Nymphaea odorata* | 1.10 | 2.50 | 1.07 | 3 | 11 | 1.00 |
| Large purple bladderwort | *Utricularia purpurea* | 1.10 | 2.50 | 1.07 | 3 | 4 | 1.00 |
| Brown-fruited rush | *Juncus pelocarpus g. submerses* | 1.10 | 2.50 | 1.07 | 3 | 3 | 1.00 |
| Ribbon-leaf pondweed | *Potamogeton epihydrus* | 0.73 | 1.67 | 0.71 | 2 | 6 | 1.00 |
| Hardstem bulrush | *Schoenoplectus acutus* | 0.73 | 1.67 | 0.71 | 2 | 3 | 1.00 |
| Slender waterweed | *Elodea nuttallii* | 0.73 | 1.67 | 0.71 | 2 | 2 | 1.00 |
| Creeping spearwort | *Ranuculus flammula* | 0.73 | 1.67 | 0.71 | 2 | 2 | 1.00 |

**Frequency of occurrence within vegetated areas (%):** Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

**Table 2. Continued.**

| Common name | Scientific name | Frequency of occurrence at sites less than or equal to maximum depth of plants | Frequency of occurrence within vegetated areas (%) | Relative Frequency (%) | Number of sites where species found | Number of sites where species found (including visuals) | Average Rake Fullness |
|---|---|---|---|---|---|---|---|
| Northwest territory sedge | *Carex utriculata* | 0.37 | 0.83 | 0.36 | 1 | 2 | 1.00 |
| Three-way sedge | *Dulichium arundinaceum* | 0.37 | 0.83 | 0.36 | 1 | 3 | 1.00 |
| Pipewort | *Eriocaulon aquaticum* | 0.37 | 0.83 | 0.36 | 1 | 2 | 1.00 |
| Small duckweed | Lemna minor | 0.37 | 0.83 | 0.36 | 1 | 2 | 1.00 |
| Coontail | Ceratophyllum demersum | 0.37 | 0.83 | 0.36 | 1 | 2 | 1.00 |
| Common waterweed | *Elodea Canadensis* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Northern manna grass | *Glyceria borealis* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Farwell's water-milfoil | *Myriophyllum farwellii* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Dwarf water-milfoil | *Myriophullum tenellum* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Spiral-fruited pondweed | *Potamogeton spirillus* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Water bulrush | *Schoenoplectus subterminalis* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Short-stemmed bur-reed | *Sparganium emersum* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Floating-leaf bur-reed | *Sparganium fluctuans* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Small bladderwort | *Utricularia minor* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Small purple bladderwort | *Utricularia resupinata* | 0.37 | 0.83 | 0.36 | 1 | 1 | 1.00 |
| Water horsetail | *Equisetum fluviatile* | | | Visual | | 7 | |
| Tussock sedge | *Carex stricta* | | | Boat Survey | | | |
| Marsh cinquefoil | *Comarum palustre* | | | Boat Survey | | | |
| Beardless irises | *Iris sp.* | | | Boat Survey | | | |
| Northern blue flag | *Iris versicolor* | | | Boat Survey | | | |
| Water lobelia | *Lobelia dortmanna* | | | Boat Survey | | | |
| Reed canary grass | *Phalaris arundinacea* | | | Boat Survey | | | |
| American common reed | *Phragmites australis subsp. americanas* | | | Boat Survey | | | |
| Common arrowhead | *Sagittaria latifolia* | | | Boat Survey | | | |
| Softstem bulrush | *Schoenoplectus tabernaemontani* | | | Boat Survey | | | |
| Woolgrass | *Scirpus cyperinus* | | | Boat Survey | | | |
| Broad-leaved cattail | *Typha latifolia* | | | Boat Survey | | | |
| | *Unknown grass* | | | Boat Survey | | | |

**NOTES:**

Thread-like naiad (Najas gracillima) and Small purple bladderwort (*Uttricularia resupinata*) is considered a Special Concern species in Wisconsin.

Reed canary grass (*Phlarais arundinacea*) is Restricted in Wisconsin

Dr. Freckmann (U.W. Stevens Point – Herbarium) confirmed the plant vouchers January 2019.

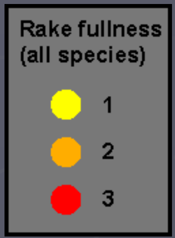
**Frequency of occurrence within vegetated areas (%):** Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

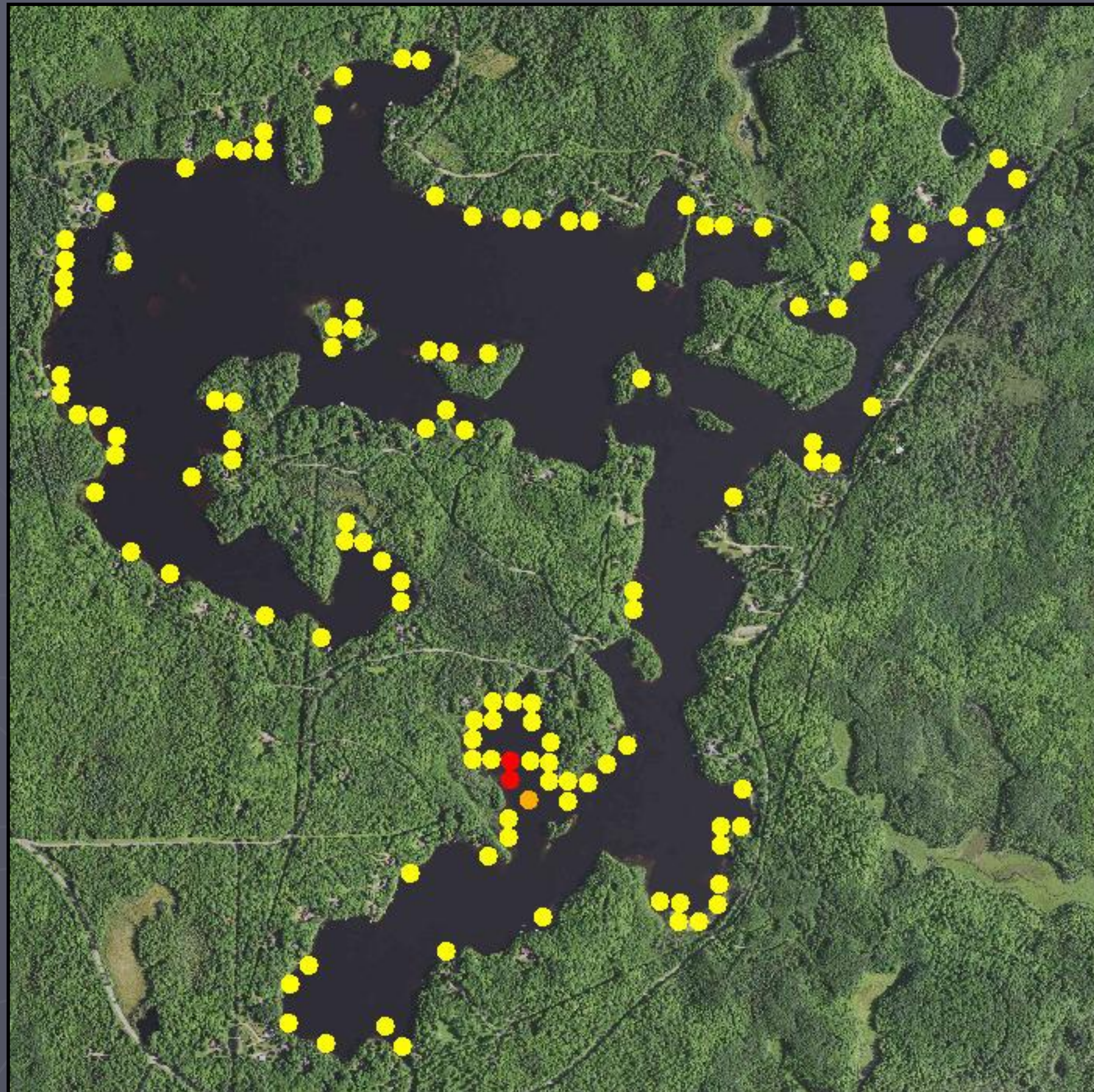
**Table 3. Comparison of summary statistics for 2007, 2014 and 2018 point-intercept aquatic plant surveys in Oxbow Lake.**

| Summary Statistic | 2007 | 2014 | 2018 |
|---|---|---|---|
| Total number of sites on grid | 843 | 843 | 843 |
| Total number of sites visited | | 584 | 642 |
| Total number of sites with vegetation | | 111 | 120 |
| Total number of sites shallower than maximum depth of plants | | 337 | 273 |
| Frequency of occurrence at sites shallower than maximum depth of plants | 45.47 | 32.94 | 43.96 |
| Simpson Diversity Index | 0.88 | 0.93 | 0.93 |
| Maximum depth of plants (ft.) | 13.0 | 12.0 | 10.0 |
| Number of sites sampled with rake on rope | | 20 | 16 |
| Number of sites sampled with rake on pole | | 391 | 341 |
| Average number of all species per site (shallower than max depth) | 0.92 | 0.58 | 1.03 |
| Average number of all species per site (vegetated sites only) | 2.02 | 1.77 | 2.34 |
| Average number of native species per site (shallower than max depth) | 0.92 | 0.58 | 1.03 |
| Average number of native species per site (vegetated sites only) | 2.02 | 1.77 | 2.34 |
| Species Richness | 23 | 29 | 39 |
| Species Richness (including visuals) | | 37 | 40 |
| Floristic Quality Index (FQI) | 33.5 | 37.0 | 45.4 |
| Annual Mean Secchi Transparency (in feet) | 11.1 | 7.8 | 6.5 |

Figure 1. Number of plant species recorded at Oxbow Lake sample sites (2018).


Figure 2. Rake fullness ratings for Oxbow Lake sample sites (2018).

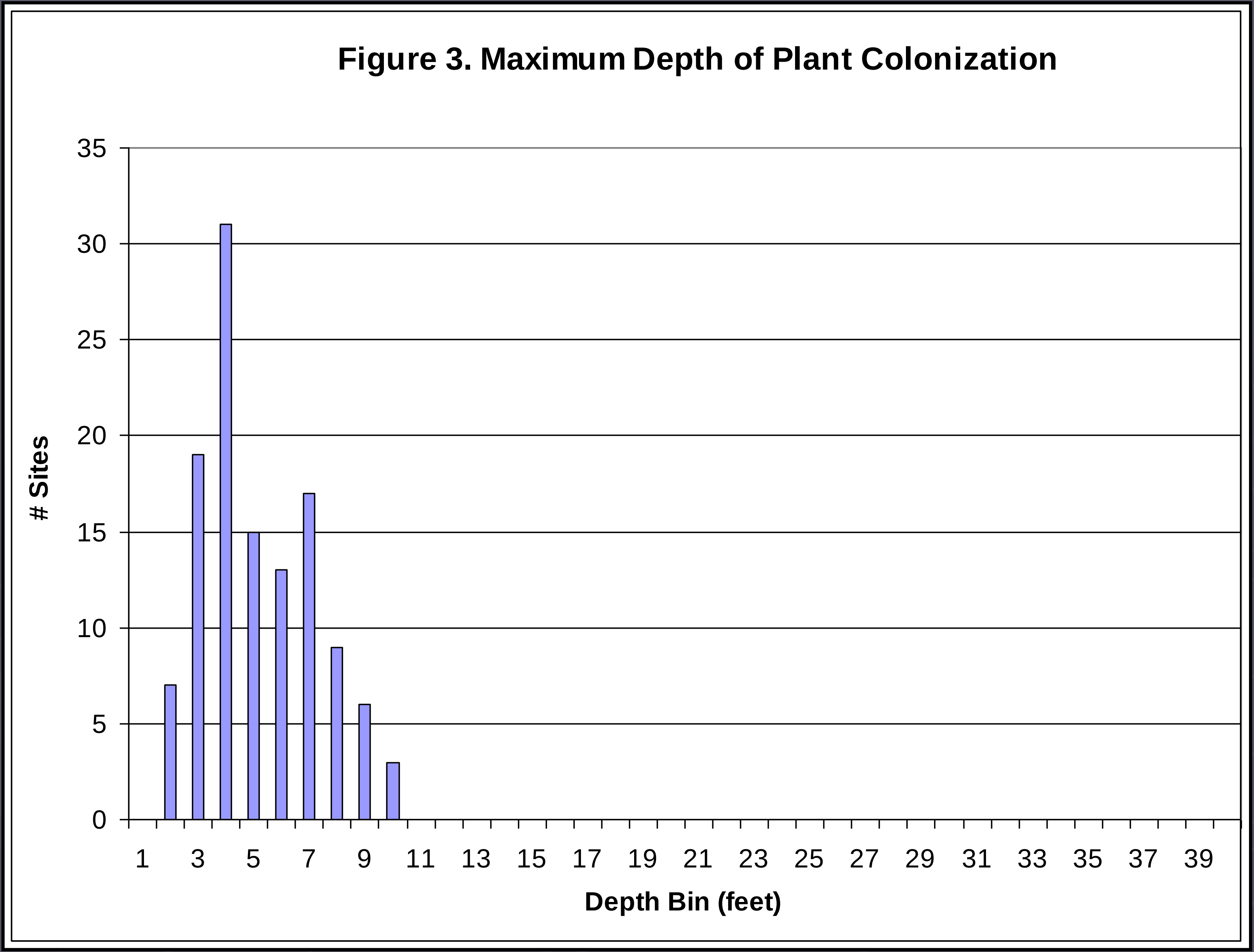
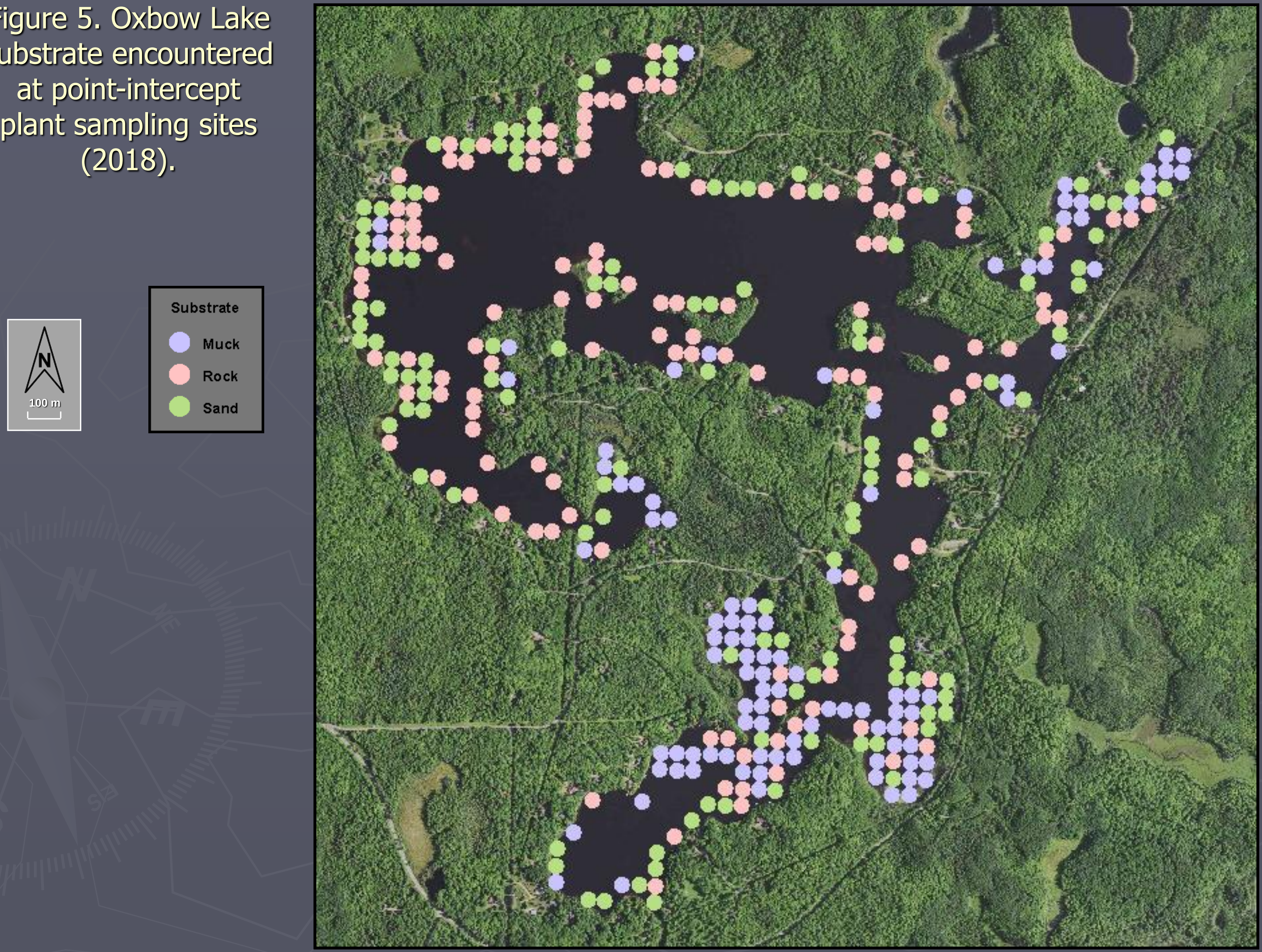


Figure 3. Maximum Depth of Plant Colonization
# Sites
Depth Bin (feet)
0
5
10
15
20
25
30
35
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39

Figure 4. Oxbow Lake sampling sites less than or equal to maximum depth of rooted vegetation (2018).

Figure 5. Oxbow Lake substrate encountered at point-intercept plant sampling sites (2018).



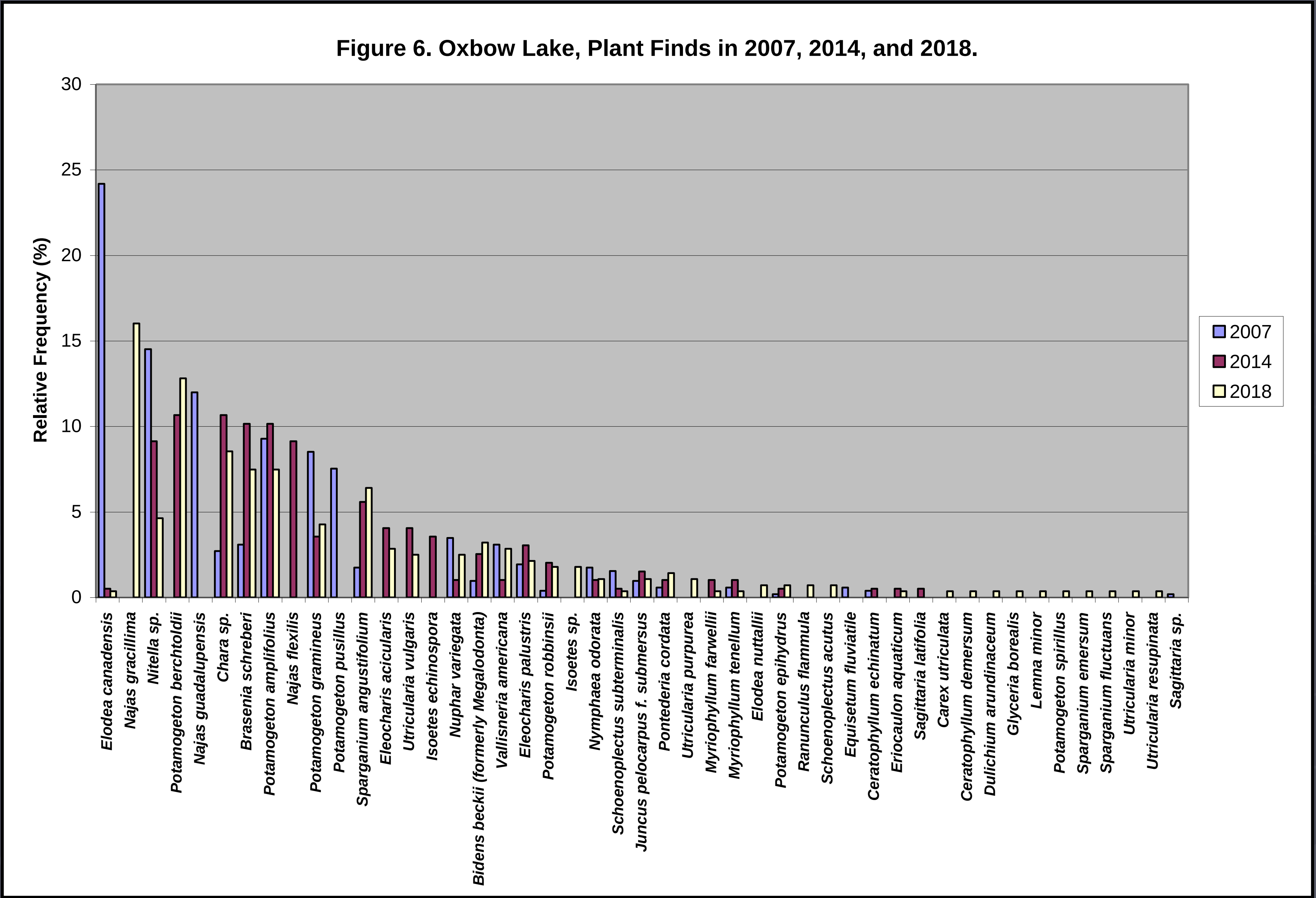
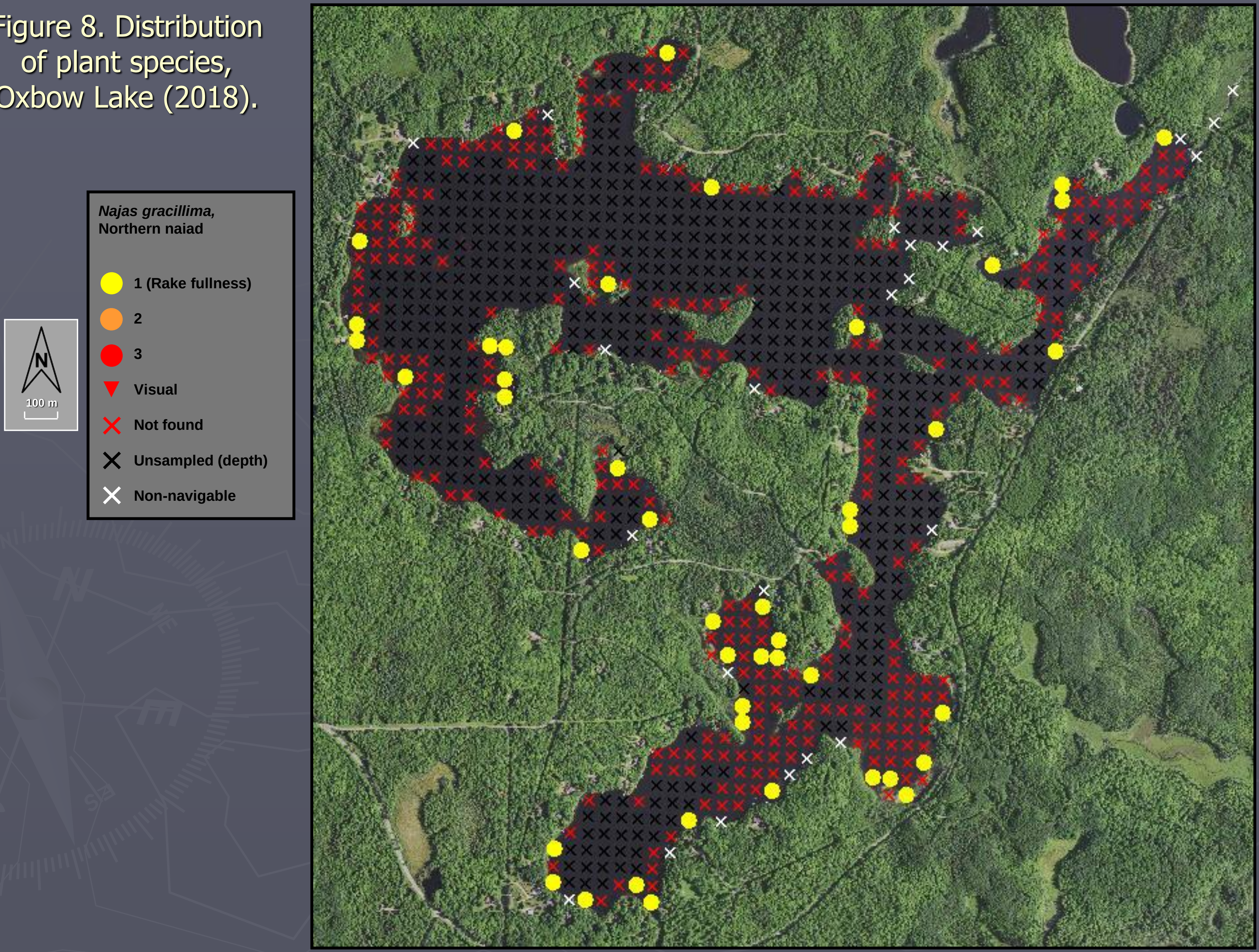


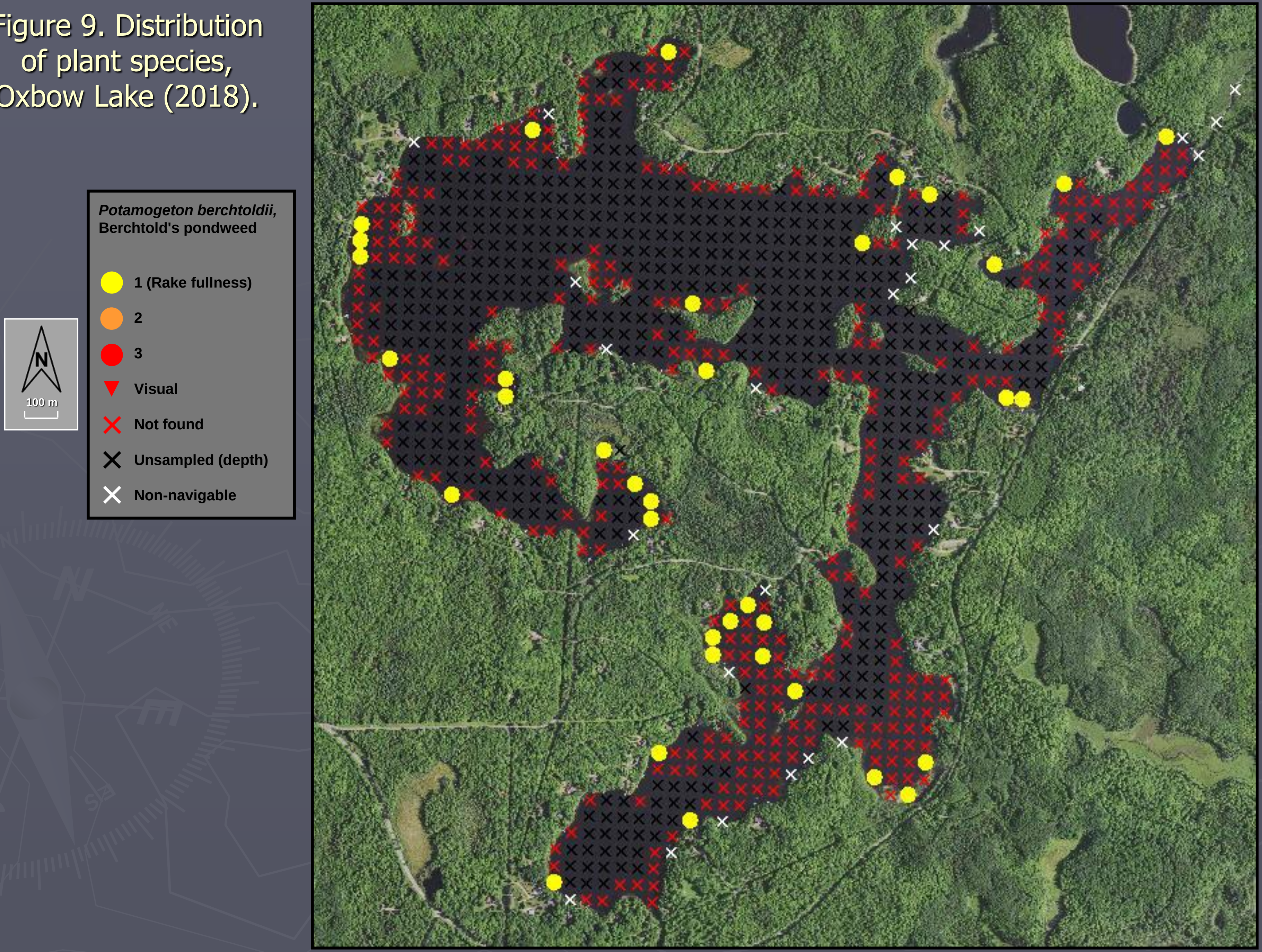
Figure 6. Oxbow Lake, Plant Finds in 2007, 2014, and 2018.
Relative Frequency (%)
30
25
20
15
10
5
0
2007
2014
2018
Elodea canadensis
Najas gracillima
Nitella sp.
Potamogeton berchtoldii
Najas guadalupensis
Chara sp.
Brasenia schreberi
Potamogeton amplifolius
Najas flexilis
Potamogeton gramineus
Potamogeton pusillus
Sparganium angustifolium
Eleocharis acicularis
Utricularia vulgaris
Isoetes echinospora
Nuphar variegata
Bidens beckii (formerly Megalodonta)
Vallisneria americana
Eleocharis palustris
Potamogeton robbinsii
Isoetes sp.
Nymphaea odorata
Schoenoplectus subterminalis
Juncus pelocarpus f. submersus
Pontederia cordata
Utricularia purpurea
Myriophyllum farwellii
Myriophyllum tenellum
Elodea nuttallii
Potamogeton epihydrus
Ranunculus flammula
Schoenoplectus acutus
Equisetum fluviatile
Ceratophyllum echinatum
Eriocaulon aquaticum
Sagittaria latifolia
Carex utriculata
Ceratophyllum demersum
Dulichium arundinaceum
Glyceria borealis
Lemna minor
Potamogeton spirillus
Sparganium emersum
Sparganium fluctuans
Utricularia minor
Utricularia resupinata
Sagittaria sp.

Figure 7. Oxbow Lake point-intercept plant sampling sites with emergent and floating aquatic plants (2018).

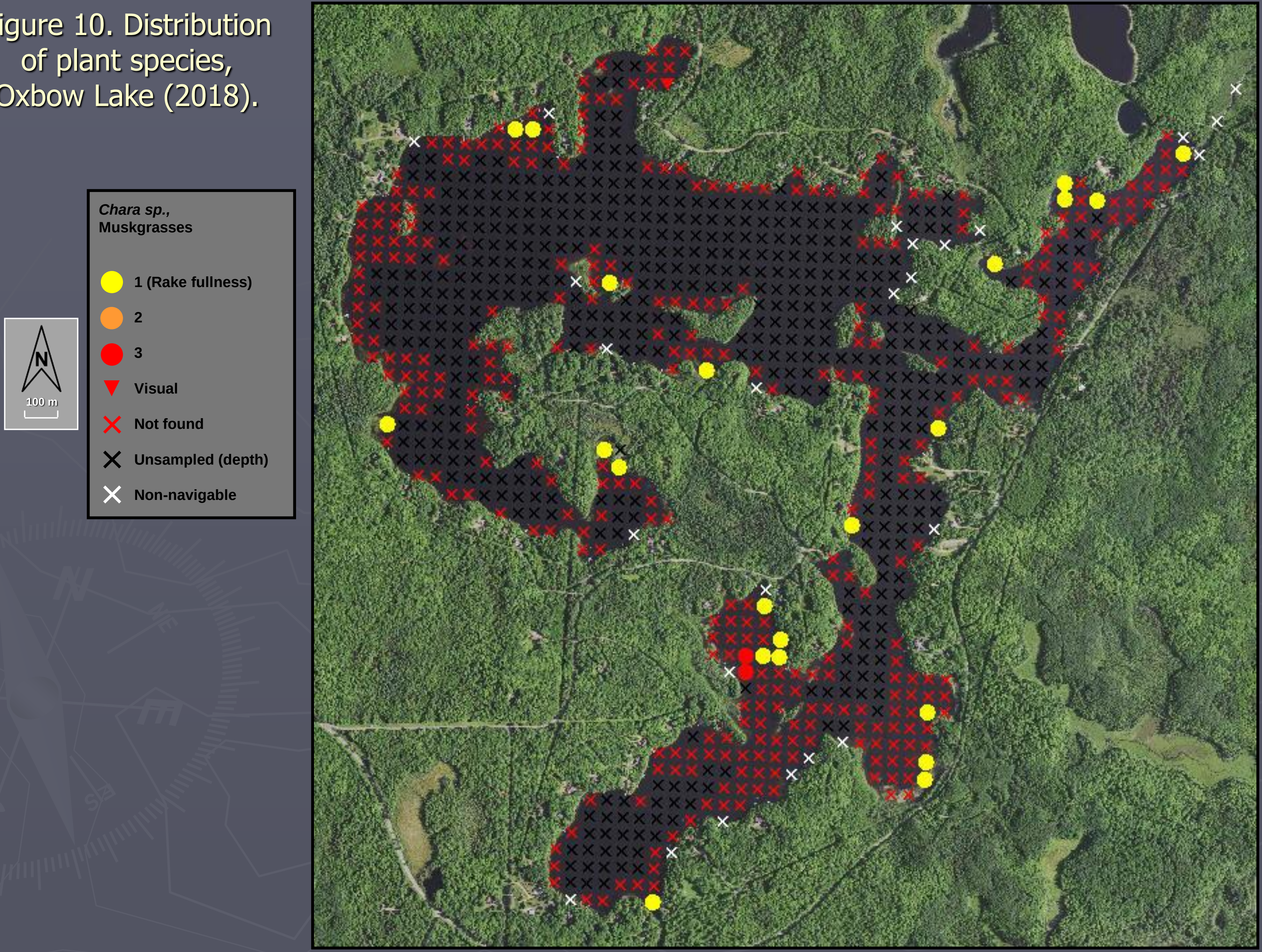

# Figure 8. Distribution of plant species, Oxbow Lake (2018).



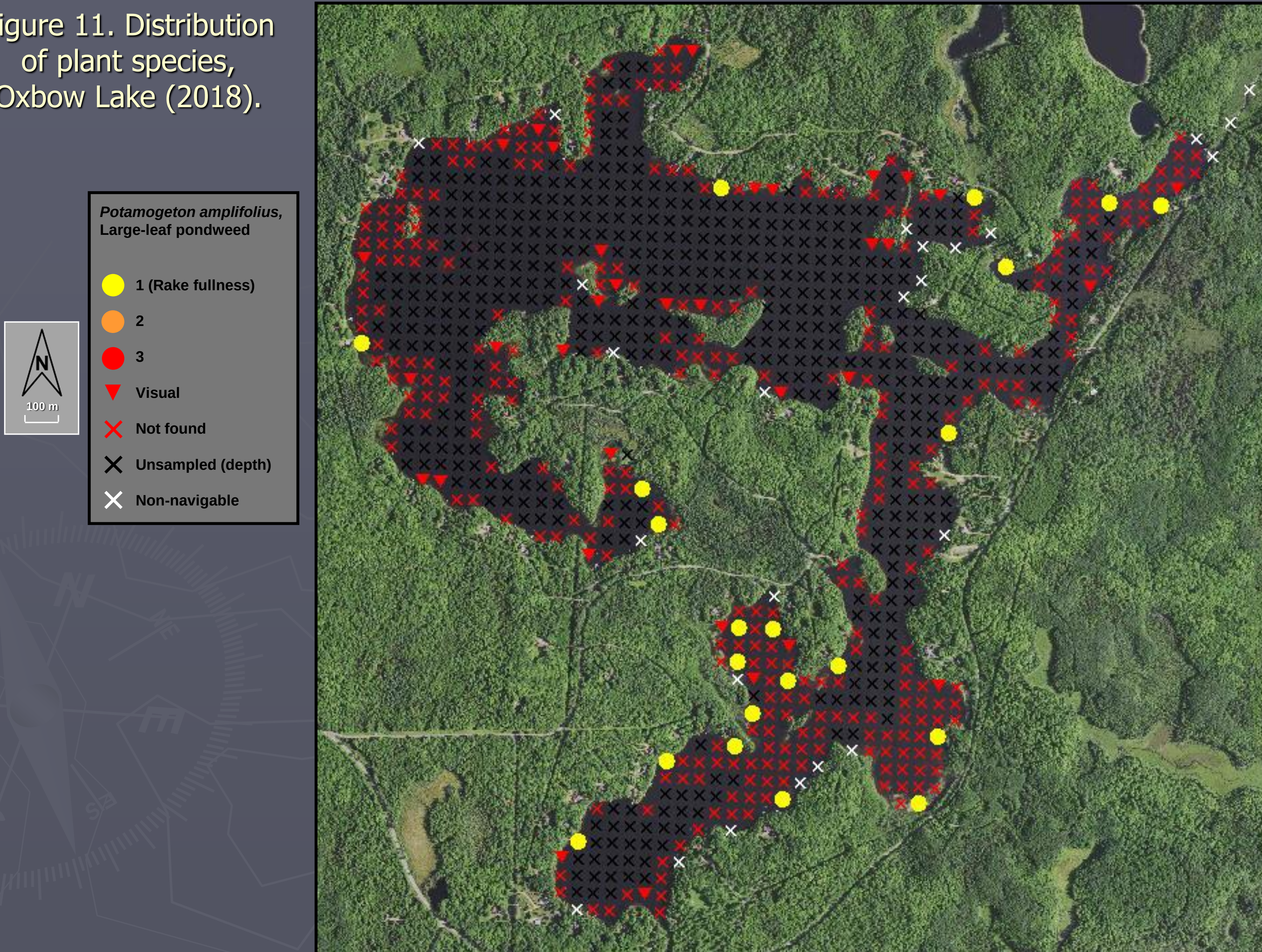
# Figure 9. Distribution of plant species, Oxbow Lake (2018).



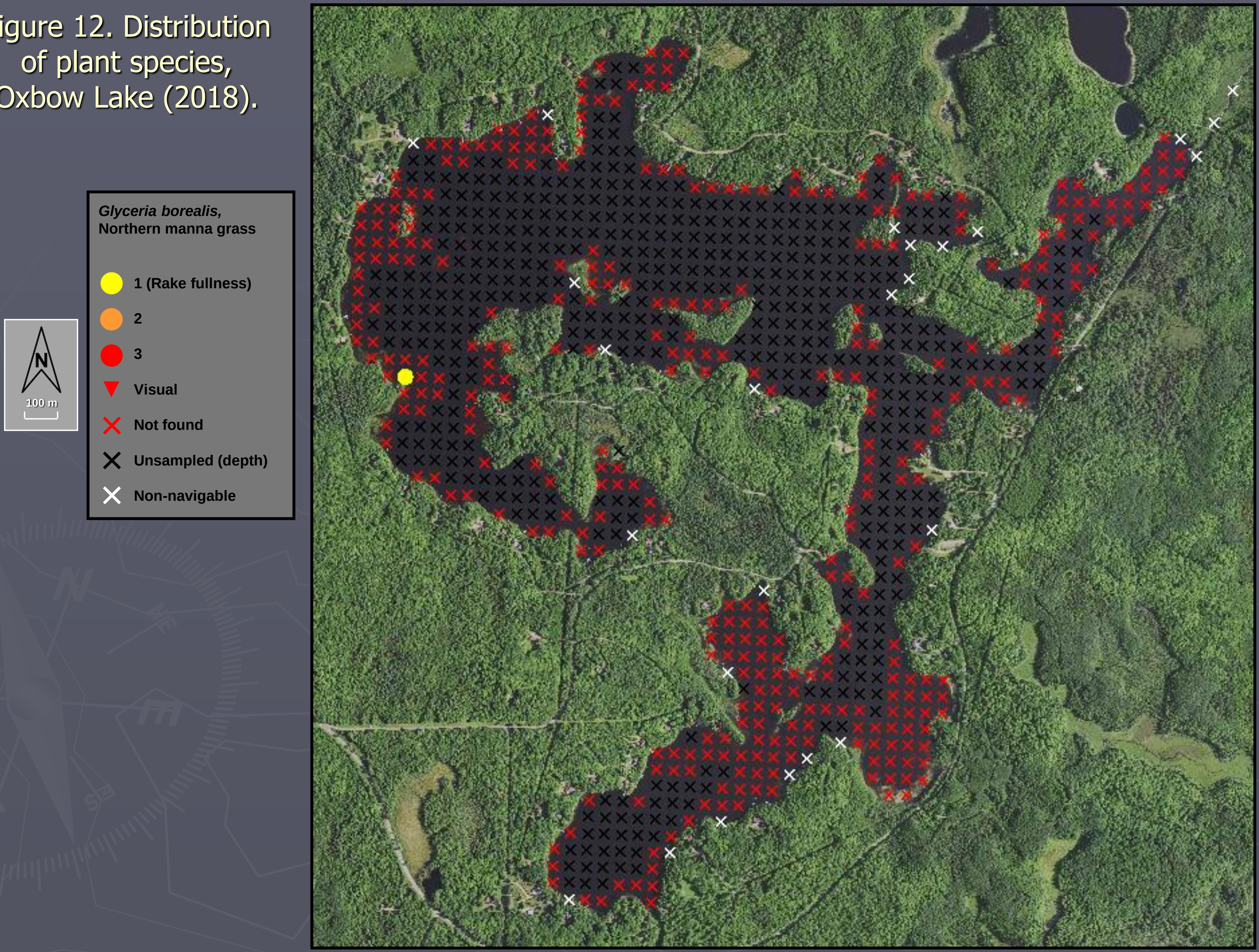
# Figure 10. Distribution of plant species, Oxbow Lake (2018).



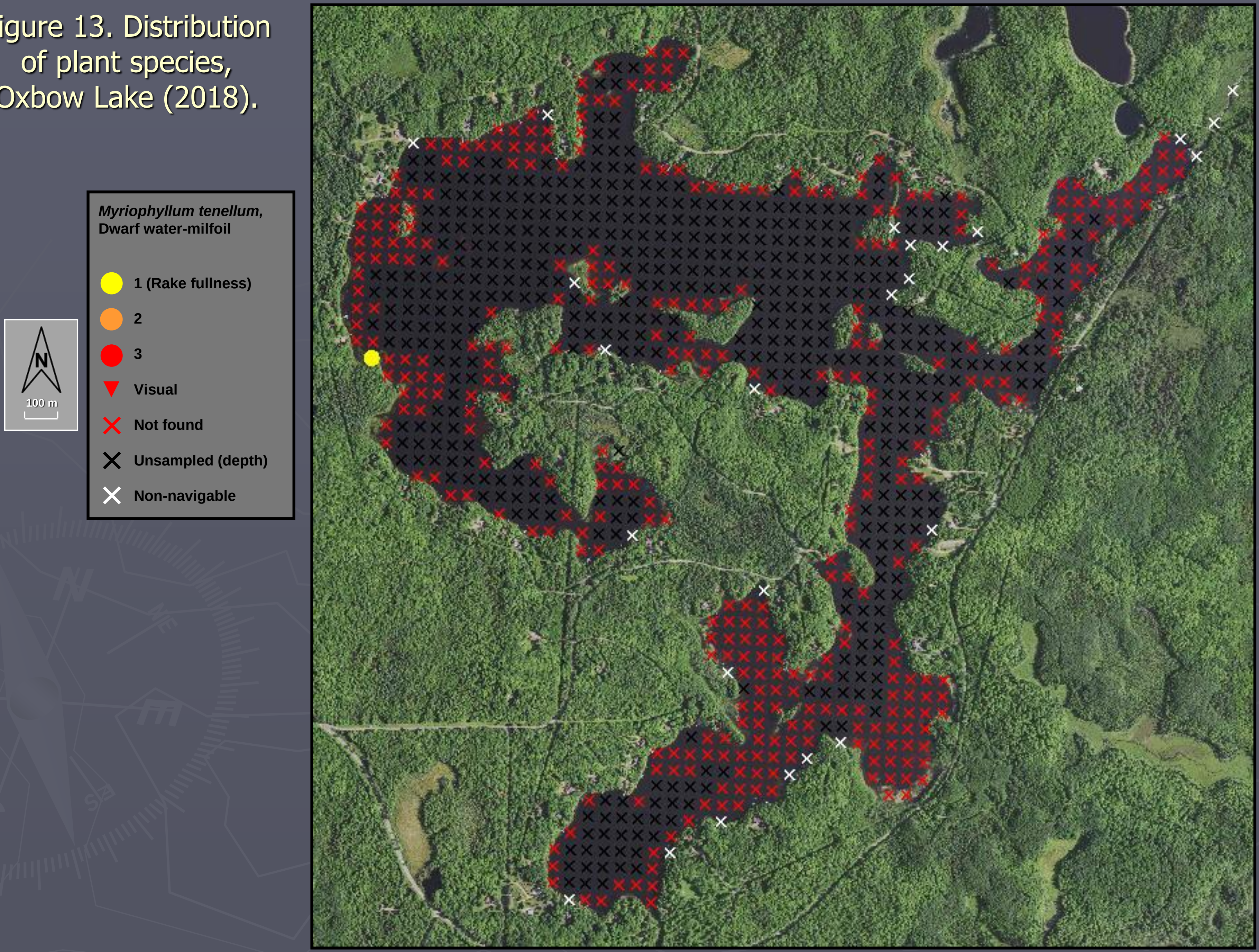
# Figure 11. Distribution of plant species, Oxbow Lake (2018).



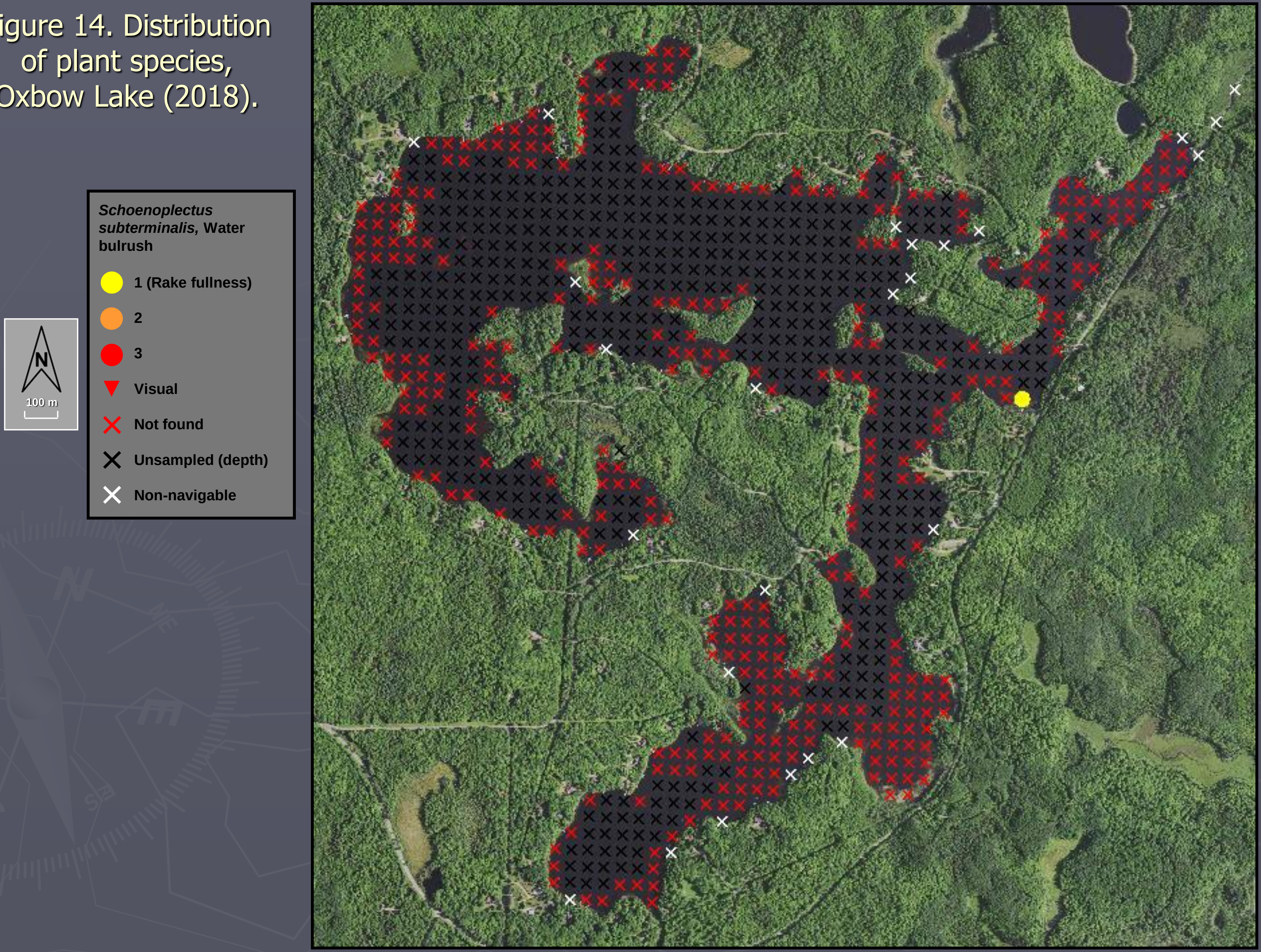
# Figure 12. Distribution of plant species, Oxbow Lake (2018).



# Figure 13. Distribution of plant species, Oxbow Lake (2018).



# Figure 14. Distribution of plant species, Oxbow Lake (2018).



# Appendix C

# Oxbow Lake Water Quality Report

**Appendix C**

**Review of Lake Water Quality**

## Table of Contents

# Review of Oxbow Lake Water Quality

**Prepared by Angie Stine, B.S., White Water Associates, Inc.**

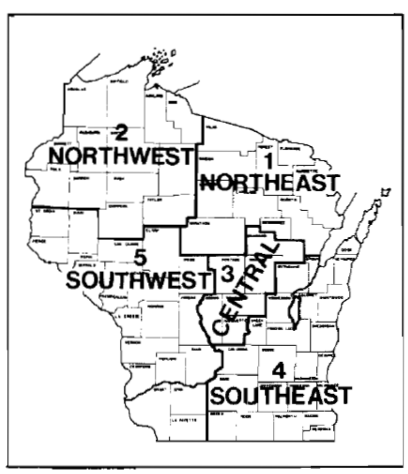
## Introduction

Oxbow Lake is located in Vilas County, Wisconsin. It is a 523 acre drainage lake with a maximum depth of 44 feet. The Waterbody Identification Code (WBIC) is 2954800. The purpose of this study is to develop baseline data. Our goal is to collect existing water quality data to give us a starting point, and continue to monitor Oxbow Lake for a comparison of environmental and human changes. Water quality data was retrieved from the Wisconsin DNR SWIMS database between 1984 and 2019. On August 29, 2007 a Dissolved Organic Carbon (DOC) Assessment was conducted by remote sensing technology. Secchi disk measurements were collected by Citizen Lake Monitoring Network (CLMN) volunteers in 1996 and from 2004 to 2019. Chlorophyll *a* was collected in 1984, 1985, 2007, and from 2009 to 2019. Total phosphorus was collected in 1985, 1992, 2007, and from 2009 to 2019 by CLMN volunteers.

## Comparison of Oxbow Lake with other datasets

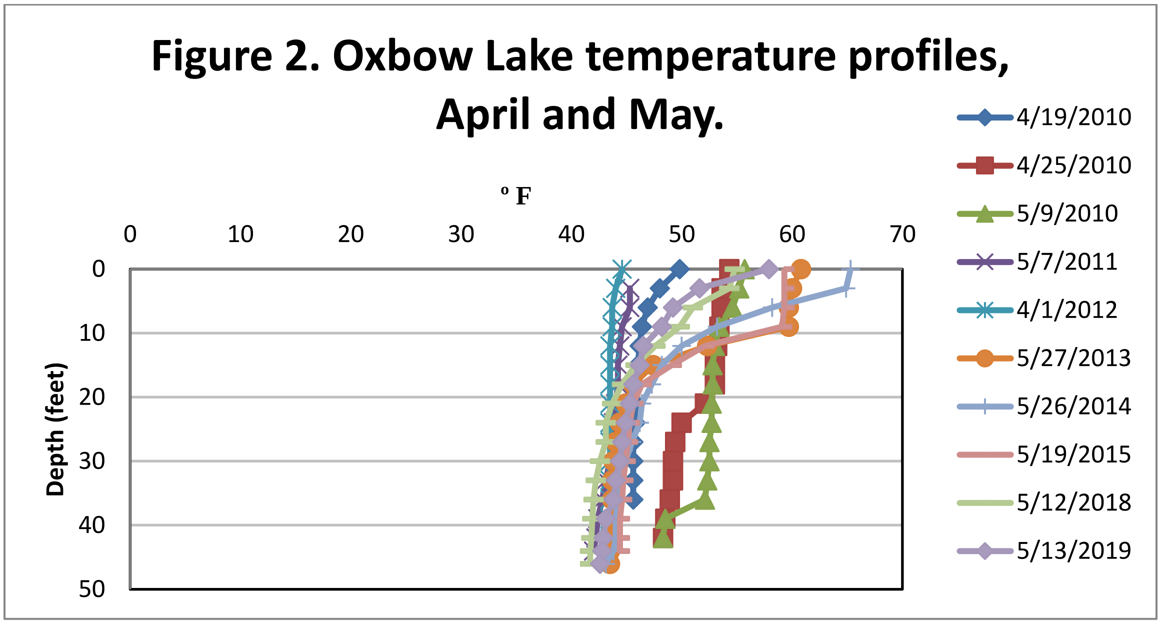
Lillie and Mason's *Limnological Characteristics of Wisconsin Lakes* (1983) is a great source to compare lakes within our region to a subset of lakes that have been sampled in Wisconsin. Wisconsin is divided into five regions of sampling lakes. Vilas County lakes are in the Northeast Region (Figure 1) and were among 243 lakes randomly selected and analyzed for water quality.

**Figure 1. Wisconsin regions in terms of water quality.**



## Temperature

Measuring the temperature of a lake at different depths will determine the influence it has on the physical, biological, and chemical aspects of the lake. Lake water temperature influences the rate of decomposition, nutrient recycling, lake stratification, and dissolved oxygen (D.O.) concentration. Temperature can also affect the distribution of fish species throughout a lake. Figure 2 indicates the changes in water temperature from April and May in 2010-2019. In June, the temperatures began to stratify around 12 feet (Figure 3). The July temperature levels show stratification beginning at 15 to 18 feet (Figure 4). In August the thermocline started at 18 to 22 feet (Figure 5).



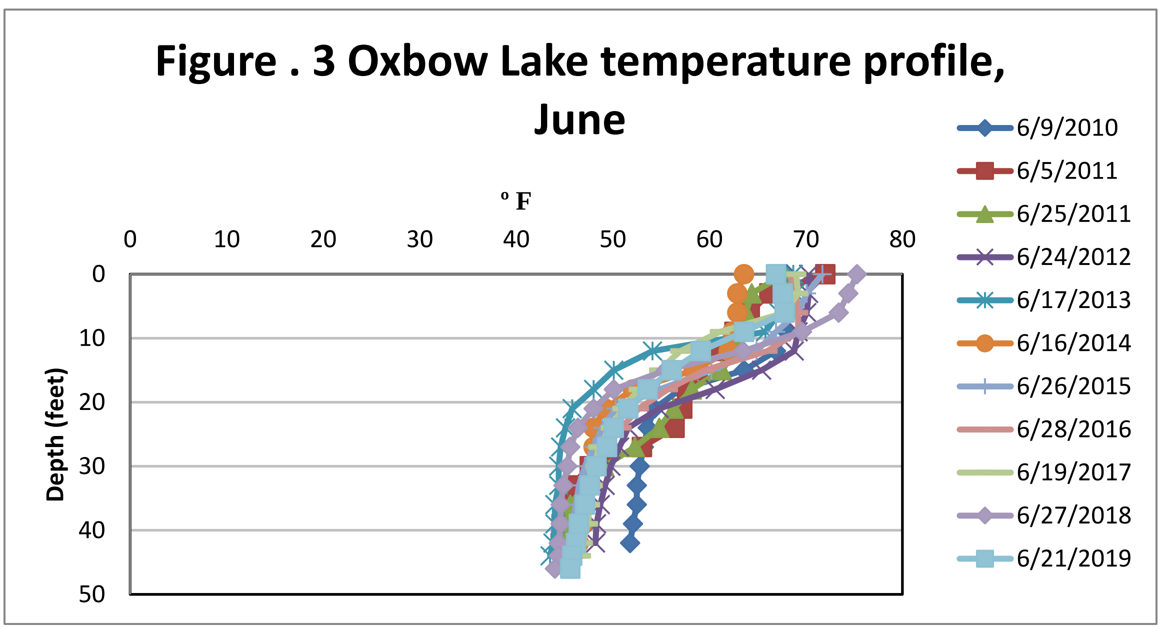



Figure 4. Oxbow Lake temperature profiles, July.

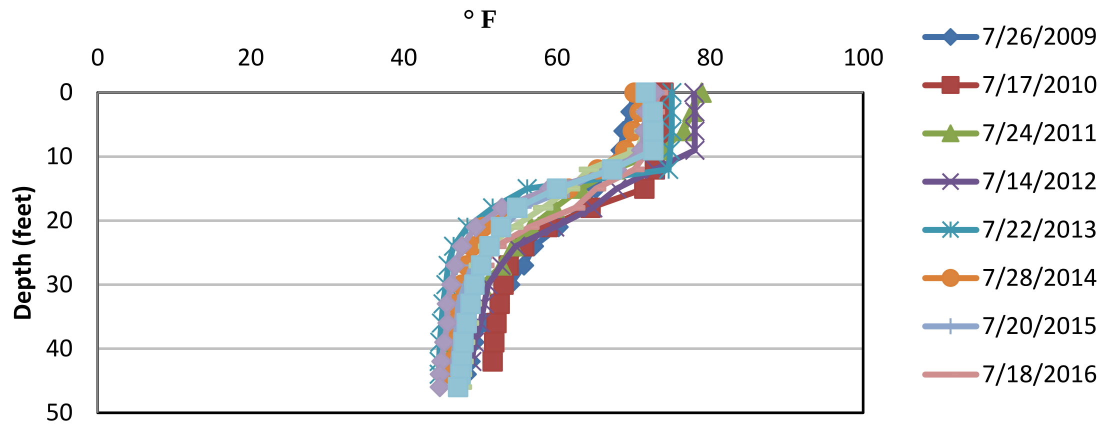
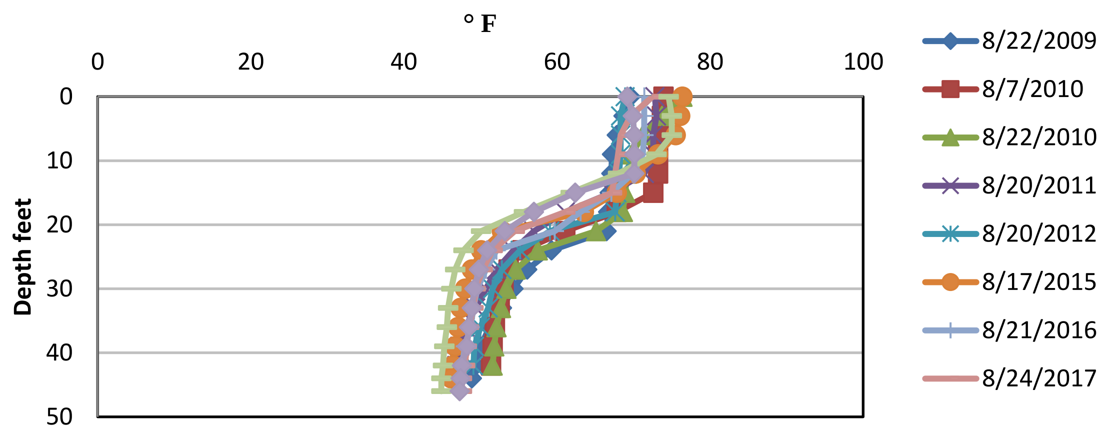


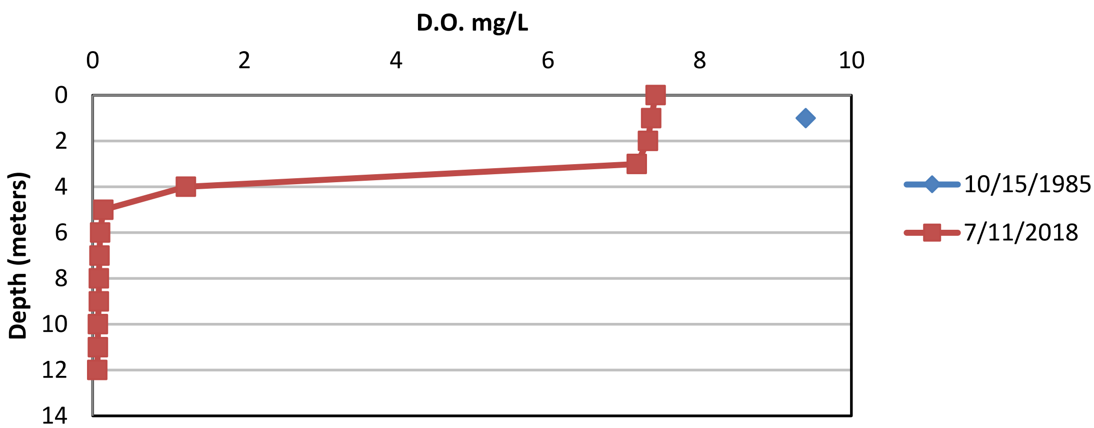

Figure 5. Oxbow Lake temperature profile August.



## Dissolved Oxygen

The dissolved oxygen (D.O.) content of lake water is vital in determining presence of fish species and other aquatic organisms. Dissolved oxygen also has a strong influence on the chemical and physical conditions of a lake. The amount of dissolved oxygen is dependent on the water temperature, atmospheric pressure, and biological activity. Oxygen levels are increased by aquatic plant photosynthesis, but reduced by respiration of plants, decomposer organisms, fish, and invertebrates. The amount of dissolved oxygen available in a lake, particularly in the deeper parts of a lake, is critical to overall health. On October 15, 1985 D.O. was 9.4 mg/L at 3 feet. Oxbow Lake had a D.O. profile conducted July, 2018. The D.O. was below 1 mg/L at 4 meters.

Figure 6. Oxbow Lake dissolved oxygen profile.

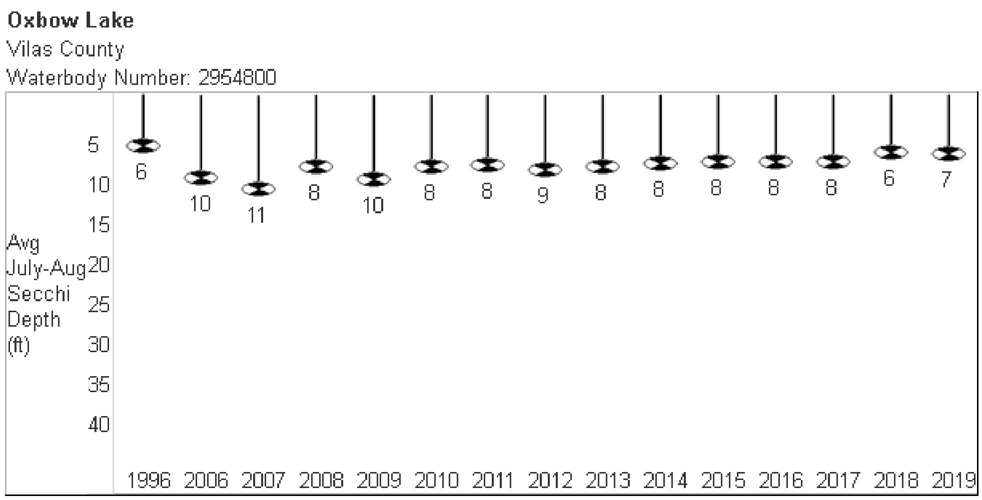



## Water Clarity

Water clarity has two main components: turbidity (suspended materials such as algae and silt) and true color (materials dissolved in the water) (Shaw et al., 2004). Water clarity gives an indication of the overall water quality in a lake. Water clarity is typically measured using a Secchi disk (black and white disk) that is lowered into the water column on a tether. In simple terms, the depth at which the disk is no longer visible is recorded as the Secchi depth.

Figure 7 displays the July and August mean Secchi depths from 1996, 2006 to 2019. The shallowest mean Secchi depth was 5.5 feet in 1996, and the deepest mean depth was at 11.1 feet in 2007 (Figure 8). According to Table 1, the 2019 mean Secchi depth classifies Oxbow Lake as “fair” with respect to water clarity.

**Figure 7. Oxbow Lake Secchi depth averages (July and August only).**




Past secchi averages in feet (July and August only).

(WDNR, 2019)

**Figure 8. Oxbow Lake's July and August Secchi Data: Mean, Min, Max, and Secchi Count (1996-2019).**

| Year | Secchi Mean | Secchi Min | Secchi Max | Secchi Count |
|---|---|---|---|---|
| 1996 | 5.5 | 5.5 | 5.5 | 1 |
| 2006 | 9.67 | 8 | 10.5 | 3 |
| 2007 | 11.08 | 9.25 | 12.75 | 3 |
| 2008 | 8.2 | 7.75 | 8.75 | 5 |
| 2009 | 9.88 | 9.25 | 10.5 | 2 |
| 2010 | 8.17 | 8 | 8.25 | 3 |
| 2011 | 8 | 8 | 8 | 2 |
| 2012 | 8.63 | 8.5 | 8.75 | 2 |
| 2013 | 8.25 | 8 | 8.5 | 2 |
| 2014 | 7.75 | 7.75 | 7.75 | 1 |
| 2015 | 7.63 | 7.5 | 7.75 | 2 |
| 2016 | 7.5 | 7.25 | 7.75 | 2 |
| 2017 | 7.5 | 7.25 | 7.75 | 2 |
| 2018 | 6.49 | 5.6 | 7.5 | 4 |
| 2019 | 6.63 | 6.5 | 6.75 | 2 |

Report Generated: 12/11/2019

(WDNR, 2019)

**Table 1. Water clarity index (Shaw et al., 2004).**

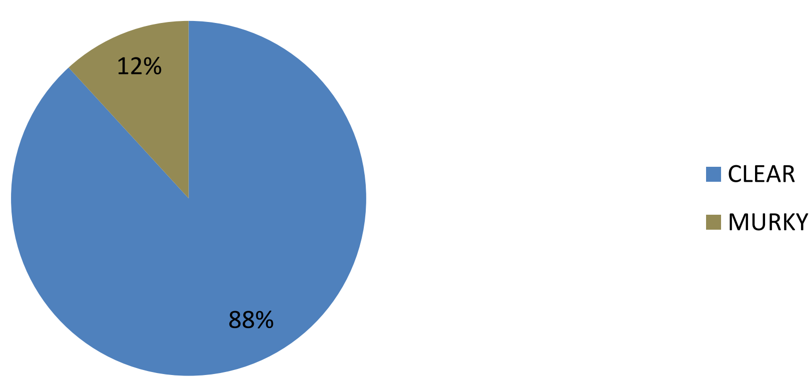
| Water clarity | Secchi depth (ft.) |
|---|---|
| Very poor | 3 |
| Poor | 5 |
| Fair | 7 |
| Good | 10 |
| Very good | 20 |
| Excellent | 32 |

## Turbidity

Turbidity is another measure of water clarity, but is caused by suspended particulate matter rather than dissolved organic compounds (Shaw et al., 2004). Particles suspended in the water dissipate light and reduce the depth at which the light can penetrate.  This affects the depth at which plants can grow. Turbidity also affects the aesthetic quality of water.  Water that runs off the watershed into a lake can increase turbidity by introducing suspended materials. Turbidity caused by algae is the most common reason for low Secchi readings (Shaw et al., 2004). In terms of biological health of a lake ecosystem, measurements less than 10 Nephelometric Turbidity Units (NTU) represent healthy conditions for fish and other organisms.  Oxbow Lake turbidity has not been tested, and should be included in future water quality sampling.

While checking Secchi depth, the CLMN volunteers also rate the water clarity and describe the water as “clear” or “murky.”  Figure 9 show that 88% of CLMN volunteers rated the water in Oxbow Lake as “clear”.

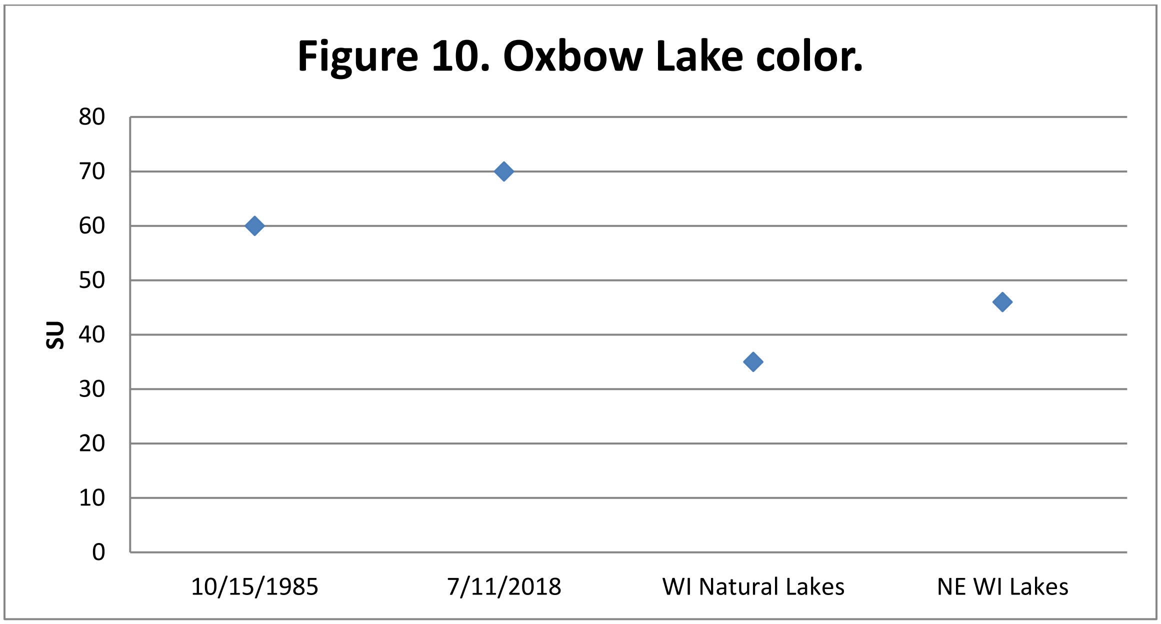
**Figure 9. Oxbow Lake water appearance 2006-2019.**

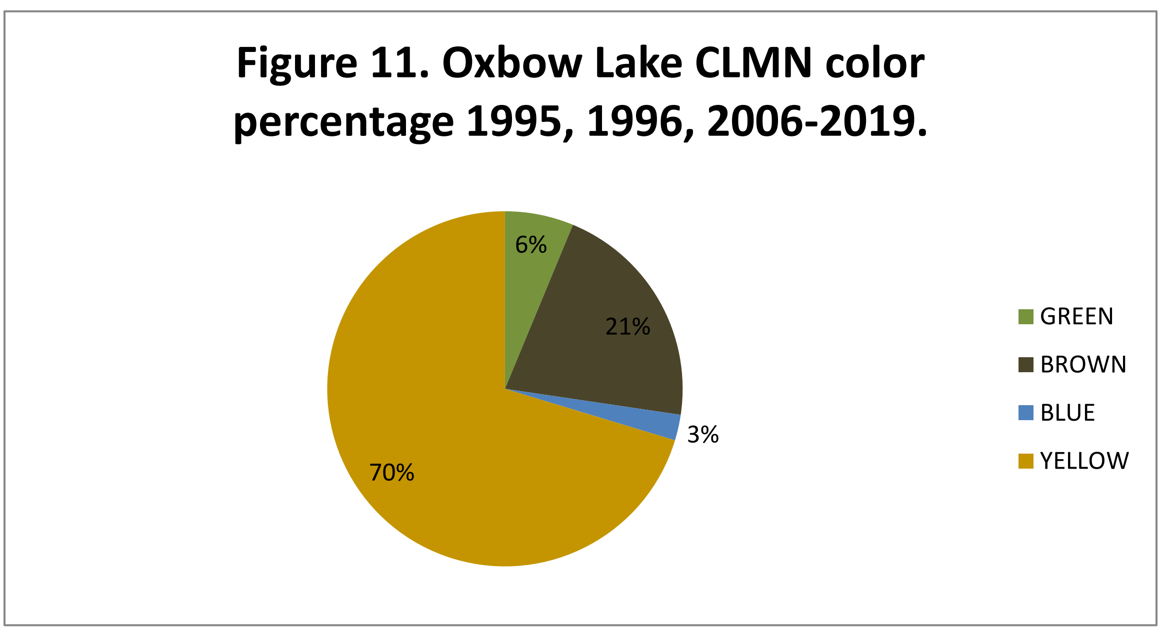


**Water Color**

Color of lake water is related to the type and amount of dissolved organic chemicals. Its main significance is aesthetics, although it may also influence light penetration and in turn affect aquatic plant and algal growth. Many lakes have naturally occurring color compounds from decomposition of plant material in the watershed (Shaw et al., 2004). Units of color are determined from the platinum-cobalt scale and are therefore recorded as Pt-Co units. Shaw states that a water color between 0 and 40 Pt-Co units is low. Oxbow Lake was analyzed for color in 1985 and 2018. The values were high in comparison to Wisconsin natural and Northeastern lakes (Figure 10).

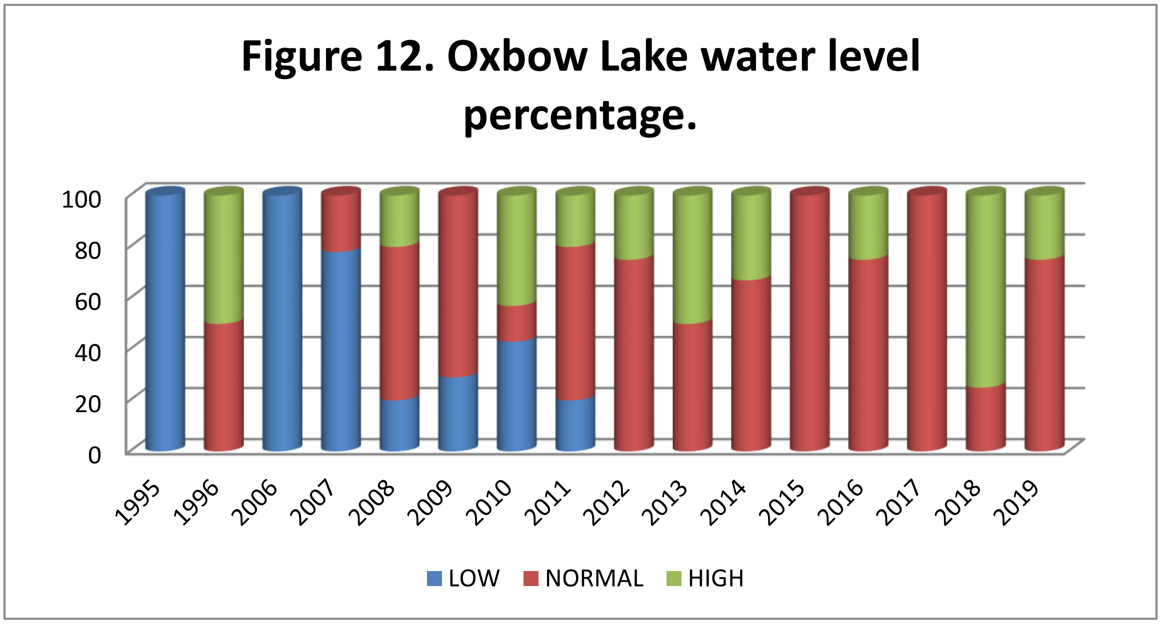
The CLMN have also recorded their perceptions of water color in Oxbow Lake. Since 1995, 70% of volunteers said the water appeared "yellow," and 21% indicated the water appeared "brown" (Figure 11).



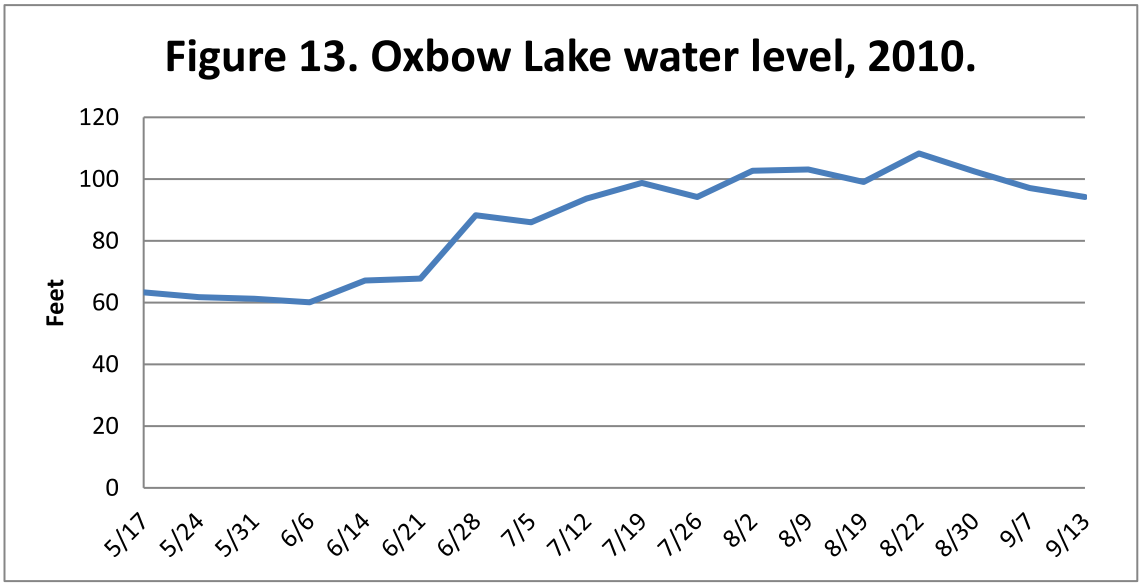



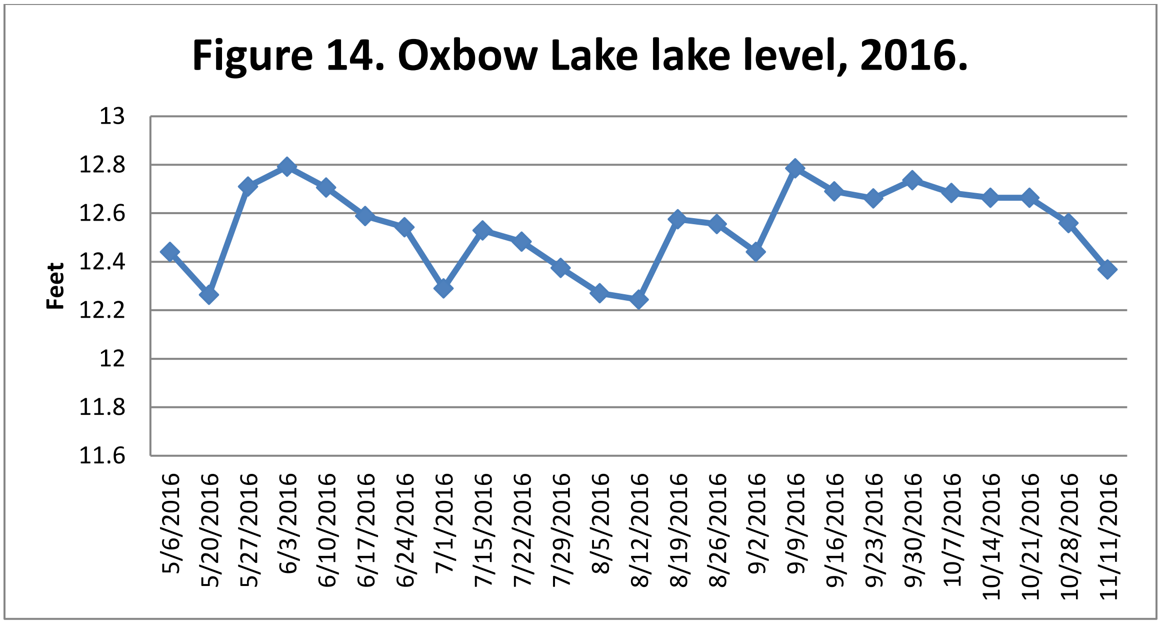
## Water Level

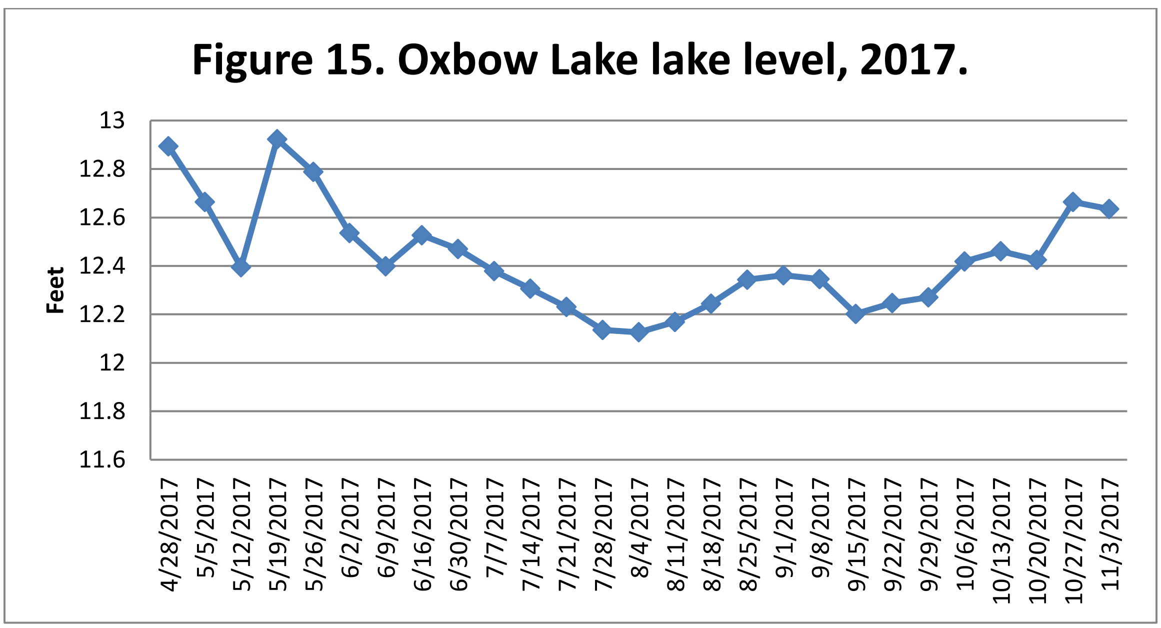
CLMN volunteers also recorded their opinion of the lake level as "high," "normal," or "low." Figure 12 indicates that in 1995 and 2006, 100% of CLMN volunteers said the water level was "low."




In 2010 (Figure 13), 2016 (Figure 14), and 2017 (Figure 15), volunteers monitored the water level of Oxbow Lake during the ice-free season.

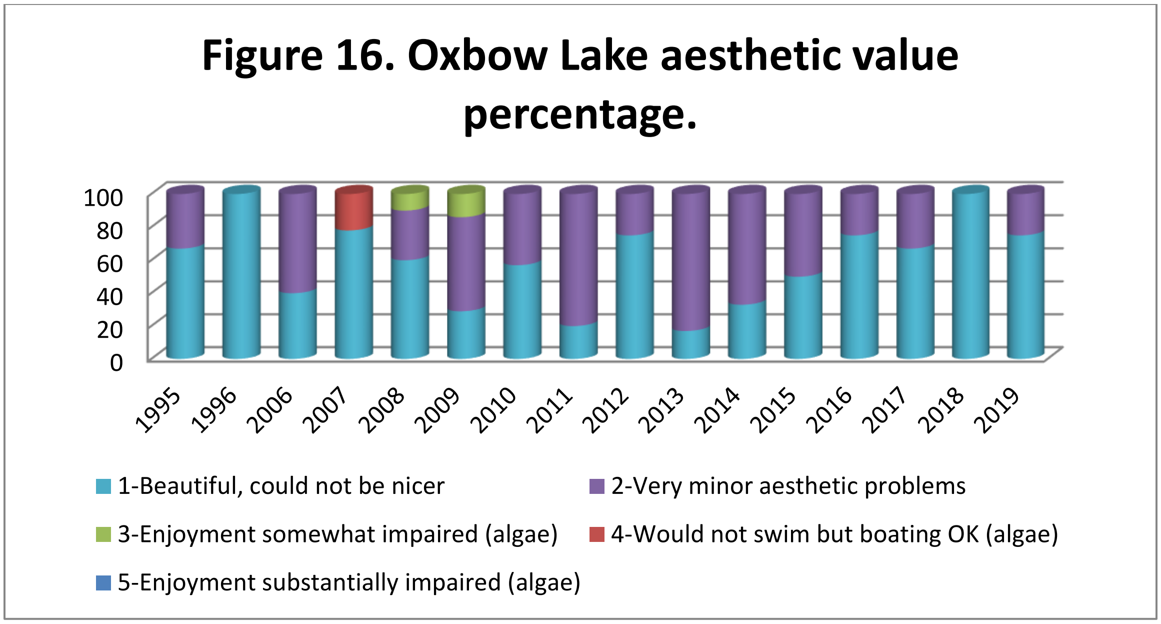




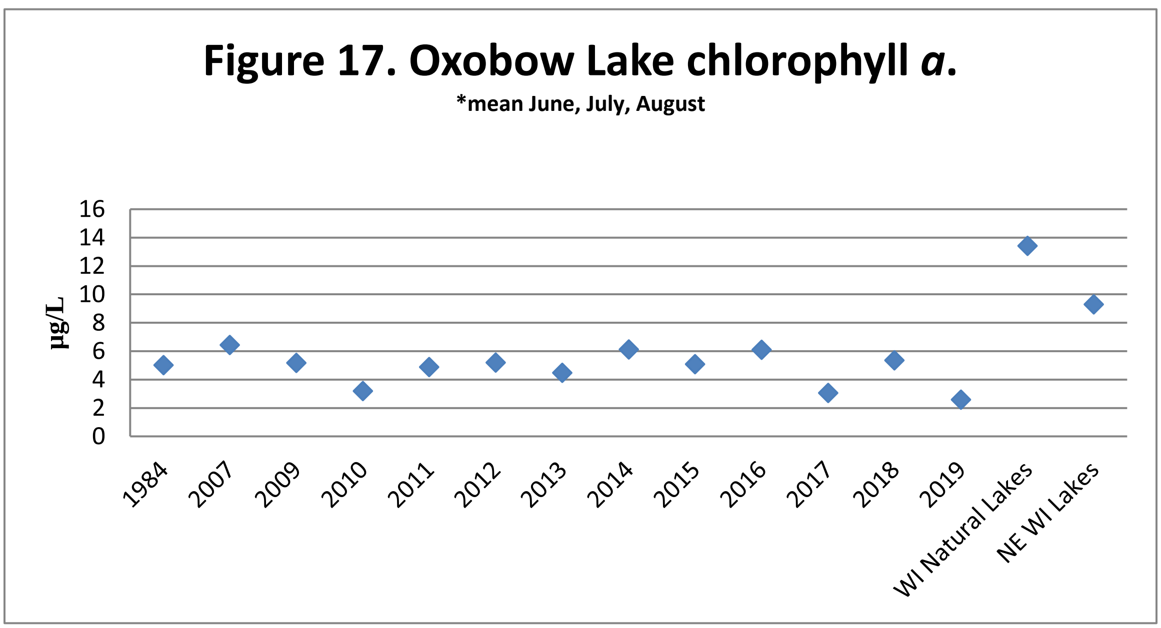

## User Perceptions

The CLMN also record their perceptions of the water, based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake user would experience the lake at that time. When interpreting the transparency data, we see that when the Secchi depth decreases, the rating of the lake's physical appearance also decreases. These perceptions of recreational suitability are displayed by year in Figure 16. In 1996 and 2018, 100% of CLMN volunteers said the Lake was "beautiful, could not be nicer." In 2007, 22% of volunteers said they "would not swim but boating was OK."




## Chlorophyll *a*

Chlorophyll *a* is the photosynthetic pigment that makes plants and algae green. Chlorophyll *a* in lake water is therefore an indicator of the amount of algae. Chlorophyll *a* concentrations greater than 10 µg/L are perceived as a mild algae bloom, while concentrations greater than 20 µg/L are perceived as a nuisance. Chlorophyll *a* values were below nuisance levels and below the average levels for Wisconsin natural and Northeastern lakes (Figure 17).



## Phosphorus

In more than 80% of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of algae and plant growth. If phosphorus levels are high, excessive aquatic plant growth can occur.

Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or lawns (Shaw et al., 2004). Phosphorus provokes complex reactions in lakes. An analysis of phosphorus often includes both soluble reactive phosphorus and total phosphorus. Soluble reactive phosphorus dissolves in the water and directly influences plant growth (Shaw et al., 2004). Its concentration varies in most lakes over short periods of time as plants take it up and release it. Total phosphorus is considered a better indicator of a lake's nutrient status than soluble reactive phosphorus because its levels remain more stable (Shaw et al., 2004). Total phosphorus includes soluble phosphorus and the phosphorus in plant and animal fragments suspended in lake water. Ideally, soluble reactive phosphorus concentrations should be 10 µg/L or less at spring turnover to prevent summer algae blooms (Shaw et al., 2004). A concentration of total phosphorus below 20 µg/L for lakes should be maintained to prevent nuisance algal blooms (Shaw et al., 2004).

Figure 18 shows the total phosphorus values for Oxbow Lake. In 1992, 2013, 2016, and 2017 the total phosphorus was greater than the nuisance threshold. According to Figure 19, the average total phosphorus of Oxbow Lake can be classified as "very good."

Figure 18. Oxbow Lake total phosphorus.

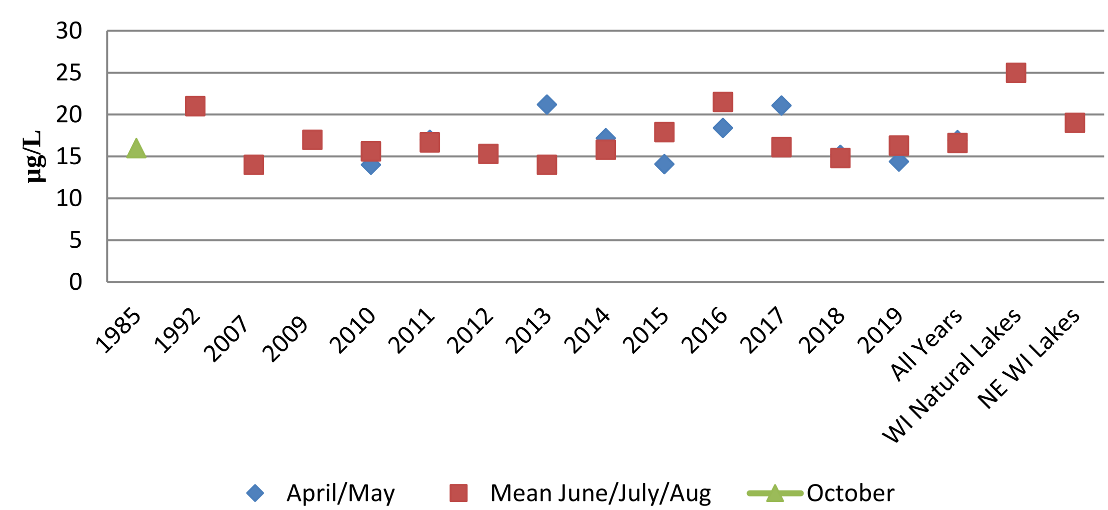
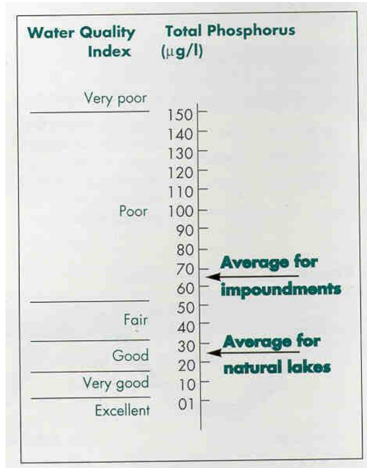


**Figure 19. Total phosphorus concentrations for Wisconsin's natural lakes and impoundments (Shaw et al., 2004).**

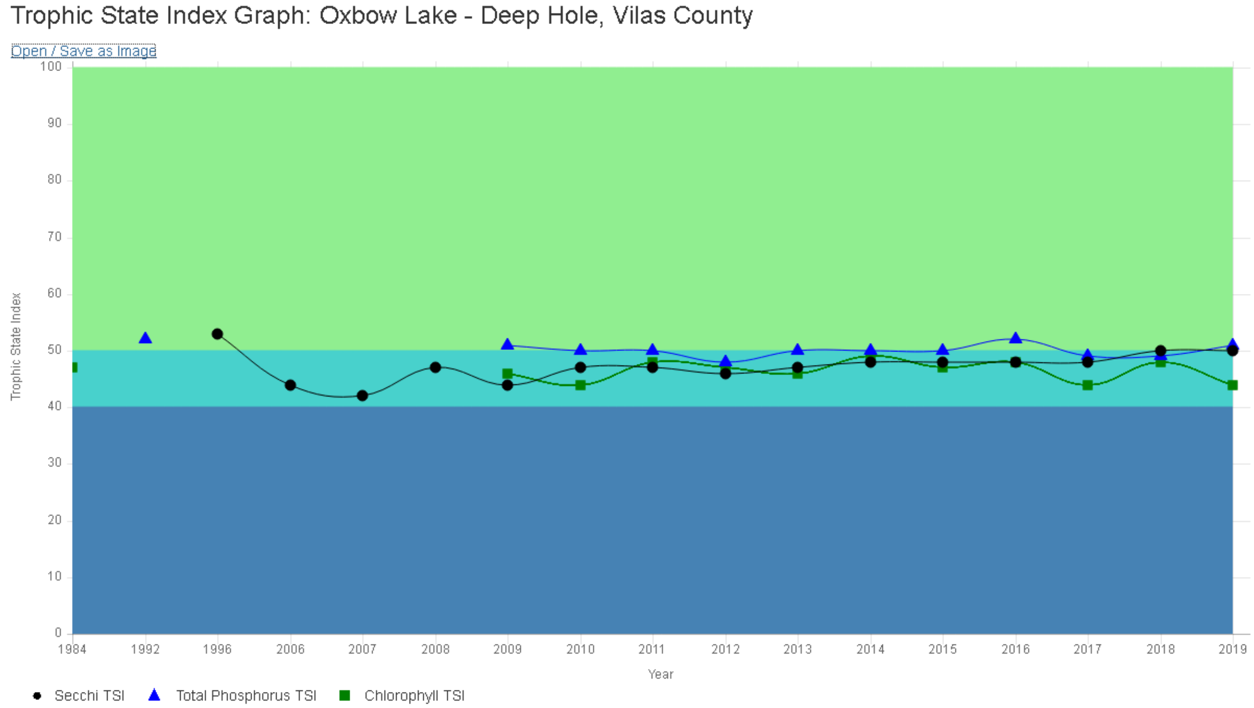



## Trophic State

Trophic state is another indicator of water quality (Carlson, 1977). Lakes can be divided into three categories based on trophic state – oligotrophic, mesotrophic, and eutrophic. These categories reflect a lake's nutrient and clarity levels (Shaw et al., 2004).

Trophic State Index (TSI) was calculated by the WDNR using Secchi measurements (1996, 2006-2019), chlorophyll *a* (1984 and 2009-19), and total phosphorus (1992, 2009-2019) collected from the CLMN. The July and August average for 2019 Secchi TSI (50), chlorophyll *a* TSI (44) and total phosphorus TSI (51) classify Oxbow Lake as "mesotrophic" (Table 2).

**Figure 20. Oxbow Lake Trophic State Index (1984, 1992, 1996, 2006-2019).**




(WDNR, 2019)

| Table 2. Trophic State Index. | |
|---|---|
| **30-40** | **Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery |
| **40-50** | **Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer |
| **50-60** | **Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common |
| **60-70** | **Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill |
| **70-80** | **Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels |

(WDNR, 2019)

Researchers use various methods to calculate the trophic state of lakes. Common characteristics used to make the determination are: total phosphorus (important for algae growth), chlorophyll *a* concentration (a measure of the amount of algae present), and Secchi disk readings (an indicator of water clarity) (Shaw et al., 2004) (Table 3).

**Table 3. Trophic classification of Wisconsin Lakes based on chlorophyll *a*, water clarity measurements, and total phosphorus values (Shaw et al., 2004).**

| Trophic class | Total phosphorus µg/L | Chlorophyll *a* µg/L | Secchi Disk (ft.) |
|---|---|---|---|
| Oligotrophic | 3 | 2 | 12 |
| | 10 | 5 | 8 |
| Mesotrophic | 18 | 8 | 6 |
| | 27 | 10 | 6 |
| Eutrophic | 30 | 11 | 5 |
| | 50 | 15 | 4 |

## Nitrogen

Nitrogen is second only to phosphorus as an important nutrient for aquatic plant and algae growth (Shaw et al., 2004). Human activities on the landscape greatly influence the amount of nitrogen in a lake. Nitrogen may come from lawn fertilizer, septic systems near the lake, or from agricultural activities in the watershed. Nitrogen may enter a lake from surface runoff or groundwater sources. Nitrogen exists in lakes in several forms. Oxbow Lake was analyzed for total Kjeldahl nitrogen October, 1985 (0.6 mg/L) and July, 2018 (0.547 mg/L), ammonium October, 1985 (0.04 mg/L) and July, 2018 (no detection), and nitrate-nitrite October, 1985 (0.03 mg/L) and July, 2018 (no detection). Nitrogen is a major component of all organic (plant and animal) matter. Decomposing organic matter releases ammonia, which is converted to nitrate if oxygen if present (Shaw et al., 2004). All inorganic forms of nitrogen can be used by aquatic plants and algae (Shaw et al., 2004). If these inorganic forms of nitrogen exceed 0.3 mg/L (as N) in spring, there is sufficient nitrogen to support summer algae blooms (Shaw et al., 2004). Elevated concentrations of ammonium, nitrate, and nitrite, derived from human activities, can stimulate or enhance the development, maintenance and proliferation of primary producers (phytoplankton, benthic algae, marcrophytes), contributing to the widespread phenomenon of the cultural (human-made) eutrophication of aquatic ecosystems (Camargo et al., 2007). The nutrient enrichment can cause important ecological effects on aquatic communities, since the overproduction of organic matter, and its subsequent decomposition, usually lead to low dissolved oxygen concentrations in bottom waters, and sediments of eutrophic and hypereutrophic aquatic ecosystems with low turnover rates (Camargo et al., 2007).

## Chloride

The presence of chloride ($Cl^-$) where it does not occur naturally indicates possible water pollution (Shaw et al., 2004). Chloride does not affect plant and algae growth and is not toxic to aquatic organisms at most of the levels found in Wisconsin (Shaw et al., 2004). Oxbow Lake chloride was 1.24 mg/L on July, 2018.

## Sulfate

Sulfate in lake water is primarily related to the types of minerals found in the watershed, and to acid rain (Shaw et al., 2004). Sulfate concentrations are noted to be less than 10 mg/L in Vilas County (Lillie and Mason, 1983). Oxbow Lake was sampled for sulfate in October, 1985 (4.1 mg/L) and July, 2018 (no detection).

## Conductivity

Conductivity is a measure of the ability of water to conduct an electric current. Conductivity is reported in micromhos per centimeter **(**µmhos/cm) and is directly related to the total dissolved inorganic chemicals in the water. Usually, values are approximately two times the water hardness, unless the water is receiving high concentrations of human-induced contaminants (Shaw et al., 2004). Oxbow Lake conductivity levels were sampled in October, 1985 and had a conductance of 35 µmhos/cm and on July, 2019 the conductance was 57.1 µmhos/cm.

## pH

The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is considered neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid, bog lakes to 8.4 in hard water, marl lakes (Shaw et al., 2004). Natural rainfall in Wisconsin averages a pH of 5.6. Some minerals become available under low pH (especially aluminum, zinc, and mercury) and can inhibit fish reproduction and/or survival. Mercury and aluminum are not only toxic to many kinds of wildlife, but also to humans (especially those that eat tainted fish). The pH scale is logarithmic, so every 1.0 unit change in pH increases the acidity tenfold. Water with a pH of 6 is 10 times more acidic than water with pH of 7. A lake's pH level is important for the release of potentially harmful substances and affects plant growth, fish reproduction and survival. A lake with neutral or slightly alkaline pH is a good lake for fish and plant survival. The pH is shown in Figure 21. Oxbow Lake appears to be neutral in pH for the sampling dates. Table 4 indicates the effects pH levels less than 6.5 will have on fish. While moderately low pH does not usually harm fish, the metals that become soluble under low pH can be important. In low pH waters, aluminum, zinc, and mercury concentrations increase if they are present in lake sediment or watershed solids (Shaw et al., 2004).

Figure 21. Oxbow Lake pH.

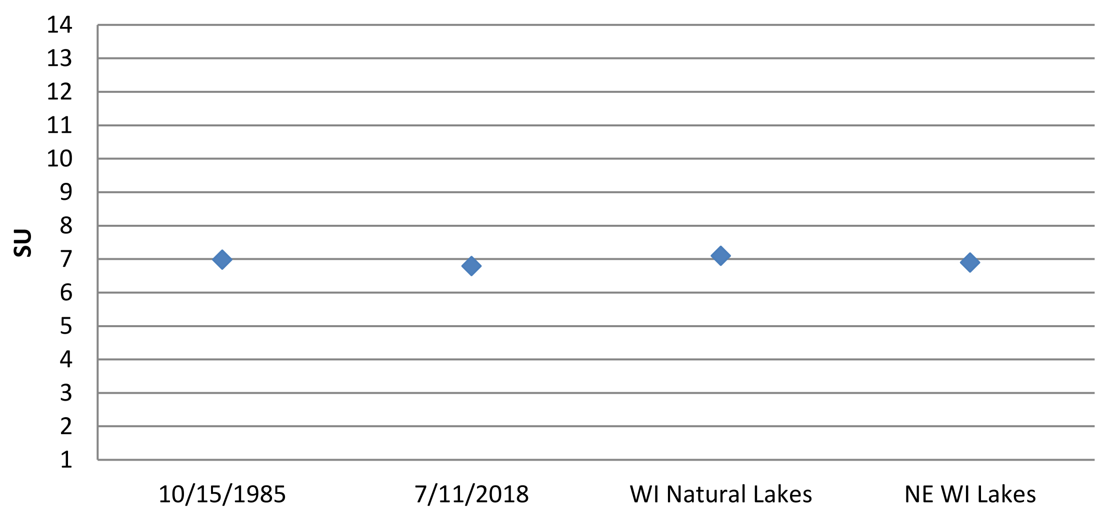


**Table 4. Effects of acidity on fish species (Olszyk, 1980).**

| *Water pH* | *Effects* |
|---|---|
| 6.5 | Walleye spawning inhibited |
| 5.8 | Lake trout spawning inhibited |
| 5.5 | Smallmouth bass disappear |
| 5.2 | Walleye & lake trout disappear |
| 5 | Spawning inhibited in most fish |
| 4.7 | Northern pike, sucker, bullhead, pumpkinseed, sunfish & rock bass disappear |
| 4.5 | Perch spawning inhibited |
| 3.5 | Perch disappear |
| 3 | Toxic to all fish |

## Alkalinity

Alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. Acid rain has long been a problem with lakes that have low alkalinity levels and high potential sources of acid deposition. Alkalinity was 9.86 mg/L on July, 2018. The one value is low in relation to natural lakes of Wisconsin (45 mg/L) and Northeast Wisconsin Lakes (37 mg/L).

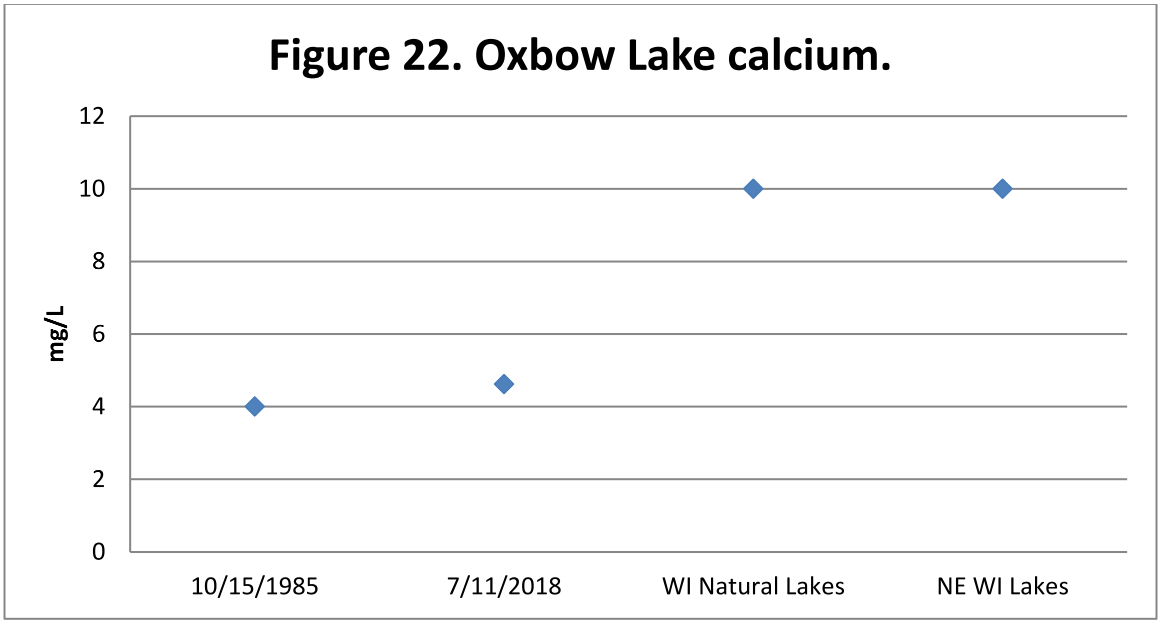
## Hardness

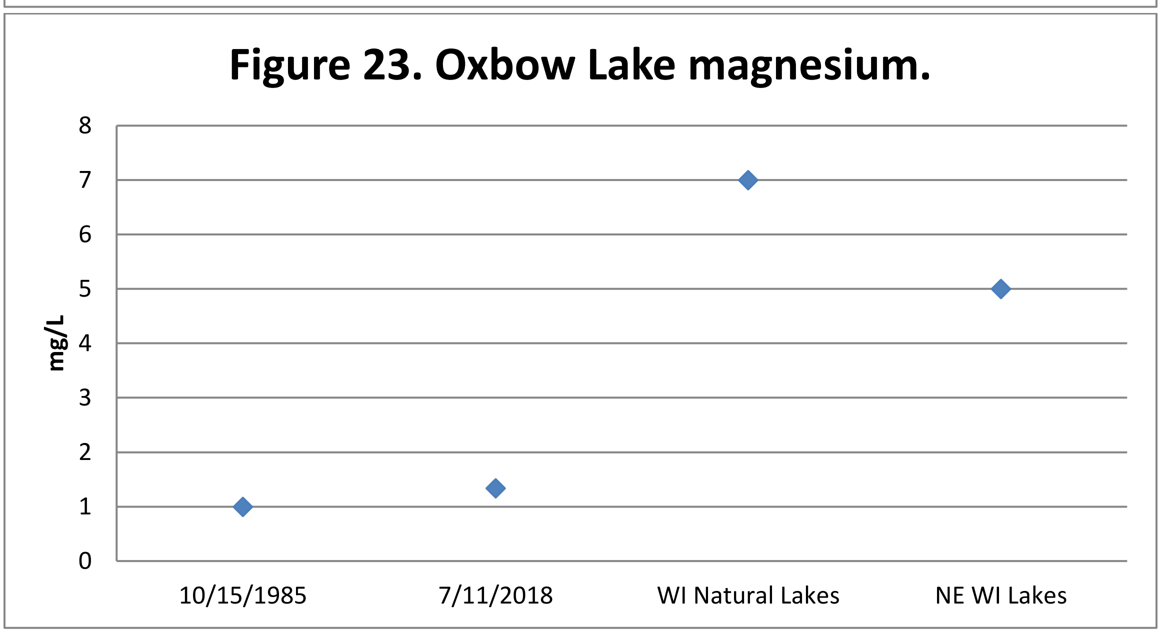
Hardness levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). One method of evaluating hardness is to test for calcium carbonate ($CaCO_3$). Oxbow Lake hardness was 14.1 mg/L in October, 1985 and 17 mg/L on July, 2018. Table 5 indicates Oxbow Lake to have "soft water."

| **Table 5. Categorization of hardness (mg/L of calcium carbonate ($CaCO_3$)) (from Shaw et al., 2004).** | |
|---|---|
| Soft water | 0-60 |
| Moderately hard water | 61-120 |
| Hard water | 121-180 |
| Very hard water | >180 |

## Calcium and Magnesium Hardness

The carbonate system provides acid buffering through two alkaline compounds: bicarbonate and carbonate. These compounds are usually found with two hardness ions: calcium and magnesium (Shaw et al., 2004). Calcium is the most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-bearing minerals in the lake watershed (Shaw et al., 2004). Aquatic organisms such as native mussels use calcium in their shells. The aquatic invasive zebra mussel tends to need calcium levels greater than 20 mg/L to maintain shell growth. Oxbow Lake had low calcium levels in 1985 and 2018 (Figure 22) which is an indication that zebra mussels should not flourish. Magnesium was also 1985 and 2018 (Figure 23) with low values compared to Wisconsin natural lakes and Northeastern lakes.




## Sodium and Potassium

Sodium and potassium are possible indicators of human pollution in a lake, since naturally occurring levels of these ions in soils and water are very low. Sodium is often associated with chloride and gets into lakes from road salting, fertilizations, and human and animal waste (Shaw et al., 2004). Potassium is the key component of commonly-used potash fertilizer, and is abundant in animal waste. Both of these elements are held by soils to a greater extent than is chloride or nitrate; therefore, they are not as useful as indicators of pollution impacts (Shaw et al., 2004). Although not normally toxic themselves, they provide a strong indication of possible contamination by more damaging compounds (Shaw et al., 2004). Oxbow Lake sodium was sampled on October, 1985 (1 mg/L) and July, 2018 (0.951 mg/L) and potassium October, 1985 (1 mg/L) and July, 2018 (0.473 mg/L).

## Dissolved Organic Carbon

Dissolved Organic Carbon (DOC) is a food supplement, supporting growth of microorganisms, and plays an important role in global carbon cycle through the microbial loop (Kirchman et al., 1991). In general, organic carbon compounds are a result of decomposition processes from dead organic matter such as plants. When water contacts highly organic soils, these components can drain into rivers and lakes as DOC. DOC is also extremely important in the transport of metals in aquatic systems. Metals form extremely strong complexes with DOC, enhancing metal solubility while also reducing metal bioavailability. Baseflow concentrations of DOC in undisturbed watersheds generally range from 1 to 20 mg/L carbon. Oxbow Lake DOC was analyzed by remote sensing satellites in August, 2007 and had a value of 8.7 mg/L.

## Silica

The earth's crust is abundant with silicates or other compounds of silicon. The water in lakes dissolves the silica and pH can be a key factor in regulating the amount of silica that is dissolved. Silica concentrations are usually within the range of 5 to 25 mg/L. Generally lakes that are fed by groundwater have higher levels of silica. Oxbow Lake was tested for silica in October, 1985 and was 1.4 mg/L.

## Aluminum

Aluminum occurs naturally in soils and sediments. In low pH (acidic) environments aluminum solubility increases greatly. With a low pH and increased aluminum values, fish health can become impaired. This can have impacts on the entire food web. Aluminum also plays an important role in phosphorus cycling in lakes. When aluminum precipitates with phosphorus in lake sediments, the phosphorus will not dissolve back into the water column as readily. Oxbow Lake aluminum was 69 µg/L in October, 1985.

## Iron

Iron also forms sediment particles that store phosphorus when dissolved oxygen is present. When oxygen concentration gets low (for example, in winter or in the deep water near sediments) the iron and phosphorus dissolve in water. This phosphorus is available for algal blooms. Oxbow Lake iron levels have not been tested, and should be included in future water quality sampling.

## Manganese

Manganese is a mineral that occurs naturally in rocks and soil. In lakes, manganese is usually in particulate form. When the dissolved oxygen levels decrease, manganese can convert from an insoluble form to soluble ions. A manganese concentration of 0.05 mg/L can cause color and staining problems. Manganese data is unknown for Oxbow Lake, so future water quality sampling should include this parameter.

### Sediment

Lake bottom sediments are sometimes analyzed for chemical constituents that they contain. This is especially true for potentially toxic metals such as mercury, chromium, selenium, and others. Lake sediments also tend to record past events as particulates settle down and become part of the sediment. Biological clues for the historic conditions in the lake can be gleaned from sediment samples. Examples include analysis of pollen or diatoms that might help understand past climate or trophic states in the lake. Sediment data was not collected for Oxbow Lake, and future sampling should include this parameter.

### Total Suspended Solids

Total suspended solids are all particles suspended in lake water. Silt, plankton, and wastes are examples of these solids and can come from runoff of agricultural land, erosion, and can be produced by bottom-feeding fish. As the suspended solid levels increase, they absorb heat from sunlight which can increase the water temperature. They can also block the sunlight that plants need for photosynthesis. These events can in turn affect the amount of dissolved oxygen in the lake. Lakes with total suspended solids levels less than 20 mg/L are considered “clear,” while levels between 40 and 80 mg/L are “cloudy.” Total suspended solids data is unknown for Oxbow Lake, so future water quality sampling should include this parameter.

### Aquatic Invasive Species

Two invasive species have been found in Oxbow Lake: freshwater jellyfish (1999) and banded mystery snail (2005).

Freshwater jellyfish are native to the Yangtze River valley in China (McKercher et al., 2015). It is likely that they were introduced into northern waters by transportation with ornamental plants, transportation by water fowl or fish stocking (McKercher et al., 2015). It is unclear what the jellyfishes’ impact is on native plant and animal species, but it is possible that they prey on fish eggs and other zooplankton (McKercher et al., 2015). Freshwater jellyfish are not considered dangerous to humans.

Banded mystery snails are native to northeastern United States down to Florida, the Gulf of Mexico, and some states along the Mississippi River. Records show that an amateur conchologist (scientist of sea shells and the animals that inhabit them) intentionally released banded mystery snails into the Hudson River, which led to its dispersal throughout the Great Lakes area (Kipp et al., 2015). There is no known negative impact caused by the snails in the Great Lake region (Kipp et al., 2015).

The University of Wisconsin-Madison’s Aquatic Invasive Species Smart Prevention program classifies Oxbow Lake as “Not Suitable” for zebra mussels, based on calcium and conductivity levels found in the lake (UW-Madison).

AIS monitoring was conducted by CLMN volunteers in September, 2009, 2010, 2011, and 2015 with no invasives species found. The WDNR conducted zebra mussel veliger tows in August, 2010 and 2014, and September, 2017 and did not find any veligers. An AIS sign: "Prevent the Spread" was posted at the Oxbow public landing in April, 2011. The Great Lakes Indian Fish and Wildlife Commission conducted an AIS survey August, 2016 and noted the Aquatic forget-me-not and the banded mystery snail. White Water Associates, Inc. biologist conducted a survey June, 2018 and found no AIS. A more detailed report can be found in Appendix E.

Clean Boats, Clean Waters (CBCW) is a program that inspects boats for aquatic invasive species and in the process educates the public on how to help stop the spread of these species. Clean Boats, Clean Waters has not been conducted on Oxbow Lake. It would be beneficial for Oxbow Lake to use the CBCW program on a regular basis.

## Resources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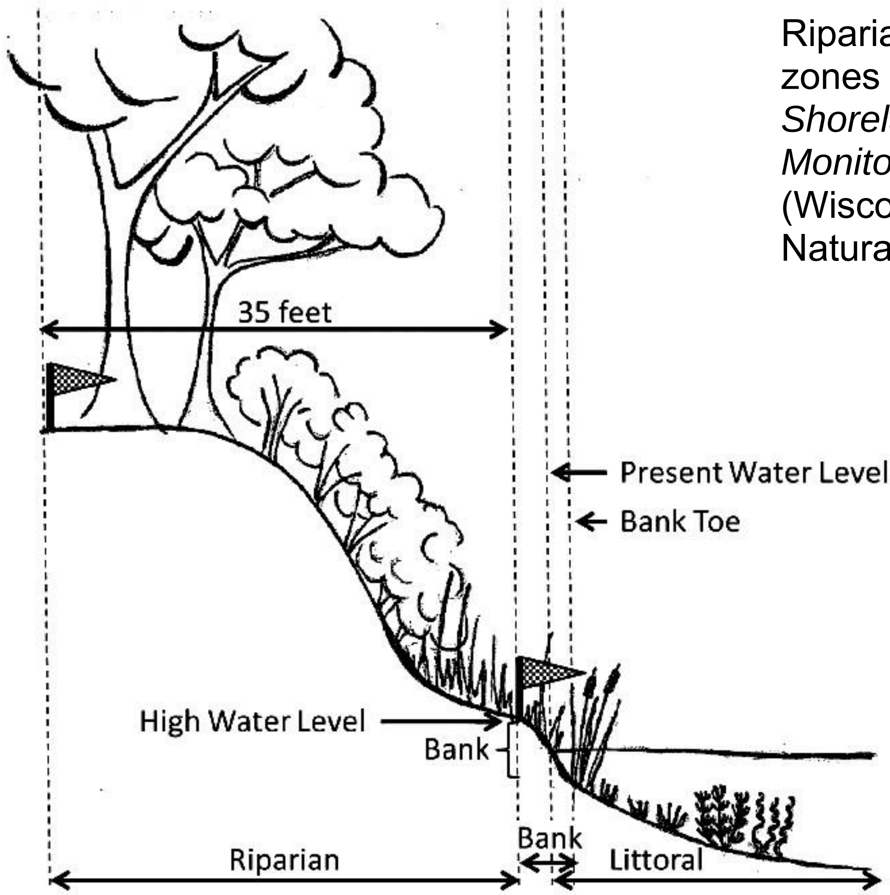
# Appendix D

# Oxbow Lake Shoreland and Shallows

# Habitat Monitoring Report

# Oxbow Lake (Vilas County, Wisconsin)

# Shoreland and Shallows Habitat Monitoring Report




Riparian, bank, and littoral zones covered by the *Shoreland & Shallows Habitat Monitoring Field Protocol* (Wisconsin Department of Natural Resources 2016)

WHITE WATER ASSOCIATES, INC.

**Date: March 2019**

# INTRODUCTION

White Water Associates, Inc. is retained by the Presque Isle Town Lakes Committee (PITLC) as a consultant for the *Presque Isle Wilderness Waters Program.* A recent Wisconsin Department of Natural Resources (WDNR) lake planning grant to the PITLC included an assessment of the shoreland area and shallows habitat for Oxbow Lake (Vilas County, Wisconsin). The assessment was conducted using the *Lake Shoreland and Shallows Habitat Monitoring Field Protocol* (WDNR 2016)[1]. This protocol provides a standard methodology for surveying, assessing, and mapping habitat in lakeshore areas, including the riparian buffer, bank, and littoral zone (WDNR 2016). This information will be useful to local and regional resource managers, community stakeholders, and others interested in protecting and enhancing Wisconsin's lakes and rivers (WDNR 2016).

# METHODS

There are three principal components to the shoreland and shallows habitat monitoring: (1) obtain georeferenced photos of the entire lake shoreline area, (2) assess the riparian, bank, and littoral habitat by ownership parcel, and (3) count and map all pieces of large woody material in water less than 2 feet deep. In this section, we describe each of these components.

The photographic component of the monitoring documented shoreland habitat conditions around the lake at the time of the survey. Results may be referred to in future years (WDNR 2016). Digital photos were taken with the intent to slightly overlap, thus capturing the entire shoreline. The survey crew used the boat to circumnavigate the lake at a distance of approximately 50 feet perpendicular from shore where conditions permitted. This standardized relative position on the lake allowed the photos to include the water's edge and understory vegetation 35 feet inland. A digital camera with an internal GPS was used to capture the photos. Exhibit 1 provides an example photograph. In the laboratory, photos were processed, georeferenced, and provided as part of the data package to the WDNR.

[1] Wisconsin Department of Natural Resources. May 27, 2016. *Draft Lake Shoreland & Shallows Habitat Monitoring Field Protocol.* WDNR 2016.

Exhibit 1. Photo of the water's edge and understory vegetation on Oxbow Lake (White Water Associates, Inc., 2018)

The shoreline habitat assessment was conducted for every ownership parcel on the lake. To facilitate this effort, parcel data was obtained March 2017 via the Wisconsin Statewide Parcel Map, which can be found at https://maps.sco.wisc.edu/Parcels/. Parcel IDs and shoreline lengths were derived from these spatial data files. Parcel IDs and parcel lines, together with a "riparian buffer" line at 35 feet from the shoreline, were layered onto aerial photography maps saved as a georeferenced image file viewed on the Avenza Maps application on an Apple® iPad Pro 9.7 equipped with GPS for offline navigation. The GPS function of the iPad allowed the survey crew to know their position relative to the shoreline and specific parcels. Data sheets were prepared that included parcel ID numbers and frontage feet of each parcel (an example data sheet is shown in Exhibit 2). Exhibit 2 also shows the categories that were documented for each parcel. Back in the laboratory, data recorded on field data sheets were input to a Microsoft Office Excel spreadsheet and later conveyed to the WDNR as part of the data package to be included in a publicly available database.

The woody habitat component of the assessment was conducted on a separate circumnavigation of the lake. Before starting, a Secchi depth was measured. The protocol specifies that if the Secchi depth is less than two feet, no woody habitat survey will be conducted due to poor visibility (WDNR 2016). In addition to the Secchi depth, lake water level was documented relative to the lake's *high water level* (HWL). As the lake was circumnavigated, large wood was enumerated. The protocol defines "large wood" as wood greater than 4 inches in diameter somewhere along its length and at least 5 feet long. Eligible large wood was that which was located between the high water level and the 2 foot depth contour and the large wood section must be in the water or below the high water level. Tree "branchiness" ranking was recorded as "0" (no branches), "1" (few branches), or "2" (tree trunk with full crown). Additional details on eligible large wood are provided in the protocol document (WDNR 2016). A GPS was used to document each eligible piece of large wood. A datasheet entry corresponded to each large wood piece. An example datasheet is provided as Exhibit 3.

## FINDINGS

The data and photos for the assessment of shoreland area and shallows habitat for Oxbow Lake have been delivered to the WDNR. Any user can view the results in the Wisconsin Department of Natural Resources Lakes and AIS Mapping Tool found at: https://dnr.wi.gov/lakes/viewer/. In this section we summarize a few of the data and provide some example maps that illustrate the findings from the assessment.

The assessment was conducted on June 25, 2018. At the time of the survey there were 187 ownership parcels on Oxbow Lake. The shoreline perimeter of Oxbow Lake is 13.5 miles. Exhibit 4 summarizes some of the Oxbow Lake data. Exhibits 5 through 13 provide maps of findings on Oxbow Lake. Any interested party can access the data in the database and create maps of this type or maps specific to detailed areas of shoreland and shallow water habitat.

In general, the assessment shows the shoreland and shallow water habitat of Oxbow Lake to be of high quality. There is excellent tree canopy coverage as well as shrub and herbaceous coverage. That being said, there is evidence of human influence in the riparian buffer zone and bank zone. The number of large wood pieces per mile of shoreline is somewhat low.

# LAKE STRATEGY

Oxbow Lake is a high quality lake with good shallow water habitat and intact riparian area. Lake stewardship could primarily be directed toward protection of the current conditions and monitoring to detect changes over time. Although Oxbow Lake is in a mostly natural state, there are a few parcels that could undertake some restoration to ameliorate possible runoff and erosion issues. These areas can be identified by investigating the 2018 monitoring data in maps and tables in this report as well as in the WDNR database (link given previously). The Healthy Lakes program in Wisconsin provides simple, practical, and inexpensive best practices that improve habitat and water quality on lakeshore property (see https://healthylakeswi.com/ for additional information and guidance on funding projects). Oxbow Lake large woody habitat is somewhat moderate but could be augmented with the “fish sticks” best practice.

## Habitat Assessment Data Sheet (one per parcel)

Date ______________ Lake name ____________________________ WBIC__________

Parcel ID__________________ Observers__________________________________________________

**RIPARIAN BUFFER ZONE**

| **Percent Cover** | Percent | |
|---|---|---|
| Canopy | | (0-100) |
| Shrub ☐ Herbaceous ☐ | | |
| Shrub/Herbaceous | | sum=100 |
| Impervious surface | | |
| Manicured lawn | | |
| Agriculture | | |
| Other (e.g. duff, soil, mulch) | | |

description:_________________________

| **Human Structures** | Number |
|---|---|
| Buildings | |
| Boats on shore | |
| Fire pits | |
| Other | |

description:_________________________

| **Runoff Concerns in Riparian or Entire Parcel** | Present in Riparian | Present out of Riparian |
|---|---|---|
| Point source | ☐ | ☐ |
| Channelized water flow/gully | ☐ | ☐ |
| Stair/trail/road to lake | ☐ | ☐ |
| Lawn/soil sloping to lake | ☐ | ☐ |
| Bare soil | ☐ | ☐ |
| Sand/silt deposits | ☐ | ☐ |
| Other | ☐ | ☐ |

description:_________________________

**Notes:**

| **BANK ZONE** | Length (ft) |
|---|---|
| Vertical sea wall | |
| Rip rap | |
| Other erosion control structures | |
| Artificial beach | |
| Bank erosion > 1 ft face | |
| Bank erosion < 1 ft face | |

**LITTORAL ZONE**

| **Human Structures** | Number |
|---|---|
| Piers | |
| Boat lifts | |
| Swim rafts/water trampolines | |
| Boathouses (over water) | |
| Marinas | |
| Other | |

description:______________________

| **Aquatic Plants** | Present |
|---|---|
| Emergents | ☐ |
| Floating | ☐ |
| Plant Removal | ☐ |

**If Applicable (low water level):**

**EXPOSED LAKE BED ZONE**

| **Plants** | Present |
|---|---|
| Canopy | ☐ |
| Shrubs | ☐ |
| Herbaceous | ☐ |
| **Disturbed** | |
| Plants (mowed or removed) | ☐ |
| Sediment (tilled or dug) | ☐ |

Exhibit 2. Example habitat assessment data sheet.

## Exhibit 3. Coarse woody habitat inventory data sheet.

**Date** ______________ **Lake name** __________________________ **WBIC**___________
**Observers**_______________________________________________________

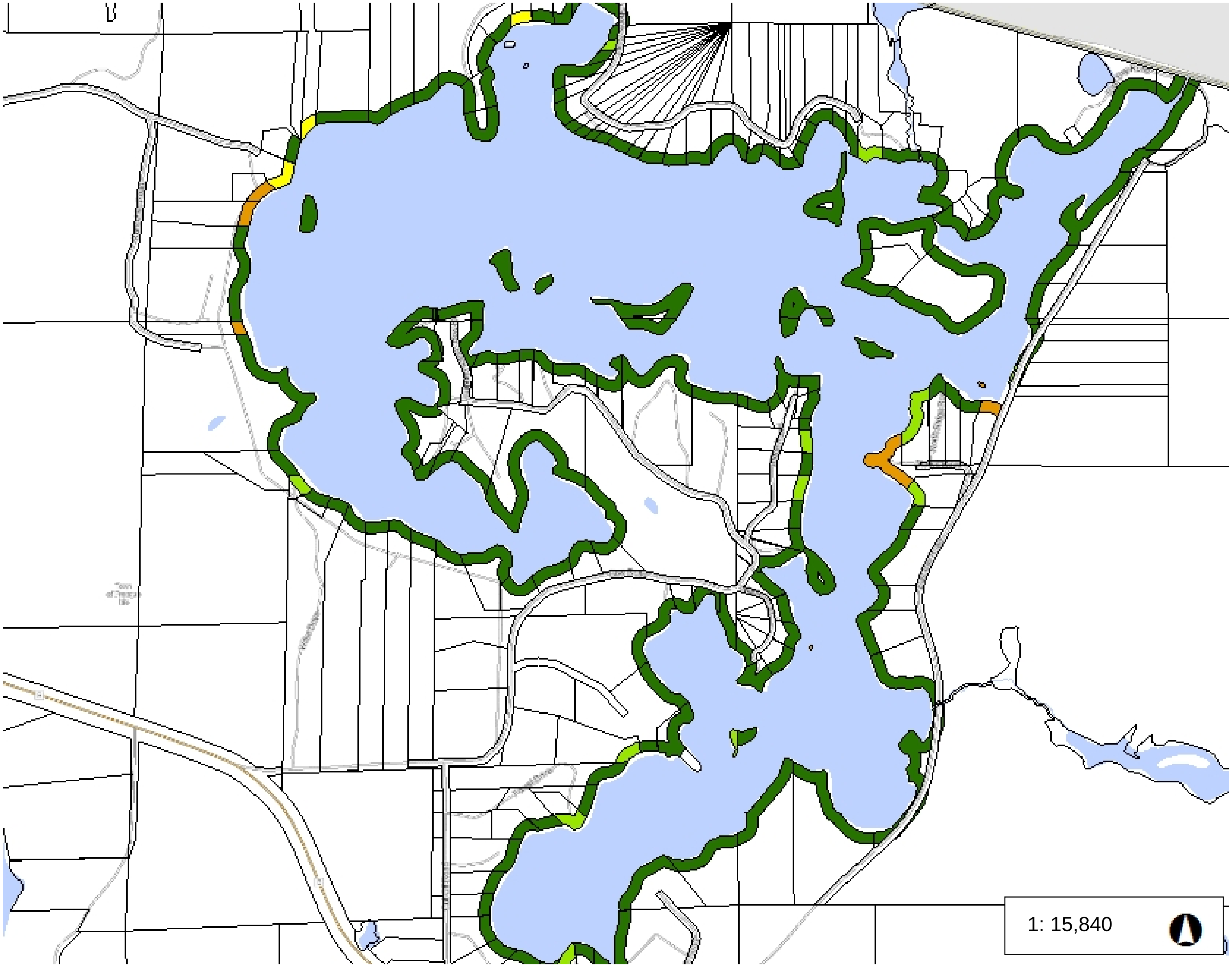
**Present water level is** ☐ Below ☐ At ☐ Above the High Water Level **Secchi depth** ______ **ft**

| ID | Branch | Touch Shore | In Water | ID | Branch | Touch Shore | In Water | ID | Branch | Touch Shore | In Water | ID | Branch | Touch Shore | In Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | 26 | | | | 51 | | | | 76 | | | |
| 2 | | | | 27 | | | | 52 | | | | 77 | | | |
| 3 | | | | 28 | | | | 53 | | | | 78 | | | |
| 4 | | | | 29 | | | | 54 | | | | 79 | | | |
| 5 | | | | 30 | | | | 55 | | | | 80 | | | |
| 6 | | | | 31 | | | | 56 | | | | 81 | | | |
| 7 | | | | 32 | | | | 57 | | | | 82 | | | |
| 8 | | | | 33 | | | | 58 | | | | 83 | | | |
| 9 | | | | 34 | | | | 59 | | | | 84 | | | |
| 10 | | | | 35 | | | | 60 | | | | 85 | | | |
| 11 | | | | 36 | | | | 61 | | | | 86 | | | |
| 12 | | | | 37 | | | | 62 | | | | 87 | | | |
| 13 | | | | 38 | | | | 63 | | | | 88 | | | |
| 14 | | | | 39 | | | | 64 | | | | 89 | | | |
| 15 | | | | 40 | | | | 65 | | | | 90 | | | |
| 16 | | | | 41 | | | | 66 | | | | 91 | | | |
| 17 | | | | 42 | | | | 67 | | | | 92 | | | |
| 18 | | | | 43 | | | | 68 | | | | 93 | | | |
| 19 | | | | 44 | | | | 69 | | | | 94 | | | |
| 20 | | | | 45 | | | | 70 | | | | 95 | | | |
| 21 | | | | 46 | | | | 71 | | | | 96 | | | |
| 22 | | | | 47 | | | | 72 | | | | 97 | | | |
| 23 | | | | 48 | | | | 73 | | | | 98 | | | |
| 24 | | | | 49 | | | | 74 | | | | 99 | | | |
| 25 | | | | 50 | | | | 75 | | | | 100 | | | |

Branch: 0 = no branches, 1 = a few branches, 2 = full tree crown
Touch Shore: 0 = entirely below High Water Level (HWL), 1 = crosses HWL
In Water: 0 = less than 5 ft of log is currently underwater, 1 = at least 5 ft of log is currently underwater

| Exhibit 4. Summary of shoreland and shallow water habitat for Oxbow Lake. | | |
|---|---|---|
| Date of Survey: June 25, 2018 | Miles of shoreline: 13.5 | |
| Number of ownership parcels: 187 | Mean parcel frontage feet: 381 | |
| **Riparian Buffer Zone** | **# of parcels** | **% of parcels** |
| Impervious surfaces | 131 | 70% |
| Manicured lawn | 79 | 42% |
| Agriculture | 1 | 1% |
| Other (duff, soil, mulch) | 16 | 9% |
| Human structures (buildings, boats on shore, fire pit, other) | 134 | 72% |
| Broad Runoff concerns (incl. point source; channelized water flow; strait stair, trail, or road to lake; lawn or soil sloping; bare soil; sand/silt deposits; other erosion). Note: Exhibit 10 is less inclusive. | 132 | 71% |
| **Bank Zone** | **# of parcels** | **% of parcels** |
| Concerns in the bank zone (e.g., vertical sea wall, rip rap, other erosion control structures, artificial beach, active erosion) | 3 | 2% |
| **Littoral Zone** | **# of parcels** | **% of parcels** |
| Human structures in littoral zone (e.g., piers, boat lifts, swim rafts, water trampolines, boat houses over water, marinas, other) | 129 | 69% |
| Emergent and/or floating aquatic plants | 178 | 95% |
| Evidence of aquatic plant removal | 0 | 0% |
| **Large Wood Habitat** | | |
| Total Number of large wood pieces | 263 | |
| Number of large wood pieces per mile of shoreline | 19.5 | |

# Exhibit 5. Oxbow Lake Riparian Coverage - % Canopy - 2018



Legend

Percent Canopy
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100

Shoreland Parcels

County Boundary

Municipality

State Boundaries

County Boundaries

Major Roads
- Interstate Highway
- State Highway
- US Highway

County and Local Roads
- County HWY
- Local Road

Railroads

Tribal Lands

Rivers and Streams

Intermittent Streams

Open Water

Great Lakes

1: 15,840

0.5 0 0.25 0.5 Miles

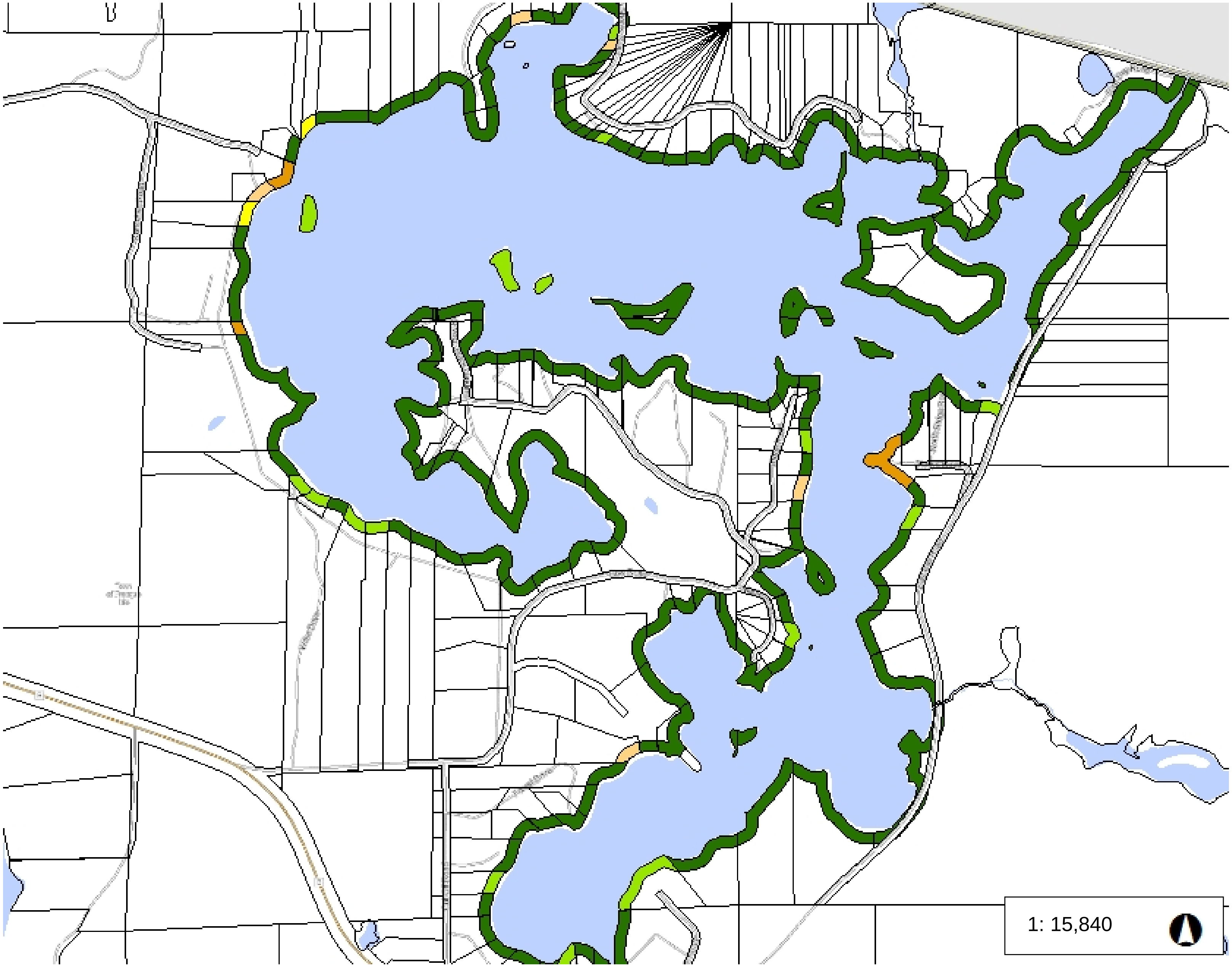
NAD_1983_HARN_Wisconsin_TM





Notes

# Exhibit 6. Oxbow Lake Riparian Coverage - % Shrub Herbaceous - 2018



Legend

Percent Shrub Herbaceous

- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100

Shoreland Parcels

County Boundary

Municipality

State Boundaries

County Boundaries

Major Roads

- Interstate Highway
- State Highway
- US Highway

County and Local Roads

- County HWY
- Local Road

Railroads

Tribal Lands

Rivers and Streams

Intermittent Streams

Open Water

Great Lakes

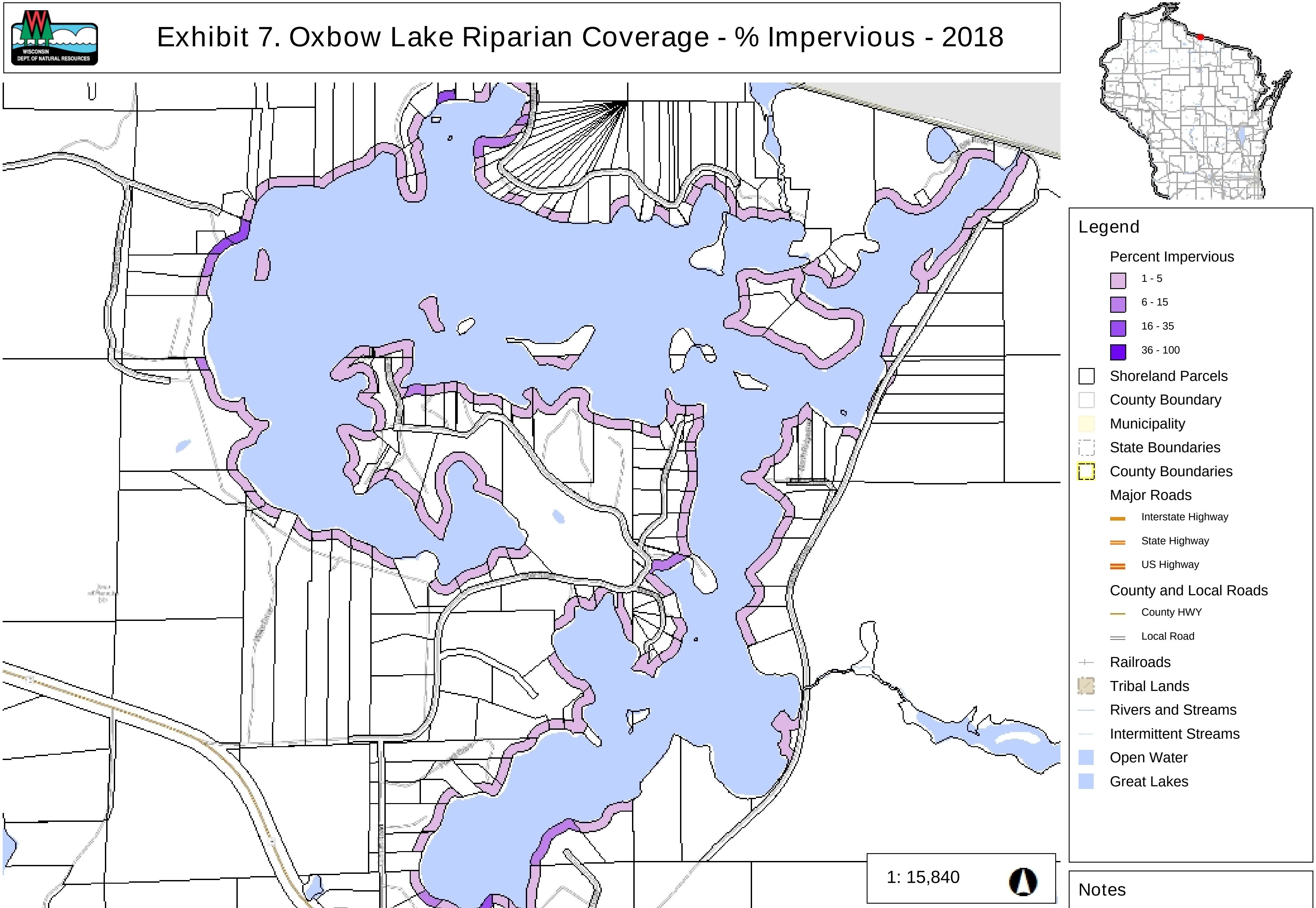
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

# Exhibit 7. Oxbow Lake Riparian Coverage - % Impervious - 2018



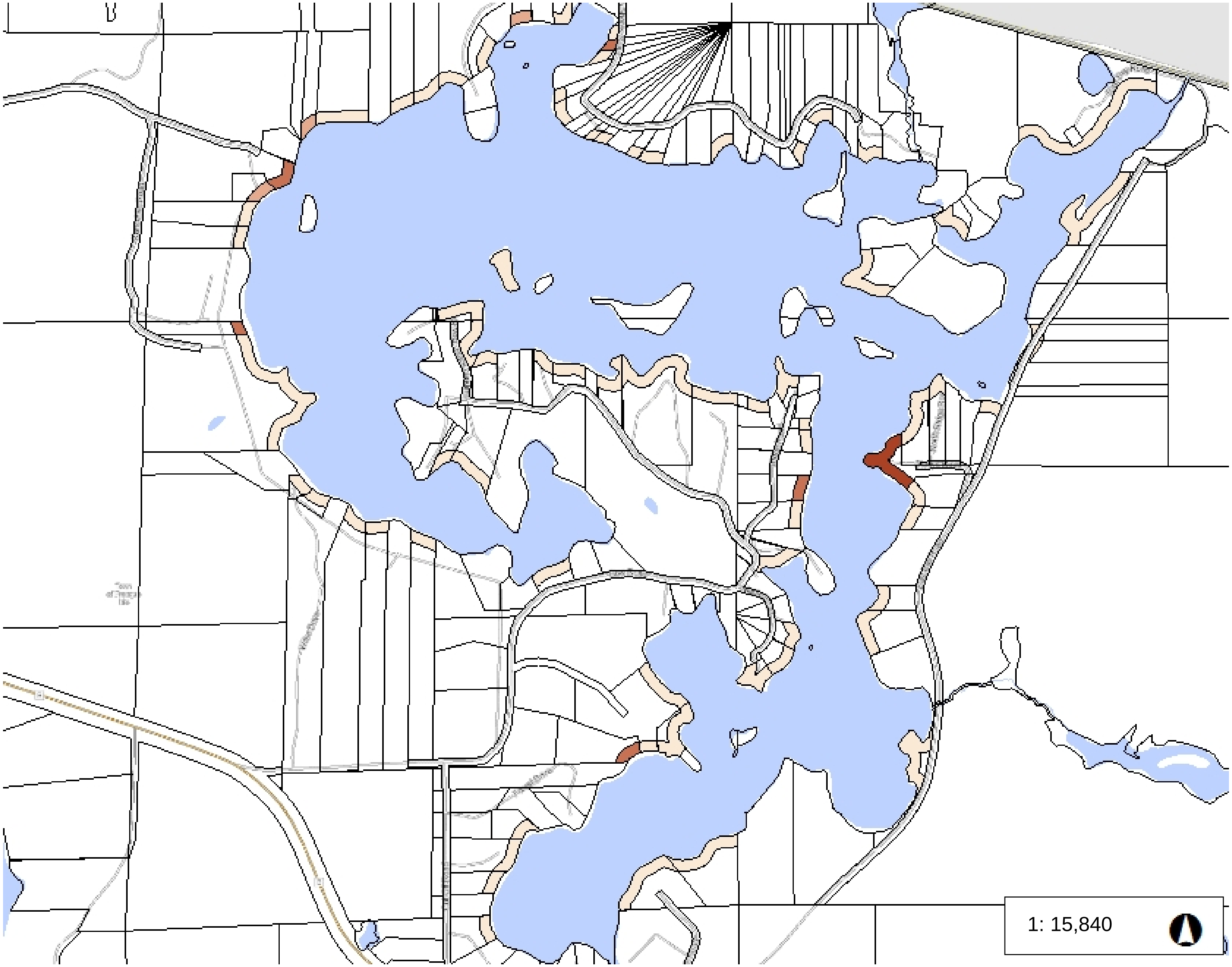

Notes

NAD_1983_HARN_Wisconsin_TM



DISCLAIMER: The information shown on these maps has been obtained from various sources, and are of varying age, reliability and resolution. These maps are not intended to be used for navigation, nor are these maps an authoritative source of information about legal land ownership or public access. No warranty, expressed or implied, is made regarding accuracy, applicability for a particular use, completeness, or legality of the information depicted on this map. For more information, see the DNR Legal Notices web page: http://dnr.wi.gov/legal/

# Exhibit 8. Oxbow Lake Riparian Coverage - % Manicured Lawn - 2018



## Legend

**Percent Manicured Lawn**
- 1 - 25
- 26 - 50
- 51 - 75
- 76 - 100

- Shoreland Parcels
- County Boundary
- Municipality
- State Boundaries
- County Boundaries

**Major Roads**
- Interstate Highway
- State Highway
- US Highway

**County and Local Roads**
- County HWY
- Local Road

- Railroads
- Tribal Lands
- Rivers and Streams
- Intermittent Streams
- Open Water
- Great Lakes

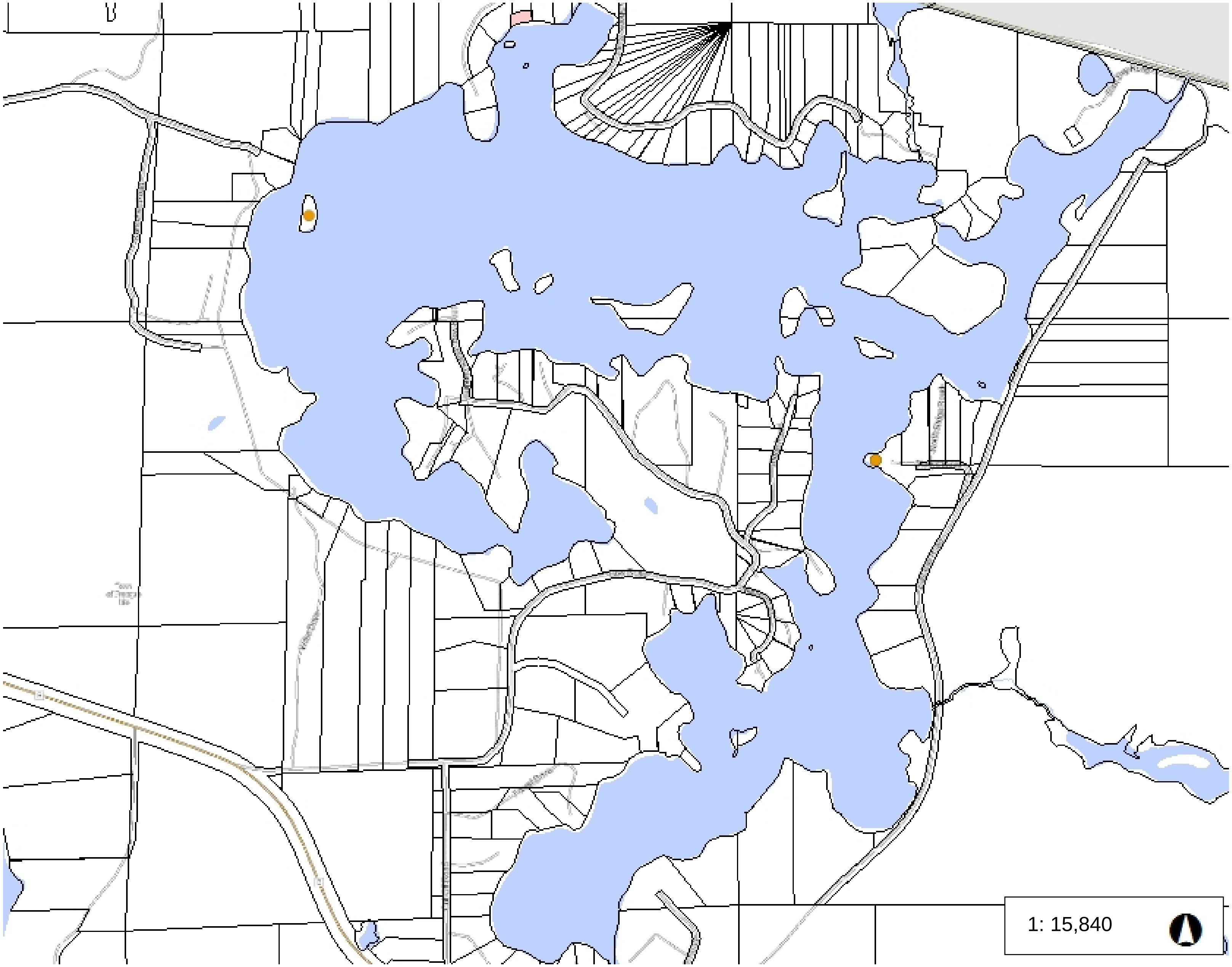
1: 15,840

## Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

# Exhibit 9. Oxbow Lake Bank Erosion and Modifications - 2018



## Legend

- Bank Erosion >1ft
- Bank Erosion <1ft

Vertical Sea Wall
- 1 - 50 ft
- 51 - 100 ft
- 101 - 200 ft
- 200 + ft

Rip Rap
- 1 - 50 ft
- 51 - 100 ft
- 101 - 200 ft
- 200+ ft

Other Bank Modifications
- 10 - 50 ft
- 51 - 100 ft
- 101 - 200 ft
- 200+ ft

Artificial Beach
- 0 - 50 ft
- 51 - 100 ft
- 101 - 200 ft
- 200+ ft

- Shoreland Parcels
- County Boundary
- Municipality
- State Boundaries

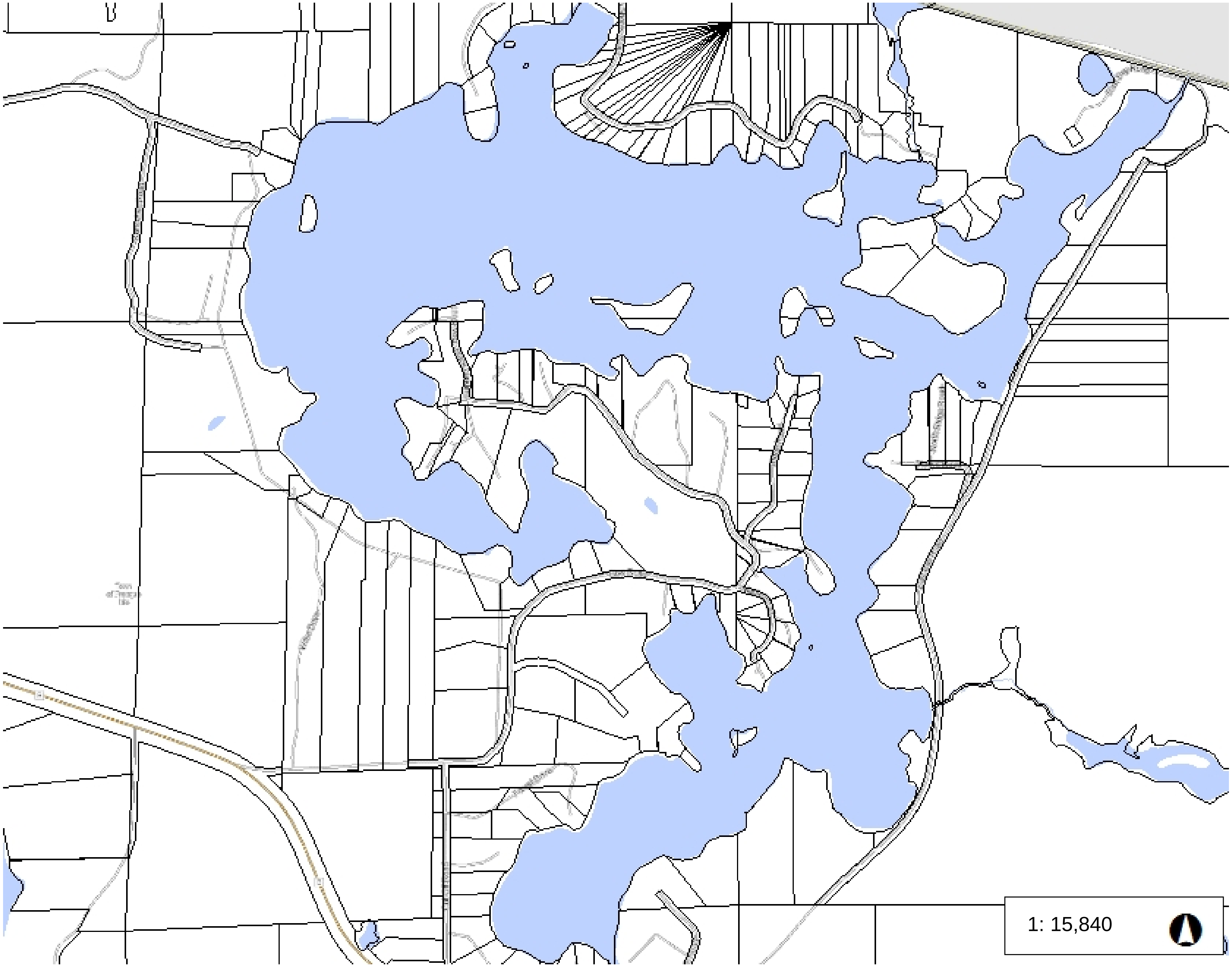
1: 15,840

## Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

# Exhibit 10. Oxbow Lake Runoff Concerns - 2018



Legend

- Channelized Flow
- Point Source
- Shoreland Parcels
- County Boundary
- Municipality
- State Boundaries
- County Boundaries
- Major Roads
  - Interstate Highway
  - State Highway
  - US Highway
- County and Local Roads
  - County HWY
  - Local Road
- Railroads
- Tribal Lands
- Rivers and Streams
- Intermittent Streams
- Open Water
- Great Lakes

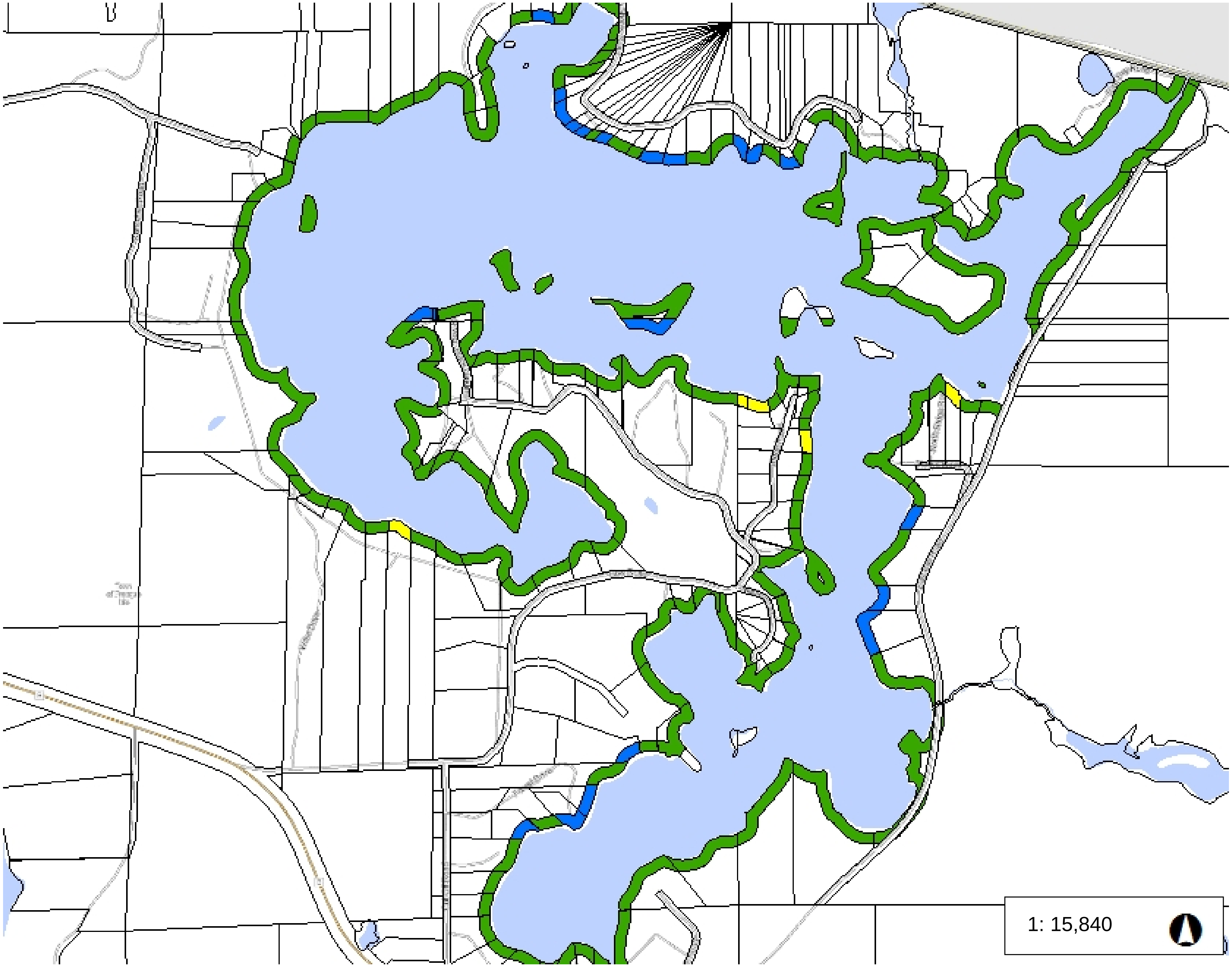
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

# Exhibit 11. Oxbow Lake Littoral Zone - Aquatic Plants - 2018



Legend

- Aquatic Plant Removal
- Floating & Emergent Plants
- Emergent Plants
- Floating Plants
- Shoreland Parcels
- County Boundary
- Municipality
- State Boundaries
- County Boundaries
- Major Roads
  - Interstate Highway
  - State Highway
  - US Highway
- County and Local Roads
  - County HWY
  - Local Road
- Railroads
- Tribal Lands
- Rivers and Streams
- Intermittent Streams
- Open Water
- Great Lakes

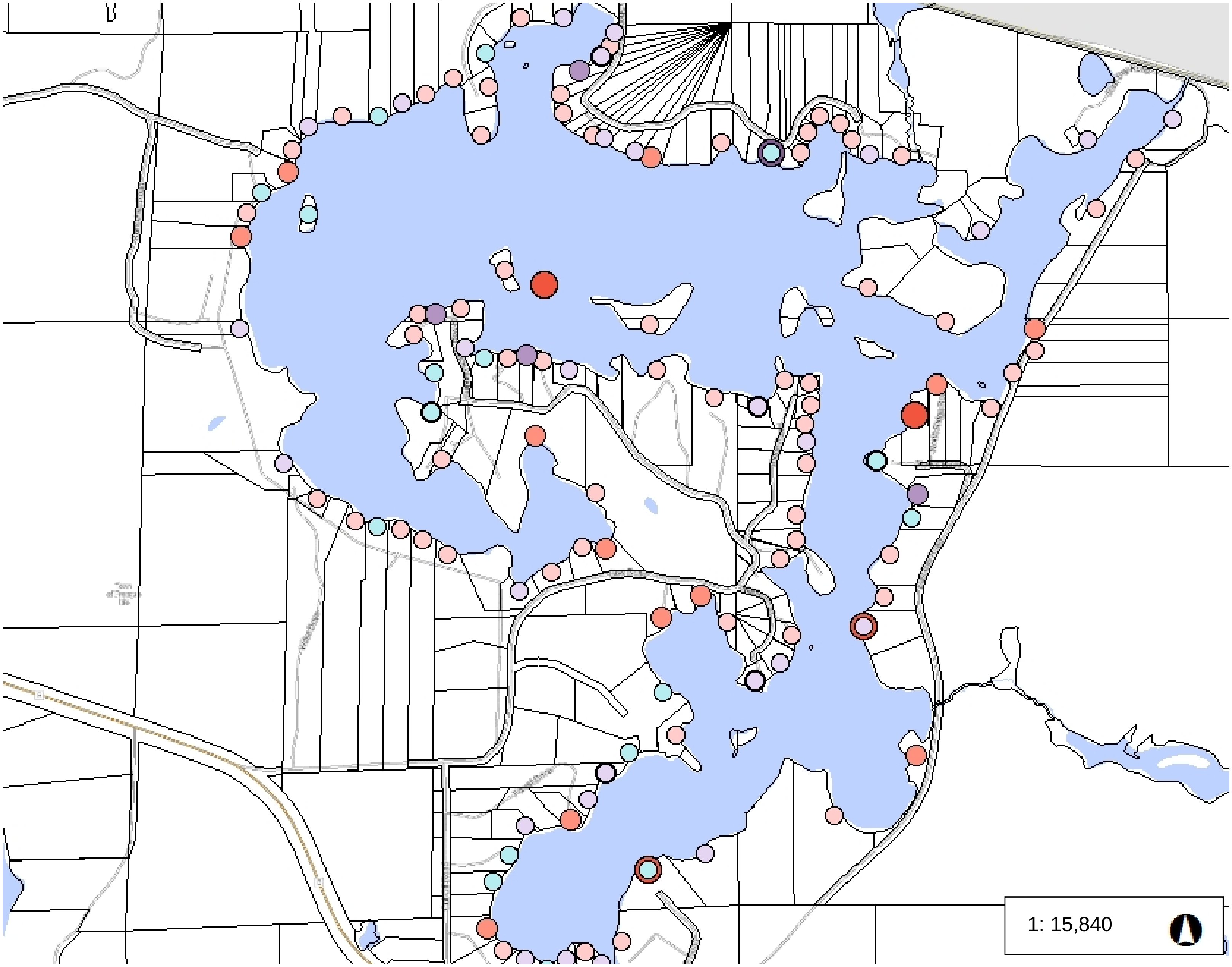
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

# Exhibit 12. Oxbow Lake Littoral Zone - Human Structures - 2018



Legend

Swim Rafts
- 1
- 2
- 3 - 5
- 6+

Boat Lifts
- 1
- 2
- 3 - 5
- 6+

Piers
- 1
- 2
- 3 - 5
- 6+

Boat Houses
- 1
- 2
- 3 - 5
- 6+

Marinas
- 1
- 2
- 3 - 5
- 6+

Shoreland Parcels

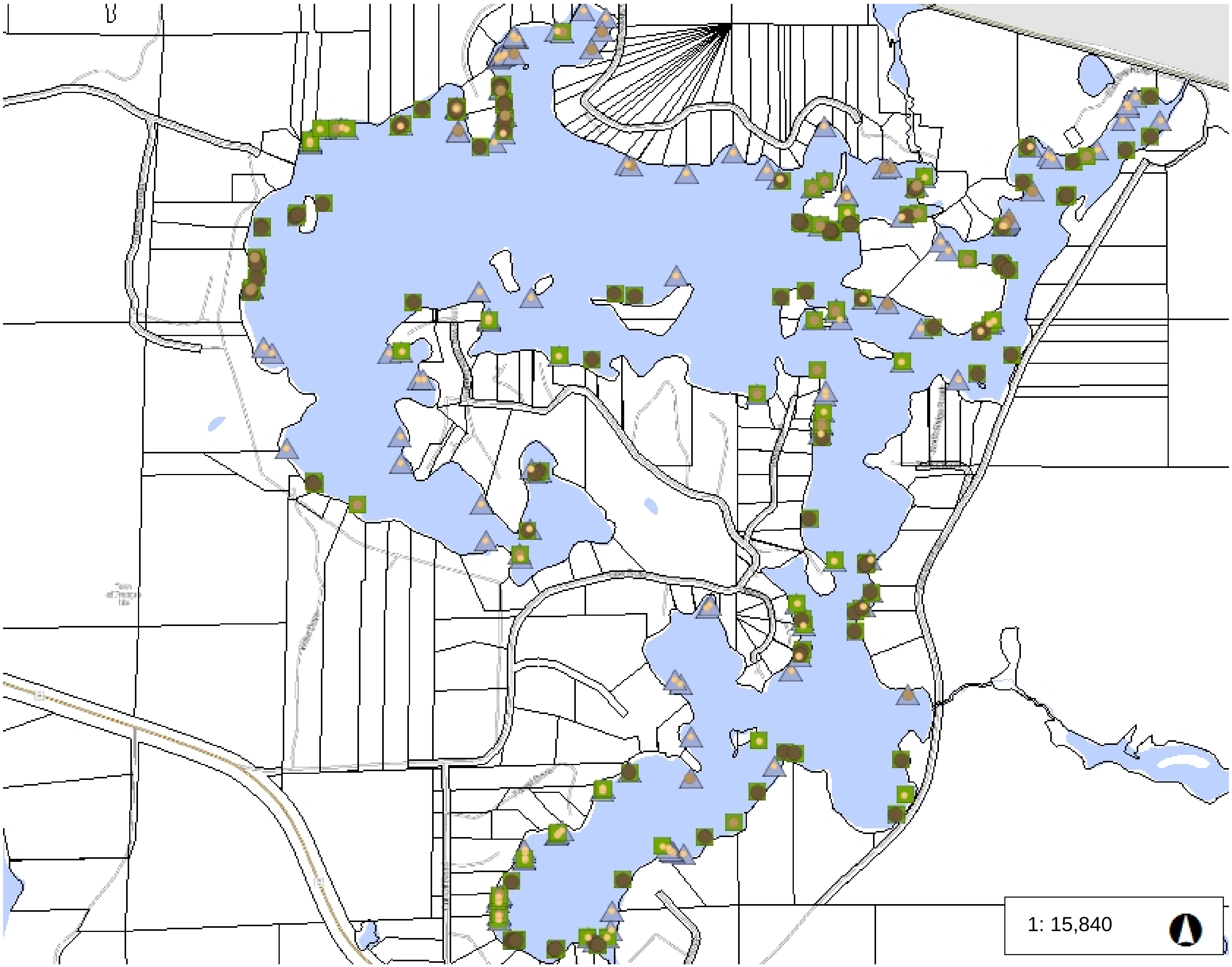
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

# Exhibit 13. Oxbow Lake Woody Habitat - 2018




Legend

WH Branchiness
- No branches
- Few branches
- Full tree crown

WH Touching Shore

WH In Water

Shoreland Parcels

County Boundary

Municipality

State Boundaries

County Boundaries

Major Roads
- Interstate Highway
- State Highway
- US Highway

County and Local Roads
- County HWY
- Local Road

Railroads

Tribal Lands

Rivers and Streams

Intermittent Streams

Open Water

Great Lakes

Notes

0.5 0 0.25 0.5 Miles

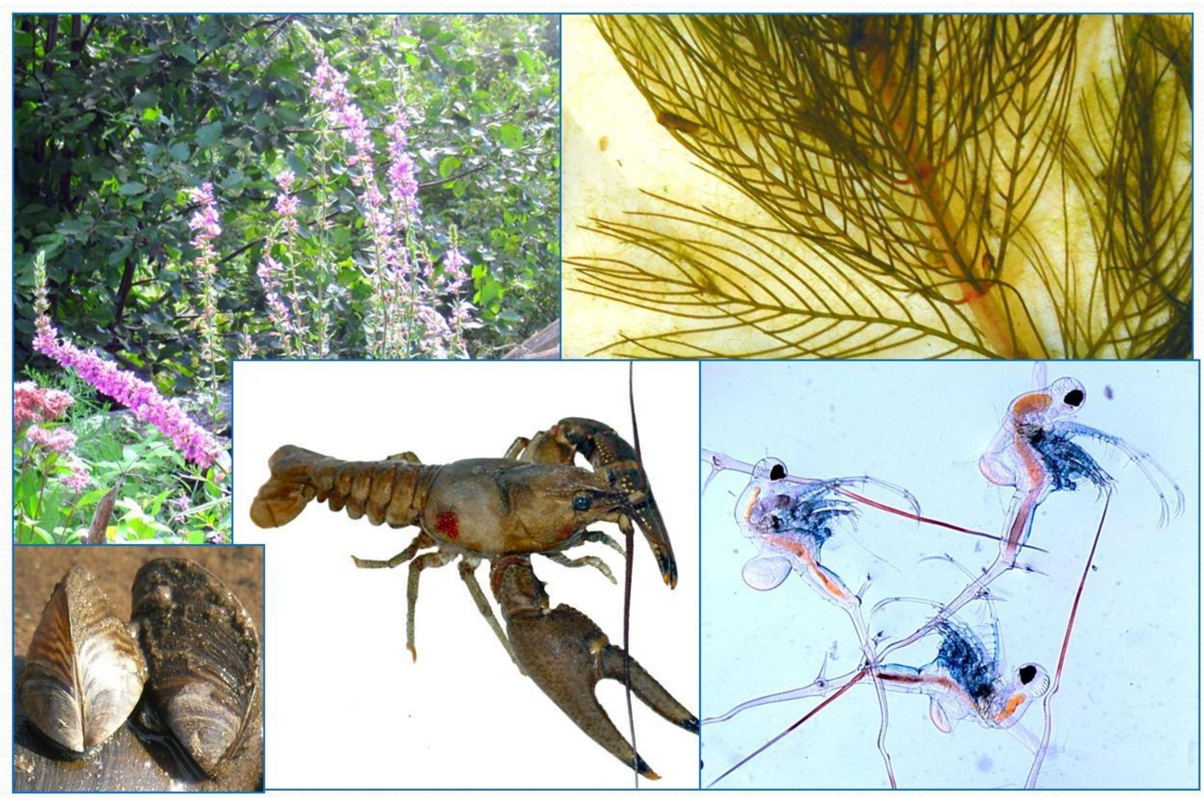
NAD_1983_HARN_Wisconsin_TM

# Appendix E

# Oxbow Lake Aquatic Invasive Species Report

# Oxbow Lake (Vilas County, Wisconsin)

# Aquatic Invasive Species Report



WHITE WATER
ASSOCIATES, INC.

2019

# INTRODUCTION

White Water Associates, Inc. has been retained by the Presque Isle Town Lakes Committee through a Wisconsin Department of Natural Resources (WDNR) Education, Prevention, and Planning Grant for lake consulting services on Oxbow Lake (Vilas County, Wisconsin). Some tasks for this grant focused on aquatic invasive species (AIS). Efforts are intended to increase the understanding of AIS as well as native species in Oxbow Lake. This work prepares Oxbow Lake stakeholders to conduct actions that serve lake health. As part of this effort White Water staff monitored Oxbow Lake for AIS using WDNR protocol. This approach assesses the lake as to its vulnerability to AIS and documents AIS detected. Findings from the survey were entered into the SWIMS database. A *floating workshop* on lake health, riparian ecology, and AIS was conducted for interested Oxbow Lake stewards.

# AQUATIC INVASIVE SPECIES EARLY DETECTION MONITORING

In order to determine if other aquatic invasive species (AIS) were present in study areas, biologists followed the *Aquatic Invasive Species Early Detection Monitoring Standard Operating Procedure* (WDNR, 2014). This procedure outlines several types of monitoring techniques, including: boat landing searches, sample site searches, targeted searches, waterflea tows and/or a Ponar dredge, and a meander search. The Oxbow Lake survey took place June 25, 2018.

Five sites around the lake shoreline were thoroughly searched and a meander search was conducted while traveling from one site to another. The public boat landing was surveyed for 30 minutes by checking the dock and walking 200 feet of shoreline. The other four shoreline sites were randomly selected and are identified in Exhibit 1 and 2. Snorkeling was used to search for AIS at the sampling sites and the boat landing. A long rake was used to collect any suspicious aquatic plants for closer inspection and identification. A D-net was used to collect invertebrate animals to look for AIS. Any invasive species observed were recorded. In the event of a new AIS record, specimens are collected for verification.

Spiny water fleas are an aquatic invasive zooplankton that is found in a few lakes in Wisconsin. They can be monitored by way of plankton tow nets or by an examination of sediment for dead waterflea exoskeleton fragments. In Oxbow Lake, a Ponar dredge was used to collect a sediment sample in the middle of the lake (Exhibit 1 and 3). The sample was brought back to the lab and filtered to look for spiny water flea spines under magnification. No AIS were found.

There were two known AIS that were established in Oxbow Lake prior to this survey, the banded mystery snail and the freshwater jellyfish. During the survey the only AIS noted were aquatic forget-me-not and reed canary grass. A voucher specimen of reed canary grass (from the aquatic plant survey) was sent to Dr. Freckmann (UW Steven's Point: Herbarium) and was confirmed in January of 2019. The aquatic forget-me-not was not vouchered, but was present in abundance. An AIS Monitoring Wetland Data Form was filled out and emailed to the WDNR on February, 9, 2019. Many locations on the shoreline had reed canary grass and the aquatic forget-me-not. Site 2 and 5 had the aquatic forget-me-not (Exhibit 2).


Exhibit 1. Oxbow Lake AIS survey sites 1-5 and location of dredge site.

| Exhibit 2. AIS Survey on Oxbow Lake 6/25/2018. Density (1-5), and live (L) or dead (D). | | | |
|---|---|---|---|
| **Site** | **Latitude** | **Longitude** | **Species found** |
| 1 | 46.23488 | -89.68005 | None |
| 2 | 46.24180 | -89.68530 | Aquatic forget-me-not (1,L) |
| 3 | 46.24125 | -89.69528 | None |
| 4 | 46.24133 | -89.67097 | None |
| 5 | 46.23725 | -89.67423 | Aquatic forget-me-not (2, L) |

| Exhibit 3. Spiny Water Flea Sediment Sample from Oxbow Lake | | | |
|---|---|---|---|
| **Date: 6/25/2018** | **GPS Coordinates** | | **Depth of sample (feet)** |
| Dredge Site | 46.24623 | -89.68932 | 42 |

Banded mystery snails are native to northeastern United States down to Florida, the Gulf of Mexico, and some states along the Mississippi River. Records show that an amateur conchologist (scientist of sea shells and the animals that inhabit them) intentionally released banded mystery snails into the Hudson River, which led to its dispersal throughout the Great Lakes area (Kipp et al., 2019). There is no known negative impact caused by the snails in the Great Lake region (Kipp et al., 2019).

Freshwater jellyfish are native to the Yangtze River valley in China (McKercher et al., 2019). It is likely that they were introduced into northern waters by transportation of ornamental plants, by water fowl or fish stocking (McKercher et al., 2019). It is unclear what the jellyfishes' impact is on native plant and animal species, but it is possible that they prey on fish eggs and other zooplankton (McKercher et al., 2019).

Reed canary grass (*Phalaris arundinacea*) grass has been found in nearly every county in Wisconsin. It is on the *Restricted* species list. It forms dense, monocultured stands in wetland and riparian areas (Czarapata, 2005). It reproduces by spreading rhizomes, and seeds

(Czarapata, 2005). It is one of the first grasses to sprout in the spring, increasing its chances of out-competing other plants.

Aquatic Forget-me-not (*Myosotis scorpioides*) grows in shallow water along the shoreline. It is an aggressively growing plant that can crowd out native plant species. It can form large monocultures, especially in situations where it is in or near a stream (WDNR, 2019). This plant is restricted in Wisconsin. A photo of a bed of the blue aquatic forget-me-not along the shoreline of Oxbow Lake is presented as Exhibit 4.

Oxbow Lake stakeholders are the first line of defense when it comes to protecting the lake from introduction and establishment of AIS. Early detection and action is critical. The Wisconsin DNR has a very informative website on aquatic invasive species: https://dnr.wi.gov/topic/Invasives/.

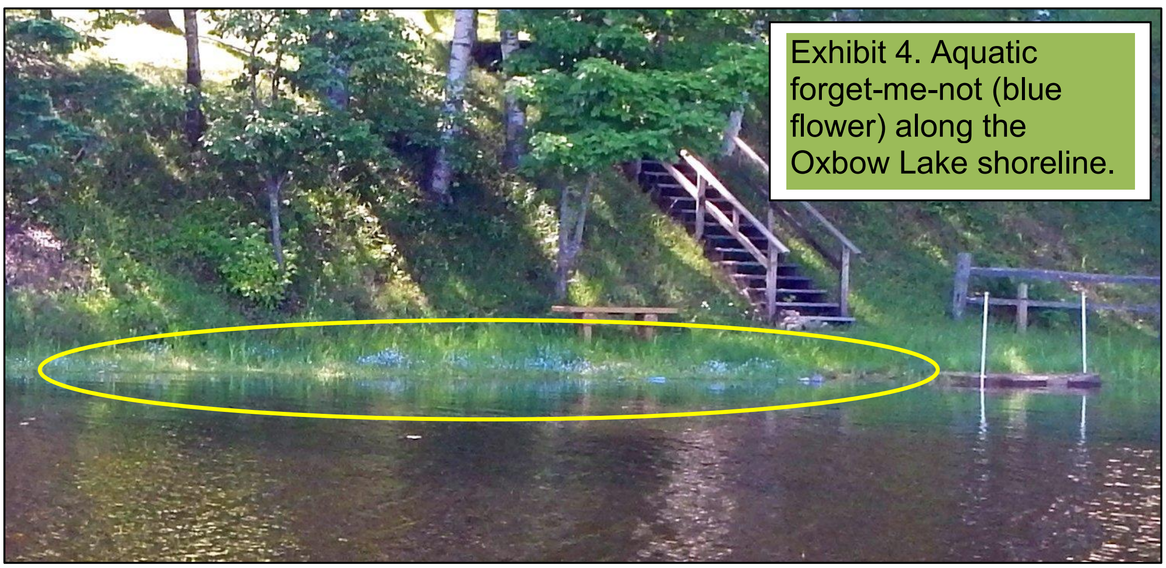


Exhibit 4. Aquatic forget-me-not (blue flower) along the Oxbow Lake shoreline.

## FLOATING WORKSHOP

A floating workshop for Oxbow Lake stewards was conducted by Dean Premo (White Water Associates). This field trip discussed lake and riparian ecology including ways AIS might impact these important ecosystems. The workshop took place on July 27, 2019 using several pontoon boats. Participants learned about the point-intercept plant survey and shoreland survey conducted on Oxbow Lake and how the information gathered from these surveys could influence lake stewardship. The Oxbow Lake aquatic plant community was discussed at length. Other aspects of the Oxbow Lake Stewardship Program were also discussed (wildlife observations, water quality, and more).

## Literature Cited

Czarapata, Elizabeth. 2005. *Invasive Plants of the Upper Midwest: An Illustrated Guide to Their Identification and Control*. University of Wisconsin Press.

Kipp, R.M., A.J. Benson, J. Larson, and A. Fusaro. 2019. *Viviparus georgianus*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Retrieved 2015. <http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1047>

McKercher, L., D. O'Connell, P. Fuller, J. Liebig, J. Larson, and A. Fusaro. 2019. *Craspedacusta sowerbyi*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Retrieved 2015. <http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1068>

Wisconsin Department of Natural Resources. 2014. *Aquatic Invasive Species Early Detection Monitoring Standard Operating Procedure.* Retrieved 2017. <http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=99459630>

Wisconsin Department of Natural Resources. 2019. *Aquatic Forget-me-not*. Retrieved 2019. < https://dnr.wi.gov/topic/Invasives/fact/AquaticForgetMeNot.htm>