INTRODUCTION

Mount Morris Lake, Waushara County, is a lowland drainage lake with a maximum depth of 40 feet with five main basins. The lake's water level is maintained by a dam at the outlet on the east side of the lake. This mesotrophic-eutrophic lake has a relatively large watershed when compared to the size of the lake. In 2017, 16 native plant species were found during the point-intercept survey on Mount Morris Lake, of which muskgrasses being the most common.

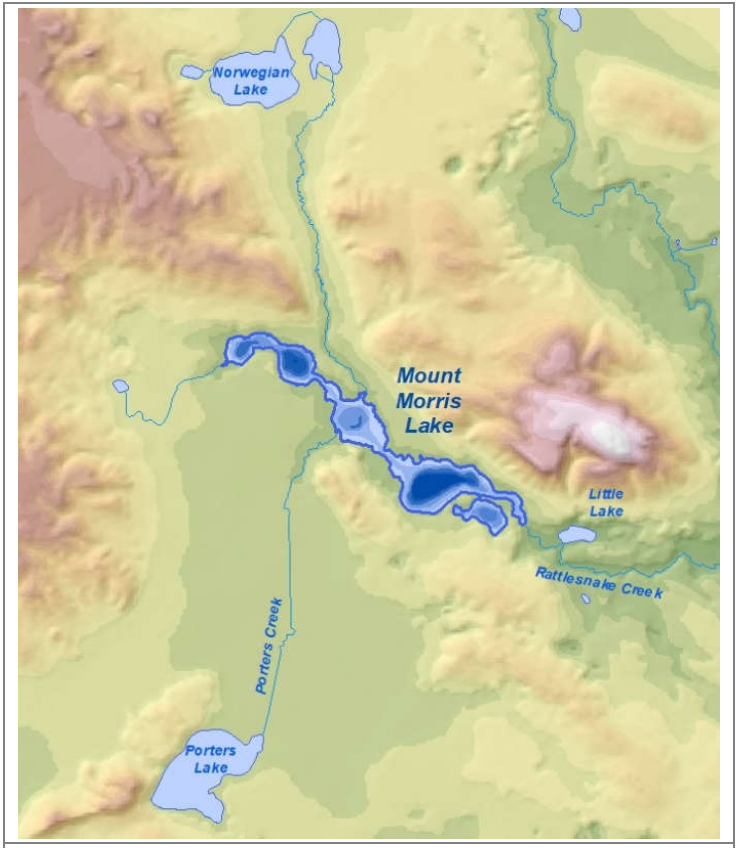


Figure 1. Mount Morris Lake, Waushara County.

Mount Morris Lake has three tributary inlets and is drained by Rattlesnake Creek, which leads to Little Lake (Figure 1). Mount Morris Lake Management District (MMLMD) is the local citizen-based organization leading the management of Mount Morris Lake. The group has worked for years to protect and enhance the lake and has utilized Wisconsin Department of Natural Resources (WDNR) grant funds to conduct lake management planning activities and control invasive plant species.

It is unknown when CLP was first introduced to Mount Morris Lake, but dense, widespread distribution was documented in 2004. Total phosphorus spikes were documented surrounding the early-summer die-off of this species. The nuisance conditions and water quality impairments prompted the MMLMD to initiate approximately a decade of repetitive early-season endothall herbicide treatments. Herbicide concentration monitoring occurred from 2010-2016, allowing the MMLMD to adjust application rates to meet control goals. The project goals were met, with only low-density CLP occurrences being documented since 2016 when herbicide management ceased. Map 1 shows the results of the May 2019 CLP mapping survey.

Following detection in 2004, Eurasian watermilfoil (EWM) populations have been managed initially through hand-harvesting and recently with herbicide treatment. Unfortunately, the contact and exposure time required to kill EWM is longer than can be achieved in Mount Morris Lake due to the flow of the system. EWM treatments have been able to knock back the EWM for much of the growing season, but it rebounds by the end of the summer. At least a portion of Mount Morris Lake's invasive watermilfoil population is comprised of hybrid EWM (HWM), a cross between EWM and native northern watermilfoil. Studies have shown that most strains of HWM are less responsive to commonly used herbicides compared to pure-strain EWM. Unless specifically indicated, this report will use "EWM" when discussing the invasive milfoil (EWM and HWM) population of Mount Morris Lake.

The EWM population of Mount Morris Lake has been increasing over time, with the 2019 Late-Summer EWM Mapping Survey documenting EWM throughout the entire littoral zone of Mount Morris, with numerous areas of *dominant* conditions (Map 2). The MMLMD is discussing water level management (i.e. drawdown) as a possible tool for managing the EWM population within the system.

As outlined in the MMLMD's 2013 *Comprehensive Management Plan for Mount Morris Lake*, sediment buildup in particular areas of the lake is also a large concern to many riparians. The *Plan* conducted an alternatives analysis, with extended drawdown (winter-summer-winter) being the best option to achieve increases in water depth through sediment compaction and consolidation.

In 2019, the MMLMD conducted a lake-wide bathymetric modeling study to give preliminary insight into drawdown scenarios and feasibility considering the dam operations. The MMLMD also was awarded a WDNR AIS-Education, Prevention, and Planning Grant (AEPP-596-20) to assist with additional scoping components during 2020, which some of the surveys may serve as a pre-drawdown dataset if this management strategy is implemented.

WATER LEVEL MANAGEMENT: FEASIBILITY

The term "water level drawdown" or "drawdown" can mean many things in lake management. Actually, there are many types of drawdowns used to managed certain aspects of the lake environment. There are winter drawdowns that typically last from just after Labor Day to spring. Some lakes have been exposed to summer drawdowns, while other to drawdowns lasting a year or more. The timing and longevity of a drawdown are critical in meeting the goal of the action. Common goals for drawdowns in lake management (not dam maintenance or shoreline/near-shore modification) are aquatic invasive species (AIS) control, native plant restoration/enhancement, and sediment decomposition/consolidation.

Photo 1. Lac Sault Dore during 2010-2011 drawdown. Photo courtesy of Soo Lake United.

It is believed that the dam on Mount Morris Lake can be manipulated to reduce the water level by 6 feet at the dam. However, it is unclear if the full 6-foot reduction will be observed in all basins of the system. Using the bathymetric data collected from the early-spring 2019 acoustic survey, a set of drawdown scenarios were modeled assuming that the lake could be drawn down to target level. Figure 2 shows that the connections between the basins are less than 6 feet deep and actually closer to 3-4 feet deep. This means that in order for all of the basins to experience a 6-foot drawdown, water flow will need to head-cut a channel at least 2-3 feet deeper to allow the upstream basin to be lowered six feet.

A 4-foot drawdown was modeled in Figure 3. These data indicate that the channel between Lake C and Lake D is sufficient to reduce the water the full 4 feet. The stretch between Lake B and Lake C is not quite 4-feet deep, but it is likely that sufficient water flow during the drawdown will create a channel

deep enough to drain the upstream basins at least 4 feet. The channel between Emerald and Lake D is approximately 3 feet deep throughout. It is unclear if sufficient outflow from Emerald Lake exists to achieve more than a 3-foot water level reduction regardless of how far the dam is lowered.

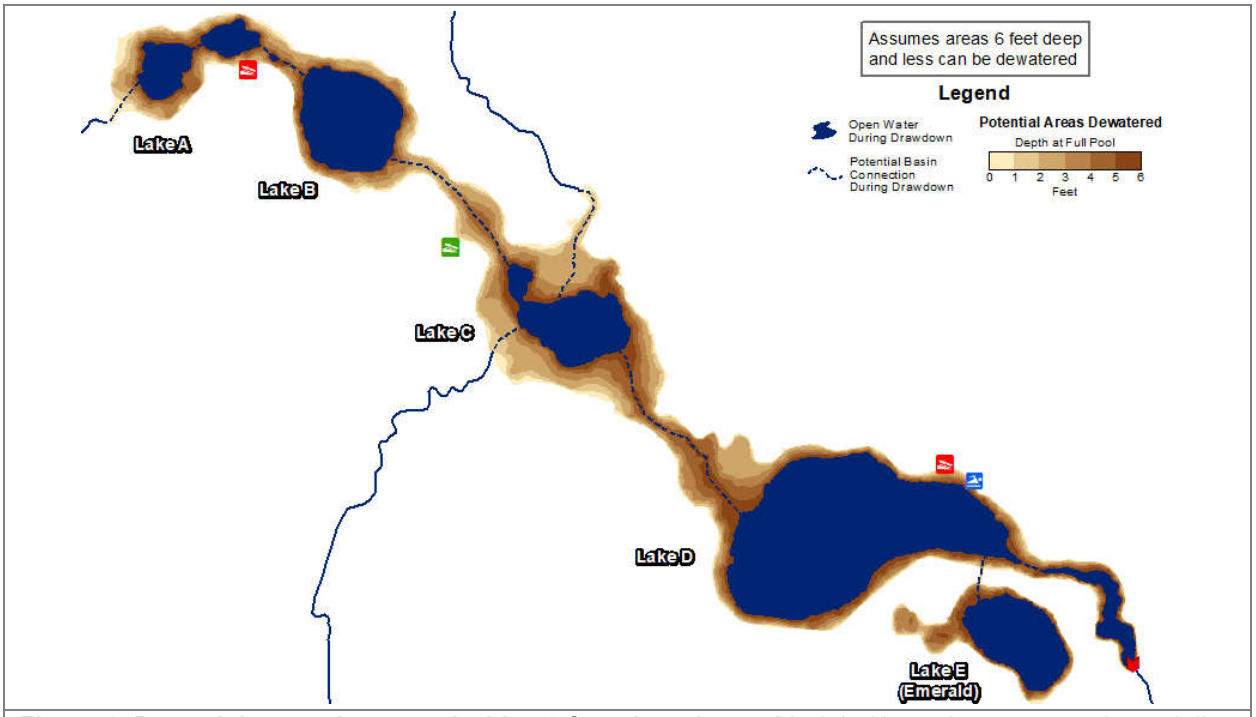


Figure 2. Potential areas dewatered with a 6-foot drawdown. Modeled based upon acoustic modeling survey.

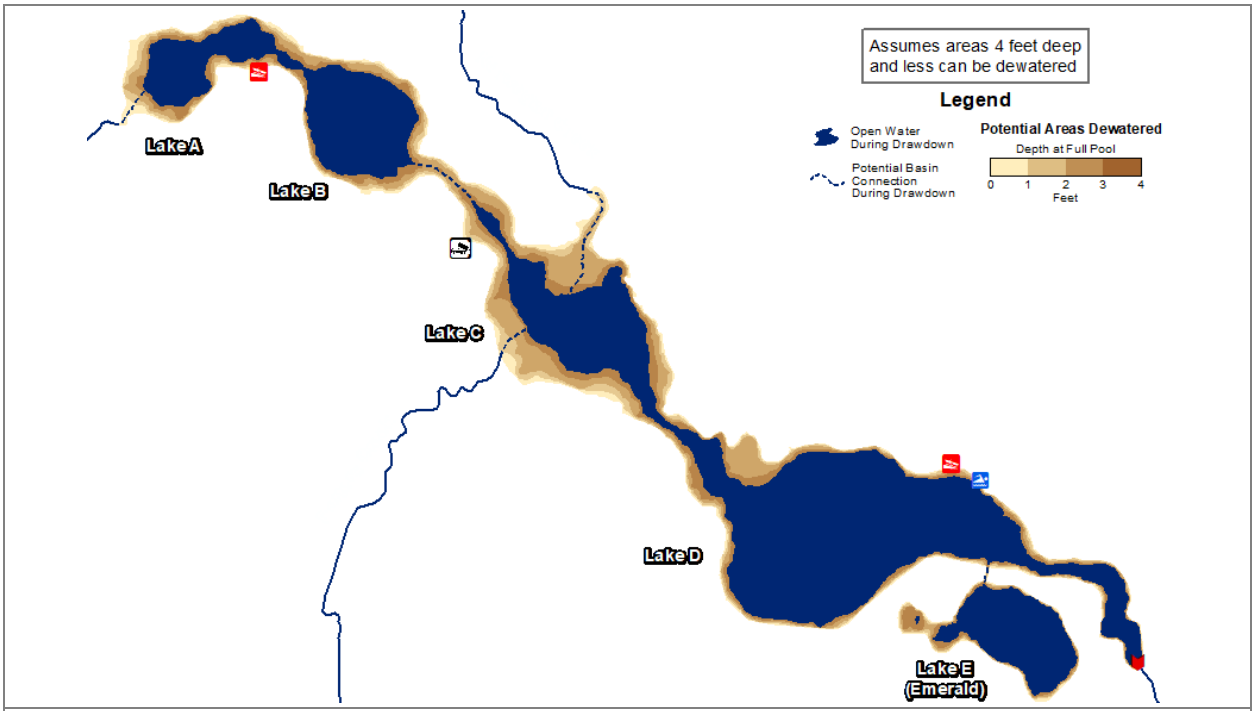


Figure 3. Potential areas dewatered with a 4-foot drawdown. Modeled based upon acoustic modeling survey.

In summary, Lake D is likely to achieve a full 6-foot drawn. The upstream basins of Lake A-C will likely achieve at least a 4-foot drawdown. If sufficient flows exist to head-cut a channel between the upstream basins, they will also observe a 6-foot water level reduction. On average, water flows are less in the fall compared to spring. Therefore, the likelihood of achieving sufficient cutting of channels between basins increases for an extended drawdown (winter-summer-winter) compared to just a winter drawdown. To be clear, the first winter of a winter-summer-winter drawdown may only achieve a 4-foot reduction, but with the onset of spring flows, head-cutting may occur that would ultimately reduce the levels in all basins closer to 6 feet for at least a portion of the summer, through the fall and the second winter.

WATER LEVEL MANAGEMENT: INCREASE LAKE DEPTH

Water level management is often conducted to increase the lake depth, particularly in shallow impounded systems. The main way to increased water depth from a water level drawdown is through decomposition. This refers to the actual chemical and physical change in sediment brought on by oxidation of the sediments leading to aerobic decomposition, not just drying out (dehydration) of the sediments. To achieve substantial sediment decomposition/consolidation, the drawdown period must include significant bottom sediment exposure during the growing season – typically an entire summer. The rate of sediment decomposition is highest under hot and dry conditions (summer) and the greatest gains in water depth are made from decomposition highly organic sediments. Aerobic decomposition of the organic sediments reduces the sediment bulk and increases lake depth. These modified sediments do not return to their original bulk when rehydrated following the refilling of the lake. During the summer of 2020, studies will be conducted to better understand sediment composition, in terms of organic and mineral content, within key areas of the lake that may be exposed during a drawdown.

While sediments may become dehydrated and channel cutting may occur during winter water level drawdowns, the decomposition of organic sediments does not occur to a significant extent with this type of water level management. As a result, winter water level drawdowns do not typically facilitate significant increases in water depth. If the MMLMD's goal is to achieve the largest depth increases possible in areas 6-feet deep or shallower, a drawdown that includes an entire summer must be conducted. Often this includes a winter-summer-winter drawdown.

WATER LEVEL MANAGEMENT: REDUCE AIS POPULATIONS

Both EWM and HWM have been shown to be impacted greatly by winter drawdowns when the system can be dewatered to a sufficient depth to desiccate (i.e. dry out) and freeze the EWM/HWM's root crown. In order to achieve sediment desiccation and freezing, the drawdown must be implemented during a cold and dry winter. If the exposed sediment is kept hydrated by deep snow, winter rains, or hydrologic springs; the impacts to EWM will likely not meet expectations. In fact, an incomplete or poor winter drawdown has been shown to exasperate the EWM problem in some cases (Photo 2).

Photo 2. Exposed shoreline during drawdown. Photo by Onterra.

Using the 2019 Late-Season EWM Survey Results (Map 2), the amount of EWM impacted by the drawdown models outlined in Figure 2 and Figure 3 are shown

in Figure 4. If a 6-foot drawdown is possible throughout Mount Morris Lake, approximately 80% of the EWM would be impacted. If some areas are only able to be dewatered by 4 feet, closer to 50% of the EWM would be impacted in these areas.

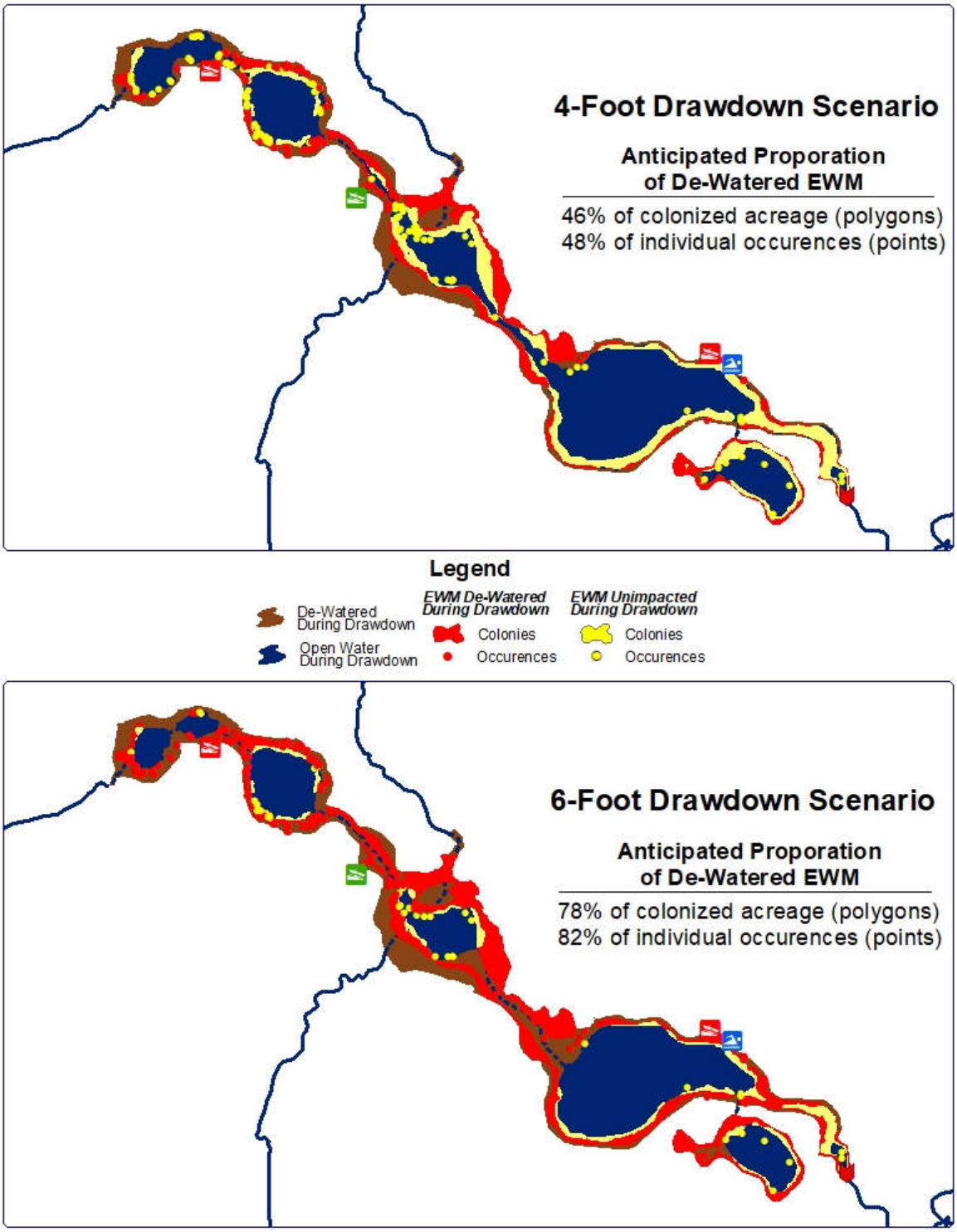


Figure 3. Potential EWM response to drawdown scenarios. Based upon overlaying 2019 Late-Season EWM Survey with spring 2019 acoustic bathymetric modeling survey.

The response of CLP to winter water level drawdowns has been met with mixed results. It is believed that the turions of CLP need to be exposed to drying and/or freezing for mortality to occur. While CLP is present in Mount Morris Lake, the June 2019 surveys indicate its population remains relatively small comprised mainly of low-density colonies and single-plant occurrences (Map 1). The primary target of control with a water level drawdown would be the expanding EWM population.

WATER LEVEL MANAGEMENT: NATIVE PLANT ENHANCEMENT

Native plant restoration and enhancement from drawdowns is mostly seen in the emergent plant community (e.g. bulrushes, cattails, etc.). To see these improvements, the drawdown must include exposure of bottom sediments during the warm growing season months in order to stimulate seed germination.

Photo 3. Emergent and floating-leaf plant community on Mount Morris Lake. Photo by Onterra.

The response of floating-leaf species has been variable to drawdowns. These species rely on large underground structures called tubers, which can be resilient to desiccation and freezing. White water lily has been found to expand following some drawdowns.

Several native submergent plants are reduced following drawdown, while some experience no impact, and others increase. An extended drawdown of winter-summer-winter is likely to have increased impact on those native submersed species that are vulnerable to being dewatered.

Table 1 contains a list of the submersed aquatic plants documented in Mount Morris Lake and their response following winter water level drawdowns from a few case studies in Wisconsin. The five most abundant aquatic plants in Mount Morris Lake from the latest point-intercept survey (2017) have seen documented declines in their occurrence following winter water level drawdowns. Aside from muskgrasses, these are the species the MMLMD targets with their mechanical harvesting operations.

While these submergent plants may see declines in their occurrence, emergent and floating-leaf species such as cattails and white water lily, have been observed to increase following winter water level drawdowns. While there will likely be changes in the abundance of native species in Mount Morris Lake following a water level drawdown, it is not anticipated that there will be any long-term adverse impacts to the native plant community.

Table 1. Aquatic plant species located in Mount Morris Lake in 2017 and documented responses to winter water level drawdown in three Wisconsin waterbodies. NC = no change.

Mount Morris Submergent Plant Community			Drawdown Response		
Scientific Name	Common Name	2017 LFOO	Little Muskego	Soo	Musser
Chara spp.	Muskgrasses	74.9	↓		
Vallisneria americana	Wild celery	20.9	↓	↓	NC
Ceratophyllum demersum	Coontail	12.6	↓	↓	↓
Elodea canadensis	Common waterweed	10.5	↓	↓	↓
Stuckenia pectinata	Sago pondweed	6.3	↓		
Myriophyllum spicatum	Eurasian watermilfoil	3.7	↓	↓	
Nitella spp.	Stoneworts	3.1		↑	
Myriophyllum sibiricum	Northern watermilfoil	2.1			
Potamogeton gramineus	Variable-leaf pondweed	1.6			
Potamogeton richardsonii	Clasping-leaf pondweed	1.6	NC		
Najas guadalupensis	Southern naiad	1.0	↓		
Potamogeton crispus	Curly-leaf pondweed	1.0			↓
Ranunculus aquatilis	White water crowfoot	1.0			NC
Najas flexilis	Slender naiad	0.5	↑	↑	
Utricularia vulgaris	Common bladderwort	0.5		NC	NC
Heteranthera dubia	Water stargrass		NC		
Myriophyllum verticillatum	Whorled water milfoil			NC	
Potamogeton friesii	Fries' pondweed		↑		
Potamogeton illinoensis	Illinois pondweed		↓		
Potamogeton praelongus	White-stem pondweed				
Zannichellia palustris	Horned pondweed				
Callitriche palustris	Common water starwort				
Lychnothamnus barbatus	Lychnothamnus barbatus				
Potamogeton natans	Floating-leaf pondweed				↑
Potamogeton zosteriformis	Flat-stem pondweed			↓	

WATER LEVEL MANAGEMENT: ADDITIONAL CONSIDERATIONS

With any management activity, there may be unintentional impacts that need to be considered. The following section will highlight some of the potential negatives of performing a drawdown.

The previous section outlined how different aquatic plant species are impacted by drawdown. During a summer drawdown, woody species (e.g. alders, willows, etc) may start to establish on the exposed lake bed. On Mount Morris Lake this is likely to occur within the channels between basins. These species would eventually die when the water levels return; but without intervening management, may persist for sufficient time to become a nuisance to some. The MMLMD has a plan to manage this type of vegetation prior to refilling.

On shallow lakes, the drawdown can result in few, if any, remnants pools of water for fish refugia. This is not the case on Mount Morris Lake as there will continue to be significant water volume for fish refugia. There will also be sufficient area of the lake to recreate within regardless of the duration of the drawdown. If the drawdown extends over the summer months, the recreational use may shift

towards smaller and/or non-motorized watercraft. Some drawdowns can greatly impact the local economy, whereas the impacts may not be as large for Mount Morris Lake.

When channel-cutting occurs, the sediment will likely be transported downstream. Some biologists believe this can improve deficient downstream nutrient levels and habitat if done in a controlled manner. A typical drawdown rate of 6 inches per day would minimize pulses of sediment from being sent downstream.

Coarse woody habitat, such as logs and snags, may become dislodged during a drawdown and float around in the lake. These floaters should be returned to shore so they do not present a danger or obstacle to boaters.

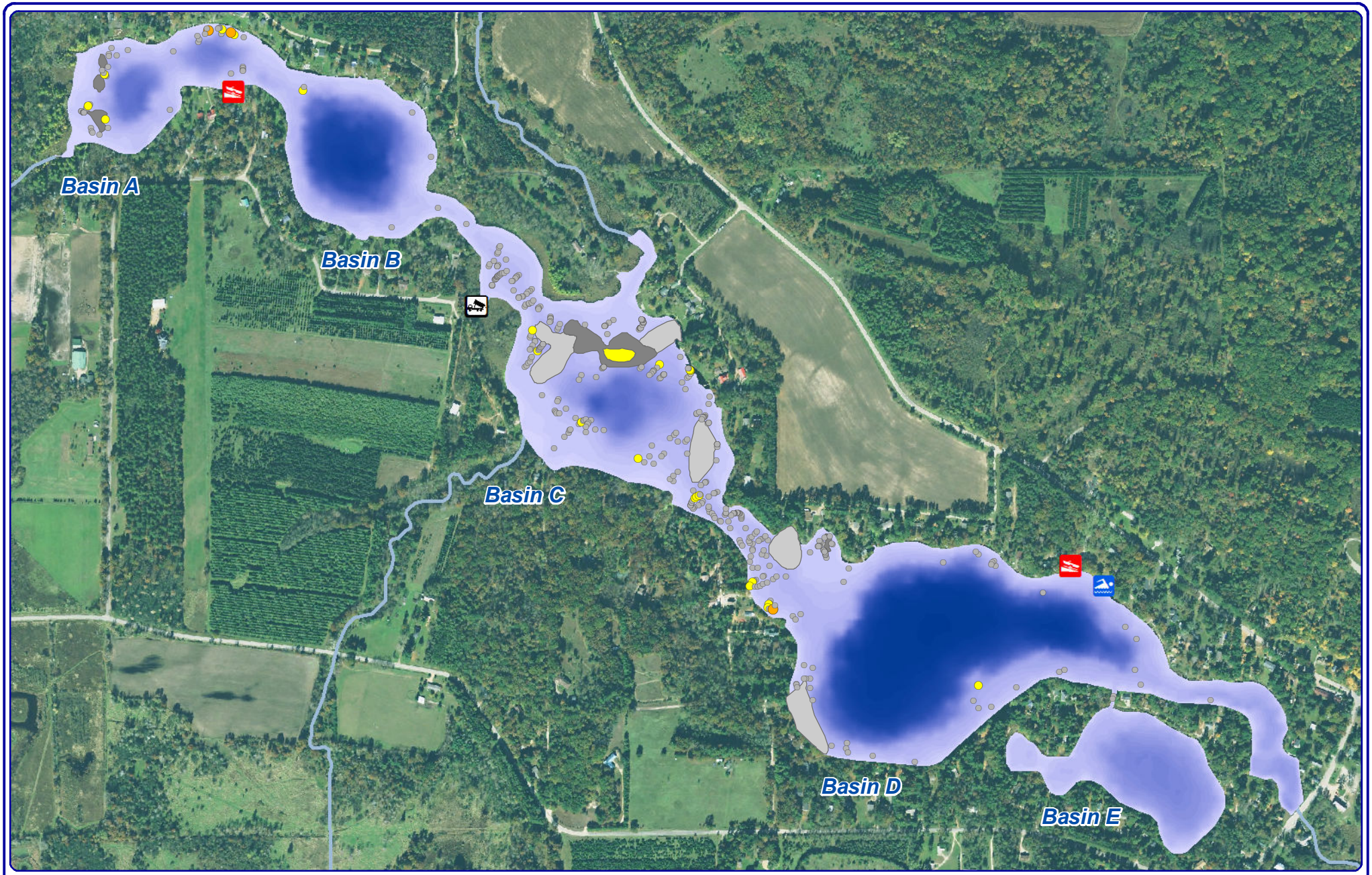
Some riparians see a drawdown event as an opportunity to complete nearshore dredging and shoreline modification. The WDNR has regulatory authority for dredging projects under Chapter 30, but offers an exemption if the dredging meets a certain criterion. This applies to projects that are manually dredged and do not exceed 100 square-feet in surface area and one foot in depth. Also, motorized vehicles cannot be used on exposed lake beds. More information can be found by searching "manual dredging" in the WDNR's website search tool.

DISCUSSION

The MMLMD continues to discuss the applicability of drawdown to meet their lake management needs. A winter-summer-winter drawdown (roughly October 2020 through May 2022) would meet EWM management goals as well as provide the greatest amount of increased water depth to the system. However, a drawdown of this extent would be more disruptive to lake use than a winter drawdown. A winter drawdown may be sufficient to meet EWM management goals if that winter is cold and dry, but minimal increase in water depth outside of channel cutting would be expected.

To be prepared for a potential drawdown starting in October 2020, monitoring will be conducted in 2020. These surveys will be replicated during the summer after water levels are returned to full pool (2021 for a winter drawdown or 2022 for a winter-summer-winter drawdown).

In order to make a full assessment of the aquatic plant community of Mount Morris Lake, four types of surveys would be performed in 2020: an early-season AIS survey (document CLP population), a point-intercept survey (quantitative assessment of all plants), an aquatic plant community mapping survey (document emergent and floating-leaf communities), and a late-season AIS (document EWM population) survey. Water quality monitoring in 2020 would continue, with some additional water chemistry samples being periodically taken by the MMLMD volunteer.



N
W E
S

800
Feet

Onterra LLC
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra, 2019
Aquatic Plant Survey: Onterra, 2019
Orthophoto: NAIP, 2018
Map date: March 12, 2020 - EJH

Project Location in Wisconsin

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant (none)
- Surface Matting (none)
- Single or Few Plants
- Clump of Plants
- Small Plant Colony

Map 1

Mount Morris Lake

Waushara County, Wisconsin

May 2019 CLP Survey Results

N
W E
S

800
Feet

Onterra LLC
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra, 2019
Aquatic Plant Survey: Onterra, 2019
Orthophoto: NAIP, 2018
Map date: March 12, 2020 - EJH

Project Location in Wisconsin

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant *(None)*
- Surface Matting *(None)*
- Single or Few Plants
- Clump of Plants
- Small Plant Colony

Map 2

Mount Morris Lake

Waushara County, Wisconsin

September 2019
EWM Survey Results