1.0 INTRODUCTION

Mount Morris Lake, Waushara County, is a lowland drainage lake with a maximum depth of 40 feet with five main basins. Mount Morris Lake has three tributary inlets and is drained by Rattlesnake Creek, which leads to Little Lake prior to merging with the Willow Creek (Figure 1.0-1).

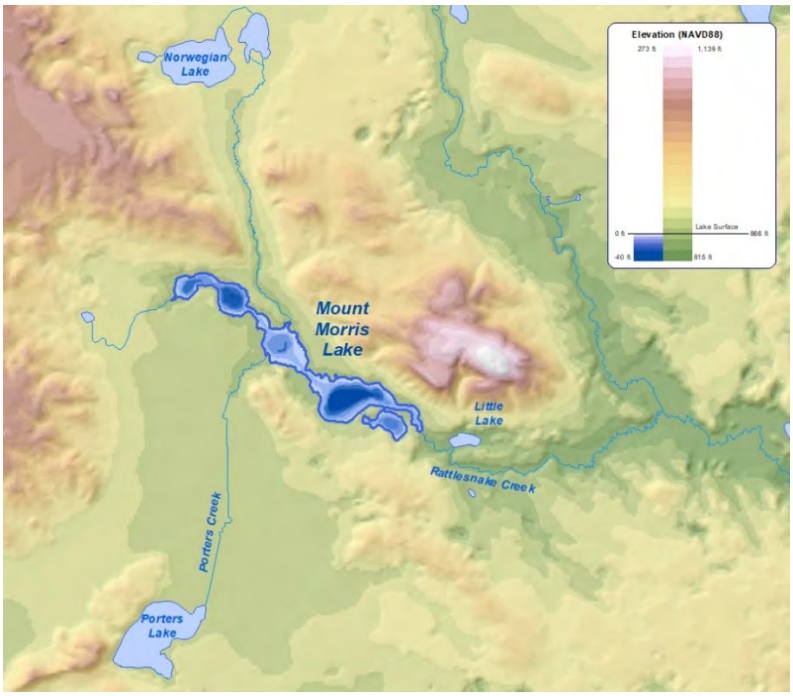

Figure 1.0-1. Mount Morris Lake, Waushara County.

The Mount Morris Lake Management District (MMLMD) is the local citizen-based organization leading the management of Mount Morris Lake (Map 1). 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 aquatic plant species (AIS).

Mount Morris Lake's water level is maintained by a dam at the outlet on the east side of the lake. The dam was first constructed in 1861, impounding waters to operate a grist mill. In the 1920s, the mill was modified to also generate electricity. The mill ceased operations in the early 1970s. The dam was reauthorized by the WDNR in 1977. In order to pass flows in excess of a 100-year storm event, per the Wisconsin Department of Transportation, the dam was modified in 1995. The State Highway 152 bridge and dam spillway were also upgraded in 1995. The dam is inspected annually, with the latest inspection occurring in June, 2021.

The dam is currently owned and operated by the MMLMD. The water levels are maintained within a 1-foot operating range (866.1 – 865ft) through two vertical slide gates. To provide for emergency repair, removal of debris from the flume, or for large water level changes, 12-inch notched stop logs can be individually removed.

2.0 WATER LEVEL MANAGEMENT PLANNING DISCUSSIONS

Mount Morris Lake has been able to manage CLP populations with strategic herbicide applications, but the flow of the system has not allowed sufficient herbicide concentrations and exposure times for EWM control. It was later confirmed in 2011 through DNA analysis that the Mount Morris system also contained a hybrid (HWM) variety of EWM, which is a cross between EWM and the native, northern watermilfoil (*Myriophyllum sibiricum*). Emerging research is indicating that HWM may be more tolerant to herbicides than pure-strain EWM. The terms EWM and HWM may be used interchangeably throughout this report.

As outlined in the MMLMD's 2013 *Comprehensive Management Plan for Mount Morris Lake*, water level management can be used for AIS control and to rectify sedimentation. Extended drawdowns (winter-summer-winter) are the best technique to achieve increases in water depth through sediment compaction and consolidation. EWM/HWM and curly-leaf pondweed (CLP) have been shown to be negatively impacted by winter drawdowns when the system can be dewatered to a sufficient depth to desiccate (i.e. dry out) and freeze the plant.

In 2019, the MMLMD engaged Onterra to conduct a lake-wide bathymetric modeling study to give preliminary insight into drawdown scenarios and feasibility considering the dam operations. The additional studies were integral to investigating drawdown options more specifically related to Mount Morris Lake; particularly, can the lake feasibly be dewatered six feet (Map 2). The findings of the survey indicate that Lake D is likely to achieve a full 6-foot drawdown. 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 up to a 6-foot water level reduction. The Lake E to Lake D channel is only 2 feet deep, consequently dewatering of that basin will not exceed two feet. There is insufficient flow between Lake E and D to facilitate any channel cutting.

The MMLMD 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 would serve as a pre-drawdown dataset if this management strategy is implemented. This included the collection of surface sediment cores from 18 locations around Mount Morris Lake during the summer of 2020 in an effort to understand the percent organic matter at these key locations within the lake (Map 3). The higher the organic content, the more depth would be gained if the sediments are oxidized during a summer drawdown. Said another way, if the organic content was low, a summer drawdown would not likely cause significant increase in depth from consolidation. Using the acoustic data collected during early-spring of 2019, a sediment hardness model was also created. The acoustic data collected in waters less than 2 feet deep can be problematic due to interference, but the data look fairly sound. While these data continue to be investigated, harder and sandy sediments are more prolific than soft and organic sediments. This suggests that some areas may not see large water level changes from decomposition. Based upon these data, in combination with district concerns about the loss of recreation during an extended drawdown, the MMLMD decided to only peruse a winter drawdown for AIS management at this time.

During a March 2, 2019 MMLMD meeting, Ted Johnson (WDNR lakes biologist) and Tim Hoyman (Onterra) educated attendees on the general pros and cons of water level management as it applies to Mount Morris Lake. A recorded presentation was constructed and placed on the MMLMD's website during 2020 with the intent of making decisions on water level management during the July 2020 annual meeting. Ultimately this vote was postponed due to Covid-19 and the timeline for when a drawdown would commence was pushed back a year.

The MMLMD held an advisory referendum vote by mail to determine support or opposition for a winter drawdown during spring 2021. All district members were sent a ballot by USPS to cast their vote, using the official County Tax role as the mail list. The ballot was returned by May 1, 2021. 70% of the returned ballots were in support of the 2021-2022 winter drawdown. The results of the referendum vote were discussed at the Regular Commissioners' meeting on May 8, 2021, and the data was used to compile a budget for presentation at the annual meeting. The MMLD confirmed, through vote at their July 2021 annual meeting, support for a winter drawdown during 2021/2022

3.0 DRAWDOWN IMPLEMENTATION

The temporary winter drawdown was designed to start soon after Labor Day 2021, a high-use recreation weekend. The Mount Morris dam can be manipulated to reduce the water level by 6 feet at the dam by removing 12-inch stop logs. Upon removing each stop-log, it was anticipated to take a few days for the water level to go down by that increment, with a target of 4-6 inches of water level reduction per day. This slow change in water level allows reptiles (e.g. turtles) and amphibians (e.g. frogs, salamanders) a chance to migrate with the water level, as they would soon be burrowing into the muddy shoreline for winter hibernation.

The Mount Morris Lake drawdown started on September 15, 2021, removing the first stop log as described above. The lake was down the full six feet on September 27, 2021. The lake was approximately maintained down the full six feet for the duration of the winter. Some extended rains during spring of 2022 occurred, but the water level at the dam remained roughly constant.

The de-watered period was anticipated to end on roughly May 1, 2022 with the goal of increasing water levels at a pace of 4-6 inches per day. However, the refill process was slightly postponed to start on May 5. One reason for the delay was to allow more time for the new concrete pad at the Town of Mount Morris Landing to dry. Another reason was to allow more time for the reptiles and amphibians to emerge from winter dormancy. The cool spring may have delayed the timing of these activities, and concerns exist that these species would drown if the water level is elevated before they evacuate their hibernation burrows. The water level of the lake is anticipated to be at full pool by May 17, 2022.

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. The Midwestern Regional Climate Center (MRCC) collects data from federal atmospheric observational sites which provides data to users in the public and private sector. Snowfall depth data collected from the MRCC from Labor Day 2021 to May 1, 2022 is displayed in Figure 3.0-1. The data show that there was zero or only a trace of snow on the ground for 69% of the days within this range.

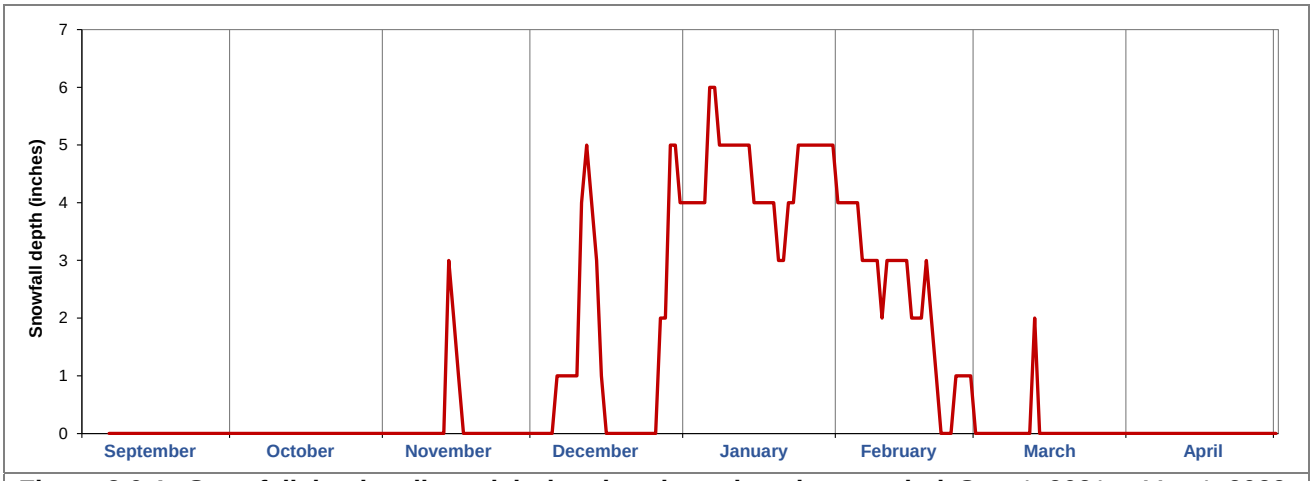

Figure 3.0-1. Snowfall depth collected during the winter drawdown period. Sept 1, 2021 to May 1, 2022.

In Mid-March, Onterra volunteered to collect photos and videos of the dewatered condition, some with the assistance of an aerial drone. The site visit confirms areas of exposed lakebed and channel cutting between basins (Photo 3.0-1). More videos and pictures were compiled into an approximately 4-minute YouTube video: https://youtu.be/kaheIT87g80 The standard settings are 720p, but can be manually increased to high-definition (HD) quality in the YouTube settings.

Photo 3.0-1. Aerial photo of Mount Morris Lake during winter drawdown. Photo credit: Onterra, LLC March 16, 2022.

4.0 DRAWDOWN MONITORING

The MMLMD is conducting water level management primarily for managing AIS populations within the lake. EWM/HWM population reductions are the chief goal, with impacts to the CLP population also likely. The pre-drawdown studies were completed with WDNR Grant-funding under AEPP-596-20, and the post drawdown studies will be partially funded under WDNR Grant AEPP-651-22. Together, these projects will provide an in-depth assessment of the drawdown for use by the MMLMD in future management planning efforts and to further the knowledge of the impact of winter drawdowns on AIS in Wisconsin. An annual report documenting the *year of refill* (2022) results will be distributed over the winter of 2022-2023 and a final project report looking at all years of the project will be distributed over the winter of 2023-2024.

Aquatic plants are the base of the lake ecosystem; therefore, a complete assessment of the community is vital when considering any management strategy. In order to make a full assessment, the following four types of aquatic plant surveys were performed *prior to the drawdown* (2021) and are planned to occur during the *year of refill* (2022), and the *year after the drawdown* (2023).

- ***Early-Season AIS (ESAIS) Survey*** – This survey will map the population of curly-leaf pondweed (CLP) in the system during the early part of the season when CLP is at its peak growth stage. CLP naturally dies back (senesces) on lakes at this latitude by the end of June each year. 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 pre-drawdown surveys (Map 4) indicate its population remains relatively small comprised mainly of low-density colonies and single-plant occurrences.
- ***Late-Season AIS (LSAIS) Survey*** – This survey will map the population of EWM/HWM in the system during the end of the season when this species is at its peak growth stage, typically late-August and September. The primary purpose of the drawdown is to control EWM/HWM within the lake, as this species is susceptible to freezing and drying out. The pre-drawdown mapping survey results are shown on Map 5.
- ***Point-intercept Survey*** – This survey is completed utilizing standard WDNR protocols and would systematically inventory the submergent plant population of Mount Morris Lake. This survey would occur in late-June/early-July in attempt to capture CLP prior to naturally annual die-off (senescence), but not too early to capture native plants that are emerging from winter dormancy. Several native submergent plants are known to be negatively impacted from winter drawdowns, while some experience no impact, and others increase. An analysis of which species are most susceptible to drawdown was conducted as a part of previous planning stages of this process.
    - As part of a Great Lake Restoration Initiative-funded project with Montana State University (MSU) and the US Army Corps of Engineers, Onterra collected an apical meristem (12-inch growing tip) of any watermilfoil species encountered at each of the 2021 point-intercept survey locations. The 64 processed and dried samples were sent to Montana State University for genetic fingerprinting not only to determine which species (e.g. northern watermilfoil, EWM, or hybrid EWM), but to understand which genotypes (i.e. strains) exist in the lake.
        - Mount Morris Lake was determined to be dominated by a single hybrid watermilfoil strain that was also found in Emerald Lake (Lake E).
        - Emerald Lake contained two hybrid strains, one that was also found in Mount Morris Lake proper and another that has not been found in any other lake that MSU has investigated.

Photo 4.0-1. Preserved watermilfoil samples for Mount Morris Lake.

Of the samples analyzed by MSU, none were determined to be pure-strain EWM, only hybrid watermilfoil (HWM). As more lakes with these strains of HWM are tested and management conducted, a database of how these strains react can be built up. For instance, if this drawdown is extremely successful, these strains would be tagged with this information. The district may also consider a follow-up project to identify the

strains of any surviving invasive watermilfoil following the drawdown. If it is all one strain that survives, perhaps that strain is tolerant of winter drawdowns.

- ***Community Mapping Survey*** – would focus upon emergent and floating-leaf communities, documenting population extents with sub-meter GPS and documentation of dominant species present. Emergent and floating-leaf species such as cattails and white-water lilies, respectively, have been observed to increase following winter water level drawdowns. A pre-drawdown survey was conducted in 2021 (Map 6) and planned to occur during the year of refill (2022).

In addition to aquatic plant surveys, basic water quality data was collected in 2021 prior to the drawdown and will be collected during the year of refill (2022) to understand any potential changes in water quality that can be linked to the winter drawdown. While not anticipated on Mount Morris Lakes, some drawdowns have resulted in decreased water clarity and depressed dissolved oxygen rates, as well as serve cyanobacteria (blue-green algae) blooms during the year of refill. This proposed project dovetails with the volunteer-based Citizens Lake Monitoring Network program on Lake D and will conduct trend analysis on historic data. Professional surveys will assist with understanding hypolimnetic (bottom waters) conditions.

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. That being said, changes in water depth will be investigated during the year of refill (2022). Conducting this survey early in the season can help to avoid issues with dense vegetation interfering with bathymetric outputs. Post drawdown acoustic surveys may shed light on where channel cutting occurred, sedimentation was scoured or deposited, and if overall water depth was increased in any area. However, the limitations of this methodology would require changes to be at least 6 inches to a foot to discern differences.

Lake A

Lake B

Lake C

Lake D

Lake E
(Emerald)

CTH
G

WI
152

N
W E
S

830
Feet

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Lake Management Planning
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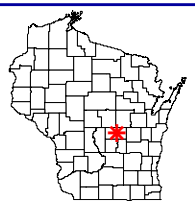
www.onterra-eco.com

Sources:
Orthophotography: NAIP, 2020
Bathymetric Survey: Onterra, 2019
Map Date: July 13, 2021 - EJH
Filename: *MM_2019Bathy.mxd*



Project Location in Wisconsin

Legend

- Canoe Portage
- Public Landing
- Town Beach
- Mechanical Harvester Parking Location
- Mount Morris Lakes Management District Boundaries
- Dam Property

Map 1

Mount Morris Lake

Waushara County, Wisconsin

Project Location & District Boundaries

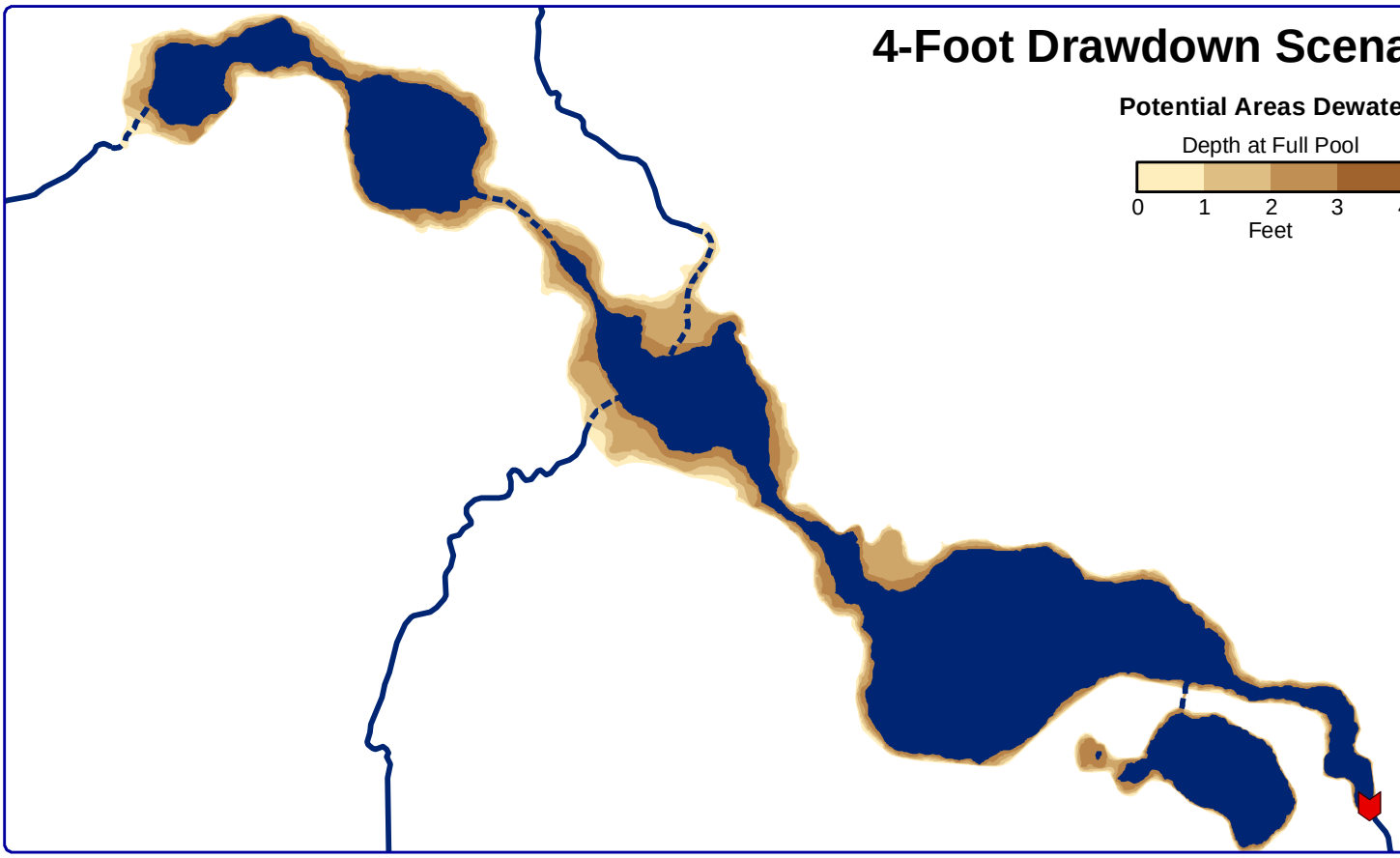
4-Foot Drawdown Scenario

Potential Areas Dewatered

Depth at Full Pool

0 1 2 3 4

Feet



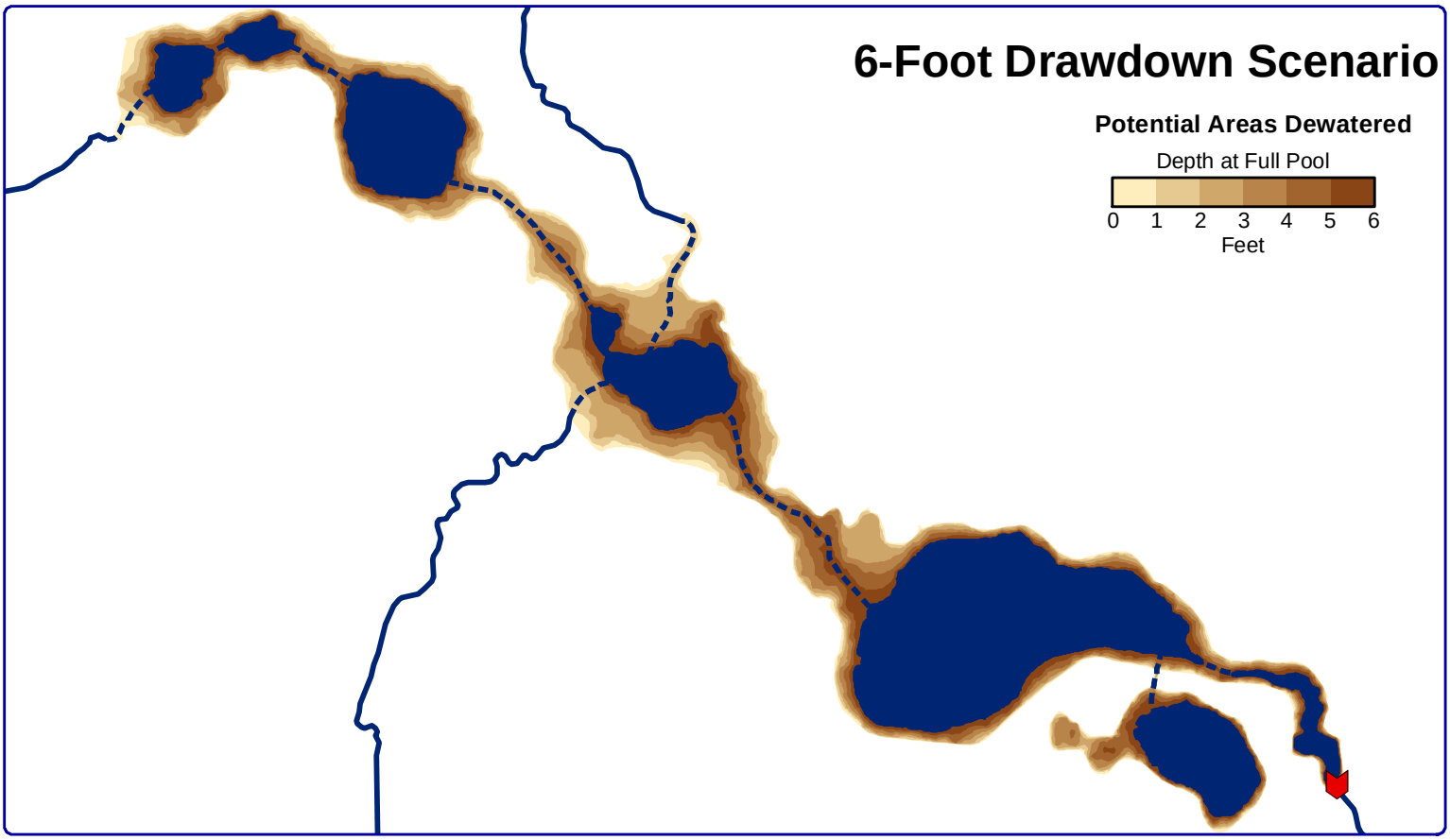
6-Foot Drawdown Scenario

Potential Areas Dewatered

Depth at Full Pool

0 1 2 3 4 5 6

Feet



N

W E

S

1,200

Feet

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Sources:
Hydro: WDNR
Bathymetric Survey: Onterra, 2019
Map Date: July 13, 2021 - EJH

Project Location in Wisconsin

Legend

Open Water During Drawdown

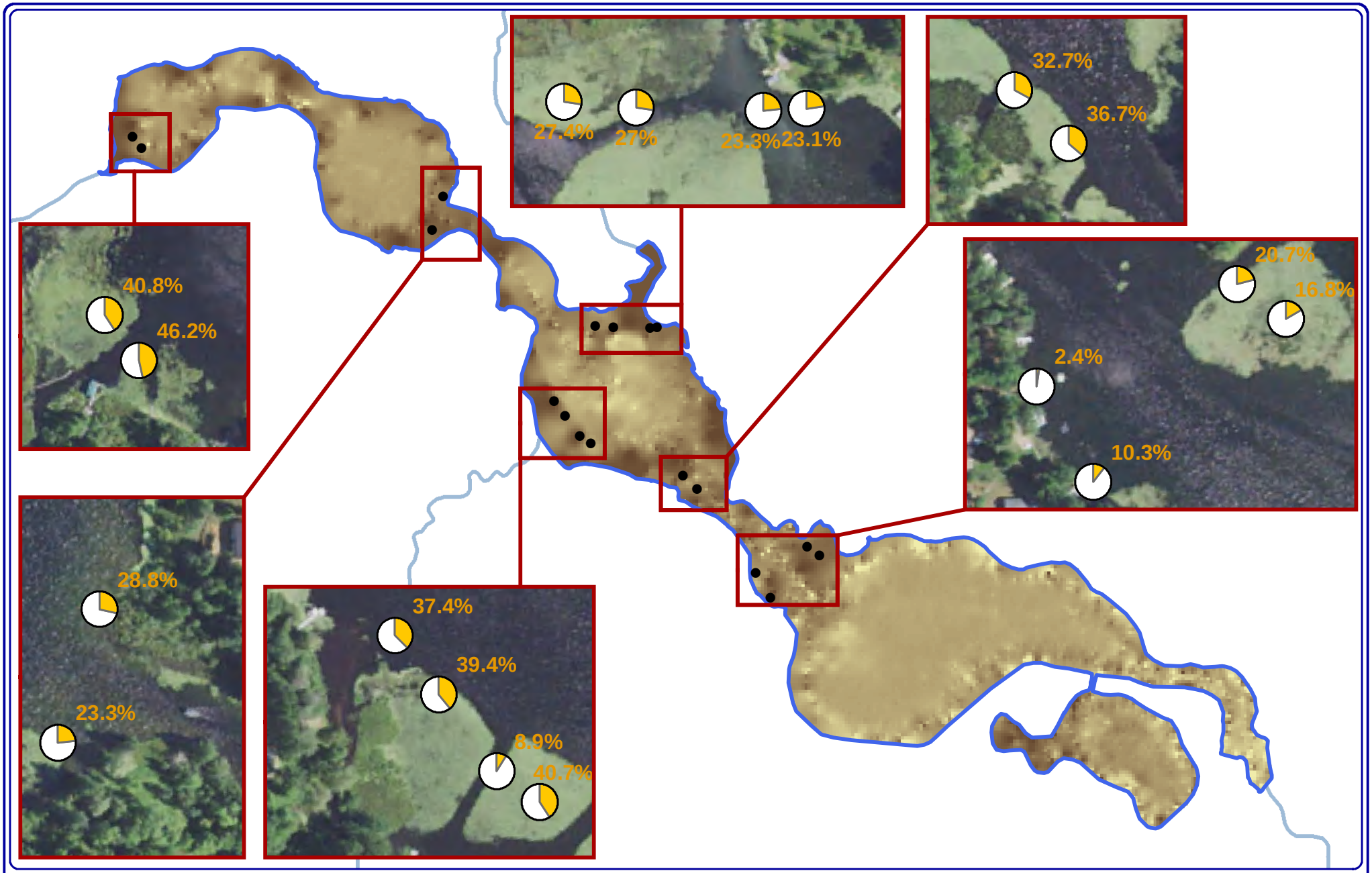
Potential Basin Connection During Drawdown

Map 2

Mount Morris Lake

Waushara County, Wisconsin

Potential Area Dewatered



N
W E
S

830
Feet

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Sources:
Roads and Hydro: WDNR
Orthophotography: NAIP, 2018
Acoustic Model: Onterra, 2019
Sediment Survey: Onterra, 2020
Map Date: November 25, 2020


Project Location in Wisconsin

Legend

Sediment Core Analysis

Percent Organic Matter

Acoustic Model

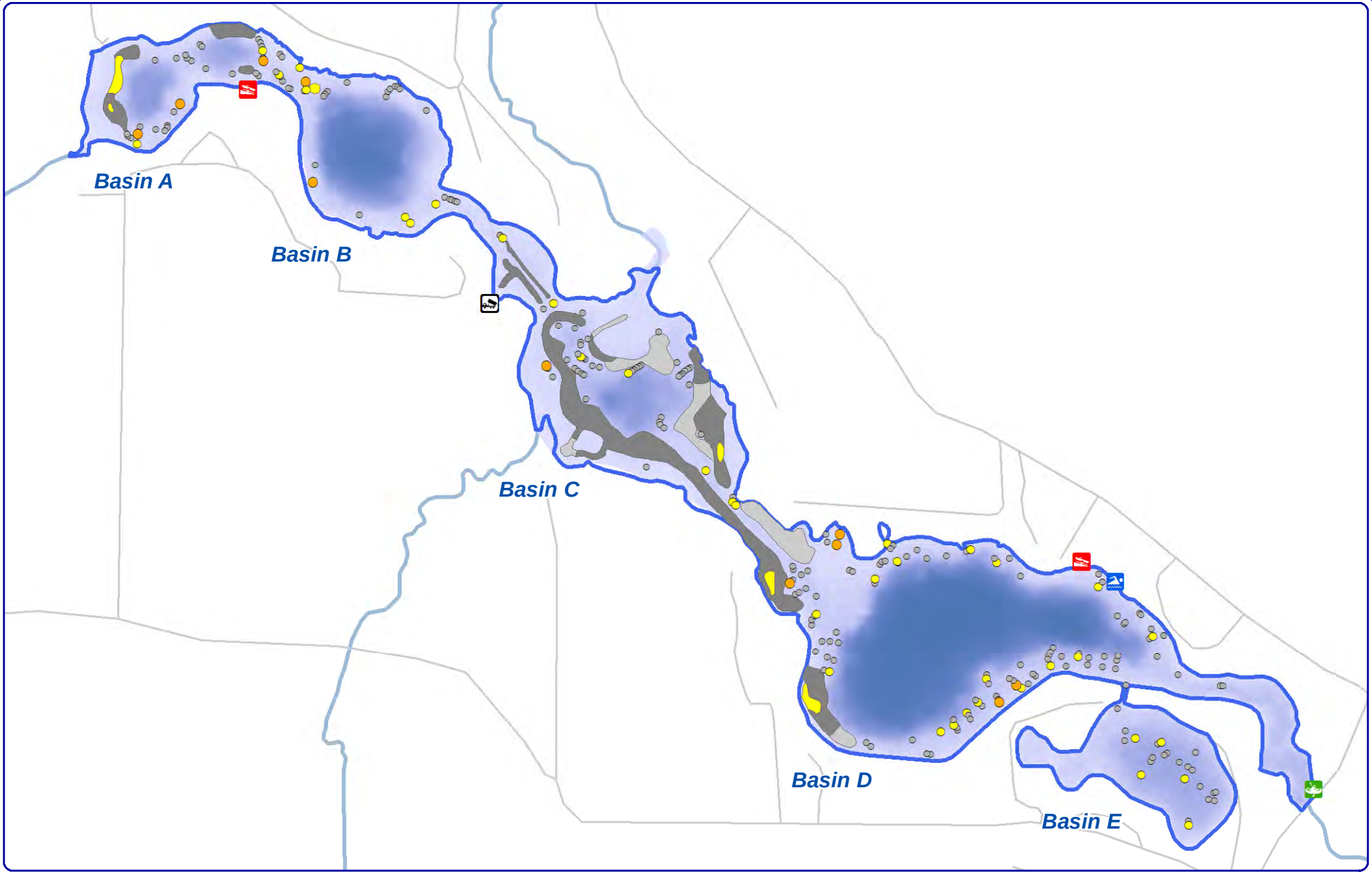
Hard — Soft

Substrate Hardness

Map 3

Mount Morris Lake
Waushara County, Wisconsin

Sediment Surveys: Acoustic Model & Core Analysis



N
W E
S

800
Feet

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Sources:
Roads & Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Aquatic Plant Survey: Onterra, 2020
Map date: May 28, 2021 JMB
File Name: *MM_CLP_May21.mxd*

Project Location in Wisconsin

Legend

ESAIS Survey Results (5/27/2021)

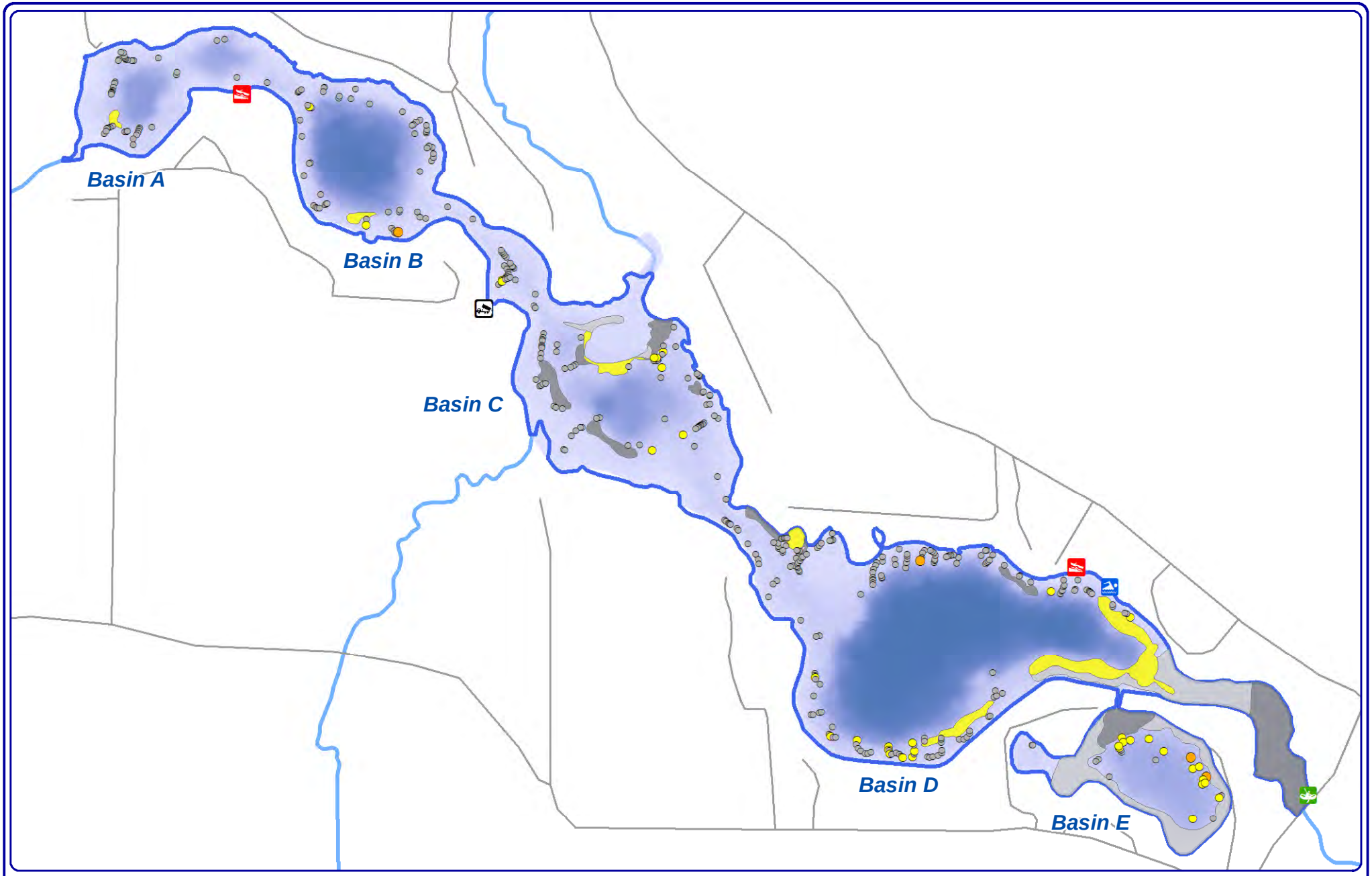
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant (none)
- Surface Matting (none)
- Single or Few Plants
- Clump of Plants
- Small Plant Colony

Map 4

Mount Morris Lake

Waushara County, Wisconsin

May 2021 CLP Survey Results



N
W E
S

800
Feet

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Sources:
Roads & Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Aquatic Plant Survey: Onterra, 2021
Map date: September 27, 2021 JMB

Project Location in Wisconsin

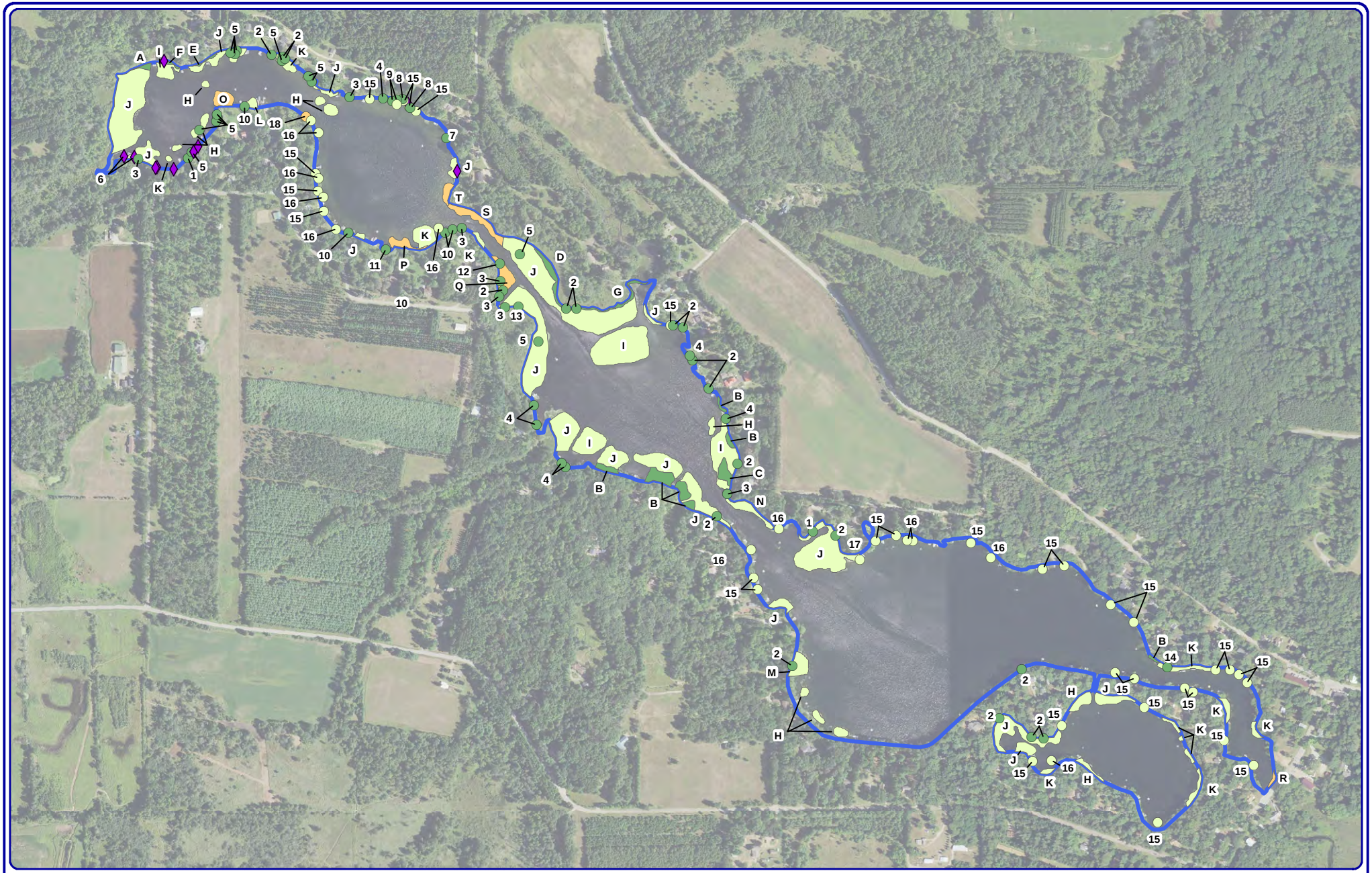
Legend

LSAIS Survey Results (8/4/2021)

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

Map 5
Mount Morris Lake
Waushara County, Wisconsin

2021 Late-Season EWM/HWM Survey Results



N
W E
S

700
Feet

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Sources
Hydro: WDNR
Aquatic Plants: Onterra, 2021
Orthophotography: NAIP, 2020
Map date: November 5, 2021

Project Location in Wisconsin

Legend

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent
- Purple Loosestrife

Large Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Map 6

Mount Morris Lake

Waushara County, Wisconsin

Aquatic Plant Communities

Mount Morris Lake 2021 Emergent & Floating-Leaf Plant Species

Corresponding Community Polygons and Points are displayed on Map 6

Large Plant Community (Polygons)									
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**	**Acres**
A	**Cattail sp.**	**Misc. Wetland Species**							0.05
B	**Broad-leaved cattail**								0.76
C	**Hardstem bulrush**								0.22
D	**Hardstem bulrush**	**Cattail sp.**							0.29
E	**Hardstem bulrush**	**Broad-leaved cattail**	**Misc. Wetland Species**						0.03
F	**Broad-leaved cattail**	**Narrow-leaf bur-reed**							0.04
G	**Broad-leaved cattail**	**Hardstem bulrush**							0.10
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**	**Acres**
H	**Spatterdock**								0.91
I	**Spatterdock**	**White water lily**							3.31
J	**White water lily**	**Spatterdock**							12.76
K	**White water lily**								1.33
L	**White water lily**				Spatterdock				0.10
M	**Spatterdock**				White water lily				0.31
Floating-leaf & Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**	**Acres**
N	**White water lily**	**Hardstem bulrush**			Spatterdock	Common arrowhead			0.24
O	**Hardstem bulrush**	**White water lily**			Spatterdock	Broad-leaved cattail			0.18
P	**White water lily**	**Spatterdock**			Misc. Wetland Species				0.38
Q	**White water lily**	**Broad-leaved cattail**			Softstem bulrush				0.04
R	**Hardstem bulrush**	**Broad-leaved cattail**	**White water lily**	**Spatterdock**	Common arrowhead				0.37
S	**Hardstem bulrush**	**White water lily**							0.13
								Total	**21.6**

Small Plant Community (Points)								
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**
1	**Common arrowhead**							
2	**Broad-leaved cattail**							
3	**Cattail sp.**							
4	**Iris sp.**							
5	**Hardstem bulrush**							
6	**Purple loosestrife**							
7	**Bristly sedge**	**Hardstem bulrush**						
8	**Cattail sp.**	**Misc. Wetland Species**						
9	**Cattail sp.**	**Hardstem bulrush**	**Misc. Wetland Species**					
10	**Pickerelweed**							
11	**Calla palustris**							
12	**Water willow**							
13	**Cattail sp.**	**Hardstem bulrush**						
14	**Bristly sedge**							
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**
15	**White water lily**							
16	**Spatterdock**							
17	**Pink water lily**							
Floating-leaf & Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**
18	**Spatterdock**	**Soft rush**						

*Species listed in **Bold** are dominant species in that community.*